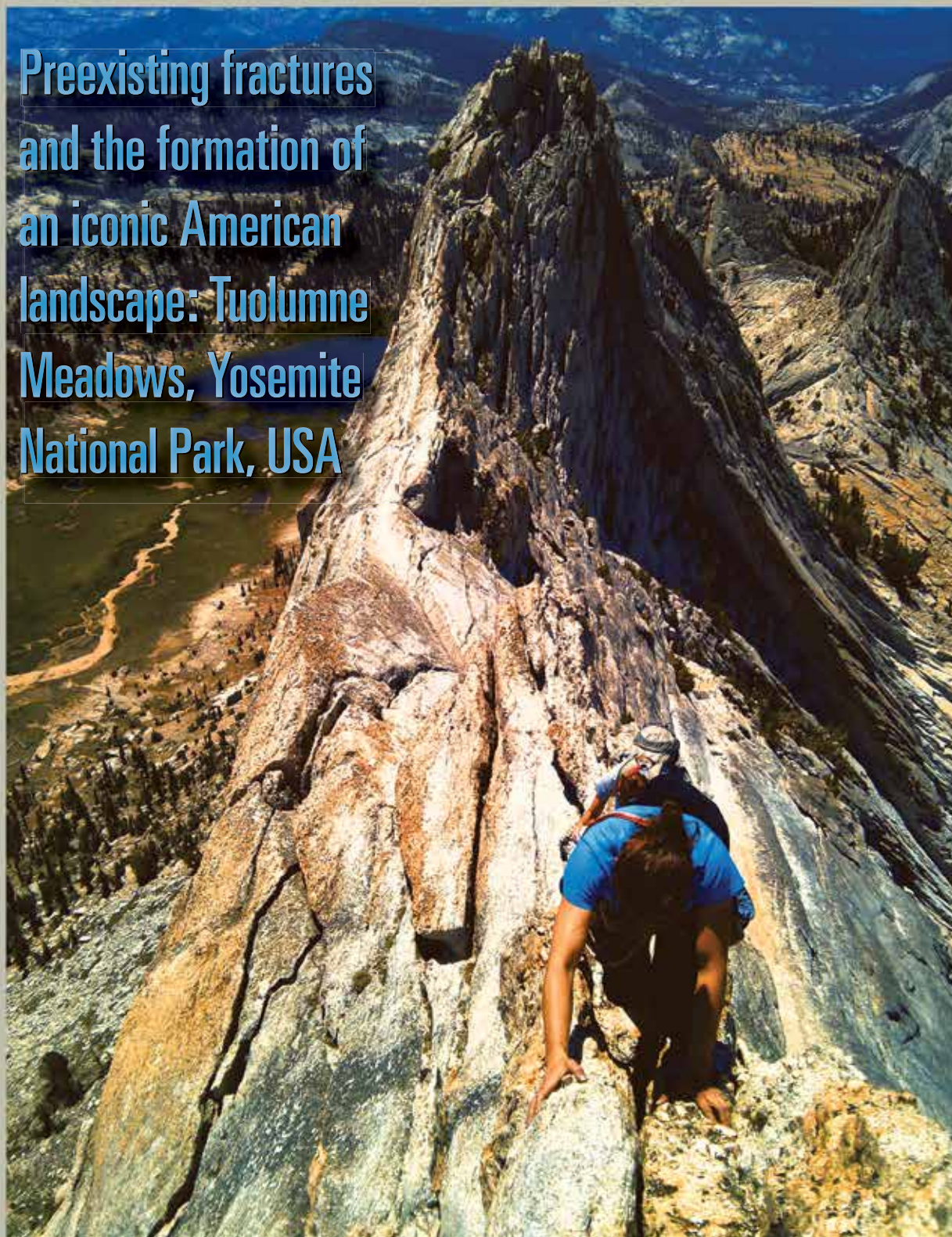


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Cover: Matthes Crest, just south of Tuolumne Meadows, is a famous climbing locality. The ridge owes its prominence to the glacial erosion of tabular fracture clusters lying on either side of it. Photo courtesy of Frank Klein. See related article, p. 4–10.



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Preexisting fractures and the formation of an iconic American landscape: Tuolumne Meadows, Yosemite National Park, USA

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ABSTRACT

Tuolumne Meadows, in Yosemite National Park (USA), is a large sub-alpine meadow in the Sierra Nevada Mountains. Immediately adjacent to Tuolumne Meadows—and underlain by the same bedrock lithology (Cathedral Peak Granodiorite)—are vertical rock faces that provide exceptional opportunities to climbers. While the presence of a broad meadow suggests bedrock erodibility, the vertical rock walls indicate bedrock durability. We propose that the Tuolumne Meadows's landscape is the result of variable glacial erosion due to the presence or absence of pre-existing bedrock fractures. The meadows and valleys formed because of concentrated tabular fracture clusters—a distinctive and locally pervasive type of fracturing—that were particularly susceptible to glacial erosion. In contrast, the vertical rock walls consist of sparsely fractured bedrock that was originally bounded by zones of pervasive tabular fracture clusters. Glacial erosion preferentially removed the highly fractured rock, forming prominent ridges in the upland surrounding Tuolumne Meadows. The orientation and spacing of the tabular fracture clusters, relative to ice flow, has exerted a fundamental control on the geomorphology of the area. The erosional variability exhibited by a single lithology indicates that the degree of fracturing can be more important than the host lithology in controlling landscape evolution.

INTRODUCTION

Tuolumne Meadows in Yosemite National Park is an iconic American landscape: It is a sub-alpine meadow surrounded by glacially sculpted granitic outcrops in the Sierra Nevada Mountains. Owing to its accessibility and aesthetic appeal, it has been a focal point for both vacationers (up to ~4,200 people per day according to a 2014 National Park Service report [p. ES-19]) and geological research in the Sierra Nevada (e.g., Coleman and Glazner, 1997; Loheide et al., 2009; Lowry et al., 2011). It also has historical significance; the idea for a Yosemite National Park came to John Muir and Robert Underwood Johnson over a campfire there (Duncan, 2009, p. 52).

As the largest sub-alpine meadow in the Sierra Nevada (Matthes, 1930, p. 15), Tuolumne Meadows is also a geomorphic anomaly (Fig. 1). The presence of broad and open topography is

commonly associated with bedrock erodibility (e.g., Augustinus, 1995; Glasser and Ghiglione, 2009; Krabbendam and Glasser, 2011). In contrast, the nearby vertical rock walls—including Cathedral Peak, Matthes Crest, and Lembert Dome—suggest bedrock durability. Despite these geomorphic differences, the entire region is underlain by the same lithology, the Cathedral Peak Granodiorite (Bateman, 1992).

In this paper, we present evidence that this anomalous landscape is the result of preferential glacial erosion of highly fractured bedrock. In particular, tabular fracture clusters (TFCs) are common in the Cathedral Peak Granodiorite in the Tuolumne Meadows area (Riley and Tikoff, 2010; Riley et al., 2011). TFCs are dense networks of sub-parallel opening-mode fractures that are clustered into discrete, tabular (book-like) zones. We conclude that Tuolumne Meadows resulted from ice flowing perpendicularly to high TFC concentrations. In contrast, ice flowing parallel to variable TFC concentrations formed the vertical rock walls. Thus, the exceptional rock climbing around Tuolumne Meadows is a direct result of fracture-controlled variations in erodibility—on the 10–100 m scale—within a single lithology. This finding supports the contention that landscape evolution is strongly controlled by bedrock fracturing (e.g., Matthes, 1930) and that tectonic processes that result in fracturing may generally exert a fundamental and underappreciated role in geomorphology (Molnar et al., 2007).

PREVIOUS WORK ON PREEXISTING FRACTURES AND GEOMORPHOLOGY IN YOSEMITE NATIONAL PARK

Yosemite National Park is justifiably known as the landscape of John Muir. Yet, it is equally the landscape of François Matthes, despite the fact that he is much less well known, even among geologists. Matthes studied Yosemite's geomorphology for 25 years (Schaffer, 1997, p. 63–70) before publishing a benchmark paper (Matthes, 1930) in which he concluded that fracture concentrations were responsible for the size, shape, and location of the roches moutonnées as well as for the morphology of its stair-stepped valleys (see figures 33 and 34 *in* Matthes, 1930). He also observed that stair-stepped valleys formed where fracture concentrations were oriented transverse to ice flow and speculated that deep, straight, and flat-floored valleys, such as Tenaya Canyon, formed where fracture concentrations were parallel to ice flow. Matthes (1930, p. 91) concluded that variability in fracture concentration and orientation was “the key to the secret of the Yosemite's origins.”

Over the subsequent 84 years, there have been significant advances in our understanding of fracture development (e.g., Lockwood and Moore, 1979; Martel, 2006) and the geomorphology

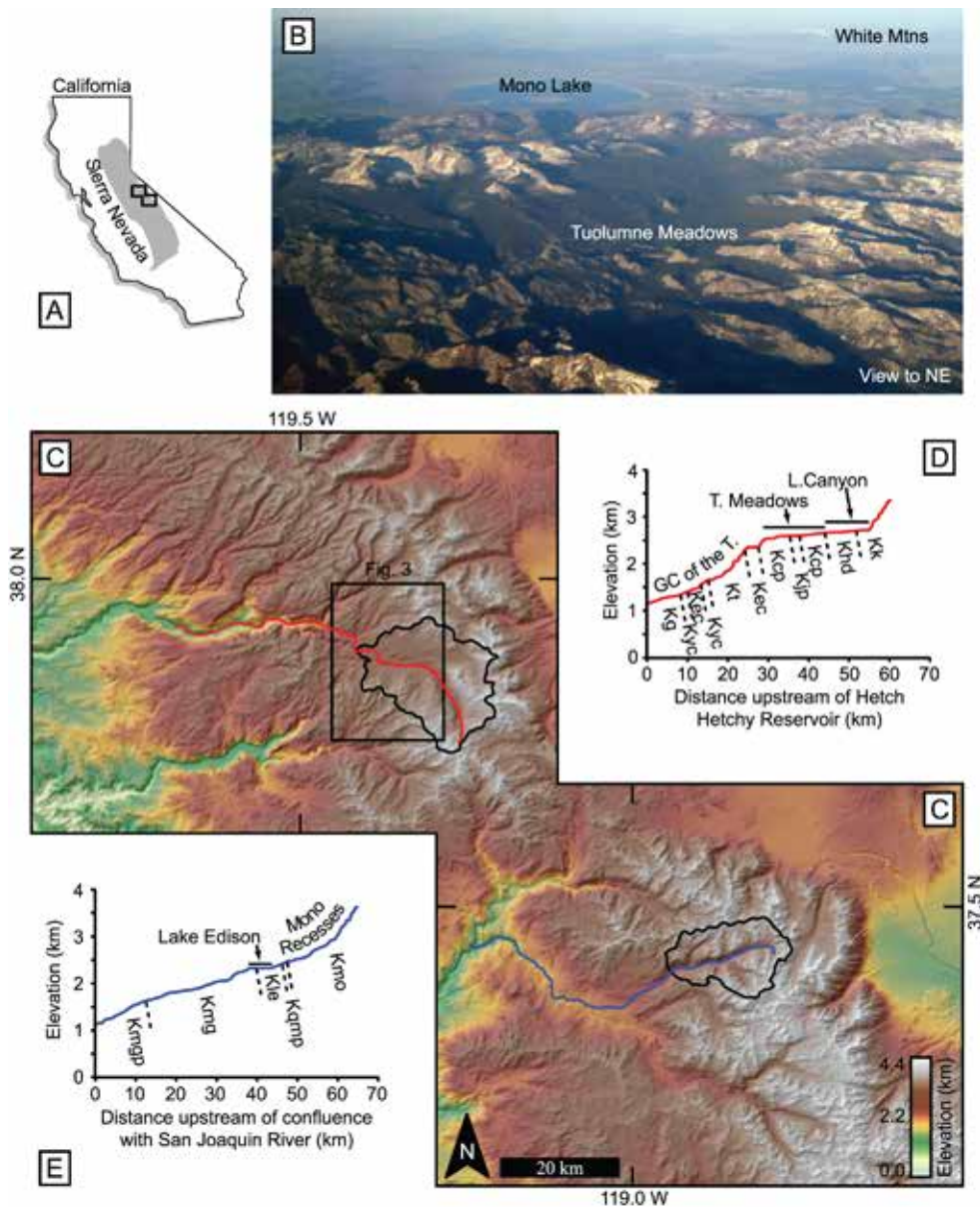


Figure 1. (A) Outline of California and the Sierra Nevada Mountains, showing panel C's position. (B) Tuolumne Meadows from the southwest; courtesy of Heidi Crosby. (C) Shaded digital elevation model, colored by elevation, of the central Sierra Nevada. Red and blue lines are the traces of the stream profiles described below in D and E. The drainage basins of the Tuolumne River above Little Devils Postpile (i.e., the Tuolumne Meadows area) and of Mono Creek above Lake Edison (i.e., the Mono Recesses) are shown. The black box indicates Figure 3's location. (D) Longitudinal profile of the Tuolumne River above Hetch Hetchy Reservoir. The locations of Tuolumne Meadows, the Grand Canyon of the Tuolumne, and Lyell Canyon are indicated. Topography from USGS maps; geology from Huber et al. (1989). Lithologic abbreviations: Kg—Undivided Cretaceous(?) granitic rocks; Kyc—Yosemite Creek Granodiorite; Kec—El Capitan Granite; Kt—Taft Granite; Kcp—Cathedral Peak Granodiorite; Kjp—Johnson Granite Porphyry; Khd—Half Dome Granodiorite; Kk—Kuna Crest Granodiorite. (E) Longitudinal profile of the South Fork of the San Joaquin River above its confluence with the San Joaquin River and continuing up Mono and Golden Creeks. Topography from USGS maps; geology from Bateman et al. (1971) and Lockwood and Lydon (1975). The artificially dammed Lake Thomas Edison is noted. Lithologic abbreviations: Kmgp—Mount Givens Granodiorite, porphyritic; Kmg—Mount Givens Granodiorite, equigranular; Kle—Lake Edison Granodiorite; Kqmp—porphyritic quartz monzonite; Kmo—Mono Creek Granite (from Bateman, 1992).

of the Sierra Nevada (e.g., Stock et al., 2004). The interaction of preexisting fractures and glacial erosion rates, however, has remained difficult to address. Dühnforth et al. (2010) helped quantify the role of fracture spacing in the glacial erosion of the Tuolumne River drainage. They dated 28 glacially striated outcrops and found that six outcrops contained inherited ^{10}Be from pre-glacial exposures. These six locations averaged fracture spacings of 3.3 m, whereas other, fully reset outcrops averaged 1.1 m between fractures. Dühnforth et al. (2010) concluded that the spacing of preexisting fractures exerts an important influence on the rate and style of glacial erosion and emphasized the efficiency of quarrying (in contrast to abrasion).

TABULAR FRACTURE CLUSTERS: A MESOZOIC INHERITANCE OF WEAKNESS

Assessing the geomorphic significance of preexisting fractures around Tuolumne Meadows requires recognition of a distinctive and locally pervasive fracturing style that is particularly erodible.

TFCs were first described based on Cathedral Peak Granodiorite outcrops in the Tuolumne Meadows area (Riley and Tikoff, 2010). TFCs in this locality are bands of closely spaced (<1 cm), opening-mode fractures that occur in zones 4–40 cm wide and 3–100 m long (Fig. 2).

Opening-mode fractures, such as joints, typically do not exhibit clustered distributions. Rather, opening-mode fractures are generally anti-clustered and display a fairly regular spacing in a given locality and lithology due to the stress shadow that forms as a result of joint propagation (e.g., Price, 1966; Hobbs, 1967; Gross, 1993). So, how did the TFCs form? The map pattern of TFCs in the Tuolumne Meadows area (Fig. 3) provides information about their origin. TFCs only occur in the ca. 88.1 Ma Cathedral Peak Granodiorite—but adjacent to the mapped and geophysically inferred extent (Titus et al., 2005) of the ca. 85.4 Ma Johnson Granite Porphyry (U-Pb dates on zircon from Coleman et al., 2004). This distribution, and the clustered nature of TFCs, led Riley and Tikoff (2010) to conclude that they formed by dynamic

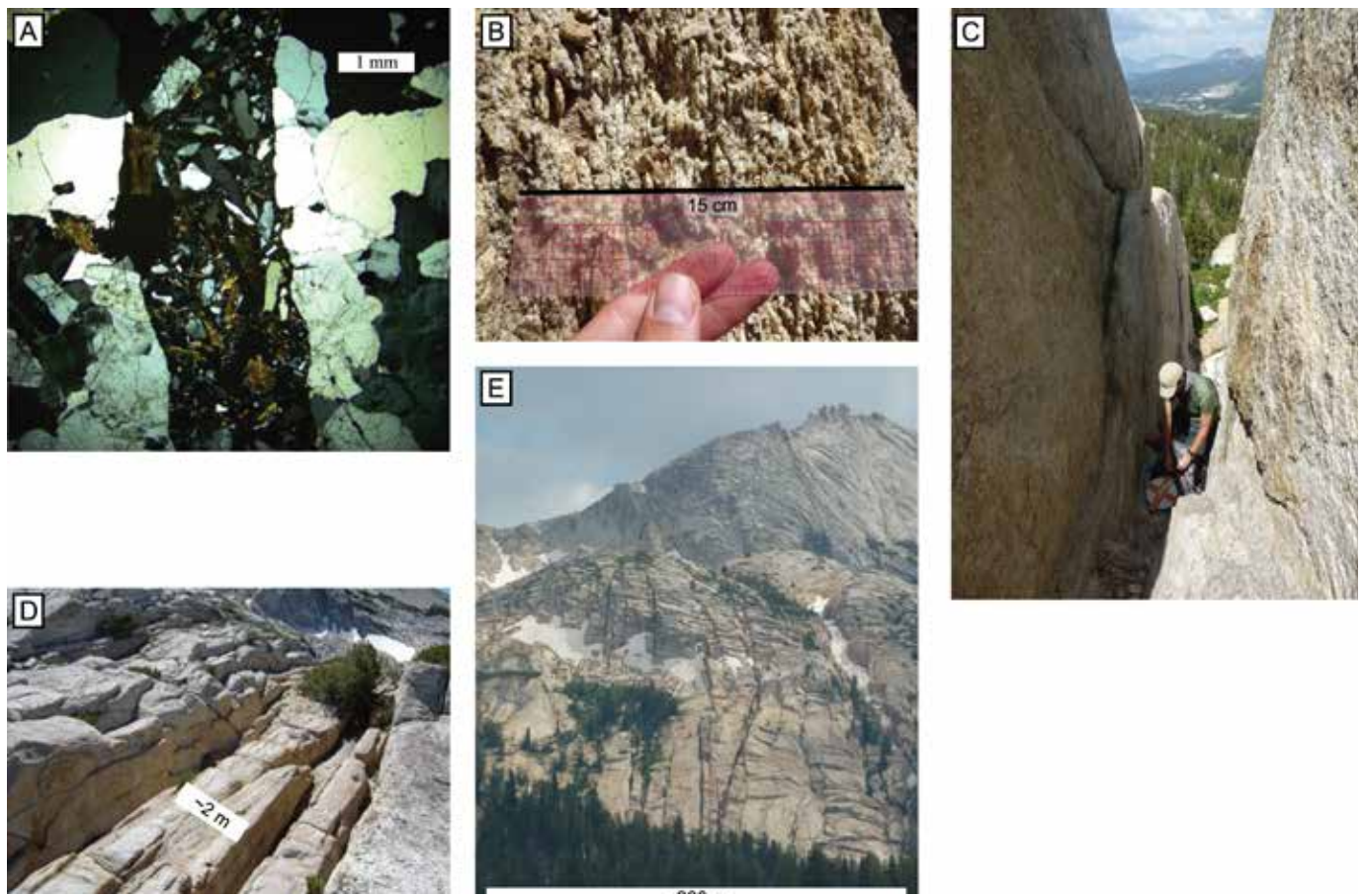


Figure 2. (A) A cross-polarized photomicrograph of an individual fracture from a tabular fracture cluster (TFC). Angular clasts are found within the fracture, and the matching grains on either side indicate a lack of shearing. (B) Photograph of a TFC illustrating their highly fractured nature, with abundant vertically oriented fractures separating thin (<1 cm) panels of unfractured rock. (C) Bedrock furrow that was eroded by ice flowing parallel to the TFC exposed along the furrow's bottom. (D) The outcrop-scale geomorphic expression of TFCs oriented parallel to ice flow; at least one TFC is located along the bottom of every bedrock furrow. (E) Furrows in the bedrock slope between Budd Lake and Tuolumne Meadows, resulting from the preferential erosion of TFCs oriented parallel to ice flow.

fracturing associated with fluid release from the crystallizing Johnson Granite Porphyry. This interpretation is further supported by microbreccia observed within the individual fractures of TFCs (Fig. 2A). The association of TFCs with magmatic structures in the Tuolumne Intrusive Suite clearly indicates that they are Cretaceous, similar to other fractures in the Sierra Nevada (Segall et al., 1990).

TFCs likely underlie all of Tuolumne Meadows, although it is not possible to directly observe the bedrock below the Meadows because it is obscured by Quaternary sediments. There are, however, three indications that TFCs are locally abundant. First, TFCs are concentrated in the bedrock slopes north and south of Tuolumne Meadows and strike into the valley from both sides (Fig. 3). Second, although there are only a few small bedrock outcrops in the Meadows proper, TFCs are common there. In fact, TFCs occur in two orientations: a dominant NNE-SSW orientation and a subsidiary, approximately orthogonal WNW-ESE orientation. Because these TFC-laden outcrops in Tuolumne Meadows are surrounded by sediment, we infer that they were less erodible—and less fractured—than the concealed bedrock beneath Tuolumne Meadows. Third, a gravity survey determined that the Johnson Granite Porphyry is within 500 m of the surface

in Tuolumne Meadows (Titus et al., 2005). Because TFCs are attributed to dynamic fracturing caused by fluid release from the Johnson Granite Porphyry into the surrounding Cathedral Peak Granodiorite (Riley and Tikoff, 2010), the bedrock of Tuolumne Meadows likely hosts a high TFC concentration.

The significance of TFCs for landscape development is that they are zones of profound erodibility. The clustered nature of the fractures *within* a TFC makes any individual TFC susceptible to preferential erosion (Fig. 2C). However, the TFC zones themselves are also clumped, ranging from the outcrop (10–100 m) to map (kilometer) scales (Fig. 3). Areas where TFCs are closely spaced are highly erodible (Fig. 2D). Zones of unfractured bedrock, surrounded by individual or “clumps” of TFCs, occur as prominent and often linear topographic highs (e.g., Matthes Crest).

BEDROCK TWINS, GEOMORPHIC COUSINS

We hypothesize that high TFC concentrations allowed the formation of Tuolumne Meadows's broad and open topography. To test this hypothesis, it would be ideal to know what the landscape would look like without TFCs. The bedrock geology of the Sierra Nevada provides this analog: Tuolumne Meadows can be directly compared with the landscape of the Mono Recesses. The

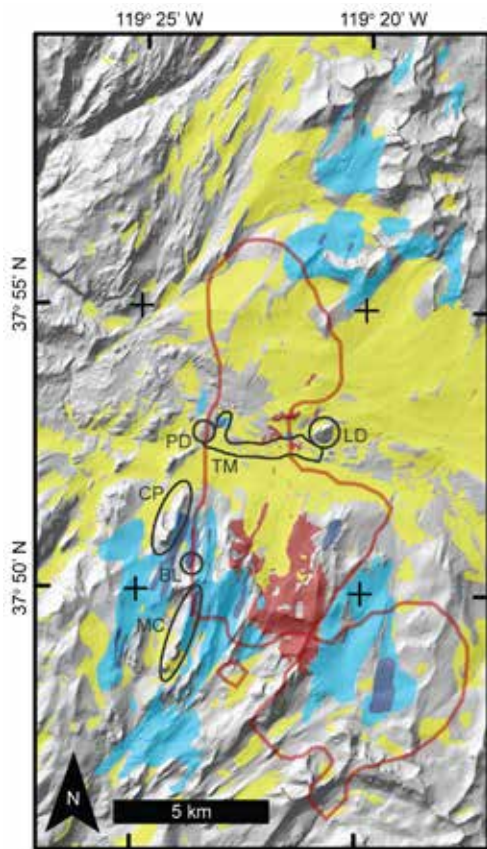


Figure 3. Geologic map draped on Tuolumne Meadows's topography (see Fig. 1 for location). Red regions represent Johnson Granite Porphyry outcrops. The rest of the map area is mostly Cathedral Peak Granodiorite. The red line represents the inferred subsurface extent of the Johnson Granite Porphyry (after Titus et al., 2005), which correlates well with the distribution of tabular fracture clusters (TFCs; blue). Light blue indicates low TFC density (2–5 m spacing) and dark blue indicates high TFC density (<2 m spacing) (after Riley and Tikoff, 2010). Yellow signifies Quaternary sediment cover. Tuolumne Meadows proper (TM) is indicated, as are Budd Lake (BL), Cathedral Peak (CP), Lembert Dome (LD), Matthes Crest (MC), and Pothole Dome (PD). Tuolumne Meadows is inferred to overlay highly fractured bedrock that was preferentially eroded by glaciation (see text for details).

Mono Recesses are located within Mono Creek's drainage basin above Lake Thomas Edison, ~70 km southeast of Tuolumne Meadows. The bedrock geology there is an en echelon series of Cretaceous plutons (the John Muir Intrusive Suite; Bateman, 1992) that are identical in age and composition with the Tuolumne Intrusive Suite, hence the phrase, "Twin of the Tuolumne" (Gaschnig et al., 2006). In particular, the Cathedral Peak Granodiorite (Kcp on Fig. 1D) is nearly identical in composition to the Mono Creek Granite (Kmo; Fig. 1E). The geological histories of the drainage basins are similar, and both are located along the Sierra Nevada's western crest. The major differences are that the Mono Recesses have few to no TFCs and the topography there is that of classic, glacial U-shaped valleys (Fig. 1C).

A comparison of the topography reveals that the landscapes are similar (e.g., glacially eroded) but not identical (Fig. 1C). The Tuolumne Meadows area is anomalously broad for its elevation and it is surrounded by a distinct NNE-SSW topographic grain that parallels the orientation of the TFCs and other fractures

(Ericson et al., 2005; Riley and Tikoff, 2010). The Mono Creek drainage is different: The drainage pattern there is basically dendritic but elongated parallel to the Sierra Nevada's regional slope (e.g., Matthes, 1930; McPhillips and Brandon, 2010). Thus, it suggests that the Mono Creek Granite is near isotropic in its erodibility.

The longitudinal profiles of the streams draining these landscapes also differ substantially (Figs. 1D and 1E). Readily apparent in the Tuolumne River's profile above Hetch Hetchy Reservoir is a prominent knickpoint that separates the Grand Canyon of the Tuolumne from Tuolumne Meadows (Fig. 1D). This knickpoint is unlikely to be a transient response to a fall in the river's base level because no corresponding knickpoint is observed in the South Fork of the San Joaquin River–Mono Creek profile (Fig. 1E). Likewise, it does not correspond to the confluence of another major stream with the Tuolumne River. Thus, the knickpoint is not likely associated with a step-change in ice discharge (e.g., MacGregor et al., 2000). Consequently, we infer that the bedrock of Tuolumne Meadows is more erodible than the knickpoint's bedrock. *Yet*, both locations are underlain by Cathedral Peak Granodiorite (Fig. 1D). The fundamental difference is *not* lithology, but rather TFC abundance. TFCs are rare to absent near the knickpoint but are concentrated adjacent to the Johnson Granite Porphyry (Kjp; Fig. 3) in the middle of Tuolumne Meadows. Thus, the TFCs control its broad, level expanse.

HOW TFC DISTRIBUTION CONTROLS GLACIAL EROSION

If the Tuolumne Meadows area is more erodible, by what mechanism was it eroded? The primary processes of glacial erosion are abrasion and quarrying/plucking (e.g., Iverson, 1995). Quarrying is generally thought to be volumetrically more important (e.g., Jahns, 1943; Riihimaki et al., 2005; Dühnforth et al., 2010). Gordon (1981) noted that the orientation of quarried faces was controlled by pre-glacial joint and fracture orientations, and that these faces were rarely perpendicular to ice flow. Hooyer et al. (2012) also found that ice-flow direction mattered little to quarried surface orientation, while preexisting fracture orientation was critical. In one area, a 64° change in ice-flow direction made no difference in the orientation of the quarried surfaces; the same joint set was exploited. These results suggest that preexisting fractures are as important to the quarrying process, if not more important, than the stress induced by water-pressure fluctuations in subglacial cavities.

We present an empirical framework for glacially eroded, fracture-dominated landscapes and identify three parameters linking fractures to landscape morphology: (1) TFC orientation (relative to ice flow); (2) TFC concentration; and (3) TFC "clumpiness" (the variability in spacing between adjacent TFCs). We present six scenarios in Figure 4, illustrated with examples from the Tuolumne Meadows area. Clumpiness (or clustering) can be quantified using the maximum Lyapunov exponent (Riley et al., 2011). Here, however, we adopt a qualitative measure of clumpiness as it relates to adjacent TFCs (rather than the individual fractures within them). Low clumpiness implies nearly periodic spacing, while high clumpiness indicates an irregular distribution (Fig. 4). Note that clumpiness is *not* correlated with TFC concentration; both sparsely and densely fractured areas can have identical clumpiness. We recognize that all three variables (orientation, concentration, and clumpiness) are actually continuums and that other factors (fracture aperture and

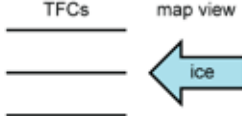



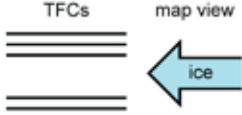

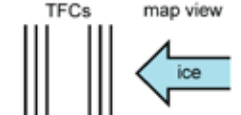

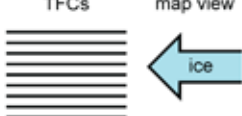

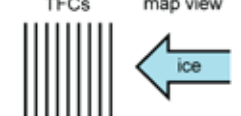

Ice-Flow Parallel	Ice-Flow Perpendicular	Average TFC Concentration	TFC "Clumpiness"
<p>TFCs map view</p>  <p>Ex: bedrock furrow between Budd Lake and T. Meadows</p>  <p>A</p>	<p>TFCs map view</p>  <p>Ex: bedrock furrow in an outcrop in Tuolumne Meadows</p>  <p>B</p>	Low	Low
<p>TFCs map view</p>  <p>Ex: Matthes Crest</p>  <p>C</p>	<p>TFCs map view</p>  <p>Ex: Lambert Dome</p>  <p>D</p>	Medium	High
<p>TFCs map view</p>  <p>Ex: Bedrock fins N of Budd Lake</p>  <p>E</p>	<p>TFCs map view</p>  <p>Ex: Tuolumne Meadows</p>  <p>F</p>	High	Low

Figure 4. An empirical, conceptual framework for fracture-dominated landscapes resulting from glacial erosion, illustrated with pictures from various locations in the Tuolumne Meadows area. The effects of tabular fracture cluster (TFC) orientation (relative to ice flow), concentration, and clumpiness (or clusteredness) are considered. The best rock climbing in the Tuolumne Meadows area is associated with clumps of TFCs (middle of the diagram); here, erosion removed the more highly fractured areas, leaving the relatively *unfractured* intervening areas as ridges (if ice-flow parallel) and domes (if ice-flow perpendicular).

dip, presence or absence of multiple fracture orientations, glaciological conditions, etc.) could be incorporated if data were sufficient. In all six cases, we assume glacial quarrying was the dominant erosional process, although it deviates from the standard geometry (Fig. 5A).

Where preexisting fractures are isolated, there will be little geomorphic effect, regardless of TFC orientation (Figs. 4A and 4B). Although not well illustrated here, there may be a subtle difference in the geometry of the resulting bedrock furrows, depending on the orientation of the TFCs relative to ice flow. Some observations suggest that the furrows have a more rectangular cross section where ice flow was parallel to TFC strike. This is a qualitative impression and not always true.

The area between Budd Lake and Tuolumne Meadows (Fig. 4E) is an example of the result of ice flowing parallel to closely spaced TFCs. In this case, erosion rates are higher than those associated with isolated fractures. Since the TFCs were parallel to ice flow, the fracture zones were preferentially eroded (Figs. 2C and 2D), and a prominent series of bedrock furrows or fins resulted (Figs. 4E and 5B). An important attribute of this landscape is that the intervening, unfractured rock masses were not removed.

We propose that Tuolumne Meadows proper exemplifies a case where ice flow was perpendicular to closely spaced fractures (Figs. 4F and 5C). As discussed earlier, the bedrock volume eroded from the space now occupied by Tuolumne Meadows was

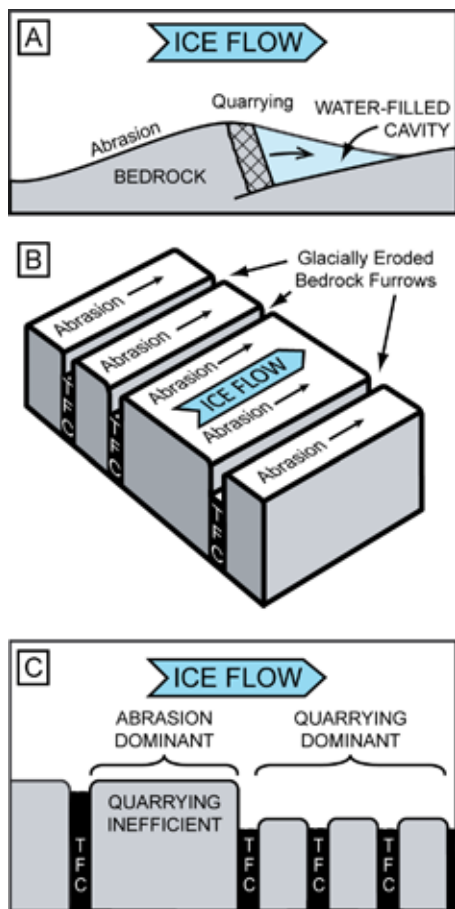


Figure 5. (A) The classic model of glacial erosion: Abrasion occurs on the stoss side of bedrock undulations, while quarrying occurs in the lee side, facilitated by water-pressure fluctuations in the subglacial cavity. (B) Glacial erosion in cases where tabular fracture clusters (TFCs) are oriented parallel to ice flow. While erosion is effective within individual TFC zones, glacial erosion is limited to abrasion on the top surface (e.g., the Budd Lake area). (C) Glacial erosion in cases where TFCs are oriented orthogonal to ice flow. Quarrying is efficient where TFCs are closely spaced (e.g., inferred for Tuolumne Meadows), but glacial erosion is restricted to abrasion where TFCs are widely spaced (e.g., up-ice section of Lembert Dome; Dühnforth et al., 2010).

likely a “chessboard” of fractured rock. Abundant fractures perpendicular to ice flow enabled the development of the anomalously flat segment in the Tuolumne River’s profile (Fig. 1D). The roches moutonnées at the east (up-ice; Lembert Dome) and west (down-ice; Pothole Dome) ends of Tuolumne Meadows are largely devoid of TFCs: Two solitary TFCs are present in Lembert Dome, and Pothole Dome only has TFCs along its eastern (up-ice) margin. The TFC concentration in Pothole Dome increases in the up-ice direction, at least until Quaternary sediments obscure the outcrop. Tuolumne Meadows is primarily oriented E-W, but here, at its westernmost extent, the valley reorients to the NNE, paralleling the dominant TFC orientation.

Thus, the case of high concentration and low clumpiness (the lower third of Fig. 4) appears ideal for quarrying. In the case of ice-flow parallel to the TFCs (e.g., near Budd Lake; Fig. 4E), glacial erosion was highly effective in the TFCs proper but did

not remove the intervening, unfractured bedrock. In cases where ice flowed perpendicularly to the TFCs (e.g., Tuolumne Meadows), we infer that close TFC spacing allowed effective removal of the intervening, unfractured rock masses (Fig. 4F).

Figure 4 (middle) illustrates the high clumpiness case, in which low and high TFC concentrations alternate. The glaciation of this fracture pattern efficiently removed the fractured rock within and immediately adjacent to the TFCs. However, because of the clumped nature of the TFC distribution, large blocks of intact bedrock remained. Matthes Crest and Cathedral Peak illustrate the case of ice-flow parallel to TFCs (Figs. 4C and 5B); Lembert Dome illustrates the perpendicular case (Figs. 4D and 5C). The best climbing in the Tuolumne Meadows area is where TFC-affected bedrock has been preferentially eroded from adjoining sparsely fractured bedrock, generating vertical rock walls; in other words, where fractures are clustered.

CONCLUSIONS

Lithology is not the only—or even necessarily the most important—control on bedrock erodibility. Anderson and Anderson (2010), using data presented by Dühnforth et al. (2010), interpreted the Cathedral Peak Granodiorite as among the least erodible lithologies in Yosemite National Park. Although it can be highly resistant to erosion, we interpret the Cathedral Peak as being highly *variable* in its erodibility. In some locations (e.g., Tuolumne Meadows), it is among the *most* erodible lithologies in Yosemite. In these locations, the TFC concentration—essentially a very high fracture density—makes the rock particularly susceptible to erosion. If our hypothesis is correct, the landscape of Tuolumne Meadows illustrates that preexisting fractures influence erosion more than lithology.

This research avenue’s relevance is perhaps best described by considering the influence of tectonics on geomorphology. The primary contribution of tectonics is typically considered to be raising and lowering rock bodies relative to base level. Molnar et al. (2007), however, proposed that tectonics may instead exert its greatest influence by crushing rock masses into parcels readily transportable by surficial processes prior to their arrival at the surface. If so, our ability to characterize erodibility in terms of both lithologic and fracture characteristics is critical. TFCs are an extreme example of fracturing that may aid in characterizing the effect of more typical fracture patterns on bedrock erodibility.

We conclude that Tuolumne Meadows’s current landscape can be directly linked to a short-lived Cretaceous fracturing event associated with the Johnson Granite Porphyry’s emplacement. The orientation, concentration, and distribution (clumpiness) of the TFCs provide first-order constraints on the subsequent landscape evolution. The conceptual framework presented here—for explaining how glacial erosion proceeds in this kind of highly fractured landscape—is a result of simultaneously investigating both the bedrock geology and the geomorphology. It comes from the same tradition as F. Matthes and his 25 years of observations in Yosemite. In this respect, it is perhaps useful to remember a quote from John Muir (1911, p. 104): “When we try to pick out anything by itself, we find it hitched to everything else in the Universe.”

ACKNOWLEDGMENTS

We thank Rebecca Steffy-Couch, Zach Michels, and the UW-Madison structure group for comments on draft versions of this manuscript. Frank Klein and Heidi Crosby are acknowledged for providing photographs from spectacular vantage points to help illustrate it. Becker recognizes field assistants David Brink-Roby and Heidi Crosby for their assistance. We express gratitude to Melly Meyer for drafting help. Two anonymous reviewers provided a large number of helpful suggestions; we appreciate their interest! Funding from the UW-Madison Geoscience Department and the Packard Foundation is gratefully acknowledged.

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Manuscript received 26 Nov. 2013; accepted 9 Apr. 2014 ❖

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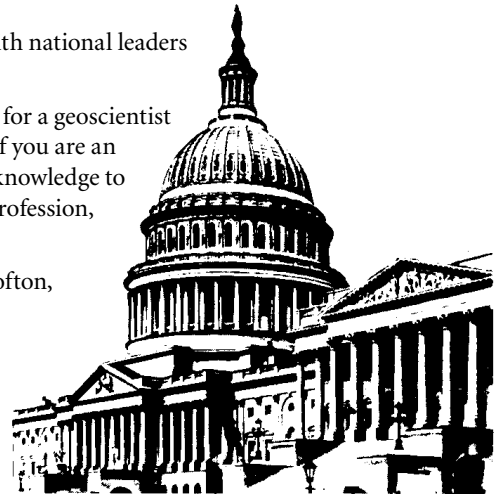
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Are you looking for a way to bring geoscientists together in a non-traditional format to share ideas and perspectives? Consider proposing a Pardee Keynote Symposium for the 2015 GSA Annual Meeting, or any future GSA Annual Meeting.

Joseph T. Pardee worked for the USGS between 1909 and 1941 on a variety of projects, from surficial deposits to bedrock studies, mostly in the northwest United States. He is best known for two *GSA Bulletin* papers: “Unusual Currents in Glacial Lake Missoula” (1942) and “Late Cenozoic Block Faulting in Western Montana” (1950).

The Joseph T. Pardee Memorial Fund was established in 1994 as a gift from family trusts and is designated for research, study, and educational advancement in the field of geology and science. Some of the proceeds from the endowment are used to fund Pardee Keynote Symposia at the GSA Annual Meeting, the first of which were held in 1999.

The goals of Pardee Keynote Symposia are to engage a large number of attendees and to utilize innovative formats to encourage the exchange of ideas. Pardee Keynote Symposia are generally half-day sessions, although full-day sessions will be considered. No more than eight are accepted for each annual meeting. The Annual Program Committee reviews each proposed Pardee Keynote Symposium and is putting new emphasis on innovation in content and/or format. While these proposals can be paired with a Topical Session(s), competitive proposals for Pardee Keynote Symposia must be significantly different and be innovative in content. Proposers are encouraged to propose different and flexible formats, such as having talks of various lengths, possibly combining posters with talks, using alternative seating arrangements, or using a variety of presentation media. Perhaps you want to propose a symposium as a result of a productive Penrose Conference. Or maybe your Pardee Keynote Symposium could be integrated with a workshop or field trip at the annual meeting. The list of possibilities is endless, restricted only by your creativity.

Of course, innovation costs money, and that’s where the Pardee Memorial Fund comes in. Each Pardee Keynote Symposium will have access to approx. US\$4,000 on average, depending on how many sessions are selected. Monies can be used to bring speakers to GSA who normally attend other meetings, but they can also be used to accommodate posters in meeting rooms, different seating arrangements, or media needs—whatever the proposed session requires. Contact Nancy Wright, GSA’s Technical Program manager, nwright@geosociety.org, for assistance in estimating such costs when developing the proposal budget.

So think outside the box! A Pardee Keynote Symposium is your opportunity to try out innovative conference formats, to encourage conversation among people who share your research interests, and to enhance scientific collaborations.

ADDITIONAL READING

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2014–2015 Richard H. Jahns Distinguished Lecturer



Eldon Gath has been named the 2014–2015 Richard H. Jahns Distinguished Lecturer in Applied Geology. Gath, a consulting engineering geologist, has more than 30 years of experience in the identification, investigation, and remediation of geologic hazards involving land-use planning, environmental assessments, field-exploration programs, and presentation of findings. He has particular experience with the evaluation of active faults for construction site planning and

the development of seismic safety programs and policies, and he is currently engaged in efforts to modernize California's 40-year-old active fault zoning act (Alquist-Priolo Earthquake Fault Zoning Act).

Gath is the president of Earth Consultants International, a geological consulting firm that he co-founded in 1997, following 12 years with Leighton Consulting in southern California. He has considerable international experience, including field projects in Turkey, Panama, Mexico, Costa Rica, and Papua New Guinea, as well as project involvement in many others.

Gath is a graduate of the University of Minnesota Institute of Technology, earning a B.S. in geology in 1978. He has been in graduate school ever since—M.S. program at Cal State (1982–1990), Ph.D. program at UC Riverside (1993–1996), Ph.D. program at UC Irvine (1998–2008)—but despite getting very close, he has never managed to complete the degree due to his busy consulting responsibilities, professional organization involvement, and travel schedules—or conflicted priorities, if you ask his advisors.

Gath has received several research grants from the U.S. Geological Survey's National Earthquake Hazard Research Program, the Southern California Earthquake Center, and the National Science Foundation for earthquake geology research in California, including paleoseismology of the Whittier fault, tectonic development of the San Joaquin Hills, tectonic geomorphology of the eastern Los Angeles Basin, and the seismic hazards of the Santa Ana Mountains. He served as the geosciences member on a National Research Council panel to develop the research agenda for the NEES (Network for Earthquake Engineering Simulation) program. He also served on the Los Angeles County Land Development Technical Advisory Committee for a decade and on the California Board for Engineering, Land Surveyors and Geologists' Technical Advisory Committee for two years. In addition, Gath has participated multiple times as an occupational expert for the U.S. Department of Labor.

Gath is a frequently invited speaker to local Southern California colleges. Since his first professional presentation on the Whittier fault at AGU in 1987, he has given over one hundred presentations

before professional, academic, and public groups, and has published dozens of papers on a wide range of geological and professional practice topics, several of which have received awards for outstanding presentations and papers.

In 1995, he was awarded the Aki Award for Outstanding Paper Presentation at the California Academy of Sciences Annual Meeting for "Active tectonic structures in the eastern Los Angeles basin." In 2007, Gath received the Outstanding Presentation Award at the AAPG Annual Meeting for "Quaternary geomorphic development and seismic hazards of Orange County, California." Along with coauthors, he has received the 2010 GSA E.B. Burwell Outstanding Paper Award for "The Geology of Los Angeles," and the 2012 AEG Claire P. Holdredge Outstanding Paper Award for "Paleoseismology of the Pedro Miguel fault, Panama Canal." He served as South Coast Geological Society (SCGS) President in 1987; AEG Southern California Section Chair from 1990 to 1992; AEG Treasurer, Vice President, and President from 1993 to 1997; received the AEG Floyd T. Johnston Service Award in 2008; was elected a Fellow by GSA in 2011; and was made an Honorary Member of the SCGS in 2012. He is a member of AEG, GSA, AIPG, AAPG, EERI, IAEG, IAPG, AAAS, AGU, SSA, PDAC, and all local geological societies.

Gath is offering a broad range of talks, including several that focus on the process and methodology of the work that would be suitable to a classroom presentation, as well as several results-oriented science talks that would be good for a graduate symposium.

Interested institutions should contact Eldon Gath at gath@earthconsultants.com to schedule a lecture on one of the following topics:

1. **The Santa Ana Mountains: Indenter Tectonics and the Earthquake Hazards of "The OC":** This talk explains the tectonic geomorphic evolution of Orange County in Southern California over the past million years.
2. **Tectonic Geomorphic and Paleoseismic Investigations for the Panama Canal:** This talk summarizes five years of geological exploration in Panama to quantify the fault hazards to the Panama Canal and the Canal Expansion Project using tectonic geomorphic mapping and analysis, paleoseismic trenching, and seismic hazard analysis.
3. **Quantitative Kinematic Investigation of the AD 1621 Pedro Miguel Fault Rupture for Design of the Panama Canal's Borinquen Dam:** This talk focuses on a detailed analysis of the AD 1621 Panama Viejo earthquake, how the source fault was identified using archaeoseismology along the Camino de Cruces (Spanish trail), and how several quantitative 3-D paleoseismic trenching studies of the Pedro Miguel fault were used to quantify the coseismic displacement kinematics of that earthquake for design of a major Canal expansion project dam across the fault.
4. **Active Faulting and Beverly Hills High School: An Unexpected Journey into Geo-Ethics:** This talk is oriented

toward the ethics of hazard disclosure, using the case of an “Active Fault Map” that was recently released by a public agency and that showed multiple active faults through Beverly Hills High School, plus numerous other high-rise buildings in the Century City area of western Los Angeles.

5. **Paleoseismology of the North Panamá Deformed Belt from Uplifted Coral Platforms at Moín and Limón, Costa Rica:** This talk illustrates the value of Quaternary geomorphology to understand the paleoseismic history of a large offshore thrust fault.
6. **Natural Hazard Identification, Impact Analysis, and Risk Assessment for Community Disaster Mitigation Planning:** This talk presents the methodology of hazard map preparation for use by city and county governments for land-use planning, hazard mitigation, and loss prevention.
7. **Engineering Geology: An Overview of the Profession:** This talk presents an overview of the broad scope of the engineering geology profession, based on Gath’s personal experience of 35 years as a consulting engineering geologist working in Turkey, Portugal, Costa Rica, Mexico, Papua New Guinea, Panama, the western U.S., and more to come.

March 16-20, 2015, Washington, DC



As global headlines focus on climate change, ocean acidification, and tsunamis, marine geoscientists stand well positioned to serve the needs of society while pushing the frontiers of scientific research. To solve these challenges and forge the necessary links between science and society, marine geoscientists must reach beyond their individual laboratories, form interdisciplinary collaborations, and communicate their discoveries to the public and policymakers. The Marine Geoscience Leadership Symposium introduces these skills to early career marine geoscientists. Participants will engage in small group discussions, participate in proposal workshops, and meet with funding agencies, media representatives, and policymakers. The symposium will provide leadership and communications training and begin the process of forming interdisciplinary research collaborations.

Applicants may be from any subfield of marine geology or geophysics and should have completed their Ph.D. between December 2011 and December 2014. Selected participants will receive full participation support. **The deadline to apply is December 22, 2014.**

For more information, visit www.oceanleadership.org/mgls.

2014 Honorary Fellow



GSA is pleased to announce the selection of the Society’s 2014 Honorary Fellow: **Shigenori Maruyama**, of the Tokyo Institute of Technology.

Honorary Fellowship is presented to an international geoscientist who has distinguished him or herself in geoscience investigations, promoting environmental awareness, linking science and society, providing notable service to implementing public policy in natural resource

managements, or otherwise making outstanding contributions to science. This award was presented at the GSA Awards Ceremony during the 2014 GSA Annual Meeting in October.

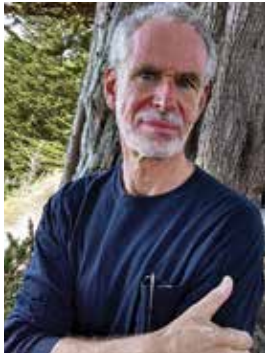
Maruyama is a prominent leading scientist, evident through his contributions. They include (1) the research for blueschist and related rocks; (2) a proposed exhumation model, called wedge extrusion; (3) contrasting Pacific-type and collision-type orogenies; (4) UHP geology in Kokchetav, Kazakhstan, which includes petrology, mineralogy, and an unfolded exhumation history; (5) the concept of superplume and its role on whole mantle dynamics; and (6) the three-layer-continents model. His research

is based on consistent and systematic geological fieldwork all over the world, which includes the methodical and comprehensive analyses of more than 30,000 collected samples for a full understanding of the history of Earth based on the newly established principle of accretionary complex geology.

Maruyama has published 29 books and more than 330 peer-reviewed papers. Many of the published papers have appeared in top international journals, receiving more than 7,800 citations. His research is driven by highly interdisciplinary approaches, which straddle multiple science fields such as geology, biology, chemistry, planetary science, and astronomy. Also, his spear-headed research is international, with collaboration among 50 faculties in 25 countries.

Maruyama’s interdisciplinary and international research field has recently expanded to the investigation of the origin and evolution of life, which are arguably the greatest mysteries in natural science to be solved. In 2014, he was granted funding by the Japanese government (JSPS) to unfold these mysteries through his project “Hadean Bioscience.” The specific aim of the project is to scientifically clarify when, where, and how life emerged on Earth. Maruyama’s team has already proposed the new concept of “Habitable Trinity,” which successfully replaces the enduring (since the 1950s) “Habitable Zone” concept, to detect habitable planetary bodies having elevated potential to bear life.

2015 Birdsall-Dreiss Distinguished Lecturer



Clifford I. Voss has been selected as the 2015 Birdsall-Dreiss Distinguished Lecturer by GSA's Hydrogeology Division. Voss is an internationally recognized expert in groundwater modeling and is a senior scientist with the U.S. Geological Survey's (USGS) National Research Program. He has more than 35 years of project management, implementation, field-work, and research experience in groundwater systems, including

computer model development and effective model use for scientific evaluation of hydrogeologic systems; groundwater resources development, management, and protection; coastal and island groundwater resources subject to seawater intrusion; and use of the subsurface for energy production/storage and toxic waste isolation. Voss advises extensively on groundwater system evaluation and management, and he lectures worldwide on these and related subjects. His scientific interests in hydrogeology include addressing hydrogeologic heterogeneity, physics of solute and energy transport, behavior of fluids with varying density, phase change in geothermal and frozen systems, inverse modeling and network design, and evaluating extensive aquifer systems in light of sparse data.

The practical methodology and models that Voss and his colleagues developed are now widely used for managing both the quantity and quality of water supply. In particular, the *SUTRA* computer code, developed and maintained by Voss and his USGS colleagues, has been a standard tool for groundwater resource assessment ever since the USGS made it publicly available in 1984. *SUTRA* has made possible hundreds of practical and research investigations worldwide since its release.

Examples of Voss's work include nuclear waste repository safety (Germany, Japan, Sweden); transboundary water resource management (Nubian Aquifer of Egypt, Libya, Sudan, Chad); sustainability of water supply (arsenic-free groundwater supply from the Bengal Aquifer of India, Bangladesh); groundwater management in coastal areas subject to saltwater intrusion (USA); evaluation of water resources emergency (2004 tsunami in Thailand); and assessment of climate-change impacts on permafrost-mediated hydrology in cold regions (Alaska, USA), in part using simulation methodology for groundwater flow with freeze/thaw developed by Voss and colleagues.

Voss is the executive editor of *Hydrogeology Journal*, the official journal of the International Association of Hydrogeologists (IAH), which has become a premier venue for worldwide progress in theoretical and practical hydrogeology and groundwater-resource management under his twenty years of leadership. *Hydrogeology Journal* is co-sponsored by GSA's Hydrogeology Division.

For more information on Voss' work and a list of his publications, go to <https://profile.usgs.gov/cvoss>.

LECTURE INFORMATION

Deadline for priority lecture requests: 15 December 2014

Use the form at <http://water.usgs.gov/nrp/2015-Birdsall-Dreiss-Lecture-Voss/> to request a visit to your institution. If you have questions, you can contact Voss at cvoss@usgs.gov.

This lecture tour is sponsored by GSA's Hydrogeology Division. GSA will pay travel expenses and the host institution will provide local accommodation and meals and, if needed, some local travel expenses. Voss needs to organize several lectures in each region to make effective use of the travel funds, so lecture requests received by 15 Dec. will be given priority.

Voss will present one of the following three lectures. All three lectures are appropriate for a general audience with some science background or interest.

Informing Management of the World's Largest Groundwater Systems with Simply Structured Model Analysis

During the 50 years since its development, groundwater flow modeling has become the tool of choice that, when used wisely, provides deep insight into the functioning of aquifer systems that can become a foundation of effective water-resources management. This presentation reviews typical difficulties in characterizing aquifer systems (due to heterogeneity and data scarcity) and argues that simply structured models are the most effective means of dealing with inevitable uncertainties. Two examples of simply structured model analyses of very large aquifer systems with sparse data will be presented. (1) In West Bengal, India, and Bangladesh, dissolved arsenic concentrations exceeding world standards exists in the drinking water of about 50 million people, making this the world's largest groundwater contamination problem. Previous scientific and technological efforts aimed at solving the problem had been largely directed toward understanding the chemistry of arsenic occurrence and release, but this groundwater modeling study is unique in providing a possible region-wide solution to the problem. (2) The Nubian aquifer is the world's largest non-renewable groundwater resource. It is a transboundary aquifer belonging to Chad, Egypt, Libya, and Sudan. International questions regarding resource fate, equitable use of the resource by each country (most current usage is by Egypt and Libya), and adverse impacts of cross-border pumping drawdown on shallow wells and oases were the reason for development of this model as part of a four-country Global Environmental Facility (GEF) project led by the International Atomic Energy Agency (IAEA). Simply structured model development provided robust answers to these questions and provided a relatively simple tool that could be adopted and used by water managers in each country.

Ground Ice and Permafrost—“Foundations” of the Hydrology of Cold Regions

As much as one third of Earth’s land surface undergoes yearly freezing, and one quarter of Earth’s land surface is underlain by perennially frozen ground—permafrost. There is limited knowledge about the hydrogeology of these dominant cold regions of Earth because most human population lives in temperate-climate areas. This knowledge base, cryohydrogeology, is the study of the dynamic interaction of groundwater with freezing and thawing processes. Subsurface ice is a barrier to flow; thus, the pattern of frozen ground is a major control on surface and subsurface water flows. Consequently, ice distribution controls cold-regions hydrology, which in turn affects the geochemistry and ecology of cold regions. Motivated by international concern regarding global warming impacts on ground ice distribution and resulting changes to ecosystems, and by the opportunity to study the intriguing hydrological processes mediated by water-ice phase change, recent work by the U.S. Geological Survey and partner institutions has focused on a permafrost region of interior Alaska. This presentation describes some results of that work, including observed cold-region hydrologic phenomena, efforts to understand the ground ice and water flow mechanisms that control them, and assessment of likely hydrologic changes resulting from climate evolution. The study produced extraordinary maps of permafrost distribution and thickness (from airborne geophysical surveys)—never before obtained for such large regions. The study found that complex inter-related ice-hydrology mechanisms cause surface-water bodies to shrink and expand, and that permafrost continuity affects groundwater discharge to rivers (impacting river chemistry). A new model that simulates groundwater flow with heat transport and groundwater freezing and thawing, being finalized as part of this effort, has already allowed evaluations of paleoclimate-change permafrost evolution and of future climate-change scenario impacts on today’s permafrost. It is found that

groundwater flow and permafrost formation and thaw are strongly coupled processes; where groundwater flows in cold regions, it accelerates permafrost thaw during climate warming.

Density-Driven Groundwater Flow: Seawater Intrusion, Natural Convection, and Other Phenomena


Difficulties in understanding and managing hydrogeologic systems with variable-density groundwater flow are often due to the common notion that groundwater flow is driven in the direction of decreasing water-table elevation or hydraulic head—i.e., “downhill.” However, even small variations in groundwater density can drive flow in directions that have no relationship to decreasing elevation or head. Groundwater density varies due to spatial or temporal differences in temperature and concentration of dissolved solids. These differences in density can lead to interesting and sometimes unexpected flow patterns. In coastal aquifers, seawater intrusion (and contamination of groundwater supplies) occurs because denser salty sub-sea groundwater pushes laterally inland below less-dense fresh groundwater flowing seaward. Saltwater also occurs above fresher groundwater (in sabkhas, salt ponds, areas of coastal sea incursion) and here, denser saltwater “falls” downward through the fresher, less-dense groundwater, also salinizing the aquifer. Vertical density-driven flow giving rise to natural convection similarly occurs where warmer groundwater exists below cooler water, such as in geothermal, volcanic, and ocean-ridge regions. This presentation reviews variable-density groundwater flow phenomena and their importance in practical settings. It is shown that the flow pattern in cases of lateral density differences is rather uniform in comparison with the flow pattern generated by vertical density differences, which exhibits fascinating variety and evolution. Examples of lateral and vertical density-driven flows in coastal aquifers show how modeling variable-density groundwater flow can be used to understand and effectively manage coastal resources.



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Upcoming Award, Recognition & Grant Deadlines



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

2015 GSA Medals And Awards

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

Nomination deadline: 1 Feb. 2015.

GSA Fellowship

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

Nomination deadline: 1 Feb. 2015.

AGI Medal in Memory of Ian Campbell

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

Nomination deadline: 1 Feb. 2015.

AGI Marcus Milling Legendary Geoscientist Medal

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

Nomination deadline: 1 Feb. 2015.

2015 National Awards

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

Nomination deadlines vary.

John C. Frye Environmental Geology Award

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

Nomination deadline: 31 March 2015.

2015 Student Research Grants

Applications will be accepted online only beginning early December. Paper applications or letters will not be accepted.

Submission deadline: 2 Feb. 2015 at 5 p.m. (MST) to www.geosociety.org/grants/gradgrants.htm.

2015 Post-Doctoral Research Awards

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

Application deadline: 1 Feb. 2015.

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



Upcoming Award, Recognition & Grant Deadlines



NEW

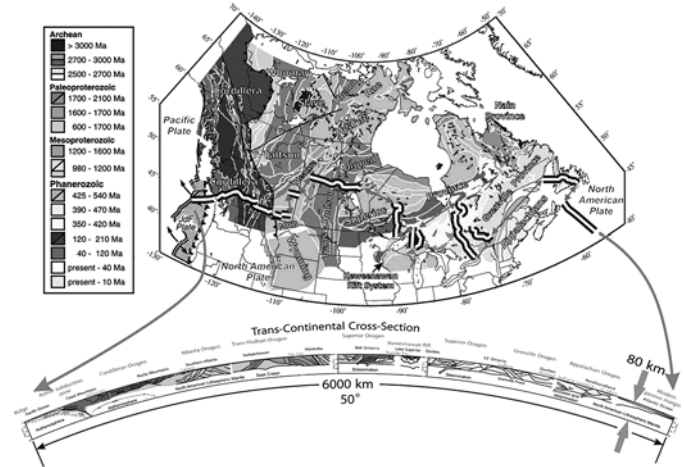
Geologic Mapping Award

Nominations due 1 Feb. 2015

The first GSA Geologic Mapping Award will be presented in 2015 to recognize a recipient's contributions to published, high-quality geologic mapping leading to significant new scientific or economic-resource discoveries and a greater understanding of fundamental geologic processes and concepts. The objective is to encourage training and support toward production of excellent, accurate, detailed, purposeful geologic maps and cross sections. There are no restrictions on map products with respect to size or scale.

How to Nominate

- Nomination form:** Please go to <https://rock.geosociety.org/forms/Awardform.asp> to submit the form online or to download a hardcopy to submit via post.
- Supporting documents,** to be submitted as e-mail attachments or via post:
 - Curriculum vitae;
 - Letter of nomination (300 words or fewer);
 - Letters of support from three scientists with at least two from GSA Fellows or members and one from a member of another professional geoscience organization; and
 - A selected bibliography of no more than 20 titles.



Map example: Figure 1 from Hammer et al., 2011 (*GSA Today*, v. 21, no. 6, p. 4–10, doi: 10.1130/GSATG95A.1).

2015 Student Research Grants

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

The GSA student research grant application process is available online only; no paper applications or letters will be accepted. Apply online at www.geosociety.org/grants/gradgrants.htm starting early December 2014. Online submissions must be completed by Monday, 2 Feb. 2015, at 5 p.m. MST.

For further information on the 2015 Research Grants Program, go to www.geosociety.org/grants/gradgrants.htm, call +1-303-357-1028, or e-mail awards@geosociety.org.

Congratulations to All the 2014 GSA Division Award Recipients



The primary Division awards were announced in the July 2014 issue of GSA Today; those are included again below along with other GSA Division awards presented at this year's annual meeting. Learn more about GSA's specialty Divisions at www.geosociety.org/divisions/.

ARCHAEOLOGICAL GEOLOGY

Rip Rapp Archaeological Geology Award

William R. Dickinson, University of Arizona–Tucson

Claude C. Albritton Jr. Memorial Student Research Award

Brendan Fenerty, Indiana University–Bloomington

COAL GEOLOGY

Gilbert H. Cady Award

Jack Pashin, Oklahoma State University

Antoinette Lierman Medlin Field Award

Emily Schultz, Texas A&M University

Jayeeta Chakraborty, The University of Texas at Dallas

Antoinette Lierman Medlin Research Award

Fotios Fouskas, The University of Texas at El Paso

ENGINEERING AND ENVIRONMENTAL GEOLOGY

E.B. Burwell, Jr., Award

A. Keith Turner and **Robert L. Schuster**, *Rockfall; Characterization and Control: Transportation Research Board*, National Academy Press, 2012.

Distinguished Practice Award

Lew Rosenberg, posthumously

Meritorious Service Award

Jim McCalpin, Geo-Haz Consulting Inc.

Richard H. Jahns Distinguished Lecturer (2013–2014)

Gregory Hempfen, URS Corporation

Roy J. Shlemon Scholarship Awards

Sara Lindsay Poluga, Kent State University

Ethan Faber, Colorado School of Mines

Na-Hyun Jung, University of Wisconsin–Milwaukee

John Wall, North Carolina State University

GEOBIOLOGY & GEOMICROBIOLOGY

Outstanding Contributions in Geobiosciences Award

Shuhai Xiao, Virginia Tech

Sara Pruss, Smith College

Rob Sansom, University of Manchester

GEOINFORMATICS

Outstanding Contributions Award

Ian Jackson, formerly of the British Geological Survey

GEOLOGY AND HEALTH

The Distinguished Service Award

Geoffrey Plumlee, U.S. Geological Survey

GEOLOGY AND SOCIETY

Best Student Presentation Award

Kevin McCoy, Colorado School of Mines

Niaz Morshed, Texas State University–San Marcos

GEOPHYSICS

George P. Woollard Award

Joe Kirschvink, California Institute of Technology

Allan V. Cox Student Research Award

Justin Cox, Auburn University

Geophysics Division Student Research Award

Ross Anderson, Yale University

GEOSCIENCE EDUCATION

Biggs Award for Excellence in Earth Science Teaching

Callan Bentley, Northern Virginia Community College

HISTORY AND PHILOSOPHY OF GEOLOGY

Mary C. Rabbitt History of Geology Award

Henry Robert Frankel, University of Missouri–Kansas City

Gerry and Sue Friedman Award for Distinguished Service

Bob Dott, retired

History and Philosophy of Geology Student Award

Ashley Inglehart, Indiana University

Stacy Phillips, Memorial University of Newfoundland

HYDROGEOLOGY

O.E. Meinzer Award

Charles F. Harvey, Massachusetts Institute of Technology

Birdsall–Dreiss Distinguished Lecturer

Lawrence Band, University of North Carolina

George Burke Maxey Distinguished Service Award

Robert W. Ritzi, Wright State University

Kohout Early Career Award

Peter Shawn Kuehl Knappett, Texas A&M University

Hydrogeology Student Research Award

Jason Nolan, University of Nebraska–Lincoln

Amanda Pruehs, Wayne State University

Md. Aminul Haque, University of Manitoba

Mary Lusk, University of Florida

Charlene King, Colorado State University

LIMNOGEOLOGY

Israel C. Russell Award

Robin W. Renaut, University of Saskatchewan

Kerry Kelts Student Research Awards

Cindy Frickle, University of Minnesota

Jordon Bright, University of Arizona

MINERALOGY, GEOCHEMISTRY, PETROLOGY, AND VOLCANOLOGY

Distinguished Geologic Career Award

Frederick A. Frey, Massachusetts Institute of Technology

MGPV Student Research Grant Award

Joshua Garber, University of California, Santa Barbara

Thomas Benson, Stanford University

Ming Tang, University of Maryland

Rohanna Gibson, Queen's University

PLANETARY GEOLOGY

G.K. Gilbert Award

Bill McKinnon, Washington University in St. Louis

Ronald Greeley Award for Distinguished Service

Louise Prockter, Johns Hopkins University Applied Physics Laboratory

Pellas-Ryder Award

Eike Beitz, Technische Universität Braunschweig

Stephen E. Dwornik Research Awards

Best Undergraduate Oral: **George D. McDonald**, Cornell University

Best Graduate Oral: **Diane T. Wetzel**, Brown University

Honorable Mention Graduate Oral: **Michelle S. Thompson**, University of Arizona

Best Graduate Poster: **Yuyan Sara Zhao**, Stony Brook University

Honorable Mention Graduate Poster: **Jinping Hu**, Arizona State University

QUATERNARY GEOLOGY AND GEOMORPHOLOGY

Kirk Bryan Award for Research Excellence

John C. Ridge, **Greg Balco**, **Robert L. Bayless**, **Catherine C. Beck**,

Laura B. Carter, **Jody L. Dean**, **Emily B. Voytek**, and **Jeremy H.**

Wei, “The new North American varve chronology: A precise

record of southeastern Laurentide Ice Sheet deglaciation and climate, 18.2–12.5 kyr BP, and correlations with Greenland ice core records,” *American Journal of Science*, 2012, v. 312, p. 685–722.

Distinguished Career Award

Thomas Dunne, University of California, Santa Barbara

Farouk El-Baz Award

Dan Muhs, U.S. Geological Survey in Denver

Arthur D. Howard Student Research Grant

April Sawyer, University of Montana

J. Hoover Mackin Student Research Grant

Lee Corbett, University of Vermont

Marie Morisawa Student Research Award

Katherine Lininger, Colorado State University

Robert K. Fahnestock Memorial Award

Melissa Foster, University of Colorado–Boulder

John Montagne Research Award

Nadine Orejola, Plymouth State University

Gladys W. Cole Research Award

Kyle Nichols, Skidmore College

SEDIMENTARY GEOLOGY

Laurence L. Sloss Award

Chris Paola, University of Minnesota

Sedimentary Geology Division Student Research Award

Kelsi Ustipak, University of Texas at Austin

STRUCTURAL GEOLOGY AND TECTONICS

Career Contribution Award

Darrel Cowan, University of Washington

Outstanding Publication Award

J.A. Tarduno, **Duncan, R.A.**, **Scholl, D.W.**, **Cottrell, R.D.**, **Steinberger, B.**, **Thordarson, T.**, **Kerr, B.C.**, **Neal, C.R.**, **Frey, F.A.**, and **Torii, M.**, The Emperor Seamounts: Southward motion of the Hawaiian hotspot plume in Earth's mantle: *Science*, 2003, v. 301, p. 1064–1069.

Stephen E. Laubach Research Award

Randolph Williams, University of Wisconsin–Madison

Structural Geology & Tectonics Student Research Award

Ross Anderson, Yale University

Rebekah Cesmat, University of Washington

Benjamin Johnson, West Virginia University

Andrea Stevens, University of Arizona

Randy Williams, University of Wisconsin

Long Wu, Colorado School of Mines

Preliminary Announcement and Call for Papers

CORDILLERAN SECTION

111th Annual Meeting of the Cordilleran Section, GSA
Anchorage, Alaska, USA
11–13 May 2015

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



Anchorage skyline. Photography provided by Visit Anchorage; photo by Jody Overstreet.

LOCATION

The 111th annual meeting of GSA's Cordilleran Section will be held on the University of Alaska's Anchorage campus. Anchorage is Alaska's largest and most diverse city. Situated at the base of the Chugach Mountains, Anchorage is built on glacial deposits associated with the last major ice age. The waters of Cook Inlet, a major marine embayment, surround the city on its north, west, and south sides. Turnagin Arm to the south experiences the second highest tides in North America. To the west of Anchorage, across Cook Inlet, are the Tordrillo Mountains and Mount Spurr Volcano, the closest active volcano to Anchorage. To the north are the high peaks of the Alaska Range, including Mount McKinley, the highest mountain in North America. Because of its location, Anchorage is a key international air hub in the North Pacific region as well as one of the primary gateways to the Alaskan wilderness.

CALL FOR PAPERS

Abstract deadline: 10 February 2015

Submit online at www.geosociety.org/Sections/cord/2015mtg

Abstract submission fee: US\$10 for students; US\$15 for all others

If you cannot submit an abstract online, please contact Heather Clark, +1-303-357-1018, hclark@geosociety.org.

SYMPOSIA

- S1. **Origins and Orogenies of Arctic Alaska—Honoring the Career of Alison Till, U.S. Geological Survey—Anchorage.** Sarah Roeske, University of California—Davis, smroeske@ucdavis.edu; Julie Dumoulin, USGS, dumoulin@usgs.gov; Jamey Jones, USGS, jvjones@usgs.gov; David Houseknecht, USGS, dhouse@usgs.gov; Richard Lease, USGS, rlease@usgs.gov.
- S2. **From Alaska and the Appalachians to Lithium Resources and Secular Trends in the Geologic Record: Honoring the Eclectic Geologic Career of Dwight Bradley.** Ken Ridgway, Purdue University, ridge@purdue.edu; Jamey Jones, USGS, jvjones@usgs.gov; Julie Dumoulin, USGS, dumoulin@usgs.gov.

THEME SESSIONS

- T1. **Tectonics, Sedimentation, and Energy Resource Potential of the Northern Cordillera.** Marwan Wartes, Alaska Division of Geological & Geophysical Surveys, marwan.wartes@alaska.gov; Trystan Herriott, Alaska Division of Geological & Geophysical Surveys, trystan.herriott@alaska.gov.
- T2. **New Discoveries in Resolving the Terrane Assembly of Western North American and Northeast Asia.** Robert Blodgett, Blodgett & Associates LLC, robertblodgett@gmail.com; James Clough, Alaska Division of Geological & Geophysical Surveys, jim.clough@alaska.gov; Valeryi Baranov, Institute of Diamond and Precious Metals Geology, Russian Academy of Sciences, baranowvalera@yandex.ru.
- T3. **Undergraduate Research (Posters).** Diane Smith, Trinity University, dsmith@trinity.edu.
- T4. **Engineering Geology in the Northern Latitudes.** Eric Cannon, Golder Associates Inc., ecannon@golder.com.
- T5. **Stratigraphy, Tectonics, and Metallogeny of Wrangellia: The Original Accreted Terrane.** Evan Twelker, Alaska Division of Geological & Geophysical Surveys, evan.twelker@alaska.gov; Karri Sicard, Alaska Division of Geological & Geophysical Surveys, karri.sicard@alaska.gov; Steve Israel, Yukon Geological Survey, steve.israel@gov.yk.ca.
- T6. **Geologic Hazards Evaluation along Important Infrastructure Corridors.** Trent Hubbard, Alaska Division of Geological & Geophysical Surveys, trent.hubbard@alaska.gov; Ronnie Daanen, Alaska Division of Geological & Geophysical Surveys, ronald.daanen@alaska.gov; Margaret Darrow, University of Alaska—Fairbanks, mmdarrow@alaska.edu.
- T7. **Characterizing Paleoseismic Parameters of Crustal Faults from the Subduction Margin to the Hinterland.** Rich Koehler, Alaska Division of Geological & Geophysical Surveys, richard.koehler@alaska.gov; Robert Witter, USGS—Alaska Science Center, rwitter@usgs.gov.
- T8. **Tectonic-Surface Process Interactions during Terrane Accretion and Mountain Building along the Cordillera.** Richard Lease, USGS, rlease@usgs.gov; Eva Enkelmann, Univ. Cincinnati, eva.enkelmann@uc.edu.
- T9. **Metalloids and the Environment.** Sarah Hayes, University of Alaska—Fairbanks, s.hayes@alaska.edu.
- T10. **Tempo of Arc Emplacement and Accretion.** Elisabeth Nadin, University of Alaska—Fairbanks, enadin@alaska.edu;

Chad Hults, National Park Service, chad_hults@nps.gov;
Erin Todd, USGS, etodd@usgs.gov.

- T11. **Communicating Geologic Hazard Information in the 21st Century: New and Emerging Approaches to Effectively Prepare Those at Risk.** Christina Neal, USGS–Alaska Volcano Observatory, cneal@usgs.gov; Sue Perry, USGS, scperry@usgs.gov.
- T12. **The Structure, Age, and Processes Associated with Alaskan and Northern Cordillera Strike-Slip Faults: Local Examples with Global Implications.** Jeff Benowitz, University of Alaska–Fairbanks, jbenowitz@alaska.edu; Jonathan Caine, USGS, jscaine@usgs.gov; Peter Haeussler, USGS, pheuslr@usgs.gov; Steve Israel, Yukon Geological Survey, steve.israel@gov.yk.ca.
- T13. **The Art and Science of West Coast Fossils: A Tribute to Paleo-Artist Ray Troll.** Constance Soja, Colgate University, csoja@colgate.edu; Kirk Johnson, National Museum of Natural History, bwhite@smith.edu.
- T14. **The Alexander Terrane: Multidisciplinary Comparisons with Caledonide Tectonic Patterns and Depositional Styles.** Constance Soja, Colgate University, csoja@colgate.edu; Sue Karl, USGS, skarl@usgs.gov.
- T15. **Modern and Legacy Geogenic Contaminants in a Changing Environment.** Birgit Hagedorn, University of Alaska–Anchorage, bhagedorn@uaa.alaska.edu; Keith Torrance, APC Services LLC, ktorrance@apcservicesllc.com.
- T16. **Translation and Displacement of Terranes in the Cordillera.** John Garver, Union College, garverj@union.edu; Cameron Davidson, Carleton College, cdavidso@carleton.edu.
- T17. **Large Eruptions in the Aleutians: New Insights into Chronology, Physical Volcanology, Tephrochronology, Petrology, and Impacts.** Kristi Wallace, USGS–Alaska Volcano Observatory, kwallace@usgs.gov; Christina Neal, USGS–Alaska Volcano Observatory, cneal@usgs.gov; Jessica Larsen, University of Alaska–Fairbanks, jflarsen@alaska.edu; Kirsten Nicolaysen, Whitman College, nicolakp@whitman.edu.
- T18. **Tectonics and Metallogeny of the Hinterland of the Yukon and Alaskan Cordillera—Recent Advances and Future Directions.** Maurice Colpron, Yukon Geological Survey, maurice.colpron@gov.yk.ca; Jamey Jones, USGS, jvjones@usgs.gov; Rick Saltus, USGS, saltus@usgs.gov.

FIELD TRIPS

For additional information please contact the field trip chair, Kristine Crossen, at kjcrossen@uaa.alaska.edu.

1. **Geology of the Chugach–Prince William Sound Accretionary Complex and Resurrection Ophiolite.** Cameron Davidson, Carleton College, cdavidso@carleton.edu; John Garver, Union College, garverj@union.edu.
2. **Backstage Tour of the New Alaska Geologic Materials Center.** Kenneth R. Papp, Alaska Division of Geological & Geophysical Surveys, kenneth.papp@alaska.gov; Jean Riordan, Alaska Division of Geological & Geophysical Surveys, jean.riordan@alaska.gov; Kurt Johnson, Alaska Division of Geological & Geophysical Surveys, kurt.johnson@alaska.gov.

3. **Cretaceous–Paleogene Bedrock Geology of the Matanuska Valley Area.** Ron Cole, Allegheny College, rcole@allegheny.edu; Dave Sunderlin, Lafayette College, sunderld@lafayette.edu; Jeff Trop, Bucknell University, jtrop@bucknell.edu.
4. **Stratigraphy and Sedimentology of Neogene Coal-Bearing Strata on the Kenai Peninsula, Cook Inlet, Alaska.** David LePain, Alaska Division of Geological & Geophysical Surveys, david.lepain@alaska.gov; Ken Helmhold, Alaska Division of Oil and Gas; Richard Stanley, USGS, rstanley@usgs.gov.
5. **Transect of the Mesozoic Subduction Complex, South-Central Alaska.** Sue Karl, USGS, skarl@usgs.gov; Chad Hults, National Park Service, chad_hults@nps.gov.
6. **Volcanic Mass-Flow Deposits of the Copper River Lowland near Chitina, Alaska.** Chris Waythomas, USGS, cwaythomas@usgs.gov; Kristi Wallace, USGS, kwallace@usgs.gov.

ACCOMMODATIONS

A block of rooms has been reserved at the **Hilton Anchorage**, 500 West Third Ave., Anchorage, Alaska 99501, USA, which is located in downtown Anchorage. Rate: US\$129. To make your reservation, please call +1-907-272-7411. Be sure to mention that you are attending the GSA Cordilleran Meeting, or use the “GSAC15” code. Shuttle transportation to and from the meeting venue on the University of Alaska–Anchorage campus will be provided.

STUDENT OPPORTUNITIES

Mentor Programs

The Roy J. Shlemon Mentor Program in Applied Geoscience. Students will have the opportunity to discuss career prospects and challenges with professional geoscientists from multiple disciplines over a FREE lunch. Learn more at www.geosociety.org/mentors/shlemon.htm.

The John Mann Mentors in Applied Hydrogeology Program. Students interested in applied hydrogeology or hydrology as a career will have the opportunity to network with professionals in these fields over a FREE lunch. Learn more at www.geosociety.org/mentors/mann.htm.

On To the Future (OTF): Stop by the GSA Foundation booth at the Welcome Reception to ask an onsite representative about applying to OTF, which provides travel support to students under-represented in the geosciences to attend their first GSA Annual Meeting (the next one is 1–4 Nov. 2015 in Baltimore, Maryland, USA). Learn more at community.geosociety.org/OTF/home/.

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2015 Section Meetings



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

SOUTHEASTERN

19–20 March

Chattanooga, Tennessee, USA
Abstracts deadline: 9 Dec. 2014



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

SOUTH-CENTRAL

19–20 March

Stillwater, Oklahoma, USA
Abstracts deadline: 16 Dec. 2014



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

NORTHEASTERN

23–25 March

Bretton Woods, New Hampshire, USA
Abstracts deadline: 9 Dec. 2014



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

CORDILLERAN

11–13 May

Anchorage, Alaska, USA
Abstracts deadline: 10 Feb. 2015



Madison, Wisconsin, USA. Photo courtesy GMCVB.

NORTH-CENTRAL

19–20 May

Madison, Wisconsin, USA
Abstracts deadline: 17 Feb. 2015



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

ROCKY MOUNTAIN

21–23 May

Casper, Wyoming, USA
Abstracts deadline: 17 Feb. 2015

GSA EDUCATION & OUTREACH PROGRAMS

2015 Section Meetings

On To the Future (OTF)

Stop by the GSA Foundation booth at your Section Meeting's Welcome Reception to ask an onsite representative about applying to OTF, which provides travel support to students underrepresented in the geosciences to attend their first GSA Annual Meeting (the next one is 1–4 Nov. 2015 in Baltimore, Maryland, USA).

CAREER PATHWAYS WORKSHOPS

Geoscience Career Workshop Part 1: Career Planning and Informational Interviewing:

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

Geoscience Career Workshop Part 2: Geoscience Career Exploration:

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

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

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

MENTOR PROGRAMS

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

South-Central Section: Stillwater, Oklahoma, USA
Shlemon Mentor Luncheon Program: Thursday, 19 March
Mann Mentors in Applied Hydrology Luncheon: Friday, 20 March

Southeastern Section: Chattanooga, Tennessee, USA
Shlemon Mentor Luncheon Program: Thursday, 19 March
Mann Mentors in Applied Hydrology Luncheon: Friday, 20 March

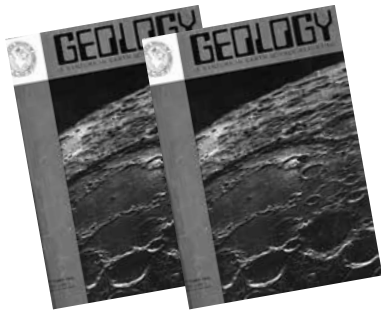
Northeastern Section: Bretton Woods, New Hampshire, USA
Shlemon Mentor Luncheon Program: Monday, 23 March
Mann Mentors in Applied Hydrology Luncheon: Tuesday, 24 March

Cordilleran Section: Anchorage, Alaska, USA
Shlemon Mentor Luncheon Program: Monday, 11 May
Mann Mentors in Applied Hydrology Luncheon: Tuesday, 12 May

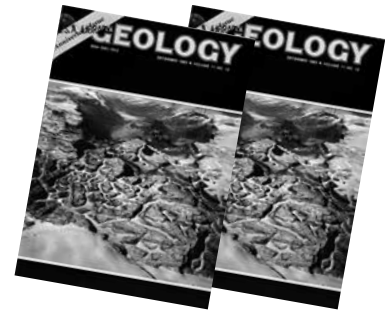
North-Central Section: Madison, Wisconsin, USA
Shlemon Mentor Luncheon Program: Tuesday, 19 May
Mann Mentors in Applied Hydrology Luncheon: Wednesday, 20 May

Rocky Mountain Section: Casper, Wyoming, USA
Shlemon Mentor Luncheon Program: Thursday, 21 May
Mann Mentors in Applied Hydrology Luncheon: Friday, 22 May





Geology—Past & Future REVISITED



Editor's note: The following is the seventh installment of our encore presentation of articles that highlighted the 10th anniversary of the first issue of *Geology*, as published in *Geology* in Dec. 1983 [v. 11, no. 12, p. 679–691, doi: 10.1130/0091-7613(1983)11<679:GAF>2.0.CO;2]. Each section was written by a different author (author affiliation notations are as originally published in 1983). See the August 2013 *GSA Today* (v. 23, no. 8, p. 18–19) for the first installment and table of contents. In this issue: article 14: “**Marine geology and geophysics,**” by Eli A. Silver; and article 15: “**Sedimentology,**” by R.H. Dott Jr.

Marine geology and geophysics

Eli A. Silver, Earth Sciences Board and Center for Coastal Marine Studies, University of California, Santa Cruz, California 95064

In 1973 we anticipated breakthroughs in the use of hot-spot traces in plate kinematics, in the study of seafloor-spreading processes using submersibles, and in the use of multichannel seismic reflection for refining the Seely-Vail model of accretion at active margins. Breakthroughs were hoped for in the use of ocean bottom seismographs (OBS); and they were ongoing in many fields, such as paleoceanography, as a result of the Deep Sea Drilling Project. We anticipated that collision tectonics would clarify the nagging inability of plate-tectonic theory to deal with orogenesis.

Although both hot-spot and OBS research have made significant advances, breakthroughs have not occurred in either field. Use of submersibles in studying seafloor-spreading processes was already providing startling new information on rift development through the FAMOUS project; since then, work in the Pacific has produced the remarkable discoveries of hydrothermal vent systems and their implications for ocean-crust formation and weathering, metallogenesis, the chemistry of the oceans, and their support of rich biological oases, dependent on *in situ* chemosynthesis. One aspect of the spreading process that was not anticipated in 1973 but is commonly accepted today is the idea of propagating rifts. Breakthroughs in paleoceanography include recognition of oceanic anoxic events.

The past decade of convergent-margin research, based on the combination of excellent multichannel seismic data and deep-sea drilling, has shown that processes of nonaccretion or even tectonic erosion are probably as common as that of accretion. D. Scholl and his co-workers had formulated such concepts as early as 1968, but their opinions were considered extreme by many, and they preceded critical data such as high-quality

seismic profiles and deep-sea drilling. The view of orogenesis in 1973, developed as a corollary to the simple mechanisms of plate tectonics, has been greatly modified by evidence for numerous small plates and for widespread plastic behavior in Asia, and by the new paradigm of terrane accretion.

Significant breakthroughs in our understanding of the structure and dynamics of convergent margins in the next decade will occur through use of swath-mapping, improved submersibles, and greater understanding of the role of fluids in tectogenesis. In addition to surface mapping (e.g., GLORIA, SEABEAM, Deep Tow, SeaMARC I and II), side-scanning seismic reflection will be common in the next decade. By 1993 we will see a new generation of submersibles that will allow much greater freedom of movement, potential for detailed sampling and photography, and ability to carry out geophysical experiments. Significant advances in understanding the role of fluids are occurring in studies of hydrothermal vent systems and the hydrogeology of convergent margin settings. In the next decade we may find that variations in pressures and compositions of fluids very sensitively govern progressive structural evolution in active continental margins. Breakthroughs in paleoceanography should follow from major advances in understanding the physical and chemical processes that control balances in the modern oceans, and from better understanding of the relationships between oceanic micro-organisms used as environmental indicators and their habitats. Our ability to discern such processes from the sedimentary record has improved significantly because of such tools as the hydraulic piston core.

During the next decade we will discover detailed modern analogs to many ancient orogenic processes and will develop a framework in which to interpret and reconstruct ancient orogenic belts. I anticipate breakthroughs also in our ability to identify various environments of formation of ophiolites, based on much better understanding of the modern sites of crustal generation, both in open-ocean and island-arc settings.

Send brief comments to gsatoday@geosociety.org. Should this article spark a longer comment, please consider writing a *GSA Today* Groundwork or science article; learn more at www.geosociety.org/gsatoday/.

Sedimentology

R.H. Dott, Jr., Department of Geology and Geophysics, University of Wisconsin, Madison, Wisconsin 53706

Ten years ago plate tectonics was being hailed as “A Revolution in the Earth Sciences” by A. Hallam in a book with that title (1973, Oxford Press) and *Geotimes* carried an ad for a little-noticed book on the creationist-evolution controversy in California. A flattening employment curve was being predicted for the seventies, and one can find in the January 1973 *Geotimes* that “only the best *men* are likely to find openings.” This was to change dramatically after the 1973 oil crisis, only to reverse drastically with the 1982 oil glut.

The past decade is put nicely into perspective by recalling that the Pioneer 10 spacecraft was launched in 1972 and passed the orbit of Pluto on June 13, 1983. When *Geology* was born in September 1973, the probe was approaching Jupiter. What were the frontiers in sedimentology then? A sampling of several journals for 1972–1974 revealed no overt predictions and surprisingly few papers on sedimentology in *Geology*. Nonetheless, plate tectonics, deep-sea drilling, and submersible vehicles obviously would be important to this as well as other specialties for at least a decade. The Kay Conference on modern and ancient geosynclinal sedimentation held in 1972 had already put into tectonic perspective many aspects of sedimentology. Perhaps the most dramatic revelation from deep-sea drilling at the time of *Geology*'s inception was the postulate of late Miocene drying up of the entire Mediterranean Sea. Less dramatic but of great importance was the beginning flow of literature on another Mediterranean, the Arctic Ocean.

In carbonate sedimentology, several trends were emerging. These included studies of the carbonate compensation depth through time and space, submarine cementation, and the seemingly intractable origin of dolomite (the Dorag Model was proposed in 1973). Of particular note was a 1973 Penrose

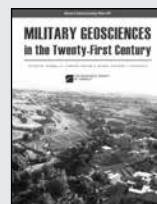
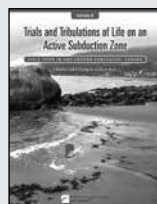
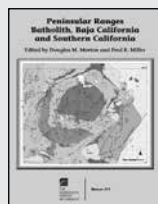
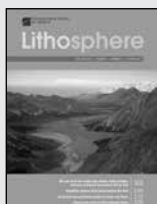
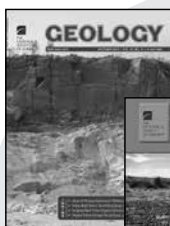
Conference, Water and Carbonate Rocks, at which the word “hydropetrocyberisotopicarbiogeophysichemistry” was coined. What is there left after that? If one topic stands out above all others in carbonate studies for the past decade, it would be the geochemistry of diagenesis. In clastic sedimentology, both modern and ancient deep-sea fans received much attention during the seventies, as did tidalites, braided fluvial sediments, and eolian sands. Diagenetic studies of sandstones began to accelerate after a late start. Experimental work continued to bear fruit, especially for the genesis of bed forms. Discovery of the Red Sea brine pools stimulated renewed interest in evaporites as well as sedimentary ore deposits. Identification of petroleum source rocks and the conditions for hydrocarbon maturation reached a level of almost routine confidence.

Clearly, the unifying plate-tectonics theory and the deep-sea drilling program *have* produced significant advances in sedimentology during the past decade, but the seeds of other important though less predictable trends were also sown in the early seventies. A 1973 symposium in Zurich on pelagic sedimentation helped to highlight a new thrust with much future promise for understanding fine, muddy sediments. One surprising result has been the recognition that mud dominates some very shallow shelf areas (e.g., Surinam and Yellow Sea). Studies of animal-sediment relationships continued to yield fruitful insights, especially in terms of relative rate of deposition. Evidence from both the modern sea floor and the ancient record for submarine erosion and the development of hardgrounds has increased greatly. From all of these and from studies of storm deposits has emerged a general theme of profound importance, namely the increasing realization that sedimentation in nearly all environments has been very episodic. This has important philosophical implications for the renewed advocacy of catastrophism by the extreme creationists. As Pioneer 10 plunges from the known limits of our solar system into deep space, sedimentologists and other geologists should be mindful of what *we* mean by words like uniform and catastrophic. From the Channeled Scablands to the deep sea, episodicity of processes seems to be the norm.

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Anna K. Mebust

Getting Science into the Hands of Policymakers

My year in Congress has officially come to a close. It was an incredible time, chock full of new experiences and knowledge. As I reflect back on this truly unique and transformative experience, I find myself thinking a lot about communication and its relationship to the role science plays in policymaking. Before I took the fellowship, I was frustrated with how science was used, or rather not used, by policymakers. I felt that the work I had done in graduate school was several stages removed from any policy influence, and I was at a loss for how to change this. I hoped that the fellowship would give me tools to help ensure that science influences policymaking in a concrete and comprehensive way.

So, what have I learned after a year? It turns out that scientists can do a lot to better facilitate the incorporation of science into the public-policy scene simply by changing their strategies for communication. Based on what I learned over the last year, let me humbly offer some suggestions for those who want to get science into policymaking. Of course, the best suggestion I can give is to apply for the fellowship program, no matter where you are in your career, and get the hands-on experience yourself! If that is not an option for you right now, here are a few suggestions.

First of all, do not be afraid to **reach out**. Unfortunately, many scientists seem to steer clear of direct interaction with the policy realm. This is a missed opportunity. If you want to impact policy, you should take the initiative to reach out to your members of Congress and request a meeting with their staff. And remember, sharing your research with congressional staff not only helps science to more strongly influence policy, it can promote science more directly. When you demonstrate the value of scientific research to your members of Congress, you can also influence funding levels for that research. If you have the opportunity, I would suggest participating in the annual Geosciences Congressional Visit Day (www.geosociety.org/geopolity/CVD/). If you can't make the next CVD, GSA may still be able to help set up visits whenever you're in D.C., and

you can also reach out directly to your members' offices in D.C. or in your state or district.

During your meetings, **be direct and to the point**. As I learned during some professional development sessions, scientists often try to communicate to the public in the same structure that we write papers and give presentations. We start with the background, then describe our methods, and finally end with our conclusions. Unfortunately, non-scientists often find the background boring or the methods confusing and are lost or disinterested by the time you get to the meaty conclusions. In a meeting with Congressional staff, you typically have a half-hour or less to identify your "ask" (i.e., what you want the office to do, such as vote a particular way on some legislation or write a letter in support of a program) and make your case as to why they should do it. If you spend the first fifteen minutes on detailed background, you may well lose their interest.

The key to making the most of your time is to identify your ask, as well as a few (three or four) clear and compelling takeaway points that support your request. Supporting background and details should come up only if they show interest in diving a little more deeply. Remember, the office has limited time and energy, and your ask is one among many, so your case needs to be strong and clear.

When discussing your research, also make sure you **communicate the value of your work**. Aside from the handful of current and former scientists floating around the Hill, most staffers are not very interested in what you do for its own sake. They are interested in what it means for their boss, the country, and the office's constituents. Policymakers have a finite amount of funding to distribute to several very deserving programs and a limited amount of time to put into supportive activities. "Knowledge for the sake of knowledge" is not as compelling as "my research has a direct effect on your constituents."

In fact, it can be extremely helpful to **identify what motivates policymakers** more broadly. Some useful questions to think about when shaping the case for your ask might include the following: Are there any positive or negative impacts on their constituents? What will their voters think about it? How can I describe my ask so that it is consistent with their previously established positions? Does it give them a good press opportunity? If you can make an argument for your ask that plays into their other priorities, you have a better chance of convincing them to take action.

Finally, if you want to offer yourself as a resource, and you actually want them to use you as one, make sure you demonstrate that you are **credible and reliable**. Sometimes congressional offices may just have an hour—or less—to put something together, so they turn to people whom they know will quickly get them good information that is ready to be used. If you want them to turn to you more often, make sure you respond quickly

and with information in a useful form (e.g., punchy, short sentences with a clear point that aren't polluted with qualifiers or figures that are simple and clear and express a single message). While you may regret the additional work, you will certainly have a significant opportunity to influence policy.

Now that the fellowship is over, I have begun a slow transition to the next stage of my career. I have moved back to the San Francisco area and am taking some much-needed vacation after several exhausting years of work. After that, I have some temporary work lined up and plan to take my time investigating different career options and finding a position that is truly a good fit. Wherever I end up, I am sure my fellowship experience will continue to help me facilitate the use of science in policymaking.

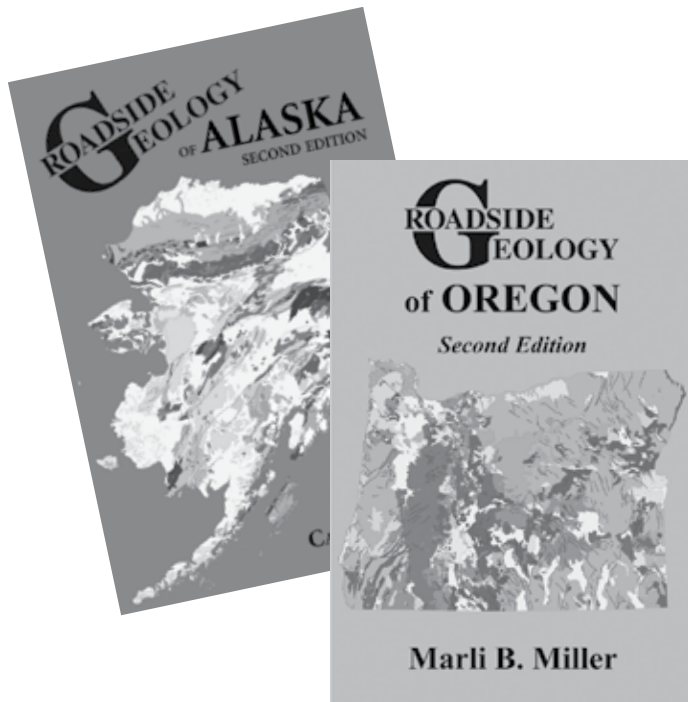
I strongly suggest that anyone interested in learning more about the political system and science policy consider the fellowship program, regardless of your career stage. If you have any questions about the fellowship program or science policy, I encourage you to contact me via e-mail at anamebust@gmail.com. With that, I sign off as the 2013–2014 GSA-USGS Congressional Science Fellow and welcome Susanna Blair, whom I expect will do a fantastic job over the coming year as the next fellow.

This manuscript is submitted for publication by Anna K. Mebust, 2013–2014 GSA-USGS Congressional Science Fellow, with the understanding that the U.S. government is authorized to reproduce and distribute reprints for governmental use. The one-year fellowship is supported by GSA and by the U.S. Geological Survey, Department of the Interior, under Assistance Award No. G13AP00095. The views and conclusions contained in this document are those of the author and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. government. Anna worked in the office of Senator Bernie Sanders (I-VT).

GSA Member in the News



GSA Fellow and Executive Director **John W. "Jack" Hess** has been named an Honorary Fellow of the Geological Society (GSL; London, UK). GSL notes that "during Jack's tenure [at GSA], collaboration between our Societies has developed dramatically in terms of co-sponsored meetings and marketing, and as a joint influence in international geopolitics."



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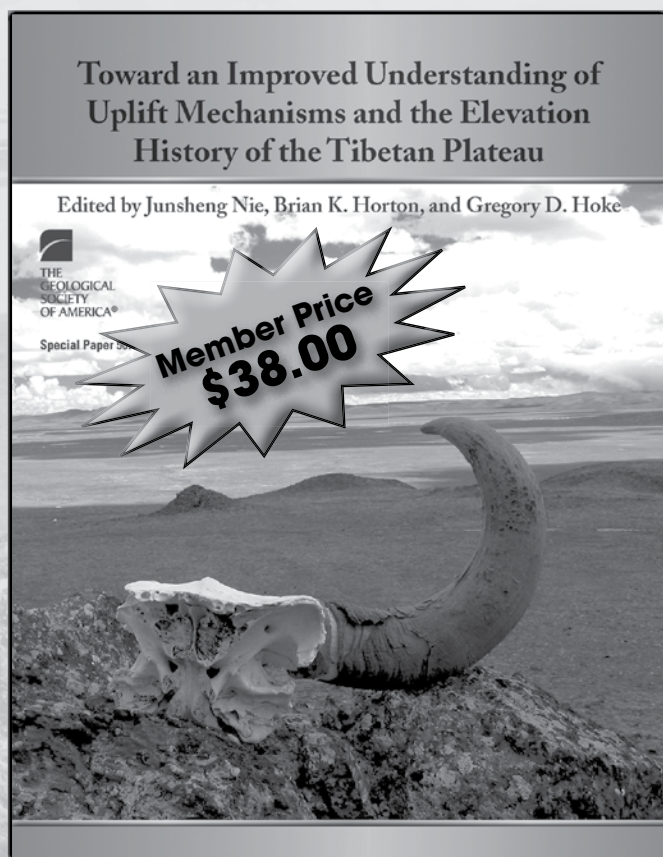
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Toward an Improved Understanding of Uplift Mechanisms and the Elevation History of the Tibetan Plateau

Edited by Junsheng Nie, Brian K. Horton, and Gregory D. Hoke



Defining the mechanisms responsible for topographic growth of the Tibetan Plateau has challenged geoscientists for decades. Deformation histories, sediment accumulation records, and thermochronology results suggest that plateau construction is likely the result of a protracted history of deformation that initiated before and continued throughout the Cenozoic India-Asia collision. However, key questions remain. What were the relative importance and magnitudes of pre-Cenozoic, Paleogene, and Neogene shortening? Has elevation gain in Tibet been punctuated or continuous? Did the Tibetan Plateau experience a shift in deformation kinematics during the Cenozoic and, if so, what were the driving mechanisms? How have tectonics and climate interacted during construction of the Tibetan Plateau? Advances in our understanding of these issues can be found in this volume.

SPE507, 154 p., ISBN 978-0-8137-2507-9
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LETTER

Dear Sirs,

This is in response to L.B. Platt.

All of the things he states in his recent letter (*GSA Today*, v. 24, no. 6, p. 45) are true. But in his hurry to find a recurrent cycle that could explain away the data, he is silent on the clear effects that the CO₂ we are putting into the air should have. Has he an idea where all of that CO₂ is going so that it has no effect? Let's be quantitative about the warming and potential causes. Simply citing "natural causes" without a reason dodges the issue. Can Dr. Platt put numbers to the cycles he speaks about that fit the recent observations? Does he have a sink for our current CO₂ emanations? Can he speak with authority (I can't) about what might have caused the "Medieval warm time"? Are those causes viable explanations today?

This is far too important an issue to muddle up with idle comments that may be peripheral to the argument.

Sincerely,
Dr. Harry W. Green II

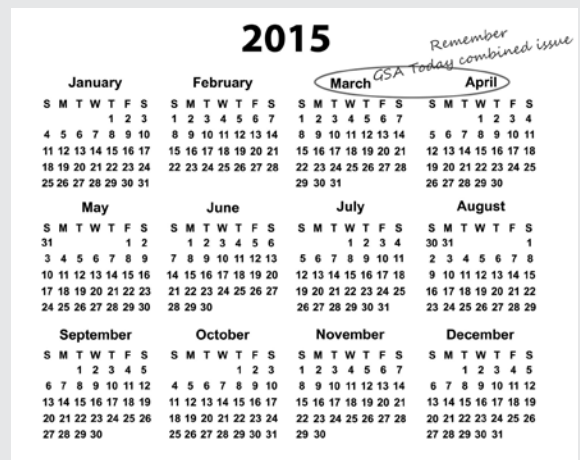
*Distinguished Professor of the Graduate Division, Department of Earth Sciences,
University of California*

Editor's note: This letter is one of many received in response to Platt. Rather than continue to publish letters on this topic, we encourage members to use GSA's Connected Community—our new online discussion forum. Log in at community.geosociety.org and post a message by selecting **Open Forum** in the main site navigation, and clicking on the **Discussions** tab.

Send letters by e-mail to gsatoday@geosociety.org or by post to Managing Editor, *GSA Today*, P.O. Box 9140, Boulder, CO 80301-9140, USA. Please keep your letter to 300 words or fewer; letters longer than 300 words will not be published. All letters will be forwarded to the *GSA Today* science editors for review for publication, and *GSA Today* reserves the right to reject any letter at the discretion of the science editor. Opinions presented do not reflect official positions of the Society.

New Publication Calendar for *GSA Today*

GSA Today is published 11 times a year, and that won't change. But beginning in 2015, the March issue will be combined with April (for a single March/April issue), and the May issue will stand on its own (not combined with April as in the past). *GSA Today* is making this change in order to provide more, and more up-to-date, information to you about GSA Annual Meetings.

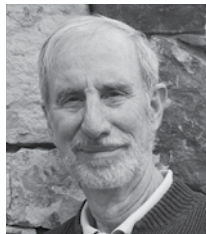


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www.geosociety.org/gsatoday/.



GSA FOUNDATION UPDATE

P. Geoffrey Feiss, GSA Foundation President



P. Geoffrey Feiss

The last four-and-a-half years as president of the Geological Society of America Foundation have been as rewarding as any in my career. I have had the pleasure of working with the superb professional staff at the Foundation and the Society. I have worked with the leadership of GSA and attest to their dedication to the Society's future. And, I have been supported in this work by the Foundation's trustees, whose

commitment is without peer.

As I approach retirement, I am pleased that Jack Hess will be the next president of the Foundation. Jack's leadership at GSA, care for the Society's future, and stewardship are legendary. Now he brings his unequaled insight, work ethic, and experience to the Foundation.

Moments like this are opportunities to look back and see how far we have come. First of all, and most gratifying, is that the bonds between the Society and the Foundation have never been stronger. Consultation and communication among staff and officers of the Society and Foundation are routine and substantive. Councilors and trustees have confidence in one another and are committed to the same priorities and goals. We work as a team for a common cause: furthering our science, our profession, and the welfare of GSA members.

Within the Foundation, we have seen significant changes in staffing and staff responsibilities while holding operating costs stable for five years. We have added two full-time development officers—one for individual and planned giving and one for corporate sponsorships. We have digitized our records, upgraded computer systems, automated gift receipts and tracking, and modernized our website.

I am proud of our success in fundraising. This is attributable first and foremost to the spirit and generosity of GSA members. As a result, numbers of donors, total annual contributions, funds transferable to GSA programs, the value of the Foundation's investments, and corporate support are at all-time highs. Student giving is growing. New restricted funds in support of GSA priorities are being created at two to three a year. We have new initiatives in diversity, professional career development for GSA members, recognition for excellence in geological mapping, and support of geoscience policy. There are the new Thompson International Lectureships, greatly increased support for student research grants and travel awards, and new funds bolstering scientific meetings of all kinds.

Much of this success has been member-driven. While the Foundation's staff is ready to assist in new projects, I have learned in the past four to five years that success comes when a member or group of members approaches the Foundation with an idea that captures the enthusiasm of GSA leadership and our trustees. The On To the Future initiative came directly from GSA's Diversity Committee as a challenge to the Society and Foundation on the occasion of the 125th anniversary of the Society. The Thompson International Lectureships grew out of a challenge from former GSA Treasurer Robbie Gries to enhance GSA's global presence. The Geoscience Careers in Industry Program at the annual meeting came from member-expressed needs articulated during GSA strategic planning and from conversations with corporate partners who felt that GSA should do more to offer students and early-career professionals exposure to job possibilities in the private sector. And, it was GSA member Pete Rowley who, in 2013, approached Council with the idea of creating an award for Distinguished Geologic Mapping—a new fund-raising priority for the Foundation this year.

GIVING TO THE GSA FOUNDATION

- Give online at www.gsafweb.org/makeadonation.html;
- Transfer securities: Contact Ed Smith, Merrill Lynch Senior Financial Adviser, +1-866-834-0756;
- Give when renewing your membership;
- Designate the GSA Foundation as a beneficiary of your IRA or your estate;
- Mail a donation to the GSA Foundation, P.O. Box 9140, Boulder, CO 80301-9140, USA.

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


GSA Foundation Update continued

What of the future? GSA members and corporate partners will, I am confident, step forward with new initiatives and generous support. Still, challenges lie ahead; GSA is not immune to change. The nature of scientific publications is changing in the digital era. We hear rumblings that electronic, synchronous media will change forever the nature of scientific gatherings. Membership organizations of all kinds see greater competition for member support and must earn the confidence that members place in them when they write their annual dues checks.

But, we are scientists. We thrive on what others describe (lament?) as “disruptive innovation.” The work we do every day is built upon an acceptance of and, indeed, an enthusiasm for, new ideas, discoveries, and change. In ever-closer partnership with the Society, the Foundation is eager to take on these new challenges.

I have had great fun in the past four-and-a-half years. I encourage all GSA members to be involved in your Society—and, not surprisingly, to continue supporting GSA through your generous contributions to the GSA Foundation.

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Thank You 2014 GeoCorps™ America Participants, Partners, and Donors!



Phillip Varela, Badlands National Park.

GeoCorps™ America places geoscientists of all levels—university students, teachers, professionals, and retirees—in short-term geoscience projects on public lands throughout the United States. GeoCorps projects are hosted by three major federal partners—the National Park Service (NPS), the U.S. Department of Agriculture (USDA) Forest Service, and the Bureau of Land Management (BLM). Projects cover a wide variety of subjects related to the geosciences, including geology, hydrology, paleontology, soils, geohazards, mapping, GIS, education, and interpretation. GeoCorps positions are sponsored by individual donors and the organizations listed below. Most GeoCorps positions take place during the spring/summer season, but some also take place during the fall and winter. The GeoCorps program also includes “Guest Scientist” positions, GeoCorps Diversity Internships, and GeoCorps American Indian Internships.

Positions for spring/summer 2015 will be posted 1 December 2014. Positions for fall/winter 2015 will be posted 1 May 2015.
www.geosociety.org/geocorps

Government Partners include

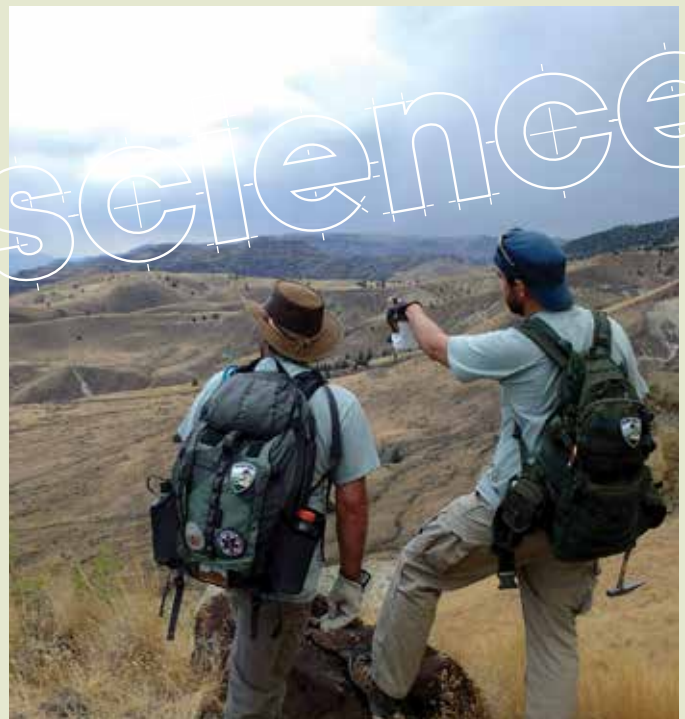
- National Park Service (NPS)
- United States Department of Agriculture (USDA) Forest Service
- Bureau of Land Management (BLM)

Major donors to the GeoCorps program include

- Geological Society of America Foundation (GSAF)
- Ms. Sally Newcomb

GeoCorps was also funded by the following organizations in the past year:

- Badlands Natural History Association
- Bryce Canyon Natural History Association
- Capitol Reef Natural History Association
- Colorado National Monument Association
- Devils Tower Natural History Association
- Friends of The Florissant Fossil Beds
- Grand Canyon Association
- Rare Element Resources
- Rocky Mountain Nature Association
- Western National Parks Association



Hayden Lewis, John Day Fossil Beds National Monument.

Government Partners and Major Donors to the GeoCorps Program

Government Partners



National Park Service (NPS)



U.S. Dept. of Agriculture (USDA) Forest Service



Bureau of Land Management (BLM)

Major Donors



GSA Foundation

Ms. Sally Newcomb

PARTICIPANTS—FALL/WINTER 2013–2014

Bureau of Land Management

BLM Carlsbad Field Office: **Heidi Breid**

BLM Public Lands Office: **Ross Mower**

National Park Service

Assateague Island National Seashore: **Joshua Hansen**

Chesapeake and Ohio Canal National Historical Park: **Ivan Carabajal**

Colorado National Monument: **Jennifer Kolm**

Congaree National Park: **Kathryn Moldawer**

Congaree National Park: **Samantha Stanford**

Conservation and Outdoor Recreation (COR) Division, NPS,
Washington Office: **Douglas Hessler**

Conservation and Outdoor Recreation (COR) Division, NPS,
Washington Office: **Peter Bonsall**

Death Valley National Park: **Vanessa Calder**

Dinosaur National Monument: **Meredith Dennis**

Grand Canyon National Park: **Graham Schindel**

Grand Canyon–Parashant National Monument: **Mitra Sartipi**

Kenai Fjords National Park: **Julie Markus**

Little Bighorn Battlefield National Monument: **Nancy Parker**

Mount Rainier National Park: **Laura Walkup**

Redwood National and State Parks: **Jason Padgett**

Rocky Mountain National Park: **Meredith Dennis**

Yosemite National Park: **Lauren Austin**

Yosemite National Park: **Roger Putnam**

USDA Forest Service

Klamath National Forest: **Rebecca Anderson**

PARTICIPANTS—SUMMER 2014

Bureau of Land Management

Bruneau Field Office: **Paige Kercher**

Colorado State Office: **Taylor Holden**

Craters of the Moon National Monument: **Megan Saalfeld**

Dominguez–Escalante and McInnis Canyons National

Conservation Areas: **Lucy Harrington**

Fairbanks District Office: **Jacob Wickemeyer**

Grand Junction Field Office: **Elizabeth Haussner**

Grand Staircase–Escalante National Monument: **Katja Knoll**

Grand Staircase–Escalante National Monument: **Robert**

D’Andrea

National Historic Oregon Trail Interpretive Center, Vale District:

Emma Howey

National Landscape Conservation System (NLCS): **Clayton Schmidt**

New Mexico State Office: **Briana Smith**

New Mexico State Office: **Garrett Williamson**

Price Field Office: **Mary Brill**

Public Lands Office: **Russell Pildes**

Royal Gorge Field Office: **Bridgette Miller**

Royal Gorge Field Office: **Ian Cannon**

Royal Gorge Field Office: **Kassandra Lindsey**

Royal Gorge Field Office: **Michele Gandee**

Taos Field Office: **Christopher Hitsman**

Taos Field Office: **David Banuelas**

Taos Field Office: **Nelson Stauffer**

Taos Field Office: **Rodney Betzer**

Upper Missouri River Breaks National Monument: **Ramia Bashara**

White River Field Office: **Christopher Moreno**

National Park Service

Assateague Island National Seashore: **Danna Muise**

Badlands National Park: **Alaina Fike**

Badlands National Park: **Alexis Godeke**

Badlands National Park: **Phillip Varela**

Bighorn Canyon National Recreation Area, Grant-Kohrs Ranch
National Historic Site, Little Bighorn Battlefield National
Monument: **Diana Boudreau**

Biological Resource Management Division: **Colleen Hunter**

Biological Resource Management Division: **Mary Klass**

Bryce Canyon National Park: **Kara Baker**

Bryce Canyon National Park: **Mark Green**

Cape Cod National Seashore: **Bradford Folta Jr.**

Capitol Reef National Park: **Sophie Westacott**

Chaco Culture National Historical Park: **Chelsea Lucas**

Chattahoochee National Recreation Area: **Jeffrey Hundley**

Colorado National Monument: **Alexander Slorby**

Colorado National Monument: **Angela Lexvold**

Colorado National Monument: **Brandon Mauk**

Colorado National Monument: **Curtis Logsdon**

Colorado National Monument: **Cyrus Green**

Colorado National Monument: **Jesse Zacher**

Colorado National Monument: **Kelly Wood**

Colorado National Monument: **Michael Davlantes**

Colorado National Monument: **Morgan Ynigues**

Colorado National Monument: **Nancy Lamm**

Colorado National Monument: **Thomas Hertenstein**

Colorado National Monument: **William Springer**

Colorado National Monument: **Zack Schuler**

Conservation and Outdoor Recreation (COR) Division, NPS,
Washington Office: **Peter Bonsall**

Coronado National Memorial: **Jessica Garcia**

Coronado National Memorial: **Quinn Butler**

Craters of the Moon National Monument and Preserve: **Kera Judy**

Craters of the Moon National Monument and Preserve: **Susan**

Birnbaum

Cuyahoga Valley National Park: **Laura Scaggs**

Delaware Water Gap National Recreation Area: **Michael Stepowyj**

Denali National Park and Preserve: **Andrew Collins**

Denali National Park and Preserve: **Sarah Strand**

Denali National Park and Preserve: **Sasha Leidman**

Devils Tower National Monument: **Mark Sprigler**

Dinosaur National Monument: **Benjamin Otoo**

Dinosaur National Monument: **Nicole Ridgwell**

El Malpais National Monument: **Andrew Wakefield**

Florissant Fossil Beds National Monument: **Bridget Borce**

Florissant Fossil Beds National Monument: **Kyrie Baumgartner**

Florissant Fossil Beds National Monument: **Mariah Slovacek**

Fossil Butte National Monument: **Amanda Meacham**

Gateway National Recreation Area: **Irina Beal**

Gateway National Recreation Area, Northeast Coastal and Barrier

Network: **David Riddell**

Gateway National Recreation Area, Northeast Coastal and Barrier

Network: **Kyle Nicholas**

Geologic Resources Division, National Park Service: **Joe Camacho**

Geologic Resources Division, National Park Service: **John Wood**

Geologic Resources Division, National Park Service: **Justin Tweet**

Geologic Resources Division, National Park Service: **Limaris Soto**

George Washington Carver National Monument: **Kyle Scherlinck**

Glacier National Park (East Glacier): **Dori Gorczyca**

Glacier National Park (East Glacier): **Sarah Francis**

Grand Canyon National Park (North Rim): **Charles Shobe**

Grand Canyon National Park (North Rim): **Christie Wilkins**

Grand Canyon National Park (South Rim): **Cassi Knight**

Grand Canyon National Park (South Rim): **Marissa Kelly**

Grand Canyon–Parashant National Monument: **Kyle Eastman**

Grand Canyon–Parashant National Monument: **Mitra Sartipi**

Grand Teton National Park: **Claudia Velasco**

Grand Teton National Park: **Peri Sasnett**

Great Basin National Park: **AnnMarie Jones**

Great Sand Dunes National Park and Preserve: **Katherine Schultz**

Hagerman Fossil Beds National Monument: **Salvatore Caporale**

Harpers Ferry National Historical Park: **Brandee Carlson**

John Day Fossil Beds National Monument: **Gabe Hinding**

John Day Fossil Beds National Monument: **Hayden Lewis**

John Day Fossil Beds National Monument: **Meaghan Emery**

John Day Fossil Beds National Monument: **Nicholas Famoso**

Mammoth Cave National Park: **Raemy Winton**

Mount Rainier National Park: **Benjamin Gross**

Mount Rainier National Park: **Arianna Goodman**

Mount Rainier National Park: **John Russell**

Mount Rainier National Park: **Mariah Doll**

Mount Rainier National Park: **Matthew Thomas**

Mount Rainier National Park: **Megan Killeen**

Mount Rainier National Park: **Nora Rose Hencir**

Mount Rainier National Park: **Rebecca Rossi**

Oregon Caves National Monument: **Bryn Keenhold**

Oregon Caves National Monument: **David Mason**

Oregon Caves National Monument: **Isidro Montemayor**

Oregon Caves National Monument: **Nathaniel Gilbert**

Oregon Caves National Monument: **Raphael Velazquez**

Pictured Rocks National Lakeshore: **Sarah Van der Meer**

Redwood National Park: **Jeffrey Prado**

Redwood National Park: **Misha Craddock**

Shenandoah National Park: **Andrea Rocchio**

Shenandoah National Park: **Dominique Poncelet**

Water Resources Division, National Park Service: **Somalia Randle**

USDA Forest Service

Custer National Forest, Sioux Ranger District: **Ethan Schreuder**

Gila National Forest: **Nathan La Fontaine**

Huron-Manistee National Forests: **Trevor Hobbs**

Medicine Bow–Routt National Forest and Thunder Basin

National Grasslands: **Emily Woolsey**

Medicine Bow–Routt National Forests: **Jennifer Aldred**

Monongahela National Forest: **Ellen Was**

Monongahela National Forest: **Kathryn McConahy**

Sierra National Forest: **Alejandra Jimenez**

Sierra National Forest: **Julio Alvarez**

Tongass National Forest: **Behnaz Hosseini**

Tongass National Forest: **Ian Putnam**

Tongass National Forest: **Jake Tholen**

White Mountain National Forest: **Kaitlyn Perham**

Willamette National Forest, McKenzie River and Middle Fork

Ranger Districts: **Julie Scott**



Ramia Bashara, Upper Missouri River Breaks National Monument.

Thank You

2014 Mosaics in Science Participants and Partners!



Roxanne Pourshoushtari, El Malpais National Monument.

The NPS–GSA **Mosaics in Science** program provides youth who are typically underrepresented in science career fields with on-the-ground, science-based work experiences with the U.S. National Park Service (NPS). Established in 2013, this multidisciplinary program provides opportunities for youth to work on inventory and monitoring, research, GIS, and interpretation and education projects. After the work experiences are completed, program participants attend a career workshop in Washington, D.C., where they present the results of their work. They are also exposed to different science career paths and develop skills for applying for and obtaining a federal job. The program is administered by The Geological Society of America in close collaboration with the NPS Geologic Resources Division (GRD) and the NPS Youth Program Office. Generous funding is provided by the National Park Foundation (NPF).

PROGRAM OBJECTIVES:

- Encourage diverse youth (17–25 years old) to pursue studies in geoscience and other STEM fields;
- Introduce youth to geoscience and other STEM careers in the National Park Service;
- Provide meaningful and relevant STEM-based internships in parks; and
- Increase relevance, diversity, and inclusion in the NPS workplace.

Positions for spring/summer 2015 will be posted 1 December 2014.

PARTICIPANTS—SUMMER 2014

Biscayne National Park: **Jeneva Wright**

Congaree National Park: **Binal Rana**

Coronado National Memorial: **Rachel Lopez**

Cuyahoga Valley National Park: **Yeyzy Vargas**

Denali National Park and Preserve: **Chelsea Lewis**

El Malpais National Monument: **Roxanne Pourshoushtari**

Florissant Fossil Beds National Monument: **Gabriella Rossetto**

Fort Union National Monument–Pecos National Historical Park:

Madeleine Pluss

Grand Teton National Park: **Anton Yelk**

Great Basin National Park: **Kaytan Kelkar**

Guadalupe Mountains National Park: **Salvador Amador**

Hopewell Culture National Historical Park: **Stephen Roethle**

Lava Beds National Monument: **Sarina Patel**

Manassas National Battlefield Park: **Nyambura Njagi**

North Cascades National Park Complex: **Justin Tran**

Ozark National Scenic Riverways: **Alianora Walker**

Petrified Forest National Park: **Shelby Matsuoka**

Prince William Forest Park: **Darius Naraine**

Saguaro National Park and other Southern Arizona Parks:

Kristan Culbert

San Juan Island National Historical Park: **Graham Crawbuck**

Valley Forge National Historical Park: **Sydney Mathis**



The National Park Service
The Geological Society of America®

www.geosociety.org/mosaics

Geoscience Jobs & Opportunities

Positions Open

ASSISTANT PROFESSOR OF ENVIRONMENTAL SCIENCE PENN STATE ERIE

Penn State Erie, The Behrend College, invites applications for a tenure-track faculty position in **Environmental Science** at the Assistant Professor level to begin August 2015. A Ph.D. in an environmental science or engineering area (e.g.: env. geochemistry, aqueous geochemistry, env. engineering, soil geochemistry, env. toxicology) is required at the time of appointment. The successful candidate should have demonstrated skills and interests in undergraduate education, and in mentoring undergraduate research in field and lab settings. The candidate should have the ability to develop a strong research program in their area of environmental expertise and participate in collaborative research with program faculty.

Penn State Behrend is a four-year, primarily undergraduate college of Penn State University with approximately 4,400 students and thirty-four baccalaureate majors. The College is committed to balance between teaching and research. The School of Science offers four-year majors in biology, chemistry, mathematics, math education, nursing, physics, and general science.

The new interdisciplinary major in Environmental Science at Penn State Behrend has a strong emphasis on natural and environmental resources in the Great Lakes region, environmental considerations related to Pennsylvania's growth in energy production, and national and international environmental topics. The program is currently housed in the School of Science and fosters collaboration across the School's other science programs. This hire will join with faculty from the biology, chemistry, geography, and geoscience programs to lead the growth of environmental science within the College. The successful candidate will contribute to upper-division courses in the major (Environmental Chemistry & Analysis; Water Resources Geochemistry; Soil Environmental Chemistry; Sediment Geochemistry; an interdisciplinary Capstone course), as well as to introductory science courses related to the candidate's area of specialization.

Erie Pennsylvania, a metropolitan area of 280,000 residents, is a major service, tourism, medical, and industrial center on Lake Erie's Presque Isle Bay and is located two hours from Cleveland, Pittsburgh, and Buffalo. The region offers many cultural, sports, and recreational resources, as well as modest living costs and affordable housing.

To apply for this position, please click on www.psu.jobs. Choose Campus: Penn State Erie, The Behrend College; Type of Job: Academic Jobs, see Job #53931. Submit four documents (1) cover letter, (2) curriculum vitae including names and contact information for three references, (3) copies of graduate and undergraduate transcripts and 4) teaching and research statements including a brief explanation of suitability of research at an undergraduate college. Questions regarding the position can be directed to Dr. Martin G. Kociolek, Director, School of Science, at kociolek@psu.edu. Review of applica-

tions will begin November 17 and continue until the position is filled. Employment will require successful completion of background check(s) in accordance with University policies.

CAMPUS SECURITY CRIME STATISTICS: For more about safety at Penn State, and to review the Annual Security Report which contains information about crime statistics and other safety and security matters, please go to www.police.psu.edu/clery/, which will also provide you with detail on how to request a hard copy of the Annual Security Report.

Penn State is an equal opportunity, affirmative action employer, and is committed to providing employment opportunities to minorities, women, veterans, disabled individuals, and other protected groups.

ASSISTANT PROFESSOR SEDIMENTARY GEOSCIENCE WEBER STATE UNIVERSITY

The Dept. of Geosciences at Weber State University invites applications for a tenure-track position at the Assistant Professor level starting August 2015. We seek a person with expertise in applied/emerging areas of sedimentary geoscience (e.g., basin analysis, depositional systems, sedimentary geochemistry, carbon sequestration, energy resources).

For a more detailed position description and to apply, please go to <http://jobs.weber.edu>. All applicants must complete the online application, which includes uploading a cover letter, statement of teaching philosophy and research plans, CV, and unofficial transcripts. In addition, three letters of reference addressing the candidate's qualifications for this position must be mailed to Dr. Rick Ford, Search Committee Chair, Dept. of Geosciences, Weber State University, 1415 Edvalson Street, Dept. 2507, Ogden, UT 84408-2507. **Applications received by December 5, 2014, are guaranteed full consideration, although screening will continue until the position is filled.**

Weber State University is an affirmative action, equal opportunity employer. Women and minorities are encouraged to apply. EOE/M/F/Vet/Disability. A criminal background check is required as a condition of employment.

ASSISTANT PROFESSOR GEOPHYSICS UNIVERSITY OF ARIZONA

The Dept. of Geosciences at the University of Arizona seeks applications for a tenure track faculty position in geophysics in the broad areas of geodynamics, seismology and/or geodesy. Candidates must hold a PhD degree by the time of appointment. Postdoctoral or other postgraduate research experience is desirable. We anticipate hiring at the tenure-track assistant professor level. The appointee is expected to develop and maintain a vigorous, collaborative, externally funded research program and to teach at the undergraduate and graduate level. Screening of applications will begin November 20, 2014, and the search will continue until the position is filled. The University of Arizona is a committed Equal Opportunity/Affirmative Action Institution. Women, minorities, veterans and individuals with disabilities are encouraged to apply. Applicants must apply online at: www.hr.arizona.edu/jobs, job

number 56514. Please include: a cover letter, including references, curriculum vita, and statements of research and teaching experience and interests.

GEOPHYSICIST DEPARTMENT OF GEOLOGY AND ENVIRONMENTAL SCIENCE JAMES MADISON UNIVERSITY 0406253

The Dept. of Geology and Environmental Science (www.jmu.edu/geology/) at James Madison University seeks applications for a Geophysicist at the Assistant Professor level for a tenure-track position beginning August 2015. A Ph.D. related to the geosciences is required at the time of employment. We seek a colleague who is committed to excellence in teaching and research involving undergraduates. Teaching responsibilities include introductory and upper level undergraduate geophysics courses, and general education science courses. Information on existing equipment housed in the department can be found at www.jmu.edu/geology/facilities.shtml. Collaborations are encouraged with faculty in other STEM fields. The department has 14 full-time faculty, 2 staff members, and approximately 125 undergraduate majors. Degree options include a BS in Geology, a BA in Earth Science, and minors in Geology and in Geophysics. Our graduates are recognized for their strong foundation in core geoscience disciplines with experience in undergraduate research. The department has an excellent record of placing students in graduate programs and employment in geoscience professions. To apply go to JobLink.jmu.edu, reference posting number 0406253 and submit a faculty profile, cover letter, a detailed curriculum vitae, a statement of teaching philosophy, a statement of research interests, and the names and addresses of three references. Questions regarding this position may be directed to Elizabeth Johnson, Search Committee Chair, at geophysics@csn.jmu.edu. Screening of applicants will begin December 21, 2014; however, applications will continue to be accepted until the position is filled. Salary is commensurate with experience. *JMU does not tolerate discrimination or harassment on the basis of age, color, disability, gender identity, genetic information, national origin, parental status, political affiliation, race, religion, sex, sexual orientation, or veteran status.*

TENURE TRACK FACULTY POSITION CLIMATE GEOSCIENTIST DEPARTMENT OF GEOLOGY COLLEGE OF WILLIAM & MARY

The Dept. of Geology at the College of William & Mary invites applications for a tenure-track faculty position at the Assistant Professor level that will begin in August 2015. We seek a broadly-trained climate geoscientist whose research and teaching interests may include, but are not limited to, paleoclimatology, climate dynamics/modeling, or climate and landscape change at short or long time scales. We encourage applicants with interests in broader questions relating to the impacts of climate change on society (water resources, food, health, energy, land use). The successful candidate will teach courses and advise research students in their area of specialty as well as contribute introductory-level courses in geology and environmental science.

The department has six full-time faculty and a laboratory coordinator, and graduates ~25 undergraduate majors per year all of whom complete a senior research project. The Geology department works closely with the College's interdisciplinary Environmental Science and Policy program.

Candidate must apply online at <https://jobs.wm.edu>. Submit a curriculum vitae, a cover letter, and statements of teaching and research interests. You will be prompted to submit online the names and email addresses of three references who will be contacted by us with instructions on how to submit a letter of reference.

For full consideration, submit application materials by the review date, November 21, 2014. Applications received after the review date will be considered if needed.

At the AGU Conference in San Francisco in December, selected interviews will be conducted.

Required: A Ph.D. is required at the time the candidate begins the appointment (August 10, 2015).

Information on the degree programs in the Dept. of Geology can be found at www.wm.edu/as/geology/.

The College of William & Mary values diversity and invites applications from underrepresented groups who will enrich the research, teaching and service missions of the university. The College is an Equal Opportunity/Affirmative Action employer and conducts background checks on applicants for employment.

TENURE-TRACK ASSISTANT PROFESSOR OF HYDROGEOLOGY GEORGIA STATE UNIVERSITY

The Dept. of Geosciences at Georgia State University seeks to hire a tenure-track faculty member in the area of Hydrogeology, pending budgetary approval. Candidates should have expertise in one or more area of physical, chemical, or biological hydrogeology; these include, but are not limited to, hydrogeochemistry, biogeochemistry, environmental hydrogeology, groundwater-surface water interactions, contaminant flow and transport, groundwater resources, and others. Candidates may have expertise in numerical modeling, field studies, and/or experimental techniques. We particularly invite candidates with a willingness to participate in interdisciplinary collaborations centered on urban issues, in line with one of GSU's strategic goals of understanding the complex challenges of cities and developing effective solutions. The successful candidate will develop a strong externally-funded research agenda at GSU, and will be expected to teach both lower- and upper-division courses in hydrogeology and other topics of interest, and to direct graduate students. A Ph.D. in Geosciences or a closely related discipline is required by the time of appointment. The position will begin in August 2015.

Georgia State University is a growing research university in the heart of downtown Atlanta with a diverse student body of over 32,000 students. The Dept. of Geosciences (<http://geosciences.gsu.edu/>) offers bachelors and masters degrees in Geosciences, with concentrations in geography and geology, and a Ph.D. in Chemistry with a concentration in geology. Extensive geochemical facilities are available in

Geosciences, and many other analytical facilities are available in Biology and Chemistry. Atlanta is a fast-growing, dynamic, and diverse metropolitan area with ~6 million people, world-class cultural and entertainment opportunities, access to the mountains and the coast, and an airport with direct service to destinations around the globe. The GSU campus sits blocks from the State Capitol and the largest federal building in the southern U.S., housing regional headquarters of EPA, USDA, DOT, DOI, and others.

Candidates should e-mail a cover letter, curriculum vitae, statements of research and teaching interests and goals, and the names and email addresses of at least three references to Dr. Hassan Babaie, Chair of the Hydrogeology Search Committee, at geosjobsearch@gsu.edu. To ensure full consideration, applicants should send their materials by November 15, 2014; the search will remain open until the successful candidate is identified and the position is filled. An offer of employment will be conditional upon background verification. Georgia State University is a Research University of the University System of Georgia and is an EEO/AA employer.

TENURE TRACK POSITIONS IN REMOTE SENSING AND GEOMATERIALS TEMPLE UNIVERSITY

The Dept. of Earth and Environmental Science is entering a period of growth with a newly launched Ph.D. program. To achieve this growth, the department seeks to fill two tenure-track faculty positions to begin in August 2015. One of the positions will be in the area of REMOTE SENSING. A second position will be in the area of GEOMATERIALS. Exceptional candidates holding a Ph.D. are encouraged to apply at any level (assistant, associate, or full professor). Mentoring of undergraduate and graduate students and securing external funding are expected. Applicants must have a Ph.D. in a relevant science discipline.

REMOTE SENSING: We especially encourage applicants with a focus on the analysis of Earth using airborne or satellite remote sensing platforms, expertise in digital signal processing for geoscience applications, and the use satellite data for understanding climate change. This appointment will complement existing expertise in geophysics, hydrogeology, structural geology, geomorphology, and planetary geology, and make use of the new high-performance computing cluster. Applicants should be able to teach undergraduate and graduate courses including Remote Sensing and Physical Geology.

GEOMATERIALS: Of particular interest are applicants with a focus on energy as well as earth science, and with expertise in mineralogy and petrology that crossover to material science. The candidate should investigate crystalline, glassy, or melt geomaterials with a goal of understanding the atomic-scale characteristics that lead to macroscopic properties in earth sciences. The individual is expected to use a combination of field or experimental based data collection and modeling approaches. This appointment will complement existing expertise on the properties of nano-minerals and geochemistry within EES as well as materials research conducted through supercomputing, engineering, chemistry, and physics

STEPHEN F. AUSTIN STATE UNIVERSITY NACOGDOCHES, TEXAS

CHAIR DEPARTMENT OF GEOLOGY

The Department of Geology at Stephen F. Austin State University invites applications for the department chair position. We seek an individual with strong management, communication, and interpersonal skills to provide innovative and energetic leadership. Duties include managing curricula, budgets, student enrollment, personnel, program assessment, and developing strong, mutually beneficial relationships with industry and alumni. The incumbent will teach a reduced load of courses and develop a research program in his/her area of expertise. Applicants must have credentials for appointment at the associate or professor rank in geology.

Submit a letter of application, CV, and contact information for three references to <https://careers.sfasu.edu> (posting 0603046).

Also mail official transcripts to:
Dr. Kenneth Farrish
Search Committee Chair
Stephen F. Austin State University
Department of Geology
PO Box 13011 SFA Station
Nacogdoches, TX 75962-3011
(936) 468-3701

Review of applications will begin on Jan. 9 and will continue until the position is filled. Equal Opportunity Employer; Security-sensitive position; this position will be subject to a criminal history check.



utilizing a variety of in place instrumentation and the newly formed Temple University Energy Frontier Research Center. Applicants should be able to teach undergraduate and graduate courses including Mineralogy and Petrology.

Applications should first email a letter of intent to the appropriate Search Committee Chair. REMOTE SENSING applicants should send a letter of intention to apply and any inquiries to **Alexandra Davatzes, Chair, Search Committee**, alix@temple.edu, whereas GEOMATERIALS applicants should email **Nick Davatzes, Chair, Search Committee**, davatzes@temple.edu. Applicants should upload a CV, statement of teaching goals, a research plan, names and addresses of at least three references, and selected reprints via the following website: <http://ees.cst.temple.edu/>. We request application material be submitted by **December 1, 2014**. Temple University is a state-related research-intensive institution with an undergraduate enrollment of more than 27,000 and nearly 10,000 graduate and professional students. More information about our department is available at www.temple.edu/geology/. Temple University is an equal opportunity, equal access, affirmative action employer committed to achieving a diverse community (AA, EOE, M/F/D/V). The department specifically encourages applications from women and minorities.

**TENURE-TRACK FACULTY POSITION
SEDIMENTOLOGY
DEPT. OF GEOLOGICAL SCIENCES
THE UNIVERSITY OF ALABAMA**

The Dept. of Geological Sciences at The University of Alabama invites applications for an Assistant Professor tenure-track faculty position in sedimentology beginning August 2015. Candidates must have a strong record of research and teaching, and must have received their Ph.D. in Geosciences at the time of appointment. The successful candidate will be expected to establish an externally-funded research program, attract and supervise graduate students, and teach undergraduate and graduate courses in sedimentology/stratigraphy, and introductory geology. The department has a broad range of isotopic, geochemical and modeling research facilities available, in addition to University-shared instrumentation at the Central Analytical Facility (www.caf.ua.edu). Details regarding existing research programs, equipment, facilities, and departmental activities are at www.geo.ua.edu. Questions should be directed to Dr. Delores Robinson (dmr@ua.edu). Go to <http://facultyjobs.ua.edu/postings/35994> to electronically apply. When submitting an application, candidates must provide a cover letter, CV, research and teaching statements, and a list with the contact information for at least three referees. Review of applications will begin November 17, 2014. The University of Alabama is an Equal Opportunity Affirmative Action Employer and actively seeks diversity in its employees.

**TENURE-TRACK FACULTY POSITION
SEISMIC STRATIGRAPHY
DEPT. OF GEOLOGICAL SCIENCES
THE UNIVERSITY OF ALABAMA**

The Dept. of Geological Sciences at The University of Alabama invites applications for a tenure-track faculty position in seismic stratigraphy, begin-

ning August 2015. The position will be filled at the Assistant Professor level. Candidates are invited to apply who have specialties within the broad field of seismic stratigraphy. Energy industry experience is a plus. It is expected that this position will enhance our existing faculty research areas in geophysics, sedimentology, basin analysis, and petroleum geology. Candidates must have a strong record of research and teaching, and must have received a Ph.D. in geology, geophysics, or a related field, at the time of appointment. The successful candidate will be expected to establish a vigorous, externally funded research program and attract and advise high-quality graduate students. Teaching responsibilities will include undergraduate and graduate courses in her/his specialty and introductory geology. The department has a broad range of geophysical, geochemical, and computational facilities, in addition to University shared facilities, including the Dauphin Island Sea Lab. Departmental software includes industry standards such as ProMAX, Petrel, IHS Kingdom, Geosoft, ArcGIS, and Matlab. Details regarding existing research programs, equipment and facilities, and departmental activities can be found at www.geo.ua.edu. Questions should be directed to Dr. Ibrahim Cemen (icemen@as.ua.edu). Applicants should go to <http://facultyjobs.ua.edu/postings/36000> to electronically apply for this position. When submitting an application, candidates must provide a cover letter, CV, research and teaching statements, and a list with the contact information for at least three referees. Applications will be reviewed beginning November 17, 2014. The University of Alabama is an Equal Opportunity Affirmative Action Employer and actively seeks diversity in its employees.

**ASSISTANT PROFESSOR
GEOSCIENCE EDUCATION
GRAND VALLEY STATE UNIVERSITY**

The Geology Dept. at Grand Valley State University (www.gvsu.edu/geology) seeks a creative and dynamic educator with expertise that complements the existing strengths of the department's faculty, a demonstrated commitment to effective teaching, academic experiences with culturally diverse populations, and a record of active scholarship. For more information about the responsibilities of the position, please visit https://www.gvsujobs.org/applicants/jsp/shared/position/JobDetails_css.jsp?postingId=369978. Either a Ph.D./Ed.D. in science education with at least a M.S. in geoscience or Ph.D. in geoscience with demonstrated interest/experience in K-12 science education is required.

Apply online at www.gvsujobs.org. Attach a letter of application, vitae, statements of teaching philosophy and research interests, and the names and contact information of at least three references familiar with your teaching and/or research potential. Review of applications will begin on December 1, 2014, and continue until position is filled.

**CLIMATOLOGY AND ENERGY GEOPHYSICS
POSITIONS AT BINGHAMTON UNIVERSITY**

Binghamton University will make two tenure-track appointments in the broad area of geophysics starting Fall 2015. We seek outstanding candidates with research and teaching interests in climatology and energy geophysics. Appointments are planned at the assistant professor level, however exceptionally

qualified applicants may be considered for a higher level appointment.

Position 1: Climatology (Geophysical Fluid Dynamics): We anticipate hiring a **climatologist** who employs geophysical fluid dynamics to study global scale energy exchange within the Earth System. Possible research areas might include: (1) past, present and future climate change; (2) understanding modern climate systems to interpret paleoclimate archives preserved in ice and sediments, and to predict future climate changes; (3) the dynamics of sea-level changes as ice sheets respond to changing energy levels in the atmosphere and oceans; (4) impact of climate variations on renewable energy resources; and (5) impacts of climate change on ecosystems and human health. Geophysicists with other research areas in the broad field of climatology are also encouraged to apply.

Position 2: Energy Geophysicist: We anticipate hiring an **energy geophysicist**, with expertise in the exploration of Earth's shallow subsurface structure and composition. We are particularly interested in geophysicists familiar with the acquisition and processing of seismic data and other geophysical tools for the interpretation of rock structures and sequences in sedimentary basins. This hire will likely collaborate with current faculty working on basin analysis, tectonics, and sedimentary processes. Possible research areas might include: (1) advanced seismic imaging; (2) attribute analysis to differentiate lithologic and fluid variability in sedimentary sequences to better understand processes leading to hydrocarbon or ore accumulation; (3) documenting the sequence of events and rates of tectonic and sedimentological processes; and (4) 3D analysis of sedimentary sequences.

The successful candidates must develop and sustain nationally recognized, externally funded research programs in their areas. We also expect the candidates to develop a strong record of teaching and mentoring students and to teach undergraduate courses in geophysics and advanced undergraduate/graduate level courses in their areas of expertise. We are seeking candidates who will strengthen our existing research programs in geochemistry, sedimentary geology, or Earth surface processes, and who will seek to interact with geologists, environmental scientists, chemists, physicists and engineers on the Binghamton University campus. Candidates must have a Ph.D. with a focus in these fields, at the time of appointment. Interested candidates should submit a letter of application, curriculum vitae, statements of research and teaching interests, and names and contact information of at least three references to the Binghamton University Interview Exchange site at <http://binghamton.interviewexchange.com>. For further information about the department, visit the Geological Sciences and Environmental Studies website (www.binghamton.edu/geology).

For questions about the Climatology position, contact Professor Steve Dickman (dickman@binghamton.edu); for questions about the energy geophysics position, contact Professor Bob Demicco (demicco@binghamton.edu).

These positions are affiliated with the Smart Energy Area, one of five Transdisciplinary Areas of Excellence (TAEs) that Binghamton University has identified for growth under the auspices of the

SUNY2020 plan. The successful candidate will contribute to the development of this TAE as an area of intensive research and teaching. The search committee will include members of the Smart Energy TAE steering committee. For more information on the TAEs [and SUNY2020], go to www.binghamton.edu/academics/provost/tae2013.html. Women and minorities are encouraged to apply. Binghamton University is an equal opportunity/affirmative action employer. The position will remain open until filled. The review of applications will begin on November 30, 2014.

**GEOLOGY TENURE-TRACK
FACULTY POSITION
HUMBOLDT STATE UNIVERSITY**

Starting August 2015 / Job #7619

Seeking candidates with specialization in one or more areas of Mineralogy and Petrology. Instructional assignments may include: introductory and general education geology courses; required courses in mineralogy/earth materials, earth resources, petrology/petrography, field geology; at least one upper division/graduate level course in the successful candidates' specialty; and summer field camp every two or three years.

To view full vacancy announcement, please visit <http://apptrkr.com/517800>.

HSU is a EO/Title IX/ADA Employer

**TENURE TRACK POSITION IN
SEDIMENTARY GEOLOGY
SAN FRANCISCO STATE UNIVERSITY**

San Francisco State University's Dept. of Earth & Climate Sciences seeks candidates for a tenure-track position in Sedimentary Geology at the Assistant or Associate Professor level, to begin August 2015. A Ph.D. is required, and postdoctoral experience is preferred. We seek a scientist committed to furthering the understanding of sedimentary processes through a variety of applications. Salary for this position is to be negotiated and will be commensurate with experience. Applicants must have a commitment to excellence in teaching and demonstrate ability to develop an outstanding, externally-funded research program. Use AcademicJobsOnline.org (<https://academicjobsonline.org/ajo/jobs/4546>) to see full ad and apply. For questions, contact Dr. Karen Grove: kgrove@sfsu.edu; +1-415-338-2061. The search committee will begin reviewing applications on November 14, 2014. San Francisco State University is an Equal Opportunity employer with a strong commitment to diversity and encourages applications from women, members of all ethnic groups, veterans, and people with disabilities.

**ASSISTANT PROFESSOR
LECTURER AND INSTRUMENT/
ACADEMIC SPECIALIST POSITIONS
INDIANA UNIVERSITY—
PURDUE UNIVERSITY
AT INDIANAPOLIS (IUPUI)**

The Dept. of Earth Sciences at IUPUI invites applications for three positions, a tenure track position in mineralogy, a lecturer in earth sciences, and an instrumentation/academic specialist.

We seek a tenure-track faculty member at the Assistant Professor level with experience in mineralogy and/or nanoparticle sciences as applied to solid

earth systems or environmental geosciences and human health. A Ph.D. in earth sciences or closely related field received prior to August 2015 is required and postdoctoral experience is desirable. Candidates should have a strong research record, an interest in multidisciplinary research, the ability to initiate and sustain an externally funded research program, and a commitment to both undergraduate and graduate mineralogy education. Field-based research and teaching programs are important and preference will be given to individuals who can interface with interdisciplinary research teams in earth sciences as well as chemistry, biology and public health. Applicants for the tenure track position should submit a letter of application, curriculum vitae, statement of research interests, statement of teaching interests, and the names and contact information of at least four references. Interested individuals are encouraged to submit their application as a single PDF file to ibsz100@iupui.edu.

We also seek a full-time, non-tenure-track lecturer who has a strong commitment to excellence in teaching and mentoring students. An M.S. degree in earth sciences is required, a Ph.D. preferred. Candidates must have a record of quality teaching in physical, environmental, or historical geology, and an ability and interest in teaching upper division courses. Experience with developing curriculum and specific courses such as field trips and short courses in his/her specialty is desirable. Candidates are expected to engage in scholarship of teaching and learning as well as actively serve on both departmental and university committees. Interest and ability to mentor and coordinate graduate teaching assistants is essential. Individuals with experience in instrumentation and/or data analysis as it applies to instruction in the earth sciences are strongly encouraged to apply. Applicants for the lecturer position should submit a letter of application, curriculum vitae, a statement of teaching philosophy, summaries of recent peer and student teaching evaluations if available, and at least three letters of recommendation addressing the candidate's teaching qualifications. Any other materials that document teaching experience and effectiveness are recommended. Applicants should submit these materials, in a single PDF file, to the Lecturer Search Committee at LL3@iupui.edu.

We also have an immediate opening for a full-time position as instrumentation/academic specialist who will supervise teaching and research laboratories including instrumentation support and maintenance. Review of applications will begin October 27th and continue until position is filled. An M.S. degree in earth sciences, chemistry, biology or closely related field is required. For further details on this position, please visit the Dept. of Earth Sciences website.

We are a growing department that offers undergraduate degrees in geology and environmental science, the M.S. in geology, and an interdisciplinary Ph.D. degree in Applied Earth Sciences (<http://earthsciences.iupui.edu/>). The department has 12 faculty with active research programs in aqueous, stable isotope and microbial geochemistry, biogeosciences, paleoclimatology and global change, medical geology, terrestrial surface and hard rock geology, planetary geology, glacial geology and geomorphology, hydrology, and remote sensing. State-of-the-art

geochemistry labs are equipped with stable isotope ratio mass spectrometers, a cavity ring down spectrometer, GC-MS, ICP-MS, ICP-OES, electrochemical equipment, chromatographs (IC, GC, and HPLC), and a multisensor core scanner. IUPUI is home to the Integrated Nanosystems Development Institute (<http://indi.iupui.edu/>) that houses modern SEM and XRD facilities shared by Earth Sciences faculty.

Applications for either position may also be mailed to the committees at Dept. of Earth Sciences, IUPUI, 723 West Michigan Street, Indianapolis, IN, 46202-5132. Review of applications for the mineralogist and lecturer position will begin December 1, 2014, and continue until the positions are filled.

IUPUI is Indiana's premier urban public research university and is home to 30,000 students. IUPUI is an equal opportunity, affirmative-action employer.

**ASSISTANT PROFESSOR OF GEOSCIENCES
HAMILTON COLLEGE**

The Geosciences Dept. at Hamilton College seeks applicants for a tenure-track **Assistant Professor of Geosciences** to begin in July 2015. The successful candidate for the position must have a Ph.D. in the geosciences with a broad background in sedimentary geology and related field experience. The candidate will be expected to establish a strong scholarly record in sedimentary geology and to advise undergraduate research projects. Teaching responsibilities will include a required course in sedimentary geology, a topical introductory course in geology, and one or more electives in the candidate's specialty. At least one of the elective courses will contribute to the interdisciplinary Environmental Studies Program as a cross-listed Geosciences/Environmental Studies course on climate change.

Our program in sedimentary geology is supported by an isotope ratio mass spectrometer with elemental analyzer, a scanning electron microscope with EDS analytical capabilities, a small research vessel for inland lake studies equipped with a variety of sonar and coring devices, a full-time departmental technician, and by four supportive faculty colleagues with diverse research interests.

A candidate interested in the position and who meets these requirements should submit (1) a cover letter that addresses his/her qualifications for the position; (2) a statement describing his/her teaching philosophy; (3) a statement of research interests; (4) a complete *curriculum vitae*; and (5) letters from three professional referees who know the candidate well and understand the expectations of a competitive liberal arts college. Your cover letter should address ways in which issues of diversity are brought into your teaching, scholarship, and/or service. Experience teaching or working with diverse student populations is an asset. Candidates should submit these materials to Professor Todd Rayne via Interfolio at <http://apply.interfolio.com/25839>. Review of applications will begin on December 5, 2014, and continue until the position is filled.

Hamilton (www.hamilton.edu) is a residential liberal arts college located in upstate New York. Applicants with dual-career considerations can find other Hamilton and nearby academic job listings at www.upstatenyherc.org. Hamilton College is an affirmative action, equal opportunity employer and

is committed to diversity in all areas of the campus community (www.hamilton.edu/diversity). Hamilton provides domestic partner benefits. Candidates from underrepresented groups in higher education are especially encouraged to apply.

**ASSISTANT PROFESSOR OF
EARTH AND PLANETARY SCIENCES
WASHINGTON UNIVERSITY IN ST. LOUIS**

The Dept. of Earth and Planetary Sciences at Washington University in St. Louis invites applications for a tenure-track Assistant Professor in high-T geochemistry, isotope geochemistry, or cosmochemistry. The ideal candidate will combine analytical and theoretical approaches to study the chemical and isotopic evolution of Earth, other terrestrial planets, and/or small bodies of the Solar System. The successful candidate will be responsible for developing a vigorous, externally funded research program, teaching a range of undergraduate and graduate courses, writing for publication, advising students, and university service.

We seek individuals who will enhance existing strengths in geochemistry and cosmochemistry, petrology, and solid-earth geophysics. Candidates must have a Ph.D. with a focus in high-T geochemistry, isotope geochemistry, cosmochemistry, or a related field, at the time of appointment. A wide range of instrumentation is available in the EPS department including a Neptune Plus multicollector ICP-MS, Cameca 7f-geo SIMS, and many other related and supporting analytical facilities. The appointment includes membership in the McDonnell Center for the Space Sciences, a world-class intellectual cluster in the field of space sciences.

Interested individuals should send a letter of application, curriculum vitae, statement of teaching and research interests, and names and contact information of at least four references to Prof. Brad Jolliff, Geochemistry Search Committee Chair, Washington University, Campus Box 1169, 1 Brookings Drive, St. Louis, MO 63130, or via e-mail: geochem_search@levee.wustl.edu. Women and minority candidates are encouraged to apply. Washington University is an equal opportunity/affirmative action employer. Employment eligibility verification required upon employment. Applications will be considered until the position is filled, but priority will be given to those received by November 15, 2014.

**ENVIRONMENTAL GEOPHYSICIST
& LOW-TEMPERATURE GEOCHEMIST
POSITIONS, DICKINSON COLLEGE**

The Dickinson College Dept. of Earth Sciences is expanding its faculty and invites applications for TWO tenure track positions at the Assistant Professor level, ABD or PhD (preferred). (1) **Environmental Geophysicist:** Teaching responsibilities for this position will include hydrogeology, an upper level course in environmental geophysics, a required introductory course and upper level electives in the candidate's field of expertise. (2) **Low-Temperature Geochemist:** Teaching responsibilities include a required upper level low temperature Geochemistry course for the major, a required introductory course, upper level electives in the candidate's field of expertise (e.g., climate change, critical zone studies, environmental geochemistry).

The successful candidates will be committed to teaching excellence in the liberal arts tradition and will have broad interests in geosciences beyond their specialty. Experience in student-faculty undergraduate research is highly desirable. Applicants must demonstrate a strong potential for interacting effectively with undergraduate students and an ability to collaborate effectively with students and colleagues from diverse backgrounds.

The Dickinson Earth Sciences curriculum emphasizes project-based learning with a strong field component, which is greatly facilitated by our location in the Great Valley, near the folded Appalachians, the northern terminus of the Blue Ridge, and the Triassic rift basins. The department has excellent analytical (AAS, SEM-EDS, CL, XRD, XRF, TOC, laser particle size analyzer, digital 3-component seismometer, a 5-well instrumented well field for hydrogeologic investigations) and computing facilities. More information can be found on the college (www.dickinson.edu) and department (www.dickinson.edu/homepage/96/earth_sciences) web pages. Dickinson College is a highly selective private liberal arts college in south-central Pennsylvania within easy drive of the New York-Washington, D.C., metro corridor.

Applicants should apply on-line using jobs.dickinson.edu. Review of applications will begin November 17 and continue until each position is filled. Dickinson College, an EEO Employer, is committed to building a representative and diverse faculty, administrative staff, and student body. We encourage applications from all qualified persons. We value the ability to create an inclusive classroom for an increasingly diverse student body

**ENVIRONMENTAL BIOGEOCHEMISTRY,
GEOBIOLOGY, DARTMOUTH COLLEGE**

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

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

of sabbatical leave for each three academic years in residence, and flexible scheduling of teaching responsibilities.

Dartmouth College, a member of the Ivy League, is located in Hanover, New Hampshire (on the Vermont border). Dartmouth has a beautiful, historic campus located in a scenic area on the Connecticut River. Recreational opportunities abound all year round. To learn more about Dartmouth College and the Dept. of Earth Sciences, visit www.dartmouth.edu/~earthsci.

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

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

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

**TENURE TRACK ASSISTANT PROFESSOR
PALEOCLIMATE/PALEONTOLOGY
CALIFORNIA STATE UNIV. NORTHRIDGE**

The Dept. of Geological Sciences at California State University Northridge invites applications for a full-time tenure-track faculty position at the level of Assistant Professor in Paleoclimatology/Paleontology. We offer B.S. and M.S. degrees in Geology and in Geophysics. The successful candidate must have a Ph.D. at the time of appointment. Experience in post-doctoral research and/or University-level lecture instruction is desirable. We seek an innovative paleoclimatologist/paleontologist with technical expertise in one or more of the following fields: paleontology, paleoecology, low-temperature geochemistry, paleo-oceanography, geochronology, dendrochronology, palynology, or other techniques. We particularly seek candidates who both complement our current research program and integrate across tectonics, sedimentology, and stratigraphy. The successful candidate is expected to develop a vigorous research program, which includes seeking extramural funding, publishing peer-reviewed papers, and involving undergraduate and M.S. students. Furthermore, the successful candidate is expected to demonstrate teaching excellence and provide effective instruction to students of diverse backgrounds. Potential classes to be taught by the new hire include: a new undergraduate core course in Earth Systems, a general education course in climate change, and elective offerings at the upper-division and/or graduate level in the candidate's research specialty.

Applicants should submit a cover letter, CV, three letters of recommendation, statement of teaching philosophy and experience, and statement of research interests. Electronic submissions are strongly

encouraged and should be sent to: paleontology.search@csun.edu. Materials can also be sent to: Paleontology Search Committee, Dept. of Geological Sciences, California State University Northridge, 18111 Nordhoff Street, Northridge, CA 91330-8266. Review of applications will begin 1 January 2015. Priority will be given to applications received by this date, but the position remains open until filled. For additional information, see www.csun.edu/geology. The University is an EO/AA employer.

**TENURE TRACK ASSISTANT PROFESSOR
GEOPHYSICS**

CALIFORNIA STATE UNIV. NORTHRIDGE

The Dept. of Geological Sciences at California State University Northridge invites applications for a full-time tenure-track faculty position at the level of Assistant Professor in Solid Earth Geophysics or Earthquake Processes. The successful candidate must have a Ph.D. at the time of appointment. Experience in post-doctoral research and/or University-level lecture instruction is desirable. We seek an innovative geophysicist with technical expertise in passive or active source seismology, geodynamics, numerical modeling, or earthquake geophysics. We particularly seek candidates who both complement our current research program and integrate across tectonics and geophysics. We offer B.Sc. and M.Sc. degrees in Geology and in Geophysics. The successful candidate is expected to develop a vigorous research program, which includes seeking extramural funding, publishing peer-reviewed papers, and involving undergraduate and M.S. students. Furthermore, the successful candidate is expected to demonstrate teaching excellence and provide effective instruction to students of diverse backgrounds. A successful candidate will enthusiastically contribute to teaching courses that provide rigorous preparation for students in our geophysics program at a range of levels. Course offerings include: an introductory course Living with Earthquakes in California, a new undergraduate core course in Earth Tectonics and Structure, undergraduate courses in geophysics, and elective offerings at the upper-division and/or graduate level in the candidate's research specialty.

Applicants should submit a cover letter, CV, three letters of recommendation, statement of teaching philosophy and experience, and statement of research interests. Electronic submissions are strongly encouraged and should be sent to: geophysics.search@csun.edu. Materials can also be sent to: Geophysics Search Committee, Dept. of Geological Sciences, California State University Northridge, 18111 Nordhoff Street, Northridge, CA 91330-8266. Review of applications will begin on 1 January 2015. Priority will be given to applications received by this date, but the position remains open until filled. For additional information, see www.csun.edu/geology. The University is an EO/AA employer.

**TENURE-TRACK FACULTY POSITION
IN GEOSCIENCE EDUCATION
DEPT. OF GEOLOGICAL SCIENCES
CALIFORNIA STATE
UNIVERSITY FULLERTON**

The Dept. of Geological Sciences at California State University Fullerton <http://geology.fullerton.edu/> invites applications for a tenure-track Assistant

Professorship that will begin August 2015. Area of expertise shall include the study of geoscience education. The successful candidate will be expected to develop an active, externally funded program involving undergraduate and Master's students in the candidate's field of study. The successful candidate must demonstrate interest and ability to teach courses in geoscience education at lower- and upper-division levels. Additional teaching may include introductory-level geosciences and upper-division/graduate courses. The successful candidate shall: (1) coordinate geoscience education courses; (2) help facilitate the integration of teacher preparation into our B.A. program; and (3) be involved in program-level assessment for our department. For a complete position description, see http://diversity.fullerton.edu/jobs/ft/geoscience_education.asp.

To apply, send a single pdf file including: (1) a detailed curriculum vita; (2) a letter of application; (3) a teaching statement that includes: a discussion of relevant course work and/or experience in preparation for teaching, a list of courses you are qualified to teach, and a statement of your teaching philosophy; and (4) a statement of your future research plans and/or goals, as the pertain to the geoscience education position. Letters of recommendation from at least three referees familiar with your teaching and research potential should be sent separately. Applicants and referees should email materials directly to: Dr. Matthew Kirby, Geoscience_ed_search@fullerton.edu. Applications will be accepted until the position is filled. To ensure full consideration, submit all application materials by November 14, 2014.

California State University Fullerton celebrates all forms of diversity and is deeply committed to fostering an inclusive environment within which students, staff, administrators and faculty thrive. Individuals interested in advancing the University's strategic goals are strongly encouraged to apply. EEO employer. Reasonable accommodations will be provided for qualified applicants with disabilities who self-disclose.

**DIRECTOR
KENTUCKY GEOLOGICAL SURVEY
UNIVERSITY OF KENTUCKY**

Founded in 1865 as a land-grant institution adjacent to downtown Lexington, UK is nestled in the scenic heart of the Bluegrass region of Kentucky. Recently ranked as one of the safest, most creative, and the brainiest cities in the nation, Lexington is an ideal location to experience the work-life balance that the University strives to provide to its employees. See for yourself what makes UK one great place to work.

The University of Kentucky seeks a Ph.D.-level geoscientist to serve as the Director of the Kentucky Geological Survey in Lexington, Kentucky and the 13th State Geologist of Kentucky. This is a high-level administrative position within the university. For more information about the duties of this position go to kgs.uky.edu/StateGeologist. To apply for job # RE00309, submit a UK Online Application at www.uky.edu/ukjobs. If you have any questions, contact HR/Employment, phone +1-859-257-9555, press 2. **Application deadline is November 16, 2014.**

The University of Kentucky is an equal opportunity employer and encourages applications from minorities and women.

**GEOCHEMIST/PETROLOGIST
OCCIDENTAL COLLEGE**

The Dept. of Geology at Occidental College invites applications for an Assistant or Associate Professor in Geochemistry or Petrology. Occidental is a nationally ranked liberal arts college recognized for its diverse student body and outstanding undergraduate research program. We seek a colleague who values undergraduate teaching and can sustain an active research program involving undergraduates. Training applicable to teaching mineralogy, petrology, and geochemistry is required; these courses should enhance students' understanding of chemical processes acting on the earth, and increase students' expertise in quantitative and instrumental methods. The successful candidate will also contribute to teaching introductory geology and engage undergraduates in research projects.

Applications should include a statement of teaching and research interests in the context of a liberal arts college with a diverse undergraduate student body. Candidates should specifically address their ability to teach a diverse undergraduate student body and engage students in an ongoing research program. Submit statement, a curriculum vitae, 1-3 significant publications, and contact information for three referees to Dr. Margi Rusmore, Search Committee Chair, at geosearch1@oxy.edu. Search committee members will meet interested candidates at the GSA and AGU meetings; email the committee to make arrangements. Members of underrepresented groups are especially encouraged to apply. **Review of applications will begin October 15, 2014, and will continue until the search closes on December 31, 2014.**

Opportunities for Students

Lindahl Ph.D. Scholarships, The University of Alabama, Dept. of Geological Sciences (DGS) seeks highly qualified Ph.D. students with specializations in topics that complement faculty research interests. Exceptional students will receive Research or Teaching Assistantships and a Lindahl Scholarship totaling \$22,000 for a nine-month appointment. The University of Alabama covers the cost of non-resident tuition and fee waivers, and health insurance. Funding is renewable for at least 4 years if expectations are met. Other fellowships are available from the Graduate School on a competitive basis. Further details on the DGS and the faculty members can be found at www.geo.ua.edu. Applicants should contact Dr. Dolores Robinson (dmr@ua.edu) to express interest. Review of applications for Fall 2015 admission will begin January 15, 2015.

Assistantships, Dept. of Geosciences, Univ. of Akron. The Dept. of Geosciences, Univ. of Akron, Ohio has assistantships available starting in the spring and fall 2015 for students who have the drive and curiosity to succeed in graduate school. Examples of the on-going research include studies in geobiology, structural and environmental geology, studies of the climate record contained in lake sediments, oceans, and caves, and in global biogeochemical cycles. Interested students may contact Dr. John Peck at jpeck@uakron.edu for more information and apply online at www.uakron.edu/gradsch/apply-online/.

Evolution of paleontology: Long-term gender trends in an earth-science discipline

Roy E. Plotnick, *Dept. of Earth and Environmental Sciences, University of Illinois at Chicago, 845 W. Taylor Street, Chicago, Illinois 60607, USA, plotnick@uic.edu*; **Alycia L. Stigall**, *Dept. of Geological Sciences and Ohio Center for Ecology and Evolutionary Studies, Ohio University, 316 Clippinger Laboratories, Athens, Ohio 45701-2979, USA*; and **Ioana Stefanescu**, *Dept. of Earth and Environmental Sciences, University of Illinois at Chicago, 845 W. Taylor Street, Chicago, Illinois 60607, USA*

The historical development of gender diversity in paleontology may be representative of similar changes across the geosciences. An analysis of the programs of the ten North American Paleontological Conventions held since 1969 shows a steady increase in the participation by women in the discipline. Notably, the proportion of male authorship on abstracts was stable while female authorship contribution increased. Much of the growth in female authorship is due to increased collaboration and recognition of student participation with junior authorship. These changes are just starting to be reflected at more senior levels; strategies need to be implemented to ensure that young female geoscientists are retained and developed.

Studies of long-term trends in gender dynamics in science can help identify strategies that are working and highlight additional actions to further reduce barriers to full participation. We examined such long-term changes in meeting participation in paleontology. By examining meeting participation, rather than employment trends (e.g., Holmes and O'Connell 2003), we investigate gender dynamics within the intellectual development of a discipline.

Paleontology is a diverse field, and workers in the various subdisciplines often attend different conferences. Every four to five years, however, all flavors of paleontologist converge for the North American Paleontological Convention (NAPC). The first of these was held in 1969 (Yochelson, 1996); the tenth and most recent this past February. The programs of these meetings reflect transformations in how, and by whom, the science of paleontology is practiced.

The first NAPC was limited to 79 presentations in organized symposia. Nearly all of the presentations were single-authored, and only two talks were presented by women. In contrast, the 2014 meeting included 315 separate talks, many in posters and contributed sessions. Most were multi-authored, and 130 of the presenters were women, a two order of magnitude increase in female participation since 1969.

There clearly have been some fundamental changes in the nature of paleontological conferences and, by implication, the field of paleontology. To track how these changes occurred over time, we analyzed the program and abstract volumes for all ten

NAPCs. For each, we counted the total number of abstracts; the number of authors per abstract; whether an abstract had at least one female or male author and if so, how many; and whether a woman was the senior or sole author. Gender was determined either by first name or by personal knowledge of the author in ambiguous cases. To measure how many times an author appeared on multiple abstracts, we divided the total number of authors on abstracts by the number of unique names of authors (multiple authorship index). We standardized the data by dividing each value by the number of published abstracts. When possible, we recorded whether a woman chaired or co-chaired a session and whether a woman was a keynote or plenary session presenter; this data was incomplete. Key results are summarized in Figure 1.

Notably, participation by women has increased over the past 45 years (Fig. 1). Women comprised only 2% of authors in 1969, but were senior authors on 40% of abstracts and contributed to 58% of abstracts in 2014. This increased participation occurred largely due to collaboration with, rather than replacement of, male paleontologists. Indeed, ~90% of all abstracts included a male author at each NAPC. In addition, the proportion of papers with female authors has increased faster than the proportion of women who are lead authors. At the 2014 NAPC, there was a statistically significant difference (Kolmogorov-Smirnov test) in the median number of authors on papers with at least one female author (3.0; $n = 222$) and those without a women author (2.0; $n = 158$). Thus women are more likely to work in larger groups and are less likely to be the sole author, which explains the discrepancy between the proportion of total authorship and proportion of lead authorship by women. When women were senior authors on multi-authored abstracts, they had female co-authors 55% of the time, whereas 44% of the male senior authors had at least one female co-author. Both the trend lines and statistical comparisons indicate that much of the increased female involvement is as secondary authors and that women tend to publish with other women.

The increases in authors per abstract and multiple authorship index indicate both increasingly collaborative projects and changing social patterns whereby junior project participants are increasingly recognized with authorship. The coincident increases in female authorship and authors per abstract may be related to the documented propensity for female scientists to collaborate more broadly (van Rijnsoever and Hessels, 2011) and to more often pursue “mentoring” collaboration strategies compared to the “expertise” strategies of men (Bozeman and Gaughan, 2011). The inclusion of junior collaborators in authorships is a likely mechanism for increased female authorship because there are more paleontologists at junior than senior ranks.

The attrition of women from student to senior scientist ranks has been well studied (e.g., deWet et al., 2002; Shen, 2013).

Membership data for the Paleontological Society (PS), which includes a diversity of paleontologists similar to the demographic sampled by NAPC, indicates that women comprise 48% of student members but only 23% of professional members (Stigall, 2013). These values compare closely with the demographics of The Geological Society of America (GSA) in which women comprise 45% and 27% of student and professional members, respectively (GSA, 2014). The substantially higher percentage of student versus professional women in these data supports the earlier assertion that increased collaboration with and participation by students may underlie the trends in increased participation by women, thereby linking the patterns of multi-authorship and higher proportions of women in meeting presentations.

The roles of female participants at NAPC also reflect the more limited female involvement at more advanced career stages observed in the membership data. Notably, participation by women in prominent roles at the NAPC as keynote/plenary speakers or symposium conveners has increased much later and more sporadically than abstract participation. Only the recent Gainesville meeting had equal participation by women as symposia organizers or keynote speakers. Limited participation by women in high-profile roles is documented in other disciplines (Isbell et al., 2012) and cannot be fully attributed to historical lags.

The nearly continual increase in female participation and collaboration over the past 45 years as valued contributors in scientific presentations is encouraging. Gender equity, however, is only beginning to emerge within the prominent roles of conveners and keynote speakers. A 90% inclusion of males versus 60% inclusion of females on presentations and the continued underrepresentation of women in high-profile speaking or organizational roles underscores that more work is needed to achieve gender equity. The high participation by women in NAPC presentations and the high percentage of female student members of the PS and GSA clearly show that there is a pool of talented, engaged young women in paleontology and geosciences in general. Future studies should address how this is reflected in participation in meetings and publications among other geoscience disciplines.

Strategies to support these students and early-career women in all areas of geosciences, such as providing childcare at meetings (Williams and Ceci, 2012) and fostering mentoring opportunities, can promote retention of these talented scientists within the professional ranks. Further strategies to enhance representation by women in prominent conference roles, such as directed

invitations, flexible scheduling of organizational tasks, and confronting internal biases, are necessary to remove barriers to full participation by mid- and late-career women. The substantial improvements in gender equity over the past 45 years coupled with an awareness of and plans to mitigate current barriers and limitations has the potential to produce an historical record of a discipline much evolved from its mid-20th-century record.

ACKNOWLEDGMENTS

We would like to thank Dena Smith and Sandra Carlson and two anonymous reviewers for their substantive and useful suggestions on this contribution.

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Manuscript received 12 May 2014; accepted 27 Aug. 2014. @

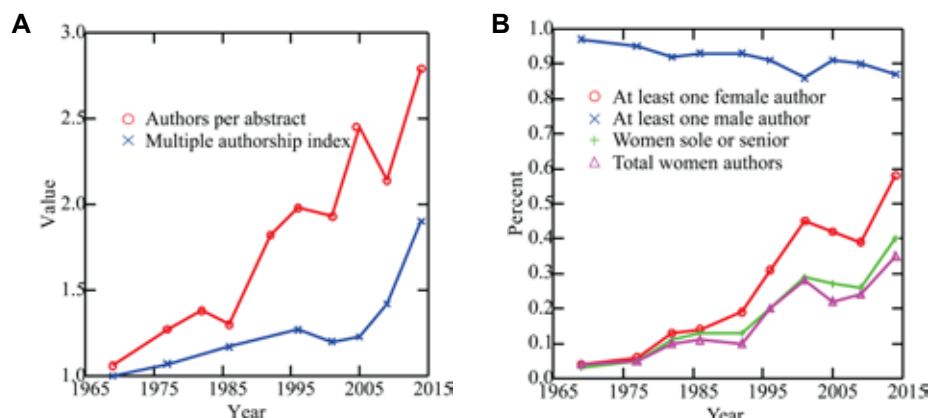
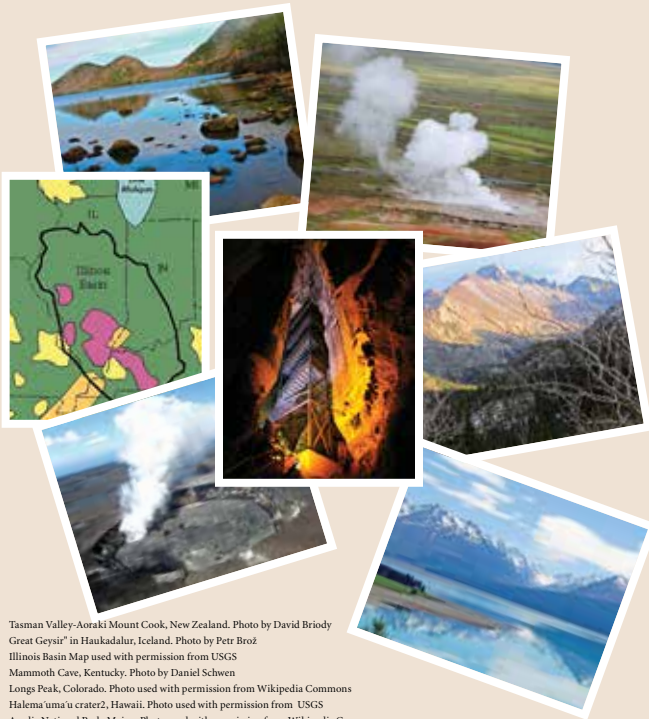


Figure 1. Authorship trends at the North American Paleontological Convention. Meetings were held in 1969, 1977, 1982, 1986, 1992, 1996, 2001, 2005, 2009, and 2014. (A) Average number of authors per abstract. Multiple authorship index is total number of authors on abstracts divided by number of unique authors in the program index. The number of authors per abstract has nearly tripled, whereas the number of authors appearing on multiple papers has almost doubled. (B) Proportion of papers with at least one male author, at least one female author, of total authors who are women, and with a woman as sole or senior author. The proportion of female authors has increased in all metrics, whereas the proportion of male authorship has been stable.

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