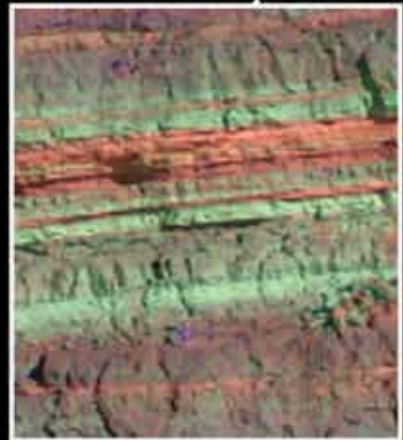
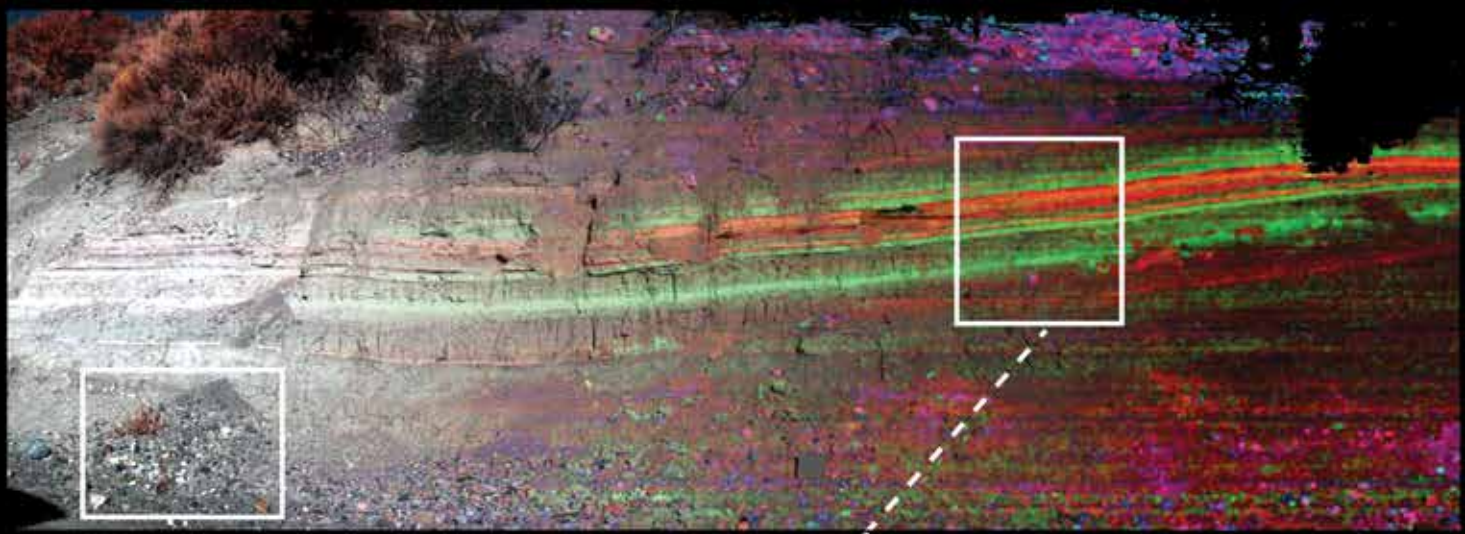


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**Imaging
spectroscopy
of geological
samples
and outcrops:
Novel insights
from microns
to meters**

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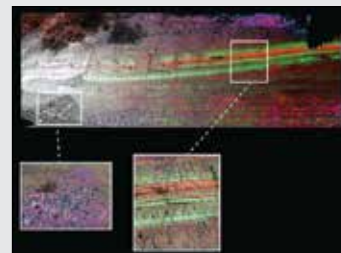


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4 Imaging spectroscopy of geological samples and outcrops: Novel insights from microns to meters

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Cover: Top: Hyperspectral image of an outcrop of sedimentary rocks along Mills Creek in California fading from near true color (left) into a spectral parameter map highlighting lithologic differences (right). Below are close-up views of portions of the outcrop with semi-transparent spectral parameters overlain. This image was acquired with the Ultra Compact Imaging Spectrometer developed by the Jet Propulsion Laboratory, California Institute of Technology. See related article, p. 4–11.

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Erratum: In the October 2015 issue of *GSA Today*, it was incorrectly noted that GSA members could renew their membership at a 15% discount through 15 Dec. 2016. The end date for the 15% discount is 15 Dec. **2015**.

Imaging spectroscopy of geological samples and outcrops: Novel insights from microns to meters

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ABSTRACT

Imaging spectroscopy is a powerful, non-destructive mineralogic tool that provides insights into a variety of geological processes. This remote measurement technique has been used for decades from orbital or aerial platforms to characterize surface compositions of Earth and other solar system bodies. These instruments have now been miniaturized for use in the laboratory and field, thereby enabling petrologic analyses of samples and outcrops. Here, we review the technique and present four examples showing the exciting science potential and new insights into geological processes.

INTRODUCTION

Imaging spectroscopy is a technique whereby images are acquired in hundreds of wavelengths simultaneously, permitting spectral analysis of each discrete pixel (Goetz et al., 1985). Compositionally distinct materials reflect and absorb light differently as a function of wavelength, creating unique spectra that are used to identify and map compositional units remotely. The application of imaging spectroscopy to planetary surfaces has transformed our understanding of surface compositions throughout the solar system. The Observatoire pour la Minéralogie, l'Eau, les Glaces et l'Activité (OMEGA) and the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) have revealed the

presence of clays, sulfates, carbonates, and other minerals formed through interaction with water on Mars, illuminating potentially habitable past environments (e.g., Bibring et al., 2006; Mustard et al., 2008; Murchie et al., 2009). The Moon Mineralogy Mapper (M^3) provided new insights into the formation, igneous evolution, and composition of the Moon and discovered small and varying amounts of hydroxylated or water-bearing materials in its regolith (Green et al., 2011; Pieters et al., 2009, 2011). The Near Infrared Mapping Spectrometer (NIMS) on the Galileo spacecraft (Carlson et al., 1992) detected hydrated salts on Europa (McCord et al., 1998) and mapped SO_2 volcanism on Io (Douté et al., 2001). The Visible and Infrared (VIR) Mapping Spectrometer mapped lithologic units on Vesta's surface (de Sanctis et al., 2012a, 2012b) and has arrived at the dwarf planet Ceres. The Visual and Infrared Mapping Spectrometer (VIMS) on the Cassini spacecraft mapped surface compositions on satellites of Saturn and discovered a large ethane cloud on Titan (Brown et al., 2006; Griffith et al., 2006). Closer to home, imaging spectrometers flown on aircraft, such as the Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) and HyMap, and in space, such as Hyperion, have mapped mineralogies and monitored dynamic changes in ice, vegetation, and other surface processes on Earth (e.g., Vane et al., 1993; Cocks et al., 1998; Green et al., 1998; Painter et al., 2003; Pearlman et al., 2003; Asner et al., 2004, 2007).

For geological applications, at the typical tens to hundreds of meters spatial resolutions of these imaging spectrometers (Fig. 1), regional or global lithologic units can be distinguished, and some components of the mineral assemblages can be identified. The highest-resolution airborne imaging spectrometers currently achieve spatial resolutions of meters, permitting discrimination of mineralogies at scales of boulders or larger outcrops. However, spatial resolutions of a centimeter or less are generally necessary to investigate the mineralogic and petrologic relationships within rocks—essential to understanding the geologic history—and airborne and orbital imaging spectrometers cannot achieve these resolutions. The next revolution is field- and laboratory-based imaging spectroscopy at sub-millimeter to centimeter resolutions capable of petrologic analyses (e.g., Fig. 1).

Recently, visible-shortwave infrared (VSWIR) imaging spectrometers have been miniaturized and are now commercially available for use in the field and laboratory (e.g., manufactured by Headwall Photonics, Inc., Norskk Elektro Optikk AS, and SPECIM), and prototypes have been deployed and demonstrated for use on planetary missions (Blaney et al., 2014; Ehlmann et al., 2014; Van Gorp et al., 2014; Pilorget and Bibring, 2013). Specifically, the Ultra Compact Imaging Spectrometer (UCIS) is in development by the Jet Propulsion Laboratory for a future

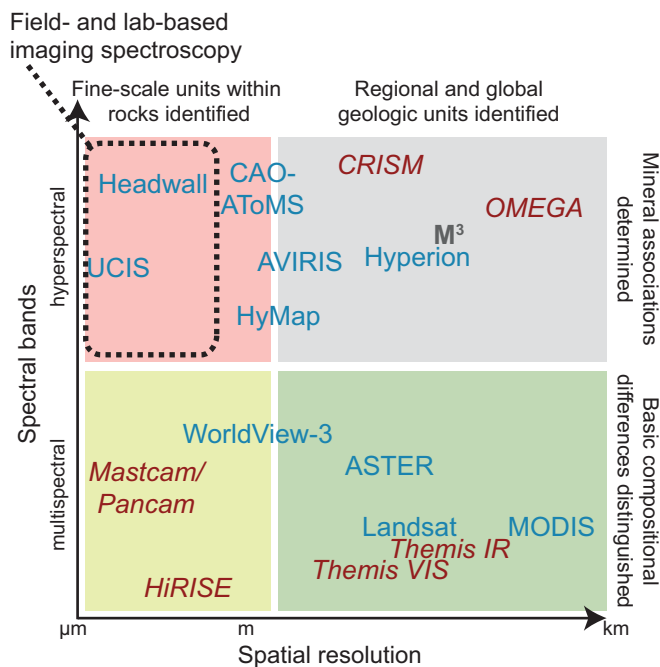


Figure 1. Conceptual plot of the relative spectral sampling versus the spatial scales of observations by various imaging systems and the gap that ground-based imaging spectroscopy fills (dashed box). Blue text indicates imaging systems on Earth, red italicized text is for Mars, and gray bolded text is for the Moon. The number of spectral bands and the spatial resolutions used in this plot are generally those in the visible-shortwave infrared regions. The Headwall and Ultra Compact Imaging Spectrometer (UCIS) imagers were used to acquire data presented in this paper. ASTER—Advanced Spaceborne Thermal Emission and Reflection Radiometer; AVIRIS—Airborne Visible/Infrared Imaging Spectrometer; CAO-AToMS—Carnegie Airborne Observatory—Airborne Taxonomic Mapping System; CRISM—Compact Reconnaissance Imaging Spectrometer for Mars; M³—Moon Mineralogy Mapper; OMEGA—Observatoire pour la Minéralogie, l’Eau, les Glaces et l’Activité; HiRISE—High Resolution Imaging Spectrometer Experiment; MODIS—Moderate Resolution Imaging Spectrometer; THEMIS VIS/IR—Thermal Emission Imaging System (visible/infrared).

mission (Van Gorp et al., 2014), and the MicrOmega instrument will be on the upcoming ExoMars rover and Hayabusa-2 mission (Pilorget and Bibring, 2013). An orbital VSWIR imaging spectrometer has also been selected to fly to Europa. The shortwave infrared wavelengths are critical for mineralogic analyses because unique overtones and combination tones of vibrations within mineral structures occur in this region. The visible wavelengths alone cannot distinguish mineralogies. While not the focus of this paper, similar systems are in development to measure thermal infrared emissivity in the laboratory (e.g., Edwards and Christensen, 2013). There is a steadily growing suite of literature on the use of imaging spectroscopy of outcrops and samples, including core scanning, to answer geologically relevant questions (e.g., Kruse et al., 2012; Kurz et al., 2012; Murphy et al., 2012, 2014; Butz et al., 2015; Greenberger et al., 2015a, 2015b; Yokoyama et al., 2015). Here we highlight some exciting applications of this emerging, non-destructive technology and the science discoveries enabled.

EXAMPLE 1: CHARACTERIZING HABITABILITY AND SEARCHING FOR BIOSIGNATURES IN SERPENTINE-BEARING ROCK

The serpentinization process liberates molecular hydrogen that can sustain microbial communities and react through biotic and abiotic processes to form methane (e.g., Kelley et al., 2001, 2005; Sleep et al., 2004; Oze and Sharma, 2005; Schulte et al., 2006; Cardace and Hoehler, 2009; Etiope and Sherwood Lollar, 2013; McCollom and Seewald, 2013). The oxidation states and coordination environments of iron produce diagnostic absorption features readily detected and mapped with imaging spectroscopy but not so easily spatially resolved with traditional analysis techniques. In serpentinized bodies, the oxidation state and iron coordination chemistry are related to the volume of hydrogen produced and the availability of reduced gasses capable of supporting microbial metabolisms (Marcaillou et al., 2011; Andreani et al., 2013). Though degrees of serpentinization are not readily apparent visually, work by Greenberger et al. (2015b) used imaging spectroscopy in the 0.42–1.1 μm region to map the depth of an electronic transition of tetrahedrally coordinated Fe^{3+} occurring at 0.45 μm as a proxy for hydrogen production. Using new imaging data that cover an extended wavelength range (0.40–2.5 μm ; Fig. 2), the 0.45 μm feature is shown with the two dominant minerals, carbonate and serpentine, which exhibit sharp vibrational absorptions mapped through calculation of the depths of these features (Clark and Roush, 1984) and other spectral parameters (data processing algorithms are described in the GSA Supplemental Data Repository¹). Different portions of this sample have undergone different degrees of serpentinization; those areas with tetrahedral Fe^{3+} have undergone advanced serpentinization and are promising areas to search with still higher spatial resolution compositional or isotopic techniques (e.g., scanning electron microscopy, mass spectrometry) for microbial biosignatures and to understand the production of reduced gasses.

EXAMPLE 2: HYDROTHERMAL ALTERATION AND DIAGENESIS OF LACUSTRINE PILLOW BASALTS

Alteration rinds illuminate conditions of water-rock interactions, and progressive changes from interior to exterior reflect increasing degrees of alteration (e.g., Hausrath et al., 2008). With sub-millimeter spatial resolutions, imaging spectroscopy measurements of alteration rinds resolve fine changes in mineralogy with alteration. Data from an Early Jurassic lacustrine pillow lava from the Hartford Basin are shown in Figure 3 (Greenberger et al., 2015a). In this work, coordinated imaging spectroscopy, electron microprobe, microscopic X-ray diffraction, microscopic thermal emission spectroscopy, and microscopic Raman spectroscopy analyses of a thick section across an alteration rind (Fig. 3C) characterized spectral, mineralogic, and chemical transformations. Unexpected key identifications with imaging spectroscopy include calcic clinopyroxenes interpreted to have formed through >400 °C hydrothermal alteration (e.g., Bird et al., 1984; Manning and Bird, 1986), pervasive oxidation, Fe/Mg-phyllsilicate signatures that increase in strength toward the exterior, and higher water content of calcites in the rind, either as

¹ GSA supplemental data item 2015342, imaging spectroscopy methods and calibration, is online at www.geosociety.org/pubs/ft2015.htm. You can also request a copy from GSA Today, P.O. Box 9140, Boulder, CO 80301-9140, USA; gsatoday@geosociety.org.

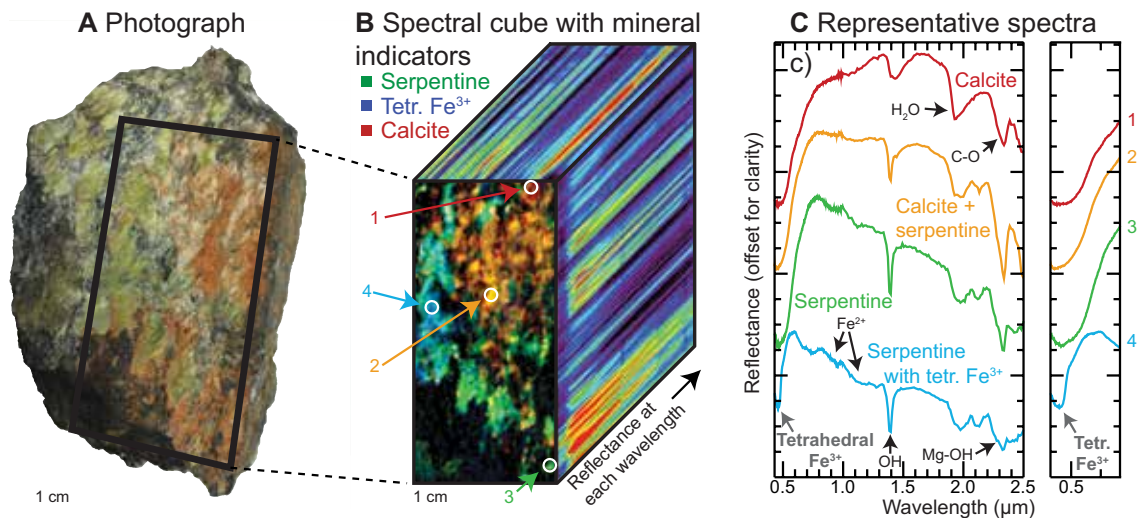


Figure 2. Hyperspectral image of a serpentinite sample with red and green coatings (Nor4-14, described in Greenberger et al., 2015b) from Norbestos, Quebec, Canada. (A) Photograph of the full rock. (B) Image showing spectral parameters that map calcite (red), serpentine (green), and a feature at 0.45 μm (BD450; blue) due to tetrahedral Fe^{3+} within serpentine. The third dimension shows the reflectance as a function of wavelength for each pixel within the image, with black and purple being low and red high. (C) Plot with representative spectra of different units within the hyperspectral image. Colors correspond to colors in the spectral parameter image with locations numbered. Close-up views of the 0.45 μm feature are shown on the right. These images were acquired with Headwall Photonics Inc. High Efficiency Hyperspec[®] visible–near-infrared E-series (0.4–1.0 μm , 7 nm spectral resolution, 0.382 mrad instantaneous field of view) and High Efficiency Hyperspec[®] shortwave infrared X-series pushbroom systems (1.0–2.5 μm , 12 nm spectral resolution, 1.2 mrad instantaneous field of view) imaging spectrometers (see GSA Supplemental Data Repository [see footnote 1] for more information).

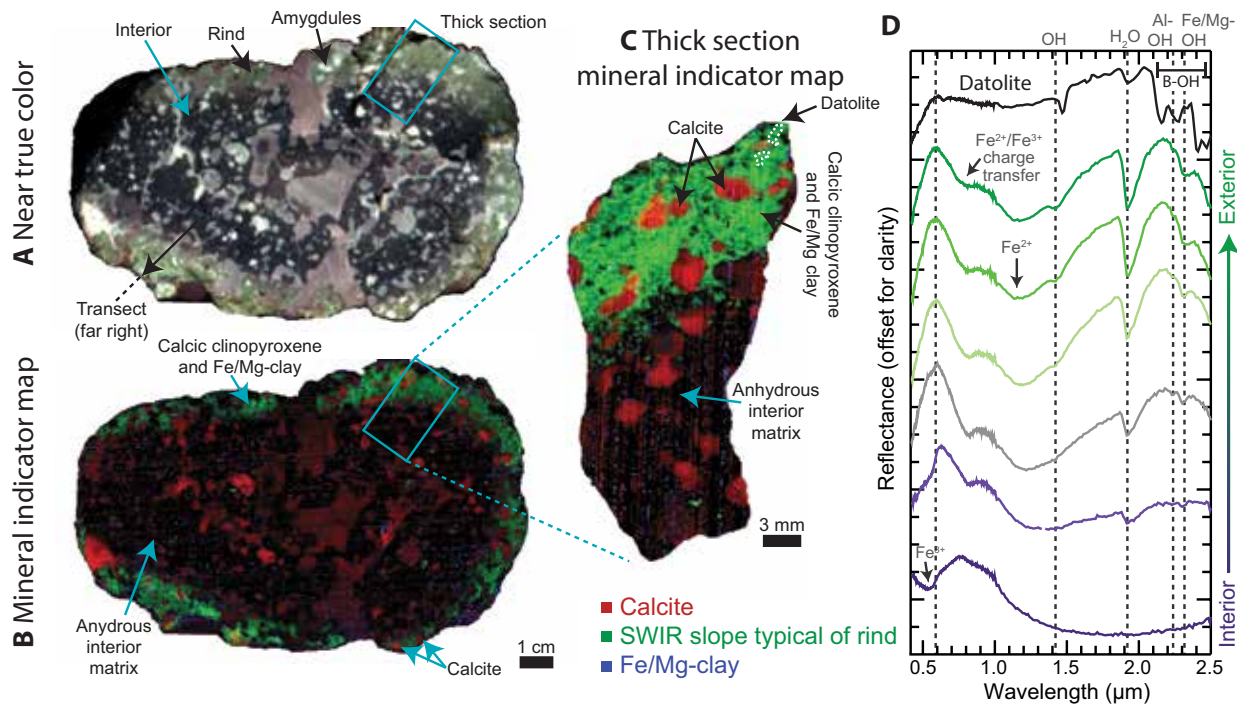


Figure 3. (A) Color composite image from a hyperspectral image acquired with the same imaging system used in Figure 2, approximating the true color of a pillow lava cross section. (B) Mineral indicator map showing calcite in red, a spectral slope indicative of the rind in green, and Fe/Mg-clay in blue. The cyan box shows the approximate location of the material on the adjacent cut face from which a thick section was prepared and imaged. (C) Mineral indicator and spectral parameter image of the thick section using the same parameters as (B). The dashed white outline shows the location of identified datolite. (D) Plot with spectral transect from the interior through the alteration rind (purple to green; location of transect shown in A). The spectrum of the innermost point (purple) reflects the oxidized, anhydrous nature of the interior matrix. Spectra of the rind (green) are consistent with an Fe/Mg-clay (chlorite and/or nontronite) and calcic clinopyroxenes. Guidelines show absorption features due to various molecular vibrations or other key spectral characteristics. A scaled, three-point moving average spectrum of datolite (black) acquired within the thick section is also shown. This figure is modified from data presented in Greenberger et al. (2015a).

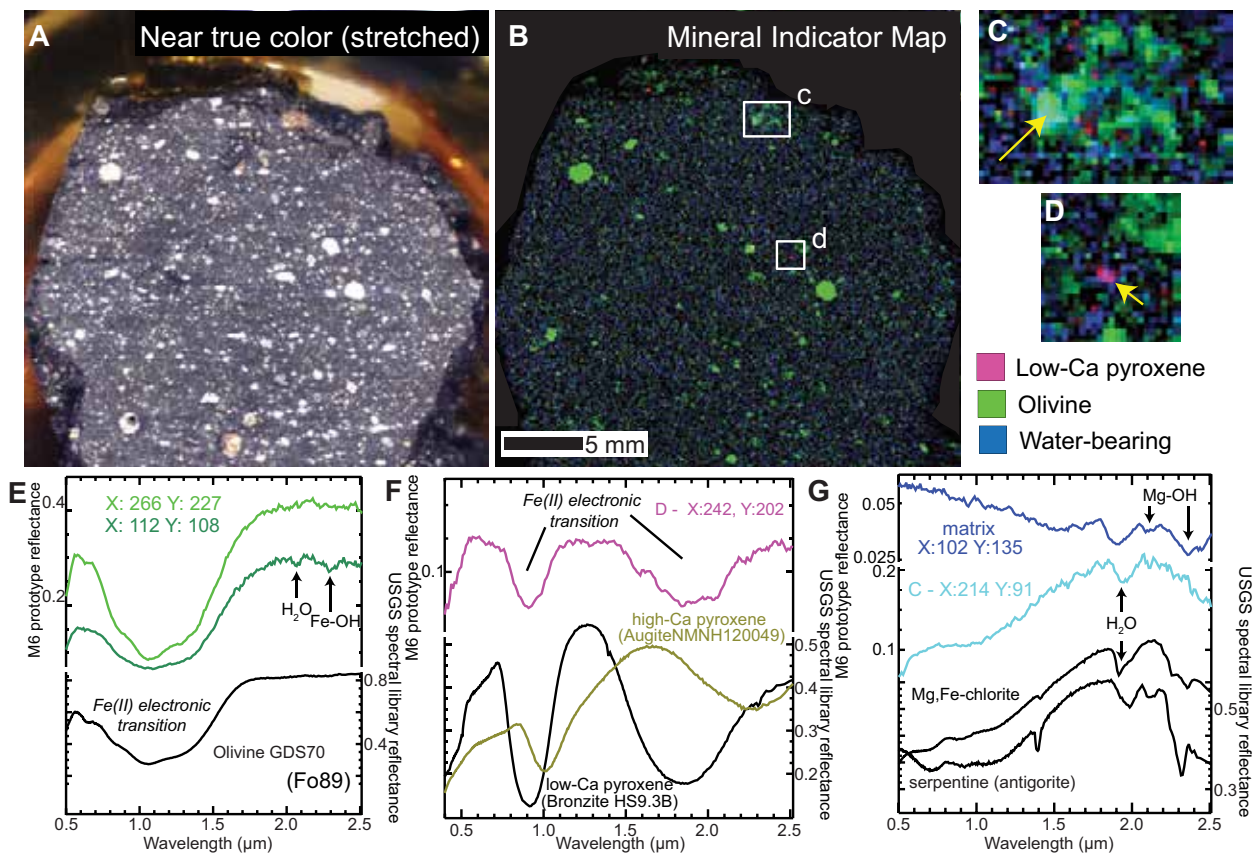


Figure 4. Image of the Murchison meteorite acquired with UCIS. (A) Near true color composite image of a cut face of the meteorite using hyperspectral data. (B) Mineral indicator map in which low-calcium pyroxene appears magenta, olivine is green, and water-bearing materials are blue. Close-up of two interesting regions of the meteorite with a (C) zone of altered olivine and (D) fragment of low-calcium pyroxene. Spectra from the USGS spectral library are shown in black and gold in (E)–(G) for comparison with meteorite spectra (Clark et al., 2007). (E) Spectra of olivine-bearing spots with (dark green) and without (light green) spectral features indicative of hydration. (F) Spectrum of low-Ca pyroxene (shown in D), likely from a chondrule fragment. (G) Matrix materials within the chondritic sample are clearly water-bearing but are distinctive in composition from typical terrestrial chlorites and serpentines. The light blue spectrum is from (C).

structural H₂O or fluid inclusions (Greenberger et al., 2015a). In addition, <2 mm-sized areas of datolite [CaBSiO₄(OH)] formed from boron-rich hydrothermal fluids. While datolite is apparent elsewhere in this outcrop and has been reported throughout the Hartford Basin, the areas of datolite mineralization in this sample were unexpected because they are too small to be distinguished visually from the abundant calcite. However, they are spectrally distinct in the ~133 μm/pixel VSWIR imaging data. Imaging spectroscopy correlates and scales all of these results to the hand-sample (full cross section of the pillow lava; Figs. 3A–3B) and to portions of the outcrop characterized by similar green alteration rinds, and the same spectral features are observed at all scales. These results are consistent with a scenario in which the pillow lavas were altered initially after emplacement at high temperatures, overprinted by a progressively cooling hydrothermal system, and then altered after burial through diagenesis, specifically albitization followed by calcite precipitation (Greenberger et al., 2015a, and references therein).

EXAMPLE 3: METEORITES, MAPPING OF PRECIOUS MATERIALS NON-DESTRUCTIVELY

Analysis of geological samples typically requires preparation of thin sections or powders for determination of crystal structure

and chemical composition. Simultaneous analysis of small-scale mineralogy and texture with VSWIR microimaging spectroscopy requires no sample preparation and can be performed on a rough or cut surface. This approach is ideal for the survey of a collection of rare or precious samples to best target locations for follow-up destructive or high spatial resolution analyses. It is also ideal for in situ exploration of planetary surfaces when conducting multi-step sample preparation procedures may be prohibitively complex. Analyses of the CM2 carbonaceous chondrite Murchison from the Arizona State University meteorite collection were conducted with UCIS in micro-imaging mode (~80 μm/pixel; Fig. 4) (Ehlmann et al., 2014; Van Gorp et al., 2014; Green et al., 2015). Olivine-rich chondrules (green areas, Fig. 4B) of varying sizes are observed throughout the sample, and UCIS data permit ready identification of an atypical area, no more than a few pixels in size, with a low-calcium pyroxene-rich clast, most likely a chondrule fragment (magenta, Figs. 4D and 4F). Chondrules where olivine is affected by aqueous alteration (dark green spectrum) versus those unaffected (light green) can be discriminated (Fig. 4E), and several Fe/Mg phyllosilicate alteration phases are mapped in the matrix (blue areas in Fig. 4B; blue spectra in Fig. 4G). In addition, comparisons of the near true color image with infrared mapping in Figures 4A–4B show that visually

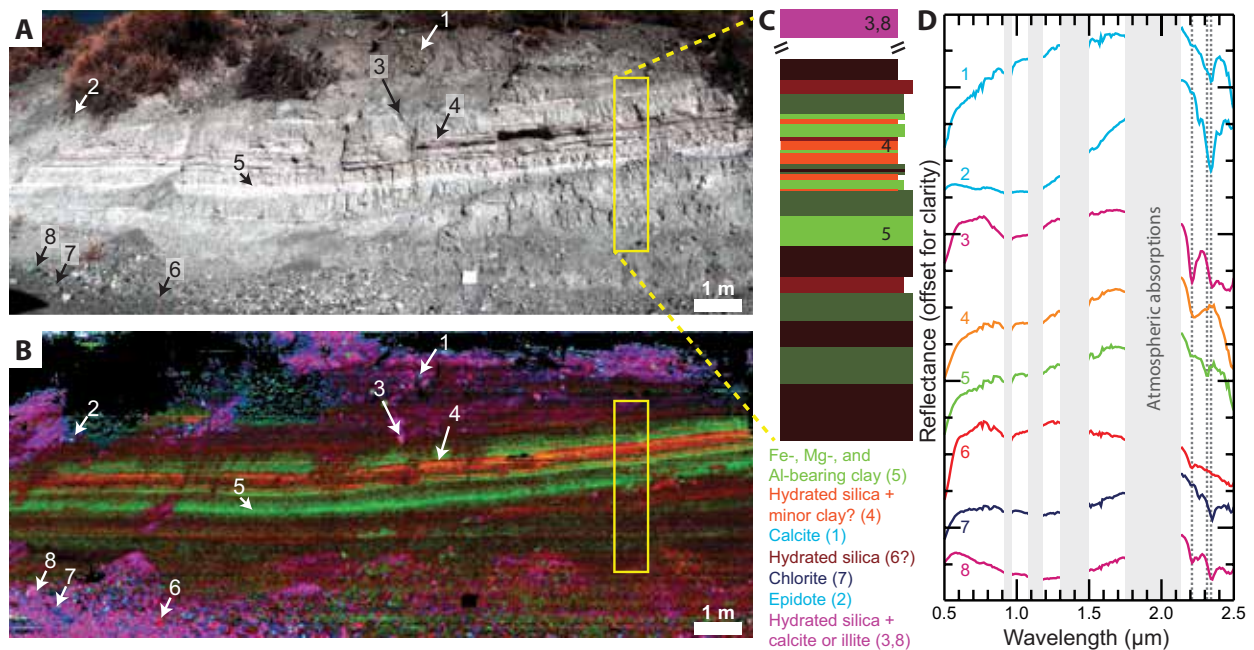


Figure 5. (A) Color composite image approximating true color of an outcrop along Mills Creek imaged with UCIS. (B) Spectral parameter map. Red is the band depth of a spectral feature at 2.21 μm (BD2210) due to Si-OH and/or Al-OH combination absorptions. Green is the band depth of a feature at 2.31–2.32 μm (BD2310-20) likely due to Mg-OH combinations. Blue is the band depth of a feature at 2.34–2.35 μm (BD2340-50) due to either a C-O combination in calcite or Fe-OH combinations in a mineral such as chlorite or epidote (Clark et al., 1990). (C) Schematic lithostratigraphic section from area outlined in yellow boxes in (A) and (B) with colors corresponding to the colors in (B). Dark green layers have weak Fe/Mg/Al clay features. Other colors correspond with mineral names under the stratigraphic section. (D) Example spectra of different units with colors corresponding to (B) and (C). Locations of each spectrum are numbered on both images. Dashed lines are, from left to right, at 2.21, 2.31, and 2.34 μm , corresponding with the positions of spectral features mapped in (B). Spectral regions with terrestrial atmosphere are removed and covered with light gray boxes.

similar areas are compositionally quite variable. VSWIR micro-images acquired in minutes quickly map distributions of mafic and altered phases while highlighting key compositional variations, allowing investigators to zero-in on sample locations of highest interest for more accurate but time-consuming instrumental techniques such as electron microprobe, transmission electron microscopy, or NanoSIMS analyses.

EXAMPLE 4: MAPPING OF SEDIMENTARY ROCKS EXPOSED AT MILLS CREEK

We imaged an outcrop of sedimentary rocks exposed along Mills Creek near Mono Lake, California, with UCIS in field mapping mode (Fig. 5; 0.5–2.5 μm ; instantaneous field of view 1.35 mrad, 12 nm spectral resolution). Using spectral parameters, we mapped specific mineral phases present at the site, including hydrated silica (opal A), clays (Fe-, Mg-, and Al-bearing), calcite, illite/muscovite, and epidote (Fig. 5B). From these results, the stratigraphy of the outcrop lithologies can be inferred (Fig. 5C), showing variations in the depths of absorption features related to hydrated silica (red or orange) and clay mineral (green) contents of the sedimentary layers. The float rocks above the outcrop and along the creek bed at the bottom of the image have diverse compositions. Based on the higher proportions of rocks with significant calcite (cyan) and illite (magenta), we infer the likely presence of calcite- and illite-rich units higher in the stratigraphy that are not exposed at this outcrop. Much of this calcite- and illite-rich talus is located on the left portion of the outcrop near a small fan and likely is sourced from above the layered section,

whereas the float rocks to the right are more similar compositionally to the exposed layered outcrop.

CONCLUSIONS

Imaging spectroscopy of samples and outcrops enables new science investigations and yields novel or unexpected mineralogic and petrologic insights into a variety of geological processes (Greenberger, 2015). This technique rapidly and non-destructively maps mineralogies with little sample preparation, showing mineral associations that might not otherwise be apparent and guiding further investigations using other, more time-consuming techniques. Other investigations have used imaging spectroscopy at similar scales to find economically viable deposits of minerals (Kruse et al., 2012), map carbonate lithologies (Baissa et al., 2011; Kurz et al., 2012), characterize alteration of basaltic samples from an impact structure (Yokoyama et al., 2015) and in a cold and arid environment (Cannon et al., 2015b), quantify the abundances of iron in a mine wall (Murphy and Monteiro, 2013), map clay layers (Murphy et al., 2014), and study the Black Beauty meteorite from Mars (Cannon et al., 2015a). These types of studies also aid in preparing for imaging spectrometers on future landed planetary missions. Imaging spectrometers used herein are currently employed in laboratories such as at Brown University, the California Institute of Technology, and the University of Winnipeg.

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GSA Honorary Fellow: Manfred R. Strecker



Manfred Strecker's research activities link studies of tectonics, climate, and landscape evolution with the goal to better understand tectonic and climatic forcing mechanisms of surface processes and their conspiring activity in sculpting the surface of our planet. In particular, he and his team have worked to better understand how the morphology of landscapes can be used to reconstruct crustal deformation processes and to bridge the

temporal gap between long-term geologic manifestations of deformation and short-term observations and instrumental measurements. By joint application of morphometric analyses, neotectonic observations, paleoseismology, surface exposure dating, and thermochronological methods, they have successfully deciphered tectonic and climatic signals within sedimentologic archives and within the context of landscape evolution.

This work has been carried out in various mountain belts, including the Andes, the Himalaya, Central Asia, and the ranges bordering the Turko-Iranian Plateau. He and his team also focus on stress-field histories in the context of the structural development of linked fault systems and their impact on the evolution of sedimentary basins in the East African Rift.

Strecker did his undergraduate work at Göttingen University (Germany) and the University of North Carolina at Chapel Hill. He received his M.Sc. degree at Cornell University in 1983 and his Ph.D. from the same university in 1987. After postdoc appointments at University of Karlsruhe (Germany) and Stanford University, he joined the University of Potsdam (Germany) in 1995. Since then, he and his colleagues have been responsible for establishing a geoscience program with a strong research-based curriculum. Strecker was Visiting Professor at Vienna University, IPG Paris, and Stanford University. Since 2009 he has also been Adjunct Professor at Cornell University. He is a member of Leopoldina, the German Academy of Sciences.

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Questions? Please contact Jennifer Nocerino at jnocerino@geosociety.org.



GSA Honorary Fellow: Brian Windley



Brian Windley is a leading, preeminent geoscientist whose career has revolved around understanding the manifold facets of the tectonic development of orogens through geological time, and especially application of the plate tectonic paradigm to Precambrian accretionary and collisional orogens worldwide. These include

1. Field-based studies of (a) the accretionary Central Asian Orogenic Belt/Altaids, the Mona Complex of Anglesey/Lleyn (Wales, UK), and terranes in Yemen; and (b) the collisional Himalayan (Kohistan) and Karakoram orogens (Pakistan), the Tian Shan mountains (China), Sergipano belt (Brazil), Mozambique orogen (Madagascar), the Kumta-Coorg suture (SW India), and the Aravalli-Delhi belts in Rajasthan (India).
2. Geotectonic growth of deep continental crust in W. Greenland, S. India, and NW Scotland (Neoproterozoic), and the Ketilidian orogen in Greenland (Paleoproterozoic).
3. Tectonic uplift of Cenozoic mountains in West Mongolia, and climate-tectonic relationships in Central Asia.
4. Neoproterozoic ocean plate stratigraphy and accretion in Anglesey/Lleyn, and Ballantrae, Scotland.
5. Petrology of eclogitic rocks at Glenelg, Scotland; Beishan, China; Vietnam; and Kyrgyzstan, and blueschists in Anglesey and Ballantrae.
6. Chromite-layered anorthositic complexes from the roots of island arcs at Fiskenaeset (Greenland), Sittampundi (India), Chilas (Pakistan Himalayas), Limpopo (South Africa), and Chimalpahad (Eastern Ghats).
7. Tectonic development of ophiolitic complexes in Beishan, Ballantrae, Tartoq (Greenland), and Bayankhongor (Mongolia).
8. Petrology of sapphirine-bearing rocks especially at Fiskenaeset.
9. Crustal rheology and elastic thickness of the Indian Shield, and Ninetyeast Ridge (Andaman Islands).
10. Delamination of sub-continental lithosphere in eastern China.
11. Geotectonic evolution of Precambrian cratons—West Greenland and North China Craton. These projects involved collaborative fieldwork and laboratory studies with innumerable students and staff in 23 countries.

Windley has published nine edited/co-edited books and 320 peer-reviewed papers, with >19,000 citations. Syntheses of the interdisciplinary geology of crust/mantle evolution through time integrated with the atmosphere, oceans, and metallogensis led to *The Evolving Continents* in three editions.

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2016 Post-Doctoral Research Awards

The following post-doc research awards are available. Learn more at www.geosociety.org/grants/postdoc.htm.

- The **Gladys W. Cole Memorial Research Award** for research on the geomorphology of semiarid and arid terrains in the United States and Mexico is awarded annually to a GSA member or Fellow between 30 and 65 years of age who has published one or more significant papers on geomorphology.
- The **W. Storrs Cole Memorial Research Award** for research on invertebrate micropaleontology is awarded annually to a GSA member or Fellow between 30 and 65 years of age who has published one or more significant papers on micropaleontology.

Application deadline: 1 Feb. 2016.

Other Awards

Call for Nominations: AGI Awards

AGI Medal in Memory of Ian Campbell

AGI Marcus Milling Legendary Geoscientist Medal

Go to www.agiweb.org/direct/awards.html to submit your nominations. **Nomination deadline:** 1 Feb. 2016.

Call for Nominations: National Awards

• **William T. Pecora Award:** <http://remotesensing.usgs.gov/pecora.php>.

• **National Medal of Science:** www.nsf.gov/od/nms/medal.jsp.

• **Alan T. Waterman Award:** www.nsf.gov/od/waterman/waterman.jsp.

Nomination deadlines vary.



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With deepest appreciation, the Museum acknowledges Kathryn W. Davis for her generous founding support of the MAT Program.

Leadership support for the MAT program is provided by The Shelby Cullom Davis Charitable Fund.

The MAT program is supported in part by the New York State Education Department, the National Science Foundation under Grant Numbers DRL-119444 and DUE-1340006, and the U.S. Department of Education under Grant Number U3365140026.

amnh.org/mat

mat@amnh.org | 212-313-7464 | [@amnh](https://twitter.com/amnh) | facebook.com/amnhmat

Writing A Successful GSA Grant Proposal

Paul H. Wetmore, Univ. of South Florida, and **Amy Draut East**, U.S. Geological Survey

Each year, GSA funds approximately half of the proposed graduate student research grants. In addition to providing our graduate student members with the means to complete their research, this program gives them an introduction to the all-important skill of proposal writing. Here, we provide some suggestions to help the next generation of scientists develop this skill. To augment this piece, you can find resources at www.geosociety.org/grants/ap_tips.htm.

Like all grant proposals, GSA's has rules that you need to read and follow if you hope to get funded. Before you begin writing, read the policies and procedures at www.geosociety.org/grants/gradgrants.htm. Note the deadline—NO LATE SUBMISSIONS! Note eligibility, and what items are permitted in your budget.

Your proposal will be evaluated on six factors: how well you address each of the four sections, your figure, and the overall writing in your proposal. The four sections ask you to

1. Present the problem, hypotheses, and overall project objectives;
2. Discuss the scientific and, if appropriate, societal importance of your project;
3. State your research plan and how it will test your hypotheses; and
4. Provide an itemized budget with detailed justification for each item.

The core task of your proposal is to identify a real scientific question or problem, develop hypotheses, and convince the reviewers that it is an important problem worthy of funding, that you have a plan for testing your hypotheses, and that you have carefully identified the costs involved in conducting your study. The vast majority of funded studies follow the scientific method (i.e., problem identification, propose hypotheses, develop/conduct tests, and evaluate hypotheses based on results). A subordinate number involve discrete solutions to a problem (e.g., the probability of an area/facility being inundated by lava as part of a volcanic hazard assessment). In either case you must clearly relate why and to whom the results of your study will be important. The best proposals focus on a scientific problem rather than starting with a specific field area. The motivation for your study cannot simply be “because nobody has studied this before.”

Your research plan must describe in detail the steps you will take to address your question. A common mistake here is the lack of connection between problems/hypotheses from the first two sections and the tasks proposed in this section. Your planned study should test a hypothesis and state clearly how your proposed research will accomplish this task. This can be as simple as “Since

the goal of this study is to determine if this fault was active during the Sevier orogeny or Miocene extension, I will determine U/Pb zircon ages of intrusions emplaced concomitant with slip on the fault.”

Show that your work plan is carefully thought out, with methods that are necessary and sufficient to address the problem. Provide specific details. If you are mapping: what features, where, and at what scale? If collecting or analyzing samples: what, how many, with what methods or equipment? The scope of work also must be reasonable for the time frame you propose.

In many proposals, the budget section is treated as an afterthought. Nothing could be further from the truth; one of the easiest means of being denied funding is to include disallowed items in your budget. Your budget should be as explicit and realistic as possible. Determine the actual costs in detail (e.g., sample analysis, campsite and vehicle rentals, airfare, and baggage fees) and provide them on a per-sample/day/night/mile basis. Justify every item listed in the budget.

Perhaps the most important part of your proposal is your figure. This is your chance to present a figure that can explain what would require paragraphs of text. Location maps and photos of the fossil/mineral/etc. you'll be working on are great, but is it the best use of your figure? The strongest proposals tend to use multi-box figures illustrating the concepts to be tested in their studies. Design a figure specifically for your study. Be sure your graphics are clear and high resolution, and use text that is legible at a normal full-page viewing scale. A well-written caption is very helpful. Include legends, scale bars, and use colors and annotations that make the figure intuitive to understand.

Finally, take care with the proposal's language and writing style. Start paragraphs with strong topic sentences and keep the rest of the paragraph on topic. Avoid unnecessary technical jargon—the reviewers are professional earth scientists, but may be outside of your study's discipline. Explain and minimize acronyms (three or fewer). Check and re-check grammar and spelling. Check the math in your budget. Cite the work of others properly (the reviewers might have published on your topic!), using the superscripted reference numbering system to save space. And make sure that you have addressed the topic of each section and connected them logically to each other (problem/hypotheses, importance, research plan, budget, and justification).

Constructing a solid proposal not only improves your chance of receiving GSA funds; it also sets the stage for a successful research plan to generate interesting and useful results that the scientific community will want to see.

—Good luck!

2015 ExxonMobil Minority Student Scholarship Recipients

ExxonMobil



GSA FOUNDATION

In 2015, ExxonMobil, in partnership with the GSA Foundation, helped to fund a long-standing scholarship program to encourage minority undergraduate GSA student members to continue their studies in the geosciences. The ExxonMobil Minority Student Scholarship Program provides US\$1,500 to one student in each of GSA's six regional Sections. The students also receive free registration to attend the GSA Annual Meeting and a one-year complimentary membership in GSA.

Diamond Tachera, University of Hawaii at Mānoa (Cordilleran Section)

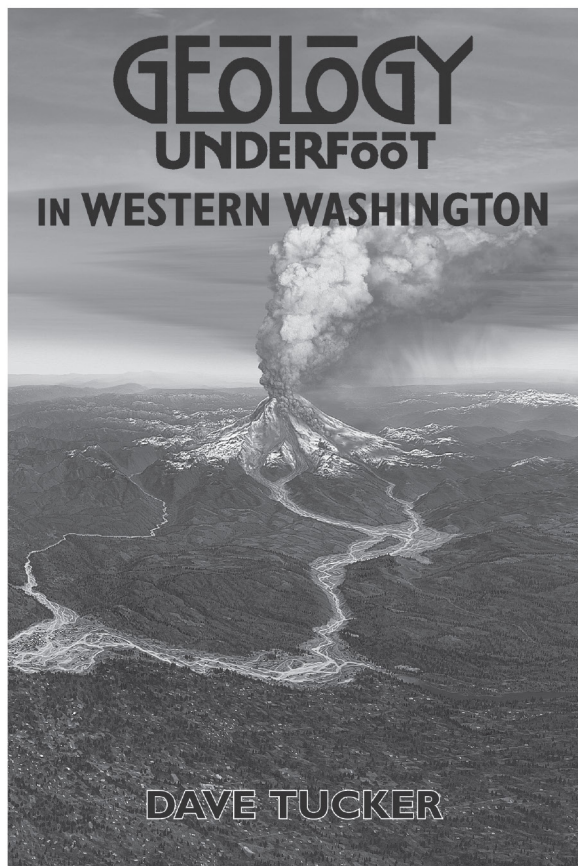
Detaya Johnson, University of Wisconsin–Milwaukee (North-Central Section)

Stephanie Sang, Cornell University/University of Bristol (Northeastern Section)

Ida Clarke, Black Hills State University (Rocky Mountain Section)

Justin Brundin, Tarleton State University (South-Central Section)

Eric Hanna, Austin Peay State University (Southeastern Section)



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Susanna Whitman Blair

A Legislative Win and Final Thoughts

My GSA-USGS Congressional Fellowship year has come to an end. Over the past year I have learned an incredible amount and feel deeply indebted to this experience. As a wrap-up, I want to discuss a piece of legislation that I worked on.

One of my projects in Senator Gillibrand's (D-NY) office was to assist in researching and developing legislation as it pertains to pollinator protection. Pollinators, such as honey bees, native bees, butterflies, and other insects, are essential to many of the specialty crops, such as apples and cucumbers, in New York. Globally, pollination is necessary for at least 35% of the world's crops and upward of 90% of wild plants. This past spring, the President released the *National Strategy to Promote the Health of Honey Bees and Other Pollinators*, highlighting the national problem of declining bee populations and laying out a number of initiatives to reduce the impacts of stressors on pollinator health. Beekeepers throughout the U.S. have noticed an unusually high overwintering mortality among honey bee colonies, known as colony collapse disorder (CCD). Researchers investigating CCD and the overall general population decline are finding that there is no one single culprit, but a combination of stressors, including pesticides, disease, parasites, changes to habitat quality, and habitat loss.

From a legislative perspective it is difficult to craft (and get passed) one encompassing bill that would help alleviate the problem of pollinator population decline. Beekeepers have stated that one beneficial step would be to increase the natural foraging landscape so that it is free from pesticides and contains a diversity of vegetation. The Highways Bettering the Economy and the Environment (BEE) Act attempts to do this. The bill proposes integrated vegetation management practices, such as reduced mowing and increased planting of pollinator-friendly native vegetation along highway right-of-ways. The bill has the potential to create 17 million acres of natural pollinator habitat throughout the country. This type of vegetation management has already been implemented in many states and is shown to save nearly 20% in right-of-way maintenance costs. It was first introduced in the House by Representatives Denham (R-CA) and Hastings (D-FL). I worked with my office to create a Senate companion bill.

The nation's current surface transportation legislation will expire at the end of October. This past summer the Environment

and Public Works Committee (EPW) began the process of reauthorizing this legislation, which must first pass out of committee before it can be voted on by the whole Senate. To move the BEE Act forward, we worked with EPW staff to include the bill language in the original base transportation bill that was first voted on in EPW. Getting language in the bill requires approval by the committee members who are drafting the bill, and in this case was agreed upon by both parties due to the bipartisan importance of getting this legislation reauthorized. By comparison, if the pollinator legislation was introduced as an amendment or even a stand-alone bill, it would require a separate individual vote, which, given the climate of the Hill and the other legislation that necessitates votes, it probably would not have gotten a chance. By including the language in the base bill it nearly ensures that it will become law (if the bill passes).

The six-year transportation reauthorization, The DRIVE Act, with the BEE Act language, passed the Senate on 30 July 2015. Unfortunately, the committee did not accept the entire bill language, but only included portions that encourage the use of pollinator friendly vegetation, and excluded the portions that hold states accountable or require reporting, leaving little to no teeth or actionable items in the effort. I think this was a great piece of legislation that could easily have been supported by both parties, namely because it would save money—not a common occurrence. I was pretty disappointed at the end result, but have accepted this small success as a bee-sized step in the right direction for pollinator protection. This whole process was really instructive, because I was able to follow an idea through to becoming law (almost). Even with this seemingly non-divisive legislation, it truly was a nuanced process.

I am very grateful to GSA and the USGS for funding this fellowship, and I leave with determination and focus. I will remain in D.C. and have accepted a position working for the EPA. My position will be to translate and communicate chemical safety research to further the mission of the agency to protect human health and the environment. It is without a doubt that my experience over the past year helped me define the role of science in the political process and my commitment to it. I encourage anyone interested in this process to consider this fellowship, and if you have any questions, please contact me at susanna.blair@gmail.com. I want to welcome the 2015–2016 GSA-USGS Congressional Science Fellow Karen Paczkowski, who will undoubtedly do a great job over the next year.

The manuscript is submitted for publication by Susanna W. Blair, 2014–2015 GSA-USGS Congressional Science Fellow, with the understanding that the U.S. government is authorized to reproduce and distribute reprints for governmental use. The one-year fellowship is supported by GSA and the U.S. Geological Survey, Department of the Interior, under Assistance Award No. G14AP00161. The views and conclusions contained in this document are those of the author and should not be interpreted as representing the official policies, either expressed or implied, of the U.S. government.

GSA Education & Outreach Programs: 2016 Section Meetings

ON TO THE FUTURE (OTF)

Stop by the GSA Foundation booth at your Section Meeting's Welcome Reception to find out about applying to OTF, which provides travel support to students underrepresented in the geosciences to attend their first GSA Annual Meeting (the next one is 25–28 Sept. 2016 in Denver, Colorado, USA).

CAREER WORKSHOPS

Geoscience Career Workshop Part 1: Career Planning and Informational Interviewing

Your job-hunting process should begin with career planning, not when you apply for jobs. This workshop will help you begin this process and will introduce you to informational interviewing. This section is highly recommended for freshmen, sophomores, and juniors. The earlier you start your career planning the better.

Geoscience Career Workshop Part 2: Geoscience Career Exploration

What do geologists in various sectors earn? What do they do? What are the pros and cons of working in academia, government, and industry? Workshop presenters, and professionals in the field, will address these issues.

Geoscience Career Workshop Part 3: Cover Letters, Résumés, and CVs

How do you prepare a cover letter? Does your résumé need a good edit? Whether you are currently on the job market or not, learn how to prepare the best résumé possible. You will review numerous résumés to help you learn the important dos and don'ts of the process.

MENTOR PROGRAMS

Enjoy a free lunch while meeting with geoscience mentors working in the applied sector. The popularity of these programs means that space is limited, so plan to arrive early, because lunch is first-come, first-served. For further information, contact Jennifer Nocerino at jnocerino@geosociety.org.

South-Central Section: Baton Rouge, Louisiana, USA
Roy J. Shlemon Mentor Program in Applied Geoscience
Luncheon: Monday, 21 March
John Mann Mentors in Applied Hydrogeology
Luncheon: Tuesday, 22 March

Northeastern Section: Albany, New York, USA
Roy J. Shlemon Mentor Program in Applied Geoscience
Luncheon: Monday, 21 March
John Mann Mentors in Applied Hydrogeology
Luncheon: Tuesday, 22 March

Southeastern Section, Columbia, South Carolina, USA
Roy J. Shlemon Mentor Program in Applied Geoscience
Luncheon: Thursday, 31 March

John Mann Mentors in Applied Hydrogeology
Luncheon: Friday, 1 April

Cordilleran Section, Ontario, California, USA
Roy J. Shlemon Mentor Program in Applied Geoscience
Luncheon: Monday, 4 April
John Mann Mentors in Applied Hydrogeology
Luncheon: Tuesday, 5 April

North-Central Section, Champaign, Illinois, USA
Roy J. Shlemon Mentor Program in Applied Geoscience
Luncheon: Monday, 18 April
John Mann Mentors in Applied Hydrogeology
Luncheon: Tuesday, 19 April

Rocky Mountain Section, Moscow, Idaho, USA
Roy J. Shlemon Mentor Program in Applied Geoscience
Luncheon: Wednesday, 18 May
John Mann Mentors in Applied Hydrogeology
Luncheon: Thursday, 19 May

GSA Section Meetings Call for Mentors



PROFESSIONALS: *Interested in sharing information about your applied geoscience career with students?* Being a mentor is a rewarding experience. If you are interested in serving as a mentor at one of GSA's Section Meetings, contact Jennifer Nocerino at jnocerino@geosociety.org.

STUDENTS: *Interested in a career in the applied geosciences?* Plan now to attend a Roy J. Shlemon Mentor Program in Applied Geoscience and/or a John Mann Mentors in Applied Hydrogeology Program at your 2016 Section Meeting to chat one-on-one with practicing geoscientists. These volunteers will answer your questions and share insights on how to get a job after graduation.

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Eastward Pivoting Turboides, Magallanes Foreland Basin, Chile. Photo by David G. Soter



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THE
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Layered Mafic Intrusions and Associated Economic Deposits

8–12 August 2016
Red Lodge, Montana, USA

CONVENERS

Alan E. Boudreau, School of the Environment, Duke University, Durham, North Carolina, USA, boudreau@duke.edu

Eric C. Ferré, Department of Geology, Southern Illinois University, Carbondale, Illinois, USA, eferre@geo.siu.edu

Brian O'Driscoll, School of Earth, Atmospheric and Environmental Sciences, University of Manchester, Manchester, UK, brian.odriscoll@manchester.ac.uk

Edward M. Ripley, Department of Geological Sciences, Indiana University, Bloomington, Indiana, USA, ripley@indiana.edu

ORGANIZING COMMITTEE

Steve Barnes, CSIRO Mineral Resources; **Mike Cheadle**, University of Wyoming; **James Day**, Scripps Institution of Oceanography; **Jeff Gee**, Scripps Institution of Oceanography; **Allen Glazner**, University of North Carolina–Chapel Hill; **Tom Kalakay**, Rocky Mountain College; **Mike Koski**, Stillwater Mining Company; **Craig Lundstrom**, University of Illinois Urbana-Champaign; **Wolfgang Maier**, University of Manchester; **Larry Meinert**, U.S. Geological Survey, Mineral Resources Program; **Bill Meurer**, ExxonMobil; **Phil Moffitt**, Rocky Mountain Association of Geologists; **James Scoates**, University of British Columbia; **Bob Stewart**, North American Platinum

Cosponsored by National Science Foundation, GSA Foundation, U.S. Geological Survey, Rocky Mountain Association of Geologists Foundation.

DESCRIPTION AND OBJECTIVES

Layered mafic intrusions play a central role in our understanding of magmatic systems. They also represent one of the fundamental modes of magma transfer from the upper mantle to the crust. These magmatic systems formed throughout geologic time from the Archean (e.g., Stillwater Complex) to the Paleogene (e.g., Skaergaard Complex) on all five continents. Because many of the best-studied layered intrusions are associated with Large Igneous Provinces, they are largely independent from tectonic processes at plate boundaries. Layered intrusions have generated significant historic interest from the igneous petrology and geochemistry communities because they lie at the heart of some of the most fundamental petrologic precepts, such as *fractional crystallization* and *Bowen's reaction series*. These intrusions also host first-class economic deposits of platinum group elements (PGE), chrome, and nickel around the world. As an illustration of how unique and important these environments are, it is worth highlighting that the Bushveld Complex (South Africa) hosts >75% of the world's exploited platinum. The Stillwater Complex also hosts significant economic quantities of these precious metals, at even higher grades (i.e., 18 ppm Pt + Pd) than the Bushveld, so it is an important location for understanding ore forming processes. In general, it is the combination of the industrial and scientific relevance of layered intrusions that has ensured support for research on these intrusions for the past six decades.

Despite the large volume of literature dedicated to layered intrusions, advances in various sub-disciplines are somewhat scattered, and there is a need for synthesis of the past twenty years of research as well as an urgent need to define the new scientific challenges that the broad community and graduate students



should focus on. The Stillwater Complex is an ideal setting in which to consider these challenges, because it combines a rich tradition of petrological research with active economic interests in a relatively easily accessible location. More simply, it is one of the most important layered intrusions on Earth, in terms of historical study and quality of exposure.

The subject of layered mafic-ultramafic intrusions will bring together a range of researchers from the fields of petrology, geochemistry, mineralogy, and economic geology. These scientists use different approaches that have the potential to be better integrated to further our understanding of complex magmatic systems. This conference will provide an opportunity for researchers to address these and other recent developments in a format that allows for discussion, integration of ideas, and development of collaborations and future directions.

The meeting is an opportunity for integration of academic and industrial observations, experiments on magmatic systems, and results of petrological/geochemical modeling. The topics that will be emphasized as part of the program include:

- Petrology of layered mafic intrusions, including experimental petrology;
- Geochemistry of layered mafic intrusions; and
- Geophysics of layered mafic intrusions and prospective science forum.

Preliminary Agenda

Day 1: 8 Aug.: Petrology of layered mafic intrusions

Day 2: 9 Aug.: Visit of the Stillwater mine

Day 3: 10 Aug.: Visit of Stillwater Complex key exposures

Day 4: 11 Aug.: Geochemistry of layered mafic intrusions

Day 5: 12 Aug.: Geophysics of layered mafic intrusions and prospective science forum

This five-day conference will begin in Billings, Montana, USA, where transportation will be arranged by the organizers to Red Lodge, Montana, USA. The first day of the conference begins with two sessions focusing on recent developments on the petrology of layered mafic intrusions. On the first day of excursions (Tuesday), participants will visit the following localities: (1) sill/dike and basal series at the Hamslice; (2) ultramafic series cliff section; (3) finger structures in large boulder at the Mountain View mine entrance; (4) ultramafic-lower banded series section; (5) inch-scale doublets/octa-scale layering; and (6) mine core shed view of J-M reef section. The second day of excursions (Wednesday), participants will (1) drive up to Picket Pin, with a stop at upper unconformity; (2) hike the middle banded series section (Hess's eggs), replacement troctolite, AN-II, Picket Pin PGE zone; and (3) continue into olivine-bearing zone V, snowball oiks in N-III, and inverted pigeonite "oiks" in GN-III. The fourth day of the conference will be dedicated to geochemical aspects of layered mafic intrusions, and the fifth day will focus on geophysical aspects of layered mafic intrusions (morning) and a discussion of future research with industry representatives. Transportation to the Billings airport will be arranged at the end of the conference.



Attendees and Estimated Costs

The registration fee will cover hotel lodging for six nights (double occupancy), breakfast, lunch, and coffee breaks for five days, handouts, and transportation for the field trips and meeting dates. Airfare is not included, and participants must make their own travel arrangements. Registration fees have not been finalized. Please check the GSA website for updates: www.geosociety.org/penrose/.

Applications and Registration

Application deadline: 31 Jan. 2016

Registration deadline: 31 Mar. 2016

Participants will have to commit to attending the full five days of the conference. **To apply**, please contact the conveners at eferre@geo.siu.edu with a letter of intent that includes a brief statement of interests, the relevance of your recent work to the themes of the conference, the subject of a proposed presentation, and contact information. Interested graduate students and early career faculty are strongly encouraged to apply. Once you have been selected to participate, you will be sent registration information.

Second Announcement

SOUTH-CENTRAL SECTION

50th Annual Meeting of the South-Central
Section, GSA

Baton Rouge, Louisiana, USA

21–22 March 2016

www.geosociety.org/Sections/sc/2016mtg/

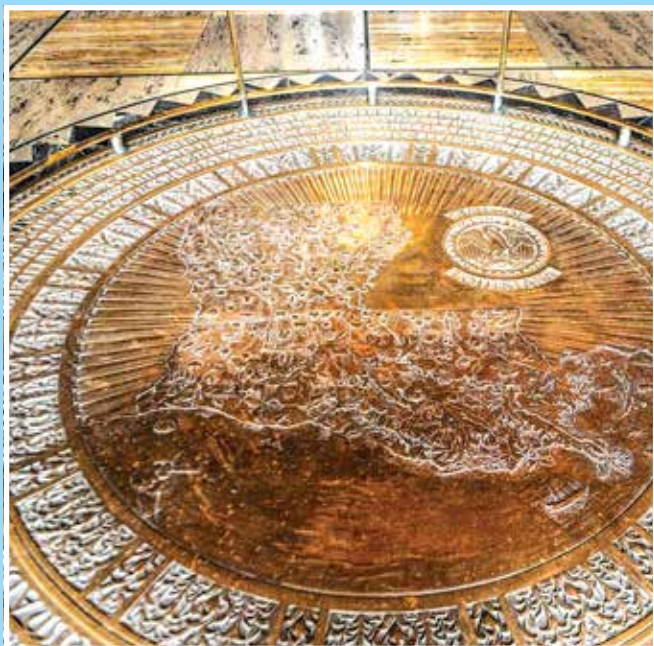


Photo courtesy of Visit Baton Rouge.

Celebrating the Section's Golden Anniversary

GSA's South-Central Section will celebrate its Golden Anniversary by meeting at the Hilton Baton Rouge Capitol Center, located in the state capital of Louisiana, Baton Rouge. Founded in 1719, Baton Rouge is located on the banks of the Mississippi River, just upstream from the world-famous delta that is building out into the Gulf of Mexico. The region is a classic area for the study of fluvial sedimentology, coastal geology, and hydrocarbon systems and salt tectonics. Geology underlies much of the economy of the region, which is also challenged by issues such as coastal land loss, including fragile wetlands, as a result of rising sea levels and subsidence. The region is also strongly affected by hurricane systems from the Gulf of Mexico. Interest in this 50th anniversary meeting is rapidly developing! Early registration and accommodation reservations are strongly recommended.

REGISTRATION

Early registration deadline: 16 Feb.

Cancellation deadline: 22 Feb.

For further information or if you need special accommodations, please contact Peter Clift, pclift@lsu.edu. Professionals registering for the meeting are encouraged to add US\$15 to their registration fee to help a student attend the 50th Anniversary Celebration.

REGISTRATION FEES (in U.S. dollars)

	Early Registration		Onsite	
	Full	One Day	Full	One day
Professional Member	\$165	\$110	\$220	\$165
Professional Member 70+	\$110	\$60	\$165	\$110
Professional Non-Member	\$180	\$130	\$240	\$180
Student Member	\$60	\$50	\$110	\$75
Student Non-Member	\$80	\$70	\$130	\$90
K–12	\$65	n/a	\$110	n/a
Guest/Spouse	\$40	n/a	\$50	n/a
Field Trip or Short Course only	\$40	n/a	\$50	n/a

ACCOMMODATIONS

Reservation deadline: 29 Feb.

GSA has reserved blocks of specially priced rooms and townhomes at the Hilton Baton Rouge Capitol Center, 201 Lafayette Street, Baton Rouge, LA 70801, USA. Reservations can be made by calling +1-225-344-5866 or +1-800-955-6962. In order to receive the special rate, please mention that you are attending the GSA South-Central Meeting. Individual and double rooms are US\$109 per room/night, plus a 13% Louisiana tax. Bookings can also be made online at <https://aws.passkey.com/event/13930413/owner/32164/home> (use code "GSA"). For those who would like to come early or stay after the meeting, these special rates are available 19–22 March 2016.

CALL FOR PAPERS

Abstract deadline: 15 Dec. 2015

Submit abstracts online at www.geosociety.org/sections/sc/2016mtg/techprog.htm. Fee: US\$15 for students and US\$20 for all others. If you cannot submit an abstract online, please contact Heather Clark, +1-303-357-1018, hclark@geosociety.org.

TECHNICAL PROGRAM

Symposium

- S1. The Bones May Be Dry but the Ideas Don't Have to Be: Fossil Vertebrates from the Gulf Coastal Plain.** Judith Schiebout, Louisiana State Univ., jschie@lsu.edu; Gary Stringer, Univ. of Louisiana at Monroe, stringer@ulm.edu.

Theme Sessions

- T1. Climate Change in the Gulf Coast Region: Past, Present, and Future.** Brian Schubert, Univ. of Louisiana at Lafayette, schubert@louisiana.edu; Grant Harley, Univ. of Southern Mississippi, grant.harley@usm.edu.

- T2. **Flow through Carbonate Aquifers and Reservoirs.** Carol Wicks, Louisiana State Univ., cwicks@lsu.edu.
- T3. **Big Geoscientific Problems in the South-Central Region.** Robert J. Stern, Univ. of Texas at Dallas, rjstern@utdallas.edu; Kevin Mickus, Missouri State Univ., kevinmickus@missouristate.edu; Raphael Gottardi, Univ. of Louisiana at Lafayette, rxg0121@louisiana.edu.
- T4. **The Geochemistry of Sedimentary Systems.** David Borrok, Univ. of Louisiana at Lafayette, dborrok@louisiana.edu; Achim Hermann, Louisiana State Univ., aherrmann@lsu.edu.
- T5. **Petroleum Geology of the Gulf of Mexico.** Peter D. Clift, Louisiana State Univ., pclift@lsu.edu.
- T6. **Geochemistry and Water Quality of Gulf Coast Groundwaters.** Karen Johannesson, Tulane Univ., kjohanne@tulane.edu; Ningfang Yang, Tulane Univ., nyang@tulane.edu.
- T7. **Subsidence, Accretion: Coastal Depletion?** Christopher Esposito, Tulane Univ., cesposit@tulane.edu; Elizabeth L. Chamberlain, Tulane Univ., echamberl@tulane.edu; Krista L. Jankowski, Tulane Univ., kjankows@tulane.edu.
- T8. **Hazards Related to Induced Earthquakes.** Randel T. Cox, Univ. of Memphis, randycox@memphis.edu; Arleen A. Hill, Univ. of Memphis, aahill@memphis.edu; Jian Chen, Univ. of Louisiana at Lafayette, jchen@louisiana.edu.
- T9. **Coastal and Shelf Sediment Transport Processes and Products of the Northern Gulf of Mexico.** Sam Bentley, Louisiana State Univ., sjb@lsu.edu; Kehui Xu, Louisiana State Univ., kxu@lsu.edu; Jeff Obelcz, Louisiana State Univ., jobelc1@lsu.edu; Jiase Wang, Louisiana State Univ., jwang72@lsu.edu; Crawford White, Louisiana State Univ.
- T10. **Fluvial Forms and Processes with Special Focus on Gulf Coast Rivers.** Kory Konsoer, Louisiana State Univ., kkonsoer@lsu.edu; Jeff Nittrouer, Rice Univ., nittrouer@rice.edu; Inci Güneralp, Texas A&M, iguneralp@geos.tamu.edu.
- T11. **Toward Sustainable Water Systems: Impacts of Climate Variability and Changing Demands.** Emad Habib, Univ. of Louisiana at Lafayette, habib@louisiana.edu; Ning Zhang, McNeese State Univ., nzhang.mcneese@gmail.com; Robert Miller, C.H. Fenstermaker & Associates, robert@fenstermaker.com.
- T12. **Computational Geosciences and Data Visualization.** Margarete Jadamec, Univ. of Houston, mjadamec@central.uh.edu; Matthew Knepley, Rice Univ., kneply@rice.edu; M. Burak Yikilmaz, Univ. of California Davis, mbyikilmaz@ucdavis.edu.
- T13. **Salt-Water Intrusion.** Doug Carlson, Louisiana Geological Survey, dcarlson@lsu.edu.
- F3. **Water Flow, Sediment Flux, and Boat Traffic between the Mississippi and Atchafalaya Rivers.** Sun., 20 March; departs 8 a.m. from the Hilton and returns by 4:30 p.m., with lunch provided. US\$75; min.: 4/max. 18. Principal organizer: Gary Kinsland, gkinsland@louisiana.edu.

SPECIAL EVENT

Welcoming Reception: 50th Anniversary Section Meeting. Sun., 20 March, 6:30–8:30 p.m. Visit with friends and colleagues as you enjoy the hospitality of the Hotel Capitol Center. One complimentary drink, then cash bar.

OPPORTUNITIES FOR STUDENTS

For **mentor programs, career workshops, and On To the Future**, see p. 19.

Volunteering

Students can earn free meeting registration by volunteering for two shifts of ~4 to 5 hours of work. If you are interested in volunteering, please contact the Student Volunteer Coordinator, Adam Turner, aturn49@lsu.edu. The volunteer application is part of the meeting registration process.

Travel Grants

Application deadline: 17 Feb.

Please review the eligibility guidelines and application procedure at www.geosociety.org/Sections/sc/grants.htm.

LOCAL CONTACTS

Coordinating Chair: Peter Clift, Louisiana State University, pclift@lsu.edu

Technical Chair: David Borrok, University of Louisiana Lafayette, dmb5953@louisiana.edu

Exhibits Chair: Carl Richter, University of Louisiana Lafayette, richter@louisiana.edu

Field-Trip Chair: Tara Jonell, Louisiana State University, tjonell@lsu.edu

Student Coordinator: Adam Turner, Louisiana State University, aturn49@lsu.edu

FIELD TRIPS

- F1. **Quaternary and Recent Sedimentation in the Wax Lake Delta.** Sun., 20 March; departs 8:30 a.m. from the Hilton. US\$220; min.: 16/max.: 28. Principal organizer: Harry Roberts, Louisiana State Univ., hrober3@lsu.edu.
- F2. **Miocene Vertebrates in the Pascagoula Formation: A Site Yielding Mastodon to Marine Turtle Material.** Sun., 20 March; departs 9 a.m. from the Hilton and returns at 3:30 p.m., with lunch provided. US\$35; min.: 5/max.: 15. Principal organizer: Judith A. Schiebout, jschie@lsu.edu.

Second Announcement

NORTHEASTERN SECTION

51st Annual Meeting of the Northeastern
Section, GSA
Albany, New York, USA
21–23 March 2016

www.geosociety.org/Sections/ne/2016mtg/



Aerial view of Albany, New York.

*In the midst of it all... slices
through space and time.*

Albany, New York, USA, is centrally located on the historic Hudson River, where the Appalachian Mountains meet the Allegheny Plateau and the Valley and Ridge province nudges up to the Taconic and Adirondack Mountains. From Paleozoic shelf strata and complexly metamorphosed Precambrian bedrock to Mesozoic rift basins and Pleistocene glacial cover, the fascinating transect from Buffalo to Boston leads right through Albany.

REGISTRATION

Early registration deadline: 16 Feb.

Cancellation deadline: 22 Feb.

REGISTRATION FEES (in U.S. dollars)

	Early Registration		Onsite	
	Full	One Day	Full	One day
Professional Member	\$180	\$130	\$225	\$150
Professional Member 70+	\$100	\$80	\$130	\$100
Professional Non-Member	\$200	\$150	\$250	\$185
Student Member	\$60	\$50	\$80	\$70
Student Non-Member	\$70	\$60	\$90	\$80
K–12	\$65	\$50	\$85	\$60
Guest/Spouse	\$50	n/a	\$60	n/a
Field Trip or Short Course only	\$40	n/a	\$40	n/a

ACCOMMODATIONS

Reservation deadline: 29 Feb.

Blocks of specially priced rooms have been reserved at the Hilton Albany Hotel (40 Lodge Street, Albany, NY 12207, USA), which is three blocks from the convention center. Individual and double rooms at US\$172 per room/night can be reserved by calling +1-800-445-8667 and referring to the “NEGSA conference.” Rates do not include 14% New York tax.

For students only: A block of rooms (each can accommodate up to four people) has been reserved at the 74 State Hotel (one block from the Hilton and four blocks from the convention center) at a special rate. Booking information is on the meeting website.

CALL FOR PAPERS

Abstract deadline: 8 Dec. 2015

Submit abstracts online at www.geosociety.org/sections/ne/2016mtg/techProg.htm. Fee: US\$15 for students and US\$20 for all others. If you cannot submit an abstract online, please contact Heather Clark, +1-303-357-1018, hclark@geosociety.org.

TECHNICAL PROGRAM

Symposia

- S1. Applications of Geochemistry and Geochronology to Understanding Tectonic Processes: In Honor of Raymond A. Coish.** David P. West, Jr., Middlebury College, dwest@middlebury.edu; Peter Ryan, Middlebury College, pryan@middlebury.edu; Jonathan Kim, Vermont Geological Survey, jon.kim@state.vt.us.
- S2. Timing and Nature of Deformation in the Adirondack Mountains.** Mike Williams, Univ. of Massachusetts, mlw@geo.umass.edu; Jeff Chiarenzelli, St. Lawrence Univ.; Tim Grover, Castleton State College.

Theme Sessions

- T1. Insights from Microfossils, from Terrestrial to Marine Environments (Posters).** Miriam Katz, Rensselaer Polytechnic Institute, katzm@rpi.edu; Chiara Borrelli, Univ. of Rochester, cborrelli@ur.rochester.edu; Samuel Bowser, Wadsworth Center, NYS Dept. of Health, samuel.bowser@health.ny.gov.

- T2. **High-Resolution Records of Holocene Climate Change.** Eugene Domack, College of Marine Science, Univ. of South Florida, edomack@usf.edu; Amy Leventer, Geology Department, Colgate Univ., aleventer@colgate.edu.
- T3. **Tropical Climate and Paleoclimate.** Alice Doughty, Dartmouth College, alice.m.doughty@dartmouth.edu; Meredith A. Kelly, Dartmouth College; Margaret Jackson, Dartmouth College.
- T4. **Glacial Landscapes as Recorders of Geomorphic Process and Climate Change.** Lee Corbett, Univ. of Vermont, ashley.corbett@uvm.edu; Jeremy Shakun, Boston College; Aaron Putnam, Univ. of Maine, aaron_putnam@umit.maine.edu.
- T5. **Marine and Terrestrial Coastal Mapping: Data, Discovery, and Science.** Mark Borrell, Univ. of Massachusetts Boston, mark.borrelli@umb.edu; Bryan Oakley, Univ. of Massachusetts Boston.
- T6. **Integrating Structural Geology with Hydrogeology.** Edwin Romanowicz, State Univ. of New York at Plattsburgh, romanoea@plattsburgh.edu; Jonathan Kim, Vermont Geological Survey.
- T7. **Interaction between the Landscape and Aquatic Biogeochemistry.** Andrew Vermilyea, Castleton State College, andrew.vermilyea@castleton.edu; Andrew Schroth, Univ. of Vermont.
- T8. **Integrating Complementary Records of Paleozoic Orogenies in the Appalachians: Bridging the Foreland and Hinterland.** Paul Karabinos, Williams College, pkarabin@williams.edu; Francis Macdonald, Harvard Univ., fas.harvard.edu; Charles E. Mitchell, SUNY Buffalo, cem4graps@gmail.com; Charles A. Ver Straeten, New York State Museum, charles.verstraeten@nysed.gov.
- T9. **New Perspectives on the Use of Structural Analysis to Solve Tectonic Problems: Examples from Slices through Space and Time in Northeastern North America.** *Cosponsored by GSA Structural Geology and Tectonics Division.* Jean Crespi, Univ. of Connecticut, jean.crespi@uconn.edu; Keith Klepeis, Univ. of Vermont, keith.klepeis@uvm.edu.
- T10. **Pegmatites: Most Evolved Components of the Continental Crust.** Paul Tomascak, SUNY, Oswego, tomascak@oswego.edu; Marian Lupulescu, New York State Museum.
- T11. **Interpretation of Quaternary Environments: Through Geology, Paleontology, and Archaeology in the Glaciated Great Lakes and New England.** Andrew Kozlowski, New York State Museum/Geologic Survey, andrew.kozlowski@nysed.gov; Robert Feranec, New York State Museum, robert.feranec@nysed.gov.
- T12. **A New Look at Terrane Affinity of Old Rocks in Western New England: Peri-Laurentian or Peri-Gondwana?** Craig Dietsch, Univ. of Cincinnati, dietscc@ucmail.uc.edu; Bob Wintsch, Indiana Univ., wintsch@indiana.edu.
- T13. **Teaching Geoscience Concepts Using Geospatial Tools.** John Van Hoesen, Green Mountain College, vanhoesenj@greenmtn.edu.
- T14. **The Grenville-Age Low Ti-Fe Oxide Deposits from New York State: Igneous or Hydrothermal?** Phil Geer, Univ. of Massachusetts; Marian Lupulescu, New York State Museum, pgeer@geo.umass.edu; Peter Valley, Weatherford Laboratories.
- T15. **Stratigraphy, Sedimentology, and Paleontology of the New York Paleozoic.** James Ebert, SUNY Oneonta, james.ebert@oneonta.edu; D. Jeffrey Over, SUNY Geneseo, over@geneseo.edu.

Call for Applications

2016–2017 GSA-USGS Congressional Science Fellowship

Application deadline: 1 Feb. 2016

Bring your science and technology expertise to Capitol Hill to work directly with national leaders at the interface between geoscience and public policy.

The GSA-USGS Congressional Science Fellowship provides a rare opportunity for a geoscientist to spend a year working for a Member of Congress or congressional committee. If you are an earth scientist with a broad geologic background, experience applying scientific knowledge to societal challenges, and a passion for helping shape the future of the geoscience profession, GSA and the USGS invite your application. The fellowship is open to GSA members who are U.S. citizens or permanent residents, with a minimum requirement of a master's degree with at least five years of professional experience or a Ph.D. at the time of appointment.

Learn more at www.geosociety.org/csf or by contacting Kasey White, +1-202-669-0466, kwhite@geosociety.org



- T16. **Deciphering the Devonian: Paleobiology, Stratigraphy, and Geochemistry.** Andrew M. Bush, Univ. of Connecticut, andrew.bush@uconn.edu; J. Andrew Beard, Univ. of Connecticut, james.beard@uconn.edu; Diana L. Boyer, SUNY Oswego, dboyer@oswego.edu.
- T17. **Geophysical Methods in the Hydrogeologist's Toolbox.** Laura Lautz, Syracuse Univ., lklautz@syr.edu; Robin Glas, Syracuse Univ., rlglas@syr.edu; Zeno Levy, Syracuse Univ., zflevey@syr.edu.
- T18. **Professional Licensing of Geologists in New York State: Where We've Been, Where We're Going.** Jim Ridenour, New York State Council of Professional Geologists, jim.ridenour@health.ny.gov.
- T19. **Applications of Geologic Mapping to Address Geologic Hazards, Natural Resources, and Natural History Studies.** Andrew Kozlowski, New York State Museum/Geologic Survey, andrew.kozlowski@nysed.gov; Brian Bird, New York State Museum/Geological Survey, brian.bird@nysed.gov.
- T20. **Radioactivity in the Environment.** John Garver, Union College, garverj@union.edu.
- T21. **Trace Metals in the Environment.** Tara Curtin, Hobart and William Smith Colleges, curtin@hws.edu; Melissa Lombard, Georgia Southern University.
- T22. **Organic Geochemistry in the Geosciences.** Elizabeth Thomas, University of Buffalo and Univ. of Massachusetts Amherst, ekthomas@buffalo.edu; Isla Castañeda, Univ. of Massachusetts Amherst.
- T23. **Eastern North American Rift Valleys through Time.** Stephen A. Nathan, Eastern Connecticut State University, nathans@easternct.edu; Peter A. Drzewiecki, Eastern Connecticut State University.
- T24. **Connecting K-12 and Higher Education: What Teachers Need, What Faculty Can Offer.** Laura Guertin, Penn State Brandywine, guertin@psu.edu; Michael Passow; Missy Holzer, Chatham High School.
- T25. **Earth Science Student Research at the Secondary Level.** Margaret Brewer-LaPorta mbrewer@pace.edu; Philip C. LaPorta, Pace University and The Center for the Investigation of Native and Ancient Quarries.
- T26. **Pleistocene to Anthropocene Landscape Evolution in the Northeastern U.S.** Will Ouimet, University of Connecticut, willouimet@gmail.com; Noah Snyder, Boston College.
- T27. **New Evidence for Glacial and De-Glacial Timing and Processes in the Northeastern Region and Beyond.** John Rayburn, SUNY New Paltz, rayburnj@newpaltz.edu; David De Simone.
- T28. **Records of Environmental Change from Lacustrine Archives.** Jeff Munroe, Middlebury College, jmunroe@middlebury.edu; Don Rodbell, Union College.
- T29. **Landscape and Hydrologic Response and Recovery from Watershed Disturbance.** Brian Yellen, UMass Amherst, brian.yellen@gmail.com; John Gartner, UMass Amherst.
- T30. **Processes in Biogeochemistry and Biomineralization.** Dawn Cardace, University of Rhode Island, cardace@uri.edu; Zsuzsanna Balogh-Brunstad, Hartwick College.

FIELD TRIPS

- All field trips take place on Sunday, 20 March. Please contact **John van Hoesen**, vanhoesenj@greenmtn.edu, with any questions.
- F1. **Geology & History of the Rosendale Cement Industry.** Steven Schimmrich, SUNY Ulster County Community College, schimmrs@sunyulster.edu.
- F2. **The Geology of Thacher Park: A Classic North American Geologic Site.** Charles Ver Straeten, New York State Museum, charles.verstraeten@nysed.gov; Ed Stander, SUNY Cobleskill, standeej@cobleskill.edu; Thom Engel, Northeastern Cave Conservancy, necaver@earthlink.net.
- F3. **Karst Hydrogeology of the Kingston-Rosendale Karst Aquifer Region within the Hudson Valley Fold-Thrust Belt.** Paul A. Rubin, HydroQuest, hydroquest@yahoo.com; Kurtis C. Burmeister, Univ. of the Pacific, kburmeister@pacific.edu; Alexander Bartholomew, SUNY New Paltz, barthola@newpaltz.edu.

OPPORTUNITIES FOR STUDENTS

For **mentor programs**, **career workshops**, and **On To the Future**, see p. 19.

Volunteering

Application deadline: 17 Feb.

Earn free meeting registration by volunteering for two shifts of ~4 to 5 hours of work. Please contact Helen Mango, helen.mango@castleton.edu, for more information. The volunteer application is part of the meeting registration process.

Travel Grants

Application deadline: 17 Feb.

Travel grants may be awarded to students presenting at the meeting. Please review the eligibility guidelines and application procedure at www.geosociety.org/grants/negrant.htm.

Travel Awards for Non-Traditional Students

Non-traditional students in the geosciences have the opportunity to receive a generous travel award to attend this meeting. Students who work full time, are financially independent, or are caring for dependents while earning an undergraduate degree are highly encouraged to apply. Check the website for details or contact Tahlia Bear at tbear@geosociety.org.

LOCAL CONTACTS

General Co-Chairs: Helen Mango, helen.mango@castleton.edu; Tim Grover, tim.grover@castleton.edu

Technical Program Co-chairs: Don Rodbell, rodbell@union.edu; Jacqueline Smith, smithj@mail.strose.edu

Field Trip Chair: John van Hoesen, vanhoesenj@greenmtn.edu

Short Course/Workshop Chair: Robert Badger, badgerrl@potdam.edu

Geoscience Jobs & Opportunities

Positions Open

ASSISTANT PROFESSOR PALEONTOLOGY, SUNY POTSDAM

The Geology Department at SUNY Potsdam is accepting online applications for a tenure-track Assistant Professor of Paleontology with expertise in paleoclimatology and/or paleoceanography. Teaching includes, but is not limited to, Principles of Paleontology, Historical Geology, and a high-enrollment general education course focusing on either fossils/evolution or climate change. Ideal candidate can teach a physical oceanography course. Required qualification: Ph.D. by August 15, 2016. To apply, visit: employment.potsdam.edu, Job Posting No. U-00081. Position is open until filled.

ASSISTANT PROFESSOR OF STRUCTURAL GEOLOGY SUNY POTSDAM

The Geology Department at SUNY Potsdam is accepting on-line applications for a tenure-track Assistant Professor of Structural Geology specializing in deformation of the upper crust. Teaching includes, but is not limited to, Physical Geology, Structural Geology, and an upper-level elective. Ideal candidate can teach an applied geophysics course and utilize the College's existing seismic network. Required qualification: Ph.D. by August 15, 2016. To apply, visit: employment.potsdam.edu, Job Posting No. U-00081. Position is open until filled.

ASSISTANT/ASSOCIATE PROFESSOR WATERSHED ANALYSIS MONTANA STATE UNIVERSITY

The Land Resources and Environmental Sciences Department, Montana State University, Bozeman [<http://landresources.montana.edu>] seeking a talented and enthusiastic individual to undertake a tenure-track, fiscal-year faculty position (63% research/27% teaching/ 10% service) in watershed analysis. Details of the position are available at [<http://www.montana.edu/jobs/faculty>]. Screening will begin January 15, 2016 until an adequate applicant pool has been established.

DEPARTMENT CHAIR, PROFESSOR MURRAY STATE UNIVERSITY

The Jesse D. Jones College of Science, Engineering and Technology at Murray State University (MSU) is seeking applicants for the Chair of the Department of Geosciences. The department, with nine full-time tenured/tenure track faculty and approximately 50 majors, offers baccalaureate degrees in geosciences with options in earth science, environmental geology, geoaerchaeology, and geographic information science; a master's degree in geosciences; and a certificate in geographic information science. The department is closely affiliated with the Mid-America Remote Sensing Center (MARC), a core entity in the MSU Watershed Studies Institute.

Qualifications: Ph.D. in the geological sciences or physical geography. Qualifications for the position include documented evidence of excellence in teaching, research productivity, and service accomplishments sufficient to merit appointment at the rank of associate or full professor. Evidence of successful administrative leadership experience or the potential for successful leadership, strong written and verbal communication skills, effective interper-

sonal skills, and a commitment to undergraduate and graduate education are also required.

Familiarity with GIS and remote sensing is required.

Responsibilities: Responsibilities of this position include, but may not be limited to: budget management; strategic and long-range planning; evaluation of faculty performance; coordination of student recruitment and retention efforts; coordination of student advising; oversight of MARC; oversight of laboratory and curricular development; outreach activities; development activities; scheduling of classes; and teaching.

Application Deadline: December 31, 2015.

To apply please visit: <http://www.murraystatejobs.com/postings/4943>.

Women and minorities are encouraged to apply. Murray State University is an equal education and employment opportunity, M/F/D, AA employer.

FACULTY POSITION IN EARTH AND PLANETARY MATERIALS UNIVERSITY OF CALIFORNIA DAVIS

The Department of Earth and Planetary Sciences at the University of California Davis seeks an outstanding scholar whose study of the origin, transformation, or deformation of Earth and planetary materials addresses major processes in the solid Earth. This tenure-track faculty position is the first of multiple anticipated faculty searches directed at understanding the formation and evolution of Earth and other rocky planets, and we seek applicants whose work expands and amplifies our current research strengths. Appointment at the Assistant Professor level is anticipated. Candidates must possess a Ph.D. or equivalent in geoscience or a related field by the time of appointment. The appointee is expected to develop and maintain a vigorous externally funded research program and to be (or potential to be) an excellent teacher at the undergraduate and graduate levels. The department's research programs and experimental, analytical and computational facilities are described at <http://geology.ucdavis.edu/facilities>.

Candidates should submit a cover letter, CV, publication list, statements of research plans and teaching interests, and names and addresses of four references by December 20, 2015, as no new applicants will be accepted after this date. Applicants will have until January 8, 2016 to complete or revise their applications. An optional "Statement of Contributions to Diversity" is strongly encouraged. Guidance for diversity statements may be found at http://academicaffairs.ucdavis.edu/diversity/equity_inclusion. Applications should be submitted online via the job listing JPF00738 at <https://recruit.ucdavis.edu/apply/JPF00738>. Inquiries may be addressed to the Search Committee Chair at epm_search@ucdavis.edu.

UC Davis is an affirmative action/equal employment opportunity employer and is dedicated to recruiting a diverse faculty community. We welcome all qualified applicants including women, minorities, individuals with disabilities, and veterans. UC Davis recognizes the necessity of supporting faculty with efforts to integrate work, family and other work-life considerations. The campus sponsors a Work Life Program that supports faculty as they strive to honor their commitments to work, home and community. For more information see <http://academicaffairs.ucdavis.edu/programs/worklife>.

ASSOCIATE/FULL PROFESSOR SEDIMENTARY GEOLOGY AND DIRECTOR POTENTIAL GAS AGENCY DEPARTMENT OF GEOLOGY AND GEOLOGICAL ENGINEERING COLLEGE OF EARTH RESOURCE SCIENCES AND ENGINEERING COLORADO SCHOOL OF MINES

Colorado School of Mines invites applications for the anticipated position of Associate/Full Professor position in the fields of Sedimentary Geology with an emphasis in applied Petroleum Geochemistry and Director, Potential Gas Agency to begin in May 2016.

The successful candidate will be expected to develop a strong and vibrant externally funded program and establish an international reputation through publication, in addition to teaching at the undergraduate and graduate levels, directing graduate research and supervising thesis projects. The successful candidate will also direct the Potential Gas Agency. As Director of the Agency the successful candidate will be expected to devote at least 33% time during the Academic Year and up to one month during the summer to the work of the Committee.

Candidates must possess a doctoral degree in geology, a record of excellence in teaching, scholarship and service, management and leadership, and national/international professional recognition. Applicants must demonstrate, or show evidence of, excellent written, oral communication and interpersonal skills. Research interests must be in areas that complement existing campus programs (unconventional petroleum research, sedimentary geology research).

For the complete job announcement, full statement of qualifications and directions on how to apply, visit: <http://inside.mines.edu/HR-Academic-Faculty>.

Mines is an EEO/AA employer and is committed to enhancing the diversity of its campus community. Women, minorities, veterans, and individuals with disabilities are encouraged to apply.

TENURE-TRACK ASSISTANT PROFESSOR IN TECTONICS, DEPARTMENT OF GEOLOGICAL SCIENCES AND ENGINEERING UNIVERSITY OF NEVADA, RENO

The Department of Geological Sciences and Engineering at the University of Nevada, Reno seeks an Earth Scientist for a tenure-track faculty position at the Assistant Professor level specializing in Tectonics and Deformation. This position is expected to bring expertise in tectonic processes and deformation within the crust and/or mantle. We seek an outstanding scientist who explores Earth processes using a combination of field, laboratory, and numerical techniques and, in doing so, will establish an innovative, world-class externally-funded research program. It is expected that, depending on the candidate hired, s/he will contribute to both undergraduate and graduate curricula in regional tectonics, cordilleran evolution, our summer field camp, and required course work in structural geology as well as graduate courses in the individual's area of expertise. The successful applicant will be expected to direct graduate student research at the M.S. and Ph.D. levels. The specific field of interest is open, but

preference will be given to candidates who would complement and interact with our existing strengths in the structural and metamorphic evolution of the lithosphere, economic geology, geothermal systems, and natural hazards. Interested applicants must have a doctorate in geology or a related geoscience field by the time of hire. The Department is part of the Mackay School of Earth Sciences and Engineering, which also includes two state-funded Earth Science units, the Nevada Bureau of Mines and Geology and the Nevada Seismological Laboratory. More information about the Department can be found at <http://www.unr.edu/geology>.

Applications are due by December 31, 2015, and review will begin shortly after. All interested applicants should view the application and submit their materials at <http://www.unrsearch.com/postings/19324>.

Materials that will need to be uploaded include a cover letter, CV, statement of research, statement of teaching philosophy, and complete contact information for at least three letters of reference. We are expecting to fill the position by May 1, 2016, with a start date of July 1, 2016. Questions regarding the search may be addressed to the head of the search committee, Dr. Greg Arehart, at arehart@unr.edu. The University of Nevada, Reno is an Equal Opportunity/Affirmative Action Employer. Women and underrepresented groups are encouraged to apply.

**ROGER E. DEANE
POSTDOCTORAL FELLOW
DEPARTMENT OF EARTH SCIENCES
UNIVERSITY OF TORONTO**

The Department of Earth Sciences at the University of Toronto invites applications for the Roger E. Deane Postdoctoral Fellowship, a highly competitive fellowship in any field of Earth Science. The department is interested in supporting innovative research and outstanding young geoscientists to work in collaboration with one or more faculty members. Applicants are encouraged to contact potential hosts in advance to discuss areas of common interest. The Deane Postdoctoral Fellowship has an annual salary of CAD\$50,000 and is awarded for a one-year period, with an anticipated extension for a second year. Anticipated start date is Sept. 2016, but earlier start dates are possible.

Application: A complete application includes: a curriculum vitae, a research proposal (2 pages maximum excluding references), and the names & addresses of at least three references. **Deadline:** Applications are due January 15, 2016. **Submit electronic PDF applications to:** [Ampy Tolentino, geol_sec@es.utoronto.ca](mailto:Ampy.Tolentino@es.utoronto.ca) (subject line: Deane Postdoctoral Fellowship).

Employment as Postdoctoral Fellow at the University of Toronto is covered by the terms of the CUPE 3902 Unit 5 Collective Agreement.

**ASSISTANT PROFESSOR
ENVIRONMENTAL GEOCHEMISTRY/
APPLIED BIOGEOSCIENCES
WEBER STATE UNIVERSITY**

The Department of Geosciences at Weber State University invites applications for a tenure-track position starting Fall 2016. We seek a person with expertise in **Environmental Geochemistry, Environmental Mineralogy, and/or Applied Biogeosciences**. The successful candidate will be appointed at the Assistant Professor level and will be expected

to: (1) teach upper-division courses in area(s) of expertise and lower-division courses as required, (2) establish an active and sustained research program that includes mentoring undergraduate students, (3) seek external funding in support of teaching or research, (4) establish collaborations with colleagues in the College of Science; and (5) contribute to the development of new interdisciplinary curricula including a planned environmental/sustainability science program.

Minimum Requirements include: A Ph.D. in Geology or related field (candidates who expect to complete a Ph.D. by the beginning of the Fall 2016 semester also will be considered), excellent verbal and written communication skills, evidence of teaching excellence and interest in using active-learning pedagogies, and a demonstrated commitment to conducting high-quality research, to mentoring undergraduate researchers, and to integrating research interests into the classroom.

Preferred qualifications include: Ability to forge connections along disciplinary interfaces to address environmental/sustainability opportunities and challenges, postdoctoral experience, and ability to build connections with local industries or government agencies.

To learn more about the position, and to apply, please visit <http://jobs.weber.edu>. To apply, please complete the online application and attach a cover letter, statements of teaching philosophy and research plans, a CV, and unofficial transcripts. In addition, three letters of reference that address the candidate's qualifications for this position must be mailed to Dr. Rick Ford, Search Committee Chair, Department of Geosciences, Weber State University, 1415 Edvalson St. - Dept. 2507, Ogden, UT 84408-2507. **Highest priority will be given to applications received by January 4, 2016, although screening will continue until the position is filled.**

A criminal background check is required as a condition of employment.

EOE/Minorities/Females/Vets/Disability.

**VISITING ASSISTANT OR
ASSOCIATE PROFESSOR IN PETROLOGY
AND MINERALOGY, DEPARTMENT OF
GEOLOGY AND GEOPHYSICS
TEXAS A&M UNIVERSITY**

The Department of Geology and Geophysics at Texas A&M University invites applications for a full-time, non-tenure track position at the rank of Visiting Assistant or Associate Professor to teach courses in Petrology, Mineralogy, and Mineral Resources. The position is a nine-month appointment beginning January 1, 2016, contingently renewable for up to three years. Responsibilities consist of teaching at least four courses per academic year in some combination of Mineralogy, Petrology, and/or Mineral Resources. The department will support the successful candidate's pursuit of independent research and development of a professional academic portfolio, with the opportunity to collaborate with students and colleagues in the College of Geosciences, including the Berg-Hughes Center for Sedimentary and Petroleum Systems, the Center for Tectonophysics and the Deep Crust and Mantle Group.

For more information about TAMU, the College of Geosciences and the Department of Geology and Geophysics, see <http://geoweb.tamu.edu/>.

A Ph.D. with specialization in mineralogy or petrology at the time of appointment is required, but ABD candidates also will be considered. Interested candidates should submit electronic versions of a curriculum vita, statement of research interests and teaching philosophy, the names and email addresses of at least three references, and up to four reprints by email attachments, to the Chair of the Mineralogy/Petrology Search Committee (petrosearch@geos.tamu.edu). Screening of applications will begin November 1, 2015, and continue until a suitable candidate is appointed. The Department of Geology and Geophysics is part of the College of Geosciences, which also includes the Departments of Atmospheric Sciences, Geography, and Oceanography, Sea Grant, the Geochemical and Environmental Research Group (GERG), and the Integrated Ocean Drilling Program (IODP). Texas A&M University, a land-, sea-, and space-grant university is located in a metropolitan area with a dynamic and international community of 172,000 people. Texas A&M University is an affirmative action/equal opportunity employer committed to excellence through the recruitment and retention of a diverse faculty and student body and compliance with the American with Disabilities Act. We encourage applications from minorities, women, veterans, and persons with disabilities. Texas A&M University also has a policy of being responsive to the needs of dual-career partners.

**TENURE-TRACK ASSISTANT PROFESSOR
PHYSICAL GEOGRAPHY
DEPARTMENT OF EARTH SCIENCE
UTAH VALLEY UNIVERSITY**

OREM, UTAH. The Department of Earth Science at Utah Valley University (UVU) invites applications for a full-time, tenure-track position in Physical Geography, to begin August 2016. The successful candidate will have a Ph.D. in physical geography or a closely related field, as well as a demonstrated commitment to excellence in undergraduate teaching. Expertise in GIS and remote sensing is highly valued by our program. Responsibilities will include teaching introductory and upper division courses in the candidate's area of expertise, as well as engaging in some combination of research, supervision of undergraduate research, activity in professional organizations, continuing education, and service.

UVU is a fast-growing comprehensive state institution with an enrollment of over 30,000 students. UVU values student-centered instruction and provides strong support for undergraduate research. The Department of Earth Science consists of 13 faculty and 2 full time staff members, excellent facilities, and B.S. programs in Geology, Environmental Science & Management, and Earth Science Education. The department's Geography program has expanded with the addition of a new minor, a geography education endorsement, a GIS certificate program, and plans to develop a B.S. in Geography.

UVU is located at the foot of the Wasatch Mountains 40 minutes south of downtown Salt Lake City. The area offers outstanding outdoor recreation opportunities and a vibrant cultural scene including highly acclaimed ballet, symphony and outdoor concert series. For more information, please visit www.uvu.edu/earthscience, contact

Michael Bunds, the Department Chair (michael.bunds@uvu.edu), or Weihong Wang, the Search Committee Chair (weihong.wang@uvu.edu). To apply, please visit <https://www.uvu.jobs/postings/17466>. Applications will be evaluated beginning 12/31/2015. Utah Valley University is an Affirmative Action / Equal Opportunity/ Equal Access Employer.

**LECTURER, DEPARTMENT OF GEOLOGY
AND ENVIRONMENTAL SCIENCE
UNIVERSITY OF PITTSBURGH**

The Department of Geology and Environmental Science at the University of Pittsburgh is seeking qualified applicants for a faculty position at the rank of Lecturer, pending budgetary approval. This position is outside of the tenure stream and is contracted for 3 years, with renewals and promotion expected. The successful candidate will teach a variety of undergraduate courses for a new B.S. major in Environmental Science, ideally including a scientific writing class. The duties associated with this position would include advising Environmental Science and Geology majors, preparation of course materials, and academic program assessment. Additional duties may include, at the option of the successful candidate, developing proposals for undergraduate research, curriculum development, outreach, or attracting underrepresented minorities. The candidate must possess a Ph.D. in Geoscience, Environmental Science, or other related disciplines. Teaching experience is essential. Excellent communication and writing skills are required. The appointment begins in the fall term of 2016.

Applicants should submit a cover letter explaining their qualifications along with their CV, teaching and advising statements, and arrange for 3 letters to be uploaded to: <https://facultysearch.as.pitt.edu/apply/index/MTM0>. For each reference, you will have the opportunity to input a personal email address or an email address generated through Interfolio's Online Application Delivery. In both cases, an email notification will be sent to the designated address with instructions about uploading the letters to our system. To ensure full consideration, applications must be received by January 15, 2016. The University of Pittsburgh is an Affirmative Action, Equal Opportunity Employer. Women, members of minority groups under-represented in academia, veterans, and disabled are especially encouraged to apply.

**FULL TIME, ASSISTANT RESEARCHER
(COLLECTION MANAGER)
KU BIODIVERSITY INSTITUTE**

The KU Biodiversity Institute seeks a full time Assistant Researcher (Collection Manager) to oversee its world-class collections of invertebrate fossils. Required qualifications include master's degree in museum studies, geology, systematics, or paleontology, knowledge of invertebrate fossil taxonomy and identification, knowledge of care and management of natural history collections, and familiarity with biodiversity informatics. For additional information and complete application instructions please visit <https://employment.ku.edu/staff/4566BR>. KU is an EO/AAE. All qualified applicants will receive consideration for employment without regard to race, color, religion, sex (including pregnancy), age, national origin, disability, genetic information or protected Veteran status. Review begins 1 Feb. 2016.

**TWO TENURE-TRACK
ASSISTANT PROFESSOR POSITIONS
IN BASIN-MODELING/SOLID EARTH
GEOPHYSICS AND SEDIMENTOLOGY
KANSAS STATE UNIVERSITY**

The Department of Geology at Kansas State University invites applications for two tenure-track faculty positions at the assistant professor level beginning in August 2016 in the areas of (1) **sedimentology and/or stratigraphy**, (2) **basin-scale modeling or solid earth geophysics**. A detailed advertisement for both positions is located at www.ksu.edu/geology. Screening of applications begins December 21, 2015, and continues until the position is filled. Full consideration will be given to applications received by December 1, 2015. Kansas State University is an EOE of individuals with disabilities and protected veterans. Kansas State University actively seeks diversity among its employees. Background check required.

**TENURE TRACK POSITION
IN HYDROLOGY, SURFACE PROCESSES
INDIANA UNIVERSITY**

The Department of Geological Sciences at Indiana University invites applications for a tenure-track faculty position in hydrology or surface processes at the rank of Assistant Professor. Applicants' areas of research expertise may include, but are not limited to: fluid processes within the critical zone, surface and groundwater flow, catchment-scale hydrology, landscape evolution, physical surface processes on earth and other planets, tectonic geomorphology, computational modeling in any of these fields and the study of their connections to global climate. We seek individuals whose research complements one or more of our strengths in sedimentation and stratigraphy, near-surface processes and environmental geosciences, geophysics and tectonics, geochemistry, and atmospheric sciences. Our departmental research and teaching resources include a premiere Geologic Field Station and the instrumented Willow Creek Watershed in Montana, extensive analytical instrumentation, GIS and remote sensing facilities, coupled with exceptional campus infrastructure for high performance computing, and engagement with the Integrated Program for the Environment. Successful candidates, who must hold a PhD degree by the time of appointment, are expected to develop a strong, collaborative, externally funded program, to supervise research by graduate and undergraduate students, and to teach both undergraduate and graduate courses in their fields of expertise.

Please submit a cover letter, a curriculum vitae, statements of teaching and research interests, the names and email addresses of three individuals willing to provide reference letters, and electronic copies of up to five relevant publications. General inquiries should be addressed to search_geo15@indiana.edu and specific questions should be referred to the Chair of the Search Committee, Professor Simon Brassell (simon@indiana.edu) or sent to Geology, 1001 E. Tenth Street, Bloomington, IN 47405. Applications should be completed online via <http://indiana.peopleadmin.com/postings/1924>. Review of applications will begin November 1, 2015, and continue until the position is filled.

Indiana University is an equal employment and affirmative action employer and a provider of ADA

services. All qualified applicants will receive consideration for employment without regard to age, ethnicity, color, race, religion, sex, sexual orientation or identity, national origin, disability status or protected veteran status.

**MARSHALL-HEAPE CHAIR IN GEOLOGY
TULANE UNIVERSITY**

The Department of Earth and Environmental Sciences at Tulane University invites applications for the newly established Marshall-Heape Chair in Geology. We seek a scholar with an outstanding international reputation who will be appointed at the Full Professor level with tenure. We particularly seek a broad-based Earth scientist who complements current faculty expertise and offers potential for collaborative research. The Marshall-Heape Chair is expected to lead a widely recognized, externally funded research program that will attract PhD-level graduate students and postdoctoral scholars of the highest caliber. Teaching duties are both at the graduate and undergraduate levels. For full consideration, applications should be received by January 10, 2016, but the position will remain open until filled. Applications should include a curriculum vitae, research and teaching statements that articulate how the mission of the department would be enhanced, and the names and contact information of at least three references. Applications must be submitted electronically via the following link: apply.interfolio.com/31900. Any inquiries may be directed to Dr. Torbjörn Törnqvist, Department of Earth and Environmental Sciences, Tulane University, 6823 St. Charles Ave., New Orleans, LA 70118-5698 (tor@tulane.edu). Further information about the department and university can be obtained at <http://tulane.edu/sse/eens>. Tulane University is an EEO/ADA/AA employer.

**TENURE-TRACK FACULTY POSITION
ENERGY GEOSCIENTIST, DEPARTMENT
OF GEOLOGICAL SCIENCES
THE UNIVERSITY OF ALABAMA**

The Department of Geological Sciences at The University of Alabama invites applications for a tenure-track faculty position in energy geoscience, beginning August 2016, to be filled at the assistant professor level. Candidates are invited to apply who have specialties within any field of geoscience pertaining to energy exploration. Scientists with industry experience are encouraged to apply. Candidates must have a strong record of research and must have received a Ph.D. in geology, geophysics, or a related field at the time of appointment. The successful candidate will establish a vigorous, externally funded research program, develop relationships with the energy industry, work closely with the Center for Sedimentary Basin Studies, and attract and advise high-quality graduate students. Teaching responsibilities will include undergraduate and graduate courses in her/his specialty and introductory geology. The department has a broad range of geophysical, geochemical, and computational facilities, in addition to University shared facilities, including the Dauphin Island Sea Lab. Departmental software includes industry standards such as ProMAX, Petrel, TechLog, PetroMod, Move, Petra, Geosoft, ArcGIS, and Matlab. Details regarding existing research programs, equipment and

facilities, and departmental activities are at <http://www.geo.ua.edu>.

Questions should be directed to Dr. Fred Andrus (fandrus@ua.edu). Applicants should go to <http://facultyjobs.ua.edu> to electronically apply for this position. When submitting an application, candidates must provide a cover letter, CV, research and teaching statements, and a list with the contact information for at least three referees. Applications will be reviewed beginning **December 7, 2015**, and will continue until the position is filled. The University of Alabama is an Equal Opportunity Affirmative Action Employer and actively seeks diversity in its employees.

VISITING INSTRUCTOR VISITING ASSISTANT PROFESSOR HYDROGEOLOGY, MIAMI UNIVERSITY

The Department of Geology and Environmental Earth Science at Miami University invites applications for a temporary, full-time faculty position on the Oxford campus, beginning August 2016. This is a nine-month (two academic semesters) appointment that may be renewed for up to four years pending funding availability and satisfactory performance. The primary responsibility of this position is teaching, including foundation courses in physical and environmental geology, and intermediate and upper level courses such as Water & Society and Hydrogeology. An M.S. in geology or a related field is required for appointment as Instructor; a Ph.D. is preferred and is required for appointment as a Visiting Assistant Professor. Submit cover letter, vitae, statement of teaching philosophy and experience, unofficial copy of transcripts, and three letters to reference to <https://miamioh.hiretouch.com/job-details?jobID=1862>. Inquiries can be directed to Cathy Edwards at edwardca@miamioh.edu. Review of applications will begin on January 15, 2016, and continue until position is filled. Miami University, an EO/AA employer encourages applications from minorities, women, protected veterans and individuals with disabilities. Miami does not permit, and takes action to prevent, harassment, discrimination and retaliation. Requests for reasonable accommodations for disabilities should be directed to Ms. Mary Jane Leveline at (513) 529-2027. Annual Security and Fire Safety Report may be found at: <http://www.MiamiOH.edu/campus-safety/annual-report/index.html>. Criminal background check required. All campuses are smoke- and tobacco-free.

THREE ASSISTANT PROFESSOR POSITIONS DEPARTMENT OF GEOLOGY & GEOGRAPHY WEST VIRGINIA UNIVERSITY

The Department of Geology and Geography at West Virginia University seeks to fill three geology faculty positions. Applicants should have a PhD or equivalent degree in geology, earth science or related field by the start date. Review of applications for all positions will begin January 15, 2016 and continue until each position is filled; start date for all positions is August 15, 2016.

Paleobiology: We seek to hire a full-time (9-month), tenure-track Assistant Professor specializing in Paleobiology, which could include expertise in Invertebrate or Vertebrate Paleontology, Micro-paleontology, Paleocology, Paleobotany/Paly-

nology, Ichnology, or related fields. The successful candidate will be expected to develop a vigorous externally-funded research program, teach core undergraduate classes in paleontology, graduate courses in the area of his/her expertise, and mentor graduate and undergraduate students. Candidates should demonstrate potential to establish a strong externally-funded research program, publish in peer-reviewed journals, and excel in teaching at the undergraduate and graduate levels. To apply, please visit jobs.wvu.edu and navigate to the position title listed above. Upload (1) a single PDF file containing a curriculum vitae, statement of research interests, statement of teaching philosophy, and names, titles, and full contact information for 3 references; and (2) PDF files of up to 3 publications. In addition, arrange for 3 letters of reference to be sent to Paleobiology@mail.wvu.edu. For additional information, please see pages.geo.wvu.edu/Paleobiology or contact the search chair, Amy Weislogel, at Paleobiology@mail.wvu.edu or (304) 293-6721.

Quantitative Structural Geology or Geomechanics: We seek to hire a full-time (9-month), tenure-track Assistant Professor specializing in quantitative structural geology with interests in the study of fractured reservoirs and geomechanics. The successful candidate will be expected to develop a vigorous externally-funded research program, teach undergraduate classes in structural geology or geomechanics, teach graduate courses in the area of his/her expertise, and mentor graduate and undergraduate students. Candidates should demonstrate potential to establish a strong externally-funded research program, publish in peer-reviewed journals, and excel in teaching at the undergraduate and graduate levels. To apply, please visit jobs.wvu.edu and navigate to the position title listed above. Upload (1) a single PDF file containing a curriculum vitae, statement of research interests, statement of teaching philosophy, and names, titles, and full contact information for 3 references; and (2) PDF files of up to 3 publications. In addition, arrange for 3 letters of reference to be sent to Geomechanics@mail.wvu.edu. For additional information, please see pages.geo.wvu.edu/Geomechanics or contact the search chair, Dengliang Gao, at Geomechanics@mail.wvu.edu or (304) 293-3310.

Teaching Assistant Professor of Geology: We seek to hire a full-time (9-month), non-tenure track Teaching Assistant Professor. The successful candidate will teach a variety of undergraduate courses, including both large introductory and smaller upper-division classes, in the classroom and online, and the field component of the B.S. capstone course, Geology Field Camp (the last with an additional summer stipend). Specialty area is open. Teaching Assistant Professors at WVU are eligible for promotion; however, promotion to senior ranks is not a requirement for institutional commitment and career stability. This position is a nine-month renewable appointment (no maximum number of terms) and includes full benefits. The position carries an 80% teaching (4 courses per semester) and 20% service assignment. The successful candidate will join a faculty that takes great pride in having members recognized at the university, state, and national levels for excellence in teaching. The

Department occupies the recently renovated Brooks Hall with state-of-the-art teaching technologies and facilities. To apply for this position, interested candidates should visit jobs.wvu.edu and navigate to the position title listed above. Upload a single PDF file containing a curriculum vitae, statement of teaching interests and philosophy, teaching evaluations as available, and full contact information for 3 references. In addition, please arrange for three letters of reference to be sent directly to GeologyTAP@mail.wvu.edu. For additional information, please see pages.geo.wvu.edu/GeologyTAP or contact the search chair, Thomas Kammer, at GeologyTAP@mail.wvu.edu or (304) 293-9663.

WVU is an EEO/Affirmative Action Employer and welcomes applications from all qualified individuals, including minorities, females, individuals with disabilities, and veterans. For additional information about the department visit www.geo.wvu.edu.

LECTURER FACULTY POSITION GEOSCIENCE, MIAMI UNIVERSITY

The Department of Geology and Environmental Earth Science at Miami University invites applications for a full-time Lecturer faculty position on the Oxford campus, beginning August 2016. The Lecturer will teach undergraduate courses, including foundation courses in physical and environmental geology, as well as intermediate level courses; advise undergraduate students; provide professional service to the department and university. Required: M.S. in geoscience by date of appointment and documented teaching experience. Desired: Ph.D. in geoscience with interest in contributing to supervision of undergraduate student research and field-based experiences. Submit cover letter, vitae, statement of teaching philosophy and experience, unofficial copy of transcripts, and names of three (3) referees to <https://miamioh.hiretouch.com/job-details?jobID=1874>. Letters of reference will be requested upon receipt of application. Inquiries can be directed to Cathy Edwards at edwardca@miamioh.edu. Review of applications will begin on January 15, 2016 and continue until position is filled. Miami University, an EO/AA employer encourages applications from minorities, women, protected veterans and individuals with disabilities. Miami does not permit, and takes action to prevent, harassment, discrimination and retaliation. Requests for reasonable accommodations for disabilities should be directed to Ms. Mary Jane Leveline at (513) 529-2027. Annual Security and Fire Safety Report may be found at: <http://www.MiamiOH.edu/campus-safety/annual-report/index.html>. Criminal background check required. All campuses are smoke- and tobacco-free.

TENURE-TRACK ASSISTANT PROFESSOR HYDROGEOLOGY, CALIFORNIA STATE UNIVERSITY, NORTHRIDGE

The Department of Geological Sciences at California State University, Northridge invites applications for a full-time tenure-track faculty position at the level of Assistant Professor in hydrogeology. We offer B.S. and M.S. degrees in Geology and in Geophysics. The successful candidate must have a Ph.D. at the time of appointment. Experience in post-doctoral research

and/or University-level lecture instruction is desirable. We seek an innovative hydrogeologist with technical expertise in one or more of the following fields: subsurface measurement and modeling of groundwater flow, reactive transport modeling, or remote and/or geophysical sensing of groundwater. Research areas may include, but are not limited to, local and regional-scale groundwater dynamics and groundwater quality; the impact of climate change on groundwater recharge, storage and use; water injection and/or withdrawal and induced seismicity; or groundwater transport of contaminants. We particularly seek candidates who both complement our current research program and integrate across sedimentology, stratigraphy and geophysics. The successful candidate is expected to develop a vigorous research program, which includes seeking extramural funding, publishing peer-reviewed papers, and involving undergraduate and M.S. students. Furthermore, the successful candidate is expected to demonstrate teaching excellence and provide effective instruction to students of diverse backgrounds in a multicultural setting. Potential classes to be taught by the new hire include: a new undergraduate core course in Earth Systems, general education courses in water resources and environmental geology and elective offerings at the upper-division and/or graduate level in the candidate's research specialty.

Applicants should submit a cover letter, CV, the names and full contact information for three references, statement of teaching philosophy and experience, and statement of research interests. Electronic submissions are strongly encouraged and should be sent to: geology.hydro.search@csun.edu. Materials can also be sent to: Hydro Search Committee, Department of Geological Sciences, California State University Northridge, 18111 Nordhoff Street, Northridge, CA 91330-8266. Review of applications will begin 1 January 2016. Priority will be given to applications received by this date, but the position remains open until filled. For additional information, see <http://www.csun.edu/geology>. The University is an EO/AA employer.

**ASSISTANT PROFESSOR
OF GEOLOGY AND GEOPHYSICS
MISSOURI UNIVERSITY OF
SCIENCE AND TECHNOLOGY**

The Department of Geosciences and Geological and Petroleum Engineering invites applications for a full-time tenure-track faculty position in Geology and Geophysics at the Assistant Professor level in petroleum geology with expertise in carbonate reservoirs and basin analysis to begin in August, 2016. Review of applications will begin in November and continue until the search is completed. The successful candidate will be expected to develop an externally-funded research program integrated with excellence in teaching at both the graduate and undergraduate levels with a commitment to interdisciplinary work. Teaching responsibilities will include courses as part of degree requirements as well as in the candidate's area of expertise. The Department currently has 20 full-time faculty, and 371 undergraduate and 309 graduate degree-seeking students with established B.S., M.S., and Ph.D. programs in Geology & Geophysics, Petro-

leum Engineering, and Geological Engineering. Closely associated departments include Environmental Engineering and Mining Engineering. Local area establishments with active research include the U.S. Geological Survey (Mid-continent Geospatial Mapping Center), Missouri Department of Natural Resources, Fort Leonard Wood, the Missouri S&T Rock Mechanics and Explosives Research Center, Materials Research Center, and Energy Research and Development Center. Interested applicants should submit a cover letter, a current curriculum vitae, a statement of research and teaching interests and experience, and complete contact information for four references electronically to the Missouri University of Science and Technology's Human Resource Office at <http://hr.mst.edu/careers/academic/>. Applicants should ask for Position Number 00031149 to be included on each reference sent directly to the chair of the search committee, Dr. Wan Yang (yangwa@mst.edu). The final candidate is required to provide copies of official transcript(s) for any college degree(s) listed in application materials submitted, prior to the start of employment. In addition, the final candidate may be required to verify other credentials listed in application materials. Failure to do so may result in the withdrawal of the job offer. All job offers are contingent upon successful completion of a criminal background check. The University of Missouri is an equal access, equal opportunity, affirmative action employer that is fully committed to achieving a diverse faculty and staff. Equal Opportunity is and shall be provided for all employees and applicants for employment on the basis of their demonstrated ability and competence without unlawful discrimination on the basis of their race, color, national origin, ancestry, religion, sex, sexual orientation, gender identity, gender expression, age, genetic information, disability, or protected veteran status.

**GEOCHEMISTRY LAB MANAGER
MIAMI UNIVERSITY**

The Department of Geology and Environmental Earth Science at Miami University invites applications for a Geochemistry Lab Manager. The Lab Manager will be expected to manage new trace metal geochemistry and ICP-OES labs, and to share responsibility for ICP-MS, HPLC and powder XRD labs. Duties will include training and supervision of lab users, laboratory maintenance, data quality assurance, assistance in teaching laboratory-based courses, oversight of radiation and environmental health and safety compliance, and laboratory financial management. Laboratory technique development and adaptation for analysis of diverse geologic and environmental materials expected, with opportunities to pursue research and external funding. Required: M.S. or Ph.D. in geology or related field, at least 4 years of experience in major and trace element analysis of geologic materials by plasma techniques at the time of the appointment, and proven experience in successful training and supervision of geochemistry lab users. Desired: experience in powder XRD and HPLC analysis; expertise in laboratory technique development, computer programming and electrical and mechanical abilities. Submit cover letter, vita and unofficial copy of transcripts to: [https://miamioh.hiretouch.com/](https://miamioh.hiretouch.com/job-details?jobID=1868)

[job-details?jobID=1868](https://miamioh.hiretouch.com/job-details?jobID=1868). Arrange to have three (3) letters of recommendation sent to GeochemistrySearch@miamioh.edu. Screening of applications will begin January 15, 2016, and continue until the position is filled. Miami University, an EO/AA employer encourages applications from minorities, women, protected veterans and individuals with disabilities. Miami does not permit, and takes action to prevent, harassment, discrimination and retaliation. Requests for reasonable accommodations for disabilities should be directed to Ms. Mary Jane Leveline at (513) 529-2027. Annual Security and Fire Safety Report may be found at: <http://www.MiamiOH.edu/campus-safety/annual-report/index.html>. Criminal background check required. All campuses are smoke- and tobacco-free.

**DEPARTMENT CHAIR
TENURE-TRACK ASSISTANT PROFESSOR
AND INSTRUCTOR, DEPARTMENT OF
GEOGRAPHY AND GEOLOGY, THE
UNIVERSITY OF SOUTHERN MISSISSIPPI**

The University of Southern Mississippi invites applicants for (i) a full-time, 12-month, tenure-track administrative faculty position as **department chair**, (ii) a full-time, nine-month, tenure-track faculty position as an **assistant professor of geology**, and (iii) a full-time, nine-month faculty position as an **instructor of geology** in the Department of Geography and Geology in the College of Science and Technology to begin in fall 2016 (July 1 for chair). Research and teaching specializations that are preferred for these positions are purposely broad and include one or more of the following: structural geology, geophysics, environmental geochemistry, mineralogy, petrography/petrology, invertebrate paleontology, stratigraphy, and/or other specialties pertinent to the Gulf Coast region. These positions require colleagues to balance a traditional geological curriculum with courses consistent with the candidates' expertise.

Department Chair (Posting 0003695): Applicants are required to have a Ph.D. in geology or a closely related field from an accredited university with a minimum of 18 hours of graduate coursework in geology or a closely related field. Further, candidates should have professional credentials sufficient to be considered eligible for appointment as a full professor. Expectations for this position include (1) providing leadership and direction in shared governance in areas of goal-setting and assessment, faculty recruitment, hiring, mentoring and tenure/promotion evaluation; (2) providing leadership and guidance to advance the research capabilities and scholarly activities of the department; (3) promoting and participating in an active research agenda within the department; (4) ensuring that academic programs in the department maintain high standards; (5) excellence in instruction of general education, advanced undergraduate, and graduate-level courses in geology; (6) directing the administration of the department; and (7) service to the college, university and greater academic community.

Assistant Professor (Posting 0003736): Applicants are required to have a Ph.D. in geology or a closely related field from an accredited university with a minimum of 18 hours of graduate coursework in geology or a closely related field. Expectations for this position include (1) developing a consistent

and productive externally funded research program that includes graduate and undergraduate students; (2) excellence in instruction of general education, advanced undergraduate and graduate-level courses; and (3) service to the department, college, university and greater academic community.

Instructor (Posting 0003737): Applicants are required to have a master's degree or Ph.D. in geology or a closely related field from an accredited university with a minimum of 18 hours of graduate coursework in geology or a closely related field. Expectations for this position include (1) excellence in instruction of general education and advanced undergraduate courses in geology; (2) advisement services to undergraduate geology students; (3) service to the department, college and university; and (4) public outreach and advocacy for geology in the community.

Applications must be submitted online at <https://jobs.usm.edu>. Required application materials can also be found at this website. Applications must be completed by December 1, 2015, to ensure full consideration for the chairperson position, and December 15, 2015, for the assistant professor and instructor positions. More information about the department can be found at www.usm.edu/geography-geology.

Founded in 1910, The University of Southern Mississippi is a comprehensive doctoral and research-driven university with a proud history and an eye on the future. A dual-campus university, Southern Miss serves students on campuses in Hattiesburg and Long Beach, in addition to five teaching and research sites in Mississippi and through Online at Southern Miss. Since 2006, Southern Miss students have collected seven Goldwater Scholarships, three Truman Scholarships and 14 National Science Foundation Graduate Research Fellowships. Our Center for Undergraduate Research affords our students meaningful research opportunities, and as a proven leader in innovation, we conduct transformative research that translates into real-world solutions. As one of a select number of institutions in the nation accredited in art, dance, music and theatre, we are a haven for creativity and artistic expression. In the classroom or lab, on the playing field, or in the performance hall, we strive to have a positive impact not only on our students, but also the world around us. Further information is found at www.usm.edu.

As an Affirmative Action/Equal Employment Opportunity employer/Americans with Disabilities Act institution, The University of Southern Mississippi encourages minorities, women, veterans and persons with disabilities to apply.

**ASSISTANT PROFESSOR
(ECONOMIC GEOLOGY/MINERALOGY)
SOUTHERN ILLINOIS UNIVERSITY
CARBONDALE**

The Department of Geology at Southern Illinois University Carbondale invites applications for a tenure-track position in economic geology/mineralogy at the assistant professor level, starting August 16, 2016, contingent upon available funding. More information, including qualifications and how to apply is available at <http://affect.siu.edu/faculty.php> (Search COS-351). Application deadline: January 4,

2016, or until filled. SIU Carbondale is an Affirmative Action/Equal Opportunity employer of individuals with disabilities and protected veterans that strives to enhance its ability to develop a diverse faculty and staff and to increase its potential to serve a diverse student population. All applications are welcomed and encouraged and will receive consideration.

**W.B. HAMILTON PROFESSOR
OF EARTH SCIENCES
SOUTHERN METHODIST UNIVERSITY**

Position No. 06029. The Roy M. Huffington Department of Earth Sciences at SMU announces a search to fill a named tenure-track or tenured professorship (the rank is open) honoring WB Hamilton. We solicit nominations and applications from earth scientists who maintain vigorous and sustainable research programs and who have a commitment to full participation in the educational mission of the department to provide professional training in a liberal arts environment. As the fourth holder of the chair established in 1921, the successful candidate will extend existing departmental strengths in earth science. The department's focus is on pure research to understand Earth history and geologic processes with applied research on problems in the national interest such as climate and environmental change, earthquake seismology including induced seismicity, natural hazards, nuclear test ban monitoring and resources including geothermal energy. The expected start date is August 1, 2016.

Applications can be submitted electronically to sschwob@smu.edu or in writing to: Professor John Walther, Search Committee Chair, Department of Earth Sciences, Southern Methodist University, P.O. Box 0395, Dallas TX 75275.

Applicants should include curriculum vitae, statements of research and teaching interests, and contact information for three references. To insure full consideration applications must be received by December 5, 2015, but the committee will continue to accept applications until the position is filled. The committee will notify applicants of its employment decisions after the position is filled.

Southern Methodist University will not discriminate in any program or activity on the basis of race, color, religion, national origin, sex, age, disability, genetic information, veteran status, sexual orientation, or gender identity and expression. The Executive Director for Access and Equity/Title IX Coordinator is designated to handle inquiries regarding nondiscrimination policies and may be reached at the Perkins Administration Building, Room 204, 6425 Boaz Lane, Dallas, TX 75205, 214-768-3601, accessequity@smu.edu.

Hiring is contingent upon the satisfactory completion of a background check.

**JUNIOR LEVEL FACULTY POSITION
SEDIMENTARY BASIN ANALYSIS
DEPARTMENT OF MARINE, EARTH,
AND ATMOSPHERIC SCIENCES
NORTH CAROLINA STATE UNIVERSITY**

The Department of Marine, Earth, and Atmospheric Sciences (MEAS) at North Carolina State University (NC State) intends to fill a junior (Assistant / Associate Professor) tenure-track faculty position

in sedimentary basin analysis. Possible research areas include, but are not limited to, the relationship of basin evolution to mantle processes, linkages of stratigraphy to landscape evolution as a function of tectonics, climate, and sea-level change, the prediction of sub-surface porosity and permeability to model the movement of water and hydrocarbons, and the use of stratigraphy in paleo-environmental and paleobiological studies. The starting date for this position is 15 August 2016. Candidates that combine surface and/or subsurface observations with numerical simulations, analogue models, or laboratory experiments to investigate the geologic history of sedimentary basins are preferred, and applicants should have a strong interest in interdisciplinary collaborations across and beyond the geosciences.

Applicants must hold a Ph.D. degree in the geosciences or a related field. Postdoctoral experience is preferred, but not required. The successful candidate must demonstrate strong potential for outstanding accomplishments in research, research supervision, and teaching. The successful applicant will be expected to teach an undergraduate-level course in stratigraphy, as well as other undergraduate and graduate classes commensurate with the candidate's interest and expertise. An interest in participating in the Department's capstone undergraduate geology field course also is desirable. MEAS places a high value on excellent instruction and the use of innovative teaching methods.

Affiliated with the College of Sciences at NC State, MEAS is one of the largest interdisciplinary geoscience departments in the nation. Opportunities exist for disciplinary and interdisciplinary interactions with more than 30 marine, earth, and atmospheric scientists. Additional information about the department and its facilities can be found on the web page: <http://www.meas.ncsu.edu>.

Review of applications will begin on 15 November 2015; the position will remain open until filled. Applications, including cover letters, curriculum vitae, teaching and research statements, and contact information for three references must be submitted online at <https://jobs.ncsu.edu/>. Please search for position number 00001300.

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Lindahl Ph.D. Scholarships, Department of Geological Sciences, The University of Alabama. The University of Alabama, Department of Geological Sciences seeks highly qualified Ph.D. students with specializations in topics that complement faculty research interests. Exceptional students will receive Research or Teaching Assistantships and a Lindahl Scholarship totaling US\$22,000 for a nine month appointment. The University of Alabama covers the cost of non-resident tuition and fee waivers. Funding is renewable for at least 4 years if expectations are met. Other fellowships are available from the Graduate School on a competitive basis. Further details are at <http://www.geo.ua.edu/>. Applicants should contact Dr. Delores Robinson (dmr@ua.edu) to express interest. Review of applications for Fall 2016 admission will begin January 15, 2016.

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Full announcement and application info. at www.kgs.ku.edu/General/jobs.html. Review will begin January 25, 2016, position open until filled. For further information contact Jim Butler (jbutler@kgs.ku.edu) or Greg Ludvigson (gludvigson@kgs.ku.edu). KU is an EO/AEE, <http://policy.ku.edu/IOA/nondiscrimination>.



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INTRODUCTION

The geoscience workforce in the United States may be facing a critical shortage of trained personnel (Gonzalez and Keane, 2011; NRC, 2013; Mosher et al., 2014; Wilson, 2014a). The National Bureau of Labor Statistics projects a 16% increase in geoscience jobs by 2022. If, as projected, more than half of the present geoscience workforce retires by that time (Wilson, 2014a, 2014b), up to 185,000 new geoscientists will be needed. Graduation rates in U.S. geoscience programs (Wilson, 2014a) are slowly increasing but still lack the capacity to produce such numbers by 2022 (Fig. 1A). The result is a projected shortfall of 135,000 trained geoscientists within the next decade (Wilson, 2014a, 2014b). To meet these growing challenges to our ability to research, assess, and utilize our natural resources in an environmentally responsible manner, we must increase the number of geoscience students.

RECENT PROGRESS

The National Research Council (NRC) and National Science Foundation (NSF) addressed the impending shortage of

geoscientists (NRC, 2013; Mosher et al., 2014) in the context of federal funding and undergraduate education (Fig. 1A). The NRC identified a three-tiered framework, *Awareness, Engagement, and Professional Preparation*, as steps in the process of training the next generation of geoscientists and suggested a “System Approach” to coordination of existing federal funding (NRC, 2013). The NRC called for better connections among Federal agencies, academic institutions, and professional societies to clarify educational and training pathways, as well as the need to collect more and better data on which programs are successful and why, with a focus on critical incident analysis as a means of understanding what brings students into the geosciences.

The recent NSF-supported Summit on the Future of Undergraduate Geoscience Education (Mosher et al., 2014) focused on *Curriculum and Competencies, Pedagogy/Technology, and Underrepresented Groups*. Participants agreed that the next generation of geoscience students needs to approach the field as the applied sum of all sciences (Mosher et al., 2014) and effectively communicate across disciplines as well as with the public. The K–12 Next Generation Science Standards can help develop these skills, but most school districts lack teachers with geoscience training, and most students will never take a K–12 geoscience course (Wilson, 2014a, 2014c; LaDue and Brown Manning, 2015). Of particular concern is how poorly the geosciences have recruited and retained students from underrepresented groups (Fig. 1B; Wilson, 2014a). Workforce data demonstrate that students exposed to K–12 geoscience are more likely to pursue geoscience degrees (Wilson, 2014a). Therefore, expanded opportunities and support for underrepresented students at all levels, as well as expanded opportunities for K–12 teacher training in the geosciences (LaDue and Brown Manning, 2015), are critical to rebuilding the geoscience workforce.

INCREASING CAPACITY

Nearly half of all students receiving a geoscience degree decide to become a geoscientist at some point after their first year of undergraduate education (Wilson, 2014c). Considered in light of the growing numbers of students who enter higher education at two-year colleges, the transition between two-year and four-year institutions is critical to expanding the geoscience student pipeline. Entry-level courses need to highlight the geosciences as a potential career path. These upstream improvements in awareness must include efforts to engage underrepresented students by recruiting them into introductory courses and providing mentorship and research opportunities in pursuit of geoscience degrees.

Undergraduate geoscience student enrollments are increasing (Wilson, 2014a); however, undergraduate and graduate professional training opportunities are relatively stagnant or even

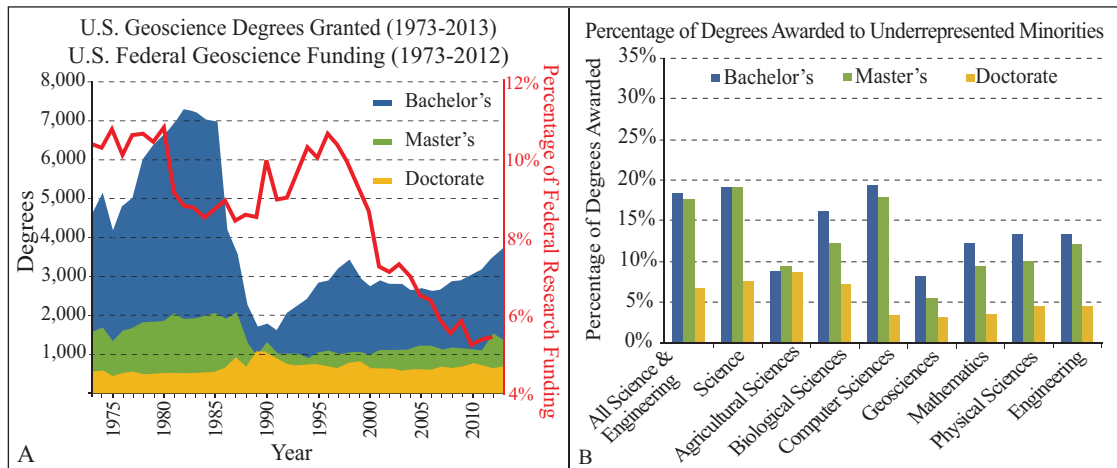


Figure 1. (A) Geoscience degrees granted by year and U.S. federal funding of geoscience as a percentage of total research spending. (B) Percentage of degrees awarded to underrepresented minorities. Data and figures from the American Geosciences Institute (Wilson, 2014a).

contracting. Student numbers in field camps are up nationwide, yet the number of universities offering field camps has declined by 60% since 1995 (Petcovic et al., 2014). Many universities offer anecdotal evidence that the number of applicants to geoscience graduate programs is increasing, yet the number of funded graduate student positions available has not kept pace. The M.S. degree is the “working” degree in the geosciences, but decades ago a trend began to remove M.S. programs to focus exclusively on Ph.D. programs, applying further pressure on the number of funded graduate student positions available. Increases in the number of students entering the upstream end of the geoscientist pipeline must be matched by growth in opportunities for advanced and graduate training downstream in the form of graduate funding, mentorship, and field and research opportunities.

Participation in the process of science (LaDue and Brown Manning, 2015) is critical to training the next generation of geoscientists, and more than half of all geoscience undergraduate students participate in some form of faculty-directed research (Wilson, 2014c). However, the average age of geoscience faculty in the U.S. is 60 years (Wilson, 2014a). As with industry, the lack of younger personnel is threatening the ability to train future students in key disciplines of the geosciences. This problem is exemplified by the looming extinction of paleontology in both academia and industry (Saucier, 2015). We must maintain our ability to train the future geoscience workforce by rebuilding the aging academic workforce.

SELF-IDENTIFICATION & COMPETENCIES

Student specialization, and increased social self-identification with that specialty, often comes increasingly early in academic careers. Students self-identifying as specialists, instead of geoscientists, leads to an increasingly narrow focus of study. Instead of embracing the interrelated facets of geology, early-career students are frequently advised to specialize at the expense of expanding their potential interests in disciplines they may not encounter early on. Furthermore, such specialization limits their core competencies and their ability to cross-train others in the future. Increased student specialization must be matched by mentorship that advocates for multidisciplinary research activities.

Colleges and universities can help bridge the gap between geoscience education and training objectives and end-user competencies by reengaging their alumni. Competency objectives should be driven by the eventual employers of geoscience students

(both public and private), not exclusively by geoscience departments. Academia is just one of the professions in which geologists find employment, and it is critical that we expose students to other voices and perspectives early and often during their education if we are to rebuild the geoscience workforce.

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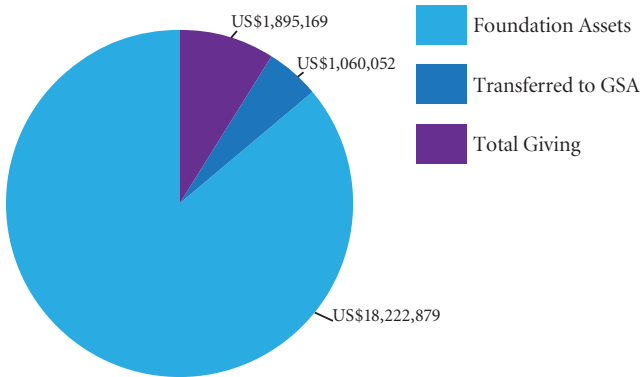
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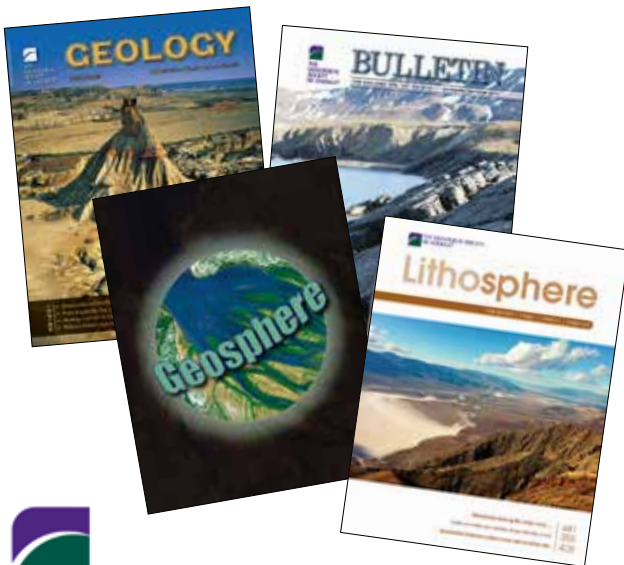
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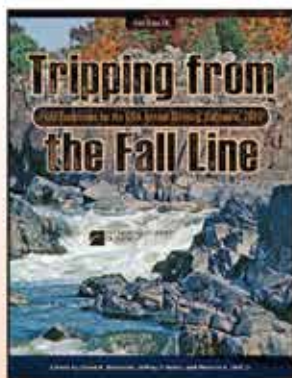
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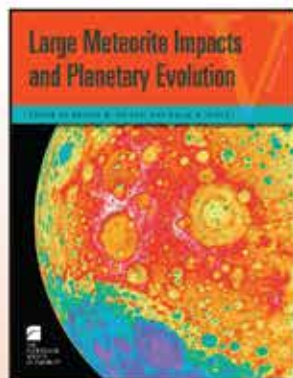
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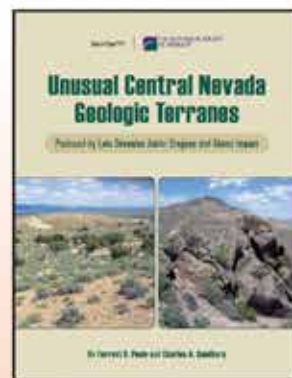
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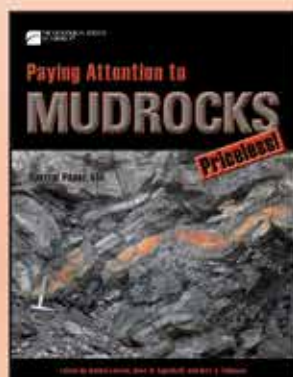
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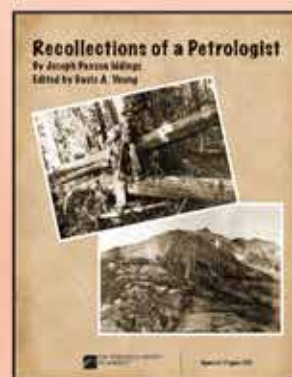
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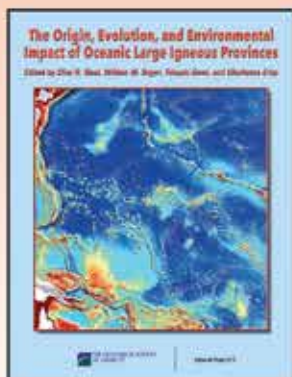
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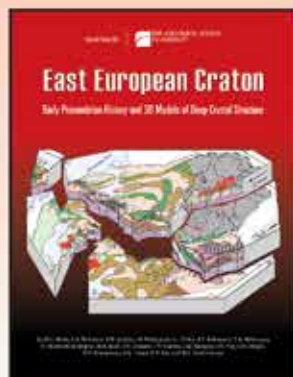
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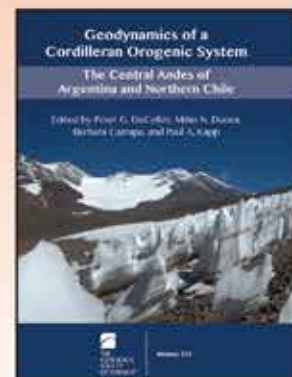
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