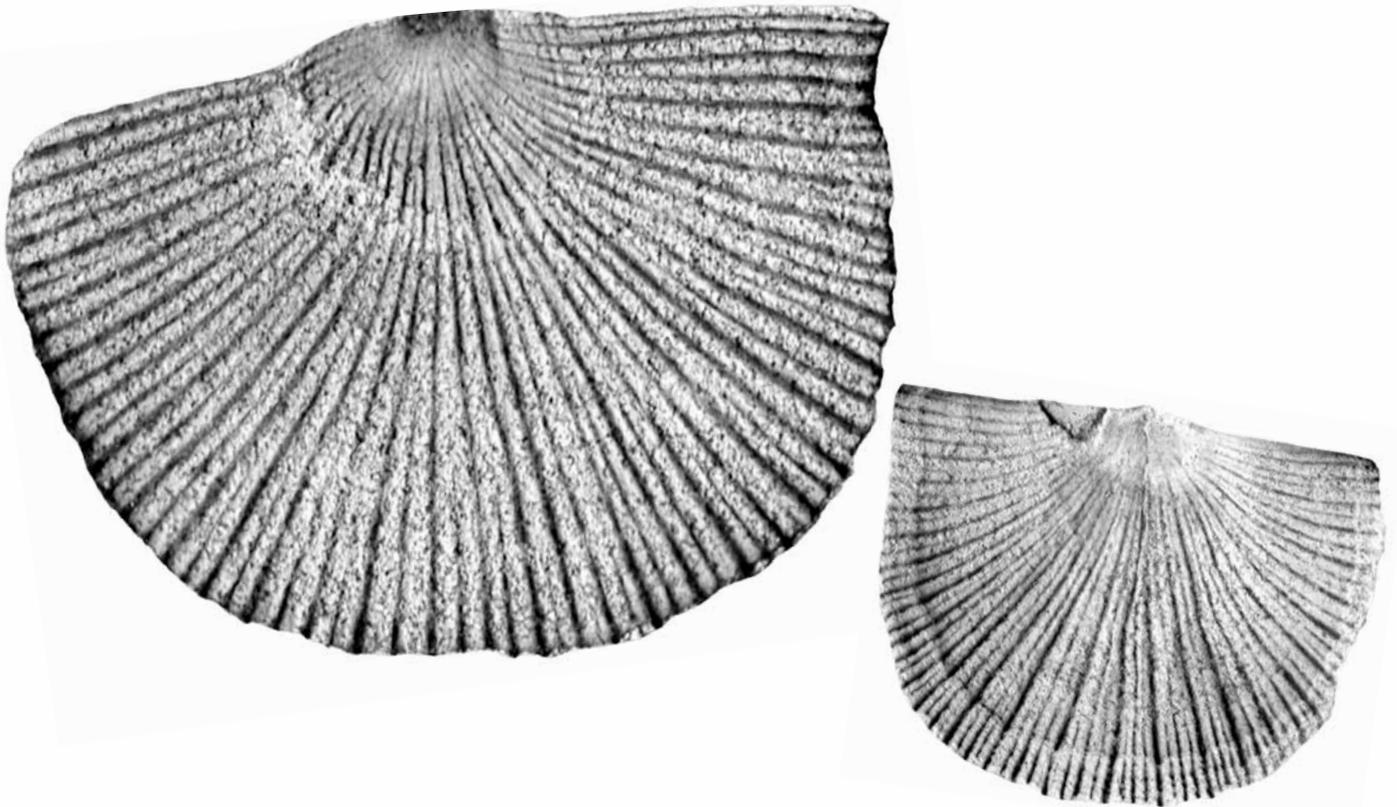


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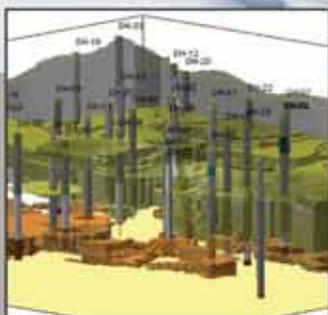
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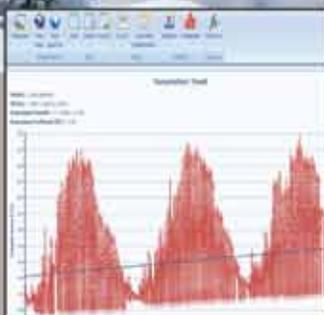


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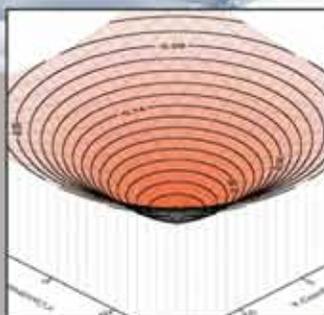
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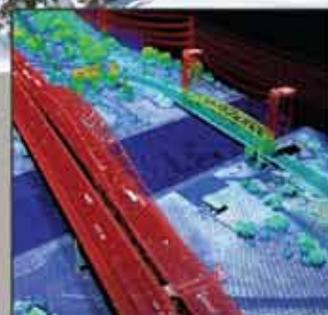


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GSA TODAY STAFF

Executive Director and Publisher: John W. Hess

Science Editors: Bernie Housen, Western Washington Univ. Geology Dept. (ES 425) and Advanced Materials Science and Engineering Center (AMSEC), 516 High Street, Bellingham, WA 98225-9080, USA, bernieh@wwu.edu; R. Damian Nance, Ohio University Dept. of Geological Sciences, 316 Clippinger Laboratories, Athens, OH 45701, USA, nance@ohio.edu

Managing Editor: K.E.A. "Kea" Giles, kgiles@geosociety.org, gsatoday@geosociety.org

Graphics Production: Margo McGrew

Advertising (classifieds & display): Ann Crawford, +1-800-472-1988 ext. 1053; +1-303-357-1053; Fax: +1-303-357-1070; advertising@geosociety.org; acrawford@geosociety.org

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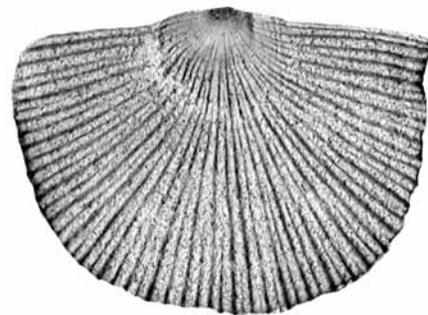
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4 Speciation collapse and invasive species dynamics during the Late Devonian "Mass Extinction"

Alycia L. Stigall

Cover: Ventral valve of *Floweria chemungensis* (Conrad, 1842) (specimen AMNH 37157b) from the Chemung Group of New York, USA. This was a long-lived species in the Late Devonian. Although native to eastern North America, *F. chemungensis* participated in a westward invasion event in the mid-Frasnian and subsequently colonized the New Mexico region. See related article, p. 4–9.



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Speciation collapse and invasive species dynamics during the Late Devonian “Mass Extinction”

Alycia L. Stigall, Dept. of Geological Sciences and Ohio Center for Ecology and Evolutionary Studies, Ohio University, Athens, Ohio 45701, USA, stigall@ohio.edu

ABSTRACT

The Late Devonian (Frasnian-Famennian) interval includes one of the most dramatic intervals of biotic turnover in the Phanerozoic. Statistical evaluation of diversity change reveals that the primary cause of biodiversity decline was reduced speciation during the crisis interval, not elevated extinction rates. Although various hypotheses have been proposed to explain extinction increase during the Late Devonian, potential causes for reduced speciation have previously been largely unaddressed. Recent analyses focusing on biogeographic and phylogenetic patterns of species in shallow marine ecosystems of Laurentia indicate that a dramatic increase in interbasinal species invasions, facilitated by transgressive pulses, fundamentally affected biodiversity by enabling range expansion of ecological generalists and eliminating vicariance, the primary pathway by which new species typically form. Modern species invasions may result in similar speciation loss, exacerbating the current biodiversity crisis.

INTRODUCTION

A dramatic interval of biodiversity loss and ecosystem reorganization occurred at the boundary between the Frasnian and Famennian stages of the Late Devonian Period (ca. 375 Ma). This event was originally considered to rank among the “Big Five” mass extinction events in the Phanerozoic (Raup and Sepkoski, 1982), and it is still listed as the “Frasnian-Famennian Mass Extinction” in most introductory and historical geology textbooks. The designation of “mass extinction,” however, is misleading because the Frasnian *extinction* rate was neither elevated relative to the Middle Devonian nor statistically higher than the background rate of extinction throughout the Phanerozoic (Bambach et al., 2004; Alroy, 2008). Rather, an anomalously low rate of *speciation*, the origination of new species, was the primary cause of this decline in biodiversity (Bambach et al., 2004).

Global standing biodiversity is controlled equally by the number of new species forming and the number of species becoming extinct during an interval. All episodes of biodiversity loss require that extinction rate exceeds speciation rate. For an event to be classified as *bona fide* mass extinction, however, the extinction rate of the crisis interval must statistically exceed both the background extinction rate of the Phanerozoic and be elevated above that of the adjacent stages. Biodiversity crises occur when speciation rates have a statistically significant decline compared to the background rate while extinction rates remain within the limits of statistical normal. Reduced speciation rate combined

with slightly elevated extinction levels can result in a dramatic biodiversity crisis, and this is what transpired during the Late Devonian. The Frasnian-Famennian event is, therefore, better termed a “biodiversity crisis” than a “mass extinction.”

The shift in status of the Frasnian-Famennian event from a “mass extinction” to a “biodiversity crisis” does not imply a reduction in the severity of the effects on global ecosystems. In fact, the level of marine ecosystem reorganization that occurred during the Late Devonian, including a fundamental collapse of the reef ecosystem, is second only to the Permo-Triassic mass extinction (McGhee et al., 2004). The Middle Devonian included the most geographically widespread metazoan reef ecosystem in Earth’s history, but its extent was reduced by a factor of 5000 following the crisis interval (Copper, 1994). Other biotic changes included the spread of cosmopolitan species facilitated by rampant species invasions documented across many clades (reviewed in McGhee, 1996).

A series of local and global environmental changes occurred coincident with biotic overturn. These included changes related to the development of complex forest ecosystems on land, such as eutrophication and alteration of terrestrial weathering patterns (Algeo and Scheckler, 1998), high frequency sea-level changes (ver Straeten et al., 2011), widespread anoxia events (Buggisch and Joachimski, 2006), overall warming of the global oceans (van Geldern et al., 2006), and pulses of enhanced carbon burial that resulted in rapid cooling events at the Frasnian-Famennian boundary (van Geldern et al., 2006; also see reviews in McGhee, 1996, 2005; Racki, 2005). Most of these environmental factors (and various combinations of them) have been proposed as drivers for the “mass extinction.” Theoretically, abrupt or even gradual changes in environmental conditions could result in increased extinction of species because extinction occurs when members of a species can no longer cope with changing environmental conditions (abiotic or biotic) and population size decreases to zero. These environmental factors are undoubtedly involved with ecosystem degradation and certainly contributed to the observed elevation of extinction levels.

None of these abiotic changes, however, supply a satisfactory explanation for speciation collapse because they do not directly impact the speciation process. In order to better understand the ecological crisis during the Late Devonian, the mechanisms of speciation decline must be examined. A speciation event is a unique episode in geologic time that transpired at a discrete geographic location within a specific lineage of organisms. Identifying causal factors for speciation decline requires both a detailed *temporal and geographic framework* and robust hypotheses of *ancestor-descendant relationships* (Benton and Pearson, 2001). This type of detail is only available in clades for which species-level phylogenetic hypotheses have been generated. Therefore, speciation analysis requires a fundamentally different and more

detailed dataset than analyses of potential extinction mechanisms. Although the significance of speciation reduction during this interval has been known for more than 25 years (McGhee, 1984), sufficiently resolved phylogenetic data have only recently become available to assess changes in speciation mode across the Middle to Late Devonian interval. Significantly, recent analyses discussed herein indicate that the widespread extra-basinal migrations of species (analogous to modern invasive species) during the Late Devonian facilitated speciation decline by preventing geographic isolation, the primary process by which new species arise.

ORIGINATION AND SPECIATION RATE ANALYSES

The importance of reduced origination in driving Frasnian diversity decline was first recognized by McGhee (1984) from analyses of genera of articulate brachiopods from Catskill delta complex of eastern North America and from the Ural Mountains. Subsequent analyses (e.g., Foote, 1994; Bambach et al., 2004; Alroy, 2008) using stratigraphic range data for marine invertebrate families and genera culled from global compendia confirmed that reduced origination was the primary driver of biodiversity collapse (Fig. 1A). Certainly, patterns of biodiversity change were not congruent across all clades. Some previously prolific clades, such as the atrypid brachiopods, experienced high extinction rates, while other clades, including the crinoids, radiated to effect a pronounced change in post-crisis shallow marine ecosystems (see discussion in Racki, 2005). However, the general pattern of depressed origination—but only moderately elevated extinction rates—documented in cross-faunal database analyses is robust to variations in sampling procedures, rate metric used, taxonomic level (family vs. genus) analyzed, or database employed (Foote, 1994; Bambach et al., 2004; Alroy, 2008). This supports depressed origination as a primary driver of Late Devonian biodiversity loss.

From a biological standpoint, the most appropriate taxonomic level to assess reduced origination is the species level. Species are biological entities that are defined by attributes related to reproductive cohesion in both time and space (deQueiroz, 2007). Therefore, analysis of origination at the species level equates to examination of actual biological processes, whereas generic and familial analyses are increasingly distant proxies. Species-level phylogenetic hypotheses, which include an evolutionary framework to constrain timing of speciation events, are necessary to calculate the most accurate speciation rates (Smith, 1994). Unfortunately, very few species-level phylogenies have been published with substage temporal resolution for Late Devonian clades (e.g., Rode, 2004; Stigall Rode, 2005).

Stigall (2010a) utilized recently published species-level phylogenetic hypotheses of Rode (2004) and Stigall Rode (2005) for three Late Devonian clades (two articulated brachiopod genera and one bivalve subgenus), primarily from North America, to examine whether reduced origination was also significant at the species level. These clades serve as a reasonable proxy for shallow marine biota of Laurentia because these monophyletic lineages had excellent preservation potential, include common members of the shallow marine benthos, and their combined fifty species inhabited the full suite of nearshore to offshore marine environments. Results are consistent with the earlier analyses based on higher taxa (Fig. 1B). Overall biodiversity plummeted during the Frasnian crisis interval, and this change was driven

primarily by speciation loss (Stigall, 2010a). Late Frasnian extinction rates, while moderately elevated, do not exceed pre-crisis levels for any clade and are not statistically higher during the crisis interval than the average value for each rate over the duration of the clade (Stigall, 2010a).

The combination of species, generic, and family-level analyses firmly establishes the loss of speciation as a fundamental driver for biodiversity loss during the Late Devonian, at least among shallow marine taxa where the crisis was most pronounced. Examining the process of speciation and the factors that promote or hinder that process is, therefore, required to identify causal factors for the crisis.

SPECIATION MODE ANALYSIS

Investigating the cause of speciation collapse during the Late Devonian first requires determining which speciation mechanisms were compromised during the crisis interval. Speciation requires a group of organisms to become reproductively isolated from its ancestral population in order to establish a new biological entity. This isolation typically occurs via

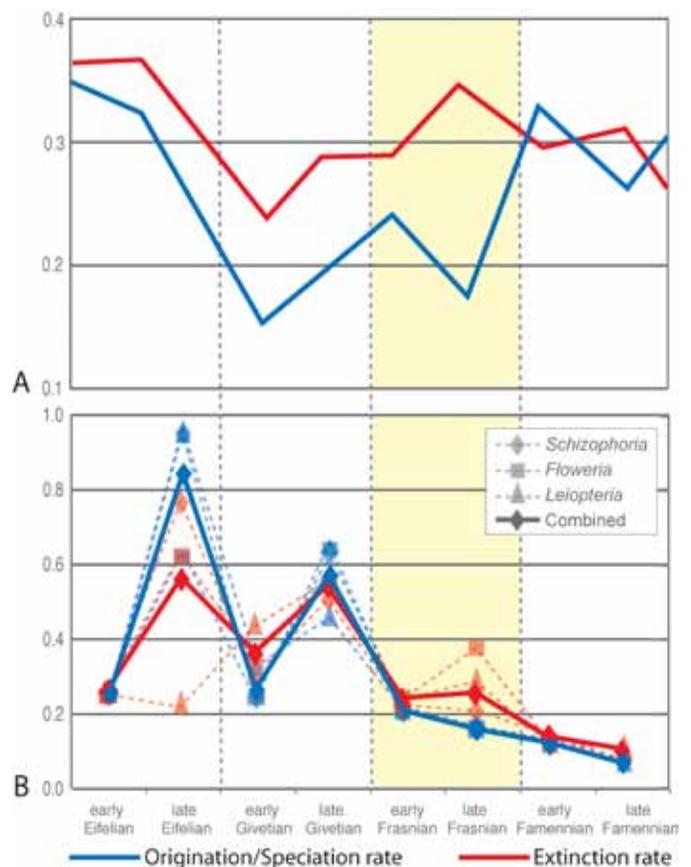


Figure 1. Comparison of extinction versus origination/speciation across the Middle to Late Devonian interval. Late Devonian Biodiversity Crisis interval is indicated in yellow. (A) Proportion of generic extinction or origination per interval. Modified from Bambach et al. (2004). (B) Instantaneous rates of species extinction and speciation for two brachiopod genera (*Schizophoria* and *Floweria*), one bivalve genus (*Leiopteria*), and all three clades combined. Modified from Stigall (2010a). Similar patterns occur at both taxonomic levels: Origination/speciation rates are substantially reduced during the crisis interval, but extinction rates are lower than during the Middle Devonian background interval.

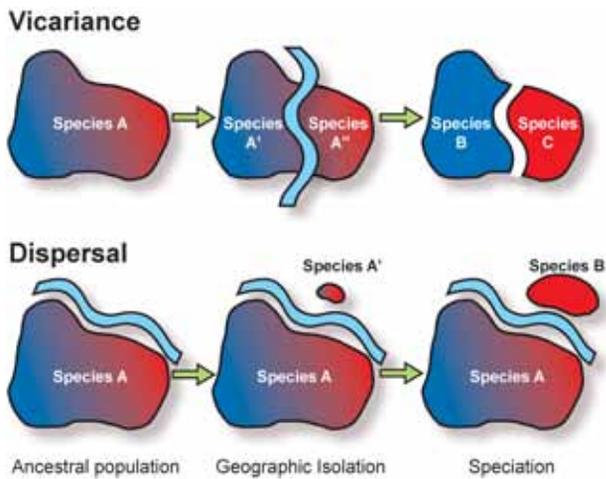


Figure 2. Geography of allopatric speciation modes. In vicariance, the ancestral population (Species A) is passively divided by a geographic barrier. Incipient species (Species A' and A'') form during geographic isolation and later diverge to become new species (Species B and C). In dispersal, a subpopulation of the ancestral species (Species A) actively migrates across a geographic barrier to form an incipient species (Species A'), which later diverges to become a new species (Species B).

either geographic separation of the incipient species from the ancestral population (allopatric speciation) or via shifts in reproductive timing or chromosomal count within the same geographic space as the ancestor (sympatric speciation) (Mayr, 1963). Sympatric speciation is commonly undetectable in the fossil record, but allopatric speciation is perceptible because it typically results in morphological shifts as incipient species adapt to environmental conditions that differ from those of the ancestral range. Allopatric speciation occurs via two primary mechanisms: vicariance and dispersal, which are characterized by discrete biogeographic patterns related to the geographic range of daughter species relative to the ancestral population (Fig. 2) (Wiley and Mayden, 1985). Thus, it is possible to identify speciation events of each type in fossil taxa where evolutionary relationships are known and ancestral ranges can be inferred (Lieberman, 2000) (Fig. 3).

To assess speciation mode during the Late Devonian, Stigall (2010a) conducted a biogeographic analysis on species-level phylogenetic hypotheses of four common groups of Devonian marine organisms: an order of predatory crustaceans, one bivalve genus, and two brachiopod genera, published in Rode and Lieberman (2002), Rode (2004), and Stigall Rode (2005), respectively. This cross-phyla analysis included common taxa within both the sessile benthos and pelagic predator guilds and, thus, is a reasonable proxy for faunal dynamics in shallow marine environments of Laurentia. Speciation by vicariance was limited relative to speciation by dispersal in each of these clades, ranging from only 12% to 50% of quantifiable speciation events, for a combined rate of 28% speciation by vicariance versus 72% speciation by dispersal. Similar analyses of the modern biota have demonstrated vicariance to be the dominant form of speciation by a factor of almost 3 to 1 (Brooks and McLennan, 2002), and analyses of speciation mode conducted for other Paleozoic intervals (reviewed in Stigall, 2010a) have always recovered higher frequencies of speciation by vicariance versus dispersal (Table 1).

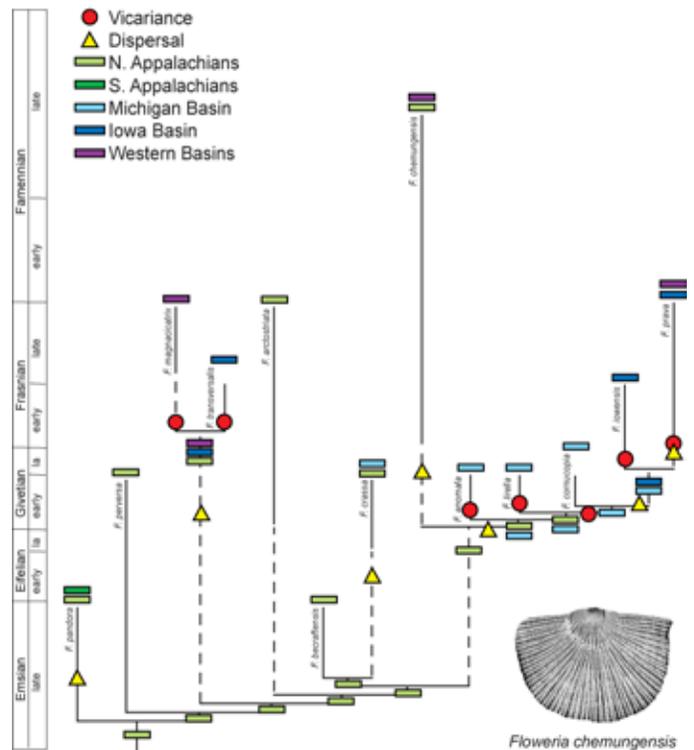


Figure 3. Biogeographic areas mapped onto a strato-cladogram for the brachiopod genus *Floweria*. Speciation events where daughter species occupy a subset of the ancestral range are interpreted as vicariance events. Speciation events where daughter species occupy areas additional to the ancestral areas are interpreted as dispersal events. Modified from Stigall (2010a).

Speciation mode during the Late Devonian is evidently different from the typical pattern in Earth history. This incongruity provides the framework for a mechanistic explanation for speciation decline during the crisis interval. During the Late Devonian, vicariance, normally the most prevalent style of speciation, was essentially extinguished. In fact, each of the few vicariance events present in the clades analyzed precede the late Frasnian crisis interval (Stigall, 2010a). Speciation by dispersal, although still operational during the crisis interval, typically occurred at a lower rate and accordingly resulted in few Late Devonian speciation events. Therefore, elimination of the dominant mode of speciation led to the dramatic reduction in speciation rate, and consequently biodiversity, at the end of the Frasnian.

The differential loss of speciation type provides a foundation against which to analyze causes of biodiversity decline. Satisfactory causes for biodiversity collapse must be able to explain both the lack of vicariant speciation and the slight

Table 1. Comparison of speciation mode through geologic time

Geologic interval	% Speciation by vicariance	% Speciation by dispersal
Late Devonian	28% (sd 16%)	72% (sd 16%)
Cambrian to Middle Devonian	54% (sd 16%)	46% (sd 16%)
Recent	74% (sd 35%)	26% (sd 34%)

Late Devonian clades exhibit substantially limited speciation by vicariance when compared to taxa in other geologic intervals. Modified from Stigall (2010a); sd—standard deviation.



Figure 4. Interbasinal invasions of Late Devonian brachiopod, *Pseudatrypa devoniana*. (A) During the early Frasnian Stage, *P. devoniana* occupied its ancestral basin in the New York region. (B) This species invaded the Iowa basin during the middle Frasnian and (C) subsequently invaded the New Mexico basin during the late Frasnian. Invasions correspond to sea-level rises indicated by the second and third arrow in Figure 5. Modified from Rode and Lieberman (2004).

elevation in extinction rates. Abiotic explanations alone, such as global cooling or basin anoxia, do not provide adequate explanations for the differential reduction in vicariance compared to speciation by dispersal; however, biotic factors, such as the spread of invasive species, potentially could.

INVASIVE SPECIES DURING THE LATE DEVONIAN

Extensive interbasinal species migrations have been documented in many clades during the Frasnian (reviewed in McGhee, 1996). These migrations are characterized by the dispersal of a species native to one tectonic basin into a second tectonic basin outside its original geographic range (Fig. 4). Because these species establish secondary populations in ecosystems in which they did not evolve, they are analogous to modern invasive species (Vermeij, 2005; Stigall, 2010b). Species migrations have occurred throughout geologic time; however, most episodes of biotic exchange are limited to a localized dispersal pathway (e.g., Great American Biotic Interchange; see review in Vermeij, 2005). During the Late Devonian, species introductions were rampant on a global scale.

The impact of these Late Devonian invasions was quantified by Rode and Lieberman (2004) using Geographic Information Systems–based analyses to calculate geographic ranges and map invasion events in more than 300 Middle and Late Devonian articulate brachiopod and bivalve species of Laurentia. Species ranges were mapped at conodont zone resolution to produce a high-precision temporal framework for identifying invasion events (Fig. 5). A substantial increase in invasion intensity occurred coincident with the decline in speciation during the Frasnian; 68% of all identified invasion events occurred in the Frasnian. Rapid transgressions provided pathways for species dispersal; 65% of Frasnian invasion events correlate with transgressive events. Additionally, the mean size of both native and invasive species' geographic ranges increased during the Frasnian (Rode and Lieberman, 2004). Moreover, species with larger geographic ranges, an episode of interbasinal invasion in their history, and/or expansion of their geographic ranges during the late Frasnian survived into the Famennian at statistically higher rates than non-invasive species with narrow geographic ranges (Rode and Lieberman, 2004; Stigall Rode and Lieberman, 2005).

These species invasions, facilitated by sea-level changes, could have caused the observed reduction in speciation coupled with

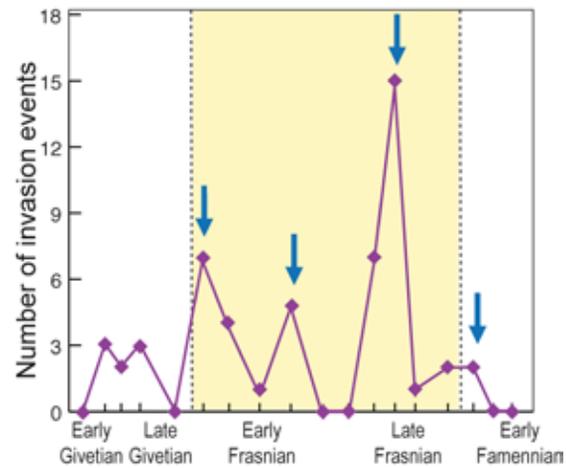


Figure 5. Interbasinal invasion intensity during the Middle and Late Devonian. The spread of invasive species was facilitated by sea-level rises, indicated by blue arrows. Modified from Rode and Lieberman (2004).

moderately elevated extinction. The combination of overall range expansion and frequent invasive events would have prohibited sustained geographic isolation, thereby impeding the primary requirement for vicariant speciation, as well as hindered the successful development of migrant populations into new species, thus restricting speciation by dispersal. The preferential extinction of species with small geographic ranges could have produced the observed elevation of extinction levels.

SYNTHESIZING INVASIVE SPECIES EFFECTS, ECOLOGY, AND SPECIATION

The results of speciation and biogeographic analyses provide a framework in which to examine the mechanisms that reduced speciation and slightly elevated extinction rates during the Late Devonian Biodiversity Crisis. In particular, three features—differential extinction of narrowly ranging species, impact of invaders on native species, and macroevolutionary differences between ecological generalist and specialist species—are critical for explaining biodiversity decline.

A striking feature of the Late Devonian biogeographic pattern is the differential survival of species with large geographic ranges. Species with larger geographic ranges tend, on average, to have broader ecological tolerances than those with small ranges (Jackson, 1974; Fernández and Vrba, 2005). Ecological specialists

are confined in terms of both their habitat preferences and the geographic region where those conditions occur (Stanley, 1979). Conversely, ecological generalists can successfully utilize a wider set of environmental conditions, which typically allows them to occupy larger geographic areas. Thus, although Middle Devonian biotas included both ecological specialists and generalists, most native species that survived the crisis had large geographic ranges (Rode and Lieberman, 2004) and were presumably ecological generalists.

Furthermore, Devonian invaders were dominantly, if not exclusively, ecological generalists. Modern invasive species are characterized by broad environmental tolerances, which contribute to their ability to survive during both the transport and establishment phases of invasion (Lockwood et al., 2007). Devonian invaders were likely similar, because ecological niches of Devonian invaders must have been sufficiently broad to allow colonization of both the invasion pathway and the new tectonic basin. Consequently, the arrival of the Devonian invaders into new tectonic basins effectively resulted in an influx of new ecological generalists into the ecosystem. Studies of modern and Cenozoic invasive species have demonstrated that invader species regularly displace native species through higher resource efficiency (Johansson, 2007) or competitive ability (Vermeij, 2005). Similar processes operating during the Late Devonian would have caused differential extinction of narrowly ranging ecological specialist species. This resulted in elevated extinction rates and a proportional increase of broad ranging ecological generalists versus geographically restricted specialists in the biota.

Clades of ecological generalists tend to have lower speciation rates and contain fewer species relative to specialist lineages (Vrba, 1987; Eldredge, 1989). This discrepancy relates to the mechanics of the allopatric speciation process. If a group of specialists undergoes vicariance, it will likely be exposed to environmental conditions that differ in some way from their ancestral range, and the population must either adapt to those conditions or become extinct. On the other hand, generalists are more likely to be pre-adapted via their broad ecological niche to the new set of conditions encountered so that no adaptive change is required. Consequently, specialist lineages experience both higher speciation and extinction rates than ecological generalists.

The differential extinction of native specialist species during the Late Devonian reduced the potential ancestral species pool from which new specialist species could evolve, which resulted in speciation depression. Furthermore, native and invasive generalist lineages would have had few opportunities to speciate as expansion of geographic ranges facilitated by sea-level rise prevented effective long-term vicariance from ancestral populations. Rather, incipient generalist species were more likely to be subsumed as a geographic extension of the expanding ancestral species than to develop into new species. This combination of preferential extinction of specialist species and expansion of the geographic ranges of generalist species (native and invasive) facilitated the dramatic speciation reduction of the Late Devonian.

This pattern of differential survival, range expansion, and speciation occurred within the most common components of the Late Devonian shallow marine ecosystem but may not be transferable to all marine clades or other environments. Central to this argument is the frequency of range expansion among native

generalist species and the introduction of invaders resulting in competitive interactions on the seafloor. Continental ecosystems, including both terrestrial and freshwater habitats, and marine taxa potentially less amenable to these processes did not experience the same level of biodiversity loss during the Late Devonian (reviewed in McGhee, 1996).

CONCLUSIONS

The Late Devonian Biodiversity Crisis was one of the most significant intervals of biodiversity loss and faunal overturn during the Phanerozoic. Unlike “true” mass-extinction events, such as the Late Permian and End Cretaceous events, the primary driver of biodiversity loss was a severe reduction in speciation rate, not substantially elevated levels of extinction. Purely abiotic explanations for biodiversity loss during the Late Devonian fail to provide a complete explanation for the biodiversity crisis. Shifts in Late Devonian biogeographic patterns were driven by range expansion of generalist taxa within basins and rampant species invasions between basins associated with transgressive events. These shifts provide a mechanistic explanation for the reduction in speciation during the crisis interval, particularly speciation by vicariance.

The central role of invasive species in mediating biodiversity decline during that Late Devonian Biodiversity Crisis parallels aspects of modern biodiversity crisis affecting our planet. The primary drivers of the current biodiversity crisis are habitat destruction, climate change, and the spread of invasive species (Thuiller, 2007). The current rate of biodiversity loss is as high as or higher than during any interval in the Phanerozoic (Barnosky et al., 2011). The impacts of habitat degradation and climatic change have long been analyzed within the context of geologic time and are known to cause substantial elevation of extinction rates. Comparison with the Late Devonian interval suggests that the modern influx of invasive species will result in substantially reduced speciation rates. The modern combination of habitat destruction coupled with species introductions is, therefore, likely to result in total biodiversity loss that may be even greater than that experienced during the Late Permian coupled with an extensive recovery interval due to speciation depression. These implications highlight the need for conservation efforts to target specialist taxa for protection in addition to preventing species introductions and preserving habitat.

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Our next annual meeting will be 4–7 November 2012 in Charlotte, North Carolina, USA. The field trip proposal deadline has passed, and the technical session proposal deadline is 10 Jan. 2012, but there's still plenty of time for you to submit a short course proposal (deadline 1 Feb.)—short courses are quite popular, and the more varied topics we can offer, the better. Please go to www.geosociety.org/meetings/2012/ to learn more.

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Minneapolis, Minnesota, skyline at night. Photo by Greg Benz, <http://carbonsilver.com/blog>.

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The Importance of the Global Professoriate in the Geosciences—The Students We Are Teaching, and Learn from, Today May Represent the Last Great Hope



*Delivered to the GSA Annual Meeting in Minneapolis, Minnesota, USA, on Sunday, 9 October 2011, by GSA President **John Geissman**, Dept. of Geosciences, ROC 21, The University of Texas at Dallas, 800 West Campbell Road, Richardson, Texas 75080, USA; geissman@utdallas.edu*

“Make them like me adorers of the good science of rock-breaking.” —Charles Darwin giving advice to Charles Lyell, personal letter, 9 August 1838

I started thinking about the 2011 Presidential Address a year ago, vowing that I would be impeccably prepared and cool, calm, and collected, and of course would have the complete address finished for *GSA Today* well in advance of the deadline. Aspirations are one thing ... then reality sets in. Knowing that, unlike previous Annual Meetings, at least in the recent past, this year’s address was to be given after a full day of science and interactions with colleagues old and new, the typically well-attended, very early morning ExxonMobil Student Breakfast, AND the opening of the exhibit hall, with tickets that one can redeem for particular beverages, I thought it wise to choose a topic that likely is or has been near and dear to many a geoscientist’s heart and that could be discussed with brevity and vigor.

The views expressed in this address are those of a single very appreciative and fortunate individual.

As the weeks and months passed since late October 2010, many chance events convinced me that the topic of this address was indeed a correct one, and that my title, as provocative as it may be, was far from unreasonable. On Wednesday, 15 Dec. 2010, I sat in the Moscone Center at the AGU meeting and listened, along with several hundred others, to an Oregon high school science teacher, Greg Craven, present his talk, “What is the Worst that Could Happen?” He started his talk with a phrase, repeated over and over, about what scientists really should do with their science, right now, because, in his opinion, their science mattered little in the grand scheme of things considering what was facing the human race in the near future. The phrase, if repeated in a classroom, certainly might land someone in a heap of trouble!

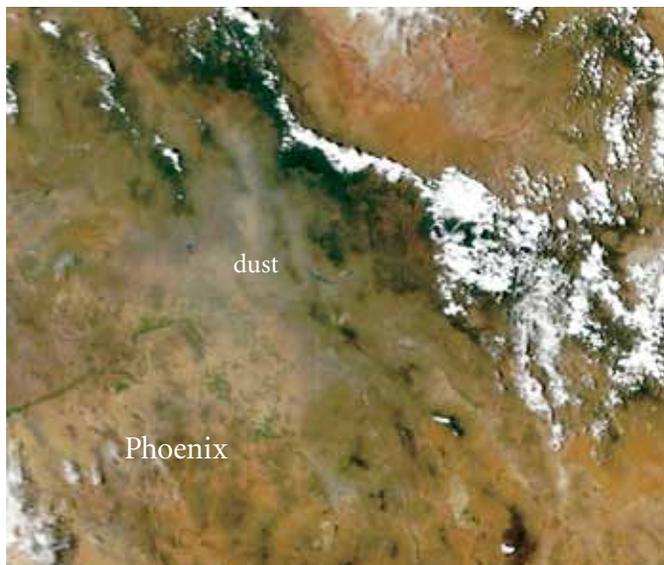
In late spring, in front of a large group of young, aspiring, excited students on the first day of their field geology class, on a lovely day in north-central New Mexico, after talking over all sorts of logistics-related matters with the students, we talked about why, in these times, a field geology course was still in their curriculum. They listened to my opinion, and then I closed by

saying, “Besides, yet I hope that I am wrong about this, I am very concerned that you and your colleagues—geoscience students across the world—may represent the last great hope.” Three weeks later, when the students had submitted their last field project and were relaxing that evening, a couple of them caught me and said, “We have been thinking about the comment you made on the first day of the class and cannot get it out of our minds. Now we understand why you said it.”

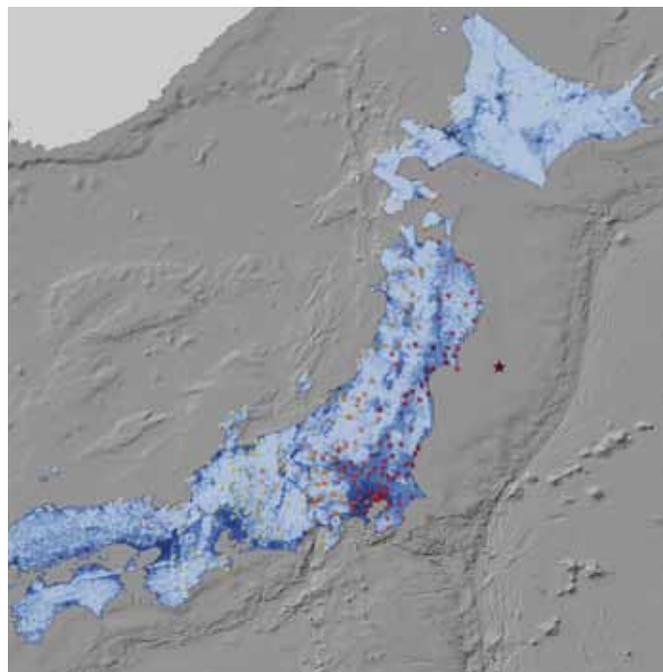
Earlier this fall, I participated in a lively and very productive series of events in Washington, D.C. At one meeting, a geoscience professor remarked publicly, during an engaging discussion, “Geoscientists are terrible teachers!” Two days later, while meeting with the staff of a U.S. Senator in the Hart Office Building, during the Geosciences Congressional Visits Days, the senator’s executive assistant, who had served for several senators on both sides of the aisle, took a deep breath to quiet her colleagues and then said, “Professor Geissman, I have heard many of these types of conversations; tell me, is it really too late?”

And finally, after a very early transit to the Dallas/Fort Worth airport on the morning of Friday, 7 October, I settled in, Starbucks in hand and laptop open, to wait for my plane to depart. Across from me were a man and a woman with what were obviously poster tubes, engaged in a discussion about paleosols and the undergraduate courses for which they were currently teaching assistants. The passion, energy, and enthusiasm for both their research and teaching were hard not to listen to and feel really good about! Eventually, I looked up and said, “You must be on your way to the GSA meeting.” My new friends were Ph.D. students at Baylor University; they asked me why I was going so early to the GSA meeting, and I remarked that I needed to chair an Executive Committee meeting for GSA later that afternoon. One remarked, “You’re the GSA President!” I think that we could have talked almost forever. To the two of you—you know who you are—great fortune!

The Presidential Address begins, only appropriately, with a tribute to a legendary son of Minnesota. As Bob Dylan typed out in 1964 (not that long ago!) the lyrics to an American classic, “The Times They Are A-Changin’,” I wonder if he contemplated how so very much they would apply to the future, say Fall 2011, RIGHT NOW. One might argue forever about what he meant by such lines as “and admit that the waters around yuh have grown” and “don’t criticize what yuh can’t understand,” among others. On the last day of October 2011, somewhere on Earth, our seven-billionth person was born. In well less than a decade, the eight-billionth person is expected to be born. At the 2010 Annual Meeting, Past President Joaquin Ruiz spoke passionately about the grand accomplishments made by the geoscience community and the



NASA image acquired 6 July 2011 of dust storm near Phoenix, Arizona, USA; courtesy MODIS Rapid Response Team, Goddard Space Flight Center, <http://earthobservatory.nasa.gov/NaturalHazards/view.php?id=51285> (last accessed 10 Nov. 2011).



March 2011 Tohoku, Japan, earthquake ground motion and shaking intensity map. NASA Earth Observatory Image by Jesse Allen and Robert Simmon, using data from the USGS Earthquakes Hazard Program and Oak Ridge National Laboratory Geographic Information Science and Technology, <http://earthobservatory.nasa.gov/IOTD/view.php?id=49719> (last accessed 10 Nov. 2011).

great opportunities for and challenges associated with future grand-thinking and groundbreaking research. I share his passion, optimism, and enthusiasm, yet, like many of you, I also have some concerns. An important component of the solution to many of these concerns is the first part of the title of this Presidential Address.

None of you would disagree that it is not uncommon for engaging and enjoyable conversations to center around testable hypotheses. After all, science is the organized exploration of the natural world and must be based on testing hypotheses, through rigorous intellectual discussion, with the most accurate information available. The testable hypothesis in this conversation with you is the second part of the title of this address. I hope that it will be proven invalid, yet I remain nervous about the possibility that my hypothesis has considerable validity, but also optimistic that wisdom and reason will be allowed to guide us. In the book *Eaarth*, Bill McKibben (2010) writes,

My only real fear is that the reality described in this book, and increasingly evident in the world around us, will be for some an excuse to give up. We need just the opposite—increased engagement. Some of that engagement will be local: building the kinds of communities and economies that can withstand what’s coming. And some of it must be global: we must step up to fight to keep climate change from getting even more powerfully out of control. (p. xv)

The geosciences will undeniably play a grand role in that engagement; our students we teach, and learn from today, are key to seeing it happen.

I suspect many of you as well are genuinely concerned about what is ahead of us in terms of the ongoing and inevitable changes in the environment of the surface of our home. We cannot deny that several activities and factors are presently conspiring to make what we describe, and take for granted, as life on our only home more and more unsustainable. There is thus a need for reality to be understood as clearly and as universally as possible. As Dianne

Dumanoski (2009) wrote in *The End of the Long Summer*, “In times of danger, bitter truths serve us better than sweet lies” (p. 247). These concerns exist at a time of tremendous opportunities in the geosciences. Besides the great advances in understanding Earth processes and deep time over the past decades, we are witnessing an enormous increase in demands for base and precious metals, rare earth elements, and other critical minerals, with some of this demand reflecting the increase in the recognized need for alternative energy sources. Many institutions are experiencing large increases in geoscience majors; yet, at the same time, geoscience workforce concerns become more and more acute (Gonzales and Keene, 2011). We are striving to improve the overall representation of minority groups in the geosciences, at all levels, yet increasingly recognize that we must do better (O’Connell and Holmes, 2011).

In my Presidential Address, I showed image after image, many scanned from newspapers, of just what has taken place, or has been front and center, over the past year, from the March Tohoku earthquake off northern Japan, to the enormous dust storms affecting Phoenix, to the huge Wallow and Las Conchas fires in the southwest, to the major volcanic eruptions in Iceland and Indonesia, to record-breaking high temperatures across much of North America, to rapidly fluctuating demands for (and costs of) conventional energy, to the 6% jump in annual global emissions of carbon dioxide in 2010. These frames, and many similar to them (e.g., Rosenthal, 2011), are cause for concern. The next to the last frame in the series was filled with covers of recent books or popular science articles dealing with what is happening to our planet (McKibben, 2010; Kolbert, 2006; Dumanoski, 2009; Mann

and Kump, 2009; Kump, 2011). To exacerbate this, we are challenged by well-organized and large groups of individuals whose goal is to destroy science education in the United States and elsewhere by interjecting completely non-scientific means of “understanding” the natural world in science classrooms.

One wonders if, and when, it may become necessary for alternative approaches, whatever they may be, to be used to make certain that we have not placed ourselves on an irreversible path. In 1975, the economist Nicholas Georgescu-Roegen asked, “Will mankind listen to any program that implies a constriction of its addition to . . . comfort? Perhaps the destiny of man is to have a short, but fiery, exciting, and extravagant life?” (p. 381).

I have a reason for drawing your attention to the fact that in 1959, a master’s student at the University of New Mexico was contemplating these kinds of issues, admittedly from more of the perspective of social unrest and change. He wrote in his thesis,

Is violence the only possible means for the achievement of the desired result? If violence is regarded as an intrinsic evil, then its use cannot be fully justified through success alone; to give it a sufficient justification the anarchist must establish that his revolutionary ends cannot be achieved through better, meaning non-violent, means. Rather than resorting to violence and bloodshed, in other words, would it not be possible, perhaps even easier, to effect the desired improvements in the social order through education and propaganda, through peaceful agitation in one form or another, through piecemeal and incremental reforms, through a broadly evolutionary course of action, rather than a violently revolutionary one? (p. 62)

I suspect that all of you know him—Edward Abbey. We must rise above the common human trait of frustration; there are solutions “through a broadly evolutionary course of action.”

We, as members of a soon-to-be 125-year-old professional society, have important responsibilities to students—not just those who are presently aspiring toward careers in the geosciences but also the many others whose intellectual curiosity draws them into numerous geoscience courses, public lectures, national parks and monuments, museums, and other venues for geoscience learning. If we do not speak, and speak vigorously, in support and defense of the geosciences and geoscience education, at all levels, with an obligation to confront reality with wisdom and reason as our guide, who will? I contend that the geosciences professoriate is a key part of that responsibility, and is thus vital to the future of our home and must itself have a tremendous future. Rather than being about “for the sake of our *grandchildren*” (a phrase that I bet if Craig Schiffrics had a nickel for every time he heard on Capitol Hill he would be a very wealthy person), this issue may be first and foremost about the sake of our *children*—then we’ll see what comes next. From the hallowed halls of what some describe as the elite institutions in America to the large-volume state bastions of public education to smaller four-year and two-year institutions and community colleges, as well as the many other forms it takes around the world, the professoriate must remain a rewarding, stimulating, and downright enjoyable profession. It must remain allowed and supported to seek, and speak, the “bitter truth.” I assert that many, if not all, of you, no matter what career path (or paths) you have chosen (including K–12 education as well as higher education), were influenced in a profoundly positive manner by

one or more geoscience faculty member in higher education and that your memories are indelible.

That said, I consider myself a very fortunate individual, for many reasons. For one, in the fall semester of 1970, fresh out of high school, I was one of several hundred in Professor Frank H.T. Rhodes’ physical geology (Geology 101) course at the University of Michigan. Professor Rhodes rose through the administrative ranks at Michigan and was President of Cornell University for 18 years (at the 2002 GSA Annual Meeting, he received the AGI’s Ian Campbell Award). I still have my notes from that class, and his subsequent Historical Geology course, and I will never forget the lectures. His remarkable clarity, wisdom, and passion riveted the packed Natural Science Building lecture hall every Monday, Wednesday, and Friday. Similarly, the energy, intelligence, intellectual curiosity, kindness, and friendship of last year’s Penrose Medalist, Eric J. Essene, will be remembered forever, not just by this student, but by countless others who benefitted from his mentorship. I suspect that such memories pervade the geoscience community; they are irreplaceable. The geosciences professoriate must remain strong, vibrant, stimulating, and exciting in order for current and future students to have the positive intellectual experiences that have guided and instilled confidence in many generations of geoscientists.

Yet there are large—if not daunting—challenges. The years’ old downturn in the U.S., as well as global, economy is resulting in a rapidly changing “climate” in higher education. Efforts by institutions to “cheapen” the education of their students (e.g., online classes taught to students who are regularly enrolled members of the institution’s student body) are not uncommon today. I wonder if I would be writing this, right now, were I to have taken physical geology as an online course in fall 1970. Consistent with this is the “shrinking professoriate syndrome”—beginning in 2006, fewer than 50% of the full-time, professional positions in higher education were held by faculty (Jaschik, 2008). Federal support for geoscience research, in particular the kind of support that directly affects individual or small groups of faculty, is not growing; in fact, such support could actually decrease. State support of public institutions, as a percentage of total operational costs, continues to decline; for many institutions, 2008 was the beginning of major decreases in support. With such recent changes in higher education, new faculty may begin to formulate new sets of questions: What really are the expectations placed on me? Can they actually be the same as even ten years ago? What are my expectations? Can they, realistically, be the same as even ten years ago? Can I devote sufficient quality time to both teaching and research? When will my department be able to fill vacant faculty positions? Answers to many of these questions lie in the hands of deans, provosts, and presidents of institutions, who struggle with tough budgetary decisions.

Geoscience departments cannot be considered as sacrificial lambs. The geoscience professoriate must be recognized for its broad importance to the institution, in part to assure that future aspirants to the professoriate will have meaningful and rewarding careers. A large part of that assurance is intimately tied into the need for the geoscience professoriate to recognize our part in the broader community of higher education. As much as we may enjoy the sanctity and quiet of our relatively unique opportunities to conduct much of our “work” on remote and, perhaps, peaceful parts of Earth, we still do not operate in a vacuum. To my readers who aspire



Photo by John Geissman.

to make the geosciences professoriate a rewarding life experience, and to my readers in the professoriate who might like a “refresher,” much has been written about that community. I cite Kerr (1963), Gardner (1968), Rosovsky (1990), Kennedy (1997), Kernan (2000), Rhodes (2001), and Vest (2004) as examples of required reading. In *The Creation of the Future*, Frank H.T. Rhodes (2001) writes,

The research university places heavy demands upon the individual faculty member: he or she must be a successful investigator, a scholar of originality, a successful entrepreneur and fundraiser, a substantial author, an effective mentor of graduate and professional students, a challenging and inspiring undergraduate teacher and adviser, an effective participant in the life of the department, an informed citizen in the affairs of the college and university, and a responsible public servant contributing the benefits of professional insight to the continuing needs of the local community, the larger society, and the professional guild. (p. 24)

After such a statement, one might ask, “Is it worth it?” My answer is, absolutely, and that it must continue to be! *The Creation of the Future*, and the other contributions cited above are, in my opinion, celebrations of the many positives associated with institutions of higher education, not just in the United States, but throughout the world. That said, the success and stature of such institutions did not just appear overnight. Rhodes (2001) continues,

Faculty members must affirm that membership in a university—like American Express—has not only its privileges but also its price. And that price is a commitment to common discourse. The fundamental reason for the existence of the university is the benefit of shared dialogue. Without it, the claim to be a university or a collegium is groundless. (p. 54)

In *No Easy Victories*, Gardner (1968) writes,

I like to think that no matter how much the university becomes entangled with the world on its outer fringes, the inner city of the university will be above the battle in some quite distinctive way. ... I’d like to think that it will stand for things that are forgotten in the heat of battle, for values that get pushed aside in the rough-and-tumble of everyday living, for the goals we ought to be thinking about and never do, for the facts we don’t like to face and the questions we lack the courage to ask. (p. 90)

In my opinion, these and many other comments that I could continue to quote in this address do far more than instill a sense of pride in the geosciences professoriate and professoriate in general. The global geosciences professoriate must continue to be as healthy as possible; it has tremendous commitments to its students. In C.P. Snow’s (1959) *The Two Cultures* (the title of his May 1959 Rede Lecture at Cambridge University), he states, “To put it in provokingly stark terms, an education in physics or chemistry is a better preparation for handling the world’s problems than an education in history or philosophy” (p. 1xx). I am willing to bet that had he given that same lecture in 1972, for example, five years after the acceptance of plate tectonics as a unifying theory of earth processes, he would have included the geosciences along with physics and chemistry. Again, to the aspiring professoriate, as well as those firmly entrenched in the geosciences professoriate: Remember that you never know with whom you may have that “common discourse.”

In chapter five, “Teaching as a Moral Vocation,” Rhodes (2001) writes,

After thirty-five years of teaching American history, the most striking thing about Professor Walter LaFaber is that he has not lost a glimmer of his love for his subject, and still finds the birth of a similar passion in his students a cause

for celebration. “It’s the best thing about teaching,” he said, “You see them livening up in class. You see their interests take off. And you sit there, thinking, ‘Is this going to be the next Secretary of State?’” (p. 82)

I close this conversation with some suggestions, or polite recommendations, if you will.

First, to Faculty with Students Who Aspire to the Professoriate:

1. Nurture them;
2. Engage them; and
3. Always consider what is best for them, not you.

To Deans, Provosts, Presidents, and Regents:

1. Treat your geoscience department with the great respect that it deserves;
2. Encourage and work with your geoscience department to strengthen the diversity of its faculty;
3. Do not pressure your geoscience department to teach “online” courses, at any level, to students who are physically present and enrolled at your own institution!; and
4. Recognize the continuing need for solid field-based instruction of geoscience majors and assure that adequate support is provided for those departments that still maintain field geology programs.

To Department Heads and Chairs (Current, Future, and Past):

1. Your junior faculty may become colleagues for decades—help them foster and grow;
2. Use GSA’s position statement “Expanding and Improving Geoscience in Higher Education”;
3. Use the AGI workforce documents “U.S. geoscience today and in the next decade” and the “Status of the Geoscience Workforce 2011” (Gonzales and King, 2011); and
4. Reward your colleagues, especially your junior faculty, who are willing to stick their necks out and commit themselves, and make the sacrifices associated with such commitment, to field-based geoscience education, including rigorous field geology courses.

To Faculty Teaching Lower Division “Introductory” Classes (e.g., “Physical”, “Shake ‘n Bake”, “Environmental”, “Earth History”, etc.):

1. Read Manduca (2011) and utilize the array of resources available at SERC and other organizations established to foster quality geoscience education;
2. Walk into every class as excited (and as organized) as possible;
3. Refuse to teach “online” geoscience courses, at any level, to students who are physically present and enrolled at your own institution!; and
4. Consider the possibility that Student X in Introductory Physical Geology may be a future senator, or secretary of state, or science advisor to the president!

And Finally, to Students Entering or Aspiring to the Professoriate:

1. Yours is a most noble profession, but it only remains noble through your conscious efforts;

2. Your importance and relevance to all of society has never been greater;
3. Relish your interactions with YOUR students; and
4. As a close friend and outstanding geoscientist and past GSA President repeatedly says, “Don’t take yourself too seriously!”

Let us strive to make certain that we, and our students, and then their students, will always have the opportunity to fulfill the words of T.S. Eliot in *Little Gidding*: “We shall not cease from exploration. And the end of all our exploring will be to arrive where we started and know the place for the first time.”

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2012 GSA ANNUAL MEETING & EXPOSITION

CHARLOTTE

4-7 NOVEMBER 2012 • CHARLOTTE, NORTH CAROLINA, USA

CALL FOR PROPOSALS

TECHNICAL SESSIONS

Deadline: 10 Jan. 2012

<http://gsa.confex.com/gsa/2012AM/sessionproposal.epl>

Help ensure that your area of research and expertise is represented in next year's technical program. Individuals, groups, and geoscience organizations are welcome to suggest topics and submit proposals for both Topical Sessions and Pardee Keynote Symposia. Pardee Symposia are high-profile sessions on significant scientific developments, with invited speakers only. Topical Sessions are a combination of invited and volunteered papers. Unique formats are allowed, but they must be outlined in the proposal, along with the technical support needs. Sessions that promote discussion are encouraged.

SHORT COURSES

Deadline: 1 Feb. 2012

Have something that your peers need to know? Then lead a Short Course at the 2012 GSA Annual Meeting in Charlotte! Proposals for Short Courses are now being accepted. Courses can be run to develop professional, teaching, and research skills at all levels. Proposal guidelines are available at www.geosociety.org/meetings/2012/scProposals/ or by contacting Jennifer Nocerino at jnocerino@geosociety.org.



THE GEOLOGICAL SOCIETY
OF AMERICA®

Looking ahead to 2012



Photo courtesy of Visit Chimney Rock State Park

www.geosociety.org/meetings/2012

GSA's success depends on you—its members—and the work of the officers serving on GSA's Executive Committee and Council.

you to review at that time. Paper versions of both the ballot and candidate information will also be available.

In early March, you will receive a postcard with instructions for accessing your electronic ballot via our secure Web site, and biographical information on the nominees will be online for

Please help continue to shape GSA's future by voting on the nominees listed here.

2012 OFFICER AND COUNCIL NOMINEES

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University of Arizona
Tucson, Arizona, USA

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(July 2012–June 2016)
Laurie Brown
University of Massachusetts–Amherst
Amherst, Massachusetts, USA

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(July 2012–June 2016)
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Arlington, Virginia, USA

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(July 2012–June 2016)
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Waco, Texas, USA

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Davis, California, USA

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Houston, Texas, USA

William W. Simpkins
Iowa State University
Ames, Iowa, USA

Elections begin 10 March; ballots must be submitted electronically or postmarked by 8 April 2012.

Students and Early Career Scientists, IGC Travel Grant and Mentoring Program

Brisbane, Australia 5–10 August 2012

The Geological Society of America is accepting applications for the 34th IGC Students and Early Career Scientists Travel Grant and Mentoring Program. This program is organized in collaboration with the U.S. National Committee for Geological Sciences (National Academy of Sciences). To be eligible, applicants must be U.S. residents or citizens and be enrolled in or employed at a U.S. institution. Early career scientists are defined as those within seven years of receiving their Ph.D. Each award is anticipated to be a maximum of US\$3,000.

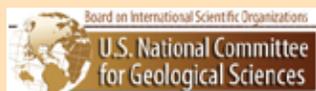
Applications open 12 Dec. at www.geosociety.org/grants/travel.htm. In addition to the online form, the following supplemental information is required: a cover letter addressing reasons for attending the meeting and a prioritized budget of expenses; proof of abstract submission and a copy of the submitted abstract; and two letters of reference.

The online application and supplemental material must be received electronically no later than **17 Feb. 2012**. Applicants will be notified of the results by 15 Apr. 2012.

Questions?

Please contact Jennifer Nocerino,
jnocerino@geosociety.org.

Sponsored by:



GeoCorps™ America Summer 2012



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 geologists—students, educators, professionals, retirees, and others—are encouraged to apply.

The summer 2012 positions will include Guest Scientist positions, Diversity Internships, and American Indian Internships.

www.geosociety.org/geocorps/



Application deadline: 1 Feb. 2012



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LAST CALL FOR APPLICATIONS 2012–2013 GSA-USGS Congressional Science Fellowship

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

Deadline: 1 Feb. 2012

The GSA-USGS Congressional Science Fellowship provides a rare opportunity for a unique individual to work in a House or Senate office for one year. Prospective candidates are GSA members with a broad geoscience background and excellent written and oral communication skills. The fellowship is open only to U.S. citizens or permanent U.S. residents, with a minimum requirement of a master's degree with at least five years professional experience or a Ph.D. at the time of appointment. **Questions?** Contact Ginger Williams, +1-303-357-1040, gwilliams@geosociety.org.

www.geosociety.org/csf/



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CALL FOR NOMINATIONS and APPLICATIONS: Medals, Awards, Grants, and Recognition

Questions? Contact GSA Grants, Awards & Recognition, P.O. Box 9140, 3300 Penrose Place, Boulder, CO 80301-9140, USA, +1-303-357-1028, awards@geosociety.org.

GSA AWARDS, MEDALS & RECOGNITION

Deadline: 1 February

- **2012 GSA Medals and Awards:** Penrose Medal, Day Medal, Young Scientist Award (Donath Medal), GSA Public Service Award, GSA Distinguished Service Award, Bromery Award for the Minorities, and the Subaru Outstanding Woman in Science Award. Go to www.geosociety.org/awards/nominations.htm to get started.
- **2012 AGI Medal in Memory of Ian Campbell:** Go to www.agiweb.org/direct/awards.html.
- **2012 AGI Marcus Milling Legendary Geoscientist Medal:** Go to www.agiweb.org/direct/awards.html#legend.
- **GSA Fellowship:** Nominate your colleagues at www.geosociety.org/members/fellow.htm.
- **2012 Post-Doctoral Research Awards:** Gladys W. Cole Memorial Research Award and W. Storrs Cole Memorial Research Award: www.geosociety.org/grants/postdoc.htm.

Deadline: 31 March

- **John C. Frye Environmental Geology Award** nominations due. Learn more at www.stategeologists.org/awards_honors.php?id=19&award_infomation=details.

GSA DIVISION AWARDS

Award funds are administered by the GSA Foundation. To learn more, see the Dec. 2011 issue of *GSA Today* at www.geosociety.org/gsatoday/archive/21/12/ (p. 16–17) or go to www.geosociety.org/awards/divisions.htm.

Deadline: 1 February

- **Geoscience Education Division Biggs Award for Excellence in Earth Science Teaching.** Send nominations and supplemental materials (see <http://gsaged.org/biggsaward/award2012.htm>) that demonstrate your colleague's excellence in innovative and effective teaching of college-level earth science to Elizabeth A. Heise, elizabeth.heise@utb.edu. Instructors and faculty who have been teaching geoscience full time for 10 years or fewer at any academic institution engaged in undergraduate education are eligible for this award.
- **History and Philosophy of Geology Division Mary C. Rabbitt History and Philosophy of Geology Award.** Nominate colleagues who have made exceptional scholarly contributions of fundamental importance to the understanding of the history and philosophy of geoscience by sending supporting information to Jane P. Davidson, University of Nevada, Reno, NV 89557-0001, USA; +1-775-747-2252; jdhexen@unr.edu.

Deadline: 15 February

- **Geophysics Division George P. Woollard Award.** Nominations should include a description of the nominee's specific contributions to the principles and techniques of geophysics

and the scientific impact of his or her work. Submit online at http://gsageop.org/index.php?option=com_content&view=article&id=49:gsa-geophysics-division-george-p-woollard-award&catid=34:awards&Itemid=58.

Deadline: 20 February

- **Sedimentary Geology Division Lawrence L. Sloss Award for Sedimentary Geology.** Submit (1) a cover letter describing the nominee's accomplishments in sedimentary geology and contributions to and support of GSA; and (2) a curriculum vitae via e-mail to Paul Link, linkpaul@isu.edu.

Deadline: 1 March

- **Coal Division Gilbert H. Cady Award.** Submit three copies of the following to Jack C. Pashin, Energy Investigations Program, Geological Survey of Alabama, P.O. Box 869999, Tuscaloosa, AL 35486-6999; jpashin@gsa.state.al.us: (1) name, office or title, and affiliation of the nominee; (2) date and place of birth; (3) education, degree(s), honors, and awards; (4) major events in his or her professional career; and (5) a brief bibliography noting outstanding achievements and accomplishments in coal geology that warrant recognition.

Deadline: 2 April

- **Quaternary Geology and Geomorphology Division Farouk El-Baz Award for Desert Research.** Submit nominations of colleagues who have demonstrated excellence in desert geomorphology research to Jim O'Connor, U.S. Geological Survey, 2130 SW 5th Ave., Portland, OR 97201, USA; occonnor@usgs.gov. Nominations should include (1) a statement of the significance of the nominee's research; (2) a curriculum vitae; (3) letters of support; and (4) copies of no more than five of the nominee's most significant publications related to desert research. Please submit via e-mail; hardcopy submission must be previously approved.

STUDENT GRANTS, AWARDS & SCHOLARSHIPS

Deadline: 11 January 2012

- **Stephen E. Dwornik Student Paper Award:** GSA's Planetary Geology Division encourages applications for this award, which recognizes excellence in student papers prepared for the 43rd Lunar and Planetary Science Conference. To apply, go to www.lpi.usra.edu/meetings/lpsc2012/. Two awards for outstanding future planetary scientists are given each year—best oral presentation and best poster presentation. Student applicants must be (1) the senior author of the abstract (the paper may be presented orally or in a poster session); (2) a U.S. citizen; and (3) enrolled in a college or university, at any level of their education, in the field of planetary geoscience.

Deadline: 1 February

- **Graduate Student Research Grants:** The primary role of GSA's 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. Up to US\$2500

per student will be awarded, with notifications made in late April. To access information and the application form go to www.geosociety.org/grants/gradgrants.htm.

- **Farouk El-Baz Student Award:** This award is intended to encourage and promote desert research in the broadest sense. Up to two students will be awarded an honorarium of US\$2500 at the 2012 GSA Annual Meeting in Charlotte, North Carolina, USA, based on proposals for arid land research and advisor recommendations. Recipients will be selected by a GSA International Section-appointed Committee. Guidelines and the application form are online at <http://rock.geosociety.org/forms/el-bazGrant.asp>. Established and managed by the GSA Foundation.

Deadline: 15 March

- **Antoinette Lierman Medlin Scholarship in Coal Geology:** GSA's Coal Geology Division offers two scholarships: (1) Financial support of ~US\$2,000 for one year for full-time students involved in coal geology research; and (2) a field study award of ~US\$1,500. In addition, recipients may receive a stipend to present their results at the 2012 or 2013 GSA Annual Meeting. Students may apply for both awards; however, only one award will be made to a successful applicant. To apply, send five copies of the following to Margo Corum, U.S. Geological Survey, Eastern Energy Resources Science Center, 12201 Sunrise Valley Dr., Reston, VA 20192-0002, USA; mcorum@usgs.gov: (1) a cover letter indicating which award(s) is(are) sought; (2) a concise (no more than five double-spaced pages, including references) statement of

objectives and methods as well as how the scholarship funds will be used to enhance the project; and (3) a letter of recommendation from the student's immediate advisor that includes a statement of financial need and the amount and nature of other available funding for the research or field study.

Deadline: 1 May 2012

- **History and Philosophy of Geology Student Award:** The GSA History and Philosophy of Geology Division offers a US\$1000 award for student proposals for presentations at an upcoming GSA Annual Meeting. The topic of the proposed paper may be, but is not limited to, (1) the history of geology; (2) a literature review of ideas for a technical work or thesis/dissertation; or (3) some imaginative aspect of the history of geology we have not thought of before. Proposal guidelines and the application form are online at <http://gsahist.org/HoGaward/awards.htm>. If you have questions, please contact the Division secretary-treasurer, Jane P. Davidson, jdhexen@unr.edu.



Kasey S. White

GSA Welcomes Kasey S. White as New Director for Geoscience Policy

Kasey Shewey White joined The Geological Society of America in December as Director for Geoscience Policy, bringing a wealth of knowledge and experience to the Washington, D.C., office. White was most recently serving as Project Director in the American Association for the Advancement of Science's Office of Government Relations, where she focused on climate change and environmental issues, as well as the use of science in policymaking. She recently authored *Working with Congress*, a book to guide scientists in their policy involvement.

White formerly served as Director of Public Affairs for the Joint Oceanographic Institutions, where she led outreach efforts to the media, the general public, and Congress related to the Ocean Drilling Program.

She worked with the Intergovernmental Panel on Climate Change as a co-editor of *Climate Change 2001: Impacts, Adaptation, and Vulnerability*, and was the lead author of the technical summary of the report. For her effort in this position, she received a share of the 2007 Nobel Peace Prize! White has also worked for the American Geological Institute's Government Affairs Program.

White has a B.A. in Environmental Science and Policy from Duke University and a M.A. in Environmental Sciences from The Johns Hopkins University.

In welcoming White to GSA, Executive Director Jack Hess comments, "Her accomplishments in the fields of science policy and science communication are notable, and we are honored to have someone of this caliber working with GSA to help realize our vision and fulfill our mission in support of the geosciences."

2011 OEST AWARDS

The National Association of Geoscience Teachers (NAGT) has announced the 2011 Outstanding Earth Science Teacher (OEST) Awards, recognizing excellence in earth-science teaching at the pre-college level. In support of these awards, the Geological Society of America provides US\$500 to Section awardees for travel to attend a GSA meeting, US\$500 for classroom supplies, and complimentary GSA membership for three years. State awardees receive a one-year complimentary GSA membership.

SECTION AWARDEES

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Rosemarie Sanders

Longfellow Middle School
Mount Vernon, N.Y., USA

New England Section

Karen A. Saul

Nicholas A. Ferri Middle School
Johnston, R.I., USA

Pacific Northwest Section

Frank R. Hladky

Coquille High School
Coquille, Ore., USA

Southeastern Section

Valerie Willis

Camden Middle School
Camden, S.C., USA

Southwestern Section

Bonnie B. Dodge

Infinity High School
Belen, N.Mex., USA

Texas Section

Michael Brunt

Eagle Pass Junior High School
Eagle Pass, N.Mex., USA

STATE AWARDEES

Alaska

Kathleen Galau

Thunder Mountain High School
Juneau, Alaska, USA

Georgia

Ann S. Lenderman

Rising Starr Middle School
Fayetteville, Ga., USA

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Barry J. Guillot

Harry M. Hurst Middle School
Destrehan, La., USA

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Greensboro Day School
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Oregon

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Coquille High School
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South Carolina

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Camden, S.C., USA

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Spokane Valley, Wash., USA

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Oak Glen High School
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2012



SOUTH-CENTRAL

8-9 March 2012

Alpine, Texas, USA

Local Committee Chair: Kevin Urbanczyk
Early reg. deadline: 6 Feb. 2012

NORTHEASTERN

18-20 March 2012

Hartford, Connecticut, USA

Local Committee Chair: Jean Crespi
Early reg. deadline: 13 Feb. 2012

CORDILLERAN

29-31 March 2012

Querétaro, Mexico

Local Committee Chair: Luca Ferrari
Abstracts deadline: 10 Jan. 2012
Early reg. deadline: 27 Feb. 2012

SOUTHEASTERN

1-2 April 2012

Asheville, North Carolina, USA

Local Committee Co-Chairs: Blair Tormey;
Cheryl Waters-Tormey
Abstracts deadline: 17 Jan. 2012
Early reg. deadline: 27 Feb. 2012

NORTH-CENTRAL

23-24 April 2012

Dayton, Ohio, USA

Local Committee Chair:
Charles Ciampaglio
Abstracts deadline: 24 Jan. 2012
Early reg. deadline: 19 Mar. 2012

ROCKY MOUNTAIN

9-11 May 2012

Albuquerque, New Mexico, USA
Local Committee Chair: Laura Crossey
Abstracts deadline: 14 Feb. 2012
Early reg. deadline: 9 Apr. 2012

GSA Section Meeting Schedule

GSA-ExxonMobil Bighorn Basin Awards

GETTING GEOLOGY STUDENTS INTO THE FIELD

The importance of field schools to practicing geologists is unquestionable; yet, the opportunities to experience field geology are dwindling. The Geological Society of America (GSA), in cooperation with ExxonMobil, is currently offering three programs to support and encourage field geology. This non-profit/industry collaboration has proven very successful; in 2011 over 300 geology students and professors applied for these awards.

1. **The GSA/ExxonMobil Big Horn Basin Field Award** (application deadline 2 April 2012) is a one-week field seminar that offers 20 undergraduate/graduate students and five faculty members a chance to receive a high-quality educational experience in the spectacular Bighorn Basin of north-central Wyoming. The course is free to accepted participants, and all transportation, meals, and living expenses are covered. This seminar is team-taught by four ExxonMobil professionals. These geoscientists represent over 100 years of research in integrated basin analysis, with specific skills in tectonics, geochemistry, structure, sequence stratigraphy, sedimentology, paleontology, hydrocarbon systems analysis, and integrated play analysis. GSA's role is to select awardees and to handle all logistics.

The seminar focuses on multidisciplinary integrated basin analysis and enables awardees to study exposures of individual hydrocarbon system play elements, such as source, seal, reservoir and structure, within a prolific hydrocarbon basin. For more than a century, the Bighorn Basin has been studied by academic, industry, and government geoscientists, who have focused on the exceptional outcrop exposures, as well as subsurface borehole and seismic data. The current understanding of the basin derives from both industry and academic perspectives. This is not, however, a course on the detailed geology of the Bighorn Basin. Instead, the objectives are to introduce the concepts of integrated basin analysis, including evaluation, prediction, and assessment of play element distribution and quality, using the Bighorn Basin as a natural laboratory. Via this laboratory, instructors will explore the concepts, methods, and tools of petroleum geoscience that are used on a day-to-day basis in the energy industry. Discussions on the outcrop and in the classroom will focus on how decisions are made with limited data and how critical information is identified in order to evaluate risk versus uncertainty. Instructors will also use the excellent field setting to teach fundamental geoscience skills in structure, stratigraphy, geochemistry, etc. By the end of the seminar,



student/faculty teams will generate play element maps, play summary charts, cross sections, and play fairway maps. The highlight of this course is the presentation of these ideas to the group and the ensuing discussions about how these ideas and play assessments could be further developed.

2. **The GSA/ExxonMobil Field Camp Scholar Award** (application deadline 12 March) provides 17 undergraduate students with US\$2,000 each to attend the field camp of their choice based on diversity, economic/financial need, and merit. Funds for this award are provided by ExxonMobil; GSA is responsible for selection of awardees.
3. **The GSA/ExxonMobil Field Camp Excellence Award** (application deadline 12 March) acknowledges safety awareness, diversity, and technical excellence in one geologic field camp by awarding it US\$10,000 to support their summer field season.

To apply for these awards, go to <https://rock.geosociety.org/ExxonMobilAward/index.asp>. Students and recent graduates must submit an online application form, a record of relevant courses and grades, two letters of recommendation, and a cover letter. **Questions?** Please contact Jennifer Nocerino, jnocerino@geosociety.org, or +1-303-357-1036.

Bighorn Basin Awards supported by



▶▶ 2012 Section Meeting Mentor Programs ◀◀

Plan now to attend a Shlemon and/or a Mann Mentor luncheon at your 2012 Section Meeting to chat one-on-one with professional geoscientists. These volunteers will answer your questions and share insights on how to get a job after graduation.

Lunches served at these events are FREE. Students will receive lunch tickets with their registration badge. These events are very popular, and space is limited, so try to arrive early to ensure your participation.

The John Mann Mentors in Applied Hydrogeology Program is designed to acquaint undergraduate, graduate, and recent graduate students with careers in applied hydrogeology through mentoring opportunities with practicing professionals. The Roy J. Shlemon Mentor Program in Applied Geoscience is designed to acquaint advanced undergraduate and beginning graduate students with careers in applied geoscience. For further information, contact Jennifer Nocerino at jnocerino@geosociety.org.



SOUTH-CENTRAL SECTION MEETING

8–9 March • Alpine, Texas, USA

Shlemon Mentors Luncheon: Thurs., 8 March

Mann Mentors Luncheon: Fri., 9 March

Big Bend, Alpine, Texas. Photo courtesy USGS.



NORTHEASTERN SECTION MEETING

18–20 March • Hartford, Connecticut, USA

Shlemon Mentors Luncheons: Sun. & Mon., 18 & 19 March

Mann Mentors Luncheon: Tues., 20 March

Boudins in metaigneous rocks, Tolland, Connecticut. Photo by Tim Byrne.

CORDILLERAN SECTION MEETING

29–31 March • Querétaro, México

Shlemon Mentors Luncheon: Thurs., 29 March

Mann Mentors Luncheon: Fri., 30 March

Spectacular skies over Querétaro, México. Photo by Michelangelo Martini.



SOUTHEASTERN SECTION MEETING

1–2 April • Asheville, North Carolina, USA

Shlemon Mentors Luncheon: Sun., 1 April

Mann Mentors Luncheon: Mon., 2 April

Looking Glass Rock. Photo courtesy Blair Tormey.



NORTH-CENTRAL SECTION MEETING

23–24 April • Dayton, Ohio, USA

Shlemon Mentors Luncheon: Mon., 23 April

Mann Mentors Luncheon: Tues., 24 April

Wright Flyer with crowd. Photo courtesy Dayton Montgomery County and Visitors Bureau.



ROCKY MOUNTAIN SECTION MEETING

9–11 May • Albuquerque, New Mexico, USA

Shlemon Mentors Luncheon: Thurs., 10 May

Mann Mentors Luncheon: Fri., 11 May

Petroglyph National Monument. Credit: Petroglyph National Monument.

▶▶ STUDENTS—*Mark Your Calendars!* ◀◀

SOUTH-CENTRAL

46th Annual Meeting of the South-Central
Section, GSA
Alpine, Texas, USA
8–9 March 2012

www.geosociety.org/Sections/sc/2012mtg/



The entrance to Santa Elena Canyon. Credit: NPS/
Eric Leonard.

Paradise or Purgatory: Geology in the Big Bend!

LOCATION

Located in the Trans-Pecos, Alpine is the “gateway to the Big Bend.” Sparse vegetation in the region allows the diverse depositional styles and formations, which have occurred over a vast interval of time, to be easily observed and studied. Due to the complex geologic history of the area, it also presents unique challenges to students and researchers. The added dimensions of understanding hydrology in the arid, bi-nationally significant Rio Grande watershed, historic and modern mining and Permian Basin petroleum enterprise make for a prolific research and educational setting.

REGISTRATION

Early registration deadline: 6 Feb.

Cancellation deadline: 13 Feb.

Register online at www.geosociety.org/sections/sc/2012mtg/registration.htm.

REGISTRATION FEES (all fees are in U.S. dollars)

	EARLY		STANDARD	
	Full Mtg.	One day	Full Mtg.	One day
Professional Member	\$160	\$100	\$200	\$110
Professional Nonmember	\$180	\$120	\$220	\$130
Student Member	\$55	\$45	\$75	\$55
Student Nonmember	\$65	\$60	\$85	\$75
K–12 Teacher	\$65	\$50	\$75	\$60
Guest	\$40	n/a	\$40	n/a
Field Trip/Workshop Only	\$13	n/a	\$13	n/a

ACCOMMODATIONS

Reserve online: www.geosociety.org/Sections/sc/2012mtg/lodging.htm.

Blocks of rooms have been reserved at several Alpine hotels. To qualify for special rates, please reference the block name (GSA Conference) or identify yourself as an SC-GSA attendee when making your reservation.

TECHNICAL PROGRAM

For more information and for local committee e-mail addresses, see the meeting website, www.geosociety.org/Sections/sc/2012mtg/techProg.htm.

Symposium

1. **Big Bend National Park and Vicinity: A Decade of Research.** Don Corrick, Big Bend National Park; Dee Ann Cooper, The University of Texas at Austin; Roger Cooper, Lamar University.

Theme Sessions

Session descriptions are online at www.geosociety.org/Sections/sc/2012mtg/techprog.htm.

1. **Tectonic History of the Trans-Pecos Region.** John White, Eastern Kentucky University.
2. **The Rio Grande and Its Tributaries in the Big Bend Region: Hydrology, Water Quality, and Restoration Efforts.** Jeff Bennett, Big Bend National Park; Joe Sirotinak, Big Bend National Park.
3. **Long-Term Biogeochemical Responses to Global Change.** John Zak, Texas Tech University.
4. **Stratigraphy and Paleontology of the Permian.** David Rohr, Sul Ross State University; Robert Trentham, The University of Texas of the Permian Basin.
5. **Aquifers of West Texas.** James Ward, Angelo State University.
6. **Geoarchaeological Investigations in the Big Bend Region, Southwestern Texas.** Andy Cloud, Center for Big Bend Studies, Sul Ross State University.
7. **Issues in Earth Science Education.** Kevin Urbanczyk, Sul Ross State University.

FIELD TRIPS

Learn more about these trips at www.geosociety.org/Sections/sc/2012mtg/, or contact Field Trip Chair John White at john.white@eku.edu.

1. **Quaternary Geology and Hydrogeology of the Big Bend: The Rio Grande/Rio Bravo.** Mon., 5 March, 8 a.m.–6 p.m. US\$60 for professionals; US\$45 for students; includes lunch/snacks/drinks. Jeff Bennett and Joe Sirotiak, National Park Service and Wild and Scenic Rivers Program. Day trip to Big Bend National Park and Big Bend Ranch State Park.
2. **Igneous Petrology of the Big Bend.** Tues., 6 March, 8 a.m.–6 p.m. US\$60 for professionals; US\$45 for students; includes lunch/snacks/drinks. John White, Eastern Kentucky Univ. Day trip to Big Bend National Park.
3. **Geology of Colorado Canyon, Big Bend Ranch State Park.** Sat., 10 March, 8 a.m.–6 p.m. US\$135; includes lunch/snacks/drinks. Trip starts at Desert Sports, Terlingua, Texas, USA; www.desertsportstx.com; participants are responsible for their own transportation before and after the trip. Kevin Urbanczyk, Sul Ross State Univ. Raft/canoe tour of Colorado canyon.

WORKSHOP

Techniques in Field Hydrogeology and Hydrology. Wed., 7 March. US\$20; includes lunch. Max.: 27. Joe Yelderian, Baylor University, and Kevin Urbanczyk, Sul Ross State University, kevinu@sulross.edu. This is a student-oriented workshop that will include a morning lecture session, midday data collection, and afternoon data analysis.

OPPORTUNITIES FOR STUDENTS

Mentor Luncheons

Cosponsored by GSA Foundation. Learn more at www.geosociety.org/mentors/, or contact Jennifer Nocerino, jnocerino@geosociety.org.

Roy J. Shlemon Mentor Program in Applied Geoscience. Thurs., 8 March. Students will have the opportunity to discuss career prospects and challenges with professional geoscientists from multiple disciplines over a FREE lunch.

John Mann Mentors in Applied Hydrogeology Program. Fri., 9 March. 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.

Travel Grants

Application deadline: 6 Feb.

Applications and information are online at www.geosociety.org/Sections/sc/2012mtg/students.htm.

Volunteering

GSA's South-Central Section offers free meeting registration to student volunteers in return for two half-days (4 hours each) of work. Contact student volunteer coordinator Kristopher Farmer, kristopher.farmer@gmail.com, for more information.

MBL

Biological Discovery in Woods Hole

Founded in 1888 as the Marine Biological Laboratory

Substantial financial assistance is available for many of our courses!

2012 Microbial Diversity Course

June 11 - July 28, 2012

An intensive 6.5-week course for graduate or postdoctoral students, as well as established investigators, who want to become competent in microbiological techniques for working with a broad range of microbes, and in approaches for recognizing the metabolic, phylogenetic, and genomic diversity of cultivated and as yet uncultivated bacteria.

For applications and more information go to:

mbl.edu/education

or contact:
Admissions Coordinator
admissions@mbl.edu
(508) 289-7401

The MBL is an Equal Opportunity/Affirmative Action Institution.

Second Announcement & Call for Papers

CORDILLERAN

108th Annual Meeting of the Cordilleran
Section, GSA

Querétaro, México
29–31 March 2012

www.geosociety.org/Sections/cord/2012mtg/



Spectacular skies over Querétaro, México. Photo by Michelangelo Martini.

REGISTRATION

Early registration deadline: 27 Feb. 2012

Cancellation deadline: 5 March 2012

Register at www.geosociety.org/sections/cord/2012mtg/.

REGISTRATION FEES (all fees are in U.S. dollars)

	EARLY		STANDARD	
	Full Mtg.	One Day	Full Mtg.	One Day
Professional Member	\$160	\$100	\$190	\$110
Professional Nonmember	\$180	\$140	\$210	\$170
Student Member	\$60	\$45	\$80	\$55
Student Nonmember	\$80	n/a	\$100	n/a
Professional +70	\$100	n/a	\$120	n/a
Guest or Spouse	\$60	n/a	\$80	n/a
Field Trip Only	\$35	n/a	\$35	n/a

LOCATION

The 108th meeting of the GSA Cordilleran Section will be held at the Hotel Misión Juriquilla in Querétaro, central Mexico. The Center of Geoscience and the Institute of Geology of the Universidad Nacional Autónoma de México (UNAM) will host the meeting.

VENUE & ACCOMMODATIONS

The conference will be hosted at the Hotel Misión Juriquilla, which occupies the main building of an eighteenth-century hacienda and is about one mile from the UNAM campus in Querétaro. GSA's room block offers the following special rates: single/double with breakfast: US\$127/\$132 per night (incl. tax); Single/double all-inclusive (breakfast, lunch & dinner): US\$160/\$224 per night (incl. tax). For more information, go to www.hotelesmision.com/mexico/queretaro/queretaro/hotels/Mision-Queretaro-Juriquilla/description.aspx.

TECHNICAL PROGRAM

Abstract deadline: 10 January 2012

Submit abstracts via www.geosociety.org/Sections/cord/2012mtg/techprog.htm.

An abstract submission fee of US\$10 for students and US\$15 for all others will be charged. If you cannot submit the abstract online, please contact Linda Battan, +1-303-357-1018, lbattan@geosociety.org.

Symposium

- S1. **Amalgamation and Breakup of Pangea in the Americas.** Co-sponsored by IGCP 597 (*Origin and Evolution of Pangea*) and IGCP 574 (*Bending and Bent Orogens, Continental Ribbons*). Brendan Murphy, St. Francis Xavier University; Jarda Dostal, Saint Mary's University; Damian Nance, University of Ohio.

Theme Sessions

Session descriptions are online at www.geosociety.org/Sections/cord/2012mtg/techprog.htm.

- T1. **Silicic Volcanism.** Cathy Busby, Univ. of California; Graham Andrews, Univ. of California.
- T2. **Ore Deposits and Ore Genesis in the American Cordillera.** Antoni Camprubi, UNAM.
- T3. **Convergent Margin of Western Pangea: Triassic-Jurassic Magmatism, Sedimentation, and Tectonics from Colombia to Oregon.** Timothy Lawton, New Mexico State University; Rafael Barboza-Gudiño, Universidad Autónoma de San Luis Potosí; Roberto Molina-Garza, Centro de Geociencias, UNAM, rmolina@geociencias.unam.mx.
- T4. **Flat-Slab Subduction from Past to Present.** Vlad Manea, UNAM; Marina Manea, UNAM.
- T5. **Mechanisms of Arc Magma Generation along the Cordillera.** Laura Mori, UNAM; Peter Schaaf, UNAM; Arturo Gómez Tuena, UNAM.
- T6. **Terrane Accretion, Flat Slab Subduction, and Convergence Rate Variations: What Caused the Cretaceous-Paleogene Shortening across the Mexican Cordillera?** Michelangelo

Martini, UNAM; Elisa Fitz Díaz, UNAM; Timothy Lawton, New Mexico State University.

- T7. **Structural Style, Timing, and Stratigraphy of the Laramide Orogeny in Mexico.** Mariano Cerca, UNAM; Gabriel Chavez-Cabello, Universidad de Nuevo León–Linares; Martín Valencia, UNAM.
- T8. **Lithosphere Stretching and Magmatism Leading to the Gulf of California.** Luca Ferrari, UNAM; Arturo Martin Barajas, CICESE; Joann Stock, California Institute of Technology.
- T9. **What Fossil Ages and Distributions Tell Us about the History of the Ancient Gulf of California?** Judy Terry Smith, Smithsonian Institution; Ana Luisa Carreño, UNAM; Javier Helenes, CICESE.
- T10. **The Caribbean Plate and Its Geologic Connections with North and South America.** Luigi Solari, UNAM; Uwe Martens, Tectonic Analysis Ltd.
- T11. **Developments in Geophysical Investigations of Volcano Hydrothermal Systems: Exploration and Hazards.** Jonathan M.G. Glen, USGS; Shaul Hurwitz, USGS; Vyacheslav M. Zobin, Universidad de Colima; Robert A. Sohn, Woods Hole Oceanographic Institution.
- T12. **Limnogeology Studies and Paleoenvironmental Records from Ancient and Modern Lakes.** Beatriz Ortega, UNAM; Margarita Caballero, UNAM; Socorro Lozano, UNAM.
- T13. **Heterogeneous Geologic Formations: Modeling Spatial Variability.** Eric Morales Casique, Instituto de Geología, UNAM; Martín Díaz Viera, Instituto Mexicano del Petróleo.
- T14. **Ground Deformation Related to Anthropogenic Activities: Achievements in the Development of Geoscience Information System for Improved Management of Natural Resources.** Dora Carreón-Freyre, UNAM; Mariano Cerca, UNAM; Devin Galloway, USGS; Penélope López-Quiroz, Centro de Investigación en Geografía y Geomática.
- T15. **Pushing the Envelope: Recent Advances in Teaching Geoscience with Technology.** Ralph Dawes, Wenatchee Valley College.
- T16. **Undergraduate Research (Posters).** *Cosponsored by Council on Undergraduate Research (CUR).* Kathleen D. Surpliss, Trinity University.
- T17. **Environmental Geochemistry.** Mario Villalobos, UNAM; Laura Beramendi, Francisco Romero, Priyadarsi Roy, Ofelia Morton, UNAM.

FIELD TRIPS

Learn more about these trips at www.geosociety.org/Sections/cord/2012mtg/fieldTrips.htm.

Pre-Meeting

Trip 4. **Sierra de Catorce: Remnants of the Ancient Pacific Margin of Western Pangea in Central Mexico.** Sun.–Tues., 25–27 March. US\$520. José Rafael Barboza-Gudiño, Universidad Autónoma de San Luis Potosí; Roberto S. Molina-Garza, UNAM; Timothy F. Lawton, New Mexico State University.

Trip 5. **Late Pleistocene Rhyolitic Explosive Volcanism at Los Azufres Volcanic Field, Central Mexico.** Sun.–Tues., 25–27 March. Cost: US\$450. José Luis Arce, UNAM; José Luis Macías, UNAM; Elizabeth Rangel, Paul Layer, Victor Hugo Garduño, Ricardo Saucedo, Felipe García, Renato Castro, Héctor Pérez Esquivias.

Trip 7. **Geology and Tectonics of the Southeastern Portion of the Sierra de Guanajuato.** Sun.–Tues., 25–27 March. Cost: \$380. José Jorge Aranda-Gómez, UNAM; Pablo Dávila-Harris, Luis Vassallo.

Trip 3. **Environmental Geochemistry of the Pozos Mining District, Guanajuato, East-Central Mexico.** Wed., 28 March. Cost: \$80.

Alejandro Carrillo, UNAM; Juventino Martínez, Gilles Levrèsse.

Post-Meeting

Trip 1. **Late Paleozoic–Early Mesozoic of the Acatlán and Ayu Complexes, Southern Mexico: Events on the Periphery of Pangea Synchronous with Amalgamation and Breakup.** *Cosponsored by IGCP 597: Amalgamation and Breakup of Pangea.* Sat.–Tues., 31 March–3 April. Cost: \$588. Duncan Keppie, UNAM; Brendan Murphy, Gonzalo Galaz, Moritz Kirsch, Maria Helbig.

Trip 8. **Recent Volcanism and Hazards at the Eastern Trans-Mexican Volcanic Belt.** Sat.–Mon., 31 March–2 Apr. US\$320. Gerardo Carrasco-Núñez, UNAM; Pablo Dávila-Harris, Nancy Riggs, Michael Ort, Brian Zimmer, Chris Willcox, Mike Branney.

Trip 6. **Ground Deformation Related to Anthropogenic Activities in Urbanized Areas of the Mexico Basin.** Sun.–Mon., 1–2 April. US\$288. Mariano Cerca, UNAM; Dora Carreón.

Trip 2. **The Late Cretaceous Mexican Fold-and-Thrust Belt and Its Possible Relation with the Accretion of the Guerrero Terrane.** Sun.–Tues., 1–3 April. US\$344. Michelangelo Martini, UNAM; Elisa Fitz, Timothy Lawton.

Trip 9. **Geology and Geochronology of Tlaloc and Telapon Volcanoes, Sierra Nevada, Central Mexico.** Sun.–Wed., 1–4 April. US\$477. José Luis Macías, UNAM; J.L. Arce, F. García, Paul W. Layer, G. Reyes-Agustín, F. López Pizaña, H. Rueda.

OPPORTUNITIES FOR STUDENTS

Undergraduate and Graduate Student Presentation Awards

GSA encourages abstract submissions by student authors. To recognize exceptional work, the Cordilleran Section will offer awards for outstanding oral and poster presentations to both graduate and undergraduate students.

Mentoring Luncheons

Sponsored by the GSA Foundation. Learn more at www.geosociety.org/mentors/, or contact Jennifer Nocerino, jnocerino@geosociety.org.

Roy J. Shlemon Mentor Program in Applied Geoscience. Thurs., 29 March. Students will have the opportunity to discuss career prospects and challenges with professional geoscientists from multiple disciplines over a FREE lunch.

John Mann Mentors in Applied Hydrogeology Program. Fri., 30 March. 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.

Volunteering

GSA's Cordilleran Section is pleased to offer student volunteers free registration in return for ~6 hours of work. Contact Mariano Cerca, mcerca@geociencias.unam.mx, for more information.

Travel Grants

Deadline to apply: 27 Feb.

To qualify, students must be Cordilleran Section members at the time of application, as well as first author of a paper or poster to be presented at the meeting. Learn more and apply at www.geosociety.org/sections/cord/2012mtg/students.htm.

SOUTHEASTERN

61st Annual Meeting of the Southeastern Section, GSA

Asheville, North Carolina, USA

1–2 April 2012

www.geosociety.org/Sections/se/2012mtg/

Shaping Continents, Shaping Landscapes, Shaping Policy

LOCATION

The Dept. of Geosciences and Natural Resources at Western Carolina University is pleased to host the 61st Annual Meeting of GSA's Southeastern Section at the Renaissance Asheville Hotel, located in historic downtown Asheville, North Carolina, USA. Asheville offers easy access to the world-renowned geology of the Blue Ridge, Piedmont, Valley and Ridge, and Cumberland Plateau, with geologic venues ranging from ancient orogenic belts and exotic mineral districts, to active landslides, karst landscapes, and unique fossil sites.

REGISTRATION

Early registration deadline: 27 February 2012

Cancellation deadline: 5 March 2012

Register online at www.geosociety.org/Sections/se/2012mtg/.

REGISTRATION FEES (all fees are in U.S. dollars)

	EARLY		STANDARD	
	Full Mtg.	One Day	Full Mtg.	One Day
Professional Member	\$180	\$100	\$210	\$110
Professional Nonmember	\$200	\$120	\$220	\$130
Student Member	\$70	\$50	\$75	\$55
Student Nonmember	\$80	\$60	\$110	\$80
K–12 Teacher	\$30	\$20	\$35	\$25
Guest	\$50	n/a	\$60	n/a
Short Course/Field Trip only	\$35	n/a	\$45	n/a

ACCOMMODATIONS

Hotel reservation deadline: 2 March 2012

A block of rooms has been reserved at the Renaissance Asheville Hotel (31 Woodfin Street, Asheville, NC, 28801, USA,

+ 1-800-266-9432) at US\$119 per night + tax. Please identify yourself as a SE-GSA attendee when making your reservation to qualify for this rate. Reserve your room via the link at www.geosociety.org/Sections/se/2012mtg/lodging.htm.

TECHNICAL PROGRAM

Abstract deadline: 17 Jan. 2012. View Session descriptions online.

Symposia

1. **Transcurrent Motion in the Southern Appalachians: Comparing Kinematics and Timing across the Orogen.** *Cosponsored by GSA Structural Geology and Tectonics Division.* Cheryl Waters-Tormey, Western Carolina Univ.; Jim Hibbard, North Carolina State Univ.
2. **Industrial Minerals of the Spruce Pine (NC) District and the Southeast.** *Cosponsored by SME Carolinas Section; GSA Structural Geology and Tectonics Division.* Bob Ganis, Consultant, bobganis@mac.com, Alex Glover, Active Minerals International, a.glover@activeminerals.com.
3. **Practical Applications of Engineering Geology.** *Cosponsored by AEG Carolinas Section.* Paul Weaver, Chair, AEG-Carolinas; Brad Worley, North Carolina Dept. of Transportation.

Theme Sessions

Session descriptions and leader contact information are online at www.geosociety.org/Sections/se/2012mtg/techProg.htm.

1. **Terranes of the Southern Appalachian Blue Ridge and Piedmont: Insights into Their Tectonic Heritage and Incorporation into the Orogen from Recent Geochronologic, Isotopic, Provenance, and Field Studies.** *Cosponsored by GSA Structural Geology and Tectonics Division.* Arthur J. Merschat, USGS; Brendan R. Bream, ExxonMobil Exploration Co.
2. **Ancient and Modern Eolian Systems of Eastern North America.** *Cosponsored by Eastern Section, SEPM; GSA Sedimentary Geology Division.* Chris Swezey, USGS, cswezey@usgs.gov; Rich Whittecar, Old Dominion Univ.
3. **Sedimentation and Stratigraphy of Fine-Grained Strata: Insights from Modern and Ancient Marine Systems.** *Cosponsored by Eastern Section, SEPM; GSA Sedimentary Geology Division.* J.P. Walsh, East Carolina Univ.; Don Neal, East Carolina Univ.
4. **Hydrological Processes and Problems in the Southern Appalachians.** *Cosponsored by GSA Hydrogeology Division.* Mark Lord, Western Carolina Univ.; Dave Kinner, Western Carolina Univ.; Jerry Miller, Western Carolina Univ.
5. **Hydrogeology and Geomorphology of Carbonate Aquifers in the Southeastern United States.** *Cosponsored by Eastern Section SEPM; GSA Sedimentary Geology Division; GSA Hydrogeology Division.* Lee J. Florea, Ball State Univ.
6. **Coastal Hydrogeology.** *Cosponsored by GSA Hydrogeology Division.* Samuel Mutiti, Georgia College and State Univ.; Alex Manda, East Carolina Univ.
7. **Building the Foundation for Geoscience Education, a Next Step: Working with Expert Earth Science Teachers to**

Create More Highly Qualified Earth Science Teachers.

Cosponsored by National Association of Geoscience Teachers Southeastern Section; North Carolina Geological Survey. Randy Bechtel, North Carolina Geological Survey.

8. **Geologic Maps, Digital Geologic Maps and Derivatives (Poster Session).** Michael W. Higgins, The Geologic Mapping Institute; Ralph F. Crawford, The Geologic Mapping Institute.
9. **Undergraduate Research (Poster Session).** *Cosponsored by Council on Undergraduate Research.* Lee Phillips, Univ. of North Carolina.
10. **Coastal Response to Sea-Level and Climate Changes.** *Cosponsored by Western Carolina University Program for the Study of Developed Shorelines; Eastern Section, SEPM; GSA Sedimentary Geology Division.* Katie Peek, Western Carolina Univ.; David Mallinson, East Carolina Univ.
11. **Outstanding Field Trip Stops in the Carolinas and Beyond for Professionals and Teachers (Poster Session).** *Cosponsored by Carolina Geological Society; North Carolina Geological Survey; NAGT Southeastern Section.* Phil Bradley, North Carolina Geological Survey.
12. **The 23 August 2011 Virginia M_w 5.8 Earthquake: Highlighting Earthquake Hazards throughout the Southeastern United States.** *Cosponsored by AEG Carolinas Section; GSA Structural Geology and Tectonics Division.* David B. Spears, Virginia Dept. of Mines, Minerals and Energy; Russell A. Green, Virginia Tech; Mark W. Carter, USGS.
13. **Applied and Environmental Paleontology: Using Fossils to Understand Modern and Ancient Environments.** William J. Garcia, Univ. of North Carolina; Scott P. Hippensteel, Univ. of North Carolina.
14. **Characterizing Fluid Flow in Porous/Fractured Media.** *Cosponsored by GSA Sedimentary Geology Division; GSA Hydrogeology Division.* Attila Fohnagy, Univ. of Idaho.
15. **Conservation Paleobiology: Using the Fossil Record to Improve Living Species Conservation.** Michael L. McKinney, Univ. of Tennessee; Rowan Lockwood, College of William and Mary.

FIELD TRIPS

Learn more about these trips at www.geosociety.org/Sections/se/2012mtg/ft-wks.htm.

1. **Central and Eastern Blue Ridge Tectonics.** *Cosponsored by GSA Structural Geology and Tectonics Division.* Thu.–Sat., 29–31 March. US\$190; incl. transportation, lunches, and 2 nights lodging. Arthur Merschat, USGS; Robert D. Hatcher, Jr., Univ. of Tennessee.
2. **Caves and Karst of the Cumberland Plateau in Southeast Kentucky.** *Cosponsored by Eastern Section, SEPM; GSA Sedimentary Geology Division; GSA Hydrogeology Division.* Fri.–Sat., 30–31 March. US\$190; incl. transportation, lunch, and lodging. Lee J. Florea, Ball State Univ.
3. **Industrial Minerals of the Spruce Pine (NC) Mineral District.** *Cosponsored by SME Carolinas Section; GSA Structural Geology and Tectonics Division.* Sat., 31 March. US\$75; incl. transportation and lunch. Alex Glover, Active Minerals International; Bob Ganis, Consultant; Sam Swanson, Univ. of Georgia.

WORKSHOPS

1. **Creating Your Own Geological Maps, Models, and Geoscience Learning Resources Using Google Earth.** Sat., 31 March, 8 a.m.–5 p.m. US\$25; does not include lunch. Declan De Paor, Old Dominion Univ.; Steve Whitmeyer, James Madison Univ.
2. **Facilitating Classroom Innovation in the Geosciences: The TUES and Other NSF Educational Funding Programs, and Strategies for Successful TUES Proposals.** *Subsidized by NSF; Cosponsored by Southeastern Section NAGT; Council on Undergraduate Research.* Sat., 31 March, noon–5 p.m. US\$10; food & beverages provided. Jeff Ryan, Univ. of South Florida; Jill Singer, Buffalo State College.
3. **Field Safety Leadership.** *Cosponsored by ExxonMobil Upstream Research Co.; ExxonMobil Exploration Co.* Tues.–Wed., 3–4 April, 8 a.m.–5 p.m. US\$25. Amy Ruf, ExxonMobil Upstream Research Co.; Stephen Oliveri, ExxonMobil Corp.; Kevin Bohacs, ExxonMobil Upstream Research Co.

OPPORTUNITIES FOR STUDENTS

Mentor Luncheons

Cosponsored by GSA Foundation. Learn more at www.geosociety.org/mentors/, or contact Jennifer Nocerino, jnocerino@geosociety.org.

Roy J. Shlemon Mentor Program in Applied Geoscience. Sun., 1 April, noon–1:30 p.m. Students will have the opportunity to discuss career prospects and challenges with professional geoscientists from multiple disciplines over a FREE lunch.

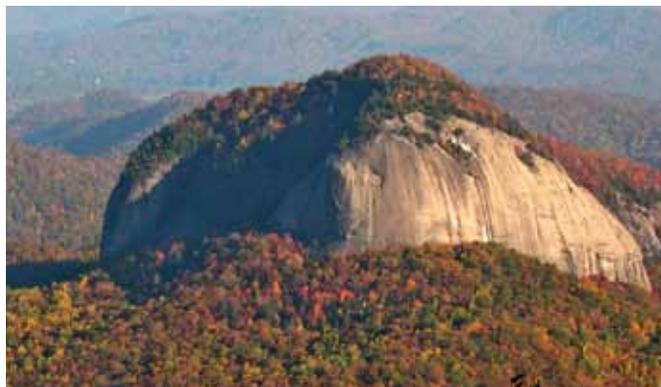
John Mann Mentors in Applied Hydrogeology Program. Mon., 2 April, noon–1:30 p.m. Students interested in applied hydrogeology or hydrology as a career will have the opportunity to network with professionals in these fields over a FREE lunch.

Travel Grants

Application deadline: 27 Feb. 2012; learn more and apply at www.geosociety.org/Sections/se/2012mtg/students.htm.

Volunteering

GSA's Southeastern Section will cover meeting registration for student volunteers in return for two half-days (3–4 hours each) of work. Learn more at www.geosociety.org/Sections/se/2012mtg/students.htm.

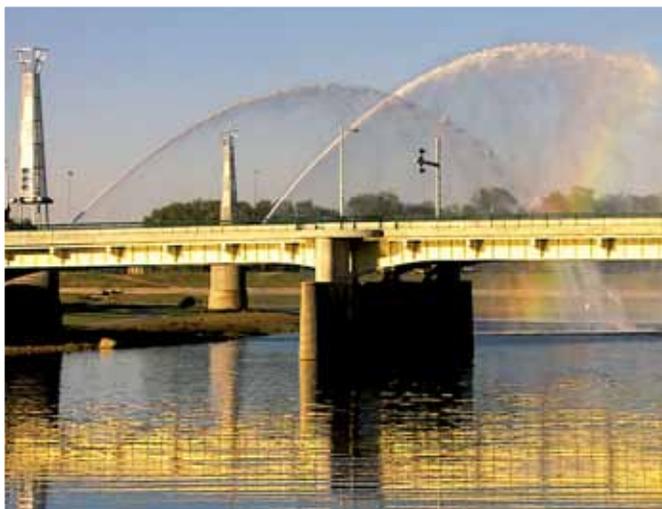


Looking Glass Rock. Photo courtesy Asheville Convention and Visitors Bureau.

NORTH-CENTRAL

46th Annual Meeting of the North-Central Section, GSA
Dayton, Ohio, USA
23–24 April 2012

www.geosociety.org/Sections/nc/2012mtg/



Riverscape Fountains. Photo courtesy Dayton Montgomery County and Visitors Bureau.

Change through Time

REGISTRATION

Early registration deadline: 19 Mar. 2012

Cancellation deadline: 26 Mar. 2012

Register at www.geosociety.org/Sections/nc/2012mtg/registration.htm. Online registration opens Feb. 2012. For further information, or if you need special accommodations, please contact Chuck Ciampaglio at chuck.ciampaglio@wright.edu.

REGISTRATION FEES (all fees are in U.S. dollars)

	EARLY		STANDARD	
	Full Mtg.	One Day	Full Mtg.	One Day
Professional Member	\$190	\$120	\$210	\$120
Professional Nonmember	\$200	\$130	\$230	\$140
Professional Member 70+	\$110	\$60	\$110	\$60
Student Member	\$50	\$35	\$60	\$35
Student Nonmember	\$85	\$70	\$95	\$70
K–12 Professional	\$45	\$30	\$45	\$40
Guest or Spouse	\$60	n/a	\$60	n/a
Field Trip Only	n/a	\$45	n/a	\$45

ACCOMMODATIONS

Hotel reservation deadline: 30 Mar. 2012

The meeting will take place at the Dayton Convention Center. A block of rooms has been reserved at the Crowne Plaza Hotel, directly across from the convention center at 33 East Fifth Street, Dayton, Ohio 45402, USA. The group rate is US\$104/night +13% tax. Please make your reservations by calling +1-888-233-9527 and requesting the 2012 GSA North-Central Section Meeting group rate.

CALL FOR PAPERS

Abstract deadline: 24 Jan. 2012

Please submit your abstract at <http://gsa.confex.com/gsa/2012NC/cfp.epl>. An abstract submission fee of US\$12 for students and US\$15 for all others will be charged. If you cannot submit an abstract online, please contact Nancy Wright, +1-303-357-1061, nwright@geosociety.org.

Theme Sessions

Session descriptions are online at www.geosociety.org/Sections/nc/2012mtg/techprog.htm.

- Applications of Remote Sensing to the Geological and Environmental Sciences.** Doyle Watts, Wright State University; Umesh Haritashya, University of Dayton.
- Mercury Biogeochemistry.** Chad R. Hammerschmidt, Wright State University; Gary Conley, Ohio University.
- Special Poster Session on Undergraduate Research.** *Cosponsored by the Council on Undergraduate Research Geoscience Division.* Robert D. Shuster, University of Nebraska.
- Critical Thinking in Geoscience Education: Theory, Pedagogy, and Best Practices for K–16 Classrooms.** K.M. Bower Eastern Illinois University.
- Geoscience Student Engagement: Innovations in Labs, Activities, Field Trips, and In-Class Pedagogy for K–16 Classrooms.** Carrie L. Wright, University of Southern Indiana.
- Issues in Geoscience Education.** Solomon Isiorho, Indiana University–Purdue University Fort Wayne.
- Geoscience Education and Outreach: Bringing Cutting-Edge Science and Technology to Undergraduates, K–12 Teachers, and the Public.** *Cosponsored by National Assoc. of Geoscience Teachers North-Central Section.* Katherine Johnson, Eastern Illinois University; Shelley Judge, College of Wooster.
- Vertebrate Paleontology.** Jeremy L. Green, Kent State University at Tuscarawas.
- Bridging the Gap between the Great Ordovician Biodiversification Event and Late Carboniferous Life: Conodonts, Climate Change, and Biodiversity Patterns.** *Cosponsored by Pander Society and IGCP Projects 591 and 596.* Mark Kleffner, The Ohio State University; Jeff Bauer, Shawnee State University.
- Navigating Ancient Midwestern Seas: The Geologic Record of Flooding and Emergence on a Large Paleozoic Platform.**

Cosponsored by Great Lakes Section SEPM. Don Mikulic, Illinois Geological Survey.

11. **Dimensions of Biodiversity: A Paleontological Perspective.** Alycia L. Stigall, Ohio University; Daniel I. Hembree, Ohio University.
12. **New Methods in Stratigraphic Analysis.** Daniel Goldman, University of Dayton.
13. **New Frontiers in Planetary Geology.** Keith A. Milam, Ohio University.
14. **Applications, Quantification, and Modeling of Groundwater–Surface-Water Interactions.** Jonathan Levy, Miami University.
15. **Watersheds, Hydrogeology, and Environmental Site Investigation in the Midwest Basin and Arches Region.** E. Scott Bair, The Ohio State University; Robert W. Ritzi Jr., Wright State University.
16. **Climate Change: Past, Present and Future.** Shuang-Ye Wu, University of Dayton.
17. **Issues in Geology and Public Policy: A Clash of Cultures/An Intersection of Interests.** *Cosponsored by GSA Geology and Society Division; GSA Geology and Public Policy Committee.* Mike Phillips, Illinois Valley Community College.
18. **Economic Development and State Geological Surveys.** Larry Wickstrom, Ohio Geological Survey.
19. **Geothermal Resources of the Central United States—An Important Source of Renewable Energy.** Mike Angle, Ohio Division of Natural Resources Geologic Mapping & Industrial Minerals Section.
20. **The Museum as Geological Muse: Outreach, Online Catalogs, Blogs, Student Internships, and More.** Joe Hannibal, Cleveland Museum of Natural History; Brenda Hunda, Cincinnati Museum Center.
21. **Geoarchaeology and Cultural Geology: Exploring the Geological Aspects of Archaeological and Cultural Materials and Settings.** Andrew Bauer, DePauw University; Joe Hannibal, Cleveland Museum of Natural History.
22. **Shales during the Devonian: Facies Observed through New Stratigraphic, Sedimentologic, and Paleoenvironmental Perspectives.** Gordon Baird, SUNY Fredonia; Jeff Over, SUNY Geneseo; Charles Ver Straeten, New York State Geological Survey.
23. **Near-Surface Geophysics.** Ernie Hauser, Wright State University.
24. **Below the Mount Simon Sandstone of Ohio, Indiana, and Kentucky.** Ernie Hauser, Wright State University.
25. **Explorations in Mineralogy and Petrology: The View from the Midcontinent.** Andrea Koziol, University of Dayton; Allen J. McGrew, University of Dayton.
26. **Constructed Wetlands: Boom or Bust?** Michael Enright, Five Rivers MetroParks; Donald Geiger, University of Dayton; James Amon, Wright State University.
27. **Biogeochemistry of Natural and Restored Wetlands and Their Role in Treatment of Contaminated Water and Wastewater.** Abinash Agrawal, Wright State University.
28. **CO₂ Sequestration.** Neeraj Gupta, Battelle Labs.

FIELD TRIPS

Learn more about these trips at www.geosociety.org/Sections/nc/2012mtg/fieldTrips.htm.

Premeeting

1. **The Serpent Mound Impact Crater and Paleozoic Stratigraphy of Southern Ohio.** Two-days: departs Fri., 20 Apr., 5 p.m.; returns Sat., 21 Apr., 9 p.m. US\$177. Keith A. Milam, Ohio University.
2. **Lower Silurian of West-Central Ohio and the Case of the Disappearing Dayton.** One-day: Sat., 21 Apr., 8 a.m.–5 p.m. US\$81. Mark Kleffner, The Ohio State University at Lima; Bradley Cramer, Kansas Geological Survey; Carlton Brett, University of Cincinnati.
3. **Bourbon and Springs in the Bluegrass Region of Kentucky.** One-day: Sat., 21 Apr., 6:45 a.m.–6:45 p.m. US\$81. Alan Fryar, University of Kentucky; Ashley Barton, University of Kentucky.
4. **Introduction to the Geology of Dayton and Environs for Earth-Science Teachers.** One-day: Sat., 21 Apr., 9 a.m.–5 p.m. US\$66. Michael R. Sandy, University of Dayton.
5. **Upper Ordovician Strata of Southern Ohio-Indiana: Shales, Shell Beds, Storms, Sediment Starvation, and Cycles.** One-day: Sun., 22 Apr.; 9 a.m.–8 p.m. (includes evening meal). US\$83. Benjamin Datillo, Indiana University–Purdue University Fort Wayne; Carlton Brett, University of Cincinnati; Thomas Schramm, Louisiana State University.
6. **Scales of Stream Study in West-Central Ohio.** One-day: Sun., 22 Apr., 8 a.m.–5 p.m. US\$76. John Ritter, Wittenberg University.
7. **Dayton Region Geology in Core and Outcrop—A Field Guide for Citizens, Environmental Investigators, Geologists, and Educators.** One-day (morning workshop and afternoon field trip): Sun., 22 Apr., 9 a.m.–5 p.m. US\$71. Gregory A. Schumacher, Michael P. Angle, Douglas J. Aden, Ohio Dept. of Natural Resources Div. of Geological Survey; Brian E. Mott, DLZ Ohio Inc.
8. **The First Fossil-Vertebrate Locality in North America—“Big Bone Lick,” Kentucky.** One-day: Sun., 22 Apr., 8 a.m.–6 p.m. US\$134. Richard Arnold Davis, College of Mount St. Joseph; Stanley Hedeon, Xavier University; H. Gregory McDonald, National Park Service; Kenneth B. Tankersley, University of Cincinnati.
9. **Fossil Collecting from the Middle Devonian Silica Shale, West-Central Ohio.** One-day: Sun., 22 Apr., 9 a.m.–5 p.m. US\$90. Dave Mielke, Botkins, Ohio; Alex Fabian, Michigan; Michael R. Sandy, University of Dayton.

During the Meeting

10. **Downtown Dayton Walking Tour: Building Stones, Geology, and Commemorating 99 Years since the Dayton Flood of 1913.** Two-hour walking tour, Tues., 24 Apr., 2–4 p.m. US\$17. Michael R. Sandy, University of Dayton.



GSA FOUNDATION UPDATE

Donna L. Russell, Director of Operations

Diversity in the Geosciences

The Foundation's Minority Fund, which was established in the early 1980s, has been updated in both name and purpose and will now be known as the Diversity Fund.

The purpose of the Diversity Fund follows the charge of GSA's Diversity in the Geosciences Committee, which is to stimulate recruitment and promote positive career development for ethnic minorities, women, and persons with disabilities in the geoscience professions. The committee will formulate a program to reach out to these segments of our society to fulfill the goals of the GSA.

The principal objectives of the committee are as follows:

- To provide advice and support to GSA Council in matters regarding ethnic minorities, women, and persons with disabilities in the geosciences at all levels;
- To undertake activities and initiate programs that will raise the opportunities for members of these groups to participate in the geosciences;
- To raise awareness in the geoscience community of the positive role that people of ethnic minority, women, and persons with disabilities play within the geosciences; and
- To assist GSA Council and member universities with the development of strategies to interest, recruit, and retain members of these groups within the geosciences.

Currently, the Diversity Fund sponsors two research grants annually. If you would like to support this fund, please make a donation using the coupon below or go to www.gsafweb.org.



Most memorable early geologic experience

A Historic Opportunity: By a lucky chance, I witnessed mankind's first close view of another planet. During a visit to Pasadena's Jet Propulsion Lab on 14 July 1965, arranged long before and having nothing to do with planets, somebody casually asked, "Did you know that this is the day of the *Mariner 4* flyby of Mars?" I didn't, my visit having interrupted an out-of-touch family beach vacation. "Would you like to see Mission Control?" "You betcha!"

At Mission Control, all eyes were on monitors lining a long wall. Compared with later missions, the results were puny and misleading: Twenty grainy images, some blank, and a few showing a bleak cratered lunar landscape. No signs of tectonic or volcanic activity let alone canals and exotic life. But the air of tense excitement in that near-silent room left no doubt about the significance of another "giant step for mankind."

—Wolfgang E. (Wolf) Elston, University of New Mexico



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In Memoriam

The Society notes with regret the deaths of the following members (notifications received between 29 July and 31 October 2011).

George E. Becraft
Homosassa, Florida, USA
31 May 2011

James B. Benedict
Ward, Colorado, USA
1 Mar. 2011

Glenn W. Berger
Reno, Nevada, USA
Notified 21 Sept. 2011

Edgar C. Bowman
Gilroy, California, USA
1 April 2011

Scott Creely
Santa Cruz, California, USA
7 Feb. 2011

George A. Desborough
Golden, Colorado, USA
Notified 16 Aug. 2011

H. Stewart Edgell
Canberra, A.C.T., Australia
13 Apr. 2010

John A. Ferguson
Eaglemont, Victoria,
British Columbia, Canada
1 May 2011

William H. Forbes
Washburn, Maine, USA
3 May 2011

Richard W. Galster
Edmonds, Washington, USA
1 April 2011

Ronald M. Greeley
Tempe, Arizona, USA
27 Oct. 2011

Seymour S. Greenberg
West Chester,
Pennsylvania, USA
26 Sept. 2011

C. Earl Harris Jr.
Bagdad, Kentucky, USA
13 April 2011

James W. Hood
Salt Lake City, Utah, USA
Notified 18 Aug. 2011

William R. Muehlberger
Austin, Texas, USA
14 Sept. 2011

W. Robert Power
Camarillo, California, USA
Notified 24 Aug. 2011

Norman J. Silberling
Lakewood, Colorado, USA
Notified 27 Oct. 2011

Archibald M. Stalker
Ottawa, Ontario, Canada
Notified 24 Oct. 2011

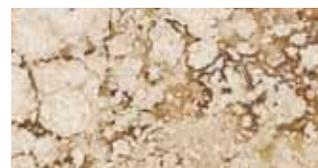
Jack A. Sunderman
Fort Wayne, Indiana, USA
23 Aug. 2011

Warren C. Thompson
Monterey, California, USA
1 July 2011

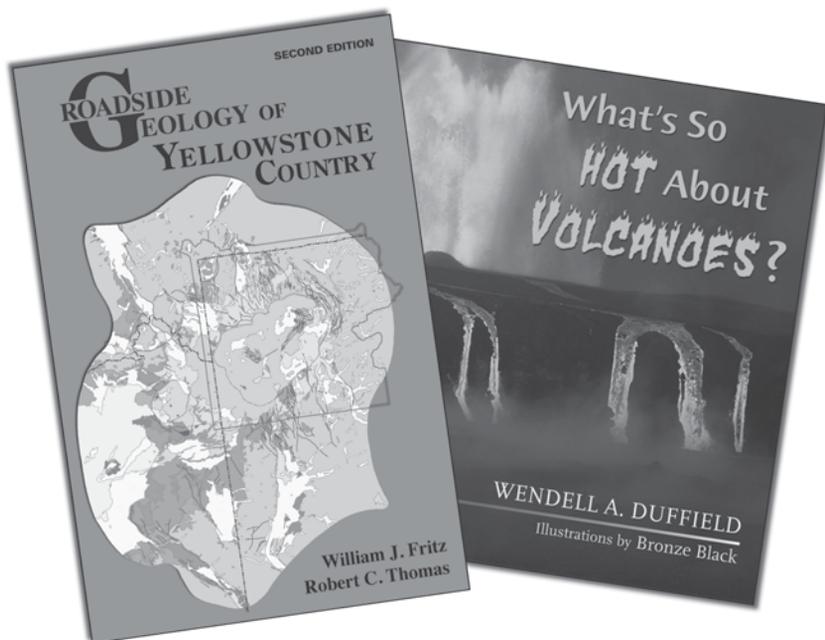
Michael J. Walawender
Moravia, New York, USA
1 Sept. 2011

Howard H. Waldron
Anacortes, Washington, USA
Notified 29 Sept. 2011

Richard F. Wilson
Flagstaff, Arizona, USA
2 Aug. 2011



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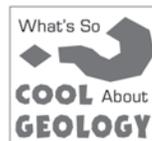
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Peer Review—The Cornerstone of Scientific Publishing

GSA Honors Its Exceptional Reviewers for 2011

Where would GSA's journals, most tops in the geoscience field*, be without reviewers? That's a rhetorical question we hope never to have to answer. This year, GSA's science editors have again compiled their list of exceptional reviewers—colleagues who have tirelessly provided prompt, insightful, meticulous, and tactful reviews of papers submitted to *Geology*, *GSA Bulletin*, *Geosphere*, *Lithosphere*, and *GSA Today*.

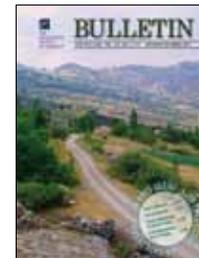


GEOLOGY

Ilya Bindeman, University of Oregon
Aaron Cavosie, University of Puerto Rico
Claude Herzberg, Rutgers University
Douwe van Hinsbergen, University of Oslo
Jeff Lee, Central Washington University
Ali Polat, University of Windsor
Gary Stevens, Stellenbosch University

GSA BULLETIN

Kathryn Amos, The University of Adelaide
Marjorie A. Chan, University of Utah
Jaume Dinares-Turell, Istituto Nazionale di Geofisica e Vulcanologia (Italy)
Ralph Lorenz, Johns Hopkins University Applied Physics Laboratory
Steve Martel, University of Hawaii
James Pindell, Rice University, The University of Houston, and Cardiff University
Brian Schubert, University of Hawaii
Micol Todesco, Istituto Nazionale di Geofisica e Vulcanologia (Italy)

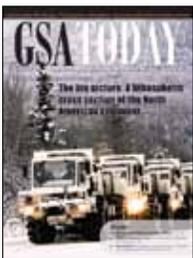
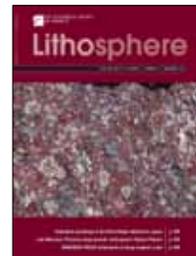


GEOSPHERE

Michael Abrams, Jet Propulsion Laboratory/California Institute of Technology
John M. Bartley, University of Utah
M. Robinson Cecil, California State University at Northridge
Jean-Daniel Champagnac, Swiss Federal Institute of Technology, Zürich (ETHZ)
Christopher Henry, University of Nevada–Reno
Richard P. Langford, The University of Texas at El Paso
Kevin Schmidt, U.S. Geological Survey Landslides Hazards Program

LITHOSPHERE

Megan L. Anderson, Colorado College
Bob Holdsworth, Durham University
Shannon Mahan, U.S. Geological Survey
Jason Saleeby, California Institute of Technology
Joann Stock, California Institute of Technology
Donna Whitney, University of Minnesota

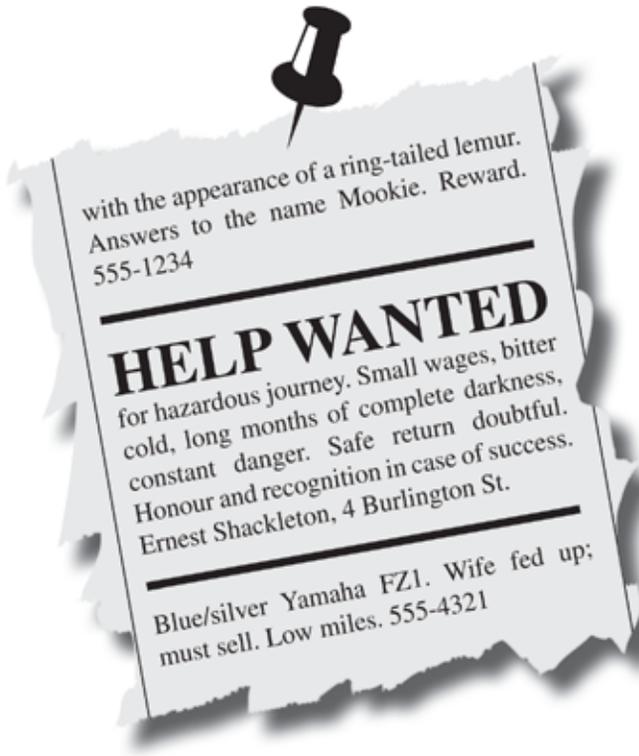


GSA TODAY

Steven Cather, New Mexico Bureau of Geology and Mineral Resources
Peter Harries, University of South Florida–Tampa
Dave Kidder, Ohio University
Steve Sheriff, University of Montana
Noah Snyder, Boston College
Martha O. Withjack, Mobil Exploration and Producing Technical Center

*See, for example, www.scimagojr.com/journalrank.php?category=1907.

Call for Applications and Nominations



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GSA is soliciting applications and nominations for science co-editors for *Geology*, *Geosphere*, and *Lithosphere*, with four-year terms beginning 1 January 2013. Duties include: ensuring stringent peer review and expeditious processing of manuscripts; making final acceptance or rejection decisions after considering recommendations of reviewers; and maintaining excellent journal content through active solicitation of diverse and definitive manuscripts.

Positions Available

Research interests that would best complement those of the continuing editors include—but are not necessarily limited to—the disciplines listed in parentheses.

Geology, 2 positions (tectonics, deformation, tectonophysics, structural geology, geodynamics, geophysics, Quaternary geology/geomorphology, thermochronology, neotectonics/paleoseismicity, remote sensing/GIS, hydrogeology, economic geology, engineering geology)

Geosphere, 1 position (geodynamics, geophysics, marine geology, tectonics, tectonophysics)

Lithosphere, 1 position (deformation [crustal, lithosphere, petrofabrics]; geodynamics; geophysics [gravity and geoid, marine geophysics]; seismology [crust and lithospheric structure, seismic anisotropy, seismotectonics, tomography]; structural geology; tectonics [flexure and isotasy, geodesy, neotectonics, plate motions]; tectonophysics)

Desirable characteristics for a successful editor include:

- a broad interest and experience in geosciences, including familiarity with new trends;
- international recognition;
- a progressive attitude and a willingness to take risks and encourage innovation;
- familiarity with many geoscientists and their work (essential for soliciting and encouraging reviewers);
- comfortable working with online systems, able to make timely decisions, organized; and
- a sense of perspective and humor.

Interested?

Each editor will work out of his or her current location at work or at home. GSA provides an annual stipend and funds for office expenses; for specifics, contact Jeanette Hammann, +1-303-357-1048, jhammann@geosociety.org. If you wish to be considered, please submit a curriculum vitae and a brief letter describing why you are suited for the position. To nominate another, submit a letter of nomination and the individual's written permission and CV. Send nominations and applications to Jeanette Hammann, GSA Publications, P.O. Box 9140, Boulder, CO 80301, USA; jhammann@geosociety.org. Nominations or applications received by 15 February 2012 will be given first consideration.



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Penrose Conference and Field Forum Proposals Encouraged

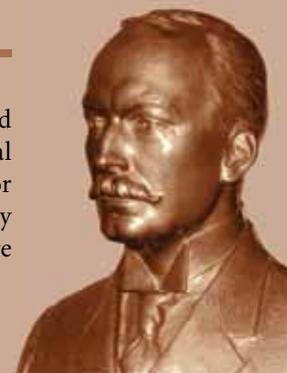
PENROSE CONFERENCES

GSA's Penrose Conferences were established in 1969 to provide opportunities for the exchange of current information and exciting ideas in geology and related fields and to stimulate and enhance individual and collaborative research. Go to www.geosociety.org/Penrose/ for guidelines and a proposal form.

FIELD FORUMS

Have a great idea for a Penrose Conference that would be much more effective in a field setting or a field trip idea that captures the essence of new discoveries or a controversial topic? Then submit a Field Forum proposal! Field Forums provide an opportunity for the exchange of current knowledge and ideas that are well expressed by the geology of a specific area. Go to www.geosociety.org/fieldforums/ for proposal guidelines and more information.

QUESTIONS? Contact Becky Sundeen, +1-303-357-1041, bsundeen@geosociety.org.



Classified Rates—2012

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

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Positions Open

FULL-TIME RESEARCH ASSOCIATE DEPARTMENT OF GEOLOGICAL SCIENCES INDIANA UNIVERSITY

The Department of Geological Sciences at Indiana University invites applications for a full-time research associate position in the metal isotope geochemistry laboratory. The facility includes a Nu Plasma II multi-collector ICP-MS, an Agilent 7700 quadrupole ICP-MS, and a clean room. We seek a highly motivated individual to operate and maintain the instruments, develop analytical methods, train users, and help manage the clean room. Pursuit of independent and/or collaborative research will be encouraged, and the lab's location in the new Multidisciplinary Science Building II at IU offers rich possibilities for collaboration in earth, planetary, and environmental geochemistry. Experience with ICP-MS methods, isotope geochemistry, and/or clean lab protocols is preferred, as well as an aptitude for working with ICP-MS hardware and associated electronics and plumbing. The position requires excellent interpersonal skills in order to promote hands-on participation of undergraduates, graduate students, postdocs, and visiting scientists. Salary will be commensurate with appointment rank and experience. A B.S. degree is required, but an M.S. or Ph.D. in earth science or chemistry is strongly preferred. Although four years of funding have already been committed for the position, the initial appointment will be for one year, with annual renewals and opportunities for promotion dependent upon performance. For full consideration, we request a letter of application, vitae, statement of research experience and interests, and contact information for three referees. One referee should be a student or collaborator who has been trained by the applicant and can comment on teaching and interpersonal skills. Applications received by 15 January 2012 will receive full consideration, but the search will remain open until the position is filled. Preferred start date is 15 March 2012, but is negotiable. Please send application materials to Professor Laura Wasylenki (lauraw@indiana.edu), Department of Geological Sciences, 1001 E. Tenth Street, Bloomington, IN 47405. Indiana University is an Equal Opportunity/Affirmative Action employer; women and minorities are especially encouraged to apply.

EXECUTIVE DIRECTOR DIVISION OF HYDROLOGIC SCIENCES DESERT RESEARCH INSTITUTE

Position #40-001, Rank III or IV

The Desert Research Institute is the non-profit environmental research institution of the Nevada

System of Higher Education (NSHE). DRI is a leader in environmental sciences through the application of knowledge and technologies to improve people's lives throughout Nevada and the world.

The Division of Hydrologic Sciences, one of the DRI's three research divisions, supports a highly diversified research portfolio focused primarily on surface water hydrology, hydrogeology, groundwater flow and transport modeling, sediment transport, cryosphere (ice/polar group), ecological engineering, limnology, vadose zone hydrology, geomorphology, geochemistry and water quality, coupled with an expanding emphasis on climate change, environmental sustainability, and implications for human health and ecology. Visit www.dri.edu/dhs for more detailed information on DHS research activities.

The primary function of the DHS Executive Director is to support, facilitate, and expand Division research activities through leadership that augments and enhances the Division's multi-disciplinary scientific skills. Responsibilities include supporting the scientific and programmatic needs of the Division and its faculty; developing and maintaining knowledge of Division research faculty expertise and areas of research interest; leveraging that knowledge to promote and facilitate research with external sponsors of funded research; ensuring DHS faculty and staff compliance with institute policy and procedures; performance-based evaluation of Division faculty and staff; coordination of Division research and administrative tasks with the EVPR and other Division Executive Directors within DRI; facilitating cooperation in teaching and research with related departments at UNR and UNLV; representing DRI to sponsors and government agencies and executing administrative responsibilities for the Division.

REQUIRED QUALIFICATIONS: Ph.D. or equivalent graduate degree from an accredited institution in hydrology, hydrogeology, water resources, environmental engineering, aquatic geochemistry, or professional experience commensurate with an advanced degree. Ability to supervise/manage budgets for organizations similar to DHS. Evidence of innovation and success in building and leading research programs in governmental, private sector, or university settings. Evidence of successful administration in an environment in which a significant portion of funding comes from extra-mural competitive grants and contracts. Record of peer-reviewed publications. Any applicant must be a citizen of the United States and be able to obtain and maintain both U.S. Department of Energy "Q" and U.S. Department of Defense Top Secret clearances, which may require a background investigation by the Federal government with possible subsequent reinvestigations.

STRONGLY PREFERRED QUALIFICATIONS: Direct experience in the soft-money research environment, such as in a national laboratory, university institute, or internationally recognized consulting firm. Examples of creativity in identifying research issues and pursuing research avenues that enhanced a similar organization's prestige and financial standing.

APPLICATION/REVIEW PROCESS: To ensure full consideration, your application materials must refer to position #40-001 and include: (1) A cover letter detailing your qualifications; (2) A summary of your career interests and goals; (3) A current curriculum vitae; and (4) Contact information for three professional references.

Send materials by email (preferred) to: Human Resources at recruit@dri.edu with MS Word or PDF compatible attachments; for further information, you may contact Kelsey Carter, kelsey.carter@dri.edu or +1-775-673-7332.

In lieu of email submission, written application materials may be directed to: Desert Research Institute, Human Resources Office, c/o DHS Executive Director search, 2215 Raggio Parkway, Reno, NV 89512.

Priority will be given to applications received by 27 Jan. 2012.

For more information, visit www.dri.edu/ employment.

The Desert Research Institute is an Affirmative Action / Equal Employment Opportunity employer, and employs only U.S. citizens and persons lawfully authorized to work in the United States.

TENURE-TRACK ASSISTANT PROFESSOR EARTH SCIENCE EDUCATION NORTHERN ILLINOIS UNIVERSITY

Northern Illinois University Department of Geology and Environmental Geosciences invites applications for an anticipated tenure-track position in Earth Science Education. The position, which will be at the rank of Assistant Professor, will be a joint appointment with the Center for Secondary Science and Math Education (CSSME) and form part of the College of Liberal Arts and Sciences teacher education program (initial certification and professional development in teacher education). The anticipated starting date is August 2012. Both teacher certification credentials and a Ph.D. in geology or associated science are required at the time of appointment. Teaching duties will include graduate and undergraduate courses in geoscience and in earth science teacher education, including geological field capability. The successful candidate will also be expected to develop a nationally recognized and externally funded research program in geology and/or earth science education and to work with faculty across disciplines to move NIU to a position of national leadership in science education. For additional information about the department, its faculty, and the position see www.niu.edu/geology. Applications including CV, statement of teaching and research interests, and names of three references should be submitted to Dr. Paul Stoddard, Department of Geology & Environmental Geosciences, Northern Illinois University, DeKalb, IL 60115 (teachgeology@niu.edu). Preference will be given to applications received by 30 Jan. 2012. NIU is an AA/EEO Institution that values diversity in its faculty, staff, and students; we strongly encourage applications from a diverse field of candidates including women and minorities. A state-mandated pre-employment criminal background investigation is required.

ASSISTANT/ASSOCIATE PROFESSOR GEOSCIENCE & CHEMISTRY UNIVERSITY OF CONNECTICUT

Search # 2012231

The Center for Integrative Geosciences and the Department of Chemistry at The University of Connecticut-Storrs, invite applications for a joint tenure-track Assistant Professor appointment to begin August 2012. Appointments at the Associate Professor level will be considered for extraordinarily well-qualified candidates. We seek candidates who combine expertise in solid earth materials, low-temperature geochemistry, and earth-surface processes. Possible interests include, but are not limited to, mineral-fluid interactions (e.g., applications in hydrogeology, geochemical cycles) and geochemistry (e.g., applications in isotope geochemistry, geochronology, paleoclimatology).

Minimum Qualifications: A Ph.D. in Geoscience or a related field; capacity to incorporate a course on

Earth Materials, including mineralogy and petrology, into an interdisciplinary, undergraduate Geoscience curriculum; demonstrated record and vision for excellence in research and publication. Equivalent foreign degrees are acceptable.

Preferred Qualifications: Capacity to teach in the Environmental Chemistry program; research interests complementing and bridging existing programs in Geosciences and Chemistry, including low-temperature geochemistry and earth-surface processes; post-graduate research experience; demonstrated excellence in teaching; demonstrated ability to contribute through research, teaching, and/or public engagement to the diversity and excellence of the learning experience.

Appointment Terms: This is a full-time, 9-month appointment. Salary is competitive based on experience and qualifications. The successful candidate's primary academic appointment will be at the Storrs campus with the possibility of work at UConn's regional campuses.

To Apply: Please submit a curriculum vitae, letter of application, statement of research and teaching interests using Husky Hire (www.jobs.uconn.edu). In addition, please arrange for three confidential letters of recommendation to be sent to Mrs. Abigail Hastillo, University of Connecticut, Center for Integrative Geosciences, 354 Mansfield Road U-2045, Storrs, CT 06269-2045 or to geology@uconn.edu. Screening of applications will begin 15 Feb. 2012 and will continue until the position is filled. Please include the search number with all correspondence. The University of Connecticut encourages minorities, women, and people with disabilities to apply for this position. The University of Connecticut is an EEO/AA employer.

**FULL-TIME, TENURE-TRACK POSITION
ASSISTANT PROFESSOR
DEPARTMENT OF GEOGRAPHY AND
GEOSCIENCES, BLOOMSBURG UNIVERSITY
OF PENNSYLVANIA**

Department of Geography and Geosciences invites applications for a full-time, tenure-track position at the Assistant Professor level (AA# 41-1-137) to begin fall semester 2012. We seek a physical scientist who specializes in **environmental resources** with expertise in exploration, conservation, or remediation. Demonstrated ability to work with diverse populations preferred. For full consideration, completed applications must be received by 30 Jan. 2012. For a full position description, including application procedures, visit www.bloomu.edu/jobs. AA/EEO Employer

**TECTONICS/DYNAMICS/
SURFICIAL PROCESSES
WESTERN WASHINGTON UNIVERSITY**

Washington University invites applications for a tenure-track Assistant Professor whose interdisciplinary research and teaching specialties connect tectonics/structural geology and surface processes. The appointment will begin effective 16 Sept. 2012. The ideal candidate will enhance our existing strengths in field geology, geomorphology, geophysics, and tectonics, and contribute to the development of emerging departmental directions in engineering geology and geohazards research. Some examples of desirable research directions include influences of tectonic processes on landform evolution, rock/soil mechanics, or surficial deformation/seismic hazards associated with active plate margins. Candidates must have a Ph.D. in an appropriate Earth Science field at the time of appointment; teaching/research

specialty in tectonics + surface processes; ability to teach Structural Geology, Introduction to Geology, and Field-based courses (such as a portion of Field Geology or a section of a field-taught Structure course); ability to develop high-quality undergraduate teaching program; ability to establish externally supported research program; ability to involve students in research; ability to contribute to graduate (MS) degree program; and excellent understanding of fundamental physical principles and processes and a demonstrated ability to apply that understanding in field-based and quantitative ways to important problems in the Earth sciences. Preferred qualifications include post-doctoral experience; college-level teaching experience; ability to teach GIS, Engineering Geology, or Geophysics/Geodynamics; and ability to work with a diverse student body. Interested candidates must apply online. To see full position description and log in to WWU's Electronic Application System for Employment (EASE), please go to <https://jobs.wvu.edu/JobPostingsBrowse.aspx?CatID=85>. Applications need to include a cover letter outlining your teaching and research experience and accomplishments with specific reference made to the required and preferred qualifications described above. The application should also include a C.V., graduate school transcripts, statements describing teaching and research philosophy and effectiveness, as well as goals and plans for teaching and research at WWU. The names and contact information for letters of reference from four persons familiar with the candidate's research and teaching must be provided; one of these references must be from outside the applicant's current institution. Review of all application materials will begin on 17 Feb. 2012; position is open until filled. Questions regarding this position should be directed to the search committee chair, Elizabeth Schermer (schermer@geol.wvu.edu) or the Geology Department chair, Bernie Housen (bernieh@wvu.edu). WWU is an EO/AA employer and encourages applications from women, minorities, persons with disabilities and veterans.

**SUPERVISING OIL AND GAS ENGINEER
DIVISION OF OIL, GAS, AND GEOTHERMAL
RESOURCES, CALIFORNIA DEPARTMENT
OF CONSERVATION**

Monthly salary: \$9,339-\$11,354 DOQ. Five+ years experience as an engineer or geologist in oil, gas, or geothermal resource exploration, production, or development, two years supervisory experience required. Graduate degree in petroleum engineering, geology or closely related field may be substituted for two years of the nonsupervisory experience. Registration as a professional engineer or geologist desirable.

For application instructions please contact: Pam Derby, CPS HR Consulting, 241 Lathrop Way, Sacramento, CA 95815, Phone: 916/263-1401, Fax: 916/561-7205, e-mail: resumes@cps.ca.gov, online brochure: www.cps.ca.gov/search. EOE.

**ASSISTANT PROFESSOR
SUBSURFACE ANALYSIS OF SEDIMENTARY
ROCKS, WEST VIRGINIA UNIVERSITY**

The Dept. of Geology and Geography at WVU seeks to hire at the Assistant Professor level a dynamic geoscientist who studies sedimentary rocks in the subsurface. Possible areas of expertise include, but are not limited to, subsurface study of sequence stratigraphy, petrophysics, diagenesis of reservoirs, fracture modeling, basin analysis or geocellular modeling. This new position is part of the WVU Advanced Energy Research Initiative ([\[www.wvu.edu/\]\(http://www.wvu.edu/\)\). A primary focus will be to develop a vigorous externally funded research program which contributes to the WVU Advanced Energy Initiative \(\[energyresearch.wvu.edu\]\(http://energyresearch.wvu.edu\)\). The successful applicant will also teach at the undergraduate and graduate levels. We require a Ph.D. in Geology or a related field, evidence of ability to establish a strong, externally funded research program, and potential for/commitment to teaching excellence. We are open to candidates with diverse academic and professional backgrounds and will consider more senior applicants. The department values intellectual diversity and demonstrated ability to work with diverse students and colleagues.](http://energyresearch</p>
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The 1 July 2011 edition of *The Scientist* (the-scientist.com) ranks West Virginia University among the top 20 places to work in academia. The department is located in an outstanding newly renovated facility.

Visit www.geo.wvu.edu/files/subsurface.pdf for a full description of the position and how to apply. Review of applications will begin 31 Jan. 2012 and will continue until the position is filled. The anticipated start date is 16 Aug. 2012. West Virginia University is an Equal Opportunity/Affirmative Action employer and the recipient of an NSF ADVANCE award for gender equity. Women and minority candidates are encouraged to apply.

**TIER II CANADA RESEARCH CHAIR
IN GEOCHEMISTRY, DEPT. OF EARTH
SCIENCES (DES) AND MINERAL
EXPLORATION RESEARCH CENTRE (MERC),
LAURENTIAN UNIVERSITY**

The CRC Program was created by the Government of Canada to cultivate world-class research and development. Canada Research Chairs are funded by the Canadian government (www.chairs.gc.ca) and are designed for exceptional emerging researchers. The position is contingent on the successful candidate being approved by the Canada Research Program. These positions are tenure-track. The Canada Research Chair is a five year appointment.

The Dept. of Earth Sciences (DES) and Mineral Exploration Research Centre (MERC) at Laurentian University invites applications for a tenure-track *Tier II Canada Research Chair in Geochemistry*.

The successful applicant is expected to maintain an existing LA-ICP-QMS facility (fully specified Resonetics RESolution M50 laser probe installed in October 2010, and a dedicated Thermo-Fisher XSeriesII ICP-QMS installed in 2006) and to lead the effort to obtain additional equipment that will expand and upgrade the existing facilities.

We seek an innovative individual with an excellent record of research and publication, who will provide leadership for national and international collaborative research, and who will develop initiatives involving DES, MERC, the Ontario Geological Survey, and the Canadian mining industry. The Chair will teach two half year courses (half of the regular load) in our B.Sc., M.Sc., and Ph.D. programs and help maintain our status as one of the leading global centers in the study of mineral deposits and Precambrian geology. The successful candidate will have access to a wide range of sample preparation and analytical equipment. The department has a full lapidary workshop and full mineral separation facilities, and operates a variety of equipment, including a fluid inclusion stage (equipped with IR), a variety of XRD equipment, a SEM with a top-of-the-line CL detector, and a Raman microscope. Members of the department also have access to EPMA, WD-XRF, ICP-AES, and solution ICP-MS facilities, at preferential rates, in the Ontario Geoscience Laboratories (located in

the same building as DES and MERC). Additional information about DES and MERC can be found at www.earthsciences.laurentian.ca and www.merc.laurentian.ca.

Applicants should provide a letter of intent *clearly indicating which position they are applying for*, a summary of research interests (including research program), a complete curriculum vitae, and at least three letters of reference to: Robert Kerr, Vice-President, Academic and Provost, Laurentian University, 935 Ramsey Lake Road, Sudbury, ON P3E 2C6, Canada, or by e-mail to vpap@laurentian.ca.

Laurentian University (LU) is located in Sudbury, Ontario, an attractive modern city offering unique culture, recreational, and educational opportunities. LU is a bilingual institution and an equal opportunity employer. It has a policy of passive bilingualism (English/French) as a condition of tenure. LU faculty members are part of LUFU (the Laurentian University Faculty Association). Information and the Collective Agreement can be found at www.lufapul.ca. More information on the University can be found at www.laurentian.ca.

Applications will be reviewed commencing in January 2012 but will be accepted until the position is filled.

ASSISTANT OR ASSOCIATE PROFESSOR GEOLOGICAL ENGINEERING UNIVERSITY OF UTAH

The Department of Geology & Geophysics at the University of Utah is inviting applications for a tenure-track faculty position in Geological Engineering beginning fall semester 2012. Applicants must have a Ph.D. and an established and productive research program in a field of geological engineering. Examples of appropriate research areas include, but are not limited to, landslides and slope stability, geological hazard mapping and risk assessment, earthquake engineering, reservoir engineering, rock mechanics and petrophysics. The position requires teaching capstone undergraduate design and other courses in support of the ABET accredited Geological Engineering Program. For further details and to apply please go to: <http://utah.peopleadmin.com/postings/11278>.

The University of Utah is an Equal Opportunity/Affirmative Action employer and educator. Minorities, women, and persons with disabilities are strongly encouraged to apply. Veterans preference. Reasonable accommodations provided. For additional information: www.regulations.utah.edu/humanResources/5-106.html.

The University of Utah values candidates who have experience working in settings with students from diverse backgrounds, and possess a strong commitment to improving access to higher education for historically underrepresented students.

COASTAL GEOLOGICAL OCEANOGRAPHER THE UNIVERSITY OF SOUTHERN MISSISSIPPI

The Department of Marine Science at the Stennis Space Center is seeking a coastal geological oceanographer at the tenure-track, assistant or associate professor level. Applicants must hold a Ph.D. in a geological field and have demonstrated field and research experience in sedimentology, preferably in shelf and coastal environments. Post-doctoral experience is desirable for assistant-level applicants. A nationally recognized record of publication, demonstrated successful grantsmanship, and at least five years of service at another degree-granting institution or equivalent service at a non-degree-granting

institution are needed at the associate-level. A successful candidate is expected to conduct an active research program and develop courses for an interdisciplinary academic program for graduate and undergraduate students. The successful candidate must demonstrate a commitment to collaborative research and teaching. Information is available online about the department at www.usm.edu/marine/.

Applicants should submit a letter of interest outlining their qualifications for the position, including a research plan, teaching philosophy with a curricular plan, a curriculum vitae, and names and contact information of at least four references. All application materials will be accepted online at <https://jobs.usm.edu>. For inquiries about the position, contact Dr. Charlotte Brunner at charlotte.brunner@usm.edu or +1-228-688-3576. Applicant review will begin 15 Jan. 2012, and continue until the position is filled. AA/EOE/ADA.

DEPARTMENT OF GEOLOGICAL SCIENCES THOMPSON CHAIR OF GEOLOGICAL SCIENCES, UNIVERSITY OF FLORIDA

The Dept. of Geological Sciences, University of Florida, invites applications for the **Thompson Chair of Geological Sciences**, an endowed position at the rank of Full Professor. The successful candidate will be expected to teach at the undergraduate and graduate levels, mentor students for M.S. and Ph.D. degrees, and conduct a dynamic, externally funded research program in an area of globally significant earth science. Research interests of the successful candidate should relate to geological problems of Florida and the surrounding region, although prior experience in the region is unnecessary. Ph.D. is required. Salary will be commensurate with qualifications and experience.

For additional information or nominations please contact Dr. Jonathan B. Martin, Thompson Chair Search Committee, Department of Geological Sciences, University of Florida, P.O. Box 112120, Gainesville, FL 32611-2120 (jbmartin@ufl.edu). Applications are currently being reviewed and to ensure complete consideration, they should be received no later than 15 Jan. 2012. Candidates must apply online at <http://jobs.ufl.edu> (requisition # 0806180). For full consideration, the application should include: (1) cover letter; (2) curriculum vitae; (3) statement of research, teaching, vision, and goals; (4) reprints of no more than three publications; and (5) the names of three colleagues who might be contacted for letters of recommendation. The University of Florida is an Equal Opportunity Institution. If an accommodation due to a disability is needed to apply for this position, please call +1-352-392-2477 or the Florida Relay System at +1-800-955-8771 (TDD). The selection process will be conducted under the provisions of Florida's "Government in the Sunshine" and Public Records laws.

ASSISTANT PROFESSOR, GEOPHYSICS DEPT. OF EARTH AND PLANETARY SCIENCES UNIVERSITY OF NEW MEXICO

The Dept. of Earth and Planetary Sciences at the University of New Mexico invites applications for a tenure track faculty position at the rank of Assistant Professor in the field of geophysics. The position is a full-time, probationary appointment leading to a tenure decision.

We seek candidates with expertise in any area of geophysics. Candidates with demonstrated research expertise that complements existing departmental strengths (epswww.unm.edu) are especially encouraged to apply.

Minimum qualifications are a Ph.D. in Geosciences or a related field at the time of appointment, targeted for August 2012.

The application package, containing a letter of interest, resume, a statement of teaching and research interests, and the names of three references with contact information, should be submitted electronically to UNM Jobs: <https://unmjobs.unm.edu/applicants/Central?quickFind=65166>.

For best consideration, all materials must be received by 31 Jan. 2012. However, the position will remain open until filled.

For questions regarding the application process please contact Paula Paschetti (paschetti@unm.edu), Search Coordinator, Department of Earth and Planetary Sciences (+1-505-277-1633).

Women and under-represented minorities are strongly encouraged to apply. The University of New Mexico is an equal employment/affirmative action employer and educator.

DIRECTOR, NEW MEXICO BUREAU OF GEOLOGY & MINERAL RESOURCES NEW MEXICO INSTITUTE OF MINING AND TECHNOLOGY

The New Mexico Bureau of Geology and Mineral Resources is seeking a new director and state geologist. The bureau is a research and service division of the New Mexico Institute of Mining and Technology (New Mexico Tech), located in Socorro, New Mexico. With close to 60 employees, the bureau serves as the state geological survey, with a long-standing reputation for excellence in research, service, and outreach. Our mission includes research on the geologic framework of the state, with an emphasis on applied geosciences and the state's geologic resources; and the gathering, preservation, and dissemination of geologic information to the geoscience community, state and federal agencies, and the general public. The director manages the administrative, personnel, and financial affairs of the bureau, including direct supervision of a significant portion of the professional staff, and must be proactive in seeking additional, external funding to support new and ongoing programs. As a division of the university, the bureau works in collaboration with other divisions of the university. The director reports directly to the university president. As state geologist, the director serves on several state advisory commissions. Requirements include a Ph.D. in the geosciences, ten years of professional experience, and five years of administrative experience. Anticipated appointment date: as soon as filled, but no later than September 2012. Salary: Negotiable. Full details of the position and information regarding application procedures may be found at www.geoinfo.nmt.edu/DirectorSearch and at www.nmt.edu/hr-jobs-at-nmt. For more information about the application process, contact JoAnn Salome in Human Resources at +1-575-835-5955 (JSalome@admin.nmt.edu). For more information about the position itself, contact L. Greer Price, search committee chair, at +1-575-835-5752 (gprice@gis.nmt.edu). For full consideration, application materials must be received by 1 March 2012.

ASSISTANT PROFESSOR OF GEOLOGY UNIVERSITY OF ARKANSAS AT LITTLE ROCK

The University of Arkansas at Little Rock Dept. of Earth Sciences invites applications for a tenure-track assistant professor position in either Mineralogy/Petrology or Environmental Geology/Geochemistry. We seek a broadly trained scientist who will complement existing faculty strengths.

We expect faculty to develop and maintain an innovative, extramurally funded research program, to supervise student research projects, and to publish results in refereed journals. The successful applicant should have a Ph.D. degree at the time of employment and demonstrated potential to perform teaching duties. Teaching duties will include introductory geology and courses in the candidate's specialty.

The Department of Earth Sciences, with over 70 undergraduate geology majors, offers a BS in Geology, a Graduate Certificate in Geospatial Technology, and participates in college graduate programs. Research facilities include geochemical instrumentation, mineral separation equipment, and a state-of-the-art spectroscopy and microscopy facility (<http://ualr.edu/nanotechnology/>).

Submit applications electronically in PDF format to jbconnelly@ualr.edu. Please use the subject line Assistant Professor Geology-R97703-01. Applications should include a cover letter, curriculum vitae, statement of teaching and research interests and goals, and contact information for at least three professional references. The position begins 15 Aug. 2012. Review of applications will begin 1 Dec. 2011 and will continue until the position is filled. For more information, please contact Dr. Jeffrey Connelly, Chair, Department of Earth Sciences, jbconnelly@ualr.edu.

The University of Arkansas at Little Rock is an equal opportunity, affirmative action employer and actively seeks candidacy of women, minorities and individuals with disabilities. Persons hired must provide proof of legal authority to work in the United States. Under Arkansas law, all applications are subject to disclosure.

Opportunities for Students

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 new Spatial & Earth Sciences Program. The Department offers a new and exciting field- and laboratory-intensive curriculum emphasizing environmental geology and geochemistry, medical geology, geoarchaeology, surface processes, paleoecology, geobiology, dendrochronology, GIS/remote sensing, paleoceanography, marine geology, biogeochemistry, climatology, and paleoclimatology. The department

supports a number of state-of-the-art laboratory facilities, and our faculty is committed to providing students with hands-on learning experiences. Application review begins immediately and preference is given to applications received before 1 Feb. 2012. Application forms can be obtained by visiting www.indstate.edu/ees/. For more information contact Dr. Anthony Rathburn, Department of Earth & Environmental Systems, Indiana State University, Terre Haute, Indiana 47809, Tony.Rathburn@indstate.edu.

M.Sc. student opportunities: Caribbean climate change of the last two millennia, University of Puerto Rico 2012. The Departments of Geology and Marine Sciences, University of Puerto Rico at Mayagüez (<http://geology.uprm.edu/>) are seeking 1–2 M.Sc. candidates for an NSF-funded project to use a network of speleothems and Cariaco Basin data in an international collaboration. A degree in physical sciences is preferred, as well as experience with scientific programming and instrumentation, and field collection and laboratory analysis. Being bilingual (Spanish/English) is an asset but not required.

The position starts immediately, 2012, and will run at least two years. Candidates should send a complete CV, a statement of interest, copies of academic certificates, and names and emails of three referees to Dr. Thomas Miller by e-mail: thomasmiller@upr.edu.

Graduate Student Opportunities, Ohio University. The Dept. of Geological Sciences at Ohio University invites applications to its graduate program for the Fall of 2012. The department offers an MS degree in Geological Sciences with areas of emphasis including paleontology, stratigraphy/sedimentology, hydrogeology, geochemistry, geomorphology, planetary geology, geophysics, and tectonics. Prospective students are encouraged to contact faculty directly to discuss potential research topics. Qualified students are eligible to receive teaching or research assistantships that carry a full tuition scholarship and a competitive stipend. For program and application information, visit the department website at www.ohiou.edu/geology/ or contact the graduate chair, Dr. Keith Milam (milamk@ohio.edu) for additional information. Review of applications begins 1 Feb. 2012.

Geoscience Education, Department of Marine, Earth and Atmospheric Sciences at North Carolina State University. The Dept. of Marine, Earth and Atmospheric Sciences at North Carolina State University

seeks applicants for two multiyear graduate research assistantships for students wishing to pursue a M.S. or Ph.D. degree focused on Geoscience Education. Applicants should have a strong interest in reformed teaching methods and a B.S. or M.S. degree in a geoscience discipline. Teaching experience at the college level is desired but not required. Assistantships include a 12-month stipend, tuition, fees and health benefits. Successful students will work within the Geoscience Learning Process research group and will have potential roles in the NSF-funded InTeGrate (Interdisciplinary Teaching of Geoscience for a Sustainable Future) project described at <http://serc.carleton.edu/integrate/index.html>.

The Department of Marine, Earth, and Atmospheric Sciences (MEAS) is one of the largest interdisciplinary geoscience departments in the nation. Review of applications will begin in January and initial decisions will be made as early as February 2012. Applications can be submitted online from www.ncsu.edu/grad/applygrad.htm. For more information contact Dr. David McConnell, Department of Marine, Earth and Atmospheric Sciences, Campus Box 8208, North Carolina State University, Raleigh, NC 27695.

Graduate Assistantships and Fellowships, University of Kentucky. The Dept. of Earth and Environmental Sciences at the University of Kentucky has assistantships and fellowships available for the 2012–2013 academic year for M.S. and Ph.D. students. All awards include tuition and health insurance. The department has eight regular faculty members (with additional faculty members joining during 2012–2013), three lecturers, and 13 adjuncts at the Kentucky Geological Survey and the UK Center for Applied Energy Research. Research specializations include geochemistry, geophysics, hydrogeology, igneous/metamorphic petrology, sedimentary geology, and tectonics. Facilities include a state-of-the-art stable isotope laboratory; the Sedimentary, Environmental and Radiochemical Research Laboratory; the Kentucky Seismic and Strong-Motion Network; instruments for potential field geophysics; electron microprobe and X-ray diffraction laboratories; and extensive library holdings. UK is located in Lexington, a vibrant community of nearly 300,000. The surrounding area offers a wealth of outdoor and cultural opportunities. For more information, visit <http://ees.as.uky.edu> or contact Dr. Alan Fryar, Director of Graduate Studies (+1-859-257-4392 or alan.fryar@uky.edu).

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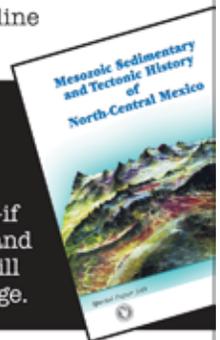
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An Astrophysicist Looks at Global Warming

Richard D. Schwartz*

Absent in much of the public debate on climate change has been discussion of the basic science behind it. This perspective discusses that science by comparison with the well-known laws of motion and gravitation. The basic science behind global warming is firmly established. The connection between observed temperature and atmospheric CO₂ increase is much more than sheer supposition.

A great deal of confusion is present within the general public on the role of greenhouse gases in causing global warming. Even within the scientific community there sometimes seems to be a lack of understanding of the physics of greenhouse gas warming, especially among scientists who are not familiar with molecular physics. It is often assumed, especially within the general public, that global warming can be understood by supposition only. The reported correlation between the increase in global temperature and the increase in atmospheric greenhouse gases is taken to represent the basis of the science.

There has been little public discussion of the actual scientific basis of greenhouse gas warming. In this note, I present the case from the viewpoint of an astrophysicist. Geologists are probably most familiar with the role of orbital insolation variations (Milankovitch cycles) as a major contribution of astronomy to geosciences. But astrophysicists have long appreciated the important contribution of greenhouse gases in the warming of planetary atmospheres and that the scientific basis for this warming is firmly established in the science of molecular physics. Here, a parallel is drawn between the relatively simple application of Newtonian physics to problems in mechanics and the more complex enterprise of applying molecular physics to greenhouse warming.

The scientific basis, in theory and experiment, underlying greenhouse gas warming is as robust as any aspect of modern science. A good analogy can be found in our understanding and application of the laws of motion and the law of gravity. Few would question the efficacy of the basic mathematical laws of motion and the inverse square law of gravitation in computing the trajectories of artillery shells, orbiting satellites, and interplanetary spacecraft. Classical Newtonian laws can be used to determine the trajectory of an artillery shell to a high degree of

accuracy. Given the velocity of the artillery projectile, wind, and the effects of gravity, the point of impact can be located with great precision. Of course, there are uncertainties that must be considered. But “uncertainty” or “error” is not meant to imply that the laws of physics are incorrect. Unfortunately, the latter seems to be the interpretation of “uncertainty” held by much of the general public in the context of global warming discussions.

Uncertainty in the context of global warming models refers to the numerical uncertainties for the input information that must be factored into calculations. In the case of the trajectory of the artillery projectile, it might be computed for given wind conditions that the projectile has a 98% probability of hitting within 10 feet of the intended target position if fired from a distance of one mile. The point is that the laws of motion and gravitation permit highly accurate calculations of the trajectory of a projectile, but that in the real world there are many factors that can slightly perturb the trajectory. To reach an estimate of the actual trajectory, one must include these perturbing factors.

The scientific basis and calculations for greenhouse gas warming of the atmosphere have many parallels to the problem of computing projectile trajectories (“greenhouse warming” is a misnomer; in a greenhouse, warming is due to confinement of air warmed by sunlight, whereas in “greenhouse gas” warming, gases confine more heat in the atmosphere).

What is the physical theory behind the greenhouse gas effect, and can it be computed from the laws of physics? The answer is a resounding yes! The effects of heat trapping by greenhouse gases was first noted over a century ago and understood from the viewpoint of classical physics involving the absorption and emission of electromagnetic radiation by matter and the thermodynamics of gas. The mathematical and physical laws of the interaction of electromagnetic radiation and matter underlie our understanding of greenhouse gas warming.

This understanding gained a firm basis with the development of quantum mechanics in the 1920s. This development enabled detailed calculations of the physics of absorption, scattering, and emission of electromagnetic radiation by atoms and molecules that make up Earth’s atmosphere. Highly sophisticated radiation transfer codes have been perfected to calculate the energy balance in an atmosphere as energy is transferred through atmospheric layers. Trace polyatomic molecules such as water vapor, CO₂, and methane have rotation, bending, and vibration degrees of freedom, and are quite effective at intercepting infrared radiation radiated by Earth’s surface and the atmosphere.

When a greenhouse molecule absorbs an infrared photon, the molecule rotates or vibrates faster and is said to be in an “excited” state. At low gas densities, an excited greenhouse gas molecule will

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* Deceased 28 July 2011 (corresponding e-mail: Thomas Crowley, tcrowley111@googlemail.com). The author was professor emeritus and former chair of the Department of Physics and Astronomy at the University of Missouri–St. Louis. He obtained a Ph.D. in astronomy at the University of Washington in 1973 and published an analysis of global “dimming” using transmission coefficients obtained from astronomical data.

spontaneously (by the rules of quantum mechanics) reradiate an infrared photon, which may escape the atmosphere into space and produce no net warming.

At the higher densities of Earth's atmosphere, the excited molecule will bump into (collide with) another molecule (any molecule in the atmosphere). In the collision, the energized greenhouse gas molecule loses its rotational energy, which is transferred to the kinetic energy of the molecule it collides with (this is called collisional de-excitation). The increased kinetic energies of the colliding molecules means that the molecules are moving faster than they were prior to the collision, and the increased velocities of such molecules represents a direct measure of increased atmospheric temperature.

“Greenhouse gas” warming occurs because the collisional de-excitation time for greenhouse molecules in Earth's lower atmosphere is much shorter than the radiation lifetime of excited molecular states. This is the basic science of greenhouse gas warming, and can be computed from the laws of physics and demonstrated and measured in laboratory experiments. There is no doubt about the efficacy of the science behind greenhouse gas warming (see www.youtube.com/watch?v=SeYfl45X1wo).

Although there are parallels between computing projectile trajectories and computing global warming, there are also differences. In the case of trajectories, one can repeat an experiment many times and measure the uncertainty. In the case of global warming, there is only one Earth's atmosphere with which to “experiment.” One arrives at formal uncertainties in the models by varying the input parameters (for example, the rate of CO₂ input into the atmosphere from fossil fuel burning) and computing many such models.

Modeling global warming is more complex than the relatively simple modeling of the trajectory of a projectile. A great many uncertainties, including the effects of clouds, solar variation, volcanism, and the complex coupling of atmosphere, oceans, land, and the carbon cycle, must be incorporated into models.

There are other planets, however, for which greenhouse gas warming is important, and for which modeling can test the importance of the process. In particular, both Mars and Venus have predominantly CO₂ atmospheres. If the Martian atmosphere consists of 95% CO₂, why is it not much warmer? The basic answer is that the very low gas pressure (0.01 earth atmosphere) of the Martian atmosphere allows most excited CO₂ molecules to radiate away their energy before they have a chance to collide with another molecule and deposit heat in the atmosphere. Even so, there is enough warming to raise the temperature by ~6 °C over what the case would be if the Martian atmosphere consisted of nitrogen rather than CO₂.

In the case of Venus, not only is the atmosphere dominated by CO₂ (98%), but the pressure is ~90 earth atmospheres (because Venus and Earth are of comparable size, and outgassing accounts for the CO₂, the total carbon in the Venusian atmosphere is approximately the same as in Earth's atmosphere, ocean, and crust). This means that excited CO₂ molecules will collide with one another so frequently that few will have a chance to lose energy through radiation to outer space. Therefore a much higher

fraction of the infrared radiation from the surface and the atmosphere is trapped within the lower atmosphere, leading to a very high (nearly 900 °F [460 °C]) atmospheric temperature.

In the case of Earth's atmosphere, it has been known for some time that the most important greenhouse gas is water vapor, contributing ~75% of the total atmospheric greenhouse gas warming of some 33 °C. CO₂ and other trace greenhouse gases are responsible for the remaining 25% of heating. Without these greenhouse gases, Earth would be in a frozen state.

Most contrarians fail to recognize the great importance of carbon dioxide in producing the warming of Venus and Mars. The fundamental physics of the important feedback of increasing water vapor (another important greenhouse gas) in response to carbon dioxide warming (i.e., warmer air holds more water vapor) has been applied in thermodynamics for more than 150 years. These two powerful concepts provide a very firm foundation for the fundamental soundness of global warming physics.

Even a cursory reading of international climate assessments (IPCC, Intergovernmental Panel for Climate Change) indicates inclusion of quantitative estimates of many factors that influence radiation forcing and their uncertainties. Scientists may disagree with the uncertainties associated with, for example, the net effect of clouds on radiation forcing. But those disagreements must be weighed in the context of a mountain of published evidence that supports the conclusions and uncertainties reported by the IPCC.

In summary, many criticisms of global warming models are specious and fail to reflect an understanding of the basic science behind the models and the extensive history of the development of radiation transfer codes in modeling planetary and stellar atmospheres. Some contrarians engage in arguments that the warming observed is due to “natural” mechanisms that have been in play for millions of years. *Such proposals should be required not only to identify the specific natural mechanisms in question, but quantify them and present observational or experimental evidence that the mechanisms play a role on a time scale of the past 150 years.* Such proposals also ignore the fact that proxy geochemical data show strong support for the conclusion that CO₂ increases have played the largest role in explaining these past intervals of global warmth!

Most important, contrarians *must* show why the scientific basis of greenhouse gas warming is incorrect. It remains unfortunate that the opinions of a handful of contrarians should be given the same weight in the press and the popular media as the studied conclusions of thousands of scientists. This reinforces the general perception that the “science” of global warming is uncertain, and provides fodder for some (but by no means all) business and political factions to question the reality of anthropogenic global warming.

RECOMMENDED READING

Pierrehumbert, R.T., 2011, Infrared radiation and planetary temperature: *Physics Today*, v. 64, p. 33–38.

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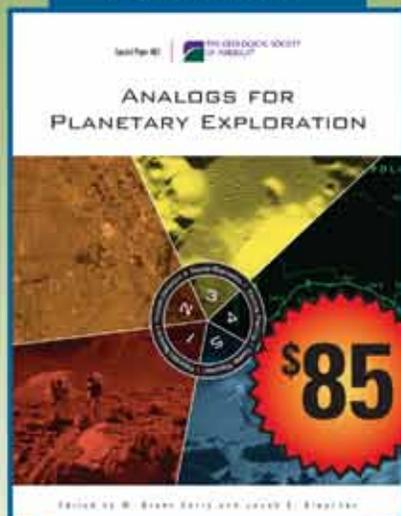
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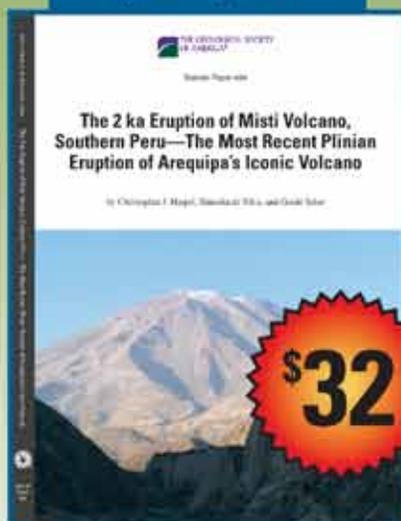
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