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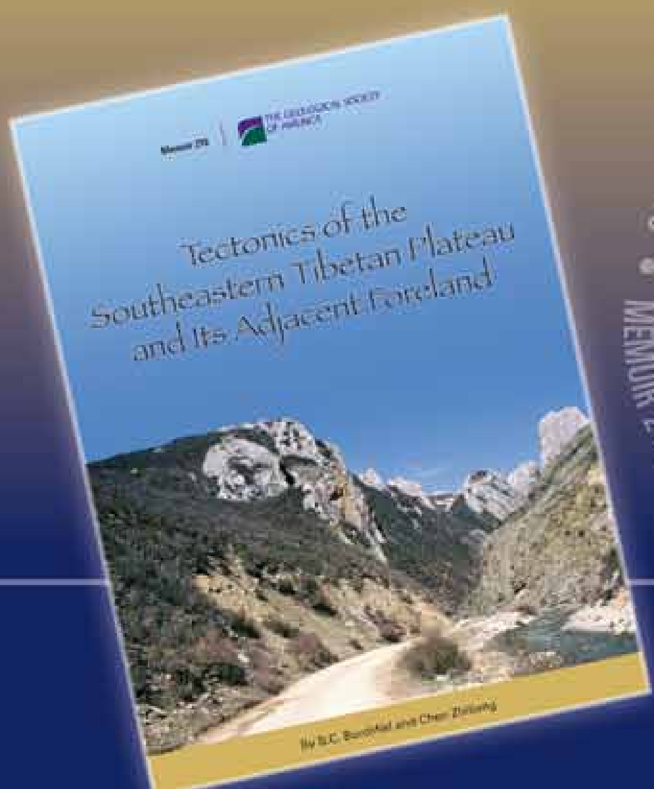

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SCIENCE ARTICLE

Cover: Cullasaja Falls, North Carolina, USA. Photo © Dave Allen Photography; used with permission.

Miocene rejuvenation of topographic relief in the southern Appalachians

Sean F. Gallen*, Karl W. Wegmann, and **DelWayne R. Bohnenstiehl,** *Dept. of Marine, Earth, and Atmospheric Sciences, North Carolina State University, 2800 Faucette Drive, Raleigh, North Carolina 27695, USA*

ABSTRACT

Conventional wisdom holds that the southern Appalachian Mountains have not experienced a significant phase of tectonic forcing for >200 myr; yet, they share many characteristics with tectonically active settings, including locally high topographic relief, steep slopes, incised river gorges, and frequent mass-wasting events. Two competing hypotheses are commonly used to explain their modern topographic expression. One suggests that relief is largely controlled by variable lithologic resistance to weathering and that their modern form has long persisted in a dynamic equilibrium. The second postulates that their relief is a product of recent rejuvenation, driven either by climate change or the epeirogenic uplift of the land surface driven by mantle forcing. Within portions of the Cullasaja River basin of the southern Appalachians, we show that relief has increased by >150% since the Miocene. Evident within the basin are a set of retreating knickpoints that delineate a rugged, actively incising landscape from lower-relief relict topography. Constraints on the timing of knickpoint entry into the basin suggest that the process of landscape rejuvenation began well prior to the late Cenozoic (<4 myr) transition to a more oscillatory (glacial-interglacial) climate regime. Furthermore, the geomorphology of the Cullasaja River basin is difficult to reconcile in the context of a transition to a more erosive climatic regime but is consistent with an epeirogenically uplifted landscape. Consequently, these observations lend new support to the idea that the rugged topography of the southern Appalachians has developed in response to post-orogenic regional uplift in the Miocene.

INTRODUCTION

Topographic relief exerts an essential control on the rates and processes involved in landscape denudation (Ahnert, 1970; Montgomery and Brandon, 2002), influencing feedbacks between atmospheric, earth-surface and rock exhumation processes, variations in sediment flux, and the magnitude and style of gravity-driven natural hazards. A long-standing debate in the geosciences is centered upon the nature of topographic decay in post-orogenic mountain ranges (Davis, 1889; Hack, 1960; Bishop, 2007). Central to this debate are the still-rugged terrains within the modern Appalachians Mountains of eastern North America, where the last significant phase of tectonic activity presumably ceased shortly after Late Triassic rifting of the Atlantic margin (Hatcher, 1989).

Two hypotheses have been put forth to explain the occurrence of locally high topographic relief, steep slopes, incised river gorges, and frequent mass-wasting events along the passive margin of the southern Appalachians (e.g., Gallen et al., 2011; Wooten et al., 2008). One suggests that topography has persisted though time in a dynamic equilibrium, with relief largely controlled by the variable erodibility of rock units (Hack, 1960; Matmon et al., 2003). The second posits that modern relief is a product of recent rejuvenation (Hack, 1982); however, whether the process governing this resurgence is climate change (Molnar, 2004; Hancock and Kirwan, 2007) or dynamic mantle processes forcing epeirogenic uplift (Pazzaglia and Brandon, 1996) is debated. Recent results obtained from the application of thermochronology (Boettcher and Milliken, 1994) and terrestrial cosmogenic radionuclides (CRNs; Matmon et al., 2003; Hancock and Kirwan, 2007) have not led to a consensus regarding the processes governing the evolution of relief within this landscape—a result of contrasting interpretations drawn from different datasets.

We test the competing hypotheses of dynamic equilibrium and topographic rejuvenation with a study of the geomorphology of the ~300 km^2 Cullasaja River basin of the southern Appalachian Mountains in western North Carolina (Figs. 1A and 1B). The Cullasaja is a tributary to the Little Tennessee River, its waters traveling >1500 river kilometers before discharging into the Gulf of Mexico (Fig. 1A). The timing and magnitude of changes in relief within the basin are quantified through the analysis of a 6-m horizontal resolution LiDAR elevation dataset. Results indicate that the Cullasaja basin landscape has undergone a period of rejuvenation, with relief increasing >150% since the Miocene. The timing of this rejuvenation and the geomorphic expression of the Cullasaja basin landscape, however, suggest that climate change is not the fundamental driving process (cf. Molnar, 2004). Rather, observational evidence favors a model where relief develops as the landscape is epeirogenically uplifted.

STUDY AREA

The Cullasaja River basin contains the geomorphic features required to reconstruct its paleo-relief, including numerous active river knickpoints—sharp convexities in an otherwise concave-up longitudinal river profile—and a preserved relict landscape "surface." The study area lacks evidence of late Pleistocene glaciation and because of its distance from the maximum extent of late Quaternary ice sheets (Thelin and Pike, 1991), the Cullasaja basin experienced little, if any, glacial isostatic response (Fig. 1A). This is supported by studies using decade-long continuous GPS

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*E-mail: sfgallen@ncsu.edu

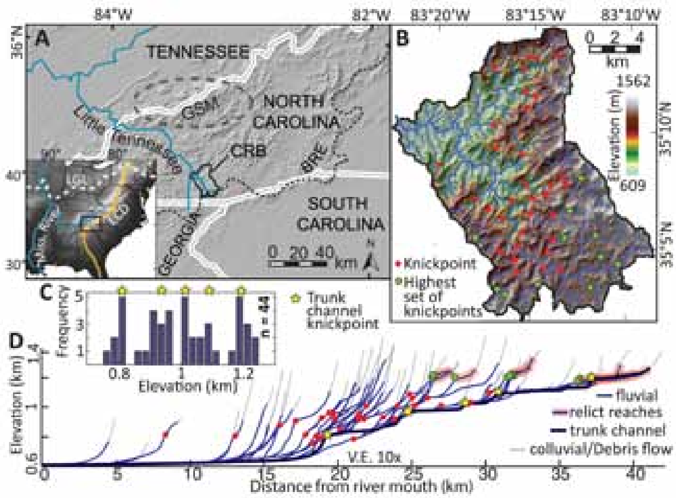

Figure 1 (A) Shaded relief map of the southern Appalachians of western North Carolina and eastern Tennessee, USA. BRE (black dashed line)—Blue Ridge Escarpment; GSM (gray dashed oval)—Great Smoky Mountains. Inset map shows the location of this region in the context of the eastern continental divide (ECD) and the southern limit of glaciation during the last glacial maximum (LGL) (Thelin and Pike, 1991). The headwaters of the Cullasaja River basin (CRB) are >1500 km from the outlet of the Mississippi River. (B) Shaded relief image of the Cullasaja basin with the position of the 44 knickpoints identified in this study. (C) Histogram of knickpoint elevations in 25 m bins. Yellow stars denote the elevations of the trunk channel knickpoints identified in D. (D) Longitudinal river profiles of 52 streams showing the location of 44 knickpoints, relict reaches, and the approximate transition between fluvial and colluvial/debris flow–dominated channels that occurs at drainage areas ≥1.25 × 10^5 m^2. Red dots—knickpoints; green dots—highest knickpoints.

and satellite gravity surveys to estimate vertical motions due to glacial isostatic adjustments and marine flooding of the North American continental shelf. These datasets demonstrate that the southern Appalachians are either a null region or are slowly subsiding at rates <0.3 mm yr^{-1} (Sella et al., 2007; Wu et al., 2010).

The Cullasaja basin is a detachment-limited geomorphic system with bedrock channels flowing across mostly high-grade gneisses (Gallen et al., 2011) (Fig. DR1, GSA supplemental data repository[1]). A distinct break in log-log channel slope versus upstream drainage area scaling is interpreted to represent the transition between debris flow and fluvial-dominated channels (cf. Montgomery and Foufoula-Georgiou, 1993; Wobus et al., 2006). The maximum drainage area where this scaling break was observed in the Cullasaja basin is ~1.25 × 10^5 m^2. We choose this as the minimum contributing area in defining the fluvial network. Three observations suggest that lithologic control on hillslope erosion and river incision is relatively uniform throughout the basin: (1) most river channels do not follow lithologic contacts; (2) channel steepness shows no obvious correlation to rock-type; and (3) the observed location of fluvial knickpoints is generally discordant with lithologic contacts (Gallen et al., 2011) (Fig. DR1B [see footnote 1]).

Tributary knickpoints cluster within five altitudinal bands that are coincident with the elevations of five prominent main-stem knickpoints (Figs. 1C and 1D). We appeal to a kinematic model of active knickpoint retreat (e.g., Niemann et al., 2001), which predicts uniformity in vertical velocity for knickpoints resulting from a common base level fall. We interpret the knickpoint clusters as independent waves of bedrock incision actively propagating though the drainage network. The process(es) responsible for knickpoint initiation is unknown; however, eustatic fluctuations are an unlikely mechanism, as it has been shown that such signals do not propagate beyond the lower alluvial reaches of the Mississippi River (Schumm, 1993). Furthermore, the size of knickpoints identified (gradients ≥0.1, dropping >20 m), the total amount of knickpoint relief in the Cullasaja basin (>400 m), and the absence of localities for large-magnitude stream capture events or deep-seated rockslides preclude autogenic knickpoint formation (cf. Wooten et al., 2008; Korup et al., 2006; Prince et al., 2011). With no obvious mechanism for generating the knickpoints, we assess the paleo-topographic conditions in the basin to test the hypothesis that the knickpoints represent a change in geomorphic boundary conditions external to the Cullasaja basin and attempt to determine when this transition began. In doing so we aim to clarify the process(es) driving landscape evolution in the southern Appalachians through the generation of these knickpoints.

DYNAMIC EQUILIBRIUM VERSUS TOPOGRAPHIC REJUVENATION

The highest flight of 11 knickpoints demarcates an important topographic transition in the Cullasaja basin; downstream of the knickpoints, local relief, hillslope and stream channel steepness, and the frequency of landslides all increase significantly when compared to the portion of the landscape isolated above the knickpoints (>1150 m) (Gallen et al., 2011) (Figs. 2A–2D; Table DR1 [see footnote 1]). The occurrence of the knickpoints across a spread in drainage areas (1.4 × 10^5–7.5 × 10^6 m^2) implies that they are not stalled at a threshold drainage area, an assumption later tested with numerical modeling (i.e., Crosby and Whipple, 2006; Berlin and Anderson, 2007). Rather, the highest set of knickpoints defines the propagating front of river incision, representing the boundary between an upper-relict landscape and a lower-actively adjusting zone (Fig. 2D) (Clark et al., 2005). This evidence has two important implications: (1) the Cullasaja basin, and probably the entirety of the southern Appalachians, is in a transient state of adjustment, rather than a dynamic equilibrium (cf. Hack, 1960; Matmon et al., 2003), where topography is rejuvenated in the passing wake of mobile knickpoints; and (2) the highest knickpoints and the relict landscape that they isolate contain information about the onset of enhanced incision and the temporal evolution of topography in this region.

ESTIMATING RATES OF EROSION

Ahnert (1970) observed that mean local relief in temperate mid-latitude drainage basins from tectonically inactive settings scales linearly with mean denudation rate. Application of Ahnert's relationship to the Cullasaja basin suggests that erosion rates,

[1]GSA supplemental data item 2013103, extended methods, results, discussion, and figures, is online at www.geosociety.org/pubs/ft2013.htm. You can also request a copy from *GSA Today*, P.O. Box 9140, Boulder, CO 80301-9140, USA; gsatoday@geosociety.org.

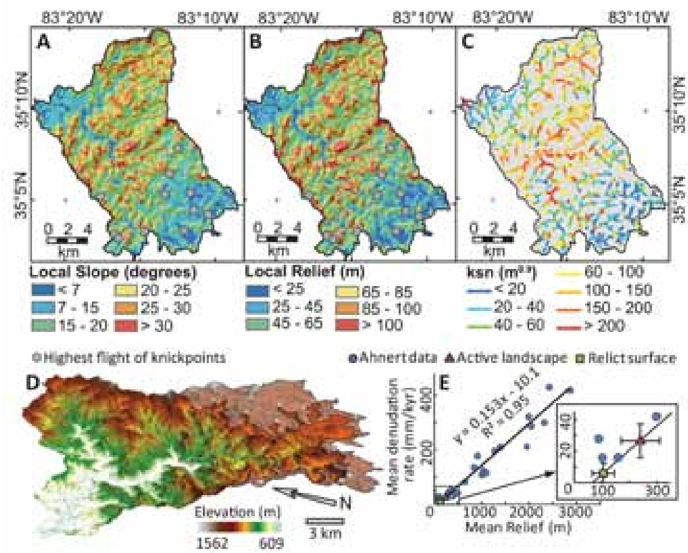

Figure 2. Topographic and fluvial metrics and characterization of relict surface. (A and B) Maps of local (A) slope and (B) relief for the Cullasaja River basin. (C) Normalized channel steepness (k_{sn}) averaged every 100 m along each stream reach. (D) Perspective view of the Cullasaja River basin highlighting the relict reach (shaded) preserved above the highest flight of knickpoints. (E) Plot showing Ahnert's (1970) global relationship between mean relief and mean denudation and the estimated mean denudation rates of the active and relict portions of the Cullasaja River basin with 1σ errors as determined in mean local relief calculations.

based on calculations of mean local relief, are 27 ± 11 and 6 ± 6 mm kyr^{-1} in the active and relict portions of the landscape, respectively (Fig. 2E; Table DR1). A slower rate of erosion for the relict landscape is supported by a reduction in landslide occurrence (Wooten et al., 2008) (Fig. DR1; Table DR1 [see footnote 1]) and an increase in mean soil thickness (Thomas, 1996) relative to the active landscape. These estimates closely align with regional ^{10}Be CRN studies; the active landscape erosion rate matches basin average rates from the Great Smokey Mountains of 27 ± 4 mm kyr^{-1} (Matmon et al., 2003), and the relict landscape prediction is consistent with West Virginia bedrock summit lowering rates (6 ± 3 mm kyr^{-1}) (Hancock and Kirwan, 2007), indicating that they are reasonable values.

PALEO-RELIEF RECONSTRUCTIONS

To estimate the magnitude of paleo-relief in the Cullasaja basin, we first determined the paleo–base level of the relict surface using the channel segments above the highest flight of knickpoints. Equilibrium longitudinal river profiles of the relict channel reaches are reconstructed using the empirically derived scaling law that relates local channel slope (S) to drainage area (A) through the channel parameters of steepness (k_s) and concavity (θ) (e.g., Flint, 1974):

$$S = k_s A^{-\theta}. \qquad (1)$$

Of the 11 reaches analyzed, eight had sufficient data to determine estimates of channel steepness and concavity (Fig. DR2; Tables DR2 and DR3 [see footnote 1]). To avoid geomorphic and hydrologic complications introduced at a smaller drainage area, channel steepness indices (k_{sn}) were normalized using the mean concavity (θ_{ref}) of the eight reaches (Table DR3) (Clark et al., 2005; Wobus et al., 2006).

The elevations of the reconstructed tributary and trunk channel profiles fall within error at their confluences and are therefore graded to the same paleo–base level that is ~480 m higher than the present-day river mouth (Figs. 3 and DR2). Assuming that the ridge line erosion rates determined in West Virginia (Hancock and Kirwan, 2007) are regionally applicable to the southern Appalachians implies that the vertical distance between the ridge lines and the relict landscape of the Cullasaja basin has remained approximately the same through time. Paleo-relief in the relict landscape is thus determined to be ~300 ± 25 m by differencing the elevations of the reconstructed river profile from the modern-day drainage divide (Fig. 3). This estimation suggests that relief in the Cullasaja basin has increased 163% ± 24% since the highest knickpoints entered the mouth of the Cullasaja River (Fig. 3).

TIMING OF TOPOGRAPHIC RESURGENCE

The time that the highest trunk channel knickpoint, Highland Falls, passed the mouth of the Cullasaja basin represents a minimum age for the relict landscape and hence the initiation of newly imposed geomorphic boundary conditions. To our knowledge, there are no preserved fluvial terraces related to the upper-most knickpoints in the Cullasaja basin, eliminating more conventional methods for determining their age and propagation rates. Instead, a simple yet novel approach is used to constrain the timing of knickpoint entry into the basin. Assuming that knickpoint propagation proceeded as a kinematic wave, the travel time of the highest knickpoints from the river mouth to their current position is the same as the time required to erode the rock

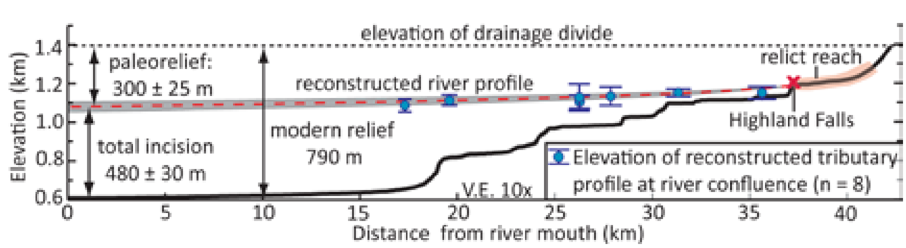

Figure 3. Modern and reconstructed paleo-river profiles with the modeled elevations of tributary-trunk channel junctions projected to the paleo profile. The 2σ elevation errors are from the normalized steepness indices and are based on linear regressions through log-log channel slope-drainage area data (Fig. DR2 [see text footnote 1]). The amount of paleo-relief in the Cullasaja River basin is based on the assumption that the ridge lines have eroded at a rate commensurate with the mean denudation rate of the relict surface (6 ± 6 mm kyr^{-1}).

volume "missing" from the active landscape (Fig. 4A) (Norton et al., 2008). The knickpoint travel time (t_k) is estimated by:

$$t_k = \left(\frac{V}{A_c}\right)\dot{E}^{-1}, \qquad (2)$$

where A_c and V are the area below the knickpoint elevation contour and volume, respectively, and $\dot{E}$ is the average erosion rate within the active landscape (Fig. 4A). A minimum estimate of the volume of rock eroded from beneath the highest knickpoints is found by differencing the basin topography with a sloping surface fit to the modern drainage divide, and a maximum estimate is determined by differencing the basin topography with a horizontal surface defined by the elevation contour at the top of Highland Falls (Fig. 4B).

Using estimates of the basin average erosion rate for the active landscape between 16 and 38 mm kyr^{-1} (Figs. 2E and 4C), Highland Falls would have entered the mouth of the river between 17.6 and 4.6 Ma. Applying the mean denudation rate and average volume of eroded rock, the entry time becomes ca. 8.5 Ma (Fig. 4C). It is, however, unlikely that these knickpoints were formed at the mouth of the Cullasaja basin. Even if the Cullasaja River was not incising (0 mm kyr^{-1}), while the Little Tennessee River cut down at 600 mm kyr^{-1} (estimated from the fastest rates of river incision measured in Appalachian draining rivers by Reusser et al., 2004), such conditions would need to be sustained >150 kyr to form the largest Cullasaja basin knickpoints (>100 m). The long-term persistence of such conditions is unrealistic; rather, the knickpoints likely formed

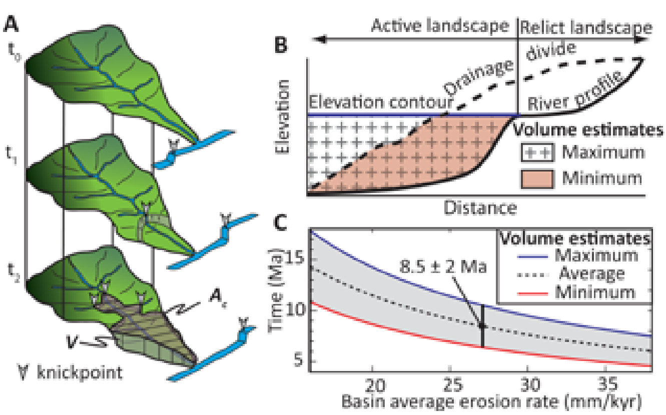

Figure 4. Conceptual model and results of volume-for-time substitutions. (A) Cartoon illustrating the idealized evolution of a drainage basin experiencing base-level lowering brought on by the propagation of a knickpoint as a kinematic wave. The final time step (t_2) identifies the volume of eroded material (V) and area of the active landscape (A_c), which are the parameters used to calculate the time since a knickpoint entered the mouth of a drainage basin using equation 2. (B) Schematic cross section illustrating the two methods used to estimate "missing" volume below the elevation of the highest trunk channel knickpoint. (C) Plot of the estimated time since the Highland Falls knickpoint entered the mouth of the Cullasaja River basin. The vertical black line is the mean basin average erosion rate determined for the active portion of the Cullasaja River basin predicted by the Ahnert (1970) trend (27 ± 11 mm kyr^{-1}) and matches that of the nearby Great Smokey Mountains (Matmon et al., 2003; 27 ± 4 mm kyr^{-1}).

some distance down the Little Tennessee River by some other mechanism. This 17.6–4.6 Ma time range therefore provides an extreme minimum value for the age of the relict surface, and thus the onset of modern relief production in the southern Appalachians almost certainly pre-dates the transition to significant orbitally driven climate unsteadiness beginning 4 to 3 Ma (Peizhen et al., 2001; Molnar, 2004).

Moreover, it is difficult to explain the geomorphology of the Cullasaja basin in the framework of climate change. A transition to a cooler, wetter, and rapidly fluctuating climate should enhance regional erosional efficiency (Molnar, 2004), but it would need to be locally absent in order to preserve a relict surface, which is highly unlikely in the Appalachians. A change to a more erosive environment also is predicted to reduce channel steepness (Whipple and Tucker, 1999; Wobus et al., 2010), not increase it as is observed in the Cullasaja basin. Collectively, the timing of topographic rejuvenation and geomorphology of the Cullasaja basin eliminates late Cenozoic (<4 myr) climate change as the fundamental driver of the enhancement of relief in the southern Appalachians.

TESTING KEY ASSUMPTIONS

We numerically model the spatial distribution of the 11 highest knickpoints in the Cullasaja basin to test the assumptions that the knickpoints are: (1) genetically related and (2) verify that they are still actively propagating and not stalled. Testing these assumptions is important because it will show that the uppermost knickpoints originated from a single source and are currently moving through and dissecting the relict landscape. Further, modeling will support the age constraints from above if knickpoint velocity is determined to be reasonable (e.g., within measured values). To this end, a generic knickpoint celerity model is used (Crosby and Whipple, 2006):

$$\frac{dx}{dt} = CA^p, \qquad (3)$$

where dx/dt is the upstream knickpoint migration rate in m yr^{-1}, C is a dimensional coefficient of erodability in units m$^{(1-2p)}$ yr^{-1}, A is contributing drainage area, and p is a non-dimensional constant reflecting knickpoint celerity dependence on drainage area, a proxy for discharge. A brute-force two-parameter search is used to find the best-fitting C and p parameters that minimize the misfit between the observed and modeled knickpoint positions (Crosby and Whipple, 2006; Berlin and Anderson, 2007).

Using the results from the volume-for-time substitutions (eq. 2), we consider a suite of 28 model runs with knickpoints entering the Cullasaja basin between 4.5 to 18 Ma (0.5 myr intervals). Each model run worked equally well, with <2% difference in the sum of the least squares residual between the observed and modeled knickpoint positions for any given travel time (Figs. DR3 and DR4 [see footnote 1]). These models predict the position of the 11 highest knickpoints remarkably well (Figs. 5A and 5B), implying that the knickpoints do behave as a kinematic wave. Present-day minimum knickpoint velocity varies between 0.13 and 2.25 mm yr^{-1} for the set of modeled travel times, confirming that the knickpoints are mobile and dissecting the relict landscape. Best fitting p parameters ranging from 0.51 to 0.54 are consistent with a square root of area scaling (Berlin and Anderson, 2007) (Fig. DR3). The erosional

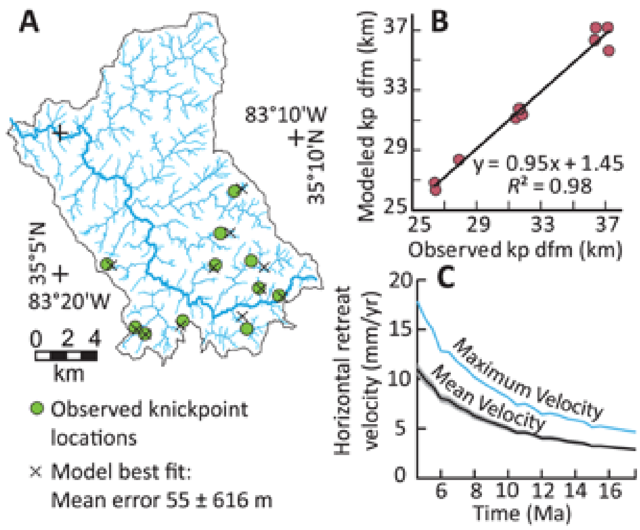

Figure 5. Knickpoint celerity model results. Example of results from the best-fitting *C* and *p* parameters for a knickpoint travel time of 8.5 myr, which is the mean time prediction based upon the estimated basin average erosion rate from the Ahnert (1970) relationship as well as the average of the two volume-for-time estimates (see Fig. 4). (A) Observed and modeled knickpoint distribution. Mean error refers to the mean of the differences between the observed knickpoint and the modeled knickpoint distance from the mouth of the Cullasaja River. (B) Relationship between observed and modeled knickpoint (kp) positions, expressed with respect to their distance from the mouth (dfm) of the Cullasaja River. (C) Maximum and mean (gray is ±1σ error) velocity of the best fitting model result associated with each run.

coefficient *C*, however, adjusts over nearly an order of magnitude to accommodate the modeled knickpoint travel time (Figs. DR3 and DR4). Nonetheless, the maximum and mean knickpoint velocity predicted by the numerical modeling are within the range of measured knickpoint propagation rates (Loget and Van Den Driessche, 2009) (Fig. 5C), suggesting that calculated knickpoint travel times are reasonable. Independent support for reasonable knickpoint travel times comes from estimates of river incision that are within the range of measured long-term (10^4–10^6 yr) valley incision for Appalachian-draining rivers (Mills, 2000; Reusser et al., 2006) that, based on our longitudinal profile reconstructions (Fig. 3), fall between 24 and 140 mm kyr^{-1}.

DRIVING MECHANISM FOR TOPOGRAPHIC REJUVENATION

The proposed timing of the topographic resurgence reported here is roughly concurrent with previous studies that demonstrate increased sedimentation rates and grain sizes delivered from the Appalachians eastward to off-shore basins along the Atlantic margin (Poag and Sevon, 1989; Pazzaglia and Brandon, 1996) and westward to the Mississippi embayment (Potter, 1955) and Gulf of Mexico (Galloway et al., 2011) ca. 16 to 12 Ma. This coincidence suggests a causative link between the process responsible for relief rejuvenation in the Appalachians and the flux of sediment to adjacent depocenters and implies a regional disturbance to the Appalachians in the Miocene. With no obvious surficial process driving the Miocene topographic resurgence, what mechanism can be called upon to explain the results reported in this paper? The formation of large knickpoints, the steepening of river gradients, the ongoing dissection of a relict landscape, and the pulse of sediment to offshore basins are broadly consistent with a region that has undergone uplift; however, the Appalachians generally lack evidence of late Cenozoic deformation (Hatcher, 1989).

Epeirogenic uplift of the southern Rocky Mountains and Colorado Plateau (Karlstrom et al., 2012) and the southern Sierra Nevada range (Clark et al., 2005) has produced a similar geomorphic response to what is reported here. In these settings, the uplifted regions also exhibit strong spatial correlations with geophysical anomalies in the crust and lithospheric mantle, providing insight into the driving mechanism(s). Although large-scale geophysical imaging of the tectonically passive eastern United States has received relatively little attention compared to the western United States, Grand et al. (1997) and Ren et al. (2007) have documented fragments of the relict Farallon oceanic slab within the mantle beneath the modern Appalachians. More recently, Wagner et al. (2012) produced receiver function profiles crossing the southern Appalachians of North Carolina. They document Moho holes, double Moho arrivals, and localized seismic scatters in the lithospheric mantle. One interpretation of these results is that portions of the over-thickened crust have delaminated (cf. Zandt et al., 2004), perhaps driving the uplift and rejuvenation of the southern Appalachian landscape. Further testing of this hypothesis is possible by continued collaborations between the geomorphic and geophysical communities and the arrival of the EarthScope USArray seismic observatory experiment to the eastern United States in 2013.

CONCLUSIONS

Our results show that topography in the Cullasaja River basin, and likely much of the west-draining southern Appalachians, is in a transient state of adjustment to a newly imposed regional base level (Gallen et al., 2011), and thus it is not in a dynamic equilibrium. Relief has increased here >150% since the Miocene, predating the amplification of glacial-interglacial cycles that initiated in the Pliocene and continue today. Our results favor the hypothesis that some form of dynamic mantle forcing has caused epeirogenic uplift of the Appalachians that began in the Miocene, because it can explain the generation of knickpoints and the preservation of a relict landscape in the Cullasaja basin that are difficult to account for in the context of climate change alone. Importantly, it appears that this event may be related to the increase in grain size and rate of sediments delivered to basins both east (Poag and Sevon, 1989; Pazzaglia and Brandon, 1996) and west (Potter, 1955; Galloway et al., 2011) of the Appalachian mountains, implying that the surface response to relief generation in the Cullasaja basin is likely related to a broad, regional phenomenon. This research sheds light on a long-standing enigma in the geosciences; yet, the results presented here also bring up new questions and testable hypotheses about the geomorphology and late Cenozoic geodynamic evolution of the southern Appalachians.

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GSA DIVISION AWARDS

■ GEOPHYSICS

George P. Woollard Award
Nominations due 15 February

Submit nominations online at http://bit.ly/THIifK. Nominations should include a description of the nominee's specific contributions and their scientific impact. This award recognizes outstanding contributions to geology through the application of the principles and techniques of geophysics. A highlight of the presentation is the honorary George P. Woollard Technical Lecture by the recipient before the award ceremony. Award funds are administered by the GSA Foundation.

■ SEDIMENTARY GEOLOGY

Laurence L. Sloss Award for Sedimentary Geology
Nominations due 20 February

Submit (1) a cover letter describing the nominee's accomplishments in sedimentary geology and contributions to GSA and (2) a curriculum vitae electronically to Linda Kah, secretary, Sedimentary Geology Division, lckah@utk.edu. This award recognizes a sedimentary geologist whose lifetime achievements best exemplify those of Larry Sloss (i.e., contributions to the field of sedimentary geology and service to GSA). Monies for the award are derived from the annual interest income of the Laurence L. Sloss Award for Sedimentary Geology Fund, administered by the GSA Foundation.

■ COAL GEOLOGY

Gilbert H. Cady Award
Nominations due 28 February

Send three copies of the following to Jack C. Pashin, Energy Investigations Program, Geological Survey of Alabama, P.O. Box 869999, Tuscaloosa, AL 35486-6999; jpashin@gsa.state.al.us: (1) name, office or title, and affiliation of the nominee; (2) date and place of birth; (3) education, degree(s), honors, and awards; (4) major events in his or her professional career; and (5) a brief bibliography noting outstanding achievements and accomplishments that warrant nomination. Monies for the award are derived from the annual interest income of the Gilbert H. Cady Memorial Fund, administered by the GSA Foundation.

■ ENVIRONMENTAL AND ENGINEERING GEOLOGY

Richard H. Jahns Distinguished Lecturer
Nominations due 28 February

Send nominations to Dennis Staley, U.S. Geological Survey, Box 25046, MS 966, Denver, CO, 80225, USA; dstaley@usgs.gov. This award is given to an individual who through research or practice has made outstanding contributions to the advancement of environmental and/or engineering geology. The awardee will speak on topics of earth processes and the consequences of human interaction with these processes, or the application of geology to environmental and/or engineering works. Award funds are administered by the GSA Foundation.

■ QUATERNARY GEOLOGY AND GEOMORPHOLOGY

Farouk El-Baz Award for Desert Research
Nominations due 2 April

Submit nominations, including (1) a statement of the significance of the nominee's research, (2) a curriculum vitae, (3) letters of support, and (4) copies of no more than five of the nominee's most significant publications related to desert research to Alan R. Nelson, anelson@usgs.gov. Please submit electronically unless hardcopy previously approved. This award rewards excellence in desert geomorphology research worldwide, and any scientist from any country may be nominated. Monies for the award are derived from the annual interest income of the Farouk El-Baz Fund, administered by the GSA Foundation.

GSA STUDENT SCHOLARSHIPS AND AWARDS

■ Antoinette Lierman Medlin Scholarship in Coal Geology

Application deadline: 15 March

This GSA Coal Geology Division scholarship provides full-time students who are involved in coal geology research with financial support for their project for one year (~US$2,000 for 2013–2014). In addition, the recipient may be provided with a stipend to present project results at the 2013 or 2014 GSA Annual Meeting.

For the academic year 2013–2014, the Coal Geology Division is also offering a field study award of ~US$1,500. The recipient of this award will also be eligible to receive travel funds to present results at the 2013 or 2014 GSA Annual Meeting.

A panel of coal geoscientists will evaluate proposals for the scholarship and the field study award. Students may apply for both; however, only one award will be made to a successful applicant.

Submit five copies of the following to Mark Engle, Dept. of Geological Sciences, The University of Texas at El Paso, El Paso, TX 79968, USA, mercurous@gmail.com: (1) a cover letter indicating which award(s) is(are) sought; (2) a concise statement of objectives and methods and a statement of how the scholarship funds will be used to enhance the project (the proposal should be no more than five double-spaced pages, including references); and (3) a letter of recommendation from the student's immediate advisor that includes a statement of financial need and the amount and nature of other available funding for the research project.

■ **History and Philosophy of Geology Student Award**
Applications deadline: 1 May

The History and Philosophy of Geology Division is offering a US$1,000 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, and 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.

Proposal guidelines and the application form are online at http://gsahist.org/HoGaward/awards.htm. If you have questions about the award, please contact the Division secretary-treasurer, Jane P. Davidson, jdhexen@unr.edu. Nominees need not be members of the History and Philosophy of Geology Division or of the Geological Society of America.

■ **Stephen E. Dwornik Student Paper Award**

Please go to **http://www.lpi.usra.edu/meetings/lpsc2013/** for instructions, an application form, and further information. The 2013 award applies to papers presented at the 44th Lunar and Planetary Science Conference on **18–22 March 2013** in The Woodlands, Texas, USA.

GSA's Planetary Geology Division encourages applications for the Stephen E. Dwornik Student Paper Award, established in 1991, to provide encouragement, motivation, and recognition to outstanding future planetary scientists. Two awards are given each year—one for the best oral presentation, the other for the best poster presentation. Student applicants must be (1) the senior author of the abstract (the paper may be presented orally or in a poster session); (2) a U.S. citizen; and (3) enrolled in a college or university, at any level of their education, in the field of planetary geoscience. Papers will be judged on the quality of the scientific contributions, including methods and results, clarity of material presented, and method of delivery (oral or display). The program is administered through GSA's Planetary Geology Division; the GSA Foundation manages the award funds.

Call for Nominations

John C. Frye Environmental Geology Award

Deadline: 31 March

In cooperation with the Association of American State Geologists (AASG), GSA makes an annual award for the ***best paper on environmental geology*** published either by GSA or by a state geological survey during the preceding three full calendar years.

Each nominated paper will be judged on its uniqueness or significance as a model of its type of work and its overall worthiness for the award. The paper must (1) establish an environmental problem or need; (2) provide substantive information on the basic geology or geologic process pertinent to the problem; (3) relate the geology to the problem or need; (4) suggest solutions or provide appropriate land-use recommendations based on the geology; (5) present the information in a manner that is understandable and directly usable by geologists; and (6) address the environmental need or resolve the problem. It is preferred that the paper be directly applicable to informed laypersons (e.g., planners, engineers).

Please send your nominations (including a paragraph stating the pertinence of the paper) to Program Officer, Grants, Awards & Recognition, GSA, P.O. Box 9140, Boulder, CO 80301-9140, USA.

2012 Award Recipients

John T. Neubert, Jeffrey P. Kurtz, Dana J. Bove, and **Matthew A. Sares** for their paper "Natural Acid Rock Drainage Associated with Hydrothermally Altered Terrane in Colorado," published in 2011 in *Bulletin 54* of the Colorado Geological Survey.

Formation of the Sierra Nevada Batholith: Magmatic and Tectonic Processes and Their Tempos

CONVENERS

Scott R. Paterson, *Department of Earth Sciences, University of Southern California, Los Angeles, California 90089-0740, USA, paterson@usc.edu*

Jade Star Lackey, *Pomona College, Claremont, California 91711, USA*

Vali Memeti, *Department of Earth Sciences, University of Southern California, Los Angeles, California 90089-0740, USA*

Robert B. Miller *and* ***Jonathan S. Miller,*** *Department of Geology, San José State University, San José, California 95192-0102, USA*

Roland Mundil, *Berkeley Geochronology Center, Berkeley, California 94709, USA*

Keith D. Putirka, *Department of Earth and Environmental Sciences, California State University, Fresno, California 93740, USA*

OVERVIEW

Fifty-seven geologists from all over the world came together for this week-long GSA Penrose Field Forum in the superbly exposed Sierra Nevada of sunny California to think about magmatic and tectonic processes and their tempos in arcs. These participants have expertise in diverse fields, including field geology, petrology, geochemistry, geo- and thermochronology, structural geology, tectonics and geodynamics. Twenty-one of the attendees were students or post-docs. Several geologists actively working in different parts of the central Sierra Nevada combined efforts to present data from individual intrusions and their host rocks to arc-scale data syntheses collected over the past decade. The goal was to foster cross-disciplinary discussions with the multidisciplinary group of participants so as to provide a better understanding of batholith formation, as well as the significance of important new field, structural, geochronologic, and geochemical databases, and the tectonic controls on the tempo of arc development implied by such.

The field forum started in Oakhurst, in the western foothills of the Sierra Nevada, and worked its way across the arc to Mammoth Lakes, on the east side of the Sierra Nevada, examining different intrusive complexes and/or host rocks each day. On the last day, the arc was traversed again on the return trip from Mammoth Lakes to Oakhurst, where we dedicated our discussions to the synthesis of arc-scale datasets and of observations from prior days. Each evening participants of the field forum led follow-up group discussions. These discussions were enriched by a number of posters presented by the participants. Two students, Laura Waters at the University of Michigan, and Jesse Hahm from the University of Wyoming, received Best Student Poster awards, which earned them each a trip to the GSA Annual Meeting in Charlotte, North Carolina, USA. Plans are underway to publish the field guide as a GSA Special Paper following this field forum.

DAILY ACTIVITIES

Day 1 was organized by Keith Putirka and Scott Paterson, who kicked off the field forum by presenting outcrops of the Jurassic, 28° tilted, upper crustal Guadalupe Igneous Complex and nearby Hornitos pluton intruding oceanic host rocks of the western foothills of the Sierra Nevada. The Hornitos consists of vertical mafic and felsic dikes, which appear to feed compositionally equivalent magmas into the overlying Guadalupe Igneous Complex (GIC). The GIC is in turn composed of moderately dipping sheets of gabbro and meladiorite at its base, which are overlain by a mingled granite and gabbro zone. These lower sheets are capped by layers of granite, granophyre, and rhyolite at the top of the section. Discussions revolved around the geochemical imprint indicating whether a simple fractionation model could explain overall compositional variations, the significance of mingling, lack of true mixing in this bimodal system, and finally, to what extent the GIC is representative of other intrusions in the Sierra Nevada arc. The group also debated whether the temporally related rhyolite was genetically connected to the rest of the intrusive complex.

Day 2 was led by Jade Star Lackey, who introduced various units of the >3300 km^2 Fine Gold Intrusive Suite (FGIS)—the Bass Lake tonalite being its largest—and some outcrops of the host rock into which the suite intruded. The host rock is only preserved in highly deformed and metamorphosed interplutonic screens, a picture that is commonly seen in the Sierra Nevada arc, which is composed of 80%–90% plutonic material. A prevalent theme on this day was to think about the derivation of the magmas that created this huge composite intrusion and what the plutonic geochemistry implies about the location of "terrane" boundaries (Foothills suture) and the variable recycling of accreted arc terranes versus continental crust in the production of the melts. Also discussed was the issue of how to "map a pluton" using geochronologic data and how to decide what belongs to the same magmatic system given the heterogeneous nature and the more than 19-m.y. magmatic history of the Fine Gold Intrusive Suite.

Day 3 was organized by Jonathan Miller, Bob Miller, and Greg Stock, and was spent examining outcrops of the Yosemite Valley Intrusive Suite, Sentinel granodiorite, and Yosemite Creek granodiorite, which form the western plutonic host rock units of the Tuolumne Intrusive Complex. We started the day with Yosemite National Park geologist Greg Stock, who presented results of detailed mapping on the North American wall of El Capitan in Yosemite Valley in collaboration with Roger Putnam at the University of North Carolina. Their work shows complex mingling between different composition rocks in the El Capitan granite as well as numerous dikes; Greg also showed results obtained from rockfall studies in Yosemite Valley and the implications these have for safety and park planning operations. The rest of the day was spent looking at different degrees of compositional heterogeneity, particularly in the Sentinel and Yosemite Creek granodiorites. In addition, Jonathan and Bob presented structural, geochemical, and geochronologic results that suggest that these plutons were assembled by multiple increments, which recycled earlier intrusive increments. Production of the high-SiO_2 rocks in the plutons is consistent with late stage fractionation in the presence of titanite. But the question of the time scale of these processes and length scales of heterogeneity were a topic of extensive discussion.

Day 4 was dedicated entirely to the growth and evolution of the Tuolumne Intrusive Complex (TIC). Vali Memeti, Scott Paterson, and Roland Mundil presented data and interpretations on the tectonic context of the complex at the time of intrusion, geochronologic and geochemical patterns from whole rocks and single minerals from the different units, and the magmatic structures observed and their implications for magma chamber processes. The presenters stressed the importance of recycling and mixing of older pulses into younger in the TIC that requires extended areas of magma mush, and the necessity of downward flow of the host rocks (including older intrusive units) during the rise of magmas (vertical material transfer) to "make space" for subsequent pulses. Other discussions focused on the structural and petrologic importance of local magmatic structures and magmatic fabrics and how these can be used as tools to evaluate the growth and evolution of these magmatic systems.

Day 5 was organized by Scott Paterson, who led the group on a hike along Sawmill Canyon near and into the eastern edge of the TIC. We started at the Triassic base of the arc, which unconformably overlays Paleozoic strata, and hiked up the steeply tilted section of Triassic, Jurassic, and Cretaceous volcanic and sedimentary strata to where the eastern margin of the TIC intrudes and cuts out parts of the Cretaceous and Jurassic sections. The large Steelhead Lake shear zone cuts across this volcanic arc section, exhibiting a more distributed, ductile expression and a younger, narrower, brittle expression, with a number of discrete brittle fault splays with impressive quartz vein breccias and pseudotachylite localities. Participants spent the afternoon looking at an amazing collection of magmatic structures (layering, tubes, troughs, pipes, diapirs, magmatic folds, and faults) in the Sawmill Canyon sheeted complex, a spot where the older Kuna Crest and Half Dome units are abruptly truncated by porphyritic Half Dome and Cathedral Peak magmas.

Day 6 ended the field forum with the conveners presenting large, synthesized datasets collected at the arc scale (e.g., geochronology, geochemistry, structures, strain, emplacement, numerical modeling), plus comparisons of the different intrusive

Participants: *From left to right, upper row:* John Bartley, Norbert Gajos, Philip Ruprecht, Barry Walker, Chip Lesher, Gareth Davies, Roland Mundil, Ryan Ickert, Ryan Taylor, Jesse Hahm, Calvin Barnes, Adam Kent, Rose Turnbull, Michelle Gevedon, Scott Paterson. *Middle row:* John Williams, Keith Putirka, Sergio Rocchi, George Bergantz, Bill Leeman, Greg Dunning, David Greene, Moritz Kirsch, Bill Hirt, Mark Brandriss, Monte Marshall, Ian Hagmann, Graham Andrews, Harold Stowell, Karen Parker, Oliver Jagoutz, Jill vanTongeren, John Neil, Bob Hildebrand, Bob Wiebe, David Mustart, Craig Lundstrom, Bob Miller, Ben Clausen, Sam Coleman. *Lower row:* Giorgio Pennacchioni, Erik Klemetti, Dave Westerman, Chunzeng Wang, Stacy Phillips, Jonathan Miller, Peter Lipman, Laura Waters, Laura Bilenker, Callie Sendek, Claire McLeod, Crystal Hout, Wenrong Cao, Xiaofei Pu, Rebecca Lange. *Not pictured:* Greg Stock, Jade Star Lackey, and Vali Memeti.

suites seen during Days 1–5, in order to discuss arc-scale magmatism and tectonic processes and their tempos in the Sierra Nevada arc. Discussions were carried out at scenic stops at June Lake, Lee Vining Canyon, Olmsted Point, Tenaya Lake, and Yosemite Valley.

In summary, much of what was discussed during the field forum concerned the building and evolution through time of the Sierran arc at scales ranging from parts of individual intrusive suites to a large section of the arc. Also discussed were the connections of these magmatic systems to different melt sources, to the intruded crustal columns, and to the once overlying volcanic section. Comparisons with other ancient and modern arcs were drawn and differences and similarities established. The incremental growth of the Sierra Nevada arc and enclosed magmatic systems emphasized the importance of temporally constrained datasets, and discussions focused on the shape and frequency of the intruding magma pulses, the resulting size and duration of magmatic activity of an individual magma body, and its interconnectedness with the greater magmatic system in both horizontal and vertical dimensions through time.

Participants recognized the variations in the degree of magmatic interaction at the emplacement level in different intrusive suites (e.g., significance of mixing, mingling, magmatic recycling, and crustal assimilation in the upper crustal GIC versus mid-crustal FGIS or TIC). Episodes of rotations of host rock units to steep dips, regional faulting, and host rock strain during contraction (Triassic) to dextral transpression (Cretaceous) and downward displacement of host rock and magmatic material during the rise of magmas were stressed as an important mechanism of material transfer in the Sierra Nevada. When viewed in 4-D at arc scales, it becomes apparent that these processes in the magmatic bodies and the host rocks are interconnected and undergo temporal patterns or “arc tempos,” creating mutual feedbacks and resulting in a waxing and waning of magmatism and tectonism in the arc. The discussion of the underlying causes of arc tempos had just begun during the latter stages of this field forum, and much remains to be studied. We hope to see you in the field to continue the discussions!

ACKNOWLEDGMENTS

The forum conveners gratefully acknowledge financial support for students and early postdocs from GSA, NSF EAR 1247432, REU funding from the Petrology and Geochemistry panel, and TecTask. Thanks also to the Mineralogy, Geochemistry, Petrology, and Volcanology (MGPV) Division of GSA for providing the two best student poster presentations awards. This report was written by Vali Memeti.

Read more about this trip at http://geosociety.wordpress.com/2012/10/03/gsa-sierra-nevada-field-forum/.

CRITICAL MINERAL RESOURCES

GSA members are invited to submit comments and suggestions regarding the following Position Statement DRAFT by 15 March 2013. Go to www.geosociety.org/positions/ to learn more and submit comments.

Position Statement

Mineral resources are essential to modern civilization; a thorough understanding of their distribution, consequences of their use, and the potential effects of mineral supply disruption is important for sound public policy.

Purpose

This position statement (1) summarizes the consensus views of The Geological Society of America on critical minerals resources; (2) advocates better understanding of their distribution, potential for supply disruption, and consequences of use; (3) encourages educational efforts to help the general public, lawmakers, and other stakeholders understand that mineral resources are used in almost every aspect of their daily lives, including modern technology, housing, transportation, information systems, and defense; (4) recommends enhanced assessment of critical mineral resources and the potential for supply disruption, scientific investigation of non-conventional resources, better understanding of the full life-cycle consequences of use, and international collaboration; and (5) provides a communications tool for geoscientists and general GSA member use.

Rationale

Demand for a variety of mineral resources, such as rare earth elements (REE), platinum group elements (PGE), cobalt, beryllium, lithium, and iodine has increased with the continued consumption in developed economies and the emergence of Brazil, China, India, and other developing economies (Price, 2010). These elements are crucial to a variety of manufacturing, high-tech (National Research Council, 2008), and military applications (U.S. DOE, 2010; Parthemore, 2011). Demand for energy-related minerals has increased as global energy production diversifies beyond carbon- and nuclear-based sources. For example, REEs are used in many renewable energy devices, including high-strength magnets for wind-power generators, and lithium is used in electric car batteries. In addition, photovoltaics, computers, cell phones, phosphors, liquid crystal displays (LCD), and other components crucial to a high-tech, low-carbon, sustainable future require increased production and/or recycling of REEs, PGEs, lithium, tellurium, gallium, and other elements (CCD, 2010). A stable supply of mineral resources is essential for economic prosperity and national security.

The mineral production that supplies many of these elements is concentrated in certain countries. For example, China produces >95% of the global REE supply (Tse, 2011), the United States produces >85% of the world beryllium supply (USGS, 2012), and nearly 80% of global platinum production is in South Africa (APS/MRS, 2011). Furthermore, reserves of some elements are often concentrated in one location (e.g. platinum in South Africa and lithium in South America; Tahil, 2007). The tenuous nature of the mineral supply chain was highlighted in 2010 when China stopped exporting REEs to Japan for almost two months (Bradsher, 2010).

Geoscientists have a prominent role in the exploration for, management of, and environmentally safe handling of critical mineral resources. To provide a solid base for the future, it is necessary to identify the global distribution, potential for supply disruption, and environmental consequences of the use of these resources. These needs will become even more important as the world's population and standards of living continue to increase.

In 2008, the National Research Council issued a report defining a critical mineral as one that is both essential in use and subject to the risk of supply restriction. Subsequently, this has been expanded to include other factors, such as environmental impacts (Graedel et al., 2012). However, the concept of criticality is context specific and dynamic. For example, what is critical for a specific manufacturer or product may not be critical for another, what is critical for a state may not be critical for a country, and what is critical for national defense may be different than what is necessary to make a television brighter or less expensive. Nonetheless, the notion that minerals are critical to society is valid and has important implications for our economic prosperity.

Recommendations

Government, educational, and private sector organizations, individually as well as collectively, should address the following critical resource challenges:

1. **Assessment of mineral resources**—There is a vital need to understand the abundance and distribution of critical mineral resources, both within the United States and globally. Sufficient funding to ensure that this task is met by federal agencies, such as the U.S. Geological Survey, is required.
2. **Life-cycle assessment**—Governments need to devote sufficient resources to define critical elements and support research and development that allow for economically efficient and environmentally sound mineral discovery and development, mineral processing technology advances, and materials manipulation, including recycling to meet national needs.
3. **Sustainability**—The adequacy of mineral resources at a given moment in time is important but should not substitute for a longer-term view of finite global resources in the context of population growth and rising standards of living. The world is not likely to run out of mineral resources in a broad sense, but shortages of particular resources at a specific time and place are likely. Advances in technology will make many marginal resources economic, and price changes will alter the use and desirability of some elements. Substitution and recycling will also affect the need for newly mined mineral resources.
4. **Education**—Although there is growing awareness of the importance of energy to our nation's future, there is less

appreciation of the impact of mineral resources on the nation's health and well-being and the fundamental role of minerals in industrial development. Efforts to ensure a better-educated public in regard to mineral resources are important.

5. **International collaboration**—Modern society depends on critical minerals. However, such resources are heterogeneously distributed across the planet. The most common supply risks for critical minerals may be reduced through open communication and collaboration across borders.

Opportunities for GSA and GSA Members to Help Implement Recommendations

To facilitate implementation of the goals of this position statement, The Geological Society of America recommends that its members take the following actions:

- Support funding for geoscience organizations (federal, state, and provincial governments) and academic institutions involved in understanding the global distribution of mineral resources.
- Encourage companies and governments to collaborate internationally and share information that helps society understand the limitations and potentials of mineral-resource development.
- Encourage research and data gathering to determine which mineral resources are "critical" from different private sector and governmental perspectives.
- Encourage research on the consequences of exploiting resources in different environments and on new opportunities for substitution, recycling, and the discovery of new types of resources.
- Promote the inclusion of mineral-resource information (global distribution, use and criticality for society, consequences of use, etc.) in educational materials at the K–12 and college levels and in popular media.

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2013 GSA Section Meeting Calendar

Northeastern
18–20 March
Bretton Woods, New Hampshire, USA

Southeastern
20–21 March
San Juan, Puerto Rico

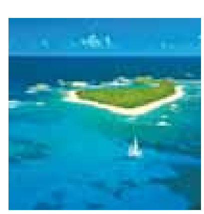
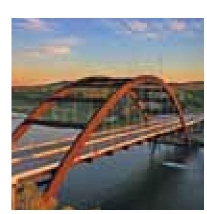
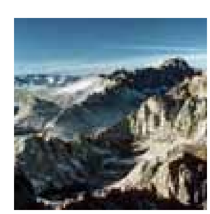
South-Central
4–5 April
Austin, Texas, USA

North-Central
2–3 May
Kalamazoo, Michigan, USA
Abstracts deadline: 5 February

Rocky Mountain
15–17 May
Gunnison, Colorado, USA
Abstracts deadline: 12 February

Cordilleran
20–22 May
Fresno, California, USA
Abstracts deadline: 19 February

International
Roof of the World
17–19 June
Chengdu, Sichuan Province, China
Abstracts deadline: 15 March

www.geosociety.org/Sections/meetings.htm

GSA Position Statements

GSA Council recently approved revised versions of the following Position Statements. Full versions of the statements are online at **www.geosociety.org/positions/.** GSA members are encouraged to use the statements as geoscience communication tools when interacting with policy makers, students, colleagues, and the general public. In addition to the statements below, Council endorsed an updated statement by AGU and SSA titled "Monitoring the Comprehensive Nuclear-Test-Ban Treaty" (see www.geosociety.org/positions/position14.htm).

GEOSCIENCE DATA PRESERVATION

GSA supports the preservation of geoscience samples and data sets for the public good and urges public and private sector organizations and individuals to routinely catalog and preserve their collections and make them widely accessible.

OPEN DATA ACCESS

GSA strongly supports open access to scientific data to promote advancement in research, support education, and improve the economic progress, health, and welfare of society.

REWARDING PROFESSIONAL CONTRIBUTIONS

GSA affirms and supports positive contributions to geoscience, public perception of the geosciences, and the professional stature of individual geoscientists, all of which are derived from the time, effort, talent, and scholarly activity invested by geoscientists in public policy, education, and research on teaching and learning. As such, GSA recommends that geoscientists in academia and government service receive formal recognition and reward for such efforts through positive performance evaluations, reappointments, promotions, and tenure reviews. GSA also encourages support, by means of appropriate reassigned time or travel assistance, to those individual geoscientists engaged in substantive scholarly and professional activity on issues of public policy, education, and research on teaching and learning.

TEACHING EVOLUTION

GSA strongly supports the teaching of evolution and the directly related concept of deep time as part of science curricula at all levels of education. The evolution of life on Earth stands as one of the central concepts of modern science. During the past two centuries, research in geology, paleontology, and biology has produced an increasingly detailed, consistent, and robust picture of how life on Earth has evolved. GSA opposes teaching creationism alongside evolution in any science classroom and rejects the characterization of evolution as scientifically controversial. Science, by definition, is a method of learning about the natural universe by asking questions in such a way that they can be answered empirically and verifiably. If a question cannot be framed so that the answer can be tested, and the test results can be reproduced by others, then it is not science. Creationism, whether presented as creation "science," intelligent design, or hydroplate theory, attempts to explain complicated phenomena of the natural world by invoking a creator or designer. Creationism is not science because it invokes supernatural phenomena that cannot be tested. It therefore has no place in a science curriculum. Because science is limited to explaining natural phenomena through the use of empirical evidence, it cannot provide religious explanations. Science teachers should not advocate any religious interpretations of nature and should be nonjudgmental about the personal beliefs of students.

If you have questions or comments, please contact GSA's Director for Geoscience Policy, Kasey S. White, in GSA's Washington D.C. office, 1200 New York Avenue NW, Suite 400, Washington, DC 20005, +1-202-669-0466, kwhite@geosociety.org.

Final Announcement &
Registration Information

SOUTH-CENTRAL

47th Annual Meeting
Austin, Texas, USA
4–5 April 2013

www.geosociety.org/Sections/sc/2013mtg/

Cattle in Wildfowers. Photo by Dan Herron, HerronStock.com. Used with permission of the Austin CVB.

LOCATION

The Jackson School of Geosciences at The University of Texas at Austin welcomes you to celebrate the 125th Anniversary of The Geological Society of America in Texas' capital city. Austin is the gateway to the Texas Hill Country, with rolling hills, sparkling waterways, and fascinating geology.

REGISTRATION

Early registration deadline: 4 March
Cancellation deadline: 11 March
Registration fees (all fees in U.S. dollars)

	EARLY		STANDARD	
	Full Mtg.	**One Day**	**Full Mtg.**	**One Day**
Professional Member	$140	$100	$160	$120
Professional 70+	$90	$70	$120	$90
Professional Nonmember	$170	$120	$210	$140
Student Member	$55	$40	$70	$50
Student Nonmember	$70	$50	$85	$60
K–12 Teacher	$45	$35	$60	$45
Guest/Spouse	$35	n/a	$45	n/a
Field Trip/Short Course only	$35	n/a	$45	n/a

KEYNOTE SPEAKERS

Astronaut Serena Aunon M.D.: "Doc on the Ice—Antarctic Search for Meteorites, 2010–2011 Field Season"
Cliff Frohlich: "Texas Earthquakes: Natural and/or Man Made?"
John Dewey: "Advances in Structural Geology"

HOT TOPICS

1. **Texas Earthquakes: Natural and/or Man Made?** This talk by Cliff Frohlich of the Institute for Geophysics at The University of Texas at Austin will center on controversies surrounding the presence, nature, and potential sources of earthquakes in Texas.
2. **Drought Decision Making: Analysis of the Effectiveness of Planning for Dry Times through a Review of the Response to the Historical 2011 Drought in Texas.** Panelists will draw from the experiences of those who led the state's response to the 2011 drought and discuss implications for future drought event planning.
3. **The Ophiolite Enigma Resolved.** This talk by John Dewey of London's Natural History Museum will focus on the origins of ophiolites and suggest that none represent obducted sheets from the young oceanic crust and mantle of large oceans.

THEME SESSIONS

T1. **Tectonic Evolution of South-Central Laurentia: Megacontinents and Exotic Terranes, Orogenic Belts and Rifts: Celebrating the Career of Wm. R. Muehlberger.** Ian W.D. Dalziel, Univ. of Texas at Austin, ian@utig.ig.utexas.edu; Staci Loewy Mickler, Univ. of Texas at Austin, sloewy@jsg.utexas.edu; Patricia Wood Dickerson, AGI and Univ. of Texas at Austin, patdickerson@earthlink.net.

T2. **Origins of Granites: A Tribute to Chappell and White.** David London, Univ. of Oklahoma, dlondon@ou.edu; Calvin G. Barnes, Texas Tech Univ., Dept. of Geosciences, cal.barnes@ttu.edu.

T3. **Teaching Central Texas Geology: Honoring the Career of Leon Long.** Hilary Olson, Univ. of Texas at Austin, hilaryclementolson@gmail.com; Laurie Schuur Duncan, Univ. of Texas at Austin, laurieduncan@jsg.utexas.edu.

T4. **The Paleontology of Texas: A Session in Honor of Wann Langston Jr.** Michelle R Stocker, Univ. of Texas at Austin, mstocker@utexas.edu; William Parker, Univ. of Texas at Austin; Ernie Lundelius, Univ. of Texas at Austin, erniel@utexas.edu; Chris Brochu, Univ. of Iowa, christopher-brochu@uiowa.edu.

T5. **The Ouachita Orogenic Belt: Structure, Foreland Basins, Tectonics, and Geophysics.** Ibrahim Çemen, Univ. of Alabama, icemen@as.ua.edu; Gregory Dumond, Univ. of Arkansas, gdumond@uark.edu; Randy Keller, Univ. of Oklahoma, grkeller@ou.edu.

T6. **Delving Deeper into Petrogenesis: Advances in Petrology and Geochronology with Applications to Tectonics.** Jeff Marsh, Univ. of Texas at Austin, jhmarsh@jsg.utexas.edu; David Young, Univ. of Texas at San Antonio, david.young@utsa.edu; Eric Kelly, Univ. of Texas at Austin, eric.kelly@utexas.edu; Spencer Seman, Univ. of Texas at Austin, spencer.seman@gmail.com.

T7. **New Ideas about the Geologic Evolution and Petroleum Potential of the Gulf of Mexico.** Robert J. Stern, Univ. of Texas at Dallas, rjstern@utdallas.edu; Peter D. Clift, Louisiana State Univ., pclift@lsu.edu.

T8. **Novel Geochemical and Isotopic approaches to Reconstructing Sedimentary Provenance, Sediment Dispersal, and Paleogeography of the Gulf of Mexico.** Daniel Stockli, Univ. of Texas at Austin, stockli@jsg.utexas.edu; John Snedden, Univ. of Texas at Austin, jsnedden@utig.ig.utexas.edu.

T9. **Temporal and Kinematic Linkage between Rifting in the Gulf of Mexico and U.S. Atlantic Margins and the Influence of CAMP.** Harm Van Avendonk, Univ. of Texas at Austin, harm@ig.utexas.edu; and Daniel Stockli, Univ. of Texas at Austin, stockli@jsg.utexas.edu.

T10. **Results from EarthScope and Related Studies in the South-Central United States.** Jay Pulliam, Baylor Univ. and Univ. of Texas at Austin, jay@ig.utexas.edu; Harold Gurrola, Texas Tech Univ., harold.gurrola@ttu.edu.

T11. **Magmatic and Metamorphic Petrology in the South-Central United States.** Callum J. Hetherington, Texas Tech Univ., callum.hetherington@ttu.edu; Kenneth Johnson, Univ. of Houston Downtown, johnsonk@uhd.edu.

T12. **Desired Future Conditions and Modeled Available Groundwater: The New Groundwater Management Paradigm in Texas.** W.F. (Kirk) Holland, Barton Springs/Edwards Aquifer Conservation District, kholland@bseacd.org; John Dupnik, Barton Springs/Edwards Aquifer Conservation District, jdupnik@bseacd.org.

T13. **The Role of the Geosciences in Water Sustainability: Examples, Challenges, and Societal Impacts.** David M. Borrok, Univ. of Louisiana at Lafayette, dborrok@gmail.com; Durga D. Poudel, Univ. of Louisiana at Lafayette, ddpoudel@louisiana.edu; Johnathan R. Bumgarner, USGS, jbumgarner@usgs.gov.

T14. **Proxy Records of Abrupt Holocene Climate and Environmental Change.** Mark R. Besonen, Texas A&M Univ. at Corpus Christi, mark.besonen@tamucc.edu; Peter D. Clift, Louisiana State Univ., pclift@lsu.edu; Rong Fu, Univ. of Texas at Austin, rongfu@jsg.utexas.edu.

T15. **Climate Change, Earth Process, and Human Impacts in Determining Earth's Landscapes.** Rong Fu, Univ. of Texas at Austin, rongfu@jsg.utexas.edu; Suzanne A. Pierce, Univ. of Texas at Austin, suzpierce@jsg.utexas.edu.

T16. **Scientific Ocean Drilling and the Reconstruction of Past Environments.** Debbie Thomas, Texas A&M Univ.–College Station, dthomas@ocean.tamu.edu; Peter D. Clift, Louisiana State Univ., pclift@lsu.edu.

T17. **Coastal and Estuarine Sedimentary Processes in Modern and Holocene Systems.** Tim Dellapenna, Texas A&M Univ.–Galveston, dellapet@tamug.edu; Elizabeth Heise, Univ. of Texas at Brownsville, elizabeth.heise@utb.edu.

T18. **Reefs and Reef-Like Structures of the Southwestern USA: Their Current Economic Value and Deep Time Biological Implications.** Ann Molineux, Univ. of Texas at Austin, annm@austin.utexas.edu; Robert W. Scott, Univ. of Tulsa, rwscott@cimtel.net.

T19. **From Micro to Nano: Applications of Electron Microbeam Techniques in the Geosciences.** Donggao Zhao, Univ. of Texas at Austin, dzhao@jsg.utexas.edu; George Morgan, Univ. of Oklahoma, gmorgan@ou.edu; Terry Colberg, Oklahoma State Univ., terry.colberg@okstate.edu.

T20. **Frontiers in 3-D Imaging for Geoscience.** Rich Ketcham, Univ. of Texas at Austin, ketcham@jsg.utexas.edu.

T21. **Fractures, Faults, and Fluids: From Observations to Numerical Models.** Estibalitz Ukar, Univ. of Texas at Austin, esti.ukar@gmail.com; John M. Sharp, Univ. of Texas at Austin, jmsharp@jsg.utexas.edu.

T22. **Nano-Petrophysics and Fluid Flow in Porous Media.** Qinhong (Max) Hu, Univ. of Texas at Arlington, maxhu@uta.edu.

T23. **Soil as a Mediator of Geological Processes.** M.H. Young, Univ. of Texas at Austin, michael.young@beg.utexas.edu; T.G. Caldwell, Univ. of Texas at Austin, todd.caldwell@beg.utexas.edu.

T24. **Building Comprehensive Models of Epicratonic Paleoenvironments from Integrated, Basin-Scale, Lithostratigraphic and Chemostratigraphic Datasets.** Harry Rowe, Univ. of Texas at Austin, hrowe@uta.edu; Stephen Ruppel, Univ. of Texas at Austin, stephen.ruppel@beg.utexas.edu.

T25. **New Directions on Basin Analysis: Linking Structure with Stratigraphy Using Geochemical and Isotopic Techniques.** Edgardo Pujols, Univ. of Texas at Austin, edgardopujols@utexas.edu; Josh Burrus, Univ. of Texas at Austin, josh.burrus@utexas.edu; Michael Gordon Prior, Univ. of Texas at Austin, mprior@utexas.edu.

T26. **Engaging the Next Generation of Geoscientists.** Kathy Ellins, Univ. of Texas at Austin, kellins@ig.utexas.edu; Laurie Serpa, Univ. of Texas at El Paso, lfserpa@utep.edu.

T27. **Confronting the Challenges of Climate Literacy.** Alison Mote, The Ann Richards School for Young Women Leaders, Austin Independent School District, alison.mote@austinisd.org; Leslie Salter Vancleave High School, Jackson County School District, lsalter@jcsd.k12.ms.us.

T28. **Undergraduate Research.** Elizabeth Heise, Univ. of Texas at Brownsville, elizabeth.heise@utb.edu.

T29. **A Tale of Two Aquifers: Deciphering Characteristics of the Edwards and Trinity Aquifers in Central Texas.** Marcus Gary, Edwards Aquifer Authority, mgary@edwardsaquifer.org.

FIELD TRIPS

1. **Urban Hydrogeology of Austin, Texas.** Wed., 3 April. **Cost:** US$75; includes transportation, lunch, and a field guide. C.M. Woodruff, Jr., Univ. of Texas at Austin, chockw@swbell.net; Edward W. Collins; Raymond M. Slade Jr.
2. **The Llano Uplift, Central Texas: Field Trip for Teachers and Geologists at Any Level.** Sat., 6 April. **Cost:** US$100 (teachers: US$40, with up to 25 teachers at this rate); includes transportation, box lunch, water, and BBQ dinner at County Line on the Hill. Leon Long, Univ. of Texas at Austin, leonlong@jsg.utexas.edu; Laurie Schuur Duncan; Hilary Olson; Rich Ketcham.
3. **Late Cretaceous Strata and Vertebrate Fossils of North Texas.** Sat., 6 April. **Cost:** US$75; includes transportation from Southern Methodist Univ. in Dallas and to and from the field localities, lunch, and a field guide. Louis L. Jacobs,

Southern Methodist Univ., jacobs@smu.edu; Michael J. Polcyn; John Wagner; Dale Winkler.

4. **Friesenhahn Cave: Late Pleistocene Paleoecology and The Predator-Prey Relationships of Mammoths with the Extinct Scimitar Cat.** Sat., 6 April. **Cost:** US$75; includes transportation, lunch and beverages, fieldtrip guidebook, and supplemental materials. Russell W. Graham, EMS Museum, The Pennsylvania State Univ., rgraham@ems.psu.edu; Ernest L. Lundelius Jr.; Laurence Meissner.
5. **The Search for Devil's Eye: Retrace the Historic Dumble Survey with Modern Mobile Technology.** Sat., 6 April. **Cost:** US$220; includes transportation, canoe safety equipment and rental, lunch, and a field guide. Most of the time will be spent in canoes. Ann Molineux, Texas Natural Science Center, Univ. of Texas at Austin, annm@austin.utexas.edu; Louis Zachos; Unmil Karadker.
6. **Traversing the Trinity and Edwards Karst Aquifers along the Blanco River Basin.** Sat., 6 April. **Cost:** US$93; includes transportation, lunch, and a field guide. Marcus Gary, Edwards Aquifer Authority, mgary@edwardsaquifer.org.
7. **Late Cretaceous (Campanian) Submarine Volcanism and Associated Carbonate Deposition, Austin Area, Central Texas.** Sat., 6 April, **Cost:** US$95, includes transportation, lunch and beverages, fieldtrip guidebook, and supplemental materials. S. Christopher Caran, Texas Water Development Board, chris.caran@twdb.texas.gov; Alan J. Cherepon, Texas Commission on Environmental Quality, alan.cherepon@tceq.texas.gov.
8. **Basal Eocene Sabinetown Transgression in the Upper Wilcox Group of Central Texas, Bastrop County, Texas.** Sat., 6 April. **Cost:** US$70; includes transportation, lunch, and a field guide. Thomas E. Yancey, Texas A&M Univ.–College Station, tyancey@geos.tamu.edu.
9. **Geology and Geomorphology of the Enchanted Rock State Natural Area, Central Texas.** Sat., 6 April. **Cost:** US$90; includes transportation, lunch, a field guide, admission to the park, and snacks. Rob Reed, Univ. of Texas at Austin, rob.reed@beg.utexas.edu.
10. **Traverse of Tertiary Sedimentary Rocks (Paleocene-Miocene), Central Texas Gulf Coastal Plain.** Sat., 6 April. **Cost:** US$95, includes transportation, lunch, and a field guide. Earle F. McBride, Univ. of Texas at Austin, efmcbride@jsg.utexas.edu; Charles M. Woodruff.
11. **Carbon Capture and Geologic Storage: Global Research Centered in Texas.** Fri., 5 April. **Cost:** Free, but please mark your registration form if you are planning to attend. Includes hors d'oeuvres, beverages, and transportation. Susan Hovorka, The Univ. of Texas at Austin, susan.hovorka@beg.utexas.edu; Tip Meckel, The Univ. of Texas at Austin, tip.meckel@beg.utexas.edu.
12. **A Tale of Two Aquifers: Deciphering Characteristics of the Edwards and Trinity Aquifers in Central Texas.** Fri., 5 April. **Cost:** US$50; includes hors d'oeuvres, beverages, and entrance to the cave. Marcus Gary, Edwards Aquifer Authority, mgary@edwardsaquifer.org.

ACCOMMODATIONS

The meeting will be held at the AT&T Executive Education and Conference Center. A block of rooms have been reserved there *until 5 March* for US$189/night (standard king, standard double queens) and US$199–US$599/night for higher-end rooms. Twenty student-rated rooms have been reserved at US$169/night; for the code to reserve a student room, please e-mail a copy of a valid student ID and a statement from a faculty member to Elizabeth Catlos, ejcatlos@gmail.com.com. Guest rooms include free high-speed Internet; parking is $14/night with in & out privileges. To make reservations, go to http://tinyurl.com/cpm8gug or https://resweb.passkey.com/go/geosaa0413, or call +1-877-744-8822 and reference the program name "2013 Annual Meeting-South-Central GSA AT&T Center."

OPPORTUNITIES FOR STUDENTS

Mentor Programs

Cosponsored by GSA Foundation. For more information, go to www.geosociety.org/mentors/ or contact Jennifer Nocerino, jnocerino@geosociety.org.

Roy J. Shlemon Mentor Program in Applied Geosciences Luncheon: Thursday, 4 April. Students will have the opportunity to discuss career prospects and challenges with professional geoscientists from multiple disciplines over a FREE lunch.

John Mann Mentors in Applied Hydrogeology Program Luncheon: Friday, 5 April. Students interested in applied hydrogeology or hydrology as a career will have the opportunity to network with professionals in these fields over a FREE lunch.

Travel Grants

Deadline to apply: 4 March

The GSA Foundation has funds available for student travel grants. To qualify, you must be (1) the senior author and presenter of the paper; (2) a current student member of the South-Central Section; and (3) registered for the meeting. For more information, contact Jay Sims, wmjaysims@gmail.com.

Volunteering

The local committee and officers of GSA's South-Central Section are pleased to offer student volunteers free registration in return for ~6 hours of volunteer work. For more information, contact Jessica Smith, jsmith@jsg.utexas.edu.

Final Announcement & Call for Papers

NORTH-CENTRAL

47th Annual Meeting of the North-Central Section, GSA
Kalamazoo, Michigan, USA
2–3 May 2013

www.geosociety.org/Sections/nc/2013mtg/

The Great Lakes of North America, April 2005. Image Credit: Jeff Schmaltz; courtesy NASA.

LOCATION

The meeting will take place on the campus of Western Michigan University in Kalamazoo, Michigan, USA. Easily accessible by air, bus, and car, Kalamazoo is a vibrant small city with a relaxed atmosphere and a variety of restaurants, microbreweries, and cultural attractions. The meeting venue is the university's Fetzer Center conference center.

REGISTRATION

Early registration deadline: 1 April
Cancellation deadline: 8 April
REGISTRATION FEES (all fees are in U.S. dollars)

	EARLY		STANDARD	
	Full Mtg.	**One Day**	**Full Mtg.**	**One Day**
Professional Member	$195	$115	$215	$135
Professional Nonmember	$215	$135	$235	$155
Student Member	$55	$50	$65	$60
Student Nonmember	$75	$70	$90	$85
K–12 Teacher	$45	$30	$55	$40
Guest	$60	n/a	$70	n/a
Short Course/Field Trip only	$45	n/a	$55	n/a

ACCOMMODATIONS

Blocks of rooms have been reserved at the Holiday Inn Kalamazoo West, 2747 S. 11th Street, Kalamazoo, Michigan 49009, USA; +1-269-484-4950 (US$99 + tax), and the Red Roof Inn Kalamazoo West, 5424 W. Michigan Ave., Kalamazoo, Michigan 49009, USA; +1-269-375-7400 (US$64.99 + tax). Please mention the GSA meeting when making a reservation. Special room rates will be available until 9 April.

THEME SESSIONS

T1. **Advances in Glacial Sediment Characterization: Implications for Groundwater Flow and Contaminant Transport Modeling.** Larry Lemke, Wayne State Univ., ldlemke@wayne.edu; Remke Van Dam, Michigan State Univ., rvd@msu.edu.

T2. **Applications of Near-Surface Geophysics.** Bill Sauck, Western Michigan Univ., sauck@wmich.edu; Remke Van Dam, Michigan State Univ., rvd@msu.edu.

T3. **Applications of Stable Isotopes to Environmental Problems.** Eliot Atekwana, Oklahoma State Univ., eliot.atekwana@okstate.edu; R.V. Krishnamurthy, Western Michigan Univ., r.v.krishnamurthy@wmich.edu.

T4. **Quaternary Research in the Great Lakes Region I: The Pleistocene.** Randy Schaetzl, Michigan State Univ., soils@msu.edu; Catherine Yansa, Michigan State Univ., yansa@msu.edu.

T5. **Quaternary Research in the Great Lakes Region II: The Holocene.** Catherine Yansa, Michigan State Univ., yansa@msu.edu; Randy Schaetzl, Michigan State Univ., soils@msu.edu.

T6. **Quaternary Time Machine: Methods and Analyses of Soils and Sediments to Reveal Secrets of Past Environments.** M. Kathyrn Rocheford, Univ. of Iowa, kat-rocheford@uiowa.edu; Maija Sipola, Univ. of Iowa, maija-sipola@uiowa.edu.

T7. **Cultural Geology: Heritage Stone, Buildings, Parks, Exhibits, and More.** Nelson Shaffer, Indiana Geological Survey, shaffern@indiana.edu; Joe Hannibal, Cleveland Museum of Natural History, jhanniba@cmnh.org.

T8. **Addressing Environmental Aspects of Geology: Research, Pedagogy, and Public Policy.** Mike Phillips, Illinois Valley Community College, mike_phillips@ivcc.edu.

T9. **Sources, Transport, and Fate of Trace Elements and Organics in the Environment.** *Cosponsored by the International Association of GeoChemistry.* Ryan Vannier, Michigan State Univ., vannierr@msu.edu; Colleen McLean, Youngstown State Univ., cemclean@ysu.edu.

T10. **Mapping the Glacial Geology of the Great Lakes States.** *Cosponsored by the Great Lakes Geologic Mapping Coalition.* Kevin Kincare, USGS, kkincare@usgs.gov; Dick Berg, Illinois State Geological Survey, berg@isgs.illinois.edu.

T11. **Working with Pre-Service Teachers—Issues and Ideas.** Kyle Gray, Univ. of Northern Iowa, kyle.gray@uni.edu; Anthony Feig, Central Michigan Univ., anthony.feig@cmich.edu.

T12. **Research in Earth Science Education.** *Cosponsored by Central Section, NAGT.* Heather Petcovic, Western Michigan Univ., heather.petcovic@wmich.edu; Sandra Rutherford, Univ. of Wisconsin, srutherford@wisc.edu.

T13. **Innovative Earth Science Teacher Professional Development.** Mark Klawiter, Michigan Technological Univ., mfklawit@mtu.edu; Carol Engelmann; Emily Gochis; Erika Vye; Heather Petcovic; Stephen Mattox.

T14. **Teaching and Learning Earth Science: K–16 Educational Pedagogy.** *Cosponsored by North-Central Section, NAGT*). Katie Johnson, Eastern Illinois Univ., kjohnson4@eiu.edu; Stephen Mattox, Grand Valley State Univ., mattoxs@gvsu.edu.

T15. **Paleontology as a Murder Mystery: How the Study of Predation and Taphonomy Reveals the Means, Motives & Opportunities of Ancient Perpetrators and Their Victims.** Karen Koy, Missouri Western Univ., kkoy@missouriwestern.edu; Joseph E. Peterson, Univ. of Wisconsin–Oshkosh, petersoj@uwosh.edu.

T16. **Paleozoic Vertebrates: Evolution, Paleoecology, Systematics, and Assemblages.** Chuck Ciampaglio, Wright State Univ., chuck.ciampaglio@wright.edu.

T17. **Special Poster Session on Undergraduate Research (Posters).** Ed Hansen, Hope College, hansen@hope.edu; Robert Schuster, Univ. of Nebraska, rshuster@unomaha.edu.

T18. **Recent Advances in Exploration and Evaluation of Economic Mineral Deposits in the Upper Midwestern United States.** Joyashish Thakurta, Western Michigan Univ., joyashish.thakurta@wmich.edu.

T19. **Hydrogeologic Investigations for Improved Assessment of Water Availability and Use in the Glaciated United States.** Randall Bayless, USGS, ebayless@usgs.gov; Howard Reeves, USGS.

T20. **Applied Geology: Engineering, Environmental, Geotechnical, and Hydrogeology.** *Cosponsored by the Association of Environmental and Engineering Geologists.* Terry R. West, Purdue Univ., trwest@purdue.edu.

T21. **Field Trips, Guidebooks, and Apps: Exploring the Present, Past, and Future of Geological Field Trips and Field Trip Guidebooks.** Joe Hannibal. Cleveland Museum of Natural History, jhanniba@cmnh.org; Kevin R. Evans, Missouri State Univ., KevinEvans@missouristate.edu.

T22. **Topics in Vertebrate Paleontology**. Michael J. Ryan, Cleveland Museum of Natural History, mryan@cmnh.org; Evan Scott, Case Western Reserve Univ., ees20@case.edu.

SHORT COURSE

Rationale and Methods for Regional 3-D Geological Mapping. Wed., 1 May 1, 8 a.m.–5 p.m. Cost: US$50, includes workshop manual and breaks; lunch not included. Limit: 40. CEU: 0.8.

CORE WORKSHOP

The Carboniferous of the Michigan Basin: Mississippian (Osagean) Marshall through the Pennsylvanian (Morrowan-Atokan) Saginaw Formations. Sun., 5 May, 9 a.m.–4 p.m., MGREE Facility. Cost: US$75; includes workshop manual, lunch, and breaks.

FIELD TRIPS

1. **Kentland Quarry & Kentland, Indiana Impact Structure.** Sat., 4 May, 8 a.m.–6 p.m. Cost: US$115; includes field trip guide, transportation, lunch, and refreshments. John Weber, Grand Valley State Univ., weberj@gvsu.edu.
2. **The Detroit Salt Mine.** Sat., 4 May, 8 a.m.–6 p.m. Cost: US$105; includes field trip guide, transportation, lunch, and refreshments. William B. Harrison III, Michigan Geological Repository for Research and Education (MGREE), harrison@wmich.edu; E.Z. Manos (on-site leader), Detroit Salt Mine Company.
3. **Contrasting Terrains of the Lake Michigan and Saginaw Lobes in Southern Michigan.** Sat., 4 May, 8 a.m.–6 p.m. Cost: $125; includes field trip guide, transportation, lunch, and refreshments. Alan Kehew, Western Michigan Univ., alan.kehew@wmich.edu; Andrew Koslowski, New York State Museum–Albany, akozlows@mail.nysed.gov; Brian Bird, New York State Museum, bbird@nysed.gov; John Esch, Michigan Dept. of Environmental Quality, eschj@michigan.gov.
4. **Pennsylvanian Fluvial-Deltaic Depositional Systems in Central Lower Michigan: Sedimentology, Stratigraphy, and Hydrogeology of the Saginaw Aquifer.** Sat., 4 May, 8 a.m.–5 p.m. Cost: US$105, includes field trip guide, transportation, lunch, and refreshments. Peter J. Voice, Western Michigan Univ., peter.voice@wmich.edu; David Barnes, Michigan Geological Survey/Western Michigan Univ., dave.barnes@wmich.edu; Dave Westjohn; Amanda Walega; Niah Venable.
5. **Michigan Sand Dunes.** Sat., 4 May, 7 a.m.–7 p.m. Cost: US$125, includes field trip guide, transportation, lunch, and refreshments. Edward Hansen, Hope College, hansen@hope.edu.
6. **Geology and Slope Stability along the Lake Michigan Coastal Zone.** Sat., 4 May, 8 a.m.–5 p.m. Cost: US$105, includes field trip guide, transportation, lunch, and refreshments. Ronald Chase, Western Michigan Univ., ronald.chase@wmich.edu; James P. Selegean, U.S. Army Corps of Engineers, Detroit District.
7. **Spouse/Guest Trip to Frederik Meijer Gardens and Sculpture Park in Grand Rapids.** Sat., 4 May, 9 a.m.–5 p.m. Cost: US$50; includes transportation and admission.

OPPORTUNITIES FOR STUDENTS

Mentor Programs

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Roy J. Shlemon Mentor Program in Applied Geoscience Luncheon. Thursday, 2 May. Students will have the opportunity to discuss career prospects and challenges with professional geoscientists from multiple disciplines over a FREE lunch.

John Mann Mentors in Applied Hydrogeology Program Luncheon. Friday, 3 May. Students interested in applied hydrogeology or hydrology as a career will have the opportunity to network with professionals in these fields over a FREE lunch.

Travel Grants

Application deadline: 1 April
Learn more and apply at www.geosociety.org/Sections/se/2013mtg/students.htm.

About People

GSA member **Louis L. Jacobs** has been presented with the 2012 Science Teachers Association of Texas Skoog Cup for leadership in science education, advocacy for quality K–12 science education, contributions to professional science organizations, and development of effective programs for pre-service and in-service teachers of science. Jacobs is a professor in Southern Methodist University's (SMU) Roy M. Huffington Dept. of Earth Sciences and president of SMU's Institute for the Study of Earth and Man. The Skoog Cup is named for the first award recipient, Dr. Gerald Skoog, professor emeritus, Texas Tech University.

Learn more about the achievements of GSA members at **www.geosociety.org/news/memberNews.htm,** and send your stories to gsatoday@geosociety.org.

Final Announcement & Call for Papers

CORDILLERAN

109th Annual Meeting of the Cordilleran Section, GSA
Fresno, California, USA
20–22 May 2013

www.geosociety.org/Sections/cord/2013mtg/

Looking north toward Mount Whitney and the Sierra Nevada from Mount Langley, California, USA. Photo by Mel Stoutsenberger; used with permission via Wikimedia Commons.

LOCATION

Fresno is ideally located for exploring the best of Cordilleran geology—nestled at the foot of the Sierra Nevada yet still within a short drive time of the geologic wonders of the California Coast Ranges. The field trips for this meeting fully exploit these advantages. We expect guest activities to include tours of Yosemite and Sequoia–Kings Canyon National Parks.

REGISTRATION

Early Registration deadline: 15 April
Cancellation deadline: 22 April
REGISTRATION FEES (all fees are in U.S. dollars)

	EARLY		STANDARD	
	Full Mtg.	**One Day**	**Full Mtg.**	**One Day**
Professional Member	$160	$100	$195	$115
Professional Nonmember	$180	$140	$220	$170
Professional 70+	$65	$55	$70	$60
Student Member	$60	$45	$80	$55
Student Nonmember	$85	$65	$110	$80
K–12 Teacher	$50	$30	$60	$40
Guest/Spouse	$50	n/a	$60	n/a
Field Trip/Workshop Only	$35	n/a	$45	n/a

ACCOMMODATIONS

Hotel reservation deadline: 29 April

A large block of rooms is being held for the meeting at the Radisson Hotel and Conference Center, 2233 Ventura Street, Fresno, CA 93721, USA. Room rate: US$109 per night plus taxes, with free wireless high-speed Internet, and a complimentary airport/Amtrak/bus shuttle. Reserve your room via www.geosociety.org/Sections/cord/2013mtg/lodging.htm.

TECHNICAL PROGRAM

Abstract deadline: 19 February
Abstract submission fee: US$10 for students; US$15 for all others. Contact Nancy Wright, +1-303-357-1061, nwright@geosociety.org, if you are unable to submit your abstract online.

THEME SESSIONS

T1. **Tectonic Processes that Build the Stratigraphic and Structural Record of Ancient and Modern Convergent Margins.** David Scholl, USGS, dscholl@usgs.gov; Roland von Huene, Univ. of California Davis, rhuene@mindspring.com; Trevor A. Dumitru, Stanford, tdumitru@stanford.edu; John Wakabayashi, California State Univ. Fresno, jwakabayashi@csufresno.edu.

T2. **Mélanges: Comparison and Contrast between Circum-Pacific and Tethyan Chaotic Rock Bodies, and Modern Submarine Analogues.** Yildirim Dilek, Miami Univ., dileky@muohio.edu; Andrea Festa, Università di Torino, andrea.festa@unito.it; Yujiro Ogawa, Century Tsukuba-Miraidaira, fyogawa45@yahoo.co.jp.

T3. **Oceanic Petrogenesis of Pacific-Type Convergent Margins.** Tatsuki Tsujimori, Okayama Univ. Misasa, tatsukix@misasa.okayama-u.ac.jp; W.G. Ernst, Stanford, wernst@stanford.edu; John Wakabayashi, California State Univ. Fresno, jwakabayashi@csufresno.edu.

T4. **Ophiolites and Suture Zones.** Yildirim Dilek, Miami Univ., dileky@muohio.edu; John Wakabayashi, California State Univ. Fresno, jwakabayashi@csufresno.edu; John Shervais, Utah State Univ., john.shervais@usu.edu.

T5. **Critical Zone: Where Rock Meets Water and Life at Earth's Surface.** Clifford S. Riebe, Univ. of Wyoming, criebe@uwyo.edu; Leonard S. Sklar, San Francisco State Univ., leonard@sfsu.edu; Kate Maher, Stanford, kmaher@stanford.edu.

T6. **Using Detrital Zircon Age Data to Reassemble the Cordilleran Jigsaw Puzzle.** Trevor Dumitru, Stanford, tdumitru@stanford.edu; Elizabeth Miller, Stanford, elmiller@stanford.edu.

T7. **Hydrogeologic Issues of Irrigated Agricultural Regions—Problems and Solutions.** C. John Suen, California State Univ. Fresno, johns@csufresno.edu; Dong Wang, USDA Agricultural Research Service, dwang@fresno.ars.usda.gov.

T8. **Quantitative Approaches in Sedimentology and Stratigraphy.** Mara Brady, California State Univ. Fresno, mebrady@csufresno.edu.

T9. **AFC Processes in the Formation of Intermediate Magmas from Mantle to Crust.** Michael Farner, Rice Univ., mfarner01@gmail.com; Cin-Ty Lee, Rice Univ., ctlee@rice.edu.

T10. **Reconstructing the Pacific–North America Plate Boundary through Late Cenozoic Time.** Scott Bennett, Univ. of

California Davis, sekbennett@ucdavis.edu; Rebecca Dorsey, Univ. of Oregon, rdorsey@uoregon.edu; Michael Oskin, Univ. of California Davis, meoskin@ucdavis.edu; Michael Darin, ConocoPhillips, mike.h.darin@conocophillips.com.

T11. **The Engineering Geology of Transporting Water in the Western U.S.** Jerome V. De Graff, USDA Forest Service, jdegraff@csufresno.edu.

T12. **Quaternary Environmental Change; the Cordilleran Record and Its Implication for Our Future in a Changing World.** Peter K. Van de Water, California State Univ. Fresno, pvandewater@csufresno.edu; Mathieu Richaud, California State Univ. Fresno, mathieu@csufresno.edu.

T13. **Irvingtonian Paleoecology of Western North America.** Robert G. Dundas, California State Univ. Fresno, rdundas@csufresno.edu; Eric Scott, San Bernardino County Museum, escott@sbcm.sbcounty.gov.

T14. **Quaternary Geology of California's Central Valley and Its Relevance to Water Infrastructure.** Fugro Consultants Inc.: Justin Pearce, j.pearce@fugro.com; Janet Sowers, j.sowers@fugro.com; Jennifer Wilson, jm.wilson@fugro.com; and Cooper Brossy, c.brossy@fugro.com.

T15. **Undergraduate Research (Posters).** Chris Pluhar, California State Univ. Fresno, cpluhar@csufresno.edu.

FIELD TRIPS

1. **Critical Zones in the NW Sierra Nevada.** Sat.–Sun., 18–19 May. US$205. Beth Weinman, California State Univ. Fresno, bweinman@csufresno.edu.
2. **Granite, Glaciation, and Rockfall in Yosemite Valley, California.** Sat.–Sun., 18–19 May. US$205. Allen Glazner, Univ. of North Carolina–Chapel Hill, afg@unc.edu; Greg Stock, National Park Service, Yosemite National Park, greg_stock@nps.gov; Roger Putnam, Univ. of North Carolina–Chapel Hill, rputnam@live.unc.edu.
3. **From Deep to Modern Time along the Western Sierra Nevada Foothills between the San Joaquin and Kern River Drainages.** Sat.–Sun., 18–19 May. US$240. Jason Saleeby, Caltech, jason@gps.caltech.edu; Zorka Saleeby, Caltech, zorka@gps.caltech.edu; Frank Sousa, Caltech, sousa@gps.caltech.edu.
4. **Middle Irvingtonian Fairmead Landfill Fossil Site and Fossil Discovery Center of Madera County, California.** Sun., 19 May. US$50. Robert Dundas, California State Univ. Fresno, rdundas@csufresno.edu; James C. Chatters, California State Univ. Fresno Foundation, paleosci@gmail.com; Eric Scott, San Bernardino County Museum, escott@sbcm.sbcounty.gov.
5. **LOCKED ROCKS: Hard-to-Access Outcrops of the Mesozoic Metasedimentary Framework and Gabbroids of the Early Cretaceous Sierra Nevada Batholith.** Thurs., 23 May. US$70. Diane Clemens-Knott, California State Univ. Fullerton, dclemensknott@fullerton.edu; Jason Saleeby, Caltech, jason@gps.caltech.edu.
6. **New Views on the Evolution of the San Andreas Fault Zone in Central California and the Carrizo Plain.** Thurs.–Sat., 23–25 May. US$310. Sinan Akciz, Univ. of California Irvine, sakciz@uci.edu; Ramon Arrowsmith, Arizona State Univ., ramon.arrowsmith@asu.edu, Robert Zatkin.
7. **Mélanges, HP Metamorphism, Subduction Accretion and Erosion, Subduction Megathrusts, and Ophiolites: The Franciscan and Related Rocks**. Thurs.–Fri., 23–24 May. US$205. John Wakabayashi, California State Univ. Fresno, jwakabayashi@csufresno.edu.
8. **Debris Flows in Recently Burned Watersheds in the Southeastern Sierra Nevada.** Thurs.,–Sat., 23–25 May. US$250. Dave Wagner, California Geological Survey, dave.wagner@suddenlink.net; Jerry De Graff, Sierra National Forest, jdegraff@fs.fed.us; Jeremy Lancaster, California Geological Survey, jeremy.lancaster@conservation.ca.gov.

OPPORTUNITIES FOR STUDENTS

Mentor Programs

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Roy J. Shlemon Mentor Program in Applied Geoscience Luncheon, Monday, 20 May.

John Mann Mentors in Applied Hydrogeology Program Luncheon, Tuesday, 21 May.

Travel Grants

Application deadline: 15 April
Learn more and apply at www.geosociety.org/Sections/cord/2013mtg/students.htm.

Join GSA's Section Meeting Mentor Programs

Being a Mentor is a Rewarding Experience!

Looking north toward Mount Whitney and the Sierra Nevada from Mount Langley, California, USA—near the Cordilleran Section Meeting. Photo by Mel Stoutsenberger; used with permission via Wikimedia Commons.

"I have enjoyed volunteering as a mentor and realize the significance of sharing information with students."

"The students' questions were thought-provoking and they made me realize what a satisfying job I've got. I'd like to do this again!"

The Roy J. Shlemon Mentor Program in Applied Geoscience is designed to acquaint advanced undergraduate and beginning graduate students with careers in applied geoscience. The mentor's goal is to provide real-world information and insight, based on his or her own career, to which students may not be exposed through their academic experiences.

The John Mann Mentors in Applied Hydrogeology Program provides a forum for undergraduate and graduate students interested in hydrogeology or hydrology as a career to participate in informal conversation with professionals currently practicing in these fields.

Cattle in Wildfowers. Photo by Dan Herron, HerronStock.com. Used with permission of the Austin CVB. Austin, Texas, USA, is the location of the upcoming South-Central Section Meeting.

STUDENTS: INTERESTED IN WORKING IN APPLIED GEOLOGY?

Meet Your Career Mentors at Your Next GSA Section Meeting!
Program luncheons sponsored by the GSA Foundation.

Northeastern Section Meeting

Bretton Woods, New Hampshire, USA
Shlemon Program in Applied Geoscience Luncheon: Monday, 18 March
Mann Mentors in Applied Hydrogeology Luncheon: Tuesday, 19 March

Southeastern Section Meeting

San Juan, Puerto Rico
Shlemon Program in Applied Geoscience Luncheon: Wednesday, 20 March
Mann Mentors in Applied Hydrogeology Luncheon: Thursday, 21 March

South-Central Section Meeting

Austin, Texas, USA
Shlemon Program in Applied Geoscience Luncheon: Thursday, 4 April
Mann Mentors in Applied Hydrogeology Luncheon: Friday, 5 April

North-Central Section Meeting

Kalamazoo, Michigan, USA
Shlemon Program in Applied Geoscience Luncheon: Thursday, 2 May
Mann Mentors in Applied Hydrogeology Luncheon: Friday, 3 May

Rocky Mountain Section Meeting

Gunnison, Colorado, USA
Shlemon Program in Applied Geoscience Luncheon: Wednesday, 15 May
Mann Mentors in Applied Hydrogeology Luncheon: Thursday, 16 May

Cordilleran Section Meeting

Fresno, California, USA
Shlemon Program in Applied Geoscience Luncheon: Monday, 20 May
Mann Mentors in Applied Hydrogeology Luncheon: Tuesday, 21 May

If you are interested in becoming a mentor at one of the GSA Section Meetings, please contact Jennifer Nocerino at jnocerino@geosociety.org.

GSA Foundation Update

P. Geoffrey Feiss, GSA Foundation President

Happy 125th Birthday GSA!

GSA is celebrating its 125th anniversary in 2013. Are you wondering what to give GSA on such a momentous birthday? GSA and the GSA Foundation are asking GSA members and friends to **GIVE 125**! You can give what makes the most sense for you—dollars, time, possessions, or yourself. Our goal is for all GSA members to contribute in increments of 125 to show support for GSA during this anniversary year.

Contributions can be made by individuals or groups to meet the 125 goal. For example, members could pool their talents and tackle a project to get it to the 125 level as a group. GSA's birthday wish list includes

1. ***Dollars:*** In multiples of 125 (e.g., $\$125 \times 10^n$).
2. ***Time:*** Raise awareness of the geosciences by talking to K–12 students, social groups (e.g., Boy/Girl Scouts, Rotary clubs, etc.), legislators, congressional representatives, or members of the public, with the goal of connecting with 125 individuals.
3. ***Things:*** Donate geoscience materials such as rock and mineral samples, books, maps, or tools to local schools, community colleges, libraries, or other places in need. The goal would be to donate 125 items.
4. ***Yourself:*** Be creative and give through other types of geosciences community service in increments of 125. For example, contribute hours of volunteer tutoring of geosciences students, or provide descriptions of the geology for parks or trails, or develop lesson plans and labs for K–12 teachers, etc.

The possibilities are endless!

Again, the goal is to **GIVE 125!**

When you have completed your goal, or if you wish to contribute financially to our celebration, go to the GSA 125th Anniversary Web page, **www.geosociety.org/125/.** We will log your project and your name as a contributor into a database, and the cumulative results will be displayed online to track progress all year long. You can also make contributions directly to the GSA Foundation via **www.gsafweb.org** or via the coupon below. At the 2013 GSA Annual Meeting & Exposition in Denver, all participants will be recognized with a special memento. Please join us and **GIVE 125!**

FIELD OPPORTUNITIES

GSA/EXXONMOBIL FIELD AWARDS

Undergraduates, Graduate Students, and Faculty
Deadline to apply: 8 April
https://rock.geosociety.org/ExxonMobilAward/index.asp

The importance of field schools to practicing geologists is unquestionable, yet the opportunities to experience field geology are dwindling. The Geological Society of America (GSA), in cooperation with ExxonMobil, offers three programs to support and encourage field geology. This non-profit/industry collaboration has proven very successful and is now in its sixth year.

THE GSA/EXXONMOBIL BIGHORN BASIN FIELD AWARD

The GSA/ExxonMobil Bighorn Basin Field Award is a one-week field seminar that offers 20 undergraduate and/or graduate students and five faculty members a chance to receive a high-quality educational experience in the spectacular Bighorn Basin of north central Wyoming, USA. The course is free to accepted participants, and all transportation, meals, and living expenses are covered. The seminar focuses on multidisciplinary integrated basin analysis, and it enables awardees to study exposures of individual hydrocarbon system play elements, such as source, seal, reservoir, and structure, within a prolific hydrocarbon basin.

For more than a century, the Bighorn Basin has been studied by academic, industry, and government geoscientists, who have focused on the exceptional outcrop exposures, as well as subsurface borehole and seismic data. Our current understanding of the basin derives from both industry and academic perspectives.

This seminar is team-taught by four ExxonMobil professionals, who represent more than 100 combined years of research in integrated basin analysis, with specific skills in tectonics, geochemistry, structure, sequence stratigraphy, sedimentology, paleontology, hydrocarbon systems analysis, and integrated play analysis. GSA's role in this program is to select awardees and to handle all logistics.

Participants have said…

"The Bighorn Basin opportunity of last summer has had monumental impacts on my life. Thank you so much for this amazing award."

"The Bighorn Basin Field Award was one of the greatest field experiences I have ever had."

THE GSA/EXXONMOBIL FIELD CAMP SCHOLAR AWARD

The GSA/ExxonMobil Field Camp Scholar Award provides undergraduate students US$2,000 each to attend the field camp of their choice based on diversity, economic/financial need, and merit. Funds for this award have been provided by ExxonMobil; selection of awardees is completed by GSA.

Students have said…

"Were it not for this generous scholarship attending geology field camp would have been financially difficult. I sincerely thank both The Geological Society of America and ExxonMobil for their commitment to fostering geological science education with the field camp scholarship."

"Your support through this award has helped further my long-term goal of becoming a researcher, and for that I am grateful.

THE GSA/EXXONMOBIL FIELD CAMP EXCELLENCE AWARD

The GSA/ExxonMobil Field Camp Excellence Award provides one geologic field camp leader an award of US$10,000 to assist with their summer field camp, based on safety awareness, diversity, and technical excellence.

2012 Bighorn Basin Field Camp Awardees

supported by

THE GEOLOGICAL SOCIETY OF AMERICA®

ExxonMobil

Connect with GSA

through the Web and Social Media

www.geosociety.org/w2/

GSA TODAY

GSA Today, GSA's science and news magazine, is always open access at **www.geosociety.org/gsatoday/**. All back issues, from 1991 to the present, are now online.

GSA CONNECTION

GSA's monthly e-newsletter brings you current information on GSA programs, events, books, government, and international affairs, pending deadlines, and media coverage of GSA science. Read it now at **www.geosociety.org/GSA_Connection/**.

FACEBOOK

"Like" us on Facebook, **www.facebook.com/GSA.1888**, and find links to GSA publications, photos, event information, and more; plus, check out the GSA timeline, from 1888 to today.

LINKEDIN

GSA invites members and interested geoscience professionals to use **www.linkedin.com/groups/Geological-Society-America-1298547** for discussion and networking opportunities.

TWITTER

Follow @geosociety on Twitter. Peruse our profile, updates, and followers at **twitter.com/geosociety**. Most of GSA's 7,000+ followers are "geotweeps"—your fellow scientists, students, and colleagues.

PLUS: Send us your ideas for making GSA's yearlong 125th Anniversary Celebration something to remember for the next 125 years: e-mail GSA125@geosociety.org. Learn more at **www.geosociety.org/meetings/2013/**.

THE GEOLOGICAL SOCIETY OF AMERICA®
1888 125 Years 2013
CELEBRATING ADVANCES IN GEOSCIENCE

Classified Rates—2013

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

Classification	Per Line for 1st month	Per line each addt'l month (same ad)
Positions Open	$9.00	$8.75
Fellowship Opportunities	$9.00	$8.75
Opportunities for Students		
First 25 lines	$0.00	$4.75
Additional lines	$4.75	$4.75

Positions Open

TENURE-TRACK POSITION STRUCTURAL GEOLOGY APPLIED TO MINERAL DEPOSIT CHAIRE DE LEADERSHIP EN ENSEIGNEMENT VIRGINIA-GAUMOND DEPARTMENT OF GEOLOGY AND GEOLOGICAL ENGINEERING, UNIVERSITÉ LAVAL

The Department of Geology and Geological Engineering at Université Laval is seeking applications for a tenure-track faculty position in Structural Geology. Located in the heart of Quebec City, Université Laval is a major university recognized for its culture of excellence in teaching and research. The department is in the Faculty of Science and Engineering and has 11 full-time professors, including two research chairs, and excellent analytical and computing facilities.

Description

- Tenure-track faculty position, holder of the ***Chaire de leadership en enseignement Virginia-Gaumond***;
- Teach undergraduate and graduate courses in structural geology and tectonics;
- Develop a strong, funded, research program in structural geology with a focus on application to mineral deposits and contribute to the training of graduate students;
- Contribute to the academic life and administration of the department;
- Participate in the faculty's activities related to the *Chaires de leadership en enseignement* program.

Selection criteria

- Ph.D. in Earth Sciences or equivalent;
- Recognized expertise in structural geology/tectonics research applied to mineral deposits geology and mineral exploration;
- Excellent potential to develop a high level, funded, research program;
- Aptitude or experience in teaching university-level courses
- Strong interest to apply innovating teaching methods, including continuous education;
- Oral and written proficiency in French;
- Member of the Ordre des géologues du Québec or the Ordre des ingénieurs du Québec. A successful applicant who is not currently a member of either Order will have to meet this requirement before obtaining tenure.

Salary and benefits

- According to the collective bargaining agreement at Université Laval.

Recruitment calendar

- Deadline for application: 1 March 2013
- Expected start of position: 1 August 2013

Candidates should send a detailed curriculum vita in French, a description of their research expertise, their research plan and teaching philosophy, and the names and coordinates of three people who can provide references, either by e-mail to direction-ggl@listes.ulaval.ca or by mail to Marc Constantin, Chair, Département de géologie et de génie géologique, Université Laval, 1065, avenue de la Médecine, Québec (Québec) G1V 0A6 Canada.

Valuing diversity, Université Laval encourages all qualified individuals to apply, particularly women, visible and ethnic minorities, aboriginal persons, and persons with disabilities, but priority will be given to Canadians and Canadian permanent residents.

VISITING ASSISTANT PROFESSOR IN SEDIMENTARY GEOLOGY UNIVERSITY OF NEVADA LAS VEGAS

The Department of Geoscience at UNLV invites applications for a full time, 9-month, non-tenure track faculty position for the 2013–2014 academic year with the possibility of extension of funding for up to three years. Primary responsibilities are teaching of upper division and graduate courses in Sedimentary Geology. Additional responsibilities include introductory level courses for non-science majors, and participation in teaching field geology. Preferences will be given to applicants with expertise in field-based sedimentology/stratigraphy. The Department seeks a dynamic and enthusiastic individual with a commitment to undergraduate and graduate education. A minimum requirement is a Ph.D. degree in geoscience or sub-discipline of geoscience from a regionally accredited College or University. Salary is commensurate with qualifications and experience.

The department (http://geoscience.unlv.edu/) has an enthusiastic faculty of 21, undergraduate and M.S./Ph.D. degree programs, and state of the art laboratory facilities including stable isotope, argon geochronology, XRF/XRD, soils, and electron microprobe/SEM labs.

Application materials must include a cover letter, curriculum vitae, statement of teaching philosophy and interests, and contact information for five referees. To receive full consideration, application materials should be received by February 25, 2013. Materials should be addressed to Dr. Michael Wells (michael.wells@unlv.edu), and are to be submitted via online application at https://hrsearch.unlv.edu. For assistance with UNLV's online applicant portal, contact UNLV Employment Services at +1-702-895-2894 or hrsearch@unlv.edu.

Salary competitive with those at similarly situated institutions. Position is contingent upon funding. UNLV is an Equal Opportunity/Affirmative Action educator and employer committed to achieving excellence through diversity.

TENURE-TRACK ASSISTANT PROFESSOR POSITION IN GEOLOGY

University of Victoria

The School of Earth and Ocean Sciences at the University of Victoria invites applications for a Tenure Track Assistant Professor position in Geology to begin July 1st 2013. We seek applicants who work with the stratigraphic/sedimentary record. This could include sedimentary geochemistry, paleoclimate studies, surface/lithosphere structure, tectonics and geodynamics, and basin analysis. The successful candidate will develop a vigorous, independent, externally funded research program that complements our existing strengths by integrating fieldwork, laboratory analyses, and/or experiments and numerical modeling. It is also expected that the candidate will mentor graduate students and teach undergraduate and graduate courses, including geological field schools. A Ph.D. is required at the time of appointment and post-doctoral experience is desirable.

Applicants should submit a letter of application, CV, contact information (name, address, fax, e-mail) for three references, a two-page statement describing their teaching experience and philosophy, and a two page statement describing their current and future research direction. Applications should be sent to Dr. Stephen T. Johnston, Director, School of Earth and Ocean Sciences, University of Victoria, P.O. Box 1700, STN CSC, Victoria,B.C. V8W 2Y2, Canada; fax: 250-721-6200; email: seos@uvic.ca. Review of applications will begin on March 1, 2013, and continue until a suitable candidate is identified. Information about the department can be found at http://www.seos.uvic.ca/.

The University of Victoria is an equity employer and encourages applications from women, persons with disabilities, visible minorities, Aboriginal Peoples, people of all sexual orientations and genders, and others who may contribute to the further diversification of the University. All qualified candidates are encouraged to apply; however, in accordance with Canadian Immigration requirements, Canadians and permanent residents will be given priority.

PETROLEUM GEOCHEMIST
EXXONMOBIL UPSTREAM
RESEARCH COMPANY, HOUSTON

ExxonMobil Upstream Research Company has an immediate opening for a Petroleum Geochemist at its Upstream Research Laboratory located in Houston, Texas, USA.

The succesful candidate will conduct research and research applications in organic geochemistry. Our investigations focus on developing broad understanding and predictive models of geological processes involved in hydrocarbon systems ranging from deposition and evolution of source rocks, generation, expulsion and retention of oil and gas, and migration, accumulation, and alteration of hydrocarbons. Our research goals are tied to addressing both immediate concerns and emerging trends in exploration, development, and production.

Candidates should have the following qualifications:

- A Ph.D. in petroleum geochemistry, analytical chemistry, organic geochemistry or related field.
- Experience in one or more areas pertinent to petroleum geochemistry including but not limited to molecular geochemistry, stable isotope geochemistry, fluid inclusion analysis, and/or organic petrography.
- Experience in one or more analytical techniques including but not limited to chromatography, mass spectrometry, isotopic analysis, solid-state characterization, and/or organic petrography.
- Creative, adept at team work, and able to drive projects to completion.
- Strong communication, organization, and interpersonal skills.
- Industry or post-graduate experience in petroleum geochemistry and/or experience in integrated hydrocarbon systems analysis including basin modeling would be a plus.

The candidate filling this position will be expected to immediately contribute to on-going projects as well as formulate and direct future endeavors. Collaboration is required with corporation geoscientists and engineers with a broad range of disciplines, including organic geochemistry, stratigraphy, structural and regional geology, hydrocarbon-system integration, analytical chemistry, reservoir engineering, and production engineering.

Please submit your application and resume to our website: www.exxonmobil.com\ex. Please apply to Job No. 16211.

ExxonMobil is an Equal Opportunity Employer.

PETROGRAPHER/CONSULTANT
SIMPSON GUMPERTZ & HEGER (SGH)
WALTHAM, MASS., USA

Simpson Gumpertz & Heger (SGH) is actively recruiting an experienced candidate for a position as Petrographer/Consultant in our Waltham, MA office. SGH is a nationally known civil and structural engineering firm that works in all aspects of design, investigation, and rehabilitation of structures. At SGH, petrographers provide front-line collaborative support to our investigative teams as well as for external clients, including other engineering firms. The successful candidate will work on investigations of concrete, masonry, stone, and related construction materials.

Applicants should have at least 10 years of experience with stone and concrete petrography; meet the requirements of ASTM C856 and C295; and understand the use of supplemental testing and analytical techniques such as XRD, IR, SEM/EDS, and chemical testing. Exceptional communication skills, experience in research and investigations, and a demonstrated ability for managing and developing staff are also required skills.

To learn more about SGH and to apply for this position, please visit our website at www.sgh.com or email your resume to Stella Mereves-Carolan, Corporate Recruiter at smereves-carolan@sgh.com or Apply online at www.sgh.com.

Equal Employment Opportunities Employer.

PALEONTOLOGY /SEDIMENTARY GEOLOGY
POST-DOCTORAL TEACHER-SCHOLAR
CORNELL COLLEGE

Cornell College, a private undergraduate liberal arts college, seeks a Post-Doctoral Teacher-Scholar in paleontology/sedimentary geology. This 5/6th position (with possible renewal for a 2nd year) involves teaching four courses per year, including (over two years) invertebrate paleontology, historical geology, marine science, sedimentology/stratigraphy, an advanced elective, and an upper-level course for students pursuing independent research. Additional funds are available for the candidate to involve undergraduate students in independent research and to support conference attendance. A Ph.D. in geology with a specialization in paleontology, sedimentology, or a related field is required. Cornell College employs the distinctive "One Course at a Time" academic calendar. Teaching responsibilities begin in late August 2013.

Submit a letter of application, vita, graduate transcripts, statements of teaching philosophy and research interests, and two letters of reference (Word or PDF format) to apovey@cornellcollege.edu.

Consideration of applications will begin March 1st and continue until the position is filled.

Cornell is an AA/EO employer and encourages applications from women and minority candidates. Cornell complies with Iowa's smoke free air act.

For more information, please visit the website at www.cornellcollege.edu/academic-affairs/job-openings/index.shtml.

Philmont Scout Ranch Volunteer Geologist Program

Cimarron, New Mexico, USA

Sponsored by the Rocky Mountain Association of Geologists

Volunteer to teach and demonstrate area geology in back-country New Mexico this summer!

Philmont Scout Ranch is one of three national high-adventure bases owned and operated by the Boy Scouts of America. Located in the southern Sangre de Cristo Mountains of northern New Mexico, Philmont is a 137,000 acre ranch dedicated to outdoor activities. The twelve-day backpacking experience serves over 27,000 high-school-age boys and girls from all over the USA as well as several foreign countries. Learn more about the geology of the area at **http://pubs.usgs.gov/pp/pp_505/html/pdf.html.**

Fifty-four positions are open this year, to be filled on a first-come, first-served basis. Volunteers will receive a sign-up packet with scout applications (you have to be a scout, at least for the summer!), medical forms, and brochures in May 2013. Students who would like to volunteer must show proof of enrollment in a graduate-level program. The 2013 season begins on Saturday, 15 June; last week of the program begins on Saturday, 10 August.

For more information and to sign up, contact Ed Warner, P.O. Box 480046, Denver, CO 80248-0046, USA, +1-303-331-7737, ewarn@ix.netcom.com. Alternate contact: Bob Horning, P.O. Box 460, Tesuque, NM 87574, USA, +1-505-820-9290, rrhorning@gmail.com.

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GSA ELECTIONS

Elections begin 8 March 2013

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

In early March, you will receive a postcard with instructions for accessing your electronic ballot via our secure website, and biographical information on the nominees will be online for you to review at that time. Paper versions of both the ballot and candidate information will also be available.

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

2013 OFFICER AND COUNCIL NOMINEES

PRESIDENT
(July 2013–June 2014)
Suzanne Mahlburg Kay
Cornell University
Ithaca, New York, USA

VICE PRESIDENT/PRESIDENT ELECT
(July 2013–June 2014)
Harry (Hap) McSween
University of Tennessee–Knoxville
Knoxville, Tennessee, USA

TREASURER
(July 2013–June 2014)
Jon Price
Jonathan G. Price LLC
Reno, Nevada, USA

COUNCILOR POSITION 1
(July 2013–June 2017)

Elizabeth J. Catlos
The University of Texas at Austin
Austin, Texas, USA

Carmala N. Garzione
University of Rochester
Rochester, New York, USA

COUNCILOR POSITION 2
(July 2013–June 2017)

Neil Fishman
Hess Corporation
Houston, Texas, USA

H. Tom Kuper
Kuper Consulting LLC
Helena, Montana, USA

COUNCILOR POSITION 3
(July 2013–June 2017)

John J. Clague
Simon Fraser University
Burnaby, British Columbia, Canada

Brendan Murphy
Saint Francis Xavier University
Antigonish, Nova Scotia, Canada

Ballots must be submitted electronically or postmarked by 6 April 2013.

FUTURE GSA ANNUAL MEETINGS

Denver, Colorado, USA—125th Anniversary Event:
Celebrating Advances in Geoscience—Our Science, Societal Impact, and Unique Thought Processes:
27–30 October 2013

Vancouver, British Columbia, Canada:
19–22 October 2014

Baltimore, Maryland, USA:
1–4 November 2015

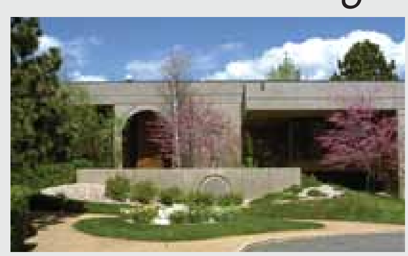
Denver, Colorado, USA:
25–28 September 2016

Seattle, Washington, USA:
22–25 October 2017

Indianapolis, Indiana, USA:
4–7 November 2018

Denver, Colorado, USA:
October 2019 (dates TBD)

NOTICE *of Spring 2013 GSA Council Meeting*



Meetings of the GSA Council are open to Fellows, Members, and Associates of the Society, who may attend as observers, except during executive sessions. Only councilors and officers may speak to agenda items, except by invitation of the chair.

Council will meet next on Saturday, 27 April, 3–4:30 p.m.; and Sunday, 28 April, 8 a.m.–noon. The GSA corporate meeting will be Saturday, 27 April, 4:30–5 p.m. All meetings will be held in the Boulder, Colorado, USA, area with exact locations to be announced at a later date.

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+1-303-357-1000, option 3, or +1-888-443-4472