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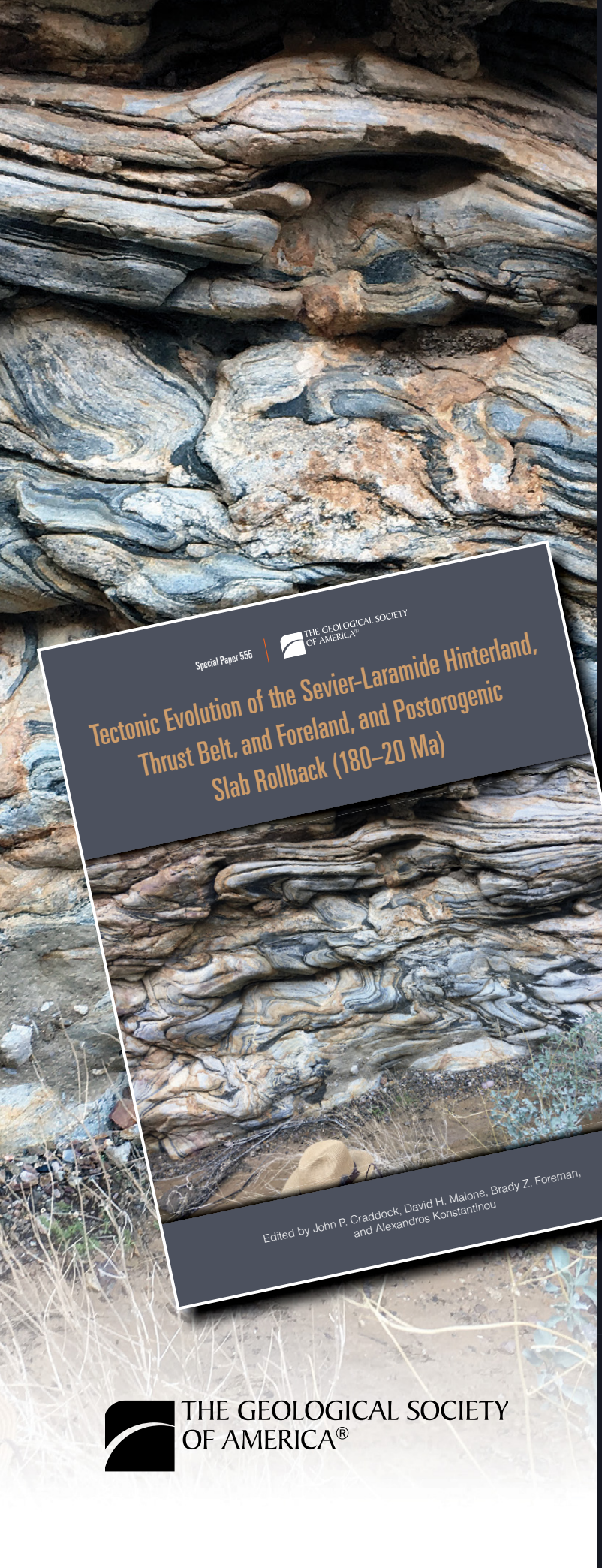
Nuclear Winter and the Anthropocene



Tectonic Evolution of the Sevier-Laramide Hinterland, Thrust Belt, and Foreland, and Postorogenic Slab Rollback (180–20 Ma)

Edited by John P. Craddock, David H. Malone, Brady Z. Foreman, and Alexandros Konstantinou

This Special Paper focuses on the evolution of the crust of the hinterland of the orogen during the orogenic cycle, and describes the evolution of the crust and basins at metamorphic core complexes. The volume includes a regional study of the Sevier-Laramide orogens in the Wyoming province, a regional seismic study, strain analysis of Sevier and Laramide deformation, and detrital zircon provenance from the Pacific Coast to the foreland between the Jurassic and the Eocene.

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SCIENCE

Cover: Eruption of Raikoke Volcano in the Kuril Islands, 22 June 2019. The eruption cloud crossed the tropopause at ~11 km altitude and spread out in the lowermost stratosphere at 13–17 km. The flat top of the cloud reflects the impediment to convective cloud ascent into the stratosphere, which forms a global inversion layer. In nuclear-winter scenarios solar heating of soot would gradually loft the soot to higher altitudes in the stratosphere, a process observed with smoke from large wildfires. (NASA Earth Observatory digital photograph ISS059-E-119250 taken from the International Space Station.). See related article, p. 4–9.

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Nuclear Winter and the Anthropocene

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ABSTRACT

In 2019, the Anthropocene Working Group proposed the creation of an Anthropocene chronostratigraphic time unit to follow the Holocene Epoch. The Anthropocene time period would begin in the mid-twentieth century, coincident with rapid acceleration of multiple, ongoing anthropogenic changes to Earth's surface and environments. Radioactive isotopes dispersed during the 1952–1962 period of atmospheric thermonuclear-bomb tests form a proposed global marker for the beginning of the Anthropocene. This marker is proposed for purely geological reasons as it is reasonably precise and global in scope. These isotopes are also a marker for the initiation of a new human capacity to trigger global environmental change in a period of hours. The possibility of a global, multiyear nuclear winter following a nuclear war between North Atlantic Treaty Organization nations and Russia is suggested by recent studies of wildfires that injected sunlight-blocking smoke into the stratosphere, and by increasingly sophisticated numerical simulations of global climate following a major nuclear war. Although the proposal for an Anthropocene time period was made without consideration of the consequences of nuclear war or nuclear winter, designating the period of thermonuclear weapon tests as initiating an Anthropocene time period is supported here specifically because it indicates a new human capability for rapid and destructive environmental change on a global scale.

INTRODUCTION

The Anthropocene is a proposed time period that would begin with geologic evidence of human modifications of Earth's surface and environments, but with an unspecified future end date (Zalasiewicz et al., 2019). The abundance and severity of such modifications since the industrial revolution provoked consideration of an anthropic (human-related) time period following the Holocene (Crutzen, 2002). The "Great Acceleration" of environmental change associated with rapid post-WWII economic growth and technological innovation (Steffen et al., 2015) is now the leading candidate for the beginning of the Anthropocene (Anthropocene Working Group, 2019). The Great Acceleration also coincides with hundreds of atmospheric nuclear-bomb tests, primarily by the United States and the Union of Soviet Socialist Republics (USSR), that injected radioisotopes into the global atmosphere. Some of these isotopes will be measurable in various materials for tens of thousands of years, thus providing a geologic marker for the beginning of the Anthropocene (Waters et al., 2015). The purpose of this paper is to outline some of the environmental and geological consequences of a major nuclear war as suggested by recent studies in atmospheric sciences that indicate the possibility of severe global cooling following such a war, a consequence termed "nuclear winter" (e.g., Turco et al., 1983, 1990; Robock et al., 2007). Mid-twentieth-century radioisotope fallout is not simply a convenient marker for accelerated environmental change and a new geologic time period but indicates a new human capacity to abruptly initiate catastrophic global change.

THE BEGINNING OF THE ANTHROPOCENE

The International Commission on Stratigraphy (ICS) defines and modifies units of the International Chronostratigraphic Chart (Cohen et al., 2013). In 2009, the ICS tasked the Subcommission on Quaternary Stratigraphy with forming an Anthropocene Working Group to study possible designation of a formal Anthropocene chronostratigraphic time unit and to make recommendations regarding modification of the geologic time scale. Consideration of a formal lower boundary for the Anthropocene requires conformity with criteria used to establish other boundaries within the geologic time scale, including global synchroneity or near synchroneity (Waters et al., 2018). Although the beginning of the industrial revolution was initially proposed as the beginning of the Anthropocene (Crutzen and Stoermer, 2000), the great acceleration of anthropogenic environmental change following WWII (Steffen et al., 2007, 2015) led the Anthropocene Working Group to propose that an Anthropocene epoch begin in the mid-twentieth century.

Radioisotope Fallout

Explosive energy is derived entirely from nuclear fission in atomic bombs ("A-bombs") whereas an atomic bomb is the trigger for second-stage nuclear fusion in thermonuclear bombs ("H-bombs"). Atmospheric atomic-bomb tests dispersed radioactive fission products to the troposphere where fallout was largely confined to the general region around the test site. In contrast, much larger thermonuclear weapon tests during 1952–1962 (Fig. 1A) each produced a fireball that ascended into the stratosphere and resulted in global dispersal of radioisotopes (UNSCEAR, 2000). Two plutonium isotopes in thermonuclear-bomb fallout, plutonium-239 (^{239}Pu) with a half-life of 24,110 years and plutonium-240 (^{240}Pu) with a half-life of 6563 years, will be identifiable in sediment and ice for tens of thousands of years (Fig. 1B; Hancock et al., 2014).

Earth's upper atmosphere is bombarded with high-energy protons and atomic nuclei derived from the Sun ("solar wind") and from outside the solar system ("cosmic rays") (Damon and Sternberg, 1989). Resulting nuclear reactions include transformation of nitrogen-14 (^{14}N) to carbon-14 (^{14}C), which has a half-life of 5730 years. This carbon promptly reacts with oxygen to produce CO_2 and is well mixed with the atmosphere within a few years. Roughly one in a trillion CO_2 molecules in Earth's

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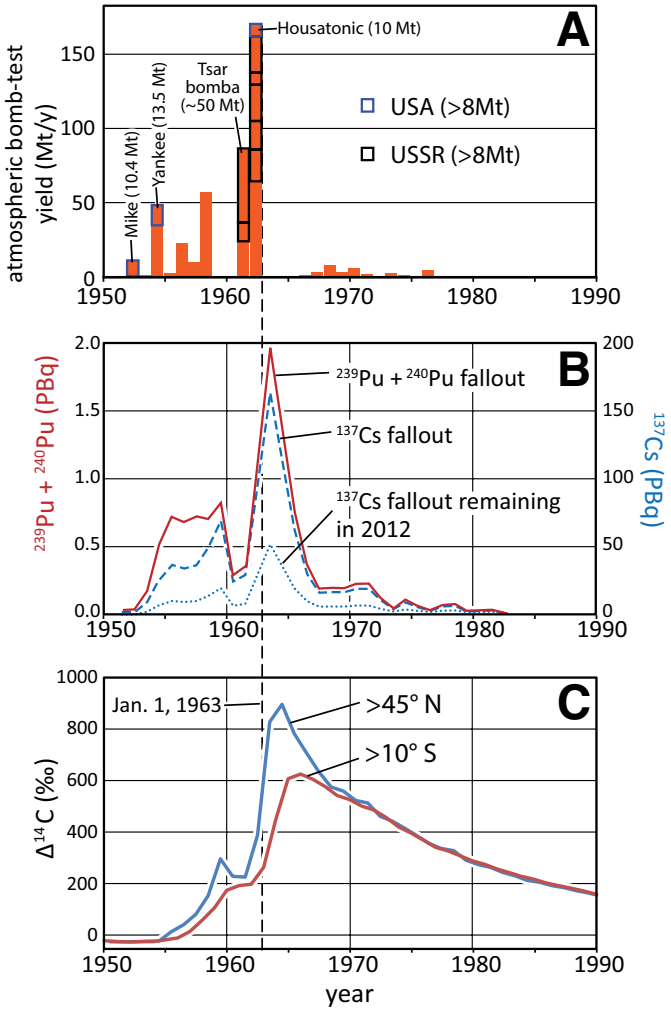

Figure 1. (A) Histogram of annual yield, in megatons of TNT equivalent, for atmospheric nuclear-bomb tests (UNSCEAR, 2000; USDOE, 2015). Atomic bomb-test yields before the first thermonuclear bomb test in 1952 are too small to plot at the scale shown. Names of some major tests are also shown. Atmospheric testing by the United States (USA) and Union of Soviet Socialist Republics (USSR) ended with the 1963 Partial Test Ban Treaty. Later atmospheric tests were conducted by China and France. (B) Combined ^{239}Pu and ^{240}Pu fallout as calculated from more readily measured ^{137}Cs and ^{90}Sr fallout, with higher (^{239}Pu+^{240}Pu)/^{137}Cs in earlier U.S. (neutron-rich) tests versus later Soviet tests (Koide et al., 1985; UNSCEAR, 2000; Hancock et al., 2014). (C) Graph of ^{14}C as measured in tree rings and in the atmosphere showing the high values measured at sites >45° N and low values measured at sites >10° S before global atmospheric mixing (modified from fig. 4 of Hua et al., 2021).

atmosphere contain ^{14}C rather than stable ^{12}C or ^{13}C (e.g., Dutta, 2016). Neutrons produced by nuclear explosions also cause transformation of ^{14}N to ^{14}C. Thermonuclear-bomb tests during 1952–1962 produced so much ^{14}C that concentrations of ^{14}C in atmospheric CO_2 almost doubled (Fig. 1C; Hua et al., 2021). Elevated ^{14}C concentrations are measurable in tree rings and ice cores (e.g., Levchenko et al., 1996) and have been proposed as the most precise geologic marker for the beginning of the Anthropocene (Turney et al., 2018).

NUCLEAR WAR

Radioisotope fallout in the mid-twentieth century occurred during the development and deployment of thousands of nuclear weapons by North Atlantic Treaty Organization (NATO) nations and the USSR. The military posture represented by these nuclear weapons, known as "mutual assured destruction," ensures a catastrophic nuclear response to a major nuclear attack, thus restraining adversaries as long as those in charge behave rationally and command and control infrastructure performs as intended.

The United States currently has ~1400 thermonuclear warheads deployed on land- and submarine-based ballistic missiles and another ~400 at U.S. Air Force bases (Kristensen and Korda, 2021). A recent estimate of Russian nuclear-weapon deployment is similar (Kristensen and Korda, 2022). Both nations have several thousand additional nuclear warheads in storage and available for deployment, with a total of ~8300 warheads and bombs available for use in a major nuclear war. NATO members France and UK have another ~500 nuclear weapons. The nuclear-weapon arsenal of the United States is intended to defend the 30 member nations of NATO, with a population of ~950 million, plus an additional 200 million people in Japan, South Korea, and Australia. The Russian arsenal is intended to defend the ~146 million people in Russia plus the additional 47 million people in allied countries of the Collective Security Treaty Organization.

The primary targets of Russian and American nuclear weapons are the nuclear weapons of the opposing countries (Hafner, 1987). Stationary land-based missile sites would be targeted with the intent of destroying the missiles before launch. Other military facilities, including those in and near cities, would be targeted, with higher-elevation detonation for more dispersed targets. The number and types of non-military targets, including infrastructure, industry, and cities, is not public knowledge, but enormous destruction and loss of life could result from attack on these targets with a small fraction of either nation's nuclear forces (Glasstone, 2020).

NUCLEAR WINTER

Nuclear winter is the concept that, during a major nuclear war, firestorms caused by nuclear explosions will engulf cities and inject smoke into the stratosphere where it will spread around the globe and reduce sunlight at ground level to the point where winter-like conditions persist for months or years (e.g., Crutzen and Birks, 1982; Turco et al., 1983, 1990). The severity of a nuclear winter would depend on the fuel load and flammability of targeted areas as well as atmospheric conditions and other environmental factors. While the primary targets of U.S. and Russian nuclear weapons are the opposing nation's nuclear weapons and command and control infrastructure, most of which are not particularly large or flammable, potential secondary targets include

all other military bases, many of which are near or within cities or their surrounding suburbs. Other likely targets include infrastructure for manufacturing and transportation, power generation and distribution, and oil and gas refining and distribution. Many if not most of these targets are within or near cities and suburbs. Even cities themselves could be targets if the intention is to prevent, for as long as possible, an adversary's ability to recover and re-arm (Richelson, 1985). Of the 1.35 billion people under the U.S. and Russian protective nuclear umbrellas, 85% of them are potentially targeted by Russian nuclear forces. This makes Russian nuclear-weapon–targeting far more important in determining the potential for nuclear winter.

The severity and duration of a nuclear winter would also depend on the amount of smoke that ascends to the upper troposphere and lower stratosphere. The tropopause, which is the boundary between the troposphere and stratosphere (Fig. 2A), is typically 10–15 km above sea level, with lower altitudes in polar regions and higher in the tropics. At this boundary, the vertical temperature gradient reverses so that temperature increases upward above the tropopause. Heating of the stratosphere, due to absorption of solar ultraviolet radiation by ozone, creates a global inversion layer that generally prevents dust, water, and smoke from rising into the stratosphere. This boundary must be breached for smoke to cause global nuclear winter.

Pyrocumulonimbus (pyroCb) clouds produced by rising hot air and smoke from large wildfires can inject smoke into the upper troposphere and lower stratosphere (Fromm et al., 2010, 2021). PyroCb clouds are similar to typical thunderstorm clouds and form under similar conditions (Fig. 2B), but they receive an extra boost from hot air rising above a fire (Fromm et al., 2006; Rodriguez et al., 2020). Rainout of smoke due to water condensation on smoke particles is suppressed because of the warmth of the pyroCb cloud, the rapid ascent rate of heated air, and the small size of the abundant water-condensation droplets (Rosenfeld et al., 2007). As a result, smoke particles in large pyroCb clouds are effectively delivered to the upper troposphere and lower stratosphere.

Unlike volcanic aerosols and wind-blown mineral dust, the black carbon (soot) content of smoke absorbs sunlight and warms the surrounding air, which can result in gradual rise in a process called "self-lofting." In nuclear-winter scenarios, convective ascent of smoke to the upper troposphere and lower stratosphere is followed by self-lofting to higher altitudes in the stratosphere where very low water content prevents condensation and particulate rain-out. Furthermore, the black carbon component of smoke is highly resistant to degradation by sunlight and can have a residence time of months to years in the stratosphere (Peterson et al., 2021).

The potential for smoke to enter the stratosphere and remain there for a long time is illustrated by recent studies of pyroCb clouds generated by large forest fires. PyroCb clouds during a 2017 forest fire in southern British Columbia injected, or delivered by lofting, an estimated 33–300 thousand metric tons (0.033–0.300 Tg) of smoke particles into the lower stratosphere (Yu et al., 2019; Fromm et al., 2021) where their presence was apparent for ~10 months as the smoke traveled around Earth (Torres et al., 2020). The enormous New Year fires in southeastern Australia (2019–2020) burned ~74,000 km^2 and produced 38 pyroCb events, leading to injection and self-lofting of 400–900 thousand tons (0.4–0.9 Tg) of smoke into the stratosphere (Khaykin et al., 2020; Peterson et al., 2021; Yu et al., 2021). The black-carbon fraction of smoke ascended to 35 km and was detectable for at least 15 months (Khaykin et al., 2020; Peterson et al., 2021).

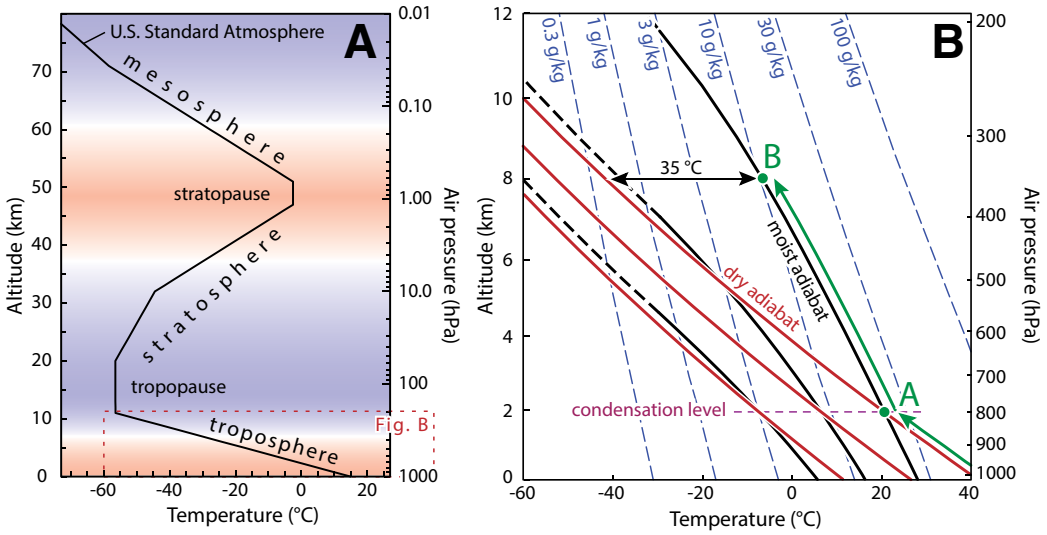

Figure 2. (A) Profile of atmospheric temperature as represented by the U.S. Standard Atmosphere. (B) Profile of three pairs of dry and moist adiabats in Earth's atmosphere intended to illustrate thermodynamic processes involved in exothermic condensation of ascending air masses. Each pair crosses a condensation level at 2 km altitude. The green arrow highlights the adjacent ascent path of a parcel of air rising from sea level to 2 km along a dry adiabat. The starting temperature of this ascent path (>40 °C) is unusually high for typical weather but low for air heated by fire. Humidity reaches 100% at the condensation level (point "A") and exothermic water condensation begins with further ascent. Ascent to 8 km (point "B") produces so much heat from water condensation that the temperature of the air parcel is 35 °C greater than it would have been if there had been no water condensation. Blue dashed lines represent water content of saturated air. In a skew-*T*/log-*P* diagram (*T*—temperature; *P*—pressure) used by weather forecasters to plot conditions during weather-balloon ascent, the entire diagram is sheared top-right so that the adiabatic ascent path is closer to vertical (Petty, 2008).

Evaluating the severity of nuclear winter following a major nuclear war between the United States and Russia is hampered by many unknowns and poorly constrained variables, including specifics of weapon targeting, number of targets hit during a war, flammability and fuel load of targeted areas, quantities and properties of resulting smoke, weather conditions, effectiveness of updrafts and self-lofting at delivering smoke to the stratosphere, and the fraction of black-carbon aerosol delivered. Weather conditions will affect fire intensity and pyroCb genesis while self-lofting by solar heating will be affected by the latitude and season.

Regardless of these numerous uncertainties, increasingly sophisticated numerical simulations of global atmospheric response to an all-out nuclear war have attempted to determine the possible duration and severity of a nuclear winter. The recent study by Coupe et al. (2019) modeled the consequences of direct injection of 150 million metric tons (150 Tg) of soot into the stratosphere above the United States and Russia during a time (15 May) of high and increasing northern-hemisphere insolation. Model results include an ~10-year period of soot residence in the stratosphere (Fig. 3A) and depressed temperatures at Earth's surface with a huge reduction in precipitation (Fig. 3B). Temperatures would be so depressed north of ~30° N latitude that crop failures would be widespread (if crops were even planted) (Fig. 3C).

One criticism of the relevance of this numerical simulation to real-world fires and nuclear winter is that black carbon is only a minor constituent of most fire smoke (estimated at ~12% for open-air burning [Bond et al., 2004]; and estimated at only 2%–2.5% for stratospheric smoke injection from two wildfires [Yu et al., 2019, 2021]). Smoke particles produced by burning vegetation and fossil-fuel combustion consist of complex carbonaceous compounds typically containing some hydrogen and oxygen (brown carbon). Black carbon, the most carbon-rich fraction, is the most resistant to degradation by sunlight and the most effective at absorbing sunlight and warming the air around it (Turco et al., 1990; Bond et al., 2013). Brown carbon can attract moisture, adhere to black carbon, and contribute to aggregation and settling of smoke particles and removal of soot from the stratosphere (Bond et al., 2013; Pausata et al., 2016), processes that were not modeled by Coupe et al. (2019). Smoke from burning cities would have compositional differences and could be substantially higher in black carbon than from forest fires, but 100% black carbon is unlikely if not impossible.

On the other hand, some aspects of the simulations may represent underestimates of potential environmental consequences. (1) Estimates for the mass of injected smoke used by Coupe et al. (2019) were originally made by the National Research Council (1985) before a 40% increase in U.S. population and associated construction of housing and other potentially flammable infrastructure over the past 37 years (see also Toon et al., 2008). (2) Numerical simulations with only 5 Tg of soot injected in the stratosphere suggest 20%–50% ozone depletion and resulting 30%–80% increased UV radiation at mid-latitudes, along with significant global cooling (Mills et al., 2014). (3) Abrupt, nuclear-explosion–triggered fires over large, roughly circular areas, and ascent of mushroom clouds and inward-flowing near-surface air, might be particularly effective at creating firestorms that loft large amounts of soot. (4) Rapidly growing Chinese housing and infrastructure materials add greatly to the fuel load for climate-modifying soot if China is targeted in a nuclear war (Toon et al., 2008).

Nuclear war and nuclear winter would leave a significant geologic record in areas affected by nuclear explosions. Destroyed cities and suburbs might be surrounded by dusty and nearly lifeless environments due

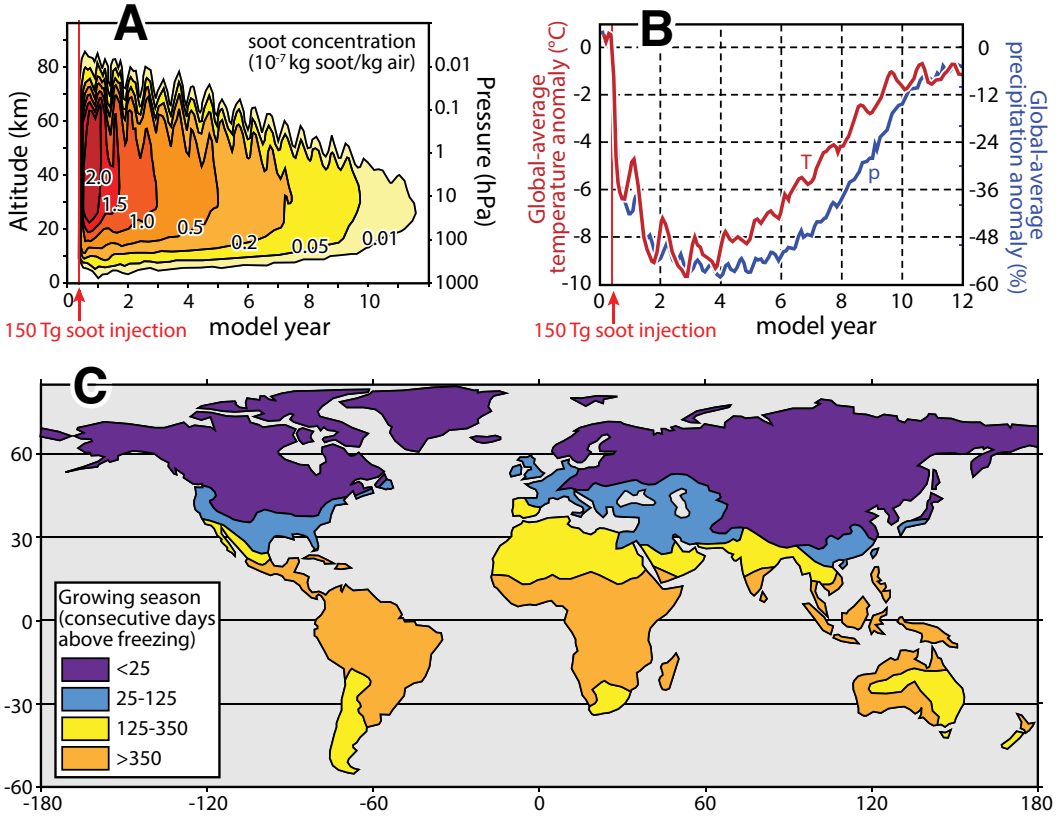

Figure 3. Simplified results from the numerical simulation of Coupe et al. (2019) showing the predicted consequences of injecting 150 million tons (150 Tg) of black-carbon aerosol (soot) into the stratosphere. (A) Soot concentration over time. hPa—hectoPascal. (B) Depression of global average temperature and precipitation due to solar radiation absorption above the troposphere. (C) Map showing approximate duration of growing season (without frost) following soot injection for the growing season in the year following soot injection.

to intermittent freezing over most of the year during a multiyear nuclear winter. Debris and other artifacts of civilization would be dispersed and buried by geologic processes, perhaps over decades before reconstruction and re-occupation. Materials most resistant to long-term environmental degradation would potentially add long-term economic value to a nuclear-war debris layer (Fig. 4). Some materials such as concrete and brick would have been melted on surfaces that faced a nearby nuclear detonation. Multiple such layers could be produced over future geologic time. The Anthropocene is thus a time when such disasters have become a potential contributor to the geologic record.

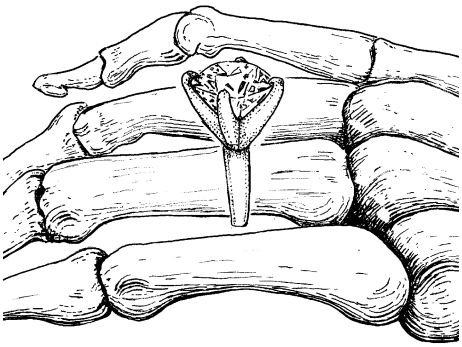

Figure 4. Index fossil for major nuclear war.

CONCLUSION

Designation of an Anthropocene time period is motivated partly by concern that ongoing human environmental modifications will leave a damaged planet to future generations (e.g., Steffen et al., 2007). Designation of the time period will highlight the fact that people are now agents of rapid environmental change and non-renewable resource destruction, and that we have a responsibility to minimize damage and destruction so that future generations can thrive. This is understandably difficult because so much of this environmental change is the result of activities that directly improve people's lives. Similarly, mutual assured destruction has restrained nuclear warfare between opposing world powers and contributes to ongoing peace among allied countries (Rauchhaus, 2009). Leaders and voting citizens in major nuclear-armed states, and in allied counties, also have a responsibility to ensure that these arsenals are never discharged in a manner that might precipitate a planet-wide catastrophe. Designation of an Anthropocene time period as beginning with atmospheric tests of thermonuclear weapons might help focus human minds on possibilities for reducing the threat of a major nuclear war. This is a reason to support the proposal of the Anthropocene Working Group for such a designation, although a reason not directly related to strictly geologic criteria.

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Registration and Information

Early registration deadline: 11:59 p.m. MDT on 6 Sept.

Cancelation deadline: 11:59 p.m. MDT on 12 Sept.

Take advantage of early registration prices and ensure your spot on field trips, short courses, and events by registering now at **community.geosociety.org/gsa2022/registration.**

STUDENT VOLUNTEERS

The Student Volunteer Program is now open. Help us out by volunteering to work at least ten hours at the meeting, and we'll help you out by covering the cost of your registration! See how the meeting works from the inside, and fill vital roles that help to make the meeting a success for everyone. Detailed information and sign-up links are online at **community.geosociety.org/gsa2022/registration/volunteers.**

STUDENT/EARLY CAREER PROFESSIONAL TRAVEL GRANTS

Various groups are offering grants to help defray your costs for registration, field trips, travel, etc. Check the website at **community.geosociety.org/gsa2022/connect/student-ecp/travel-grants** for application and deadline information. Note: Eligibility criteria and deadline dates may vary by grant. The deadline to apply for the GSA Student Travel Grant is 6 Sept.

EVENTS REQUIRING TICKETS/ADVANCE REGISTRATION

Several GSA Divisions and Associated Societies will hold breakfasts, lunches, receptions, and awards presentations that require a ticket and/or advance registration (see the meeting website for a complete list). Ticketed events are open to everyone, and tickets can be purchased in advance when you register. If you are not attending the meeting but would like to purchase a ticket to one of these events, please contact the GSA Meetings Department at meetings@geosociety.org.

EVENT SPACE REQUEST

The group alumni reception is back for 2022 and we hope to see many schools return. 1 Sept. is the LAST day to submit a request for event space and event listing at **community.geosociety.org/gsa2022/connect/events/plan.**

ACCOMMODATIONS & SERVICES

GSA strives to create a welcoming, inclusive, and professional experience for every attendee. Let us know in advance of the meeting if you have needs that require further attention. Most dietary considerations can be met without any extra charge. Be sure to provide your request when registering online. GSA will also have a **self-care room** and **nursing room** onsite.

CRITICAL HOUSING DATES

6 Sept.: The last day to cancel hotel rooms without a penalty.
14 Sept.: Room rates are guaranteed as long as there are rooms available in the GSA block.
29 Sept.: All changes, cancelations, and name substitutions must be finalized through Orchid.Events (OE).
After 29 Sept.: You must contact the hotel directly for all changes, cancelations, and new reservations.

Once you receive your hotel acknowledgement and have booked your travel, please review your hotel arrival/departure dates for accuracy. If you do not show up on the date of your scheduled arrival, the hotel will release your room and you will be charged for one night's room and tax. If you have travel delays and cannot arrive on your scheduled arrival date, please contact the hotel directly to make the hotel aware of your new arrival date.

ROOM SHARING/RIDE SHARING

Use the GSA Roommates & Rides board at **community.geosociety.org/gsa2022/travel/rooms-rides** to share housing, airport shuttles, and/or carpool. You can also use this service to meet up with your colleagues at the meeting.

HEALTH AND SAFETY

Learn more about how GSA Connects 2022 is making this meeting happen with health and safety as a top priority at **community.geosociety.org/gsa2022/information/health.**

Childcare by KiddieCorp

Location: Colorado Convention Center

Hours: Sun.–Wed., 7 a.m.–6 p.m. daily

Ages: Six months to 12 years

Cost: US$10 per hour per child for children 2 years or older and US$12 per hour per child for children under 2 with a 1-hour minimum per child. At least one parent must be registered for the meeting. This is a discounted rate as GSA subsidizes 85% of the total cost for this service to attendees.

Late pick-up fee: US$5 per child for every five minutes the parent is late.

More info: www.kiddiecorp.com/parents.html

Register securely at https://form.jotform.com/KiddieCorp/gsakids

Reserve Childcare in Advance: To ensure that the center is properly staffed and to facilitate planning of games and other activities for the children, advance registration is required. On-site registration may be possible, at a slightly higher cost, if space is available. The deadline for advance child-care registration is 9 September.

Cancelations: For a full refund, cancelations must be made to KiddieCorp prior to 9 September. Cancelations made after 9 September will incur a 50% fee. No refunds after 23 September.

About: KiddieCorp is a nationally recognized company that provides onsite children's activities for a comfortable, safe, and happy experience for both kids and parents. Childcare services are a contractual agreement between each individual and the childcare company. GSA assumes no responsibility for the services rendered.

Contact: KiddieCorp, +1-858-455-1718, info@kiddiecorp.com

Success in Publishing: Navigating the Process

Led by experienced GSA science editors (and GSA Distinguished Service Awardees) Rónadh Cox and Nancy Riggs, this workshop focuses on the bigger creative picture. Learn how to:

- frame and structure your work for publication,
- create well-thought-out figures and tables that communicate your ideas,
- write an attention-getting cover letter,
- choose the right journal for your work,
- and more!

Plus, hear from the experts on what constitutes a good review, how you would benefit from being a reviewer, and how it can advance your career toward an editorship.

This highly successful, free workshop for early career geoscientists on the process of preparing and publishing papers will be held in person for its tenth year during GSA Connects 2022. For more information and to receive email updates, go to **www.geosociety.org/GSA/ Publications/ GSA/Pubs/WritersResource.aspx.**

The Geological Society of America®
GEOCAREERS

Your Guide to Career Success

Envision your future career in the geosciences, and learn about how to make it a reality by attending these events.

GEOCAREERS DAY

(Sun., 9 Oct.)
Direct access to company representatives

- Career Workshop (9–10 a.m.)
- Company Information Booths (10 a.m.–noon)
- Mentoring Roundtables (10 a.m.–noon)
- Panel Luncheon (noon–1 p.m.)

GEOCAREERS CORNER

(Sun.–Tues., 9–11 Oct.)
Career Guidance and Information

- Women in Geology Program (Sun., 5:30–7 p.m.)
- Early Career Professional Coffee (Mon., 9–10 a.m.)
- Networking Event (Mon., 11:30 a.m.–1 p.m.)
- Geology Club Meet Up (Mon., 2–3 p.m.)
- Résumé Review Clinic (Sun.–Tues., 10 a.m.–3 p.m.)
- Drop-In Mentoring (Sun.–Tues., 10 a.m.–3 p.m.)
- Career presentations
- Post or view jobs

Go to **community.geosociety.org/gsa2022/connect/student-ecp/geocareers** for event details.

Share Your Story and Make a Difference

"I appreciated the many student mentorship opportunities and career panels aimed at demonstrating what diverse 'professional geology' career paths look like." —Past Mentor

- On To the Future Mentor
- Résumé/CV Mentor
- Drop-in Mentor
- GeoCareers Day Table Mentor
- Women in Geology Mentor
- Networking Event Mentor

Sign up to share your story and meet with students at **community.geosociety.org/gsa2022/connect/student-ecp/mentor.**

Noontime Lecture: Culture and Ethics of Geologic Sampling Town Hall

Marjorie A. Chan and **David Mogk**

Endorsed by the U.S. National Committee on Geological Sciences (USNC-GS); American Geosciences Institute (AGI); Mineralogical Society of America (MSA); International Association for Promoting Geoethics (IAPG).

Monday, 10 Oct., 12:15–1:15 p.m.

Come explore contemporary attitudes and practices of the geoscience community about sampling natural sites and review relevant policies and guidelines that already exist from related professional societies. This session builds on liaisons with American Geophysical Union (AGU) and their town hall on geological sampling at their 2021 fall meeting.

This GSA Connects 2022 interactive town hall will examine our current culture and ethics of geologic sampling, as well as guidelines and aspirations for the future. We will use this feedback to begin to formulate recommendations for a future GSA Position Statement and possible educational materials for the geoscience curriculum.

A. **Experiences,** levels of priorities/needs for samples. For example: What are the needs for in situ versus float, different types and quantities of samples? How should samples be collected (hammer vs. drill, etc.), and is remediation appropriate?
B. **Alternatives** to renewed or continuing sampling? Opportunities and multi-use purposes for samples, sample repositories, sample exchanges? For example: Can we re-purpose samples during times of COVID or cooperate with the U.S. Geological Survey National Geological and Geophysical Data Preservation Program? How should important/unique collections be saved and made available for new types of collaborative research?
C. **Archiving** and maintaining current sample collections. What is the long-term fate of legacy collections (can departments and museums assimilate samples)? For example: life after retirement or project completion? What are the lessons from state and federal agencies?
D. **Legal** and liability issues: permitting, permissions, licenses. What is legal may not be ethical. Who enforces guidelines (are they only aspirational)? How do sampling guidelines differ internationally and at specific sites?
E. **Culturally sensitive areas.** How do we respectfully propose research and gain permissions on indigenous lands or other sensitive areas? Identify best practices.
F. Should there be **limits** to sampling? Who reviews and enforces sampling guidelines? For example: Would it help to have some sort of institutional review board or a process for oversight, particularly for sensitive geoheritage sites?
G. **Impacts** and consequences of sampling (even if unintended), including tagging outcrops.

We welcome the input of geoscientists from diverse backgrounds and experiences and at all career stages, from interested students to experienced professionals. Responsible sampling is relevant to protecting exemplary sites, being respectful of indigenous cultures, and other societal issues. Sampling is a global issue related to geodiversity and geoconservation and is important to all geoscientists. Although a range of guidelines exists in various societies (e.g., Society of Vertebrate Paleontology, the Geological Society of London), GSA has yet to adopt any sampling guidelines. The goal of this town hall is to open up more communication and have community participation on this relevant topic that affects teaching, research, and our geoheritage.

Short Courses

Learn and explore a new topic. Build your skills.

Early registration deadline: 6 Sept. Early registration is highly recommended to ensure that courses will run.
Registration after 6 Sept. will cost an additional US$55.
Cancelation deadline: 12 Sept.

Can I take a short course if I am not registered for the meeting? YES! You're welcome to—just add the meeting nonregistrant fee (US$55) by 6 Sept. to your course enrollment cost. Should you then decide to attend the meeting, your payment will be applied toward meeting registration.

GSA K–12 teacher members: You are welcome to take short courses without registering for the meeting or paying the nonregistrant fee.

Continuing education units (CEUs): Most professional development courses and workshops offer CEUs. One CEU equals 10 hours of participation in an organized continuing education experience under responsible sponsorship, capable direction, and qualified instruction.

See **https://community.geosociety.org/gsa2022/program/short** or contact Jennifer Nocerino, jnocerino@geosociety.org, for course abstracts and additional information.

ONLINE COURSES

501. **NSF Graduate Research Fellowship Program (GRFP) Proposal Preparation Course.** Mon., 26 Sept., 8 a.m.–noon MDT. US$20. Limit: 30. CEU: 0.4. **Instructors:** Kristina Butler, University of Texas at Austin; Sarah George, University of Arizona. **Course Endorser:** *GSA Geoscience Education Division.*

502. **Climate Adaptation Planning for Emergency Management.** Tues., 27 Sept., 10 a.m.–2 p.m. MDT *and* Wed., 28 Sept., 10 a.m.–2 p.m. MDT. FREE. Limit: 50. CEU: 0.8. **Instructors:** Jeff Rubin, semi-retired emergency manager; Monica Gowan, independent consultant. **Course Endorsers:** *GSA Geology and Health Division; GSA Geology and Society Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; National Disaster Preparedness Training Center (NDPTC) at the University of Hawai'i; Federal Emergency Management Agency (FEMA).*

503. **Resistivity Surveying: Getting the Best and Making the Most from Electrical Resistivity Tomography and Induced Polarization Data.** Thurs., 29 Sept., 8 a.m.–noon MDT. US$40. Limit: 50. CEU: 0.4. **Instructors:** Morgan Sander-Olhoeft, Guideline Geo Americas Inc.; Harry Higgs, Guideline Geo Americas Inc. **Course Endorser:** *Guideline Geo.*

504. **Introduction to Geostatistical Modeling of Geochemical Data.** Thurs., 29 Sept., 8 a.m.–noon MDT *and* Fri., 30 Sept., 8 a.m.–noon MDT. US$50 professionals; US$25 students. Limit: 50. CEU: 0.8. **Instructors:** Abani Samal, GeoGlobal LLC; Sankar Sasidharan, Harte Research Institute.

505. **How to Create Your Own 3D Videogame-Style Geologic Field Trip and Host it Online: Accessible, Immersive Data Visualization for Education and Research.** Fri., 30 Sept., 9:30 a.m.–5 p.m. MDT. US$40. Limit: 40. CEU: 0.7. **Instructors:** Mattathias (Max) Needle, University of Washington; John Akers, University of Washington; Juliet Crider, University of Washington. **Course Endorser:** *GSA Structural Geology and Tectonics Division.*

FRIDAY COURSES

506. **Geological Modeling and Uncertainties Using Multiple Point Statistics.** Fri., 7 Oct., 8 a.m.–5 p.m. US$115. Limit: 20. CEU: 0.8. **Instructors:** Mats Lundh Gulbrandsen, I-GIS; Tom Martlev Pallesen, I-GIS. **Course Endorser:** *I-GIS.*

507. **Exploring Surface Processes with the CSDMS Workbench: Building Coupled Models.** Fri., 7 Oct., 9 a.m.–5 p.m. US$60. Limit: 40. CEU: 0.8. **Instructors:** Mark Piper, University of Colorado Boulder; Benjamin Campforts, University of Colorado Boulder. **Course Endorser:** CSDMS@HydroShare.

508. **Multiphysics Modeling for the Geosciences.** Fri., 7 Oct., 8 a.m.–5 p.m. US$160. Limit: 30. CEU: 0.8. **Instructors:** Susan Sakimoto, Space Science Institute; Heidi Haviland, NASA Marshall Space Flight Center. **Course Endorsers:** *GSA Planetary Geology Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; COMSOL Inc.*

509. **Methods and Geological Applications in Geo-Thermo-Petro-Chronology I.** Fri., 7 Oct., 9 a.m.–5 p.m. US$40. Limit: 50. CEU: 0.7. **Instructors:** Sarah George, University of Arizona; George Gehrels, University of Arizona; Kurt Sundell, Idaho State

INDUSTRY TRACKS

GSA's program offers short courses relevant to applied geoscientists.
Look for these icons, which identify sessions in the following areas:

Economic Geology | **Energy** | **Engineering** | **Hydrogeology and Environmental Geology**

University; Mauricio Ibanez, University of Arizona; Kendra Murray, Idaho State University; Allen Schaen, University of Arizona.

FRIDAY–SATURDAY COURSES

510. **Field Safety Leadership.** Fri.–Sat., 7–8 Oct., 8 a.m.–5 p.m. US$45 professionals; US$25 students. Limit: 24. CEU: 1.6. **Instructors:** Kevin Bohacs, ExxonMobil (retired); Kurt Burmeister, California State University, Sacramento; Greer Barriault, ExxonMobil Technology and Engineering Company. **Course Endorser:** *ExxonMobil Technology and Engineering Company.*

511. **Teaching SfM and GNSS Methods to Undergraduates in the Field.** Fri.–Sat., 7–8 Oct., 8 a.m.–5 p.m. US$40. Limit: 30. CEU: 1.6. **Instructors:** Beth Pratt-Sitaula, UNAVCO; Benjamin Crosby, Idaho State University; Bruce Douglas, Indiana University; Christopher Crosby, UNAVCO. **Course Endorsers:** *GEodesy Tools for Societal Issues (GETSI) Field Project; UNAVCO; National Association of Geoscience Teachers (NAGT); OpenTopography.*

512. **Sequence Stratigraphy for Graduate Students.** Fri.–Sat., 7–8 Oct., 8 a.m.–5 p.m. US$25 (those who complete the course will receive three free GSA ebooks of their choice—a US$25 value). Limit: 55. CEU: 1.6. **Instructors:** Morgan Sullivan, Chevron Energy Technology Company; Bret Dixon, Tall City Exploration. **Course Endorser:** *Chevron Energy Technology Company.*

513. **Introduction to the Paleobiology Database.** Fri.–Sat., 7–8 Oct., 8 a.m.–5 p.m. US$100 professionals; free for students. Limit: 100. CEU: 1.6. **Instructor:** Mark D. Uhen, George Mason University. **Course Endorsers:** *Society of Vertebrate Paleontology; Paleontological Society.*

514. **Improve Your Computational Petrology Skills: Designing and Executing a Computational Petrology Research Project and an Introduction to the Magma Chamber Simulator.** Fri., 7 Oct., 1–5 p.m. *and* Sat., 8 Oct., 8 a.m.–5 p.m. US$163. Limit: 40. CEU: 1.2. **Instructors:** Wendy Bohrson, Colorado School of Mines; Frank Spera, University of California Santa Barbara; Valerie Strasser, Colorado School of Mines; Monike Distefano, Colorado School of Mines; Paula Antoshechkina, Caltech. **Course Endorsers:** *GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Planetary Geology Division; GSA Geophysics and Geodynamics Division.*

SATURDAY COURSES

515. **Machine Learning for Small, Uncertain, and Sparse Datasets.** Sat., 8 Oct., 8 a.m.–5 p.m. US$116. Limit: 40. CEU: 0.8. **Instructors:** Velimir Vesselinov, Los Alamos National Laboratory; Bulbul Ahmmed, Los Alamos National Laboratory. **Course Endorsers:** *Computational Earth Science Group; Los Alamos National Laboratory.*

516. **Digital Petrography: Bringing Petrologic Imaging into the Modern Era with Automation, Robotics, Image Analysis, and AI.** Sat., 8 Oct., 8 a.m.–5 p.m. US$60. Limit: 40. CEU: 0.8. **Instructors:** Matthew Andrew, Carl Zeiss X-ray Microscopy; Kitty Milliken, The University of Texas; Brice Lacroix, University of Kansas; Mingyue Yu, University of Illinois. **Course Endorser:** *Carl Zeiss X-ray Microscopy.*

517. **Foundations in the Design and Teaching of Geoscience Courses Using Active Learning Strategies.** Sat., 8 Oct., 8 a.m.–5 p.m. US$25 (Those who complete the course will receive three free GSA ebooks of their choice—a $25 value). Limit: 40. CEU: 0.8. **Instructors:** Leilani Arthurs, University of Colorado Boulder; Chu-Lin Cheng, University of Texas Rio Grande Valley; Ming-Tsan Lu, University of Texas Rio Grande Valley; Patrick Shabram, Front Range Community College.

518. **Introduction to Drones (sUAS) in the Geosciences.** Sat., 8 Oct., 8 a.m.–5 p.m. US$126. Limit: 40. CEU: 0.8. **Instructor:** Gregory Baker, Colorado Mesa University. **Course Endorsers:** *GSA Hydrogeology Division; GSA Geoarchaeology Division; GSA Quaternary Geology and Geomorphology Division; GeoAvatar LLC.*

519. **Three-Dimensional Geological Mapping and Modeling.** Sat., 8 Oct., 8 a.m.–5 p.m. US$106. Limit: 60. CEU: 0.8. **Instructors:** Richard Berg, Illinois State Geological Survey; Harvey Thorleifson, Minnesota Geological Survey; Kelsey MacCormack, Alberta Geological Survey.

520. **On To the Future Professional Development Workshop: Looking Forward to a Career in Geosciences.** Sat., 8 Oct., 8 a.m.–5 p.m. By invitation only to On To the Future participants and alumni; workshop fee for invitees will be provided from NSF #1801569. Limit: 150. CEU: 0.8. **Instructors:** Stephen Boss, University of Arkansas; Kathy Ellins, University of Texas (retired); Susan Eriksson, Eriksson Associates. **Course Endorser:** *National Science Foundation (Award #1801569).*

521. **Talking Science: A Communicating Science Workshop.** Sat., 8 Oct., 8 a.m.–5 p.m. US$30 professionals; US$15 students. Limit: 40. CEU: 0.8. **Instructor:** Steven Jaret, American Museum of Natural History. **Course Endorsers:** *GSA Planetary Geology Division; National Science Foundation Integrated Earth Science project EAR-1814051.*

522. **Ground-Penetrating Radar—Principles, Practice, and Processing.** Sat., 8 Oct., 8 a.m.–5 p.m. US$95 professionals; US$50 students. Limit: 25. CEU: 0.8. **Instructor:** Greg Johnston, Sensors & Software Inc. **Course Endorser:** *Sensors & Software Inc.*

523. **AGeS Geochronology Workshop.** Sat., 8 Oct., 8 a.m.–5 p.m. US$40. Limit: 100. CEU: 0.8. **Instructors:** Rebecca Flowers, University of Colorado Boulder; Ramon Arrowsmith, Arizona State University; James Metcalf, University of Colorado Boulder. **Course Endorser:** *GSA Geochronology Division.*

524. **Hydrogeological Layered Modeling—Use of Data, How to Build, and How to Use Output for Informed Decision Making.** Sat., 8 Oct., 8 a.m.–5 p.m. US$115. Limit: 20. CEU: 0.8. **Instructor:** Tom Martlev Pallesen, I-GIS. **Course Endorser:** *I-GIS.*

525. **Introduction to Planetary Image Analysis with ArcGIS.** Sat., 8 Oct., 8 a.m.–5 p.m. US$40. Limit: 40. CEU: 0.8. **Instructor:** Zoe Learner Ponterio, Cornell University. **Course Endorsers:** *Spacecraft Planetary Image Facility; Cornell University.*

526. **Applying Virtual Microscopy to Geoscience.** Sat., 8 Oct., 8 a.m.–5 p.m. US$100 professionals; US$50 students. Limit: 25. CEU: 0.8. **Instructors:** Christopher Prince, PetroArc International; Suzanne Kairo, Indiana University. **Course Endorser:** *PetroArc International.*

527. **Volcanic Crisis Awareness.** Sat., 8 Oct., 8 a.m.–5 p.m. FREE. Limit: 40. CEU: 0.8. **Instructors:** Jeff Rubin, semi-retired emergency manager; Monica Gowan, independent consultant. **Course Endorsers:** *GSA Geology and Health Division; GSA Geology and Society Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; National Disaster Preparedness Training Center (NDPTC) at the University of Hawai'i; Federal Emergency Management Agency (FEMA).*

528. **Head, Shoulders, Knees, and Toes: Medical Geology Fundamentals.** Sat., 8 Oct., 8 a.m.–5 p.m. US$84. Limit: 40. CEU: 0.8. **Instructors:** Laura Ruhl, University of Arkansas at Little Rock; Robert Finkelman, University of Texas at Dallas; Reto Gieré, University of Pennsylvania; Malcolm Siegel, University of New Mexico. **Course Endorsers:** *GSA Geology and Health Division; International Medical Geology Association.*

529. **Quantitative Analysis, Visualization, and Modeling of Detrital Geochronology Data.** Sat., 8 Oct., 8 a.m.–5 p.m. US$75 professionals; US$50 students. Limit: 40. CEU: 0.8. **Instructors:** Joel Saylor, University of British Columbia; Kurt Sundell, Idaho State University; Glenn Sharman, University of Arkansas.

530. **Cave and Karst Research on Federal Lands.** Sat., 8 Oct., 8 a.m.–5 p.m. US$75. Limit: 40. CEU: 0.8. **Instructors:** Patricia Seiser, National Park Service; Limaris Soto, U.S. Forest Service; Kyle Rybacki, Bureau of Land Management. **Course Endorsers:** *National Cave and Karst Research Institute; National Park Service; U.S. Forest Service; Bureau of Land Management.*

531. **Using the StraboSpot and StraboMicro Data Systems for Geology.** Sat., 8 Oct., 8 a.m.–5 p.m. US$25. Limit: 40. CEU: 0.8. **Instructors:** Doug Walker, University of Kansas; Julie Newman, Texas A&M University. **Course Endorsers:** *GSA Structural Geology and Tectonics Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Geoinformatics and Data Science Division.*

532. **Methods and Geological Applications in Geo-Thermo-Petro-Chronology II.** Sat., 8 Oct., 9 a.m.–5 p.m. US$40. Limit: 50. CEU: 0.7. **Instructors:** Sarah George, University of Arizona; George Gehrels, University of Arizona; Kurt Sundell, Idaho State University; Mauricio Ibanez, University of Arizona; Kendra Murray, Idaho State University; Allen Schaen, University of Arizona.

536. **Advances in Applications of Laser Ablation to the Geosciences.** Sat., 8 Oct., 8 a.m.–5 p.m. US$132. Limit: 40. CEU: 0.8. Instructors: Ian Ridley, U.S. Geological Survey; Michael Pribil, U.S. Geological Survey; Alan Koenig, Newmont Mining Co.; Jay Thompson, U.S. Geological Survey.

HALF-DAY SATURDAY COURSES

533. **Inclusive Educational Outreach with NASA SCoPE.** Sat., 8 Oct., 8 a.m.–noon. US$25. Limit: 40. CEU: 0.4. **Instructors:** Jessica Swann, Arizona State University; David Williams, Arizona State University. **Course Endorsers:** *National Aeronautics and Space Administration; Arizona State University.*

534. **Improv to Improve the Geoscience Community.** Sat., 8 Oct., 1–5 p.m. US$20. Limit: 20. CEU: 0.4. **Instructor:** Erik Haroldson, Austin Peay State University. **Course Endorsers:** *Austin Peay State University College of STEM; National Association of Geoscience Teachers (NAGT); National Association of Geoscience Teachers (NAGT) Teacher Education Division (TED).*

535. **Using Geophysics to Address Societally Relevant, Urban and Environmental Real-World Questions in Introductory-Level Geoscience Courses.** Sat., 8 Oct., 1–5 p.m. US$10. Limit: 40. CEU: 0.4. **Instructors:** John Taber, Incorporated Research Institutions for Seismology (IRIS); Andrew Parsekian, University of Wyoming; Sarah Kruse, University of South Florida; Carol Ormand, Carleton College.

Scientific Field Trips

401. **Black Hills and Badlands: A Synopsis of Geological Time.** Thurs.–Sat., 6–8 Oct. US$681. Endorser: *Edmunds Central School District*. Leader: Spencer Cody, Edmunds Central School District.

402. **PC² = PreCambrian Colorado: The Role of the Mesoproterozoic Picuris Orogeny in Colorado.** Fri.–Sat., 7–8 Oct. US$350. Endorsers: *GSA Structural Geology and Tectonics Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; Colorado Scientific Society (CSS); Denver Regional Exploration Geologists' Society (DREGS); Escalante Resources Group*. Leaders: Ruth F. Aronoff, Furman University; Yvette Kuiper; Christopher G. Daniel.

403. **PC² = PreCambrian Colorado: Geology and Economic Geology of the Colorado Central Front Range; Field Observations and Perspectives Bearing on the Growth and Metallogeny of the North American Craton.** Fri.–Sat., 7–8 Oct. US$670. Endorsers: *Colorado Scientific Society Denver Regional Exploration Geologists' Society; Escalante Resources Group*. Leaders: Lisa Fisher, Colorado Scientific Society; Lewis Kleinhans.

404. **A Bike Tour: Geology, Geochronology, and Geochemistry of the Table Mountain Shoshonite, Golden, Colorado.** Sat., 8 Oct. US$194. Endorsers: *GSA Geochronology Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division*. Leaders: Leah Morgan, Geology, Geophysics, and Geochemistry Science Center; Alexie Millikin.

405. **Dinosaur Tracks and Microbial MAT in Photogrammetric 3D Relief: The Classic Trace Fossils of the Dinosaur Ridge Area.** Sat., 8 Oct. US$205. Endorser: *Dinosaur Ridge*. Leaders: Martin Lockley, Dinosaur Trackers Research Group; Nora Noffke; Brent Breithaupt.

406. **World-Class Geologic Heritage Sites of the Metropolitan Denver, Colorado, Area (pre-meeting).** Sat., 8 Oct. US$128. Endorsers: *Colorado Scientific Society; GSA Geology and Society Division*. Leader: Tim Connors.

407. **Accessible Tour of Colorado Geoscience for Students & Faculty.** Sat., 8 Oct. US$148. Endorser: *UNAVCO-NSF GAGE*. Leaders: Anika Knight, UNAVCO; Kelsey Russo-Nixon.

408. **Mountain Highs and Valley Lows: An Accessible Introduction to the Geology of the Pikes Peak Area.** Wed.–Thurs., 12–13 Oct. Apply at https://theiagd.org/2022-gsa-field-trip-geology-of-pikes-peak/. Endorser: *International Association for Geoscience Diversity (IAGD)*. Leaders: Anita Marshall, University of Florida; Christine Siddoway; Michele Cooke; Nancy R. Riggs; Chris Atchison.

409. **PC² = PreCambrian Colorado: Peraluminous Gold Deposits Emplaced above a 1.75 Ga Flat Subduction Zone in South-Central Colorado.** Wed.–Thurs., 12–13 Oct. US$470. Endorsers: *PC2 = Precambrian Colorado; Denver Region Exploration Geologists' Society (DREGS); Colorado Scientific Society (CSS); MagmaChem Research Institute; Escalante Resources Group*. Leaders: Monte Swan, MagmaChem Research Institute; Lewis Kleinhans; Stanley B. Keith.

410. **PC² = PreCambrian Colorado: Paleoproterozoic Tectonics of the Northern Colorado Front Range.** Thurs., 13 Oct. US$120. Endorsers: *GSA Structural Geology and Tectonics Division; The Colorado Scientific Society (CSS); Denver Regional Exploration Geologists' Society (DREGS); Escalante Resources Group*. Leaders: Graham Baird, University of Northern Colorado; Timothy Grover, Kevin H. Mahan.

411. **World-Class Geologic Heritage Sites of the Metropolitan Denver, Colorado, Area (post-meeting).** Thurs., 13 Oct. US$128. Endorsers: *Colorado Scientific Society; GSA Geology and Society Division*. Leader: Tim Connors.

412. **Exploring Morrison: Jurassic Morrison Formation at Dinosaur Ridge and Beyond.** Thurs.–Fri., 13–14 Oct. US$396. Leaders: Matthew Mossbrucker, Morrison Natural History Museum; Erin Rose LaCount, Dinosaur Ridge; Robert Bakker, Paul Murphey.

INDUSTRY TRACKS

GSA's program offers field trips relevant to applied geoscientists. Look for these icons, which identify trips in the following areas:

Economic Geology | **Energy** | **Engineering** | **Hydrogeology and Environmental Geology**

Geoheritage: Progress toward Preservation

Renee M. Clary, *Dept. of Geosciences, Mississippi State University, Mississippi State, Mississippi 39762-5448, USA, RClary@geosci.msstate.edu;* ***William Andrews,*** *Kentucky Geological Survey, University of Kentucky, Lexington, Kentucky 40506-0107, USA, WAndrews@uky.edu;* ***Tim Connors,*** *National Park Service, Geologic Resources Division, Denver, Colorado 80225, USA, Tim_Connors@nps.gov*

Geoheritage sites exemplify the connections between geology and our history and culture. These connections may be illustrated through landscapes, dramatic natural features, natural resources, or geohazards. These sites range in scale from individual local outcrops through state parks and national monuments to international geoparks, and the sites are managed by a wide array of agencies and entities. The common theme coursing through these sites is *geoconservation*; Geoheritage seeks to protect sites for future scientific research, promote sustainable development through geotourism, and foster public geoliteracy via educational outreach in both formal K–16 and informal education (Andrews and Clary, 2021).

At GSA Connects 2021, an enthusiastic group convened both virtually and on site in Portland, Oregon, USA, to celebrate Geoheritage and empower one another to recognize, conserve, and sustain the landscapes that impact our lives. In our 2021 Pardee Keynote Symposium, we explored Geoheritage life cycles, resources, tools, and networks; thoughtfully considered how Geoheritage efforts must include multiple voices and develop community and respect through compromise; and investigated how best to incorporate Geoheritage in science education and outreach. We highlighted volunteered videos and vignettes that featured participants' favorite Geoheritage sites. Our discussion will continue at GSA Connects 2022 in Denver, Colorado, USA, with a new Pardee Keynote Symposium: P1 Geoheritage: Connecting Our Stories to Earth's History.

GEOHERITAGE RESOURCES FOR CLASSROOM, ADVOCACY, AND ENJOYMENT

The assembled resources from our 2021 Pardee Geoheritage session endure: The Geological Society of America reposited volunteered videos, a composite StoryMap©, and other Geoheritage links and files on our Pardee website (www.geosociety.org/geoheritage), ensuring that Geoheritage source materials are consolidated and freely available for K–16 education, outreach, and personal enrichment (Fig. 1). We aligned the eight volunteered videos and featured StoryMap© to the Next Generation Science Standards (NGSS, NGSS Lead States 2013), specifically the Earth and Space Science (ESS) Disciplinary Core Ideas (DCIs), from which K–12 educators can identify Performance Expectations, Science and Engineering Practices, and Crosscutting Concepts appropriate to their grade level and curriculum. Table S1[1] provides selected examples of how educators may use these Geoheritage resources in K–16 classrooms; many videos and StoryMaps© also align with other science content, including physical science and life science. Video and StoryMap© resources additionally address Common Core State Standards in English Language Arts (ELA)/Literacy and Mathematics. In Table S1 (see footnote 1), we suggest lesson plans that are freely available on the Teach the Earth website (https://serc.carleton.edu/teachearth), housed within the Science Education Resource Center at Carlton College. Teachers can locate additional teaching resources, available for free or minimal charge, on the National Science Teaching Association (NSTA) website (www.nsta.org/), such as "Using Big Data to Understand the History of Planet Earth" (www.nsta.org/science-scope/science-scope-julyaugust-2021-0/using-big-data-understand-history-planet-earth).

Figure 1. Geoheritage resources assembled from the 2021 Pardee session include StoryMaps©, Geoheritage videos, and links to relevant proceedings, webpages, and position statements. The QR code provides easy access to the website.

CONTRIBUTE YOUR GEOHERITAGE!

With California, Texas, Illinois, and Maine represented in the collections, the 2021 Pardee Geoheritage videos and composite StoryMap© represent the United States "from sea to shining sea" (Fig. 2). Our video and StoryMap© collection is only beginning, though, and we seek additional volunteered videos of local, state, regional, and international sites. Do you want your favorite Geoheritage site featured at GSA Connects 2022 and available on the Geoheritage website for educators, geoscientists, and the interested public? Please register your interest by **16 September 2022** by accessing the form with the QR code (Fig. 2, https://forms.gle/1gj3W1UAkA7nqxkKA). We will provide guidelines on how to record and submit a 3–5-minute mp4 video in landscape format that can be included on our website. The second Geoscientists' Choice Geoheritage Video Award winner will be named in Denver. If you have any questions, please contact us.

GSA Today, v. 32, no. 8, https://doi.org/10.1130/GSATGeoH-v32.1.

[1]Supplemental Material. Table S1. Geoheritage videos and StoryMaps©, aligned to the Next Generation Science Standards (NGSS) Earth and Space Science (ESS) Disciplinary Core Ideas, with suggested free resources from SERC Carlton Teach the Earth Collection. Go to https://doi.org/10.1130/GSAT.S.20010227 to access the supplemental material; contact editing@geosociety.org with any questions.

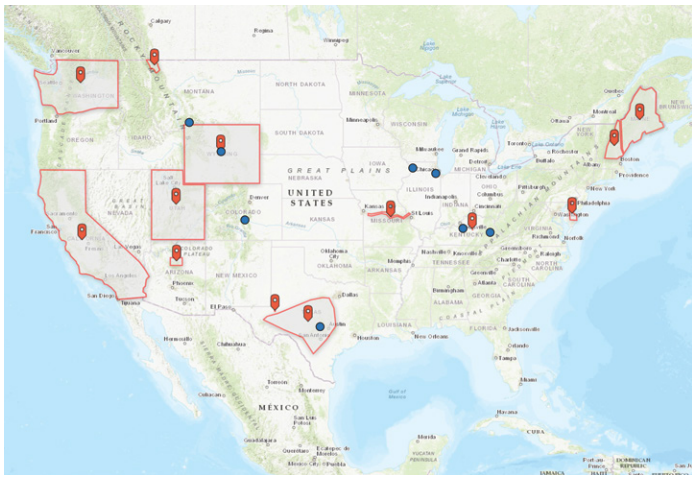


Figure 2. Use the QR code to express your interest in contributing to videos or StoryMap© for GSA Connects 2022.

EXTENDING GEOHERITAGE IN 2022 AS NATURE'S NARRATIVE

At GSA Connects 2022, our Geoheritage Pardee will further the discussion and seek input for processes and procedures to acknowledge and conserve the geodiversity of our planet. Join us as we discuss criteria for identifying Geoheritage sites at different scales—international, national, state, and local—and how these criteria fit within current initiatives of the International Union of Geological Sciences, the National Park Service, the U.S. Geological Survey, and the state geological surveys. We will investigate national priorities for labeling a site as a U.S. Geoheritage site and if these methods differ from international methodologies. Our Geoheritage Pardee will fundamentally address *whose* heritage we seek to showcase, and how we should honor and preserve sacred spaces while increasing inclusivity and accessibility through Geoheritage. Join the conversation to discuss the academic considerations in research and education for Geoheritage and what metadata and tools are required to communicate Geoheritage to a broad audience and increase accessibility in K–12, undergraduate, and informal community education. Our interactive town hall requests your feedback on Geoheritage initiatives as we encourage audience participation to share best practices and brainstorm ideas for increasing the visibility of Geoheritage sites and initiating Geoheritage efforts in our professions and community.

Figure 3. GSA Connects 2022 provides an opportunity to experience Geoheritage in the Denver area, including Red Rocks—either before or after the meeting—with Tim Connors, National Park Service. Photo credit: Bigmacthealmanac, CC-BY-SA 4.0 <https://creativecommons.org/licenses/by-sa/4.0>, via Wikimedia Commons.

GSA attendees have an option to experience the Geoheritage in the Denver area, either before or after the conference (Fig. 3). Tim Connors of the National Park Service will lead two identical field excursions (406, 411) for GSA attendees to experience world-class sites, including Morrison-Golden Fossil Areas National Natural Landmarks (e.g., Dinosaur Ridge and Fossil Trace), Red Rocks Park, the type section of the Jurassic Morrison Formation, Table Mountain lava flows, and the Uranium roll front. Join one of our excursions to investigate the Precambrian through the Cenozoic in a globally recognized Geoheritage landscape.

SUMMARY

The concept of Geoheritage encompasses a growing and enthusiastic geoscience community of practice dedicated to identifying, understanding, and communicating the critical geosites with connections to our diverse cultures and heritages. Please join us, either in person, online, or through volunteered contributions to our resource page, as we continue to make progress toward preserving and interpreting these incredible and critical places.

REFERENCES CITED

Andrews, W., and Clary, R.M., 2021, Geoheritage: Geology *of* the community, *for* the community, *by* the community: GSA Today, v. 31, no. 8, p. 16–17.

Carlton College Science Education Resource Center (SERC), n.d., Teach the Earth: https://serc.carleton.edu/teachearth/index.html (accessed 6 June 2022).

NGSS Lead States, 2013, Next Generation Science Standards: For States, By States: Washington, D.C., The National Academies Press, 533 p.

The Geological Society of America®

GEOCAREERS

Mentoring Tomorrow's Geoscience Leaders at the 2022 Section Meetings

The Geological Society of America (GSA) GeoCareers Program provides mentoring and career pathway events at all meetings. At Section Meetings, students are invited to participate in the Roy J. Shlemon Mentor Program in Applied Geology and the John Mann Mentors in Applied Hydrogeology Program. These popular events, supported by the GSA Foundation through gifts from Roy J. Shlemon and John Mann, are designed to extend the mentoring reach of individual professionals. Together, mentor volunteers and students meet in a relaxing, informal setting to discuss careers in geology.

In 2022, there were Shlemon and Mann Programs and Career Exploration Workshops at each of the four Section Meetings. There were 213 students and 29 mentors who participated in the Shlemon Program; 115 students and 21 mentors attended the Mann Program; and 74 students and 13 mentors for the Career Exploration Workshop. As a result of these events, new friendships were made, and professional contacts were established that will last well into the future. Additionally, both mentors and students left the events expressing feelings of personal and professional growth.

Students said:

"The student mentor luncheons were both amazing and very informative. I had a great experience. Thank you!!"

"Being able to pick at the mentors' brains and ask as many questions as I could was one of the most valuable experiences to have right before graduation."

Mentors said:

"As a professional, I appreciated the many student mentorship opportunities and career panels aimed at demonstrating what diverse 'professional geology' career paths look like."

GSA gratefully acknowledges the following mentors for their individual gifts of time and for sharing their insight with students. To learn more about these programs, or to be a mentor at a future Section Meeting, please contact Jennifer Nocerino, jnocerino@geosociety.org.

THE ROY J. SHLEMON MENTOR PROGRAM IN APPLIED GEOLOGY

Helping Mentor Students Since 1996

SOUTH-CENTRAL SECTION
Susan Eriksson, Eriksson Associates
Will Ernst, National Association of State Boards of Geology

CORDILLERAN–ROCKY MOUNTAIN SECTIONS
Mairin Balisi, La Brea Tar Pits and Museum
Katharine Dahm, U.S. Geological Survey
Carla Eichler, Oklahoma Geological Survey
Rebecca Finger-Higgens, U.S. Geological Survey
Randall Irmis, Natural History Museum of Utah
Lily Jackson, University of Wyoming
Dallin Laycock, ConocoPhillips Canada
Martin Messmer, Department of the Interior
Jessica Preston, Republic Services
William Schenck, Association of State Boards of Geology
Eugene Szymanski, Utah Geological Survey

NORTHEASTERN SECTION
Erika Amir-Lin, Weston & Sampson
Drew Andrews, Kentucky Geological Survey
Aaron Bierly, DCNR: Bureau of Geological Survey
Teresa Bowers, Gradient
David Crotsley, HDR Engineering Inc.
Mary DiGiacomo-Cohen, U.S. Geological Survey
Morgan Disbrow-Monz, Geological Society of America
Will Ernst, Association of State Boards of Geology
Samantha Stenson, Leidos

NORTH-CENTRAL–SOUTHEASTERN SECTIONS
Kenneth Czoer, Applied Science and Engineering LLC
Erika Danielsen, Ohio Geological Survey
Morgan Disbrow-Monz, Geological Society of America
Grant Elliott, Groff Engineering
Erik Haroldson, Austin Peay State University
Arthur Merschat, U.S. Geological Survey
Jeff Oslund, Anadarko (retired)

THE JOHN MANN MENTORS IN APPLIED HYDROGEOLOGY PROGRAM

Helping Mentor Students Since 2004

SOUTH-CENTRAL SECTION
Randall Hanson, One-Water Hydrologic
Jack Sharp, Consulting Professional Hydrogeologist

CORDILLERAN–ROCKY MOUNTAIN SECTIONS
Snir Attia, New Mexico Bureau of Geology and Mineral Resources
Colin Chupik, Bureau of Reclamation
Mike Darin, University of Nevada–Reno
Daniel Koning, New Mexico Bureau of Geology and Mineral Resources
Dan Larsen, University of Memphis
Stephanie Mills, Utah Geological Survey
William Schenck, Association of State Boards of Geology

NORTHEASTERN SECTION
Erika Amir-Lin, Weston & Sampson
Amber Boyd, Geo-Technology Associates
Margaret Dunkelberger, ECS Limited
William Schenck, Association of State Boards of Geology
Scott Stanford, New Jersey Geological and Water Survey
Stephen Urbanik, New Jersey Department of Environmental Protection

NORTH-CENTRAL–SOUTHEASTERN SECTIONS
Randy Blood, DRB Geological Consulting
Mark Carter, U.S. Geological Survey
Robert Denton Jr., Terracon
Lee Florea, Washington Geological Survey
Craig Nelson, Ohio Geological Survey
Blair Tormey, Western Carolina University

GEOSCIENCE CAREER EXPLORATION WORKSHOP

Helping Mentor Students Since 2014

SOUTH-CENTRAL SECTION
Will Ernst, National Association of State Boards of Geology
Elizabeth Petsios, Baylor University

CORDILLERAN–ROCKY MOUNTAIN SECTIONS
Mairin Balisi, La Brea Tar Pits and Museum
Lily Jackson, University of Wyoming
Jessica Preston, Republic Services
Sandy Schenck, Association of State Boards of Geology

NORTHEASTERN SECTION
Vincent Carbone, HDR
Will Ernst, National Association of State Boards of Geology
Allie Nagurney, Virginia Tech
William Odom, U.S. Geological Survey

NORTH-CENTRAL–SOUTHEASTERN SECTIONS
Lee Florea, Washington Geological Survey
Erik Haroldson, Austin Peay State University
Daphanee Waters, Applied Science and Engineering LLC

Incorporating New Media into Geoscience Communication

Emily Zawacki

As a creative outlet throughout much of my undergraduate and graduate studies, I spent a lot of my free time making educational geology content on sites like Tumblr and YouTube. Whether a blog post on an awesome feature I got to see on a class field trip or a video detailing the geologic setting of the Walt Disney World Resort, I loved sharing my excitement for and knowledge of the geosciences with others.

During the GSA 2019 annual meeting in Phoenix, Arizona, USA, I was fortunate enough to participate in GSA's Science Communication Internship Program, where we interviewed two presenters and compiled a summary of their work suitable for non-technical audiences. I created two pieces, one written piece on ancient oases in the Sahara Desert that was published on GSA's *Speaking of Geoscience* blog and a video on earth fissures that was posted to GSA's YouTube channel. With this experience, I was able to start to see how I could translate my hobby for science communication into a possible career path.

Toward the end of completing my Ph.D. in geology, it became more clear that my passions were less in pursuing my own research questions and more so in sharing and communicating geoscience research and discoveries with others. I was beyond elated when I was selected as the 2021–2022 Science Communication Fellow for GSA. I have been presenting my own research at GSA meetings for the better part of a decade, and it was a thrill and an honor to work with an organization that is central in the careers of so many geoscientists like myself.

During my 10-month tenure as the Science Communication Fellow, my role has been to develop monthly press releases featuring new, newsworthy research from GSA's premier journals and GSA Connects. Developing a press release first involved scanning hundreds of abstracts and working with GSA's communications staff to identify ones that were exceptionally notable and would intrigue the public. I then interviewed the research scientists and worked to translate their research into plain language, emphasizing the broad implications of their research.

I was able to write press releases that highlighted a broad range of research topics including environmental justice in dam removal, updates from the Perseverance rover on Mars, glacial advances in Greenland, and new trilobite fossil discoveries. Writing each press release tested my translational and communication skills, as each branch and discipline within the geosciences has their own specific jargon and lingo. As a geoscience communicator, you need to be able to understand and navigate the science itself, but also know how to translate it from the scientific jargon that makes it inaccessible for many people to language that can easily be understood.

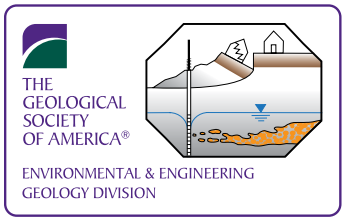
As my background in science communication has largely been rooted in new media and social media platforms, I created accompanying ~90-second TikTok videos for six of the press releases I wrote. While TikTok still largely has the stigma of being a "dance app" for Gen Z, in reality, TikTok is home to an abundance of educational content and has an extremely large and diverse audience base. By making corresponding TikTok videos, the geoscience research could be directly shared with an even broader audience. As well, I created a TikTok video during GSA Connects 2021 in Portland, Oregon, USA, to highlight and show what it's like to attend a scientific conference, because that experience is unfamiliar to many outside the scientific research community.

Creating geoscience videos on TikTok allows science communicators to be presented in an approachable and relatable way, which is helpful in improving the public perception of science and combating scientific misunderstanding and misinformation. By incorporating new media into geoscience communication, I hope to increase the accessibility and visibility of the geosciences. The geosciences still remain one of the least diverse STEM fields, but capitalizing on communication through new media provides a means to bring in and inspire a new wave of geoscientists.

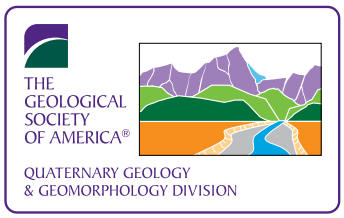
The GSA Science Communication Fellowship has afforded me the opportunity to hone my skills as a professional science communicator, mixing traditional writing with multimedia products. It has been a pleasure to work with Justin Samuel, as well as Christa Stratton and the rest of the GSA staff, and I look forward to seeing the work that the next Fellow contributes.

GSA Scientific Division Milestones

GSA acknowledges and congratulates the following GSA Scientific Divisions for reaching these milestones:

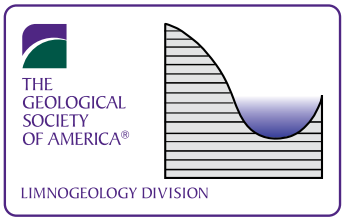


The **Environmental & Engineering Geology Division** is 75 years old this year. Established in 1947, this Division seeks to advance the ability of geologists to identify, characterize, and mitigate adverse geological and environmental conditions and hazards affecting human safety and the built environment. The Division promotes research and education on an immense array of disciplines ranging from geologic hazards, hydrogeology, environmental geology, economic and mining geology, geoinformatics, geomechanics, remote sensing, and others.



The **Quaternary Geology and Geomorphology Division** is 65 years old this year. The purpose of the Division is to bring together scientists from all backgrounds, communities, and age groups who are interested in Quaternary geology and geomorphology to facilitate presentation and discussion of ideas and to promote research and publication of results in those fields of geology.

The **Geoarchaeology Division** is 45 years old. Established in 1977, this Division provides a forum for the presentation and discussion of papers on archaeological geology in order to stimulate and promote research and teaching within this field.



The **Limnogeology Division** is 20 years old. Established in 2002, the Division encourages research on both ancient and modern lakes around the world, the collaboration of scientists from all disciplines on lake research, and the fostering of student research and careers in lake studies.

Submit your Groundwork article to *GSA Today*

Have an idea for a short, hot-topic, or issue-driven article?
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From Doc to Postdoc: Taking the Next Academic Step

Sarah W.M. George, *University of Arizona;* ***Kristina Butler,*** *University of Texas at Austin;* ***Emily E. Mixon,*** *University of Wisconsin–Madison*

Postdocs can be an exciting time for an academic. Postdoctoral research allows an academic to branch out from their Ph.D. work, develop new collaborations, and focus on research, without many of the obligations of a faculty position. The path to a postdoc, however, is often nebulous. Many postdocs are found via word of mouth, so start talking to researchers in your discipline at conferences several years before you plan to defend. A rough timeline might look like the graphic below.

Here is a brief list of some of the types of postdoc positions. Keep in mind that some of these positions are limited to U.S. citizens and residents, and others are only for those who just finished a Ph.D. This list has been modified from a longer blog post at **www.futureROCKdoc.com,** which includes advice from >20 current and recent postdocs.

Departmental Fellowships are a great way to get postdoc funding. Typically, these fellowships require a short proposal and come with research funds. A few places with departmental fellowships include Arizona State University, Harvard, Princeton, Yale, University of Chicago, MIT, Johns Hopkins, Caltech, Brown, University of Texas, Scripps, Carnegie, Smithsonian, Lamont-Doherty, and Rice University.

National Science Foundation EAR Postdoctoral Fellowships provide two years of salary and research funds. These are usually due in October and involve writing an eight-page proposal. They require a host institution, collaborator letters, and a well-thought-out research plan, so start early.

NOAA Global Change Fellowships fund researchers interested in climate studies. Applications are due in January and require letters of intent and mentorship plans from the host institution.

USGS Mendenhall Research Fellowships require a proposal in response to a specific solicitation. These positions can lead to full-time employment at the U.S. Geological Survey.

NASA Postdoctoral Programs are a good option for geoscientists with interests in planetary science. These postdocs can extend from one to three years, and there are three application deadlines per year.

National Labs often host postdocs. Each lab hosts a website with open positions.

Other state and federal agencies and private foundations also offer postdoc positions. Check websites and ask around!

Advertised positions are great if you can find a principal investigator (PI) looking to hire someone with your skillsets. Check out job boards (GSA, the American Geophysical Union [AGU], Earth Science Women's Network), and join discipline-specific listservs to hear about these positions.

Postdocs abroad: In addition to advertised positions abroad, there are several international fellowship programs. The **Marie Curie Fellowship Program** provides one to two years of research in Europe. The **Humboldt Research Fellowship** provides six months to two years of funding for research in Germany. Finally, the **Fulbright Postdoctoral and Early Career Awards** are an option for researchers working abroad.

Opportunities outside academia: Interested in testing the waters in science policy or communication? Professional societies, nonprofits, and policy groups are often looking for scientific expertise! If you want to explore this kind of avenue, check out the GSA-USGS Congressional Science Fellowship or the GSA Science Policy Fellowship. AGU, the American Geosciences Institute, and the Union of Concerned Scientists also have similar programs.

Starting to think about your next academic step? See the full article at **www.futureROCKdoc.com**—a website with career and wellness resources for geoscience students created by grad students and early career geoscientists.

GSA Expanding Representation in the Geosciences Scholarships

These six undergraduate students from groups underrepresented in the geosciences have been awarded $1,500 scholarships plus one-year GSA memberships and full registration to GSA Connects 2022.

Adrian Alves, Occidental College

Sydney Cloutier, University of Miami

Angela Douglass, Wellesley College

Olivia Gadson, Georgetown University

Alicia Hernández, University of Illinois at Chicago

Brandon Walters, Angelo State University

Seven Reasons You Should Accept That Reviewer Invitation

1. **Network.** Reviewing helps you build relationships with well-respected colleagues. You never know where this may lead—one day, you may be asked to serve on the editorial board or become an editor yourself.

2. **Stay on the cutting edge.** As a reviewer, you have an opportunity to be among the first to read about new research and findings in your field—often directly related to your area of expertise.

3. **Return the favor.** They say that for every paper you've authored you should review two others. Being a reviewer gives you the chance to contribute to the scientific community.

4. **Help promote good science.** At GSA, we rely on peer review to uphold the quality and integrity of our publications. Your insights and expertise can help authors to improve their manuscripts, and your feedback can help editors ensure that only high-quality research gets published.

5. **Help prevent bad science.** Your knowledge of the field can be instrumental when it comes to sniffing out plagiarism or detecting instances of similar manuscripts published (or under consideration for publication) elsewhere. Though relatively rare, ethical breaches do happen, and reviewers form a first line of defense.

6. **Gain an insider perspective.** Being a reviewer gives you valuable insight that will benefit you when it comes time to present your own research in a paper. You'll know what a reviewer will be looking for and what things to avoid in your own writing.

7. **Achieve professional goals.** Find out if the evaluation committee at your institution takes note of referee activity. If so, we can provide you with a letter to certify your reviewer service to GSA journals. Contact the managing editor of the journal or email editing@geosociety.org for details.

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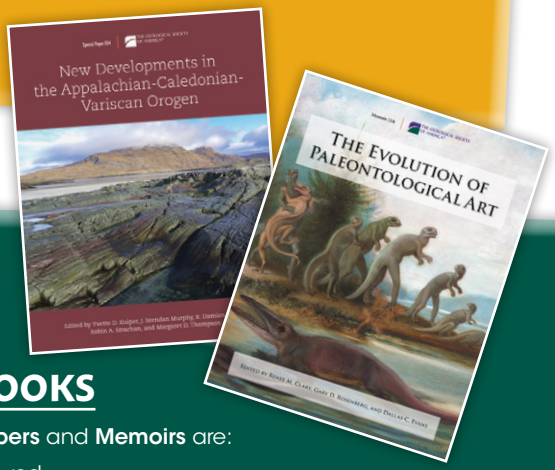

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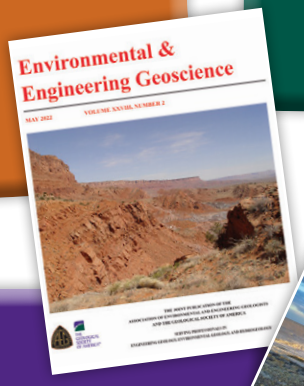

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Corporate Partners Add to the GSA Experience

Corporate partners and sponsors generate unique opportunities at GSA. Each of the various mechanisms for company participation are important to the Society's programming in distinctive ways.

Meeting sponsorship can be tailored and more expansive than it might first sound. After exhibiting at GSA's annual meeting over the years, Bruker opted for greater participation in 2022. In fact, if you attended any of GSA's Section Meetings this past spring, you probably picked up a bottle of hand sanitizer that Bruker provided to enhance the Society's health and safety measures during some of our first in-person gatherings since the start of the pandemic. Bruker also sponsored each Section Meeting, and their participation in GSA Connects 2022 (9–12 October in Denver, Colorado, USA) includes lead sponsorship of GEO.SCI, the tech demo area you will experience in the Resource & Innovation Center; an expanded exhibit booth; and badge lanyards for all attendees.

What compels a company like Bruker to choose GSA as a partner? Jonathan Knapp, Ph.D., Geosciences Market Segment Manager, explains the strategic reasoning: "Our partnership with GSA has been hugely beneficial to us. We have found the personal contact with members of the community at the regional shows to be extremely important. We get more out of the annual meeting by being at each of the regional meetings—it lets us have more intimate conversations and set up dedicated time at the annual meeting. We also enjoy the ability to have detailed conversations with students at their posters.

"GSA has been a great partner to work through innovative ideas with. We think that the ability to showcase new technologies and provide more hands-on and experiential exhibit halls benefits our goals. We aim to expand awareness and adoption of methods, not just our products.

"Our partnership with the Geological Society of America has been part of our overall engagement plan to build more informal connections with the scientific community. It has been a resounding success. It's particularly important for us to engage with discussions about the development of new methods and technology. Such discussions take time, and attending multiple meetings a year helps us have multiple touch points with important partners."

Other companies find paths of engagement that meet their needs as well. Chevron is a steadfast example of a returning ***program sponsor***, actively participating in GSA's GeoCareers program for many years. This year, they are also supporting GSA's Expanding Representation in the Geosciences Scholarships, an ideal avenue to demonstrate our mutual priority of broadening participation in the field. We are grateful to companies like Brunton who choose to be an ***organizational partner***, providing exclusive member discounts for their products, meeting sponsorship, unique opportunities like demo fleets for GSA field trips, and the tremendous contribution of personalized, engraved Transits for GSA's J. David Lowell Field Camp Scholarship recipients. And longtime GSA vendor Image AV partners is an ***in-kind sponsor*** by including extensive audio/visual equipment throughout GSA Connects outside of GSA's contracted services.

To discuss how your company or organization can find valuable engagement through these kinds of partnerships, please contact Debbie Marcinkowski at +1-303-357-1047 or dmarcinkowski@geosociety.org.

A Bruker representative was at each GSA Section Meeting this spring, along with hand sanitizers contributed by the company to help promote health and safety measures.

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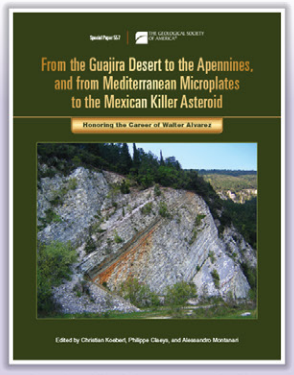

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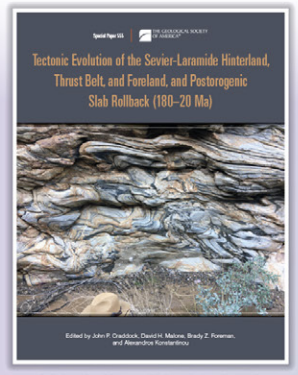

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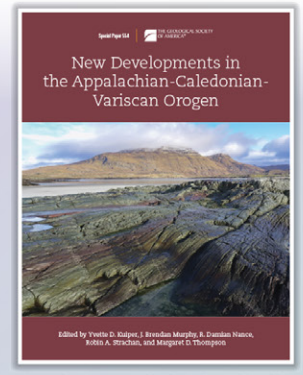

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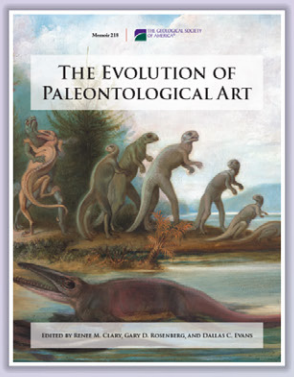

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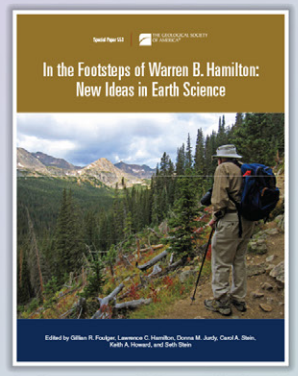

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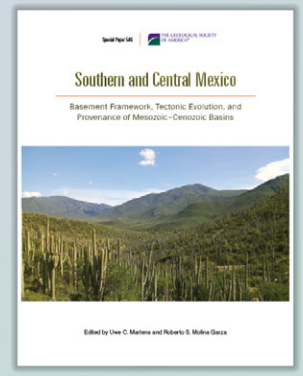

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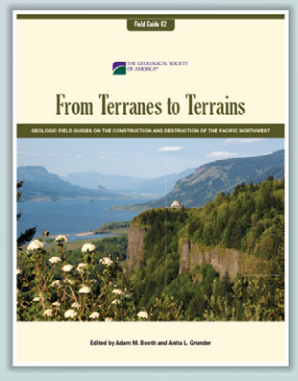

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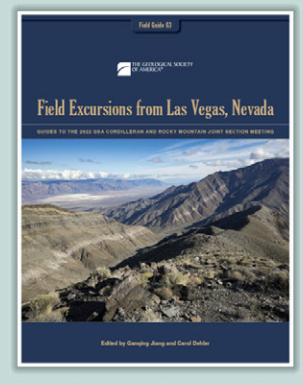

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Assistant Professor of Geosciences, Trinity University

The Department of Geosciences at Trinity University invites applications for a tenure-track Assistant Professor of Geosciences. A Ph.D. in Geosciences is required. The successful candidate must have a commitment to undergraduate teaching and will be expected to develop an active research program that involves undergraduates. Preference will be given to those with experience teaching at the college level. The successful candidate will teach introductory geosciences courses, a core course in earth materials, and other upper-level courses related to geologic and environmental sciences. Preference will be given to candidates who can also contribute to department and university core curricula (e.g., the First-Year Experience) and have experience with interdisciplinary instruction and/or global education. We are open to specialties that include but are not limited to igneous and/or metamorphic petrology, mineralogy, economic mineral deposits, volcanology, and high-temperature geochemistry.

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Complete applications must include a cover letter, curriculum vitae, a statement of undergraduate teaching experience and philosophy, documentation of teaching effectiveness, a description of research plans, a statement of commitment to diversity and inclusion, and three letters of recommendation (with at least one that directly addresses the applicant's teaching effectiveness). Please send materials electronically to Dr. Benjamin E. Surpless, Acting Chair, Department of Geosciences, at geossearch@trinity.edu. Review of completed applications will begin on August 15, 2022. Questions about the search can be directed to Dr. Benjamin Surpless [bsurples@trinity.edu]. Trinity University is committed to diversity and inclusion and strongly encourages candidates from underrepresented groups to apply. Trinity University is an Equal Opportunity Employer. As such it provides equal opportunity for employment and advancement of all employees without regard to race, color, religion, sex, age, national origin, disability, military/veteran status, sexual orientation, gender identity, gender expression, or any status protected by federal, state or local laws. Trinity welcomes applications from candidates who share those values and who will harness them on behalf of the University's mission.

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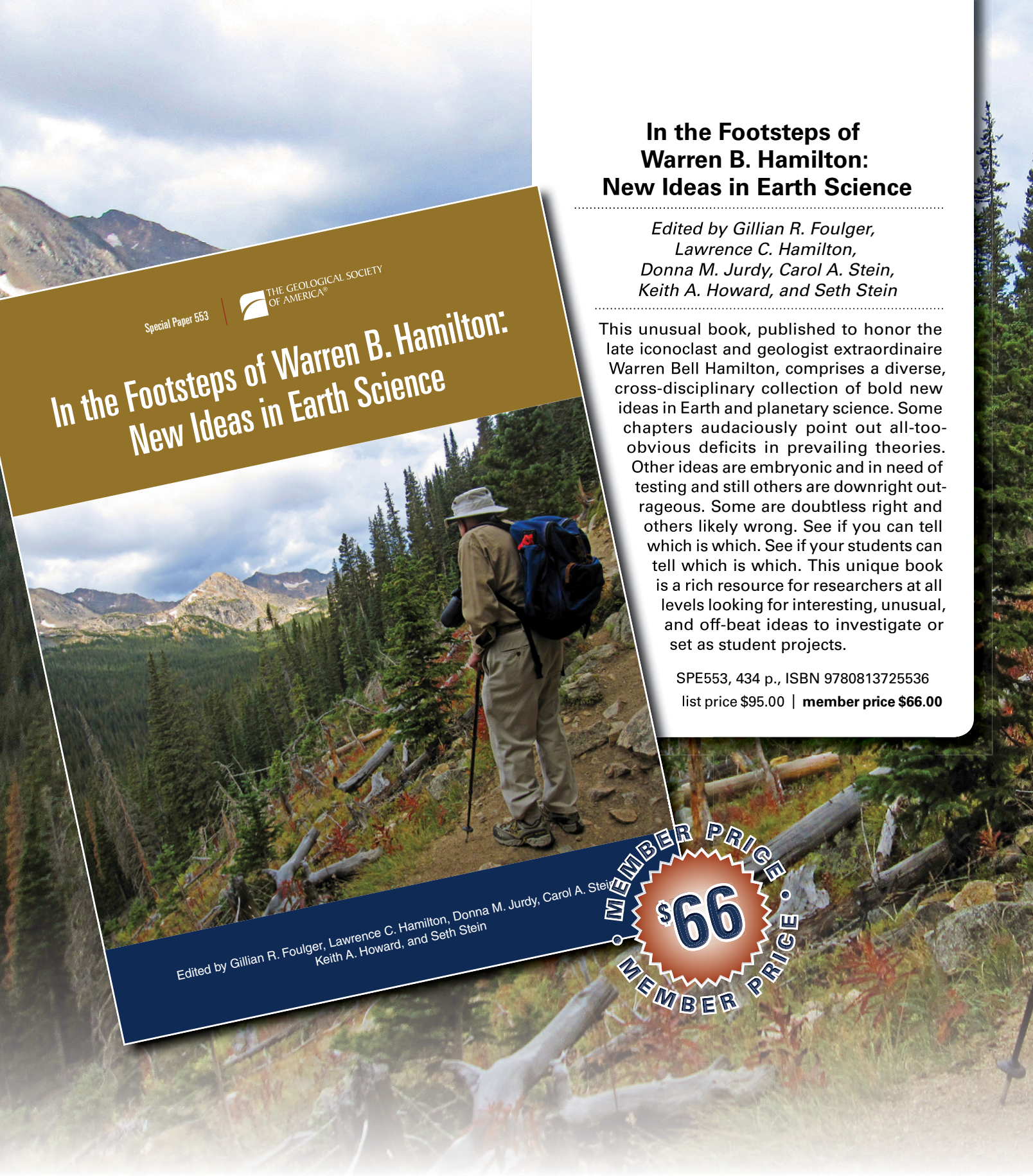

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This unusual book, published to honor the late iconoclast and geologist extraordinaire Warren Bell Hamilton, comprises a diverse, cross-disciplinary collection of bold new ideas in Earth and planetary science. Some chapters audaciously point out all-too-obvious deficits in prevailing theories. Other ideas are embryonic and in need of testing and still others are downright outrageous. Some are doubtless right and others likely wrong. See if you can tell which is which. See if your students can tell which is which. This unique book is a rich resource for researchers at all levels looking for interesting, unusual, and off-beat ideas to investigate or set as student projects.

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New analytical and field techniques, as well as increased international communication and collaboration, have resulted in significant new geological discoveries within the Appalachian-Caledonian-Variscan orogen. Cross-Atlantic correlations are more tightly constrained and the database that helps us understand the origins of Gondwanan terranes continues to grow. Special Paper 554 provides a comprehensive overview of our current understanding of the evolution of this orogen. It takes the reader along a clockwise path around the North Atlantic Ocean from the U.S. and Canadian Appalachians, to the Caledonides of Spitsbergen, Scandinavia, Scotland and Ireland, and thence south to the Variscides of Morocco.

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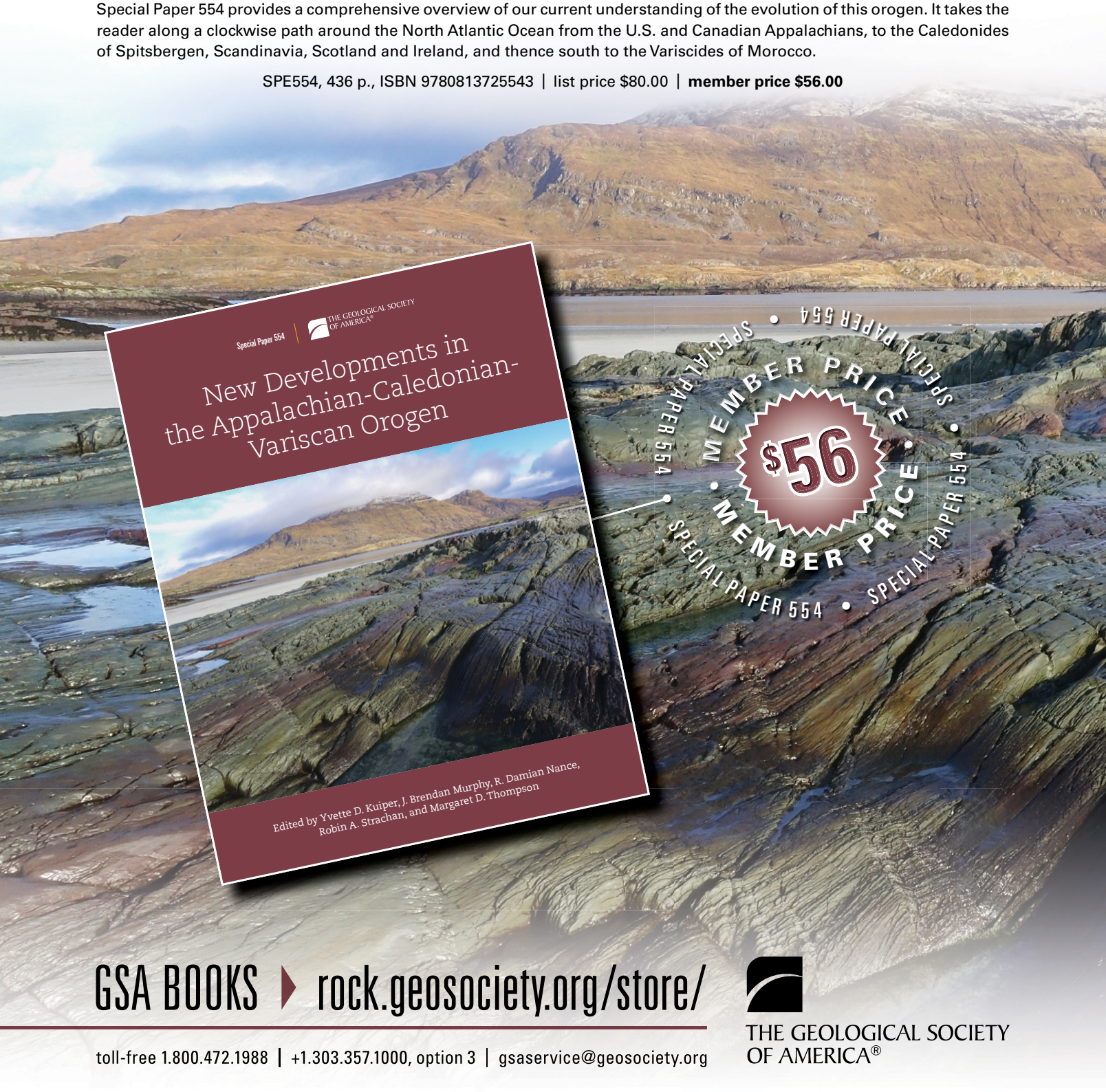

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