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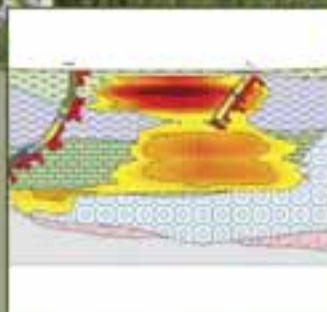


The digital revolution in geologic mapping

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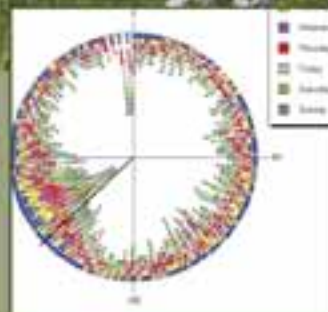
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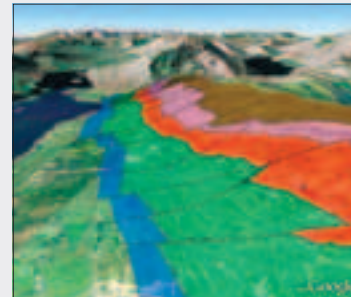
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Steven J. Whitmeyer, Jeremy Nicoletti, and Declan G. De Paor



Cover: Westward-looking view of a Google Earth-based geologic map of the mountain of Knock Kilbride in the Connemara region of western Ireland. See “The digital revolution in geologic mapping” by S.J. Whitmeyer et al., p. 4–10.

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Errata

1. On pages 7 and 8 of the Feb. 2010 science article (v. 20, no. 2, p. 4–9), weathering rates listed as mm yr⁻¹ and mm k.y.⁻¹ were inadvertently changed to m yr⁻¹ and m k.y.⁻¹. Please note that the correct measurement is **millimeters**, not meters.
2. The participants list for the Penrose Conference on p. 24–25 of the Feb. 2010 issue (v. 20, no. 2) did not include one attendee, George T. Stone, of Milwaukee Area Technical College.

The digital revolution in geologic mapping

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ABSTRACT

Geologic field data collection, analysis, and map compilation are undergoing a revolution in methods, largely precipitated by global positioning system (GPS) and geographic information system (GIS) equipped mobile computers paired with virtual globe visualizations. Modern, ruggedized personal digital assistants (PDAs) and tablet PCs can record a wide spectrum of geologic data and facilitate iterative geologic map construction and evaluation on location in the field. Spatial data, maps, and interpretations can be presented in a variety of formats on virtual globes, such as Google Earth and NASA World Wind, given only a basic knowledge of scripting languages. As a case study, we present geologic maps assembled in Google Earth that are based on digital field data. Interactive features of these maps include (1) the ability to zoom, pan, and tilt the terrain and map to any desired viewpoint; (2) selectable, draped polygons representing the spatial extent of geologic units that can be rendered semi-transparent, allowing the viewer to examine the underlying terrain; (3) vertical cross sections that emerge from the subsurface in their proper location and orientation; (4) structural symbols (e.g., strike and dip), positioned at outcrop locations, that can display associated metadata; and (5) other data, such as digital photos or sketches, as clickable objects in their correct field locations.

Google Earth-based interactive geologic maps communicate data and interpretations in a format that is more intuitive and easy to grasp than the traditional format of paper maps and cross sections. The virtual three-dimensional (3-D) interface removes much of the cognitive barrier of attempting to visualize 3-D features from a two-dimensional map or cross section. Thus, the digital revolution in geologic mapping is finally providing geoscientists with tools to present important concepts in an intuitive format understandable to the expert and layperson alike.

INTRODUCTION

The presentation of spatial geologic data as maps and cross sections essentially began with Cuvier and Brongniart's (1808) map of the Paris Basin and Smith's (1815) geologic map of England and Wales. Their approach to presenting field data as color-coded units in recognizable map formats became the de facto standard for geologists around the globe (e.g., Griffith, 1838; Hitchcock, 1878). These geologic maps were based on

countless hours of classifying, measuring, cataloguing, and interpolating rock units across field areas at outcrop to continental scales. Over the years, the means of transportation for fieldwork advanced from horseback to four-wheel drive vehicles, but the basic methods of field data collection and presentation remained largely unchanged.

The first years of the twenty-first century saw a major advance in the methods of field data acquisition and geologic map presentation. This was facilitated by three main technological advances: (1) the descrambling of global positioning system (GPS) satellite signals, (2) the advent of affordable mobile computers capable of running geographic information system (GIS) software in the field, and (3) the universal availability of free, Web-based virtual globes (also known as digital globes or *geobrowsers*). Although GPS had been operational since the mid-1990s, it wasn't until 2000, when Selective Availability was discontinued, that GPS became effective as a precise positioning tool for the general populace (White House Office of Science and Technology Policy [OSTP], 2000). Manufacturers began producing inexpensive handheld and car-mounted GPS devices as backpacking and motorized travel aids. At the same time, computer manufacturers started marketing portable personal digital assistants (PDAs) and tablet PCs capable of integrating GPS with GIS software for mobile digital data collection. Today, advanced mobile computing systems, such as the Trimble Explorer series and xPlore tablet PCs, are ruggedized and water-resistant enough to handle the typical bumps, scratches, and rain showers common to geologic field mapping and research.

Techniques for the digital presentation of geologic maps advanced during the late twentieth century using an assortment of proprietary platforms (e.g., Selner and Taylor, 1993; Condit, 1995). Recent developments utilize free and almost universally accessible global terrain models within Web-based virtual globes, such as NASA World Wind, Google Earth, and Microsoft Virtual Earth. These "geobrowsers" generally support the open-source scripting language KML (Keyhole Markup Language), an XML-derived language that facilitates user manipulation of a geobrowser environment. KML scripting has enabled geoscientists, as well as other producers of spatial data sets, to display field data and maps in a virtual three-dimensional (3-D) interface. Provided the user has an active, reasonably fast Internet connection, the possibilities for exploring an ever-expanding collection of geospatial data sets from locations around the globe are almost unlimited. Users can bypass the requirement for an active Internet connection by loading pertinent data and maps into the cache of a geobrowser, thereby enabling access to a virtual 3-D interface on location in the field.

This article documents an approach to geologic field mapping and presentation that utilizes recent technological and

methodological advances and illustrates this approach with examples from two field areas in western Ireland. The approach is twofold: (1) mobile computers and software with integrated GPS are used to record and interpret geologic data in the field, and (2) digital field data and map interpretations are then presented in virtual 3-D terrains using Google Earth. Interactive geologic maps built within the Google Earth environment allow users to independently view individual map components (units, faults, etc.), data points, and sample locations with associated metadata (orientation measurements, small-scale structures, outcrop photos, etc.), and related components, like cross sections. Material presented in Google Earth is open source by design (although KML files are not readily apparent to the average user), but geologic maps and data should still be subjected to rigorous peer review prior to official publication in a journal or professional report. Most journals can store electronic data in a repository, although authors can also opt to make digital data available from their personal Web sites. We recommend that readers examine the appendices associated with this article¹, which illustrate features and concepts discussed in the text below.

DIGITAL MAPPING IN THE FIELD

Background

The development of digital field mapping has been facilitated by hardware improvements and new software that can take advantage of mobile computers with integrated GPS receivers. Advances in the methods of digital field mapping have come from geoscientists with an established field-based research and education program and an interest in new technologies (Knoop and van der Pluijm, 2006; Whitmeyer et al., 2009). Digital mapping pioneers have done a great service to the geoscience community by experimenting with an assortment of hardware and software systems that showed potential for field applications (Kramer, 2000; McCaffrey et al., 2005). Early portable digital equipment, such as PDAs with plug-in GPS receivers (e.g., HP iPAQ, NAVMAN), proved serviceable but slow and were not weather- or shock-resistant (De Paor and Whitmeyer, 2009). All-weather field use required that these PDAs be enclosed within sealed plastic cases, like Otter Boxes™, although sealable plastic bags often sufficed in a light mist. Either way, accessing the PDA screen in inclement weather was problematic and awkward. Other issues included intermittent and patchy connections with plug-in GPS modules that resulted in poor tracking during field traverses. At less than US\$1,000 for the PDA, GPS module, and waterproof enclosure, these systems remain the cheapest mobile digital mapping solutions. However, to be most efficient in the field, we recommend using more advanced and rugged computers with capabilities on par with the Trimble and xPlore systems discussed in the next section.

GIS software, such as ArcGIS and GRASS, has been used widely by geographers and environmental specialists for many years as a storage and presentation medium for geospatial data (Longley et al., 2001). Initially, the size and complexity of GIS

programs, as well as practical limitations for geoscientists (e.g., the lack of toolboxes with standard geologic symbology and complications associated with cross-section construction; Schetselaar, 1995), slowed the adoption of GIS software as a tool for geologic map preparation (Mies, 1996). In addition, early versions of GIS programs were not well integrated with mobile computing hardware. This changed with the development of ArcPAD, a smaller version of ArcGIS that can integrate GPS location data with field data and facilitate concurrent map development. Modern versions of GIS software include features that cater more directly to geoscientists and field mappers (including geologic symbols). There are still issues with software complexity, the steep learning curve, and the cost of an ArcGIS license (more than US\$10,000) that make it impractical for individual users. Nevertheless, GIS software has become the standard interface for handling geospatial data, and familiarity with these programs has become a necessary skill for geoscience professionals in both academics and industry (e.g., Ray, 2002).

Modern Equipment and Methods

Modern handheld pocket PCs, like the Trimble GeoExplorer™ series, have fast processors with seamless GPS integration and can handle driving rain and minor plunges off of outcrops. These units have 4-inch screens, which keeps them small, light (1.6 lbs), and portable. They use the Microsoft (MS) Windows Mobile operating system, which is fast but doesn't have the capacity to run complex graphics programs like ArcGIS or Adobe Illustrator. Data are collected in the field using ArcPAD and must be uploaded to a PC workstation for final map preparation.

An alternative is to use ruggedized tablet PCs, such as the xPlore iX104™ series from xPlore Technologies (Fig. 1), which have larger (10-inch) screens and use standard MS Windows



Figure 1. xPlore iX104C tablet PC with ArcPAD field map shown on the screen.

¹GSA Supplemental Data item 2010102, Appendices A–D, consisting of Google Earth geologic maps (as KMZ files) and descriptive text, is available at www.geosociety.org/pubs/ft2010.htm; copies can also be obtained by e-mail to GSAToday@geosociety.org.

operating systems. These computers can run complex graphics programs (ArcGIS, Illustrator, etc.), but an external GPS receiver and ArcPAD software are needed to integrate GPS location data in the field. Also, their larger size and increased weight (5 lbs) make them functionally less portable for an eight-hour day of fieldwork. Both the Trimble and xPlore systems are fairly expensive, each of them retailing for a few thousand dollars with accessories.

Our preferred method uses either a Trimble GeoXM pocket PC or an xPlore iX104C pre-loaded with bit-mapped scans of topographic maps and aerial photos of our field areas. These images are georectified and re-projected within ArcGIS and then downloaded to ArcPAD along with shapefiles (data files for spatial information). These files incorporate attribute data, such as lithology names, orientation measurements, and other pertinent outcrop data recorded on location (see Appendix A for examples [footnote 1]). Linear features, such as contacts and faults, are recorded in a separate shapefile by tracing or walking the features in the field. Polygons of lithologic units are drawn in ArcPAD while in the field, based on current working hypotheses. We still record data in a field book as a backup, because battery power (typically about eight hours) or GPS signals can be lost prematurely. Once back in the office, we upload the ArcPAD data and interpretations recorded in the field to ArcGIS. We follow the uploading process with a visual examination of the day's field data, and correct any field data entered in an incorrect format. It is important to emphasize that faults, contacts, and unit polygons must be interpreted and drawn on the digital (ArcPAD) map while on location in the field. This is easily accomplished using the digital methods described here, though geologists unfamiliar with these techniques might find that it initially requires more time in the field. A significant advantage to digital fieldwork is the ability to easily assemble draft versions of field maps, which can be continually evaluated in the field. We strongly advocate this iterative method of field mapping, having developed and tested it over several years of field courses and field research projects (De Paor and Whitmeyer, 2009; Whitmeyer et al., 2009). Ultimately, the working field map becomes the final version, and the ArcGIS shapefiles are then ready for export to KML files for use in Google Earth or other virtual globes.

VIRTUAL 3-D PRESENTATION OF GEOLOGIC DATA

Background

Perhaps the most significant recent advance for geologic map and cross-section interpretation is software that facilitates virtual 3-D display of geologic data. GIS software, such as ArcGIS, has long incorporated 3-D terrain construction (e.g., ArcGIS 3-D Analyst) that allows users to view and analyze GIS data in a virtual 3-D environment. However, achieving the full potential of computerized display and evaluation of geologic maps has been hampered by such issues as the cost and steep learning curve of GIS software—months to years can be required to build a working knowledge of the software tools. These issues have been largely alleviated by the advent of Web-based global digital elevation model (DEM) databases (Google Earth, NASA World Wind), which have put virtual 3-D terrains at the fingertips of the novice user. These software

packages are freely available, with intuitive, easy-to-use interfaces that only require a computer with high-speed Internet access. Access in the field is also possible with a remote wireless receiver.

Virtual globes became available shortly after Al Gore proposed a “Digital Earth” Internet browser in 1998. The first serious digital globe application was unveiled by NASA in 2001 as World Wind, which was designed to display planetary data in the new format of a rotatable 3-D globe. This was closely followed by the development of Keyhole Markup Language (KML) by the startup Keyhole Corporation. Google's subsequent purchase of Keyhole led to the release of Google Earth in 2005. Google Earth incorporates KML as the open-source scripting language that allows users to customize the presentation of geospatial data within the virtual globe interface. At present, most major virtual globes (Google Earth, World Wind, and Microsoft's Virtual Earth) use KML as their scripting language (Wilson et al., 2007; Wernecke, 2009). KML is primarily responsible for the versatility of Google Earth as an effective medium for interactive presentation of geospatial data. This is accentuated when combined with COLLADA, an XML-based scripting language incorporated within Google's SketchUp program that allows users to include 3-D models within Google Earth. This is the method we use to design cross sections and structural map symbols as 3-D models, which are exported to specific locations and orientations within Google Earth.

Google Earth as an Interactive Presentation Tool

Over the past several years, Google Earth has become popular as a presentation tool for geoscience data. The ease with which images of geologic maps and other two-dimensional (2-D) data can be draped over the 3-D terrain and ortho-imagery within Google Earth (as “ground overlays”) has led to a flurry of quickly-rendered visual applications (e.g., USGS, 2006). There is no denying the effectiveness of viewing and interpreting current and historical geologic maps draped over a



Figure 2. Simplified geologic map of central western Ireland showing the Knock Kilbride and Ben Levy field areas near the eastern contact of the South Mayo Trough and Connemara terranes (modified from Chew et al., 2007).

DEM, and this method certainly provides a level of map evaluation unimaginable by previous generations of geoscientists. Unfortunately, in many cases, these images are imported as excessively large files (10 MB or larger), which can slow the performance of Google Earth dramatically. A much better solution is to subdivide maps into nested images of increasing resolution and create a pyramid structure in which each image resolution level appears at the appropriate altitude for viewing as the user zooms in or out (see De Paor and Whitmeyer, 2010, for details). This is the method virtual globes use to quickly and smoothly display aerial photography of increasing resolution as one zooms closer to the ground surface.

Ground overlays are an effective display and presentation tool, but they don't encourage much interaction or inquiry from the user. To achieve the full potential of virtual globes as an interactive, inquiry-driven resource, we have developed a methodology for the presentation of geologic maps within Google Earth that goes beyond traditional 2-D imagery. Principal components of these maps include

1. Units and contacts as individually selectable objects that can be turned on and off;
2. Floating orientation symbols that show strike and dip or trend and plunge in the proper 3-D orientation at the precise location where measured in the field;
3. Field data, such as outcrop photos or biostratigraphic information, as clickable objects linked to their field locations;
4. Map legends as screen overlays; and
5. Cross sections as vertical models that can emerge from the ground surface at the appropriate positions.

BUILDING A GOOGLE EARTH INTERACTIVE GEOLOGIC MAP

Case Study: Digital Mapping in Western Ireland

Digital field mapping and data collection for our case studies was conducted in conjunction with the James Madison University (formerly Boston University) field course in western Ireland

(Johnston et al., 2005; Whitmeyer et al., 2009). We chose field areas with well-known stratigraphic relationships and interesting, but not overly complex, structural relationships. The Knock Kilbride field area (Appendix C [see footnote 1]) consists of a sequence of early to middle Paleozoic, moderately to steeply dipping sedimentary units, with several cross-cutting normal faults that offset the stratigraphy (Graham et al., 1989; Chew et al., 2007). The Ben Levy field area (Appendix D [see footnote 1]) is located 10 km southeast of Knock Kilbride (Fig. 2) and features the same stratigraphic units, with the addition of overthrust Neoproterozoic schists (Williams and Harper, 1991). This field area is important in a regional sense, because the boundary between the Neoproterozoic schists and the Paleozoic sedimentary rocks has been interpreted as the suture between the exotic Connemara Terrane and the South Mayo Trough (Williams and Rice, 1989; Dewey and Ryan, 1990).

Over the past five years, large data sets were collected using the digital techniques described in the previous sections. By incrementally moving our field areas along the mountains of Knock Kilbride and Ben Levy each year, we assembled composite digital data sets of hundreds of points that blanketed our field areas (Fig. 3). The overwhelming majority of accurate data made occasional incorrect orientation measurements easy to identify. Anomalous points were reevaluated during subsequent field days and fixed if necessary. ArcGIS attribute tables and shapefiles were exported and converted to KML using a combination of ArcGIS, Arc2Earth™ software, and custom scripts. Although current versions of ArcGIS (9.3) and Google Earth Pro (5.0) facilitate the exchange of data between shapefiles and KML, efficient export of data from lengthy attribute tables remains a challenge. A template for doing this is included in Appendix A (see footnote 1).

Assembling Google Earth Map Components

One of the useful aspects of a Google Earth geologic map is the ability to view and evaluate geologic units as semitransparent, colored polygons superimposed on the 3-D terrain. However, in many regions, the stock Google Earth aerial imagery is

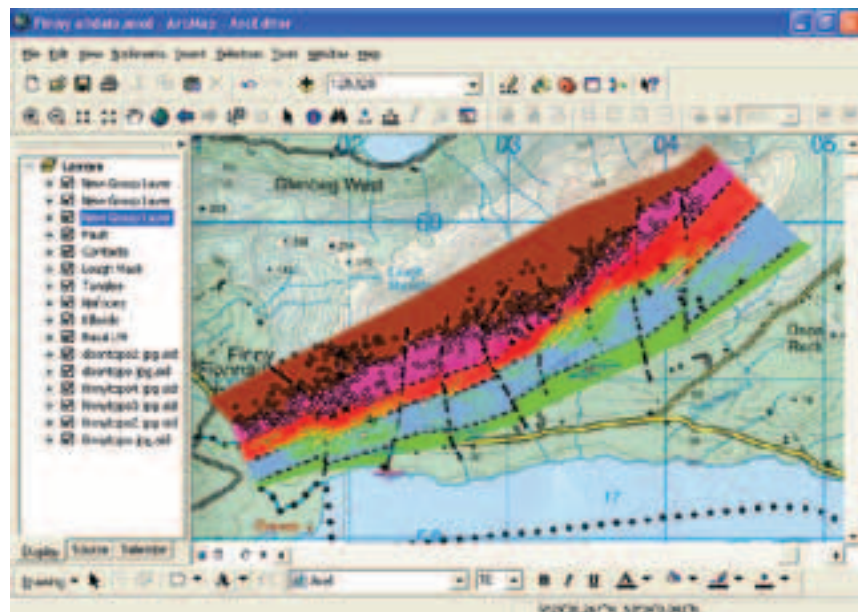


Figure 3. Composite geologic map of the Knock Kilbride field area in ArcGIS, showing the accumulation of hundreds of data points from several summers of digital mapping. Points, lines, and polygons were exported from this ArcGIS map to create the Google Earth geologic map in Appendix C and shown in Figure 4.

too poorly resolved for professional geologic applications. To improve the Google Earth imagery for western Ireland, we created image pyramids from high-resolution aerial photos to serve as our base map. Individual photo tiles occupy only 20 KB and load efficiently, which avoids delays that occur when Google Earth loads multi-megabyte images. This technique is also applicable to environmental maps on which seasonal change needs to be presented, because Google Earth ground images are usually months, if not years, out of date.

Google Earth contains tools to create placemarks (points), polylines, and polygons, and one approach to generating geologic map components is to use these built-in tools. However, caution is required when using placemarks for geologic map symbols: Though placemarks are fixed to a specific location, the placemark icon always

rotates to be perpendicular to the point of view of the user. This isn't a problem when marking unoriented outcrop data (e.g., identifying fossil locations), but it will not work for data with an associated spatial orientation, like strike and dip symbols or outcrop photographs taken in a referenced direction.

One approach to presenting strike and dip data is to generate images of strike and dip symbols with a transparent background (e.g., PNG or TIFF format) and use the "Image Overlay" feature to drape them in Google Earth (Fig. 4). This works only when viewed from above; from other viewpoints, symbols can be distorted by oblique projection onto a sloping terrain. Our preferred solution is to generate 3-D strike and dip symbols that hover a few meters above the ground in their proper latitude/longitude location and orientation (Fig. 5). This display method takes some familiarization, as most geoscientists are used to seeing orientation symbols on a flat map surface, but we find that these 3-D symbols are often easier for nongeologists to comprehend and thus preferable to traditional symbology.

The latest version of KML includes a "photo overlay" feature. Unlike image overlays, photo overlays are automatically structured into image pyramids when imported into Google Earth; thus, very high-resolution images may be loaded without slowing system response. Appendix B (see footnote 1) is an example of a photo overlay created from an oriented field photograph of pillow lavas near the Knock Kilbride field area. The viewer can zoom in on the outcrop photo until fine detail is visible.

Generating 1-D and 2-D features, such as traces of contacts or faults, and surface exposures of stratigraphic units works reasonably well using the Google Earth polyline and polygon tools. However, draw levels cannot be specified for these features. This is a problem when map images need to be overlain in a specific order, as with our maps, on which imported aerial photographs must underlie stratigraphic units and symbology. Our approach is to create colored polygons for each stratigraphic unit in PNG format with a transparent background. These images are directly and easily exportable from an ArcGIS geologic map. After obtaining the latitude and longitude coordinates for the

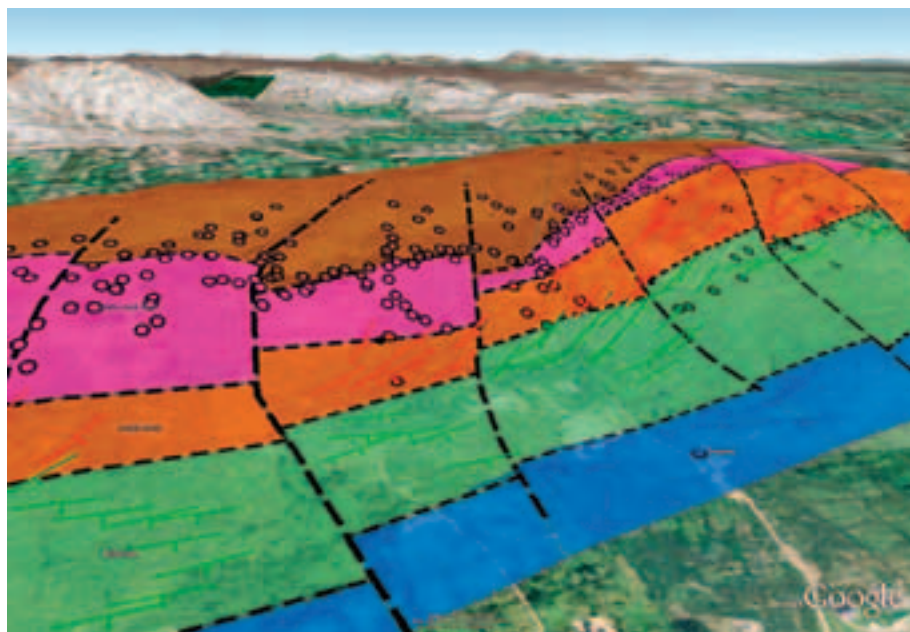


Figure 4. Oblique, tilted view of the Knock Kilbride geologic map showing strike and dip symbols as colored ground overlays. Note how the orientation symbols get distorted in areas of high relief.

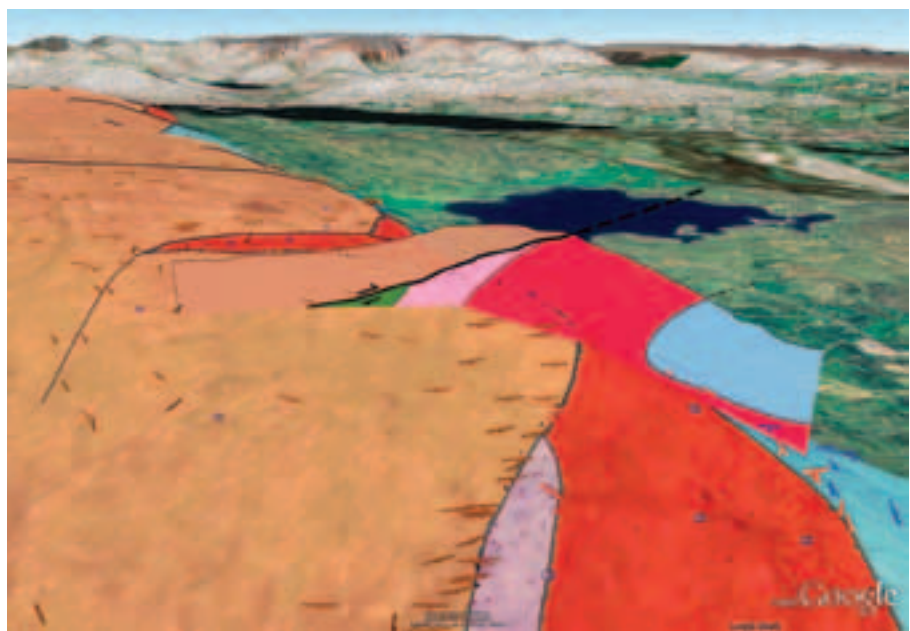


Figure 5. Tilted view (looking northwest) showing a vertical cross section extracted from the terrain surface of the Ben Levy geologic map. Note the colored, 3-D strike and dip symbols (both bedding and foliation) that hover a few meters off the terrain surface.

boundaries of each image exported from ArcGIS, we overlaid these images in the correct locations in Google Earth. Since image overlays can be assigned a specific draw level, we ensured that the images were stacked in the proper order for viewing. The advantage of overlaying each unit as a separate image is that users can toggle the display of each unit on or off in the Google Earth “places” window.

Geologic maps generally include a map legend or explanation. This is accomplished within Google Earth by using the “screen overlay” function. This function cannot be invoked directly from the pull-down menus in Google Earth, but requires KML coding using a text editor (see Appendix A for an example [footnote 1]). The position of the screen legend is fixed, but it can be toggled on and off to view the features on the Google Earth globe. Scale bars and north arrows are not included in screen legends, as the underlying globe can be zoomed, panned, and rotated independent of the fixed screen overlay.

Cross Sections

Since the initial work of Smith (1815), it has been customary for geologic maps to include vertical interpretations of the subsurface as cross sections. Unfortunately, many nonprofessionals and students find it difficult to visualize 3-D structures using traditional paper geologic maps with cross sections and locations indicated on the map via thin lines marked A–A', B–B', etc. (Piburn et al., 2002; Kastens and Ishikawa, 2006). Fortunately, Google Earth has the capacity to incorporate 3-D models as user-generated structures. These models can be designed using Google SketchUp, exported as COLLADA script in .dae files, and positioned within Google Earth using KML or the “import model” menu. This is the basic method for creating and positioning vertical cross sections within Google Earth (Fig. 5). A newly developed technique allows users to “pull” a geologic cross section up out of the Google Earth ground surface using a slider control. This approach intuitively conveys the concept that cross sections represent subsurface geology. Creating these emergent cross sections does require some advanced KML programming; see De Paor and Whitmeyer (2010) for details.

Other Digital Techniques

Several digital mapping technologies are not discussed here because they involve equipment that is not typically carried by a field geologist. These include LiDAR (McCaffrey et al., 2008) and GigaPan (e.g., Schott, 2008), both of which require specialty equipment mounted on tripods. Further miniaturization and commercialization may lead to their general adoption by field geologists in the future.

CONCLUSIONS AND IMPLICATIONS

There are disadvantages to the digital mapping and geologic map presentation methods discussed in this paper. First is the initial time commitment needed to get comfortable with the hardware and software necessary for digital mapping. Some field workers may be reluctant to depend on computer equipment for collecting data in the field, and the necessity for keeping a hard copy backup of digital field data may induce some to wonder “why go digital?” in the first place. However, the ability to compile hundreds of measurements from many

sources makes the benefits of digital data-gathering abundantly clear. In addition, since all modern professional geologic maps are published using computer-based graphics design programs, such as Adobe Illustrator or ArcGIS, field mappers can simplify and streamline the process by using coordinated computer equipment and software for the whole procedure of field data collection, interpretation, and map generation. Many academic and industry geoscientists have already reached this conclusion, such that a working knowledge of ArcGIS and digital field methods is no longer a luxury, but rather a necessary skill in today's selective, but lucrative, geoscience-related fields (AGI, 2009).

A limitation to interactive geologic maps rendered on virtual globes is their current inability to be repackaged for export as paper maps. Similar to civil engineers who need blueprints for the job site, geoscientists still have a need for paper geologic maps in situations where computer equipment is not readily available. This is one reason we prepare versions of final geologic maps in ArcGIS, which can be printed as traditional paper maps if desired. ESRI has developed virtual 3-D viewers (ArcGIS Explorer, ArcGlobe) that can use the same shapefiles and attribute tables that are incorporated into ArcGIS-generated paper maps. Ease of use is still an issue with these ESRI products, but their efficient data transfer between paper and virtual formats may prove to be an advantage over other virtual globes.

Developing interactive geologic maps for virtual globes requires new skills, such as KML scripting, but many of today's generation of technologically savvy students and professionals are quite comfortable with these new techniques. Computer-aided 3-D design (CAD) has long been standard in manufacturing and engineering industries. Plus, many of our students have grown up playing computer games with realistic, high-resolution images and view paper-based geologic maps and cross sections as antiquated. Perhaps the most important reason to develop interactive Google Earth-based geologic maps is their utility in presenting geologic data and interpretations in a format that is easier for the layperson or introductory-level student to understand. Individual geologic units can be directly related to the surface topography using transparent, selectable ground overlays. Important field data and photos of key features can be viewed and highlighted by tags that link to the precise location of an outcrop. Orientation symbols can be correctly oriented in 3-D space, making the concepts of strike and dip easier to grasp. Finally, cross sections, as interpretations of subsurface geology, are far more intuitive when the user can “pull” these vertical slices up out of the ground in their correct positions. Complete Google Earth geologic maps for our case study field areas in western Ireland are discussed in Appendix A and included as KMZ files in Appendix C (Knock Kilbride field area) and Appendix D (Ben Levy field area) (see footnote 1). Readers are encouraged to experiment with these interactive geologic maps to explore the methods discussed herein.

ACKNOWLEDGMENTS

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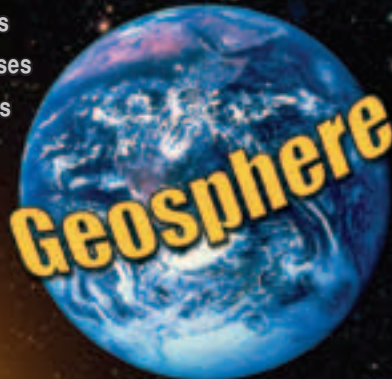
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Special Paper #61

Field Geology Education: Historical Perspectives and Modern Approaches

Edited by Steven J. Whitmeyer, David W. Mogk, and Eric J. Pyle

Field instruction has traditionally been at the core of the geoscience curriculum. The field experience has been integral to the professional development of future geoscientists, and is particularly important as it applies to student understanding of spatial, temporal, and complex relations in the Earth system. As important as field experiences have been to geosciences education and the training of geoscientists, the current situation calls for discipline-wide reflection of the role of field experiences in the geoscience curriculum in light of practical and logistical challenges, evolution in employment opportunities for geoscientists, and changing emphases in the geoscience curriculum. This volume seeks to broaden participation in field instruction by showcasing diverse approaches to teaching in the field across the many geo-disciplines encompassed by GSA.

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This year's Pardee Symposia, special events of broad interest to the geoscience community, will be highlighted in the June *GSA Today*.

So far in the works: mineral evolution, LiDAR, and the impact of ocean acidification.

FIELD TRIPS



2010 Denver Field Trips

GSA's 2010 "Reaching New Peaks in Geoscience" field trips cover a wide spectrum of geologic terrains and topics. Trips along excellent geologic exposures in the Colorado Rockies region will emphasize how glaciation, tectonism, volcanism, landslides, tectonic collapse, mineralization, and dinosaurs have shaped this region and how this geologic foundation influences hazards, resources, and human habitation.

This year's schedule ranges from local afternoon excursions to four-day regional adventures. One trip even calls for mountain bikes! Field trips are a great time to interact with colleagues, get out in the field, and even involve your family.

We'll have more information about field trips in the June *GSA Today* and on the meeting Web site, www.geosociety.org/meetings/2010/.

2010 Field Trip Co-Chairs

Lisa Morgan, lmorgan@usgs.gov

Steve Quane, steve.quane@gmail.com

Red Rocks Amphitheatre. Photo by Bob Ashe for Denver Metro Convention & Visitors Bureau.



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Cultural and Convention Centre, Middle East Technical University

Abstract Submission Deadline: 25 May 2010 • **Standard Registration Deadline:** 23 August 2010



Photos by Dr. Yildirim Dilek

For information visit: www.geosociety.org/meetings/2010turkey/

Letter from the 2010 Technical Program Chair

The Geological Society of America is in its 122nd year of providing geoscientists with multiple opportunities for communicating and sharing geoscience research. The Society is deeply rooted in its commitment to best-communicate the science and ensure that the full relevance of its significance is transferable from scientist to scientist, scientist to teacher, teacher or scientist to student, and, perhaps most importantly, from scientist, teacher, or student to decision maker.

Geoscience is not without controversy, and the discipline is sometimes viewed as a “gray science.” Unlike many fields of engineering where the “bolt fits the nut” and solutions are sought to fix problems (such as with many environmental issues), geoscientists seek to understand the underlying reasons leading to problems in the first place and then offer solutions based on understanding the systematic context of the issue. The “bolt doesn’t always fit the nut perfectly,” but understanding and communicating why it doesn’t can be key to solving the problem. Also, unlike many of its hard science “cousins,” geoscience is more of an interpretive science that often relies on predictability based on disparate and regionally sparse information. It is only through the skills of the geoscientist that predictive conceptual models can be extended through the subsurface based on the sedimentology, structure, paleontology, hydrogeology, geochemistry, mineralogy, or geomorphology of bodies of rock or unconsolidated materials. It is also through this understanding that conceptual models of earth processes and climatic variabilities can be extended from early to recent geologic time and projected into the future.

A critical component of all geoscience interpretations that lead to viable models is having others clearly understand the full range of data inputs and logical outputs. Significant “color” (substance) is added when the true experts responsible for interpretations are the geoscientists that we rely on for scientifically defensible and meaningful communications to each other, teachers, students, and decision makers. It is upon this pure goal that we strive to provide the most cutting-edge and significant accomplishments on a yearly basis through our annual meeting, and the Denver 2010 theme of *Reaching New Peaks in Geoscience* reflects that goal.

Each year, GSA’s Annual Program Committee, Joint Technical Program Committee (JTPC), and Technical Program Chair work closely with GSA staff to seek ways to improve the scientific and educational content of its meetings, as well as the overall meeting experience for attendees, while taking full advantage of various technological innovations that further enhance the ease of presentations and ability to communicate. The 2010 GSA Annual Meeting will be no exception. Over 150 topical sessions were submitted, covering a wide range of subdisciplines that address pure and applied research and education issues. These include “Assessing Groundwater Availability and Sustainability,” “Ocean Acidification,” “The Geoenvironmental Context of Human Migrations,” “Advances in Clean Coal Technology,” “Tectonic Controls on Volcanism,” “Geochemistry and Mineralogy of Fossils,” “The Emerging Science of Field Geology on Other Planets,” “Proterozoic Crustal Evolution of Southern Laurentia,” “Timing of Pleistocene Glaciation in the North American Cordillera,” and “Applications of OSL Dating for Geomorphological Processes.” All make up a varied program awaiting your abstracts. For the 2009 GSA Annual Meeting in Portland, we had a record 4,004 abstracts; we hope to top that figure this year with your participation. Please submit abstracts to our topical sessions, or alternatively, if you do not see a topical session that addresses your interests, to a general discipline session.

To help build the strongest possible program and ensure that all of our topical sessions have enough abstracts to make them viable, I encourage abstract submitters to contact the JTPC members listed on page 16, as well as the officers and representatives of GSA’s 17 Divisions and 53 Associated Societies, with specific questions.

Dick Berg, 2010 Technical Program Chair

Illinois State Geological Survey, berg@isgs.illinois.edu

Events & Deadlines

Early June

- Registration Opens
- Housing Opens

7 June

- Space Request Deadline

10 August

- Abstract Submission Deadline

27 September

- Early Registration Deadline
- Housing Deadline

4 October

- Registration Cancellation Deadline

27–30 October

- Premeeting Field Trips

29–31 October

- Short Courses & Workshops

30 October

- GSA Presidential Address & Awards Ceremony: 7–9 p.m.

31 October

- Welcoming Party & Exhibits Opening: 6–8 p.m.

31 October–3 November Technical Program

- Oral Sessions
- Posters: Hung all day with half-day sessions, authors present a.m. or p.m.

31 October–3 November

- Lunchtime Keynote Lectures: 12:15–1:15 p.m.

1 November

- Group Alumni Reception: 7–9:30 p.m.
- Private Alumni Receptions

1–2 November

- Exhibit Hall Open: 9 a.m.–6 p.m.

3 November

- Exhibit Hall Open: 9 a.m.–2 p.m.

4–6 November

- Postmeeting Field Trips



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SUBMITTING AN ABSTRACT

- Submit your abstract at <http://gsa.confex.com/gsa/2010AM/index.epl>.
- Abstracts must be 2,000 characters or less, not counting spaces. Do not include your title and authors in the abstract.
- A non-refundable fee of US\$35 per abstract submission will be charged to professionals; graduate and undergraduate students will be charged a non-refundable fee of US\$20 per submission.
- Payment by credit card must be made when you submit your abstract, or your paper will not be considered for the meeting.
- You may present two volunteered abstracts during the Annual Meeting, *as long as one of these abstracts is a poster presentation*.
- Please don't miss the deadline for abstract submission—Tuesday, 10 August 2010.
- *Reminder:* All speakers and poster presenters must pay the meeting registration fee.

Oral Presentations

- The normal length of an oral presentation is 12 minutes, plus three minutes for Q&A.
- You *must* visit the Speaker Ready Room at least 24 hours before your scheduled presentation.
- All technical session rooms are equipped with a PC.
- If your presentation was created on a Macintosh, please save it to run on a PC, and test it before coming to the meeting as well as in the Speaker Ready Room. If you have questions about this, please contact Nancy Wright, nwright@geosociety.org.
- If your presentation includes embedded video, please convert any .mov files to .avi format, or create a link in your slide show to an external .mov file. If you choose the latter, your animation will play in a separate QuickTime window outside of your PowerPoint presentation.
- The decision by the Joint Technical Program organizers to place your paper in an oral session is final.

Poster Presentations

- You will be provided one horizontal, freestanding 8-ft by 4-ft display board along with Velcro for hanging the poster.
- Posters will be on display 9 a.m.–6 p.m. Authors should be present either 9–11 a.m. *or* 2–4 p.m. and are encouraged to be at their posters during the 4:30–6 p.m. beer reception as well.
- Each poster booth will share a 6-ft by 30-in table.
- Electricity in the poster area will be available at no charge.
- The decision by the Joint Technical Program organizers to place your paper in a poster session is final.

SHORT COURSES



2010 Short Courses

Find new topics to explore & add to your learning repertoire!

Professionals can attend a Gale software training session or learn more about field hydrogeology.

Faculty topics span terrestrial laser scanning, geoinformatics, online volcano data monitoring, knowledge surveys, education research, plate tectonics, how to establish undergraduate research programs, and teaching energy in the classroom.

Graduate students will have the benefit of courses that address geographic information systems, sequence stratigraphy, seismic structural interpretation, and stratigraphic concepts applied to basin exploration.

K–12 teachers will gain skills for engaging high school students in the geosciences.

For details and course descriptions, check the upcoming June issue of *GSA Today* or go to www.geosociety.org/meetings/2010/courses.htm.

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Mon., 1 Nov.

Geology in Industry

Tues., 2 Nov.

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GRADUATE SCHOOL INFORMATION FORUM

Here's a great opportunity to promote your school and meet face-to-face with over 1,500 prospective students in a relaxed, informal setting at the 2010 GSA Annual Meeting & Exposition. Stationed in the Exhibit Hall between the exhibits and poster sessions, the forum will be open Sunday through Wednesday, 31 October to 3 November.

Booths may be booked for one day or up to all four days. Sunday and Monday will be the first to sell out, and schools reserving multiple days will be assigned to the most visible booths. Space is limited, so reserve early!

Participating schools will be promoted in the September *GSA Today* (pending submittal date of the reservation form), the 2010 Annual Meeting Program, and e-mail links on the GSA Web site so that prospective students may schedule appointments prior to the Annual Meeting.



Reserve your space at www.geosociety.org

2010 Joint Technical Program Committee

2010 Technical Program Chair
Richard C. Berg, berg@isgs.uiuc.edu

GSA Technical Program Manager
Nancy Wright, nwright@geosociety.org

Discipline Categories

Can't find a topical session that fits your abstract? No problem! In addition to the topical sessions, we offer the following discipline categories. Discipline sessions are equally vital to a robust annual meeting. Please feel free to contact the JTTC member associated with your discipline if you have any questions about your abstract.

Review Group	Discipline	Contact(s)
GSA Archaeological Geology Division	archaeological geology	Andrea Freeman, freeman@ucalgary.ca
GSA Coal Geology Division	coal geology	Sharon Swanson, smswanson@usgs.gov; Sue Rimmer, srimmer@geo.siu.edu
GSA Engineering Geology Division	engineering geology	John C. Jens, jenscjens@earthlink.net; William H. Schulz, wschulz@usgs.gov
Environmental Geoscience	environmental geoscience	John F. Bratton, jbratton@usgs.gov
GSA Geobiology & Geomicrobiology Division	geomicrobiology	Jack D. Farmer, jack.farmer@asu.edu; Stuart Birnbaum, stuart.birnbaum@utsa.edu
Geochemical Society	geochemistry; geochemistry, organic	Troy Rasbury, troy.rasbury@sunysb.edu
GSA Geoinformatics Division	geoinformatics	Sally Brady, sbrady@usgs.gov; Hassan A. Babaie, hbabaie@gsu.edu
GSA Geology and Health Division	geology and health	Syed Hasan, hasans@umkc.edu
GSA Geology and Society Division	public policy	Karen McCurdy, kmccurdy@georgiasouthern.edu; James F. Davis, jamesdavis93@comcast.net
GSA Geophysics Division	geophysics/tectonophysics/seismology	Kevin Mickus, kevinmickus@missouristate.edu; Audrey D. Huerta, huerta@geology.cwu.edu
GSA Geoscience Education Division; National Association of Geoscience Teachers (NAGT)	geoscience education	Paul E. Baldauf, pb501@nova.edu; Mike Taber, mike.taber@coloradocollege.edu; Steven H. Schimmrich, schimmrs@sunyulster.edu; Elizabeth Wright, ewrigh@saic.edu
Geoscience Information Society (GSIS); Association of Earth Science Editors (AESE)	geoscience information/communication	Janet Dombrowski, jdombrow@uwyo.edu; Monica Easton, monica.easton@ontario.ca
GSA History of Geology Division	history of geology	Vic Baker, baker@hwr.arizona.edu; John A. Diemer, jadiemer@unc.edu; Kenneth R. Aalto, kral@humboldt.edu
GSA Hydrogeology Division	hydrogeology	Bill Cunningham, wcunning@usgs.gov; Madeline E. Schreiber, mschreib@vt.edu
GSA Limnogeology Division	limnogeology	Michael Rosen, mrosen@usgs.gov; Dan Deocampo, deocampo@gsu.edu
Marine/Coastal Geology	marine/coastal science	Mark Kulp, mkulp@uno.edu
Mineralogical Society of America (MSA)	mineralogy/crystallography; petrology, experimental; petrology, igneous; petrology, metamorphic; volcanology	James Beard, jim.beard@vmnh.virginia.gov; Philip Brown, pbrown@geology.wisc.edu
GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division	mineralogy; geochemistry; petrology; volcanology	Cathy J. Busby, cathy@crystal.ucsb.edu; Russell S. Harmon, russell.harmon@us.army.mil
Paleoceanography/Paleoclimatology	paleoclimatology/paleoceanography	Sharon Kanfoush, skanfoush@utica.edu
Paleontological Society (PS)	paleontology, biogeography/biostratigraphy; paleontology, diversity, extinction, origination; paleontology, paleoecology/taphonomy; paleontology, phylogenetic/morphological patterns	Ellen Currano, ecurrano@smu.edu; Thomas D. Olszewski, tomo@geo.tamu.edu; Matthew E. Clapham, mclapham@es.usc.edu
GSA Planetary Geology Division	planetary geology; remote sensing/geographic info system	Jayne Aubele, jayne.aubele@state.nm.us; David Williams, david.williams@asu.edu
Precambrian Geology	Precambrian geology	Joe Meert, jmeert@geology.ufl.edu
GSA Quaternary Geology and Geomorphology Division	geomorphology; Quaternary geology	Paul Bierman, pbierman@zoo.uvm.edu; Kyle House, khouse@unr.edu
GSA Sedimentary Geology Division	sediments, carbonates; sediments, clastic; stratigraphy	Troy Rasbury, troy.rasbury@sunysb.edu; Brenda Beitler Bowen, bbowen@purdue.edu
Society of Economic Geologists (SEG)	economic geology	Karen D. Kelley, kdkelley@usgs.gov
GSA Structural Geology and Tectonics Division	neotectonics/paleoseismology; structural geology; tectonics	Scott Johnson, johnsons@maine.edu; David P. West, Jr., dwest@middlebury.edu

▶▶ Topical Sessions ◀◀

Topical sessions are designed to promote the exchange of interdisciplinary, state-of-the-art information. You may submit an abstract directly to a specific topical session.

T1. Assessing Groundwater Availability and Sustainability

Cosponsor: *GSA Hydrogeology Division*

Disciplines: Hydrogeology; Environmental Geoscience; Public Policy

Advocates: Kevin F. Dennehy, USGS, Reston, Va.; William M. Alley, USGS, San Diego, Calif.

Description: Having an adequate supply of water to meet human and ecological needs is essential. Approaches and methodologies to quantify, forecast, and secure groundwater resources at large scales for short- and long-term availability warrant examination.

T2. Impacts of Land Use and Climate Change on Water Resources Sustainability

Cosponsor: *GSA Hydrogeology Division*

Disciplines: Hydrogeology; Remote Sensing/Geographic Info System; Paleoclimatology/Paleoceanography

Advocates: David A. Stonestrom, USGS, Menlo Park, Calif.; Bridget R. Scanlon, Univ. of Texas, Austin, Tex.

Description: This session focuses on impacts of climatic and land-use change on groundwater and surface-water resources. Past and projected impacts from natural and anthropogenic forcings will be examined by field studies, satellites, speleothems, modeling, etc.



Rock glacier, northern Colorado. Photo by Marli Bryant Miller, University of Oregon. www.marlimillerphoto.com.

T3. The Hydrogeological Effects of Urbanization

Cosponsors: *GSA Hydrogeology Division; GSA Engineering Geology Division; GSA Quaternary Geology and Geomorphology Division; GSA Geology and Society Division; U.S. National Chapter of the International Assoc. of Hydrogeologists*

Disciplines: Hydrogeology; Engineering Geology; Environmental Geoscience

Advocates: John M. Sharp, Jackson School of Geosciences, Univ. of Texas, Austin, Tex.; Barry J. Hibbs, California State Univ., Los Angeles, Calif.

Description: This session examines how urbanization affects groundwater systems, including recharge rates, flow patterns, stream and spring flows, water quality, climatic effects, geotechnical design, and urban planning.

T4. Advances in Understanding Aquifer Heterogeneity and Multi-Scale Flow and Transport in Porous and Fractured Media

Cosponsor: *GSA Hydrogeology Division*

Disciplines: Hydrogeology; Sediments, Clastic

Advocates: Ramya Ramanathan, Wright State Univ., Dayton, Ohio; Gary S. Weissmann, Univ. of New Mexico, Albuquerque, N.Mex.

Description: This session focuses on the advances in understanding aquifer heterogeneity and its effect on flow and transport processes. Approaches of interest include field characterization, flow and transport modeling, upscaling, inverse modeling, and designing remediation systems.

T5. Mountain Hydrogeology, Faults, Fractures, Fluid Flow, and Sustainability of Natural Resources: In Memory of the Contributions of Craig Burton Forster

Cosponsors: *GSA Hydrogeology Division; GSA Structural Geology and Tectonics Division; GSA Geology and Society Division; GSA Geophysics Division*

Disciplines: Hydrogeology; Structural Geology; Public Policy

Advocates: Jonathan Saul Caine, USGS, Denver, Colo.; Shemin Ge, Univ. Colorado, Boulder, Colo.; Andrew H. Manning, USGS, Denver, Colo.; Jessica Thompson, Colorado State Univ., Fort Collins, Colo.

Description: Focused on multidisciplinary natural resources science and its use in public policy; fundamental to applied research, contributions are sought to highlight fieldwork, new approaches, modeling, sustainability, and (or) how laypersons use and perceive scientific information.

T6. Regional Karst Aquifers

Cosponsor: *GSA Hydrogeology Division*

Disciplines: Hydrogeology; Public Policy; Environmental Geoscience

Advocates: Eve L. Kuniandy, USGS, Norcross, Ga.; Brian G. Katz, USGS, Tallahassee, Fla.; Lawrence E. Spangler, USGS, Salt Lake, Utah; W. Barclay Shoemaker, USGS, Ft. Lauderdale, Fla.

Description: Regional karst aquifers are important water resources. They underlie ~20% of Earth's surface, and supply ~25% of the world's population with drinking water (Ford and Williams, 1989).

T7. Contaminant Hydrogeology of Karst— Characterization, Modeling, and Remediation

Cosponsor: *GSA Hydrogeology Division*

Disciplines: Hydrogeology; Environmental Geoscience; Sediments, Carbonates

Advocates: David S. Lipson, ARCADIS, U.S., Inc, Lakewood, Colo.; Keith A. White, ARCADIS, U.S., Inc, Syracuse, N.Y.

Description: This session will bring together academic and professional scientists, engineers, and regulators faced with solving contaminated karst problems to discuss issues related specifically to characterization, modeling, and remediation of karst groundwater.

T8. Flow in Fractured and Karstic Aquifers: Models and Methods

Cosponsors: *GSA Hydrogeology Division; U.S. National Chapter of the International Assoc. of Hydrogeologists; Karst Waters Institute*

Disciplines: Hydrogeology; Environmental Geoscience; Engineering Geology

Advocates: Carol Wicks, Louisiana State Univ., Baton Rouge, La.; Todd Halihan, Oklahoma State Univ., Stillwater, Okla.

Description: Fractured and karstic aquifers remain difficult to characterize, but significant advances have been made in field methods and modeling of flow and transport through these systems. This session will examine these advances.

T9. Sources of Acid Rock Drainage to Draining Mine Tunnels and in Complex Geologic Systems

Cosponsor: *GSA Hydrogeology Division*

Disciplines: Hydrogeology; Geochemistry; Environmental Geoscience

Advocates: Katie Walton-Day, USGS, Denver, Colo.; Mike Wireman, U.S. EPA, Boulder, Colo.; Bruce Stover, Denver, Colo.

Description: This session seeks a range of geochemical, geologic, geophysical, hydrogeologic, and engineering studies that present research and techniques used to understand sources of acid rock drainage for draining mine tunnels in complex geologic systems.

T10. The Hydrogeologic and Regulatory Environments of Phosphate Mining and Processing

Cosponsors: *U.S. National Chapter of the International Assoc. of Hydrogeologists; GSA Hydrogeology Division; GSA Geology and Health Division*

Disciplines: Hydrogeology; Environmental Geoscience; Economic Geology

Advocates: Gerry V. Winter, Kuna, Idaho; Neil Coleman, Washington, DC

Description: This session will discuss the hydrogeologic and regulatory environments related to mining and processing of phosphate ore and the impact of both on the economics of mining.

T11. Arsenic in Bedrock and Associated Groundwater: Mineralogy, Geochemistry, and Transport Processes

Cosponsors: *GSA Hydrogeology Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Geobiology & Geomicrobiology Division*

Disciplines: Geochemistry; Hydrogeology; Environmental Geoscience

Advocates: Carol L. Stein, Gannett Fleming Inc., New Ipswich, N.H.; David F. McTigue, Gannett Fleming Inc., New Ipswich, N.H.

Description: This session focuses on arsenic minerals in bedrock and the mobilization of arsenic to groundwater. We welcome abstracts across a variety of perspectives, from arsenic mineralization to regional-scale studies that link lithology and groundwater chemistry.

T12. Arsenic in Geologic Systems

Cosponsors: *GSA Hydrogeology Division; GSA Geology and Society Division; GSA Geology and Health Division; International Society for Groundwater for Sustainable Development (ISGSD); GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Geobiology & Geomicrobiology Division*

Disciplines: Hydrogeology; Geology and Health; Environmental Geoscience

Advocates: Prosun Bhattacharya, Royal Institute of Technology (KTH), Stockholm, Sweden; Abhijit Mukherjee, Alberta Geological Survey, Edmonton, Canada; Alan E. Fryar, Univ. of Kentucky, Lexington, Ky.; David A. Polya, Univ. of Manchester, Manchester, UK

Description: Global occurrence of arsenic in geologic systems, groundwater, soil, and the food chain has raised serious environmental concern. This session will deal with the occurrence, mobility, biogeochemical cycling, epidemiological, socio-economic effects, and sustainable mitigation of arsenic.

T13. CO₂ Sequestration in Deep Saline Aquifers: Leakage Pathways, Risk Assessment, and Impact on Overlying Aquifers

Cosponsor: *GSA Hydrogeology Division*

Disciplines: Hydrogeology; Geochemistry; Environmental Geoscience

Advocates: John E. McCray, Colorado School of Mines, Golden, Colo.; Alexis K. Navarre-Sitchler, Colorado School of Mines, Golden, Colo.; Assaf Wunsch, Colorado School of Mines, Golden, Colo.

Description: As CO₂ sequestration in deep aquifers increasingly becomes an attractive solution for reduction of CO₂ release to the atmosphere, studies are underway to assess possible leakage risks to overlying aquifers.

T14. Enhanced Geothermal Systems (EGS): Sustainable, Carbon-Free Energy

Cosponsor: *GSA Geophysics Division*

Disciplines: Hydrogeology; Engineering Geology; Geophysics/Tectonophysics/Seismology

Advocates: Warren W. Wood, Michigan State Univ., East Lansing, Mich.; Wolfgang W. Bauer, Michigan State Univ., East Lansing, Mich.

Description: Session will highlight complete life cycle costs and benefits in developing this sustainable, environmentally benign, carbon-free resource. Uncertainty in capital, planning, permitting, and hazard management costs, earthquake hazards, and hydro and geologic characterization are addressed.

T15. Field and Interpretive Methods for Borehole Flow Log Analysis

Cosponsor: *GSA Hydrogeology Division*

Disciplines: Hydrogeology; Geophysics/Tectonophysics/Seismology

Advocates: Carole Johnson, USGS-OGW, Branch of Geophysics, Storrs, Conn.; John W. Lane, USGS, Storrs, Conn.

Description: This session focuses on borehole flow, which can be measured with flowmeter, borehole-dilution, fluid-replacement, or tracer tests and can be interpreted quantitatively to obtain depth-dependent hydraulic parameters, such as transmissivity and head.

T16. Geochemical and Isotopic Evolution of Sedimentary and Crystalline Formation Brines

Cosponsors: *GSA Hydrogeology Division; International Association of GeoChemistry (IAGC); GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division*

Disciplines: Hydrogeology; Geochemistry

Advocates: Orfan Shouakar-Stash, Univ. of Waterloo, Waterloo, Ontario; Randy L. Stotler, Univ. of Kansas, Lawrence, Kans.

Description: Although formation brines have been extensively investigated, evolutionary pathways are still disputed. This session will explore new findings and evaluate different evolutionary pathways for brines based on geochemical and isotopic evidence.

T17. Geologic Maps, Digital Geologic Maps, and Derivatives from Geologic and Geophysical Maps (Posters)

Cosponsors: *GSA Engineering Geology Division; Association of American State Geologists; U.S. Geological Survey; GSA Geology and Society Division; GSA Geophysics Division; GSA Quaternary Geology and Geomorphology Division*

Disciplines: Geoscience Information/Communication; Hydrogeology; Engineering Geology

Advocates: Richard C. Berg, Illinois State Geological Survey, Champaign, Ill.; Ralph F. Crawford, The Geologic Mapping Institute, Atlanta, Ga.; Michael W. Higgins, The Geologic Mapping Institute, Clayton, Ga.; Linda Jacobsen, USGS, Reston, Va.; E. Donald McKay, Illinois State Geological Survey, Champaign, Ill.; David R. Soller, USGS, Reston, Va.; L. Harvey Thorleifson, Univ. of Minnesota, St. Paul, Minn.

Description: This poster session will highlight new geologic maps, mapping programs, and innovations in geological mapping, including data management, web accessibility, 3-D, and applications in water and land management.

T18. Reaching New Peaks in Geoscience: Geoscience in the Service of a Sustainable Future

Cosponsors: *GSA Geology and Society Division; GSA Geology and Public Policy Committee; GSA Hydrogeology Division; GSA Engineering Geology Division; Association of American State Geologists*

Disciplines: Environmental Geoscience; Public Policy; Geoscience Information/Communication

Advocates: D. Craig Cooper, Energy Resources Recovery and Management, Idaho Falls, Idaho; Jonathan H. Goodwin, Illinois State Geological Survey, Champaign, Ill.

Description: This session will explore ways that geoscience research and effective communication of its results contribute to sustainability. Topics include overcoming hazards and climate change, supplying water resources, energy and minerals, using geologic maps, and geomorphology.



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T19. New Approaches to Addressing Earthquake Hazards and Cost-Effective Mitigation Policies in the Mid-Continent

Cosponsors: *GSA Geology and Society Division; GSA Geophysics Division; GSA Quaternary Geology and Geomorphology Division*

Disciplines: Geophysics/Tectonophysics/Seismology; Tectonics; Public Policy

Advocates: Seth Stein, Northwestern Univ., Evanston, Ill.; Zhenming Wang, Univ. of Kentucky, Lexington, Ky.

Description: Assessing seismic hazards in the mid-continent and developing mitigation strategies is challenging because damaging earthquakes are rare. We solicit papers exploring scientific and policy aspects of the earthquakes, their hazards, and appropriate mitigation strategies.

T20. National and International Geological Licensure, The ASBOG Fundamentals of Geology and Practice of Geology Examinations, Accreditation, and Assessment of Academic Degree Programs

Cosponsors: *GSA Geology and Society Division; National Association of State Boards of Geology*

Disciplines: Geoscience Education; Geoscience Information/Communication

Advocate: Richard K. Spruill, East Carolina Univ., Greenville, N.C.

Description: Geological licensure in the U.S. and Canada is based in part on successful completion of national examinations. Results of these examinations are now available to geoscience departments for use in assessment and accreditation.

T21. Ocean Acidification and Other Societally Relevant Environmental Changes: Using the Past to Infer Our Future (Cushman Session)

Cosponsors: *GSA Geology and Society Division; Cushman Foundation for Foraminiferal Research*

Disciplines: Paleontology, Diversity, Extinction, Origination; Paleontology, Biogeography/Biostratigraphy; Paleontology, Paleoecology/Taphonomy

Advocates: Joan M. Bernhard, Woods Hole Oceanographic Institution, Woods Hole, Mass.; Michael Martínez-Colón, Univ. of South Florida, St. Petersburg, Fla.

Description: This session will highlight geobiological, paleontological, and biogeochemical research on fossil or modern organisms to address time-sensitive issues, such as ocean acidification and other types of environmental change, including global warming and sea-level rise.

T22. Exposing Myths and Misrepresentations of Climate Change and Evolution Science: Strategies and Case Studies for Geoscientists, Educators, Policy Makers, and the Press

Cosponsors: *GSA Quaternary Geology and Geomorphology Division; American Quaternary Association (AMQUA);*

GSA Geobiology & Geomicrobiology Division; GSA Geology and Society Division; GSA Geoscience Education Division; International Union for Quaternary Research (INQUA); National Association of Geoscience Teachers; Paleontological Society

Disciplines: Quaternary Geology; Paleontology, Diversity, Extinction, Origination; Geoscience Education

Advocates: George T. Stone, Milwaukee Area Technical College, Milwaukee, Wis.; Michael E. Mann, Penn State Univ., University Park, Pa.; Andrew M. Buddington, Spokane Community College, Spokane, Wash.

Description: Public mistrust of evidence-based knowledge compels clear explanation of science and exposure of myths and misrepresentations. This session presents strategies and case studies in climate-change and evolution science to help meet this imperative.

T23. Reconstructing Interactions between Humans and the Natural Environment during the Holocene

Cosponsors: *GSA Archaeological Geology Division; GSA Limnogeology Division; GSA Quaternary Geology and Geomorphology Division*

Disciplines: Archaeological Geology; Limnogeology; Quaternary Geology

Advocate: Michelle F. Goman, Cornell Univ., Ithaca, N.Y.

Description: The Holocene is unique in experiencing significant human impacts to the natural environment and conversely the impact of natural hazards on civilizations. This session seeks papers that reconstruct and examine these impacts.

T24. Sediments and Settlements

Cosponsors: *GSA Archaeological Geology Division; GSA Sedimentary Geology Division; GSA Quaternary Geology and Geomorphology Division*

Disciplines: Archaeological Geology; Sediments, Clastic; Sediments, Carbonates

Advocates: Cynthia M. Fadem, Earlham College, Richmond, Ind.; Katherine A. Adelsberger, Knox College, Galesburg, Ill.

Description: The long history of archaeological sediment analysis provides precedent and inspiration for a diversity of recent approaches in geoarchaeology. This session explores developments in sedimentological analysis in the context of human settlement.

T25. The Geoenvironmental Context of Human Migrations

Cosponsors: *GSA Archaeological Geology Division; GSA Quaternary Geology and Geomorphology Division; GSA Geobiology & Geomicrobiology Division; American Quaternary Association (AMQUA)*

Disciplines: Archaeological Geology; Quaternary Geology; Paleontology, Paleoecology/Taphonomy

Advocate: E. Arthur Bettis, Univ. of Iowa, Iowa City, Iowa

Description: This session examines the geological and environmental context of human migrations by

exploring constraints and opportunities for human migrations in the light of interactions among landscapes and the flora, fauna, and humans inhabiting them.

T26. Advances in Clean Coal Technology, Carbon Sequestration, and Enhanced Resource Recovery

Cosponsors: *GSA Coal Geology Division; GSA Geology and Society Division*

Disciplines: Coal Geology; Environmental Geoscience; Public Policy

Advocates: Jack C. Pashin, Geological Survey of Alabama, Tuscaloosa, Ala.; Stephen F. Greb, Kentucky Geological Survey, Lexington, Ky.

Description: This session examines advances in clean coal technology, including geologic carbon sequestration and enhanced oil and gas recovery. The environmental impacts of greenhouse gas emissions and carbon capture and storage programs are considered.

T27. Frontiers in Coal Science: Basic Research to Applied Technology

Cosponsors: *GSA Coal Geology Division; GSA Sedimentary Geology Division*

Disciplines: Coal Geology; Environmental Geoscience; Sediments, Clastic

Advocates: Sharon M. Swanson, USGS, Reston, Va.; James C. Hower, Univ. of Kentucky, Lexington, Ky.

Description: This session highlights recent advances in coal science. Topics include environmental effects of coal utilization, characterization of coal combustion products, coal gasification/liquefaction, coal bed methane, economics of coal use, carbon sequestration, coal petrology, and sedimentology.

T28. Engineering and Environmental Impacts of Evaporite Karst Processes

Cosponsors: *GSA Engineering Geology Division; GSA Hydrogeology Division; GSA Quaternary Geology and Geomorphology Division; National Cave and Karst Research Institute*

Disciplines: Engineering Geology; Geomorphology; Hydrogeology

Advocates: Lewis A. Land, New Mexico Tech., Carlsbad, N.Mex.; Jonathan L. White, Colorado Geological Survey, Denver, Colo.

Description: Environmental hazards associated with karst processes are often produced on a human time scale in evaporitic rocks. Papers are welcome on these hazards, natural and human-induced, and geophysical and engineering methods for characterization and remediation.

T29. Landslides, Debris Flow, and Rock Fall: Reaching New Peaks in Research and Monitoring

Cosponsors: *GSA Engineering Geology Division; GSA Quaternary Geology and Geomorphology Division; U.S. Geological Survey*

Disciplines: Engineering Geology; Geomorphology; Public Policy

Advocates: Rex L. Baum, USGS, Denver, Colo.; Brian D. Collins, USGS, Menlo Park, Calif.

Description: This session will explore new insights about landslide processes and hazards. Contributions that address field, instrumental, or modeling studies about any type of landslides are especially welcome.

T30. Motion of Landslides, Debris Flows, and Avalanches

Cosponsors: *GSA Engineering Geology Division; GSA Quaternary Geology and Geomorphology Division*

Disciplines: Engineering Geology; Geomorphology

Advocates: William H. Schulz, USGS, Denver, Colo.; Jeffrey A. Coe, USGS, Denver, Colo.; Mark E. Reid, USGS, Menlo Park, Calif.

Description: This session seeks presentations describing factors that control motion in all types of landslides, ranging from creeping slides to rapid debris flows and rock avalanches. Contributions describing recent research advances and case studies are encouraged.

T31. Secondary Processes of Landslides

Cosponsors: *GSA Engineering Geology Division; GSA Quaternary Geology and Geomorphology Division; Association of Environmental & Engineering Geologists*

Disciplines: Engineering Geology; Geomorphology; Environmental Geoscience

Advocates: Nicholas J. Roberts, Simon Fraser Univ., Burnaby, British Columbia; John J. Clague, Simon Fraser Univ., Burnaby, British Columbia

Description: Secondary processes can greatly extend and amplify landslide impacts. Topics include case histories, theoretical advances, and social and economic impacts of processes, including displacement waves, dam impoundment and outburst, and extreme run-out through debris fluidization.

T32. Seeing the True Shape of Earth's Surface: Applications of Airborne and Terrestrial LiDAR in the Geosciences (Posters)

Cosponsors: *GSA Engineering Geology Division; GSA Structural Geology and Tectonics Division; GSA Quaternary Geology and Geomorphology Division; GSA Sedimentary Geology Division; GSA Geoinformatics Division; GSA Geophysics Division*

Disciplines: Engineering Geology; Neotectonics/Paleoseismology; Quaternary Geology

Advocates: Ian P. Madin, Oregon Dept. of Geology and Mineral Industries (DOGAMI), Portland, Ore.; Kurt L. Frankel, Georgia Institute of Technology, Atlanta, Ga.

Description: High-resolution LiDAR data are now becoming available over large areas. This session will examine how these highly detailed images of the land surface provide unprecedented opportunities for qualitative and quantitative analysis of earth processes.

T33. Debris Flows: From Hazard Mitigation to Landscape Evolution

Cosponsors: *GSA Quaternary Geology and Geomorphology Division; GSA Engineering Geology Division*

Disciplines: Geomorphology; Engineering Geology; Hydrogeology

Advocates: Scott W. McCoy, Univ. of Colorado, Boulder, Colo.; Jason W. Kean, USGS, Denver, Colo.; Leslie Hsu, Univ. of California, Berkeley, Calif.

Description: We encourage field, laboratory, and modeling contributions on all aspects and types of debris flows, their controls on steep-land morphology, and their impact on downstream fluvial systems.

T34. Vapors, Brines, Sulfides, and Mines: Understanding Metal Mobility in Magma-Hydrothermal Systems and Their Supergene Successors

Cosponsors: *Society of Economic Geologists; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Hydrogeology Division*

Disciplines: Economic Geology; Environmental Geoscience; Geochemistry

Advocates: Jacob B. Lowenstern, USGS, Menlo Park, Calif.; Adam Simon, UNLV, Las Vegas, Nev.; Charles Alpers, California Water Science Center, Sacramento, Calif.

Description: This session explores the processes and phases that control metal partitioning in Earth's crust, ranging from magmas to their related hydrothermal systems, into mineral deposits, and finally during erosion and oxidation near the surface.

T35. Critical Metals (REE, In, Te, Nb, Ta, Ga, Li, etc.) for the New Energy Future

Cosponsors: *Society of Economic Geologists; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division*

Disciplines: Economic Geology; Mineralogy/Crystallography; Petrology, Igneous

Advocates: Yasushi Watanabe, AIST, Tsukuba, Japan; Murray W. Hitzman, Colorado School of Mines, Golden, Colo.

Description: The session aims to discuss geneses of the critical metal-bearing deposits, as well as the present and potential supply sources for the critical metals that are indispensable for the productions of high-technology materials.

T36. Metal-Fertile versus Barren Magmatic Systems at the Arc- to Individual Pluton-Scale: Applying an Improved Understanding of Volatile and Trace-Element Behavior and Experimental Constraints to Petrogenetic Studies

Cosponsors: *Society of Economic Geologists; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; Mineralogical Society of America*

Disciplines: Economic Geology; Geochemistry; Tectonics

Advocates: James D. Webster, American Museum of Natural History, New York, N.Y.; Kéiko H. Hattori, Univ. of Ottawa, Ottawa, Ontario

Description: Why are some intrusions in subduction zones associated with metallic mineralization and others are not? Coupling petrogenetic studies with improved understanding of fractionation behavior in magmatic systems and experimental constraints may provide answers.

T37. Environmental Geochemistry for Modern Mining

Cosponsor: *Society of Economic Geologists*

Disciplines: Economic Geology; Geochemistry; Environmental Geoscience

Advocates: Robert R. Seal, USGS, Reston, Va.; LeeAnn Munk, Univ. of Alaska, Anchorage, Alaska

Description: This session encourages contributions on baseline characterization, geochemical characteristics of mine wastes, ecological and human health effects associated with mine waste and drainage, pit lake geochemistry, and case studies.

T38. International Research Experiences for Undergraduates (Posters)

Cosponsors: *Council on Undergraduate Research; National Association of Geoscience Teachers*

Discipline: Geoscience Education

Advocates: Edward Hansen, Council for Undergraduate Research, Geoscience Division, Holland, Mich.; Jeff Marshall, Cal Poly Pomona Univ., Pomona, Calif.

Description: This session will highlight examples of international research involving undergraduate students. Emphasis will be on the process of setting up and carrying out these projects, including benefits and drawbacks, what works and what doesn't.

T39. Energy, Climate, and Global Communities: New Pathways for Education and Workforce

Cosponsors: *Society of Economic Geologists; GSA Geophysics Division; GSA Structural Geology and Tectonics Division; National Association of Black Geologists and Geophysicists*

Disciplines: Geoscience Education; Environmental Geoscience; Public Policy

Advocates: Marilyn J. Suiter, National Science Foundation, Arlington, Va.; Lina C. Patino, National Science Foundation, Arlington, Va.

Description: This session provides information on geoscience education programs that address new methods in workforce development in energy and climate change in light of the globalization of (geo)science, with data and outcomes.

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T40. Clickers in the Classroom: Fun and Games, Learning Tool, or Both?

Cosponsors: *National Association of Geoscience Teachers; GSA Geoscience Education Division*

Discipline: Geoscience Education

Advocates: David Steer, The Univ. of Akron, Akron, Ohio; Jeffrey R. Knott, California State Univ., Fullerton, Fullerton, Calif.; Karen Kortz, Community College of Rhode Island, Lincoln, R.I.

Description: This session explores how and why faculty use clickers and provides evidence that such systems impact teaching and learning. Presentations describe best practices, evidence-based learning, student satisfaction, and comparisons of response patterns to summative assessments.

T41. Learning Outside the Geoscience Classroom: Engaging Students Beyond the Lecture and Laboratory Setting (Posters)

Discipline: Geoscience Education

Advocates: Lauren Neitzke Adamo, Rutgers Univ., New Brunswick, N.J.; Kelsey S. Bitting, Rutgers Univ., Piscataway, N.J.

Description: The number of field trips incorporated into geoscience curriculums has declined in recent years due to a variety of reasons. This section will showcase innovative activities that engage students in experiences outside of the traditional classroom.

T42. Participation of Undergraduates and K–12 Students in Environmental and Geoscience-Related Research: A Critical Tool for Experiential Learning Technique (Posters)

Cosponsors: *National Association of Geoscience Teachers; GSA Geoscience Education Division; GSA Geology and Society Division*

Disciplines: Environmental Geoscience; Geoscience Education; Geoscience Information/Communication

Advocates: Nazrul I. Khandaker, York College (CUNY), Jamaica, N.Y.; Stanley Schleifer, York College (CUNY), Jamaica, N.Y.

Description: Undergraduates and K–12 students interested in earth-system science and current environmental hot topics are highly encouraged to share their research experience and benefit from interacting with fellow geoscientists, academicians, and concerned citizens.

T43. Research on Diversity in the Geosciences and S&E Workforce: Data and Successful Strategies

Cosponsors: *National Association of Geoscience Teachers; GSA Geology and Society Division*

Disciplines: Geoscience Education; Public Policy

Advocates: Michael G. Loudin, ExxonMobil Exploration Co., Houston, Tex.; Marilyn J. Suiter, National Science Foundation, Arlington, Va.; Jill Karsten, National Science Foundation, Arlington, Va.; Roman Czujko, American Institute of Physics, College Park, Md.

Description: Many programs addressing increased diversity in the geosciences have been instituted, but the scholarly compilation of data and strategies of successful methods seems lacking. This session will provide data on geoscience diversity development and outcomes.

T44. Geoscience Programs at Community Colleges: Models for Success and Innovation

Cosponsors: *GSA Geoscience Education Division; National Association of Geoscience Teachers*

Disciplines: Geoscience Education; Geoscience Information/Communication

Advocates: Eric M.D. Baer, Highline Community College, Des Moines, Wash.; R. Heather Macdonald, College William & Mary, Williamsburg, Va.

Description: Community college geoscience programs are diverse and multifaceted and succeed in a variety of roles. This session will highlight programs and how they achieve their goals.

T45. Energy Education in the Geoscience Classroom: Preparing Future Citizens, Scientists, and Policy Makers

Cosponsors: *GSA Geoscience Education Division; National Association of Geoscience Teachers*

Disciplines: Geoscience Education; Public Policy; Environmental Geoscience

Advocates: James D. Myers, Univ. of Wyoming, Laramie, Wyo.; Karin B. Kirk, Carleton College, Northfield, Minn.; Fred Loxsom, Eastern Connecticut State Univ., Willimantic, Conn.; Devin N. Castendyk, State Univ. of New York, College at Oneonta, Oneonta, N.Y.; Glenn A. Richard, Stony Brook Univ., Stony Brook, N.Y.

Description: Issues associated with supply, production, and use of energy pose a great challenge for both science and society. This session will showcase proven educational strategies for addressing energy themes in the geoscience classroom.

T46. Using Real- and near-Real-Time Data in the Classroom (Posters)

Cosponsors: *GSA Geoscience Education Division; National Association of Geoscience Teachers; GSA Geology and Society Division*

Disciplines: Geoscience Education; Geoscience Information/Communication

Advocates: Michael P. Poland, Hawaiian Volcano Observatory, Hawaii National Park, Hawaii; Rachel Teasdale, California State Univ., Chico, Calif.; Katrien J. Kraft, Mesa Community College, Mesa, Ariz.

Description: This session will focus on the innovative use of earth-science data, particularly that which is provided online in real- and near-real-time, in academic settings (both formal and informal).

T47. Passageways to Success: Promoting Geoscience and Environmental Literacy through Cave and Karst Education and Outreach Programs

Cosponsors: *GSA Geoscience Education Division; National Cave and Karst Research Institute*

Disciplines: Geoscience Education; Geoscience Information/Communication; Environmental Geoscience

Advocates: Dianne Gillespie, National Cave and Karst Research Institute, Carlsbad, N.Mex.; Rickard S. Toomey, Mammoth Cave International Center for Science and Learning, Mammoth Cave, Ky.

Description: Educators will describe cave and karst programs that promote geoscience and environmental literacy as well as some dos and don'ts to consider in program development.

T48. Teacher Research and Instruction Abroad: A Pathway to Improved Geoscience Education

Cosponsors: *National Association of Geoscience Teachers; Council on Undergraduate Research; GSA Geoscience Education Division*

Discipline: Geoscience Education

Advocates: Jacquelyn E. Hams, Los Angeles Valley College, Valley Glen, Calif.; Janis D. Treworgy, Principia College, Elsah, Ill.; Kate S. Pound, St. Cloud State Univ., St. Cloud, Minn.

Description: Have you participated in travel abroad experiences as a geoscience educator? This session will highlight teacher-research experiences, learning communities, and other travel abroad programs. Come share the experiences, activities, and lesson plans that you have developed.

T49. Minority-Serving Institutions: Progress and Promise in Geoscience Education

Cosponsors: *National Association of Geoscience Teachers; GSA Geoscience Education Division*

Disciplines: Geoscience Education; Public Policy

Advocates: Laura F. Serpa, Univ. of Texas, El Paso, Tex.; Lisa D. White, San Francisco State Univ., San Francisco, Calif.; Marilyn J. Suiter, National Science Foundation, Arlington, Va.; Louis A. Fernandez, California State Univ., San Bernardino, Calif.

Description: Many Minority-Serving Institutions (MSIs) have degree-granting geoscience programs. Challenges and strategies for positive outcomes are potential topics. Presentations will provide information on geoscience programs at MSIs, with data and outcomes documenting useful strategies applied.

T50. Undergraduate Student Research with Solitary Geoscience Faculty

Cosponsors: *National Association of Geoscience Teachers; GSA Geoscience Education Division; Council on Undergraduate Research*

Discipline: Geoscience Education

Advocates: Janis D. Treworgy, Principia College, Elsah, Ill.; Laura A. Guertin, Penn State–Brandywine, Media, Pa.; Suzanne M. Smaglik, Central Wyoming College, Riverton, Wyo.

Description: Have you, as a solitary geoscience faculty member, figured out how to involve your students in research? Come share both your successes and perceived failures to help others develop their own research programs.

T51. Neutral Mine Drainage: Release, Transport, and Attenuation of Metals and Trace Elements in Circumneutral Mining Environments

Cosponsors: *GSA Hydrogeology Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; International Association of GeoChemistry (IAGC); Geochemical Society*

Disciplines: Environmental Geoscience; Geochemistry; Hydrogeology

Advocates: Matthew B.J. Lindsay, Univ. of Waterloo, Waterloo, Ontario; David W. Blowes, Univ. of Waterloo, Waterloo, Ontario; D. Kirk Nordstrom, USGS, Boulder, Colo.

Description: This session will center on the geochemistry, mineralogy, and microbiology of metals and trace elements in mining-impacted environments characterized by circumneutral-pH conditions. Topics may range from mine waste characterization to down-gradient transport and attenuation processes.

T52. Karst Environments: Problems, Management, Human Impact, and Environmental Sustainability (Posters)

Cosponsors: *GSA Hydrogeology Division; National Cave and Karst Research Institute; Karst Waters Institute; GSA Quaternary Geology and Geomorphology Division*

Disciplines: Environmental Geoscience; Public Policy; Engineering Geology

Advocates: Robert Brinkmann, Univ. of South Florida, Tampa, Fla.; Mario Parise, CNR-IRPI, Bari, Italy

Description: Karst systems are among the most fragile and vulnerable environments in the world. This session will explore current research on how humans are interacting with karst with a focus on management and sustainability.

T53. Advances in the Prediction and Prevention of Acid Rock Drainage and Metal Leaching

Cosponsor: *GSA Hydrogeology Division*

Disciplines: Environmental Geoscience; Geochemistry; Geomicrobiology

Advocates: Patricia Beth Moran, Tetra Tech, Denver, Colo.; James F. Ranville, Colorado School of Mines, Golden, Colo.

Description: This session will explore recent advances in the field of acid rock drainage and metal leaching management. General topics of interest may include sample selection, geochemical characterization, predictive modeling, and field verification of predictions.

T54. Pyrogenic Black Carbon, or Biochar, in Soils and Sediments—Its Characterization and Fate, Its Effects on the Carbon Cycle and Carbon Sequestration, and Its Effects on Soil Properties

Cosponsors: *GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Geobiology & Geomicrobiology Division*

Disciplines: Environmental Geoscience; Geochemistry, Organic

Advocates: Colleen E. Rostad, USGS, Water Resources Discipline, Denver, Colo.; David W. Rutherford, USGS, Denver, Colo.

Description: This session addresses pyrogenic carbon in soils and sediments. The presence of this material can have profound effects on the nature of soil and may have an increasing role to play in carbon sequestration.

T55. Environmental Geology of Oil Shale and Tar Sands

Cosponsor: *GSA Quaternary Geology and Geomorphology Division*

Disciplines: Environmental Geoscience; Geology and Health; Public Policy

Advocates: Jeremy Boak, Colorado School of Mines, Golden, Colo.; Justin E. Birdwell, USGS, Denver, Colo.

Description: This session seeks contributions focused on the impacts of nontraditional hydrocarbon resource development on environmental quality, with emphasis on water use, greenhouse gases, and hazardous residues.

T56. Sigma Gamma Epsilon Undergraduate Research (Posters)

Cosponsor: *Sigma Gamma Epsilon*

Disciplines: Environmental Geoscience; Paleontology, Biogeography/Biostratigraphy; Hydrogeology

Advocates: Richard L. Ford, Weber State Univ., Ogden, Utah; James C. Walters, The Univ. of Northern Iowa, Cedar Falls, Iowa

Description: The goal of this session is to highlight recent and ongoing undergraduate research in a student-friendly forum. The session is open to students and faculty co-authors working in any area of the geosciences.

T57. Frontiers in Experimental Petrology: In Honor of Robert C. Newton

Cosponsors: *GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; Mineralogical Society of America*

Disciplines: Petrology, Experimental; Petrology, Metamorphic; Petrology, Igneous

Advocates: Craig E. Manning, Univ. of California, Los Angeles, Calif.; John M. Ferry, Johns Hopkins Univ., Baltimore, Md.; David Jenkins, Binghamton Univ., Binghamton, N.Y.

Description: Experiments are central to igneous and metamorphic petrology. They constrain properties of minerals, melts, and fluids. This session honors

contributions of Robert C. Newton to this discipline. Contributions in all current and emerging topics welcome.

T58. Frontiers in Metamorphic Petrology: Integrating Mass Transport, Heat Transport, Reaction Kinetics, and Tectonics with Mineral Equilibria

Cosponsors: *GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; Mineralogical Society of America*

Disciplines: Petrology, Metamorphic; Mineralogy/Crystallography; Tectonics

Advocates: William D. Carlson, Univ. of Texas, Austin, Tex.; John M. Ferry, Johns Hopkins Univ., Baltimore, Md.; Thomas Müller, Rensselaer Polytechnic Institute, Troy, N.Y.

Description: Advances in metamorphic petrology increasingly integrate mineral equilibria with heat and mass transport, tectonics, and reaction kinetics. The session encompasses all of these components of metamorphic systems, with a focus on how to link them.

T59. High-Pressure and High-Temperature Metamorphism: P - T - t Paths and Tectonics

Cosponsors: *GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; Mineralogical Society of America; GSA Structural Geology and Tectonics Division*

Disciplines: Petrology, Metamorphic; Tectonics

Advocates: Michael Brown, Univ. of Maryland, College Park, Md.; Fraukje Brouwer, Vrije Universiteit Amsterdam, Amsterdam, Netherlands; Nigel Kelly, Colorado School of Mines, Golden, Colo.

Description: Advances in reliability of pressure-temperature-time information retrieved from orogens and in sophistication of numerical modeling studies make this session timely for those who integrate multiple techniques to understand orogenesis at extreme pressure or temperature.

T60. Volcanic and Landscape Evolution of the Jemez Mountains Volcanic Field

Cosponsors: *GSA Geophysics Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Quaternary Geology and Geomorphology Division; Mineralogical Society of America*

Disciplines: Volcanology; Tectonics; Geomorphology

Advocate: Fraser Goff, Univ. of New Mexico, Albuquerque, N.Mex.

Description: Presentations in this session will highlight new interpretations of geochronology, geochemical, and stratigraphic data gathered during recent 1:24,000-scale surface mapping in the Jemez Mountains and environmental drilling at Los Alamos National Laboratory.

T61. Tectonic Controls on Volcanism: Geologic Perspectives

Cosponsors: *GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Structural Geology and Tectonics Division; GSA Geophysics Division; Mineralogical Society of America*

Disciplines: Volcanology; Tectonics; Structural Geology
Advocates: Cathy J. Busby, Univ. of California, Santa Barbara, Calif.; Luca Ferrari, UNAM, Queretaro, Mexico
Description: Tectonic-structural controls on volcanism will be examined, mainly focusing on geologic and geophysical aspects. Submissions should relate local or regional-scale structures and tectonic processes to volcano types or volcanic styles or architecture of volcanic successions.

T62. Geochemical Behavior and Reactivity of Nanostructures in Natural Systems

Cosponsors: *GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; International Association of GeoChemistry (IAGC)*

Discipline: Geochemistry

Advocates: Russel S. Harmon, Research Triangle Park, N.C.; Huifang Xu, Univ. of Wisconsin, Madison, Wis.

Description: This session will focus on understanding geochemical reactions and mass transfers at nanometer scales, especially the formation of nanostructures (e.g., particles, films, and pores) in geologic materials and their effects on geochemical processes.

T63. Sources, Transport, and Fate of Trace and Toxic Elements in the Environment

Cosponsors: *GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; International Association of GeoChemistry (IAGC); GSA Geobiology & Geomicrobiology Division*

Disciplines: Geochemistry; Environmental Geoscience

Advocates: LeeAnn Munk, Univ. of Alaska, Anchorage, Alaska; David T. Long, Michigan State Univ., East Lansing, Mich.; W. Berry Lyons, Ohio State Univ., Columbus, Ohio

Description: Relevant research dealing with trace and potentially toxic elements in the environment. Basic and applied research topics on trace elements in water, sediment, and rocks that relate to sources, transport, and fate are encouraged.

T64. Geochemistry of Geologic Sequestration of CO₂: Understanding Gas-Water-Mineral Interactions over Wide Temporal and Spatial Ranges

Cosponsors: *GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; International Association of GeoChemistry (IAGC); GSA Hydrogeology Division*

Disciplines: Geochemistry; Environmental Geoscience; Hydrogeology

Advocates: Yousif K. Kharaka, Menlo Park, Calif.; David R. Cole, Oak Ridge National Lab, Oak Ridge, Tenn.

Description: Successful geologic sequestration of anthropogenic CO₂ to mitigate global warming requires accurate predictions of CO₂-brine-mineral interactions from pore space to basin scale. These geochemical interactions determine CO₂ long-term storage security, reservoir performance, and environmental impacts.

T65. Advances in the Geology, Geochemistry, Geochronology, Isotope Geochemistry, Geophysics, Structural Geology, and Tectonics of Central Colorado

Cosponsors: *GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Structural Geology and Tectonics Division; U.S. Geological Survey; Colorado Geological Survey; GSA Geophysics Division*

Disciplines: Geochemistry; Structural Geology; Tectonics

Advocates: Terry Klein, USGS, Denver, Colo.; Karl Kellogg, USGS, Denver, Colo.; Cal Ruleman, USGS, Denver, Colo.

Description: Focused on multidisciplinary geoscience investigations and their use interpreting the Proterozoic to Neogene geologic history of the eastern Rocky Mountains in central Colorado.

T66. Geochronology of the American West: In Honor of the Careers of Bill Cobban and John Obradovich and the Roots of EARTHTIME

Cosponsors: *Geochemical Society; Paleontological Society*

Disciplines: Paleontology, Biogeography/Biostratigraphy; Geochemistry; Paleoclimatology/Paleoceanography

Advocates: S.A. Bowring, Massachusetts Institute of Technology, Cambridge, Mass.; Kirk R. Johnson, Denver Museum of Nature & Science, Denver, Colo.; Brad S. Singer, Univ. of Wisconsin, Madison, Wis.

Description: John Obradovich and Bill Cobban recognized the power of integrating stratigraphy, geochronology, and biostratigraphy to understand the chronostratigraphy of the Cretaceous. We seek papers that build on the pioneering work of these geologists.

T67. Frontiers in Geochemistry: Kinetics and Thermodynamics of Chemical Reactions in Earth Environments through Integrated Field, Experimental, and Theoretical Studies: In Honor of J. Donald Rimstidt

Cosponsors: *Geochemical Society; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division*

Disciplines: Geochemistry; Environmental Geoscience; Sediments, Carbonates

Advocates: Patricia M. Dove, Virginia Tech, Blacksburg, Va.; John Chermak, Newmont Mining, Denver, Colo.

Description: This session honors J. Donald Rimstidt and his many contributions to geochemistry as a professor at Virginia Tech. We seek presentations on forward-looking topics that reflect the breadth of his interactions with students and colleagues.

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T68. EARTHTIME: In Honor of the Contributions of James Mattinson to High-Precision U-Pb Geochronology

Cosponsor: *Geochemical Society*

Disciplines: Geochemistry; Tectonics

Advocates: Samuel A. Bowring, Massachusetts Institute of Technology, Cambridge, Mass.; Daniel Condon, British Geological Survey, Nottingham, UK; Matthew Rioux, Massachusetts Institute of Technology, Cambridge, Mass.

Description: Jim Mattinson has been a major force in the development of high-precision U-Pb geochronology for over 30 years. We seek contributions that reflect Jim's influence, from U-Pb systematics to Cordilleran tectonics.

T69. Innovative Techniques and Applications for Detrital Thermo- and Geochronologic Data

Cosponsors: *Geochemical Society; GSA Quaternary Geology and Geomorphology Division; Mineralogical Society of America; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division*

Disciplines: Geochemistry; Structural Geology; Tectonics

Advocates: Todd LaMaskin, URS Corporation, Gaithersburg, Md.; Jeff D. Vervoort, Washington State Univ., Pullman, Wash.

Description: This session will focus on detrital-mineral geochronology, thermochronology, and isotope geochemistry. We encourage papers presenting new analytical tools and approaches to detrital-mineral investigations as well as application of these data to diverse geological problems.

T70. Geochemistry and Mineralogy of Fossils

Cosponsors: *Geochemical Society; Mineralogical Society of America; Paleontological Society; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Geobiology & Geomicrobiology Division*

Disciplines: Geochemistry; Paleontology, Paleoecology/Taphonomy; Mineralogy/Crystallography

Advocates: Matthew J. Kohn, Boise State Univ., Boise, Idaho; Dennis O. Terry, Temple Univ., Philadelphia, Pa.; David Grandstaff, Temple Univ., Philadelphia, Pa.

Description: We encourage submissions on processes of fossilization and application of trace element geochemistry in vertebrate fossils to further interests in such fields as paleoecology, sedimentology, histology, geochronology, paleoclimatology, and rates, conditions, and mechanisms of fossilization.

T71. Mineral Behavior and Molecular-Scale Processes in the Environment

Cosponsor: *Geochemical Society*

Disciplines: Mineralogy/Crystallography; Geochemistry; Environmental Geoscience

Advocates: Aaron Celestian, Western Kentucky Univ., Bowling Green, Ky.; Andrew H. Wulff, Western Kentucky Univ., Bowling Green, Ky.

Description: This session will focus on model and real-world systems for understanding inorganic and

biologically mediated mineral growth, dissolution, and transformation resulting from interaction with the environment.

T72. Noble and Trace Gas Geochemistry: Practical Applications and Current Research

Cosponsors: *GSA Hydrogeology Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; Geochemical Society*

Disciplines: Geochemistry; Hydrogeology; Environmental Geoscience

Advocates: Andrew G. Hunt, USGS, Denver, Colo.; L. Niel Plummer, USGS, Reston, Va.; Andrew H. Manning, USGS, Denver, Colo.

Description: This session will provide a forum to present studies, applied and theoretical, involving noble and trace gases in practical applications relating to groundwater studies as well as geothermal and natural gas investigations.

T73. Reducing the Environmental Impact of Uranium In Situ Recovery

Cosponsor: *Geochemical Society*

Disciplines: Environmental Geoscience; Geochemistry; Hydrogeology

Advocates: Ardyth M. Simmons, Los Alamos National Laboratory, Los Alamos, N.Mex.; Malcolm D. Siegel, Sandia National Laboratories, Albuquerque, N.Mex.

Description: This session will explore the current technical approaches to reducing the environmental effects of uranium ISR in comparison to the historical environmental impact of uranium mining to demonstrate advances in this controversial subject.

T74. Integrated Approaches to Modeling Geochemical, Hydrological, and Ecological Processes in Watersheds

Cosponsors: *GSA Hydrogeology Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Geobiology & Geomicrobiology Division; GSA Quaternary Geology and Geomorphology Division; Geochemical Society*

Disciplines: Hydrogeology; Geochemistry; Environmental Geoscience

Advocates: Kathleen S. Smith, USGS, Denver, Colo.; Jill S. Baron, USGS, Fort Collins, Colo.; JoAnn M. Holloway, USGS, Denver, Colo.; Andrew H. Manning, USGS, Denver, Colo.

Description: This session will focus on integrated watershed modeling methodologies for understanding the interface between hydrological, geologic, geochemical, biogeochemical, and ecological processes, and the utility of numerical, empirical, and GIS modeling to evaluate perturbations in watersheds.

T75. Marine Redox Evolution: Controls and Consequences

Cosponsor: *Geochemical Society*

Disciplines: Paleoclimatology/Paleoceanography; Geochemistry; Paleontology, Paleoecology/Taphonomy

Advocates: Bradley B. Sageman, Northwestern Univ., Evanston, Ill.; Matthew T. Hurtgen, Northwestern Univ., Evanston, Ill.; Richard Barclay, Northwestern Univ., Evanston, Ill.; Derek D. Adams, Northwestern Univ., Evanston, Ill.; Jennifer C. McElwain, Univ. College, Dublin, Ireland

Description: This session will gather a diverse set of earth scientists to discuss the causes and consequences of oxygen-depleted periods in the geologic record, integrating modern and ancient records from all temporal and spatial scales.

T76. Understanding High-Amplitude Stable Isotope Variations in Proterozoic Strata

Cosponsors: *Geochemical Society; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division*

Discipline: Geochemistry

Advocates: Louis A. Derry, Cornell Univ., Ithaca, N.Y.; Timothy Lyons, Univ. of California, Riverside, Calif.

Description: Wide variations in $\delta^{13}\text{C}$, $\delta^{18}\text{O}$, and $\delta^{34}\text{S}$ in Proterozoic sediments pose challenges to our understanding. Do they represent major changes in the C, S, and water cycles, dominance of particular biogeochemical pathways, and/or diagenesis?

T77. Common Approaches to Investigating Patterns and Processes of Bioerosion across Substrates

Cosponsors: *GSA Geobiology & Geomicrobiology Division; Paleontological Society*

Disciplines: Geomicrobiology; Paleontology, Paleoecology/Taphonomy; Sediments, Carbonates

Advocates: Nicola McLoughlin, Univ. of Bergen, Bergen, Norway; Leif Tapanila, Idaho State Univ., Pocatello, Idaho

Description: This session will address bioerosion in carbonates, silicate minerals, volcanic glass, and biominerals. We will share concepts and tools to investigate mechanisms of bioerosion, the resulting fossil-record, and implications for the evolution of biogeochemical cycles.

T78. Geomicrobiology of Arsenic Transformation and Mobilization in Arsenic-Enriched Alluvial Aquifers and Subsequent Impact on Ecosystem as Well as Human Health

Cosponsors: *GSA Geobiology & Geomicrobiology Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division*

Disciplines: Hydrogeology; Geomicrobiology; Geology and Health

Advocates: Jiin-Shuh Jean, National Cheng Kung Univ., Tainan, Taiwan

Description: This session serves as a platform for scientific exchange to improve the understanding of geochemical characterization, including microbial transformation and mobilization of arsenic in alluvial aquifers, and bioaccumulation of arsenic in ecosystem and health effects.

T79. Geoscience Information Services: "Peak" Performances

Cosponsors: *Geoscience Information Society; GSA Geoinformatics Division; National Association of Geoscience Teachers*

Disciplines: Geoscience Information/Communication; Geoscience Education; Geoinformatics

Advocate: Janet E. Dombrowski, Univ. of Wyoming, Laramie, Wyo.

Description: Geoscience information providers apply their expertise to add value to information and deliver exceptional services for library users in complex and diverse roles, such as consultation, contract negotiation, metadata description, instruction, and Web site development.

T80. Earth System Science in Museums: Tapping the Potential to Engage the General Public in the Complexity of the Earth

Cosponsors: *GSA Geoscience Education Division; Denver Museum of Nature & Science; American Association of Museums*

Disciplines: Geoscience Information/Communication; Geoscience Education

Advocates: Ian M. Miller, Denver Museum of Nature & Science, Denver, Colo.; Kirk R. Johnson, Denver Museum of Nature & Science, Denver, Colo.; James W. Hagadorn, Amherst College, Amherst, Mass.

Description: Museums play a key role in informal science education. This session is designed to discuss the potential of and challenges involved in delivering effective earth-system science exhibits and programming.

T81. Geology in the National Parks: Research, Mapping, Education, and Outreach

Cosponsor: *GSA Geoscience Education Division*

Disciplines: Geoscience Information/Communication; Environmental Geoscience; Geoscience Education

Advocates: Bruce Heise, National Park Service, Lakewood, Colo.; Tim Connors, National Park Service, Denver, Colo.

Description: This session addresses the role of geoscience in the national parks. Presentations are encouraged on geologic research, mapping, paleontology, glacier studies, education and outreach, and resource management in U.S. national parks, monuments, seashores, and historic sites.

**T82. Geology in the National Forests and Grasslands—
Stewardship, Education, and Research**

Cosponsors: *GSA Geology and Society Division; GSA Engineering Geology Division; GSA Hydrogeology Division; GSA Quaternary Geology and Geomorphology Division; GSA Geoscience Education Division; USDA Forest Service*

Disciplines: Environmental Geoscience; Engineering Geology; Public Policy

Advocates: Christopher P. Carlson, USDA Forest Service, Arlington, Va.; Joseph T. Gurrieri, USDA Forest Service, Ogden, Utah; J. Courtney Cloyd, USDA Forest Service, Portland, Ore.; Michael A. Crump, USDA Forest Service, Atlanta, Ga.

Description: This session will explore aspects of the geological sciences conducted on the national forests and grasslands. Topics include paleontology, geomorphology, hydrogeology, geoecology, natural-hazard mitigation, cave and karst, engineering, interpretive and recreational geology, and more.

**T83. Challenges in Reaching Peak Communication in
Geoscience Publishing**

Cosponsor: *Association of Earth Science Editors (AESE)*

Discipline: Geoscience Information/Communication

Advocate: Monica Gaiswinkler Easton, Ontario Geological Survey, Sudbury, Ontario

Description: Presenters will discuss a variety of issues confronted in geoscientific publishing from either the technical realm or in communicating the science to the public (e.g., intellectual property rights/copyright, confidentiality, conflicts of interest, plagiarism, review quality).

**T84. Combining Geophysics and Geology: The George
P. Woollard Award Session**

Cosponsor: *GSA Geophysics Division*

Disciplines: Geophysics/Tectonophysics/Seismology; Tectonics

Advocates: Kevin Mickus, Missouri State Univ., Springfield, Mo.; Audrey Huerta, Central Washington Univ., Wash.

Description: This session honors the recipient of the George P. Woollard recipient for his or her outstanding contribution of geophysics to advancing our understanding of geology. Contributions combining geophysics and geology to solve geologic problems are welcome.

**T85. Recent Advances in Paleoseismology and
Neotectonics of Eastern and Central North America
and Northern Caribbean**

Cosponsors: *GSA Geophysics Division; GSA Structural Geology and Tectonics Division*

Disciplines: Neotectonics/Paleoseismology; Tectonics; Quaternary Geology

Advocates: Randel Tom Cox, Univ. of Memphis, Memphis, Tenn.; Martitia Tuttle, M. Tuttle & Associates,

Georgetown, Maine; Phyllis Steckel, Washington, Mo.; Robert Williams, USGS, Golden, Colo.

Description: This session focuses on evidence of strong earthquake shaking and crustal deformation during the Quaternary. Presentations are solicited on earthquake-induced liquefaction, landslides, and tsunamis, as well as surface and subsurface deformation related to active faulting.

**T86. Transformative Science in the Himalaya and Tibet:
Insight from Geophysical, Geochemical, and
Geologic Studies**

Cosponsors: *GSA Geophysics Division; GSA Quaternary Geology and Geomorphology Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division*

Disciplines: Tectonics; Geophysics/Tectonophysics/Seismology; Geochemistry

Advocates: Aaron J. Martin, Univ. of Maryland, College Park, Md.; Delores M. Robinson, Univ. of Alabama, Tuscaloosa, Ala.

Description: This session highlights recent advances in our knowledge of the tectonics of Tibet and the Himalaya. We encourage interdisciplinary submissions that integrate multiple data types to transform our understanding of tectonic processes in collisional orogens.

T87. Climate Change and Human Health

Cosponsors: *GSA Geology and Health Division; GSA Geobiology & Geomicrobiology Division; GSA Geology and Society Division; GSA Hydrogeology Division*

Disciplines: Geology and Health; Geomicrobiology; Hydrogeology

Advocate: Syed E. Hasan, Univ. of Missouri, Kansas City, Mo.

Description: Climate change has resulted in a higher incidence of infectious diseases and geographic shifts in the occurrence of tropical disease. This timely session will feature earth- and health scientists discussing measures for assessing and combating the problem.

T88. Minerals, Microbes, and Health

Cosponsors: *GSA Geology and Health Division; GSA Geobiology & Geomicrobiology Division; GSA Geology and Society Division; Mineralogical Society of America; International Medical Geology Association*

Disciplines: Geology and Health; Mineralogy/Crystallography; Geochemistry

Advocate: Robert B. Finkelman, Univ. of Texas at Dallas, Richardson, Tex.

Description: Shielding humans from infection via local or global pathogens requires interdisciplinary action. The crossover of geological, biological, and medical scientists melds research on minerals and microbes that can have profound impacts on human health.

T89. Geochemistry of Atmospheric Particulates: From Sources to Impacts on the Environment and Health

Disciplines: Geology and Health; Geochemistry; Environmental Geoscience

Advocates: Jean M. Morrison, USGS, Denver, Colo.; Suzette A. Morman, USGS, Denver, Colo.; Geoffrey S. Plumlee, USGS, Denver, Colo.

Description: This session highlights the impact of dusts and other atmospheric particulates from geogenic sources (rocks, soils, volcanic eruptions, wildfires, etc.) on the environment and health.

T90. Publishing in the Digital Age: Making the Most of Publishing in Electronic Journals

Cosponsors: *GSA Geoinformatics Division; Geosphere*

Disciplines: Geoinformatics; Geoscience Information/Communication

Advocates: Dennis L. Harry, Colorado State Univ., Fort Collins, Colo.; Carol Frost, Univ. of Wyoming, Laramie, Wyo.

Description: This session focuses on maximizing content in electronic journals through creation of dynamic figures. Dynamic figures go beyond what authors typically provide in static figures, allowing readers to manipulate and explore the information provided.

T91. Successes and Societal Benefits of Data Preservation

Cosponsors: *GSA Geoinformatics Division; U.S. Geological Survey; Association of American State Geologists; GSA Geophysics Division; GSA Geology and Society Division*

Disciplines: Geoinformatics; Geoscience Information/Communication; Public Policy

Advocates: Frances W. Pierce, USGS, Reston, Va.; John C. Steinmetz, Indiana Univ., Bloomington, Ind.

Description: Preservation of geological, biological, and cultural data is important to the nation's well-being. This session will provide examples of data preservation and the societal benefits of preservation and access to these data.

T92. Technology-Enabled Field Geologic Research: Challenges, Successes, and Requirements for Future Systems

Disciplines: Geoinformatics; Planetary Geology; Geoscience Education

Advocate: Dean B. Eppler, NASA-Johnson Space Center, Houston, Tex.

Description: This session will review the utility of portable computational and analytical tools for field geologic research. Issues limiting adopting electronic mapping and in situ analytical tools and requirements for next-generation technologies will be presented.

T93. Community Remote Sensing: A New Approach for Geoscience Applications

Cosponsors: *GSA Geoinformatics Division; GSA Geoscience Education Division; GSA Geology and Society Division; Secure World Foundation*

Disciplines: Remote Sensing/Geographic Info System; Geoinformatics; Geoscience Education

Advocates: Suzanne T. Metlay, Secure World Foundation, Superior, Colo.; William Gail, Microsoft Startup Business Group, Boulder, Colo.

Description: Community remote sensing encourages citizen-scientists worldwide to contribute remotely sensed data about immediate surroundings using easily downloadable apps for their mobile phones. Session considers CRS uses and how to apply and share data across professional disciplines.



Maroon Bells, near Aspen, Colorado. Photo by Ron Ruhoff for Denver Metro Convention & Visitors Bureau.

T94. The Colorado Scientific Society and 150 Years of Geologic Research in Colorado: Early Colorado Geology and Important Scientific Contributions by the Founders and Members of the Rocky Mountain Region's Oldest Scientific Society, Founded in 1882

Cosponsors: *GSA History of Geology Division; Colorado Scientific Society; Colorado Geological Survey*

Disciplines: History of Geology; Paleontology, Paleoecology/Taphonomy; Stratigraphy

Advocates: Lisa Rae Fisher, Colorado School of Mines, Golden, Colo.; Libby Prueher, Univ. of Northern Colorado, Greeley, Colo.; Scott A. Minor, Denver, Colo.; Thomas R. Fisher, Colorado School of Mines, Golden, Colo.

Description: Join us for the 1859 Gold Rush, the Great Surveys, Arthur Lakes' dinosaur quarries, the establishment of the CSS, and important contributions and advances by its founders and members, along with fascinating related new research.

T95. High Country of the Geological Mind: Philosophy of Geohistory

Cosponsor: *GSA History of Geology Division*

Discipline: History of Geology

Advocates: Victor R. Baker, Univ. of Arizona, Tucson, Ariz.; Gary Rosenberg, Indiana Univ.–Purdue Univ.

Description: This session encourages contributions from philosophers, historians, and geologists on the nature of geology as a historical science and on the related implications of geology's historical nature for the betterment of humankind.

T96. Glacier National Park Centennial: 100 Years of Science and Scenery

Cosponsor: *GSA Quaternary Geology and Geomorphology Division*

Disciplines: History of Geology; Geoscience Education; Precambrian Geology

Advocates: Bruce Heise, National Park Service, Lakewood, Colo.; Robert C. Thomas, Univ. of Montana–Western, Dillon, Mont.; Jeffrey A. Kuhn, Helena, Mont.; Trista L. Thornberry-Ehrlich, Colorado State Univ., Fort Collins, Colo.

Description: This session seeks presentations on any aspect of Glacier National Park's geology as it celebrates its centennial. Presentations are encouraged on topics from ongoing or previous geologic research, climate change, personal vignettes, and resource management.

T97. Temporal Trends in Anthropogenic Contaminants from Lacustrine, Coastal, and Marine Sediment Cores: The Good, the Bad, and the Future

Cosponsors: *GSA Limnogeology Division; GSA Geology and Health Division; GSA Quaternary Geology and Geomorphology Division; GSA Sedimentary Geology Division*

Disciplines: Limnogeology; Sediments, Clastic; Geology and Health

Advocate: Michael R. Rosen, USGS, Carson City, Nev.

Description: Lacustrine, coastal, and marine cores can provide archival changes in contaminant inputs from anthropogenic sources on catchment-wide to global scale. This session explores how contaminant profiles can explain changes in inputs and degradation of contaminants.

T98. African Lakes and Paleolakes: Processes, Paleoenvironments, and Paleoclimate

Cosponsors: *GSA Limnogeology Division; GSA Sedimentary Geology Division; GSA Quaternary Geology and Geomorphology Division; GSA Archaeological Geology Division; GSA International Section; Paleontological Society*

Disciplines: Limnogeology; Quaternary Geology; Sediments, Clastic

Advocate: Daniel Deocampo, Georgia State Univ., Atlanta, Ga.

Description: This session will examine the limnogeology of both modern and ancient lakes across Africa, especially interdisciplinary approaches involving modern processes, limnology, paleolimnology, paleoenvironmental reconstructions, paleoclimatology, paleobiology, and geoarchaeology.

T99. Limnogeology: Interdisciplinary Studies of Lakes and Paleolakes (Posters)

Cosponsor: *GSA Limnogeology Division*

Discipline: Limnogeology

Advocate: Daniel Deocampo, Georgia State Univ., Atlanta, Ga.

Description: Posters presenting advances in all aspects of the study of lakes are encouraged. Topics include those of complementary oral sessions cosponsored by GSA's Limnogeology Division, but contributions are sought from all areas of limnogeology.

T100. Of Isotopes and Lakes: A Tribute to Mike Talbot

Cosponsors: *GSA Limnogeology Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division*

Disciplines: Limnogeology; Paleoclimatology/Paleoceanography; Geochemistry

Advocates: David B. Finkelstein, Univ. of Tennessee, Knoxville, Tenn.; Thomas C. Johnson, Univ. of Minnesota, Duluth, Minn.

Description: This session explores stable, radiogenic, and clumped isotopes in paleoclimate, geomicrobiology, and geochemical studies of modern and ancient lake environments and sediments. Topics will include geochemical and isotopic signatures of waters, microbes, and mineral facies.

T101. Near Field Geochemical Conditions of Geological Repositories for Nuclear Waste: New Experimental Work and Computer Modeling

Cosponsors: *Mineralogical Society of America; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division*

Disciplines: Geochemistry; Geochemistry, Organic; Mineralogy/Crystallography

Advocates: Yongliang Xiong, Sandia National Laboratories, Carlsbad, N.Mex.; Larry Brush, Sandia National Laboratories, Carlsbad, N.Mex.

Description: Studies on chemical species present in waste packages and waste inventories are encouraged. Contributions related to interactions of chemical species in natural solutions with chemical species in waste packages and waste inventories are also encouraged.

T102. Structure, Properties, and Geochemistry of Nanoparticles, Nanoclusters, and Nanocomposites in Biogeochemical Systems: In Honor of Benjamin Gilbert, Recipient of the 2010 MSA Award

Cosponsor: *Mineralogical Society of America*

Disciplines: Environmental Geoscience; Geochemistry; Mineralogy/Crystallography

Advocates: Glenn Waychunas, Lawrence Berkeley National Laboratory, Berkeley, Calif.; Jill F. Banfield, Univ. of California, Berkeley, Calif.

Description: Nanoparticle formation, structure and properties; nanoparticle geochemistry, environmental chemistry, and reactivity; nanocomposite materials including carbonate skeletons; nanoclusters found in aqueous solutions; related simulations, spectroscopy; microbial biomineralization.

T103. Accessory Minerals as Monitors of Magmatic Processes: New Ideas, Applications, and Pitfalls

Cosponsors: *GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; Mineralogical Society of America*

Disciplines: Petrology, Igneous; Mineralogy/Crystallography; Volcanology

Advocates: Lily L. Claiborne, Vanderbilt Univ., Nashville, Tenn.; Calvin F. Miller, Vanderbilt Univ., Nashville, Tenn.; Jonathan S. Miller, San José State Univ., San José, Calif.

Description: This session focuses on the explosive growth in applications of accessory mineral studies to understanding evolution of magmatic environments. It will consider opportunities as well as problems and pitfalls presented by new methods.

T104. Garnet and Its Use in Unraveling Metamorphic and Tectonic Processes

Cosponsors: *GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Structural Geology and Tectonics Division; Mineralogical Society of America*

Disciplines: Geochemistry; Petrology, Metamorphic; Tectonics

Advocates: Ethan F. Baxter, Boston Univ., Boston, Mass.; Mark Caddick, ETH Zürich, Zurich, Switzerland; Jay J. Ague, Yale Univ., New Haven, Conn.

Description: Garnets uniquely preserve an integrated record of metamorphic and tectonic processes. This session will highlight innovations in geochronology, microanalysis, diffusion studies, thermodynamic

modeling, and experimentation that create unique opportunities to exploit the garnet record.

T105. Impact Cratering: From the Lab to the Field; from the Earth to the Planets

Cosponsors: *GSA Planetary Geology Division; GSA Geophysics Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Sedimentary Geology Division; GSA Structural Geology and Tectonics Division; GSA Quaternary Geology and Geomorphology Division; International Continental Scientific Drilling Program (ICDP); Geological Society of America Bulletin*

Disciplines: Planetary Geology; Petrology, Metamorphic; Mineralogy/Crystallography

Advocates: Christian Koeberl, Univ. of Vienna, Austria; Jared Morrow, San Diego State Univ., San Diego, Calif.

Description: This session welcomes contributions on any aspect of the study of terrestrial impact craters, from their formation to structure, from ejecta to shock deformation, from geological to biological effects, including comparative planetology, and recent controversies.

T106. Explosive Volcanism across the Solar System: Insights From Qualitative, Quantitative, and Geochemical Approaches

Cosponsors: *GSA Planetary Geology Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division*

Disciplines: Planetary Geology; Volcanology; Petrology, Igneous

Advocates: Nicholas P. Lang, Mercyhurst College, Erie, Pa.; James R. Zimbelman, Smithsonian Institution, National Air and Space Museum, Washington, D.C.

Description: This is a broad session meant to outline our current knowledge of explosive volcanism on any planetary body as gained through qualitative, quantitative, and geochemical approaches in order to highlight outstanding questions regarding this process.

T107. Field Geology on Other Planets: An Emerging Science

Cosponsors: *GSA Planetary Geology Division; GSA Quaternary Geology and Geomorphology Division*

Disciplines: Planetary Geology; Remote Sensing/ Geographic Info System; Stratigraphy

Advocates: Larry S. Crumpler, New Mexico Museum of Natural History & Science, Albuquerque, N.Mex.; W. Brent Garry, Smithsonian Institution, Washington, D.C.

Description: This session will report some of the accomplishments in the study of geologic relationships on other planets through human and robotic use of field geologic methods at outcrops on the surface and from near orbit.

T108. Planetary Exploration through Remote Compositional Analysis—The G.K. Gilbert Award Session

Cosponsor: *GSA Planetary Geology Division*

Disciplines: Planetary Geology; Remote Sensing/ Geographic Info System

Advocates: Jayne C. Aubele, New Mexico Museum of Natural History and Science, Albuquerque, N.Mex.; James W. Head, Brown Univ., Providence, R.I.

Description: This session on remote compositional analysis, including planetary surfaces, laboratory spectroscopy, and theoretical models, honors the winner of the Planetary Geology Division's G.K. Gilbert Award for Outstanding Achievement. The recipient will give a keynote talk.

T109. Online Citizen Science: Engaging the Public to Solve Real Science Challenges in Planetary Geology and Terrestrial Geoscience

Cosponsors: *GSA Planetary Geology Division; GSA Geoscience Education Division; GSA Geology and Society Division*

Disciplines: Planetary Geology; Geoscience Education; Geoscience Information/Communication

Advocates: Cassie Bowman, Raytheon SDSIO, Pasadena, Calif.; Jayne C. Aubele, New Mexico Museum of Natural History and Science, Albuquerque, N.Mex.; Eric J. Pyle, James Madison Univ., Harrisonburg, Va.

Description: Present projects that engage the public in planetary or terrestrial geoscience research by collecting, processing, or analyzing data in large datasets, including online databases or data collected at distributed sites and uploaded to central repositories.

T110. Mountain Formation and Landscape Evolution in the Solar System: Implications for the Origin of Life

Cosponsors: *GSA Quaternary Geology and Geomorphology Division; GSA Planetary Geology Division*

Disciplines: Planetary Geology; Tectonics

Advocates: Joseph Kula, Syracuse Univ., Syracuse, N.Y.; Suzanne L. Baldwin, Syracuse Univ., Syracuse, N.Y.

Description: Terrestrial mountain formation in the solar system is related to thermal decay, tectonics, and impact events. The processes and timescales of landscape evolution will be explored with implications for the origin of and search for life.

T111. Teaching Paleontology in the Twenty-First Century: Resources for Teaching Paleontology at the Undergraduate Level

Cosponsors: *Paleontological Society; Society of Vertebrate Paleontology; Paleontological Research Institution; On the Cutting Edge: Professional Development for Geoscience Faculty; GSA Geoscience Education Division; National Association of Geoscience Teachers; National Earth Science Teachers Association*

Disciplines: Paleontology, Paleoecology/Taphonomy; Paleontology, Diversity, Extinction, Origination; Paleontology, Phylogenetic/Morphological Patterns

Advocates: Margaret M. Jacobucci, Bowling Green State Univ., Bowling Green, Ohio; Rowan Lockwood, College of William and Mary, Williamsburg, Va.; Warren D. Allmon, Paleontological Research Institution, Ithaca, N.Y.; Bruce J. MacFadden, National Science Foundation, Arlington, Va.

Description: This session will explore topics related to teaching paleontology effectively at the undergraduate level, including course content and design, digital resources, approaches to teaching evolution, and exemplary classroom, laboratory, museum, and field activities.

T112. Paleontology, Paleobiogeography, and Stratigraphy of the Late Cretaceous North American Seas: A Tribute to Bill Cobban

Cosponsors: *GSA Sedimentary Geology Division; Paleontological Society; Society for Sedimentary Geology (SEPM)*

Disciplines: Paleontology, Biogeography/Biostratigraphy; Stratigraphy; Paleontology, Diversity, Extinction, Origination

Advocates: Richard A. MacKenzie, Univ. of Florida, Gainesville, Fla.; Corinne Myers, Univ. of Kansas, Lawrence, Kans.

Description: This session is dedicated to the extensive work of W.A. Cobban and encourages papers relating to the Cretaceous Seaways of North America. This includes, but is not limited to, paleontology, paleobiogeography, stratigraphy, and biostratigraphy.

T113. Geological and Paleobiological Collections: Best Practices for Preservation, Access, and Use in a Changing World

Cosponsors: *Paleontological Society; Society for the Preservation of Natural History Collections; Mineralogical Society of America; GSA Geoinformatics Division*

Disciplines: Paleontology, Biogeography/Biostratigraphy; Geoinformatics; Geoscience Information/Communication

Advocates: Ann Molineux, Univ. of Texas, Austin, Tex.; Tim White, Yale Univ., Newhaven, Conn.; Christopher Michael Holl, Princeton Univ., Princeton, N.J.

Description: Efficient access to well-archived geological specimens and effective ways to retrieve their related data are critical elements for research and education in the geosciences. We examine and share innovative methods to achieve these goals.

T114. Symbiosis as a Driver of Global Change in Ancient and Modern Earth Systems (Posters)

Cosponsors: *Geochemical Society; GSA Geomicrobiology & Geobiology Division; Paleontological Society*

Disciplines: Paleontology, Diversity, Extinction, Origination; Geomicrobiology; Geochemistry

Advocates: Laurie Anderson, Louisiana State Univ., Baton Rouge, La.; Annette Summers Engel, Louisiana State Univ., Baton Rouge, La.

Description: Symbiosis has profoundly impacted Earth's biosphere and geosphere. Contributions are welcome that deal with ancient to modern symbiosis in the context of biological, geological, and geochemical evolution, including chemosymbiosis and environmental genomics.

T115. The Precambrian-Cambrian Ecosphere

(R)evolution: Insights from Chinese Microcontinents

Cosponsors: *GSA Geobiology & Geomicrobiology Division; GSA Sedimentary Geology Division; Paleontological Society*

Disciplines: Paleontology, Diversity, Extinction, Origination; Paleoclimatology/Paleoceanography; Geochemistry

Advocates: Christoph E. Heubeck, Freie Universitaet Berlin, Berlin, Germany; Maoyan Zhu, Nanjing Institute of Geology and Paleontology CAS, Nanjing, China; Shaoyong Jiang, Nanjing Univ., Nanjing, China

Description: This interdisciplinary session will highlight recent stratigraphic, paleontological, and geochemical studies from the three Chinese cratons that significantly changed our understanding of causes and effects in ecosphere evolution during this dramatic period in Earth's history.

T116. Links between Mesozoic Climate and Biodiversity

Cosponsor: *Paleontological Society*

Disciplines: Paleontology, Diversity, Extinction, Origination; Paleoclimatology/Paleoceanography

Advocates: Gregory D. Price, Univ. of Plymouth, Plymouth, UK; Richard J. Twitchett, Univ. of Plymouth, Plymouth, UK; Peter J. Harries, Univ. of South Florida, Tampa, Fla.

Description: This session examines linkages between biotic crises within the Mesozoic and episodes of global warming and cooling and associated oceanographic changes, via biotic, geochemical and/or isotopic data.

T117. Lagerstätte through Time: An Examination of Exceptional Preservation Pathways from the Terminal Proterozoic through Today

Cosponsors: *Paleontological Society; GSA Geobiology & Geomicrobiology Division*

Disciplines: Paleontology, Paleoecology/Taphonomy; Paleontology, Diversity, Extinction, Origination

Advocates: James D. Schiffbauer, Virginia Polytechnic Institute and State Univ., Blacksburg, Va.; Marc Laflamme, Yale Univ., New Haven, Conn.

Description: "Lagerstätte through time" brings together current research on the varying modes of exceptional preservation from the Neoproterozoic through Cenozoic, in an effort to further our knowledge on paleoenvironmental, biogeochemical, and sedimentological aspects of fossil Lagerstätte.

T118. Filling the Hole: Sedimentary Geology and Paleontology of Caves and Karst

Cosponsors: *Paleontological Society; Karst Waters Institute; Society for Sedimentary Geology (SEPM); GSA Sedimentary Geology Division; GSA Archaeological Geology Division; GSA Quaternary Geology and Geomorphology Division; GSA Geobiology & Geomicrobiology Division*

Disciplines: Paleontology, Paleoecology/Taphonomy; Sediments, Clastic; Hydrogeology

Advocates: Roy Plotnick, Univ. of Illinois, Chicago, Ill.; Ira D. Sasowsky, Univ. of Akron, Akron, Ohio

Description: The spaces produced by karstification can protect portions of the surface fossil and stratigraphic record otherwise removed by subsequent erosion. This session will include talks on the sediments and fossils preserved in these environments.

T119. Holocene Paleoclimate Records from Western North America: Exploring Pacific Influences

Cosponsors: *GSA Quaternary Geology and Geomorphology Division; GSA Sedimentary Geology Division; GSA Limnogeology Division*

Disciplines: Paleoclimatology/Paleoceanography; Quaternary Geology; Limnogeology

Advocates: Lesleigh Anderson, USGS, Denver, Colo.; John A. Barron, USGS, Menlo Park, Calif.

Description: This session seeks presentations of multi-proxy marine and terrestrial paleoclimatic records from geological archives to explore climate links with past Pacific Ocean-atmosphere dynamics, including ENSO and the Pacific Decadal Oscillation.

T120. New Developments in Permian-Triassic Paleocyanography

Cosponsors: *GSA Sedimentary Geology Division; Society for Sedimentary Geology (SEPM)*

Disciplines: Paleoclimatology/Paleoceanography; Paleontology, Biogeography/Biostratigraphy; Geochemistry

Advocates: Thomas J. Algeo, Univ. of Cincinnati, Cincinnati, Ohio; Margaret Fraiser, Univ. of Wisconsin, Milwaukee, Wis.

Description: New developments in research on environmental changes within the Tethys and Panthalassic oceans during the Late Permian to Early Triassic and their link to the largest mass extinction event of the Phanerozoic Eon.



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T121. The Western Interior Seaway Revisited (Posters)

Cosponsors: *Paleontological Society; GSA Sedimentary Geology Division*

Disciplines: Paleoclimatology/Paleoceanography; Paleontology, Biogeography/Biostratigraphy; Structural Geology

Advocates: Dee A. Cooper, Univ. of Texas, Lumberton, Tex.; Roger W. Cooper, Lamar Univ., Beaumont, Tex.

Description: This session is intended as a continuation of “The Western Interior Seaway” session held at the 2008 GSA Annual Meeting. Ideally, previous presenters will be joined by others also working in any aspect of this important topic.

T122. Cenozoic Terrestrial Environmental Change in North America: From Paleosols to Paleobotany

Cosponsor: *GSA Geobiology & Geomicrobiology Division*

Disciplines: Paleoclimatology/Paleoceanography; Paleontology, Diversity, Extinction, Origination; Paleontology, Biogeography/Biostratigraphy

Advocates: Nathan D. Sheldon, Univ. of Michigan, Ann Arbor, Mich.; Selena Y. Smith, Univ. of Michigan, Ann Arbor, Mich.; Caroline A.E. Stromberg, Univ. of Washington, Seattle, Wash.

Description: This session will bring together a broad, interdisciplinary community of scientists interested in understanding Cenozoic environmental, biological, and paleoclimatic changes on land in North America as analogs for the impacts of future global climate change.

T123. Deciphering Paleozoic Paleoenvironmental Changes Using Stable and Radiogenic Isotope Proxies

Disciplines: Paleoclimatology/Paleoceanography; Geochemistry; Sediments, Carbonates

Advocates: Maya Elrick, Univ. of New Mexico, Albuquerque, N.Mex.; James R. Wheeler, Univ. of Birmingham, Birmingham, UK

Description: This interdisciplinary session will highlight new research using stable and radiogenic isotopes to understand Paleozoic climatic, oceanographic, biologic, and environmental changes.

T124. Proterozoic Crustal Evolution of Southern Laurentia: Tectonic Settings, Petrology, Geochemistry, and Geochronology

Cosponsors: *Precambrian [At Large]; GSA Geophysics Division; GSA Structural Geology and Tectonics Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; Mineralogical Society of America*

Disciplines: Precambrian Geology; Tectonics; Geochemistry

Advocates: Paul Mueller, Univ. of Florida, Gainesville, Fla.; J.L. Wooden, Stanford Univ., Stanford, Calif.; M.E. Bickford, Syracuse Univ., Syracuse, N.Y.

Description: This session will explore controversies regarding Proterozoic evolution of southern Laurentia. Topics include Paleoproterozoic arc-accretion versus

rift-related reactivation and assembly and the nature of ca. 1.45–1.0 Ga Mesoproterozoic activity, and questions will involve supercontinent assembly.

T125. Terrestrial Laser Scanning: Applications in Geology and Geomorphology

Cosponsors: *GSA Quaternary Geology and Geomorphology Division; GSA Engineering Geology Division*

Disciplines: Geomorphology; Engineering Geology; Remote Sensing/Geographic Info System

Advocates: Dennis Staley, USGS, Denver, Colo.; Thad.A. Wasklewicz, East Carolina Univ., Greenville, N.C.

Description: Terrestrial laser scanning permits the development and analysis of digital terrain data at unprecedented spatial and temporal resolutions. Contributions describing the applications of this technology in the study of geologic and geomorphic processes are encouraged.

T126. Exploring Spatial and Temporal Variability of Latest Pleistocene and Holocene Alpine Glacier Fluctuations

Cosponsor: *GSA Quaternary Geology and Geomorphology Division*

Disciplines: Quaternary Geology; Geomorphology; Paleoclimatology/Paleoceanography

Advocates: P. Thompson Davis, Bentley College, Waltham, Mass.; Shaun A. Marcott, Oregon State Univ., Corvallis, Ore.; Douglas H. Clark, Western Washington Univ., Bellingham, Wash.

Description: We solicit contributions about alpine glacier activity from new sites, new or refined methods to develop glacier chronologies, and/or the climatic events that were responsible for glacier advances over the past 13,000 calendar years.

T127. Timing of Pleistocene Glaciation in the North American Cordillera

Cosponsor: *GSA Quaternary Geology and Geomorphology Division*

Disciplines: Quaternary Geology; Geomorphology; Stratigraphy

Advocates: Brent C. Ward, Simon Fraser Univ., Burnaby, British Columbia; Jason P. Briner, Univ. at Buffalo, Buffalo, N.Y.; Duane G. Froese, Univ. of Alberta, Edmonton, Alberta

Description: The North American Cordillera supported numerous episodes of ice sheet and mountain glacier growth. This session will highlight new glacial chronologies that span the Pleistocene and innovative methods for improving chronologic and paleogeographic reconstructions.

T128. Geologic Records and Consequences of Subglacial Processes

Cosponsor: *GSA Quaternary Geology and Geomorphology Division*

Disciplines: Geomorphology; Quaternary Geology; Hydrogeology

Advocate: Scott Lundstrom, USGS, Denver, Colo.

Description: This session seeks contributions from the range of studies of glacial geologic records and modern processes that improve our understanding of subglacial processes, including field and laboratory characterization, experimental studies, and model development.

T129. OIS 4 and 3 Were Bigger Than You Think—Geomorphic Evidence from Glacial, Fluvial, Lacustrine, and Eolian Records

Cosponsor: *GSA Quaternary Geology and Geomorphology Division*

Disciplines: Geomorphology; Quaternary Geology; Paleoclimatology/Paleoceanography

Advocates: Tammy M. Rittenour, Utah State Univ., Logan, Utah; Glenn D. Thackray, Idaho State Univ., Pocatello, Idaho

Description: While global ice volume was greatest in OIS 2, geomorphic response during OIS 4 and OIS 3 was greater in many geomorphic systems. Session includes research on alluvial fans, loess, pluvial lakes, river terraces, and glacial chronologies.

T130. Dunes, Loess, and Dust: Paleo- and Modern Perspectives on Activation, Stratigraphy, and Processes

Cosponsor: *GSA Quaternary Geology and Geomorphology Division*

Disciplines: Geomorphology; Paleoclimatology/Paleoceanography; Quaternary Geology

Advocates: William C. Johnson, Univ. of Kansas, Lawrence, Kans.; Marith Reheis, USGS, Denver, Colo.; Daniel R. Muhs, USGS, Denver, Colo.

Description: With the advent of optically stimulated luminescence dating, sophisticated satellite sensors, new generations of AGCMs and other technological advances, eolian research is coming to the forefront as a major geomorphic and climatological area of inquiry.

T131. Cenozoic Landscape Evolution of the Rocky Mountain–Colorado Plateau Region: The Colorado River System from the Rockies through Grand Canyon to the Gulf of California

Cosponsor: *GSA Quaternary Geology and Geomorphology Division*

Disciplines: Tectonics; Geomorphology; Quaternary Geology

Advocates: Karl Karlstrom, Univ. of New Mexico, Albuquerque, N. Mex.; Andres Aslan, Mesa State College, Grand Junction, Co.; Kyle House, Univ. of Nevada, Reno, Nev.; R.A. Young, SUNY-Geneseo, N.Y.

Description: Papers are solicited on tectonic, geomorphic, and climatic controls on landscape evolution of the

Colorado Plateau–Rocky Mountain region, including all reaches of the Colorado River system, uplift studies, and modeling studies using this field laboratory.

T132. Fluvial Sediment Movement into the Twenty-First Century: What Have We Learned after 50+ Years of Soil Conservation Practices?

Cosponsor: *GSA Quaternary Geology and Geomorphology Division*

Disciplines: Geomorphology; Engineering Geology; Environmental Geoscience

Advocates: Faith A. Fitzpatrick, USGS, Middleton, Wis.; William H. Renwick, Miami Univ., Oxford, Ohio; James C. Knox, Univ. of Wisconsin, Madison, Wis.; Monica Rakovan, Miami Univ., Oxford, Ohio

Description: This session explores the linkages between fluvial sediment and channel processes and why we don't necessarily see an expected improvement in water quality and ecological integrity following widespread reductions in upland soil erosion.

T133. Pre-Industrial Fluvial Discontinuity

Cosponsor: *GSA Quaternary Geology and Geomorphology Division*

Disciplines: Geomorphology; Environmental Geoscience; Hydrogeology

Advocates: Denise Burchsted, Univ. of Connecticut, Storrs, Conn.; Ellen Wohl, Colorado State Univ., Fort Collins, Colo.

Description: Fluvial discontinuities are generated by bedrock variability, colluvium, glacial processes, woody debris, beavers, and others. They fragment river corridors and maintain connections. We will explore these with field, modeling, and conceptual talks, and restoration implications.

T134. Historical Range of Variability in Landscapes

Cosponsor: *GSA Quaternary Geology and Geomorphology Division*

Disciplines: Geomorphology; Quaternary Geology

Advocates: Ellen Wohl, Colorado State Univ., Fort Collins, Colo.; Sara L. Rathburn, Colorado State Univ., Fort Collins, Colo.

Description: This session will explore what geomorphologists and Quaternary geologists can contribute to restoration and management of landscapes based on their ability to infer the historical range of variability in specific processes and forms.

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T135. Hydrogeomorphic Processes in Hillslopes, Rivers, and Landscapes

Cosponsors: *GSA Quaternary Geology and Geomorphology Division; GSA Hydrogeology Division*

Disciplines: Geomorphology; Hydrogeology

Advocates: Anne J. Jefferson, Univ. of North Carolina, Charlotte, N.C.; Benjamin T. Crosby, Idaho State Univ., Pocatello, Idaho; Christopher Tennant, Idaho State Univ., Pocatello, Idaho

Description: This session focuses on linkages between geomorphic and hydrologic processes at varying temporal and spatial scales, highlighting connections between flow regimes, flowpaths, and earth-surface processes ranging from event initiation to landscape evolution.

T136. Soil Geomorphology: Deciphering Landscapes, Surficial Processes, and Quaternary History through Pedology-Based Geomorphic Study: In Honor of Pete Birkeland

Cosponsors: *GSA Quaternary Geology and Geomorphology Division; GSA Archaeological Geology Division*

Disciplines: Geomorphology; Quaternary Geology; Archaeological Geology

Advocates: Vance T. Holliday, Univ. of Arizona, Tucson, Ariz.; Martha C. Eppes, Univ. of North Carolina, Charlotte, N.C.; Leslie D. McFadden, Univ. of New Mexico, Albuquerque, N.Mex.; R.M. Burke, Humboldt State Univ., Arcata, Calif.

Description: To honor Pete Birkeland's profound research and teaching contributions to soil geomorphology, papers are encouraged that deal with active research and historical perspectives on spatial and/or temporal variability of soils, surfaces, and/or paleoenvironments.

T137. Developing Chronologies for Tectonic Geomorphic Studies

Cosponsors: *GSA Quaternary Geology and Geomorphology Division; GSA Structural Geology and Tectonics Division*

Disciplines: Geomorphology; Tectonics; Quaternary Geology

Advocates: Edward J. Rhodes, Univ. of California, Los Angeles, Calif.; A. Yin, Univ. of California, Los Angeles, Calif.; Lewis A. Owen, Univ. of Cincinnati, Cincinnati, Ohio

Description: We encourage presentations of chronological methods applied to inform studies within tectonic geomorphology, both novel applications and new developments, including assessment of rates, patterns, and feedbacks.

T138. Applications of Optically Stimulated Luminescence (OSL) Dating in Studies of the Mode, Timing, and Rate of Geomorphological Processes

Cosponsor: *GSA Quaternary Geology and Geomorphology Division*

Disciplines: Geomorphology; Quaternary Geology; Paleoclimatology/Paleoceanography

Advocates: Kenneth Lepper, North Dakota State Univ., Fargo, N.Dak.; Shannon A. Mahan, USGS, Denver, Colo.

Description: Presentations of results from studies utilizing optically stimulated luminescence (OSL) dating to constrain the timing and rates of geomorphological processes in all types of sediment transport and depositional systems are welcome.

T139. The Barrier Island System: Evolution in Response to Changing Sea Levels

Cosponsor: *GSA Quaternary Geology and Geomorphology Division*

Discipline: Marine/Coastal Science

Advocates: Christopher J. Hein, Boston Univ., Boston, Mass.; Zoe J. Hughes, Boston Univ., Boston, Mass.

Description: Evolution of barrier islands as integrated systems, from the foreshore to backbarrier marshes and tidal flats. Examples will derive from the geologic record, modern analogues, and forecasts for evolution during accelerated sea-level rise.

T140. Decadal Changes in Marine Sediments and Ecology: Quantifying with New and Legacy Datasets

Cosponsor: *GSA Quaternary Geology and Geomorphology Division*

Discipline: Marine/Coastal Science

Advocates: Chris Jenkins, Univ. of Colorado, Boulder, Colo.; Mark A. Kulp, Univ. of New Orleans, New Orleans, La.

Description: In the marine realm, substrates and ecosystems are strongly linked. This session focuses on the use of new and legacy sediment-ecologic datasets to document and quantify change in patterns of substrates and benthic ecologies.

T141. Ancient Floodplains and Rivers: Unraveling the Mysteries of Colorado's Conglomerates

Cosponsors: *Colorado Geological Survey; Colorado Scientific Society; GSA Quaternary Geology and Geomorphology Division; GSA Sedimentary Geology Division*

Disciplines: Sediments, Clastic; Stratigraphy; Paleoclimatology/Paleoceanography

Advocates: Matthew L. Morgan, Colorado Geological Survey, Denver, Colo.; Peter E. Barkmann, Colorado Geological Survey, Denver, Colo.

Description: The origins and ages of many conglomeratic units within Colorado are enigmatic. This session seeks to enlighten the fascinating topic by convening geologists with an emphasis on field-based experience to share data, observations, and insights.

T142. Stratigraphic, Structural, Geomorphic, and Tectonic Evolution of the Lake Mead Region, Southwestern United States, from the Oligocene to the Present

Cosponsor: *GSA Quaternary Geology and Geomorphology Division*

Disciplines: Stratigraphy; Structural Geology; Geomorphology

Advocates: Andrew D. Hanson, Univ. of Nevada, Las Vegas, Nev.; Amy Brock, Western Illinois Univ., Macomb, Ill.

Description: This session will focus on new studies related to the stratigraphic, structural, geomorphic, and tectonic evolution of the Lake Mead region from the Oligocene to recent times.

T143. Stratigraphic Standards: Where Have They Gone, What Should They Do, Where Should They Go?

Cosponsors: *GSA Sedimentary Geology Division; North American Commission on Stratigraphic Nomenclature (NACSN); International Subcommittee on Stratigraphic Classification (ISSC); Association of Earth Science Editors (AESE); Paleontological Society*

Disciplines: Stratigraphy; Paleontology, Biogeography/Biostratigraphy; History of Geology

Advocates: Arthur Donovan, BP, Houston, Tex.; Brian R. Pratt, Univ. of Saskatchewan, Saskatoon, Saskatchewan; L.E. Edwards, USGS, Reston, Va.

Description: Stratigraphic nomenclature is the fundamental way geoscientists communicate the spatial, temporal, and physical characteristics of the rocks we study. This session provides a forum to discuss topical issues associated with current and future stratigraphic standards.

T144. Coupling of Deformation and Chemical Processes in Earth

Cosponsors: *GSA Structural Geology and Tectonics Division; GSA Geophysics Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division*

Disciplines: Tectonics; Geochemistry; Petrology, Metamorphic

Advocates: Stacia Gordon, Univ. of California, Santa Barbara, Calif.; Ethan F. Baxter, Boston Univ., Boston, Mass.; Holger Stünitz, Universitetet i Tromsø, Tromsø, Norway; Donna L. Whitney, Univ. of Minnesota, Minneapolis, Minn.; Michael L. Williams, Univ. of Massachusetts, Amherst, Mass.; Eric Goergen, Brown Univ., Providence, R.I.; Mark Jessell, CNRS Université Paul-Sabatier IRD, Toulouse, France

Description: Deformation and chemical reactions are intimately coupled, and both processes drive Earth's geodynamic evolution through heat/mass transfer and strain localization. We encourage abstracts that describe the interaction between deformation and chemical processes throughout the lithosphere.

T145. Virtual Tectonics

Cosponsors: *GSA Structural Geology and Tectonics Division; GSA Geoscience Education Division; GSA Geoinformatics Division; GSA Geology and Society Division; National Association of Geoscience Teachers*

Disciplines: Structural Geology; Geoscience Education; Geoinformatics

Advocates: Declan G. De Paor, Old Dominion Univ., Norfolk, Va.; S.J. Whitmeyer, James Madison Univ., Harrisonburg, Va.

Description: Application of virtual reality to tectonics: virtual field trips, LiDAR, Gigapans, Google Earth, Second Life, virtual specimens, animations, simulations of tectonic and neotectonic processes, interactive maps, lunar and planetary VR, and the geology of exoplanets.

T146. Applications of Structural Geology in Meeting the Natural Resource and Energy Needs of Society: Challenges and Innovations for the Twenty-First Century

Cosponsors: *GSA Structural Geology and Tectonics Division; GSA Geophysics Division*

Disciplines: Structural Geology; Economic Geology

Advocates: Bob Krantz, ConocoPhillips, Houston, Tex.; Christopher J. Potter, USGS, Denver, Colo.; Rasoul Sorkhabi, Energy & Geoscience Institute, Salt Lake City, Utah; Byron R. Berger, USGS, Denver, Colo.

Description: Modern structural geology methods address subsurface geometry, kinematics, permeability, fluid flow, and geo-mechanics to address critical issues regarding the occurrence, availability, economics, and long-term impacts of the production of energy and mineral resources.

T147. Where Does Earthquake Physics Meet Earthquake Geology?

Cosponsors: *GSA Structural Geology and Tectonics Division; GSA Geophysics Division*

Disciplines: Structural Geology; Geophysics/Tectonophysics/Seismology; Tectonics

Advocates: Christie D. Rowe, Univ. of California, Santa Cruz, Calif.; Heather M. Savage, Univ. of California, Santa Cruz, Calif.; Jean-Philippe Avouac, California Institute of Technology, Pasadena, Calif.; W. Ashley Griffith, Univ. of Akron, Akron, Ohio; Zoe K. Shipton, Univ. of Glasgow, Glasgow, UK

Description: Seismology, rock mechanics, field geology, remote sensing, geodesy, geomorphology, and neotectonics all provide insights into earthquake physics. Understanding is advanced by integration and comparison of observations with theoretical predictions and numerical simulation of seismic rupture.

T148. Orogeny: Relating Rigid Plates to Diffuse Lithospheric Deformation

Cosponsors: *GSA Structural Geology and Tectonics Division; GSA Geophysics Division*

Disciplines: Structural Geology; Tectonics; Geophysics/Tectonophysics/Seismology

Advocates: Craig H. Jones, Univ. of Colorado, Boulder, Colo.; David M. Whipp, Dalhousie Univ., Halifax, Nova Scotia; Basil Tikoff, Univ. of Wisconsin, Madison, Wis.; Gregory A. Houseman, Univ. of Leeds, Leeds, UK; Ian W.D. Dalziel, Univ. of Texas, Austin, Tex.

Description: This session addresses progress in understanding orogenesis in the wake of plate tectonics through advances in field observations, geochronology, geophysics, and geodynamics, focusing on connections between plate tectonics and diffuse deformation from mantle to surface.

T149. Successes, Failures, and the Future of Area-Volume Balancing and Structural Restoration: A Critical Evaluation Honoring the Centennial of R.T. Chamberlin's Groundbreaking Paper on Depth-to-Detachment Calculation

Cosponsor: *GSA Structural Geology and Tectonics Division*

Disciplines: Structural Geology; Tectonics; Geophysics/Tectonophysics/Seismology

Advocates: Richard H. Groshong, Jr., Univ. of Alabama (emeritus), Tuscaloosa, Ala.; Bob Ratliff, Halliburton/Geo-Logic Systems, Boulder, Colo.; Alan D. Gibbs, Midland Valley Exploration, Glasgow, UK

Description: Area balance and kinematic restoration techniques are established methods for structural interpretation, prediction, and validation, yet remain controversial and underutilized. Why? This session will address the problems, pitfalls, controversies, current applications, and future directions.

T150. New Insights on the Tectonic, Paleobiogeographic, and Metallogenic Evolution of Terranes in the North American Cordillera

Cosponsor: *GSA Structural Geology and Tectonics Division*

Disciplines: Tectonics; Paleontology, Biogeography/Biostratigraphy; Economic Geology

Advocates: Luke Beranek, Geological Survey of Canada, Vancouver, British Columbia; Andrew H. Caruthers, The Univ. of British Columbia, Vancouver, British Columbia; Tyler William Ruks, Univ. of British Columbia, Vancouver, British Columbia

Description: This session focuses on recent advancements and future challenges on the origin and evolution of terranes in the North American Cordillera.

T151. Distributed Continental Shear: Styles, Rates, and Variations in the Characteristics of Dextral Deformation along the Walker Lane and Eastern California Shear Zone

Cosponsors: *GSA Structural Geology and Tectonics Division; GSA Geophysics Division; GSA Quaternary Geology and Geomorphology Division*

Disciplines: Tectonics; Neotectonics/Paleoseismology; Geophysics/Tectonophysics/Seismology

Advocates: Ryan D. Gold, USGS, Denver, Colo.; Richard W. Briggs, USGS, Denver, Colo.

Description: This session explores geologic, geodetic, and geophysical constraints on the spatial and temporal characteristics of net dextral shear east of the Sierra Nevada, primarily along the Walker Lane and Eastern California Shear Zone.

T152. Magmatic and Tectonic History of Southwestern Alaska

Cosponsors: *GSA Structural Geology and Tectonics Division; GSA Geophysics Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division*

Disciplines: Tectonics; Volcanology; Stratigraphy

Advocates: Anjana K. Shah, USGS, Denver, Colo.; Dwight C. Bradley, USGS, Anchorage, Alaska; Marti L. Miller, USGS, Anchorage, Alaska

Description: This session highlights geologic and geophysical studies bearing on the evolution of southwestern Alaska. This region of accreted terranes, basins, magmatic belts, and associated ore deposits remains among the least understood places in the United States.

T153. Initiation and Termination of Subduction: Rock Record, Geodynamic Models, Modern Plate Boundaries

Cosponsors: *GSA International Section; GSA Structural Geology and Tectonics Division; GSA Geophysics Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division*

Disciplines: Tectonics; Structural Geology; Geophysics/Tectonophysics/Seismology

Advocates: John Wakabayashi, California State Univ., Fresno, Calif.; John W. Shervais, Utah State Univ., Logan, Utah; Yildirim Dilek, Miami Univ., Oxford, Ohio

Description: We encourage researchers of orogenic belts and modern plate margins, as well as geodynamic modelers, to present research bearing on processes of subduction initiation and termination.

T154. Tortoise to Hare Tectonics: Steady and Transient Deformation

Cosponsors: *GSA Structural Geology and Tectonics Division; GSA Geophysics Division*

Disciplines: Tectonics; Structural Geology; Geophysics/Tectonophysics/Seismology

Advocates: Jason B. Barnes, Univ. of North Carolina, Chapel Hill, N.C.; Rebecca Bendick, Univ. of Montana, Missoula, Mont.; Rebecca Flowers, Univ. of Colorado, Boulder, Colo.; Eric Hetland, Univ. of Michigan, Ann Arbor, Mich.; Yvette D. Kuiper, Boston College, Chestnut Hill, Mass.

Description: This session will explore new constraints on deformation rates (steady or transient) and timescales (short- or long-term) using a variety of approaches in a range of tectonic settings.

T155. Cryptic Uplift of the Interior of the U.S. Cordilleran Orogen

Cosponsors: *GSA Structural Geology and Tectonics Division; GSA Geophysics Division; GSA Quaternary Geology and Geomorphology Division*

Disciplines: Tectonics; Geophysics/Tectonophysics/Seismology; Structural Geology

Advocates: Rebecca Flowers, Univ. of Colorado, Boulder, Colo.; Craig H. Jones, Univ. of Colorado, Boulder, Colo.; Ian M. Miller, Denver Museum of Nature & Science, Denver, Colo.; Katharine Huntington, Univ. of Washington, Seattle, Wash.

Description: The history and causes of the higher than 1.5 km elevation of Mesozoic marine strata from the Colorado Plateau through the Rockies and Rio Grande Rift to the High Plains will be the focus of this session.

T156. Controls and Consequences of Continental Rifting: From Heat Flow, Stress, and Strain to Magmatism, Landscape-Basin Evolution, and Development of Natural Resources

Cosponsors: *GSA Structural Geology and Tectonics Division; GSA Geophysics Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Hydrogeology Division; GSA Sedimentary Geology Division; GSA Quaternary Geology and Geomorphology Division; GSA International Section*

Disciplines: Tectonics; Geophysics/Tectonophysics/Seismology; Volcanology

Advocates: Yildirim Dilek, Miami Univ., Oxford, Ohio; Benjamin J. Drenth, USGS, Denver, Colo.; Ren A. Thompson, USGS, Denver, Colo.; Harald Fernes, Univ. of Bergen, Bergen, Norway; Jonathan Saul Caine, USGS, Denver, Colo.

Description: Broad-ranging, multidisciplinary studies are sought to discuss continental rift-related topics such as lithospheric breakup, mantle response/melt evolution, magma localization, influence of preexisting structures, stress fields/kinematics, surface uplift/sedimentation, basin segmentation/evolution, natural hazards/resources, and climate change.

GSA Divisions and Associated Societies Bring it All Together

GSA's Annual Meeting brings our scientific community together around today's most current and cutting-edge research. This community consists not only of GSA members and members of one or more of GSA's 17 specialty divisions, but also members of GSA's Associated Societies and scientists from many other organizations. GSA's Annual Meeting is also the place where other organizations often hold their annual business meetings and events. We invite you to submit your research, invite other organizations along, and minimize travel and meeting time for your members who may already be planning to come to Denver this year.

For a listing of GSA's Specialty Divisions and Associated Societies, go to www.geosociety.org/divisions/.



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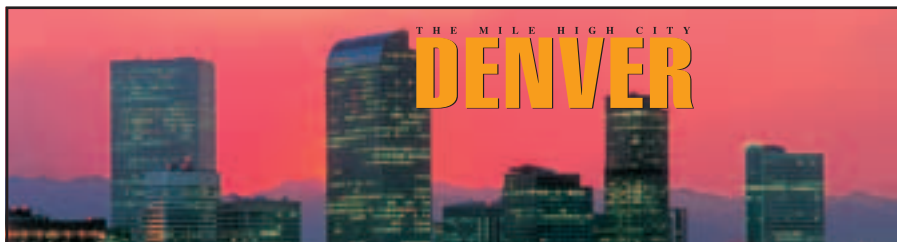


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Travel to the United States

Most travelers to the United States must hold a valid visa and a passport that is valid for six months longer than the intended visit. Please go to www.geosociety.org/meetings/2010/ to determine if you require a travel visa to attend the Annual Meeting.

If you do require a visa, please understand that the visa application process may take several months. An interview appointment is required for a visa application at all embassies and consulates. The wait time for this appointment varies, but may be as long as three months, with processing taking an additional month or more. The wait time for visa applications is available on the U.S. State Department's Web site, http://travel.state.gov/visa/temp/wait/tempvisitors_wait.php. As soon as you have decided to attend the meeting, you should begin the process of applying for a visa.

The United States has made some important changes to the US-VISIT program, which was instituted in 2004. The program now requires most foreign visitors to have fingerprints made of all their fingers and a digital photograph taken to verify their identity at the consulates as well as the port-of-entry. Most Canadians are currently exempt from US-VISIT. A departure confirmation program, as part of US-VISIT, is also now currently in place. This program applies to all visitors, including those from visa waiver countries.

ALSO NEW: Beginning in January 2010, visitors from countries participating in the Visa Waiver Program must register in the Electronic System for Travel Authorization (ESTA) before entering the country. You can check the U.S. State Department's Web site at http://travel.state.gov/visa/temp/without/without_1990.html#countries for more information.

 www.geosociety.org/meetings/2010/

Denver skyline at sunset. Photo used with permission from the Denver Metro Convention & Visitors Bureau.



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*Are you a current
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Online applications will be available during the registration period, which begins in early June. Check www.geosociety.org/meetings/2010/ for eligibility requirements.

Notification of grant status will be made by e-mail. Those receiving grants must pick up their checks in person (with photo ID) on site in Denver.

International Section Travel Grants

Application deadline: 1 August 2010

GSA's International Section is offering travel grants to assist the participation of international scientists and students in the 2010 GSA Annual Meeting in Denver, Colorado, USA, as well as at the Tectonic Crossroads meeting of the GSA International Section in Ankara, Turkey (see www.geosociety.org/meetings/2010turkey/). Funds are limited; grants will not cover the full cost of attending the meeting but are only intended to help defray the combined cost of registration, housing, and travel. To apply, please go the GSA International Section's Web page, www.geosociety.org/sectdiv/International/travelGrants.htm.

Questions?

Contact John Wakabayashi at jwakabayashi@csufresno.edu.

▶▶ Registration & Lodging ◀◀

REGISTRATION

Early registration deadline: 27 September

Cancellation deadline: 4 October

Online registration opens in early June; look for more information in the June *GSA Today* and on the Web at www.geosociety.org/meetings/2010/.

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

	Early Registration June–27 Sept.		Standard/On-site after 27 Sept.	
	Full Mtg.	One day	Full Mtg.	One day
Prof. Member	\$325	\$210	\$405	\$240
Prof. Member 70+	\$255	\$155	\$340	\$175
Prof. Nonmember	\$425	\$280	\$505	\$310
Student Member	\$105	\$70	\$140	\$80
Student Nonmember	\$145	\$90	\$180	\$100
High-School Student	\$40	n/a	\$40	n/a
K–12 Professional	\$50	n/a	\$60	n/a
Field Trip/Short Course only [†]	\$40	n/a	\$40	n/a
Guest or Spouse [‡]	\$85	n/a	\$90	n/a
Low Income Country [§]	50%	n/a	50%	n/a

GSA will provide each meeting registrant[†] with an electronic copy of the *Abstracts with Programs*, which includes the 2010 Section Meeting abstracts as well. The *Abstracts with Programs* book will be available for onsite pick-up only.

[†]Field trip or short course only & guest or spouse registrants excluded.

[§]Participants from countries classified as “low or low-middle income” by the World Bank need only pay 50% of their registration category fee for full-meeting or one-day registration.



2009 GSA Annual Meeting advance registration desk.

LODGING

The 2010 Denver Annual Meeting headquarters hotel is the Hyatt Regency Denver, which is located directly across the street from the Colorado Convention Center. The co-headquarters hotel is the Grand Hyatt Denver, located three blocks from the Colorado Convention Center. Most activities will take place at the Colorado Convention Center and the Hyatt Regency. Denver offers many affordable hotels located within a six-block area of the convention center, and within walking distance of the 16th Street pedestrian mall. GSA has booked rooms at nine hotels, offering special convention rates of between US\$129 and US\$189 per night (single or double occupancy). Housing registration will open in June; you will be able to find additional housing information in the June *GSA Today* and on the GSA Annual Meeting Web site, www.geosociety.org/meetings/2010/. GSA appreciates everyone’s support in booking within the official GSA hotel block!

HOUSING ALERT!

Please note: GSA has selected **Visit Denver** as our official housing bureau. Housing bookings through Visit Denver will not begin until the first part of June. Neither GSA nor Visit Denver will telephone or send faxes offering “special” Denver hotel reservations. You will be able to make reservations through the GSA Annual Meeting Web site or by faxing/mailing the official GSA housing form to Visit Denver. In the event that you have problems with your reservation or accommodations, GSA can only assist in reconciling those issues if the reservation was booked through the Visit Denver. If you have questions about an unauthorized solicitation, the online system, or about housing in general, please contact Becky Sundeen, bsundeen@geosociety.org.

Apply to Host a Speaker!

Ocean Leadership Distinguished Lecturer Series

Apply now to host an Ocean Leadership Distinguished Lecturer at your institution during the 2010-2011 academic year. The Consortium for Ocean Leadership's U.S. Science Support Program offers the Distinguished Lecturer Series to bring the exciting scientific results and discoveries of the Integrated Ocean Drilling Program to students at the undergraduate and graduate levels and to the geosciences community in general. Applications are due June 1, 2010 and are available by applying online at www.oceanleadership.org/DLS.

Diatom Oozes: Archives of Past Climate Change and Habitats for Microbial Life

Ivano Aiello, Moss Landing Marine Laboratories

The Chicxulub Structure: What an Impact!

Gail Christeson, University of Texas at Austin

Life in the Vast Subseafloor Basaltic Aquifer

James Cowen, University of Hawaii at Manoa

The Ice Age—Climate Experiment

Timothy Herbert, Brown University

In Situ Stress and Pore Pressure from Riser Drilling: NanTroSEIZE Stage 2

Demian Saffer, Pennsylvania State University

Changing Perspectives of Hotspots, Seamount Chains, and Ocean Plateaus

William Sager, Texas A&M University



ABOUT PEOPLE

GSA Fellow **Michael Welland** has been awarded the 2010 John Burroughs Medal in recognition of his 2009 natural history publication, *Sand*.

GSA Senior Fellow **Frank M. Richter** was awarded the 2009 AGU Harry H. Hess Medal, which recognizes "outstanding achievements in research of the constitution and evolution of Earth and sister planets."

GSA Member **William E. Dietrich** received the 2009 AGU Robert E. Horton Medal for his "outstanding contributions to the geophysical aspects of hydrology."

GSA *Bulletin* science editor and GSA Member **Christian Koeberl** has been appointed as new director general of the Natural History Museum in Vienna by the Austrian Minister of Culture and Education. Koeberl is head of the Department of Lithospheric Research at the University of Vienna.

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NEW Division, NEW Award!

MGPV Division Distinguished Geologic Career Award

Nominations deadline: 1 May 2010

The Division of Mineralogy, Geochemistry, Petrology, and Volcanology (MGPV; est. Oct. 2009) announces this award recognizing an individual who, throughout his or her career, has made distinguished contributions in one or more of the following fields of research: mineralogy, geochemistry, petrology, and volcanology, with an emphasis on multidisciplinary, field-based contributions. A single award will be given first in 2010 and annually thereafter. Nominees need not be citizens or residents of the United States, and GSA membership is not required.

Nomination Procedure

Nominations will be generated from the MGPV Division membership at large, and should consist of

1. A one- to two-page letter (that includes the name and address of the nominator) summarizing the nominee's most important accomplishments in geologic approaches to mineralogy, geochemistry, petrology, and/or volcanology. Special attention should be paid to describing how the nominee's published work demonstrates field-based multidisciplinary geologic accomplishments of a groundbreaking nature;
2. The nominee's curriculum vitae; and
3. A list of four other MGPV Division members who have agreed to support the nomination.

Send nominations to the MGPV Division secretary-treasurer, J. Alex Speer, at j_a_speer@minsocam.org.

Nominations are valid for three years; the dossiers of nominees who did not receive the award in any given year will be retained and considered for two succeeding years. Updated information for carry-over candidates may be sent to the Division secretary-treasurer during the call for nominations. Each year, a new award committee of six persons will be selected by the six-member management board, and the award committee will elect the honoree in a two-stage board vote.

This award, consisting of a plaque and US\$1,000, will be presented at the MGPV Division reception at the 2010 GSA Annual Meeting, with a brief citation from the nominator, followed by a brief acceptance speech by the awardee.

The Kerry Kelts Student Research Award of the Limnogeology Division

Application deadline: 2 August 2010

The application process for the GSA Limnogeology Division's Kerry Kelts Research Award, named in honor of Kerry Kelts, a visionary limnogeologist and inspiring teacher, is now open.

For 2010, one award of US\$1,000 will be offered in recognition of exceptional undergraduate or graduate student research related to limnogeology, limnology, or paleolimnology. Application for this award consists of a summary of the proposed research, its significance, and how the award will be used (five-page max.). Please send your summary in PDF format, including your name as part of the PDF file name, along with a short (two-page max.) curriculum vitae, to the Limnogeology Division chair, Michael Rosen, mrosen@usgs.gov.

The recipient will be announced at the Limnogeology Division Business Meeting and Reception at the 2010 GSA Annual Meeting in Denver, Colorado, USA.

GSA hopes to increase the number of awards in the future. If you are interested in supporting this program, please send your donations, designated for the Kerry Kelts Research Awards of the Limnogeology Division, to GSA, P.O. Box 9140, Boulder, CO 80301-9140, USA.

History of Geology Student Award

Applications due 3 May 2010

GSA's History of Geology Division is offering an award for proposals for a student paper to be presented 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.

This award, established in 2004, is made possible by a bequest from the estate of Mary C. Rabbitt. Consideration will be given to both undergraduate and graduate students who are in good standing at the time of application; the presentation at the GSA Annual Meeting may take place after graduation. Faculty advisor(s) may be listed as second author(s) but not as the lead author of the paper, and while both oral and poster presentations are acceptable, oral presentations are preferred.

Impact the Future of Geoscience— Serve on a GSA Committee!

2011–2012 COMMITTEE VACANCIES

Deadline to apply or submit nominations: 15 July 2010

GSA invites you to volunteer or nominate one of your fellow GSA Members to serve on Society committees or as a GSA representative to other organizations. Students and younger members are especially encouraged to become involved in Society activities both as committee volunteers and as nominators.

If you volunteer or make recommendations, please give serious consideration to the specified qualifications for serving on a particular committee, as outlined in this article, and be sure that your candidates are GSA members or Fellows.

Learn more about each committee and access the nomination form at www.geosociety.org/aboutus/committees/. You can also download the form and send a hardcopy nomination to Pamela Fistell, GSA, P.O. Box 9140, Boulder, CO 80301-9140, USA; fax: +1-303-357-1074; phone +1-303-357-1044 or +1-800-472-1988, ext. 1044; pfistell@geosociety.org. *Please use one form per candidate.*

Nominations received at GSA headquarters by **15 July 2010** on the official one-page or online form will be forwarded to the Committee on Nominations. The committee will present at least two nominations for each open position to the GSA Council at its fall meeting. Appointees will then be contacted and asked to serve, thus completing the process of bringing new expertise into Society affairs. **Terms begin 1 July 2011** (unless otherwise indicated).

COMMITTEES REQUIRING VOLUNTEERS/NOMINEES

Academic and Applied Geoscience Relations (AM, T/E): Strengthens and expands relationships between GSA members in the academic and applied geosciences. Proactively coordinates the Society's effort to facilitate greater cooperation between academia, industry, and government geoscientists.

Qualifications: Must be a member of academia, industry, or government who is committed to developing better integration of applied and academic science in our meetings, publications, short courses, field trips, and education and outreach programs; must also be a GSA Division member. **Vacancy/term:** One member-at-large/three years.

Annual Program (AM, B/E): Develops a long-range plan for increasing the quality of the annual meeting and other Society-sponsored meetings in terms of science, education, and outreach. Evaluates the technical and scientific programs of the annual meeting. **Qualifications:** Broad familiarity with different disciplines, previous program experience, or active involvement in applying geologic knowledge to benefit society and raising awareness of critical issues. **Vacancies/terms:** One student member/two years; one member-at-large/four years.

Arthur L. Day Medal Award (T/E): Selects candidates for the Arthur L. Day Medal Award. **Qualifications:** Knowledge of those who have made "distinct contributions to geologic knowledge through the application of physics and chemistry to the solution of geologic problems." **Vacancies/terms:** Two members-at-large/three years.

Diversity in the Geosciences (AM, T/E): Provides advice and support to GSA Council for undertaking activities and initiating programs that will raise opportunities and awareness in the geoscience community of the positive role that people of ethnic minority, women, and persons with disabilities play within the geosciences. Stimulates recruitment and promotes positive career development of minorities and women in the geoscience professions. **Qualifications:** Familiarity with the employment issues of minorities and women; expertise and leadership experience in such areas as human resources and education. **Vacancies/terms:** Two members-at-large/three years; one Councilor/three years.

Education (AM, B/E, T/E): Works with other members representing a wide range of education sectors in the development of informal, pre-college (K–12), undergraduate, and graduate earth-science education and outreach objectives and initiatives. **Qualifications:** Ability to work with other interested scientific organizations and science teachers' groups. **Vacancies/terms:** One student member/two years; one 4-yr faculty rep./four years; one member-at-large/four years.

Geology and Public Policy (AM, B/E, T/E): Provides advice on public policy matters to Council and GSA leadership; monitors and assesses international, national, and regional science policy; formulates and recommends position statements, and sponsors topical white papers; and encourages active engagement of GSA members in geoscience policy. **Qualifications:** Experience with public-policy issues involving the science of geology; ability to develop, disseminate, and translate information from the geologic sciences into useful forms for the general public and for GSA members; familiarity with appropriate techniques for the dissemination of information. **Vacancies/terms:** Two members-at-large/three years.

Joint Technical Program (T/E): Assists in finalizing the technical program of the Annual Meeting; reviews abstracts or provides names of reviewers to evaluate abstracts; participates in Web-based selection and scheduling of abstracts; participates in topical session proposal review. **Qualifications:** Must be familiar with computers and the Web, be a specialist in the specified fields, and be available in

mid-late July for the organization of the electronic technical program. **Vacancy/term:** One marine/coastal geology representative/three years, beginning 1 Jan. 2011.

Membership (B/E): Contributes to the growth of GSA membership and attends to members' changing needs. Focuses on attracting and retaining students, professionals working in industry, and those studying and working outside the United States. Reviews and makes recommendations for Fellowship to Council. **Qualifications:** Experience in benefit, recruitment, and retention programs. **Vacancies/terms:** One student/three years; one member-at-large from academia/three years; one member-at-large from industry/three years.

Nominations (B/E, T/E): Recommends nominees to GSA Council for the positions of GSA Officers and Councilors, committee members, and Society representatives to other permanent groups. **Qualifications:** Familiarity with a broad range of well-known and highly respected geoscientists. **Vacancy/term:** One member-at-large/three years.

Penrose Conferences and Field Forums (T/E): Reviews and approves Penrose Conference proposals and recommends and implements guidelines for the success of the conferences. **Qualifications:** Past convener of a Penrose Conference or a Field Forum. **Vacancy/term:** One member-at-large/three years.

Penrose Medal Award (T/E): Selects candidates for the Penrose Medal. Emphasis is placed on "eminent research in pure geology, which marks a major advance in the science." **Qualifications:** Familiarity with outstanding achievers in the geosciences who are worthy of consideration for the honor. **Vacancies/terms:** Two-members-at large/three years.

Professional Development (T/E): Directs, advises, and monitors GSA's professional development program; reviews and approves proposals; recommends and implements guideline changes; and monitors the scientific quality of courses offered. **Qualifications:** Familiarity with professional development programs or adult education teaching experience. **Vacancies/terms:** Two-members at large/three years.

Publications (AM, B/E, T/E): Nominates candidates for editor positions, reviews the quality and health of Society publications, and explores the initiation of new ventures, including electronic publishing. **Qualifications:** Extensive publications experience. **Vacancy/term:** One member-at-large/four years.

Public Service Award (T/E): Generates, receives, and evaluates candidates for the GSA Public Service Award and the AGI Outstanding Contribution to the Public Understanding of the Geosciences Award. The award will be given in recognition of outstanding individual contributions to either public awareness of the earth sciences or the scientific resolution of

earth-science problems of significant societal concern. A crucial factor is to recognize an individual who highlights distinction between knowledge and understanding. **Qualifications:** Knowledge of those whose contributions and accomplishments have enhanced the public's understanding of earth science. **Vacancy/term:** One member at large/three years.

Research Grants (B/E): Evaluates student research grant applications and selects grant recipients. **Qualifications:** Should have experience in directing research projects and in evaluating research grant applications. An extensive time commitment is required during the application review period (15 Feb.–15 Apr.). **Vacancies/terms:** Eleven members-at-large/three years.

Young Scientist Award (Donath Medal) (T/E): Committee members investigate the achievements of young scientists who should be considered for this award and make recommendations to Council. **Qualifications:** Should have knowledge of young scientists with "outstanding achievement(s) in contributing to geologic knowledge through original research which marks a major advance in the earth sciences." **Vacancies/terms:** One member-at-large/three years; one Councilor or former Councilor/three years.

GSA REPRESENTATIVES TO OTHER ORGANIZATIONS

GSA Conferee to the AAPG Publication Pipeline Committee (B/E, T/E): Provide the best advice in assisting the committee in their efforts to improve the task process and to spread the word of their activities to retired or other GSA members who wish to dispose of books for donation to overseas libraries. **Vacancy/term:** One member/three years.

North American Commission on Stratigraphic Nomenclature (NACSN) (AM, possibly B/E): Develops statements of stratigraphic principles, recommends procedures applicable to classification and nomenclature of stratigraphic and related units, reviews problems in classifying and naming Stratigraphic and related units, and formulates expressions of judgment on these matters. **Vacancy/term:** One member/three years, beginning Nov. 2011.

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AM—Meets at the Annual Meeting • B/E—Meets in Boulder or elsewhere • T/E—Communicates by phone or electronically



Donna L. Russell, Director of Operations

Limnogeology Division Establishes New Lifetime Achievement Award—The Israel C. Russell Award for Limnogeology



Israel C. Russell, circa 1900. Public domain image from <http://upload.wikimedia.org/wikipedia/commons/e/e1/>.

This new award from GSA's Limnogeology Division, the Israel C. Russell Award recognizes major achievements in limnogeology through research, teaching, and service. This award is now the highest honor given by the Division.

The award's namesake, I.C. Russell (1852–1906), was a pioneer in limnogeology and lake studies in general, working for both the U.S. Geological Survey and the University of Michigan in the late nineteenth and early twentieth century. His best-known lake work was in Utah and Nevada, outlining the Quaternary history of lakes and other features along the 40th parallel. While at the University of Michigan, Russell wrote a book for students, *Lakes of North America* (published in 1895), based on his earlier studies.

Russell's life work exemplifies excellence and achievement in limnogeology, which makes him the ideal inspiration for this award.

The award will initially consist of a certificate and a medal. But once sufficient monies are established in the "Israel C. Russell Award for Limnogeology Endowment Fund" (administered by the GSA Foundation), this honor will also include a cash award.

The Foundation encourages generous donations in order to quickly build funds for the monetary award. Contributions can be made at any time; just go to www.gsafweb.org and select the I.C. Russell Award from the drop-down menu, or designate the amount you wish to contribute in the comment section. Members of the Limnogeology Division are particularly encouraged to contribute. We believe this honor is one of the most significant in limnogeology, and your donations will enable a suitable reward.

You may also send your contributions in support of the Israel C. Russell Award for Limnogeology directly to the GSA Foundation by using the coupon below.

Michael R. Rosen, Chair, Limnogeology Division

New Structural Geology and Tectonics Division Student Fund

As we celebrate the 30th anniversary of the SG&T Division, the board is very excited to announce the inauguration of the *Structural Geology and Tectonics Division Student Fund*. The fund will be used to expand the Division's support of student research and travel to conferences, field trips, and short courses. Students represent the future of this Division, and the board considers the support of students who are interested in structural geology and tectonics to be among our highest priorities. Donations can be made at www.gsafweb.org.

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New GSA Foundation Fund: Stephen E. Laubach Structural Diagenesis Research Award Fund

This new fund from the GSA Foundation promotes research that combines structural geology and diagenesis with curriculum development in structural diagenesis. Multidisciplinary approaches often reveal new insights to long-standing problems and expose productive avenues for inquiry. To promote the cross-disciplinary emphasis of this annual award, GSA's Sedimentary Geology and Structural Geology and Tectonics Divisions will jointly select the recipient.

The award will be announced during the 2010 Denver GSA Annual Meeting. Graduate students, postgraduate, and faculty-level researchers are eligible.

For additional information and instructions for submitting an application, go to <http://rock.geosociety.org/sgt/laubach.htm>.

In Memoriam



GSA regrettably reports the deaths of the following members. Notifications were received between 1 December 2009 and 31 January 2010.

Zalman S. Altschuler
Rockville, Maryland, USA
notified 21 December 2009

David W. Baker
Monarch, Montana, USA
28 December 2009

Charles A. Baskerville
Bronx, New York, USA
18 September 2009

Luther W. Bridges
Aurora, Colorado, USA
1 October 2009

William Hayes Chilner III
El Cajon, California, USA
notified 17 December 2009

Richard P.K. Clark
Penrith, Cumbria, UK
notified 11 January 2010

Jack O. Colle
Houston, Texas, USA
notified 17 December 2009

Arthur R. Dahl
Arvada, Colorado, USA
30 May 2009

Harold D. Fox
East Orleans, Massachusetts, USA
9 July 2009

Howard L. Garrett
Golden, Colorado, USA
notified 16 December 2009

Carlyle Gray
Cloverdale, California, USA
14 August 2009

Norman N. Greenman
Manhattan Beach, California, USA
31 December 2009

C. Edgar Hannum
Ardmore, Oklahoma, USA
notified 22 December 2009

Chester O. Johnson
Saint Peter, Minnesota, USA
8 December 2009

Richard H. Johnston
Saint Simons Island, Georgia, USA
23 December 2009

Robert L. Laney
Salem, Oregon, USA
27 October 2009

Marvin D. Mangus
Anchorage, Alaska, USA
notified 23 December 2009

Wayne D. Martin
Oxford, Ohio, USA
17 April 2009

In Memoriam *continued*

Richard C. McMillan
Birmingham, Alabama, USA
3 October 2009

Wilbur J. Morin
McLean, Virginia, USA
26 March 2009

Donald A. Parks
Carefree, Arizona, USA
notified 17 December 2009

Samuel T. Pees
Meadville, Pennsylvania, USA
27 December 2009

Ricardo D. Presnell
Salt Lake City, Utah, USA
notified 28 January 2010

Raymond C. Richter
Turlock, California, USA
notified 17 December 2009

David M. Rolling
Dallas, Texas, USA
4 January 2010

Robert L. Rose
Hollister, California, USA
1 November 2009

Michael R. Talbot
Bergen, Norway
6 November 2009

Charles G. Van Ness
Bethlehem, Pennsylvania, USA
6 May 2009



To honor one of these colleagues with a memorial, please go to www.geosociety.org/pubs/memorials. This page also lists the memorials already completed and available for reading.

If you would like to contribute to the GSA Memorial Fund, please contact the GSA Foundation, +1-303-357-1054, drussell@geosociety.org, www.gsafweb.org.

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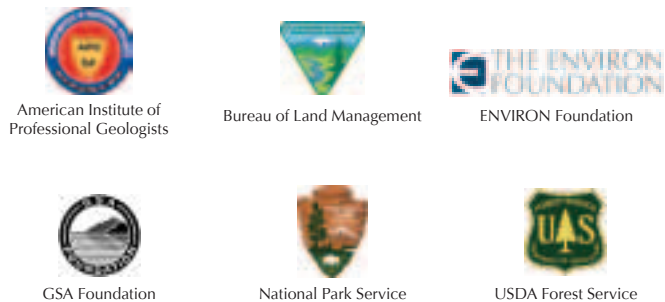


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Paleotempestology and the pursuit of the perfect paleostorm proxy

Scott P. Hippensteel, *Dept. of Geography and Earth Sciences, University of North Carolina, 9201 University City Blvd., Charlotte, North Carolina 28223, USA, shippens@uncc.edu*

Growing populations and recent hurricane activity along the Atlantic and Gulf coastlines have made clear the need for a more accurate and extensive record of storm activity. The paucity of historical descriptions of hurricane strikes along the southern Atlantic coast limits their use as a predictive tool. Only three Category 5 hurricanes have made landfall in the United States since 1900; as a result, the likelihood of a major storm impacting this region cannot be accurately determined using historical records. Proxy records collected from marginal marine environments offer the potential to extend this record back several thousand years, providing better statistical constraints on hurricane prediction and a better understanding of the influence of global warming on catastrophic hurricane development.

Although definitive paleotempest deposits from North America date back to the Oligocene, “paleotempestology” is a relatively new field of research (Boyd and Dyer, 1964). Two proxy approaches developed independently in the early 1990s from two different geographic regions; the resulting storm records offer interesting insights into the problems associated with the contrasting methodologies. At the same time that a research team from Louisiana State University was using sedimentary criteria to detect storm deposits in the coastal lakes of Louisiana, I was finding offshore-indicative foraminifers (and Oligo-Miocene taxa) in buried sand layers from the back-barrier marshes of South Carolina (Liu and Fearn, 1993, 2000; Hippensteel and Martin, 1995, 1999, 2000; Liu, 1999, 2000). Over the next decade, several follow-up studies from the same and different regions led to a series of debates as to the validity of each approach (Donnelly et al., 2000, 2001a, 2001b, 2004; Scott et al., 2003; Donnelly, 2005; Hippensteel et al., 2005; Lambert et al., 2008; Liu et al., 2008).

Previous sediment-based paleotempest proxies have been hindered by two primary issues. First, studies based on sand layers in marshes and coastal lakes have been criticized because the mechanism of deposition was not always well documented, and the source of the sediments was not clearly defined (Otvos, 1999, 2002, 2009; Liu et al., 2009). Second, the depositional history of many marsh records is short, especially in New England and the mid-Atlantic (Donnelly et al., 2000; Travis, 2000). The use of microfossil-enriched storm layers from near

Charleston, South Carolina, avoided both limitations: The mechanism for deposition is well understood because the storm deposits contain offshore-indicative foraminifers, and the record extends into at least the mid-Holocene (Hippensteel and Martin, 1999, 2000).

The micropaleontological proxy is not without problems or critics, however. The exact taxa included on a list of “offshore indicative” genera and the role of bioturbation in the preservation of storm deposits has been strongly debated (e.g., Scott et al., 2003, 2005; Hippensteel et al., 2005; Hippensteel, 2008). Further, the geochronology established for many of these studies is questionable. The washover deposits themselves are, by their very nature, the product of severe reworking of ancient offshore sediments. Dating the foraminifers in such deposits directly would yield the age of the fossils (Oligo-Miocene), not the time of storm deposition.

As a result, the quality, completeness, and comprehensiveness of the storm record from the southeastern Atlantic is not known. Barrier islands are dynamic environments, which, in a transgressive setting, roll over on themselves, destroying or obscuring the backbarrier storm record. Additionally, marsh subenvironments in a transgressive setting will shift through time. In South Carolina, for example, paleostorm frequency appears to be decreasing through time, with more storms lower in the marsh strata (Hippensteel and Harris, 2000; Hippensteel, 2008). Is this apparent decrease in catastrophic storm events a result of climate change or an artifact of the invidious processes of bioturbation and reworking? Is taphonomy partly to blame for the potentially poor preservation, or even absence, of some microfossils in the storm deposits? These marsh subenvironments have, after all, been flooded from high marsh to low marsh, and the primary bioturbators present, fiddler crabs, prefer the low marsh. Before paleotempest proxies reach their potential as a tool for paleoclimate researchers, these geological and biological factors need to be better understood.

The field of paleotempestology has never been of more importance. Prehistorical storm data would be more valuable in the current period of climate change, despite the frustratingly elusive nature of the “ideal” paleostorm record. This ideal paleostorm record, wherever and whenever it is discovered, will have four interrelated characteristics:

1. The deposits will display a clear link to the source of sediments and the mode of deposition. This may be because of the foraminifers present in the deposit, some other

form of non-cosmopolitan microfossil, or a mineralogical composition that is unique to the offshore or nearshore source material.

2. There must be an extensive record of storms dating to several thousand years. As such, the region of deposition must not be very dynamic, or both the source of sediment and the mode of deposition would be inconsistent through time.
3. The location must have received enough storm activity that the record would be of interest to meteorologists and climatologists seeking a link between sea-surface temperature and the role of the Bermuda High in deflecting storms into either the Gulf of Mexico or the eastern Atlantic coastline.
4. The record must be reproducible in the immediate region and, ideally, reproducible using various proxies. In other words, the deposits must be spatio-laterally continuous in the strata, and two records from the same depositional setting must be identical. This demands minimal physical reworking of the deposits or bioturbation.

I'm currently searching, unfortunately with marginal success, for this record in the marshes of the Outer Banks of North Carolina, and others have recently reported on searches from areas as geographically diverse as Central America (McCloskey and Keller, 2009; Urquhart, 2009) and Massachusetts (Madsen et al., 2009). The potential storm record is worth the effort, especially when the value of a millennial-scale record of hurricanes is considered with respect to growing coastal population and infrastructure.

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Manuscript received 4 Sept. 2009; accepted 25 Jan. 2010.

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Attention GSA Members

Help us to reach new peaks at the
2010 Annual Meeting

SPREAD THE WORD!

Talk to your geoscience-related businesses.
Tell them they should be partnering with your
Society at GSA annual meetings.

** Exhibit * Advertise * Sponsor **

*Engage with professionals
and students across the
earth sciences and in every
employment sector.*



Make your company the business of choice

ADVERTISE

Grab attention with convention-related products:

- ✓ Convention issues of GSA Today and e-news
- ✓ GSA Connection (special meeting edition)
- ✓ Conference Program for on site promotion

SPECIAL DISCOUNTS FOR EXHIBITORS.

EXHIBIT

INFORMATION:

[www.geosociety.org/
meetings/2010](http://www.geosociety.org/meetings/2010)

GSA Exhibits
Management Services
Cindy Lu Thompson
+1-303-914-0695, gsaexhibits@qbsoffice.com

Sunday Evening Welcoming Party Kicks Off Meeting in Exhibit Hall
There are no other events scheduled during this time in order to offer
exhibitors maximum exposure to more than 5,000 attendees!

Sun., 31 Oct., 6 – 8 p.m.
Mon. & Tues., 1 & 2 Nov., 9 a.m. – 6 p.m. | Wed., 3 Nov., 9 a.m. – 2 p.m.



SPONSOR

5 Good Reasons to Partner

- Business and science will shape the future together, and together we can shape it responsibly
- GSA is helping the communities where you do business
- Good people are not hard to find; they come to GSA
- Dollars and successful programs are worth more together
- Planet Earth is priceless

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support an
extraordinary
tradition, and
play critical
roles, in
serving the
international
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the profession.*

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