

2014 GSA Presidential Address

GSA TODAY

A PUBLICATION OF THE GEOLOGICAL SOCIETY OF AMERICA®

**Mapping the Planets—
Geology Stakes Its Claim**



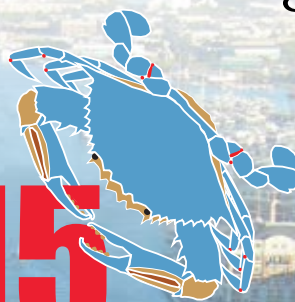
JANUARY 2015 | VOL. 25, NO. 1

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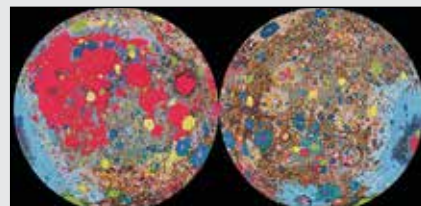
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4 Mapping the Planets—Geology Stakes Its Claim

Harry Y. McSween Jr.

Cover: Geologic maps of the front and back sides of the Moon, produced from the USGS geologic map series by P. Spudis, with permission. See related article, p. 4–9.



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Mapping the Planets—Geology Stakes Its Claim

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ABSTRACT

Planetary geoscience had very little presence in GSA's first century, but it has a long history in GSA publications. Beginning with the Moon, the transformation of the planets and their satellites from astronomical objects into geological worlds has taken place largely by geologic mapping using telescope and spacecraft imagery and by the application of stratigraphic principles to these new data sets. Compositional data from orbital remote sensing, chronological information from crater densities, and the added dimension of petrology and geochemistry from surface rovers and laboratory analyses of samples, where available, have cemented geology's central place in planetary exploration. The present focus on characterizing planetary paleoenvironments and the search for life further buttresses geology's role in planetary exploration and serves as the next step in the expansion of our discipline beyond Earth.

PLANETARY GEOLOGY AND GSA

The inaugural GSA Presidential Address (Stevenson, 1899) ended this way: "The world must advance or retrograde; it cannot stand still." J.J. Stevenson was referring to the world of science, and more specifically to geology. As prescient as he was, the Society's first President might not have imagined that geology would advance to other worlds. At that time, the only body

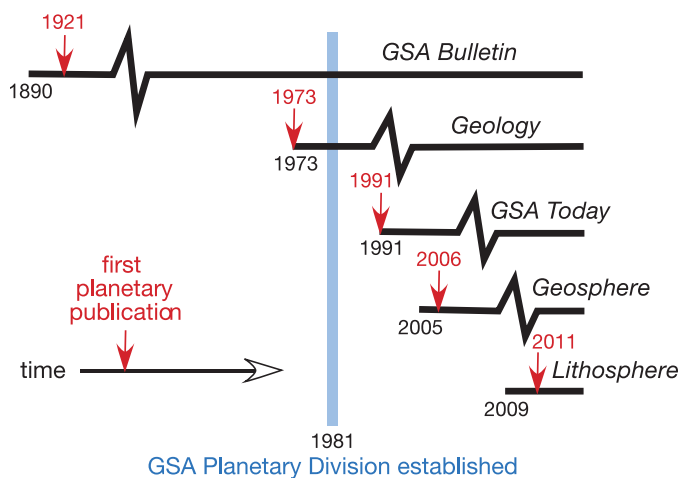


Figure 1. A timeline of GSA publications, comparing dates of establishment and publication of first planetary papers (red arrows), as well as establishment of GSA's Planetary Geology Division.

besides the Moon with features that were resolved through telescopes was Mars, and that planet famously was argued to have canals built by sentient beings. In fact, the better part of a century of GSA history would elapse before the Planetary Geology Division was established in 1981.

Planetary geoscience, though, has had a surprisingly long presence in GSA publications (Fig. 1). *GSA Bulletin* featured what I consider to be its first planetary paper in 1921. Other GSA publications have followed suit: The very first issue of *Geology* contained two planetary papers; *GSA Today* published its first planetary article during its first year, *Geosphere* during its second year, and *Lithosphere* during its third year.

BEGINNING WITH THE MOON

Planetary geology began, appropriately enough, with the geologic mapping of our nearest neighbor. Although cartography from telescopic observations of the Moon had been conducted for more than three centuries, the first lunar geologic map of the region surrounding Copernicus crater (Fig. 2), based on the stratigraphic principles so useful in terrestrial geology, appeared in a landmark study by Shoemaker in 1962. Later that same year, Shoemaker and Hackman (1962) divided the lunar timescale into periods delineated by cataclysmic impacts, with major formations defined as the ejecta blankets of these impact basins (Fig. 3). That was a new twist on time and rock units, but it was respectful of the principle of linking rocks and time and has worked well for heavily cratered planets. Lunar geologic units, as in terrestrial maps, were integrated into a stratigraphic column, and were dated first with relative ages determined from crater-density measurements. Shoemaker recognized the value that geologic maps would have in selecting landing sites for the Apollo program and in extrapolating data from these sites to the rest of the Moon. By 1966, 28 lunar quadrangle maps had been produced from telescopic imagery; subsequent lunar geologic maps and cross sections have been based on observations at higher spatial resolution from orbiting spacecraft. Similar to stratigraphic columns on Earth, which initially had only relative ages until radioactive isotope dating techniques were developed, lunar stratigraphy was relative until crater densities could be calibrated with radiometric ages from volcanic or shock-melted rocks returned by the Apollo astronauts.

EXPLORING PLANETS AND SMALL BODIES

From that beginning, geoscientists have moved forward with the audacious goal of mapping the entire solar system. Interestingly, geologic mapping of the planets has moved in an opposite direction from mapping on Earth. Local maps of our own planet are pieced together to produce regional and eventually global maps. On the other hand, planetary explorers have had a

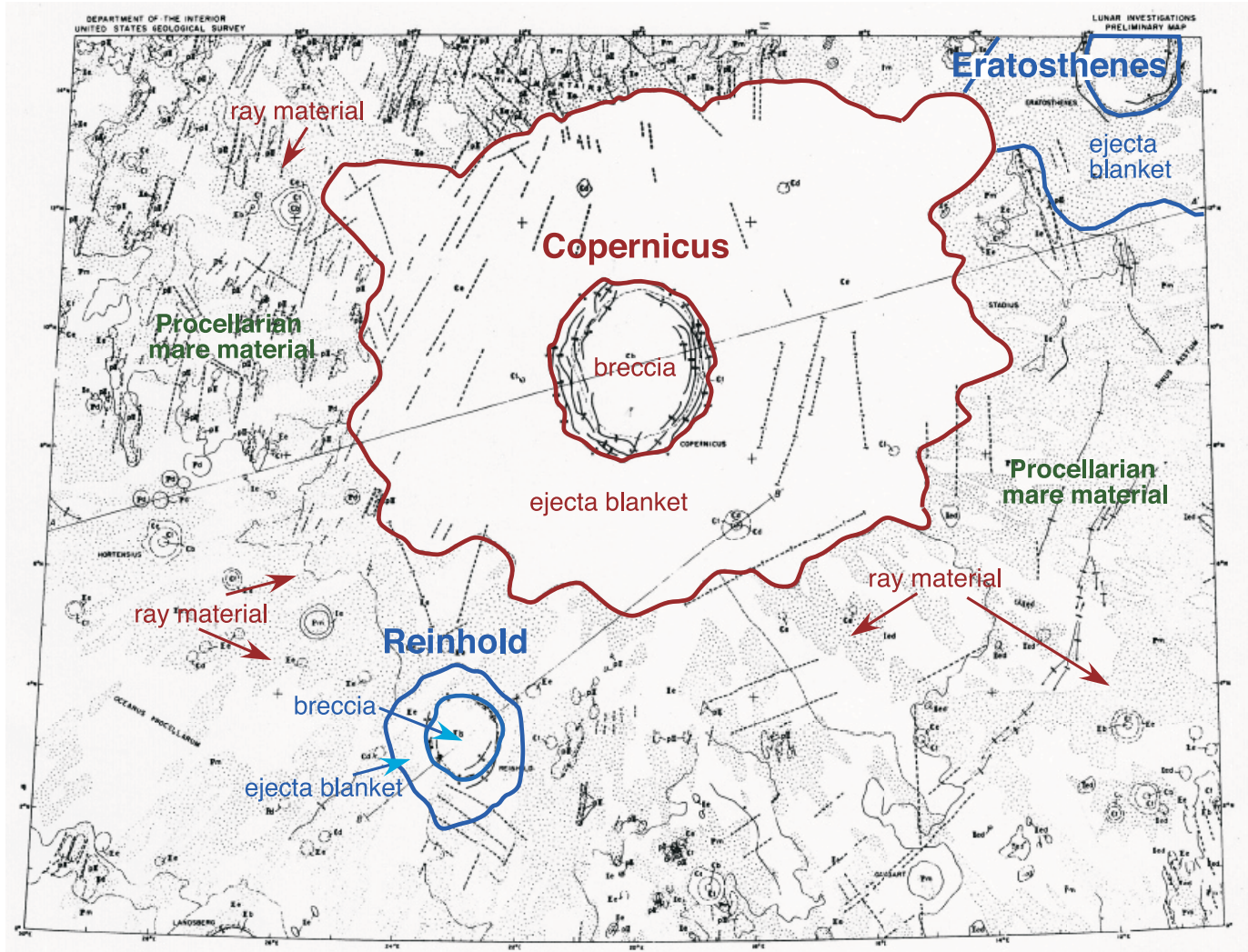


Figure 2. The earliest lunar geologic map based on stratigraphic principles (Shoemaker, 1962), shown without the legend or cross sections. This map of the Copernicus region was originally published in black and white; colorized unit contacts and labels have been added for legibility.

global perspective from the outset, and their maps progress downward to regional and local scales as spatial resolution improves.

Geologic mapping of the planets (see Carr, 2013, for a recent historical review) nowadays still depends on imagery but has been augmented by the application of remote-sensing tools. The identification of minerals from their visible, near-infrared, and thermal infrared spectra provides a means of mapping compositional units on the Moon, Mars, and Mercury. Spectroscopy can often identify only a few minerals with diagnostic absorption or emission features, and then only if they are sufficiently abundant, but adding any mineralogic information to maps allows much more rigorous interpretation. Even from orbital altitudes, the spatial resolution of spectral maps can be as small as a few tens of meters, although coarser resolutions are more common. For example, the CRISM spectrometer on the Mars Reconnaissance Orbiter has distinguished and mapped concentrations of olivine and phyllosilicates. Orbital tools for geochemical analysis are also available. Gamma-ray and neutron spectroscopy measures only a handful of elements at fairly coarse spatial resolution, but any chemical abundances are useful in distinguishing and interpreting geologic units. A prime example is a global map of compositional terranes

on the Moon (Jolliff et al., 2000) based only on iron and thorium abundances obtained by the orbiting Lunar Prospector (Fig. 4). Gamma-ray spectra are especially sensitive to these two elements, and their concentrations vary greatly in different lunar lithologies.

Other planetary bodies present different challenges. The surfaces of Venus and Titan (a moon of Saturn) are obscured by thick clouds. However, they have been imaged using radar, allowing the mapping of geologic units based on their topography and radar reflectivity.

Mapping is not restricted only to large planets. Geologic maps have been compiled for all the satellites imaged by orbiting or flyby spacecraft. Moons of the giant planets show remarkably complex geologic units, comprised of jumbled blocks of icy crust (Europa), crosscutting tectonic features and superposed impact ejecta (Ganymede), erupting volcanoes with associated pyroclastic deposits of compositionally exotic materials (Io), and lakes of liquid methane (Titan). Even smaller bodies—asteroids and comet nuclei—have been mapped where spacecraft imagery is available. The most recent example is a geologic map of asteroid 4 Vesta (Williams et al., 2014), assembled from images and spectra obtained by the *Dawn* orbiter (Fig. 5).

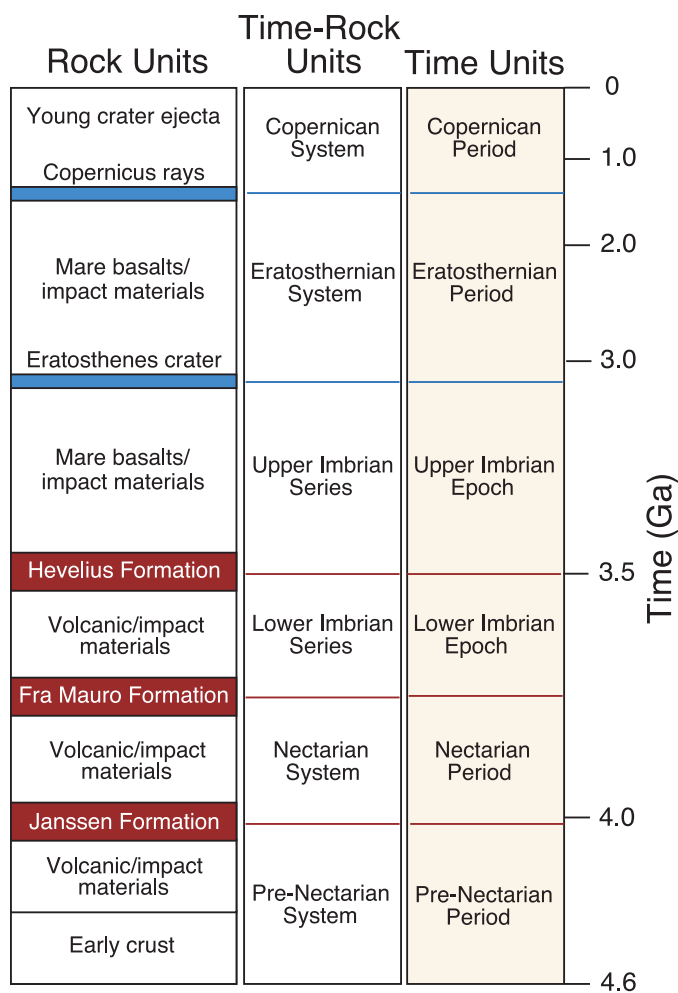


Figure 3. The lunar time-stratigraphic system, with major time units defined by widespread formations produced as ejecta blankets from large impact basins. Adapted from Wilhelms (1987).

SURFACE GEOLOGY AT HUMAN SCALE

Once a planetary body has been mapped from orbit, the next logical step is landing on its surface. The recent operation of mechanical rovers on Mars has allowed high-resolution geologic mapping at scales with which field geologists can readily identify. The traverse maps made by Mars rovers resemble those compiled from observations of the Apollo astronauts on the Moon, but rovers have extended their traverses much farther. Images and remote sensing data from *Spirit*, *Opportunity*, and *Curiosity* provide the basis for surface outcrop maps. An example is *Spirit's* 7.7-km, 6-year traverse map through the Columbia Hills in Gusev crater (Crumpler et al., 2011), reproduced in part in Figure 6. Identifications of rock types analyzed by the rover have been extended farther afield using spectrometers that can “see” for tens of meters, making the traverse map more representative. Mars surface mapping has also been supplemented with detailed stratigraphic context from the mapped and analyzed walls of impact craters, such as the Burns Formation section in Endurance crater analyzed by *Opportunity* (Fig. 7) (Grotzinger et al., 2005). Spectroscopic analyses of chemistry and mineralogy, and spatial

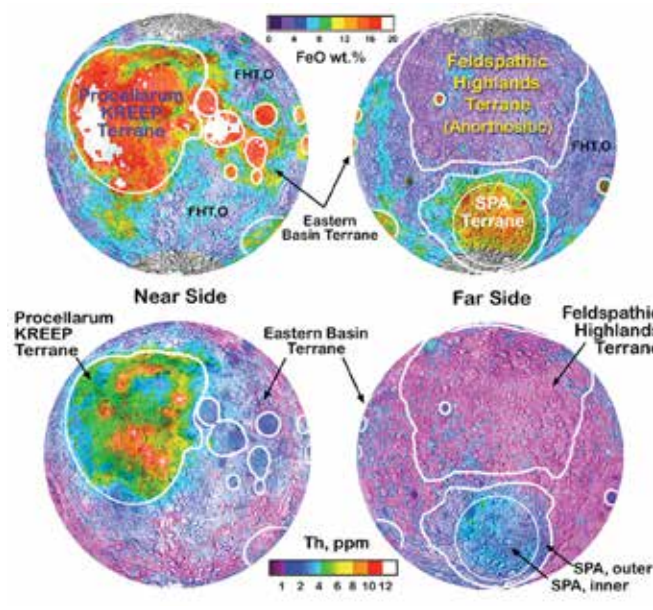


Figure 4. Global lunar maps of compositional terranes, based solely on orbital measurements of iron and thorium by Lunar Prospector. Modified from Jolliff et al. (2006).

context and textural analyses from panoramic and microscopic imagers, of the bedded rocks encountered provide sufficient information to make detailed interpretations of geologic processes and histories. These rovers have become virtual field geologists, allowing their science teams to project human observational and mapping skills onto the surface of Mars. The rovers have become so anthropomorphic that *Sojourner*, the first primitive rover on the Mars Pathfinder mission, was named a GSA Honorary Fellow in 1997. And *Spirit*, *Opportunity*, and *Curiosity* have refined the melding of humans, machines, and instruments to the point where planetary geologic mapping can arguably be done as well or better (albeit more slowly) by rovers than by astronauts.

PLANETARY SAMPLES

The return of lunar samples to Earth and the identification of meteorites from the Moon, Mars, and asteroid Vesta have also provided valuable ground truth for spacecraft remote sensing and better geologic interpretations of these data. For example, lithologic interpretation of lunar compositional terranes from their thorium and iron abundances (shown previously in Fig. 4) required comparison with laboratory measurements of those elements in Apollo rocks (Jolliff et al., 2000). Interpretation of the unexpected discovery of hydrogen in Vesta’s regolith (Fig. 8) using neutron absorption measurements by the *Dawn* spacecraft (Prettyman et al., 2012) was made possible because some meteorite breccias from Vesta contain water-bearing chondrite clasts. Comparisons of laboratory geochemical analyses of geologically young martian basaltic meteorites with rover and orbiter analyses of older volcanic rocks on the ground (Fig. 9) have provided new insights into the evolution of martian magmatism through time (McSween et al., 2009). Although the specific locations from which meteorites were extracted from their parent bodies is not known, the ability to perform petrologic and geochemical

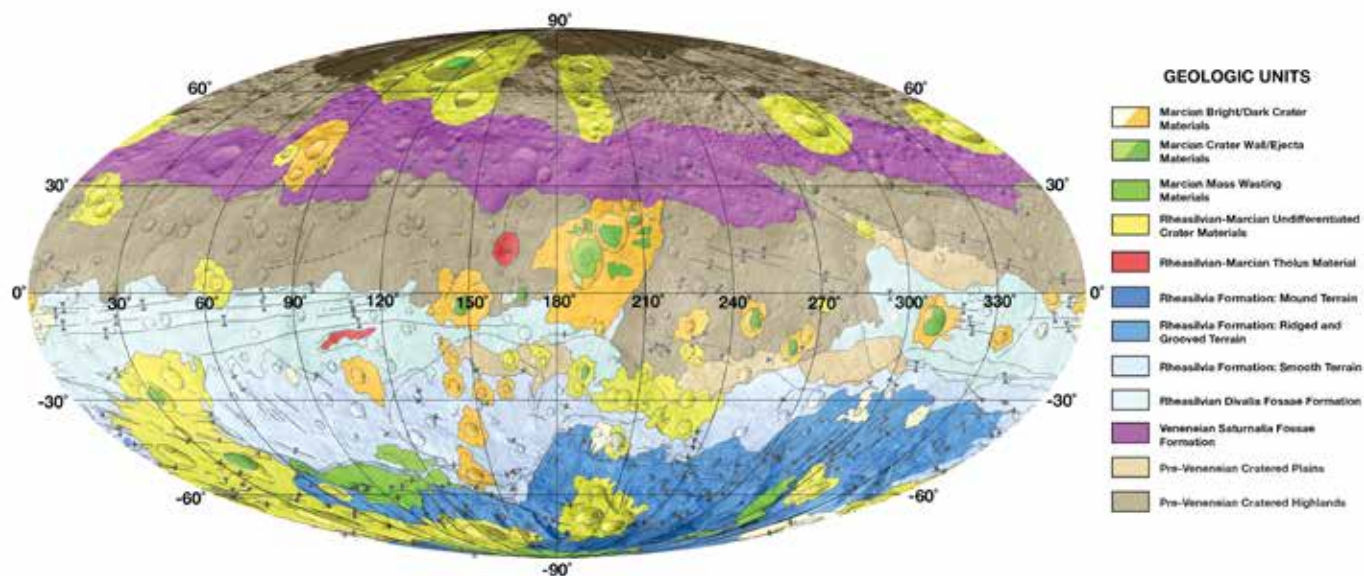


Figure 5. Geologic map of Vesta, the second-most massive asteroid, based on data from the *Dawn* orbiter. Modified from Williams et al. (2014).

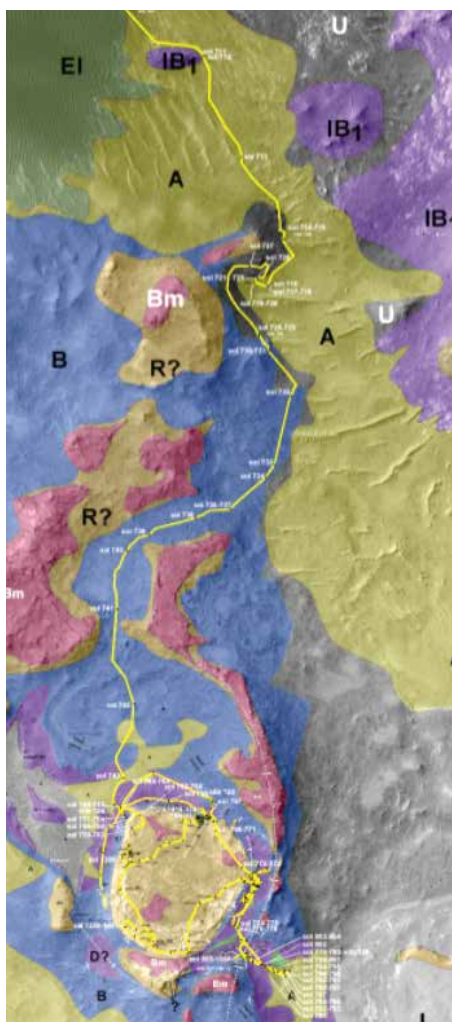


Figure 6. A portion of a geologic traverse map through the Columbia Hills in Gusev crater. The yellow line marks the route of the *Spirit* rover. For a larger version with a key of geologic units, see Crumpler et al. (2011).

analyses on rocks in the laboratory, not to mention the geochronology provided by analyses of radiogenic isotopes, strengthens the characterizations of mapped geologic units and the interpretations of geologic history.

WHAT PLANETARY GEOSCIENCE HAS WROUGHT

The geologic exploration of planetary bodies, along with the analysis of extraterrestrial samples, has demonstrated that the tried-and-true tools and methods of geology can be exported to other worlds. Like Earth, our planetary neighbors are geologic experiments conducted at a grand scale, but carried out with different starting compositions and under different physical conditions. From the study of other bodies, we can test the generality of the geologic processes we have worked so hard to understand on our own planet. And in some cases, we gain fundamentally new insights. A few examples are

- The early terrestrial planets, including Earth, had magma oceans, formed by heat from the decay of short-lived radionuclides and collisions with other bodies. Global-scale melting had profound implications for the differentiation into cores, mantles, and crusts, and for the geochemical partitioning of elements required by modern industries that fuel the world's economies.
- Plate tectonics dominates terrestrial geology, but Earth's moving plates are unique among solar system bodies. One-plate planets lose their internal heat in novel ways, and stagnant-lid tectonics allows a bewildering array of geologic structures.
- Magmatism on Earth occurs mostly at plate boundaries, so melting mechanisms on other planets are different. Basalts, albeit with distinctive compositions, are ubiquitous on all rocky bodies, but the pathways and extents of magma evolution differ, making granitic rocks virtually unrepresented outside our own planet.
- Impact cratering is the most significant geomorphic process on other planets and must have been on the early Earth as well.



Figure 7. False-color image of the walls of Endurance crater, Mars, imaged by the *Opportunity* rover. Interpreted stratigraphic column modified from Grotzinger et al. (2005).

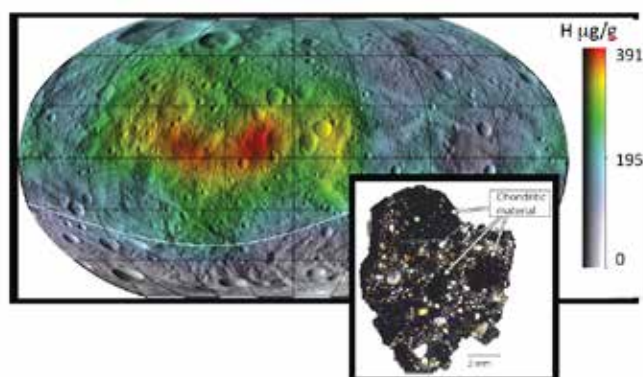


Figure 8. Global map of hydrogen on asteroid Vesta, based on neutron absorption measurements by the *Dawn* spacecraft. Also shown is a photomicrograph of a Vestan meteorite breccia containing dark, hydrous chondritic clasts. Map adapted from Prettyman et al. (2012).

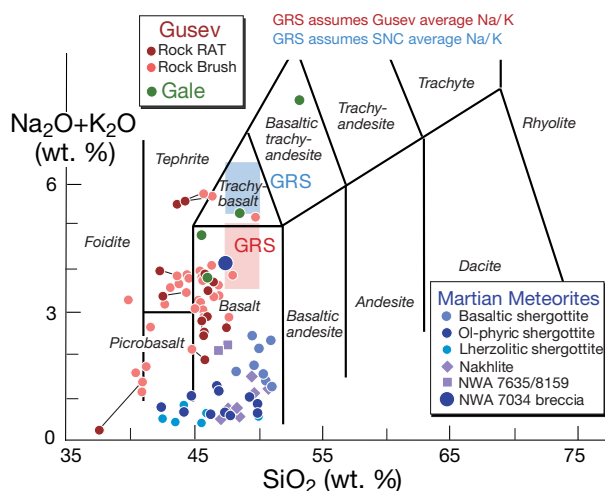


Figure 9. Geochemical classification diagram for volcanic rocks on Mars, showing the compositions of martian meteorites, Gusev and Gale crater rocks analyzed by the *Spirit* and *Curiosity* rovers, respectively, and orbital analyses by the Mars Odyssey gamma-ray spectrometer (colored rectangles labeled GRS). GRS does not measure sodium, so its abundance was estimated from Na/K ratios in Gusev rocks or martian (SNC) meteorites. Gusev rocks were either brushed or ground (RAT) by the Rock Abrasion Tool before analysis. Adapted from McSween et al. (2009), with additional data.

Large impacts have had disastrous consequences on life, and unraveling this history has prompted the realization that modern humans still live in the fast lane.

- Among the terrestrial planets, only the lithospheres of Earth and Mars have interacted with a hydrosphere. Other planetary surfaces are covered by impact-comminuted regolith.
- Active or past sedimentary processes, once thought to be unique to Earth, are now known on Mars, which hosts both clastic rocks and evaporates, and on Titan, where fluids other than water produce and distribute sediments.

As an aside, it is worth mentioning that all of geology benefits from the interest that the public displays for planetary exploration, where the application of geologic principles is played out on a large stage. It helps recruit the next generation of earth scientists and provides new data sets for our own planet. Terrestrial processes at a planetary scale can sometimes be better visualized or monitored from orbit.

WHAT THE FUTURE MAY HOLD

The reconnaissance phase of solar system exploration is well along, but geologic understanding of most planets has only

scratched the surface. Science by spacecraft is complex and expensive, and large, multidisciplinary (often international) teams of scientists and engineers have to work together seamlessly. Mission operations can last for decades, requiring several generations of investigators. This can be a new experience for geoscientists used to working in isolation and on projects of limited duration.

Understandably, an important goal for planetary exploration is the search for extraterrestrial life. Efforts so far have focused on recognizing paleoenvironments that might have been conducive to organisms. The methods used by terrestrial paleontologists to study the distribution and evolution of organisms have not yet found application on other worlds. But life's signals, especially of primitive life forms far removed from us in time, may be more readily recognized by geochemistry or biomarkers than in

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physical forms. Robotic explorers increasingly carry instruments capable of identifying the organic or isotopic tracers of life, while at the same time examining rocks for microscopic indications of fossilized material.

And what of the newly recognized additions to the solar system's retinue of planets, now being found in the frigid regions beyond Pluto, and the bonanza of extrasolar planets (~1800 at last count) that have been discovered orbiting other stars? At present, any information about these bodies is extremely limited, but as more data accrue, geological reasoning will be needed for meaningful interpretation.

This is an opportunistic time for geoscientists—astronomy has basically abdicated much of the solar system to geology. Planets and smaller bodies are no longer astronomical points of light, but are increasingly recognized as worlds shaped by more or less familiar geologic processes. This shift of a substantial quantity of scientific real estate has literally redefined the reach of our discipline. Geology has staked its claim on the planets and must play the central role in exploring this frontier.

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New Publication Calendar for *GSA Today*

GSA Today is published 11 times per year, and this won't change. What will change is that the March issue will now be combined with April, and we will have an independent May issue (instead of March). So look for your first dedicated Annual Meeting issue in May.

The image shows the cover of the March issue of *GSA Today*, titled "Geoscientists' perceptions of the value of undergraduate field education" by GSA Member Appreciation Issue. Next to it is a 2015 calendar. The calendar shows that the March and April issues are combined into a single issue, with the combined issue starting in March and ending in April. The calendar also shows the regular 11 issues per year schedule for the rest of the year.

As always, *GSA Today* is open-access online at www.geosociety.org/gsatoday/.

GSA Today Science Editor Changes



R. Damian Nance completed his term of service as *GSA Today* science editor in December 2014. Nance is Distinguished Professor of Geological Sciences at Ohio University, where he has taught since 1980. In 1982, Nance, along with fellow department member Tom Worsley, proposed the supercontinent cycle, the now-substantiated theory that Earth's geologic, climatic, and biological evolution has been dominated by the episodic assembly and breakup of supercontinents.



Incoming science editor **Gerald (Jerry) Dickens** is a professor in the Department of Earth Science at Rice University. His research interests range from Cenozoic climate change to marine methane cycling, mixed siliciclastic-carbonate margins, and sediment-hosted ore deposits. He previously was chief editor of AGU's *Paleoceanography*.



Steven J. Whitmeyer, associate professor of structural geology and tectonics at James Madison University, remains onboard through December 2018. He is primarily interested in tectonic evolution through time and uses structural and geospatial analyses to develop and visualize tectonic reconstructions. He has co-edited two GSA Special Papers (*Google Earth and Virtual Visualizations in Geoscience Education and Research* and *Field Geology Education: Historical Perspectives and Modern Approaches*) and one GSA Field Guide (*The Mid-Atlantic Shore to the Appalachian Highlands: Field Trip Guidebook for the 2010 Joint Meeting of the Northeastern and Southeastern GSA Sections*). Learn more at www.jmu.edu/geology/people/whitmesj.html.



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Go green or preserve tradition—the choice is yours!

GSA Education & Outreach Programs

Application deadline for GeoCorps™ America & Mosaics in Science:

3 Feb. 2015



GeoCorps™ America—Summer 2015

GSA is now accepting applications for paid geoscience opportunities on public lands managed by the National Park Service, the U.S. Forest Service, and the Bureau of Land Management. All levels of geoscientists—students, educators, professionals, retirees, and others—are encouraged to apply. Learn more at www.geosociety.org/geocorps and www.facebook.com/GeoCorps.

Mosaics in Science—Summer 2015

GSA is now accepting applications for paid STEM (science, technology, engineering, and math) opportunities in National Parks throughout the United States. The goal of the Mosaics program is to increase the level of diversity among those who seek STEM careers within the National Park Service. Learn more at www.geosociety.org/mosaics.



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2015 Section Meetings

Mentor Programs

Plan now to attend a Roy J. Shlemon Mentor Program in Applied Geoscience and/or a John Mann Mentors in Applied Hydrogeology Program luncheon at your 2015 Section Meeting to receive career advice and chat one-on-one with practicing geoscientists. FREE lunches will be served!

If you have questions or want to serve as a mentor, go to www.geosociety.org/Sections/meetings.htm or contact Jennifer Nocerino, jnocerino@geosociety.org.

Career Planning

Wondering how to start your career planning process or what employment sector is the best fit for you? Does your résumé need some updating? Take advantage of our three one-hour career workshops, which will run at each Section Meeting.

On To the Future

Will the 2015 GSA Annual Meeting (GSA 2015) be the first one you attend? Are you a student from an underrepresented group within the geosciences? If so, come by the GSA Foundation booth during your Section Meeting welcome reception to get more information about GSA's On To the Future program and how we can help you get to GSA 2015.



Annual Meeting & Exposition

GSA 2014



19-22 October | Vancouver, BC, Canada

WRAP-UP

Thank you to everyone who participated in GSA 2014 in Vancouver, British Columbia, Canada. We extend a special thanks to our Organizing Committee and Joint Technical Program Committee.

Host University: **Simon Fraser University**

General Co-Chairs: **James MacEachern** and **Glyn Williams-Jones**

Technical Program Co-Chairs: **Patrick Burkhart** and **Kevin Mickus**

Field Trip Co-Chairs: **Shahin Dashtgard** and **Brent Ward**

Student Committee: **Oliver Friesen**, **Patty Hayduk**, **Carly Smythe**, **Allison Westin**, and **Joshua Wiebe**

2014 GSA Joint Technical Program Committee:
community.geosociety.org/gsa2014/science/sessions/discipline

GSA 2014 BY THE NUMBERS

Attendees: 6,680	Professional presenters: 2,674
Countries represented: 52	Student presenters: 1,813
Students: 2,556	Field Trips: 15
OTF Scholars: 125	Short Courses: 32
Abstracts accepted: 4,487	Exhibit Booths: 262
Technical Sessions: 346	

We look forward to seeing you at GSA 2015 on 1–4 Nov. in Baltimore, Maryland, USA. Remember, you make the meeting—and you still have time to propose a technical session or short course; learn more at www.geosociety.org/meetings/2015/.

- **Session proposal deadline:** 1 February
- **Short Course proposal deadline:** 2 February

1-4 NOVEMBER

GSA 2015

Baltimore, Maryland, USA



Thank You Sponsors!

Your support of GSA's 2014 Annual Meeting & Exposition in Vancouver, British Columbia, Canada, continues a tradition of more than 125 years of serving science and the profession. The Society appreciates your investment in the growth of current and future leaders in the geoscience community.

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Upcoming Award, Recognition & Grant Deadlines



For details on the following awards and grants, see the October *GSA Today* or go to www.geosociety.org/awards/nominations.htm. Information and nomination forms can also be obtained from GSA Grants and Awards, P.O. Box 9140, 3300 Penrose Place, Boulder, CO 80301-9140, USA, +1-303-357-1028, awards@geosociety.org.

2015 GSA Medals and Awards

- Penrose Medal
- Day Medal
- Young Scientist Award (Donath Medal)
- GSA Public Service Award
- Bromery Award for Minorities
- GSA Distinguished Service Award
- Doris M. Curtis Outstanding Woman in Science Award
- Geologic Mapping Award
- Honorary Fellow

Nomination deadline: 1 Feb. 2015.

GSA Fellowship

Elevation to GSA Fellowship is an honor bestowed on the best of our profession at each spring GSA Council meeting. **GSA Fellows** may support two nominees each year but only **one** as a primary nominator, and **GSA members** who are not Fellows may be secondary nominators for up to **two** nominees. **Nomination deadline:** 1 Feb. 2015.

AGI Medal in Memory of Ian Campbell

The AGI Medal in Memory of Ian Campbell recognizes singular performance in and contribution to the profession of geology. To submit a nomination, go to www.agiweb.org/direct/awards.html. **Nomination deadline:** 1 Feb. 2015.

AGI Marcus Milling Legendary Geoscientist Medal

The Marcus Milling Legendary Geoscientist Medal is given to a recipient with consistent contributions of high-quality scientific achievements and service to the Earth sciences having lasting, historic value; who has been recognized for accomplishments in field(s) of expertise by professional societies, universities, or other organizations; and is a senior scientist nearing completion or has completed full-time regular employment. To submit a nomination, go to www.agiweb.org/direct/awards.html. **Nomination deadline:** 1 Feb. 2015.

2015 National Awards

- **William T. Pecora Award:** <http://remotesensing.usgs.gov/pecora.php>.
- **National Medal of Science:** www.nsf.gov/od/nms/medal.jsp.
- **Vannevar Bush Award:** www.nsf.gov/nsb/awards/bush.jsp.
- **Alan T. Waterman Award:** www.nsf.gov/od/waterman/waterman.jsp.
- **G.K. Warren Prize:** www.nasonline.org/site/PageServer?pagename=AWARDS_warren.

Nomination deadlines vary.

John C. Frye Environmental Geology Award

In cooperation with the Association of American State Geologists and supported by endowment income from the GSA Foundation's John C. Frye Memorial Fund, GSA makes an annual award for the best paper on environmental geology published either by GSA or by a state geological survey. **Nomination deadline:** 31 March 2015.

2015 Post-Doctoral Research Awards

The following post-doc research awards are available. Learn more at www.geosociety.org/grants/postdoc.htm. **Application deadline:** 1 Feb. 2015.

- 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.

2015 Student Research Grants

Submission deadline: 2 February 2015 at 5 p.m. MST

GSA is proud to offer research grants to its highly qualified student members. The primary role of the GSA research grants program is to provide partial support of master's and doctoral thesis research in the geological sciences for graduate students enrolled in universities in the United States, Canada, Mexico, and Central America. In 2014, US\$683,535 was awarded to 401 graduate students (52% of the 774 who applied), with an average grant of US\$1,680.

Students may receive a total of two GSA graduate student grants in their entire academic career, regardless of what program they are currently enrolled in. The maximum award per grant is US\$2,500.

The GSA student research grant application process is available online only at www.geosociety.org/grants/gradgrants.htm; no paper applications or letters will be accepted.



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For further information, call +1-303-357-1028, or e-mail awards@geosociety.org.

Get into the Field with GSA & ExxonMobil

FIELD CAMP SCHOLAR AWARD

Who should apply? Undergraduate students.

Deadline to apply: 17 April

This year's field award will provide US\$2,000 each to 20 undergraduate students so they can attend the summer field camp of their choice. These scholarships are based on diversity, economic/financial need, and merit.

BIGHORN BASIN FIELD AWARD

Who should apply? Undergraduate and graduate students and faculty.

Deadline to apply: 17 April

Camp dates: 2–9 August

This award covers all costs for selected students and faculty to take part in a week-long field seminar in the Bighorn Basin

of north-central Wyoming that emphasizes multidisciplinary integrated basin analysis.

FIELD CAMP EXCELLENCE AWARD

Who should apply? Anyone, but the award must be used toward field camp operations.

Deadline to apply: 17 April

One field camp instructor/director will receive an award of US\$10,000 to assist with his or her summer field season. This award will be based on safety awareness, diversity, and technical excellence.

Questions? Contact Jennifer Nocerino, jnocerino@geosociety.org, +1-303-357-1036.



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<https://rock.geosociety.org/eo>

CALL FOR NOMINATIONS

GSA DIVISION AWARDS

■ COAL GEOLOGY

Gilbert H. Cady Award

Nominations due 28 Feb. 2015

Submit nominations to Mark Engle at mercurous@gmail.com.

This award, first presented in 1973, recognizes outstanding contributions in the field of coal geology that advance the science both within and outside of North America. For more information, go to www.uky.edu/KGS/coal/GSA/awards.htm.

■ ENVIRONMENTAL AND ENGINEERING GEOLOGY

E.B. Burwell, Jr. Award

Nominations due 1 Feb. 2015

Submit nominations to Dennis Staley at dstaley@usgs.gov.

Established in 1968, this award honors the memory of one of the Division's founding members who was also the first chief geologist of the U.S. Army Corps of Engineers. It is intended to recognize an author or authors of a published paper of distinction that advances knowledge concerning principles or practice of engineering geology, or of related fields of applied soil or rock mechanics where the role of geology is emphasized. The paper must (1) deal with engineering geology or a closely related field, and (2) have been published no more than five years prior to its selection. There are no restrictions on the publisher or publishing agency of the paper. For more information, go to <http://rock.geosociety.org/egd/Awards.html#Burwell>.

Richard H. Jahns Distinguished Lecturer

Nominations due 28 Feb. 2015

Submit nominations to Matt Crawford at mcrawford@uky.edu.

This lectureship was established in 1988 by the Division in conjunction with the Assoc. of Environmental & Engineering Geologists to commemorate Jahns and to promote student awareness of engineering geology through an annual series of lectures at academic institutions. The award is given to an individual who through research or practice has made outstanding contributions to the advancement of environmental and/or engineering geology. The awardee will speak on topics of earth processes and the consequences of human interaction with these processes or the application of geology to environmental and/or engineering works. Award funds are administered by the GSA Foundation. For more information, go to <http://rock.geosociety.org/egd/Awards.html#Jahns>.

■ GEOPHYSICS

George P. Woollard Award

Nominations due 15 Feb. 2015

Submit nominations via e-mail attachment to Samantha Hansen at shansen@geo.ua.edu.

This award recognizes outstanding contributions to geology through the application of the principles and techniques of geophysics. A highlight of the presentation is the honorary George P. Woollard Technical Lecture by the recipient before the award ceremony. To submit a nomination, all you need is a name, contact information, and a short summary of the nominee's qualifications, including his or her specific work or outcomes and how these have contributed to geology. The nominee's CV is helpful but not required. Award funds are administered by the GSA Foundation. For more information, go to www.geosociety.org/divisions/geop/Awards.htm.

■ GEOSCIENCE EDUCATION

Biggs Award for Excellence in Earth Science Teaching

Nominations due 15 Feb. 2015

Submit nominations at <http://community.geosociety.org/gedivision/news/awards/biggsaward>. Any questions should be directed to geoedgsa@gmail.com.

This award recognizes innovative and effective teaching in college-level earth science. Earth-science instructors and faculty members from any academic institution engaged in undergraduate education who have been teaching full-time for 10 years or fewer are eligible (part-time teaching is not counted in this requirement). Both peer- and self-nominations will be accepted. This award, administered by the GSA Foundation, is made possible by support from the Donald and Carolyn Biggs Fund, the GSA Geoscience Education Division, and GSA's Education and Outreach Program. An additional travel reimbursement is also available to the recipient to enable him or her to attend the award presentation at the GSA Annual Meeting. For more information, go to <http://community.geosociety.org/gedivision/news/awards/biggsaward>.

■ HISTORY AND PHILOSOPHY OF GEOLOGY

Mary C. Rabbitt History and Philosophy of Geology Award

Nominations due 1 Feb. 2015

Submit nominations to Kathleen Lohff at kathylohff@msn.com.

This award recognizes exceptional scholarly contributions of fundamental importance to the understanding of the history and philosophy of the geological sciences. Achievements deserving of the award include, but may not be limited to, publication of papers or books that contribute new and profound insights into the history of geology based on original research or a synthesis of existing knowledge. Neither the nominator nor the nominee need be a member of the Division or of GSA, nor are nominees restricted to faculty in geoscience departments. The award was established in 1981 and renamed in 2005 in memory of Mary C. Rabbitt, whose generous bequest made the award possible. The awardee is given funds to defray travel expenses to the national GSA meeting. The nomination packet should include (1) a letter of nomination by the proposer detailing the contributions that

warrant the award; and (2) the nominee's current CV that includes name, title, affiliation, date and place of birth, education, degrees, honors and awards, major career events, and the contributions that warrant the award. For more information, go to www.gsahist.org/hapg_award/awards.htm.

Gerald M. and Sue T. Friedman Distinguished Service Award

Nominations due 1 Feb. 2015

Submit nominations to Kathleen Lohff at kathylohff.msn.com.

This award, established in 2005 and named for founding members of the Division, is presented for exceptional service to the advancement of the history and philosophy of the geological sciences. Neither the nominator nor the nominee has to be a member of the Division or of GSA. Such service may include, but need not be limited to, the discovery of and making available rare source materials; comprehensive bibliographic surveys; organizing meetings and symposia in the history and philosophy of geology; and exceptional service to the Division. The nomination packet should include (1) a letter detailing the contributions that warrant the award; and (2) the nominee's current CV that includes name, title, affiliation, date and place of birth, education, degrees, honors and awards, major career events, and the contributions that warrant the award. The award provides funds to defray travel expenses to the national GSA meeting and is made possible by a bequest from the estate of Mary C. Rabbitt. For more information, go to www.gsahist.org/hapg_award/awards.htm.

History and Philosophy of Geology Student Award

Nominations due 15 June 2015

Submit nominations to Kathleen Lohff at kathylohff.msn.com.

The History and Philosophy of Geology Division provides a student award in the amount of US\$1,000 for a paper to be given at the national GSA meeting. Awards may also be given for second place. The award, established in 2004, is made possible by a bequest from the estate of Mary C. Rabbitt. Oral presentations are preferred. Faculty advisors may be listed as second author but not as the lead author of the paper. The proposed paper may be (1) on the history or philosophy of geology; (2) a literature review of ideas for a technical work or thesis/dissertation; or (3) some imaginative aspect of the history or philosophy of geology we have not thought of before. Students should submit an abstract of their proposed talk and a 1,500–2,000-word prospectus for consideration.

Currently enrolled undergraduates and graduate students are eligible as are students who received their degrees at the end of the fall and spring terms immediately preceding the national GSA meeting. The award is open to all students regardless of discipline, provided the proposed paper is related to the history or philosophy of a geological idea/person. For more information, go to www.gsahist.org/hapg_award/awards.htm.

■ HYDROGEOLOGY

O.E. Meinzer Award

Nominations due 1 Feb. 2015

Submit nominations to gsa.hydro.nominations@gmail.com.

This award recognizes the author or authors of a publication or body of publications that have significantly advanced the science of hydrogeology or a closely related field. The nomination must cite the publication(s) on which the nomination is based and describe the role of the publication(s) in advancing hydrogeology or a closely related discipline. Inclusion of up to three additional third-party letters in support of the nomination is encouraged. If you have questions, please contact David Parkhurst at dlpark@usgs.gov. For more information, go to <http://gsahydrogeology.org/OEMeinzer.htm>.

George Burke Maxey Distinguished Service Award

Nominations due 1 Feb. 2015

Submit nominations to gsa.hydro.nominations@gmail.com.

This award recognizes distinguished personal service to the hydrogeology profession and to the Division. The letter of nomination should describe the distinguished service that warrants the nomination. Supporting letters are helpful but not required. If you have questions, please contact Brian Katz at brian.katz@dep.state.fl.us. For more information, go to <http://gsahydrogeology.org/DistinguishedService.htm>.

Kohout Early Career Award

Nominations due 1 Feb. 2015

Submit nominations to gsa.hydro.nominations@gmail.com.

This award will be presented to a distinguished early career scientist (35 years of age or younger throughout the year in which the award is to be presented or within 5 years of receiving their highest degree or diploma) for outstanding achievement in contributing to the hydrogeologic profession through original research and service, and for the demonstrated potential for continued excellence throughout their career. The nomination package must include the following: (1) at least one letter of nomination with a description of the significant contributions or accomplishments; (2) a copy of the nominee's CV with complete bibliography; and (3) at least four supporting letters. If you have questions, please contact Steve van der Hoven at sjvanderhoven@gmail.com. For more information, go to <http://gsahydrogeology.org/Kohout.htm>.

Birdsall-Dreiss Distinguished Lecturer

Nominations due 1 Feb. 2015

Submit nominations to gsa.hydro.nominations@gmail.com.

The lecturer is selected based on outstanding contributions to hydrogeology or a closely related field through original research and public communication and the potential for continued contributions to the profession. To nominate, include at least one letter of nomination, a copy of the nominee's CV, and at least two supporting letters describing the significant contributions or accomplishments constituting the basis for the nomination. If you have questions, please contact Dani Or at dani.or@env.ethz.ch. For more information, go to <http://gsahydrogeology.org/BirdsallDreiss.htm>.

■ MINERALOGY, GEOCHEMISTRY, PETROLOGY, AND VOLCANOLOGY (MGPV)

Nominations due 15 July 2015

Submit nominations to J. Alex Speer, Mineralogical Society of America, 3635 Concorde Pkwy, Ste 500, Chantilly, VA 20151-1110, USA; jaspeer@minsocam.org.

MGPV awards emphasize achievements in geologic and multidisciplinary approaches. Geologic work is by nature generalistic and has an important field component, with Earth as the natural laboratory. For either award outlined below, please submit (1) a cover letter from an MGPV Division member, no longer than three pages, summarizing the nominee's most important accomplishments in geologic approaches to mineralogy, geochemistry, petrology, and/or volcanology, with special attention paid to describing how the nominee's published work demonstrates field-based multidisciplinary geologic accomplishments of a ground-breaking nature. The letter should include the name, address, and contact information of nominator as well as from whom letters of support can be expected; (2) the nominee's CV; and (3) three letters of support. Nominees need not be citizens or residents of the United States, and membership in GSA is not a requirement. The awards will not be given posthumously. For more information, go to www.geosociety.org/divisions/mgpv/awards.htm.

MGPV Distinguished Geologic Career Award

This award goes to an individual who, throughout his or her career, has made distinguished contributions in one or more of the following fields of research: mineralogy, geochemistry, petrology, volcanology, with emphasis on multidisciplinary, field-based contributions.

MGPV Early Career Award

The MGPV award will go to an individual near the beginning of his or her professional career who has made distinguished contributions in one or more of the following fields of research: mineralogy, geochemistry, petrology, volcanology, with emphasis on multidisciplinary, field-based contributions. Nominations are restricted to those who are within eight years past the award of their final degree. For example, awards decided before 31 Dec. 2014 included all candidates whose final degree was awarded no earlier than 1 Jan. 2007. Extensions of up to two years will be made for nominees who have taken career breaks for family reasons or because of serious illness.

■ QUATERNARY GEOLOGY AND GEOMORPHOLOGY

Farouk El-Baz Award for Desert Research

Nominations due 1 Apr. 2015

Submit nominations to Anne Chin at anne.chin@ucdenver.edu.

This award is intended to stimulate research in desert environments by recognizing an individual whose research has significantly advanced the understanding of the Quaternary geology and geomorphology of deserts worldwide. Although the award primarily recognizes achievement in desert research, the funds that accompany it may be used for further research. The award is

normally given to one person but may be shared by two people if the recognized research was the result of a coequal partnership. Any scientist from any country may be nominated, but self-nomination is not permitted. Neither nominators nor nominees need be GSA Members. Monies for the award are derived from the annual interest income of the Farouk El-Baz Fund, administered by the GSA Foundation.

Nomination materials should include (1) a statement of the significance of the nominee's research; (2) a CV; (3) letters of support; and (4) copies of no more than five of the nominee's most significant publications related to desert research.

Distinguished Career Award

Nominations due 1 Apr. 2015

Submit nominations to Sarah Lewis at sarah.lewis@oregonstate.edu.

This award recognizes a Quaternary geologist or geomorphologist who has demonstrated excellence in his or her contributions to science. Neither nominators nor nominees need be GSA Members, and self-nomination is not permitted.

Nominations should include (1) a brief biographical sketch of the nominee; (2) a statement of no more than 200 words describing the candidate's scientific contributions to Quaternary geology and geomorphology; (3) a selected bibliography of no more than 20 titles; and (4) a minimum of four letters from colleagues supporting the nomination.

Kirk Bryan Award for Research Excellence

Nominations due 15 Jan. 2015

Submit nominations to Sarah Lewis at sarah.lewis@oregonstate.edu.

This award is bestowed upon the author or authors of a published paper of distinction that advances the science of geomorphology or some related field, such as Quaternary geology. The paper constituting the basis of the award must fulfill the following requirements: (1) it must deal with geomorphology or with a bordering field; and (2) it will have been published not more than five years prior to its selection for the award.

Nominations should include (1) a letter (1–3 pages long) by the chief nominator outlining the significance and importance of the nominated publication; (2) a copy of the publication; (3) reviews of the publications that have appeared in journals, newsletters, or books (if any); and (4) one or more letters from other supporters of the nomination.

■ SEDIMENTARY GEOLOGY

Laurence L. Sloss Award for Sedimentary Geology

Nominations due 1 Mar. 2015

Submit nominations to Linda Kah at lckah@utk.edu.

This award is given to a sedimentary geologist whose lifetime achievements best exemplify those of Larry Sloss—i.e., achievements that contribute widely to the field of sedimentary geology and service to GSA. Monies for the award are derived from the annual interest income of the Laurence L. Sloss Award for Sedimentary Geology Fund, administered by the GSA Foundation. Nominations should include (1) a cover letter describing the nominee's accomplishments in sedimentary geology and contributions to GSA; and (2) the nominee's CV. For more information, go to http://rock.geosociety.org/sed/SGD_Awards2.html#Sloss.

■ STRUCTURAL GEOLOGY AND TECTONICS

Career Contribution Award

Nominations due 10 Mar. 2015

Submit nominations to Jane Gilotti at jane-gilotti@uiowa.edu.

This award recognizes an individual who, throughout his/her career, has made numerous distinguished contributions that have clearly advanced the science of structural geology or tectonics. Nominees need not be citizens or residents of the United States, and membership in GSA is not required. Nominations should include the following information: (1) the name of nominee, present institutional affiliation, and address; (2) a summary statement of the nominee's major career contributions to the science of structural geology and tectonics; (3) selected key published works; and (4) the name and address of nominator. For more information, go to <http://rock.geosociety.org/sgt/CareerAward.htm>.


Outstanding Publication Award

Nominations due 1 Mar. 2015

Submit nominations to Dyanna Czeck at dyanna@uwm.edu.

This award recognizes a published work (paper, book, or map) of exceptional distinction that clearly advances the science of structural geology or tectonics. Nominations should include (1) a full citation; (2) a written nomination (as short as a paragraph; letters or reviews may also be included); and (3) the name and address of nominator. For more information, go to <http://rock.geosociety.org/sgt/BestPaperAward.htm>.

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Second Vice-Chair: Wendy A. Bohrson
Secretary-Treasurer: J. Alexander Speer
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First Vice-Chair: Anne Chin
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Vice-Chair: Katherine A. Giles
Secretary-Treasurer: Linda C. Kah
Past Chair: Richard P. Langford

■ STRUCTURAL GEOLOGY AND TECTONICS DIVISION

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First Vice-Chair: Jean M. Crespi
Second Vice-Chair: James (Jim) P. Evans
Secretary-Treasurer: Yvette D. Kuiper
Past Chair: Andrew Meigs

ELECTIONS: GSA OFFICERS and COUNCILORS

GSA ELECTIONS BEGIN 6 MARCH 2015

GSA's success depends on you—its members—and the work of the officers serving on GSA's Executive Committee and Council. Members will receive a postcard with instructions for accessing an electronic ballot via our secure website, and biographical information on the nominees will be online for you to review at that time. Paper versions of both the ballot and candidate information will also be available. Please help continue to shape GSA's future by voting on these nominees.

2015 OFFICER NOMINEES

PRESIDENT
(July 2015–June 2016)

Jonathan G. Price
Jonathan G. Price LLC
Reno, Nevada, USA

We congratulate our incoming president!

VICE PRESIDENT/PRESIDENT-ELECT
(July 2015–June 2017)

Claudia I. Mora
Los Alamos National Laboratory
Los Alamos, New Mexico, USA

TREASURER
(continuing term, July 2014–June 2015)

Bruce R. Clark
The Leighton Group Inc.
Irvine, California, USA

2015 COUNCIL NOMINEES

COUNCILOR POSITION 1
(July 2015–June 2019)

Frank Pazzaglia
Lehigh University
Bethlehem, Pennsylvania, USA
Mark Little
University of North Carolina
Chapel Hill, North Carolina, USA

COUNCILOR POSITION 2
(July 2015–June 2019)

Chuck Bailey
College of William & Mary
Williamsburg, Virginia, USA
Shuhai Xiao
Virginia Polytechnic Institute
and State University
Blacksburg, Virginia, USA

COUNCILOR POSITION 3
(Divisions Liaison)
(July 2015–June 2019)

Scott Burns
Portland State University
Portland, Oregon, USA
Mary Kraus
University of Colorado
Boulder, Colorado, USA

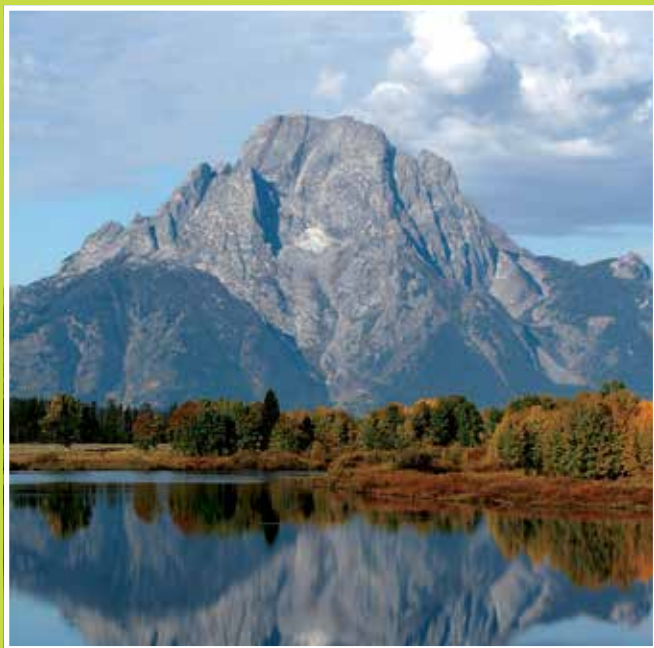
Ballots must be submitted electronically or postmarked by 5 April 2015.

Preliminary Announcement and Call for Papers

ROCKY MOUNTAIN SECTION

67th Annual Meeting of the Rocky Mountain Section, GSA
Casper, Wyoming, USA
21–23 May 2015

www.geosociety.org/Sections/rm/2015mtg/



Beautiful Mount Moran in Grand Teton National Park.

Groundbreaking Discoveries in the Rockies: Fracturing, Fossils, and Fumaroles

LOCATION

The Casper College Dept. of Earth and Environmental Sciences, the University of Wyoming, and the Wyoming Geological Association (WGA) are excited to host the 67th Annual Rocky Mountain Section Meeting in the booming city of Casper, Wyoming, USA. We have developed a technical program covering a broad scope of topics, including the fields of Cenozoic volcanism; structural geology; paleontology; paleobiology and sedimentology; geomorphology; geophysics and hydrology; applications in GIS; and mining and industry. Our location at the base of Casper Mountain along the North Platte River provides a world-class geologic setting and home base for our field trips.

REGISTRATION

Meeting registration will open in early February; the deadline for the lowest registration fees is 20 April.

CALL FOR PAPERS

Abstract deadline: 17 Feb.

Submit your abstract online at www.geosociety.org/Sections/rm/2015mtg/. Abstract submission fee: US\$10 for students; US\$15 for all others. If you cannot submit an abstract online, please contact Heather Clark, +1-303-357-1018, hclark@geosociety.org.

Symposia

- S1. **Yellowstone/Teton/Snake River Plain Volcano–Tectonic System: Honoring 55 Years of Distinguished Research and the Legacy of Bob Smith.** Jamie Farrell, Univ. of Utah, jamie.farrell@utah.edu.
- S2. **The Continental Triassic: Sedimentary and Paleobiologic Records throughout the Rocky Mountain Region.** Dave Lovelace, Univ. of Wisconsin, dlovelace@wisc.edu; Michelle Stocker, Virginia Tech, stockerm@vt.edu; Scott Hartman, Univ. of Wisconsin, sahartman@wisc.edu.
- S3. **Brittle Structures of Rocky Mountain Reservoirs and Reservoir Analogs.** Steve Laubach, Univ. of Texas at Austin, steve.laubach@beg.utexas.edu.
- S4. **Quaternary Geoarchaeology: Honoring the Work of John Albanese.** Dana Pertermann, Western Wyoming College, dpertermann@wwcc.wy.edu; Kerry Lippincott, Consultant, lippincotts@live.com.

Theme Sessions

- T1. **In Celebration of the Release of the WGA 2014 Wyoming Stratigraphic Nomenclature Chart: Topics in Rocky Mountain Stratigraphy.** Marron Bingle-Davis, Wyoming Geological Assoc., mbingledavis@yahoo.com.
- T2. **Geomorphology and Surficial Processes.** Beth Wisely, Casper College, bwisely@caspercollege.edu.
- T3. **Advancements and Issues in Petroleum Extraction Technologies.** Marron Bingle-Davis, Wyoming Geological Assoc., mbingledavis@yahoo.com.
- T4. **General Minerals and Mining.** Phil Nickerson, Bronco Creek Exploration Inc., pnickerson@broncocreek.com.
- T5. **Special Problems in Rocky Mountain Coal Mining.** Heather Lawson, Office of Mine Safety and Health (NIOSH), helawson@cdc.gov.
- T6. **Graduate Student Research.** Brandon McElroy, Univ. of Wyoming, bmcelroy@uwyo.edu.
- T7. **General Paleontology.** J.P. Cavigelli, Tate Geological Museum, jpcavigelli@caspercollege.edu.
- T8. **Paleoclimate, Paleoecology, and Evolution.** Melissa Connelly, Casper College, mconnely@caspercollege.edu.
- T9. **Mountain Building and Basin Response: New Insights to the Bighorn Mountains and Associated Basins.** Ranie Lynds, Wyoming State Geological Survey, ranie.lynds@wyo.gov; Erin Campbell-Stone, Univ. of Wyoming, erincs@uwyo.edu; Eric Erslev, Univ. of Wyoming, eerslev@uwyo.edu.
- T10. **Geoscience Education and Undergraduate Research.** Suki Smaglik, Central Wyoming College, ssmaglik@cwcc.edu; Kim Hannula, Fort Lewis College, hannula_k@fortlewis.edu.
- T11. **Shallow Geophysics and Wyoming's Water Resources.** Steve Holbrook, Univ. of Wyoming, steveh@uwyo.edu; Kent Sundell, Casper College, ksundell@caspercollege.edu.
- T12. **Applications for GIS and Geospatial Data in the Geosciences.** Jeff Sun, Casper College, jsun@caspercollege.edu.

WORKSHOPS/SHORT COURSES

Uranium Exploration. Cal Van Holland, UR Energy,
Cal.VanHolland@ur-energyusa.com.

Petroleum Well Site Geology. Arnold Woods, Casper College,
awoods@caspercollege.edu.

Photogrammetry: 3-D Digital Data Collection in the Lab and Field. Brent Breithaupt, BLM, bbreitha@blm.gov; Neffra Matthews, BLM, n1matthe@blm.gov.

Creating Google Tours for Geoscience Education. Heather Almquist, Univ. of Montana, heather.almquist@umontana.edu.

FIELD TRIPS

For additional information, please contact field trip chair Terry Logue at tlogue@caspercollege.edu.

Tectonics, Climate, and Paleogeomorphology in the Green River Formation. Michael E. Smith, Univ. of Northern Arizona, michael.e.smith@nau.edu; Jennifer Scott, Mount Royal Univ., jescott@mtroyal.ca.

Eocene-Oligocene Paleovalleys of the White River Formation. Emmett Evanoff, Univ. of Northern Colorado, emmett.evanoff@unco.edu.

Geoscience Educators Field Trip: Alcova Reservoir, Fremont Canyon and the Cotton Creek Trail. Terry Logue, Casper College, tlogue@caspercollege.edu; Melissa Connely, Casper College, mconnely@caspercollege.edu; Suki Smaglik, Central Wyoming College, ssmaglik@cw.edu.

Yellowstone and Big Horn Basin. Kent Sundell, Casper College, ksundell@caspercollege.edu; Jamie Farrell, Univ. of Utah, jamie.farrell@utah.edu; Bob Smith, Univ. of Utah, robert.b.smith@utah.edu.

ACCOMMODATIONS

A block of rooms has been reserved at the Best Western Ramkota Hotel, 800 N. Poplar, Casper, WY 82601, USA. Special room rates are US\$83 plus tax. To make your reservation, call +1-307-266-6000. Use the code "GEOLOG" when making your reservation to ensure that you are booked into the block for this meeting.



A bubbling mudpot at Yellowstone National Park.

OPPORTUNITIES FOR STUDENTS

On To the Future (OTF)

Stop by the GSA Foundation booth at the Welcome Reception to ask an onsite representative 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 1–4 Nov. 2015 in Baltimore, Maryland, USA).

Mentor Programs

Cosponsored by the GSA Foundation. For more information, contact Jennifer Nocerino at jnocerino@geosociety.org.

Roy J. Shlemon Mentor Program in Applied Geoscience.

Thurs., 21 May, lunchtime. Students will have the opportunity to discuss career prospects and challenges with professional geoscientists from multiple disciplines over a FREE lunch. Learn more at www.geosociety.org/mentors/shlemon.htm.

John Mann Mentors in Applied Hydrogeology Program.

Fri., 22 May, lunchtime. Students interested in applied hydrogeology or hydrology as a career will have the opportunity to network with professionals in these fields over a FREE lunch. Learn more at www.geosociety.org/mentors/mann.htm.

Geoscience Career Workshops

Cosponsored by the GSA Foundation. For more information, contact Jennifer Nocerino at jnocerino@geosociety.org.

Part 1: Career Planning and Informational Interviewing.

Thurs., 21 May, 8 a.m.–9 a.m. 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*.

Part 2: Geoscience Career Exploration.

Thurs., 21 May, 9 a.m.–10 a.m. What do geologists in various sectors earn? What do they do? What are the pros and cons to working in academia, government, and industry? Workshop presenters, and when possible, professionals in the field, will address these issues.

Part 3: Cover Letters, Résumés, and CVs.

Fri., 22 May, 9 a.m.–10 a.m. How do you prepare a cover letter? Does your résumé need a good edit? Whether you are currently in the job market or not, learn how to prepare the best résumé possible. You will review numerous résumés helping you to learn important résumé dos and don'ts.

LOCAL COMMITTEE

General Chair: Kent Sundell, ksundell@caspercollege.edu

Treasurer/Chief Financial Officer: Nancy Doelger, nancy.doelger@gmail.com

Field Trip Chair: Terry Logue, tlogue@caspercollege.edu

Technical Program Co-Chairs: Melissa Connely, mconnely@caspercollege.edu; Beth Wisely, bwisely@caspercollege.edu

Sponsorship Chair: Julia Lemaster, julia@goolsbyfinley.com

Meeting Facilitator: Ann Dalton, adalton@caspercollege.edu

Diversity in all its forms: IPC4 as an invaluable opportunity for STEPPE grant recipients

Javier Luque, Dept. of Biological Sciences, University of Alberta/Smithsonian Tropical Research Institute, Edmonton, Alberta, Canada, luque@ualberta.ca; **Heda Agic**, Dept. of Earth Sciences, Uppsala University, Uppsala, Sweden, heda.agic@geo.uu.se; **Evan P. Anderson**, Dept. of Geological Sciences, University of Colorado, Boulder, Colorado, USA, evan.p.anderson@colorado.edu; **Robyn Dahl**, Dept. of Earth Sciences, University of California, Riverside, California, USA, robymdahl@gmail.com; **Mike Donovan**, Dept. of Geosciences, Penn State University, State College, Pennsylvania, USA, mpd187@psu.edu; **Daniel J. Field**, Dept. of Geology & Geophysics, Yale University, New Haven, Connecticut, USA, daniel.field@yale.edu; **John A. Fronimos**, Dept. of Earth and Environmental Sciences/Museum of Paleontology, University of Michigan, Ann Arbor, Michigan, USA, jfronimo@umich.edu; **Montana Hodges**, University of Montana Paleontology Center, Missoula, Montana, USA, montana.hodges@umconnect.umt.edu; **Gary J. Motz**, Center for Biological Research Collections, Indiana University, Bloomington, Indiana, USA, garymotz@indiana.edu; **Ryan Roney**, Dept. of Earth and Planetary Sciences, University of Tennessee, Knoxville, Tennessee, USA, rroney1@utk.edu; **Erin E. Saupe**, Dept. of Geology & Geophysics, Yale University, New Haven, Connecticut, USA, erin.saupe@yale.edu; **Sarah Sheffield**, Dept. of Earth and Planetary Sciences, University of Tennessee, Knoxville, Tennessee, USA, sarahsheffield89@gmail.com; **Lydia Tackett**, Dept. of Geosciences, North Dakota State University, Fargo, North Dakota, USA, lydia.tackett@gmail.com; **Jessica N. Tashman**, Dept. of Geology, Kent State University, Kent, Ohio, USA, jtashman@kent.edu; and **Zuzanna Wawrzyniak**, Dept. of Palaeontology and Stratigraphy, University of Silesia, Katowice, Poland, zuza.wawrzyniak@gmail.com

Earth's biological diversity comprises ~1.7 million extant species known to science, and there are many millions yet to be discovered (Gewin, 2002; Mora et al., 2011). Today's biodiversity, however, is thought to represent only ~1% of the life that has ever existed on our planet. Moreover, much of this life is currently in peril from what has been called the "6th great extinction event," largely precipitated by the overwhelming influence humans have had on the biosphere (Brook et al., 2008). If modern biodiversity represents only a small fraction of the flora and fauna that once lived, what can we learn from past diversity to understand the future of modern biota? What processes acted to shape our current diversity? How do living species relate to other branches on the tree of life?

Paleontology, from the Greek *palaaios* (old, ancient), *ontos* (being, creature), and *logos* (thought, study), involves the study of

life through geological time. The fossil record provides a historical ledger that sheds light on the origins of today's biodiversity and how organisms relate to each other via ancestor-descendant relationships. Over the last several years, new paleontological discoveries and technologic developments have allowed for more efficient and innovative ways to analyze the fossil record. This, in turn, has improved our understanding of how life on Earth has waxed and waned through time.

The vigor and relevance of contemporary paleontological research were on full display at the 4th International Palaeontological Congress (IPC4) in the city of Mendoza, Argentina (28 Sept. to 3 Oct. 2014), where nearly 1,000 paleontologists from around the world converged to celebrate paleontology. The research presented at IPC4—the largest International Palaeontological Congress to date—was highly diverse in its topical, organismal, geographical, and temporal coverage. The workshops, symposia, short courses, and field trips were similarly varied, as were the conference attendees, who hailed from 50 different countries and represented many different stages of their paleontological careers, from students to emeritus professors. In short, diversity in all its forms was the very heart of IPC4.

We write this article as the fortunate recipients of 15 travel grants offered by STEPPE, an NSF-supported consortium whose purpose is to promote multidisciplinary research and education on Earth's deep-time sedimentary crust (see <http://steppe.org/>). The funding opportunities provided by STEPPE, in collaboration with The Geological Society of America, the Paleobotanical Section of the Botanical Society of America, the Paleontological Society, the Society for Sedimentary Geology, and the Society for Vertebrate Paleontology, helped to alleviate a substantial financial burden for many students. For many of us, IPC4 provided our first opportunity to visit Argentina, South America, or even the Southern Hemisphere, and without STEPPE's aid, we would not have experienced the new research and diverse perspectives the conference offered, including following in the footsteps of Charles Darwin's travels in the Andes on the many conference field trips. The student funding offered by the STEPPE consortium and collaborative professional societies has greatly assisted all of us in our nascent careers, and in this instance provided an incredibly motivating, reassuring, and intellectually stimulating experience that benefitted all of our futures in paleontology.

As STEPPE awardees, we are as diverse as the conference proceedings. We study taxa as disparate as tetrapods, plants, arthropods, and early eukaryotes, and research topics from paleoecology, paleobiogeography, and biomechanics, to exceptional preservations, functional morphology, visual systems, and

predator-prey interactions (IPC4, 2014; STEPPE, 2014). The temporal range of our research also spans from the very old (Proterozoic) to the very young (Neogene to recent). We had the opportunity to showcase our research to world experts via poster and oral presentations, generate novel research ideas that cut across disciplines, make useful contacts for future research questions, and learn of research similar to ours from around the globe. These interactions, both amongst the STEPPE awardees and our fellow paleontologists, will hopefully lay the groundwork for new discoveries, technological advances, and paradigm shifts that will unfold over the coming decades. It is interesting to note that although the overwhelming majority of the STEPPE grant recipients are student members of the five partner institutions already mentioned, many of us had never met before IPC4. Thus, in addition to the benefits of meeting established experts in our fields, we had a unique opportunity to form new, lasting research collaborative relationships with other early career scientists. This goes to show that it is through collaborative networks such as the STEPPE consortium, among many others, that the inherently multidisciplinary areas of our study can truly come together in a way they could not as individual entities.

It is an incredibly exciting time to be a young paleontologist. Owing to the accessible nature of research in our discipline, paleontology enjoys wide media coverage and enthusiastic contributions from amateurs. Further, the advent of exciting new analytical methods, combined with seemingly endless fossil

discoveries, is shedding new light on the history of life and the evolution of our planet. As the field of paleontology continues to enjoy a renaissance, the role of young, motivated researchers will be invaluable. As junior researchers on the cusp of careers in this discipline, we believe that the opportunity for early career scientists to attend these kinds of meetings, facilitated by granting agencies and institutions such as the STEPPE consortium, is pivotal to achieve our goals of becoming future leaders in the field, and contribute to our ever-improving knowledge of the origin of Earth's overwhelming diversity through deep time.

REFERENCES CITED

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- Gewin, V., 2002, Taxonomy: All living things, online: *Nature*, v. 418, p. 362–363, doi: 10.1038/418362a.
- IPC4, 2014, 4th International Palaeontological Conference: A history of life: A view from the southern hemisphere, abstract volume, 936 p., <http://www.ipc4mendoza2014.org.ar/wp-content/uploads/2014/10/Abstract-Volume-IPC4.pdf> (last accessed 14 Nov. 2014).
- Mora, C., Tittensor, D.P., Adl, S., Simpson, A.G.B., and Worm, B., 2011, How many species are there on Earth and in the Ocean?: *PLoS Biology*, v. 9, no. 8, p. e1001127, doi: 10.1371/journal.pbio.1001127.
- STEPPE, 2014, IPC4 blogs: <http://steppe.org/category/steppe-blogs/> (last accessed 14 Nov. 2014).



STEPPE travel awardees. From left to right, top row: Evan P. Anderson, Heda Agic, Ryan Roney, Javier Luque, Robyn Dahl, Gary J. Motz, Daniel J. Field; bottom row: Jessica N. Tashman, Zuzanna Wawrzyniak, Lydia Tackett, Mike Donovan, John A. Fronimos, Montana Hodges, and Sarah Sheffield (not pictured: Erin E. Saupe).

Welcome New GSA Members!

The following individuals submitted their applications for GSA membership between 20 Feb. and 10 Sept. 2014 and were approved by GSA Council during the 2014 GSA Annual Meeting & Exposition

PROFESSIONALS

Andrew Abban
Angel A. Acosta-Colon
Chari Lizette Adames-Smith
Yekeen Salau Agunleti
Abdulmehdi Ali
Ahmad Zain Amiruddin
Garth Steven Anderson
Tina M. Anderson
Meghan Armbruster
Neeraj Awasthi
Adnan Aydin
Martin George Balinsky
Emma Bee
Richard Vincent Beesley
James F. Bell
Thomas E. Bellile
Kathleen Counter Benison
Georgina L. Bennett
John P. Bethel
Kenneth Michael Biegert
Sanat Kumar Biswas
Matthew Blackett
Jerry D. Blackwell
Kyle William Blasch
Adam R. Boehlke
John F. Bolakas
David P.G. Bond
David Phillip Boon
Tashane Jessica Boothe
Sutapa Bose
Joshua Bowe
Nick Bozdog
Thomas B. Brackman
Joshua Lee Bradley
Kathleen Elizabeth Brant
Glen Arthur Brown
K.E. Brown
Rich Brown
Marc-Andre Brulotte
Donald George Brummel
Solomon Nana Buadum

Lindsay Reed Burt
Trevor Butterfield
Marc L. Buursink
Augusto Carballido
Agustin Cardona
Gerry Carlson
Fabricio Caxito
Catherine Chague-Goff
Steven Chapman
Farid Chemale Jr.
Philip Chen
Qing Chen
Patrick Tj Chidley
Kenneth T. Christensen
Thomas E. Christopher
Sang Yong Chung
Daniel Barham Corkran
Jean-Thomas Cornelis
Samuel Couture
Steven D. Craigg
Vanessa Michelle Crandell
Antoine Cuvilliez
Edgar E. D'abre III
Gian-carlo D'ottone
Audrey Dallimore
Giancarlo Davoli
Jeremy S. Delaney
Bladimir Diaz
Mark E. Dierker
Jacqueline Eaby Dixon
John Dockrey
Yannick Donnadieu
Amanda Kay Dopheide
Brendan Duffy
Brian R. Duggan
Ivo Duijnstee
Julia Michelle Dukes
John B. Dunham
Andrew Dunn
Eileen E. Dunn
Alex Dutchak
Stephanie Earls
Morgan Asbury Eddy

David A. Ellerbroek
Alan Robert English
Joseph Essilfie-Dughan
Paul K. Evans
Brian A. Fagnan
Andrei G. Filippov
John L. Flint
Thomas Flynn
Brent Foster
Rachel Friedman
Timothy R. Frinak
Fabrizio Frontalini
Eloise Gaillou
Gordana Garapic
Mohammed Ali Garba
Elizabeth Geiger
F. Jackson George
Jenifer Georgen
Jason C. Giddens
Joseph K. Giddens
Evan B. Goldstein
Cathy Gong
George Gorzynski
Matthew A. Graesch
David W. Graham
Marta Green
Mark William Grodner
Ludovic Guyonvarch
Brian Verner Hall
Lee E. Hall
Herbert Scott Hamlin
Diane Hanano
Lawrence Hanratty
Pavlina Hasalova
Mark B. Hausner
Dallas Heisler
James Henderson
Ingrid Hendy
David S. Henry
Kelly Hermanson
Richard T. Higley
Kathleen Hill
Jena Hintz
Jessica Hobbs
Paul Hoeffler
Jason L. Holcomb
Austin A. Holland
Tristan J. Horner
Xudong Hou
Peter Hughes
Crystal A. Huscroft
Mark A. Hushebeck
Maureen A. Jackson
Gajananrao N. Jadhav
Anna Jansson
Jim Jarrell
Michael Jaye
Stuart Jennings
Anne Elizabeth Jeton



David Jay Johnson
Reed Johnson
Alison Grace Johnston
Sandra E. Johnstone
Moulisree Joshi
Michelle Judson
Petr Kadera
Misun Kang
Kristina M. Keating
Paul M. Kennard
Miles Douglas Kenney
Molly Kent
Raphael Ketani
Hassan Khozyem
Georgina Elizabeth King
Timo Kirchner
Michelle R. Kirchoff
Jacki E. Klancher
Mary J. Klass
Martin Bromann Klausen
Simon K. Kline
Albert Richard Kottke
Michael E. Kress
Noboru Kubo
Nicole Ladue
L. Dhana Lakshmi
Chad Steven Lane
Joseph Large
Richard O. Lease
Alex Russell Lechler
Dean Ledgerwood
Michele Lepitre
Amelia Letvin
Victor K. Leung
Leah Levay
Vic M. Levson
Hongyi Li
Yingkuai Li
Alain Liard
Matthias Lindhuber
Leslie L. Lingley
Holly Little
James M. Logan
Kathryn Lucas
James Anthony Maceachern
William Macfarlane
Marcius Costa Machado
Paul R. Mahaffy
Jan Mangerud
Layaka Mann
Heidi Lynn Kennedy Manning
Gordon Leon Marney
Ronald Marple
Finnegan Marsh
Joseph Marsik
Martha Martinez Sr.
Patricia H. Mason
Nadine Mattielli
Heather Maxson

Colin H. McAleenan
Laura McCall
Carol McCartney
Kyle C. McDonald
Meryl McDowell
Mark D. McFaddan
Thomas Howatt McGovern
Jenny L. McGuire
J. Fred McLaughlin
Ross McMann
Phoebe McMellon
Colin James McNamara
Laura Delgado Mendes
Jack A. Meyer
Brendan G.N. Miller
Christina Marie Miller
N. Frank Miller
Steve Miller
Larry Mireku
Rudra Narayan Mishra
Debasmita Misra
Jesse H. Mitchell
Todd Andrew Mitchell
Ritayan Mitra
Kyaw Moe
Andrew Moores
Sarah Angelina Morealli
John Michael Morganti
Roger N. Morin
Moustafa Rabei Amin
Moustafa
Travis J. Naibert
Wayne Linwood Newell
Ines Nobre Silva
Jeanette M. Norton
William Kelly O'Connor
Caroline O'Hara
Brian C. O'Shea
Marianne H. Okal
Leonardo Octavio
Olarte-Sanchez
James T. Olech
Patrick John Orr
Elizabeth Osborne
Elizabeth Littlefield Pace
Darrin Pagnac
Kanchan Pande
Gopalakrishnarao
Parthasarathy
Derek Wilbur Payne
Timothy B. Pease
James Mathew Peck
Timothy J. Peck
John M. Perez
Daniel Perigo
Kerry Phibbs
Julio Murilo Martino Pinho
Susann Pinter
Lucy Anne Porritt

Trevor Porter
Vera Pospelova
Katie Pratt
Nicholas Proulx
Erich M. Purpur
Elizabeth C. Raff
Rudolf A. Raff
Debdas Ray
Robert Morris Reynolds
Fereidoun Rezanezhad
Katie Rhode
Michael G. Richter
Lani Ritchey
Irving K. Robbins
Samantha Lee Roberts
Walter A. Robinson
Robert P. Rogero
John Blackwell Rogers
Elizabeth Roller
Goetz Roller
Matteo Roverato
Christopher James Rowan
Jenny Paola Rueda
Everett Rutherford Jr.
Lisa W. Ryan
Jorge Salazar Sr.
David Sallee
Ademola Razaq Sanni
Mohammedrafi Gulabbhai
Sayeed
Janet Guidetti Schaefer
Christian Schardt
Anja Schmidt
Michael Schneider
Rhys David Schneider
Robert Vincent Schneider
Robert Adam Schneiker
Brian Schutz
Hilde Schwartz
Irfan Janmohamed Shaikh
Alison Shaw
Chung Kun Shih
Jean-Martin E. Siebenthal
Mike Simpson
Rannveig Øvrevik Skoglund
Olav Slaymaker
Allen Smith
John Edwin Smith
Jolane Sorge
Travis D. Steel
Christopher Stevens
Tim R. Stokes
Rex D. Stout
Stuart C. Strife
Kathleen Stuck
Manuel Suarez
Pamela L. Sullivan
Adam D. Switzer
Melanie Szulczewski

John Jeffrey Takach
Lan Tang
Syed Tarique
Dene J. Tarkyth
Mark A. Taylor
Ryan Zane Taylor
Brian F. Thomas
Jenna Thomson
Hal Ray Tichenor
Mark Allen Tinsley
Masako Tominaga
Jolene Teresa Traut
Kerry B. Treacy
Anthony S. Trease
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IN MEMORIAM



The Society notes with regret the deaths of the following members (notifications were received between 31 July and 26 Oct. 2014).

John K. Adams

Buckingham, Pennsylvania, USA
Date of death: 28 Mar. 2014
GSA notified: 17 Sept. 2014

Frank C. Armstrong

Spokane, Washington, USA
Date of death: 2 June 2013
GSA notified: 15 Aug. 2014

Robert J. Bourrouilh

Talence, France
Date of death: 16 July 2014
GSA notified: 18 Sept. 2014

Gordon L. Dolton

Grand Rapids, Michigan, USA
Date of death: 16 Sept. 2014
GSA notified: 25 Sept. 2014

G. Donald Eberlein

Carson City, Nevada, USA
Date of death: 4 Dec. 2003
GSA notified: 10 Oct. 2014

Samuel R. Edwards

Santa Paula, California, USA
Date of death: 25 Jan. 2014
GSA notified: 12 Sept. 2014

Theodore W. Ehring

Pismo Beach, California, USA
Date of death: 3 Sept. 2014
GSA notified: 7 Oct. 2014

Cyrus W. Field

Corvallis, Oregon, USA
Date of death: 21 Nov. 2011
GSA notified: 17 Sept. 2014

Warren I. Finch

Lakewood, Colorado, USA
Date of death: 21 July 2014
GSA notified: 17 Sept. 2014

Robert. E. Harpster

Oakland, California, USA
Date of death: 8 Mar. 2014
GSA notified: 16 Oct. 2014

L.F. Hintze

Provo, Utah, USA
Date of death: 1 July 2014
GSA notified: 17 Sept. 2014

Karen G. Jensen

Weimar, California, USA
Date of death: 2010 (unknown month and day)
GSA notified: 19 Aug. 2014

Richard R. Kennedy

Henderson, Nevada, USA
Date of death: 9 Feb. 2014
GSA notified: 16 Oct. 2014

Maynard M. Miller

Cambridge, Massachusetts, USA
Date of death: 26 Jan. 2014
GSA notified: 11 Sept. 2014

Arthur J. Pyron

Pottstown, Pennsylvania, USA
Date of death: 30 July 2014
GSA notified: 5 Sept. 2014

Paul H. Reitan

Buffalo, New York, USA
Date of death: 30 Oct. 2011
GSA notified: 15 Oct. 2014

Mark Rich

Bogart, Georgia, USA
Date of death: 29 Sept. 2014
GSA notified: 9 Oct. 2014

Edward T. Ruppel

Twin Bridges, Montana, USA
Date of death: 27 June 2014
GSA notified: 7 Oct. 2014

Maurice L. Schwartz

Bellingham, Washington, USA
Date of death: 1 Dec. 2014
GSA notified: 23 Sept. 2014

To honor a friend or colleague with a GSA memorial, please go to www.geosociety.org/pubs/memorials/mmlGuid.htm to learn how. Contact the GSA Foundation, www.gsafweb.org, if you would like to make a gift in memory of a colleague, friend, or family member.

Call for Applications

2015–2016 GSA-USGS

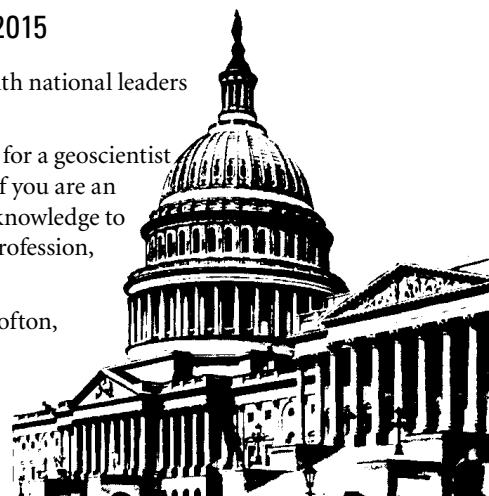
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Message from New GSA Foundation President John W. (Jack) Hess

I am pleased to begin the New Year in my role as president of the GSA Foundation. I bring with me a keen appreciation of the possibilities members and corporate and foundation partners provide for The Geological Society of America through your support of the Foundation. Every gift we receive represents a meaningful investment in programs benefiting thousands of GSA members. I look forward to building upon the impressive accomplishments of Geoff Feiss to elevate the role of the Foundation as a partner in achieving your philanthropic objectives.

A key strength of the Foundation is the commitment of its governing body, the Board of Trustees. Led by Margaret R. Eggers, the Board has shaped the Foundation into an organization achieving steadily improving performance in revenue generation, funds transferred to the Society, fiscal accountability, and transparency. I'm pleased to note that Charity Navigator (www.charitynavigator.org), an independent evaluator of charity performance, gives the Foundation a score of 85.56 out of 100 for its financial accountability and transparency. Though more difficult to measure but equally important, the spirit of collaboration between the Foundation and the Society creates a higher level of service for our members. What this means for our donors and partners is that your support is efficiently and effectively deployed to advance GSA's mission and strategic objectives.

Going forward, it is vital to continue to build a balanced mix of support from members, foundations, and corporations. Giving to the GSA Foundation reflects national trends, with 80% of charitable giving from individuals and 20% from foundations and corporations (National Philanthropic Trust: Charitable Giving Statistics for 2013, www.nptrust.org/philanthropic-resources/charitable-giving-statistics/). Support from all sources will play an increasingly essential role in providing established programs and launching and growing new initiatives like On To the Future and GSA's Geoscience Career Program.

Charitable giving to any cause is rooted in values, emotions, and experiences. The GSA Foundation looks forward to remaining your respected partner in helping realize your philanthropic support of the geosciences.



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GIVING TO THE GSA FOUNDATION

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The Geological Society of America Foundation (GSAF) secures funds for activities and programs of The Geological Society of America. GSAF is a 501(c)(3) not-for-profit corporation; tax ID# 74-215-6871.

Karst Science and The Geological Society of America

Cory W. BlackEagle, Dept. of Earth and Environmental Science, University of Kentucky

GSA'S NEW KARST DIVISION

Thanks to the efforts of a large number of people and two years of very dedicated and determined efforts, we are very pleased to announce that GSA Council approved the creation of the GSA Karst Division!

Division officers for our inaugural year are as follows:

- Chair and JTPC representative: **Cory BlackEagle**, Dept. of Earth and Environmental Science, University of Kentucky;
- 1st Vice-Chair: **Bonnie Blackwell**, Chemistry Dept., Williams College;
- 2nd Vice-Chair: **Jason Polk**, Dept. of Geography and Geology, Western Kentucky University;
- Secretary: **Penny Boston**, Dept. of Earth and Environmental Science, New Mexico Tech;
- Treasurer: **Ben Tobin**, National Park Service; and
- Webmaster and Social Media Coordinator: **Pat Kambesis**, Dept. of Geography and Geology, Western Kentucky University.

WHAT IS KARST?

Karst is a terrane¹ comprised of distinctive landforms (Fig. 1) and hydrology in which the host rock is highly soluble in the presence of naturally occurring acids. Karst terrane is an open system that contains geological, hydrological, biological, geochemical,



Figure 1. Broadway, or Main Cave, inside Mammoth Cave along the historic tour route. Photo taken from the top of the Corkscrew looking toward the Rotunda. Image courtesy National Park Service.

geomorphological, and meteorological components that interact with and upon one another both at Earth's surface and in the subsurface (Fig. 2). Connections between all components can be dynamic and operate on very short to very long time scales. Such terranes can be active and contemporary, inactive, and/or completely decoupled from current conditions. Features commonly associated with karst terrane include caves, sinkholes, springs, disappearing streams, and surface areas lacking any surface drainage or naturally occurring water bodies.

WHERE IS KARST?

In the U.S., rocks with the potential to be karstic occur in every one of the 50 states, and ~18% of their area is underlain by soluble rocks either having karst or the potential for its development (Weary and Doctor, 2014). Portions of major U.S. cities are underlain by karst (e.g., St. Louis, Missouri; Nashville, Tennessee; Birmingham, Alabama; Austin, Texas; and Louisville, Kentucky). According to Veni et al. (2001), karst terrane underlies ~25% of the global land surface. Ford and Williams (1989) estimated "that 25% of the global population is supplied largely or entirely by karst waters" (p. 6) (Fig. 3), and ~1.5 billion people live in karstic terrane.

UNDERSTANDING KARST DEVELOPMENT AND FUNCTION IS CRITICAL

Karst terrane serves as a fragile foundation for both urban and rural populations. However, for most people, karst systems are unknown or ignored, falling into the mindset of "out of sight, out of mind." Nonetheless, among karst scientists, the catch-phrase of "what goes down must come up" has long been used to summarize how water flows through karst aquifers. Perhaps even more importantly, though, this simple phrase serves as a strong warning about how easily contaminants may appear in and pollute karst wells and springs.

The world's largest springs and most productive groundwater supplies are karstic, yet water resources in karst areas are the most easily polluted. Karst hydrology and hydrogeology are complex and still confound the best efforts at modeling. Water quantity and quality can change rapidly and dramatically. Storage in karst aquifers can vary from nonexistent to time frames of thousands of years, and its character and mechanisms are still largely unknown. Contaminants can be transmitted miles from their source and re-emerge without dilution in locations completely unanticipated. Flooding in karst terrane can be extensive and dramatic.

Karst terranes are areas of exploitable and critical natural resources, such as water, limestone for building stone and aggregate, minerals, oil, and natural gas. Important oil and gas production throughout the world occurs in fields that formed in porous

¹The term "terrane" as used here is typically defined as an area or region with a distinctive stratigraphy, structure, and geological history. A specific terrane can be distinguished from neighboring terranes by its different history, either in its formation or in its subsequent deformation and/or metamorphism. The term "terrain" refers to the elevation, slope, and orientation of land features. It can be argued, therefore, that the karstic terrain (landscape) is a subset and consequence of the features and processes (stratigraphy, structure, and geologic history) that define the karst terrane in which it occurs. To describe an area of karst as "terrain" excludes the subsurface suite of geologic factors that led to its creation and critically interact with it.

THE COMPREHENSIVE KARST SYSTEM

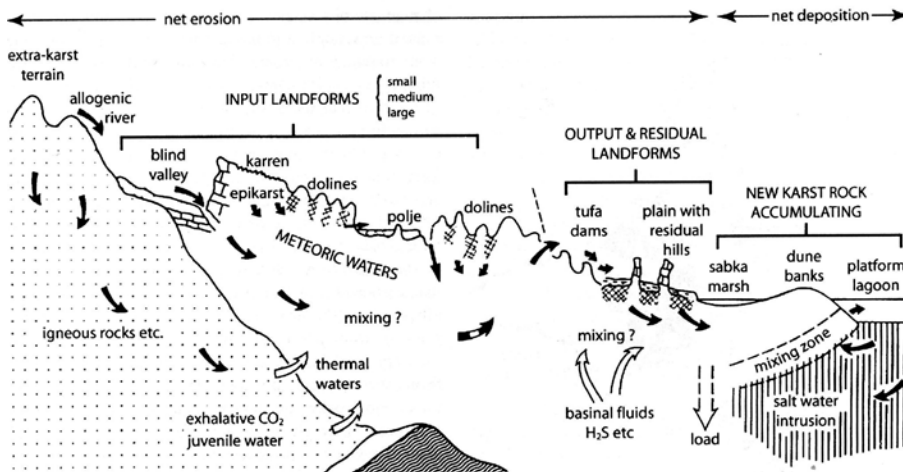


Figure 2. Diagrammatic representation of the components of the comprehensive karst system (Ford, 2006).

and permeable paleokarst reservoirs. According to Li et al. (2008), the Jingbian gas field, China, has a proven initial in-place gas reserve of ~11 trillion m³ and is the largest paleokarst carbonate gas field in China. However, paleokarst can also create numerous difficulties in exploiting such reservoirs. According to Dou and colleagues (2011), “Paleokarst systems are one of the major factors resulting in carbonate reservoir and heterogeneity” (p. 1).

Karst terrane can present hazards to life and infrastructure. Sinkholes can form without warning, causing costly damage to buildings and infrastructure, and even resulting in human death. The surface-subsurface linkage is intimate, complicated, and extremely variable spatially and temporally. Many rare and endangered flora and fauna exist solely in karst environs. Destabilization of this linkage can lead to ecosystem collapse.

Recreation opportunities in karst terrane can be a substantial source of income to area residents. For example, Mammoth Cave National Park (Kentucky, USA) generates US\$62 million annually to the south-central area of Kentucky in the form of money spent by visitors in the park and surrounding communities as well as jobs directly supported by park tourism (Carson, 2012). Mammoth Cave National Park acts as an anchor attraction in the

area that draws tourists to not only the park itself but other area attractions. As a result, cave area tourism generated US\$514 million to the region’s economy and supported 8916 jobs (Stynes, 2011). A similar story can be found at some of the other cave-centered national park units (Table 1; figures for Mammoth Cave National Park are included for comparison).

KARST SCIENCE IS COMPLEX AND MULTIDISCIPLINARY

The study of karst terranes necessarily involves a wide variety of subjects and specialties, spanning almost every division in GSA and scientific disciplines outside of GSA’s purview. These include geology, biology, microbiology, soils, environmental geology, engineering, geology, geochemistry, geophysics, structural geomorphology, archaeology, urban planning, climatology, paleoclimatology, meteorology, hydrology, speleology, and even planetary studies. Comprehensive karst studies also can require the assistance of cave explorers and mappers, cave divers, mathematicians, modelers, and computer programmers. In all cases, practitioners in each discipline bring with them their own experiences, perspectives, insights, tools, and scales of reference.

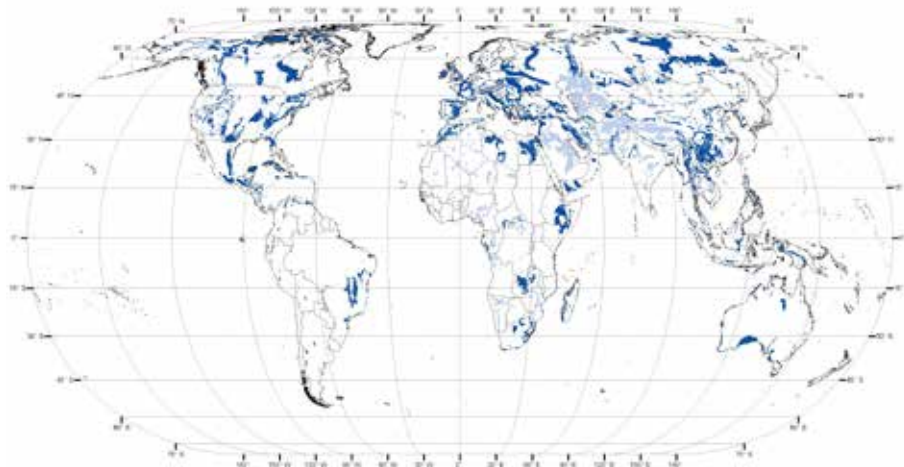


Figure 3. Approximately 25% of the global land surface is underlain by karst terrane (blue; Williams and Fong, 2010).

Table 1. Economic impact of tourism in cave-centered national park units in 2010 (Stynes, 2011)

Park	Visitors		Impacts of non-local visitor spending		
	Total	Spending	Jobs generated	Labor income	Value added
Carlsbad Caverns National Park (NM)	428,524	\$23,328,000	346	\$7,225,000	\$11,843,000
Jewell Cave National Monument (SD)	103,462	\$5,146,000	82	\$1,955,000	\$3,224,000
Mammoth Cave National Park (KY)	497,225	\$32,841,000	530	\$12,290,000	\$19,826,000
Oregon Caves National Monument (OR)	86,335	\$4,113,000	62	\$1,559,000	\$2,529,000
Russell Cave National Monument (AL)	23,374	\$1,163,000	18	\$363,000	\$589,000
Timpanogos Cave National Monument (UT)	120,241	\$7,775,000	124	\$3,647,000	\$5,996,000
Wind Cave National Park (SD)	557,141	\$51,500,000	925	\$22,350,000	\$37,231,000
Totals	1,816,302	\$125,866,000	2,087	\$49,389,000	\$81,238,000

The presence and characteristics of karst impacts a number of key scientific and infrastructure topics. Most karst studies require a multi- and inter-disciplinary approach.

- Because sediments and speleothems (mineral deposits) in caves are, in many respects, isolated from surficial processes on both short and long time scales, they provide valuable resources to study Earth's conditions recorded in them. Careful study provides information on fluctuations in regional temperature, atmospheric gases, rainfall, glaciation, sea-level change, flora, and fauna (cf. Granger et al., 2001).
- Karst terrane, like many other areas, is valuable for the economic resources it provides. The beer brewing and bourbon whiskey industries rely heavily on water from karst areas. The rock that hosts karst (e.g., limestone, dolomite, marble, gypsum, travertine, and rock salt) are quarried throughout the world. Paleokarst areas (areas containing karst that has been decoupled from the surface) contain many of the world's largest economic reserves of lead, zinc, aluminum, oil, and natural gas (cf. Barton et al., 2012, for a linkage between limestone and bourbon).
- Cave fauna, adapted to low energy and low- to no-light conditions, exist in highly specialized, unique, and extremely fragile ecosystems. Many cave species can exist in perhaps a single cave or a single region, and many are listed as rare or endangered both in the United States and worldwide. Biologists often study cave species to gain insight into ecosystem development and evolution. Further, many cave microbes are extremophiles, and studying them assists in understanding crucial geomicrobiological processes and the interplanetary search for life (cf. Engel et al., 2004). Bats, one of the most well-known species to depend on caves, eat prodigious amounts of insects on a daily basis. Boyles et al. (2011) estimate the value of bats to the agricultural industry in the continental U.S. alone to be roughly \$22.9 billion/year.
- Cave environments preserve and protect archaeological material that otherwise would have been destroyed by surface processes. As a result, many of the most important archaeological sites in the world are found in caves. For example, enjoy a virtual tour of Chauvet Cave at <http://www.culture.gouv.fr/culture/arcnat/chaudet/en/> or Husted and Edgar (2002) for an excellent example of a multidisciplinary study with archaeology at its heart.
- Due to the cavernous nature of many karst areas, infrastructure can be severely impacted by ground subsidence and

catastrophic collapse. Fortunately, deaths are rare when sinkholes form, but they can be extremely costly in terms of property damage. According to Pearson (2013), "insurance claims submitted in Florida alone between 2006 and 2010 totaled \$1.4 billion." Flooding is also a serious problem in karst terrane, and can also be extremely damaging and costly. Consequently, the ability to document the presence of karst terrane and properly design structures accordingly is crucial.

- Water is the most commonly utilized resource in karst areas, which contain some of the largest volume wells and springs in the world. Very large volumes of water are stored as groundwater in karst terrane; however, utilizing water from karst terrane is not without severe risk. Movement of water from Earth's surface into a karst aquifer is rapid and without any filtration. Whatever is on the ground will flow unmitigated into karst aquifers, making them highly susceptible to pollution (cf. Goldscheider, 2005; Jagucki et al., 2011).

WHY CREATE THE GSA KARST DIVISION?

Karst terranes have been important to distinguished GSA members since the 1890s. The *GSA Bulletin* includes landmark karst research, such as "Origin of Limestone Caverns," by William Morse Davis (1930), and "Origin and Morphology of Limestone Caves," by Arthur N. Palmer (1991). Other important research articles can be found throughout GSA's publications. For illustration, a simple search of GSA publications for any article with the word "cave" in its title or abstract resulted in 186 citations, while a similar search for the term "karst" resulted in 125 citations. These citations are spread across multiple disciplines and GSA publications, indicating a broad interest in karst within the GSA membership.

Despite this, no single division within GSA encompassed the interdisciplinary and multifaceted subject of karst. This widespread, fragile, and troublesome landscape absolutely requires a multidisciplinary forum where all aspects of karst studies can converge and share research and results. Further, there is no single organization dedicated to the scientific study of karst in the United States. The National Speleological Society does publish a journal, *Journal of Cave and Karst Studies* (formerly *The NSS Bulletin*), quarterly. However, its public persona is primarily one of cave exploration, mapping, and conservation. The American Geophysical Union has seen increased activity in karst science in recent years, with many karst scientists voicing a desire "simply to have a professional home."

GSA, with its multidisciplinary geosciences scope and large, international membership, is uniquely positioned to fill this gap, bring a prominence to karst science, and provide a scientific focal point for karst researchers across the disciplines. This step by GSA Council ensures that GSA will continue to fulfill its vision statement: "To be the premier geological society supporting the global community in scientific discovery, communication, and application of geoscience knowledge." By approving the creation of the new Karst Division, GSA may soon be able to state that it is also the premier geological society supporting the U.S. karst community.

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CALL FOR PROPOSALS

PENROSE CONFERENCES bring together multidisciplinary groups of geoscientists and facilitate an open and frank discussion of ideas in an informal atmosphere that also stimulates individual and collaborative research: www.geosociety.org/penrose/.

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RESEARCH ASSOCIATE PROFESSOR GEOHERMAL SPECIALIST (TENURE TRACK)

NEVADA BUREAU OF MINES AND GEOLOGY UNIVERSITY OF NEVADA, RENO

The Nevada Bureau of Mines and Geology (NBMG) at the University of Nevada, Reno seeks applicants with expertise in geothermal energy research. Nevada is one of the most exciting regions in the world to do research in the geosciences and one of the best in the U.S. for the study of geothermal resources.

Position Responsibilities: The primary responsibilities of this position will be to develop broad programs in research and education in the field of geothermal energy while serving as Director of the Great Basin Center for Geothermal Energy. The applicant is expected to conduct a nationally competitive research program that will include innovative approaches to understanding the complexities of fluid flow in the crust with a concentration on Nevada and the surrounding Great Basin region. The successful candidate will also be expected to contribute to the development of datasets and reports on Nevada's geothermal resources, maintain geothermal databases as part of NGDS (National Geothermal Data System), and provide state resource assessments. Education will include teaching courses in geothermal related topics in the Dept. of Geological Sciences and Engineering (DGSE), supervising graduate students, and contributing to developing a geothermal curriculum. Research and educational efforts will involve multi-departmental and multi-institutional efforts, with scientists from academia, industry, other institutions, and government labs. The successful candidate will be asked to communicate effectively with the public and community leaders regarding the geothermal resources of Nevada.

Qualifications: Applicants must have a doctorate in geology, geologic engineering, geophysics, or a related geoscience field by the time of hire and a demonstrated record of research on topics related to geothermal energy as indicated by dissertation research, industry experience, and/or peer-reviewed publications. The successful candidate must have at least 5 years of postdoctoral experience (either in industry or academia) in geothermal research in such areas as rock mechanics, 3D modeling, geophysical

techniques, reservoir engineering, and/or geochemistry. Excellent communication skills, as demonstrated in written application materials; commitment to public service; potential for, or established record of publications; and ability to attract funding are essential. The successful candidate must also have demonstrated ability to develop/coordinate programs and work in teams to accomplish major goals.

Because the individuals will be competing for funding from a variety of sources, including industry and federal agencies, for fundamental and applied geoscience research (e.g., NSF, DOE, and USGS), preference will be given to candidates who explain achievable plans for funded research on Nevada-focused topics in geothermal energy in their letters of interest. In addition, preference will be given to candidates who understand NBMG's role as the state geological survey of Nevada, especially to those who can articulate a plan of how NBMG can better serve stakeholders (citizens, government, and industry) on issues related to geothermal resources.

Salary and Date of Appointment: The position will be a tenure-track faculty appointment at the associate professor level with an academic-year base salary that is competitive with other research universities. Starting date will be July 1, 2015 or shortly thereafter, depending on availability of the successful candidate.

Application: Please submit a letter expressing your interest in the position, research plans; names, e-mail, postal addresses, and telephone numbers of at least three references; a complete vita; and electronic copies of up to three of your publications to <https://www.unrsearch.com/postings/16685>. Application deadline is March 1, 2015. For further information about NBMG, please consult our website (www.nbm.unr.edu).

The University of Nevada, Reno is committed to Equal Employment Opportunity/Affirmative Action in recruitment of its students and employees and does not discriminate on the basis of race, color, religion, sex, age, creed, national origin, veteran status, physical or mental disability, and sexual orientation. The University of Nevada employs only United States citizens and aliens lawfully authorized to work in the United States. Women and under-represented groups are encouraged to apply.

VISITING ASSISTANT PROFESSOR OF GEOLOGY, ENERGY ALLEGHENY COLLEGE

The Geology Dept. at Allegheny College invites applicants for a full-time two-year appointment in energy, starting fall 2015, with the possibility of a two-year renewal and eventual conversion to a tenure-track contract. A Ph.D. is preferred at the time of appointment but strong ABD candidates will be considered. We seek a geoscientist with demonstrated experience in an energy-related field to develop and teach one to two new courses in energy and to help shape a new interdisciplinary minor in energy and society. Our vision for this position is to provide students with rigorous technical training in energy fundamentals, grounded in the geosciences. We seek a candidate who can work with others to analyze the political, economic, and other societal facets necessary to manage properly our existing fossil fuels while we develop and implement sustainable future

energy resources. Successful candidates will have a strong commitment to liberal arts undergraduate education and will work as part of a small and active Geology departmental team. Applied work in the energy industry and/or teaching experience will be assets. The appointee will advise and work closely with undergraduate students in course work and advising, including senior research projects, and will provide evidence of excellence in teaching and ongoing scholarship. Other teaching will include physical and/or environmental geology, college-wide first-year/sophomore seminars, and/or additional Geology Dept. courses based on the expertise of the candidate and needs of the department. The teaching load will be two lab courses or three non-lab courses per semester.

Allegheny College is a highly selective private liberal arts college with a dedicated faculty of teachers-scholars. The Dept. of Geology has a tradition of high-quality undergraduate education and active involvement of students in research. Facilities include a computer lab with GIS software, Geoprobe drill rig, Rigaku Miniflex XRD, Dionex Ion Chromatograph, Perkin Elmer Flame/Furnace AAS, JEOL SEM-EDS-CL, and well-equipped instructional labs. Applicants should send electronic copies of a letter of application, teaching statement, research statement, cv, transcripts, and have three letters of reference sent to Energy Search, Dept. of Geology, Allegheny College, Meadville, PA 16335, GeoEnergySearch2015@allegheny.edu. Review of applications will begin Feb. 16, 2015. More information on Allegheny College and the Dept. of Geology may be obtained at <http://sites.allegheny.edu/geo/>. Applicant must be authorized to work in the United States to be considered. Allegheny College is an Equal Opportunity Employer, with a strong institutional commitment to develop a diverse faculty and staff. Women, veterans, and members of other under-represented groups are encouraged to apply.

ASSISTANT PROFESSOR SCHOOL OF EARTH & CLIMATE SCIENCES ENDOWED PROFESSORSHIP: PETROLOGY/MINERALOGY/HIGH P-T GEOCHEMISTRY, UNIVERSITY OF MAINE

The University of Maine invites applications for the newly established, endowed Edward Sturgis Grew Professorship in Petrology and Mineralogy in the School of Earth and Climate Sciences. This is a full-time tenure-track position with a focus on igneous and/or metamorphic petrology, geochemistry, and mineralogy. We seek a candidate who will complement the existing strengths in the Geodynamics, Crustal Studies, and Earth Rheology research group. The School of Earth and Climate Sciences has a highly interactive research and teaching environment, with staff-supported microprobe and electron microscopy laboratories. For more information on the School, please visit <http://umaine.edu/earthclimate>.

Candidates must have an earned doctorate in the discipline or a closely related field by the date of appointment, a strong research and publication record in their field, and a demonstrated commitment to teaching. Postdoctoral experience is strongly preferred but not required. The position is an academic year appointment with preferred starting date of Sept. 1, 2015. Materials must be

submitted online at <https://umaine.hiretouch.com/job-details?jobID=23153>. Review of applications will begin Jan. 15, 2015. Please e-mail esgppm@umit.maine.edu with questions about the position.

The University of Maine is an EEO/AA employer. All qualified applicants will receive consideration for employment without regard to race, color, religion, sex, national origin, sexual orientation, age, disability, protected veteran status, or any other characteristic protected by law.

**SURVEY DIRECTOR AND STATE GEOLOGIST
WISCONSIN GEOLOGICAL AND
NATURAL HISTORY SURVEY**

UNIVERSITY OF WISCONSIN—EXTENSION
Madison, Wisconsin, is home to the State Capitol, the flagship campus of the University of Wisconsin System, and the Wisconsin Geological Survey. Surrounded by lakes, our bike-friendly college town is a vibrant hub of art, music, local foods, and outdoor activities. Our city consistently ranks as a top place to live, work, and play.

The University of Wisconsin—Extension (an EEO/AA employer) is seeking a PhD-level geoscientist to serve as Survey Director and State Geologist. The Survey employs 26 professionals and has an average annual budget of \$2 million. Our academic atmosphere, focus on research and outreach, and compact size set the WGNHS apart from most geological research organizations. A complete position description is available at <http://WisconsinGeologicalSurvey.org/jobs>. **Application deadline: Feb. 28, 2015.**

**SURFACE GEOLOGIST
NORTH DAKOTA GEOLOGICAL SURVEY**

The North Dakota Geological Survey announces a permanent position opening for a geologist. Successful applicant will be responsible for generating maps and reports on the surface geology of North Dakota.

Applicants should have a master's degree in geology or a bachelor's degree in geology. Applicants must have strong written and verbal communication skills. Preference will be given to applicants with experience in the following areas; geologic surface mapping of glacial deposits or Fort Union strata, geologic hazards mapping, and delineation of sand and gravel deposits.

The successful applicant will be hired with a salary dependent upon the level of completed education and applicable experience. The State of North Dakota has very competitive health insurance and retirement plans. Deadline for applications is Jan. 30, 2015, but the position will remain open until filled.

For more information about the North Dakota Geological Survey and instructions on how to apply for this position, see <https://www.dmr.nd.gov/ndgs/>. The North Dakota Geological Survey is an Equal Opportunity Employer.

**DEPARTMENT CHAIR
GEOLOGICAL SCIENCES
THE UNIVERSITY OF TEXAS AT AUSTIN**

The Jackson School of Geosciences at The University of Texas at Austin invites applications for Chair of the Dept. of Geological Sciences. The department is composed of 58 faculty whose research focuses on processes in all parts of the Earth system and from deep time to modern day. The department and two major organized research units, the Bureau of Eco-

nomics Geology and the Institute for Geophysics, comprise the Jackson School of Geosciences. The Jackson School is ranked 8th in the nation according to U.S. News & World Report 2014.

The Jackson School is home to approximately 650 undergraduate and graduate students, averages over \$42 million in external research grants and contracts annually, and has the world's largest endowment for the geosciences. The department's scholarly, research, and teaching activities capitalize on additional strengths within the Jackson School as well as the University's Colleges of Engineering and Natural Sciences. Significant resources are available to support the mission of the Dept. of Geological Sciences.

The successful applicant is expected to be a visionary leader who will promote and enhance the department's research and educational programs. Required qualifications include significant administrative and leadership experience, ability to foster collaboration and build consensus amongst colleagues, and an internationally recognized research reputation. Appointment will be at the level of tenured Full Professor.

Applications should include a letter describing their qualifications and interest in the position. Applicants should also include a description of relevant experience and accomplishments, CV, and the names and addresses of four references (references will not be contacted without the candidate's permission).

E-mail applications to jsgchair@jsg.utexas.edu, or mail to Search Committee Chair, Office of the Dean, Jackson School of Geosciences, 2305 Speedway, Stop C1160, University of Texas at Austin, Austin, TX 78712-1692. Nominations, recommendations, expressions of interest, and inquiries should go to the same address. Review of applications will begin January 15, 2015, but applications will be accepted until the position is filled. Background check conducted on applicant selected.

The University of Texas at Austin is an Affirmative Action/Equal Opportunity Employer.

**PROFESSOR OF EARTH/ENVIRONMENTAL
SCIENCES AND DIRECTOR OF THE EARTH
RESEARCH INSTITUTE, UNIVERSITY
OF CALIFORNIA, SANTA BARBARA**

The University of California, Santa Barbara (UCSB) invites applications for the position of Full Professor and Director of the Earth Research Institute (ERI; eri.ucsb.edu). Applicants should be internationally acclaimed scholars whose area of research falls within one or more of ERI's five research clusters (Earth System Science, Earth Evolution, Natural Hazards, Human Impacts on the environment, and Environmental Informatics). The successful candidate is expected to continue his/her internationally recognized, extramurally funded research program, mentor graduate and undergraduate students, participate in on-going graduate and undergraduate teaching programs, and direct the Earth Research Institute. See <https://recruit.ap.ucsb.edu/apply/JPF00416> for more information and to submit applications. Review of applicants will begin Feb. 2, 2015 and will continue until the position has been filled. The start date of the position is July 1, 2016. UCSB is an Equal Opportunity Affirmative Action Employer. All qualified applicants will receive consideration for em-

ployment without regard to race, color, religion, sex, national origin, or any other characteristic protected by law including protected Veterans and individuals with disabilities.

**ASSISTANT PROFESSOR FOR
STRUCTURAL GEOLOGY/PETROGRAPHY/
MINERALOGY, HOFSTRA COLLEGE OF
LIBERAL ARTS AND SCIENCES
DEPT. OF GEOLOGY, ENVIRONMENT, AND
SUSTAINABILITY, HOFSTRA UNIVERSITY**

The Dept. of Geology, Environment, and Sustainability of Hofstra University invites applications for an anticipated tenure-track position at the assistant professor level beginning Sept. 1, 2015.

We seek candidates with expertise in at least two of the following areas: Structural Geology, Petrography, Tectonics, Mineralogy, Geological Mapping, or Medical Geology. Candidates must be committed to excellence in undergraduate teaching and mentoring undergraduate students in research. The successful candidate will be expected to teach one introductory level and one advanced undergraduate course per semester. The advanced courses we require are integrated lecture and laboratory courses providing instruction in structural geology, petrography/petrology/mineralogy, and additional topics of interest to the candidate that complement existing course offerings in the department. Our department has an emerging focus on the Anthropocene. Candidates able to relate their research and teaching to anthropogenic planetary change or sustainability are especially encouraged to apply. The ability to develop and implement field-based courses and field trips utilizing the geology of the New England and Middle Atlantic region is also highly desired. We are looking for a dynamic individual who combines excellence in teaching with breadth and versatility in professional productivity, and who shares our commitment to close student-faculty interaction, including a vigorous program of local field trips, student involvement in faculty research, and professional activities. Applicants should have their Ph.D. completed by Sept. 2015.

Hofstra University is located in suburban Long Island, New York, about 25 miles from Manhattan. The University occupies a beautiful 240 acre campus that is also a registered arboretum and enrolls 8,000 full-time undergraduates and 4,000 graduate and part-time students. For more information about the department and Hofstra University, visit www.hofstra.edu/Academics/Colleges/HCLAS/GEOL/index.html.

Please send a letter of introduction discussing your teaching and research interests, a curriculum vitae, and a list of references to Dr. J Bret Bennington, Chair, Dept. of Geology, Environment, and Sustainability, 114 Hofstra University, Hempstead, NY 11549-1140, e-mail: j.b.bennington@hofstra.edu.

Jan. 31, 2015 is the deadline for receipt of applications.

Hofstra University is an equal opportunity employer, committed to fostering diversity in its faculty, administrative staff and student body, and encourages applications from the entire spectrum of a diverse community.

TWO TENURE-TRACK POSITIONS AT TEXAS TECH UNIVERSITY

The Dept. of Geosciences at Texas Tech University seeks applicants for two assistant professor, tenure-track positions. A PhD in an Earth Science (or closely related) discipline at time of appointment is required.

Position 1 focuses on **sedimentary systems** with an emphasis on one or more of clay mineralogy, diagenesis, mudstones, carbonate petrology and reservoir characterization. A letter of application, including names of three referees, short statements of research and teaching philosophies, and vita can be uploaded online at [www.texastech.edu/careers/requisition #2209BR](http://www.texastech.edu/careers/requisition#2209BR). Questions should be sent to Dr. Paul Sylvester, Search Committee Chair: paul.sylvester@ttu.edu.

Position 2 focuses on **seismology**, emphasizing the imaging of crustal features (from shallow sedimentary and structural studies to investigation of crustal scale tectonic features). A letter of application, including names of three referees, short statements of research and teaching philosophies, and vita can be uploaded online at [www.texastech.edu/careers/requisition #2211BR](http://www.texastech.edu/careers/requisition#2211BR). Questions should be sent to Dr. Harold Gurrola, Search Committee Chair: harold.gurrola@ttu.edu.

Candidates with strong records of scholarship and who have the proven capacity or clear potential to bring externally sponsored research to Texas Tech University are encouraged to apply. Teaching duties include graduate and undergraduate courses in the candidate's specialty. The department (www.geosciences.ttu.edu) has active research specialties in Geology, Geophysics, Geochemistry, Geography, and Atmospheric Science. Texas Tech is located in Lubbock on the edge of the Permian Basin. The region appreciates the social and economic importance of geology and geophysics knowledge due to the importance of petroleum and groundwater to the Texas economy. Service duties include program-building, as well as commitment to extra-curricular activities. Service to the department, college, and university is expected.

As an Equal Employment Opportunity/Affirmative Action employer, Texas Tech University is dedicated to the goal of building a culturally diverse faculty committed to teaching and working in a multicultural environment. We actively encourage applications from all those who can contribute, through their research, teaching, and/or service, to the diversity and excellence of the academic community at Texas Tech University. The university welcomes applications from minorities, women, veterans, persons with disabilities, and dual-career couples. Evaluation of candidates will begin Jan. 30, 2015.

ASSISTANT PROFESSOR OF GEOLOGY IN IGNEOUS AND METAMORPHIC PETROLOGY, CALIFORNIA STATE UNIVERSITY, SAN BERNARDINO

The Dept. of Geological Sciences at California State University, San Bernardino invites applicants for a tenure-track position at the Assistant Professor level starting Sept. 2015. A Ph.D. is strongly preferred at

time of appointment; strong ABD candidates may be considered. The successful candidate will have demonstrated strength in the general area of igneous and metamorphic petrology. Courses to be taught could include mineralogy, optical mineralogy, igneous and metamorphic petrology, geochemistry, elective courses in the candidate's field of specialization, as well as a general education course in geology and an upper division capstone course in earth sciences. The appointee will be expected to advise and work closely with undergraduate students in senior research projects and with graduate students in the Earth and Environmental Sciences MS program. The appointee will provide evidence of excellence in teaching and ongoing scholarship, especially in the area of combining geologic field methods with laboratory approaches. The department strongly supports increasing diversity in both student and faculty populations; under-represented minorities, women and veterans are strongly encouraged to apply. For more information about the department, please visit <http://geology.csusb.edu>.

Applications must be submitted electronically using <http://agency.governmentjobs.com/csusb/default.cfm?transfer=1> and must include a cover letter, a curriculum vitae, recent transcripts (official transcripts will be required pending an offer), statements of research/professional accomplishments and goals, and teaching philosophy and strategies, together with the names and complete contact information of at least three references. Review of the applications will begin Jan. 12, 2015, and will continue until position is filled. Inquiries about this position may be directed to Dr. Alan L. Smith (e-mail: alsmith@csusb.edu).

California State University, San Bernardino is an Affirmative Action/Equal Opportunity Employer. We consider qualified applicants for employment without regard to race, color, religion, national origin, age, gender, gender identity/expression, sexual orientation, genetic information, medical condition, marital status, veteran status, or disability.

ASSISTANT, ASSOCIATE OR FULL PROFESSOR, STRUCTURAL GEOLOGY/ TECTONICS, SCHOOL OF THE ENVIRONMENT WASHINGTON STATE UNIVERSITY

Position #119909

Washington State University (WSU) is currently seeking to fill a tenure-track/tenured Assistant, Associate or Full Professor position in the area of Structural Geology/Tectonics. This position is a permanent, 9-month faculty position located on the Pullman Campus. This position is part of a multi-year series of new hires intended to contribute to the growth and development of the School of the Environment, an interdisciplinary academic unit at WSU that focuses on Earth, Water, and the Environment. Duties include developing and teaching undergraduate and graduate courses and mentoring MS and PhD graduate students. The successful candidate will develop an internationally recognized research program in structural geology/tectonics. Specific areas of emphasis within this broad field are open, but we are particularly interested in candidates who will develop an externally funded research program that includes a strong field-based component.

Required: Assistant Professor: Earned doctorate in a discipline related to structural geology and tectonics, at time of employment; record of research accomplishments as demonstrated by peer-reviewed publications and/or extramural grantsmanship; demonstrated ability and/or potential to successfully teach and mentor students at the graduate and undergraduate levels. Associate Professor: in addition, 6 years of experience as an Assistant Professor or equivalent. Professor: in addition, 6 years of experience as an Associate Professor or equivalent, and national/international reputation in their field.

Preferred: Demonstrated ability to develop collaborations; teach field camp and other field-based courses; lead field trips at the undergraduate and graduate level; and develop a strong field-based research component.

For questions about the position contact Jeff Vervoort at (509) 335-5597; vervoort@wsu.edu.

To apply visit: <https://www.wsujobs.com>. Application materials must include a letter describing how your experience and training meet qualifications for the position, a research plan, a statement of teaching philosophy, current vitae, and names and contact information for three professional references. Screening begins January 6, 2015. EEO/AA/ADA.

ENVIRONMENTAL BIOGEOCHEMISTRY/ GEOBIOLOGY, DARTMOUTH COLLEGE

The Dept. of Earth Sciences at Dartmouth College invites applications for a junior rank tenure-track position in the general areas of biogeochemistry and geobiology. We especially welcome applications from candidates with research interests that include microbially-mediated biogeochemical interactions in processes of mineralization, weathering, and sequestration of contaminants; hydrocarbon formation and degradation; biogeochemical cycling in fluvial and/or cold environments, including river-channel, floodplain, and lacustrine ecosystem response to environmental change. Particular attention will be given to candidates who combine a focus on understanding fundamental processes with state-of-the-art laboratory and/or field research programs that complement and contribute to ongoing research activities in the department as well as in Dartmouth's Geisel School of Medicine and Thayer School of Engineering. The successful candidate will continue Dartmouth's strong traditions in graduate and undergraduate research and teaching. Teaching responsibilities consist of three courses spread over three of four ten-week terms.

The Dept. of Earth Sciences is home to 11 tenured and tenure-track faculty members in the School of Arts and Sciences, and enjoys strong Ph.D. and M.S. programs and outstanding undergraduate majors. To create an atmosphere supportive of research, Dartmouth College offers new faculty members grants for research-related expenses, a quarter of sabbatical leave for each three academic years in residence, and flexible scheduling of teaching responsibilities.

Dartmouth College, a member of the Ivy League, is located in Hanover, New Hampshire (on the Vermont border). Dartmouth has a beautiful, historic campus located in a scenic area on the Connecticut River. Recreational opportunities abound all year round. To learn more about Dartmouth

College and the Dept. of Earth Sciences, visit www.dartmouth.edu/~earthsci.

To submit an application, send curriculum vitae, statements of teaching and research interests and objectives, reprints or preprints of up to three of your most significant publications, and the name, address (including street address), e-mail address and fax/phone numbers of at least three references to Environmental Biogeochemistry/Geobiology Search Committee, Dept. of Earth Sciences, Dartmouth College 6105 Fairchild Hall, Hanover, NH 03755, e-mail: earth.sciences@dartmouth.edu.

Applications received by Nov. 7, 2014 will receive first consideration. The appointment will be effective July 1, 2015.

Dartmouth is an equal opportunity/affirmative action employer with a strong commitment to diversity. In that spirit, we are particularly interested in receiving applications from a broad spectrum of people, including women, persons of color, persons with disabilities, veterans, or any other legally protected group.

Scholarship Opportunities

Jonathan O. Davis Scholarship, University of Nevada, Reno. The Jonathan O. Davis Scholarship supports graduate students working on the Quaternary geology of the Great Basin. The national scholarship is \$5,000 and the University of Nevada, Reno, stipend is \$1,500. The national scholarship is open to graduate students enrolled in an M.S. or Ph.D. program at any university in the United States. The Nevada stipend is open to graduate students enrolled in an M.S. or Ph.D. program at the University of Nevada, Reno. Details on application requirements can be found at www.dri.edu/GradPrograms/Opportunities/JonathanDavis. Applications must be post-marked by Feb. 17, 2015. Proposal reviews will not be returned. Applications should be addressed to Executive Director Division of Earth and Ecosystem Sciences Desert Research Institute 2215 Raggio Parkway Reno, NV, 89512.

Opportunities for Students

Graduate Student Funding Opportunities in Climatology, Geology, Geography, and Marine Science and Policy. The College of Earth, Ocean, and Environment (CEOE) at the University of Delaware is pleased to announce the availability of graduate student funding for Master's and Doctoral students interested in Marine Science and Policy, Geological Sciences, and Geography. Graduate students in these programs tackle complex environmental challenges by applying the latest technological advances to ocean, earth, and atmospheric research using high-tech satellite images, surface and underwater sensors, laboratory instrumentation, and complex computer models to help enhance climate predictions, identify and mitigate pollution, improve resource management, explore energy solutions, make marine transportation safer and more efficient, and examine the relationships between humans and the environment. Our students also are using innovative tools to better understand our valuable biological resources, investigate populations, life histories and habitats, and determine the natural and human factors affecting their survival. Eligible students

could be funded through various opportunities including fellowships, research assistantships, teaching assistantships, and tuition scholarships. Funding opportunities typically cover stipends for tuition for fall and spring semesters. Interested students should visit www.ceoe.udel.edu to learn more about the specific degrees offered within the college and available research projects with nationally ranked faculty who serve as graduate student advisor. Students who apply and are being considered for admission will be invited for a paid visit to our campus to meet with faculty and current graduate students. For more information visit www.ceoe.udel.edu or e-mail ceoe-academics@udel.edu.

Graduate Assistantships at University of Nevada Las Vegas. Research assistantships are available for M.S. and Ph.D. students interested in studying high pressure deformation of earth materials. Projects involving microstructural studies, numerical modelling and experimental work are available. In addition to participating their home department (Geoscience) students will be part of the High Pressure Science and Engineering Center, which provides a highly interdisciplinary environment, exposing students to perspectives and experimental techniques from disciplines including solid state physics and chemistry, high pressure physics and materials science and as well as geoscience. Candidates should apply to the UNLV program in geosciences at http://geoscience.unlv.edu/graduate_program.html. All application materials must be received by Feb. 1, 2015. For more information please contact Dr. Pamela Burnley, High Pressure Science and Engineering Center, University of Nevada, Las Vegas, Box 454010, 4505 Maryland Parkway, Las Vegas, NV 89154-4010, burnley@physics.unlv.edu.

Graduate Assistantships, Indiana State University. The Dept. of Earth & Environmental Systems at Indiana State University has graduate assistantships available for students wishing to pursue an MS degree in Earth and Quaternary Sciences or a Ph.D. in our Spatial & Earth Sciences Program. The department offers an exciting field- and laboratory-intensive curriculum emphasizing environmental geology and geochemistry, paleolimnology, geoarchaeology, surface processes, paleoecology, geobiology, dendrochronology, GIS/remote sensing, micropaleontology, paleoceanography, marine geology, biogeochemistry, climatology, and paleoclimatology. The department supports a number of state-of-the-art laboratory facilities, and our faculty members are committed to providing students with hands-on learning experiences. Application review begins immediately and preference is given to applications received before Feb. 1, 2015. Application information and requirements can be obtained by visiting www.indstate.edu/ees. For more information contact Dr. Anthony Rathburn, Dept. of Earth & Environmental Systems, Indiana State University, Terre Haute, IN, 47809, tony.rathburn@indstate.edu

Graduate Assistantship Opportunities at Indiana University-Purdue University Indianapolis (IUPUI). With broad expertise in applied geosciences and particular strengths in geochemistry, IUPUI's Earth Sciences department provides opportunities

for graduate training and research in the heart of downtown Indianapolis. We offer an M.S. in Geology and a Ph.D. in Applied Earth Sciences. The Ph.D. program provides opportunities for advanced interdisciplinary research at the interface of earth sciences, public health, and geospatial analysis, and will prepare graduates for tackling interdisciplinary problems of the 21st century. Given the interdisciplinary nature of this program, we welcome individuals with backgrounds in Geology, Environmental Science, Chemistry, Biology, Physics, Engineering, Medical or Mathematics and who have an interest in working on earth and environmental science issues. Several new state-of-the-art geochemistry labs have been built and equipped with stable isotope ratio mass spectrometers, cavity ring down spectrometers, GC-MS, ICP-MS, ICP-OES, electrochemical equipment, chromatographs (IC, HPLC, GC), spectrometers, XRD, multisensor core scanner, and a full suite of chemical and biological lab and field equipment. Assistantships include salary, tuition remission, and health insurance. Visit <http://earthsciences.iupui.edu/graduate/degrees> for more information on our graduate degrees, or contact Dr. Pierre Jacinth for general inquiries at pjacinth@iupui.edu

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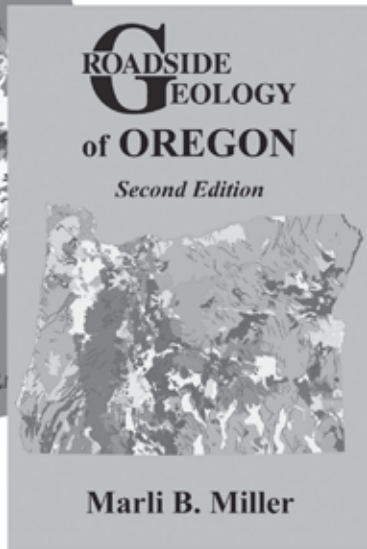
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2015 Section Meeting Calendar



Chattanooga, Tennessee, USA.
Photo courtesy of the Chattanooga Convention and Visitors Bureau.

SOUTHEASTERN

19–20 March

Chattanooga, Tennessee, USA

Early registration deadline: 17 Feb. 2015



Karston Creek, Oklahoma, USA.
Image courtesy Stillwater Convention and Visitors Bureau.

SOUTH-CENTRAL

19–20 March

Stillwater, Oklahoma, USA

Early registration deadline: 17 Feb. 2015



Mount Washington Resort, Bretton Woods, New Hampshire, USA.
Image courtesy Mount Washington Resort.

NORTHEASTERN

23–25 March

Bretton Woods, New Hampshire, USA

Early registration deadline: 17 Feb. 2015



Anchorage, Alaska, USA. Photo by Jody Overstreet, courtesy Visit Anchorage.

CORDILLERAN

11–13 May

Anchorage, Alaska, USA

Abstracts deadline: 10 Feb. 2015



Madison, Wisconsin, USA. Photo courtesy GMCVB.

NORTH-CENTRAL

19–20 May

Madison, Wisconsin, USA

Abstracts deadline: 17 Feb. 2015



Dee the Mammoth, Casper College Tate Museum. Photo courtesy Visit Casper.

ROCKY MOUNTAIN

21–23 May

Casper, Wyoming, USA

Abstracts deadline: 17 Feb. 2015

SCIENCE EDITOR

OPENINGS FOR 2016

GSA is soliciting applications and nominations for science co-editors for GSA books, GSA maps and charts, *GSA Bulletin*, *Geology*, and *Lithosphere* with four-year terms beginning 1 January 2016. Duties include: ensuring stringent peer review and expeditious processing of submissions; making final acceptance or rejection decisions after considering recommendations of reviewers; and maintaining excellent content through active solicitation of diverse and definitive manuscripts, books, or maps.

POSITIONS AVAILABLE

GSA BOOK EDITORS' duties include soliciting high-quality book proposals as well as ensuring that proper peer review procedures have been followed by volume editors. In the case of authored volumes, book editors handle the entire peer-review process. The successful candidate will have a wide range of interests and expertise, prior editing experience, and a strong publication record.

MAPS AND CHARTS The GSA maps and charts editor reviews proposals for printed and digital maps and handles the peer review of submitted maps (and accompanying manuscripts in some cases). The successful candidate will have a wide range of interests and expertise in mapping techniques and standards.

GSA BULLETIN Research interests that best complement those of the continuing editors: Quaternary geology; geomorphology; volcanology; low-T geochemistry; thermochronology; structural geology; biogeochemistry; geobiology; paleobiology

LITHOSPHERE Research interests that best complement those of the continuing editors: Quaternary processes; tectonic geomorphology; low-T thermochronology; neotectonics; geochronology; isotope geochemistry

GEOLOGY Research interests that best complement those of the continuing editors: volcanology; petrology; sedimentology; geochemistry; (paleo)climate/atmosphere/(paleo)oceans; paleontology/geobiology; planetary geology; hydrology; geophysics

GSA Books ▶ 1 position

Maps & Charts ▶ 1 position

GSA Bulletin ▶ 1 position

Lithosphere ▶ 1 position

Geology ▶ 2 positions

A SUCCESSFUL EDITOR WILL HAVE

- ▶ a broad interest and experience in geosciences, including familiarity with new trends;
- ▶ international recognition and familiarity with many geoscientists and their work;
- ▶ a progressive attitude and a willingness to take risks and encourage innovation;
- ▶ experience with online manuscript systems (journals) and the ability to make timely decisions; and
- ▶ a sense of perspective and humor.

INTERESTED?

- ▶ Please submit a curriculum vitae and a letter describing why you are suited for the position to Jeanette Hammann, jhammann@geosociety.org.
- ▶ To nominate another, submit a nomination letter and the person's written permission and CV.

Editors work out of their current locations at work or at home. GSA provides an annual stipend and funds for office expenses. Nominations or applications received by 1 February 2015 will be given first consideration.