

TPG is a publication of the American Institute of Professional Geologists

THE PROFESSIONAL GEOLOGIST

VOLUME 63 NUMBER 3

JUL.AUG.SEP 2026

National Student Scholarship Recipients

Controls on Widespread Platform-Scale Dolomitization in
Paleozoic Carbonate Systems

Field Guide: Caves, Springs, and Streams in the
Upper Cambrian of Missouri



Cell: +1-775-720-8894

Donald G. Strachan
Geologist M.S. CPG QP

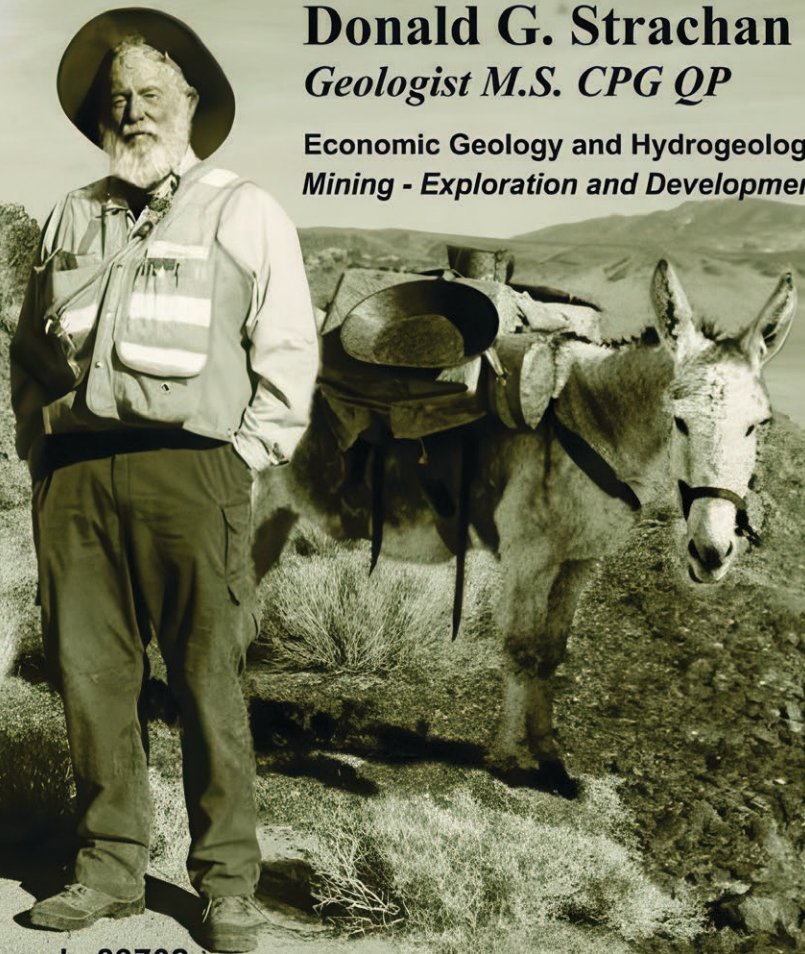
Economic Geology and Hydrogeology
Mining - Exploration and Development

Mineral Consulting
Geologic Mapping
Geochemical Surveys
Discovery Drill Programs
Deposit Development
Project Management
Resource Planning

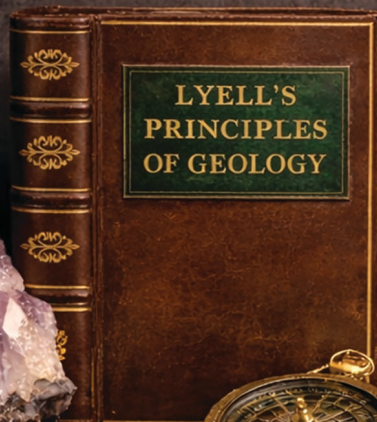
www.geostrachan.com

dgstrachan@yahoo.com

Post Office Box 4046, Carson City, Nevada 89702



From Donated Item to Student Opportunity



The Foundation of the AIPG Silent Auction transforms donated items into scholarships and educational support for geoscience students.

Held during the Welcome Reception at the AIPG National Conference in Duluth, Minnesota.

Donations welcome:

Travel experiences
Mineral and rock specimens
Books, jewelry, artwork, and other unique items.

Donate an item. Place a bid.
Support the next generation.



The Professional Geologist

Volume 63 Number 3

JUL.AUG.SEP 2026

INSIDE THIS ISSUE

FEATURES

- 5 **Horizontal Groundwater Monitoring to Detect Leaks from Lined Waste Disposal Facilities**
Paul F. Hudak
- 8 **Controls on Widespread Platform-Scale Dolomitization in Paleozoic Carbonate Systems**
Mossbah M. Kolkas, CPG-10180
- 28 **Insights into Uranium**
Barney Paul Popkin
- 31 **Field Trip Guide: Caves, Springs, and Streams in the Upper Cambrian of Missouri**
Jeffrey Crews
- 57 **The Part Nobody Warns You About: Why Every Stage of a Geology Career Deserves its Voice**
Becca May, ECP-1250

On the Cover: 2026 Photo Contest Winner - **Rock Glacier, Chugach Mountains, Alaska**

Description: *Rock glacier in the Chugach Mts. near Anchorage, Alaska* – Rock glaciers consist of a mass of loose rock or talus with lobate wrinkles and ridges, giving one the impression of down-slope movement. As such they exhibit many of the same features inherent in true glaciers, including a lobate front or tongue, lateral moraines, and crescent-shaped ridges. Many are characterized by steep fronts near the angle of repose. Most occur in areas of high latitude or altitude, in areas of steep cliffs with poor snow cover, and bedrock broken by frost action.

Rock glaciers are of two types: ice-cored and ice-cemented. Ice-cored form when rock talus debris is deposited on the surface of a pre-existing glacier; the source area being the steep walls of a glacial cirque. The underlying glacial ice provides a smooth surface for down-slope movement of the talus. Ice-cemented rock glaciers can form when ice and snow melt on the surface of a talus slope. The resulting water filters down through the underlying talus freezing to ice at depth. The ice reduces cohesion between the rock fragments, enabling down-slope movement. The turquoise-colored water in the associated lake would indicate that fine rock flour is being produced by the grinding together of moving rocks and mixed with the lake waters.

Photograph by **Joseph M. Kurtak, CPG-11359, AIPG Alaska Section, 2020.**

AIPG National Executive Committee

PRESIDENT - Charles Drake, CPG

Bio-Tech Consulting
O: (407) 256-7715, Florida Section
chuck@bio-techconsulting.com

PRESIDENT-ELECT - Douglas C. Peters, CPG

Peters Geoscience
O: (303) 970-7601, Colorado Section
dcpeters@tuveraexploration.com

PAST PRESIDENT - Sara Pearson, CPG

Michigan Geological Survey
O: (269) 387-8611, Michigan Section
sara.pearson@wmich.edu

VICE PRESIDENT - Mark Schaaf, CPG

Tradepoint Atlantic
O: (845) 325-4646, Capitol Section
Markschaaf27@gmail.com

SECRETARY - Mark J. Howell, CPG

Xenon Geosciences
O: (317) 626-0600, Indiana Section
mhowell@xenongeosci.com

TREASURER - J. Todd McFarland, CPG

WSP USA
O: (615) 336-3817, Tennessee Section
todd.mcfarland@wsp.com

EDITOR - Adam W. Heft, CPG

WSP USA
O: (517) 886-7400, Michigan Section
adam.heft@wsp.com

EARLY CAREER PROFESSIONAL - Skyler C. Vertes, ECP

Stantec
O: (803) 319-0557, Carolinas Section
Skylar.verts@stantec.com

ADVISORY BOARD REPRESENTATIVES

Michael L. Alter, CPG
Clear Creek Associates
O: (703) 740-7573, Arizona Section
malter@geo-logic.com

Luke Ducey, CPG
WSP USA
(217) 778-5555, Missouri Section
luke.ducey@wsp.com

John C. Jens, CPG
Retired – Corps of Engineers
O: (703) 244-6479, Virginias Section
jcjens@earthlink.net

Steven J. Stokowski, CPG
Stone Products Consultants
O: (508) 259-3536, Georgia Section
sstokowski@yahoo.com

NATIONAL HEADQUARTERS
10701 Melody Drive, Suite 630
Northglenn, CO 80234
7:30 AM - 4:30 PM MDT; M-F
(303) 412-6205 • Fax (303) 253-9220
aipg@aipg.org • www.aipg.org

EXECUTIVE DIRECTOR - Aaron W. Johnson, CPG - awj@aipg.org
ASSISTANT DIRECTOR - Wendy J. Davidson - wjd@aipg.org
PROFESSIONAL SERVICES MGR - Cathy L. Duran - cld@aipg.org
MEMBERSHIP SERVICES - Kayla R. Casey - aipgmembership@aipg.org
BOOKKEEPER/ADMIN ASSISTANT - Ashley M. Whalen - bookkeeper@aipg.org
OFFICE ASSISTANT - Kathy M. Glivar - officeadmin2@aipg.org
AWG ADMIN ASSISTANT - Mona J. Scott - office@awg.org
AASG ADMIN ASSISTANT - Karen I. Keeley - office.aasg@gmail.com

MEDICAL, AUTO, HOME, LIFE AND SUPPLEMENTAL INSURANCE
GeoCare Benefits Insurance Plan
Phone: 800-337-3140 or 602-870-4121
<http://www.geocarebenefits.com/member.asp>
E-mail: geocarebenefits@agia.com

PROFESSIONAL & GENERAL LIABILITY INSURANCE
Allan Crumbaker, Schomburg Insurance,
Phone (702) 328-4983
allan@schomburginsurance.com

ALAMO RENTAL CAR -
(800) 354-2322 - Member #BY-706768

AVIS RENTAL CAR -
(800) 698-5685 - Member AWD #T003300

UPS Savings Program
www.aipg.org or www.savewithups.com/aipg
Use promo code WES462

DEPARTMENTS

3	Editor's Corner
4	Letters to the Editor
14	Student Scholarship Recipients
38	Executive Director's Message
39	President's Message
40	Early Career Professional Spotlight
42	Test Your Knowledge
43	Professional Ethics and Practices
48	Tales from the Field
50	In Memoriam
52	Educator's Corner
58	The Foundation of the AIPG
60	AIPG Membership Totals
60	Professional Services Directory
Back Cover	New Certified Professional Geologists

AIPG Publication Policy, October 4, 2010. AIPG encourages submission of articles and editorials for publication in *TPG* on topics related to the science and profession of geology. Submittals shall be of interest to the members of AIPG, other professional geologists, and others interested in the earth sciences. Articles and editorials may be noted as follows at the discretion of the Editor, "The opinions, positions and conclusions presented herein are those of the author and do not necessarily reflect the opinions, positions or conclusions of the American Institute of Professional Geologists." All materials submitted for publication, including author opinions contained therein, shall include accurate and appropriate references. The Editor has the authority to solicit, edit, accept, or reject articles and editorials and other written material for publication. The Executive Committee has the authority if it so chooses to act on any particular case to support or overrule actions of the Editor regarding the solicitation, editing, acceptance, or rejection of any particular article, editorial, or other written material for publication.

American Institute of Professional Geologists (AIPG) is the only national organization that certifies the competence and ethical conduct of geological scientists in all branches of the science. It adheres to the principles of professional responsibility and public service, and is the ombudsman for the geological profession. It was founded in 1963 to promote the profession of geology and to provide certification for geologists to establish a standard of excellence for the profession. Since then, more than 12,000 individuals have demonstrated their commitment to the highest levels of competence and ethical conduct and been certified by AIPG.

The mission of the American Institute of Professional Geologists (AIPG) is to effectively advocate for the profession of geology and support members through activities and programs that advance professional growth and promote high standards of ethical conduct.



The Professional Geologist (USPS 590-810 and ISSN 0279-0521) is published quarterly by the American Institute of Professional Geologists, 10701 Melody Drive, Suite 630, Northglenn, CO 80234. Periodicals Postage Paid at Denver, Colorado and additional mailing offices.

POSTMASTER: Send address changes to *The Professional Geologist*, AIPG, 10701 Melody Drive, Suite 630, Northglenn, CO 80234. Subscriptions for all Members and Adjuncts in good standing are included in annual membership dues. Subscription prices are \$20.00 a year for Members' additional subscriptions and \$30.00 a year for non-members for 4 issues (for postage outside of the U.S. add \$10.00). Single copy price is \$5.00 for Members and \$8.00 for non-members. Claims for nonreceipt or for damaged copies are honored for three months.

Entire contents copyright 2026 by *The Professional Geologist*. Original material may be reprinted with permission. Deadline for articles and advertisements is eight weeks preceding publication. Advertising rates available upon request. Opinions and views expressed by the authors are their own and do not necessarily reflect those of the American Institute of Professional Geologists, its staff, or its advertisers.

Printed in U.S.A. by Modern Litho-Print Company in Jefferson City, Missouri.

For AIPG news and activities go to www.aipg.org.



Adam W. Heft, CPG-10265

Change (not winter) is Coming!

Welcome to summer! At least, that is what the calendar says, but for us here in Michigan, we've had a lot of rain and moderate temperatures. We've had the rainiest spring on record this year and are just starting to get some summer heat. As I write this, we are rapidly approaching the final weeks to cast your vote for next year's Executive Committee members. Your vote helps direct the way our organization will move forward, and it only takes a few minutes of your time. We are also getting closer to this year's Annual Meeting, which will be held in Duluth, Minnesota from August 29-Sept 1, 2026. In addition to some interesting field trips (who doesn't love a good field trip?) and two days' worth of technical presentations, I urge you to attend the business meetings that are held on Saturday. Students and ECPs, you'll also have the opportunity to participate in a workshop designed especially for you on Saturday.

Attending the Executive Committee and Advisory Board meetings allows you a glimpse into what initiatives the Executive Committee is working on but also allows the committee members and your peers to get to know you. Perhaps one day you will want to stand for election and giving other members a chance to know you will put you in good stead for their consideration.

This edition of *TPG* includes the annual undergraduate student scholarship essays titled: "Why I Want to be a Geologist." Ten undergraduate scholarships were awarded this year. Be sure to check them out and see what you think of this year's group of recipients. The essay for the recipient of the Siok Scholarship for graduate students is also presented and is titled "Geology's Essential Quarter-Century: Decoding Earth's Past to Navigate Our Collective Future."

We have articles on "Horizontal Groundwater Monitoring to Detect Leaks from Lined Waste Disposal Facilities" by **Paul Hudak**, nonmember, another on "Controls on Widespread Dolomitization" by **Mossbah Kolkas**, CPG 10180, one pertinent to early career professionals by **Becca May**, ECP-1250, another installment in the Tales from the Field by **Vic Ridgley**, nonmember, and a final article from **Barney Popkin**, nonmember on "Insights to Uranium". I hope you enjoy them.

Many of you have no doubt seen some or all of the television series "Game of Thrones" in which the motto of House Stark was "Winter is Coming". This was a reminder to the members of that house that they needed to be prepared for what would happen when winter finally arrived. The title of my column plays on that as it pertains to geology. Yes, change is coming, and to a certain extent, is already here.

We have already seen changes in the way fieldwork is conducted and the equipment we use. Twenty years ago we didn't use computers in the field. We used field notebooks and forms for recording information, whether it was our observations on outcrops, strike and dip measurements, static water levels, or whatever. I recall when I was just starting out that some of the

members of the company at which I worked used a pocket dictation machine to record their notes while conducting a reconnaissance of the field area. The recording had to be transcribed by our secretary, and then the resulting transcription had to be verified for accuracy. A cumbersome process indeed. Now, the use of tablets or laptops or even apps on our phones can do that and have a complete and accurate set of notes finished and sent back to our office before we can even get back there ourselves.

One of our 2026 scholarship recipients wrote about a revolution in geology and how those who are just entering the profession will make new discoveries and change what and how the way things are done. This is a good thing; moreover, those entering the profession will need to not only change what and how we do things but will also need to communicate those changes and their significance to society and policymakers. This, I think, will be the most significant contribution to the profession that can be made: getting the public and policymakers to understand the significance of what we do and its importance to society as a whole.

Many people look at the legacy of the industry and see the problems it caused. Mining left huge pits filled with discolored water, waste piles of rock, unstable or unusable ground, and often the extractive process resulted in extensive heavy metal or other chemical contamination of not just the mine site, but often entire watersheds. Sediment clogged streams, and chemicals poisoned rivers.

But today's practices are (and should be!) different. As an example, I point to a nickel-copper deposit in northern Michigan that began mining in 2014 following surface construction in 2010 (Eagle Mine). This operation occupies less than 40 acres on the surface, avoided disturbing a portion of the 40 acres that was sacred to a local native tribe, and cleans every bit of precipitation that lands on the mine site before it is allowed to be discharged. And that water is so clean that dissolved minerals have to be added to it before discharge so it doesn't alter surface water chemistry.

Initially, this mine was heavily opposed, but by communicating with the local community and showing them exactly how the mining could be done responsibly without damaging the local ecosystems and how it would benefit the surrounding communities (both by providing jobs and improved infrastructure), the community was won over. That is what we need to do – show society why what we do benefits them, and that it can be done responsibly. And often, afterwards, there are additional benefits; for instance, completion and closure of a sand and gravel mining operation may leave behind a new lake. This opens opportunity for new real estate with waterfront lots – something that is desired by many. Being able to demonstrate how geology benefits everyone helps overcome the NIMBY syndrome.

Bring the change!

Dear Editor,

For a split second looking at the picture of the sandstone "formation" heading the article "Mapping at East Canyon U-V Project in Utah, USA," in the Apr/May/June 2026 edition of *TPG*, I thought I was looking at the Sphinx. Prior to the sculpting of the latter, we are told by archeologists, it looked pretty much like the sandstone "formation" shown in the picture. I had the pleasure of seeing the Sphinx in 1981 during an exploratory visit to some of Egypt's uranium prospects as a uranium geologist for Mobil Exploration & Production Services, Inc. (MEPSI). The visit took me to Gebel Um Ara, about 60 miles southeast of Aswan in Egypt's Eastern Desert, where uranium mineralization is found in granitic rocks, and to the Fayum, an oasis about 80 miles southwest of Cairo, at the eastern edge of Egypt's Western Desert, where uranium mineralization is found in sandstone. The only other place, where I have seen a sphinx, actually two sphinxes facing each other and eroded and weathered out - not sculptured - of Iceland's ubiquitous basalt, is located just northeast of "Lundur," a

salmon-fishing lodge on the Hitara River, on the eastern side of the "highway" about 17 miles north of Borgarnes, Iceland. I always rejoiced at seeing them again and again: twenty times in all!

Needless to say, as a former uranium geologist, I thoroughly enjoyed reading the article.

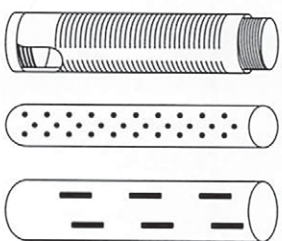
Sincerely,

Dr. Erik H. Schot, PhD, MEM-2189



Atlantic Screen & Mfg., Inc.

- Sand
- Manholes
- Bentonite
- Pond Sealer
- Filter Sock
- Sampling Bailers
- Locking Caps



Manufacturers of Slotted & Perforated Pipe ranging from 1/2" to 24" in diameter



PRODUCT CATALOG

302-684-3197
FAX 302-684-0643

142 Broadkill Rd. • Milton, DE 19968
www.atlantic-screen.com
email: sales@atlantic-screen.com

20% discount for AIPG members!

Use the code **AIPGmember** at checkout each time you order





www.brunton.com
sales@brunton.com

Horizontal Groundwater Monitoring to Detect Leaks from Lined Waste Disposal Facilities

Paul F. Hudak

Introduction

Modern landfills are built to protect the subsurface from contamination. However, leachate can escape through small tears or punctures in synthetic liners. Accurate leak detection facilitates effective source control and remediation. Depending on site circumstances, source control options may include direct access and repair, injection grouting (Ke et al, 2024), or monitored attenuation. Ideally, lysimeters beneath a landfill liner detect leachate before it reaches the water table, but narrow seeps can migrate undetected to the water table. Thus, contaminant detection wells in groundwater should be part of a comprehensive monitoring plan.

Small openings in landfill liners tend to produce narrow contaminant plumes in groundwater that are difficult to detect with vertical monitoring wells (Lee and Jones-Lee, 1994). Potentially, directionally drilled horizontal wells could enhance opportunities for detecting contaminant plumes in groundwater. Horizontal wells can enter and exit the land surface (continuous wells) or terminate underground (blind wells) (EPA, 2004). Casing and screen can be pulled through a continuous borehole or pushed into a blind borehole.

While infrequently used for groundwater monitoring, horizontal wells are widely used for natural gas production and, for environmental purposes, have been used to remediate subsurface pollution (Divine et al., 2017; Feng et al., 2023; Muller et al., 2021; Rosansky, 2020). The objective of this study was to compare horizontal and vertical strategies for detecting pollution in groundwater downgradient of a landfill.

Methods

A numerical model, MT3DMS (Zheng and Wang, 1999), was used to simulate releases from a hypothetical lined landfill above an unconfined sand aquifer (Figure 1). A graphical user interface, Processing MODFLOW 8 (Simcore Software, 2025), processed input and output data for MT3DMS.

The block-centered finite difference model had three layers, 370 columns, 310 rows, and a 1-meter (m) node spacing. Hydraulic head (H) was constant at the western ($H = 3.000$ m) and eastern ($H = 2.262$ m) boundaries, producing an average hydraulic gradient of 0.002 eastward. Groundwater did not cross the northern, southern, or lower boundaries of the model (Figure 1). Other parameters, typical of sandy alluvium (API, 1989), were: hydraulic conductivity = 2 meters/day (m/d); vertical hydraulic conductivity = 0.2 m/d; effective porosity = 0.25; longitudinal dispersivity = 1.0 m; transverse horizontal dispersivity = 0.1 m; transverse vertical

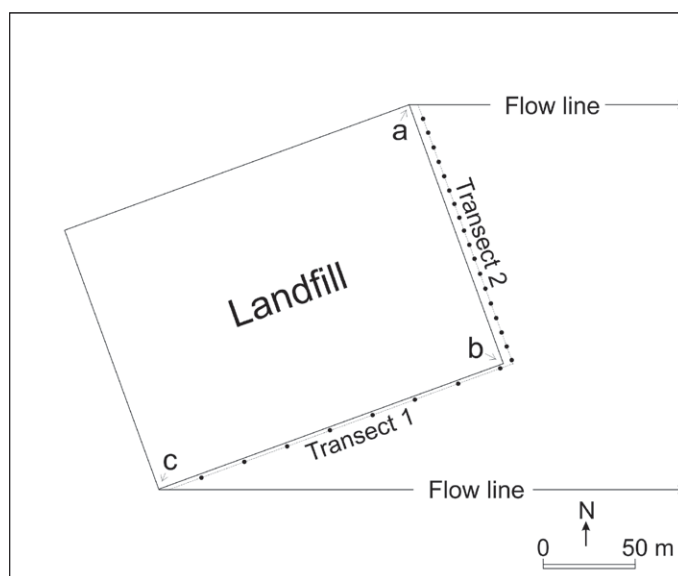


Figure 1. Map of landfill, vertical detection wells (dots), and horizontal monitoring transects; b – downgradient corner; a and c – cross-gradient corners.

dispersivity = 0.01 m; and effective molecular diffusion coefficient = $0.00001 \text{ m}^2/\text{d}$. The contaminant source, at nodes in the upper layer (one per simulation), had an area of 1 m^2 and concentration of 100 mg/L, and the plume boundary was 1 mg/L. Simulations used the preconditioned conjugate gradient solver for flow and generalized conjugate gradient solver for mass transport, which produced mass balance errors less than 0.1%.

A vertical monitoring network was designed by placing wells along linear transects located 5 m (measured parallel to groundwater flow) downgradient of the landfill (Figure 1). Each well was screened across and sampleable in each layer of the model. In practice, straddle or multipurpose packers can isolate discrete intervals of well screen (Holloway and Waddell, 2008; Pulido et al., 2004).

Contaminant plumes sourced under the landfill's downgradient boundary segments were evaluated for maximum cross-gradient width at the associated monitoring transect prior to reaching a property boundary; these widths were used to place a minimum number of wells to detect all possible releases (Figure 1). CorelDraw (Corel Corporation, Ottawa, Ontario) was used to superimpose contaminant plumes output from MT3DMS onto a digital map,

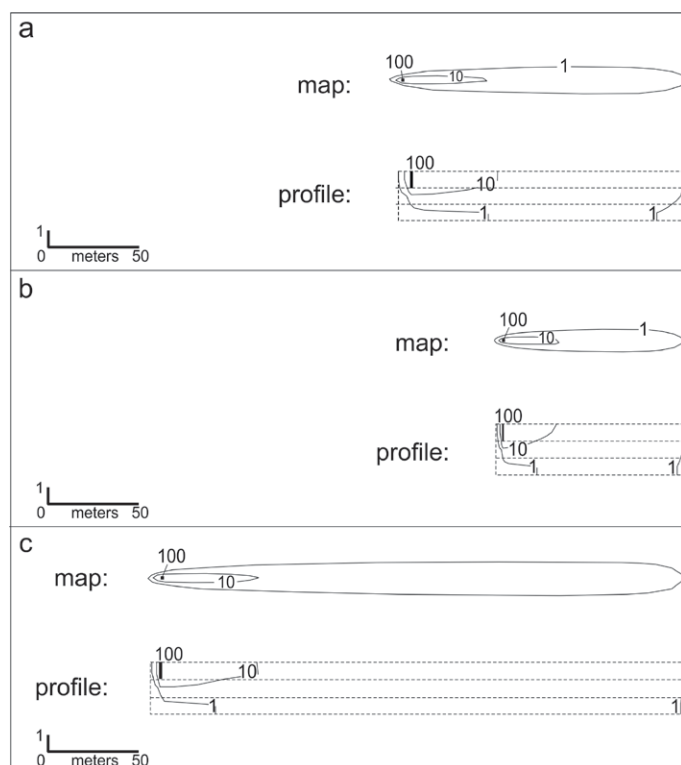


Figure 2. Maps and longitudinal cross-sections of contaminant plumes (mg/L) originating at points a, b, and c in Figure 1.

starting at the cross-gradient ends and converging at intersection of the two monitoring transects.

An alternative horizontal monitoring network consisted of two screened segments in the uppermost layer, coinciding with monitoring transects in the vertical network. These screened segments were assumed to be sampleable at discrete intervals using packers, as in the vertical network.

Results

Contaminant plumes were widest and thus easiest to detect in the upper layer. To detect all releases, the vertical network required 26 wells (Figure 1). Transect 1 required fewer wells because contaminant plumes cross it more obliquely, with a broader portion of the plume traversing the transect. Numerous wells were required due to the small point source. In practice, while many landfills of comparable size have fewer wells, they are unlikely to detect a high percentage of small leaks from random locations over the entire footprint of the landfill (Lee and Jones-Lee, 1994). Alternatively, the horizontal network consisted of two screened segments, 200-m and 150-m long, in the upper layer (Figure 2).

Rough cost estimates are higher for the vertical network, assuming \$5,000 per vertical well (\$130,000 total) and \$300 per meter of horizontal well (\$105,000 total). This linear estimate is near the low end of published estimates for horizontal wells (Rosansky, 2020), consistent with a shallow installation in readily drillable earth material.

Other than cost savings in some cases, horizontal wells have distinct advantages and disadvantages over vertical wells. In map (x-y) perspective, horizontal wells intercept narrow contaminant plumes that can move between vertical wells. Commonly over 300 m long (Muller et al., 2021), horizontal wells can extend beneath

buildings and other surface obstructions that cannot accommodate vertical drilling.

However, horizontal drilling and well completion requires specialized equipment and can be challenging. For example, filling the annulus between the casing and borehole wall can be difficult; heavy-duty centralizers lift the casing, providing access for tremie pipes that deliver sand slurry (along screened segments) or grouting (along blank segments). Site-dependent alternatives to tremie-emplaced sand pack include natural pack, geotextile wrap, pre-packed screen, and integrated porous synthetics (DTD, 2004). Horizontal wells also require specialized screens to withstand forces applied during emplacement (Rosansky, 2020).

Borehole collapse is another concern, particularly with blind horizontal holes, where the drill head is removed prior to casing the well. However, for continuous wells, casing and screen can be pulled back through the exit location to avoid collapse (Rosansky, 2020). Widely used hollow-stem auger prevents collapse when constructing vertical wells.

Horizontal wells also have longer offset requirements than vertical wells. Typically, the entry point is three to five times the depth of a horizontal well (EPA, 2004). Trenching may be an option in shallow, unconsolidated aquifers, but requires a large working area and disrupts overburden (Muller et al., 2021).

Furthermore, horizontal wells cannot access groundwater when the water table falls beneath them. To address this problem, horizontal wells can be installed at deeper intervals of the saturated zone, but doing so might lower detection efficiency. In this example, with hydrodynamic dispersion, contaminant plumes sourced beneath the landfill's downgradient boundary reached the upper and middle layers, but not the lower layer (directly beneath the boundary), before reaching the property boundary (Figure 2). Thus, horizontal wells near the landfill's downgradient boundary could occupy the upper or middle layer and perform effectively but would lose detection efficiency in the lower layer.

At some sites, downward hydraulic gradients might also transport solutes beneath a horizontal well. Potentially, stacked installations of upper and lower horizontal wells could accommodate falling water tables or diving contaminant plumes, though at greater cost.

Often, monitoring wells are sampled at discrete vertical intervals to profile a contaminant plume. This capability is lost with horizontal wells, though they add capability for resolving plumes in horizontal space. Sampling each discrete interval of a horizontal well would be impractical; instead, the well could be sampled at strategic locations, such as those identified in x-y space for vertical networks (Figure 1). Alternatively, an electrical conductivity probe could be pulled through a horizontal well and take continuous readings to target intervals that should be sampled for comprehensive laboratory analysis.

Conclusion

Horizontal wells may have unrealized potential for detecting leachate plumes released from landfills. While vertical monitoring networks are used in practice, they often lack a high degree of detection capability in horizontal (x-y) space, especially for narrow contaminant plumes from lined landfills. Single (unstacked) horizontal wells do not allow for vertical profiling of contaminant concentration, but in some cases may efficiently detect narrow plumes in horizontal space. Ultimately, vertical and horizontal networks could be used together, to capitalize on the relative strengths of each approach.

References

- API (American Petroleum Institute) (1989). Hydrogeologic Database for Groundwater Modeling. American Petroleum Institute, Washington, D.C.
- Divine, C.E., Roth, T., Crimi, M., DiMarco, A.C., Spurlin, M., Gillow, J., Leone, G. (2017). The horizontal reactive media treatment well (HRX Well®) for passive in-situ remediation. *Groundwater Monitoring & Remediation*, 38(1), 56-65.
- DTD (Directed Drilling Technologies) (2004). Horizontal Environmental Well Design and Installation. Available at: https://horizontaldrill.com/wp-content/uploads/2016/04/DTD_Horizontal_EnvWell_Handbook.pdf.
- EPA (U.S. Environmental Protection Agency) (2024). Horizontal Remediation Wells. Available at: https://clu-in.org/techfocus/default.focus/sec/Horizontal_Remediation_Wells/cat/Overview/.
- Feng, C., Kong, L., Wang, Y., Gu, A., Huang, X. (2023). Testing of a novel multi-branch horizontal well remediation technology for in situ remediation of contaminated soil and groundwater. *Journal of Environmental Management*, 344, 118583, 1-12.
- Holloway, O.G., Waddell, J.P. (2008). Design and Operation of a Borehole Straddle Packer for Ground-Water Sampling and Hydraulic Testing of Discrete Intervals at U.S. Air Force Plant 6, Marietta, Georgia. U.S. Geological Survey Open-File Report 2008-1349, 1-24.
- Ke, Q., Guo, C., Wang, F., Chu, X., Zhai, K. (2024). Investigations on the seepage characteristics of polymer grouting body for repairing HDPE geomembrane defects based on LF NMR. *Construction and Building Materials*, 414, 135004.
- Lee, F., Jones-Lee, A. (1994). A groundwater protection strategy for lined landfills. *Environmental Science and Technology*, 28(13), 584A-585A.
- Muller, K.A., Johnson, C.D., Bogwell, C.E., Truex, M.J. (2021). Methods for delivery and distribution of amendments for subsurface remediation: a critical review. *Groundwater Monitoring & Remediation*, 41(1), 46-75.
- Pulido, G., Ballester, T.P., Kinner, N.E. (2004). Multipurpose packer system. NGWA Fractured Bedrock Aquifers Conference, Portland, Maine, 809-823.
- Rosansky, S. (2020). Application of Horizontal Wells to Enhance Site Remediation. Naval Facilities Engineering Systems Command Engineering & Expeditionary Warfare Center, Technical Report TR-NAVFAC-EXWC-EV-2103.
- Simcore Software (2025). Processing MODFLOW 8. Available at: <https://www.simcore.com/wp/>.
- Zheng, C., Wang, P.P. (1999). MT3DMS: A Modular Three-Dimensional Multi-Species Transport Model for Simulation of Advection, Dispersion, and Chemical Reactions of Contaminants in Groundwater Systems; Documentation and User's Guide. U.S. Army Engineer Research and Development Center, U.S. Army Corps of Engineers, Contract Report SERDP-99-1, Vicksburg, Mississippi.

Salt Lake City, Utah

SAVE THE DATE

AIPG National Conference

SEPTEMBER 25-28, 2027



VOLUNTEERS WANTED

Contact Cathy Duran: cld@aipg.org



HAVE IDEAS FOR THE EVENT?

We'd Love Your Input.

Controls on Widespread Platform-Scale Dolomitization in Paleozoic Carbonate Systems

Mossbah M. Kolkas, CPG-10180

Abstract

Laterally extensive dolostone deposits are a defining characteristic of many Paleozoic carbonate successions, yet such platform-scale dolomitization is rarely observed in modern depositional environments. This apparent evidence reflects fundamental differences between Paleozoic and modern Earth systems, including seawater chemistry, continental configuration, paleoclimate, and the duration of diagenetic processes. This paper synthesizes geochemical, sedimentological, biological, and tectonic controls that collectively explain the widespread occurrence of dolomite during the Paleozoic Era. Elevated seawater Mg/Ca ratios, the prevalence of broad epicontinental seas, arid climatic conditions, and long-lived reflux of magnesium-rich evaporative brines created optimal conditions for regionally extensive replacement of calcite by dolomite. From an applied perspective, Paleozoic dolomitization exerts first-order control on porosity evolution, permeability architecture, and subsurface fluid-flow behavior. As a result, understanding the origin and distribution of dolostones is critical for petroleum exploration, groundwater resource evaluation, and subsurface reservoir management.

Keywords: Dolomite, Paleozoic Era, Carbonate deposits, Mg/Ca ratio, Carbonate diagenesis

Introduction

Dolomite constitutes a major component of Paleozoic carbonate platforms and commonly exhibits remarkable lateral continuity across entire sedimentary basins. In contrast, modern carbonate environments rarely produce extensive dolomite bodies, and most contemporary dolomite forms only in restricted settings or at very small spatial scales. This discrepancy has long been recognized and reflects profound differences in seawater chemistry, basin architecture, paleoclimate, and diagenetic time between Paleozoic and modern Earth systems (Hardie, 1996; Machel, 2004). Rather than representing anomalous or unusual processes, widespread Paleozoic dolomitization appears to record normal diagenetic responses to long-lived, basin-scale environmental conditions.

For professional geologists, dolomitization is far more than an academic problem. The replacement of limestone by dolomite commonly modifies primary depositional fabrics, enhances or degrades porosity, alters mechanical strength, and reorganizes permeability networks. In petroleum systems, dolostones frequently host major hydrocarbon accumulations, while in hydrogeologic settings, they commonly form productive but highly heterogeneous aquifers (Lucia, 2007). This paper summarizes the main factors controlling large-scale dolomitization during the Paleozoic Era and explains how these factors affect subsurface characterization, reservoir prediction, and fluid flow modeling.

Seawater Chemistry as a Primary Control

Geochemical reconstructions of Phanerozoic seawater chemistry indicate that the Paleozoic Era was dominated by prolonged intervals of elevated Mg/Ca ratios, often referred to as “aragonite

seas” (Hardie, 1996; Stanley and Hardie, 1998). An aragonite sea is seawater with high Mg/Ca (>2), promoting precipitation of aragonite and high-Mg calcite instead of low-Mg calcite. Under such conditions, the precipitation of low-magnesium calcite is inhibited, while magnesium availability for diagenetic replacement reactions is significantly increased. High Mg/Ca seawater, therefore, provided a necessary chemical prerequisite for large-scale dolomitization once seawater or modified marine fluids entered carbonate platforms.

Plate-tectonic processes exerted a fundamental control on long-term seawater chemistry and, consequently, on the distribution of dolomitization through geologic time. Variations in global seafloor spreading rates directly influenced the intensity of hydrothermal circulation at mid-ocean ridges. During intervals of reduced spreading, common throughout much of the Paleozoic, hydrothermal exchange between seawater and newly formed oceanic crust was diminished. Because ridge-axis hydrothermal systems act as major sinks for magnesium through high-temperature water/rock reactions to form basaltic oceanic crust, lower spreading rates resulted in reduced magnesium removal from seawater. Over multimillion-year timescales, this imbalance allowed dissolved Mg concentrations, and therefore seawater Mg/Ca ratios, to increase (Lowenstein et al., 2001).

Elevated Mg/Ca ratios fundamentally altered the chemical conditions of marine carbonate systems. Higher magnesium availability increased the thermodynamic favorability of dolomite precipitation and replacement reactions. When these seawater conditions coincided with widespread, long-lived carbonate

Table 1. Paleozoic Mg/Ca Timeline (After Hardie, 1996)

Period	Approximate Mg/Ca Ratio	Ocean Chemistry Type
Early Cambrian	2.5 - 3.0	Aragonite Sea (High Mg)
Ordovician - Devonian	0.5 - 1.5	Calcite Sea (Low Mg)
Carboniferous - Permian	Rising to more than 3.5	Aragonite Sea (Rising Mg)

platforms, characteristic of many Paleozoic passive-margin and epicontinental settings, large volumes of platform carbonates were exposed to circulating marine and reflux-derived fluids. Sustained fluid/rock interaction under Mg-enriched conditions promoted pervasive dolomite replacement, producing laterally extensive dolostone bodies rather than isolated or stratigraphically restricted dolomitized zones.

From an applied perspective, this tectonically mediated control on seawater chemistry introduces a strong stratigraphic signal in the global distribution of dolostones. Because seawater composition varied systematically through time, dolomitization was not random but preferentially concentrated within specific Paleozoic intervals characterized by elevated Mg/Ca ratios. The Paleozoic actually saw its own fluctuations. It began with an "Aragonite Sea" (high Mg/Ca), shifted to a "Calcite Sea" (low Mg/Ca) in the mid-Paleozoic, and returned to high Mg/Ca by the late Paleozoic (Table 1). This temporal predictability provides a powerful framework for basin-scale reservoir correlation. In exploration and reservoir characterization, recognizing these stratigraphic controls reduces uncertainty by linking dolostone occurrence to global geochemical cycles and tectonic regimes, thereby improving predictions of reservoir presence, quality, and lateral continuity.

Kinetic Controls on Carbonate Dissolution, Precipitation, and Dolomitization

Mineral-fluid interactions in sedimentary and hydrogeologic systems are governed not only by thermodynamic equilibrium, but also by reaction kinetics, commonly referred to as the "kinetic effect". In many natural carbonate systems, fluids may be undersaturated or supersaturated with respect to calcite or dolomite, yet mineral reactions proceed slowly due to kinetic inhibition. This behavior is especially important in applied geology contexts, including reservoir characterization, groundwater geochemistry, and carbonate diagenesis (Figure 1).

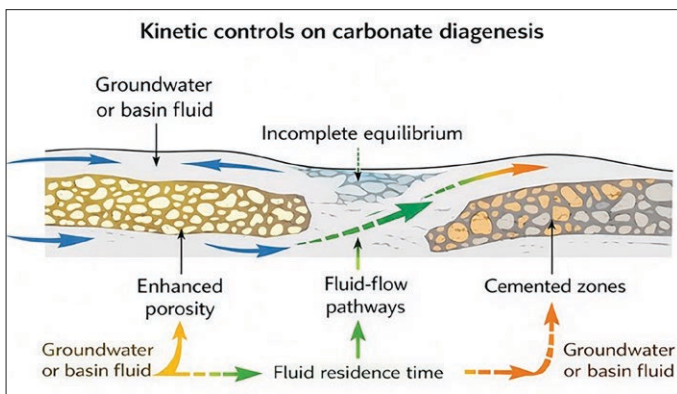


Figure 1. Conceptual model illustrating kinetic controls on carbonate diagenesis, including fluid-flow pathways, residence/time effects, incomplete equilibrium, porosity enhancement, and cemented zones (Modified from Whitaker et al., 2004; Lasaga, 1998).

- a. The rate of mineral dissolution under undersaturated conditions can be expressed as:

$$\frac{dc}{dt} = k_m (C_s - C)^n \quad (C < C_s) \quad (\text{Lerman, 1979})$$

The equation describes the kinetic rate of mineral dissolution or chemical species release into an aqueous solution, specifically stating that the rate of change in concentration (dc/dt) is proportional to the difference between the saturation concentration (C_s) and the current concentration (C) of the solute. The term ($C_s - C$) represents the degree of undersaturation, the "driving force" of the reaction, where a higher gap between saturation and actual concentration leads to faster dissolution. The parameter (k_m) is the rate constant, which accounts for factors such as surface area and reactivity, while the exponent (n) which is often close to 1 defines the reaction order, indicating how the rate slows as the solution approaches equilibrium. In conclusion, the condition $C < C_s$ clarifies that this specific formula applies to net dissolution, meaning the solid is actively dissolving into the water rather than precipitating out of the solution.

- b. The rate of mineral dissolution under saturated conditions can be expressed as:

$$\frac{dc}{dt} = k_p (C - C_s)^n \quad (C > C_s) \quad (\text{Lerman, 1979})$$

This equation describes the rate of precipitation, where the change in concentration over time (dc/dt) is determined by the difference between the current concentration and the saturation point. The term ($C - C_s$) represents the supersaturation driving force, while the rate constant (k_p) and the exponent (n) account for the specific kinetics of the reaction. In case if the condition $C > C_s$ is met, the negative sign indicates a decrease in solution concentration as the excess solute leaves the liquid phase to form a solid phase such as crystal formation from the pre-existing solution (Figure.2).

Implications for Carbonate Diagenesis and Dolomitization

Kinetic limitations provide a fundamental explanation for the widespread occurrence of metastable carbonate phases and the incomplete dolomitization of carbonate platforms. Although modern seawater and many burial fluids are thermodynamically favorable for dolomite formation, dolomite precipitation is kinetically inhibited by the strong hydration energy of Mg^{2+} ions and slow crystal nucleation rates (Land, 1985; Morse and Mackenzie, 1990). As a result, dolomitization typically requires elevated temperatures, prolonged fluid/rock interaction, or enhanced fluid flux to overcome kinetic barriers (Machel, 2004; Warren, 2000).

Dolomitization is kinetically controlled within a fractured limestone platform. Mg-rich fluids migrate through fractures and permeable bedding planes, creating focused fluid-flow pathways where dolomite replacement occurs preferentially (Figure 3).

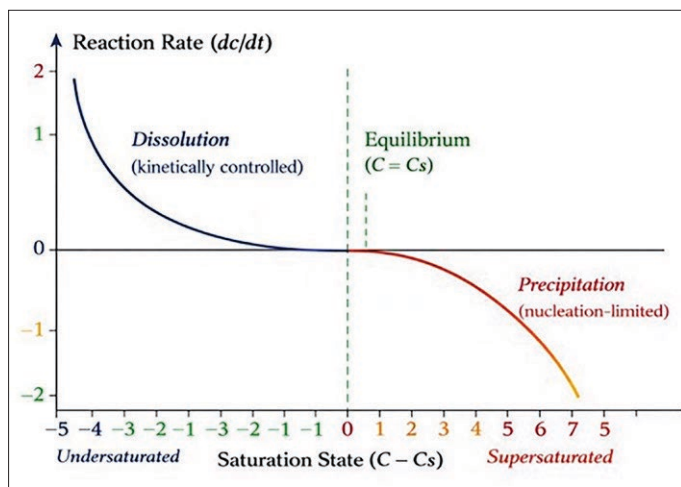


Figure 2. Conceptual relationship between reaction rate (dc/dt) and saturation state ($C - C_s$), illustrating kinetically controlled dissolution under undersaturation and nucleation-limited precipitation under supersaturation. Positive values (above zero) mean dissolution, mineral is dissolving into solution, and concentration in water increases. Zero value means the system is in equilibrium (no net dissolution or precipitation). Negative values (below zero) mean precipitation, mineral is forming from solution, and concentration decreases (Modified from Lasaga, 1998).

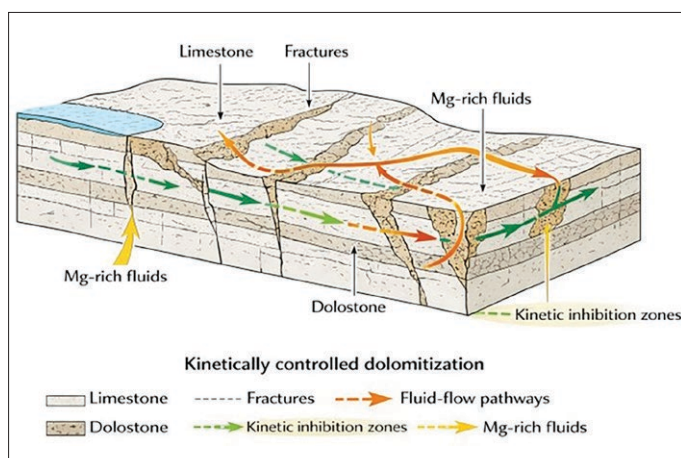


Figure 3. Conceptual model of kinetically controlled dolomitization in fractured limestone showing Mg-rich fluid pathways, reaction fronts, and kinetic inhibition zones (Modified from Whitaker et al., 2004).

Dolomite forms along these high-flux conduits, while adjacent limestone remains only partially altered due to limited fluid access and slow reaction rates. In Figure 3, the labeled “kinetic inhibition zones” represent areas where dolomitization is thermodynamically feasible but proceeds too slowly to achieve complete replacement. As a result, dolomitization is spatially heterogeneous and strongly governed by permeability architecture and reaction kinetics rather than fluid availability alone. This kinetic framework accounts for the spatially heterogeneous distribution of dolomite observed in Paleozoic carbonate successions, a feature of direct relevance to applied petroleum and environmental geology.

Platform Architecture and Basin-Scale Fluid Circulation

Paleozoic continents were repeatedly flooded by vast, shallow epicontinental seas characterized by extremely low depositional

gradients and minimal bathymetric relief (Sloss, 1963). Carbonate platforms extended across stable cratonic interiors and persisted for tens of millions of years with relatively little tectonic disruption. These conditions promoted thick accumulation of laterally continuous, permeable carbonate sediments capable of transmitting fluids over basin-wide distances (Figure 4). Such platform geometries fundamentally influenced diagenetic fluid circulation. Unlike modern rimmed platforms, where fluid flow is commonly localized

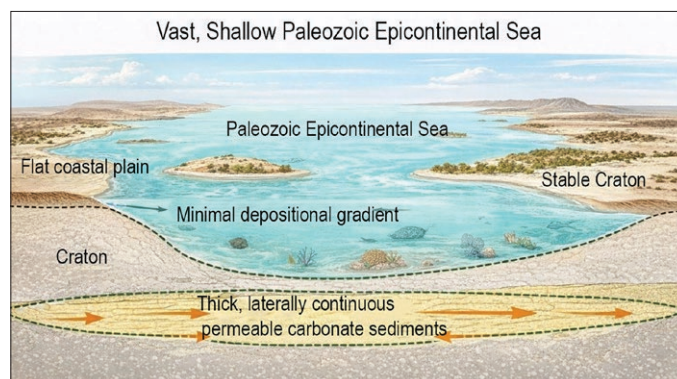


Figure 4. Paleozoic continental flooding by shallow epicontinental seas characterized by low depositional gradients, minimal bathymetric relief, and thick, laterally continuous permeable carbonate sediments capable of fluid flow over basin-wide distances (Modified from Sloss, 1963).

and topographically restricted, Paleozoic platforms favored efficient lateral and vertical movement of seawater-derived fluids. As a result, dolomitization fronts (geochemical boundaries between advanced dolomite and the unaltered limestone) were able to propagate across entire platform interiors rather than remaining confined to marginal or restricted environments (Zenger et al., 1980). For subsurface applications, the architecture of these platforms directly governs the size, continuity, and connectivity of dolostone bodies, making platform-scale depositional models essential inputs for reservoir and aquifer simulations.

Paleoclimate and Reflux Dolomitization

Paleogeographic reconstructions indicate that large portions of Paleozoic carbonate platforms developed under arid to semi-arid climatic regimes, particularly during greenhouse intervals (Scotese, 2001). High evaporation rates on restricted portions of these platforms produced dense, magnesium-rich brines. These brines are denser than normal seawater. Consequently, brines migrate downward through underlying carbonate sediments in a process known as reflux dolomitization (Adams and Rhodes, 1960). Repeated reflux events operating over millions of years result in regionally extensive, strata-bound dolostone bodies, commonly associated with evaporitic minerals such as anhydrite and gypsum (Machel, 2004). The vertical migration of refluxing fluids produces systematic dolomitization patterns, often characterized by vertically zoned porosity and permeability distributions (Figure 5). In applied settings, such reflux-related dolostones frequently form predictable stratigraphic traps and flow units, making them particularly important targets in hydrocarbon exploration and groundwater development.

Sediment Type, Bioactivities, and Diagenetic Period

The nature of Paleozoic carbonate sediments further enhanced their susceptibility to dolomitization. Early Paleozoic carbonate systems were dominated by microbial carbonates and fine-grained carbonate muds, with comparatively limited skeletal carbonate

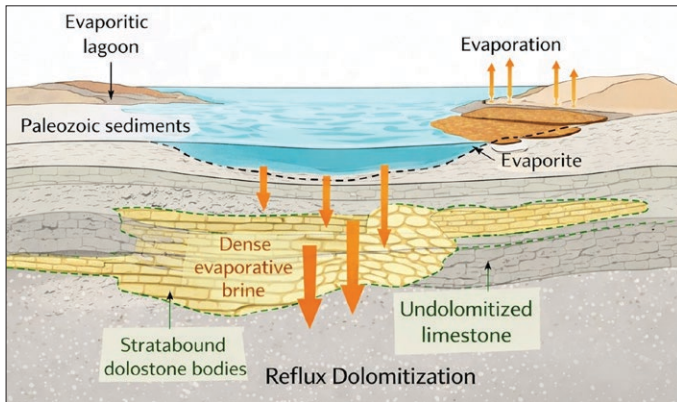
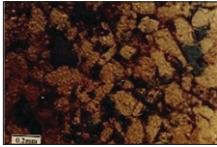
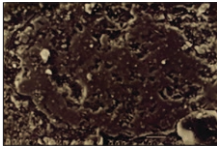


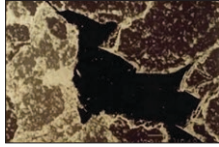
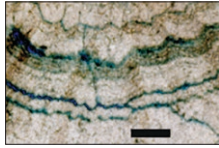
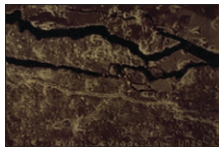
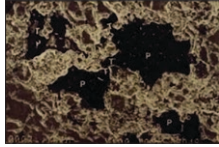
Figure 5: Conceptual model of reflux dolomitization on a Paleozoic carbonate platform showing evaporative brine generation, downward reflux, and stratabound dolostone development (Modified from Adams and Rhodes, 1960).

production relative to the Late Paleozoic systems (Riding, 2000). These fine-grained, mud-rich sediments had high surface-area-to-volume ratios and were chemically reactive, making them especially favorable for dolomitization.

Dolomitization reactions are kinetically slow at near-surface temperatures, and extensive replacement typically requires prolonged fluid–rock interaction. Paleozoic carbonate strata underwent hundreds of millions of years of burial, heating, uplift, and repeated fluid flow events. This extended diagenetic history allowed early, incomplete dolomitization to progressively evolve into well-ordered, stoichiometric dolomite, in which the molar ratio of Ca:Mg = 1:1 to form dolomite ($\text{CaMg}(\text{CO}_3)_2$) (Land, 1985). For reservoir characterization, this multi-stage history explains the common occurrence of complex pore systems and highly variable reservoir quality within single dolostone units, even where stratigraphic continuity is maintained (Table 2).

Table 2. Multi-Stage Diagenetic Evolution of Platform Dolostones

Depositional Stage	Primary interparticle & intraparticle porosity, Moderate connectivity, Baseline reservoir quality
	 Photomicrograph of a thin section under plane-polarized light, showing interparticle porosity. Bar scale = 0.25 mm (Paleozoic of Western New York State).
Marine Diagenesis	Cementation & early dolomitization Intracrystalline microporosity development Partial pore occlusion
	 Scanning-electron micrograph of a thin section showing intracrystalline microporosity. Bar scale = 10 μm. (Paleozoic of Western New York State).

Burial Dolomitization	Replacement & recrystallization Moldic and intercrystalline porosity with patchy permeability enhancement
	 Section-electron micrograph of a thin section showing intercrystalline porosity. Bar scale = 10 μm.
	 Section-electron micrograph of a thin section showing intercrystalline porosity. Bar scale = 10 μm. (Paleozoic of Western New York State).
Deep Burial/ Hydrothermal activities	Compaction, stylolitic fracturing, and cement occlusion with dual-porosity development
	 Photomicrograph of a thin section under plane-polarized light, showing stylolitic fracturing and cement occlusion. Bar scale = 0.25 μm (Paleozoic of Western New York State).
Uplift Telogenesis	Meteoric dissolution Vuggy & fracture porosity, Localized high permeability zones
	 Photomicrograph of a thin section under plane-polarized light, showing fracture porosity. Bar scale = 0.25 μm (Paleozoic of Western New York State).
	 Photomicrograph of a thin section under plane-polarized light, showing vuggy porosity. Bar scale = 0.25 μm (Paleozoic of Western New York State).

Comparative Porosity Evolution During Burial

The comparative evolution of porosity in limestone and dolostone with increasing burial depth is illustrated in Figure 6. Both lithologies exhibit a systematic decrease in porosity as depth increases, driven by mechanical compaction and chemical diagenesis; however, they follow distinct trends. Limestone begins with a relatively high initial porosity (approximately 45%) at shallow burial and undergoes a rapid exponential decline, reflecting its greater susceptibility to compaction and pressure solution. In contrast, dolostone starts with a lower initial porosity (approximately 30%) and shows a more gradual reduction with depth, indicating comparatively greater resistance to compaction (Figure 6).

At depth of approximately 1,000 meters, the porosity of both lithologies converges at around 20%, after which dolostone retains higher porosity than limestone at greater burial depths. By about 5,000 meters in depth, limestone porosity approaches near-zero values, whereas dolostone preserves about 5% porosity (Figure

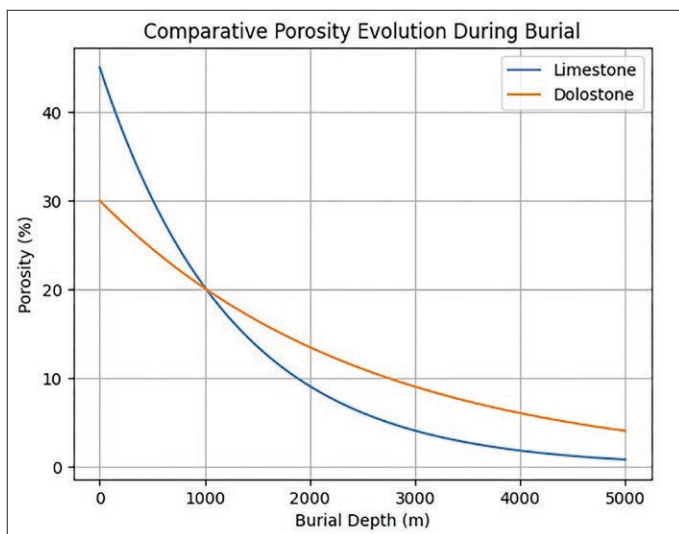


Figure 6: Porosity/depth graphs of limestone and dolostone that illustrate the schematic porosity evolution during burial as it is reported in carbonate diagenesis literature (Modified from Choquette & Pray, 1970; Moore, 2001).

6). Overall, the diagram highlights the critical role of mineralogy and diagenetic processes in controlling long-term reservoir quality during burial, with dolostone commonly maintaining superior porosity under deep-burial conditions compared to limestone.

Implications for Petroleum Geology and Hydrogeology

Dolomitization plays a critical role in controlling subsurface fluid storage and flow, with important implications for both petroleum geology and hydrogeology. When dolomite replacement occurs prior to significant mechanical compaction, it typically enhances high intercrystalline porosity and permeability compared to the original limestone. However, if dolomitization takes place at a later stage, it is often accompanied by cementation and porosity occlusion, which can reduce permeability and create internal heterogeneities or barriers to fluid flow within carbonate sequences.

In petroleum systems, Paleozoic dolostones frequently serve as primary reservoirs, migration pathways, and key elements of combined structural and stratigraphic reservoirs. In hydrogeologic settings, these rocks commonly form highly productive aquifers that exhibit pronounced anisotropy, meaning their hydraulic properties vary depending on the direction of fluid flow. Fluid movement is strongly influenced by the distribution of dolomitization fronts, where porosity and permeability may change abruptly, as well as by fracture networks and diagenetic textures. Therefore, accurately predicting reservoir and aquifer performance requires careful consideration of both the mechanisms and timing of dolomitization during subsurface evaluation.

Conclusions

The widespread occurrence of dolostone in Paleozoic carbonate platforms reflects Earth-system conditions fundamentally different from those of the modern world. Elevated seawater Mg/Ca ratios provided the geochemical foundation for large-scale dolomite formation, while broad epicontinental platforms and arid paleoclimates enabled efficient reflux and circulation of magnesium-rich fluids. Critically, long diagenetic histories allowed slow dolomitization reactions to proceed toward completion at basin scales. These combined processes exert first-order control on reservoir and aquifer properties, making recognition of Paleozoic

dolomitization mechanisms essential for applied geology, including petroleum exploration, groundwater assessment, and subsurface resource management.

Acknowledgments

I extend my sincere appreciation to Mr. Adam Heft for his valuable feedback and constructive comments during the review of this paper. I am also deeply grateful to my family, Nahla, Omar, Minnah, Hanna, and Salma, for their unwavering support, patience, and encouragement throughout the development of this work.

References

- Adams, J.E., and Rhodes, M.L., 1960. Dolomitization by seepage refluxion. *American Association of Petroleum Geologists Bulletin*, 44, 1912–1920.
- Choquette, P.W., and Pray, L.C., 1970. Geologic nomenclature and classification of porosity in sedimentary carbonates. *AAPG Bulletin*, 54, 207–250.
- Hardie, L.A., 1996. Secular variation in seawater chemistry: An explanation for the coupled secular variation in the mineralogies of marine limestones and potash evaporites over the past 600 m.y. *Geology*, 24, 279–283.
- Land, L.S., 1985. The origin of massive dolomite. *Journal of Geological Education*, 33, 112–125.
- Lasaga, A.C., 1998. *Kinetic Theory in the Earth Sciences*. Princeton University Press, 811 p.
- Lerman, A., 1979. *Geochemical Processes: Water and Sediment Environments*. Wiley-Interscience, 481 p.
- Lowenstein, T.K., Hardie, L.A., Timofeeff, M.N., and Demicco, R.V., 2001. Secular variation in seawater chemistry over the Phanerozoic: Evidence from fluid inclusions. *Science*, 294, 1086–1088.
- Lucia, F.J., 2007. *Carbonate Reservoir Characterization*, 2nd ed. Springer, 336 p.
- Machel, H.G., 2004. Concepts and models of dolomitization: A critical reappraisal. *Geological Society of London Special Publication*, 235, 7–63.
- Moore, C.H., 2001. *Carbonate Reservoirs: Porosity Evolution and Diagenesis in a Sequence Stratigraphic Framework*. Elsevier, 444 p.
- Riding, R., 2000. Microbial carbonates: The geological record of calcified bacterial–algal mats. *Sedimentology*, 47 (Suppl. 1), 179–214.
- Scotese, C.R., 2001. *Atlas of Earth History, Volume 1: Paleogeography*. PALEOMAP Project, Arlington, Texas.
- Sloss, L.L., 1963. Sequences in the cratonic interior of North America. *Geological Society of America Bulletin*, 74, 93–114.
- Stanley, S.M., and Hardie, L.A., 1998. Secular oscillations in carbonate mineralogy of reef-building organisms driven by tectonically forced shifts in seawater chemistry. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 144, 3–19.
- Warren, J., 2000. Dolomite: Occurrence, evolution and economically important associations. *Earth-Science Reviews*, 52, 1–81.
- Whitaker, F.F., Smart, P.L., and Jones, G.D., 2004. Dolomitization: From conceptual to numerical models. *Geological Society of London Special Publication*, 235, 99–139.
- Zenger, D.H., Dunham, J.B., and Ethington, R.L., eds., 1980. *Concepts and Models of Dolomitization*. SEPM Special Publication 28.

Financial Planning for Geologists, Built for the Field — and Beyond

Your work spans terrains, sectors, and economic cycles. But while your expertise is specialized, financial guidance built for geologists is rare.

**Exclusive AIPG member benefit:
15% off wealth management fees**

Mercer Advisors partners with AIPG members to deliver wealth management guidance designed for the realities of your profession. As your career shifts — from fieldwork to leadership, consulting to retirement — your financial strategy should evolve with it. Schedule a complimentary meeting to learn how we help geologists build financial clarity and long-term stability.

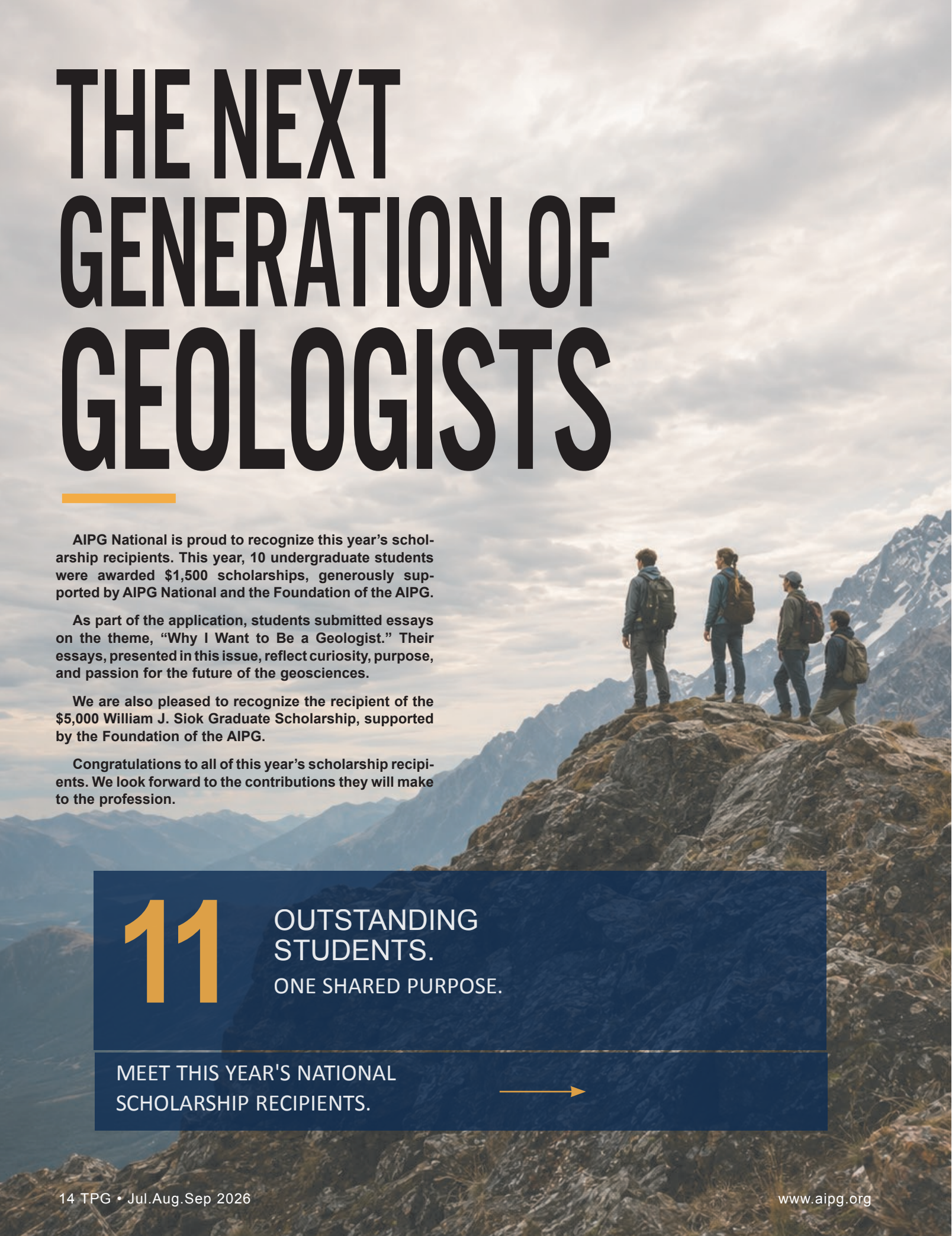
- **Integrated retirement strategy:** Consolidate 401(k)s and retirement accounts into a unified, forward-looking plan.
- **Income and cash flow resilience:** Navigate project-based earnings and market volatility with structured, adaptable strategies.
- **Tax-efficient wealth planning:** Align investment, tax, and risk management decisions to help protect and grow your income.

Learn how Mercer Advisors helps professional geologists.

Scan the QR code to schedule a complimentary consultation and secure your 15% discount.



THE NEXT GENERATION OF GEOLOGISTS



AIPG National is proud to recognize this year's scholarship recipients. This year, 10 undergraduate students were awarded \$1,500 scholarships, generously supported by AIPG National and the Foundation of the AIPG.

As part of the application, students submitted essays on the theme, "Why I Want to Be a Geologist." Their essays, presented in this issue, reflect curiosity, purpose, and passion for the future of the geosciences.

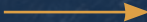
We are also pleased to recognize the recipient of the \$5,000 William J. Siok Graduate Scholarship, supported by the Foundation of the AIPG.

Congratulations to all of this year's scholarship recipients. We look forward to the contributions they will make to the profession.

11

OUTSTANDING
STUDENTS.
ONE SHARED PURPOSE.

MEET THIS YEAR'S NATIONAL
SCHOLARSHIP RECIPIENTS.



UNDERGRADUATE SCHOLARSHIP RECIPIENTS



JOHN G. BRADLEY
SA-13129

**CEDARVILLE
UNIVERSITY**

"There is a revolution happening in the world of geology."



**MUHAMMAD
RAFFAY CHAUDHRY**
SA-12658

**UNIVERSITY OF
WISCONSIN -
GREEN BAY**

"Geology to me was like water to a parched person lost in the Sahara; I needed it most."



SOFIA COMAS
SA-13222

**UNIVERSITY OF
ILLINOIS -
URBANA-
CHAMPAIGN**

"I owe my introduction to earth sciences and geology in general to my seventh-grade environmental science teacher."



ANNA HEIKES
SA-12114

**TRINITY
UNIVERSITY**

"Now I know this work may also help me protect lives."



TEAGAN JONES
SA-12980

**ARKANSAS TECH
UNIVERSITY**

"Everything changed when I took my first geology class."



CLAIRE LOEFFLER
SA-12598

**OHIO STATE
UNIVERSITY**

"I discovered how fieldwork brings geology to life."



EMMA MARIN
SA-12552

**CUNY
BROOKLYN
COLLEGE**

"We, as Earth Scientists, have the ability to make our cities a safer, more environmentally just place to live."



JESS MAYNARD
SA-13229

**CENTRAL
WASHINGTON
UNIVERSITY**

"I remember very clearly one of the first geologic field trips I took as a kid."



SARA WU
SA-13180

**CALIFORNIA
STATE UNIVERSITY**

"My principal delight in geology is the ruthless investigation required to practice it."



MIGUEL YANEZ
SA-13237

**CALIFORNIA
STATE UNIVERSITY
STANISLAUS**

"For me, my skills and passions are best applied as a geologist and educator."



“

A new generation of scientists are passionately taking the keys to the city and opening its gates to a new frontier.”

JOHN G.

BRADLEY

SA-13129 Cedarville University

Every major productive and intellectual revolution in the history of the world has been spearheaded by revolutions in the world of geology. The ages of bronze and iron were preceded by the discovery of bronze and iron, and the perfection of working with the metals. The Industrial Revolution was kickstarted by the use of coal as an energy source. The Scientific Revolution began with an interest in studying the planet and its resources. These examples, and more, are evidence that studying geology is a gateway to changing the world. I believe that a revolution is happening today, and the world would be naive to ignore it. I also believe that, as has been the pattern in history, geology is yet again at the forefront of this revolution.

The field of geology is at a major point in the history of science. A new generation of scientists are passionately taking the keys to the city and opening its gates to a new frontier. The field is beginning to change, and the rest of the world awaits anxiously to see the evolution of ideas. The revolutionaries: young men and women all over the world, all together different, but rallying together around the pursuit of the truth. This new generation of geologists will not settle for accepting the status quo, swimming downstream and living life for the next weekend. Rather this new generation is one that chases after the truth as a lion chases down a gazelle, hungry for its next meal. Our revolutionaries do not use swords or guns, but their minds. They search out new ideas like a squirrel searches for acorns, and upon finding one plant it in the ground and move on to finding a new one. Discovery is no longer a mountain yet to be climbed, but one that is traveled routinely by eager scholars. There is a revolution happening in geology, and truth is their weapon.

While it is tempting to think that a geologic revolution begins in the field, it is clear that revolutions begin in the classroom. Because of this, my passion lies in geology education of the people that will turn the world upside down. While it is important that there are people in the world to advance our knowledge of

the world, it is equally important that there are people who are passionate enough to pass on the baton to the future generations that will continue the legacy that we began. Education is such an important aspect of geology. Through education we learn more than the rock cycle and phase diagrams, although we do learn these things. We learn things like critical thinking, deciphering truth, and finding important information. These are all skills that go far beyond a useful skillset for a geologist and can be used in all aspects of life. These are the skills that are routinely used in the world of geology, and the same skills that are used to spark change. There is nothing that I love more than being able to show my passion for geology to other people so that they can enjoy the field that I find so important. This information revolution does not simply end with the passing of the torch from our generation of geologists to the next, it grows stronger and louder and continues to shape the world. It is the job of every revolutionary to pass the fire to the next great warrior, fighting for the cause of truth. In this I find my passion, and through the opportunity of education I want to join the people shaping our future.

The world is always evolving. Our future is constantly being reshaped by those audacious enough to change it. None of the major revolutions would have occurred without someone willing to grab the unknown by the reins and ride it into the horizon. There is a revolution happening in the world of geology. I want to study this ever important field because I want to train the revolutionaries of the future that will be on the front lines of the battle to change the world. I love geology, and I love the people who are devoting their lives to study it. Education opens the door for all to participate in a movement that is happening all around the globe. One day, far in the future, as I watch the sun set, I will read of a great new discovery in the world of geology and under it the name of one of my students. In that moment I will know that all that I worked so hard for will have been completed. The truth needs to be taught more than ever, and I see a generation of people running hard after that truth.

“
...I am now drawn
to its applications in
humanitarian labor that
often gets disregarded...”

MUHAMMAD RAFFAY
CHAUDHRY

SA-12658 University of Wisconsin - Green Bay

"Six hundred and forty people found dead as Cyclone Ditwah hits Srilanka," the island's Disaster Management Centre (DMC) reported. In their recent email, AIPG informed its members of the contrast between the 5,000 sites that needed evaluation and the mere 60 geologists available in the country.

Growing up in a collectivist society, living for others has always been a core value in our culture. "To give is to have," my father used to say to me. Although I entered this field for its nature-driven work, I am now drawn to its applications in humanitarian labor that often gets disregarded due to the intense nature of the tasks.

On our walk back from our outdoor soil lab on a bright sunny afternoon at UW-Green Bay, I told Dr. Berns that I am unsure of what I would like to specialize in. Knowing my love for math and physics, she instantly went, "You should explore geophysics." It was easier said than done. Finding geophysics opportunities at my school felt like finding evidence for a flat earth; they did not exist. However, a wise man once said that we all plan, but God is the best of planners. He was right. The next day, my Geoscience professor was approached by facilities asking him to find a water main leakage for them. The rest is history.

Geology to me was like water to a parched person lost in the Sahara; I

needed it most. But I did not choose it only for its high job growth, hands-on applicability, and challenging nature; I picked Geology because my brother couldn't. He loved nature as he loved us, but his geographical disadvantage made sure he never knew that fields like Geology, Ecology, and Environmental Science existed. He went into the business route, just like I would have if my first friend in college wasn't an Earth Science enthusiast.

I have come far. As I prepare for my graduation and PhD from the best programs in the world, my parents have begun to understand my pursuit of this "unconventional field." They believe that as long as "to give is to have" is at the forefront of my dreams, I could never fail.

Thus, when I read *Seismology: Earthquakes: Understanding and Predicting Seismic Events* by Mike Crawford, I, for the first time, knew the coordinates for the destination I was heading to. Caltech is now my first choice, with its Seismological Laboratory celebrating a hundred and three years of excellence today. I believe I have what it takes to change the course of this field: a burning drive, a strong "why", and the ability to be the hardest working person in any room. Someday in the future, I hope to retire and show others in Pakistan how big the world is and how much of it is kept from us.



UNIVERSITY of WISCONSIN
GREEN BAY



“

In the sandstones,
the limestones,
the shales, and
fossils embedded
in them, there
was an entire
story...”



SOFIA COMAS

SA-13222

UNIVERSITY OF ILLINOIS - URBANA-CHAMPAIGN

As is true for many geologists and earth scientists, I found myself drawn to nature as a child, curiosity always pushing me to explore the out-of-sight: the worms in the dirt, the view from up on tree branches, the rocks beneath the water. However, growing up in Chicago, I was more removed from the outdoors than I would've liked. Indoors, I loved to immerse myself in worlds painted so vividly by the words in my books, and I enjoyed solving all kinds of puzzles, piecing together the larger picture, and identifying patterns to help me do so. Paired with my early passion for science and math, it was clear from the start that my future lay in science and some form of research.

I owe my introduction to earth sciences and geology in general to my seventh-grade environmental science teacher. His class covered a variety of topics, including the basics of geology. We started the geology unit with rock type classification, examining and identifying various hand samples of sedimentary, igneous, and metamorphic rocks. I remember clear as day the gears turning in my head as my teacher explained how properties like hardness, luster, and streak could help us identify minerals and how grain size, sorting, and rounding gave us information on the history of the rock. I remember feeling that ever-famous 'click' in my head and the rush of excitement that filled my heart – there were endless stories to be told by the seemingly simple rocks around me, and even with my beginner-level knowledge, a whole new world had opened up to me.

I spent the rest of the day anxious to get home, wanting nothing more than to examine all the rocks I could find in my house, from my collection I'd picked up over the years to the decorative ones in the living room. I talked endlessly to my mother that night, explaining how the large grains in our granite countertop meant the rock had cooled within the earth, how the round pebbles I'd picked up from a stream had travelled far from their original location, eroded by the water over an incredible amount of time. I had gotten a taste of the stories hidden in the rocks, and I was hungry for more.

In the following years, I would find myself always staring a little too long at the ground, at the trees and the sidewalks, trying to erase what my eyes were seeing and willing the past to reveal itself to me. I wanted nothing more than to see what lay here before the city, before the swampy marsh, before human settlements on the continent. I wondered how many different landscapes had covered the exact place I was standing. This feeling persisted throughout high school, and I wanted to learn everything there was to know about rocks and what they could tell me. So, when it came time to apply for college, I knew I had to study geology.

My introductory physical geology course instantly brought back that feeling of excitement I had felt years before. With every lecture I attended, I knew I was on the right path. When we got to sedimentary processes, stratigraphy, and depositional environments, I realized that what I had always thought was out of reach, the landscapes I desperately longed to see, were right in front of and below me. There was so much more to geology than I had ever thought; there was so much to learn and discover in the sedimentary formations. In the sandstones, the limestones, the shales, and fossils embedded in them, there was an entire story laid out for those with the knowledge to interpret it.

Since then, my heart has been set on discovering the past environments hidden in the stratigraphic record and using sedimentology and paleontology to do so. It influenced me to begin research with my advisor on marine invertebrates in Cincinnati and get a job at the Illinois State Geological Survey, working with cores and stratigraphic descriptions. Now in my junior year of college, I'm taking sedimentology and paleobiology, honing my skills in these fields to prepare for grad school. As I enter the final stretch of my undergraduate career, I'm setting myself up to be the best paleontologist and sedimentologist I can be. I know the rest of my academic life will be dedicated to uncovering these almost alien ecosystems and environments that once covered the Earth, and I can't wait to share it with the rest of the world.



“I will utilize my fieldwork and academic skills to help bridge the gap between geologic knowledge and public action.”

ANNA HEIKES

SA-12114

Trinity University

I knew I wanted to be a geologist since I took my first class, but it wasn't until my senior year that I fully grasped the human impact of the subject. This past summer, I surveyed damage with the U.S. Geological Survey (USGS) after the devastating July 4th flood in Kerrville, TX. The flood tore through homes and ranches in an instant, claiming over 130 human lives. I looked at the makeshift crosses on the side of the riverbank, and I realized my career wasn't just a livelihood, but could mean the difference between life and death. As an aspiring hydrologist, I've always wanted to safeguard water resources. Now I know this work may also help me protect lives.

I took an important step in my journey of becoming a hydrologist my sophomore year, when I researched the mechanisms behind uranium contamination in the High Plains and Central Valley aquifers. These two major aquifers supply millions of Americans with clean drinking water. Wanting to connect my research to the hydrologic challenges facing my own community, I interned with the Edwards Aquifer Authority (EAA). The EAA is a regulatory agency responsible for managing the Edwards Aquifer, which supplies all of San Antonio's drinking water. There, I learned that while Texas is one of the fastest growing states in the nation, our water infrastructure and regulatory framework have not kept pace. Aquifers across the state deplete much faster than they are replenished, and the situation becomes more dire every day.

I hoped to be part of the solution by mapping and identifying vulnerable areas to ensure future generations have access to fresh, clean drinking water. But first, I needed to gain fieldwork experience and learn how water data is collected and analyzed.

My current internship with the USGS began in July 2024 and ever since I have dedicated my time outside of class to gaining fieldwork experience. I aid in making measurements of streams, rivers, and groundwater, and publishing that data for the public. I also assist in water quality measurements and lab work. The data I collect is used by regulatory and state agencies to determine pumping limits, aquifer recharge, and other hydrological decisions critical to my community. My home state of Texas has one of the deadliest and highest risks for flash flooding in the nation. In my surveying work, I learned that USGS scientists had been advising local officials in Kerrville to implement flood warning systems for years prior to the July 4th flood. I will utilize my fieldwork and academic skills to help bridge the gap between geologic knowledge and public action.

I want to be a professional geologist by balancing hydrological and human needs to inform policy, guide land use, and enhance water management to prevent the loss of life and infrastructure. My work will create a future where the next generation of Texans can enjoy our beautiful landscapes and rivers without fear.



“It offers a career where curiosity is essential, problem-solving is constant, and contributions truly matter.”

TEAGAN JONES

SA-12980 Arkansas Tech University

My passion for geology began long before I knew what geology was. As a child and into my teenage years, I spent countless days backpacking, camping, and hiking with my family. Those long hours on the trail shaped my earliest memories of quiet mornings overlooking valleys, the weight of a pack on my shoulders, and the excitement of discovering what was around the next bend. I knew I loved nature, but for a long time, I had no idea how to turn that love into a career. I admired the mountains and landscapes I walked through, yet I couldn't imagine a job that connected to the places that meant so much to me.

As I grew older, that uncertainty became harder to ignore. I watched people around me choose majors, commit to paths, and speak confidently about their futures, while I remained directionless. Wanting structure and purpose, I considered joining the Air Force. The clarity of that path appealed to me at a time when I felt I didn't have one of my own. Although I respected the discipline and service it represented, something about it felt disconnected from the person I was becoming. I still held onto my love for nature, even if I didn't yet know how it fit into my future.

Everything changed when I took my first geology class.

Suddenly the mountains I had hiked as a kid were no longer just scenic. They were stories written in stone. The rivers I camped beside were shaped by processes I could now understand. The landscapes I loved held meaning I hadn't known how to look for before. Learning about minerals, rocks, tectonics, and deep time felt like unlocking a language I had unknowingly been exposed to my entire life. For the first time, I saw a career that connected my curiosity, my appreciation for nature, and my desire to understand the world at its most fundamental level. Geology didn't just give me academic interest, it gave me direction, identity, and a sense of belonging.

However, as I progressed through my coursework, my focus sharpened on minerals. Their complexity, structure, and formation fascinated me. Minerals are the archives of the Earth, recording temperature, pressure, chemistry, and history. The more I learned about them, the more I realized how central they are to our modern world. That curiosity naturally led me toward economic geology; specifically critical minerals and ore deposits. These resources form the backbone of renewable energy technology, electronics, transportation, and countless industries. Understanding how they

form and how they can be extracted responsibly is increasingly vital in a world striving for sustainability. Discovering this field felt like finding the perfect intersection of science, real-world impact, and my own natural interests.

My undergraduate research experience further deepened this sense of direction. I worked on a project developing a low-cost, in-situ method for measuring volatile organic compounds (VOCs) in surface waters. Although it was not directly tied to mineral deposits, it challenged me to think like a scientist designing experiments, building instrumentation, collecting field data, and reassessing methods when results didn't match expectations. I learned the patience, creativity, and resilience required to conduct meaningful research. More importantly, I experienced the excitement that comes with uncovering new information. That feeling confirmed that I want to pursue advanced academic training, not just for a degree, but because I genuinely enjoy the process of discovery.

Leadership has also played a significant role in my development as a geoscientist. As President of my university's Geology Club, I have taken on the responsibility of building community, organizing field trips, hosting guest speakers, and supporting students new to the field. Through this role, I've seen firsthand how enthusiasm for geology spreads through shared experiences hammering out a fresh rock sample, mapping a new outcrop, or learning something unexpected during a lecture. Helping other students find their place in geology has strengthened my belief that this field is not just a scientific discipline; It's a community grounded in curiosity, collaboration, and excitement for the natural world.

Ultimately, I want to be a geologist because the field perfectly brings together everything that has shaped who I am. Geology allows me to explore the Earth the way I did as a child, but with the knowledge, tools, and purpose to understand it deeply. It challenges me scientifically while keeping me connected to the landscapes that first inspired me. It offers a career where curiosity is essential, problem-solving is constant, and contributions truly matter.

What began as childhood wonder evolved into uncertainty, then into discovery, and ultimately into purpose. Geology gave me the direction I once felt I lacked, and with it, a clear vision of the career I want to build. I look forward to continuing this journey learning from the Earth, contributing to the field, and sharing the beauty and significance of geology with others.

“

I am drawn to the idea that geologists serve both science and society.”

CLAIRE

LOEFFLER

SA-12598 Ohio State University



Some of my earliest memories come from the backseat of my family's car as we drove down long stretches of open highway. My parents loved road trips, and by the time I was ten, I had traveled through more states than I could count. At the time, I thought I was simply looking out the window. Those trips planted the curiosity that would eventually draw me to geology. One day, we would pass towering red cliffs, and the next, we would move through rolling green hills. I remember thinking the Earth seemed full of secrets, and even though I had no scientific vocabulary then, I sensed that those secrets were written in patterns that could be learned.

When I reached high school, my interest in Earth science solidified. For the first time, I learned the names of the features that fascinated me when I was young. Sedimentary layers, igneous intrusions, and fault lines were no longer just strange shapes in distant cliffs, they were evidence of forces that had been at work long before I was born. As I learned more, I found myself wanting more than a surface-level explanation. I wanted to know how landscapes formed, why rocks developed the textures they did, and what history the planet had recorded over millions of years.

When I entered college, I chose to major in Geology where I found my natural curiosity about the world around me could be studied with scientific precision while maintaining my love for the natural world. I discovered how fieldwork brings geology to life. Standing in front of an outcrop and reading its features like a timeline reminded me of the feeling I had as a child staring out the car window. Now I could interpret those transformations, which made me realize that geology was not just an interest, but the career I had chosen.

Traveling throughout the country at a young age also shaped how I see the relationship between people and the Earth. Many of the places we visited were national parks, protected areas, and communities built near sensitive environments. Geology plays a vital role in understanding natural hazards, managing resources, and supporting sustainable development. I am drawn to the idea that geologists serve both science and society. They uncover infor-

mation that guides land use planning, groundwater protection, hazard mitigation, and environmental remediation. That sense of purpose motivates me as much as my fascination with the natural world. The spark came from my childhood travels, but my commitment grew through coursework, field experiences, and the realization that geology addresses real issues facing society today.

As I look ahead, I will be pursuing a career in the geosciences, so that I can work in a field where I can apply scientific knowledge to protect communities and natural systems. Whether assessing landslide risks, studying groundwater contamination, or evaluating the stability of infrastructure, I want to be part of efforts that ensure people live safely and responsibly within their environment.

Even with all the science and structure that geology involves, my interest still comes from the sense of curiosity I had as a child. I often think about those early road trips. I remember watching the sun set over desert mesas and traveling along mountain roads where every turn revealed a different landscape. Those experiences were the first signs to me that the Earth was constantly changing and carried a long history within it. They shaped the way I began to understand the planet and set the foundation for the direction I eventually chose to follow.

I want to be a geologist because the field combines curiosity, responsibility, and discovery in a way that no other discipline does. It allows me to explore questions that fascinated me long before I knew the words for them. It provides a path toward helping communities adapt to environmental challenges. And it connects my earliest experiences of awe with a future built on knowledge, purpose, and continued exploration. Every road trip I took as a child taught me to pay attention to the land. Becoming a geologist will allow me to understand it and to contribute to the work of protecting it. That is why I have chosen this path and why I am committed to pursuing it with the same sense of wonder that inspired me from the beginning.



“I wish to make the lives of my neighbors healthier, as well as seek ways to educate and give back to the city school system that provided me with the wonder I have for my surroundings.”

EMMA MARIN

SA-12552 CUNY Brooklyn College

After finishing my first semester at Brooklyn College, I walked into my local train station and seriously noticed the building stones for the first time. After three months of classes as a newly minted Earth Science major, I was enthusiastic to test myself and see if I could determine what the stones were made of. As I peered closer, the entire train station exploded into a new world. Fossils! Everywhere! The station became a capsule for millions of gastropods and crinoid shells. I imagined all that these stones bore witness to, from an ancient seafloor to a busy commuter terminal. I began to tear up with the realization that my brief time in school had already gifted me a new set of eyes.

In my senior year at school, I come back to this moment often; the sudden comprehension of how an education could entirely shift my relationship with the world around me. It's for this reason that I want to be a geologist. Geology is a field that provides a deeper understanding of time, space, material, and change. It doesn't take for granted that our surroundings are

and always will be. It's a science that opens up the question of "how did that come to be, and what will it become?" This is the line of questioning that I hope to follow as a researcher in urban biogeochemical cycles. For my career, I hope to continue to research material flow in urban areas. I hope to be able to assist in determining how heavy metal contaminants are currently concentrated in densely populated areas and assist in finding ways of geochemically altering their states to lessen their health impacts. I am currently in the application process for graduate degrees so I can pursue this goal. We, as Earth Scientists, have the ability to make our cities a safer, more environmentally just place to live. As a kid growing up in New York, I feel a responsibility to the community that raised me. I wish to make the lives of my neighbors healthier, as well as seek ways to educate and give back to the city school system that provided me with the wonder I have for my surroundings. I still use that train station on a daily basis, and I always smile and think of gratitude when I see the whorl of the gastropod shells in the marvelous limestone.

“

I want to be a geologist to show other little girls like her that they can be scientists too.”

JESS

MAYNARD

SA-13229 Central Washington University



I remember very clearly one of the first geologic field trips I took as a kid. It was into Tijeras Canyon along Route 66, east of Albuquerque, New Mexico and to a roadcut I passed nearly everyday on the way to and from school. The trip was to show us a fault visible in the rock and to help explain to us why there are sometimes earthquakes in the Albuquerque area. I remember the rocks and how they towered above us, I remember the man who told us about them, I remember learning about the small faults sending fractures through the Sandia Mountains and about the rift that transected our state. What I don't remember learning about that day is that little girls like me could be scientists like that too. It turns out I was always meant to be a scientist like that too, it's just taken me a little longer to get there.

My academic life has not taken the shape of many people's. After studying liberal arts just out of high school, I wound up lost, uncertain, and with a less than impressive GPA, not reflective of my capabilities. I wound up in a series of accidental careers, held various roles in leadership, and ultimately found success in retail store management. That life was never quite what I wanted, I longed for academic knowledge, I longed for science, and I was always driven back to school and back to education. I took calculus, physics, and engineering classes while working full time in an effort to break out of the life I had and to try to find my way into a career in STEM. It was a tough bunch of years, I was also dealing with personal hurdles which developed because I never felt I fit into the life I built. That life also drove me back to the mountains. I grew up in the high desert east of Albuquerque, New Mexico and spent much of my childhood outside and in the wilderness. I found my way back to the mountains in Washington where they became my stress relief, my exercise, my therapy, my church, my art, and my education. I hike voraciously, hiking over

620 miles in 2022. I made art inspired by what I saw and what I felt and I longed to understand what I was seeing so I began informally exploring geology, which led to more formal exploration and ultimately led me to Central Washington University and to the formal pursuit of my postbaccalaureate in geology and the goal of a professional life as a geologist. Although I'm still an undergraduate and have so much more to learn, I've begun to understand the processes of the past and what forces are acting presently to shape the mountains I've come to love so much, the mountains that have shaped me, who I am, and my relationship to the world.

As a non-traditional student and in my strange set of experiences so far, I can absolutely say, arriving in the field of geology was the first time I truly felt like I had found myself. As a person continuously driven back toward science and academia as well as back toward nature, I've finally found my fit among like-minded, science driven people and together, we're already uncovering answers to local geologic mysteries and a multitude of questions. Geology and geochemistry allow me to understand the intricacies of complex processes through deep time and to connect them to tectonic and even local environments today. My next step is graduate school, a Master's degree in geology, further studies in geochemistry, more answers and more questions.

When I look back at myself as a little girl at the side of the road as she learned about the faults cutting the rock above her, I wish I could go back and tell her then that little girls like her get to grow up to be scientists too. I wish she could have spent her whole life knowing that, and continued exploration. I want to show her that the hard work she and I have done all been worth it. I want to be a geologist to show other little girls like her that they can be scientists too.



“I needed a profession I could respect; something investigative and sophisticated, but fascinating and lively.”

SARA WU

SA-13180 California State University

Geology is a calling. It is a passion, a devotion, a gravitational pull. Never have I met a true geologist who felt otherwise. They pored themselves over articles, maps, and outcrops not only because they chose to but because there was truly nothing they would rather do. You may distract them from their duties—other disciplines are undoubtedly attractive—but they will always find a way back to unrolling maps and sketching cross sections. This is how I feel about geology, how I have always felt. There is nothing I would rather study, nothing I would rather research for hours, spend weeks in the field for, or dedicate my best years to. Geology is scrupulous, unforgiving, unrelenting, and much, much greater than us. For years, I searched for such a calling, and ever since I found it, I have remained a dedicated devotee, however minus-cule a part I may play in the grand scheme of geology.

I first discovered this calling on a hike with peers in high school. They would gather around trees, moss, and mushrooms, but I never found much interest in those. Instead, I stared at landscapes and outcrops, scrutinizing them like an inquisitive flea on a rock trying to understand what it stood on. Why did the valleys become narrower as they ventured higher? What were the shiny fragments in the rocks? Where can I learn this, and can I do this for the rest of my life? At the time, I was in the midst of a desperate search for a career path—the bane of high school seniors. I needed a profession I could respect; something investigative and sophisticated, but fascinating and lively. Once I enrolled in geology courses at college, it was clear there could not be a discipline more fitting to that description than geology.

I wasted no time immersing myself in tectonics, mineralogy, and structural geology. I read and talked about it so much that I aced our first geology exam without needing to review. Not long after, I joined researchers in the field, mapping canyons, caves, and landslides. We used geomorphological concepts to restore meadows, analyzed samples for pluton geochemistry,

and reconstructed faulted and tilted landscapes. Yes, I acquired scars and wrinkles along the way, but what better way to earn them? There was no more preferable manner in which to spend my years than to scrupulously examine geologic evidence, which was what I enjoyed most about the science.

My principal delight in geology is the ruthless investigation required to practice it. Geologists have this strange, insatiable desire to solve mysteries. For instance, a field geologist not only reads reports on a formation, but they may travel hours to visit it themselves. They climb on outcrops to confirm observations, collect 40 pounds of hand samples to analyze mineralogy, and they may stay an extra night to reach a distant portion of the field area that could very well prove identical to the rest. It is these exhaustive measures I respect most, and geologists are nothing if not exhaustive. After all, there exists a geologic overprint in both the sayings “no stone left unturned” and “move heaven and earth.”

I was insistent on pursuing exhaustive measures as I directed my career azimuth to isotope geology research. Before I finalized my methods for stable isotope sample collection, I consulted not one but three isotopic experts to ensure my methodology was rock solid. During field excursions, I visited sites deemed inaccessible by previous generations of my study because of daunting off-trail routes—the swinging-from-branches-required routes. But that is what geology is all about: exhausting every measure, examining every possibility, and discovering all there is to know about this magnificent discipline.

Absolutely, fieldwork has earned us scars, or we accumulated hundreds of late-night lab hours, but none of us regret the work we contributed to geology, a beautiful, sophisticated science. We can only wish to contribute enough, to unearth enough mystery, or to listen closely enough to its clues, to earn a place in its venerable history.

“

His passion for science, environmental conservation, and education inspired me to pursue a life of similar service.”

MIGUEL YANEZ

SA-13237 California State University - Stanislaus



Why do I want to be a geologist? It is a question I had never asked myself until just now. Growing up, I often wondered, What do I want to be when I grow up? I never seemed to settle on an answer. I was always told that I could do or be anything I wanted, yet I generally felt uncertain about my direction. What I did know, even then, was that I wanted to do something meaningful and good for the world.

From a young age, I had a natural curiosity about the world, one carefully fostered by my mother through books on the natural sciences and hands-on experiments at home. As a teacher, she had the tools and knowledge to cultivate that curiosity, and she did so wholeheartedly. Moreover, she enrolled me in every academic program there was. While I did not always enjoy them, she made sure I participated, as if she knew there was something there for me. The experience I enjoyed most was Science Olympiad, particularly the Rocks and Minerals and Bridge events. While I performed adequately in bridge building, I excelled in Rocks and Minerals, placing fourth at the state level in middle school. At the time, however, I did not realize there was a career path connected to that interest, nor that my excellence in it meant something greater.

In high school, my mother passed away. Her loss deeply affected me and led me away from my academics. I struggled to stay engaged and had difficulty making it through high school. Despite these challenges, I eventually enrolled at my local community college, where a group of friends invited me on what they described as a “cool camping trip” through the Colorado Plateau. That trip turned out to be a geological field study, and from the very first stop at Hole in the Wall in the Mojave Desert, I fell in love with science again. Our professor, Garry Hayes, was an exceptional storyteller, teacher, mentor, and role model. His passion for science, environmental conservation, and education inspired me to pursue a life of similar service.

For a time, I struggled to balance school with other responsibilities and eventually left college. I later found work with a parks and recreation department, where I remained connected to the outdoors and served my community in a way that gave me purpose. Over the years, I gained experience and responsibility, but I eventually reached a barrier. I was unable to advance into a

managerial position due to my lack of a degree. It was then that I realized I needed to return to school, and specifically, return to geology.

By that point, I was married and saving for a home, yet I put those plans on hold. I felt a renewed sense of purpose, like a small ember that only needed the right conditions to reignite. When I returned to school and participated in another geological field study, I felt the same sense of peace and excitement I had experienced years earlier. It confirmed that I was on the right path.

It feels like a calling. I love field work, learning about Earth’s history, and understanding the processes that shape our planet. I have always felt a responsibility to serve the world in some way. While working in parks and recreation, I found fulfillment in creating spaces where communities could connect with nature, particularly at a recreational lake. As a geologist, however, I know I can do more. My current academic focus is on hydrogeology, environmental remediation, and engineering geology, areas of applied geology that allow me to directly serve people, communities, and the environment.

Equally important to me is inspiring the next generation. I have always been comfortable explaining complex ideas, and over time, I discovered a love for teaching. One of my favorite experiences as a member of my community college geology club was participating in Science Night, where community members could learn about science from various clubs and programs. Watching children light up as they handled rocks and fossils and learned how they formed was deeply rewarding. Last summer, I had the opportunity to teach geology to high school students in the TRIO Program. While not every student walked away transformed, many were genuinely engaged, and several asked about careers in geology.

I have always believed that I can contribute something good to the world. Despite its challenges, there is meaningful work to be done. For me, my skills and passions are best applied as a geologist and educator. I have much more to learn and many ways to grow, but I am confident that the path I am on will allow me to leave behind a legacy of service, understanding, and positive impact, a compassion for the world and its people through geology. That is why I want to be a geologist.

WILLIAM J. SIOK
GRADUATE
SCHOLARSHIP

OLUWAKUNLE
OGUNASKIN

SA-12619

Missouri University of
Science and Technology



Geology's Essential Quarter-Century: Decoding Earth's Past to Navigate Our Collective Future

The most important contribution geology and geologists will make in the next quarter-century is providing the temporal context humanity desperately needs to navigate climate crisis. Climate models project future outcomes, but only geology reveals how Earth's systems responded to rapid environmental changes through time. This paleoclimate perspective, delivered with rigorous competence, unwavering integrity, and ethical commitment to humanity, will define our profession's legacy.

The 2025-2050 interval represents humanity's decision window. Earth has 7 billion people currently, with at least 2 billion more by 2050, with many moving into urban centers at unprecedented rates. Coastal cities are deciding where to build seawalls, water managers are planning infrastructure to serve populations for 50+ years, and agricultural regions are determining which crops to plant as climate zones shift. These decisions require knowing not just where we're heading but what occurred on Earth before. Such knowledge exists only in geological archives. Instrumental climate records span barely 150 years while sedimentary deposits are climate archives spanning

millions of years, capturing Earth's responses to warming periods like the mid-Pliocene when atmospheric CO₂ approached modern day levels. Geologists who can extract, interpret, and translate these proxy records provide essential baselines for evaluating climate change.

I know this transformation is possible because I have lived it. I began in groundwater prospecting, then focused my master's research on hydrocarbon exploration in Nigeria's Niger Delta. My perspective evolved during a field trip to a rural community there, where crude oil shimmered on rivers with floating dead fish. The fishing industry had collapsed, indigenes were malnourished, and water wells were contaminated. That day, I decided to redirect my skills toward understanding and mitigating environmental crisis.

My current work on Guatemala's Lake Izabal Basin demonstrates this evolution. I learned seismic stratigraphy to map hydrocarbon reservoirs in Nigeria. Now I use it to understand how this tropical basin responded to Pliocene warming and Quaternary cooling, reconstructing 12 million years of climate-tectonic interactions. The elemental geochemistry I once employed for

petroleum evaluation now reveals paleoenvironmental patterns informing climate projections Central America needs for adaptation planning. On shorter timescales, I analyze sediment cores spanning 12,000 years, using charcoal and geochemistry to distinguish natural fire cycles from anthropogenic impacts, directly informing wildfire management for vulnerable communities.

The next quarter-century demands integrative skills in geophysics, geochemistry, and data science. When I interpret seismic data or element geochemistry, I must acknowledge uncertainties and distinguish observations from inferences. This intellectual humility strengthens credibility when presenting findings to policymakers making high-stakes decisions. That credibility depends entirely on integrity. Today, climate science operates in a politicized environment where scientifically established findings face public skepticism, creating deep divisions in how societies must respond. Therefore, geologists bear solemn responsibility to present findings honestly and resist pressures to overstate conclusions. If we compromise integrity for political expedience, we forfeit credibility precisely when society needs our expertise most. Paleoclimate records reveal Earth's systems can shift rapidly and biodiversity can collapse under drought stress faster than ecosystems adapt. The Niger Delta devastation I witnessed represents what happens when we ignore geological realities. We owe society honest risk assessments, not reassuring falsehoods.

Our work must deploy knowledge for the common good, especially for society's most vulnerable. This means ensuring findings

reach policymakers and affected populations. When Nigerian newspapers covered my research's implications for West African climate policy, it validated geology's role beyond academia. This ethical commitment extends to mentoring diverse geoscientists and acknowledging our profession's historical role in resource extraction that drove climate warming. We must now redirect those skills toward understanding climate impacts and enabling energy transitions. This is not betrayal but evolution toward geology serving long-term human sustainability.

The next quarter-century will determine whether humanity navigates climate change successfully. My generation of geologists, trained now, will be in prime career positions throughout 2025-2050, precisely when decisions shaping our energy and climate future will be implemented. We hold Earth's four-billion-year climate archive. Our contribution depends on translating those insights into actionable foresight with unimpeachable competence, unwavering integrity, and ethical commitment to humanity. We must decode sedimentary archives with precision, communicate findings with integrity, and deploy knowledge ethically. Only then will geology not merely document humanity's climate crisis but help humanity transcend it. My career embodies geology's necessary evolution from resource extraction to sustainability. This is our moment and our responsibility. Our discipline must prove itself not a relic of the past but humanity's essential tool for navigating the next quarter-century and building sustainable futures.

“

Our discipline must prove itself not a relic of the past but humanity's essential tool for navigating the next quarter-century and building sustainable futures.”



Congratulations to Our

STUDENT SCHOLARSHIP WINNERS

AIPG and the Foundation of the AIPG
proudly recognize the *next generation* of geologists.

CELEBRATING ACADEMIC ACHIEVEMENT, DEDICATION, AND COMMITMENT TO THE GEOSCIENCES.

Insights into Uranium

Barney Paul Popkin

Background

The element uranium (U) is the source of energy for medical, weld testing (China Syndrome, 1979), research, nuclear power (Silkwood, 1983) and weapons. The element, often an oxide or sulfide, is found throughout nature in waters and minerals, rocks and soils, oil and gas, plants and animals, and crops, animal feed, and human food and beverages. Uranium was accidentally discovered by the German Martin Klaproth in 1789. Although ubiquitous, most uranium deposits are barely detectable, except in a few dozen commercial ore bodies (EPA, 2024; 2025). Its depleted uranium can be weaponized to cut through steel and concrete. Uranium is very heavy, nearly 20 times more dense than water, and is expensive at over \$80/pound due to the rising demand for nuclear power plants.

After refining, uranium ores are generally called yellow cakes. A pound of yellow cake (U₃O₈), occupies about 25 to 30 cubic inches.

In addition, several man-made transuranic radionuclides—plutonium, neptunium, and americium, and fission products like technetium-99 and cesium-137, are produced by nuclear reactions or as byproducts of mining, coal burning, and water treatment (AI, 2024).

Approximately 60 countries have significant or commercial uranium deposits (Wikipedia, 2024). Australia, Kazakhstan, Canada, Russia, Namibia, Niger, South Africa, Uzbekistan and China lead the world in reserves. Uranium metal is a radioactive, silvery-white (Figure 1), not shown, see Gray, 2009 very dense (specific gravity about 19), hard (Mohs 6), malleable and ductile metal. It occurs as uraninite, in ultramafic rocks and phosphorites, and their derived soil and dust. Uraninite is composed of several isotopes (variations of an element) including U-234, U-235, U-238, and several others. Uraninite is mined from open pits or underground excavation, in-place leaching (which generates less overburden waste), or is extracted from seawater. Although odorless and tasteless in water, its concentrates, like powdered yellowcake have a strong, acrid odor. Uranium powder may spontaneously burst into flames. Eating or breathing uranium may cause adverse health effects. Uranium is a hazardous substance under the U.S. Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) due to its radioactivity, and potential for causing kidney damage and cancer. Depleted uranium is routinely used in military vehicle armor as it's more resistant to penetration than rolled or cast steel.

According to AI (2024), the percentage of uranium in most rocks is very low, from 0.01 to 0.1% with average concentration of around 2.5 parts per million (ppm). Very high-grade ores contain up to 200,000 ppm (20% U), low grade contains 1,000 ppm (0.1%), and very low-grade contains 100 ppm (0.01%); whereas granite typically contains only 3 to 5 ppm, and sedimentary rock contains 2 to 3 ppm Uranium. The concentration of uranium in carbonate rocks is complex due to rock history (Bell, 1963). Carbonates generally

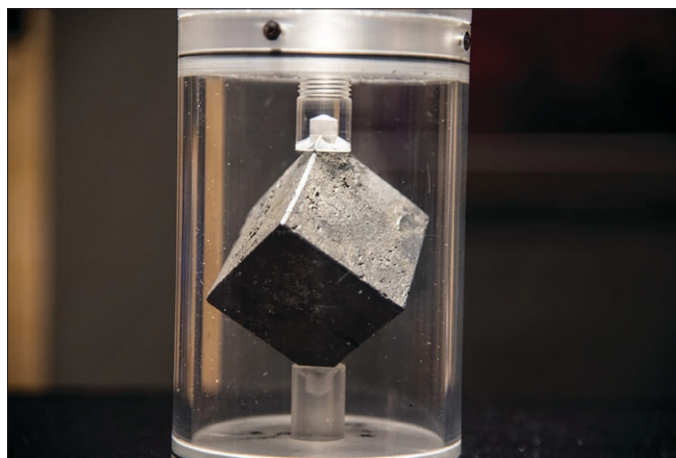


Figure 1. Silvery-White Uranium metal cube.

Image from: National Museum of Nuclear Science & History. (n.d.). Dark Cube: Heisenberg's Race for the Bomb. <https://www.nuclearmuseum.org/see/exhibits/dark-cube-heisenbergs-race-for-the-bomb-opens-march-14>. Photo credit: Matthan Brown, National Museum of Nuclear Science & History.

contain less than 10 ppm (0.001%) U. Seawater contains only about 3 ppb U (Ferguson, 2012).

Radionuclides have benefits through fair use. These include research medicine identification and treatments, in engineering and construction excavation and testing, geologic age dating, and in warfare and deterrence. It's used in nuclear power generation, as a ceramic glass colorant, early photography, yacht keels, aircraft counterweights, radiation shielding, and was used in former pesticides and as an additive in glow-in-the dark paint.

Several countries are currently known to or are suspected of processing uranium for nuclear weapons – Russia, United States, China, United Kingdom, France, Pakistan, India, Israel, North Korea, and potentially Iran (Wikipedia, August 2024). Processing the ore entails crushing, leaching, solution, and centrifuging to increase concentration of U235. Nuclear power plants require about 60% concentrations, but nuclear weapons require over 90%.

Figure 2 is a map of nuclear-weapons-armed states. It appears that about half the land mass falls into this category. Less than ten states have nuclear weapons, six have shared arrangements through international organizations, and five formerly possessed nuclear weapons. Finland and Sweden joined NATO in 2023 and 2024 due to the Russo-Ukraine War and may have sharing arrangements. Moreover, if Iran produces nuclear weapons, other states in East Asia may seek to develop, purchase, or share such weapons.

Table 1 was provided by OECD, NEA & IAEA (2022). Note that only Australia, Kazakhstan, and Canada each possess ten or more

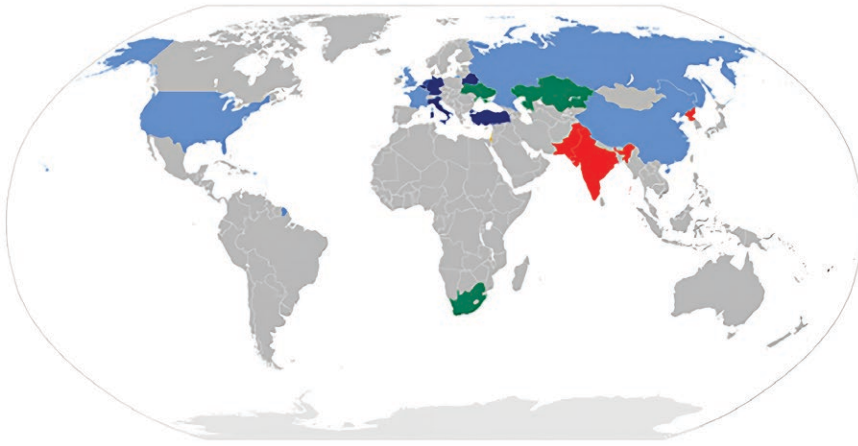


Figure 2. Map of Nuclear-Weapons Armed States of the World (Wikipedia, October 2024)

Legend:

- NPT-(Treaty of the Non-Proliferation of Nuclear Weapons) designated nuclear weapon states (China, France, Russia, United Kingdom, United States)
- Other states with nuclear weapons (India, North Korea, Pakistan)
- Other states presumed to have nuclear weapons (Israel)
- NATO (North Atlantic Treaty Organization) or CSTO (Collective Security Treaty Organization) member nuclear weapons sharing states (Belgium, Germany, Italy, Netherlands, Turkey, Belarus)
- States formerly possessing nuclear weapons (Kazakhstan, South Africa, Ukraine)

Table 1. Identified Recoverable Uranium Resources
(World Nuclear Association, 2024)

Country Source	Tonnes U	% of world
Australia	1,686,100	28
Kazakhstan	815,200	13
Canada	588,500	10
Russia	480,900	8
Namibia	470,100	8
South Africa	320,900	5
Niger	311,100	5
Brazil	276,800	5
China	223,900	4
Mongolia	144,600	2
Uzbekistan	131,300	2
Ukraine	107,200	2
Botswana	87,200	1
USA	59,400	1
Tanzania	58,200	1
Jordan	52,500	1
Other	266,600	5
World Total	6,078,500	

percent, or 51% of the world's identified recoverable uranium. The table assumes the uranium resource has a value of \$130/kg in 2021.

Nuclear power plants harvest the tremendous heat of radioactive decay to generate steam which rotates turbines (invented in 1887) at high speed to create clean electric power. The U.S. had five major operating Uranium mines in 2013, four of which were in Wyoming. Extracting Uranium is feasible through conventional underground, in-situ and open-pit mines. The traditional mining methods come with environmental challenges including changing ecological habitats and generating huge volumes of waste, which requires extensive auditing, monitoring, and regulations. While Uranium mines are located where the deposits are found, nuclear power plants are located where there is abundant cooling water near areas that have high electrical demand. In 2023, the U.S. operated 93 active reactors in 54 facilities situated in 28 states, providing about 20% of America's electrical energy. The electric energy demand is growing due to increased use and numbers of electrical appliances, vehicles, computers, autonomous vehicles, and artificial intelligence. New York is planning a new nuclear power plant in the upstate area. There are currently an additional 27 nuclear power plants under construction in the U.S.

Geopolitics

Conflicts and war are caused by disagreements, often in competition for natural resources, but other times because of boundary disputes, a desire for reuniting separated ethnic or religious groups, governance, trade, or religious differences. Whenever possible, diplomacy is the presumptive remedy, but it requires overlapping if not shared national goals. When diplomacy fails, regionally dominant countries will take action to preserve or expand their dominance. Geopolitics or Offensive Realism is that dominance or expansion by any means – diplomatic, political, economic, intimidation, or war (Mearsheimer, 2018; 2023).

The strongest and most destructive or persuasive weapons are nuclear. However, as additional states develop nuclear weapons, regional states will develop, purchase, or share them in an attempt to obtain some measure of security or negotiating power against stronger neighbors.

Producing and delivering nuclear weapons

Exploration and mining of uranium ores, processing uranium, concentrating its isotopes through the use of high-speed

centrifuges, pelletizing the concentrated isotopes, and adding a reaction fuse produces a viable nuclear weapon (Shankar, 2024). Such weapons include nuclear bombs, missile heads, or package bombs to be delivered by plane, missile, or emplacement by sabotage, respectively. Nuclear weapons or essential materials may be locally sourced and produced, purchased secretly, or stolen.

References

AI Overview, October 2024.

Bell, Kenneth G., 1963. Uranium in Carbonate Rocks. USGS Professional Paper, Shorter Contribution.

The China Syndrome, 1979.

DOE, no date. Radioactivity... Explained, Office of Science.

EPA, February 24, 2024. Radiation Projection: Radionuclides.

EPA, February 24, 2025. Radionuclide Basics: Uranium.

Ferguson, Ken, March 21, 2012. Uranium Extraction from Seawater. Stanford University, PH241, as coursework.

Gray, Theodore, 2009, The Elements, A Visual Exploration of Every Known Atom in the Universe, Black Dog & Leventhal Publishers, New York.

Lerner, Louise, 2024. Doomsday Clock, explained, UChicago News, University of Explainer Series.

Mearsheimer, John Joseph, 2018. The Great Delusion: Liberal Dreams and International Realities. Yale University Press.

_____, 2023. How States Think – The Rationality of Foreign Policy. Yale University Press.

OECD, NEA & IAEA, Uranium 2020, Resources Production and Demand (Red Book).

Shankar, Ravi, October 11, 2024. Quake or A Nuke Test? Mysteries & Dynamics of a Nuclear Iran. PGurus, 602K, YouTube.

Silkwood, 1983.

Union of Concerned Scientists.

Wikipedia, August 2024. List of countries by uranium reserves: revision history.

Wikipedia, October 8, 2024. List of states with nuclear weapons.

World Nuclear Association, August 23, 2024. Nuclear Fuel Cycle: Supply of Uranium.

About the Author:

Mr. Popkin is a retired USGS hydrologist, USAID foreign service officer, and solid and hazmat manager. During his professional career, he was an environmental auditor for nuclear power plants in Northern California and nuclear weapons facilities in the East Coast. He also wrote and reviewed several environmental documents such as NEPA Environmental Assessments, mixed waste permits and agreements, RCRA, and PSARs for proposed nuclear power plants in New England (where earth is rebounding from the several-trillion-ton weight of glaciers two-miles thick about 20,000 years ago). Southwestern USA (where treated domestic wastewater is used for nuclear power plants). He is forever grateful to the professional literature, Artificial Intelligence (AI) overviews, and clients who gave me the opportunity to serve our country in safe energy production and distribution.



-  **AIR**
 - Compliance
-  **BIOTA**
 - Remediation
-  **SOLIDS**
 - Property Transfer
-  **WATER & LIQUIDS**
 - Landfill
 - Emerging Contaminants
 - Waste Characterization



Pace® provides laboratory testing and analytical services that make the world a safer, healthier place.

Let's work together.
Contact us.

Visit: pacelabs.com Scan: 

Caves, Springs, and Streams in the Upper Cambrian of Missouri

Jeffrey Crews

Acknowledgement

The American Institute of Professional Geologists is pleased to share this reprint of Caves, Springs, and Streams in the Upper Cambrian of Missouri, prepared by Jeffrey Crews of the Missouri Geological Survey for the 2025 AIPG National Conference, held October 4–7, 2025, in St. Louis, Missouri.

Field trips are one of the most meaningful parts of an AIPG conference. They give us the opportunity to step out of the meeting room and into the geology itself—to see, question, discuss, and better understand the natural systems that shape our work as professional geologists. This guidebook captures that spirit through its focus on the caves, springs, streams, karst features, and Upper Cambrian geology of Missouri.

AIPG sincerely thanks **Jeffrey Crews** for developing this guidebook and for sharing his knowledge with conference participants. We also appreciate the Missouri Geological Survey for its support of the field trip and for its ongoing work to advance geologic understanding and serve the public.

By reprinting this guidebook, AIPG is pleased to make this valuable field resource available to a broader audience and to preserve the learning and professional exchange that were part of the 2025 National Conference in St. Louis.

Introduction

This field trip to a small part of the Missouri Ozarks showcases some of the grander karst features hosted in Cambrian and Ordovician bedrock. Located within the Meramec and Current river basins, Onondaga Cave, Meramec Spring, Round Spring, Echo Bluff and Alley spring mostly occupy the same stratigraphic position near the contact between the Ordovician Gasconade Dolomite and the Cambrian Eminence Dolomite. As each of the cave and spring systems evolve with the landscape, the spring conduit transitions through stages of maturity with respect to its hydrology and time.

Onondaga Cave State Park

Onondaga Cave is located within the Meramec River basin, a relatively large river basin covering approximately 1/16th of the Missouri Ozarks. The cave is located near to the Meramec River where surface streams have dissected the Salem Plateau into long bedrock ridges of Ordovician and Cambrian cherty dolomites and sandstones mantled by thick clay rich residuum.

Onondaga Cave is developed near the contact with the Eminence Dolomite and the Gasconade Dolomite. The lowest most member

of the Gasconade Dolomite, Gunter Sandstone Member, is exposed in the cave near the Kings Canopy (Figure 1).

The cavern has a complicated history of down cutting, internal stream piracy, and changing discharge points as the Meramec River down cut (Figure 2). Further complicating the evolution of the cave, at some point, likely during the Illinoian, the cave was inundated and air-filled passageways were submerged. The timing and mechanism is currently speculated by the author to be from ice damming of the lower Meramec in the vicinity of St. Louis by the Illinoian ice sheet. Sediment dating techniques are currently being explored to better constrain the timing of this inundation event. Evidence of inundation consists of widespread dissolution of large speleothems throughout the cave and phreatic solution features overprinted onto the walls of vadose canyons within the cave. Stalagmite dating suggest that inundation event took place earlier than 13,110 $\pm$ 260 (Denniston et al. 2001).

The recharge area of the Lost River was studied by Miller and Lerch (2011) using dye tracing techniques. The recharge area is approximately 6.3 square miles with input from as far away as 4.75 miles (Figure 3).

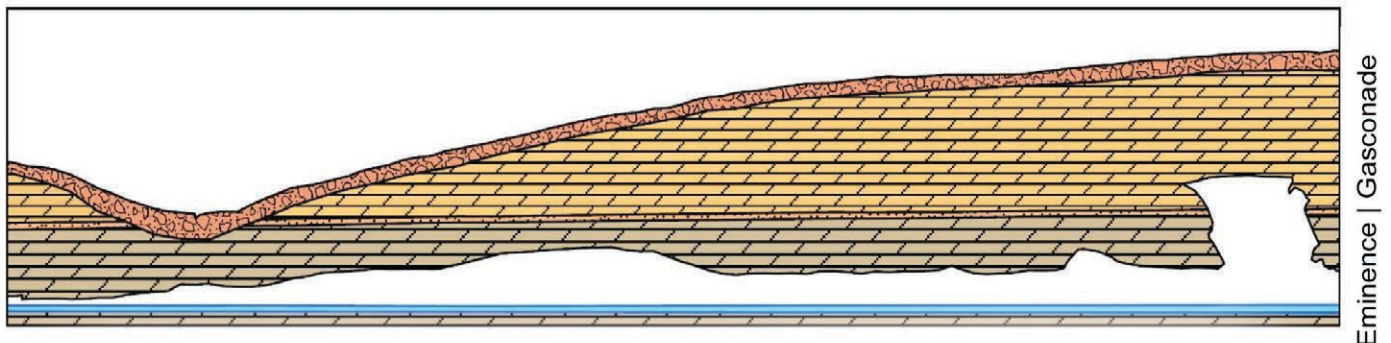
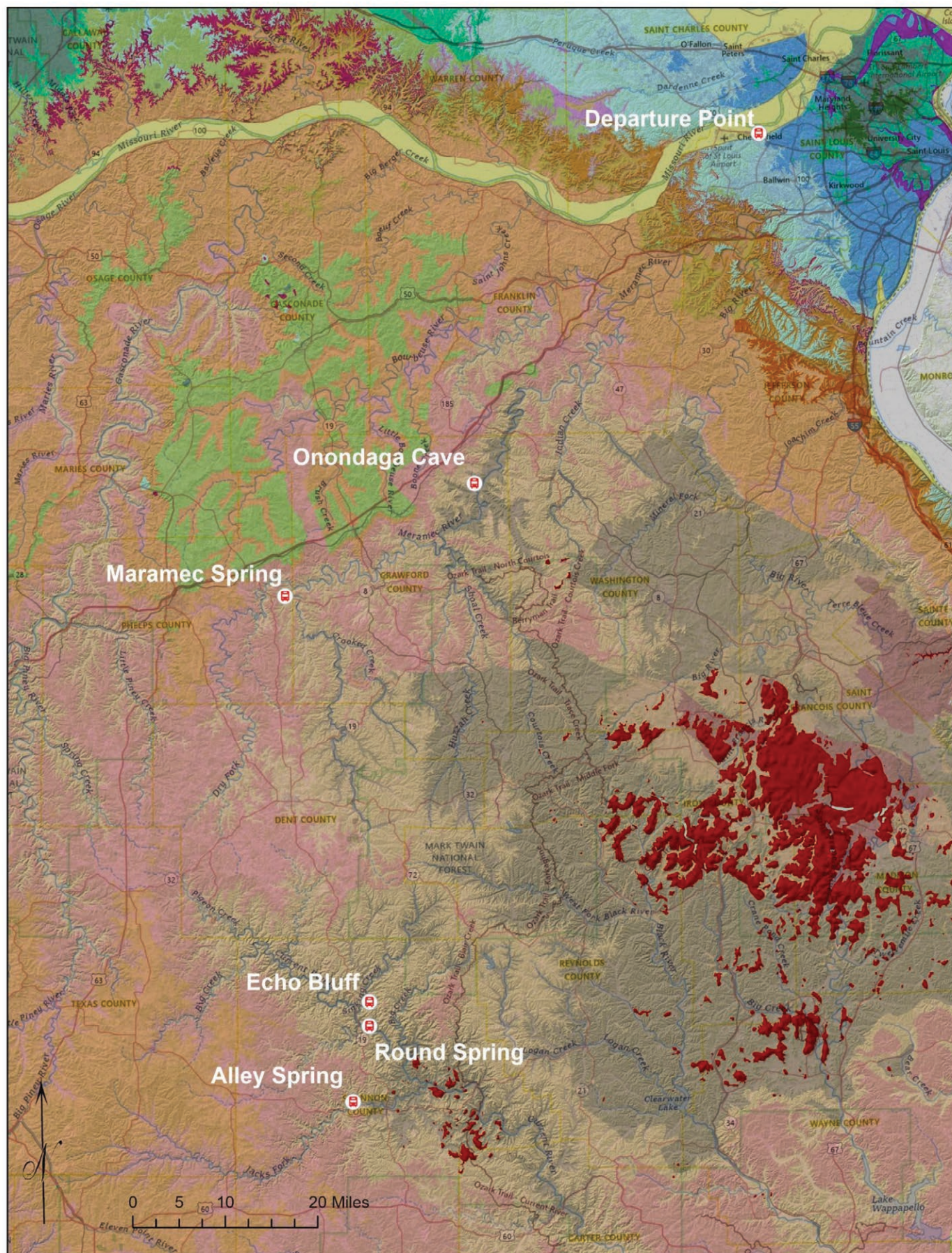


Figure 1. Cross section of the Lost River portion of the Onondaga Cave adapted from Rimbach c. 1970.

FIELD GUIDE: CAVES, SPRINGS, AND STREAMS



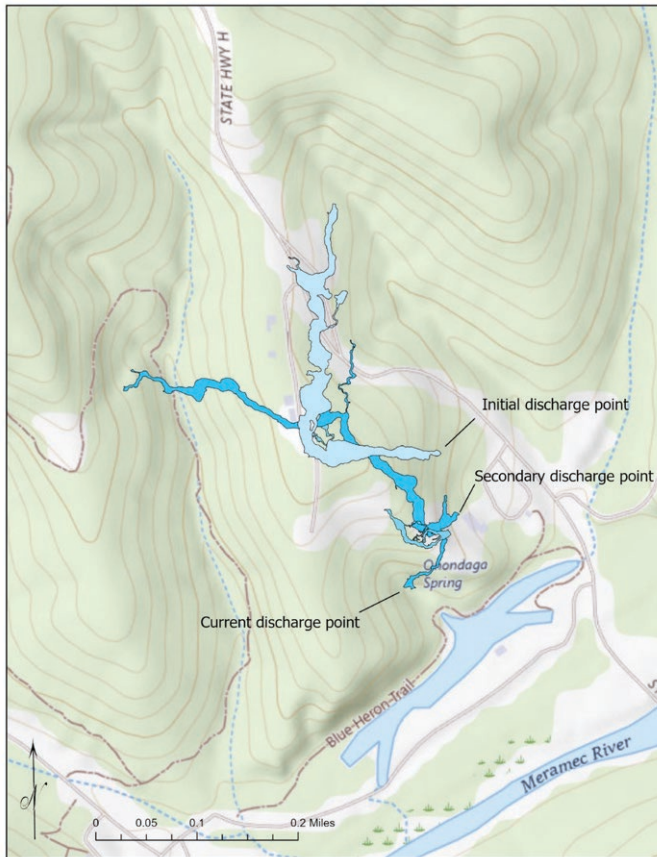


Figure 2. Plan view of Onondaga Cave highlighting levels of development. Adapted from House 1985, 1986.

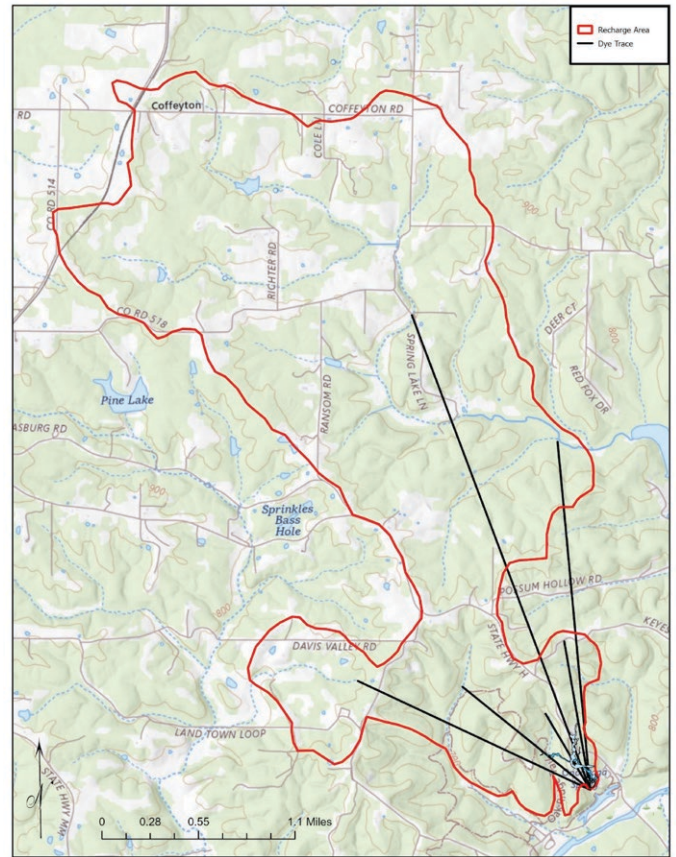


Figure 3. Recharge area of Onondaga Cave after Miller and Lerch 2011.

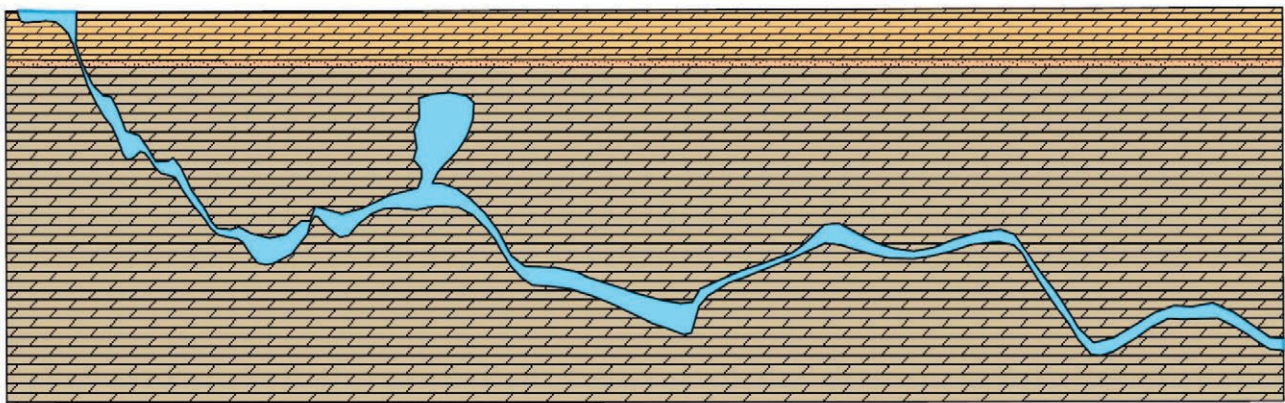


Figure 4. Cross section of Meramec Spring adapted from Ozark Cave Diving Alliance 2000.

Meramec Spring

Meramec Spring is located near the Meramec River in a side hollow. The spring waters rise from a bedrock conduit hemmed in by the Gasconade Dolomite. Remnants of the sandstone rich Roubidoux Formation cap the ridges in the area. Divers have successfully mapped 3083 feet of the underwater cave at depths as great as 209 feet below the pool level.

Much like Onondaga Cave, the conduit is developed near the contact with the Eminence Dolomite, primarily below the Gunter Sandstone Member of the Gasconade Dolomite (Figure 4).

An interesting concept to consider is the maturity of the spring system. Seeing as both Meramec Spring and Onondaga Cave have developed as roughly the same stratigraphic horizon and similar landscape position in the same river basin, it is easy to compare where each system is in its evolution. Meramec Spring, at least the explored portions, are completely submerged and the horizontal portion of the conduit is generally a hundred feet or more below the river. The conduit can become pressurized during storm events and there can be a very dynamic interplay between the conduit and the surrounding aquifer along its length. Meramec Spring could be considered more “youthful” than Onondaga Cave, which likely

initially developed well below the elevation of the river as well. Onondaga Cave has “matured” as the river basin has evolved and down cut lower into the strata than the horizons or initial and even later development. Many of the cave and spring systems throughout the Ozarks can be thought of as more or less mature depending on what stage of development they are along such factors as phreatic or vadose development, efficiency of transport, or ground water velocities, dewatering of the aquifer in the recharge area and others.

The Meramec Spring has an average discharge of 154.9 cfs. The recharge area is approximately 313 square miles (Vandike 1996) with water coming from as far away as 30 miles (Figure 5). The spring’s recharge area is roughly 50 times that of Onondaga Cave.

The spring has been an important part of the St. James economy from the founding of the town. The spring powered the smelter processing locally mined iron, forming the early economic basis of the town. Today the trout park and other tourist activity continues to contribute to the local economy.

Round Spring

Round Spring is located near to the Current River in a side hollow. The spring waters rise from a bedrock conduit into a circular collapse feature giving rise to the name Round Spring. From here the water flows through a natural bridge, discharging into the spring branch. The spring is developed well below the contact with the Gasconade Dolomite, in the Eminence Dolomite. Isolated remnants of the Roubidoux Formation are found on the highest ridges in the area. To the southeast, these sedimentary rocks lap onto exposed PreCambrian basement rocks.

Jim Vandike, wrote the following in regards to Round Spring for a guidebook in 1997:

Good flow data exists for the spring. Based on 25 years of daily flow records taken between 1928 and 1939, and 1965 and 1979, it has an average discharge of 46.9 cfs. An average of 28 instantaneous discharge measurements made by the USGS between 1980 and 1994 show a somewhat higher average, 62.4 cfs. The lower value, based on long-term daily readings, is probably more representative. According to Vineyard and Feder (1982) Round Spring ranks 14th largest in Missouri. The minimum discharge measured for the spring is 10 cfs and the maximum is 520 cfs.

Round Spring rises through a feeder conduit that is partly clogged with cave breakdown. The breakdown, most likely, is what remains of the cave roof which collapsed, leaving a nearly circular, steep sided rise pool; a sinkhole-like window to the outside surrounded by rock. A short water-filled cave separates the rise pool from the spring orifice at the head of the spring branch. The breakdown has adequately blocked the feeder conduit, still allowing water to emerge, but decreasing the size of the openings to where a diver cannot penetrate vertically more than about 55 feet. Several times, flow rising from the spring has exceeded the capacity of the cave passage between the rise pool and spring orifice, causing the pool level to rise to the point where water flows over the rim separating the rise pool from the spring branch. Such occurrences are generally limited to periods of prolonged, heavy rainfall.

Divers performing extensive underwater exploration for the National Park Service found and studied an archaeological

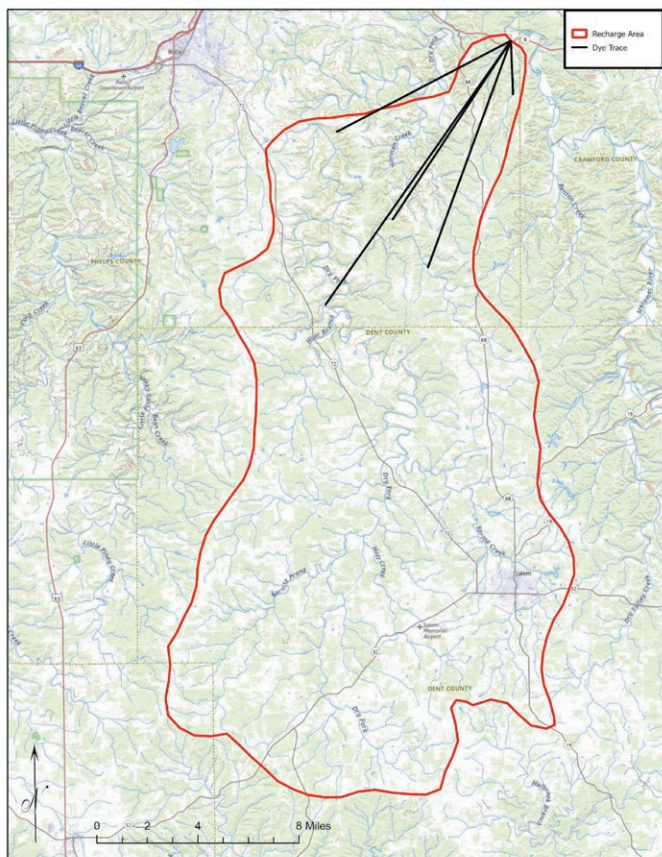


Figure 5. Recharge area of the Meramec Spring after Vandike 1996.

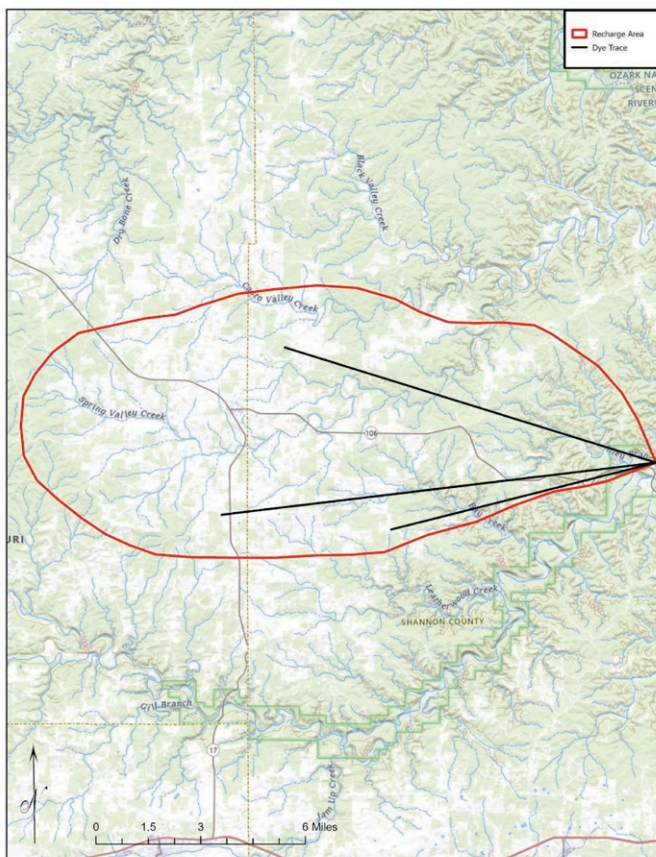


Figure 6. Recharge area of Alley Spring after Vandike 1997.

site under about 10 feet of water in the grotto beneath the natural bridge separating the rise pool from the spring opening. Excavation carried out underwater shows that sometime in the past Round Spring either ceased to flow, or flow was much less than present. Collapse of the cave roof into the feeder conduit could account for this, as well as a change in climate.

Round Spring is one of the few major springs in Missouri with a recharge area yet to be determined. Beckman and Hinchey (1944; p. 116) feel the recharge area lies to the southwest in Spring Valley watershed. Dye tracing by Aley (1976; p. 79-80 and 1978; p. 54-56) indicates that only a minor amount of recharge is provided by Spring Valley. Aley feels a recharge area to the east on the opposite side of the Current River is possible, but dye tracing has not substantiated this.

A single dye trace has been reported from by Aley from east of the Current River from Capps Hollow, but further study is needed on this possibility.

Where this spring would fit into the maturity spectrum would be hard to place. The karst landscape is quite mature as there are large air-filled caves such as Round Spring Caverns, which are developed at the Gasconade-Eminence contact. How these caves and Round Spring are or are not related genetically is not known.

Alley Spring

Round Spring is located in an alcove of Alley Branch near to its confluence with the Jacks Fork. The spring waters rise from a bedrock conduit into a circular spring basin. The spring discharges from the Gasconade Dolomite. The Roubidoux Formation caps the ridge tops. To the east, these sedimentary rocks lap onto exposed Precambrian basement rocks.

Once again, the best description of the stream was written by Vandike:

The Jacks Fork, largest tributary of the Current River, has many springs rising along its reach, but the largest by far is Alley Spring. Daily discharge data collected over a 25-year period from 1928 to 1939 and 1965 to 1979 show an average flow of 135 cfs. Vineyard and Feder (1982) show that Alley ranks 7th largest in Missouri, 3rd largest in the Current River basin. Minimum and maximum measured flows are 54 cfs and 2,750 cfs. However, Bridge (1930) reports that Alley Spring ceased to flow for about 12 hours on one occasion. Water level in the spring rise pool reportedly dropped rapidly to about 5 feet below normal pool level. After about 12 hours, flow resumed, but the water was very turbid for several days. The appearance of a new, large upland sinkhole at approximately the same time some 15 miles northwest of the spring indicates that a temporary blockage of the spring supply channel due to a sinkhole collapse may have caused the flow interruption.

Divers have been able to penetrate the feeder conduit to a depth of over 100 feet. At this point, the conduit measured about 15 feet wide and 10 feet high with the floor of the cave covered with well-worn chert gravel. The deeper, water-filled part of the spring is developed in the upper Cambrian age Eminence Dolomite, but the spring basin and bluff around it are lower Ordovician age Lower Gasconade Dolomite.

The recharge area for Alley Spring lies to the west and north of the Spring, in the area around and east of Summersville. Dye tracing by Aley (1976; p. 75-76 and 1978; p. 29-35) and others show the spring to be recharged from precipitation falling in a sinkhole area around Summersville, and from Spring Valley and other losing streams in the vicinity. Data also indicate that at least under certain conditions, water in the Alley Spring

recharge area also flows to Blue Spring on the Jacks Fork, a few miles upstream from Alley Spring.

Alley Spring, like so many in the Ozarks, was the focal point of a small community. The spring served as the local drinking water supply, as well as power source for the Alley Spring Mill. The mill, powered from a turbine driven by the spring water, ground meal, flour, cattle feed, operated a sawmill, and later furnished electrical power for nearby houses. The National Park Service has worked to restore the mill, rendering it again capable of producing stone buhr-ground corn meal and flour, and preserving the best of early Ozark culture in the museum displays in the mill.

Like Meramec Spring, Alley Spring could be considered to lie a more towards the youthful side of the maturity spectrum. The spring conduit is completely submerged, generally a hundred feet or more below the river. The conduit can become pressurized during storm events and there can be a very dynamic interplay between the conduit and the surrounding aquifer.

Echo Bluff State Park (tentative)

Echo Bluff State Park is located on the old Camp Zoe youth camp. Sinking Creek has carved 100 ft tall cliffs into the Eminence Dolomite. The Gunter Member of the Gasconade Dolomite caps the cliffs.

Other caves and springs with similar hydrogeology worth a visit

Meramec Caverns

Meramec Caverns is a popular privately operated tourist attraction. The cave is developed at the contact with the Gasconade Dolomite and the Eminence Dolomite. Like Onondaga Cave, Meramec Caverns has large passageways decorated with speleothems and an active cave stream. The cave system and surrounding caves and karst area are more on the mature side of the maturity spectrum.

Meramec State Park and Fisher Cave

This popular state park has numerous caves and springs with hiking trails and guided tours of Fisher Cave. Fisher Cave is also developed at the contact with the Gasconade Dolomite and the Eminence Dolomite. Sediments and speleothems within the cave record inundation and sedimentation that may be related to ice damming of the Meramec River.

Cathedral Cave at Onondaga Cave State Park

Cathedral Cave is the sister cave to Onondaga Cave. Guided lantern tours are available for visitors. The cave houses a seismic station operated by Saint Louis University. Cathedral Cave is located across the Leasburg Fault from Onondaga Cave and its stratigraphic position is not certain. The geology of the Onondaga Cave 7.5 minute quadrangle is currently being mapped by Missouri Geological Survey. Preliminary findings have called into question the historic mapping and interpretation of the structural and stratigraphic framework of the park.

Montauk Springs at Montauk State Park

Montauk Springs is the largest spring in Missouri that discharges through alluvium. Legend has it that a large flood buried the spring with sand and gravel and today multiple sand boils are located within the valley. The spring waters form the beginning of the Current River. A fish hatchery fed by spring water is located within the park and trout fishing is the premier local attraction.

Welch Spring

A large first magnitude spring, Welch Spring rises from a deep pool 200 feet inside Welch Spring Cave. Welch Spring is a fairly

mature hydrologic system having dewatered the Ozark Aquifer to approximately 400 feet below the surface within its recharge area. The air filled portions of the cave containing the spring rise is possibly a remnant of portion of the spring conduit abandoned by the spring.

Cave Spring, Wallace Well and Devil's Well

Cave Spring is a sizable spring discharging directly into the Current River. Canoe paddlers regularly canoe into the cave entrance to cool off on summer days. Two karst windows, Wallace Well and Devil's Well have been dye traced to Cave Spring. Devil's Well can be visited where one descends into a sinkhole to a deep pit roughly 100 feet above a large underground lake, which is approximately 80 feet in depth.

Blue Spring

A short trail leads to this deep blue first magnitude spring. The second deepest spring in the Ozarks, Blue Spring rises some 300 feet to discharge into the Current River. Given its depth and location, the spring likely rises from the oldest strata of any spring in the Ozarks and possibly from the St. Francois aquifer.

Big Spring

Discharging 400 cfs and possible over 2000 cfs, Big Spring is the largest spring in Missouri. Dye tracing has shown recharge comes from as far away as 40 miles and an area of 39 square miles.

Greer Spring

A mile long hike through the Mark Twain National Forest will bring you to the spring boil and cave overflow of Greer Spring. Dye tracing has shown that much of the recharge area is from the opposite side of the Eleven Point River. This is quite curious as the spring branch is nearly a mile long and 100 feet higher than the river at its confluence.

References

Aley, T., 1976, Identification and preliminary evaluation of areas hazardous to the water quality of Alley, Round, and Pulltite Springs, Ozark National Scenic Riverways: Ozark Underground Laboratory report to ONSR, National Park Service, 126 p., 6 pl.

Aley, T., 1978, Hydrologic studies of springs, Ozark National Scenic Riverways, Missouri: Ozark Underground Laboratory, 107 p., 5 pl.

Beckman, H. C., and N. S. Hinchey, 1944, The large springs of Missouri: Mo. Geological Survey and Water Resources, vol. 29, 2nd. ser., 141 p.

Bridge, Josiah, 1930, Geology of the Eminence and Cardareva quadrangles: Mo. Bureau of Geology and Mines, vol. 24, 2nd ser., 228 p.

Denniston, R.F., Gonzalez, L.A., Asmerom, Y., Polyak, V., Reagan, M.K., Saltzman, M.R.,

2001, A high-resolution speleothem record of climatic variability at the Allerod - Younger Dryas transition in Missouri, central United States; *Palaeogeography, Palaeoclimatology, Palaeoecology* 176 (2001) 147-155

House, S., 1985, Onondaga Cave [map]; Missouri Speleological Survey, 1:600-scale.

House, S., 1986, Onondaga Cave upstream Lost River Passage [map]; Missouri Speleological Survey, 1:600-scale.

Miller, B., and Lerch, R., 2011, Delineating recharge areas for Onondaga and Cathedral caves using groundwater tracing techniques; *Missouri Speleology*, v. 51 n. 2.

Ozark Cave Diving Alliance, 2000, Meramec Spring [map]; Ozark Cave Diving Alliance.

Rimbach, D., nd, Plan and profile views of Lost River Passage in Onondaga Cave; *Ozark Springs Studies*, 1:480-scale.

Vandike, J.E., 1996, The hydrology of Meramec Spring; Missouri Department of Natural Resources, Division of Geology and Land Survey, Water Resources Report Number 55.

Vandike, J.E., 1997, Guidebook to the hydrology of the Current River basin; Missouri Department of Natural Resources, Division of Geology and Land Survey, unpublished manuscript MSC-70564.

Vineyard, Jerry D., and G. L. Feder, 1982, Springs of Missouri: Mo. Geological Survey and

Water Resources, Water Resources Report No. 29, 212 p.



METIRI

YOUR PARTNER FOR ANALYTICAL SERVICES

Metiri Group has built a leading nation-wide environmental laboratory network focused on providing the breadth of capabilities our clients need with the service experience they want.

In addition to a full suite of analytical capabilities, Metiri Group has expanded our TO-15 and PFAS testing capacity. Investment in certifications, instrumentation, equipment and expert talent are top priorities across each location.

metirigroup.com

Soil Water Air



AIPG
American Institute of
Professional Geologists

63rd AIPG Annual Conference

Duluth, Minnesota

*Along the breathtaking shores of
Gichigami (Lake Superior)*

August 29–September 1, 2026

Join geoscientists, students, and industry professionals for field experiences, technical sessions, and exceptional networking in one of the Midwest's most scenic geologic settings.



Field Trips for Every Interest

- Bicycle tours of local geological landmarks
- Harbor boat trips to view key remediation sites
- Journeys through historic Iron Range deposits
- Exploration of classic outcrops and new developing resource sites



Technical Talks from Industry Leaders

- Helium exploration and emerging opportunities
- Complex cleanup challenges at legacy contamination sites
- The essential role of geology in advancing cleaner, sustainable energy
- The fundamentals and important aspects of Minnesota's geology



Co-Chairs, Organizing Committee
Shanna Schmitt, PG (MN), CPG
Alex Steiner, PhD, CPG



Holiday Inn & Suites Duluth-Downtown

200 West First Street
Duluth, MN 55802



\$174 per night
plus taxes and fees



Reservation deadline - 7/29/2026



For hotel/reservations call
(218) 722-1202, option 3



Learn more & register: **aipg.org/page/2026NationalConference**



Aaron W. Johnson, CPG-12229
awj@aipg.org

Where the Rubber Meets the Roadcut

This year marks the 100th anniversary of the establishment of US Route 66, the Mother Road, often called 'America's Main Street.' Those of you who know me well know that I grew up in Miller, Missouri, a small town of fewer than 700 people, just a couple of miles north of that famed highway. The car culture was big in my hometown. Every Friday and Saturday night for decades, Main Street was lined with cars cruising through the center of town. In the late 1990's, rising fuel costs and a shift in entertainment interests silenced the rumbling engines.

This year, I've made it a mission to combine work with an exploration of Route 66. Earlier this summer, I was able to cruise the Mother Road from Miller to Cuba, Missouri as I made my way to Viburnum, Missouri for a visit with AIPG 2027 President-Elect Chris Hogan at the Doe Run Company's Fletcher Mine. Just a couple of weeks ago (likely six weeks ago when this hits your mailbox), I was able to cruise to the GSA Rocky Mountain Section Meeting in Albuquerque. There I spent evenings exploring Route 66, cruising down Central Avenue, which at 18 miles, is one of the longest urban stretches of Route 66. I headed east toward Tucumcari (the punchline of many a dad joke) and west to Grants where I was able to find a brewery in a junkyard and to make my way around the New Mexico version of Dead Man's Curve. On each of these trips, I've been able to take in unique sights and experiences and explore fascinating geology. In June, I plan to make a run from Miller to Commerce and Miami, Oklahoma on my way to Picher, to take some photographs and assess the cleanup efforts as local, tribal, state, and federal agencies coordinate the remediation of 100 years of environmental impacts from base metal mining in the Tri-State Mining District.

These forays into our past have also helped me to recognize the critical work of geologists supporting such a large-scale infrastructure project. The nearly 2,500-mile length of Route 66 included hundreds of bridges and thousands of roadcuts, requiring coordination and collaboration between geologists, engineers, surveyors, and local, state, and federal agencies. Route 66 utilized some existing roads, occasionally followed wagon trails, such as the Beale Wagon Road in New Mexico and Arizona, and sometimes ran alongside the Atchison, Topeka, and Santa Fe. The result was a highway that served as an emigration trail, made famous during the Dustbowl Era and immortalized by Steinbeck as 'The Mother Road' in *The Grapes of Wrath*.

Today, a century after Cyrus Avery and John Woodruff sent a telegram from the Colonial Hotel in Springfield, Missouri, officially requesting the highway be designated Route 66, the work of geologists continues to underpin local, state, and federal infrastructure projects. Our work provides critical information for more than just roads and bridges. Landslide and other natural hazard mitigation projects require that geologists be involved as our understanding of Earth as a dynamic system makes us uniquely qualified to understand the ground stability and identify historical



evidence of past erosion and mass wasting. We work with land use planners to identify areas where flood risks are high or locations where coastal risks are greatest. Geologists identify areas prone to subsidence, outline locations where karst risks are high, and work to identify locations where clay minerals may pose a threat to the foundation of homes and businesses. Our work in many cases truly provides the foundation upon which the infrastructure of modern society is constructed.

The responsible, ethical, professional practice of geology is critical to the health, well-being, and safety of society and its citizens. Pursuing the Certified Professional Geologist credential with AIPG is an important step for all geologists but is especially important for those who work in areas where the needs of society intersect with the geological realities imposed upon us by a dynamic planet. Your CPG credential indicates that not only are you highly skilled and well-educated, but that you also voluntarily agree to be bound by the highest standards of professional ethics and specific standards of practice, **regardless of where in the world you choose to practice.** I firmly believe that the Certified Professional Geologist credential is the Gold Standard of Geoscience Professionalism and provides geologists, employers, governments, and the public with visible, overt evidence that the geologist who carries this credential is well-qualified to do the work that is required for a modern, successful, competitive, and functional society.

If you aren't a CPG yet, I strongly encourage you to apply. The application is fully electronic now, and our goal is to give a full, high-quality review and decision within 60 days of receipt of a completed application. In addition, our reciprocal agreements with the European Federation of Geologists, the Geological Society of London, and the Institute of Geologists of Ireland, make it much easier to apply for and receive the relevant title in nearly 30 countries throughout Europe. It is our hope that these partnerships will open doors for our members who wish to work in the international space. Whatever your plans for the future, the CPG will provide additional value for you.

I wish each of you a safe and productive summer, be it in the field, the lab, the office, or on a vacation.

Aaron W. Johnson, CPG-12229



Chuck Drake, CPG-11197
Chuck@Bio-Techconsulting.com

AIPG UPDATE, LEGISLATIVE NEWS AND EDUCATIONAL OPPORTUNITIES

We are halfway through 2026 and our nation's 250th anniversary is upon us! Happy 4th of July to everyone.

The staff of AIPG, Executive Committee and individual members across the nation are hard at work for you and all other geologists/ geoscientists, not just here in the U.S.A. but internationally. Applications to become a certified professional geologist are increasing, and we are receiving requests from international applicants. The increase in application requests is an indicator of how valuable to clients, employers and government the CPG is in the U.S.A., Canada and internationally. It's also a good indication of the increase in career opportunities.

Our staff at our new location in Northglenn, Colorado and our Section and National Screening Committees are reviewing and processing applications more efficiently than ever, reducing the time for qualified candidates to receive their CPG credential. Thank you

Thank you to Jim Renner, other Georgia AIPG members and associated organizations, for calling on state legislators to educate them on the importance of our license and to vote no on the bill. They suggested language changes to the original bill, some of which were accepted.

HB 1254 centralizes the regulation of geologists (and the other industries) in the Georgia Secretary of State's office. Many questions arise, one of the most important of which is: who in that office will have the expertise to review applications for licensure? Will the state have to hire a consultant with the appropriate expertise to review applications and complaints? The bill states that the Secretary of State will "...seek the advice of and counsel of industry representatives, stakeholders or subject matter experts to provide expertise and assistance in the administration and enforcement of this chapter." This is a very general statement and leaves a lot of room for interpretation, especially with respect to "stakeholders."



Applications to become a certified professional geologist are increasing, and we are receiving requests from international applicants. The increase in application requests is an indicator of how valuable to clients, employers and government the CPG is in the U.S.A., Canada and internationally.

to our AIPG staff and the Section and National Screening Committee members for your dedication and welcome to our new CPGs.

I and many others have written about the continued need to educate the public and elected officials on the importance of the unique expertise that our profession provides to meet societies' needs for basic everyday items and the modern-day conveniences we have and the ones to come. It saddens me when state legislators want to "streamline" or "reduce bureaucracy" by trying to deregulate professional licensure or eliminate state boards of geology. I've written that this has been attempted many times in Florida and because of the strength of AIPG/ Florida Association of Professional Geologists, we have prevented that from happening. The AIPG at the National level is always here to help the state sections with addressing these issues and connect members to share their experience with similar issues.

On May 11, 2026, Georgia Governor Brian Kemp signed into law HB 1254 which abolishes state boards of registration including the boards of cemetarians, hearing aid dealers, auctioneers and geologists. How we got lumped in with cemetarians, hearing aid dealers and auctioneers is beyond me.

It is almost certain that the person reviewing the application will simply refer to a checklist of criteria included in the law. Some of those criteria are easily checked such as a bachelor's degree or higher in geology, engineering geology, geological engineering from an accredited college or university. However, the following criteria are not as easily checked: "...or a comparable earth or environmental science or engi-

neering focused discipline; or has completed 45 quarter hours or the equivalent in geological science courses leading to a major in geology, of which at least 36 hours or the equivalent were taken in the third or fourth year or in graduate courses.

A state licensing board comprised of licensed professional geologists will understand the course work listed in an application and what is or isn't a comparable earth or environmental science focused discipline and what is or isn't a geological sciences course leading to a major in geology. An "industry expert" will be chosen only by what the Secretary of State understands constitutes an "industry expert." This could lead to a review of an application by someone not well-qualified to perform the review.

The AIPG Section and National Screening Committees report that geology and geoscience courses are being titled far differently than they were 20-30 years ago, so it is difficult for them to determine if the course work from an accredited college or university meets the AIPG CPG requirements. If the committee members have to ask for more information such as the course syllabus or textbook titles or other documentation to determine that while the course title was

Continued on p. 51

Shale Kennedy

RESOURCE GEOLOGIST

Interviewed by Skylar Vertes, ECP-1122



1. Tell us a little about yourself and your path into geology.

My name is Shale Kennedy, I am from St. Louis Missouri. I studied geology at Tulane University and am currently pursuing a Geoanalytical and Geointelligence certificate at Missouri S&T. This program focuses on geospatial data analysis, remote sensing, GIS, and other technical tools to better interpret and manage geologic data. I currently work as a resource geologist in the mining industry, focusing on copper, cobalt and nickel exploration and resource modeling. My path into geology started very early and over time has grown into a career.

2. What originally sparked your interest in geology?

I have grown up around geology not only because I was literally named after a rock but because my dad was passionate about

geology himself. My parents purchased an Iron Ore mine when I was born and when I was little, I remember following my dad around on the mine site collecting shiny rocks and watching him take samples around the property.

3. What does your current role involve, and what kinds of projects are you working on right now?

I am a resource geologist at a cobalt, copper, and nickel mine in SE Missouri. My role is to plan drill programs and analyze data to then estimate the orebody location, orientation and extent at our mine's location. In addition to my primary role, I have also had the opportunity to work on a rare earth project in southeast Nebraska. The project has exposed me to a very different style of mineralization and geology, which has been an incredible learning experience — it's also allowed me to work with professionals from around the world and broadened my perspective in ways I didn't expect early in my career.

4. Was there a moment, class, field experience, internship, or project that really shaped your career direction?

The summer before my senior year I had an internship with the mining company I work for now. This experience was my first real exposure to the mining industry and helped confirm that this was the path I wanted to take. I was able to enter my senior year with the confidence of knowing my career path; this internship also secured me a job at the company after graduation.

5. What's something unexpected about your job that people might not realize?

One thing people may not realize is how collaborative and continuously educational the mining industry can be. Since I started working at a startup mining company, I have been able to grow and learn with the company. They have offered to pay for my master's degree and have been very encouraging for me to take my time getting the hang of this position. They have also made sure that I have the opportunity even outside of the company to learn. I have been able to do geologic consulting work on various drill projects with different teams and see different deposits besides the deposit at the mine at which I work. These experiences have helped me broaden my knowledge across different projects and environments.

6. What's been one of the most rewarding parts of your early career, and have there been any mentors who had a big impact on your growth?

The people I have met have been the most rewarding part of my career so far. I am lucky to have an incredible boss who has been in the mining industry for over 40 years and has made sure he passes his knowledge on to me. My undergraduate professors also had a major influence on my professional growth. My honors thesis advisor was always making sure I was following the path I wanted and not a path others tried to encourage me to follow. This professor and one other remain very close to me, and I have visited them often when I am back in New Orleans. One of the things I love most about geology is that it can be surprisingly subjective — different geologists may interpret the same data differently and those discussions are what make the field so engaging.

7. What skills have been most valuable to you early in your career — technical or otherwise?

Technical skills like ArcGIS, and other mapping software, have been extremely valuable. Equally important is the ability to learn from mistakes and take criticism to grow. One thing you quickly realize after graduating is how much there still is to learn. Real-world geology is rarely as straightforward as the textbook examples and being willing to ask questions and learn from people around you is essential.

8. Are there any accomplishments, certifications, or projects you'd like to highlight?

I received the Chair Award as a senior at Tulane, my GIS certification, and completed a thesis. Post grad I have received

several certificates for Vulcan software, Deswik software and am continuing my education at Missouri S&T for my Geoanalytical and Geointelligence certificate.

9. What advice would you give students or other early career professionals entering the field?

Take as many interesting classes as you can and get involved in clubs, field experiences, and opportunities outside your comfort zone. You may think you already know exactly what field you want to pursue, but geology is incredibly broad, and some of the most valuable experiences come from unexpected places. One of my favorite classes in college was Medical Geology because it was completely different from anything I had taken before and gave me a whole new perspective. I'd also strongly encourage students to get involved in organizations and clubs. Serving as President of the Earth Science Club at Tulane allowed me to build lasting friendships, strengthen relationships with professors, and develop connections that still support me professionally today.

10. Outside of work, what are some of your interests or hobbies?

Outside of geology I am an equestrian and an artist! I especially love painting.

11. Anything else you'd like readers to know?

Geology has introduced me to incredible people, unique opportunities, and experiences I never would have imagined when I was younger collecting rocks at a mine site. It's a field that constantly challenges you to keep learning, and that's one of the things I love most about it. Organizations like AIPG have also helped me make connections and better understand the professional side of geology and the variety of career paths available in the field. AIPG has been very encouraging as I continue to build my own career and learn about other opportunities.

AIPG Member Photo Challenge

Challenge categories:

- Off the Beaten Path - Unique feature/formation.
- The Best Part - Capturing the Spirit of the AIPG National Conference.
- My Favorite Outcrop or Rock, Fossil or Mineral Sample.
- Micro-Geology - Under the microscope.

Entries must be original and taken by a member. Entry authorizes publication of the image in *The Professional Geologist* by AIPG with credit given to the photographer.

Awards:

First place in each category:

Image published on the cover of *TPG* in 2027. Winners will receive a personalized Estwing rock hammer engraved with their name and member number or AIPG Gear of choice up to \$50.

Runners Up in each category:

Images will be published inside the *TPG*. Runners up will receive AIPG gear of choice up to \$30.

Challenge Rules:

Image requirements: digital, 300 dpi, 8.5"x11," portrait orientation full color.

Members are allowed one entry per category with up to four submissions (one per category).

All images must be original and taken by the member.

Submit entries via email to aipg@aipg.org.

Entries must include:

- Name
- Member number
- Section
- Title of image
- Less than 200 word description of the image
- Names of any identifiable persons in the image and permission to publish their photo
- Year photo taken

Entry deadline: November 1, 2026.

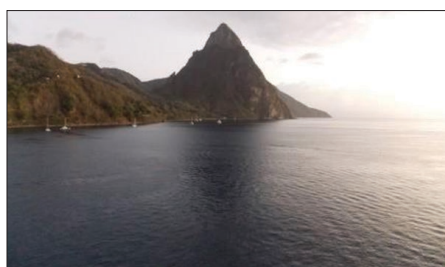




Robert G. Font, CPG-03953
 robertfontphd@gmail.com

1. Dacite is commonly found on some of the volcanic island arc of the Lesser Antilles. For example, dacite peaks known as the Gros Piton and Petit Piton are landmarks on the island of St. Lucia. Which of the choices below reflects the composition of this igneous rock?

- a) Ca-Na plagioclase feldspar, olivine, and pyroxene.
- b) Na-Ca plagioclase feldspar, biotite, hornblende, pyroxene, and quartz.
- c) K-feldspar, quartz, mica, and amphibole.
- d) Olivine, pyroxene, garnet, spinel, and plagioclase.
- e) The great philosopher I. Amm Innzane, B.S. states: "Light reflecting from microcrystals in dacite peaks and Caribbean Pitons spirals, swirls, and undulates so as to coalesce with the colossal expanses of elemental and universal space plasma domains, culminating in a superfluity of..."



2. This geoscientist is credited with the proof that fluid potential, not pressure by itself, controls groundwater flow:



- a) Marion King Hubbert
- b) Keith Edward Bullen
- c) Carl Friedrich Gauss
- d) Augustus Edward Hough Love
- e) Albert Falco

3. Which of the following statements is correct?

- a) In general, vertical burrows are formed in shallow water environments and horizontal burrows in deeper water environments.
- b) In general, horizontal burrows are formed in shallow water environments and vertical burrows in deeper water environments.

- c) In general, burrows are abundant and commonly recognizable in aeolian dune depositional environments.
- d) In general, burrows are abundant and commonly recognizable in glacial till deposits.
- e) Dood, Ay ryde hurses; ay dun't ryde burrows.

4. In geology, what is a "bajada?"

- a) A series of coalescing alluvial fans found at the foot of a mountain area.
- b) The steep limbs of a tightly folded synclinal structure.
- c) The wide area found in front of a glacier where material is deposited from the glacier's meltwater.
- d) It is equivalent to the "lower delta" or subaerial region most influenced by waves and tides.
- e) Well, hombre, I'd say that it is not a "subida."

5. The adiabatic temperature gradients are 0.4-0.5 K/km for the Earth's upper mantle and 0.3 K/km for the Earth's lower mantle. What does the "adiabatic" mean?

- a) It is a thermodynamic quantity representing the unavailability of a system's thermal energy for conversion into mechanical work. It is interpreted as the degree of disorder or randomness in the system.
- b) It is a thermodynamic quantity equivalent to the total heat content of a system. It is equal to the internal energy of the system plus the product of pressure and volume.
- c) It refers to the process or condition in which heat does not enter or leave the system.
- d) It refers to thick sequences of the igneous rock "diabase."
- e) Popular professor at D.U.M.B. University, Dr. I. M. Goofy, states: "Adiabatic temperature is a type of elevated body temperature or feverish condition, with diabetes-like symptoms that one can get if travelling to the Earth's mantle. Travel warnings apply!"



**Beware of
adiabatic!**



Compiled by David M. Abbott, Jr., CPG-04570
5055 Tamarac Street, Denver, CO 80238
303-346-6112, dmageol@msn.com

Topical Index-Table of Contents to the Professional Ethics and Practices Columns

A topically based Index-Table of Contents, "pe&p index.xls" covering columns, articles, and letters to the editor that have been referred to in the PE&P columns in Excel format is on the AIPG web site in the Ethics section. This Index-Table of Contents is updated as each issue of the TPG is published. You can use it to find those items addressing a particular area of concern. Suggestions for improvements should be sent to David Abbott, dmageol@msn.com

Carnal embraces between professors and students

In my last column, 197, I noted that "Carnal embraces are among the romantically related activities falling within the generally agreed-on rule proscribing this and related activities between professors and students.¹ The question is, "Is/are there (a) generally recognized exceptions to this rule?"

Professor-Student Romantic Relationship
—A Response by **Dominic Ombati, ECP-1260**

I am currently an assistant professor at a small Christian university in Southern California. Our institution strictly prohibits any form of sexual exploitation, harassment, and discrimination. Additionally, the university explicitly forbids employees from engaging in romantic relationships outside of marriage, which it defines as a union between a man and a woman.

Regarding your question about whether there are any widely accepted exceptions to the ban on romantic relationships between professors and students, I researched the topic and identified two exceptions that I believe are worth mentioning.

1. Preexisting Romantic Relationships

One recognized exception occurs when a romantic relationship between a professor and a student existed before the professor's employment at the univer-

sity or the student's enrollment. In such cases, the relationship is seen as having begun independently of the academic environment, which can reduce concerns about potential exploitation or conflicts of interest.

2. Relationships in Different Departments

Another possible exception occurs when a romantic relationship forms between a professor and a student who are in different academic departments. In this case, it is essential that the professor has no supervisory or evaluative authority over the student. This separation of academic roles can help minimize power imbalances that often accompany professor-student relationships, thereby addressing concerns about fairness and academic integrity.

These exceptions are meant to clarify policies while upholding the university's dedication to fostering a safe and respectful academic environment for everyone.

Personally, I find this exception questionable, and I prefer a ban on romantic relationships between professors and students at the same institution.

References

1. Hutchens, N. (2003). The legal effect of college and university policies prohibiting romantic relationships between students and professors. *JL & Educ.*, 32, 411.

2. Johnson, A. B. (2000). Current Trends in Faculty Personnel Policies: Appointment, Evaluation and Termination. *Louis ULJ*, 44, 81.
3. La Sierra University. Title IX policy. Retrieved October 27, 2023, from <https://lasierra.edu/offices/title-ix/policy/>
4. University of California, Merced. Consensual relationships policy. Retrieved October 27, 2023, from https://policies.ucmerced.edu/sites/g/files/ufvvjh1451/f/documents/policies/ucm_policy_consensual_relationships.pdf

Becca May, ECP-1250,² responded to my question as follows.

"Because power corrupts, society's demands for moral authority and character increase as the importance of the position increases" (John Adams, John Adams' Historical Society). Power dynamics in government, society, the workplace, and education were fundamental tensions that the Founding Fathers of the United States grappled with, and they will remain so another 250 years from now. As the second President of the United States, Adams understood firsthand the corrupting pull of authority. Lord Acton echoes this sentiment. Known for his piercing observations on power, Acton warns that "power tends to corrupt, and absolute power corrupts absolutely" (Lord Acton, Letter to Bishop

1. The first line in Tom Stoppard's *Arcadia* (1993) "What is a carnal embrace?" is asked by a 13-year-old heiress of her tutor in 1809 at an English country house. She has heard the term used by servants gossiping about what they saw outside the house. The tutor doesn't really want to provide the correct answer and instead observes that the heiress was to be studying Fermat's last theorem (there is not a solution to $a^x + b^x = c^x$ where x is a whole number greater than 2). *Arcadia* continues with exploration of the space-time continuum and other topics and is very much worth reading.
2. The views and opinions expressed in this essay are solely my own and do not represent, reflect, or constitute the positions of my employer, any affiliated organizations, or any professional bodies with which I am associated.

Creighton, 1887). Few environments illustrate this danger more clearly than the professor-student relationship, a dynamic ripe for manipulation, favoritism, and harm. Whether the relationship is a casual encounter, an ongoing affair, or even a marriage, romantic involvement between a professor and their student is not beneficial for the professor, the student, or the broader classroom community.

Casual romantic or sexual relationships should be strictly prohibited between professors and students. The potential for jeopardizing a student's learning, academic integrity, and the comfort of their peers is significant. A review of public discourse on platforms such as Reddit and Facebook reveals that the majority of students express strong discomfort, even disgust, when a classmate is romantically involved with their professor, citing concerns about fairness and classroom dynamics.³ Beyond the classroom atmosphere, the power imbalance creates a precarious situation for the student involved: either the student gains undue influence over their own grade, or worse, the professor gains leverage to manipulate it, particularly if the relationship sours. The case of marriage or long-term partnership, more likely to arise in graduate-level settings, may seem more defensible, but it should remain prohibited all the same, for the protection of both the academic process and the relationship itself. Consider the scenario in which a professor serves as graduate advisor or dissertation committee member for their own spouse. At some point, that professor must objectively evaluate their partner's academic performance. Even with the best intentions, the conflict of interest is profound. The emotional stakes alone (e.g., a failed comprehensive exam, a rejected dissertation chapter) could place irreparable strain on the marriage. Why subject a relationship, and an academic career, to that unnecessary risk? The solution is straightforward: change programs, institutions, advisors, or committee members. Love does not require the same classroom. Academic integrity, however, requires the same standard for everyone in it.

In column 50 (Jan '00) I published the following scenarios posed by **Jonathan Price**, CPG-7814) at the 1999 AIPG Annual Meeting in Alaska in preparation for a pre-

sentation he planned for the following GSA Annual Meeting. Price's scenarios related to the question, "When, if ever, is it acceptable for college or university professor [or instructor] to have sexual relations with a student? The scenarios are:

- Always;
- When the undergraduate student is not a student in the professor's current classes;
- When the undergraduate student is not a major in the professor's department;
- When the student is a graduate student, but not an undergraduate;
- When the graduate student is not a student in the professor's current classes;
- When the graduate student is not supervised by the professor (but is in the same department as the professor);
- When the graduate student is not in the professor's department;
- Never;
- Other circumstances (please elaborate).

A scenario not on Price's list that is an obvious exception to the general rule is when the professor/instructor and student are married. This scenario introduces a different ethical problem, the conflict of interest between the married student and the other students in the class. (See AIPG Code of Ethics Standard 3.1 and the Rules thereunder.)

The first part of resolving a conflict of interest is informing all affected or potentially affected parties of the situation. In the case of the married professor/instructor and student, the student has far greater access to the professor's/instructor's time and resources than are available to fellow students. However, the expectation that the student will succeed in the class is probably far greater than the expectations for other students.

I addressed a related issue in column 72 (Mar '02) when discussing the issue of "Conflicts of interest—office romances, relatives, harassment, etc." In all these

situations one or more individuals is, or is perceived to be, selected for attention and consideration for reasons other than job qualifications and performance. Developing hard and fast rules on conflicts of interest based on personal relationships of one sort or another can be very difficult. Romances occur. Outright bans on office romances or other sorts of activities are not sufficient to prevent them from happening and may lead to undesirable consequences. Two employees at equal level may not present a problem now, but what happens if one is promoted to a supervisory position over the other? Asking one of the couple to leave may unfairly hinder a career. Or it may deprive the company of a valued employee. The leaving employee may well be employed by a competitor, which brings up the possibility of loss of confidential information on projects or strategies. Another problem stems from unpleasant relationship breakups resulting in potential unwarranted adverse attention, the reverse of the initial problem of favoritism.

A cousin of mine was a math professor at Plymouth State College, NH who taught beginning calculus. Seniors at the local high school were allowed to take the calculus class and my cousin's son did so. In view of the conflict of interest presented, another member of the math department graded the son's homework and tests.

Consideration of these issues and resulting conflicts of interest highlights the complexities of a situation and the consequences of potential alternative solutions. Dominic Ombati, Becca May, Jon Price, and I have provided alternative answers to the question. You may agree in part and disagree in part, which is what makes the question worth discussing. Hard and fast rules can lead to undesirable consequences. Disclosure and flexibility are needed.

Accessibility of web content for state and local government

A new rule under the Americans with Disability Act (ADA), Title II on the accessibility of web content for state and local government agencies including schools requires state and local government agencies to make their web content accessible to the disabled. The rule becomes effective April 24, 2027 for agencies of ≥50,000 employees and April 26, 2028 for

3. www.reddit.com/r/SMC/comments/1gkgt5p/are_teacher_student_relationships_allowed/; www.facebook.com/groups/2421332174854501/posts/4060505337603835/.

small agencies.⁴ This rule applies to PDF files of web presentations. The US General Services Administration published their Fiscal Year 2025 Governmentwide Section 508 Assessment in March 2026—a report that reviews federal agencies and their compliance with Section 508 accessibility requirements.⁵ Some states have issued similar laws or regulations. Aside from those required to provide accessible web content, the rest of us should consider the need for accessibility and learn to create appropriate documents.

I've always recognized that the disability that would most significantly affect the ability to do geoscience tasks is blindness. The concept in the new ADA Rule is that text and audio descriptions of pictures be provided. But how do you do this in practice? How does one effectively describe a picture of the Teton Range or the Grand Canyon for the blind? If I have a presentation about prominent igneous monoliths that includes pictures of Shiprock, Devil's Tower, and inselbergs (tropical chemically weathered monoliths, e.g. the Sugar Loaf at Rio de Janeiro). How do I describe and distinguish between them? I have no clue on how to effectively do this; I'm "blind."

PowerPoint™ in its current version has an "Check Accessibility" in the "Review" topic heading at the top of each slide's screen.

Clicking on this brings up an "Accessibility Assistant" column on the right-hand side of the screen that assists in adding "alt text" to visuals. This "help" states, "Alt text helps people who use screen readers to understand what's important in the visuals in your slides. Visual content includes pictures, SmartArt graphics, shapes, groups, charts, embedded objects, ink, and videos."

The AI generated text recommended for Shiprock was "The image depicts a rugged, rocky mountain with a flat top, rising above a vast, barren desert landscape under a clear blue sky." A flat top, really? The AI generated text recommended for Devils Tower was "The image depicts a rugged, rocky mountain with a flat top, rising above a vast, barren desert landscape under a clear blue sky." This is the same as the suggestion for Shiprock. The AI generated text recommended for Sugar Loaf was "The image shows a dramatic aerial view of the iconic Sugar Loaf mountain, overlooking a coastal city with boats and a harbor." I don't regard these suggestions as particularly helpful or useful in describing what is unique and important about these igneous monoliths. I suppose making a detailed recording comparing and contrasting the pictures would be a solution. What do you think? What are your suggestions?

Stephanie Jarvis, former Student Voice columnist and now teaching at a community college, sent the following comments on the foregoing discussion of accessibility.

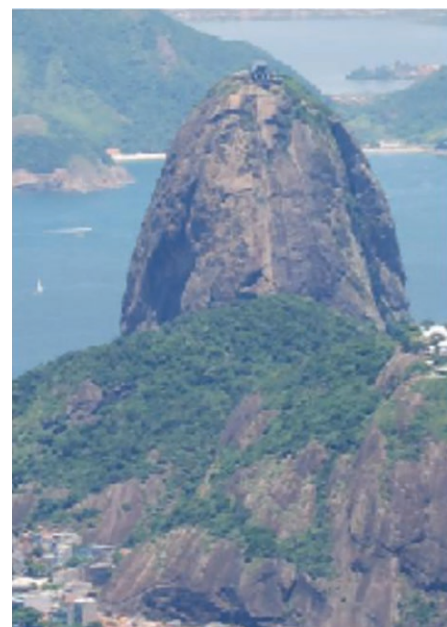
- The alt text should be pretty simple and short (<125 characters). Basically, it should describe what you expect your audience to see in the picture, i.e. what you're assuming somebody sees if they can see it. So, you'd describe the shape of the mountain or landscape or whatever it is. "Blue sky" probably isn't important but it might be. I would not put names of places in alt text, as somebody wouldn't "see" the name of the place (unless there's a sign in the picture with that information and it's important). Figures should have captions in most publications, so that kind of information would go in the captions. If there is a lot of detail, there can be extended figure descriptions either in the text referencing the image or as a footnote (I'm not sure if the footnote approach is recommended, but I've seen it used in textbooks). I would love to find an authoritative guide to writing proper alt text...so far, I've just been accumulating a lot of suggestions. While I'm definitely



Shiprock, New Mexico



Devil's Tower, Wyoming



Sugar Loaf, Rio de Janeiro

4. <https://www.ada.gov/resources/2024-03-08-web-rule/#how-long-state-and-local-governments-have-to-comply-with-the-rule>, and <https://perma.cc/UB8A-GG2F;>

5. [https://www.section508.gov/manage/section-508-assessment/2025/message-from-gsa-administrator/.](https://www.section508.gov/manage/section-508-assessment/2025/message-from-gsa-administrator/)

still learning best practices, figuring out how to apply it all, and getting pretty frustrated, I am finding that I'm producing better instructions/assignments/explanations once I have it done because writing the figure descriptions really makes me think about what I'm assuming of my audience (in my case, my students).

- I see you have the figures above in a table, which is a formatting trick you taught me that I've used many times :).⁶ However, that's now a no-go. Screen readers will see that as a table and require header row/column cells, etc. I was just working on a lab worksheet in which I wanted text next to images (for space purposes) and I ended up using section breaks and multiple columns (so a section break above and below the portion I wanted to be in two columns), which worked well. I had to turn the paragraph symbol feature on to get it right.

- The PDF conversion is probably the trickiest part of this (at least for me, right now) and I'm still learning about that. Just because a file passes Word's accessibility checker doesn't mean the PDF (if you save it as a pdf from Word) is entirely good (scanned, and I'm assuming, "print as" PDFs are not good). You have to set the document title, for example, which Word doesn't prompt you to do. We have a program set up in our learning management system (D2L) that is supposed to check PDFs but I haven't figured it out yet and I've heard mixed reviews.
- Links, like you have at the bottom, are supposed to be hyperlinks with descriptive text rather than the full URL since a screen reader will read that whole thing. So, for example, your footnote at the bottom would be something like "Fact Sheet: New Rule on the Accessibility of Web Content and Mobile Apps Provided by State and Local Governments".

This seems problematic for something that is also being made available in print and I'm not sure what the guidance on that is.

- Using Word's built-in headers systems has been strongly recommended. I can't stand the default formatting on them so I'm always changing it but apparently screen readers can detect the different heading levels and that's useful for navigating a document. So, "Accessibility of web content for state and local government" should be designated as the Title (this is not the official title of the document I referred to above—that has to be changed in title properties. Isn't this fun?!). If you had any sections, you'd use Heading 1, Heading 2, etc.

Clearly, there is a great deal more to be learned about the process of creating accessible files for the visually impaired. I'd appreciate hearing from you about your ideas, or please write an article for the *TPG* on the subject.

6. Abbott, David M., Jr., 2004, Corraling graphics in MS Word: *The Professional Geologist*, March-April 2004, p. 16-18.



KU THE UNIVERSITY OF
KANSAS

PROFESSIONAL SCIENCE MASTERS
Environmental Geology

Advance your Career with a Professional Science Master's in Environmental Geology

The PSM in Environmental Geology at the University of Kansas integrates professional skills training with in-depth coursework in geology and environmental policy. Offered primarily online with in-person field workshops which can be completed in three single-day sessions or a week-long summer field course in Colorado.

- Expand your knowledge of physical and chemical hydrogeologic principles and applications, environmental characterization, and quantitative modeling skills.
- Learn from experienced professors and industry professionals.
- Develop project management, communications, and leadership skills.
- Conduct capstone research designed to match your career goals.
- Some courses available as CEUs.

Contact the program director,
Dr. Marcia Schulmeister, Ph.D., P.G.,
mschulme@ku.edu



Answers:

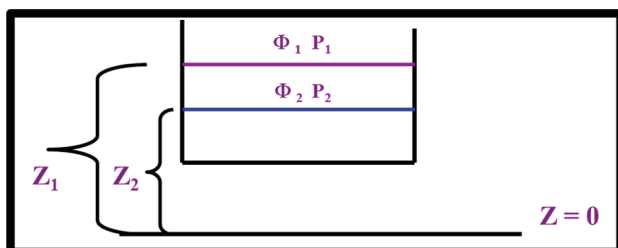
1. The answer is choice "b" or "Na-Ca plagioclase feldspar, biotite, hornblende, pyroxene, and quartz."

Choices (a), (c) and (d) are likely the composition of basalt, rhyolite, and peridotite, respectively.

2. The answer is choice "a" or "Marion King Hubbert." M. King Hubbert (1903-1989) was an American geoscientist who made significant contributions to the geosciences. He worked for Shell Oil Company at their Houston Texas research lab. In the area of petroleum geology, he came up with the concept known as the "Hubbert Peak Theory" predicting, in 1956, that oil production in the US Lower 48 would peak in the early 1970s. Can't win them all...

The proof regarding fluid potential (Φ) as the driving factor in groundwater flow is illustrated below (please refer to the figure and derivation presented here). The following is adapted from Hubbert's classic paper: "The Theory of Groundwater Flow", 1940, *The Journal of Geology*, Vol. XLVIII, No. 8, Part 1.

Consider a container filled with fluid. The fluid is at rest. Let Z = height above a reference surface; P = pressure; D = density; g = acceleration of gravity.



From the diagram we see that Φ_1 and P_1 are the fluid potential and pressure at Z_1 and Φ_2 and P_2 are the fluid potential and pressure at Z_2 . Then,

$$\Phi = gZ + P / D \quad (1)$$

$$\Phi_1 = gZ_1 + P_1 / D \quad (2)$$

$$\Phi_2 = gZ_2 + P_2 / D \quad (3)$$

$$P_2 = P_1 + (Z_1 - Z_2)Dg \quad (4)$$

$$\Phi_2 = gZ_2 + [P_1 + (Z_1 - Z_2)Dg] / D \quad (5)$$

$$\Phi_2 = gZ_2 + [P_1 / D] + gZ_1 - gZ_2 \quad (6)$$

$$\Phi_2 = [P_1 / D] + gZ_1 = \Phi_1 \quad (7)$$

Please note that in the example $P_2 > P_1$, but since $\Phi_2 = \Phi_1$ there's no flow.

As for the additional choices: Keith Edward Bullen from New Zealand (1906-1976) is known for his seismological interpretation of the deep structure of the Earth's mantle

and core. Carl Friedrich Gauss (1777-1855) from Germany is known for the first mathematical representation of the Earth's magnetic field. Augustus Edward Hough Love (1863-1940) developed the concept of the "Love Waves" in earthquake seismology. Albert Falco was not a geoscientist. He was the Chief Diver and Captain of the RV Calypso, made famous by the underwater explorer Jacques Ives Cousteau. It was Cousteau and Falco who inspired me to become a scuba diver, a sport that I enjoyed for about 20 years with annual diving trips to the Caribbean Sea area.

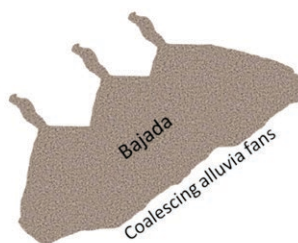
3. The answer is choice "a" or "In general, vertical burrows are formed in shallow water environments and horizontal burrows in deeper water environments."



**Worm burrows
Glen Rose Limestone
North-central Texas**

Vertical burrows (bioturbation) may indicate shallow water, specifically in the tidal zone. Within the tidal zone organisms are forced to move up and down in the substrate as the tide ebbs and flows. Vertical bioturbation may also be expected in lagoonal environments. Horizontal bioturbation may be more common in the deeper waters beyond the barrier bar environment.

4. The answer is choice "a" or "A series of coalescing alluvial fans found at the foot of a mountain area." "Bajadas" are typically found in arid or semiarid regions.



Choice "c" refers to the glacial "outwash plain." Choice "b" and choice "d" do not apply here. As far as choice "e" goes, in Castilian Spanish "bajada" implies a descent and "subida" is the antonym defining a rise.



5. The answer is choice "c" or "It refers to the process or condition in which heat does not enter or leave the system."

Choices "a" and "b" refer to "entropy" and "enthalpy", respectively. Sorry, the term "adiabatic" has nothing to do with "diabase."

Hope and Suffering in the Desert

Vic Ridgley

Background

Like most field geologists laboring under unanticipated conditions, I got embroiled in the strangest episode in my career in 1974. George & I were working for French-American Metals (FRAMCO), the US subsidiary of the French Atomic Energy Commission (Commissariat à l'Energie Atomique). Our assignment, which lasted nearly two years, was to follow up on all the Preliminary Reconnaissance Reports (PRR's) that American citizens had turned in to the US AEC in the years following the first uranium discoveries in what became the Grants (N.M.) Mineral Belt. Our remit specifically was to visit all occurrences reported in Arizona. In the course of our wanderings, we stumbled on a somewhat unusual terrane of detachment faulting in extreme western Arizona. The overlying detachment plate was composed of Devonian(?) carbonates overlying a planar, gently folded basement of Precambrian gneiss. The synclinal portions of the folded basement included rubble zones which registered as strongly radioactive on our scintillators. After evaluating the geologic setting, we identified a one-mile square area that justified a land acquisition.

The Ground Rules

To understand what happened next, you need a brief refresher on the 1972 Mining Law as it stood in 1974. Individuals or companies had the right, on Federal lands, to "stake claims" of 600' x 1500', marked by four corner posts, two side posts and one claim post. Temporary title was conferred by registering the claims in the county courthouse and performing at least \$100 worth of 'work' on the claim, measured each year from September to September. You could allow the claims to lapse by not doing the work, but you could regain and maintain the title by resuming work, so long as no rival moved in on your claim.

The Players

The protagonists in our story are:

Dennis P, who had staked claims in 1969 covering 4 square miles, including the square mile we were interested in. He had not done any work on the claims since 1970.

Yours truly (George and I), who coveted the area in 1974 and who, on behalf of FRAMCO, initiated a small staking program adequate to cover our preferred square mile.

Calm Before the Storm

George and I took a break and set up shop on August 28th in the Rancho Grande Best Western in Wickenburg. The next day, we took a leisurely drive out to the property, just north of the Bill Williams River, and visually surveyed the area to confirm that there

were no existing claim posts from 1969, nor any sign of recent activity that could impact our planned acquisition. That night, all hell broke loose.

The Response

The FRAMCO landman had been apprised of our interest in this acreage, which we had decided to call "Rawhide," and late in the afternoon of the 29th he entered the courthouse to check the current validity of the 1969 claims (based on work that should have been recorded every year since then).

We did not know that our landman had a big mouth. Instead of simply asking to see the claim documentation, which was a routine legitimate request, he ran off at the mouth to the county clerk and explained that he was working for a group that was planning to overtake the property. He mentioned the owner's name, Dennis P., and the county clerk chimed in with, "Oh, he's my boyfriend!" She – knowing that Rawhide was vulnerable to overtaking – left her post to call her boyfriend.

The landman called us to advise that 'he may have slipped up.' This prompted us to spend the entire day of the 30th frantically preparing over 100 claim notices to be filed at the courthouse as soon as possible. He drove down from Kingman (county seat) to see us in Wickenburg and retrieve our new claim notices and return to Kingman to file them.

Countermeasures

Arizona, at this time of year, is brutally hot, with noon to 3 PM temperatures easily exceeding 115°. We prepared for the worst. For the next several days we got up every morning at 3:30 AM to arrive at the Rawhide site at sunrise. From sunrise until noon we lugged bundles of 2"x2"x48" stakes all around the property, setting them up as corners, sides and claims.

We had prepared receptacles for the claim notices on the claim posts by cruising the dry bed of the Hassayampa River the night before, retrieving all the pop-top soda cans we could find, and folding the notices to shove them into the cans where they'd never be seen.

Noon to 2 PM was designated sleep time (under the vehicles), and we resumed our labors until 7-ish. Our daily companions were occasional rattlesnakes and frequent tarantulas. We took the next three days off before being pressed back into service. On September 7th, we completed the first phase of the overtaking by adding posts where some lines were incomplete.



It turned out that wasn't the only 'incomplete' issue. No sooner had we completed all the posts, that the General Manager of FRAMCO in Denver decided that we'd be in a stronger legal position if we filed the paperwork as dated AFTER August 31. That required another two nights of tramping up and down the dry Hassayampa riverbed to collect another 50 or 60 soda cans and writing a corresponding number of new claim notices to replace the ones already filed in Kingman. (I almost forgot to mention that our Hassayampa soda can supply was getting lean – we were too efficient at harvesting – so we actually had to cruise through Wickenburg trash bins and find more soda cans).

At this point, we felt entitled to take another two days off. Those days of mental relaxation were overdue, we enjoyed the respite they afforded and tinkered with laying out a 15-hole drilling program with a reverse-circulation drill contractor in Arizona.

A New Wrinkle

Our unfettered progress was interrupted on September 17th, when Dennis P. (the man himself!) showed up at the edge of the property. He was a bulky guy, with a gut that was flanked by muscle and enhanced by an angry, thin-lipped stare. He denounced FRAMCO and 'certain geologists.' We advised him to take up his complaints with the General Manager in Denver, whom we cited as the authority for our work to date. We all left.

For whatever reason I have long forgotten, all parties were absent from the property for the next week: George and I, Denis P., the local catskinner and the drill crew from Phoenix.

Enduring Confrontation

Friday, September 17th, ushered in a new phase of conflict. The parties present were George and I, the drill crew, and a security guard hired by Dennis in Kingman to stop the planned drilling activity. He delivered the following speech:

"I have the duty to inform you that you are trespassing on Dennis P.'s property. If you continue with this course of action, I will put a bullet in the radiator of your drill, and you will be subject to legal penalties for your actions. I have the authorization and the right to halt your drilling."

George and I returned to Wickenburg and consult with the Phoenix lawyer FRAMCO had retained. The lawyer, Lacy, contacted the General Manager of the guard service and demanded that he remove the guard from the premises.

The next morning was a replay of the previous day, The guard remained until, once again, our lawyer ordered the General Manager to remove him.

The following day, our lawyer once again demanded the removal of the guard. This time, the General Manager called Dennis and said he wasn't willing to put his guard in that situation, and he wasn't going to send any more guards. Then Dennis called the drilling company and threatened them. The drilling company called us and announced that they were through with us.

Not yet completely defeated, we called another drilling contractor. After he assured himself that our legal case was solid, he agreed to participate. He sent his contract to Denver for signature, which was quickly obtained, and two weeks later we were ready. Everything appeared to be a go.

On October 11 – geez, what a drawn-out story – George and I were back at Rawhide. Naturally, to protect us and our driller, our General Manager had contracted with the guard service for us to have our own guard. Not one to miss a commercial opportunity, the GM of the guard service called Dennis and said, "Hey, do you know those people are trying to keep you off your property now?" Of course, Dennis was eager for the challenge.

The next day saw the presence of some of the usual participants: George and me, and two guards from the same service, driving down to Rawhide in one vehicle. The driller was delayed by one day, so nothing happened and everybody went home.

The next day, things were more interesting. The driller was now present, so Guard #1 declared, "I have the duty to inform you that you are trespassing on Dennis P.'s property, and if you persist.... yada..yada..yada." To which Guard #2 responded, just like a Good-Old-Boy Sheriff would have, "I have a duty to protect the equipment and personnel of FRAMCO against any one, anything, or anywhere." After which all the parties (George, I, catskinner, driller and both guards) exchanged business cards, just to make it all official. And then we all drove to the first drill site.

Which prompted Guard #1 to repeat his invocation of our trespass on Dennis P.'s land. After which, fortunately, he shut up. And so went our first drill hole.

The second drill hole did not come off as well. After the first cordial exchanges, Guard #1 ran off to a telephone 30 miles away to tell Dennis that we were STILL trespassing. Two hours later, the Kingman County Sheriff came on to drill site #2 to arrest everybody

except (Guard #1). Seeing the smug and relaxed attitude of the drill crew, George and me, he elected not to arrest us, noting that the civil complaint had located the drill in the wrong township and he couldn't carry out the arrest since the trespass location was misstated. He left, promising to return the next day with the correct documentation AND a posse of deputies prepared to "take us all in. 'We set an appointment time at 9 AM for our arrest at the next drill site (#3), 300' further away. (We had suggested to drive to town that evening so that he could arrest us without having to come out the next day and make a production of it, but he didn't want to do that).

In the meantime, between this morning at #2 and tomorrow at #3, our lawyer called the Kingman County Attorney and asked him if he really wanted to make himself and the County Sheriff look like idiots (County legal authorities generally have no enforceable authority on Federal lands.) He declined.

The drilling and geologizing continued without further interruption, and poor Dennis lost his rights of possession in court. He was, however, proud of having thought up the idea of cutting expenses by having the guards commute together.

Now, if we had only located that uranium we were sure was there! (It turned out to be thorium!)

In Memoriam

William Klett, Jr., CPG-04303

The Woodlands, Texas

Passed on April 12, 2026

Member Since 1978

William Klett, Jr. was an AIPG member for 48 years.

Carlos M. Carranza, CPG-06215

Concord, Massachusetts

Passed in 2026

Member Since 1983

Carlos Carranza was an AIPG member for 43 years.

Roger G. Gallop, MEM-1076

Point Vedra Beach, Florida

Passed on March 12, 2026

Member Since 1966

Photo and obituary obtained from the Quinn Shalz website.

Roger Graham Gallop, born January 1, 1947, in Gainesville, Florida, son of the late Iva May (Lord) Gallop and Parron Graham Gallop, passed peacefully into Jesus' loving arms on March 12, 2026, at the age of 79.



Roger is survived by his cherished and devoted wife of 51 years, Katharine; his beloved son, Chris, and daughter-in-law, Rachel; and his precious grandchildren, Noah and Hannah. He was preceded in death by his sister, Gwendolyn Sharon Hinson.

Roger was a devoted son, brother, husband, father, and grandfather. Throughout his life, he persevered through many hardships, always grounded in his faith and sustained by the unwavering love of his wife, Katharine, whose kindness, patience, and generosity were

a constant blessing to him. Roger was a deeply loving and devoted husband and father, and he was dearly cherished by his family.

He often said, "I always tried hard and persevered, always loved my wife Kay and family, and kept my eyes on our Lord Jesus Christ." These words reflected the values by which he lived.

Roger served in Vietnam as an officer in the United States Marine Corps, completing his service with the rank of Captain. He received numerous decorations recognizing his combat service, professional excellence, and unit commendations. He will be laid to rest with military honors at Beaches Memorial Park cemetery.

Beyond his military service, Roger earned three college degrees, including a doctorate. He was a lifelong member of the American Red Cross Volunteer Life Saving Corps, a certified professional geologist, and owned and operated a geotechnical and environmental consulting business for more than 30 years. He was also the author of three non-fiction books. Don started and facilitated the Wyoming Natural Gas Fair in 1997, for 19 years. The family wishes to thank the doctors and nurses at Davita Hioaks Dialysis Clinic, Bon Secours Cancer Institute at St. Francis, caregivers from Care Advantage, and the staff of Ascend Hospice for their love and care of Ed during his long illness. We are also thankful to our dear family members, neighbors, church family, and friends for their prayers, help, and support during these past months.

Memorial gifts may be made to the following: The Doster-Via Family Scholarship, Brightpoint Community College Foundation, 800 Charter Colony Parkway, Midlothian VA 23114; Central Baptist Church (see address above); Virginia Tech, Blacksburg, VA specifically for student financial assistance in the Geology Department.

Exclusive Member Gear!



Gear Up with AIPG!



Hats, shirts, and bags for you to proudly represent AIPG - Wherever you go!

President's Message, continued from p. 39

"Geology of the National Parks," the course was stratigraphy. I'm just using that as an example where the course title may not indicate the true course work involved. It takes professional geologists' knowledge of our field to dig into examples like this and determine that the course work is in fact a geology course.

Leaving it to the discretion of a non-professional geologist to determine who is an "industry expert" and if they are truly an expert in geology or geological sciences is much too lax, in my opinion. I hope that the Secretary of State's program administrator will select Georgia licensed professional geologists when seeking advice and one better, will reach out to the AIPG. The good news is that PGs in Georgia have been invited to work with the Secretary of State's office in preparing guidance, and AIPG CPGs will be involved.

Attempts at de-regulating professional geologists seem to be a growing trend across the nation. We as professionals need to be ever vigilant with respect to issues that affect our licensure and our state boards of geology and must, at every opportunity, emphasize the importance of our profession.

On to the good news; I've written that I've been in contact and working with the University of Central Florida's (UCF) Dean of the College of Sciences (COS) and now with Yvette Kanouff, chairperson of the COS Dean's Advisory Board. She let me know that the Dean was asking about a certificate program that would provide course work or educational opportunities to students which would provide them with marketable skills. A certificate program would not necessarily be a minor in a particular degree but would still provide them with sufficient contact hours to understand the subject and take that with them and apply in the work environment.

As I thought about how to go about it, I realized that we in AIPG probably have the resources to assist the Dean in developing the program, and while I do know the skills that would make a student a valuable employee in Florida, I don't have the academic experience I think is needed to craft such a program. I called our Executive Director Aaron Johnson to get his help and advice. He let me know that the AIPG developed a program for Northwest Missouri State College which I think may be a good template for a program at UCF. One suggestion he made is to contact Florida geologists and ask what skills they'd like potential employees to have. From that we could begin to develop a program outline and take that to the Dean for preliminary review. Aaron and I can then work with the Dean to start to develop the certificate program and use it as a first step to reviving the geoscience minor degree.

Because the AIPG developed the certificate program for the college, we receive a fee for each certificate issued, which is reflective of the value that the AIPG brings to students, colleges and universities. The certificate shows that the student has the initiative to go above the required course work and attain higher skill levels to further their career.

On another high note, our monthly Lunch and Learn webinars are highly successful and average around 90 attendees per webinar. The subjects are wide-ranging from mining and minerals to water use permitting, ethics, critical minerals and member benefits. Go to the AIPG website and under the "Events" tab, select calendar and you can view the list of upcoming webinars. You can watch past webinars by going to AIPG.org and hover over the Education tab in the blue banner, and in the dropdown box, click on AIPG YouTube videos.

During one of our Executive Committee meetings, we were discussing potential subjects for future webinars and one member mentioned that his son is working on the tectonics of Europa (one of Jupiter's moons) and could possibly give a presentation on that work. That reminded me that I'd read about planetary studies at UCF and the University of Florida Geosciences...so the Executive Committee came up with the next Lunch and Earn series "Planetary Geology" which should be underway as you read this issue of *TPG*.

The dropdown box and the Education page list additional programs such as online learning, undergrad and graduate scholarships. Please check out all that AIPG has to offer; you'll be surprised at what's available to you.

I encourage all of you, even student members, to give a lunch and earn presentation on a project you're involved with, a research topic or anything related to the geosciences. It's a great way to educate others, for them to gain CEUs, and perhaps spark an interest in that subject.

Lastly, our Annual Conference in Duluth, MN is August 29-September 1, 2026 and is fast approaching. It is filled with field trips and opportunities to engage and connect with your fellow geoscience professionals. There will be technical sessions for geoscientists, students and professionals across the industry. The call for papers is out and information about the conference is available at www.aipg.org. I've been to several Annual Meetings over the years and have had a great time meeting old friends and making new ones and learning more about the work that we are involved with across the nation. Last year's conference in St. Louis took us to a cave system that was unreal and to a world-class lead mine. Two things I had no idea were close to St. Louis!

The AIPG Foundation runs a silent auction at the conference to make educational grants to support individual scholarships to undergraduate and graduate students in applied geosciences and prepare literature with educational content about the role of geosciences in society. Please support the Foundation directly or by participating in the silent auction at the conference.

Each of us has a responsibility to inform the public of our value to their everyday lives. Remember, we are the gold standard in our profession, and it is up to us to maintain that standard.

Share Your Insights. Publish in TPG.

TPG is now accepting article submissions for upcoming editions.



GENERAL
GEOLOGY



MINERALS &
ENERGY



GROUNDWATER



MAPPING &
GEOPHYSICS



PROFESSIONAL
PRACTICE



STUDENTS &
EARLY CAREER PROFESSIONALS



INNOVATION &
TECHNOLOGY

Submit articles to: aipg@aipg.org

Guidelines: www.aipg.org/page/TPGArticleSubmittal



Professional Societies

Do they still matter and why join them?

Rasoul Sorkhabi, Ph.D., CPG-11981

Dr. Rasoul Sorkhabi is a professor at the University of Utah's Energy & Geoscience Institute, Salt Lake City.
Email: rsorkhabi@egi.utah.edu

Professional societies or associations have been a pillar of the modern scientific enterprise for the past four centuries. However, they are all facing new challenges in recent years from funding and membership decline to global competitions and rapidly shifting technologies and work environments. This is particularly true for geoscience associations as geoscience as a whole is facing lower student enrollments. In a previous article, I discussed the importance of professional societies in geoscience education and how they can help geoscience teachers.¹ This article considers the role of professional societies in the entire geoscience landscape. Are professional societies still relevant in the twenty-first century? Why should students and early-to-late career professionals join and support these associations? These two questions, in turn, boil down to: How should professional societies remain relevant, up-to-date and appealing to their communities?

A Historical Perspective

Scientific societies in the modern sense emerged in the seventeenth century. The earliest scientific societies began in Italy. In 1601, the Academy of the Lynxes (Accademia dei Lincei) was founded in Rome with 32 members including the famed Galileo. It was, however, dissolved in 1651. Another early Italian society was the Academy of Experiments (Accademia del Cimento) that was active in Florence from 1657 to 1667. However, the first and still continuous scientific society was the Royal Society of London that was launched in 1660. This was followed by the French Académie des sciences in Paris in 1666. Scientific societies have traditionally provided organizational frameworks for community networking, expert discussions, conferences and publications.

Professional societies in geology date back to the nineteenth century with the Geological Society of London being the first of its kind founded in 1807 followed by Société géologique de France in 1830.

In the twentieth century professional societies, including geoscience societies, became a global phenomenon. Every country

currently has its own share of scientific societies with various sizes and levels of activities.

Why Join Professional Societies?

Three recent articles by Forbes Coaches Council (2025)², Miller (2025)³, and Knox (2024)⁴ have outlined the benefits of joining professional societies. Table 1 lists their arguments. I have also summarized these benefits below from my perspective.

Traditionally, students, academics, researchers and professionals have joined professional societies in their respective fields for the following major reasons.

(1) Networking and Community

Professional associations create a community and network of peers, mentors and leaders that foster both personal growth and professional development. Through collaborations, mentorship, referrals, networks, members gain guidance, exchange ideas and information, and learn about jobs, funding, and other opportunities related to their fields. Science is never done in an isolated environment; belonging to a community broadens our working environment and builds long-term relationships that strengthen our career.

(2) Professional Development and Education

Professional societies offer access to exclusive educational resources to their members. These resources include gatherings (webinars, seminars, field trips, training courses, workshops, and conferences led by experts) as well as publications (newsletters, magazines, and journals). These opportunities help members stay current on industry trends, best practices, and emerging challenges and prospects. All these ensure continuous knowledge growth and skill enhancement.

(3) Credibility and Authority

Membership signals our authority in our chosen field and our commitment to the profession. It adds merit to our resume and

1. Sorkhabi, Rasoul (2020) Educator's Corner: Professional Societies in Earth Science Education. *The Professional Geologist*, vol. 57, no. 2, pp. 44-45.
2. Forbes Coaches Council (22 July 2025) 14 coaches on the benefits of joining a professional association. <https://www.forbes.com/councils/forbescoachescouncil/2025/07/22/14-coaches-on-the-benefits-of-joining-a-professional-association/>.
3. Paul Miller (24 February 2025) Why is association membership valuable? https://www.asaecenter.org/en/resources/articles/an_plus/2025/02-february/why-is-association-membership-valuable.
4. Eric Knox (8 June 2024) The benefits of joining a professional organization. <https://resources.businessstalentgroup.com/btg-blog/benefits-joining-professional-organization>.

strengthens our reputation to clients, funding agencies, and managers. For this reason, all associations must follow and require adherence to professional standards and ethics and even offer continuing education for members. Some societies also provide professional certifications after a due review process. Professional societies usually recognize life-long contributions and excellence by giving specific awards annually.

(4) Leadership and Influence

Membership in professional societies opens doors to leadership roles such as participation in committees and boards. These positions involve teamwork, planning, problem solving and setting professional standards. In this way, we contribute to and shape the future of our profession and also develop leadership skills that are transferable to our own career.

(5) Financial Incentives

One of the benefits of membership is discounts on fees for journal subscription, conference registrations, and training courses

that professional societies offer. Some societies also arrange affordable insurance for their members through working with insurance companies. Some professional societies offer student scholarships, travel grants or similar financial assistance. Also note that because professional societies are usually nonprofit tax-exempt organizations membership dues may qualify as tax credits (business expenses) for members.

Professional Societies in the US Geoscience Landscape

Let's now review the missions, purposes and value propositions of major geoscience associations in the USA as stated on their websites. These associations are introduced alphabetically.

(1) American Association of Petroleum Geologists (AAPG)

Founded in 1917 with headquarters in Tulsa, Oklahoma

Membership: ~15,000 across 100-plus countries

Table 1. Why join professional societies? A list of arguments from three authors

Forbes Coaches Council (2025)	Miller (2025)	Knox (2024)
1) Connecting with a broader community.	1) Return on investment	1) Expand your professional networks: Referrals; Collaborations; Mentorship
2) Building alliances	2) Power of networking and cultivating professional relationships	2) Stay updates on industry trends: Newsletters and journals; Webinars and seminars; Research Papers
3) Developing qualifications and credibility	3) Leadership development	3) Learn from fellow professionals: Marketing; Growth strategies; Best practices
4) Increasing your authority	4) Mentorship for professional growth	4) Enhance your resume: Dedicated to your profession; Participating in its advancement; Committed to learning and professional development
5) Learning and connecting	5) Certifications and career path development	5) Enjoy member discounts: Software subscriptions; Office supplies; Professional services
6) Showcasing commitment to craft	6) Shift in work habits and disconnect from professional associations	6) Advocacy and representation: Lobbying; Public forms; Unified voice on issues
7) Supporting career development	7) Duty to belong: Giving back to the profession	
8) Gaining access to vetted minds		
9) Leveraging membership for learning		
10) Laying the groundwork for transformation		
11) Exchanging peer-to-peer insights in context		
12) Expanding perspectives		
13) Plugging into key conversations		
14) Helping to shape what is relevant		

"AAPG's mission is to advance the science of geology, especially as it relates to petroleum, natural gas, other subsurface fluids, and mineral resources. This includes:

- Advancing economic and environmentally sound production and procurement technology
- Fostering the spirit of scientific research throughout its membership
- Disseminating geological and technological information relating to petroleum, natural gas, other subsurface fluids, and mineral resources
- Inspiring and maintaining a high standard of professional conduct from its members
- Providing the public with the means to recognize trained and professionally responsible geologists
- Advancing its members' professional well-being

Why Join AAPG?

As an AAPG member, you position yourself among the field's expert professionals and have the opportunity to network with interdisciplinary professionals in emerging areas of science, technology, and energy solutions.

You also receive special discounts and the earliest access to in-person events, educational webinars, field trips, short courses, and more. Finally, you gain access to new research studies and energy industry news that will keep you ahead of the curve."

(2) American Geophysical Union (AGU)

Established in 1919 by the National Research Council and operated as an unincorporated affiliate of the National Academy of Sciences until 1972 when it was independently incorporated. Headquarters in Washington DC.

Membership: Nearly 60,000 in more than 130 countries

"Through broad and inclusive partnerships, AGU aims to advance discovery and solution science that accelerate knowledge and create solutions that are ethical, unbiased and respectful of communities and their values. Our programs include serving as a scholarly publisher, convening virtual and in-person events and providing career support. We live our values in everything we do, such as our net zero energy renovated building in Washington, D.C. and our Ethics and Equity Center, which fosters a diverse and inclusive geoscience community to ensure responsible conduct."

"AGU is an innovator among scientific organizations. We pioneer new approaches to growing the exchange of scientific knowledge through publishing and meetings. We encourage and facilitate new and transdisciplinary fields of study, transforming our programs and operations as we anticipate the changing needs of our worldwide community. We promote excellence in scientific research by setting and promoting standards and best practices, strengthening the integrity of published and presented research and leveraging our science to help society worldwide."

(3) American Institute of Professional Geologists (AIPG)

Established in 1963 with headquarters in Northglenn, Colorado

Membership: Nearly 4,500 in the USA and overseas

"The purposes of the Institute shall include:

- advance the geological sciences and the profession of geology;
- establish qualifications for professional geologists;
- certify the qualifications of specific individual Member geologists to the public;
- promote high standards of ethical conduct among its Members and Adjuncts, and within the profession of geology; and
- represent, and advocate for, the geological profession before government and the general public.

What AIPG does:

- Professional Certification - Certifies geologists based on their Competence, Integrity, and Ethics.
- Categories of Membership - Certified Professional Geologist, Professional, Early Career Professional, Associate, and Student.
- Ombudsman - Intervenes with regulatory boards and agencies on behalf of individual geologists, at the geologist's request. Information also is disseminated in cooperation with the Association of State Boards of Geologists.
- Lobbying - Presents testimony and position papers to Federal and State legislators and agencies on matters affecting geologists and geologists' employment opportunities. Exhibits at the National Conference of State Legislators.
- Liability Insurance - Provides access to insurance for errors and omissions, designed specifically for geologists.
- Continuing Education - Through online learning, publications, seminars, short courses, and field trips, provides educational opportunities for geologists, other scientists, engineers, and the general public.
- Supplemental, Life, and Accident Insurance - Provides access to a full line of supplemental, life, and accident insurance.
- International Comity - Through agreements with professional societies in other countries, provides access for its members to professional registration, certification, or chartered status in those countries.
- State and Section Activities - State and regional sections work on local political issues and the professional status of geologists in their geographic areas. The Institute's sections around the country hold regular meetings, featuring educational programs covering important subjects of interest to professional geologists. One of the most worthwhile benefits of AIPG Membership is the opportunity to make personal contact at the local and State level; to meet fellow geologists; and to learn from them."

(4) Geological Society of America

Founded in 1888 with headquarters in Boulder, Colorado

Membership: Over 21,000 in more than 85 countries

Mission and vision statement:

"To advance geoscience research and discovery, service to society, stewardship of Earth, and the geosciences profession.

To be the premier geological society supporting the global community in scientific discovery, communication, and application of geoscience knowledge.

Primary Activities:

- Organizing scientific meetings and conferences
- Publishing scientific journals and books
- Disbursing research grants
- Bestowing medals and awards
- Supporting geoscience teachers
- Enabling students from diverse backgrounds to seek and maintain careers in the geosciences
- Fostering public awareness of geoscience issues"

(5) Society of Economic Geologists (SEG)

Founded in 1919 with headquarters in Littleton, Colorado

Members: 6,355 in more than 110 countries

Mission statement:

"The Society of Economic Geologists (SEG) is a leading global nonprofit dedicated to advancing the understanding, development, and stewardship of Earth's resources through geoscience. It connects academia with industry, focusing on the minerals and metals essential to society. SEG provides members with access to high-quality publications, educational programs, networking, mentorship and professional development opportunities. The Society values student involvement, supporting numerous student chapters and offering fellowships and grants for research. SEG's success is built on over a century of volunteer effort, industry support, and strong partnerships with other geoscientific organizations."

Objectives:

- To advance the science of geology through the scientific investigation of mineral deposits and mineral resources and the application thereof to exploration, mineral resource appraisal, mining, and mineral extraction.
- To disseminate basic and applied scientific information arising from investigations of mineral deposits and mineral resources through SEG conferences, field trips, short courses, workshops, traveling lectures, and publications.
- To advance the status of the profession of economic geology, and to maintain a high professional and ethical standard among its members.

Membership benefits:

Both professional and student members have access to a network of fellow explorationists and essential research material—invaluable assets in today's demanding employment market. Society membership ensures early alerts and discounted rates for hands-on courses and publications designed to enhance one's skill set and knowledge base.

(6) Society of Exploration Geophysicists (SEG)

Founded in 1930 and headquarters in Houston, Texas

Membership: Over 12,000 across 100-plus countries

Mission statement:

"SEG connects geoscientists worldwide to advance applied geophysics and its role in shaping sustainable, affordable, and reliable access to Earth resources. Together, our members share knowledge, spark innovation, and develop solutions to some of the world's greatest energy and environmental challenges.

We provide trusted opportunities for learning and professional growth through continuing education, workshops, publications, and events. From students to seasoned professionals, SEG helps geoscientists sharpen skills, adopt new technologies, and stay competitive in a rapidly changing industry.

Members form the heart of our global network. SEG fosters collaboration without borders—bringing professionals together across disciplines, regions, and sectors. This culture of connection strengthens the geoscience community and drives progress that benefits both industry and society."

Purposes:

- Advancing the science of exploration geophysics
- Fostering collaboration and shared scientific knowledge
- Humanitarian and educational initiatives
- Accelerate geophysical innovation for global good

(7) Society for Sedimentary Geology (SEPM)

Formerly known as Society of Economic Paleontologists and Mineralogists (SEPM)

Founded in 1925 with headquarters in Broken Arrow, Oklahoma

Membership: Nearly 4000 in the USA and overseas

Mission and value statement:

"SEPM focuses specifically on enriching professionals and students within sedimentary geology. SEPM is dedicated to dissemination and education in all related fields. SEPM offers membership levels and resources for professionals and students in this field to connect, network, publish and grow.

SEPM values the diversity of views across the geosciences and that ethics is a required part of the scientific method. The Society values everyone in the geoscience community that follow these behaviors and maintains a Code of Conduct that supports these values."

The Shape of a Professional Society

In structural engineering there is a debate as to what geometric form is the most stable. Circle, cube, triangle and hexagon have all been cited because each has its own advantages. Following the wisdom built into beehives, I take hexagon as the optimum shape for the stability and growth of professional societies. As depicted in Figure 1 on the following page, the activities of a professional society are distributed across six inter-related and essential functions and stakeholders. Let's review them briefly.

(1) Membership

Members are the foundation of a professional society. The more members an association has, the stronger its position in finance, advocacy, geography, and operations. Designing a relevant, up-to-date and affordable membership benefits package is the first step. Then comes outreach, showcasing and value propositions. Even after all this, member engagement is critical for growth.

(2) Academia

An association must maintain close working relationships with colleges, universities, and research institutions because this is where professionals are educated and future members and leaders come from. Some large associations maintain student chapters in various universities.

(3) Corporations and industries

These commercial enterprises are the end-users of science; they are the sources of funding and sponsorship; they control jobs and markets. Successful professional associations build bridges and alliances between academia and industries.

(4) States and governments

Policies adopted by governments, both at national and provincial levels, impact a scientific community in a variety of ways – most profoundly via the volume and areas of funding. A professional association is expected to represent, promote, and even defend the interest of its members and profession by having appropriate channels with policy makers. This activity is, of course, different from partisan alignment or political activism per se.

(5) Society

Science is largely funded by taxpayers. Public support for scientific activities is therefore crucial, but this is possible if people appreciate the value of research and science. Professional associations can play a huge role in science literacy through innovative communication skills and public outreach which also help motivate and create the future generation of scientists.

(6) Science

Last but not least, an association must contribute to its science and profession. This is what the members, industries, and sponsors expect from a professional society. It does not mean that a professional society should turn into a research institution; it means that the association must offer creative and motivating situations and outlets for new science to be conducted and disseminated.

A Matter of Scale and Scope

Professional societies target their members based on the scale and scope of their activities.

In terms of scale, a society may be (1) global or international, (2) national, or (3) provincial (state level). Some national societies in economically and scientifically advanced countries often target international membership. Actually, this has almost become a survival strategy for many professional societies in the USA and European Union as the pool of overseas students and professionals outnumber the domestic pool in any scientific field. Member internationalization, however, requires offering meaningful and deliverable services to overseas communities.

In terms of scope, a society may cover



1. An entire field of science (geology, geophysics Table 1. Why join professional societies? A list of arguments from three authors, chemistry, etc.),
2. A particular sub-field or discipline (for example, volcanology, hydrology, sedimentology, etc.),
3. A particular region (for example, the Rockies, Alberta basin, Gulf of Mexico, etc.),
4. A particular methodology (e.g., mass spectrometry), or
5. A particular geo-realm (lakes, rivers, mountains, etc.).

Scale and scope obviously determine the size and personnel of a professional society. If the current trends of downsizing geoscience programs, low college enrollments, and hence shrinking pool of new geoscientists continue, geoscience professional societies will eventually need to merge and consolidate just as petroleum companies have done in order to reduce competition and strengthen their financial resources.

Bottomline

Joining a professional society has huge returns on small investments if members really use the benefits that these societies offer. By the same token, a professional society must also ensure that its member benefits package stays relevant and useful.

The vast majority of geoscience associations emerged in the twentieth centuries based on the needs, circumstances and technologies of that century. Now a quarter into the twenty-first century, circumstances have drastically changed. We are now living in a global and digital age flooded with information. Professional societies need to adapt, be creative, and evolve.

I am a member of several geoscience societies and enjoy reading perspectives from their presidents, executive officers, editors, and other managers. Such perspectives share important issues, progress, problems and future possibilities with the community. These “top-to-bottom” communications, although necessary, are not sufficient. A professional society should also create and encourage lines of “bottom-to-top” grassroots communications and listen to the feedback, needs, and suggestions of its members. “Customer experience” has been the basis of Jeff Bezo’s success in Amazon. Same business plan holds true for professional societies as well.

The Part Nobody Warns You About:

Why Every Stage of a Geology Career Deserves its Voice

Becca May, ECP-1250

There is a particular feeling of isolation and detachment that nobody is warning us about.

It doesn't come when you're struggling through coursework or pulling late nights in the lab. It doesn't come during the chaos of graduate school, when deadlines and camaraderie blur together into something exhausting but alive. It comes later, quietly, on an ordinary Tuesday in your first real job, when you realize the relentless forward momentum of academic life has simply... stopped. And you're sitting at a desk wondering why this feels so much harder than it was supposed to.

That was me, one year out of graduate school. A friend of mine who had recently graduated with her PhD in radiochemistry felt the same way. We'd arrived in our respective industries with big ambitions and the residual energy of grad school still in our systems. But the 9-to-5 was isolating in a way neither of us had anticipated. In school, you're never truly alone. There's always a cohort, a study group, an advisor, a culture built around shared struggle. The professional world doesn't come with that scaffolding. You have to build it yourself, and at first, you don't know that's even the job.

Things did turn around. They do. But I spent a long time wondering whether what I was feeling was unusual, whether I was somehow less cut out for this than my peers. I wasn't. And I wish someone had told me that sooner.

That experience is where this started.

The geology community has made meaningful strides in representation over recent years. Conversations about gender and racial diversity in the geosciences are more visible, more urgent, and more necessary than ever. But there's another dimension of representation that tends to fall through the cracks: age, or more precisely, career stage.

We celebrate students. We feature their field work, their research, their early enthusiasm, and we absolutely should. Mentorship programs for early undergraduates are valuable and well-intentioned. But somewhere between "geology student" and "established professional," a lot of us quietly disappear from the conversation. The early-career geologist, roughly one to ten years in, still learning how the industry actually works, still figuring out who they are outside of academia, is underrepresented in the professional dialogue. And that gap has real consequences.

When people don't see their experience reflected back to them, they assume something is wrong with them personally. They don't

ask for help. They don't share what they're going through. They wait it out alone, when what they actually need is to hear: this part is hard for a lot of people, and it gets better.

My second stage in realizing this was noticing this with my mother who had recently retired. She called me recently, just a few short months after her retirement as a physician's assistant. "I've worked my whole life," she said, "and now I'm just expected to have a life?" I didn't have a good answer for her. But her words stayed with me. Here was a woman at the other end of a long, accomplished career, and she felt just as unmoored as I had at the beginning of mine. If you're curious, she ended up getting a job at Whole Foods (she claims it was for the great bread and deals) but celebrated a second retirement after giving herself the time she needed to adjust to this new phase of her life.

Every stage carries its own transition. The student becoming the professional. The early-career geologist finding their footing. The mid-level professional navigating leadership for the first time. The senior scientist preparing for what comes after. None of these transitions are easy, and none of them should be faced in silence.

What I'd love to see, and what I'd like to contribute to, is a publication that reflects the full arc of a career in the geosciences. Not just the milestones, but the messy middle parts. The moments of doubt. The adjustments.

If you're early in your career and you've felt what I've described, I want you to know: it's normal. It's common. And it's worth talking about, sharing with your friends and family.

And if you're further along, a decade in, or several decades in, consider sharing your transitional struggles with those just a few years behind you. Think of it not as a warning, but a moment of vulnerability to plant the seed for those who come after you. Not to reassure them that it all works out (though it usually does), but to give them the thing I needed most when I was starting out: the knowledge that they weren't alone in the struggle. Maybe five years down the road, when they have entered the phase you are in, they will encounter some of the same hurdles and remember that patience is a virtue.

That's the kind of representation that doesn't always make it onto a diversity checklist. But it matters. Every stage of this career matters. And the more we say so out loud, the better this profession becomes for everyone in it.



Building the Future of Geology

Support the Foundation of the AIPG

The Foundation of the AIPG supports a variety of programs including student scholarships, student and young professional workshops, educational programs aimed at practitioners, the public, and policy makers, and some special needs requested by AIPG or other professional organizations. The Foundation provides support to AIPG for the undergraduate scholarships awarded by AIPG. Additionally, the Foundation awards its own William J. Siok Graduate Student Scholarship. The Foundation is proud to be able to serve AIPG and the geosciences by providing financial support for these programs. These grants are only possible through your generous donations. Every donation helps the Foundation to contribute toward building the future of geology.

Through our relationship with Mercer Advisors, the Foundation is prepared to support a variety of additional ways to give beyond cash contributions that may allow you to align your philanthropic priorities with your broader financial and legacy goals. Methods of giving include:

Direct Gifts

Outright gifts of cash or check are the most straightforward way to support the Foundation. These contributions provide immediate support for scholarships, educational programs, and initiatives that advance ethics, professionalism, and excellence within the geosciences.

Donations from an IRA

For donors age 70½ or older, qualified charitable distributions from IRAs may offer an additional opportunity to support charitable causes while satisfying required minimum distributions.

Donor Advised Funds

Many supporters choose to give through donor advised funds. A donor advised fund allows you to make a charitable contribution, receive an immediate tax deduction, and recommend grants to the Foundation over time. This approach offers flexibility and simplicity while enabling you to support the causes you care about most – now, and in the future.

Charitable Trusts

Charitable trusts can be a powerful way to combine philanthropy with long-term planning. A charitable remainder trust can provide income to you or your loved ones for a set period, after which the remaining assets support charitable organizations such as the Foundation of the AIPG. A charitable lead trust provides income to charity for a defined term, with remaining assets ultimately passing to family members or other beneficiaries. These vehicles can support both current impact and long-term legacy goals.

Planned Gifts and Bequests

Including the Foundation of the AIPG in your estate plans is a meaningful way to leave a lasting legacy in support of the geoscience profession. Planned gifts may be made through a will or trust, beneficiary designations, or other estate planning mechanisms. Such gifts help ensure continued investment in education, research, and professional development for generations to come.

Noncash Assets: High Impact Ways to Support the Foundation of the AIPG

In addition to cash, many donors choose to contribute noncash assets. These gifts can be especially impactful and, in some circumstances, more tax efficient. Below are several commonly used options. We encourage all donors to consult their financial, tax, or legal advisors when considering these types of gifts. If you are interested in supporting the organization through one of these options, please reach out directly to us.

- ***Appreciated Securities***

Donating long-term appreciated stocks, exchange traded funds, or mutual funds may allow you to support the Foundation while avoiding capital gains taxes on the appreciation. In many cases, donors may also be eligible for a charitable deduction based on the full fair market value of the asset, potentially increasing the overall impact of their gift.

- **Privately Held Business Interests**

In certain circumstances, interests in privately held businesses—such as shares of a closely held corporation, LLC interests, or partnership units—can be contributed to charity or through a charitable giving vehicle. These gifts require careful planning, valuation, and review but may offer a meaningful way to support the Foundation while addressing broader financial goals.

- **Real Estate**

Residential, commercial, or undeveloped real estate can sometimes be donated outright or structured through charitable trusts. Gifts of real estate may reduce the size of a taxable estate and potentially provide income or tax benefits, while supporting long-term investment in geoscience education and research.

- **Retirement Assets**

Designating the Foundation of the AIPG as a beneficiary of a retirement account, such as an IRA or 401(k), is often a tax efficient way to make a charitable gift. Because charitable organizations are not subject to income tax, these assets can be used fully to support the Foundation's mission rather than being reduced by taxes.

- **Life Insurance**

Life insurance can be a flexible tool for charitable giving. You may choose to name the Foundation as a beneficiary, transfer ownership of a paid-up policy, or contribute toward premiums on a policy designated for the Foundation. This approach can transform relatively modest contributions into a substantial future gift.

- **Other Assets**

In select cases, personal property or other complex assets may be suitable for charitable giving. Because these gifts can involve specialized considerations, early discussion with your advisors and the Foundation is encouraged.

Employer Matching Gifts

Many employers offer matching gift programs that can double or even triple the impact of your contribution. We encourage you to check whether your employer participates in a matching gift program and include the Foundation in your request.

We Are Here to Help

All donor's circumstances and goals are unique. The Foundation welcomes the opportunity to work with you and your advisors to explore giving options that align with your values and support the future of the geosciences. Please contact me or any of the other Trustees for additional details and check the AIPG web site for more information about the Foundation. Your continued support is greatly appreciated. Thank you.

Mike Lawless

Michael D. Lawless, CPG, PG
Chairperson, Foundation of the AIPG
540-557-1319 office phone



*The Foundation of the American Institute of Professional Geologists is a 501(c)(3) organization.
Contributions are tax deductible. EIN 45-2870397*

Invest in the future of geoscience.

Support students, education, and the next generation of geoscientists.

Foundation of the AIPG



ADVERTISE HERE!

AIPG MEMBERSHIP TOTALS

	As of 5/1/2025	5/1/2026
CPG/Active	1,966	1,936
CPG Emeritus Member	576	566
Honorary Member	19	20
Professional Member	697	661
Professional Member/Non-Practicing	46	51
Early Career Professional	162	165
Associate Member	41	36
Student Adjunct	1,036	1,132
TOTALS	4,545	4,567

fishbeck
Engineers | Architects | Scientists | Constructors

fishbeck.com | info@fishbeck.com

AIPG Is On



Subscribe to AIPG's YouTube Channel

Send your geologists in action videos to
AIPG Headquarters

Scan QR code




**Question the existing
Imagine the impossible
Create the enduring**

wsp

Find out what we can do for you.
wsp.com

**AIPG/AGI
Geoscience Online
Learning Initiative
(GOLI)
Course Offering**

**"Tracking the Global Supply of
Critical Materials"**

Scan QR code
to register.



Alpha Geological Services, DPC
Professional Geologic and Hydrogeologic Consulting

Independent Laboratory Data Validation
Emergent Contaminants • QA/QC and EDD Preparation

Mining Services
Hydrogeologic Investigation • Mine Permitting

679 Plank Road, Clifton Park, NY 12065
www.alphageoscience.com • (518) 348-6995
Steve Trader, PG strader@alphageoscience.com



Engineering solutions that work for your business

**Mannik
Smith
GROUP**
www.MannikSmithGroup.com
Walter Bolt CPG, PMP | 734.397.3100
wbolt@manniksmithgroup.com

Civil/Structural Engineering
Aquatic/Ecological Services
Geotechnical Engineering
Environmental Services
Surveying
Construction Support

Adrian • Canton • Detroit • Grand Rapids • Houghton • Lansing • Monroe • Traverse City
Cincinnati • Cleveland • Columbus • North Canton • Toledo

SUBMISSIONS DEADLINES

OCT.NOV.DEC. - August 1, 2026

JAN.FEB.MAR. - November 1, 2026

APR.MAY.JUN. - February 1, 2027

JUL.AUG.SEP. - May 1, 2027

Technical writings including peer review, student writings, field experiences, career development, member news, and more accepted.

This service is open to AIPG Members as well as non-members. The Professional Services Directory is a one year listing offering experience and expertise in all phases of geology. Prepayment required. Advertising rates are based on a 3 3/8" x 1 3/4" space.

ONE YEAR LISTING FOR ONLY:

Member	\$100.00
Non-Member	\$300.00

Space can be increased vertically by doubling or tripling the size and also the rate.

LUNCH & *Earn*

LEARN • GROW • GET CREDIT



Geoscience webinars designed
for YOU!

- **Learn** from leading experts in technical geoscience topics.
- **Earn** NYSED-Approved CEUs or PDHs.
- **Grow** your skills and advance your career.

Cost:

Members - \$15

Non-Members - \$30

AIPG Student Member - FREE

Earn 0.1 CEU / 1 PDH for attending!

Certificates will be emailed after the webinar.

Southwest Florida Water Management District



WATERMATTERS.ORG • 1-800-423-1476

CLEAR CREEK ASSOCIATES

a Geo-Logic Company

Practical solutions in groundwater science

8777 N. Gainey Center Dr., Ste. 250
Scottsdale, AZ 85258
(480) 659-7131

221 N. Court Ave., Ste. 101
Tucson, AZ 85701
(520) 622-3222

www.clearcreekassociates.com
www.geo-logic.com

Comments on proposed rule: Modernization of Property Disclosures for Mining Registrants

Comments on the U.S. Security and Exchange Commission's (SEC's) proposal are available at <https://www.sec.gov/comments/s7-10-16/s71016.htm>

Welcome

New

Certified Professional Geologists!

March 2, 2026 - June 1, 2026

Be Recognized. Be Respected. Be Certified.

AIPG Certified Professional Geologists set the Gold Standard in geoscience professionalism — leading with expertise, ethics, and innovation.



Section	Name	AIPG Member Number
Alaska	Chad P. Hults	CPG-12387
Alaska	Matthew Reece	CPG-12403
California	Brad T. Gooch	CPG-12406
Colorado	Landon Beck	CPG-12377
Colorado	Andria Dillard	CPG-12407
Florida	Brandon McBath	CPG-12398
Florida	John M. Pazel	CPG-12392
Georgia	Andrew May	CPG-12393
Idaho	Nicholas Howell	CPG-12404
Michigan	Steven Buyze	CPG-12395
Michigan	Sienna Cartwright	CPG-12396
Michigan	Anthony Mack	CPG-12401
Michigan	Rebecca Powell	CPG-12400
Nevada	Zachary Grimal	CPG-12388
Nevada	Melanie Newton	CPG-12389
Northeast	Callum Duffy	CPG-12402
Ohio	Jeff Napier	CPG-12397
South Dakota	Jacob Tielke	CPG-12399
Washington	Yen-Vy Van	CPG-12391
International	Ruben Molina Carranza	CPG-12394
International	Zahid Ullah Khan	CPG-12405

The
Gold
Standard
in
Geoscience
Professionalism.



Scan to learn more

Apply online and elevate your career.