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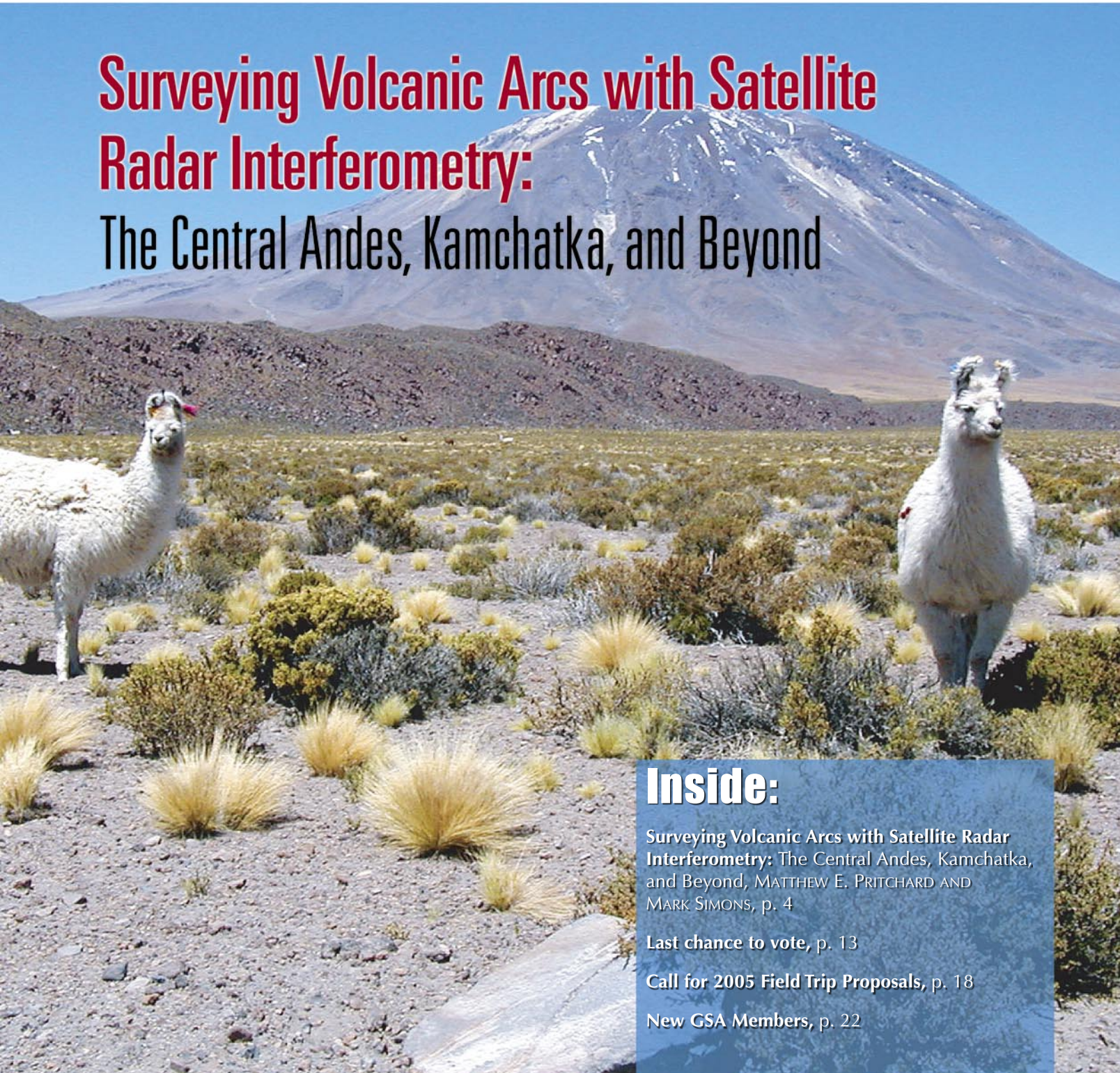
Surveying Volcanic Arcs with Satellite Radar Interferometry:

The Central Andes, Kamchatka, and Beyond



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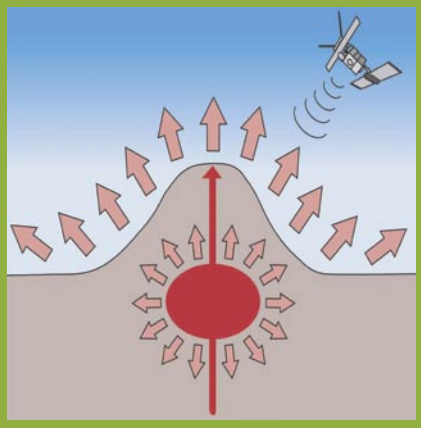

Cover: Lascar volcano, Chile (background), is the most active volcano in the central Andes, with several eruptions during the 1990s. As part of a satellite InSAR survey of more than 900 volcanoes in this area, no ground deformation was observed associated with the Lascar eruptions, and this lack of deformation provides clues about the magma plumbing system. (Photo by Mark Simons, October 2002.) **Right:** Cartoon portrays a radar satellite that measures surface inflation of a volcano above a swelling magma chamber. (Image by Doug Cummings.) See "Surveying volcanic arcs with satellite radar interferometry: The central Andes, Kamchatka, and beyond," by Pritchard and Simons, p. 4–11.

GSA TODAY

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SCIENCE ARTICLE

Surveying Volcanic Arcs with Satellite Radar Interferometry:
The Central Andes, Kamchatka, and Beyond

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ABSTRACT

Satellite Interferometric Synthetic Aperture Radar (InSAR) permits both synoptic and detailed surveys of magmatic activity in volcanic arcs. To illustrate this capability, we summarize here the results of an extended study of inferred magmatic activity in the central Andean arc (Pritchard and Simons, 2002; Pritchard, 2003; Pritchard and Simons, 2004), as well as new results from Kamchatka. In the central Andes, encompassing parts of Peru, Bolivia, Chile, and Argentina, we have observed ~900 volcanoes between 1992 and 2003 and found four previously undocumented sources of deformation. Coupled with surveys in other arcs, this deformation indicates that short-lived pulses of magma movement are common, although the relation of these movements to eruptive activity is unclear. In fact, no co-eruptive deformation was detected from eruptions at four other Andean volcanoes. In Kamchatka, the limits of current InSAR satellites are apparent in terms of the quality of the measurements and coverage of the arc. Nonetheless, we observe subsidence associated with a large lava flow that erupted 28 years ago and inflation of a geothermally active caldera. While a global inventory of volcanic arcs is impossible with current datasets, InSAR is a critical tool for understanding volcanic hazard at most of the world's poorly monitored subaerial volcanoes as well as for searching for large magma reservoirs.

INTRODUCTION

Volcanoes have different personalities—while some give notice of impend-

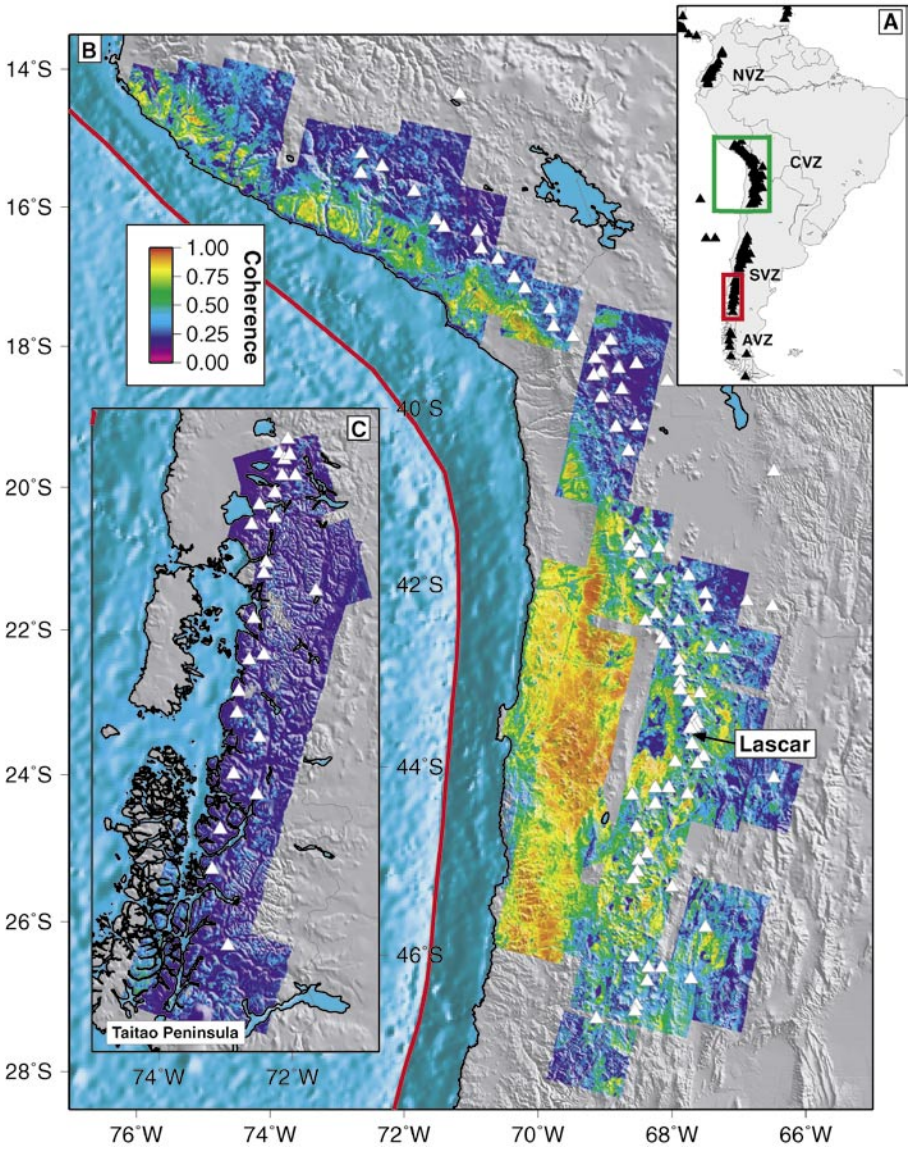

Figure 1. Interferometric coherence (a measure of the quality of the Interferometric Synthetic Aperture Radar, or InSAR, measurement) from ERS-1 and -2 (5.7 cm wavelength) draped over shaded relief for the Andes. (**A**) Reference map, with the green box showing the area in B and the red box indicating the area in C. Black lines show international borders. (**B**) The central Andes. Triangles are Holocene volcanoes (Smithsonian Institution, 2004). Even though measurements are taken during different seasons and span several years, coherence is high across the region (for a list of dates and data used, see Pritchard and Simons, 2004). We observe the highest interferometric coherence near the arid coast. (**C**) Coherence in the southern Andes taken during the austral summer and spanning only a few years. Coherence is regionally low, but high in rocky areas (like the Taitao Peninsula). Coherence is maintained on many lava flows (not resolved at the scale of this image), so that deformation measurements are still possible near many volcanoes. Usable data are only available in the southern portion of the southern arc.

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ing eruption, it is often difficult to decipher what many others will do next. Stratovolcanoes are particularly elusive because they can erupt with little warning after centuries of quiescence. For example, after more than a century of sleep, seismic activity at Mount St. Helens was only detected a few months before eruption (e.g., Dzurisin, 2003).

Satellite-based InSAR is revealing that these periods of apparent repose are not totally free of activity. In this paper, we briefly introduce the InSAR method and summarize what it has revealed about 900 volcanoes in the central Andes and other arcs. We then discuss broader issues raised by the new results: the eruptive cycle at stratovolcanoes, how earthquakes may trigger volcanic unrest, the timescales of magmatic intrusions, and the magma flux into volcanic arcs.

RADAR INTERFEROMETRY

The InSAR technique has wide application, and depending on the antenna configuration, it can be used to measure topography, ocean currents, ground moisture changes, and surface deformation (from glaciers, earthquakes, volcanoes, etc.), and even to study other planets (see reviews by Massonnet and Feigl, 1998; Rosen et al., 2000). Here, we measure ground deformation using satellites that use synthetic aperture radar (SAR) and overfly the same area at least twice (called repeat-pass Interferometric SAR, or InSAR). We use data from four satellites: ERS-1 and -2 (European), JERS-1 (Japanese), and RADARSAT-1 (Canadian). Even though none of these missions was optimized for InSAR, in some cases the radar data are appropriate for creating images of surface deformation with subcentimeter accuracy spanning hundreds of kilometers with a pixel spacing of order ten meters. Other types of measurements can provide more accurate and frequent deformation observations at a single position (e.g., continuous Global Positioning System stations, tiltmeters, and strainmeters), but InSAR is complementary in that it can measure more of the spatial complexity to help resolve the multiple sources of deformation that frequently occur in volcanic areas (e.g., Masterlark and Lu, 2004).

The differences between the recent SAR satellites illustrate the important parameters for using InSAR to monitor volcanoes (see also Zebker et al., 2000). For more detail, several publications have thoroughly outlined the technical principles of SAR and InSAR (e.g.,

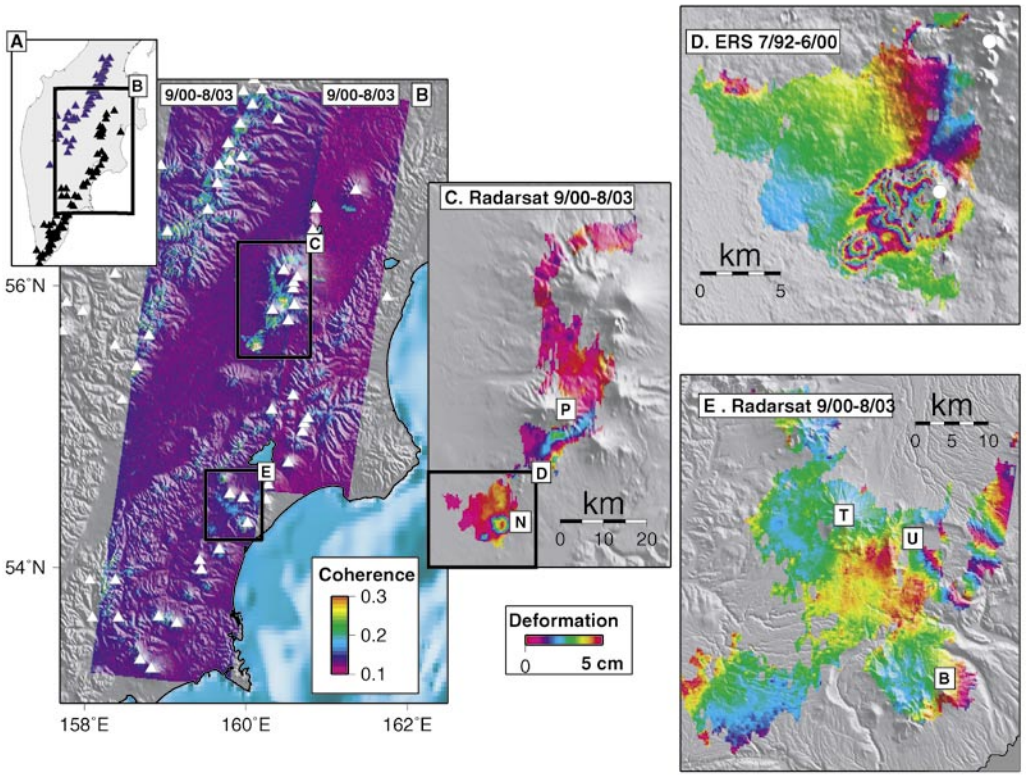

Figure 2. Maps of coherence and deformation from C-band Interferometric Synthetic Aperture Radar (InSAR) in Kamchatka. (**A**) Reference map showing Holocene volcanoes in Kamchatka (triangles; Smithsonian Institution, 2004). The Sredinny Range volcanoes are in blue and have no historical eruptions (although Ichinsky has fumarolic activity, Fedorov and Shapiro, 1998). The box shows the detail in B. (**B**) Interferometric coherence from two tracks of RADARSAT-1 data, with the timespan shown above each track. Higher resolution views showing the interferograms are in C and E. (**C**) Portion of a RADARSAT interferogram spanning 2 September 2000–18 August 2003, around the Kliuchevskoi group (Plosky Tolbachik and New Tolbachik volcanoes are labeled P, N). There is clear subsidence of the New Tolbachik lavas (erupted in 1975–1976), and shown in more detail in D. The fringes south and east of Plosky Tolbachik are likely artifacts (see Figure DR2d. that covers the same time interval). (**D**) Portion of an ERS interferogram spanning 15 July 1992–17 June 2000 showing subsidence of the New Tolbachik lava flows, where the white circles show approximate eruptive vents (Fedotov and Masurenkov, 1991). (**E**) Portion of a RADARSAT interferogram spanning 2 September 2000–18 August 2003, showing Taunshits, Uzon, and Bolshoi Semiachik volcanoes (labeled as T, U, and B, respectively). There is possible inflation at Uzon caldera (see GSA Data Repository; see footnote 1).

Massonnet and Feigl, 1998; Rosen et al., 2000; Bürgmann et al., 2000; Hanssen, 2001).

1. Wavelength: Successful measurement of surface deformation requires the radar-scattering properties of the ground to remain relatively unchanged between observations. In other words, the radar returns must maintain coherence over the time spanned by the two measurements. Coherence depends on the radar wavelength, with longer wavelengths (such as the 24 cm of JERS-1 compared to the 5.7 cm of ERS-1 and -2 and RADARSAT-1) providing higher coherence than shorter wavelengths over the same time interval because they are less sensitive to fine-scale movements of surface scatterers (leaves, pebbles, etc.; Zebker and Villasenor, 1992; Rosen et al., 1996). We have created maps of the radar interferometric coherence at 5.7 cm over parts of the Andes and Kamchatka (Figs. 1 and 2). As long as snow-free images are compared, coherence should be high in regions that have little precipitation and vegetation. Therefore, coherence is high along the arid coast of the central Andes, but low in the mountains. Coherence is low in all of the southern Andes and Kamchatka because of the wetter climate than the central Andes. Nonetheless, deformation can still be detected in the southern Andes and Kamchatka (discussed below), because measurements are possible on lava flows and rocky outcrops.
2. Data Availability: We need frequent global coverage to capture the time-dependence of ground deformation. At best, current satellite missions can provide data on a monthly basis. But in reality, usable data are rarely acquired in many volcanic arcs (see point 3). By using multiple satellites we can increase the spatial and temporal coverage, but with existing data, a global survey of all active subaerial volcanoes is impossible. A single radar scene typically costs $100s–$1000s (depending on the satellite), so that even our incomplete survey of the central Andes, including ~300 scenes, is costly, albeit dramatically cheaper than making comparable ground-based measurements.
3. Orbit Control: Usable data are rarely acquired during each satellite overpass because at least two requirements must be satisfied: the SAR data must be from the summer (to avoid snow—not a real problem in the central Andes, but a serious issue in many other places); and the two satellite flyovers must be in almost the same location (i.e., the interferometric baseline between the images must be small). Each satellite has

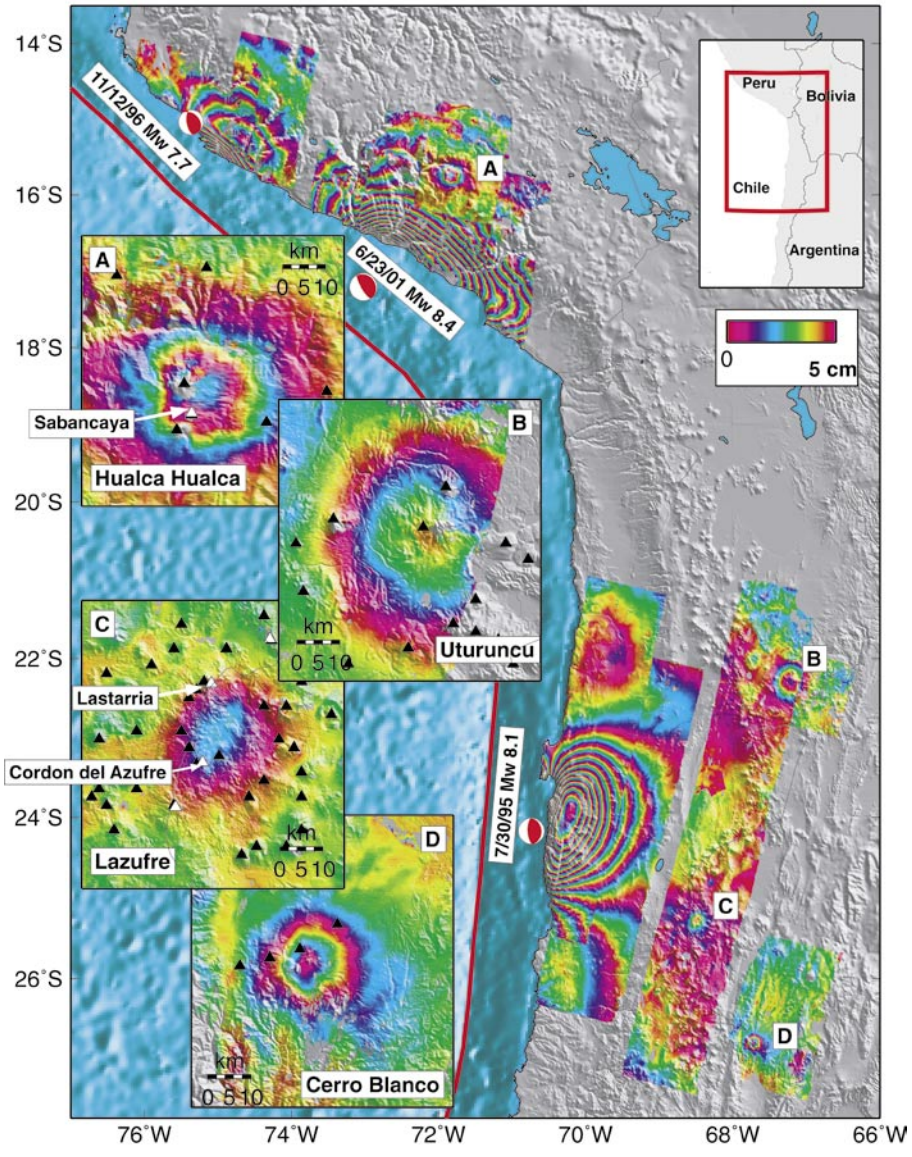

Figure 3. Color contours of ground deformation draped over shaded relief from three subduction zone earthquakes along the coast and four volcanic centers (for more details, see Pritchard et al., 2002; Pritchard and Simons, 2002; Pritchard, 2003). Black lines show international borders. Each contour corresponds to 5 cm of deformation in the radar line-of-sight direction. Inset maps show higher resolution interferograms at the four centers of active deformation, showing the relation of the center of deformation to the location of local edifices (potentially active volcanoes in white, all others in black, as classified by de Silva and Francis, 1991). Reference map in upper right corner places study area in regional context. Deformation from Hualca Hualca was not contemporaneous with the 2001 M_w 8.4 earthquake, so separate interferograms are shown there.

a different ability to achieve a small baseline between observations, and this ability can change during a satellite's lifetime.

4. Observing Geometry: InSAR only measures deformation in the line-of-sight (LOS) of the radar beam, implying that only one component of the deformation field can be measured in an individual interferogram. Multiple satellite passes with different observation geometries can be used to recover more than one component of deformation, which is important for constraining physical models of the deformation (Dieterich and Decker, 1975). For ERS-1 and -2, the satellites measure mostly vertical deformation, while the JERS-1 recovers equal parts of the horizontal and vertical deformation, and RADARSAT-1 has multiple viewing configurations.

The principal source of coherent noise for all satellite InSAR measurements of ground deformation is atmospheric and can cause errors of several centimeters (e.g., Beauducel et al., 2000). While in certain well-instrumented areas, independent data can constrain the atmospheric artifacts (e.g., Hanssen, 2001), the most globally practical method (and used in our studies) is to use multiple overlapping observations to better characterize the signal and the noise (e.g., Massonnet and Feigl, 1998).

THE CENTRAL ANDES

In the arid central Andes (Fig. 1), volcanoes are well-preserved; de Silva and Francis (1991) estimate 1113 volcanic structures younger than 20 Ma, although only 44 are classified as potentially active (with eruptions younger than the last glaciation; de Silva and Francis [1991]). We place constraints on the deformation at all of the potentially active volcanoes and 945 total volcanic structures between 1992 and 2003 with an accuracy of 1–2 cm (documented in Pritchard and Simons, 2002; Pritchard, 2003; Pritchard and Simons, 2004). We found broad (10s of km), roughly axisymmetric, centimeter-scale deformation at four centers with no previously documented deformation (Fig. 3). Because of low coherence on the edifices and the resolution of current digital elevation models, our survey is not very sensitive to deformation within the summit craters (which have diameters less than ~1 km for much of this arc).

During the period of our survey, two stratovolcanoes were inflating (Uturuncu, Bolivia, and Hualca Hualca, Peru), as was another source between Lastarria and Cordon del Azufre on the border between Chile and Argentina. This third source of inflation is not associated with a volcanic edifice (which will hereafter be called Lazufre). We also found a subsiding caldera, Cerro Blanco, (also called Robledo) in northwest Argentina. None of these deformation sources were listed as active volcanoes, although Hualca Hualca, Peru, and Lazufre could be related to potentially active volcanoes located within 10 km of the inferred source locations.

We assume that the observed deformation is caused by changes in pressure at depth due to the injection or withdrawal of magma or hydrothermal fluids and/or expansion and contraction caused by temperature or phase changes. Many different models have been considered to explain geodetic observations in volcanic areas (e.g., Dieterich and Decker, 1975; Fialko et al., 2001). Because many of these models can fit the data, we consider a suite of models to constrain the depth and volume change in the reservoir. For example, the inferred source depth is affected by the (unknown) shape of the subsurface reservoir, while variations in the seismic velocity structure appear to have secondary importance (Pritchard and Simons, 2004). Best fitting source depths (below sea level) are as follows: 8–18 km at Hualca Hualca; 12–25 km for Uturuncu; 5–13 km for the Lazufre, and 5–10 km at Cerro Blanco (Pritchard and Simons, 2004). Because hydrothermal systems are usually <10 km deep (e.g., Newhall and Dzurisin, 1988), we suspect that deformation at Uturuncu, Lazufre, and Hualca Hualca has a magmatic origin, and that subsidence at Cerro Blanco is at least augmented by hydrothermal activity. Uturuncu lies within a region of low seismic velocity and inferred partial melt (Chmielowski et al., 1999), part of the Altiplano-Puna Magmatic Complex (de Silva and Francis, 1991).

Using InSAR deformation data and some assumptions about the source model, we can place limits on the temporal evolution of inflation (see Figs. 9 and 10 in Pritchard and Simons, 2004). Deformation at all four sources is time dependent, and while these variations in deformation might represent normal intrinsic fluctuations, some of the changes could be induced by external processes. The changes in activity at Uturuncu and Lazufre may have been triggered by a M_w 7.1 subduction zone earthquake in 1998. Such remote triggering of deformation in volcanic areas has been observed before, with a variety of mechanisms proposed (e.g., Johnston et al., 1995). Inflation at Hualca Hualca stopped in 1997, perhaps induced by a large eruption of nearby Sabancaya volcano in May 1997, although there is no obvious relation between the rate of deformation and the eruptions of Sabancaya (Pritchard and Simons, 2004).

We do not observe any deformation associated with eruptions of Lascar, Chile, (the most active volcano in the arc), eruptions at 3 other volcanoes, or 13 other volcanoes that have recent fumarolic activity (Pritchard and Simons, 2004). Other recent studies indicate many primarily basaltic eruptions (smaller than the April 1993 Lascar eruption) in Alaska and at ocean islands that exhibit no observed subsidence (for a complete list, see Pritchard and Simons, 2004).

Yet, the lack of subsidence observed for the April 1993 eruption of Lascar is enigmatic because of the size of the eruption (0.1–0.4 km^3 of material, e.g., Smithsonian Institution, 2004). We can rule out injection or withdrawal of magma from a shallow magma chamber, unless the magma chamber can gain or lose magma without deforming, a process that is difficult to imagine for the silicic magmas at Lascar. Modeling indicates that the magma chamber would need to be at least 25 km deep (possibly much deeper) to explain the lack of deformation from the April 1993 eruption, and such a deep magma chamber might not be consistent with the fact that movements of the lava dome seem to trigger eruptions in at least 1986–1993 (Matthews et al., 1997). Considering the long periods between observations (see Pritchard and Simons, 2004), inflation

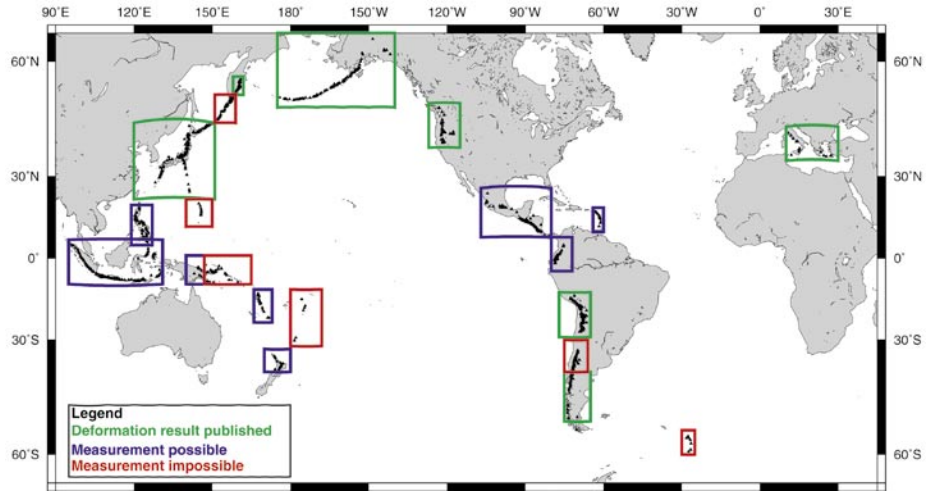

Figure 4. Interferometric Synthetic Aperture Radar (InSAR) data availability for volcanic arcs from ERS-1 and -2, JERS and RADARSAT as of March 2004. For the blue boxes, at least one interferogram has been published from the arc (e.g., Zebker et al., 2000), or more than five years of temporal coverage of the arc is possible with one or more interferograms. For the red boxes, coverage is considered incomplete if less than 5 years can be spanned by interferograms (for some arcs, no interferograms can be made). Deformation has been measured in the Japan-Izu-Bonin arc (e.g., Nishimura et al., 2001; Furuya, 2004), the Mediterranean (e.g., Massonnet et al., 1995; Lanari et al., 1998), and the USA (Cascadia and Alaska/Aleutians; e.g., Wicks et al., 2002; Lu et al., 2003a), and studies of all volcanoes in these arcs is ongoing.

and deflation could nearly exactly cancel each other, especially if the eruptive process is cyclic or the magma chamber quickly repressurizes. In order to resolve whether the Lascar chamber is deep or quickly repressurizes, petrological and seismic studies of the magma chamber location should be undertaken, and InSAR measurements with greater temporal resolution must be acquired.

ERUPTIVE HAZARD

Inflation at supposedly inactive volcanoes has been found in the Galapagos, Alaska, and the Cascades, and as in the central Andes, is assumed to be of magmatic origin (Lu et al., 2002a; Wicks et al., 2002; Lu et al., 2000a; Amelung et al., 2000). The hazard from these presumed magma intrusions is unclear: will this magma accumulation result in an eruption, or is this a benign intrusion? In this respect, the inferred source at Lazufre is especially enigmatic. It may be related to one of the nearby (within 10 km) potentially active volcanoes, a randomly located intrusion, or perhaps the birth of a new volcano or caldera. Assessing hazard is difficult without ancillary information about the eruptive history of the volcano, the subsurface magmatic plumbing (as inferred from seismic tomography or geochemical studies), or current unrest (seismicity, thermal activity, or degassing).

However, observations of deformation can provide some clues to the physical processes occurring at depth and to the potential hazard. For example, there is evidence that the intrusive episodes at dormant volcanoes are short-lived and therefore may commonly occur without eruption. A short timescale for these intrusions is consistent with the fact that deformation at Mount Peulik, Alaska, is inferred to have occurred between 1996 and 1998 (Lu et al., 2002a), and the beginning or ending of periods of deformation was seen at South Sister in Oregon and Hualca Hualca and Lazufre in the central Andes. Geochemical evidence at other volcanoes suggests multiple timescales for intrusions, and that there might be several small intrusions spanning the decades to centuries before an eruption (e.g., Zellmer et al., 2003), so that any eruption might be many years from now.

The durations of intrusive episodes can be governed by a combination of magma supply, the physics of transport, and potentially some external mechanism like earthquakes. We mentioned earlier that a M_w 7.1 subduction zone earthquake could have affected volcanic deformation in the central Andes, but M_w 8.1 and M_w 8.4 earthquakes had no obvious effects (although the M_w 8.4 earthquake may have affected shallow groundwater flow; Pritchard, 2003). A correlation between earthquakes and eruptions is suggested (e.g., Linde and Sacks, 1998), but with InSAR monitoring of volcanic arcs, we can look for the influence of earthquakes on more subtle changes in deformation rates.

Further allaying concerns about an immediate eruptive threat is the paucity of shallow seismicity that may indicate that magma is approaching the surface at Mount Peulik, Alaska, South Sister, Oregon, or Westdahl, Alaska (e.g., Dixon et al., 2002, http://www.geophys.washington.edu/SEIS/PNSN/SISTERS/). However, an earthquake swarm did occur at South Sister in March 2004. At Uturuncu, Bolivia, a short deployment of a single seismometer revealed a surprisingly high rate of seismicity, but further work is necessary to determine if this is related to magmatic or hydrothermal activity (McNutt and Pritchard, 2003).

While the duration of inflation could provide some clues to the hazard, it is less clear if the horizontal position of the source (e.g., location relative to the edifice) is important in assessing the origin or threat of the deformation. While one might assume that a source of deformation at some distance from an eruptive vent may be a noneruptive intrusion, several eruptions seem to have been fed by magma chambers 5–10 km away from the eruptive center (Curtis, 1968; Lu et al., 2000c).

To better characterize the eruptive hazard from the magmatic intrusions imaged with InSAR, we need a more complete understanding of the eruptive cycle of each stratovolcano. At some volcanoes (particularly basaltic volcanoes in Hawaii, Alaska, and Iceland) the eruptive cycle seems straightforward: magma enters a chamber, an eruption occurs, the chamber empties, and the chamber refills (e.g., Dvorak and Dzurisin, 1997; Mann et al., 2002; Lu et al., 2003b). At many stratovolcanoes, the pattern is more complicated. Magma may not refill every chamber before

or after eruption, or might not even be stored in a shallow chamber before erupting (Dzurisin, 2003). If InSAR measurements are made frequently enough so that pre-eruptive, co-eruptive and posteruptive processes can be separated, we can test where and when the simple eruptive cycle works. Ground-based sensors (particularly gravimeters and continuous geodetic stations) will be an important complement to InSAR, especially in cases where magma movements are undetectable by satellite (because the magma moves without deforming the surface or the deformation is too small).

INTER-ARC COMPARISON

In the central Andes, the deforming volcanoes are not erupting, and we do not observe deformation at the erupting volcanoes. Only four volcanoes out of the hundreds surveyed are deforming, and none of them are the usual suspects of potentially active volcanoes. To explore how representative these results are, we searched the literature and data archives of ERS-1 and -2, JERS, and RADARSAT to determine which other arcs could be surveyed in a similar comprehensive manner (Fig. 4).

A comparison between the central Andes and the Aleutian arc is illustrative of inter-arc variations, because although both have about the same number of Holocene volcanoes (70–80, Smithsonian Institution, 2004), the Aleutian arc has more historic eruptions (41 compared to 17; Smithsonian Institution, 2004), and more actively deforming volcanoes (9 compared to 4, Lu et al., 1997, 2000a, 2000b, 2000c, 2002a, 2002b, 2002c; Mann and Freymueller, 2003; Masterlark and Lu, 2004). The estimated magma flux into both arcs is similar over the long term (e.g., 10 Ma; Karig and Kay, 1981; Francis and Hawkesworth, 1994), although there are within-arc variations (e.g., Fournelle et al., 1994). Short-term temporal variations in the flux are likely (e.g., Fournelle et al., 1994), but at least over the past 10 years, the observed rates of magma intrusion are also similar between arcs, based on incomplete InSAR surveys of both arcs (summing results from Lu et al., 1997–2003, and Pritchard and Simons, 2004). Of course, the ratio of the volume of material erupted to the volume intruded could vary between arcs, and documenting how this ratio changes in different arcs and tectonic regimes is a goal for future InSAR satellites. Although it is possible that convergence rate controls overall magma flux, other factors also seem to be important, and there is currently no consensus (e.g., Karig and Kay, 1981; Simkin and Siebert, 1984).

For some arcs, we find InSAR data coverage is greater than what has been published, while for other arcs, usable data has not been acquired, or has been acquired for only part of the arc (Fig. 4). For example, in the Kamchatka-Kuril arc, viable data only exists south of Urup island and north of Petropavlovsk, because of the location of downlink stations.

In Figure 2, we present ERS-1 and -2 and RADARSAT data for northern Kamchatka between 1992 and 2003, although most volcanoes are only covered during the last three years (for a complete list, see GSA Data Repository[1]). Despite difficulties with coherence and poor knowledge of the orbital baselines, we observe two sources of deformation (Fig. 2). There is one area of subsidence (maximum of ~2.5 cm/yr LOS) associated with the basaltic lava flows from the great Tolbachik fissure eruption of 1975–1976 (~2 km^3; e.g., Fedotov and Masurenkov, 1991). Subsidence of lava flows and other eruptive products observed elsewhere has been related to thermal contraction, relaxation of the underlying substrate, and closing of pore space (e.g., Lu et al., 2003a).

We also observe inflation (maximum of ~1.5 cm/yr LOS; Fig. 2) associated with the geothermally active Uzon caldera (e.g., Belousov et al., 1984). The deformation at Uzon is less certain because of the lower coherence in the area and the existence of only a few measurements (making it harder to rule out atmospheric contamination). A magma body has been inferred below the caldera at 5 km (Waltham, 2001), and our best fitting model sources lie at this depth or shallower (see GSA Data Repository). It is difficult to determine if the movement of magmatic or hydrothermal fluids are the cause with only deformation data (e.g., Battaglia et al., 1999). We do not observe deformation associated with eruptions that occurred during the time period of observation at Kliuchevskoi, Sheveluch, or Bezymianny volcanoes, but because of the poor spatial and temporal coverage, only large signals would be detectable (see GSA Data Repository). These preliminary results confirm the diversity of sources of deformation in arcs and the need for synoptic surveys instead of point measurements.

THE FUTURE

Even though existing InSAR systems have provided new insights into volcanoes and other fields of geophysics, considering the practical difficulties mentioned above, a satellite dedicated and optimized for InSAR could discover much more, and should be a high priority for U.S. funding agencies (National Aeronautics and Space Administration, National Science Foundation, and the U.S. Geological Survey; e.g., Solomon et al., 2003). Key mission characteristics include:

- L-band (24 cm wavelength) radar to maximize interferometric coherence in nonarid environments and over extended time periods in all environments.
- Left and right looking radar from both ascending and descending orbits to provide constraints on the full three-dimensional deformation field.
- Subweekly access to the whole globe to assess time-dependent deformation, generate sufficient observations for stacking, and permit a global inventory of subaerial volcanoes.
- A free and open data policy to maximize innovative use of the data and continued algorithmic improvements.
- Tight orbital control to minimize interferometric baseline, thereby maximizing the number of allowable interferometric pairs and minimizing the sensitivity to topography.
- Accurate a posteori orbital knowledge to provide the most accurate

[1]GSA Data Repository Item 2004139, Tables DR1 and DR2 and Figures DR1–DR3, is available on request from Documents Secretary, GSA, P.O. Box 9140, Boulder, CO 80301-9140, USA, editing@geosociety.org, or at www.geosociety.org/pubs/ft2004.htm.

estimates of deformation possible.
- Large bandwidth to permit estimation and correction of ionospheric effects.

Such a satellite or constellation of satellites would allow for global volcano monitoring, and would undoubtedly discover unsuspected sources of deformation at many presumably dormant volcanoes and elsewhere. Field surveys could then be targeted at these few volcanoes to assess the threat of eruption. Even at well-monitored volcanoes, InSAR observations are useful because they can measure more of the deformation field, helping to resolve ambiguities about the multiple sources of deformation (flank instabilities, dike intrusions, magma chamber, and hydrothermal system dynamics) in volcanic areas. Such a global compilation of the types of deformation that occur and the relationship with other types of activity (including eruptions) would be invaluable for beginning to decipher how hazardous any particular volcano could be.

Furthermore, a dedicated InSAR satellite would be able to acquire enough radar images so that the data could be stacked together to reduce noise. This technique has already allowed for the detection of deformation of only a few mm/yr from the Socorro magma body, New Mexico, at a depth of ~19 km (Fialko and Simons, 2001). Stacking not only allows for the detection of smaller amplitude deformation at volcanoes, but will reveal deep magma reservoirs and place constraints on the magma flux into these arcs. Over the lifetime of several satellites, we will be able to monitor temporal variations of the magma flux, compare the flux with the geologic average, and compare fluxes between arcs, with implications for understanding the long-term evolution of volcanic arcs and continental growth.

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DIALOGUE

Vote in GSA's upcoming council election—we need to hear from you!

Rob Van der Voo, *GSA President*

Once again election time is upon us. We have a fine field of candidates for GSA Council positions, and I encourage you all to participate in this critically important process. GSA has made good progress as a Society over the past several years, thanks to a dedicated group of visionary, hardworking volunteers. We continue to need good leadership as we consider the many opportunities and challenges on the horizon. Following are some frequently asked questions about GSA's elections process. Thank you in advance for your thoughtful consideration and for casting your ballot!

Q. Who can vote in GSA elections?

A. All professional, teacher, and student members of GSA are eligible. Only student associates (undergraduates) and affiliates do not vote.

Q. Why should I vote?

A. As a member of GSA, your opinion counts! This is never truer than in these times of change within the geosciences. Your elected representatives determine the Society's response as our science evolves and changes take place in our profession. Elected representatives help shape our collective future. That's why it's so important that you read the information on each candidate posted on GSA's Web site (www.geosociety.org) and carefully consider what kind of direction and leadership he or she is likely to bring to GSA. It's your Society, after all.

Q. How are candidates for Council selected?

A. GSA has a standing Committee on Nominations consisting of seven members plus Executive Director Jack Hess (ex officio). All members serve three-year terms. The committee meets each year to consider candidates for open positions on Council. Throughout the year, possible candidates are nominated by their colleagues within GSA or people step forward and submit their own names. The committee reviews this list and all supporting documentation submitted, including each person's record of service at GSA, before making its recommendation to Council. Once Council approves the list of candidates chosen, the balloting process is organized in preparation for annual elections.

Q. Why do Council officers run unopposed?

A. Officers have already been elected to Council in a contested popular vote by the time they are considered for a position on the Executive Committee. Our organization and others have had the unfortunate experience of losing vital, well-qualified people at this level because they did not win in an Executive Committee election. We want to maintain everyone's participation and enjoy the continuity of experience that this process affords us.

Q. If I want to be considered for a position on Council, what should I do?

A. Get involved in the life of the Society. Volunteering to serve on a committee is a great place to begin. Committee service allows you to bring your knowledge, expertise, and passion to bear on one of the many exciting challenges we face as geoscientists. GSA has 23 standing committees to choose from, and all that is required is that you inform the Nominations Committee of your interest in serving. As mentioned previously, committee service is considered when selecting individuals to run for open Council positions. Visit www.geosociety.org/aboutus/commtees/ or contact Ruth Harrison, (303) 357-1000, ext. 0, rharrison@geosociety.org, for a list of committees, their functions, and contact information. Participation on GSA Section and Division management boards is also considered; relevant information can be accessed via www.geosociety.org/sectdiv.

GSA 2004–2005 Council Election Timetable

- Postcard notifications with instructions for voting mailed in early August.
- Online voting August 11–September 10 at **www.geosociety.org/ballot.asp.**
- Paper ballots available now for members unable to vote online. Contact GSA Sales and Service at 1-888-443-4472 or gsaservice@geosociety.org.
- Completed paper ballots must be postmarked no later than **September 10.**

ATTENTION Voting Members

Vote by September 10, 2004

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

You should receive a postcard in August with instructions on how to access a secure Web site and your electronic ballot listing officer nominees for 2005 and councilor nominees for the term 2005 to June 2009. Biographical information on each candidate also is available on the site.

If you do not receive these instructions, or if you need paper copies of the ballot or candidate information, contact GSA Sales and Service, (303) 357-1000, option 3, 1-888-443-4472, or gsaservice@geosociety.org.

Your vote is vital to GSA! Please take a few minutes and vote today. Ballots must be submitted electronically or postmarked by September 10, 2004.

2005 Officer and Councilor Nominees

President
William A. Thomas
University of Kentucky

Vice President
Stephen G. Wells
Desert Research Institute, Reno, Nevada

Treasurer
John Costa
U.S. Geological Survey, Portland, Oregon

Councilor (2005–June 2009)
Position 1*
Nancy J. McMillan
New Mexico State University

Warren E. Huff
University of Cincinnati

Councilor (2005-June 2009)
Position 2
John W. Geissman
University of New Mexico

Walter D. Mooney
U.S. Geological Survey, Menlo Park, California

Councilor (2005–June 2009)
Position 3
Jill S. Schneiderman
Vassar College

J. Douglas Walker
University of Kansas

Councilor (2005–June 2008)
Position 4
Robbie R. Gries
Priority Oil & Gas LLC, Denver, Colorado

Jonathan G. Price
Nevada Bureau of Mines & Geology

*Katharine Cashman has withdrawn from the election.

Enrich Your Meeting Experience with a Field Trip

GEOSCIENCE in a Changing World—Denver 2004

Complete trip descriptions, registration details, and information are in the June issue of *GSA Today* and posted at www.geosociety.org. All trips begin and end at the Colorado Convention Center, Denver, unless otherwise indicated.

Standard registration deadline: September 30
Cancellation deadline: October 7
Register online: www.geosociety.org

Questions? **Contact the field trip leader** or Edna Collis, GSA Program Officer, (303) 357-1034, ecollis@geosociety.org. Meals and lodging are noted by the follow symbols: B—breakfast, L—lunch, R—refreshments, D—Dinner, ON—overnight lodging.

PREMEETING

1. Navajo Sand Sea of Near-Equatorial Pangea: Tropical Westerlies, Slumps, and Giant Stromatolites [401]

Tues.–Sat., Nov. 2–6. Cosponsored by *GSA Sedimentary Geology Division*. David Loope, Dept. of Geosciences, University of Nebraska, Lincoln, NE 68508, (402) 472-2647, fax 402-472-4917, dloope1@unl.edu; Len Eisenberg; Erik Waiss. Max.: 15; min.: 10. Cost: $475 (5L, R, 4ON, vans). *Begins and ends in Grand Junction, Colorado.*

2. Strike-Slip Tectonics and Thermochronology of Northern New Mexico [402]

Thurs.–Sat., Nov. 4–6. Eric Erslev, Dept. of Geosciences, Colorado State University, Fort Collins, CO 80523, (970) 491-5661, fax 970-491-6307, erslev@cnr.colostate.edu; Steven Cather; Seth Fankhauser; Matt Heizler; Rob Sanders. Max.: 40; min.: 12. Cost: $255 (2L, R, 2ON, vans). *Begins and ends in Denver or Santa Fe, New Mexico.*

3. Geology of the Silver Cliff–Rosita Hills Mining District and Spanish Peaks Area [403]

Fri.–Sat., Nov. 5–6. Cosponsored by *GSA Sedimentary Geology Division.* Paul R. Krutak, P. Krutak Geoservices International, P.O. Box 369, 2118 Main Street, Rye, CO 81069-0369, (719) 489-2282 (phone and fax), pkrutakgeos@hotmail.com; John R. Barwin; Marty Horn. Max.: 36; min.: 12. Cost: $185 (2L, 1D, R, 1ON, vans).

4. Hyperpycnal Wave-Modified Turbidites of the Pennsylvanian Minturn Formation, North-Central Colorado [404]

Fri.–Sat., Nov. 5–6. Cosponsored by *GSA Sedimentary Geology Division*. Paul M. Myrow, Dept. of Geology, Colorado College, Colorado Springs, CO 80903, (719) 389-6789, fax 719-389-6910, pmyrow@coloradocollege.edu; Karen Houck; Charles Kluth; Michael Lamb; Claire Lukens; Jeff Parsons. Max.: 36; min.: 12. Cost: $155 (1L, R, 1ON, vans).

5. Structural Implications of Underground Coal Mining in the Mesaverde Group, Somerset Coal Field, Delta and Gunnison Counties, Colorado [405]

Fri.–Sat., Nov. 5–6. Cosponsored by *GSA Coal Geology Division.* Christopher J. Carroll, Colorado Geological Survey, 1313 Sherman St., Room 715, Denver, CO 80203, (303) 866-3501, fax 303-866-2461, chris.carroll@state.co.us; Greg Hunt; Wendell Koontz; Eric Robeck. Max.: 20; min.: 7. Cost: $240 (2L, 1D, R, 1ON, vans).

6. A New K-T Boundary in the Denver Basin [406]

Sat., Nov. 6. Cosponsored by *GSA Sedimentary Geology Division*. Kirk Johnson, Denver Museum of Nature & Science, 2001 Colorado Blvd., Denver, CO 80205-5732, (303) 370-6448, fax 303-331-6492, kjohnson@dmns.org; Richard Barclay. Max.: 45; min.: 12. Cost: $105 (1L, R, bus).

7. Buried Paleo-Indian Landscapes and Sites in the High Plains of Northwestern Kansas and Eastern Colorado [407]

Sat., Nov. 6. Cosponsored by the *GSA Archaeological Geology Division.* Rolfe D. Mandel, Kansas Geological Survey, 1930 Constant Avenue, Lawrence, KS 66047-3726, (785) 864-2171, fax 785-864-5317, mandel@kgs.ku.edu; Jack Hofman; Steve Holen. Max.: 36; min.: 12. Cost: $85 (1L, R, vans).

8. Colorado Front Range—Anatomy of a Laramide Uplift [408]

Sat., Nov. 6. Cosponsored by *Colorado Scientific Society*. Karl Kellogg, U.S. Geological Survey, MS 980, P.O. Box 25046, Denver Federal Center, Denver, CO 80225, (303) 236-1305, fax 303-236-0214, kkellogg@usgs.gov; Bruce Bryant; Jack Reed. Max.: 36; min.: 12. Cost: $100 (1L, R, vans).

9. Continental Accretion, Colorado Style: Proterozoic Island Arcs and Back Arcs of the Central Front Range [409]

Sat., Nov. 6. Cosponsored by *Colorado Scientific Society*. Lisa R. Lytle, Dept. of Geology and Geological Engineering, Colorado School of Mines, Golden, CO 80401-1887, (303) 478-9427, fax 303-273-3859, lfiniol@mines.edu; Thomas R. Fisher. Max.: 36; min.: 12. Cost: $90 (1L, R, vans).

10. Eco-Geo–Hike along the Dakota Hogback North of Boulder, Colorado [410]

Sat., Nov. 6. Peter Birkeland, Dept. of Geological Sciences (retired), University of Colorado, Boulder, CO 80309, birkelap@colorado.edu; Ven Barclay; Edwin Larson; Ralph Shroba. Max.: 20; min.: 7. Cost: $45 (1L). *Begins and ends in Boulder. Instructions for public transportation from Denver to Boulder will be available upon registration for this trip*.

11. Geological Reconnaissance of Dinosaur Ridge, Red Rocks, and the Front Range of the Rocky Mountains near Morrison, Colorado [411]

Sat., Nov. 6. Cosponsored by *GSA Geoscience Education Division; GSA Sedimentary Geology Division*. Norbert E. Cygan, Friends of Dinosaur Ridge, 16831 W. Alameda Parkway, Morrison, CO 80456, (303) 697-3466, fax 303-697-8911, necygan@aol.com; T. Caneer; Harald Drewes and other volunteers from Dinosaur Ridge, www.dinoridge.org. Max.: 45; min.: 12. Cost: $90 (1L, bus). *Also offered as a postmeeting trip.*

12. Glenwood Springs, Colorado Coal Fire—Observations, Discussion, and Field Data Collection Techniques [412]

Sat., Nov. 6. Glenn B. Stracher, Dept. of Science and Mathematics, East Georgia College, Swainsboro, GA 30401, (478) 289-2073, fax 478-289-2080, stracher@ega.edu; Gary Colaizzi; Steve Renner; Janet

L. Stracher; Tammy P. Taylor. Max.: 45; min.: 12. Cost: $105 (1L, R, bus, pool).

13. Overview of Laramide Structures along the Northeastern Flank of the Front Range [413]

Sat., Nov. 6. Vince Matthews, Colorado Geological Survey, 1313 Sherman St., Room 715, Denver, CO 80203, (303) 866-3028, fax 303-866-2461, vince.matthews@state.co.us. Max.: 38; min.: 12. Cost: $120 (1L, R, bus).

14. Paleoclimate, Paleohydrology, and Paleoecology of the Morrison Formation in the Front Range of Colorado [414]

Sat., Nov. 6. Cosponsored by *GSA Sedimentary Geology Division*. Stan Dunagan, Dept. of Geology, Geography & Physics, University of Tennessee, Martin, TN 38238, (731) 587-7959, fax 731-587-1044, sdunagan@utm.edu; Christine Turner; Fred Peterson; Tim Demko. Max.: 30; min.: 10. Cost: $105 (1L, R, vans).

15. Paleontology and Volcanic Setting of the Florissant Fossil Beds [415]

Sat., Nov. 6. Cosponsored by *GSA Sedimentary Geology Division; Paleontological Society*. Herb Meyer, National Park Service, Florissant Fossil Beds National Monument, P.O. Box 185, Florissant, CO 80816, (719) 748-3253, fax 719-748-3253, herb_meyer@nps.gov; Steven Veatch; Amanda Cook. Max.: 36; min.: 12. Cost: $125 (1L, R, bus).

16. Stratigraphy and Paleobiology of Mammoth Sites in the Denver Area [416]

Sat., Nov. 6. Cosponsored by *GSA Sedimentary Geology Division*. Russ Graham, Director, Earth & Mineral Sciences Museum, Pennsylvania State University, University Park, PA 16802, (814) 865-6336, fax 814-863-7708, rgraham@ems.psu.edu; Bart Weis; Jim Dixon. Max.: 36; min.: 12. Cost: $95 (1L, R, vans).

HALF DAY—DURING THE MEETING

17. Tour of U.S. Geological Survey National Earthquake Information Center, Golden, Colorado [417]

Wed., Nov. 10, 12:30–5 p.m. Peter J. Modreski, U.S. Geological Survey, MS 150, Box 25046, Denver Federal Center, Denver, CO 80225-0046, (303) 202-4766, fax 303-202-4767, pmodreski@usgs.gov; Lynn M. Highland; Lisa Ann Wald; Pamela J. Benfield; Waverly J. Person; Jill McCarthy. Max.: 45; min.: 24. Cost: $25 (bus).

POSTMEETING

18. Upper Cambrian and Lower Ordovician Stratigraphy of West Texas and Southern New Mexico [418]

Wed.–Sat., Nov. 10–13. Cosponsored by *GSA Sedimentary Geology Division*. John F. Taylor, Geoscience Dept., Indiana University of Pennsylvania, Indiana, PA 15705, (724) 357-4469, fax 724-357-5700, jftaylor@iup.edu; Raymond L. Ethington; James D. Loch; Paul R. Myrow; Robert L. Ripperdan. Max.: 20; min.: 12. Cost: $325 (2L, R, 3ON, vans). *Begins and ends in El Paso, Texas.*

19. Ancient Depositional Environments Control Modern Aquifer Quality: Stratigraphy of Groundwater Resources in the Denver Area [419]

Thurs., Nov. 11. Cosponsored by *GSA Sedimentary Geology Division*. Robert G.H. Raynolds, Denver Museum of Nature & Science, 2001 Colorado Blvd., Denver, CO 80205, (303) 370-6047, fax 303-331-6492, denverbasin@dmns.org. Max.: 22; min.: 10. Cost: $110 (1L, R, vans).

20. Cenozoic Geology and Fossils of the Pawnee Buttes Area, Northeast Colorado [420]

Thurs., Nov. 11. Cosponsored by *GSA Sedimentary Geology Division* and *Colorado Scientific Society*. Emmett Evanoff, Dept. of Geological Sciences, Campus Box 399, University of Colorado, Boulder, CO 80309-0399, (303) 444-2644 (phone and fax), emmettevanoff@earthlink.net. Max.: 36; min.: 12. Cost: $85 (1L, R, vans).

21. Consequences of Living with Geology: A Model Field Trip for the General Public [421]

Thurs., Nov. 11. Cosponsored by *GSA Engineering Geology Division; GSA Geoscience Education Division; American Institute of Professional Geologists*. David M. Abbott Jr., Consulting Geologist, 2266 Forest St., Denver, CO 80207, (303) 394-0321, fax 303-394-0543, dmageol@msn.com; David C. Noe. Max.: 40; min.: 12. Cost: $100 (1L, R, mini-bus).

22. Geological Reconnaissance of Dinosaur Ridge, Red Rocks, and the Front Range of the Rocky Mountains near Morrison, Colorado [422]

Thurs., Nov. 11. Cosponsored by *GSA Geoscience Education Division; GSA Sedimentary Geology Division*. Norbert E. Cygan, Friends of Dinosaur Ridge, 16831 W. Alameda Parkway, Morrison, CO 80456, (303) 697-3466, fax 303-697-8911, necygan@aol.com; T. Caneer; Harald Drewes and other volunteers from Dinosaur Ridge, www.dinoridge.org. Max.: 45; min.: 12. Cost: $90 (1L, bus). *Also offered as a premeeting trip.*

23. Laramide Horizontal Shortening in the Rockies: Faulting and Folding in Oblique Backlimb-Tightening Structures of the Northeastern Flank of the Front Range, Colorado [423]

Thurs., Nov. 11. Eric Erslev, Dept. of Geosciences, Colorado State University, Fort Collins, CO 80523, (970) 491-6375, fax 970-491-6307, erslev@cnr.colostate.edu. Max.: 24; min.: 10. Cost: $100 (1L, R, vans).

24. Underground Tour of Henderson Molybdenum Mine [424]

Thurs., Nov. 11. Cosponsored by *Colorado Scientific Society*. Eric Nelson, Dept. of Geology and Geological Engineering, Colorado School of Mines, Golden, CO 80401-1887, (303) 273-3811, fax 303-273-3859, enelson@mines.edu; Robert Golden; Jim Shannon. Max.: 15; min.: 5. Cost: $140 (1L, R, vans).

25. Walking with Dinosaurs along Colorado's Front Range [425]

Thurs., Nov. 11. Joanna Wright, Dept. of Geography and Environmental Sciences, University of Colorado, Denver, CO 80217-3363, (303) 556-6007, fax 303-556-6157, jwright@carbon.cudenver.edu. Max.: 36; min.: 12. Cost: $85 (1L, R, vans).

Field Trip Itineraries: Just a Click Away

Once you've received the confirmation of your field trip registration from GSA, go to: www.geosociety.org/meetings/2004/ftrip_logon.asp. Use the ID number from your confirmation or your e-mail address to access your trip itinerary sheet(s). You can download the itineraries for the trips you've registered for, and you can fill out your individual information sheet to submit back to GSA Headquarters.

It's Happening at the GSA Annual Meeting: Campus Reps = Free Breakfast—What a Match!

If you're a GSA Campus Representative (well, even if you're not but ARE willing to sign up on the spot to be one), you can enjoy a **FREE** continental breakfast on your way to the first Tech Session of the day on Monday, November 8.

We'll be located in the Convention Center and will be waiting for you to stop by for **Coffee & Conversation—An Appreciation Reception for GSA Campus Reps.**

Please help us plan for catering by signing up on the meeting registration form, event #306.

We'll be waiting for you on Monday, November 8, from 7 a.m.–9 a.m.

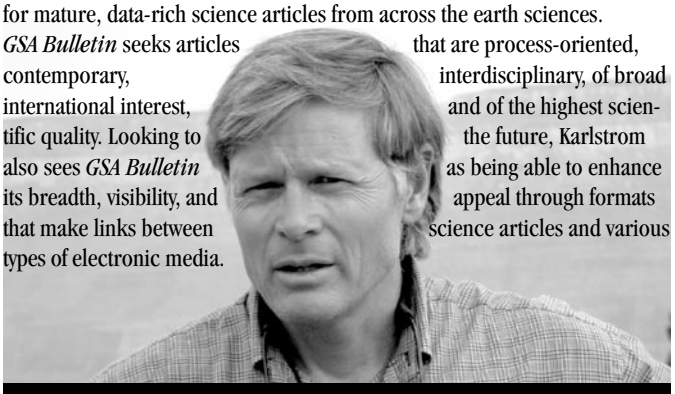
Room location to be announced.

Karlstrom Appointed *GSA Bulletin* Science Co-Editor

Karl E. Karlstrom of the University of New Mexico is the new science co-editor of *GSA Bulletin*. He replaces Peter Copeland (University of Houston), whose term ended in June 2004. Karlstrom joins Yildirim Dilek (Miami University), who joined the journal in January 2003.

Karlstrom received his M.S. and Ph.D. degrees at the University of Wyoming and taught at North Carolina State University and Northern Arizona University before accepting his current post at the University of New Mexico. His main research interests involve the tectonic evolution of the western United States, with emphasis on lithospheric assembly, stabilization, and reactivation, and the interaction of deformational, metamorphic, and magmatic processes. He has conducted field studies of Proterozoic rocks in the Arizona Transition Zone, Eastern Mojave desert, Grand Canyon (from Paleoproterozoic basement to Quaternary incision), and southern Rocky Mountains. He was coordinator of the multi-institutional collaborative research efforts of "CD-ROM," the Continental Dynamics of the Rocky Mountains, and he is currently a member of the EarthScope Science and Education Committee and the Rocky Mountain EarthScope organizing committee. He has been a member of GSA since 1982 and served as *GSA Today* Science Editor from 2000 to 2003.

Karlstrom hopes to help continue to build upon the *GSA Bulletin's* tradition as a premier geoscience journal with an important niche as a repository for mature, data-rich science articles from across the earth sciences. *GSA Bulletin* seeks articles that are process-oriented, interdisciplinary, of broad contemporary, international interest, and of the highest scientific quality. Looking to the future, Karlstrom also sees *GSA Bulletin* as being able to enhance its breadth, visibility, and appeal through formats that make links between science articles and various types of electronic media.



KARL E. KARLSTROM

Call for Applications:

Apply for the GSA–USGS Congressional Science Fellowship for 2005–2006

Opportunities to serve as a Congressional Science Fellow are rare, unique experiences. This position may be a good fit for you. It will enable you to work directly with national leaders and put your expertise and experience to work helping shape science and technology policy on Capitol Hill.

The Congressional Science Fellow will be selected from top competitors early in 2005. Prospective candidates should be GSA members with broad geoscience backgrounds and excellent written and oral communication skills. Minimum requirements are a master's degree with at least five years professional experience or a Ph.D. at the time of appointment.

If you possess this professional background, have experience in applying scientific knowledge to societal challenges, and share a passion for helping shape the future of the geoscience profession, GSA invites your application. The fellowship is open to U.S. citizens or permanent residents of the U.S.

Deadline to apply: January 21, 2005

For application information, visit www.geosociety.org/science/csf/index.htm, or contact Ginger Williams, GSA Headquarters, (303) 357-1040, gwilliams@geosociety.org.

GSA Short Courses Offered at 2004 Denver Annual Meeting

Sign up for one of these great short courses at the GSA Annual Meeting in Denver. For registration information and details on student scholarships offered by several GSA Divisions, see the June issue of *GSA Today* or visit www.geosociety.org.

Questions? Contact Edna Collis, ecollis@geosociety.org, (303) 357–1034.

GSA-Sponsored Professional Development Courses

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

Continuing Education Unit (CEU) Service

All courses sponsored by GSA offer CEUs. A CEU is defined as 10 contact hours of participation in an organized continuing education experience under responsible sponsorship, capable direction, and qualified instruction. A contact hour is defined as a typical 60-minute classroom instructional session or its equivalent. Ten instructional hours are required for one CEU.

CANCELLATION DEADLINE: OCTOBER 7, 2004.

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1. Evaporites: A Practical Approach [501]

Fri. and Sat., Nov. 5–6, 8 a.m.–5 p.m. Hyatt Regency Hotel. Cosponsored by *GSA Sedimentary Geology Division.*

Evaporites are responsible for trapping or creating hydrocarbon reservoirs worldwide and are associated with numerous base and precious metal accumulations. Yet the role of evaporites in many studies of these systems is largely ignored. This is no longer the case. John Warren brings more than 20 years of experience in the applied petroleum and mineral sciences into detailed discussion of the role of evaporites as he traces and explains the evaporate-hydrocarbon-metal association from deposition through diagenesis to halokinesis and metamorphism. Throughout, the emphasis is on recognizing and predicting the importance of subsurface dynamics when working in evaporitic terrains. Designed for practicing geologists and geophysicists or anyone holding a bachelor's degree with a specialization in the earth sciences and an interest in evaporates, participants will be shown how techniques of applied sedimentology can be successfully applied to the search and production of hydrocarbons and metals in evaporitic terrains. Participants encouraged to bring a laptop computer to this course.

Faculty: John Warren, University of Brunei Darussalam, Ph.D., Flinders University of South Australia. Limit: 30. Fee: $365; includes course manual and lunch. CEU: 1.6.

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2. Introduction to Geographic Information Systems (GIS), Using ArcGIS9 for Geological Applications [502]

Fri. and Sat., Nov. 5–6, 8 a.m.–5 p.m. Emily Griffith Opportunity School, Denver. Cosponsored by *GSA Geoscience Education Division and Environmental Systems Research Institute.*

This course will introduce the use of GIS in geology-related applications using ArcGIS, ArcMap, ArcCatalog, and Spatial and 3D Analyst extensions. Experience with ArcGIS is not necessary, but familiarity with Windows OS would be beneficial. Focus will be hands-on use of ArcGIS including ModelBuilder, data access and analysis, Geoprocessing with ArcTools, and the Geodatabase. The Geodatabase GeoModel schema will be discussed.

Faculty: Ann B. Johnson, Higher Education Manager, Environmental Systems Research Institute, Redlands, California, M.S., University of California, Riverside; Dave Fosdek, Federal Account Manager, Environmental Systems Research Institute, Redlands, California, B.S., University of Idaho. Limit: 18. Fee: $240; includes course manual and lunch. CEU: 1.6.

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3. Multi-Temporal Stereo Aerial Photography [503]

Fri. and Sat., Nov. 5–6, 8 a.m.–5 p.m. Hyatt Regency Hotel. Cosponsored by *GSA Engineering Geology Division and U.S. Army Corps of Engineers.*

This is a hands-on course using stereo aerial photographs and includes a field trip to the study example. This course teaches a simple but highly effective method to document the various terrain elements used to develop the information from analysis to interpretation in all environmental and geologic investigations. Applications to GIS will be discussed. The prerequisite is a curious mind. Stereoscopic vision is a plus.

Faculty: John C. Jens, U.S. Army Corps of Engineers, Alexandria, Virginia, Ph.D., George Mason University; Thomas E. Eastler, University of Maine at Farmington, Ph.D., Columbia University. Limit: 30. Fee: $420; includes course manual and lunch. CEU: 1.6.

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4. Calibrated Peer Review Training for Faculty and Teaching Assistants: Writing Exercises for Large and Small Classes without the Pile of Papers to Grade [504]

Sat., Nov. 6, 8 a.m.–5 p.m. Hyatt Regency Hotel. Cosponsored by *GSA Geoscience Education Division* and *National Association of Geoscience Teachers.*

This course is intended for earth science instructors interested in implementing Calibrated Peer Review (CPR) assignments in their classes. CPR is a web-based technical writing tool that facilitates learning by having students writing and reviewing essays. CPR is suited for both large and small enrollment classes. Participants will learn the mechanics of CPR and will develop a new CPR assignment for use in their class. Note: Registrants must provide their own laptop computers (equipped with network card) in order to participate in this course.

Faculty: Elizabeth Heise, University of Texas at Brownsville, Brownsville, Texas, Ph.D., Texas A&M University; Cinzia Cervato, Iowa State University, Ames, Iowa, Ph.D., ETH–Swiss Federal Institute of Technology, Zurich; Amanda Palmer-Julson, Blinn College, Bryan, Texas, Ph.D., Princeton University. Limit: 20. Fee: $340; includes course manual and lunch. CEU: 0.8.

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5. Characterization and Toxicity Assessment of Mine-Waste Sites [505]

Sat., Nov. 6, 8 a.m.–5 p.m. Hyatt Regency Hotel. Cosponsored by *Geochemical Society of America.*

Abandoned mine-waste sites cover thousands of acres in the western United States. This course will provide simple and practical methods for characterizing and assessing the toxicity potential of mine-waste piles. These methods include quick, inexpensive field

leaching tests that offer an evaluation of acid and trace-metal release from mine-waste material, field techniques to determine bioaccessibility and bioavailability of metals to aquatic organisms, and a simple decision tree to assess adverse effects from mine wastes. An afternoon field trip is included. This course is intended for professionals and students involved in the environmental sciences, federal and state personnel concerned with mining wastes, waste-site managers and personnel, and/or researchers in hydrological contamination studies.

Faculty: Sharon Diehl, U.S. Geological Survey, Denver, Ph.D., Colorado School of Mines; LaDonna Choate, U.S. Geological Survey, Denver; Ph.D., Colorado School of Mines; David Fey, U.S. Geological Survey, Denver, B.S., University of Colorado; Philip L. Hageman, U.S. Geological Survey, Denver, B.S., University of Colorado; Bruce Smith, U.S. Geological Survey, Denver, Ph.D., University of Utah; Kathleen S. Smith, U.S. Geological Survey, Denver, Ph.D., Colorado School of Mines; James Ranville, Colorado School of Mines, Ph.D., Colorado School of Mines; Thomas Wildeman, Colorado School of Mines, Ph.D., University of Wisconsin; James T. Herron, Colorado Division of Minerals and Geology, Denver, M.S., Colorado State University. Limit: 30. Fee: $300; includes course manual and lunch. CEU: 0.8.

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6. Estimating Rates of Groundwater Recharge [506]

Sat., Nov. 6, 8 a.m.–5 p.m. Hyatt Regency Hotel. Cosponsored by *GSA Hydrogeology Division*.

Good estimates of groundwater recharge are required to accurately assess water resources and evaluate aquifer vulnerability to contamination. This course will review theory, assumptions, uncertainties, advantages, and limitations of different approaches for estimating recharge rates. We will discuss physical, tracer, and numerical modeling techniques based on surface water, unsaturated zone, and saturated zone data. The course content is aimed at practicing hydrologists and advanced hydrology students.

Faculty: Richard W. Healy, U.S. Geological Survey, Denver, B.S., University of Illinois; Bridget R. Scanlon, Bureau of Economic Geology, University of Texas, Austin, Ph.D., University of Kentucky. Limit: 30. Fee: $270; includes course manual and lunch. CEU: 0.8.

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7. Hydrogeologic Field Methods [507]

Sat., Nov. 6, 8 a.m.–5 p.m. Hyatt Regency Hotel. Cosponsored by *GSA Hydrogeology Division*.

This course will present standard methods used by the U.S. Geological Survey, U.S. Environmental Protection Agency, and the American Society for Testing and Materials for planning and undertaking hydrogeologic field investigations. Conceptual models, water level measurements, well inventory, well drilling, aquifer testing, sample collection, monitor wells, project planning, and report preparation will be presented. This course is designed for engineers, geologists, entry level hydrogeologists, and environmental scientists.

Faculty: John E. Moore, Consultant, Denver, Ph.D., University of Illinois. Limit: 40. Fee: $245; includes course manual and lunch. CEU: 0.8.

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8. Management and Leadership Skills for Academic Administrators in the Geosciences [508]

Sat., Nov. 6, 8 a.m.–5 p.m. Hyatt Regency Hotel. Cosponsored by *GSA Geoscience Education Division and National Association of Geoscience Teachers*.

This course will provide an introduction to the interpersonal tools and skills needed to effectively and efficiently manage and lead in an academic setting. It is designed for faculty and research scientists who are either new to academic administration or wish to prepare themselves for a transition to administration. Even experienced department chairs and institute directors wanting to improve their administrative skills and to network with peers sharing similar responsibilities and challenges will benefit.

Faculty: Lee J. Suttner, Indiana University, Bloomington, Ph.D., University of Wisconsin; Sheila M. Moore, Training Concepts, Chattanooga, Tennessee, A.B., St. Olaf College. Limit: 25. Fee: $265; includes course manual and lunch. CEU: 0.8.

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9. Practical Geoscience Ethics: Elements and Examples [509]

Sat., Nov. 6, 8 a.m.–5 p.m. Hyatt Regency Hotel. Cosponsored by *GSA Engineering Geology Division* and *American Institute of Professional Geologists*.

The elements of professional geoscience ethics are examined using case histories illustrating a variety of issues including the significant distinction between ethical rules and ethical ideals. Review of the fundamental principles of professional ethics provides a foundation for case history discussion. Teachers can use the case histories and other information to incorporate professional ethics discussions in their classes.

Faculty: David M. Abbott Jr., Consulting Geologist, Denver, M.S., Colorado School of Mines. Limit: 40. Fee: $250; includes course manual and lunch. CEU: 0.8.

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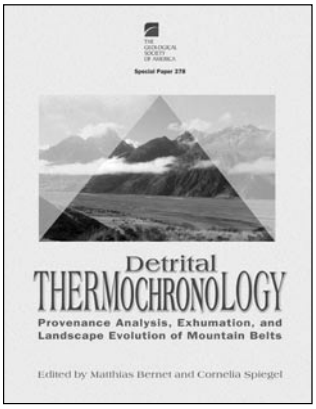
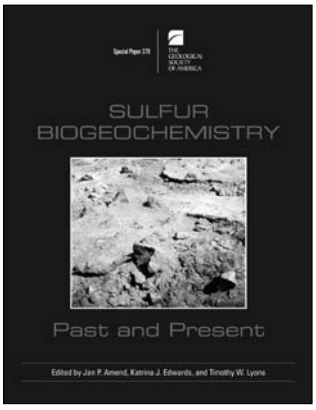


Detrital thermochronology—Provenance analysis, exhumation, and landscape evolution of mountain belts
edited by Matthias Bernet and Cornelia Spiegel
SPE378, 126 p., ISBN 0-8137-2378-7
$55.00, **member price $44.00**
Detrital thermochronology is one of the fastest-growing disciplines in geosciences today because it provides valuable insights into the long-term evolution of mountain belts and the interplay of tectonics and climate in orogenic systems. The ability to determine cooling or crystallization ages of detrital apatite, zircon, or white mica from synorogenic sediments using a variety of techniques such as fission-track, Ar-Ar, or U-Pb dating enables us to determine potential sediment source areas, reconstruct the thermal history of an orogen, calculate exhumation rates, and detect changes in topography and drainage divides. The different dating techniques can easily be combined on the same samples or with other analytical methods to obtain the maximum amount of information. This book discusses some of the fundamental aspects of detrital thermochronology and presents applications in different orogenic settings that highlight the value of this current development.



Sulfur biogeochemistry—Past and present
edited by Jan P. Amend, Katrina J. Edwards, and Timothy W. Lyons
SPE379, 205 p., ISBN 0-8137-2379-5
$75.00, **member price $60.00**
This Special Paper presents recent advances in the biogeochemistry of sulfur, loosely grouped in four thematic areas. The first three chapters primarily address microbial contributions to sulfur biogeochemistry, including sulfate reduction and organic matter conversion in marine sediments, the energetics of microbially mediated sulfur oxidation and sulfur reduction reactions, and the abundance and diversity of eukaryotic communities in deep-sea sulfidic sites. The second section focuses on sulfide oxidation in the environment—terrestrial and marine, contaminated and pristine. The next three chapters explore the formation, distribution, recycling, and burial of various sulfur species in sedimentary systems, and papers in the final section are linked by the theme that sulfur records biogeochemical conditions in the ancient ocean.

Memoir

Proterozoic tectonic evolution of the Grenville orogen in North America
edited by Richard P. Tollo, Louise Corriveau, James McLelland, and Mervin J. Bartholomew
MWR197, 798 p. plus index,
ISBN 0-8137-1197-5
$195.00, **member price $156.00**
The geological evolution of the Grenville orogenic belt represents one of the most widespread episodes of crustal modification in Earth's history. The 39 papers in this volume offer a system-wide perspective on rocks and processes of the Mesoproterozoic Grenville orogen and Appalachian inliers and include many multidisciplinary studies presenting results from integrated petrologic, geochemical, and geochronologic investigations. The volume includes contributions concerning the Grenvillian geology of Canada, the United States, and Mexico, focusing on both the tectonic evolution of the orogen and on innovative approaches to deciphering the igneous, metamorphic, structural, and metallogenic history of Mesoproterozoic assembly and Neoproterozoic rifting. The timing and regional correlation of events and processes is emphasized in order to bridge knowledge gaps within the orogen and to better understand the geodynamic framework.

In Press

Gneiss domes in orogeny
edited by Donna L. Whitney, Christian Teyssier, and Christine S. Siddoway
SPE380, ISBN 0-8137-2380-9

Hydraulic tests of Miocene volcanic rocks at Yucca Mountain and Pahute Mesa and implications for groundwater flow in the Southwest Nevada Volcanic Field, Nevada and California
by Arthur L. Geldon
SPE381, ISBN 0-8137-2381-7

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Call for Geological Papers: 2005 GSA Section Meetings

Northeastern Section
March 14–16, 2005
Prime Hotel and Conference Center, Saratoga Springs, New York
Abstract Deadline: December 14, 2004
Information: Kurt Hollocher, Union College, Department of Geology, Olin Building, Nott Sreet, Schenectady, NY 12308-3107, (518) 388-6518, hollochk@union.edu

Southeastern Section
March 17–18, 2005
Grand Casino Biloxi, Biloxi, Mississippi
Abstract Deadline: December 14, 2004
Information: Gail Russell, University of Southern Mississippi, Department of Geology, Box 5044, Hattiesburg, MS 39406-2000, (601) 266-4077, Gail.Russell@usm.edu

South-Central Section
April 1–2, 2005
Trinity University, San Antonio, Texas
Abstract Deadline: December 17, 2004
Information: Diane Smith, Trinity University, Department of Geosciences, #45, One Trinity Place, San Antonio, TX 78212-4674, (210) 999-7656, dsmith@trinity.edu

Cordilleran Section
(*Joint meeting with American Association of Petroleum Geologists*)
April 29–May 1, 2005
Fairmont Hotel, San Jose, California
Abstract Deadline: February 1, 2005
Information: Jonathan Miller, San Jose State University, Department of Geology, 1 Washington Square, San Jose, CA 95192-0102, (408) 924-5015, jsmiller@email.sjsu.edu

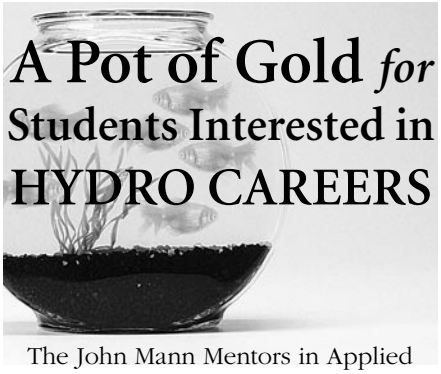
North-Central Section
May 19–20, 2005
University of Minnesota, Minneapolis, Minnesota
Abstract Deadline: February 22, 2005
Information: Carrie Jennings Patterson, University of Minnesota, Minnesota Geological Survey, 2642 University Ave. W., St. Paul, MN 55114-1032, (612) 627-4780, ext. 220, carrie@umn.edu, or Barbara Lusardi, University of Minnesota, Minnesota Geological Survey, 2642 University Ave. W., St. Paul, MN 55114-1032, (612) 627-4780, ext. 212, lusar001@umn.edu

Rocky Mountain Section
May 23–25, 2005
Mesa State College, Grand Junction, Colorado
Abstract Deadline: February 22, 2005
Information: Rex Cole, Mesa State College, Department of Physical & Environmental Science, 1100 North Ave., Grand Junction, CO 81501-3122, (970) 248-1599, rcole@mesastate.edu

www.geosociety.org/sectdiv/sections.htm

ATTENTION STUDENTS!

When you make your plans to attend your Section's 2005 meeting, be sure to include the Shlemon Mentor Program in your schedule. If you have career questions, we have the answers. You will have opportunities to chat one-on-one with practicing geoscientists over **FREE LUNCH**. All Sections will feature the Shlemon Mentor Programs in their proceedings. Watch this space for the announcements of 2005 dates and times.



A Pot of Gold *for* Students Interested in HYDRO CAREERS

The John Mann Mentors in Applied Hydrogeology Program is the first Mentor program to underwrite the cost of tickets for eligible students to attend the distinguished Hydrogeology Division Luncheon and Awards Presentation at GSA's Annual Meeting in Denver.

That's right—a free ticket, valued at $33, can be yours if you meet the eligibility requirements and are among the first 25 students to respond to an e-mail invitation from GSA headquarters.

To qualify for this e-mail invitation offer, you must be registered as a student for the GSA Annual Meeting in Denver by September 30, 2004, and you must have previously ticked off the Hydrology or Hydrogeology box on your GSA membership application. When your invitation arrives, act quickly!

Check our Web site for more information on the John Mann Mentors in Applied Hydrogeology Program, www.geosociety.org/science/mentors/mannMentor.htm.

IGC Travel Grant Recipients Named

The International Geological Congress Travel Grant Program was established as a final act of the Organizing Committee for the U.S.-hosted 28th IGC held in Washington, D.C., in July 1989. Surplus funds available at the conclusion of the 28th IGC were transferred to the GSA Foundation with the stipulation that income from the fund be used to support the attendance of young geoscientists to future congresses, until such time as the United States again hosts an IGC.

GSA received 27 applications for funding to travel to the 32nd IGC Congress in Florence, Italy, August 20–28, 2004. The IGC Travel Grant Evaluation Committee awarded $22,000 to 15 recipients. The factors considered were abstract quality, strength of the letters of recommendation, compelling reasons for wanting to attend the meeting, and any special or mitigating circumstances of the candidate.

Congratulations are extended to the following student recipients:

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Jaime D. Barnes
University of New Mexico
James Bishop
University of California, Davis
Beatriz Garcia-Fresca
University of Texas, Austin
Micah J. Jessup
Virginia Institute of Technology
Daniel Lao-Davila
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Columbia University
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The following individuals joined GSA during the period of October 2003 through January 2004. They were elected into membership by Council at its April 2004 meeting.

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The POWER of Partnerships

For nearly 25 years, GSA has worked with other organizations across the country and around the world whose missions are to advance the geosciences.

GSA currently partners with 35 associated and allied societies. These partnerships offer opportunities to reach the larger geoscience community, coupled with strengthening the public's awareness of the importance of science in today's world. Through GSA's associated and allied societies, broader services are delivered to members. For instance, GSA members have access to discounted member rates for several other societies' meetings, along with member prices for their journal subscriptions.

As GSA looks to the future, it aims to build strong, meaningful partnerships with other societies and organizations across the country and around the world to enhance service to members and the geoscience community.

AWG Links Women Geoscientists Worldwide

Eloise Kendy, *AWG Rocky Mountain Delegate, ek65@cornell.edu*

No matter where in the world women geoscientists live and work, there's a place for us to come together. Once isolated both personally and professionally, a growing number of members stays connected through the Association for Women Geoscientists (AWG).

The world's largest organization for women geoscientists, AWG provides opportunities and support for women at all stages of our careers. AWG is an international organization devoted to enhancing the quality and level of participation of women in geology and to introducing girls and young women to geoscience careers.

AWG was founded in San Francisco in 1977 to provide encouragement to women in geology, a career choice where we were largely underrepresented at the time. Today, AWG membership approaches 1,000, reflecting the increasing participation of women in diverse fields ranging from geology to hydrology, geochemistry, geophysics, paleobiology, and earth science education.

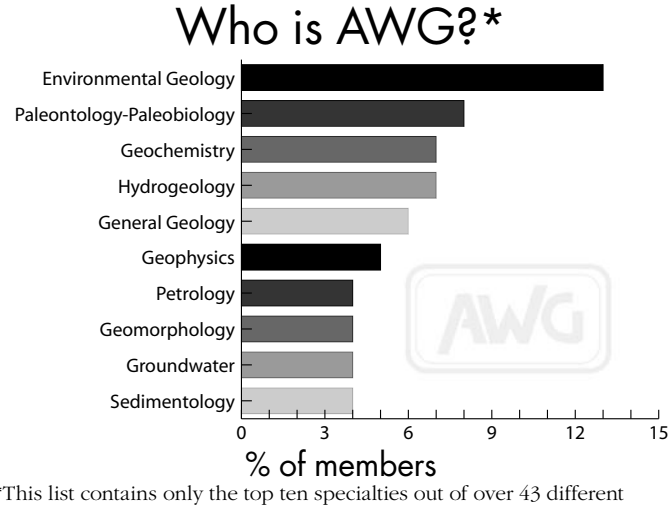
"Our membership is brought together by a common love of earth science and the desire to ensure rewarding opportunities for women in the geosciences," says AWG President Helen Delano. "Our members include professional women and men from industry, government, museums, and academia; students from a cross section of colleges and universities; retirees; and others interested in supporting our goals."

Members gain access to networking, mentoring, resume reviews, scholarship opportunities, conferences (and member rates for meetings of all the American Geological Institute–affiliated societies, including GSA), and awards that strengthen and sustain personal and career goals. Many members promote their work through the distinguished lecture series and other outreach activities to people of all ages. In addition, AWG has local chapters in Houston, San Francisco, Puget Sound, Denver, Salt Lake City, South Florida, and the Washington, D.C., area that sponsor seminars, outings, and other activities in their communities.

AWG-sponsored geology field trips are a favorite way for members to connect. This year, Kata McCarville will lead a whitewater rafting trip down the Grand Canyon, and Nadine Langley will lead a camping trip along the eastern Sierra Nevada. Past field trips have visited Mexico, Scandinavia, the Black Hills, southwestern Colorado, Big Bend National Park, the Cascade Mountains, and Yellowstone National Park.

Members share experiences, expertise, and interests in the bimonthly AWG newsletter, *Gaea*. In addition to featuring lively stories and discussions on technical and career-development topics, *Gaea* is a leading outlet for job advertisements by public and private entities seeking to expand workforce diversity.

For more information about AWG, including membership applications ($15 for students, $50 for professionals; institutional and corporate memberships are also available), visit our Web site at www.awg.org.



*This list contains only the top ten specialties out of over 43 different specialties that make up AWG!

2005 Birdsall-Dreiss Lecturer Named

***William W. Woessner** of the University of Montana has been selected as the 2005 Birdsall-Dreiss Distinguished Lecturer, sponsored by the GSA Hydrogeology Division and funded by the GSA*

William Woessner teaches at the University of Montana, where, since 1981, he has offered classes in applied hydrogeology, advanced hydrogeology, groundwater modeling, applied groundwater modeling, surface water–groundwater interaction, and groundwater remediation. A graduate with a B.A. in geology from the College of Wooster, he went on to receive an M.S. in geology from the University of Florida as well as an M.S. in water resources management and a Ph.D. in geology (hydrogeology with a minor in civil and environmental engineering) from the University of Wisconsin—Madison. From 1978 to 1981, he served as an assistant research professor at the Water Center of the Desert Research Institute, University of Nevada System.

A broad-based hydrogeologist, Woessner's research includes the study of regional hydrogeology; water supply development and protection; surface water–groundwater interactions at lakes, wetlands, and streams; and groundwater modeling of flow and groundwater contaminants. He has served on National Academy of Science committees, taught short courses on groundwater modeling, and acted as a consultant for private companies, states, and federal agencies.

Woessner has published over 60 professional papers, has presented more than 100 professional talks, and has served as the chair for over 60 graduate students. He is the author, with Mary P. Anderson, of *Applied Groundwater Modeling* (1992), which has been disseminated worldwide.

An active member of a number of multidisciplinary research teams, Woessner envisioned and now serves as director of the University of Montana Center for Riverine Science and Stream Renaturalization—a research center engaging geologists, geochemists, microbiologists, stream ecologists, hydrologists, and fluvial geomorphologists in deciphering how natural and impacted streams function. Woessner is currently serving on the National Research Council Committee of River Science at the U.S. Geological Survey. In July 2004, he was named Regents Professor by the University of Montana.

To request a visit to your institution, contact William Woessner, The University of Montana, 32 Campus Dr. #1296, Missoula, MT 59812-2341, (406) 243-5698, william.woessner@umontana.edu. The Hydrogeology Division is particularly interested in including liberal arts colleges in the itinerary. The division will pay transportation expenses and the host institution will provide local accommodations. Woessner will present either or both of the lectures below.

Lecture Topics

William W. Woessner, The University of Montana

"Examining the Exchange of Groundwater with the Stream/Floodplain System: Physical, Thermal and Geochemical Approaches with Ties to Stream Renaturalization"

Groundwater exchanges with the stream channel create gaining, losing, flow-through, and parallel-flow reaches. Such transfers of water, nutrients, and temperature are critical components driving stream-riparian-floodplain function. Groundwater and surface water interaction also produce hyporheic zones, areas in which groundwater and stream water mix at the channel-bed and near-channel scale. Physical exchanges create fluxes of geochemical constituents and complex thermal regimes that vary at daily, seasonal, and annual scales. Efforts to maintain and renaturalize stream systems require consideration of the hydrogeology.

This talk presents conceptualizations of the groundwater-river exchange process and illustrates methods used to assess such exchange. My research has recently focused on the mechanisms that regulate stream and floodplain groundwater temperatures. Specific groundwater–surface water investigations I have directed on the Middle Fork of the Flathead River, Montana; the Umatilla River, Oregon; and the Jocko River of western Montana are used as case studies. I will also propose how renaturalization efforts would benefit from including groundwater considerations.

"Occurrence, Transport and Fate of Viruses and Pharmaceuticals in Groundwater Impacted by Septic System Effluent: The Hydrogeologists and Human Health"

Over the last 20+ years, I have studied how the disposal of sewage from households and larger multiple-user facilities in unsewered areas has impacted the underlying groundwater. When the densities of dwellings using septic systems increase, concern is often raised by adjacent homeowners and/or local and state governments that potable groundwater will be impacted. Though individual household wells are usually not regularly tested, groundwater serving multiple households, communities, or the public must be free of fecal coliform bacteria and must contain nitrate-nitrogen below 10 mg/l. Recently, however, federal regulators have suggested groundwater supplies should be tested for viruses. In addition, the discovery of trace quantities of pharmaceuticals in surface water impacted by sewage and sewage treatment plant waste has raised concerns that groundwater degraded by septic system effluent may also contain low levels of pharmaceuticals.

This presentation will focus on the occurrence of a select group of viruses and pharmaceuticals in septic systems and the processes controlling the transport and fate of these constituents in the underlying shallow aquifers. I will present the results of sampling sewage impacted groundwater associated with a high school drain field and virus tracer experiments used to assess transport processes in shallow sand and gravel dominated aquifers. The results of a survey-level study that chronicled the occurrence of 20 pharmaceutical compounds in a large number of individual septic tanks and the prevalence and fate of these compounds in the associated groundwater will also be discussed. Both prescription and nonprescription drugs were detected. The presentation will conclude with a discussion of how hydrogeological data may or may not be used to examine related risks to human health.

Call for Papers:
Processes on the Early Earth Special Paper

Following on the successful GSA Field Forum "Processes on the Early Earth" (jointly organized by the Geological Society of America and Geological Society of South Africa) that examined a Kaapvaal craton traverse in early July, it has been decided to publish the proceedings of this field forum in the form of a GSA Special Paper of the same title.

The volume editors, Wolf Uwe Reimold and Roger Gibson of the University of the Witwatersrand, invite every worker on the early Earth to make use of this dedicated opportunity. **Deadline for submissions is September 30, 2004**, and the publishing plan envisages that the volume be print-ready by May 2005.

Papers for this special volume should be prepared according to the guidelines on the GSA Web site (www.geosociety.org/pubs/bookguid.htm). **For further information**, or to submit your manuscript, contact the volume editors at gibsonr@geosciences.wits.ac.za or reimoldw@geosciences.wits.ac.za. Papers should be submitted to the editors in electronic form (CD or e-mail files, with image/figure and table files as separate files). Alternatively, three hardcopies of the manuscript with original figures should be sent to W.U. Reimold, School of Geosciences, University of the Witwatersrand, Private Bag 3, P.O. Wits 2050, Johannesburg, South Africa.

STATEMENT ON THE EVALUATION OF SCIENTIFIC INFORMATION:
Panel Seeks Help

In response to growing concern about how scientific information is being used in policy-making, GSA's Council has appointed a panel to prepare a statement to present an earth science perspective on the evaluation of scientific information. The panel seeks your help in crafting the statement.

Sound policy decisions require the best available scientific information. Population growth, increasing per-capita consumption driven by globalization, and the need to preserve essential resources for future generations have sharply reduced the margin for error, and increased the need for policymakers to understand the implications of science and how the quality of scientific information can be assessed.

Many nonscientists think of science primarily in terms of laboratory experiments intended to discover laws that are precise and easily quantified. Untangling complex processes like climate change, ecosystem response, beach migration, or earthquake dynamics is much more complex. It requires collaboration among a team of scientists with complementary expertise, and it requires that the team systematically integrate results from different disciplines and gradually work toward consensus. Each step requires careful review by peer scientists in an atmosphere that encourages objective exchange, free of political pressures.

Policymakers, the media, and the general public need to understand the importance of consensus, objective exchange, and freedom from political pressure. There are signs that the process of integrating science and public policy is becoming increasingly politicized. For example:

- The Union of Concerned Scientists (UCS) published a report in February 2004 detailing incidents in which the administration was allegedly mishandling, suppressing, and distorting the scientific findings of federal agencies. Note, the administration responded to the UCS report, and the UCS has since prepared a rebuttal.
- In September 2003, the Office of Management and Budget (OMB) proposed procedures for selecting scientists for peer review of regulatory information that attempts to limit the involvement of scientists who have received grants from the federal agency involved; that seems to equate having "advocated a position" on the matter with having a bias; and, when bias so defined exists on a panel, requires that "another reviewer with contrary bias" be appointed for the sake of balance. Note, the OMB is reevaluating these proposed procedures based on extensive comments from the scientific community and other affected parties.

Scientists are already reluctant to communicate their scientific conclusions to policymakers or to the public. Redefining conclusions as bias may further inhibit scientists from participating in policy-making for fear of being perceived as "advocates."

GSA's panel on the evaluation of scientific information includes Gary Ernst (Stanford University), Co-Chair George Fisher (Johns Hopkins University), Grant Heiken (Los Alamos National Laboratory, retired), Co-Chair Mark Peters (Los Alamos National Laboratory), Raymond Price (Queen's University), Leon Silver (California Institute of Technology), and Christine Turner (U.S. Geological Survey).

Panel members are anxious to have input from a broad range of GSA members on this issue. They are particularly interested in examples of how science has been used in the policy-making process—both those that show how good science can lead to good policies, and those that show how science can be misused or misunderstood. If you have information that you think would be helpful, you are invited to contact either of the co-chairs, George Fisher, gfisher@jhu.edu, or Mark Peters, mtpeters@lanl.gov. Input received by mid-August will be most helpful.

At its April 2004 meeting, GSA Council approved the position statement, "The Importance of Teaching Earth Science in the Public Schools." The statement is on GSA's Web site, www.geosociety.org/science/govpolicy.htm. Members are encouraged to use this position statement to encourage and support the inclusion of earth science in their schools and to become involved with science certification programs.

THE IMPORTANCE OF TEACHING EARTH SCIENCE IN THE PUBLIC SCHOOLS

Authored by: ***Patricia H. Kelley,*** *University of North Carolina, Wilmington, North Carolina, and* ***Rachel J. Burks,*** *Towson University, Towson, Maryland*

Adopted in April 2004

The Geological Society of America, a not-for-profit professional scientific society of more than 17,000 members, recognizes that earth science literacy is of critical importance to our nation and adopts this statement as a reflection of our institutional and individual commitment to this activity.

Justification

Earth science literacy is of critical importance to our nation. Prominent issues facing us include land use and development, availability of energy and mineral resources, water resources and quality, preservation of wetlands, erosion, waste management, pollution remediation, and geological hazards. If our citizens are to make informed decisions about the future, every high school graduate needs to be educated in the area of earth sciences. An understanding of the earth sciences is critical to an environmentally secure future.

The National Science Education Standards, developed by the National Research Council, recognize that the earth sciences are seminal to scientific literacy. Content standards have been articulated in the areas of physical science, life science, and earth and space science. The NSES Science Content Standards include Earth and Space Science standards for grades K–4, 5–8, and 9–12. Content standards for grades K–4 include "Properties of earth materials" and "Changes in earth and sky." In grades 5–8, content is to include "Structure of the earth system" and "Earth's history." High school level material includes "Energy in the earth system," "Geochemical cycles," and "Origin and evolution of the earth system." The National Science Education Standards thus recognize that study of the earth sciences is essential at all grade levels; this view contrasts with the common practice of restricting teaching of earth sciences to grades K–8.

Not only are the earth sciences a significant component of the National Science Education Standards (of equal status with physical sciences and life sciences), the earth sciences also provide the best all-around introduction to science. The earth sciences integrate concepts from all the other major disciplines of science, including biology, chemistry, and physics. A course in earth sciences can provide to students an introduction to subject matter in all the other sciences that illustrates their relevance and connections. Earth sciences also form the essential core for the formal study of environmental science, a growing discipline at the secondary and post-secondary levels. Thus, teaching of earth sciences throughout elementary and secondary schools will promote scientific literacy in general.

Policy

The Geological Society of America endorses the adoption of the National Science Education Standards (NSES) by all public and private school systems. As proposed by the NSES, study of earth science should be incorporated into all educational levels from kindergarten through twelfth grade.

The NSES assessment underscores the fundamental position of earth science as a core science in the complete education of our citizens. Knowledge of the earth sciences is essential to science literacy and to meeting the challenges of the twenty-first century: it is fundamental to making wise decisions about public policy issues such as land use and development; use of energy, mineral, and water resources; and mitigation of pollution and geological hazards.

Strengthening the science content of certification courses will improve the education of future primary and secondary students. We encourage our members, particularly earth science faculty, to become involved with earth science certification programs for pre-service teachers at their institutions. We also enlist the aid of all of our members to support both the inclusion of an earth science course in high school science curricula and proficiency exams in earth science for graduating high school seniors.

BIOGEOSCIENCES.ORG LAUNCHES

An innovative new Web site, www.biogeosciences.org, bridging the earth and life sciences, provides a single resource for all things related to biogeoscience. Biogeosciences.org is a natural home for biogeoscience discussions, resources, and promotion. The noncommercial site, supported by a grant from the Biogeosciences Program of the National Science Foundation, draws from several partnered professional societies* and elsewhere to present an outstanding collection of biogeoscience resources for all levels of education and interest.

The dynamic site is expected to grow and change, reflecting the trends in biogeoscience and usage needs. Biogeoscience links, background information, and program resources are available, along with information on jobs, funding, and research opportunities. The site lists of degree and research programs, journals and other publications, and a complete database of relevant conferences and meetings featuring special sections and associated symposia. A discussion forum allows for the rapid dissemination of ideas and opinions and addresses important issues facing biogeoscience today, and an image gallery allows free exchange of images for educational purposes. The growing collection of biogeoscientists is highlighted by interviews and information on current research. Interviews with various program managers elicit the particulars of the funding process and provide insight into research funding decisions and important statistics.

Interested parties should contact Sarah Leibson, Biogeosciences.org Web Coordinator, web@biogeosciences.org, (303) 357-1095. Content-related suggestions or comments are encouraged.

*American Geophysical Union, American Society of Limnology and Oceanography, European Geosciences Union, Ecological Society of America, Geochemical Society, Geological Society of America, Mineralogical Society of America, and the Soil Science Society of America.

WHAT IS IT THAT YOU DO IN YOUR JOB?

Karlon Blythe, *GSA Outreach Program Officer*

Without exception, the title of this article is the question most frequently asked by students to mentors at the Roy J. Shlemon Mentor Programs in Applied Geoscience. The programs, supported by GSA Foundation, are designed to extend the mentoring reach of individual professionals from applied geology to undergraduates and graduate students attending GSA Section Meetings.

Over free lunches, mentors and students discuss professional opportunities and challenges that await students after graduation. The enthusiastic mentors come prepared for a variety of questions from the students—and they are never disappointed. Contacts are made, networking takes place, and intense discussions ensue. The professionals and students must eventually leave their lunchtime discussions—reluctantly, but with a sense of satisfaction that the time was well spent.

The 2004 season of Roy J. Shlemon Mentor Programs in Applied Geoscience has been extremely successful, with all six GSA Sections participating. New records were set this year for participation by both students and mentors, and half a dozen or more students made connections for part-time or full-time positions.

Program funds provided free box lunches to 346 students and 62 mentors. Twenty-one of the 62 mentors volunteered to participate in more than one session, thus boosting the ratio of mentor experiences to 83 mentors to 346 students. This is a commendable one to four ratio. These volunteer mentors from private and public businesses and government agencies represented a broad range of backgrounds, education, experience, and expertise.

If you are interested in participating as a mentor at a GSA 2005 Section Meeting, please contact Karlon Blythe, kblythe@geosociety.org.

The Roy J. Shlemon Mentor Program in Applied Geoscience gratefully acknowledges these mentors for their individual gifts of time and for sharing their insight with GSA's student members.

William "Drew" Andrews
Kentucky Geological Survey
Lexington, Kentucky

David Applegate
U.S. Geological Survey
Reston, Virginia

Katharine Lee Avary
West Virginia Geological and Economic Survey
Morgantown, West Virginia

Christopher J. Beal
Portage Environmental
Boerne, Texas

Jim Berg
Minnesota DNR Waters
St. Paul, Minnesota

Michael D. Campbell
M.D. Campbell and Associates
Houston, Texas

Maureen Carlisle
Burke Museum
Seattle, Washington

David L. Carpenter
Monsanto
Soda Springs, Idaho

Paul Clarke
Evergreen Resources, Inc.
Denver, Colorado

David B. Cornue
Environmental Operations, Inc.
St. Louis, Missouri

Morris M. Dirnberger
U.S. Army Corps of Engineers
St. Louis, Missouri

Edward Dullaghan
URS Corporation
Suffolk, Virginia

Sidney Egnew
Indigo Systems Corporation
Springfield, Louisiana

Mark W. Eisner
Advanced Land and Water, Inc.
Sykesville, Maryland

Jim Essman
Newmont Mining Corporation
Carlin, Nevada

Timothy J. Fagan
National Museum of Natural History
Washington, D.C.

Bill Flanigan
TXI
Dallas, Texas

Christopher W. Freeman
Geodynamics LLC
Morehead City, North Carolina

Martha N. Garcia
U.S. Geological Survey
Reston, Virginia

Marie Marshall Garsjo
Natural Resources Conservation Service
Fort Worth, Texas

J. Lynett Gillette
San Diego Natural History Museum
San Diego, California

Richard E. Gray
GAI Consultants, Inc.
Monroeville, Pennsylvania

Joe Hannibal
Cleveland Museum of Natural History
Cleveland, Ohio

Will Harman
Buck Engineering
Cary, North Carolina

Thomas A. Hauge
ExxonMobil Upstream Research Company
Houston, Texas

Elizabeth A. Haynes
U.S. Geological Survey
Hillsborough, North Carolina

Catherine M. Helm-Clark
INEEL-INRA Fellow
Idaho Falls, Idaho

Jack Hess
Geological Society of America
Boulder, Colorado

John W. Hoganson
North Dakota Geological Survey
Bismarck, North Dakota

Maria G. Honeycutt
PBS&J
Beltsville, Maryland

Jack Howard
Halliburton
Katy, Texas

John Howell
Clayton & Clayton, P.C.
San Antonio, Texas

Elaina Hurst
Schlumberger
Prairie Village, Kansas

Bushra Hussaini
American Museum of Natural History, New York, New York

Cheryl Jaworowski
Yellowstone National Park
Wyoming

Joanne Kluessendorf
Weis Earth Science Museum
Menasha, Wisconsin

Joseph Konczyk
Illinois E.P.A.
Springfield, Illinois

Todd LaMaskin
URS
Eugene, Oregon

Doug Lambert
Geotechnology, Inc.
St. Louis, Missouri

Derek Main
Dallas Museum of Natural History
Dallas, Texas

Edward G. Miller
Geo Cam, Inc.
San Antonio, Texas

Hugh C. Morris
Padre Resources Corp.
Delta, British Columbia

Keri Murch
Environmental Resolutions, Inc.
Petaluma, California

Mike Nemitz
Newmont Mining Corporation
Carlin, Nevada

Cynthia Delaney Palomares
Texas Commission on Environmental Quality
Austin, Texas

Christopher Pearsall
Specialized Engineering
Ijamsville, Maryland

Trudy G. Phelps
U.S. Geological Survey
Altamonte Springs, Florida

Stanley Radzevicius
ENSCO, Inc.
Springfield, Virginia

James M. Robertson
Wisconsin Geological Survey
Madison, Wisconsin

Randal L. Rogers
Shaw Environmental & Infrastructure, Inc.
Knoxville, Tennessee

Stacy Saari
Newmont Mining Corporation
Carlin, Nevada

Eugene Schweig
U.S. Geological Survey
Memphis, Tennessee

Phyllis J. Steckel
Consultant
Washington, Missouri

Bruce Stinchcomb
St. Louis Community College at Florissant
St. Louis, Missouri

Marilyn J. Suiter
National Science Foundation
Arlington, Virginia

Chris Sumner
Hanson Aggregates, Inc.
Irving, Texas

Mac Swinford
Ohio Geological Survey
Columbus, Ohio

Raymond W. Talkington
Geosphere Environmental Management, Inc.
Hampton, New Hampshire

Patrick Taylor
NASA
Greenbelt, Maryland

William H. Tonking
Senior Mining Consultant
Houston, Texas

Margaret Townsend
Kansas Geological Survey
Lawrence, Kansas

Rob Van der Voo
University of Michigan
Ann Arbor, Michigan

Jake M. Wilburn, IV
Advanced Land and Water, Inc.
Sykesville, Maryland

Exemplifying the Meaning of Associated Societies

Karlon Blythe, *GSA Outreach Program Officer*

Over the course of the past 5+ years as outreach program officer for the Geological Society of America, I have administered a mentor program titled the Roy J. Shlemon Mentor Program for Applied Geoscience. This program is designed to acquaint undergraduate and graduate students with careers in applied geoscience. Mentors practicing in various fields of applied geoscience are invited to join students over a free lunch to discuss professional opportunities and challenges in the applied geosciences. The mentors' goals are to provide information and insight based on their own careers.

These Shlemon Mentor Programs are held at every GSA Section Meeting—up to six per year each spring. During the years I've been managing the programs, they've been held in a different city every time. Thus, students in attendance at GSA's Section Meetings have had multiple opportunities to meet, chat with, and learn from a sizeable number of mentors representing a broad variety of disciplines, job descriptions, and employers.

This spring, GSA's South-Central Section Meeting was held in College Station, Texas. As it turned out, this was not exactly a destination spot for practicing professionals. Thus, I was faced with a huge challenge to identify and solicit appropriate mentors who were willing and available to participate in two Shlemon programs scheduled to be held during the course of the meeting. Knowing that the Association of Engineering Geologists (AEG) and GSA are Associated Societies, I checked out the Texas AEG organization's Web site and was delighted to find contact information for professionals who hold volunteer positions with Texas AEG. I sent 15 e-mail invitations to these AEG contacts and garnered eight acceptances—a very pleasant surprise. These AEG participants included Ed Miller, John Mikels, David Campbell, Michael D. Campbell, William H. Tonking, Chris Beal, Cynthia Palomares, and Bill Flanigan. These mentors, as well as those from GSA, created an awesome experience for the 54 students in attendance.

I contacted Becky Roland, AEG's Chief Staff Executive, to chat about the enthusiasm and unselfish desire exhibited by AEG professionals to "give back" to their profession through participation in events that offer student mentoring opportunities. Becky said that AEG had recently conducted a survey of its membership to identify areas in which they wished to see improvement. Outreach to students was an important area. Bingo—what a match for both AEG and GSA! Becky graciously furnished me with a brand-new copy of AEG's membership directory for use in locating AEG members for potential invitations to participate at other GSA mentor events.

I've used that directory a good bit as the spring has rolled on. Doug Lambert, David B. Cornue, Phyllis Steckel, and Eugene Schweig joined GSA volunteers for a total of 18 mentors for the Shlemon programs at GSA's North-Central Section Meeting in St. Louis, Missouri. Together, the mentors hosted 75 students over the course of two days. It was apparent that AEG's member volunteers added valued perspectives and complemented GSA's mentors, but it was the students who were the clear winners.

The moral to this story is simple. Associated Societies, working together, enhance the attributes of all. The success of these mentor programs, through combined efforts, is a perfect example of altruism applied to the next generation of geoscience professionals.

For more information about GSA's mentor programs or to indicate your interest in serving as a mentor, please contact me at kblythe@geosociety.org.

Donna L. Russell, *Director of Operations*

A Gathering for Planned Givers

The Foundation's Pardee Coterie (*co-te-rie: a group of persons with a unifying common interest or purpose*) was formed in 1995 to recognize those who had made planned gifts to the GSA Foundation in support of GSA and its programs. Members of the Pardee Coterie roster, along with their spouses and/or guests, meet once a year for breakfast and a discussion or talk on a current topic of interest to scientists and supporters of geology. This is an informal group—there are no bylaws, no officers, and no committees.

The Joseph T. Pardee Memorial Fund originated through what is perhaps a classic example of planned giving—an estate bequest, a trust, and two charitable remainder unitrusts, transiting several lives. The resulting gift was GSA's second largest ever received, exceeded only by the R.A.F. Penrose Jr. bequest in 1931.

The very first Pardee Coterie was held in November 1995 during the GSA Annual Meeting in New Orleans. Participants enjoyed a breakfast at Brennan's restaurant and a discussion with Daniel Sarewitz, who was the program officer for the Institute for Environmental Education at that time and also a former GSA–U.S. Geological Survey Congressional Science Fellow.

Last year, Coterie participants enjoyed a wonderful breakfast at the Magnolia Room at the Palisade Restaurant in Seattle, Washington. Our guest speaker was Foundation Trustee Tony Reso, who shared his "The 90 Most Influential Humans in World History" with the group.

Those who have made planned gifts to the Society or the Foundation, such as the Pooled Income Fund, bequests, and charitable remainder trusts or gift annuities, are automatically included in the Pardee Coterie. Others who have included GSA in their wills or who are contemplating planned gifts are asked to notify the Foundation by calling (303) 357-1054, e-mailing drussell@geosociety.org at the Foundation office, or by mailing the coupon printed below.

Most memorable early geologic experience:

As a first year graduate student at Harvard, I was delighted by the geologic mapping of faulted basalt dikes at Beach Bluff, Marblehead, under Don Eschman's guidance.

—James W. Skehan

GSA FOUNDATION

3300 Penrose Place, P.O. Box 9140
Boulder, CO 80301-9140
(303) 357-1054
drussell@geosociety.org

Enclosed is my contribution in the amount of $_____.
Please credit my contribution for the:
- ☐ Greatest need
- ☐ Other: _____ Fund

☐ I have named GSA Foundation in my will.

PLEASE PRINT

Name

Address

City/State/ZIP

Phone

ANNOUNCEMENTS

Memorial to John Rodgers Planned

The Department of Geology and Geophysics of Yale University announces a memorial service to commemorate the life of John Rodgers. The service will be held Thursday, September 9, 2004, at 2 p.m., Battell Chapel, Yale University (corner of College and Elm Streets), New Haven, Connecticut. A reception in Branford College will follow.

In Memoriam

H. Gassaway Brown III
Macungie, Pennsylvania
April 6, 2004

Robert F. Dill
San Diego, California
January 25, 2004

Eugene W. Grutt Jr.
Grand Junction, Colorado
February 24, 2004

Jake M. Hancock
London, United Kingdom
March 4, 2004

S. Benedict Levin
New Preston, Connecticut
December 31, 2003

John C. Mickelson
Rapid City, South Dakota
March 27, 2004

Ernest I. Rich
Davis, California
January 6, 2004

John Rodgers
Hamden, Connecticut
March 7, 2004

Nancy G. Ryan
Saint Michaels, Maryland
January 10, 2004

William A. White
Chapel Hill, North Carolina
February 12, 2004

New IGCP Project Announced

International Geological Correlation Programme (IGCP) project 499, "Devonian Land-Sea Interaction: Evolution of ecosystems and climate (DEVEC)," was recently accepted by the UNESCO/IGCP scientific board. The integrative kind of research needed for the success of the project can only be carried out by a worldwide network of research groups representing different disciplines. Complete information on the project and its goals is posted at www.senckenberg.de/igcp-499. Colleagues interested in participation should contact one of the organizers in Frankfurt.

Project leaders are: Peter Koenigshof, Forschungsinstitut und Naturmuseum Senckenberg, Senckenberganlage 25, D-60325 Frankfurt am Main, Germany, Peter.Koenigshof@senckenberg.de; Jurga Lazauskiene, Geological Survey of Lithuania, Jurga.Lazauskiene@lgt.li; Eberhard Schindler, Forschungsinstitut und Naturmuseum Senckenberg, Eberhard.Schindler@senckenberg.de; Volker Wilde, Forschungsinstitut und Naturmuseum Senckenberg, Volker.Wilde@senckenberg.de; and M. Namik Yalcin, Istanbul University, mny@istanbul.edu.tr.

MEETINGS CALENDAR

2004

October 10–13	11th Annual Conference on Tailings and Mine Waste, Vail, Colorado, USA. **Information:** Linda L. Hinshaw, Dept. of Civil Engineering, Colorado State University, Fort Collins, CO 80523-1372, (970) 491-6081, fax 970-491-7727, lhinshaw@engr.colostate.edu, www.tailings.org.

2005

April 24–27	Mining Rocks—Toronto 2005: Canadian Institute of Mining, Metallurgy, and Petroleum Annual Meeting and Exhibition, Toronto, Ontario. **Information:** Chantal Murphy, Meetings Coordinator, (514) 939-2710, ext 1309, cmurphy@cim.org, www.cim.org/mce/toronto2005/.
Aug. 29–Sept. 2	Structure, Tectonics, and Ore Mineralization Processes (STOMP) Townsville, Australia. **Information:** Tom Blenkinsop, Timothy Baker, Stewart Parker, Nick Oliver, Conveners, stomp@jcu.edu.au, +61-7-4781 4726, fax +61-7-4725 1501, www.jcu.edu.au/STOMP. (*Abstracts and presenter registration deadline: May 24, 2005.*)
September 20–23	XVI Congreso Geologico Argentino, La Plata, Argentina. **Information:** INREMI, Instituto de Recursos Minerales, Calle 64 no. 36 e/119 y 120, CP 1900, La Plata, Buenos Aires, Argentina, phone and fax +54 (0221) 422-5648, instituto@inremi.unlp.edu.ar, www.congresogeologico.org.ar/.
November 6–11	Gondwana 12 Conference, Mendoza, Argentina. **Information:** Carlos W. Rapela and Luis A. Spalletti, Conveners, Centro de Investigaciones Geológicas, Calle 1 Nº 644, B1900TAC La Plata, Argentina, phone/fax + 54 221 4215677, +54 221 421258696, gondwana@cig.museo.unlp.edu.ar, http://cig.museo.unlp.edu.ar/gondwana.

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Positions Open

DEPARTMENT OF GEOLOGY
UNIVERSITY OF MARYLAND, COLLEGE PARK

The Department of Geology at UMd is searching for an outstanding scientist as a faculty colleague in the following broadly-defined areas: structural geology and tectonics, neotectonics or tectonophysics. A Ph.D. is required at the time of appointment and the starting date is flexible. The Department anticipates filling this position at the rank of Assistant Professor, but a senior hire may be considered under exceptional circumstances. Salary will be commensurate with experience. The appointee is expected to develop and maintain an active, externally-funded research program that will involve both graduate and undergraduate students, and to participate fully in teaching at the graduate and undergraduate levels, including courses in structural geology and tectonics/neotectonics/tectonophysics, and introductory courses at the freshman level. We particularly seek applicants who will interact with and complement existing research programs; additionally, the Department encourages interdisciplinary approaches to the study of the Earth and participates in the Earth System Science Interdisciplinary Center.

The University of Maryland is an affirmative action/equal employment opportunity employer. For best consideration, applications should be submitted by October 22, 2004, preferably electronically, and should be submitted to: Chair, Search Committee, Department of Geology, University of Maryland, College Park, MD 20742, USA (at geo-apply@umd.edu). Applicants should provide a statement describing research and teaching interests, indicating how s/he envisions contributing to the Department's research and teaching activities, current curriculum vitae and names and addresses of at least four referees. Applicants should ask a minimum of two of these nominated referees to send letters directly to the Chair of the Search Committee as soon as possible (at geo-apply@umd.edu).

1 YEAR POST-DOC IN PALEOBIOLOGY
UNIVERSITY OF KANSAS

Experience in Cambrian fossils or arthropods preferred but not required. Send cv, short description of research interests, and names, addresses, and emails of two prospective letter writers by 9/15/04 to: Bruce S. Lieberman, Department of Geology, 1475 Jayhawk Blvd., 120 Lindley Hall, University of Kansas, Lawrence, KS 66045, blieber@ku.edu. Anticipated start date: January '05.

FLINT POSTDOCTORAL FELLOWSHIP AT YALE UNIVERSITY FOR THE STUDY OF GLACIAL AND CLIMATIC HISTORY AND PROCESSES

The Department of Geology and Geophysics announces a competition for the Flint Postdoctoral Fellowship. This fellowship is awarded for two years, and provides a stipend ($40,000/yr), health care benefits, and funds ($2,000/yr) for research and travel.

The Flint Fellowship is intended to advance the understanding of climatic processes as well as Cenozoic climatic history. Specific research areas include, but are not limited to, glaciology; climatology; atmospheric circulation; low-temperature geochemistry; coupling between tectonics, climate and surface processes; and the biologic record of climate change.

Applicants should submit a curriculum vita; list of publications; names, addresses and email-addresses for three referees; and a short proposal outlining

research objectives while at Yale. The application deadline is November 15, 2004. Successful applicants will start their program at Yale between January 1, 2005, and January 1, 2006.

All application materials should be sent to: Flint Postdoctoral Fellowship, Department of Geology and Geophysics, P.O. Box 208109, Yale University, New Haven, CT 06520-8109. FAX:+1-203-432-3134. Contact Professor Karl Turekian or Ronald Smith for questions regarding the fellowship.

STRUCTURAL GEOLOGY/TECTONICS
TEXAS CHRISTIAN UNIVERSITY

The Department of Geology, Texas Christian University (TCU), invites applications for a tenure-track position in Structural Geology/Tectonics. Initial appointment will be as an Assistant Professor. Preference will be given to applicants who can start in January of 2005, but consideration will also be given to applicants who cannot begin until the following fall. The department is seeking an energetic scientist with a strong theoretical background and a commitment to fieldwork. TCU operates on the teacher-scholar model. Faculty are expected to combine excellence in the classroom with an active research program, including supervision of M.S. theses. Normal teaching duties are two courses per semester, including Introductory and Structural Geology, as well as graduate courses in the candidate's specialty. For more information about the Department of Geology, visit http://www.geo.tcu.edu.

Applicants should send a vita, statement of teaching and research interests, and contact information for three references to: R.E. Hanson, Chair, Department of Geology, Box 298830, Texas Christian University, Fort Worth, TX 76129. Review of applications will begin September 15 and continue until the position is filled. TCU is an AA/EEO employer and encourages a diversity of applicants.

COLBY COLLEGE
ONE SEMESTER APPOINTMENT
SPRING SEMESTER 2005

The Department of Geology invites applications for a one-semester replacement position beginning on 1 February and terminating 31 May 2005. The successful applicant will teach three undergraduate course equivalents including a lecture section of Introductory Geology and an upper division course with laboratory in the applicant's area of expertise. The area of applicant expertise is open, but should complement those in the department. Colby is a highly selective liberal arts college recognized for excellence in undergraduate education and for close student-faculty interaction. A Ph.D. or ABD with teaching experience is preferred. The review of applications will begin on 15 September 2004 and will continue until the position is filled.

Applicants should submit a letter of application, c.v., statement of teaching interests and experience, and names, e-mail addresses, and contact information for three (3) referees. All materials should be sent to: Dr. Robert A. Gastaldo, Chair, Department of Geology, 5807 Mayflower Hill Drive, Waterville, ME 04901. Colby is an Equal Opportunity/Affirmative Action employer, committed to excellence through diversity, and strongly encourages applications and nominations of persons of color, women, and members of other under-represented groups. For more information about the College, please visit the Colby web site: www.colby.edu.

FURMAN UNIVERSITY, TENURE-TRACK POSITION: SURFACE AND GROUND WATER GEOLOGY

The Department of Earth and Environmental Sciences at Furman University invites applications for a tenure-track position at the assistant professor level for the fall of 2005.

The required qualifications are a Ph.D. in geology and a specialty in watershed processes from a sediment transport, environmental, and hydrology perspective. Interests in environmental law and policy and/or GIS would be beneficial. Teaching duties would include a basic earth systems course, surface and ground water courses, and an advanced course in area of expertise. The successful candidate would be expected to excel in teaching and to develop a strong research program involving talented undergraduates.

The department currently consists of four faculty with specializations in GIS/remote sensing, biogeochemistry, structure and tectonics, and mineralogy and petrology. Furman University is a private liberal arts university with a strong emphasis on undergraduate research and teaching. Furman's location in the Piedmont region of South Carolina at the base of the Blue Ridge escarpment provides many opportunities for field trips and research in fluvial processes, ground and surface water hydrology, and the impact of urban sprawl.

Applicants should send a vita including experience, publications, statement of teaching philosophy and research interests, and names of three references. Applicants should discuss how they would include undergraduates in their research.

More information about the department can be obtained from http://ees.furman.edu. Applications should be sent to Kenneth A. Sargent, Dept. of Earth and Environmental Sciences, Furman University, Greenville, SC 29613 or e-mailed to ken.sargent@furman.edu. Furman University is an equal opportunity, affirmative action employer.

Opportunities for Students

Ph.D. Students Wanted. Program in Infrastructure and Environmental Systems. University of North Carolina-—Charlotte. The interdisciplinary program in **Infrastructure and Environmental Systems** at UNC Charlotte is accepting applications for Ph.D. students for the 2004–2005 academic year. Full funding, including out-of-state tuition waivers, is available. Areas of student research include: biogeochemistry, applied climatology, coastal processes, contaminant transport, engineering geology, environmental geology, fluvial processes, geochemistry, geotechnical engineering, surface and groundwater hydrology, landfill design, tropical meteorology, mineralogy, Quaternary geology, sedimentology, stratigraphy, site remediation, slope stability, soil geomorphology, structural geology, surficial processes, vadose zone processes, waste containment in soils, watershed analysis and numerical weather prediction. Students have access to extensive field and analytical equipment and facilities including IC, ICPMS, XRD, XRF, GPR, grain size analysis and GIS laboratories. We are located in the beautiful Piedmont of North Carolina within easy access to pristine beaches and to the Blue Ridge Mountains of North and South Carolina. Application deadline: 7/15/04 or until positions are filled. For more information contact jadiemer@email.uncc.edu or visit http://www.uncc.edu/gradmiss/inesindex.html.

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Call for Applications and Nominations for *Geology* Co-Editor

GSA is soliciting applications and nominations for the position of co-editor of *Geology*, an international geosciences journal for rapid publication of leading research. The co-editor will serve a four-year term, beginning in January 2005 (exact start date to be negotiated), and will be one of a three-editor team. A co-editor with expertise and broad interests in tectonics/structural geology would best complement the continuing editors' strengths, but fields are flexible.

Complete details are posted at www.gsajournals.org/ (go to "Online Journals"), or see the April/May issue of *GSA Today* (p. 46).

If you wish to be considered, please submit a curriculum vitae and a brief letter describing why you are suited for the position. If you wish to nominate another, please submit a letter of nomination and the individual's permission and CV. Send nominations and applications to Jon Olsen, Director of Publications, GSA, P.O. Box 9140, Boulder, CO 80301, jolsen@geosociety.org, no later than September 7, 2004.

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