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Photo credit: Eyal Marder

This westward-looking photograph from Staunton State Park, Colorado, captures a region upstream of the Colorado Rocky Mountain front, showcasing the transition from ancient, gently eroding highlands to steeper, rapidly incising terrain downstream. See related article on pages 4–11.

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THE GEOLOGICAL SOCIETY OF AMERICA®

The Colorado Rocky Mountains Awaken: Understanding Topographic Rejuvenation in Postorogenic Mountain Belts

Eyal Marder,*[1] Sean F. Gallen,[1] Nathaniel A. Lifton,[2] and Tammy M. Rittenour[3]

ABSTRACT

Tectonically inactive postorogenic mountains enigmatically display landscape instability through fluctuations in fluvial incision, relief production, and sediment flux long after mountain building ends. The Colorado Rocky Mountains (CRM), situated in the interior of the North American plate, exemplify this phenomenon. Primarily constructed during the Laramide orogeny (ca. 80–40 Ma), the CRM maintain high-relief terrain, while the fluvial network at their ancient foreland basin, the High Plains, records a shift from net deposition to net erosion in the Pliocene to early Pleistocene. Geodynamic and climatic drivers have been proposed to explain this evidence of a geologically recent landscape rejuvenation, yet conclusive evidence favoring a given mechanism remains elusive. In this study, we analyze bedrock channels draining the CRM to the High Plains using new and existing ^{10}Be-derived basin-averaged erosion rates and bedrock incision rates from luminescence dating of fluvial terraces to determine whether the rejuvenation of the Colorado Rockies is due to regional geodynamic forces or climatic changes in the last ~5 m.y. Within fluvially dominated portions of the CRM, our results reveal two distinct geomorphic zones separated by a series of upstream-migrating knickpoints across the entire ~350-km-long mountain front: (1) a slowly eroding, lower-gradient landscape at higher elevations, and (2) a steep, rapidly eroding landscape at lower elevations. The lower and steeper landscape below knickpoints indicates a regional increase in the rate of base-level lowering relative to the CRM mountain front, implying geologically recent relief production. Additionally, our results detect a gradual increase in channel steepness below knickpoints from north to south, consistent with previous geomorphic evidence and geodynamic models for the CRM region, which predict a southward increase in rock uplift rates in the last ~5 m.y. On a broader scale, our findings demonstrate that geodynamics, along with climate, lithology, and autogenic factors, can influence the evolution of postorogenic mountain belts long after mountain building has ceased.

INTRODUCTION

Knowledge of the evolution of mountain ranges and the drivers of topographic change is essential for understanding the Earth system, with implications for global climate change, carbon and nutrient fluxes to oceans, and ecological habitats for terrestrial and riverine biodiversity (Davis, 1911; Willett and Brandon, 2002; Kirby and Whipple, 2012; Hilton and West, 2020). While the development of active mountain ranges is generally well explained by plate tectonics, the evolution of postorogenic mountains remains contentious. Traditional models for postorogenic mountain evolution suggest a slow and steady decline in mean elevation, topographic relief, and erosion rates over time (e.g., Davis, 1911). However, it is now understood that most postorogenic mountains display geomorphic and stratigraphic evidence of landscape rejuvenation, which many studies hypothesize is a key to their longevity (Gallen et al., 2013; Tucker and van der Beek, 2013). Geomorphic and geophysical studies suggest that multiple factors shape postorogenic mountains, including mantle geodynamics, climate change, erosionally induced isostatic rebound, autogenic drainage reorganization, and lithologic variability (e.g., McMillan and Heller, 2006; Wobus et al., 2010; Gallen et al., 2013; Tucker and van der Beek, 2013; Gallen, 2018; Abbott et al., 2022). This diversity of influences underscores the challenge in pinpointing the dominant processes driving landscape instability in postorogenic regions.

The Colorado Rocky Mountains (CRM) serve as a prime example of this complexity (Fig. 1). Located in the middle of

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[4] Supplemental Material. Text S1. Supplementary details on the methods used in the study. Figures S1–S3: River profile models and analyses; Figure S4: Detailed OSL results; Figure S5: Sensitivity analysis for topographic analysis; Tables S1–S2: Detailed information on ^{10}Be basin-wide samples; Tables S3–S6: Detailed information on OSL samples. Please visit https://doi.org/10.1130/GSAT.S.28012838 to access the supplemental material; contact editing@geosociety.org with any questions.

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the North American plate, the CRM are a postorogenic mountain range uplifted during the Laramide orogeny (ca. 80–40 Ma; Dickinson and Snyder, 1978). From the late Eocene to Oligocene, the CRM experienced a protracted tectonically quiescent period of declining relief and undulating smooth topography (Chapin and Kelley, 1997). However, this tectonically quiescent period was disrupted in the late Miocene by tectonic extension and normal faulting associated with Rio Grande rifting, which dismembered, structurally inverted, and uplifted parts of the CRM, particularly in the south (Ricketts et al., 2016). At the same time, the CRM were potentially affected by dynamic mantle processes associated with subduction of the Farallon-Kula plate (Mitrovica et al., 1989; Moucha et al., 2008), while the High Plains, the ancient foreland basin of the CRM (Fig. 1), experienced a period of net deposition, covering the region with Ogallala Group sedimentary units during the Miocene to Pliocene (Fig. 2; McMillan et al., 2002). In the Pliocene, the region transitioned from a phase of net deposition to a phase of net erosion due to a major shift in boundary conditions (tectonics, climate), during which major rivers rapidly incised into the Ogallala Group units in the High Plains (McMillan et al., 2002; Riihimaki et al., 2006; Duller et al., 2012; Willett et al., 2018).

Geophysical studies have shown that the relatively thin crust of the CRM (~30–40 km, compared to other mountain ranges worldwide) is insufficient to explain their steep topography and sediment flux changes through isostasy processes alone (MacCarthy et al., 2014), indicating a need for geologically recent topographic rejuvenation. Geomorphic and paleohydraulic studies in the southern parts of the High Plains have noted deformation and long-wavelength eastward tilting of Ogallala Group sediments and their underlying unconformity, originally deposited by rivers with lower gradients than today (Fig. 2; Leonard, 2002; McMillan et al., 2002; McMillan and Heller, 2006; Eaton, 2008; Duller et al., 2012). Based on this and similar evidence elsewhere, along with geophysical evidence of low-velocity anomalies in the upper mantle, studies have proposed that the CRM have undergone geodynamically driven dome-like uplift. This uplift, linked to residual effects of Farallon-Kula plate subduction and the Rio Grande rift, would have led to down-to-the-east and down-to-the-north tilting along the eastern CRM front and down-to-the-west and down-to-the-north tilting along the western CRM front (Leonard, 2002; McMillan and Heller, 2006; Rosenberg et al., 2014). This interpretation aligns with evidence from geophysical data, thermochronometric analyses, and geodynamic models (Moucha et al., 2008; MacCarthy et al., 2014; Rosenberg et al., 2014; Ricketts et al., 2016).

Alternatively, other geomorphic and modeling studies exploring the Ogallala Group and younger units in northern and central parts of the High Plains suggest that significant deformation may not be a major factor. These studies propose either minimal changes in river gradients (Duller et al., 2012) or that climate-driven changes in hydrology and sediment flux have led to reduced river gradients (Fig. 2; Wobus et al., 2010). A prevailing hypothesis among these studies is that an increase in erosional efficiency over the last 2–4 m.y., driven by a cooling and more rapidly fluctuating climate, has relaxed river gradients in the northern parts of the High Plains compared to the south through differential erosion and flexural isostatic response (Riihimaki et al., 2006; Pelletier, 2009; Wobus et al., 2010). However, it remains uncertain whether the erosion-induced flexural rebound is sufficient to explain the observed degree of tilting.

The ongoing debate between these two perspectives stems partly from their reliance on observations from the High Plains, where rivers erode sedimentary units that often do not preserve evidence of landscape changes. This makes it challenging to distinguish between tectonic and climatic drivers (Figs. 1C and 2). While numerous geomorphologic studies in the western slopes of the CRM have identified a regional increase in base-level fall and a north-to-south gradient in tectonic uplift rates (Lazear et al., 2013; Rosenberg et al., 2014; Aslan et al., 2019), only a few geomorphic studies have examined the eastern slopes of the CRM, upstream of the High Plains (Eaton, 2008; Abbey et al., 2017; Abbott et al., 2022; Marder et al., 2023), and none has done so regionally.

Here, we address this knowledge gap by conducting a regional tectonic geomorphology study of the eastern CRM, west of the High Plains. We investigate transient geomorphic signals in the CRM fluvial topography by analyzing landscape erosion rates, channel incision rates, and river morphologies associated with prevailing tectonic and climatic hypotheses. Our approach includes river profile analysis of bedrock rivers that incise into the erosionally resistant crystalline basement of the CRM (Fig. 1C), as well as new and existing ^{10}Be-derived basin-averaged erosion rates and channel incision rates from dated terraces. Our findings advance the discussion of factors driving rejuvenation in the CRM and reveal a regional pattern of steeper and more transient fluvial topography upstream of the High Plains, consistent with evidence of a doming uplift. We contextualize these results within the CRM and suggest that similar methodologies could be applied to other postorogenic mountains worldwide.

GEOMORPHIC PREDICTIONS FOR TECTONIC AND CLIMATE HYPOTHESES FOR TOPOGRAPHIC REJUVENATION IN THE CRM

By integrating basin-averaged erosion rates, channel incision rates, and river profile patterns, we evaluate our findings against predictions from end-member tectonic and climate hypotheses concerning recent landscape rejuvenation in the CRM. This assessment considered the erodibility and lithologic contrasts between the High Plains and the CRM (Figs. 1 and 2; see Fig. S1 in Supplemental Material[4]; cf. Marder et al., 2023). The prevailing geodynamic hypothesis (Fig. 2; Leonard, 2002; McMillan and Heller, 2006) predicts higher erosion and incision rates, as well as increased channel steepness, in steeper reaches below convex-upward knickpoints in river profiles relative to more moderate reaches above them (Fig. 2; Fig. S1; Marder et al., 2023). Conversely, the prevailing climate hypothesis posits regionally uniform erosional efficiency reflecting modern elevation and precipitation gradients (Fig. 1B; Wobus et al., 2010; Duller et al., 2012), predicting higher erosion and incision rates, as well as increased channel steepness in steeper reaches above convex-downward knickpoints relative to more moderate reaches below them (Fig. 2; Fig. S1).

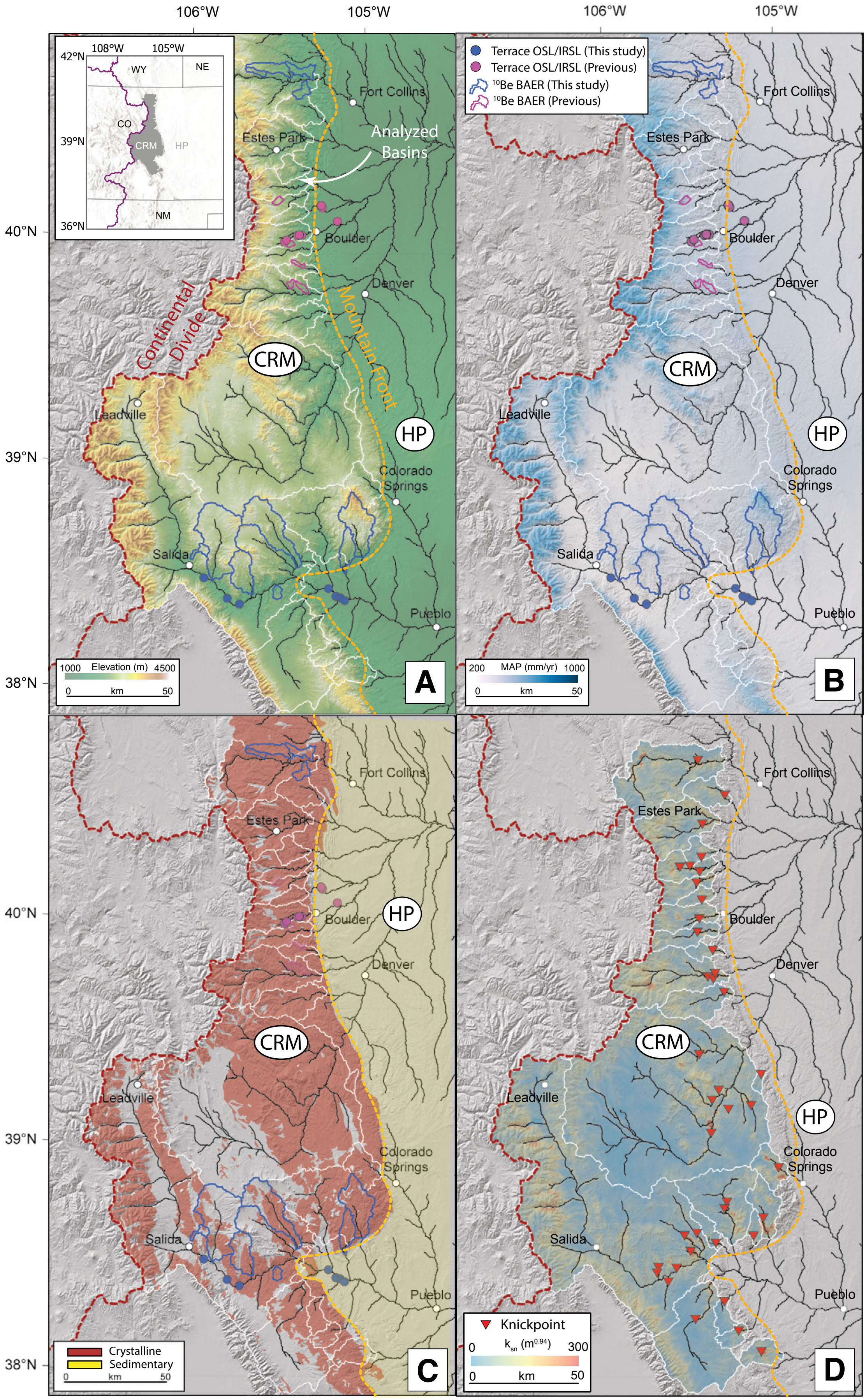
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Figure 1. (A) Topographic map of the Colorado Rocky Mountains (1 arc-second Shuttle Radar Topography Mission). (Inset) Regional map of the study area (gray polygon). WY—Wyoming; NE—Nebraska; CO—Colorado; NM—New Mexico. (B) Map of 30 yr normals for mean annual precipitation map (MAP; modified from Fick and Hijmans, 2017). OSL/IRSL—optically/infrared stimulated luminescence; BAER—basin-averaged erosion rates. (C) Extent of the crystalline basement and sedimentary units (modified from Hartmann and Moosdorf, 2012). (D) Interpolated normalized channel steepness (k_{sn}) map. CRM—Colorado Rocky Mountains; HP—High Plains. White lines mark analyzed basins. For detailed basin averaged erosion rates (BAER), terrace luminescence ages, and river profile analysis, see the Supplemental Material (text footnote 4).

METHODS

Basin-Averaged Erosion Rates and Channel Incision Rates

We used ^{10}Be terrestrial cosmogenic nuclides to measure landscape erosion rates on ~10^3–10^6 yr time scales (Granger et al., 1996) and channel incision rates to assess geologically recent relief production or decay (Pazzaglia, 2013). We quantified basin-averaged erosion rates by measuring ^{10}Be concentrations in quartz-rich fluvial sands at drainage basin outlets in the CRM using altitude- and latitude-dependent production rates and near-surface attenuation rates for different production pathways (Fig. 1; see the Supplemental Materials; Granger et al., 1996; cf. Dethier et al., 2014; Marder et al., 2023). To determine channel incision rates, we calculated incision depths below fluvial terrace straths to modern channels in the CRM and High Plains and divided them by terrace depositional ages derived from optical and infrared stimulated luminescence of quartz (OSL) and feldspar (IRSL) grains (Fig. 1; Schildgen et al., 2002; Mahan et al., 2022; see the Supplemental Materials).

River Profile Analysis of Bedrock Rivers

We used a 90-m-resolution digital elevation model (DEM) from the Shuttle Radar Topography Mission (SRTM) to analyze river profiles in the CRM, focusing on bedrock rivers, which are sensitive indicators of tectonic- and climate-induced base-level changes (Fig. 2; Fig. S1; Kirby and Whipple, 2012). We identified fluvial knickpoints, i.e., sharp changes in channel steepness along river longitudinal profiles caused by base-level fall changes at river outlets. These knickpoints were detected through changes in the normalized channel steepness index, k_{sn}, a metric that allow comparisons of channel steepness between basins with different drainage areas (Kirby and Whipple, 2012). We calculated k_{sn} for reaches above and below knickpoints using linear regression of a transformed coordinate, χ (the upstream integral of the inverse of drainage area raised to an exponent), against elevation, z (Fig. 2; see the Supplemental Materials; Kirby and Whipple, 2012; Perron and Royden, 2013; Marder et al., 2023):

$$z(x) = z(x_b) + k_{sn}\chi,$$

where $z(x_b)$ is the elevation at the river outlet (x_b is a reference distance at base level, and x is river distance).

We analyzed nonglaciated trunk channels from 24 basins that incise into a similar crystalline basement and drain the CRM to its mountain front, where x_b and $z(x_b)$ were set to

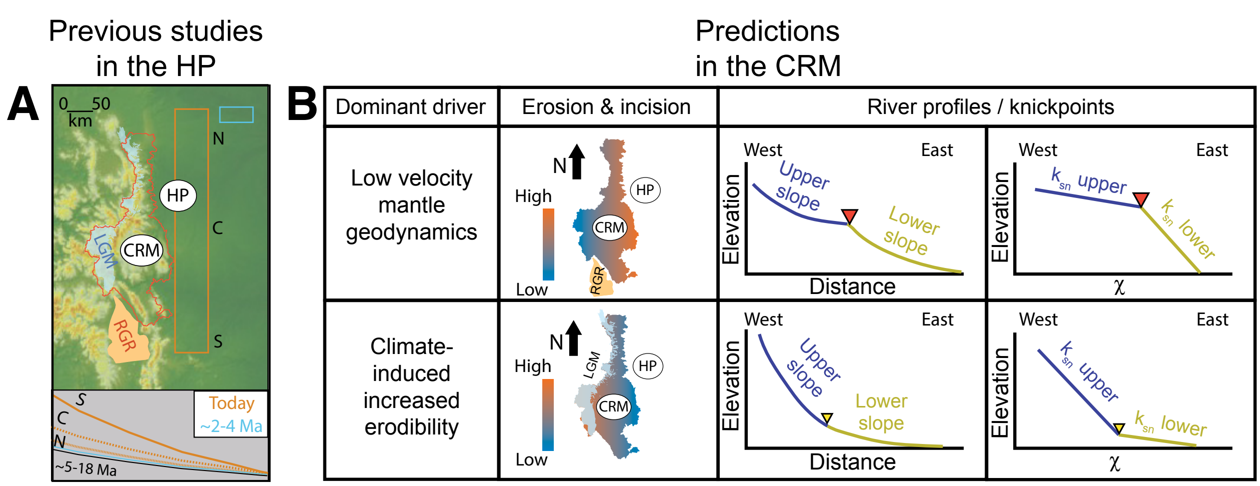

Figure 2. (A) (Top) Previous geomorphologic study extents and hypotheses for rapid incision and topographic rejuvenation in the High Plains (HP). Orange box—study by McMillan and Heller (2006) suggesting Pliocene rapid incision due to a geodynamic driver associated with the Rio Grande rift (RGR). Cyan box—study by Duller et al. (2012) suggesting rapid incision due to global climate changes in the last 2–4 m.y. Last Glacial Maximum extent (LGM; modified after Madole et al., 1998) is shown for reference. CRM—Colorado Rocky Mountains; HP—High Plains. (Bottom) Reconstructed river profiles in the High Plains from the same studies (colors correspond to top panel) and the gradient of the Ogallala Group surface at ca. 18–5 Ma (black line). N—north; C—central; S—south. (B) Predicted geomorphic patterns for tectonic and climate hypotheses for CRM rejuvenation in the last ~2–5 m.y. Geodynamic scenario: Increased landscape erosion, channel incision, and normalized channel steepness, k_{sn}, in the lower CRM below slope-break convex-upward knickpoints (red inverted triangles). Climate scenario: Increased landscape erosion, channel incision, and channel steepness in the higher CRM above slope-break convex-downward knickpoints (yellow inverted triangles). χ—upstream integral of the inverse of drainage area raised to an exponent. For one-dimensional river profile simulations under these tectonic and climate scenarios, see Figure S1 (text footnote 4).

zero (Fig. 1). Using a regional reference channel concavity index (which is consistent whether or not glaciated reaches are included; Fig. S2; see the Supplemental Materials), we calculated χ and used χ-z plots to identify fluvial knickpoints as inflection points with at least a 25% change in k_{sn} to minimize noise and DEM artifacts in our analysis (Fig. S3; see the Supplemental Materials). We confirmed that knickpoints are transient migrating features from the CRM mountain front—rather than locally formed by lithologic changes or faults—by applying a basin-wide inversion model that examined the network-wide change in k_{sn} as a function of χ (Eq. 1; Fig. S3; Gallen, 2018; Marder et al., 2023; see the Supplemental Materials).

LANDSCAPE EROSION RATES, CHANNEL INCISION RATES, AND RIVER MORPHOLOGIES IN THE CRM DRAINAGE NETWORK

Based on 12 new and six previously measured ^{10}Be basin-averaged erosion rates (see the Supplemental Materials; Tables S1 and S2; Dethier et al., 2014), and seven new and 16 previously calculated channel incision rates (see the Supplemental Materials; Tables S3–S6; Schildgen et al., 2002), we find that (1) erosion rates are ~10–20 mm k.y.$^{-1}$ in the northern and central CRM, and slightly higher at ~30–40 mm k.y.$^{-1}$ in the southern CRM (Fig. 3A; Dethier et al., 2014); and (2) average channel incision rates in the CRM and High Plains below fluvial knickpoints are an order of magnitude

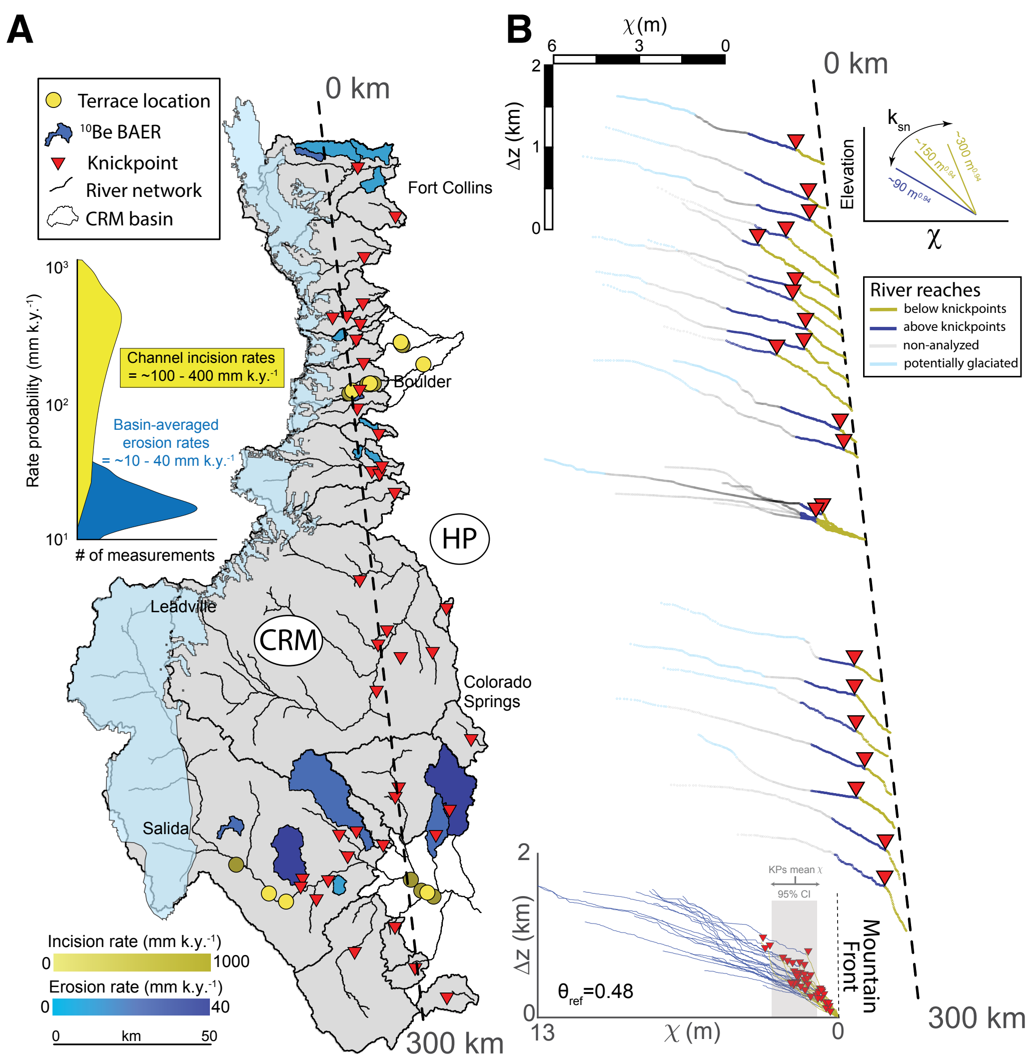

Figure 3. (A) Locations of knickpoints, basin-averaged erosion rate (BAER), and fluvial terraces across the Colorado Rocky Mountains (CRM) drainage network (shaded gray polygon) and High Plains (HP; nonshaded). Last Glacial Maximum extent (cyan polygon) is shown for reference. (Left inset) Kernel density estimator of BAER (blue) and channel incision rates (yellow). (B) River profiles of main trunks in the analyzed basins, projected north-to-south across the CRM (dashed line in A). Glaciated reaches are shown in cyan, and nonglaciated reaches above and below knickpoints are shown in blue and yellow, respectively. Note that χ transformation distorts river profiles by elongating low-drainage areas in χ plots (where χ is the upstream integral of the inverse of drainage area raised to an exponent). This distortion causes the low-drainage, glaciated portions of river profiles to appear more extensive than they actually are (cf. Fig. 3A). Scale bars show relative elevation (Δz) and χ for reference. (Upper-right inset) Channel steepness, k_{sn}, in χ-elevation space. (Lower-left inset) Stacked χ-plots of river profiles vs. relative elevation from the CRM mountain front (black dashed line). Gray shaded polygon shows mean χ and its confidence intervals (CI) for all knickpoints (KPs). Reference concavity index, θ_{ref}, used to calculate the river profiles, is noted. For full river profile analysis, see the Supplemental Material and Figure S3 (see text footnote 4).

higher than erosion rates, ranging from ~100 to 800 mm k.y.$^{-1}$ (Fig. 3A; Schildgen et al., 2002). Channel incision rates are notably higher for shorter integrated time scales <60 k.y., potentially due to a "Sadler effect" time-scale bias or an incomplete averaging of terrace strath formation and abandonment (Finnegan et al., 2014; Gallen et al., 2015). However, incision rates for terraces older than 60 k.y. do not show significant changes with age, ranging from ~100 to 400 mm k.y.$^{-1}$ (Fig. S4). This suggests that any potential temporal bias is minimized over longer time periods.

All 24 analyzed basin trunk channels in the CRM show convex-upward knickpoints that separate steeper reaches below the knickpoints from lower-gradient reaches above them upstream (Fig. 3B; see the Supplemental Material; Fig. S1; cf. Marder et al., 2023). The moderate reaches above the knickpoints show a roughly uniform lower k_{sn} of ~80–90 m$^{0.94}$, while k_{sn} in the steeper reaches below the knickpoints gradually increases from ~150 m$^{0.94}$ to 300 m$^{0.94}$ from north to south (Figs. 3 and 4). The knickpoints have a mean χ value of ~2.5 m (±1σ = 1.07 m) and a relative elevation of ~100–800 m from the CRM mountain front (Fig. 3B). Within individual basins, knickpoints coincide with the same χ value in modeled k_{sn} spikes from the basin-wide inverse model, supporting the interpretation that the knickpoints are actively migrating upstream from the CRM mountain front or farther downstream (Fig. 3B; Fig. S3).

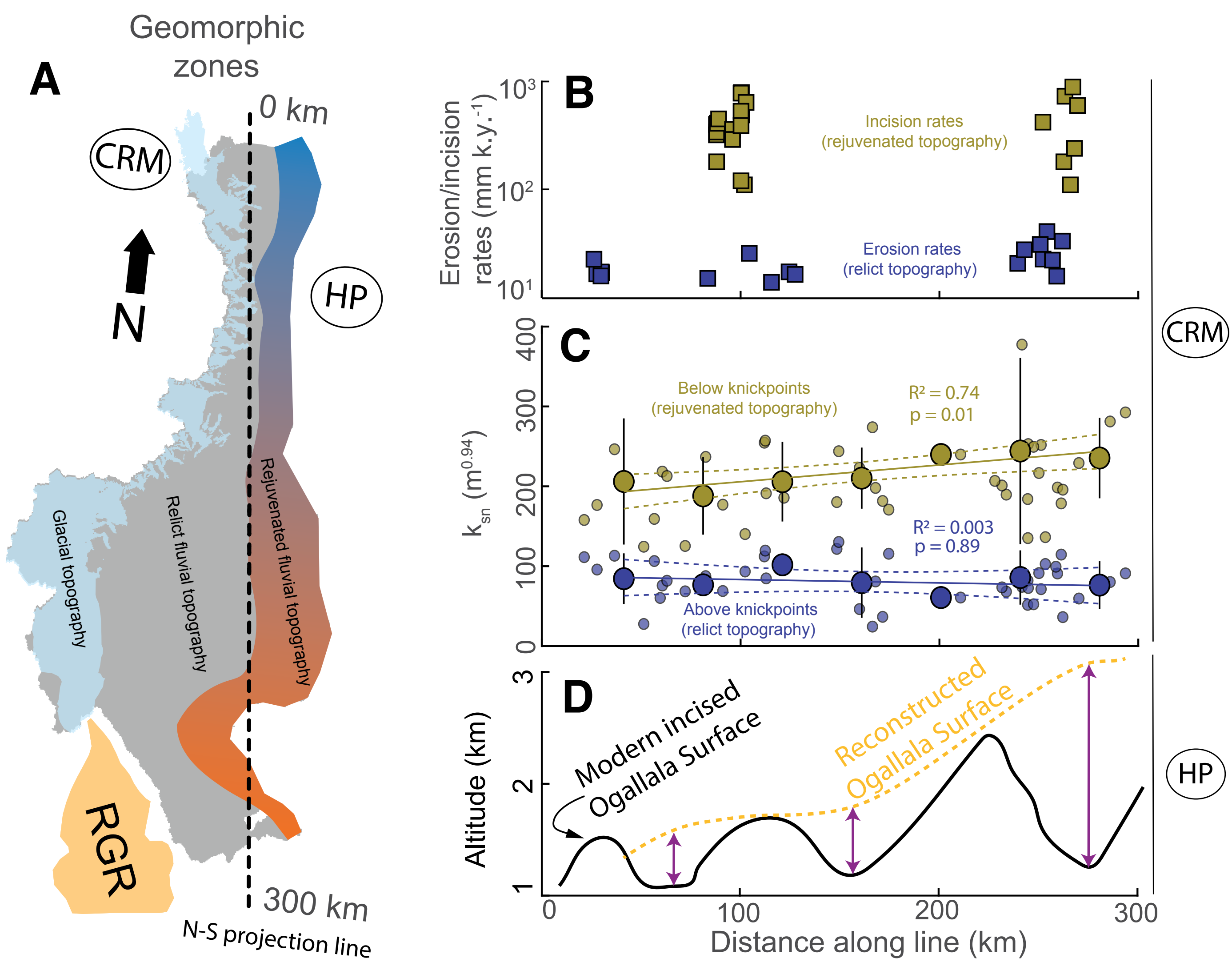

Figure 4. (A) Inferred geomorphic zones in the Colorado Rocky Mountains (CRM): (1) Rejuvenated, steeper fluvial topography (cool to warm gradient) between the CRM mountain front and 100–800 m above; (2) older, moderate fluvial topography (gray) bounded by the younger fluvial topography below and glacial topography above (light blue). Approximate location of the northern tip of the Rio Grande Rift (RGR) is marked (orange polygon). Dashed black line indicates projection line for B–C. HP—High Plains. (B) Basin-averaged erosion rates and channel incision rates projected north to south (line in A). (C) Raw and 25 km binned k_{sn} values (represented by small and large filled circles, respectively) for river reaches upstream (blue) and downstream (yellow) of knickpoints, projected from north to south (line in A). Vertical error bars on the binned data indicate the 95% confidence interval. Linear regression models (dashed lines) were applied to the binned data (see Fig. S5 for a detailed bin analysis [text footnote 4]), with the corresponding R^2 and p-value statistics noted. (D) Total incision depth of the Ogallala Group surface in the High Plains to modern rivers from north to south (after Leonard, 2002).

WHAT DRIVES LANDSCAPE REJUVENATION IN THE CRM?

The observation that channel incision rates are an order of magnitude higher than basin-averaged erosion rates is consistent with local magnitudes and patterns reported in previous studies (Schildgen et al., 2002; Dethier et al., 2014). However, our findings reveal that this pattern is regionally persistent (Fig. 4). The discrepancy between erosion rates above knickpoints and channel incision rates below knickpoints suggests a geologically recent relief production of ~100 mm k.y.$^{-1}$ since the migration of the knickpoints from the CRM mountain front to their current positions (Fig. 3). Notably, channel incision rates from the High Plains are comparable to those below knickpoints in the CRM, indicating that the increased base-level fall rate persists to the present (Fig. 3). The pronounced contrast in k_{sn} along reaches above and below knickpoints corresponds to the disparity in erosion and incision rates, with k_{sn} being low and uniform across the CRM region above knickpoints and systematically higher below knickpoints (Fig. 4C; Fig. S5).

Overall, the higher channel incision rates relative to landscape erosion rates and consistently higher k_{sn} below knickpoints suggest a sustained increase in base-level fall rate over time. These geomorphic patterns are challenging to reconcile with climatic drivers, which would predict opposite geomorphologic trends (Fig. 2; Fig. S1). Instead, our results align with predictions of a geologically recent increase in rock uplift rate driven by regional geodynamics (Fig. 2; Fig. S1). Furthermore, we observed a north-to-south increase in k_{sn} in channel reaches below knickpoints (Fig. 4C; Fig. S5), mirroring the southward increase in incision depth below a reconstructed Ogallala Group surface in the High Plains (Fig. 4D; Leonard, 2002) and a similar north-to-south trend in k_{sn} on the western slopes of the CRM above a low seismic velocity zone (Rosenberg et al., 2014).

Thus, our study, along with previous geomorphic, geophysical, and thermochronometric research in the High Plains and the western CRM (Leonard, 2002; McMillan and Heller, 2006; MacCarthy et al., 2014; Rosenberg et al., 2014; Abbey and Niemi, 2018), supports the notion of regional landscape rejuvenation in the CRM. This rejuvenation appears to be driven by the far-field effects of regional geodynamic processes (e.g., Rio Grande rift, subduction of the Farallon-Kula plate; Leonard, 2002; Moucha et al., 2008; Abbott et al., 2022), manifesting as doming uplift centered in the southern CRM and near the northern tip of the Rio Grande rift. While climate remains an important factor in the region's landscape evolution (Wobus et al., 2010; Duller et al., 2012), our study suggests that any climatic signals are likely superimposed on regional geomorphic patterns, which align more closely with a geodynamic driver.

More broadly, our results highlight that analyzing bedrock river profiles and associated data within a tectonic geomorphology framework can elucidate the drivers of transient landscape dynamics in postorogenic mountain belts. In the CRM, this approach points to geodynamics as the primary driver of recent landscape change, though different conclusions may be reached in other postorogenic mountain belts that have not experienced recent tectonic activity. Such studies could significantly enhance our understanding of the relative impacts of tectonics and climate in shaping Earth's surface.

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CONNECTS 2024 BY THE NUMBERS

- Total Attendees: 4,141
- Professionals: 1,704
- Early Career Professionals: 491
- Students: 1,419
- Mentors: 116
- K–12 Teachers: 27
- International Attendees: 9.8%
- Countries Represented: 49
- Abstracts: 2,633
- Short Courses: 19 (2 online, 1 hybrid, 16 in-person)
- Field Trips: 23
- Exhibitors: 154

THANK YOU TO ALL THE MENTORS WHO VOLUNTEERED THEIR TIME AT GSA CONNECTS 2024

Mentors are integral to GSA's meetings and are a source of motivation and support for students and early career professionals as they seek advice and information related to their academic and career pathways. The following are programs where mentors volunteered:

- On To the Future (OTF) Mentors
- GeoCareers Day Roundtable Mentors
- GeoCareers Day Panelists
- Early-Career Professional Coffee
- Résumé Clinic Mentors
- Drop-in Mentors
- Networking Reception Mentors
- Women in Geology Mentors
- Women in Geology Speakers
- GeoCareers Corner Presenters

"MENTORING IS ALWAYS A GREAT EXPERIENCE AT GSA. THE MENTEES ARE ALWAYS ENGAGED AND COME WITH SUCH GREAT QUESTIONS. THE GEOCAREERS ROOM IN GENERAL IS ALSO SUCH A FANTASTIC SPACE. I WISH I HAD SOMETHING SIMILAR WHEN I WAS A STUDENT."

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Join the global geoscience community at the Geological Society of America's Connects 2025 meeting from 19–22 October in San Antonio, Texas, USA! Share your scientific findings with colleagues, network with leaders in the field, and keep your skills relevant in a rapidly changing world. Plan now to be part of this gathering and amplify your research with your community by submitting a proposal for a short course, field trip, technical session, and/or Pardee Keynote session.

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Life on an Active Margin: Swimming Pools and Movie Stars

Christopher (Chuck) Bailey

Welcome to Anaheim! The Geological Society of America is back in Southern California, and it's been quite a while. The last time GSA's annual meeting came to California was in 1991—33 years ago—down San Diego way. I remember that conference well, as I was a third-year Ph.D. student presenting my first talk at what we now call GSA Connects.

I recall that there were a lot of dudes presenting in that session. Fortunately, much has changed for the better in the past three decades. This year's Connects features a greater diversity of presenters and participants than ever before.

Speaking of dudes, I'm honored to have *the Dude* here today. Dude, welcome to GSA!

(The Dude stands up and does a Hollywood wave, "Hey, what's up man?")

The Dude is also known as Jeffrey Lebowski from *The Big Lebowski*. The film was set in these parts and the Dude is reputedly the laziest man in all of greater Los Angeles. Nonetheless, I'm stoked he's here in the house at GSA.

In 1991, the same year *The Big Lebowski* was set, we used slide carousels—two of them at the same time! It was double-barreled projection, and in my mind that was state of the art. Here's a slide pair from my talk on mylonites formed in different tectonic environments. I have plenty more slides about mylonites, but unfortunately for me—and perhaps lucky for you—I've been advised to say no more about them during this talk.

I'd like to thank our members who step up as volunteers to make a meeting like this come together—it's a labor of love, and the process to get us here is years in the making. Over the past year, I've been to many GSA meetings across various time zones, and it's been awesome to see how the GSA staff and the local committees make field trips, short courses, and meetings a reality. For me, a high point of serving as President has been collaborating with the GSA staff to make the Society better.

During your time here at Connects, you'll notice that we've shaken things up a bit and made a few changes. For those who've never attended a GSA awards ceremony or a presidential address, thanks for taking the time to be here—my hope is you find this celebration affirming, joyful, and fun.

Today, I am highlighting my connection to this dynamic and wondrous corner of America—to Southern California and to life on this active margin. GSA Connects 2024 has two themes: *Life along an Active Margin* and *Water in a Changing World*. Both are timely and relevant.

FAMILY MATTERS

My connection to California is rooted in geology, yet over the past two decades, it's become intertwined with family. That personal perspective provides a broader relevance as to why studying the Earth is important.

No doubt some of you are wondering, "Why is he here again?" since I'm the dude (that's in lower case) who gave the address last year at Connects in Pittsburgh. I'm here for a second time because of a family tragedy that beset President-Elect Carmie Garzione earlier this year. Carmie is my colleague and friend—her counsel is always on the mark, and she's the academic leader that I aspire to be. This address is dedicated to Carmie and her family. It is wrapped around family and that's done with intention, as family is precious, fragile, and something we should always cherish.

After that 1991 GSA meeting in San Diego, I'd planned to head east to further study the mylonites exposed in the canyons of the Anza-Borrego region. But I was too young to rent a car—I was stuck in San Diego. Stuck until my Ph.D. advisor, Carol Simpson, accompanied me to the rental car counter, adroitly managing to get me on my way in that fly red Geo Storm!

It was humbling, but through the lens of time, I now see that Carol, in her brilliantly understated British manner, was doing what so many of you have done for decades—training the next generation of geoscientists through thick and thin, through all the hard bits. It's work like that which creates intergenerational community, and that's one of the hallmarks of GSA.

I'll also note that after my talk in San Diego, Carol remarked that "I'd not mucked it up too badly." I'm hoping for a similar result today.

In 1994, I finished my Ph.D. and left California's mylonites in the rearview mirror for new research endeavors. But in the twenty-first century, I returned to California for a wholly different set of reasons.

I'm from a small family; for years, it was pretty much just my mother and my brother. Here's a 2009 image of us by a sea loch in the northwest of Scotland, at the home village of my mom's grandfather. Across the loch, you can see the glacially sculpted Applecross Mountains undergirded by those problematic Torridonian strata—plus, not far away there's some fabulous mylonite exposed along the Moine Fault! But I digress.

My younger brother is a chef and an actor, and in the early 2000s he moved to Los Angeles. He is, in the parlance of our time, a raging a**hole, but I love him nonetheless.

His bachelor party in 2013 was epic, and as you can see, we were all tricked out to be in LA. From what I can

remember, we ate BBQ, then played paintball in the desert. Here you can see my brother exulting in his Scottish heritage. That's me as *Star Trek*'s Captain Kirk. Curiously, and for reasons that I still find hard to fathom, the rest of that crew continues to refer to me as Captain Jerk.

My brother Jonathan found his place in Southern California. These days, he's got a marvelous family and he's an amazing father. It's wonderful to see his peeps grow, and I'm fortunate that they are here today.

But I have another family connection here in La La Land. Straight out of high school, my stepson moved to LA to learn digital music and video production. On a hot day in mid-August, we delivered William to an unsavory mid-rise apartment complex in Hollywood to commence his studies in this City of Angels. It was a difficult trip—parents don't just drop their 18-year-old kid off on Hollywood Boulevard and feel good about it.

But later that same day, while buying groceries at the nearby Trader Joe's, I encountered Neil Young in the frozen food aisle. Neil was, of course, searching for a heart of gold. That's part of the magic that is Southern California—rock stars, movie stars, you never know who you'll run into. Today, William is thriving here in Southern California, doing production work for the likes of Bad Bunny and Sabrina Carpenter. If you know those artists, I'm glad you're here today—GSA needs you.

With both my brother's family and my son living here, we've gone on many adventures in Southern California, and invariably geology slips right in. I hope you've seen this map, either when you registered for the meeting or arrived here at Connects. It's a map of Southern California geo-sites, and it's fabulous. Chelsea McRaven Feeney at Mountain Press crafted it and, from my perspective, it's art worthy of being framed and hung in a place of honor. And as the Dude once noted, a piece like this can really hold a room together. I'm looking forward to the GSA Connects map becoming a yearly tradition as the Society ventures across North America at our annual meetings.

GSA recently became the sponsor for geoheritage in the United States. We've stepped up to host the U.S. Advisory Board on Geoheritage and Geoparks, and I'm excited to work together collectively. For me, geoheritage includes conserving geologically special places, but it's more. It's the world that's all around us. As I said last year, we need to bring our science to the public. Geoheritage provides a framework to wrap the past, the present, and the future of both spectacular and everyday places into a compelling narrative that is relevant to a broad audience.

LIFE ALONG AN ACTIVE MARGIN

Speaking of geoheritage, 80 km northwest of Anaheim there is a particularly cool geo-site—Vasquez Rocks, featured on the Connects Geo-Sites map. I've wandered this rocky ground with my family; for them it's a fine hike in the high desert, but for me, it's a place that brings together time and tectonics.

Chunky conglomerates and sandstones underlie Vasquez Rocks. These Oligocene to Miocene strata dip to the southwest, forming spectacular landforms, highlighting everything one needs to know about dip- and anti-dip slopes. These sediments, deposited in a terrestrial basin, were soon tilted and rotated as strain was partitioned across the San Andreas and its compatriot faults.

Yet, there's something more to Vasquez Rocks. Space, the final frontier. For it was upon these rocks in 1967—or was it Stardate 3045.6—that Captain James T. Kirk of the Starship *Enterprise* found himself engaged in mortal combat with a Gorn.

(The Gorn enters from stage right, and menacingly picks up a large rock.)

It seems there's a Gorn in our midst today. You see, the Gorn are a tad misunderstood.

That *Star Trek* scene from Vasquez Rocks ended peaceably. I know that we can achieve a similar result today, so let's graciously welcome the Gorn to GSA Connects 2024.

(Impressed by the welcome, the Gorn puts down the large rock and whimsically tosses a beachball to the crowd.)

My brother and his family live at the northern edge of the San Fernando Valley, where the terrain starts to rise into the Santa Susana Mountains. In these parts, the San Fernando Valley is known simply as the Valley. It's the provenance of Valley Girls—if you're of a certain vintage, that has cultural significance for you. Their house isn't far from the epicenter of the 1971 San Fernando earthquake. That magnitude 6.6 temblor, caused by slip along a thrust fault beneath the San Gabriel Mountains, jarred Southern California awake and destroyed a wide swath of significant infrastructure. Sixty-five people perished, and the damage totaled more than half a billion dollars.

However, it could have been much worse, as the Van Norman Dams barely escaped destruction. These reservoirs, at the lower end of the Los Angeles aqueduct, stockpiled gobs of water that Los Angeles has siphoned out of the Sierra Nevada and Owens Valley.

That shaking, with horizontal accelerations greater than 0.6 g, caused parts of the lower dam to collapse. These dams were constructed of fill, some of which liquefied during that shaking. It was fortunate that in the late 1960s there'd been recognition that these dams weren't sound, and consequently their water levels had been lowered a few years prior to the quake. After the partial dam collapse, it was touch and go; the lower reservoir came within 5 feet of overtopping and breaching.

Even at half capacity, the reservoir stored 3.5 billion gallons of water. Had the lower Van Norman dam breached, that water would have catastrophically inundated a significant part of the north Valley; more than 80,000 people downstream were in harm's way and evacuated after the quake. After 1971, changes were made, but it's a striking example of the connected hazards here—active tectonics thrash the municipal water storage.

In the wee hours of 17 January 1994, another major earthquake ripped off beneath Northridge in the Valley. By any measure the Northridge earthquake was significant; the Valley was pummeled, and even 30 years later it ranks as one of America's costliest disasters. The magnitude 6.7 rupture occurred along an unrecognized thrust fault, a blind thrust that tips out kilometers below Earth's surface. How could one know the fault and its consequent hazards were lurking beneath the Valley? Yet, for the better, that quake brought together different geoscience communities—seismologists, structural geologists, and petroleum geologists who, working in their own siloes, did not have the full picture. It was a real first step toward community science.

Southern California lies astride both the North American and Pacific tectonic plates. Geodetic data indicate that relative to North America, the Pacific plate is scampering to the northwest at a rate of ~45 mm/year. However, both the 1971 and 1994 quakes were firmly rooted in the Pacific Plate, not at the plate boundary. The San Andreas Fault, as it arcs across the "big bend," is well distant from Los Angeles. Plus, it's been ominously quiet in these parts for decades.

California is a kinematic circus with its active faults and growing structures—there's transpression and transtension, plus classic wrench faults. This broad region of active deformation extends well beyond the plate boundary and brings with it a plethora of geohazards to millions of people. But, hey that's life on an active margin.

In the past two weeks, more than 100,000 acres of Southern California highlands have burned. To the southeast of Anaheim, the Airport Fire is still cooking. What's still yet to come this year? The blistering downslope Santa Ana winds have yet to kick up. And next winter, when an atmospheric river from the North Pacific deluges those burned slopes, gravity may have its moment, with mudslides becoming the hazard du jour.

In 2012, one of my geologic heroes, George Davis, challenged GSA during his presidential address to make public-facing science readily available in the form of "Response Conferences" that would spring forth after a particular geo-event wrangles up trouble—say, mudslides in Vermont, floods in Houston, or perhaps an earthquake on say the Palos Verdes fault, not so distant from Anaheim. For me, George's idea is on the mark, but how can we expand upon this? How can GSA—whose mission is science, service to society, and stewardship—take it further as society needs geoscience understanding? I'd be delighted to chat more about this topic, so find me while you're here at Connects.

WATER IN A CHANGING WORLD

Southern California has its share of both swimming pools and movie stars. When I come to LA, I look forward to being in a pool. Playing in the pool is fun—although the last time I uttered those words, the Dude (in a very non-Dude way) nearly tore my rotator cuff while roughhousing in his pool.

There are approximately 250,000 swimming pools in greater Los Angeles. From Google Earth, I've discerned that the surface area of my brother's pool is 30 m^2, so let's take that to be an average LA swimming pool. Multiply up yields a whopping 7.5 km^2 of pools in this crazy tinseltown.

On a day like today, with a sun-filled sky, warm breeze, and a low dewpoint, lots of evaporation is occurring in these pools. I can dutifully report that on days like today, my brother's pool loses about half a cm off the top, invisibly evaporating away to join the atmosphere. That's ~10 million gallons of water per day going skyward from LA's pools in the summer. Is this sustainable in a changing world?

And let's not forget, the water that fills these pools is not so local. For more than 100 years, Los Angeles has reached far beyond Southern California to effectively snatch water from the Sierra Nevada. This water turned Los Angeles into a place of beauty, excitement, and excess. The California water wars ultimately robbed the Owens Valley and its native communities of their water—that legacy of environmental damage is still with us. In a few minutes, we'll learn more about this from Kathy Jefferson Bancroft, our President's medalist.

Southern California's climate and its precipitation are highly varied. Here's another one of Cheslea's brilliant maps. It's from the "B-side" of the California Geo-Sites poster, and it illustrates the wide range of average annual precipitation across Southern California. The Salton Trough typically receives a scant ~80 mm/year, yet the Imperial Valley has been a major agricultural supplier for generations—of course, that's made possible by highjacking the waters from the Colorado River. Is this sustainable in a changing world?

With all these swimming pools and the built environment all around us here in Southern California, it's clear that we are living in an "Age of Humans." Last spring, when the formal elevation of the Anthropocene to an epoch went down in flames, the debate garnered significant media attention for a hot second.

I'm fine with the Anthropocene. Does it rise to the level of a formal epoch? You tell me. Yet we must engage the public,

GEOLOGISTS STUDY THE PAST, THE PRESENT, AND THE FUTURE, BUT I'M TELLING YOU WE'D BETTER UP OUR GAME AND EMPHASIZE THE PRESENT AND THE FUTURE.

because humans are playing the star role in creating the drama that is modern change on Earth. At this meeting, we've got multiple sessions focused on the Anthropocene—go check them out. But let's face it, geologists got a hefty dose of bad press over the Anthropocene decision and that's a bummer, man. However, as the Dude once said, "This aggression won't stand."

In that vein, I've personally embraced the headline from the *Washington Post*; these days, when my family asks me to take out the trash or a dean asks that I sit on another university committee, I glibly respond, "The geologist says no."

ON TO THE FUTURE: GEOSCIENCE CHALLENGES, OPPORTUNITIES, AND RESPONSIBILITIES

So, geoscience has an image problem. But there are other disconnects. These days when an earthquake strikes, respected media outlets are likely to report the news as climate-related—that's a disconnect. For obvious reasons, climate science seems to take up an ever-larger slice of the media pie. But so much of climate-related science is geoscience, let's pitch those linkages at every opportunity. GSA needs to be a leader by highlighting the connections between the lithosphere, hydrosphere, biosphere, and atmosphere: this is the essence of geoscience. Geologists study the past, the present, and the future, but I'm telling you we'd better up our game and emphasize the present and the future.

There's also a disconnect between university enrollment, interest in the geosciences, and society's need for the geosciences. For some, this graph demonstrates that geoscience departments are in an existential crisis. To make things worse, many note that we're approaching a "demographic cliff" and with it a decline in overall university enrollments. I take issue with calling it a cliff; perhaps it's more of a knickpoint. We know the world needs geoscientists, but it's the messaging that's the challenge. To engage the next generation, let's make the link between the geosciences and sustainability front and center in what we do.

I may be old, but I'm optimistic as my lived experience tells me that if we expose students to the geosciences, then we have ample opportunity to bring them into the fold. Despite the broader national trend, my department at William & Mary is thriving and we're growing. I think that's in large part because we work hard to create community; our academic department is a place of opportunity for students. Yeah, it's a significant investment of time and resources plus it's work that never stops.

Last weekend, on our departmental community field trip, we took more than 30 students to the Blue Ridge in Shenandoah National Park. This trip is not tied to a class, but students choose to be there nonetheless. It was the first field trip for many; some students had never seen mountains before. Community grows on these trips and science happens—as do broken vans, but that's another matter.

Look more closely at this group photo. Sure, there's some unruly hair after a night of camping, but notice that cloud deck covering the Shenandoah Valley—it developed as a temperature inversion settled in overnight. See the block fields—are they relict features from the Pleistocene or hazardous active landforms? These forested slopes have endured moderate to severe acid rain for decades, but it's the underlying bedrock that either exacerbates or buffers this pollution. Geology and the Earth are engaging and trips such as this will garner another cohort of students who've found a home in the geosciences. In our program, they'll learn the old ways of geology, but they're also learning to code, do community science, consider environmental justice, and tackle applied problems. That's why I'm optimistic about the future of geoscience.

Well that about does it, wraps it all up. I hope it was a pretty good story. Take it easy dudes—I know the Dude will. Enjoy GSA Connects!

Thank you to Chuck for serving as Acting President in fall 2024. Please look for a welcome letter from Incoming President Nathan A. Niemi in the February issue of GSA Today.

Scan the QR code to watch a recording of Chuck Bailey's presidential address at GSA Connects 2024.

Grow Professionally, Connect Locally with GSA Section Meetings

Important Dates

28 January 2025: Last day to submit an abstract for the Cordilleran and Rocky Mountain section meetings

12 February: Early registration deadline for all except Rocky Mountain

17 February: South-Central hotel registration cutoff

25 February: Southeastern hotel registration cutoff

5 March: Joint Northeastern/North-Central hotel registration cutoff

10 March: Cordilleran hotel registration cutoff

16 April: Rocky Mountain early registration deadline

28 April: Rocky Mountain hotel registration cutoff

See each Section website for room reservation information.

Registration Fees

Professional Member: $225
Professional Non-Member: $265
Professional Senior Member: $150
Early Career Professional: $195
Student Member: $95
Student Non-Member: $150
K–12 (Member and Non-Member): $115
Guest: $75

South-Central Section

Dates: 9–11 March 2025
Location: University of Central Arkansas Conference Center, Conway, Arkansas, USA
www.geosociety.org/sc-mtg

FIELD TRIPS

Pennsylvanian Fluvial Systems in Southwest Missouri: A Possible Link to Fluvio-Deltaic Sedimentation in the Boston Mountains and Arkoma Basin
Leaders: Charles Rovey, Matt McKay

Exploring the Mining Districts of North Arkansas for Lead and Zinc, a Critical Mineral
Leaders: Thomas Liner, Angela Chandler

Mass Wasting in the Ozarks of Arkansas
Leaders: Martha Kopper, Rick Monk

Arkoma Foreland Basin—Frontal Ouachita Orogen Transition in Western Arkansas
Leaders: Mark R. Hudson, M. Dechesne, B. Lutz, T. Smith, N. Griffis

Eastern Ouachita Mountain Benton Uplift Structure
Leaders: Doug Hanson, Rick Kear

Magnet Cove Alkalic Igneous Complex, Hot Spring County
Leaders: Jordan Newman, J. Michael (Mike) Howard, Michael DeAngelis

Cretaceous Magmatism in the Mid-Continent: Syenite and Bauxite in Saline County
Leaders: Michael DeAngelis, John “Pat” Harris

SOUTH-CENTRAL SHORT COURSES

Using R Software to Download and Process Water Quality Portal Datasets
Endorsed by the Hydrogeology Division
Leaders: Katherine Knierim, Lucas Driver

Trace Fossils of Arkansas
Leader: Jacob Grosskopf

Utility-Scale Geothermal Power: Fundamentals and Arkansas Potential
Leader: Christopher Liner

LiDAR: A Tool for Geologic and Geohazard Mapping
Endorsed by the Sedimentary Geology Division
Leaders: Angela Chandler, Richard Hutto, Martha Kopper

Enhancing Recruitment and Retention in Undergraduate Geoscience Programs
Endorsed by the Geoscience Education Division
Leaders: Stephanie L. Shepherd, Rene Lewis

Machine Learning Applications in Earth Sciences
Leader: Dr. Steven Pirouz

* Information about technical sessions, mentoring, CEUs, and events can be found on the website.

Southeastern Section

Dates: 19–21 March 2025
Location: Hotel Madison & Shenandoah Valley Conference Center, Harrisonburg, Virginia, USA
www.geosociety.org/se-mtg

FIELD TRIPS

Stratigraphy, Structure, and Geomorphology of the Central Appalachians across the North Mountain Fault Zone near Harrisonburg, Virginia
Leaders: Daniel Doctor, Alex Gray, William Odom

Ancient and Modern Landslides of the Eastern Blue Ridge of Virginia
Leaders: Anne Carter Witt, Wendy Kelly

Geology, Water, and Mineral Resources near Harrisonburg: A Trip through the Shenandoah and Page Valleys
Leaders: Matt Heller, Steve Baedke, Joel Maynard, Lorrie Skiffington, Steve Whitmeyer

Ordovician Stratigraphy, Structure, and Karst of the Falling Springs Valley, Allegheny County, Virginia
Leaders: John T. Haynes, Richard A. Lambert, Randall C. Orndorff, Mercer Parker

Designing Modern Geoscience Field Mapping Exercises: A Field Trip in the Valley and Ridge of Northeastern West Virginia
Leader: Steven Whitmeyer

Exploring the Catskill Clastic Wedge in West Virginia: Transitions in Life, Environments, and Climate during the Devonian Period
Leaders: William Lukens, Dennis Terry, Charles Ver Straeten, Lynn Fichter

Oh Shenandoah! The Geological Heritage of Shenandoah National Park and the Blue Ridge Tunnel
Leader: Chuck Bailey

SHORT COURSES

Applied Mineralogy: Implications for Geometallurgy
Leader: Tassos Grammatikopoulos

Bringing Coding Activities into Your Undergraduate Earth Science Classroom
Leader: Joanmarie Del Vecchio

Introduction to Stable Isotopes and Isotope Ratio Mass Spectrometry
Leaders: Kyle Taylor, Valerie Conforti

Elementar IRMS (xION) Ion Source Rebuild Session
Leaders: George Grant, Valerie Conforti

Classrooms, Careers, and Communities: Maximizing Your TA Experience
Leaders: Katherine Ryker, Megan Plenge

Enhancing Science Communication Skills for Geoscientists
Leaders: Esther Oyedele, Oluwaseyi Dasho

Fluorescent Dye Tracing: Putting Principles into Practice
Leaders: LeeAnne Bledsoe, Chris Groves

Joint Northeastern and North-Central Sections

Dates: 27–30 March 2025
Location: Bayfront Convention Center, Erie, Pennsylvania, USA

www.geosociety.org/ne-mtg

FIELD TRIPS

Back in Time through the End Devonian Mass Extinction in Western New York
Leader: Thomas Hegna

Landforms and Sedimentology of Erie Bluffs State Park
Leader: Eric Straffin

Geology and Organic Design of Graycliff, Frank Lloyd Wright's Stone House on Lake Erie in Western New York State, USA
Leader: Fred Zelt

Famennian Trace Fossils Including *Rusophycus*-like Megaburrows, Covered Bridges, Beach Ridges, and Terroir of Ashtabula County and Western Pennsylvania
Leaders: Joe Hannibal, Raena Gamble

Early Use of Vermont Marble, and the Use of Other Domestic and Imported Stones over Two Hundred Years, in Erie, Pennsylvania
Leader: Joe Hannibal

Structural Geology in Erie, Pennsylvania
Leader: Nick Lang

Bluff Retreat, Sediment Budgets, and Erosion Mitigation on the NW Pennsylvania Coast of Lake Erie
Leaders: Anthony M. Foyle, Nicholas P. Lang, Christopher Dolanc

Shifting Sands and Anthropogenic Modifications along the Presque Isle Strandplain on the NW Pennsylvania Coast of Lake Erie
Leaders: Parick Burhart, Anthony M. Foyle

* Information about technical sessions, mentoring, CEUs, and events can be found on the website.

Cordilleran Section

Dates: 1–4 April 2025
Location: Holiday Inn Sacramento, Sacramento, California, USA

www.geosociety.org/cd-mtg

Submit an abstract! The deadline is 28 January.

FIELD TRIPS

The Iconic Subduction Interface-Forearc Triad: Franciscan Complex, Coast Range Ophiolite, Great Valley Group
Leaders: John Wakabayashi, Devon Orme

Sutter Buttes Volcanic Field Trip
Leader: Brian Hausback

Vineyards on Volcanoes: Clear Lake Volcanic Field
Leaders: Seth Burgess, Dawnika Blatter

Groundwater: California's Hidden Water Supply
Leaders: Amelia Vankeuren, Thomas Harter

The Birth, Growth, and Burial of the Enigmatic Triassic–Jurassic Arc System of the Sierra Nevada Foothills
Leaders: David Shimabukuro, Sarah Roeske, Kathleen Surpless, Sierra Rack, Jo Black, John Wakabayashi

A Geologic Excursion through the Sierra Foothills Metamorphic Belt along the Historic Amador Central Railroad
Leaders: Jim Wood, Pete Holland, Matt O'Neal, Tim McCrink

Forearc Volcanism and Mantle Peridotites of the Coast Range Ophiolite, Stonyford, California
Leaders: John Shervais, Marlon Jean

Cretaceous Methane Seep Ecosystems of the Forearc
Leader: Russell Shapiro

Active Tectonics of Napa Valley
Leaders: Michael Oskin, Belle Philibosian

CORDILLERAN SHORT COURSES

Practical Paleomagnetism
Leaders: Bernard Housen, Cristina Garcia-Lasanta

Envision Yourself in the Geosciences: Crafting a Vision for Your Career That Aligns with Your Values
Leaders: Theron Sowers, Kristin Hawkins

Wilderness and Remote First Aid for Field Trip Leaders and Research Scientists
(2 days, participants will receive a WFA certification)
Leader: Kurt Burmeister

Borehole Geophysics
Leader: Jan Gillespie

Submit an abstract! The deadline is 28 January.

Rocky Mountain Section

Dates: 18–20 May 2025
Location: Utah Valley Convention Center, Provo, Utah, USA

www.geosociety.org/rm-mtg

FIELD TRIPS

Revisiting the Cretaceous Mancos Group in Utah: Problems, Previous Methods, and New Perspectives on a World-Class Cretaceous Marine Section
Leaders: James I. Kirkland, Mike Ryan King, Joshua Lively

Established, Experimental, and Emergent Geothermal Energy Resources in Utah's Great Basin
Leaders: Eugene Szymanski, Christian Hardwick, Stefan Kirby, Joe Moore, Clay Jones, Stuart Simmons

A Field Trip to Observe Features of Lake Bonneville, Mountain Glaciation, and Great Salt Lake near Salt Lake City, Utah, USA
Leaders: Ben Laabs, Jack Oviatt, Paul Jewell

Catastrophic Gravity Sliding During Growth of the Cenozoic Marysvale Volcanic Field, Southwest Utah
Leaders: David Hacker, Robert F. Biek, Peter D. Rowley, David H. Malone, W. Ashley Griffith, Tiffany A. Rivera, Michael J. Braunagel

Geology of Bears Ears National Monument, Southeastern Utah
Leader: Grant C. Willis

Structural and Stratigraphic Relations of the Cordilleran Fold-Thrust Belt and Foreland Basin System, Northern Utah
Leaders: Zach Anderson, Elizabeth Balgord, Andrea Stevens Goddard, Adolph Yonkee

SHORT COURSE

Handheld Analytical Methods for Geological Field Work
Leaders: Adrian Van Rythoven, Kyle Eastman

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https://bit.ly/3Wgyt0K

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– Matthew Millado, 2024 Natural Resource Management Assistant, Channel Islands National Park, California

Mia Farmer, a 2022 GeoCorps Participant with Bureau of Land Management (BLM) in Lander, Wyoming, made lifelong professional and personal connections through GeoCorps and feels far more prepared for their postgraduate endeavors.

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– Kemi Ashing-Giwa, 2023 Graduate Student Research Grant recipient, for research proposal: "The Good, the Bad, the Hypoxic, and the Euxinic: Investigating the response of bivalves and brachiopods to low oxygen and sulfidic conditions."

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This material is based upon work supported by the National Science Foundation under grant no. 2323037.

Kemi Ashing-Giwa on a boat during a trip to dredge for brachiopods and bivalves.

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AGeS³ is supported by NSF Frontier Research in Earth Science awards EAR-2218547, -2218544, and -2218504.

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Application Deadline: 14 February 2025

Learn more and apply at **https://bit.ly/el-baz**.

Asil Newigy, of the University of Potsdam, Germany, recipient of the 2024 Farouk El-Baz Student Research Grant, for her proposal titled: "Importance of desert flash floods on shelf-incising canyons and coral reef ecosystems."

Field Camp Reflections: Geology, Growth, Gratitude

by Adrian Dias

My field camp experience consisted of two weeks in the Dallas–Fort Worth area of Texas, followed by three weeks in northern New Mexico. The DFW portion of the course included projects in limnology, hydrology, and sedimentology. In New Mexico, the fieldwork focused on structural geology and the igneous and metamorphic petrology of the Sangre de Cristo Mountains. This experience allowed me to apply the skills and knowledge I've gained through coursework, field trips, and research over the past two years.

Field camp was a very positive experience for me. Conducting longer, more in-depth projects in the field gave me valuable insight into what geology work in industry and graduate research might entail. It also provided an opportunity to collaborate more closely with other students than I had in a classroom setting. In the field, we combined our unique skill sets to solve problems as a team. This experience was instrumental in my recent decision to pursue graduate school after I graduate in December 2024.

Adrian Dias, J. David Lowell Field Camp Scholarship Recipient, conducting fieldwork in the Sangre de Cristo Mountains.

CONDUCTING LONGER, MORE IN-DEPTH PROJECTS IN THE FIELD GAVE ME VALUABLE INSIGHT INTO WHAT GEOLOGY WORK IN INDUSTRY AND GRADUATE RESEARCH MIGHT ENTAIL.

For all its benefits, field camp was not without challenges. The daily demands of fieldwork, with little downtime, tested us both physically and mentally. Days spent collecting data and mapping rugged mountain terrain were followed by evenings of analysis and report writing. On a personal level, I faced the emotional challenge of being away from my wife and three young children for three weeks. While I worked in the mountains, she managed meals, bedtime, diapers, and day camps back home. Without her support and sacrifice, I would not have been able to participate in field camp.

I am incredibly grateful for the opportunity to attend this field camp and deeply humbled to have received the GSA Field Camp Scholarship. The scholarship made the experience more manageable, and my new Brunton compass will always serve as a memento of this pivotal time in my life. This was a meaningful way to conclude my undergraduate journey, and I am already looking forward to the next steps in my geoscience career.

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Figure 1. Photograph of a channel caused by catastrophic flooding of Glacial Lake Missoula, Dry Falls, Washington. Photo by Tom Foster, provided by Nick Zentner.

Channeled Scablands, Northwest U.S., and Runnable Mental Models

Thomas F. Shipley[1] and Basil Tikoff*, [2]

Geology logline: *How a catastrophic series of floods were recognized by J Harlen Bretz and Joseph Pardee to have formed the Channeled Scablands of eastern Washington State, USA.*

Cognitive science logline: *Runnable mental models, mental simulations of geological processes applied to specific events, are used by many geologists in evaluating hypotheses.*

The Channeled Scablands of Washington State are well known in the geologic community for having been the source of a significant debate: What was the origin of a series of landforms that occur in eastern Washington, northern Idaho, and westernmost Montana? This debate was a familiar one to geologists. Did these features form through the types of surficial processes that are observed to be occurring today operating over a long time, or did they occur through a catastrophic event?

The community-accepted model in the 1920s and 1930s is that the Channeled Scablands occurred through typical fluvial erosion and hillslope movement, possibly enhanced by glacial melt, an idea that represented a deep commitment to uniformitarian processes. That is, whatever processes are active in forming a landscape at the present were likely the same ones that acted continuously in the past and occurred over long periods of time (e.g., Lyell, 1830). The analogy from the present to the past only works, however, if geological processes do not substantively change over time. Thus, many geologists were likely approaching this Channeled Scablands landscape from the viewpoint of uniformitarianism.

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The catastrophic model for channeled scablands is often associated with a single person—J Harlen Bretz. He proposed that the source of the Channeled Scablands was a cataclysmic outpouring of water that he named the Spokane Flood. Although Bretz originally proposed another source for the water, he came to accept one supplied by Joseph Pardee. Pardee worked for the U.S. Geological Survey, and he recognized that the outpouring resulted from the sudden (and repeated) demise of Glacial Lake Missoula (Pardee, 1942). Over two thousand cubic kilometers of water flowed over the landscape during the short outbursts, picking up and depositing material to form a variety of erosional and depositional landforms. These include rock basins (giant "potholes"), inner channels, subfluvial cataracts, and erosional grooves (Fig. 1; e.g., Baker, 1978). For those with a sense of the power needed to form these shapes, it is a landscape of awe: What else but a massive flood could have left these traces?

The debate ultimately resolved in favor of the catastrophic floods: At present, it is thought that there were close to 100 floods that ranged in duration and magnitude (O'Connor et al., 2020). When thinking about catastrophic events, the question often arises: "Why have geologists been so committed to uniformitarian thinking?" Here, we pick up that question by asking, "How did J Harlen Bretz and Joseph Pardee figure out the catastrophic floods?" The answer is: They could not rely on the existing concepts to explain their data. Consequently, they had to come up with a new hypothesis. Knowing that the hypothesis was viable required constructing a runnable mental model.

A mental model is constructed of mental representations of objects with their respective properties (e.g., Gentner and Stevens, 1983). We have added "runnable" to a foundational cognitive science concept of mental models to distinguish representations of something from a representation that can be tested by mentally simulating "what happens if." The "runnable" term indicates how a mind can evaluate a new hypothesis, by simulating the hypothesized events to "see" if the result resembles the observed state of the world. A runnable mental model has two key components consisting of objects (patterns) and events (processes). Moreover, runnable mental models can capture processes that are complex and occur over significant amounts of time.

To adequately capture the complexity of runnable mental models used in the geological sciences, we turn to the analogy of a theater production: Running a mental model is like a play. The objects are the actors and stage, and the events are the script (Tomkins, 1962; Schank, 1990). From a cognitive science perspective, actors and stage are two different things (Epstein et al., 2003). Actors are spatially localized things that have shape and boundaries; stages are the spatial relations between multiple objects. The script is an event, in which subevents play out (Cohn-Sheehy et al., 2022). We now watch the play of the catastrophic Spokane flood. The stage includes Glacial Lake Missoula, a retreating ice margin, and a landscape that has seen this all before. The actors are water, sediment, and bedrock. The script is fast and furious water movement over about a week, where the various actors have to respond to changed circumstances. In this analogy of a play, it is hopefully clear how a runnable mental model simulates how geologic processes transform landforms and/or the rock record over time.

How are runnable mental models of geological processes created? Generally, our memory of events is the foundation for mental animations. Memories can be abstracted from the details of each specific event to capture the regularities across events. These types of abstracted memories are sometimes referred to as schemas, in that they retain the schematic structure of an event without the details that vary from one occurrence to the next. Schemas are, essentially, aggregated memories. A schema allows the mind to think about an event as a single thing that has no clear objective beginning or end. Having developed an event schema, one can conceive of events that have never been encountered by applying the schema to new objects. For example, having learned a birthday party schema, a child may playfully stretch the schema to envision a party with animals as guests, who of course would be wearing party hats and eating cake to align with the birthday party schema. Schemas, similar to analogies, can be a cognitive engine for hypothesis generation.

HOW DOES THE MIND KEEP TRACK OF BOTH INDIVIDUAL EVENTS AND ALSO COMBINE ACROSS THEM TO EXTRACT CONSISTENT REGULARITIES AND PARTS THAT VARY?

Understanding how one creates schemas has been a challenge in cognitive science: How does the mind keep track of both individual events and also combine across them to extract consistent regularities and parts that vary? How are the variations across events separated from the consistent properties without decomposing the whole into every individual event? A relatively recent proposal by Jeff Zacks and colleagues (Cohn-Sheehy et al., 2022) is that the mind organizes memories using the overall structure of the large event schema and keeps track of where within the schema subevents may differ. For example, one has a general schema of birthdays, but also memories that some birthdays had games, but others did not, and many had candles, but the number varied. The same richness certainly applies to geologists thinking about processes (e.g., mountain building) with local variations (e.g., shaped by preexisting structures).

The objects and schema of our mental models may be formed from the memories of observed objects and events, but they need not be. Humans have the capacity for thinking about things that are other than reality, imagining and communicating *hypothetical counterfactuals*. These hypothetical counterfactuals allow us to assimilate objects and events we have not directly experienced. Rather, they can be provided by others who have seen them, inferred from indirect observation, or visualized with the application of technology that extends our senses. The schemas for these models come from another mind, not unlike the memories of models we build from reading fiction. The memories that form runnable models may be of directly experienced objects and events in the world or models of the world, or indirectly experienced objects and events, either from an external visualization or an internal mental

Figure 2. Photograph of West Bar on the Columbia River near Trinidad, Washington. The landforms are giant current ripple marks caused by catastrophic flooding. Photo by Tom Foster, provided by Nick Zentner.

simulation. A symbolic mind has the capacity to create powerful new ideas that can be shared to form the basis of runnable models in the community. This capacity is necessary for learning and practice in much of the geosciences because the important objects and events often cannot be directly seen, including those associated with catastrophic floods.

The concepts of erosion and deposition are, to a geologist, schemas. One can observe, in a typical river, how water erodes sand grains from one location and deposits them in another, thus forming ripples. A schema of erosion and deposition could be applied to a new situation. In the case of the Channeled Scablands, it needed to be applied to a place where there was a lot of water (and we mean a lot, i.e., over 25 cubic kilometers of water per hour) running over the landscape, picking up and depositing sediment as it flowed. Without the ability to apply these schemas and produce a runnable mental model, Bretz would never have invoked a Spokane Flood as a cause of the observed landforms.

Consider the utility of runnable models using the words of a geologist (V. Baker in a 2024 interview with N. Zentner, Ice Age Floods A–Z, Episode S, starting at 1:14:30). When Bretz was frustrated with colleagues about not accepting the catastrophic flood hypothesis, he would say that if he could just take them to the Wallula Gap overlook, they would accept the hypothesis. V. Baker describes the reaction of a geologist, who originally opposed the catastrophic flood hypothesis, at one of these overlooks in the Channeled Scablands: "Once he actually saw the relationships...there is no way that anything could happen but a catastrophic flood to make that landscape. It just screams at you if you look at it." Landscapes do not scream at nongeologists; the Channeled Scablands landscape just exists for most people who do not understand basic processes and patterns associated with sediment transport in water (e.g., people who do not have a schema). Figure 2 shows West Bar along the Columbia River, the location that to us most screams "catastrophic flood." Bretz was effectively saying that a geologist—given the right vantage point—would necessarily produce a runnable mental model that would require massive water volumes. In the case of the Channeled Scablands, that runnable model requires schemas of erosion and deposition. Without a perspective informed by memories of Earth processes, a person is just sightseeing. Explanation and acceptance of almost all process-based models in the geological sciences require some form of runnable mental model.

WITHOUT A PERSPECTIVE INFORMED BY MEMORIES OF EARTH PROCESSES, A PERSON IS JUST SIGHTSEEING.

The features of the Channeled Scablands landscape had the power to change minds on a wholesale level. In this sense, it is similar to Siccar Point, Scotland (e.g., Shipley and Tikoff, 2024b), insofar as the displayed geometry is sufficiently compelling to change one's worldview. If the landscape was so compelling, why did it take so long for the idea to emerge in the history of visits to this landscape? We speculate that the delay lay in the challenge of creating an internally consistent runnable mental model. Bretz and Pardee had to, singularly or jointly, connect the ideas of sediment deposition and erosion in typical river systems to the movement of house-sized rocks during catastrophic floods.

Once Bretz and Pardee began offering their account of what happened, others could attempt to run a mental model to see if they came to the same conclusions. Steven J. Gould, in his book *The Panda's Thumb*, reports that participants of a geological field trip to the Channeled Scablands run in 1965 sent Harlen Bretz a note that said, "We are all catastrophists now" (Gould, 1980, p. 202). The participants on the 1965 field trip were effectively saying that their runnable mental models confirmed that the Spokane floods could (and did) yield these landforms. Once an individual's mental connections have been stretched to align the analogy from familiar processes to the hypothesized ones, it becomes easier for subsequent geologists, who are challenged only to recognize the appropriateness of the analogy. Once a community begins to agree on the explanation for an observation, in this case the landforms of the Channeled Scablands, then not everyone needs to run the mental model to check the interpretation. In both cases, mental resources are conserved, as there is no necessity to pause to run a model in order to check the validity of the reasoning.

Often, testing the details of the explanation offered by a runnable mental model requires more precision or capacity than the mind can provide. Scientists can turn to a different type of runnable model, perhaps a computational model or a physical model (e.g., a stream table). In developing these physical and computational models, however, scientists likely begin with a runnable mental model. Scientists and educators often avail themselves of physical models to bring Earth-scale processes into the classroom and laboratory, in order to observe them and develop or refine a runnable mental model.

The importance of runnable mental models is also highlighted by the centrality of illustrations in the geological literature. It is typical for a scientific paper to contain a final figure that provides a time-progressive view of a particular geological process. Within this figure, there are the hypothesized relevant objects and the hypothesized manner in which they change over time. It is left to the reader to construct the mental model and run it. Animations can reduce the burden of mental animation and also provide the content for a memory that can be used to extract an event schema. The well-known visualizations (https://animations.geol.ucsb.edu/index.htm) of Tanya Atwater for the Cenozoic tectonic development of California (following Atwater, 1970) reflect how animations can support scientists' minds.

How do all of these pieces fit with the concept of multiple working hypotheses (discussed in Shipley and Tikoff, 2024a)? It is likely that any spatial hypothesis was evaluated with a runnable mental model. When employing multiple working hypotheses, each hypothesis is associated with a separate runnable mental model. Prior to 1920, there was a runnable mental model for normal fluvial processes to shape the Channeled Scablands; Bretz provided a description of a new runnable mental model that required a catastrophic flood. Other scientists needed to produce their own runnable mental model of the catastrophic flood upon encountering Bretz's account. Then, they could compare the catastrophic flood hypothesis to the previously existing hypothesis, to see how well each runnable mental model accounted for the observed landforms in the Channeled Scablands.

Moreover, runnable mental models can be updated, for example, when Bretz accepted that there was more than a single Spokane flood. Each mental model is supported by some combination of schemas (aggregated memories from the real world or theoretical approaches) and analogies. Both schemas and analogies are used to evaluate both the observations (patterns) and the potential explanations for the observations (processes). The conviction of the rightness of a mental model is correlated to the rightness of the schema or the analogy.

To emphasize these points, we return to the theater analogy used above. Two unresolved alternative working hypotheses (e.g., normal fluvial processes vs. catastrophic flooding) are two different scripts. Needless to say, character (e.g., landform) development and interaction between the characters (e.g., water, sediments, erosion) occur differently in the different plays. The preferred play has a more plausible explanation for the position (and state of being) of the players and stage elements at the end of the play; the preferred runnable mental model is the one that better explains the features observed in the world.

We end by noting that the mind leaves traces of its action in the history of science. That is, scientific discoveries are necessarily historical. In the era of strict uniformitarianism, in which all runnable mental models were necessarily constructed from current events, Bretz made a notable achievement to mentally simulate (e.g., create a runnable mental model of) a catastrophic flood. Further, Bretz and Pardee facilitated acceptance of the potential role of other catastrophic events in Earth's history—one example being the acceptance of a meteorite impact as an explanation for the extinction event at the end of the Cretaceous. However, historians of science have noted that transitions in scientific consensus from one model to another do not occur in an instant. The slow pace of change reflects multiple aspects of the nature of human minds in scientific communities, including the challenging effort of building runnable mental models.

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NAGT

THE GEOLOGICAL SOCIETY OF AMERICA®

This essay series is a joint effort of the National Association of Geoscience Teachers (NAGT) and the Geological Society of America (GSA). Anne Egger, Executive Director of NAGT, served as the associate editor.

2025 GSA Science Editors

GSA depends on the volunteer efforts of many science editors, associate editors, and editorial board members to ensure the timeliness and quality of our publications.

GSA thanks the editors whose terms ended 31 December 2024 for their service to the Society and to the science:
Kathleen C. Benison, *Geology*; **Marc D. Norman**, *Geology*; and **Jim Schmitt**, *GSA Today*

Thank you to our continuing editors:

GSA Books, **Joan Florsheim**, University of California, Santa Barbara
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Geosphere, **Andrea Hampel**, Leibniz University Hannover
Geosphere, **Christopher J. Spencer**, Queen's University
GSA Today, **Pete Copeland**, University of Houston

Please join us in welcoming the science editors beginning terms this month:
Geology, **Mark E. Patzkowsky**, Pennsylvania State University
Geology, **Scott D. King,** Virginia Polytechnic Institute and State University

Find the current list of editors at **www.geosociety.org/editors**.

Call for GSA Fellowship Nominations

Deadline: 1 February 2025
Nominate a deserving colleague for the honor of GSA Fellowship. GSA members are elected to Fellowship in recognition of distinguished contributions to the geosciences. See election requirements at **www.geosociety.org/Fellowship.**

NOMINATE A DESERVING COLLEAGUE FOR THE 2026 BIRDSALL-DREISS DISTINGUISHED LECTURESHIP

To nominate someone for the Birdsall-Dreiss Distinguished Lectureship, please include the following:

- At least one letter of nomination.
- The nominee's curriculum vitae.
- At least two supporting letters detailing the significant contributions or accomplishments that form the basis for the nomination.

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

Deadline: February 1 2025

If you have questions, contact a member of the Birdsall-Dreiss Committee at https://bit.ly/4f2iedJ.

About the Birdsall-Dreiss Distinguished Lectureship

The Birdsall Lectureship was established in 1978 as part of a bequest to the GSA Hydrogeology Division in memory of John Manning Birdsall, a prominent geologist from the Water Resources Division of the U.S. Geological Survey.

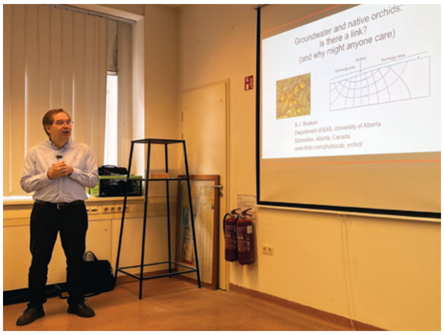
One of the most notable Birdsall Lecturers was Shirley Dreiss from the University of California, Santa Cruz. After her sudden passing in 1992, following a highly successful lecture tour, many of her friends and admirers contributed to the GSA Foundation fund in her honor. The lectureship was subsequently renamed the Birdsall-Dreiss Lectureship.

Explore past lectures in the Birdsall-Dreiss Lectures Database (https://bit.ly/4ipBiW2), which includes details such as the year, lecturer, employer, and lecture title(s).

GSA Hydrogeology Division's Birdsall-Dreiss Distinguished Lectureship

ON THE ROAD WITH BEN ROSTRON

In 2024, the Birdsall-Dreiss Distinguished Lecturer, Ben Rostron, delivered over 50 talks across 30 cities in the USA, Canada, and three overseas countries—Hungary, Germany, and Australia. He spoke in five Canadian provinces, including the first-ever visit by a GSA Birdsall-Dreiss Lecturer to Memorial University in Newfoundland, an achievement to be proud of.



Birdsall-Dreiss Distinguished Lecturer Ben Rostron in action at a lecture.

"The tour has been an absolutely amazing adventure," Ben reflects. "Certainly, a lot of work and a lot of travel, but overwhelmingly worth the time and effort."

On reconnecting with old colleagues during the tour, Ben shares, "I was honored that they would spare some of their precious time to share their work with me."

Ben highlights several favorite experiences from his tour: meeting undergraduate and graduate students from around the world, learning about their interests and projects; visiting new places and experiencing new things; and building connections for the future.

Congratulations to Ben Rostron on an outstanding tour as the 2024 Birdsall-Dreiss Distinguished Lecturer!

INTRODUCING THE 2025 BIRDSALL-DREISS DISTINGUISHED LECTURER

M. Bayani Cardenas is a professor of hydrology in the Department of Earth and Planetary Sciences at the Jackson School of Geosciences, University of Texas at Austin. His research focuses on understanding flow and transport processes across diverse hydrologic settings and addressing water quality and quantity challenges at various scales, using theoretical, computational, and observational methods. He earned his degrees from the University of the Philippines-Diliman, the University of Nebraska-Lincoln, and the New Mexico Institute of Mining and Technology.

Cardenas' lectures cover a wide range of topics, including:

- Hydrobiogeochemistry of terrestrial-aquatic interfaces: from pore to continental scales.
- How a river's periodic pulse affects its liver: hyporheic zones in the Anthropocene.
- Tidal and seasonal groundwater-surface water mixing zones: hot or cold spots for arsenic contamination?
- Groundwater on ice: hydrogeology and the fate of permafrost carbon in Arctic watersheds.
- Land-ocean connectivity in Arctic lagoons: driven by groundwater.
- Ridge to reef volcanic hydrogeology: submarine groundwater in the world's most biodiverse coasts.
- Devastation of a sole source coastal aquifer: impacts of the most powerful storm ever.
- Insights on groundwater renewability: age and residence time analysis.
- Beyond Darcy and Fick: micro-scale insights on nonlinear continuum flow and transport.

Cardenas' lecture schedule is packed, with an impressive 64 talks! More information on these lectures is available at **https://bit.ly/3OELZXr**.

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Richard H. Jahns Distinguished Lectureship

REFLECTIONS AND GRATITUDE

As Cynthia Palomares concludes her year as 2023–2024 Jahns Lecturer, she reflects with gratitude on the experience, remarking, “Students are enthusiastic, hard-working, and focused. I enjoyed interacting with many geology students at colleges and universities around the country and came to learn that these students are dedicated to earning their geology degrees and willing to do the work needed to get there.”

This commitment to exploring the possibilities that come with a career in applied geosciences is vital, especially when, as Cynthia notes, “most students don’t have a realistic idea of the careers available to them after earning their geology degrees. Without interaction with geoscience professionals, geology students generally remain unaware of their career options. In that regard, the Jahns Lectureship—and becoming a student member of AEG and/or GSA—plays an essential role in helping students better understand the professions available to them.”

Amid the nationwide decline in geoscience and applied geoscience programs due to falling enrollment, Cynthia found the Lectureship invaluable as an evolving forum to speak directly with students and share why they should consider pursuing a geoscience career and the rewards that come with it.

Cynthia leaves a final message: “If given the opportunity, I highly recommend anyone take on this important role as a Jahns Lecturer.”

On behalf of the applied geoscience community, we thank you, Cynthia, for your year of service and your efforts to bring together the geoscience community—especially its student members. Thank you so much!

Cynthia Palomares (second from left) pictured with students at Tennessee State University in Nashville.

LOOKING AHEAD TO 2025

The 2024–2025 Lecturer is Dr. John Kemeny, who has over 40 years of experience in applied geoscience. His career includes a post-doc at the Lawrence Berkeley National Laboratory, 33 years as a professor at the University of Arizona, work at a geomechanics consulting company, and co-founding a successful startup that became a world leader in vision-based rock fragmentation measurement software and point-cloud-based rock mass characterization software.

Dr. Kemeny earned BS degrees in geology and mathematics from the University of California, Santa Barbara, in 1977, and ME and PhD degrees focusing on rock mechanics from the University of California, Berkeley, in 1982 and 1986. He began his career in the Department of Mining and Geological Engineering at the University of Arizona in 1989, retiring as Emeritus Professor in 2022.

At the University of Arizona, Dr. Kemeny published over 170 papers, delivered more than 80 invited technical talks and workshops, and mentored 15 PhD students and over 50 master’s students. His research and teaching focused on rock mechanics, slope stability, rock fracture mechanics, numerical simulations in rock mechanics, and the development of 3D imaging and sensing technologies for geotechnical applications.

In 1998, Dr. Kemeny co-founded Split Engineering, a spinoff company that developed new technologies for measuring rock fragmentation and point cloud processing software for slope and underground stability. The company had offices in the US, Chile, Peru, South Africa, and Australia and was acquired by Hexagon Mining in 2019.

Since retiring from the University of Arizona, Dr. Kemeny has started a new company focused on integrating Artificial Intelligence (AI) into the applied geology fields to address the increasing hazards associated with climate change.

Dr. Kemeny’s lectures will cover a wide range of topics, including the use of AI to better understand geologic and hydrologic hazards, using point cloud data to examine rock mechanics, and entrepreneurship in geologic engineering. He emphasizes the importance of innovation and creativity in applied geoscience, especially in the face of the growing natural and manmade hazards linked to climate change.

To schedule a visit to your school or organization, contact Dr. Kemeny at kemeny@arizona.edu. For a detailed description of each talk, visit www.rockswriter.com.

Nominations for next year’s Jahns Distinguished Lecturer are due on **31 January**.

Learn more: **https://community.geosociety.org/eegdivision/awards/jahns**

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AEG ENVIRONMENTAL ENGINEERING GEOLOGISTS

AEG ENVIRONMENTAL ENGINEERING GEOLOGISTS FOUNDATION

GSA FOUNDATION

Announcing the 2024–2025 Continental Scientific Drilling Division Distinguished Lecturer

We are pleased to introduce our 2024–2025 Distinguished Lecturer, Dr. Mattia Pistone. Dr. Pistone is an Assistant Professor in Petrology and Volcanology at the University of Georgia and director of the MAGMA MIA Laboratory. He is one of seven principal investigators leading the ICDP DIVE project. His research combines experimental, analytical, and field-based approaches to investigate magma mechanics, eruption dynamics, and volatile cycles in the Earth's interior.

Affiliation: University of Georgia
Lecture Title: **Moho Mission to the Foundation of Continents: The ICDP DIVE Drilling Project**

Abstract: Exploring the Earth's interior just miles below our feet is more challenging than examining the surfaces of distant planets. Scientific drilling bridges this gap, yet increasing depth brings immense physical challenges. Since the 1960s' Project Mohole, scientists have strived to reach the crust-mantle boundary—commonly beyond our technological capabilities. However, the Ivrea-Verbano Zone in the Italian Alps offers a rare opportunity: the crust-mantle boundary is accessible at shallow depths due to tectonic plate collisions.

Phase 1 of the ICDP DIVE (Drilling the Ivrea-Verbano zonE) project, involving over 50 scientists, has yielded significant insights into the crust-mantle transition's chemistry, structure, geophysical properties, and deep biosphere activity. Dr. Pistone will share these findings and their implications for Earth sciences.

To schedule a lecture, contact Michael McGlue, chair of the Division, at michael.mcglue@uky.edu, or Dr. Pistone at Mattia.Pistone@uga.edu. The Division can assist with transportation costs for in-person talks. Remote talks are also welcome.

ABOUT THE DIVISION

GSA's Continental Scientific Drilling Division was founded in 2016 to advance the exploration and investigation of the Earth's continental subsurface through scientific drilling.

Mission:

- Provide a community for GSA members that use scientific drilling in their research.
- Foster communication and collaboration between scientists from across the GSA divisions who use scientific drilling to study the Earth's subsurface.
- Support workshops, symposia, sessions, and other activities that educate GSA members and promote research using scientific drilling.
- Advise officers and committees of the Society on issues relevant to continental scientific drilling.

Join the Division today! Learn more at **community.geosociety.org/continentaldrilling**

CALL FOR NOMINATIONS: 2025–2026 CSD DIVISION DISTINGUISHED LECTURESHIP

We invite nominations for the Continental Scientific Drilling Division (CSD) Distinguished Lectureship, to be conducted during the 2025–2026 academic year. This prestigious award honors one of our most outstanding scientists and highlights research achieved through continental scientific drilling.

Nomination Deadline:
25 March 2025

Submission Requirements:

- Name of the nominee
- A 2–3 sentence justification for their selection
- The nominee's CV

Please email nominations to Michael McGlue, chair of the Division, at michael.mcglue@uky.edu. Self-nominations are welcome. The final selection will be made by the CSD Management Board.

The Geological Society of America's Continental Scientific Drilling Division (CSD) Distinguished Lecturer award recognizes exceptional scientists who have made groundbreaking discoveries through continental drilling. Awardees present a series of lectures at academic institutions, GSA events, and public forums during their award year.

Continental Scientific Drilling Division
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CONTINENTAL SCIENTIFIC DRILLING DIVISION

GSA FOUNDATION

GEOLOGY THROUGH THE LENS

Candy Hornfels

Scattered about like striped chocolates, boulders of Mildred Lake hornfels (Lower Permian) decorate the shore below a massive section of the bluish Mount Baldwin Marble formation (Pennsylvanian to Lower Permian) rising above Lake Mildred in the eastern Sierra Nevada, California.

Richard W. Halsey is the director and founder of the California Chaparral Institute.

Want your photo to be featured in *GSA Today*? Email submissions to gsatoday@geosociety.org.

Understanding the Many Endowment Funds Stewarded by the GSA Foundation

The GSA Foundation manages a diverse portfolio of over 120 named endowment funds, each dedicated to supporting GSA programs. These funds fall into seven key categories: research grants, outreach and education, travel grants, GSA Section funds, student mentorship, international programs, and awards. Each category plays a vital role in advancing the geosciences.

RESEARCH GRANTS

Research grants, supported by numerous endowment funds, provide financial assistance to graduate students and researchers for academic studies and projects. Proposals undergo a rigorous review process, and many applicants successfully receive grants each year. For many GSA members, receiving a research grant marks the beginning of a longstanding relationship with the organization. These grants not only offer crucial financial support but also foster lasting connections and engagement with GSA.

OUTREACH & EDUCATION

Outreach and education initiatives include scholarships, lectureships, and fellowships that promote effective science communication and engagement within both the geoscience community and the public. One noteworthy program supported by an endowment fund is the Congressional Science Fellow, which applies scientific knowledge to address societal challenges.

TRAVEL GRANTS

Travel grants are crucial for supporting students attending Section and Connects meetings, as well as those conducting fieldwork. By providing financial assistance for travel, these grants enhance students' learning experiences and professional development. They also enable students to participate in key events and network with peers and professionals, ultimately contributing to their growth and success.

GSA SECTION FUNDS

Endowments for GSA's six Sections support various programs, including student travel to Section and Connects meetings and undergraduate research initiatives. By funding these activities, Section endowments contribute to the professional development and academic success of students, fostering a vibrant and thriving geoscience community.

Donate at https://gsa-foundation.org/donate/.

STUDENT MENTORSHIP

Endowment funds support the Shlemon and Mann mentor lunches at Section and Connects meetings. These events provide students with opportunities to engage with GSA mentors and explore potential career paths. Interactions between students and experienced professionals during these mentorship lunches offer valuable insights, advice, and guidance, helping students make informed decisions about their futures.

Dr. Roy Shlemon, whose philanthropic contributions have fueled transformative mentorship programs that empowers the next generation of leaders, alongside Dr. Lydia Fox, Chair, GSA Foundation Board of Trustees.

INTERNATIONAL PROGRAMS

Endowment funds for international programs facilitate global scientific exchange by inviting renowned scientists to Connects meetings and promoting cross-border collaboration. Additionally, a newer fund specifically supports undergraduate and graduate students in Africa studying African geology. This financial aid enables them to attend a Connects meeting and present their research, enhancing their academic and professional development.

AWARDS

Endowment-supported awards recognize exceptional scientific achievements and dedicated service within the geoscience community. These awards honor individuals who have made significant contributions to the field, inspiring others to continue advancing the geosciences and expanding knowledge.

SUPPORTING THE FUTURE OF GEOSCIENCES

While these categories comprehensively address the Foundation's mission, there is always a need for additional resources to secure a robust future for GSA members. Expanding these funds is essential to support the next generation of geoscientists and their growth in the field.

Your donations play a significant role in building and nurturing this community. Consider contributing to one or more funds—or even starting a new one. Your support ensures a thriving and innovative geoscience community. Feel free to contact us to explore the many options available for giving.

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