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VOLUME 63 NUMBER 1

STUDENT EDITION

JAN.FEB.MAR 2026

Mars Through Time
Exploring the Geology of the St. Francois Mountains
UNL Earth and Atmospheric Sciences
Department Closure
Under the Graduation Lights



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The Professional Geologist

Volume 63 Number 1

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On the Cover: 2026 Photo Contest Winner - Micro-Geology - Under the Microscope

Description: *Alien Sunrise* – Oil immersion grain mount of cementitious, portland cement-based mortar. Petrographic microscope with crossed nicols and $\frac{1}{4}$ wavelength insert used with a Bertrand lens set-up. The resulting conoscopic image reveals isotropic materials within the matrix, in this case, residual fly ash particles.

Photograph by **Jeffrey Varga, CPG-10275**, AIPG Ohio Section, 2025.
2026 Photo Contest: Micro-Geology - Under the Microscope.

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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.vertes@stantec.com

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NATIONAL HEADQUARTERS
10701 Melody Drive, Suite 630
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EXECUTIVE DIRECTOR - Aaron W. Johnson, CPG - awj@aipg.org
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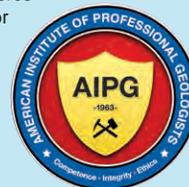
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AIPG Publication Policy, October 4, 2010. AIPG encourages submission of articles and editorials for publication in *TPG* on topics related to the science and profession of geology. Submittals shall be of interest to the members of AIPG, other professional 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.

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Ethical and Practical Considerations for Content Submittal

Adam W. Heft, CPG-10265

I hope you had a Happy New Year to ring in 2026! As usual, I have been busy working to bring you this, the annual Student Edition of *The Professional Geologist*! We have quite a variety of articles this year – thank you to all who have submitted content that helps make this publication what it is. There are articles by students and for students as well as some usual general content. Some of the topics covered in this issue include fishing, carbon capture, vapor mitigation, graduation, Mars geology, field camp, and an article about the closure of the Department of Earth and Atmospheric Sciences at the University of Nebraska-Lincoln and AIPG's letters in support of the Department. I hope you enjoy the variety!

You will also notice the annual member listing included herein. Again, in order to be included in this listing, you **MUST** have opted in – either on the AIPG website under your profile, or via direct communication with either AIPG staff or myself. AIPG headquarters sent out several emails to this effect with reminders and a link to members. Last year, I heard from several disappointed long-time members whose names were unfortunately not included on the list. Hopefully, everyone who wanted to be included this time has been.

As always, I'm continuing to request content for future editions of *TPG*; while I have a few extra articles for the next edition, I still don't have enough content to fill out a complete issue. So please, consider submitting an article. I'm sure most people have a case study, an interesting project, or research that would make a good base for an article. If need be, the article can be "sterilized" so it isn't obvious where the project is or who the client (or regulator) is. And of course, Tales from the Field, opinion pieces, and Letters to the Editor are all welcome.

Regarding submittals, the guidelines are published on the national website at: <https://aipg.org/page/TPGArticleSubmittal>. Please review these guidelines before sending your submittal (which may be sent to AIPG Headquarters or directly to me as Editor). Your adherence to these guidelines makes my task easier. Please pay particular attention to the quality of any graphics you include. These need to be high quality; if there is any hint of fuzziness to any part of the image, please replace it with a higher quality image or a different one altogether. While it is possible for our design editor to work some magic to sharpen the image, that takes time and does not always have favorable results – in which case we have to ask for a better image anyway.

During the last year, we had some issues concerning a few submittals, and, consequently, the Executive Committee and I felt it was necessary to modify the submittal guidelines to include some additional information. I will reiterate the impor-

tant points here; however, these are detailed in the updated guidelines available on the website at the link above.

When submitting an article, opinion piece or Letter to the Editor that specifically references another author's published article, opinion or letter, it must be done professionally and courteously. This is in keeping with the AIPG Code of Ethics, particularly, Canon 4, Standard 4.2, Rule 4.2.1 which reads, "A Member shall not issue (a) false statement(s), or a sensational, exaggerated, defamatory, and/or unwarranted statement(s) regarding a professional colleague. Differences of opinion occur and statements regarding opinions should be restricted to and based on logical and scientific principles and should be made in a respectful and professional manner."

Thus, no matter how much you disagree with what someone has said or written, do not resort to name-calling or other insulting or inappropriate behavior. Submitting such content may result in readers interpreting your content as an ethics violation.

Another issue is the extent to which the Editor, Assistant Editors, and/or Design Editor are responsible for revising your submittal. Anything submitted should first be rigorously reviewed by the author and/or author's peers so it is as high-quality and ready for publication as it can be. Only then should it be submitted for consideration by the Editor. Thus, articles written by those whose first language is not English should have the article reviewed by someone fluent in English to help ensure it is well written and able to be understood by our readers. The Editor or other reviewers should not have to guess what is meant by unclear statements.

Another example of this is in cases with either very long articles that could be published in two or more parts, or sections of an article that are longer than necessary or unclear. A review comment might be a suggestion for the author to revise the section or break the article into a Part I and II submittal. It is not the job of the Editor or reviewer(s) to decide how or where exactly to revise your submittal to address that comment. Suggestions may be provided by the reviewer, but it is up to the author to make the revision.

Adherence to the guidelines will help make the review process easier and faster, allowing a decision on whether the article should be published to be reached more quickly, and an edited version to be returned to the author in a timely manner. On behalf of the editorial team, thank you for understanding and complying with the guidelines! I am always happy to answer any questions a prospective author may have in advance of their submitting content.

President Sara Pearson's final message in the Oct-Nov-Dec 2025 issue of *Professional Geologist* about Geo-ACTS struck a chord with me, but not what might be expected. As an 85-year-old geologist caring for his wife of 63 years with dementia for the past several years, I've been trying to learn as much as I can about this horrible condition that is affecting so many people today. Something I learned recently about dementia really stood out to me in reading President Pearson's message as it concerns the way people are liable to perceive things.

A group in the UK called Contented Dementia Trust uses a process they call the SPECIAL method which describes memory as a photo album. Each day is a page in the album with each photo on the page a specific memory from that day. Each photo is a combination of facts and feelings about the memory. Recalling memories is basically sorting our memory photo album and as we grow older we tend to turn the pages more slowly trying to recover some memory. Dementia introduces a new type of photo in which facts of the memory are not stored but the feelings are, leaving fact-free and feeling-only photos. As dementia progresses, more and more feeling-only photos are stored in memory which eventually makes feelings more important than facts. Keeping feelings foremost in dealing the dementia patients is very important. This photo album approach has helped me better appreciate what my wife is going through and gives me a broader perspective of how people react to things. It emphasizes the importance of feelings with memory. I think that we all let feelings take on more importance than facts at times.

President Sara Pearson's description of the people in Iceland going toward an erupting volcano rather than sensibly retreating suggests to me that their feeling of excitement of seeing something exciting and different overpowered the fact that they were putting themselves in danger. I think that feelings versus facts have so much to do with the problem of science communication today. People are storing memory photos of false "facts" with positive feelings and conversely, scientific facts with negative feelings. Misinformation seems to thrive on creating negative feelings while facts, by themselves, either create no feelings, or negative feelings, in the general public. I think somehow, we need to be able to use our scientific facts to create positive feelings about those facts. If we fail to consider the feeling aspect of our facts, we may never regain public trust. Exactly how we would do that, I don't know at this time, but I think it is something to keep in mind when we are presenting things to the public.

Sincerely,
W. William (Bill) Boberg, CPG-06313

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POWER METAL

The Race for the Resources That Will Shape the Future

by Vince Beiser published by Riverhead Books 2024

Reviewed and summarized with some updates by
Frederick E. Simms, Ph.D., CPG-10292



Image: Amazon.com

BOOK REVIEW

In the 70s, I was evaluating ceramic setters for rapid glazing of insulators that had to withstand considerable thermal shock and the lithium-bearing mineral spodumene was a major constituent for fabricating the setters. I also was tasked with making a sodium containing-ceramic that conducted sodium ions for vehicle batteries and other uses. The potential customer lost interest for several reasons including durability of the solid ceramic partition. Fast forward to the 21st Century and we are using these same inorganic materials in new and innovative ways. For instance, I owned a GM Volt vehicle with two power sources one including lithium-containing battery with an overall average 160 miles to the gallon as I drive mostly in the suburbs. I replaced it with an EV recently.

The author has created an easy read by interspersing important facts with interviews and stories. It is well-known by those who might be interested in this book that common elements and more exotic elements are an absolute necessity for the coming "Electrical-Digital Age". The three pillars of this Age are the Internet, renewable energy, and electric cars as described by the author plus many other products. This book is an overview of some of the good and the not-so-good world-wide efforts to obtain from the earth and waste materials to satisfy our growing material needs. The author also describes the hopes and difficult conditions of everyday folks all over the world to find and recover materials that we hugely need now and in the future. I have listed some of the presented facts since they drive certain present day resource issues.

The author might have some bias as he says that he owns a Nissan Leaf as doing his part "to save the earth". We really depend on metals - for example, mobile phones may contain 2/3rds of all elements. Furthermore, he describes in vivid detail the world-wide environmental damage caused by the mining and getting rid of waste so that we can support the "Electrical-Digital Age" and stave off the possible effects of Climate Change. He also mentions the political upheaval, mayhem and murder that have occurred. The prospects and the difficulties are described in an impactful way.

Mr. Beiser went around the world and visited mines, protest sites, research labs, shipyards, deserts, junk yards, and garbage dumps. He met with a wide variety of people involved from investors to scientists and manual laborers to AI experts.

The author cites enormous amounts of different metals that will be needed in the next 20 years-for example the amount of copper that will be needed is equal to the entire amount ever produced. Yet at the same time approximately half the rivers of the U.S. West have been seriously affected by this mining. In the future the amount of rock and water that is expected to be disturbed is huge.

He describes with specific examples-how China got its control of many important elements and how the U.S. dropped the ball. The National Association of Manufacturers and other information sources indicate that China mines approximately 60 to 70 percent of world's rare earths and processes 90% of these essential materials. Rare earths are difficult to mine and process. This has caused significant environmental damage along the way and China has and could use their stockpiles to get their way. "One important thing to consider is that China can't control geology." But they certainly have had a world view that has made up for that.

In the 1970s the U.S. got out of the rare earth business at the Mountain Pass Site of Moly Corporation because environmental costs and other world competitors appear to be state owned. Recently the Mountain Pass site under MP Materials and others have come back with help from the U.S. Department of Defense. Most of the ore still has to be sent to China to be processed. Further, in Myanmar and other places the mining of rare earths has caused conflict and considerable pollution. Recent news indicates that rare earths and rare earth magnets of various grades are difficult to acquire because of China's actions. Several U.S. corporations have made deals to buy large amounts of magnets once U.S. manufacturers start production in the near term.

The history and importance of copper in our lives is extensively described. Copper has been called "the new oil" according to Goldman Sachs. In 10 years the need for copper will double. For example, there are 175 pounds of copper in an EV. With the exception of gold, no other metal has caused so much death and destruction. China refines and consumes far more copper than any other country and relies on foreign supplies for almost all of it. The mining difficulties are enormous; for example, the Chuquimata state-owned company needs to pump desalinated sea water up 10,000 ft. and over 100 miles from the Pacific Ocean for ore processing. There are many ways that copper is stolen and lives are lost. South Africa has prohibited the exportation of copper because of theft and related problems.

There is a description of how water is used in the Atacama Desert for mining and processing lithium and copper. There are benefits and certainly negatives for the local inhabitants growing crops. Likewise, in arid areas such as the Imperial Valley, geothermal and lithium-containing brine development has affected farming.

The possibilities of mining the deep sea nodules for cobalt, nickel and copper and other elements has been slow because of the great depths, potential environmental damage, the lack of knowledge and the International Seabed Authority has not completed rules

for the deep-sea mining industry within the agreed on two-year timeframe. Now it is possible that some companies can move forward with further exploration and mining. The island country of Nauru and Nauru Ocean Resources had planned to begin sea-floor mining in 2021. Of course land-based mining will still continue even if deep-sea mining is very productive. If Lithium phosphate batteries predominate in the future, cobalt and nickel from the nodules may not be needed as much. A Ford plant in Marshall Michigan will use iron phosphate batteries regardless of whether the Federal government cuts aid. Another battery plant has decided not to make car batteries. But six billion dollars-worth of other plant development for batteries was cut off in the first quarter of 2025 (NY Times 6/25/25).

Recycling scrap metal is a \$40 billion dollar industry involving tens of thousands of people. Three-fourths of all lead, half the iron and steel, and one third of all copper that the U.S. uses in a typical year comes from recycled scrap. The European Critical Materials Act requires that 25 percent recycled material be used by 2030 (NY Times 6/9/25). Recycling is easier on the environment but more difficult to perform and dirty and dangerous for many of the individuals that have to do it. A story of Steve, a scrap picker, tells the details of how you make money and what do you have to do to survive - like millions throughout the continents with some organized into unions. Collectors in flip flops burn the plastic off of copper wire in Africa and elsewhere. One ton of circuit boards can have 40 to 800 times the amount of gold in a ton of ore. China's metals recycling industry pulls in around 60 billion dollars per year and employs a quarter of a million people.

Part of recycling includes electronic waste that includes just about everything that includes a wired-plug or battery or associated components. "The world generates 53 million tons of e-waste every year". The United Nations estimates that only 17% of all e-waste is collected and recycled. Millions of old cell phones and other e-waste are thrown out mostly by rich countries and a considerable amount is recycled by poor countries. The components of some are taken out by thousands of Nigerian workers. The chips of phones go to Europe and China legally and illegally. China through a subsidiary CATL is recycling much of the batteries. In Nevada, Redwood Materials has created a sustainable battery supply chain by recycling batteries and production scrap that are processed into new battery components for Tesla and other companies. LI-Cycle supports GM and Glencore. There is a long way to go with recycling - for example, only five percent of lithium may be recycled. China and Europe charge some manufacturers for covering the cost of recycling at the same time there are tax breaks for metal recyclers. There are international regulations based in part by the Basel Convention regulating the shipping of wastes between poor and rich countries. Sometimes under present conditions it is cheaper to mine than recycle materials from magnets, solar panels and wind turbines. Just a few percent of rare earth magnets appear to be recycled. In many cases recycling is financially a losing proposition unless there are incentives.

There are some exploratory methods being developed, including the bioaccumulation of metals by plants.

Many manufactured products that make our lives easier have become so complicated they are difficult to repair. Repair of products could reduce CO₂ emissions significantly. Companies have been slow to help owners repair products. It is cited that Apple and Tesla in the past have taken repair manuals off of the Internet. "Right to Repair" legislation have been lobbied for against Amazon, Google, Tesla and TMobile. NY State has a "Right to Repair" law that requires manufacturers to provide information and parts to individuals and repair shops. The E.U. has promoted extending the lifetime of cell phones by a year that would significantly reduce the amount of CO₂ going into the air. A company named Fixit produces on-line manuals for fixing products. Apple has been accused of slowing down older iPhones. I have to buy a new computer mainly because Microsoft will no longer support Windows 10. B2U Storage Solutions acquires old batteries to create power storage units to sell power back to utilities. The reuse of old batteries as well as new storage systems could enhance the consistency of sun and wind power to be more like that of hydro, petroleum, geothermal and other, more reliable sources.

Diminishing the number of cars on road would reduce our power needs and emissions into the air and add many other benefits such as reducing traffic congestion. Amsterdam is unlike many cities, but it points to a possible future with only half as many cars on the street. There is a need to take a more thoughtful design of streets. Every year, worldwide, 1.3 million people die in car crashes. There are 43,000 deaths from car accidents each year in the U.S. Auto emissions contribute an additional 53,000 deaths per year according to MIT. The author has likely cited an excessive estimate of the EV advantage over gas powered cars with regards to overall air emissions. He mentions some worldwide environmental conditions (some numbers have been revised): The amount of rubber particles emitted from tire wear exceeds three million tons per year. Huge amounts of clothing items are incinerated or end up in landfills per year. Every year 30 to 40 percent of food is lost or wasted. The number of gas-powered cars is estimated by some experts to continue to grow to 2038 and then decline.

Mr. Beiser cites research that suggests that converting from the use of fossil fuel to renewable energy is not sufficient to adequately stall climate change. A partial answer is fewer cars and more bicycles. Bike commuting has doubled in Los Angeles since 2005. Bike sharing has exploded. According to Wikipedia there are presently two billion bikes - the number shows how important other modes of transportation have the potential to reduce the amount of air pollution and other environmental damage.

The author presents a very idealist way forward that includes a description of the typical office worker in the near future living in a typical North American city in an environmentally best-case version of the Electro-Digital Age. The book is a good, quick and thoughtful read!

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Mars Through Time: Climatic Transitions and Depositional Environments from the Pre-Noachian to Amazonian

Mossbah M. Kolkas, CPG-10180¹

Abstract

Remote sensing and data gathered from multiple NASA missions to Mars indicate the presence of at least four major climatic cycles that have shaped the Martian surface and governed its geologic evolution. The earliest cycle, spanning the Pre-Noachian and Noachian periods, was characterized by intense meteoritic bombardment, extensive volcanism, and significant crustal deformation. This was followed by a "warm and wet" period during the Noachian to early Hesperian, marked by widespread precipitation, fluvial activity, and the possible development of shallow epicontinental seas. Mineralogical signatures and sedimentary structures strongly support the prolonged presence of liquid water, with conditions potentially suitable for microbial life. A subsequent "warm and dry" interval in the Hesperian period witnessed the development of arid features, including evaporites, dunes, and playa lakes. Finally, from the late Hesperian through the Amazonian, Mars experienced alternating glacial and interglacial conditions, resulting in the formation of a glacial landscape that includes U-shaped valleys, cirques, aretes, grooves, tills, striations, and paternoster lake deposits. This paper integrates stratigraphic, geomorphic, and mineralogical evidence to propose a generalized paleoclimatic model for Mars, outlining climatic transitions and depositional environments and their implications for habitability.

Keywords: Mars, climatic cycles, depositional environments, paleoclimate, habitability, life on Mars

Introduction

Mars, a terrestrial planet situated approximately 228 million kilometers from the Sun, lies within the solar system's habitable zone (Smith et al., 2018). Despite this position, the planet experiences extreme surface temperature fluctuations due to its thin atmosphere and limited capacity for heat retention (Jakosky and Phillips, 2001). Typical surface temperatures on Mars vary widely, ranging from about +20 °C at the equator during daytime to around -120 °C at night, according to measurements from NASA's Thermal Emission Spectrometer (TES) on Mars Global Surveyor. In the polar regions, winter temperatures can drop even further, reaching approximately -125 °C, near the frost point of carbon dioxide (NASA, 1999; ESA, 1999).

The Martian atmosphere is tenuous, exhibiting surface pressures below 1% of Earth's and dominated by carbon dioxide (~95%) (Mahaffy et al., 2013). This low-pressure, CO₂-rich atmosphere provides insufficient thermal insulation, resulting in pronounced diurnal temperature variations (Madeleine et al., 2014). Mars is classified as a cold, arid desert planet, characterized by its distinctive reddish surface coloration, which arises from the widespread distribution of iron oxide minerals within the regolith (Christensen et al., 2001). The characteristic "Red Planet" hue has intrigued researchers since the earliest telescopic observations.

Geologically, Mars exhibits a diverse surface composed primarily of silicate rocks and dust, encompassing extensive plains, deep canyon systems such as Valles Marineris, impact craters, and large volcanic edifices (Scott and Carr, 1978; Greeley and Batson, 2001). The Tharsis volcanic province is home to Olympus Mons, the tallest known volcano in the solar system, with heights of approximately 22 km (Neukum et al., 2004). Mars formed roughly 4.6 billion years ago, contemporaneously with Earth, reflecting common early solar system processes (Hartmann, 2005). The Geologic time of Mars is divided into Pre-Noachian, Noachian, Hesperian, and Amazonian (Fig. 1) The planet's average density (~3.9 g/cm³) and surface gravity (~3.73 m/s²) are lower than Earth's, due to a smaller core and reduced metallic content, factors which influence atmospheric retention and surface geologic activity (Zuber et al., 2000).

Reconstructing Martian paleoclimate is critical for understanding its geological evolution and assessing its past potential for habitability (Carr and Head, 2010). Over recent decades, data acquired from NASA missions, including orbiters such as Mars Reconnaissance Orbiter (MRO) and Mars Odyssey, landers like Viking and Phoenix, and rovers such as Spirit, Opportunity, and Curiosity, have significantly advanced our understanding of Martian surface environments (Squyres et al., 2004; Grotzinger et al., 2014). These investigations have identified several climatic cycles, each associated with distinctive geomorphic and sedimentological features (Kite et al., 2013; Wordsworth, 2016).

1. Department of Engineering and Environmental Science, The College of Staten Island (CUNY), 2800 Victory Blvd, Staten Island, NY 10314 (mossbah.kolkas@csi.cuny.edu)

Climatic Cycles on Mars and Related Depositional Environments

Martian geologic-dynamic landscape results from a complex interplay of endogenic and exogenic processes, including volcanism, tectonism, impact cratering, fluvial erosion, glaciation, and aeolian activity (Carr, 1996; Mangold, 2005). The planet's surface is broadly divided into three physiographic provinces (Fig. 2): the heavily cratered southern highlands, typified by ancient, rugged terrain; the smoother, younger northern lowlands; and the Tharsis volcanic plateau, which hosts some of the largest volcanoes in the solar system, including Olympus Mons, Arsia Mons, and Ascraeus Mons (Tanaka et al., 2014).

Each major climatic cycle corresponds to variations in atmospheric density and temperature, which have governed the presence and stability of liquid water and ice, thereby driving the development of distinct depositional environments (Ehlmann and Edwards, 2014). These climatic phases have left identifiable stratigraphic and geomorphological signatures such as valley networks, layered sedimentary deposits, glacial landforms, and extensive dune fields, which collectively document the Martian evolving surface conditions (Hynek et al., 2010; Head and Marchant, 2014).

Geologic and geomorphologic evidence reveal a prolonged and varied history of hydrological activity on Mars. The presence of dendritic valley networks, paleolake basins, outflow channels, and polar layered deposits strongly indicates that liquid water significantly shaped the Martian surface during multiple intervals in its history. Remote sensing and in situ mineralogical analyses from missions including Mars Global Surveyor, Mars Reconnaissance Orbiter, and the Mars Science Laboratory (Curiosity) have characterized a surface composition dominated by iron oxides, particularly hematite, responsible for the planet's distinctive red coloration. Additional minerals such as pyroxenes, olivine, feldspars, and phyllosilicates reflect a complex interplay of igneous activity and

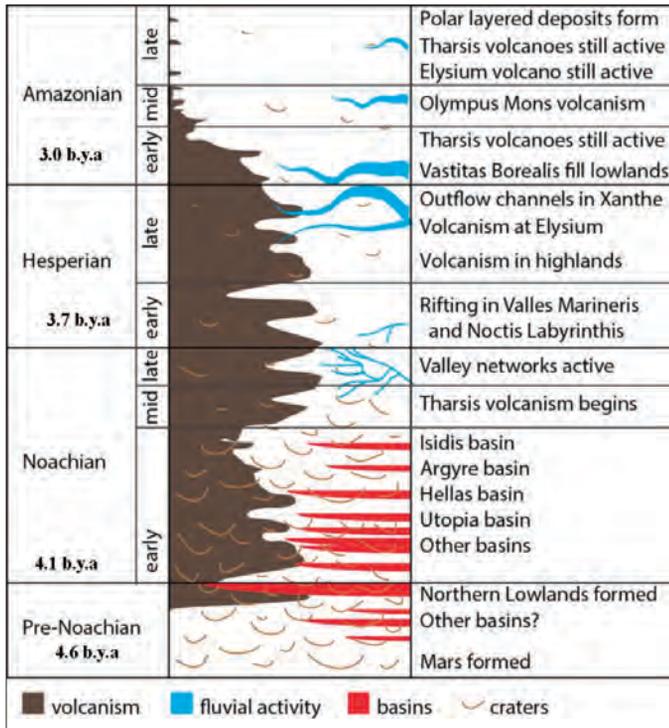


Figure 1. Geologic time scale showing the important events of Mars through time (modified from Werner and Tanaka, 2011; Lagain et al., 2021, Howari et al, 2021).

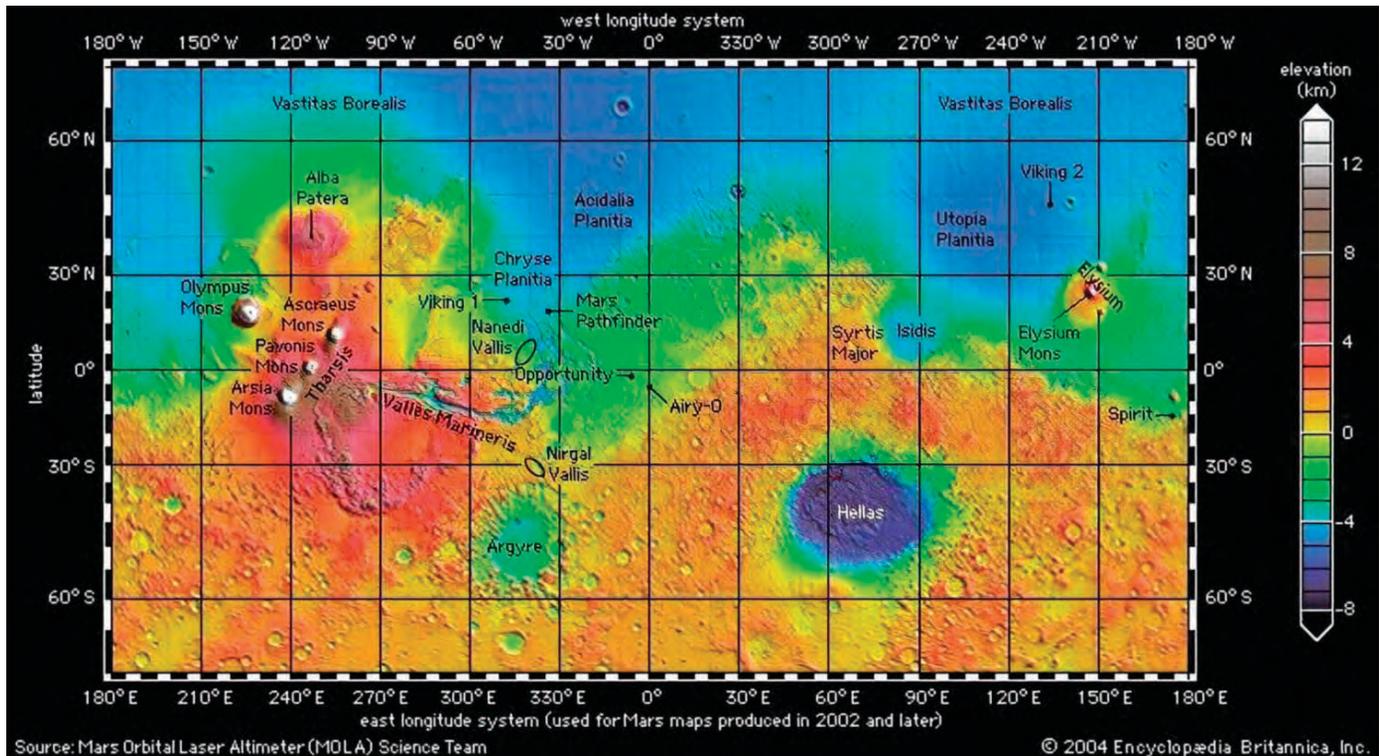


Figure 2. Topographic map of Mars with heavily cratered southern highlands and the younger northern lowlands. Encyclopedia Britannica, Inc. (2004).

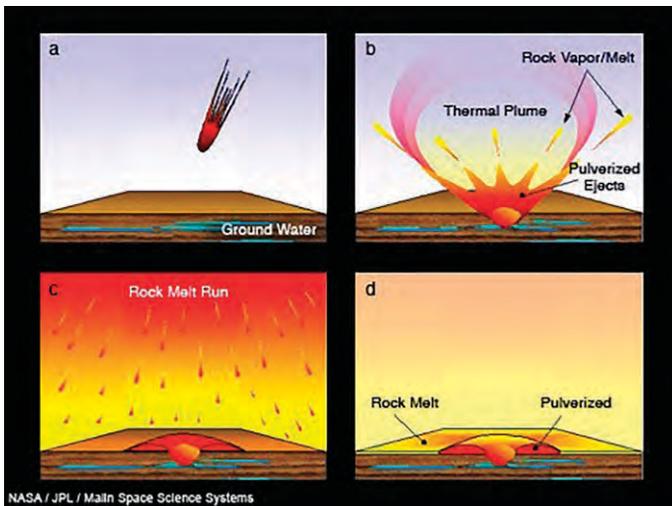


Figure 3. A diagram that visually explains the impact process of a meteorite on a planetary surface, showing stages from initial impact to the aftermath, including rock vaporization, ejecta, and subsurface effects like rock melt and groundwater interaction. (a) A meteorite approaches the surface. (b) Impact occurs, creating a thermal plume, rock vapor/melt, and ejecta. (c) Molten rock spreads outward; heated debris rains down. (d) Final stage showing a crater with rock melt and pulverized material. NASA, JPL, & Malin Space Science Systems (1999).

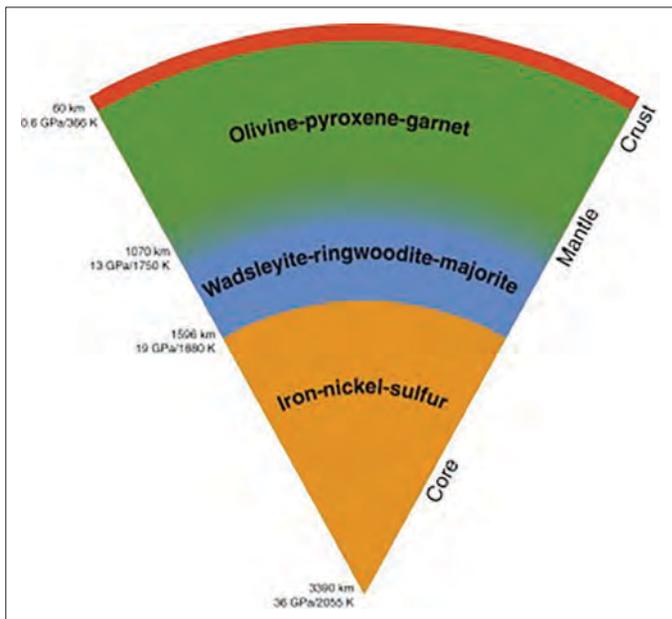


Figure 4. A diagram shows the interior structure of Mars and the differentiation of the Martian interior into core, mantle, and crust (Tackley et al., 2009).

aqueous alteration, underscoring diverse geochemical processes operating due to varying environmental conditions.

The climatic evolution of Mars, together with associated geologic modifications, can be subdivided into four major cycles as follows:

The Extreme Climatic Cycle of Early Mars: Interior Differentiation, Magnetic Field Evolution, and Surface Geodynamics during the Pre-Noachian and Early Noachian Periods

The Extreme Climatic Cycle, encompassing the Pre-Noachian and Early Noachian periods, corresponds to the earliest and most

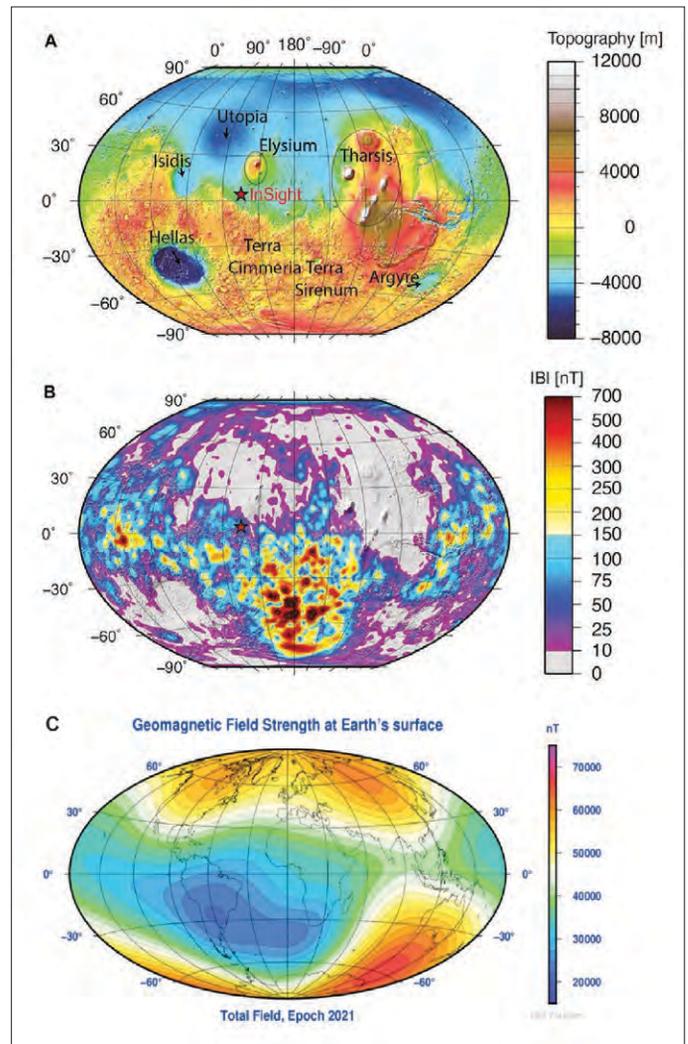


Figure 5. A. Topographic Map of Mars with the elevation in meters. B. distribution of the strength of the Martian magnetic field on Mars in nanotesla (nT). C. distribution of the strength of the magnetic field on Earth in nanotesla (nT) (modified from Langlais, B., Thébaud, E., & Sabaka, T. J., 2023).

intense phase of Martian planetary development, characterized by heavy meteoritic bombardment (Hartmann 2005; Werner 2009) (Fig. 3). During this time, the differentiation of the Martian interior into core, mantle, and crust took place due to differential densities of the original composition (McSween 2003; Taylor 2013) (Fig. 4). The crust formed primarily of basaltic rocks generated through extensive volcanic activity (Carr and Head 2010). Unlike Earth, Mars appears to lack active plate tectonics, although evidence of past crustal movements has been documented (Andrews-Hanna et al. 2008; Nimmo and Tanaka 2005). The Martian core is believed to be partially molten and composed mainly of iron, sulfur, and lighter elements (Williams and Nimmo 2004; Hauck and Phillips 2002). In contrast, Earth's magnetic field is substantially stronger due to active geodynamic processes within its liquid outer core, driven by thermally and compositionally induced convection coupled with planetary rotation, which generates electrical currents sustaining a strong global magnetic field (Roberts and King 2013; Buffett 2000). Mars, by comparison, experienced early core solidification as a consequence of its smaller size and more rapid cooling history (Stevenson et al. 1983; Zuber et al. 2000). The cessation of convective motions within the Martian metallic core terminated

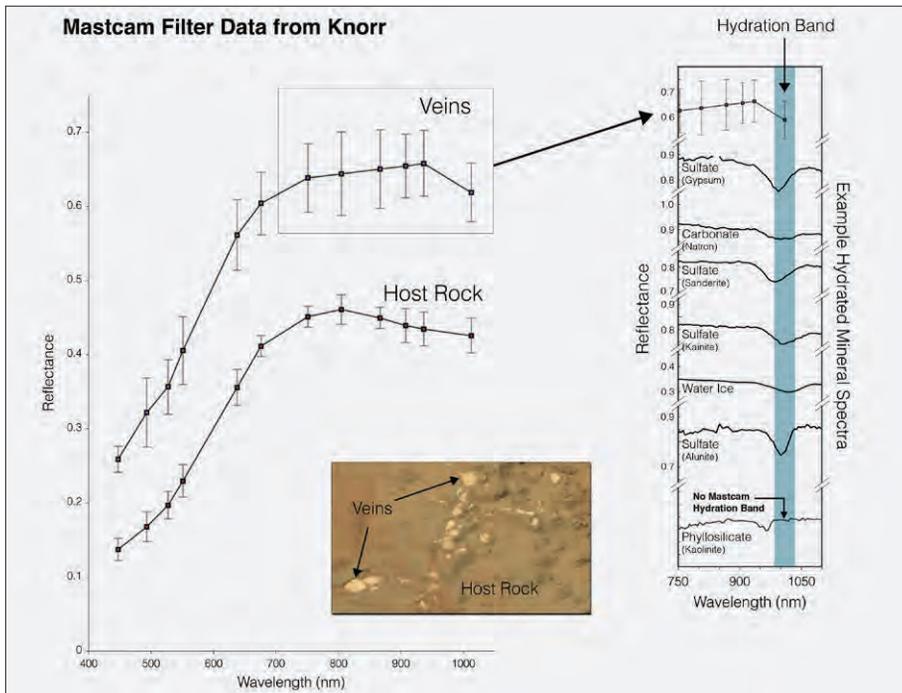


Figure 6. A diagram originates from NASA's Mars Science Laboratory (MSL) Curiosity Rover mission using Mastcam to study the chemical composition of the Knorr rock in the Gale Crater and strongly support water-related mineral formation such as kaolinite and gypsum (Grotzinger, J. P., et al., 2014).

The Warm and Wet Climatic Phase of Early Mars: Geological and Hydrological Evidence from the Noachian to Early Hesperian Periods

The Noachian to early Hesperian epochs represent a climatically significant period in Martian history, commonly referred to as the "Warm and Wet" phase. This interval is characterized by pervasive evidence of surface water activity and a sustained hydrologic cycle. Geologic indicators, including extensively developed valley networks, stratified sedimentary deposits, and aqueous alteration minerals such as phyllosilicates (clay minerals) and sulfates support the hypothesis that long-standing bodies of water were present during this time (Carr, 1996; Fassett & Head, 2008; Bibring et al., 2006) (Fig. 6). These may have included lacustrine environments and possibly shallow epeiric (epicontinental) seas.

Although Mars lacks Earth-like plate tectonics, the planet experienced considerable tectonic deformation, particularly within the Tharsis region, due to active hot spots. This region exhibits a complex array of tectonic features, including

normal faults, grabens, folds, and rift systems, most prominently expressed in Valles Marineris, one of the largest known canyon systems in the solar system (Schultz & Watters, 2009). Tectonic and volcanic processes during this period also contributed to crustal formation, especially within the southern highlands (Figs. 7 and 8).

This period is interpreted as one of the most hydrologically active in Martian geological history, marked by sustained precipitation, surface runoff, subsurface infiltration, and the development of extensive fluvial networks. Geomorphologic features such as sinuous rilles, stream channels, gullies, alluvial fans, and deltaic deposits (Fig. 9), as well as large-scale dendritic drainage patterns, indicate widespread fluvial erosion and sediment transport (Fassett

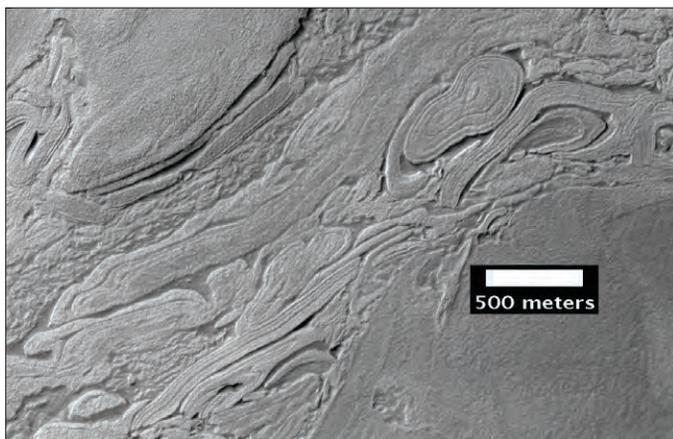


Figure 7. A photograph of a twisted terrain in Hellas Planitia (actually located in Noachis quadrangle). Highly deformed area that records the early stage of Martian formation (Moore, J. M., Belton, M. J. S., & Goldsby, D. L., 1998).

its dynamo activity, leading to the loss of a global magnetic field (Acuna et al. 1999) (Fig. 5).

This cycle also marks the onset of the fundamental hydrological systems on Mars. The extreme climatic regime during this interval was closely linked to intense meteoritic bombardment, widespread volcanism, and notable crustal deformation (Squyres and Carr 1986; Banerdt et al. 1992). These dynamic processes resulted in the formation of impact craters, tectonic structures such as folds, faults, and joints, as well as ridges and troughs, all indicative of a highly unstable and geologically active early Martian environment (Tanaka et al. 2014).

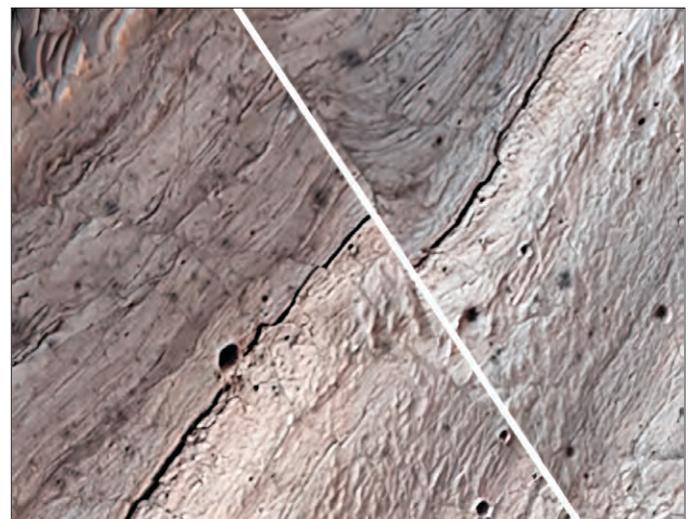


Figure 8. A photograph of a magnificent fault slip on Mars (white line) observed by the American Mars Reconnaissance Orbiter (NASA/JPL/University of Arizona, 2007).

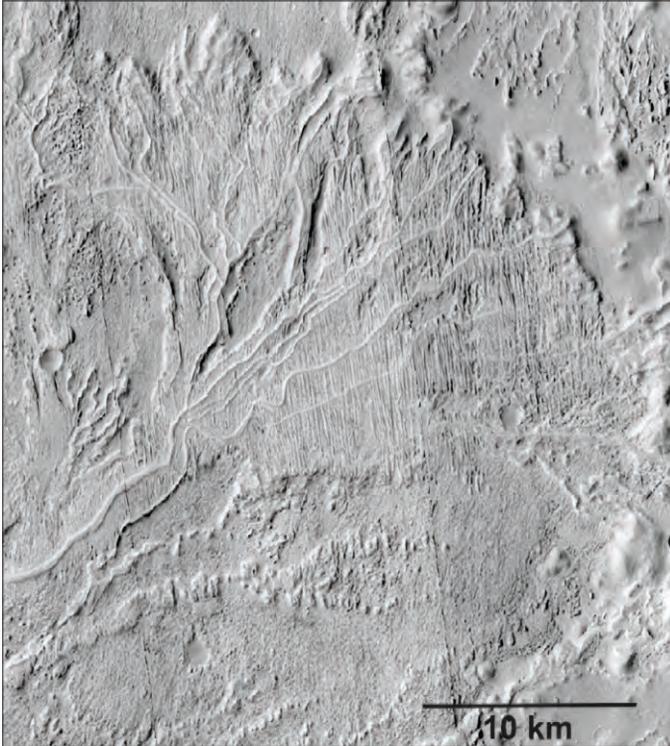


Figure 9. A photograph of a delta in the Aeolis region of Mars (NASA/JPL/USGS., 2025).

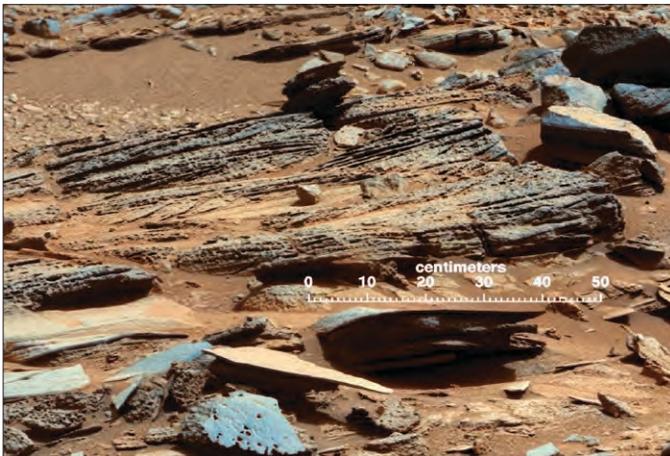


Figure 10. A photograph with a magnified view from Opportunity shows a portion of the Martian rock with fine layers at angles to each other (Cross Bedding). The dark lines trace layers that indicate the sediments (sands) were deposited in flowing water. These sand-sized grains were probably accumulated in water at least 5 centimeters (2 inches) deep and flowing at a speed in the range of 10 to 50 centimeters (4 to 20 inches) per second (Photograph, NASA, 2014).

& Head, 2008; Grotzinger & Milliken, 2012). In topographic lows, particularly within enclosed basins, the potential for shallow, semi-permanent seas is supported by sedimentological evidence (Grotzinger & Milliken, 2012).

Sedimentary structures further support aqueous depositional environments. These include cross-bedding (Fig. 10), ripple marks (Figs. 11 and 12), and fine-scale laminations (Fig. 13), all of which are indicative of sediment reworking by flowing or standing water (Grotzinger & Milliken, 2012; Bibring et al., 2006). The presence of



Figure 11. Photograph of Ripple Marks supports the existence of running water on the surface of Mars (NASA/JPL-Caltech/MSSS, 2015). Field of view = 4 meters across.

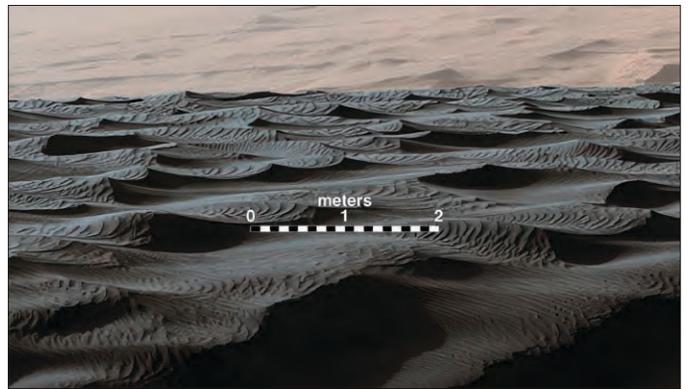


Figure 12. A photograph shows two sizes of wind-sculpted ripples are evident in this view of the top surface of Martian sand dunes and ripples that are similar to the ones that exist on Earth. The larger ripples are roughly 10 feet (3 meters) apart (NASA/JPL-Caltech/MSSS, 2016).

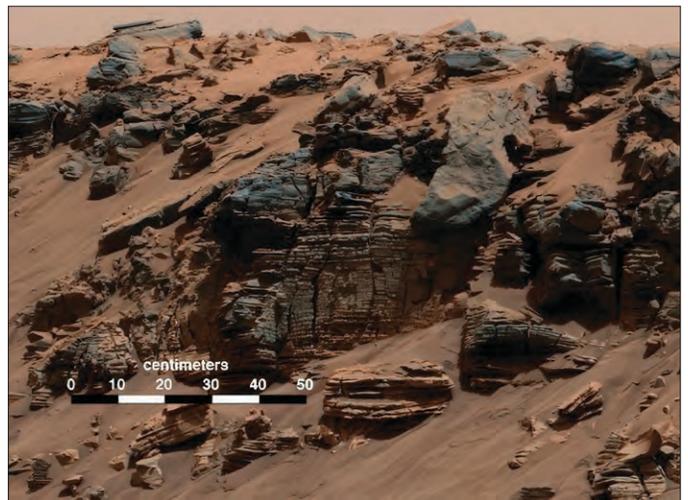


Figure 13. A photograph of evenly layered rock captured by the Mast Camera (Mastcam) on NASA's Curiosity Mars Rover (2014). It shows a pattern typical of a lake sedimentary deposit in a low-energy environment. <https://scitech-daily.com/curiosity-reveals-clues-water-helped-shape-landscape-mars/>.

hydrated silicate minerals, particularly in association with basin and deltaic deposits (Fig. 6), reinforces the interpretation of persistent surface or near-surface liquid water (Bibring et al., 2006).

MARS THROUGH TIME

Collectively, these observations suggest that the Noachian to early Hesperian periods provided environmental conditions potentially favorable to prebiotic chemistry or early microbial life. Hypothetically, such life could have emerged in aqueous settings, possibly resembling cyanobacteria-like prokaryotes inhabiting shallow lacustrine or marginal marine environments (Westall et al., 2015; Grotzinger et al., 2014).

The Warm and Dry Transition: Mars During the Hesperian Period

The Hesperian Period (~3.7–3.0 Ga) represents a critical phase in the climatic and geologic evolution of Mars, marking the transition from the relatively wetter, phyllosilicate-dominated conditions of the Noachian to the arid, sulfate-rich environments characteristic of the Amazonian (Carr and Head, 2010; Tanaka, 1986) (Fig. 14).

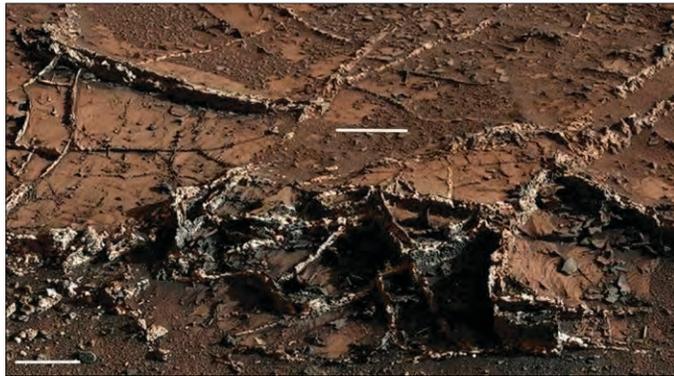


Figure 14. A photograph of dark material that lines the fracture walls reflects an earlier episode of fluid flow than the white, calcium-sulfate-rich veins do, although both flows occurred after the cracks formed, Mount Sharp (NASA/JPL-Caltech/MSSS., 2014).

Each white bar in the image represents 5 cm (2 inches).

This interval is defined by widespread volcanic resurfacing, most notably in the Tharsis and Elysium regions, where extensive basaltic lava flows altered vast portions of the Martian surface (Greeley and Spudis, 1981; Tanaka, 1986). Sustained volcanic activity throughout the Hesperian contributed to ongoing crustal deformation, thermal anomalies, and tectonic restructuring (Wordsworth, 2016; Carr and Head, 2010).

Despite the overarching trend toward planetary desiccation and dryness, geomorphological and sedimentary evidence indicates that episodic fluvial processes persisted during the Hesperian. Valley networks, deltaic deposits, and sediment-filled basins point to transient hydrological events, potentially driven by localized melting of subsurface ice, triggered by magmatic heating or short-lived climatic excursions (Howard et al., 2005; Kite et al., 2017). In particular, the Eridania Basin preserves early Hesperian deposits indicative of hydrothermal alteration, suggesting sustained interactions between volcanic and aqueous processes in a setting that may have been habitable (Bishop et al., 2018).

Simultaneously, aeolian and evaporitic processes became increasingly dominant. Surface features such as polygonal fracture networks, desert pavements (Fig. 15), and playa-lake evaporite deposits, including halite and gypsum, suggest the presence of ephemeral water bodies subject to repeated cycles of evaporation and desiccation (El-Maarry et al., 2014). In addition, some of the craters may have hosted lakes billions of years ago when the Martian climate allowed liquid water to exist on the surface for extended periods. During the drying conditions, the water evaporates leaving mud cracks as strong evidence to support this arid environment (Fig. 16). Orbital spectroscopy (e.g., CRISM) and in situ analyses from



Figure 15. A photograph of a desert surface covered with closely packed, interlocking angular or rounded rock fragments of pebble and cobble size that represent arid conditions in the area of the foothills of Mount Sharp in Gale Crater (NASA/JPL-Caltech/MSSS., 2022).

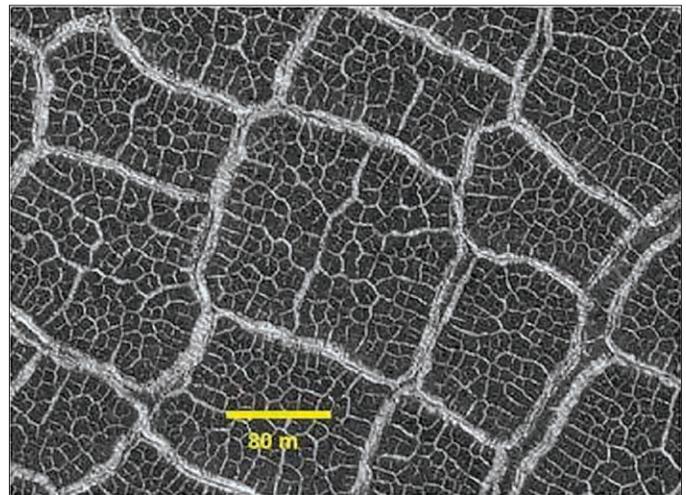


Figure 16. A photograph of a closer look at the Martian crater polygons shows cracks that strongly support drying conditions (NASA/JPL/University of Arizona, 2010).

missions such as Curiosity in Gale Crater confirm the widespread distribution of sulfate-rich stratigraphy, indicating the presence of ancient water and a shift towards acidic and increasingly arid surface conditions (Fishbaugh et al., 2007; Wordsworth, 2016).

These environmental shifts were likely driven by a combination of factors, including a decline in atmospheric pressure and enhanced volcanic degassing of sulfur-bearing gases such as SO₂. The resulting acidification of surface waters may have accelerated the geochemical transition from phyllosilicate- to sulfate-dominated weathering regimes (Carr and Head, 2010; Wordsworth, 2016). Thus, the Hesperian Period constitutes a climatically transitional epoch, bridging the warm, hydrologically active Noachian and the cold, hyper-arid Amazonian. Deciphering the spatial and temporal patterns of volcanism, hydrology, and alteration during the Hesperian remains essential for reconstructing Mars's environmental history and evaluating its potential for sustaining past microbial life.

Glacial and Interglacial Cycles during the Late Hesperian to Amazonian Periods

The transition from the Late Hesperian to Amazonian periods on Mars is marked by a significant decline in volcanic and fluvial activity,

coinciding with an increased dominance of aeolian processes, polar ice deposition, and periglacial surface modification. This interval preserves geomorphic and sedimentary evidence indicative of multiple glacial–interglacial cycles occurring under progressively colder and more arid climatic conditions.

Orbital variations, analogous to Earth's Milankovitch cycles, are hypothesized to have modulated Mars' axial tilt (obliquity) and eccentricity, driving periodic changes in insolation patterns. These orbital forcings resulted in cyclical redistribution of polar and mid-latitude ice deposits, promoting repeated glaciation and interglacial retreats (Laskar et al., 2004; Madeleine et al., 2009). During glacial maxima, extensive ice sheets expanded beyond polar regions, depositing moraines, striated and grooved bedrock surfaces, and tills as evidenced by high-resolution imagery from the Mars Reconnaissance Orbiter (MRO) and Mars Global Surveyor (MGS) (Head et al., 2005; Forget et al., 2006).

Freeze and thaw cycles associated with these glacial events contributed to the development of glacial features, including U-shaped glacial valleys, cirques, grooves, striations, and aretes (Fig. 17). Also, the melting of glacial ice resulted in the formation of glaciolacustrine sediments. Varved sequences and lithified tillites observed in ancient paleolake basins suggest transient liquid water stability and sedimentation during interglacial periods (Baker et al., 2018). These sediments provide critical records of paleoenvironmental conditions, linking surface processes with climatic fluctuations.

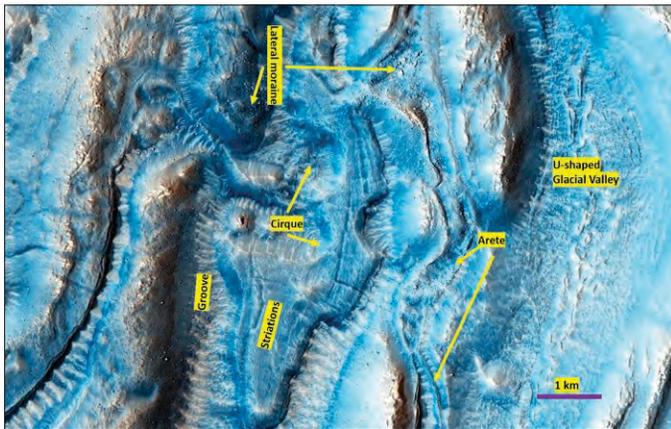


Figure 17. A photograph of the Martian glacier features. A range of ice features exists on the Red Planet today in Hadriaca Patera, Hellas Planitia, Mars (NASA/JPLCaltech/University of Arizona, 2010).

Collectively, the geomorphological and sedimentological signatures preserved across the mid-to-late Amazonian underscore the complex interplay between orbital forcing, climate evolution, and surface hydrology on Mars. These insights contribute substantially to our understanding of Mars' paleoclimate and the planet's potential for transient habitable conditions during its geologic history.

Conclusion

The Martian climate has undergone at least four significant transitions, each leaving stratigraphic, geomorphological, and mineralogical signatures. From early chaotic bombardment to potential shallow seas and eventual polar glaciation, these cycles highlight Mars' dynamic environmental history. While early phases may have supported transient habitable environments, the Amazonian has been dominated by cold, dry conditions with episodic glacial activity. Continued exploration will refine our

understanding of these climatic regimes and their role in shaping Mars' surface and potential for life.

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2025 University of Memphis Field Camp –

My Capstone Experience

Grace Y. Sandidge, SA-12627

Photo taken on June 6, 2025, during the 2025 University of Memphis Field Camp – Grace Sandidge standing in front of an overturned, thinly bedded ductile Willwood Sandstone from the Upper Cretaceous – Eocene that is exposed at Rattlesnake Mountain.

When I decided to become a geologist, field camp was painted as a rite of passage, the ultimate test applying classroom and laboratory training to solve geological problems in the field encompassed into a culminating experience. Every lecture, lab, and field exercise had been building to this moment. In June 2025, I spent four weeks in Powell, Wyoming completing my field camp course. In these four weeks I traveled and mapped across five locations in northern Wyoming and southern Montana, studying geologic structures at five different field sites: Clarks Fork Canyon, Rock Creek Canyon, Rattlesnake Mountain, Elk Basin, and the Wild Horse Range at Horseshoe Bend. Each site presented a unique geologic challenge and required me to apply the mapping and structural analysis techniques I had learned in the classroom. It was challenging in every sense: physically demanding, mentally exhausting, and emotionally intense. However, field camp became the most transformative part of my undergraduate journey and how I see geology, myself, and the world around me. I found myself navigating unfamiliar terrain with my field partner, a map, and compass, making interpretations of geologic structures, and learning to trust myself to bridge together the geologic story within the study area.

Every field site offered a different lens through which to understand geologic time, structure, and processes. At Clarks Fork Canyon, we studied rocks shaped by a combination of glacial activity, faults, and surficial deposits. The canyon's towering cliffs and exposed stratigraphy told stories of how this location was carved and shaped over geologic time. Rock Creek Canyon provided additional complexity in structural and rock formation interpreta-

tion, while Rattlesnake Mountain painted a deeper understanding of tectonics and erosion contributing to the geomorphology of this site. Elk Basin was my first time at an active oil field. The air



Photo taken on June 23, 2025, during the 2025 University of Memphis Field Camp – Grace Sandidge observing uplifted and deformed rock units at Bighorn Canyon that have been shaped by the Laramide Orogeny where exposed rocks are from the Precambrian through Pennsylvanian. An excellent site for observing structural geology, highlighted by a monocline.



Photograph taken on June 15, 2025, during the 2025 University of Memphis Field Camp of hydrothermal hot springs at Yellowstone National Park. An amazing opportunity to experience active geologic processes.

was thick with the pungent smell of hydrocarbons. The land here was flat and arid, dotted with cactus, sandy soils, and only sparse patches of shade. There was one point where my field partner and I took solace under a large boulder (named that day as shade rock) to get some relief from the intense sun that day. While the terrain could be grueling, Elk Basin gave me a hands-on introduction to petroleum geology, structural traps, and the practical importance of subsurface interpretation. We also had the incredible opportunity to spend a full day exploring Yellowstone National Park. It was my first time visiting, and I was immediately struck by the overpowering sulfur scent in the air from geothermal vents and hot springs. What amazed me even more were the vibrant, almost otherworldly hues of the aquamarine and turquoise pools, a reminder of how geology can feel like magic.

There were many days when field camp felt like bracing for a storm. Four weeks away from my family and the life I have built exacerbated the experience. Although there were many moments I felt waves of homesickness, I was fortunate enough to have gone to field camp with friends. The rigorous coursework and field excursions became doable as we worked together to think critically, solve problems, and make sound interpretations. My classmates and I shared snacks and laughs and kept each other sane when the heat grew intense. We survived cacti barbs, slips on rock formations, and rattlesnake and scorpion encounters. We survived 7:30AM starts, hiking across difficult terrain with heavy gear, taking strike and dip measurements, using the hammer test to access age of rocks found along glacial outwash, and finishing each night accessing and mapping the data observed and recorded that day. The



Photograph taken on June 15, 2025, during the 2025 University of Memphis Field Camp of hydrothermal hot springs at Yellowstone National Park. An amazing opportunity to experience active geologic processes.



Grace Sandidge awarded the AIPG Field Camp Scholarship to attend the 2025 University of Memphis Field Camp.

academic rigor was real and it was some of the most demanding work I've ever done. But it was those late nights with my peers finishing maps, trading advice, and supporting one another that made this experience memorable.

In the end, field camp taught me more than how to map a fold or interpret a cross-section. It taught me the value of collaboration, resilience, and friendship. I even learned how to skip rocks, play darts, shuffleboard, and pool. After years of lectures, lab reports, and exam prep, field camp brings these things together, testing physical endurance, critical thinking, collaboration, and mapping skills in real-world experiences. In many ways, field camp is the moment a student begins to transition into a geologist. It taught me not only how to determine rock formations and conduct

field tests but also how to think like a geologist, adapt under pressure, and work closely with others in sometimes unpredictable conditions. Overall, field camp was nerve wracking and exciting all at the same time. One of the best pieces of advice I received before applying to field camp was to choose a program where I knew someone. That guidance played a big role in my decision to attend Field Camp with the University of Memphis since several of my friends and peers from geology courses were planning to attend as well. That advice proved invaluable because geology is a science deeply rooted in community and collaboration. After four weeks of field camp, I can say with confidence that I returned with stronger skills, a deeper understanding of the Earth, and a renewed respect for geology as well as new friendships, unforgettable memories, and a clearer sense of becoming a geologist.

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The Proposed and Misguided Closure of the Department of Earth and Atmospheric Sciences at the University of Nebraska-Lincoln

Patrick H. Szopinski, SA-8499

The University of Nebraska-Lincoln (UNL) is the flagship university in all of Nebraska. It's an R1 research institute that is home to over 25,000 students, plus a few thousand more during home football games. I myself am proud to call myself a UNL alumnus, where I earned my Bachelors in Geology in 2019 and had the phrase "Go Big Red!" forever etched into my heart. And I felt part of my heart break when I heard the announcement on September 12, 2025, that UNL was planning to terminate its Department of Earth and Atmospheric Sciences (EAS).

This grave decision arose the way most grave decisions do. From financial troubles. With declining enrollment and tuition dollars, the attrition of state government funds, and rising costs in healthcare and insurance, the Nebraska University system (NU) found itself \$40 million in debt, and in dire need of a correction.¹ UNL, the biggest university campus within the NU system, went under review and found that its budget deficit was \$21 million alone, and media coverage of its financial crisis led to UNL committing to an additional \$6.5 million in proactive savings.² As a way to address the eye-watering \$27.5 million budget deficit, NU president Jeffrey Gold and UNL Chancellor Rodney Bennett hatched the momentous plan for UNL; the proposal to shut down six academic programs, with EAS being the most egregious choice. The other five programs were Statistics; Educational Administration; Landscape Architecture; Community and Regional Planning; and Textile, Merchandise, and Fashion Design. The plan also called for merging together the Entomology and Plant Pathology programs, and a mega-merger between Agricultural Leadership, Education and Communication, and Agricultural Economics. To top it off, the university would also withdraw \$550,000 in state-funded graduate assistantships for College of Engineering and College of Arts and Sciences students.² UNL's Academic Planning Committee (APC) was put in charge of nailing down the details of the budget reduction plan.

One salient detail is that the University also offered a Voluntary Separation Incentive Fund (VSIP) to tenured faculty who are over 62 years old and have taught at UNL for over 10 years. They would get 70% of their base salary and an early retirement if they took the offer.¹ The loss of the six academic programs would save UNL \$7.7 million, and the remaining debt is planned to be cut through "administrative action and efficiency." The only part of that statement that came with any certainty was that it would negatively affect the class options for students. Classes with low enrollment would be cancelled, fewer options for electives would be provided, and class sizes overall would increase.¹ Despite what it would mean for their students, media coverage confirmed the University's

conviction to their budget reduction plan, stating that "UNL has to cut \$27.5 million from its budget this year, no matter what."³

As a UNL alum, I couldn't even imagine how they got \$27.5 million in debt. A cynical part of me thought that it was just an emotional ploy to solicit more donations from alumni. But as the headlines kept rolling, it was clear that this wasn't just a talking point. They were serious about the idea of getting rid of these six programs, and EAS stood out like a lighthouse. In the Cornhusker state, with the Ogallala Aquifer and the Elk Creek carbonatite underneath and Tornado Alley above, the University was okay with there being no more Meteorology or Geology degrees from UNL.



We are Nebraska's earth and sky

Figure 1. One of the slogans made to support the Department of Earth and Atmospheric Sciences on their GitHub page.

This struck a nerve with me. I owe my geological career to UNL. I wasn't just a regular old alumnus, but I bore the name of "Nebraska grad" with pride (admittedly it helped that I entered the workforce in a different state, where hailing from Nebraska wasn't the norm). I can still recall how it felt to tour the campus as a seventeen-year-old, sifting through college applications, and feel the overwhelming yet decisive sense of "yep, this is the one!" I recall being blown away by the Smithsonian-level of quality of the Nebraska State Natural History Museum, where I would volunteer multiple times throughout my undergraduate career. It's thanks to the chance to serve the Conservation and Survey Division in their groundwater well drilling program as a summer intern that I learned to appreciate the amount of coordination, documentation, and travel involved in a career as a geologist. The curriculum for the Bachelor's of Science in Geology was also instrumental in allowing me to take (and ultimately pass) both the FG and PG exams. But one thing I'm most proud of – and most grateful to UNL for – is for allowing me to conduct an undergraduate senior thesis, which used multiple geophysical methods to map the boundary of the Midcontinent Rift System in the southeast corner of Nebraska. When I began interviewing for jobs after graduating, multiple companies told me they were impressed that I had conducted research and published my findings with the university, which absolutely helped me stand out from the crowd of applicants.

1. Lewis, Justin Diep and Izzy. "Breaking: UNL to Eliminate Multiple Programs as Part of \$27.5 Million Budget Cut." *The Daily Nebraskan*, 12 Sept. 2025, www.dailynebraskan.com/news/breaking-unl-to-eliminate-multiple-programs-as-part-of-27-5-million-budget-cut/article_271e48ea-3d90-4518-82d8-de0b0f06a5c0.html. (Oct. 2025).
2. Peal, Jolie. "UNL Proposing to Eliminate Six Academic Programs." *Nebraska Public Media*, 12 Sept. 2025, nebraskapublicmedia.org/es/news/news-articles/breaking-unl-proposing-to-eliminate-six-academic-programs/. (Oct. 2025).
3. Johnson, McKenzie. "UNL Students, Professors Hold Demonstration as \$27.5 Million Budget Cut Looms." *KLKN*, 11 Oct. 2025, www.klknv.com/unl-students-professors-hold-demonstration-as-27-5-million-budget-cut-looms/. (Oct. 2025).

No part of my thesis would have been possible without the attention and investment of my advisor, Dr. Irina Filina, who began teaching geophysics at UNL during my sophomore year. Before taking her classes, I was positive I wanted to be a paleontologist, but her passion and expertise helped me shift my view towards geophysics, where my fascination remains to this day. At present, I'm working on a Master's degree in Geological Engineering that utilizes geophysical methods, and I serve as a teaching assistant for classes that teach geophysics to undergraduate students. Acquiring that experience with geophysical methods in the field and the lab was crucial to building my career set so early on in my career, and Dr. Filina helped make that possible. Now a tenure-track faculty with ten years of service, and having advised more students than I can count, she's continued to have a truly remarkable and irreplaceable impact at UNL. Earlier this year, she received a Fullbright scholarship to conduct geophysical research in Iceland, which includes a portion to take students along for a two-week field trip. She also sponsors the student chapter of SEG (Society of Exploration Geophysicists), which won an award for team research efforts last year at the SEG-EVOLVE geophysical conference. Her leadership has also helped multiple students present their own research findings at regional and national scientific conferences. I fall into this category as well, as it's thanks to her that I was able to share my thesis at the Geological Society of America's Regional Conference in my senior year at UNL. This is by no means an exhaustive list of her accomplishments and accolades, it's just what came to my mind first when I think about her and all she's done for me. There's no way I could possibly thank her for all the tremendous work she's done, for me and for all her students, but if you read through her website, you'll find a testimony of the highest recommendation from me!

When the announcement came that EAS was being considered for closure, it was the faculty like Dr. Filina who were the first outspoken defenders of the department. The NU budget crisis was not an unknown issue, but UNL was the only campus within the system that listed closing academic programs as one of its measures.² The fallout to this announcement was swift and decisive. The news spread online, with hundreds of students, staff, and alumni (including yours truly) weighing in to provide their story with EAS and UNL.⁴ UNL's chapter of the American Association of University Professors (AAUP) got involved, helmed under the presidency of Dr. Sarah Zuckerman, who is also a professor in the Educational Administration department, one of the six programs on the chopping block. Even the general public got involved, with EAS receiving support from local news outlets and members of the community.⁵ The question everyone was asking was a simple one. "Why EAS?" The answer was also simple. In fact, it all came down to one word. Metrics.

When the NU higher-ups decided that part of the budget reduction plan would involve cutting academic programs, they needed a system to evaluate programs to see which ones would stay and which ones wouldn't. The Academic Planning Committee (APC) assembled a list of criteria by which each program would be graded, utilizing metrics that included student retention rate, number of credit hours taught, number of PhD graduates, and

research awards for the program.² However, the exact nature of the metrics – especially the mathematics used to make judgments of what constituted a "low score" – were kept in the dark. The University would not disclose the exact metrics to anyone, not even when a request for transparency was put forth by the Flatwater Free Press.⁶ One particular metric that drew a lot of ire was the inclusion of the Scholarly Research Index (SRI), which was criticized as being hastily used and comparing different departments unequally. Dr. Zuckerman described it as providing different weights to faculty in different disciplines, resulting in apples-to-oranges comparisons between programs. It also omitted conference presentations and publications from faculty's score for no apparent reason. Critics were also quick to point out that the director of Academic Analytics, the company that produces the SRI, has stated that this data is not to be used in a punitive manner, which the University was flagrantly doing.⁶

The groundswell of opposition to the UNL program closures rang out for the rest of September, culminating on the second week of October, when members of the APC scheduled hearings with supporters of the six programs. These hearings were closed to the public, but recordings and transcripts were uploaded to the university's website shortly afterwards. Outside the building where it was held on UNL's Innovation Campus, protests were carried out by students, faculty, university staff, and community members from all over Nebraska for the entire week. The support for EAS itself was tremendous, with flyers and brochures passed out and signs held up everywhere, repeating the slogan "No Earth, no atmosphere, no Nebraska".⁵ The hearing for EAS was scheduled for October 10, the final hearing conducted by the APC.⁷ Present were four current professors, one undergrad geology student, one Master's meteorology student, and multiple alumni in various professions. For an hour, the department's supporters voiced their opinion on the value of EAS to the university and to Nebraska itself, as well as their criticism of the metrics that were being used so unfavorably against the department.

One of the most glaring omissions from the University's metrics is that it didn't account for the workforce opportunities that a degree affords students. Not only are over 92% of EAS graduates currently practicing in their field or pursuing advanced degrees, but these jobs are also the ones that are in increasingly high demand.⁴ Your job title doesn't need to end in -ologist for a geology degree to be useful. One alumnus at the hearing works for the US Army Corps of Engineers in Omaha, and he hired two EAS graduates for geologist and geophysicist roles in the past five years.

Another metric that landed against EAS was their low ranking in number of degrees awarded. The annual number of students graduating from EAS has seen a lot of ups and downs since 2020. The peak academic year was 2021-2022, when 26 degrees in Geology and Meteorology were conferred.² When I graduated in the Spring of 2019, I was one of only three BS in Geology recipients. Last academic year, only 11 degrees were conferred, which is the lowest the department has seen thus far into the decade. This is old news to anyone who's been watching the annual number of "Earth Sciences" degrees dwindle over the recent years, and it's no different at UNL.

4. "Earth and Atmospheric Sciences Calls on Their Community to Share Their Story." *Department of Earth and Atmospheric Sciences, University of Nebraska-Lincoln*, 2 Oct. 2025, eas.unl.edu/news/earth-and-atmospheric-sciences-calls-their-community-share-their-story/. (Oct. 2025).
5. Lucrece, Karen. "'No Other Program like This': UNL Gets Pushback for Ending Earth and Atmospheric Sciences." *KLKN*, 15 Sept. 2025, www.klknv.com/no-other-program-like-this-unl-gets-pushback-for-ending-earth-and-atmospheric-sciences/. (Oct. 2025).
6. Wolf, Emily. "As UNL Proposes Steep Budget Cuts, Statistics Faculty Ask Leadership to Check Their Math." *Flatwater Free Press*, 17 Oct. 2025, flatwater-freepress.org/as-unl-proposes-steep-budget-cuts-statistics-faculty-ask-leadership-to-check-their-math/. (Oct. 2025).
7. Svehla, Corrie. "APC Hearings - Earth and Atmospheric Sciences." 11 Oct. 2025. *APC Hearings*, <https://mediahub.unl.edu/media/25758>. (Oct. 2025).



Figure 2. Students and faculty protesting outside the building for the Department of Earth and Atmospheric Science's hearing with the Academic Planning Committee. (News footage from Nebraska 8 NOW, McKenzie Johnson, Oct.11, 2025)

It's very common for freshman students to enroll in something else, then switch majors to Geology somewhere along their undergraduate track, usually after taking one awe-inspiring class. It's also common that a lot of freshman Meteorology majors sign up, but balk at the number of math and physics courses required. EAS has plans to address this with a new "Pathways to Success" course for freshmen. In the hearing, Dr. Clint Rowe attributed this to a lack of upfront information during undergraduate recruitment. It turns out that faculty have been cut out of the recruitment process since the pandemic. Instead, info about the Geology and Meteorology degrees is being spread by academic advisors who don't know the ins and outs of the program. EAS wants to change this. When prospective students get a chance to speak with faculty during the recruitment process, they have a better understanding of what the degree entails and how much work it can be, and these students arrive on campus feeling more prepared.⁷

The metrics also penalized EAS for its small size. The metrics ranked it low in terms of number of courses and yearly research publications. But it's a false comparison that a department with only 20 full-time faculty should match up pound for a pound with a much bigger department. Additionally, Dr. Erin Haacker pointed out that – after adjusting for size – the publication, conference presentation, and teaching track record of EAS was on par with those of other institutions. This decision was also reached last year by the UNL chapter of the AAUP.⁷

The research output of the EAS faculty was flawed in its measurement. No part of the metrics accounted for the impact or prestige of the journals in which faculty were being published. EAS's average citation rate is over 230 citations per faculty member per year. EAS also received research funding from numerous organizations that was simply unaccounted for, namely the USGS, Nebraska DOT, Nebraska Department of Education, NASA, and NOAA, totaling over \$5.3 million in research funds over the last decade.⁷ There was no regard given for some of the long-lasting research efforts EAS has done, whether that be in the Amazon, Gulf of Mexico, or Antarctica. Throughout Nebraska, the EAS faculty are highly respected for their numerous cross-disciplinary projects and efforts. One major example is the Great Plains Community Climate

Resilience Institute, which contains 29 faculty members and is led under Dr. Clint Rowe of EAS. Their research is also highly productive, with over \$24 million in externally-sourced research funds currently active as of the time of writing, and over \$90 million in research funding secured over the last decade. These numbers don't even touch on the nature of their research projects, which are critical for numerous topical issues, such as groundwater monitoring, critical minerals, alternate energy resources, climate modeling, and storm forecasting.

The metrics also only accounted for publications by faculty who are actively teaching at UNL, which heavily penalizes EAS. They have lost a lot of high-performing faculty over the last decade, and the numerous publications and contributions from these faculty were not taken into consideration at all. I checked the faculty directory and could count five professors who have since retired from when I was a student in 2019, most noteworthy being Dr. David Loope (the Sedimentology Sage) who had been at UNL since 1986.

The proposed cuts would involve terminating 12 teaching positions from EAS. Along with that, the University told EAS that certain faculty deemed "high-powered staff" would be relocated to other departments, like the School of Natural Resources. So, according to the University's own standards, the EAS faculty are too valuable to lose, but the department itself can be scrapped. I'm still confused about that. If EAS is cut, the faculty terminations would start in December 2026. But the University also said that students currently enrolled in a degree with EAS would be allowed to graduate with those degrees. I don't see how both of these can be true at the same time. How can students graduate from a department that no longer exists? How can faculty perform their teaching, research, or outreach if the department doesn't exist? As Dr. Adam Houston brilliantly stated in the hearing, "Without EAS, I effectively become a one-legged stool."

Some efforts have been suggested for damage control. In the hearing, EAS mentioned that they can increase revenue by adding a new non-thesis MS degree in Meteorology, designed to be suitable for students who are working full-time.⁷ They could also defer some cost by merging with the Environmental Sciences department, although that's not a popular option, given how it could dilute

the department's curriculum, research, and outreach efforts. At present, the BS in Geology is sufficient to allow graduates to take the FG and PG exams (as I can attest to), and the BS in Meteorology opens up pathways at NOAA and NWS that are unique in Nebraska. Such a merger may save UNL some money, but it would hamper EAS's ability to uphold the high standard it sets for its Geology and Meteorology graduates. It's also been suggested that the Nebraska Foundation (part of the university's discretionary endowment) could set aside the necessary \$7.7 million to keep the programs solvent for at least a year. Last year, 50,000 donors contributed \$389 million to the Nebraska Foundation, so less than 2% of that donation would be able to keep the six programs afloat until the University can find another way to reduce its budget deficit.⁸ Within this article by the *Nebraska Examiner*, it's clear that keeping EAS intact was the most urgent, which I certainly agree with, but all of the programs deserve to be supported. It's not my intention to say "keep the Geology program and get rid of this other one."

The APC hearings gave the programs in jeopardy a chance to provide feedback about the decisions. The final recommendations to the Board of Regents come on December 5, which will have the last word on who stays and who doesn't. The cruel irony is that, as I write this, EAS's fate hangs in the balance. But by this article's publication date, the dust will have settled and the outcome will be known. I can only hope that the vast amount of support from the faculty, the alumni, the students, and Nebraskans far and wide were enough to cause the University to reconsider. In case of the worst outcome, it won't take long for UNL to realize that it prioritized a shortsighted financial gain over the long-term pedigree of its academics, its commitment to science and innovation, and its ability to adequately train the next generation of Earth and Atmospheric Scientists. Students and staff will be forced to pick other universities, and Nebraska will emerge from its brain-drain poorer in spirit than \$27.5 million.

8. Naff, Clay Farris. "UNL Cuts Diminish Us All; Emergency Fund Could Bridge Gap." *Nebraska Examiner*, 15 Oct. 2025, nebraskaexaminer.com/2025/10/15/unl-cuts-diminish-us-all-emergency-fund-could-bridge-gap/. (Oct. 2025).

AIPG Speaks Up

The University of Nebraska–Lincoln's proposed closure of its Department of Earth & Atmospheric Sciences presents a moment of real consequence for the geoscience profession, because the program plays a critical role in meeting the state's needs for water, energy, natural-hazards expertise, and workforce development. AIPG submitted a formal response to the UNL Board of Regents on December 2, 2025 ahead of the vote on December 5, 2025 to underscore why eliminating this program would weaken Nebraska's scientific capacity and diminish the profession's ability to serve the public. But safeguarding geoscience education and the integrity of our profession cannot rest on one letter alone. Therefore, we share our response here to inform our members, to model thoughtful advocacy, and to encourage each of you to speak up—in your institutions, communities, and professional networks—whenever geoscience education and public service are at risk.

The following are the two letters AIPG sent to the University administration and regents. The first letter was sent to the department chair, dean and interim vice president and provost on October 13, 2025.

To: David Jackson, Ph.D., Interim Executive Vice President and Provost
Patrick Dussault, Ph.D., Interim Dean, College of Arts and Sciences
Clinton Rowe, Ph.D., Chairperson, Dept. of Earth and Atmospheric Sciences

Dear Drs. Jackson, Dussault, and Rowe,

The American Institute of Professional Geologists (AIPG) is the largest United States professional organization dedicated to the professional and ethical practice of geology across all subdisciplines of the profession. The AIPG has approximately 5000 members in 54 countries. While more than 95% of our membership lives and works

in the United States, we are globally recognized for our professional education and certification programs.

The AIPG is shocked and saddened to learn that the University of Nebraska-Lincoln is proposing the closure of the Department of Earth and Atmospheric Sciences and the elimination of all degree programs housed within. We feel that this proposal is short-sighted and weakens the economic and scientific strength of both Nebraska and the United States. We strongly encourage the University to reject this proposal.

At the same time that the University proposes elimination of the geology degree, the United States faces a critical shortage of college graduates suitably trained in geology and earth science. Two separate trends are combining to create this shortage. First, the post-war baby boom generation is retiring at a rapid clip, and the earliest members of Generation X are also reaching retirement age. The number of retiring geologists is outpacing the number of graduates each year. Data from the AIPG are consistent with that observation, with more than 50% of AIPG Certified Professional Geologists being over the age of 50. Second, fewer high school graduates are entering geology degree programs. The reasons for this lack of new geology students are unclear. Given the current rates of retirement and graduation rates for geoscientists, the American Geosciences Institute (AGI) predicts a shortfall of 130,000 geoscientists by 2030. It is abundantly clear that eliminating geology degree programs will only exacerbate this problem.

The United States' research I universities are the lifeblood of innovation and advancement in science and technology research. New discoveries by these "flagship schools" drive advancement in the applied sciences.

The discovery of stable isotope fractionation might have appeared, at first glance, to be esoteric science. Yet today, stable isotope fractionation is used to explore for new mineral deposits, reconstruct past climate, and understand Earth's carbon budget. Research-oriented programs, such as those in the Department of Earth and Atmospheric Sciences at the University of Nebraska-Lincoln, play a critical role in developing the new knowledge that leads to tomorrow's innovation and advancement.

The United States has committed significant resources (e.g. the Earth Material Resource Initiative, National Cooperative Geologic Mapping Program) to identify the raw materials that will be necessary for our country to compete in the global economy. Additionally, the ongoing effort to transition to lower impact energy sources will require a dramatic increase in mineral production. Geologists will play a critical role in identifying mineral deposits that can provide these critical minerals. Recently, geologists have identified a potentially world-class rare earth mineral deposit in Nebraska, just south and east of Lincoln. This deposit and others like it will be critical to future United States success. Shuttering the Earth and Atmospheric Science Department at the University of Nebraska-Lincoln, will hinder efforts to provide well-qualified new geologists to staff important projects such as this one.

We recognize that the budget process is difficult and that changes in federal policies have placed economic strain on many colleges and universities. However, we believe that the long-term damage caused by closure of the Department of Earth and Atmospheric Sciences at the University of Nebraska-Lincoln will far outweigh any short-term savings. We urge the administration to reject this proposed closure.

Respectfully,

Aaron W. Johnson, Ph.D., CPG, PG

On behalf of the AIPG Leadership Team:
Sara Pearson, President
Shanna Schmitt, Past-President
Chuck Drake, President-Elect

The following is the letter that AIPG was invited to write by the department chair, Dr. Clinton Rowe. This letter was sent December 2, 2025.

To: Jeffrey Gold (UNL President), Paul Kenney (Chair), Jim Scheer (Vice Chair), Timothy Clare, Jack Stark, Elizabeth O'Connor, Robert Schafer, Kathy Wilmot, Barbara Weitz, Libby Wilkins, (UNL Board of Regents)

Dear President Gold and Honorable Members of the UNL Board of Regents,

On behalf of the American Institute of Professional Geologists (AIPG), the nation's largest organization dedicated to advancing the ethical, scientific, and professional practice of geology, we respectfully submit this letter urging the Board to reject the proposed closure of the Department of Earth and Atmospheric Sciences (EAS). With more than 5,000 members across 54 countries, and a

strong national reputation for professional education and certification, AIPG has a vested interest in ensuring that the United States—and Nebraska in particular—maintains the scientific capacity required to steward its natural resources responsibly.

Nebraska's prosperity is inseparable from the effective management of its natural resources, especially groundwater. The High Plains Aquifer, the state's agricultural base, and the Natural Resources Districts (NRDs) depend upon professionals with a deep understanding of Nebraska's unique geologic, hydrologic, and soil systems. The Department of EAS provides the state's only comprehensive in-state training pipeline for hydrogeologists, environmental geoscientists, geochemists, and groundwater modelers. Discontinuing this program would force Nebraska's communities, NRDs, state agencies, and industries to rely increasingly on out-of-state hires who lack critical place-based expertise necessary for sound groundwater management, contamination assessment, and long-term resource planning.

The loss of Nebraska's sole Research I program in meteorology and climatology would further compromise the state's ability to prepare for and respond to severe weather, drought, flooding, and emerging climate variability. These challenges have immediate implications for public safety, agriculture, and infrastructure. At a time when the frequency and intensity of extreme weather events is increasing, eliminating Nebraska's central hub of atmospheric science capacity represents a serious and avoidable risk.

Geoscience expertise is also fundamental to responsible development of mineral resources, aggregate evaluation, infrastructure planning, and carbon sequestration. Nebraska's recently identified and potentially world-class rare-earth mineral deposit south and east of Lincoln is a case in point: its evaluation and future development will require highly trained geoscientists intimately familiar with local stratigraphy, structural history, and mineral systems. Disbanding the program that supplies this expertise would undermine Nebraska's ability to participate in national initiatives such as the Earth Mapping Resources Initiative and the National Cooperative Geologic Mapping Program.

The national workforce picture underscores these concerns. The American Geosciences Institute projects a shortfall of 130,000 geoscientists by 2030, driven by retirement of the baby boomers and early Gen-X populations and declining enrollment in geoscience degree programs nationwide. The unemployment rate for geoscience degree holders stands at 1.4%, reflecting sustained and growing demand. Eliminating EAS would not only deepen this shortage but would constrain Nebraska's ability to meet its own workforce needs in groundwater protection, agriculture, environmental compliance, hazard mitigation, and mineral development.

The Nebraska Geological Survey (NGS), housed within the School of Natural Resources, is widely recognized for its excellence in groundwater assessment, geologic mapping, and natural-resource management. Its 2024 Annual Report documents 55 peer-reviewed publications and the supervision of 19 graduate students, demonstrating the NGS's central role in supporting workforce development and applied science. The NGS depends on the graduate

NEBRASKA EAS DEPARTMENT CLOSURE

programs in EAS for talent, collaboration, and research capacity. The proposed closure would significantly diminish NGS's ability to fulfill its statutory responsibilities and provide the scientific support upon which Nebraska's communities rely.

Eliminating EAS would also impose substantial costs to the Research I status of the University of Nebraska–Lincoln (UNL). The department contributes meaningfully to federal research funding competitiveness and interdisciplinary collaboration with engineering, agriculture, and natural resources. The scientific discoveries emerging from geoscience—such as stable isotope geochemistry, sedimentological analysis, and hydroclimate modeling—feed directly into advancements in agriculture, water management, environmental remediation, and mineral exploration. Removing this engine of innovation would reduce UNL's research productivity and weaken its national standing.

AIPG acknowledges the serious financial pressures facing higher education institutions nationwide. However, eliminating a core scientific discipline central to Nebraska's identity, economy, and long-term resilience is not a fiscally prudent solution. The short-term budget relief would be eclipsed by long-term economic losses, diminished research capacity, increased dependence on external consultants, and erosion of Nebraska's ability to meet its statutory and practical responsibilities in managing water, soil, climate, and natural resources. A more forward-looking approach would be to modernize and strategically strengthen the EAS program—aligning it with the state's

most critical challenges and leveraging opportunities for external funding and partnership growth.

For these reasons, we respectfully and strongly urge the UNL Board of Regents to reject the proposed closure of the Department of EAS. Preserving and enhancing this program is essential to the university's land-grant mission, to Nebraska's workforce and resource security, and to the nation's scientific and economic competitiveness.

Respectfully,

Aaron W. Johnson, Ph.D., CPG, PG (AK)

Submitted On behalf of the AIPG Leadership Team:

Sara Pearson, President
Shanna Schmitt, Past-President
Chuck Drake, President-Elect

Despite AIPG's formal response and the strong voices of UNL alumni who spoke out against the proposed closure, the University of Nebraska Board of Regents ultimately voted to discontinue the Department of Earth & Atmospheric Sciences. But this outcome reinforces why continued advocacy is essential for our profession. Programs may close, yet our responsibility to champion geoscience education—and the vital public services it supports—remains unchanged. We are grateful to our members and alumni who stepped forward, and we encourage geoscience professionals everywhere to stay engaged, visible, and persistent in supporting the future of our discipline.

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EXPLORING THE GEOLOGY OF THE ST. FRANCOIS MOUNTAINS

The Elephants - Natural Water Park - Monuments field trip, originally offered during the 2025 AIPG National Conference in Missouri, is reprinted here for all *TPG* readers to enjoy. The guide highlights the geologic features, context, and insights shared during the excursion, offering readers an opportunity to explore and appreciate the region's remarkable geology.

Graniteville Granite boulders at Elephant Rocks State Park

General Geology of the St. Francois Mountains

The rocks in the St. Francois Mountains include extrusive and intrusive igneous, marine sedimentary, and minor metamorphic rocks. The oldest are extrusive igneous rocks, generally rhyolites and felsites. During Precambrian time these rocks accumulated as a series of lava flows, tuffs, and associated volcanic rocks, aggregating many thousands of feet in thickness. These rocks are partly exposed at Johnson Shut-Ins Park. The initial extrusive rocks later were intruded by granite batholiths, one of which will be seen at Elephant Rocks State Park. These granites have been dated by several methods, and the determinations are between 1.5 and 1.3 billion years. Later in Precambrian time there was intrusion of small mafic dikes along more or less vertical fractures. The rock formed is basaltic in composition and is diabase and/or gabbro. Several dikes will be seen a few miles from Fredericktown.

Later in Precambrian time the St. Francois Mountains area was eroded to a landscape which had a series of ridges and knobs separated by valleys several hundred feet deep. It was onto this irregular topography that the sea transgressed in late Cambrian time, about 510 million years ago. During Late Cambrian time sea level rose slowly, turning the knobs and ridges into a series of islands. Sediment was eroded from the islands and deposited in the intervening valleys as sandstone and shale. Some limestones and dolomites were also deposited during Late Cambrian time. By the Early Ordovician, the whole area was covered by the sea and all the islands were buried by sedimentary strata. At several of the stops on the trip we will see various representatives of these strata.

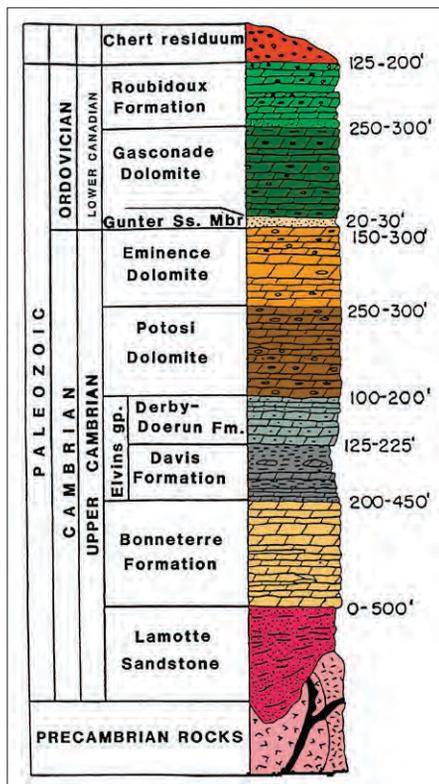


Figure 1. Stratigraphic column showing rocks present in the St. Francois Mountains area.

The Paleozoic exposures on the Ozark Plateau include Upper Cambrian, Ordovician, Mississippian, and very minor amounts of Silurian and Devonian strata (figure 1). The Ordovician strata are very widely distributed throughout southeastern Missouri, and are generally overlain by Mississippian strata. In most of the Midcontinent (read: Midwest), fairly thick (hundreds of feet) strata of Silurian and Devonian age are found between the Ordovician and Mississippian strata. The absence of these strata in the Ozark Plateau is unusual. Regional geologic studies show that in some parts of the Ozarks, Silurian and Devonian strata are found in small patches where they have been preserved in down-dropped fault blocks. These strata apparently were deposited in the Ozarks. However, sometime in the Late Devonian, the Ozarks were gently uplifted above sea level

into a dome-like structure (figure 2). Faulting and fracturing was associated with this uplift. In some places, fault blocks were dropped downward by several hundred feet. Erosion then removed most of the Silurian, Devonian, and some of the Ordovician strata. Silurian and Devonian strata are preserved only on small, down-faulted blocks. During Mississippian time, the Ozark Dome was covered by the sea, and marine limestones were deposited above the older strata.

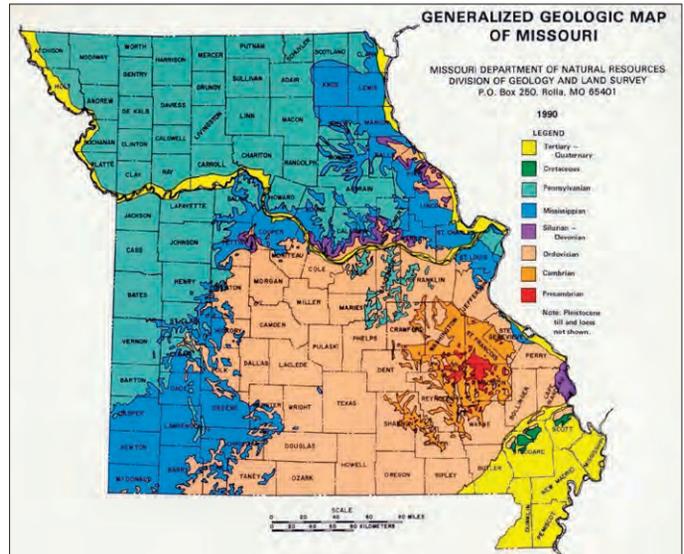


Figure 2. Generalized geologic map of Missouri.

Since Mississippian time the Ozark Dome has been gently uplifted, probably several times. Today the area is far above sea level. Taum Sauk Mountain is the highest point in the state, at 1,772 feet above MSL. Erosion has removed more strata from the uplifted area. In the center of the uplift the Precambrian rocks are exposed as the St. Francois Mountains. The mountains consist of a series of ridges and knobs with valleys between. Some of the valleys are remnants from Precambrian time and are partially filled with Cambrian strata. On a geologic map (figure 2), the St. Francois Mountains appear to be the center of a "Bulls-eye" pattern, surrounded by concentric bands of progressively younger rocks. The rocks nearest the center are Cambrian in age surrounded by concentric bands of Ordovician, and Mississippian strata.

As streams erode through the Paleozoic strata, they occasionally encounter one of the buried knobs of Precambrian rocks. Where the stream flows over the Paleozoic (generally Cambrian) strata, it flows in a fairly wide valley. Where the stream flows through a valley cut in the Precambrian rocks, the valley is narrower. (Why would this be the case?) Thus a stream may flow through a wide valley on either end of a narrower stretch underlain by Precambrian igneous rocks. Such a narrow place is called a "Shut-Ins", a term that appears to be unique to the Missouri Ozarks.

Elephant Rocks State Park

Preserved within the park boundaries are large, elephant-sized boulders of Graniteville Granite. The boulders formed as a result of extensive weathering along joint planes. Weathering along the joints has rounded the rock adjacent to the joints, and created spheroidally weathered rocks. The Missouri Department of Natural Resources (MODNR) has a nice diagram illustrating the evolution of the elephant rocks through time. The weathering process left behind these giant boulders and other, subtle weathering features such as weathering pits, etched crystals, and residual mineral grains (or when large, residual knobs).

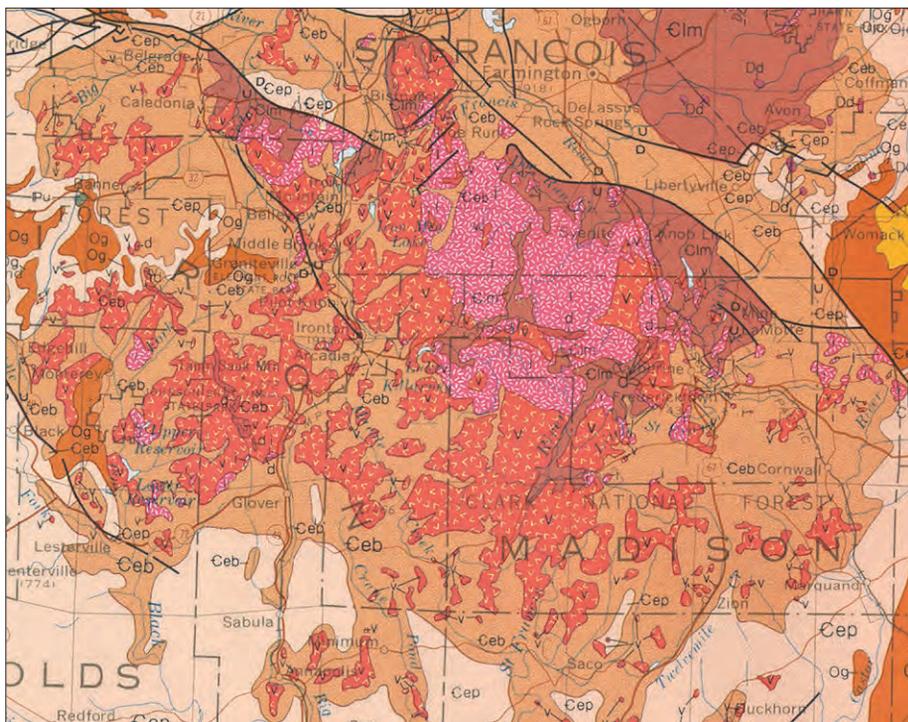


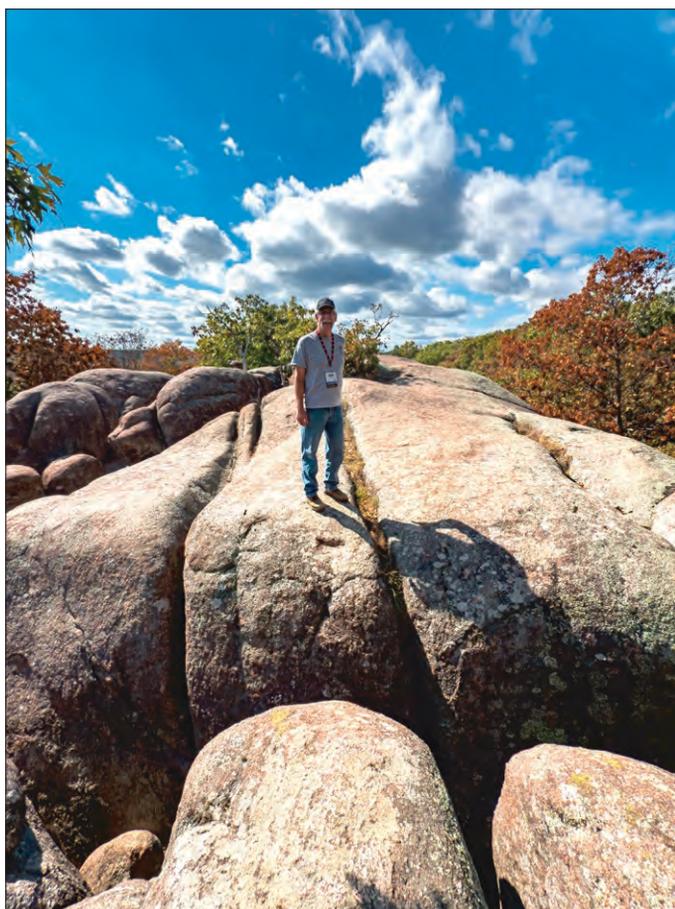
Figure 3. Geologic map of the St. Francois Mountains. In this map, units labeled 'v' are volcanic and those labeled 'i' are igneous. Both types of igneous rocks are Precambrian in age.

The Graniteville Granite commonly is known as “Missouri Red,” and has been quarried in the region since 1969 (Kisvarsanyi et al., 1981). The stone is a popular building stone and can be found in numerous buildings across the Midwest. There are only a few outcrops of Graniteville Granite in the area. Based on magnetic anomaly and gravity maps, the formation is hypothesized to underlie the Bellevue Valley, which is a topographic low.

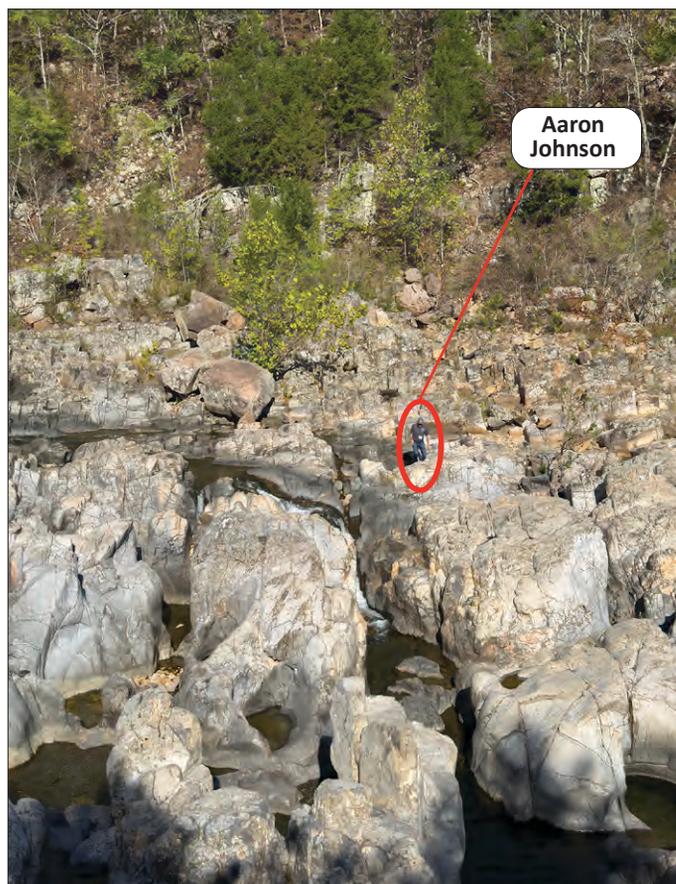
Kisvarsanyi (1980) has hypothesized that the granite pluton was emplaced during a resurgent cauldron cycle. Alternatively, intrusion of the Graniteville Granite may be due to back-arc extension during formation of the Southern Granite Rhyolite (SGR) province at ~1370 ma (Rohs, 2001).

Johnson Shut-Ins State Park

In 2005, a dam atop a nearby mountain failed, releasing a tremendous volume of water into the Black River. Most of Johnson-Shut-Ins park was damaged. Footpaths were washed away, and a tremendous volume of sediment was deposited in the river channel. We will walk down to the Shut-Ins and observe the rhyolites.



TPG Editor Adam Heft stands on the Graniteville Granite at Elephant Rocks State Park, where linear joint planes control the distinctive weathering patterns.



At Johnson’s Shut-Ins State Park, the Black River cuts through resistant Precambrian rhyolite, creating potholes and steep-walled channels. AIPG Executive Director Aaron Johnson stands near the center of the photo, highlighting the impressive scale of these geologic features.

At Johnson Shut-Ins, the Black River has cut a number of more or less circular potholes into the rhyolite. These are formed in an area where stream velocity is relatively high. How might you explain the formation of such potholes? If we look carefully we may see evidence for flowbanding in the rhyolites. How might bands form in these igneous rocks?

As we leave the Park, we will drive by exposures of the Upper Cambrian Lamotte Sandstone.

What is a Shut In?

In the Missouri Ozarks, a "shut-in" refers to a narrow, steep-walled stretch of a river where the channel is confined by erosion-resistant Precambrian igneous rock. As streams flowing across softer sedimentary units encounter the hard rhyolite and granite knobs of the St. Francois Mountains, the valley abruptly constricts, forcing water through tight chutes, plunge pools, and polished bedrock corridors. Johnson's Shut-Ins State Park provides one of the best examples of this distinctive geomorphic feature, showcasing how ancient volcanic rocks control modern river behavior.

Learn more about the Taum Sauk Dam Breach:

Association of State Dam Safety Officials. (2005).

Taum Sauk Dam failure: Case study and forensic analysis. Association of State Dam Safety Officials. <https://damsafety.org/content/dam-failure-case-study-taum-sauk-dam-missouri-2005>

Barr, M. N. (2009). *Effects of the Upper Taum Sauk Reservoir embankment breach on the surface-water quality and sediments of the East Fork Black River and the Black River, southeastern Missouri, 2006–07* (U.S. Geological Survey Scientific Investigations Report 2009–5111).

U.S. Geological Survey. <https://pubs.usgs.gov/sir/2009/5111/pdf/SIR2009-5111.pdf>

Missouri Department of Natural Resources.

(2005). *East Fork Black River: 2005 Biological Assessment Report.* Missouri DNR, Environmental Services Program. <https://dnr.mo.gov/document/east-fork-black-river-2005-biological-assessment-report>

Peterson, J., Zhang, L., Ramirez, A., & McDonnell, M. (2025). Time series analysis of vegetation recovery after the 2005 Taum Sauk outburst flood (2005–2024). *Remote Sensing*, 17(9), 1605. <https://www.mdpi.com/2072-4292/17/9/1605>

Rogers, J. D., Watkins, S., & Chung, J. (2010). *The 2005 Upper Taum Sauk Dam failure: A case history.* Missouri University of Science and Technology. <https://mst.elsevierpure.com/en/publications/the-2005-upper-taum-sauk-dam-failure-a-case-history>

Taum Sauk Dam Breach

On the morning of December 14, 2005, a triangular section on the northwest side of the upper reservoir failed, releasing a billion gallons (4 million m³) of water in twelve minutes and sending a 20 foot (7m) crest of water down the Black River. According to AmerenUE, a computer software problem caused the reservoir to continue filling even though it was already at its normal level. The water overtopped the walls, leading to the failure at 5:12 a.m. In addition, preliminary indications are that minor leakage through the dam walls over a prolonged period, had carried away fine material in the walls, weakening the reservoir's holding walls. Piping ultimately creates voids in reservoir walls and causes reservoir walls to slump and fail. The failure of the reservoir occurred as the reservoir was being filled to capacity or may have possibly been overtopped.

There was no overflow spillway. A maximum fill level was reported to be 6 feet below the top. If the reservoir was filled in 16 hours and is 55 acres across, that would calculate to about 1 ft of water rise in 12 minutes. The reservoir would have overflowed in approximately 72 minutes, once the maximum level was exceeded. It was likely that the reservoir failed once water overflowed the reservoir as earthen levees will erode when overtopped.

The reservoir had been lined with a membrane in 2004 to minimize water leakage. It had been losing two feet of water for some time prior to the installation of the lining. The phenomenon of fine material being washed out of a reservoir structure is known as "piping". When piping occurs, the reservoir structure can settle in or slump, which means water may start flowing over its top – but that is because a weakened area in the reservoir has settled down.

Periodic surveys are necessary at a reservoir to identify if leakage and "piping" is occurring.

No fatalities were reported. Jerry Toops, his wife and three children were swept away when the wall of water obliterated their home. Toops is the superintendent of Johnson's Shut-Ins State Park and Taum Sauk State Parks. They survived with injuries and suffered from exposure. The children were transported to a hospital in St. Louis and later released. One child was treated for severe burns which resulted from heat packs applied by rescue workers as treatment for hypothermia.

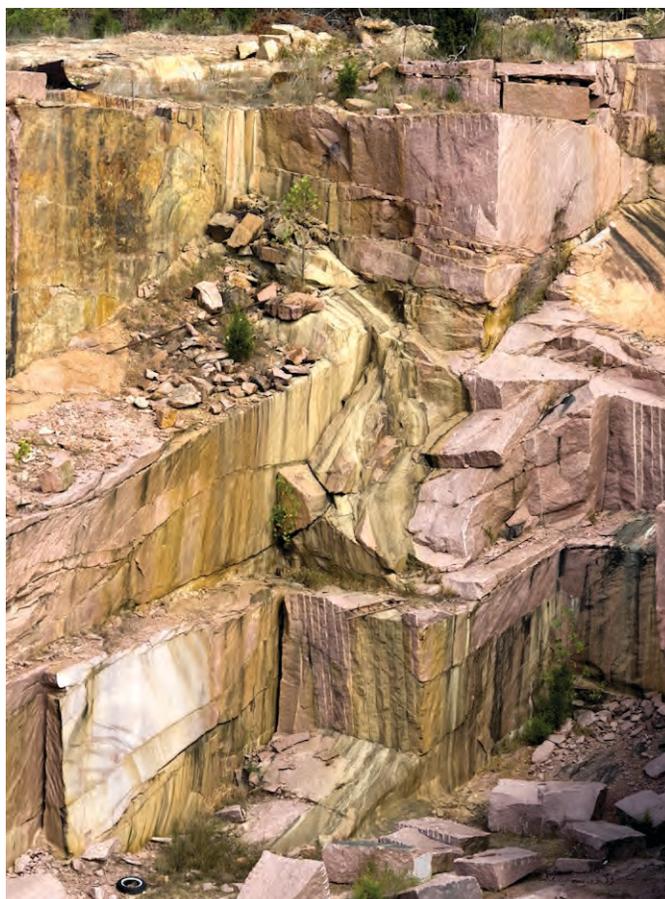
Low cloud levels prevented medical helicopters from flying to aid victims. It wasn't until the clouds cleared up that the helicopters could retrieve victims. Three victims, all children, were first taken to Farmington, then they were transported by ambulance to SSM Cardinal Glennon Children's Hospital in St. Louis. A spokesperson for the family has informed the media that they do not want the conditions of the children to be disseminated.

The dam of the lower reservoir held, trapping much of the deluge. If it had given way then towns downstream, including Lesterville and Centerville would have been in grave danger. A voluntary evacuation order was issued for those areas, but there was no damage. The high water was stopped at Clearwater Lake, the dam of which was not damaged by the rising waters.

A memo from Richard Cooper, superintendent of Ameren's Taum Sauk Hydroelectric Plant, indicated that the reservoir had a "Niagara Falls" style overflow on September 27 at the same spot that was breached, (caused by wave action related to winds from Hurricane Rita.) Another Cooper memo had also indicated that Cooper had warned that gauges used to monitor the water height in the reservoir were malfunctioning in October.

Thank you to field trip leaders Dr. Aaron Johnson, CPG-12229, and John Bognar, CPG-08341.

Just beyond Elephant Rocks State Park lies the historic Graniteville quarry district, where Missouri Red granite was first quarried in 1869. This deep red Graniteville Granite supplied stone for the Eads Bridge, St. Louis levee paving blocks, and the columns of Missouri’s Governor’s Mansion. Pictured below: Graniteville Granite with drill holes and entry to the Missouri Red Quarries facility featuring the red granite, and pictured right: the quarry wall at the facility where monuments are made.



NOTE: The Missouri Red Quarries are a privately owned and operated facility. Please note that for any field trip where you would like to access private property, permission from the property owner and any terms for access shall be requested and respected.

Learn more about Graniteville Granite and Quarries:

- Missouri DNR – Granite overview (includes Graniteville & Sheahan quarries) Missouri Department of Natural Resources. (2020). Granite (PUB2906). Missouri Geological Survey. <https://dnr.mo.gov/document-search/granite-pub2906/pub2906>.
- Missouri State Parks – Cultural history of Elephant Rocks / oldest Graniteville quarry (1869, Eads Bridge, paving blocks) Missouri Department of Natural Resources. (n.d.). *Cultural history – Elephant Rocks State Park*. Missouri State Parks. <https://mostateparks.com/basic-page/cultural-history-elephant-rock>.
- Missouri DNR brochure – Graniteville quarry, “Missouri Red,” Eads Bridge, St. Louis streets, Governor’s Mansion columns Missouri Department of Natural Resources. (2016). *Elephant Rocks State Park* (PUB0683). Missouri Geological Survey. <https://dnr.mo.gov/print/document-search/pub0683>.
- Historic quarry industry description – first extensive granite quarry at Graniteville (1869), Schneider Granite Co. Branner, J. C. (1904). *The quarrying industry of Missouri* (excerpt on Graniteville quarries). In *Report of the Geological Survey of Missouri* (reproduced by Quarries and Beyond). https://quarriesand-beyond.org/states/mo/mo-quarrying_indust_mo_1904_3.html.

SCOTLAND IN MINIATURE

AIPG 2027 International Field Trip: Isle of Arran

Join us in the "Geologist Mecca"

image source: <https://www.bgs.ac.uk/news/isle-of-arran-announced-as-unesco-global-geopark/>

Dawn Garcia, CPG-08313

Once again, AIPG will have **Down to Earth** organize an international field excursion for us in 2027. Down to Earth previously organized trips to the Scottish Highlands in 2024 and Cornwall in 2025; these trips were greatly enjoyed by those in attendance. The company arranges fantastic geologic trips with a reasonable budget. The March or April 2027 excursion will head to the Isle of Arran, known as "Scotland in Miniature". The island offers a blend of rugged highlands, rolling lowlands, ancient history and charming coastal villages. The island was officially designated a UNESCO Global Geopark on April 17, 2025. This designation celebrates Arran's exceptional geological heritage, which spans over 600 million years of Earth's history. The Isle of Arran has been described as "the geologists' Mecca" on account of the number of university students who have visited the island for fieldwork over the years. Even today, students from the likes of the University of Cambridge carry out their student mapping on the island. It's also where James Hutton identified one of the first unconformities in the world.

Arran's rocks represent all three rock types, and they range in age from lower Paleozoic to Tertiary.



image source: Google Earth 2025.

The island's landscape tells a vivid story of:

- The Tectonic plate collisions
- Continental drift from the southern hemisphere
- The opening of the Atlantic Ocean
- Glacial sculpting of the alpine mountains

Arran is home to rare and endangered species like the Arran whitebeam, a tree that has survived since the last Ice Age. The island supports over 156 bird species, more than 1,000 plant species and Scotland's "Big Five" (golden eagles, red deer, red squirrels, otters, and harbor seals).

We'll spend eight nights on the island, staying in the Kinloch Hotel at Blackwaterfoot each night on the island's west coast within sight and sound of the sea. The hotel offers excellent accommodation and food along with facilities that include a small gym, sauna, and swimming pool.

The trip includes the provision of all meals and daily coach hire. Travel from the USA would be via a flight to Glasgow, followed by a train and ferry ride to Brodick.

AIPG members are welcome to contact headquarters (aipg@aipg.org) to be put on an early list. More details will be developed in 2026 with rates and dates of the field trip.



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Project: Peregrine
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Society Asks, Geologists Answer: Two Centuries of Providing Solutions

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

Vitor Correia was one of the first people I met when I came on as AIPG's Executive Director. Vitor was the president of the European Federation of Geologists at that time, and he went on to found the International Raw Materials Observatory, where he continues to serve as the Secretary General. Vitor provides a unique perspective regarding the role that geologists play in modern society. One of the things that I have heard him say most often is that geologists are "solution providers." Vitor sees our profession as critical in finding the raw materials that society will need as we move into the future. Vitor's idea of geologists as solution providers inspired me to look more deeply into the historical role geologists have played as society has evolved.

By the late 1790s, the Industrial Revolution was in full swing. The resources available via artisanal mining, farming, and logging were insufficient to meet the needs of a growing industrial society. Enter William Smith, a surveyor working on the Somersetshire Canal. Smith noticed patterns or similarities in rock units. He studied those similarities carefully and began to map the surface distribution of rocks in the area. He went on to create what is widely regarded as the first true geological map, a product that often is referred to as "The Map that Changed the World." At the same time, James Hutton, a Scottish farmer and gentleman, was working on his book "A Theory of the Earth" which outlined the basic principles that underlie modern geology. It is no coincidence that modern geology was born at the time society began to place increasing demands for resources. Modern geology and the geological profession came to be, at least in part, in response to these societal demands.

By the early 1800s, society had begun to make other demands. The first anti-whaling protests occurred in the early 19th century. It is not a coincidence that society began to switch from whale oil lights to gas lights at about the same time, with the first gaslight installed in London in 1807, followed by installation in Baltimore in 1817 and Paris in 1820. Society had decided that it wanted to move away from commercial whaling and the use of whale oil. It was geologists that went out and found the methane sources necessary to meet society's needs. In the late 1850s, when the Bessemer process was perfected, steel became a much larger part of modern industrial society. When society decided that steel was valuable, it was geologists that went out searching for iron. No longer would bog iron deposits or even the Clinton-type iron deposits that are present in the Appalachians be sufficient

to meet the needs of industrial society. Geologists went exploring for iron and found banded iron formations on nearly every continent. Once again, society decided what was valuable, and geologists went out to find those materials society needed. Then, working with engineers and corporations, those resources were brought to market and manufactured into items that society required.

In the early 20th century, society truly began to modernize, and the automobile became ubiquitous. Copper usage increased dramatically as electricity and indoor plumbing became widespread. Cities required concrete, asphalt, and a copper-based power grid. Society demanded asphalt, gasoline, concrete, and electric wiring. It was geologists that went out and found the raw materials necessary to meet the needs of society. We identified aggregate and limestone. We found copper deposits. We explored for new sources of oil and gas to meet ever-growing demand. We did the hard work to find the materials that were necessary to meet the new demands placed by society.

The publication of *Silent Spring* in 1962 was a watershed moment, helping to usher in the modern environmental movement. In a roughly ten-year period between 1967 and 1977, political leaders around the world signed an entire industry into being with a few strokes of the pen. The establishment of Earth Day in 1970 coincided with the National Environmental Policy Act, the Clean Air Act and the establishment of the Environmental Protection Agency in the United States. These events were followed in quick succession by the London Convention on the Dumping of Marine Wastes, the Paris Summit, the United States Clean Water Act (all in 1972), and the Convention on International Trade in Endangered Species, the United States Endangered Species Act and the adoption of the First Environmental Action Program by members of the European Economic Community in 1973. Actions in Australia included the Environmental Protection and National Parks and Wildlife Acts of 1974. This global movement indicated a fundamental shift as western society decided that it valued a cleaner environment and that it wanted to address the legacy of 150 years of unfettered development. It was geologists that stepped into the breach. Geologists are ideally suited to work in the environmental industry because we have to know a little physics, some chemistry, some biology, and most of all, we understand how the Earth works. We understand

Continued on p. 34

Geologists as Solution Providers

AI Era
Geologists assess water, energy, and land to guide data center siting.

Renewable Energy Transition
Geologists locate and recover critical minerals for the energy future.

USTs & Remediation
Geologists lead cleanup and contaminant plume management.

Environmental Movement
Geologists provided the expertise needed to enforce new environmental protection laws.

Electrification & Infrastructure
Geologists unlocked the copper, aggregate, and fuels that fueled society's rapid modernization.

Steel Revolution
Geologists uncovered major iron formations that fueled global steel production.

Birth of Modern Geology
William Smith created the first true geological map - the foundation for modern geologic science.



Protecting, Defending, and Improving Our Geoscience Profession

Chuck Drake, CPG-11179
Chuck@Bio-Techconsulting.com

Past-President **Sara Pearson's** article in the October-November-December *TPG* provided an exemplary path forward for us follow. Sara described the important work she has started with NESTA (National Earth Science Teachers Association), ABET and Geo-ACTS. Her article presented "The Science Communication Gap," which we can and should use to tell our story of the importance of geosciences. I've included it here as a reminder of how to address these issues, and I will use it as often as possible to remind myself that we need to tell our story as a narrative and not use so many tables and graphs that our message gets lost, or the audience loses interest.

So here is my story, with only one graphic...

This article, which is my first as AIPG President, is a continuation of Sara's article; first because it is an excellent description of her efforts over the last year and probably when she was President-Elect, and second because I have seen the decline in geoscientists and geoscience education in high schools in Florida over my career. For this article, I want to give my historical perspective on these two observations, because it helps, I think, many of the young geologists understand the working environment of pre-professional geologist licensing, and how far we've come since then.

When I started my geology career in 1982, I worked for a government agency and didn't need to be licensed. I worked with many professional engineers, which is how I learned of their professional engineer's license. I wondered why geologists weren't licensed.

In 1985, I began working for a consulting engineering firm and reported to a Florida licensed professional engineer. He hired me because he knew the importance of geology and especially hydrogeology in Florida, and that it would expand the company's expertise. So, for two years or so, he would sign and seal my work which he did understand, and also understood that it was out of his area of true expertise.

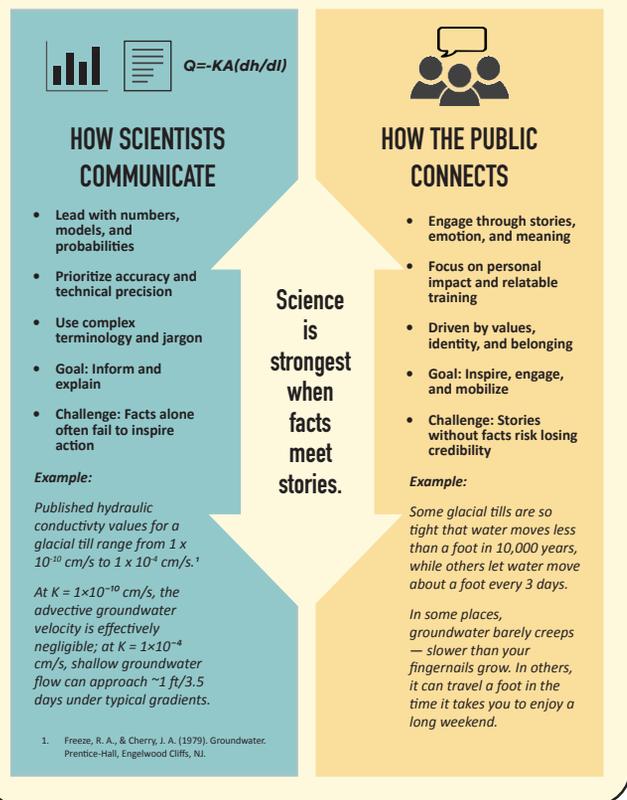
Florida Statute Chapter 492 is the set of laws governing the practice of professional geology in Florida. It was made into law in 1987 and he was all for me getting my P.G. license and was a reference for me when I applied. I give him the credit for seeing the benefit of getting my license and supporting me in the application process.

Even after receiving licensure, when many municipal governments advertised for geotechnical engineering services, they included hydrogeologic investigations and other services that were much more on the geology side of the equation rather than the engineering side. It took many years for municipalities to have separate advertisements for hydrogeologic services and to hire hydrogeologists on their staff to provide these services in-house.

After 10 years, Florida Statute Chapter 492 was scheduled to sunset, and we'd lose our licenses. The Florida Legislature was set to allow it to sunset, but many licensed professional geologists

THE SCIENCE COMMUNICATION GAP

Bridging the Divide Between Facts and Feelings



contacted the State Representatives and Senators to plead with them to not let it sunset. Fortunately, many of us knew former Senate President Jon Vogt, who at the time Statute 492 was enacted, was the Senate President, and was instrumental in getting the law passed. I have to mention that Senator Vogt was a licensed professional engineer. Even though he was termed out of the Senate, he went to bat for us to make sure that 492 did not sunset. If I got any of that out of order, call **Tom Herbert**, P.G.,CPG; he was a good friend of Senator Vogt and may have been one of the first or the first to contact him and ask for help.

We were successful in keeping our licenses; however, it seems like every few years there are legislative efforts to deregulate our

Executive Director's Message, Continued from p. 32

how fluids move through rocks. We know how to identify, map, and manage the contaminant plumes associated with human impacts. In the 1990s when I was a field technician, leaking underground storage tank removal seemed to be a daily part of our routine because society had begun to recognize that storing hydrocarbons underground came with risk. Mitigating that risk meant identifying leaking underground storage tanks and the associated contaminant plumes and doing everything we could to mitigate those impacts. Geologists were the project managers, removing and remediating leaking tanks. Once again, it was geologists that were on the front line of a new industry, working tirelessly to provide the solutions society demanded.

Today we are seeing the transformation of our energy grid as society demands more renewable energy, reducing the impact that our energy system has on Earth's carbon budget. Geologists are at the forefront, finding the materials necessary to create wind turbines, solar panels, and high-density batteries. We explore for lithium, cobalt, nickel, and copper, working with engineers and corporations to bring those materials into the marketplace and to create the goods that society requires.

Today, we stand on the brink of another revolution, the AI revolution. In less than five years, AI has gone from a novelty to an integral part of everyday life. The AI revolution promises to transform society yet again. These AI data centers require tremendous computing power, consuming large amounts of energy and requiring large volumes of water. It will be geologists working with environmental engineers and AI companies that identify locations where these data centers can be located as well as identifying places where local resources will be insufficient to meet demand.

For more than 200 years, geologists have been providing solutions for society. In many ways, our profession is a reflection of society. Just as importantly, society may very well be a reflection of our abilities. As we peer into the future, we can be sure that geologists will be involved every step of the way. As we have for two centuries, we will be building the foundation of modern society, identifying those materials that society will need to meet their expectations for the future. Society determines what is necessary for the future and geologists say, "I can help you find the materials you need."

I wish you all a warm, safe, and productive winter.

Aaron W. Johnson, CPG-12229

Protecting, Defending and Improving our Geoscience Profession

profession and lump us in with cosmetologists, body wrap spas, etc. Over the last 15 years or more, it seems like the frequency of the de-regulation efforts has increased. I think that de-regulation was attempted once a year for three years in a row. If it wasn't it sure seemed like it.

Recent legislation was put forward to de-regulate ALL licensed professionals in Florida! We could not find out why the bill sponsor even put it out there; I was at a conference in October and two state representatives said no one could figure out why it was sponsored in the first place. Since no one liked it, it fortunately went nowhere.

We formed the Florida Association of Professional Geologists (FAPG) specifically to take action to protect our licenses and we have done that successfully since its' inception in 1994.

I mention FAPG and now AIPG because the membership in AIPG was dropping and the FAPG membership was increasing, which is a reminder to us all that we have to be responsive to our members (think Sara's efforts with NESTA, ABET and Geo-ACTS!). In around 2006, Bill Siok, the AIPG executive director at the time, contacted Dr. Jon Arthur, PG, now AGI executive director, about merging the AIPG Florida section with FAPG. The FAPG executive committee met with Mr. Siok and the AIPG president. By joining forces, we improved both the AIPG and FAPG, and because of that we have protected our licenses and also provide valuable testimony to legislative committees and boost our profile.

I had heard of the AIPG from a friend and fellow geologist, but didn't join because meetings were held in the Tampa Bay region and it was primarily phosphate mining focused. That college friend, Jim Pease, wound up being a reference for me when I applied for my CPG! I wanted to join AIPG because I learned that AIPG was an important credential to have because of the ethics and integrity requirements. The AIPG and FAPG had different missions; together we are stronger than when we were separate organizations.

All of this is to say that we have made tremendous progress in having geology recognized as an important profession and increasing the career opportunities for young geologists.

However, as Sara has discussed, many universities have diluted their geoscience departments by combining them with other departments or have eliminated or are trying to eliminate them. I first heard of this as a founding member of the FAPG, and continued to hear it when I was on the AIPG Executive Committee in 2008/2009. At the AIPG Executive Committee meetings in 2025 and our monthly status calls, as well as participating in AGI calls, we've learned this trend is continuing.

In 2009, the University of Florida's geoscience department was told that they had to cut their budget so severely, that untenured professors would lose their positions and teaching assistants couldn't be paid, meaning professors would have to teach lab classes, which would result in their research time being reduced and research money would be lost. It would have been devastating to the entire department.

The UF president told the newly hired Dean of the College of Liberal Arts and Sciences (CLAS) to make targeted cuts not just a 10% cut across the board, so the Department of Geological Sciences was one of three departments in CLAS that were targeted. The dean of the college tried to tell us that geological sciences is a small department so it really doesn't matter. That didn't sit well with the advisory board, department chairman and faculty. It was pointed out that the geology department was in the black and made money for the university.

The department's existence was threatened, and the faculty and advisory board contacted many alumni to write the dean of the college and UF president and implore them to not make the significant cuts. The father of one of the geology students had taken a big interest in geology and learned of the impending cuts. Because his son found a great potential career in geology and the dad found that he loved geology, the dad contacted his friends. One of whom was Senator Bill Nelson, who flew on one of the space shuttle missions. Senator Nelson was from the space coast of Florida, who later became the NASA administrator, and had a keen interest in the earth and knew about the importance of geology.

Senator Nelson contacted the UF president and convinced him that cutting the geology department budget so severely would not be in the university's best interest. Soon after, the geology department had to take only a small budget cut and at the same time was given the approval to add an associate professor position related to climate change.

I should add that at the end of this, the Dean of CLAS met with the advisory board and said that he really did not know of the importance of geological sciences and just because it is a relatively small department, doesn't mean it isn't critical.



I should add that at the end of this, the Dean of CLAS met with the advisory board and said that he really did not know of the importance of geological sciences and just because it is a relatively small department, doesn't mean it isn't critical.

I think this is the point I want to make about this tangential story; geoscience departments have been under attack for years but because of our efforts in talking to anyone who will listen we reach the right person or persons who can help us. The UF student who found his calling in geology; his dad saw his son light up and therefore became interested in geology himself, and who happened to know Senator Nelson. This is a lesson to learn: that you never know who you know that may know someone else that can be an advocate. Same story with Senator Vogt; he remained engaged with us geologists for years after he left the Senate.

Another disruptor to our profession is the dilution of geoscience programs across the nation. As Sara has discussed in her previous articles, many universities have diluted their geoscience departments by combining them with other departments, or have eliminated or are trying to eliminate them. This was a recurring theme in our AIPG Executive Committee meetings and monthly status calls, as well as calls with AGI.

The moral of this is to talk to everyone and let them know, in story format as presented in Sara's graphic about the importance of geoscience in everyday life.

Which brings me to the second part of what I want to accomplish; with everyone's help, is to get geoscience education into or more visible in the high school curriculum. I heard of this when the fiasco that I described above was occurring. During that time, the geological sciences chair said that students would be looking for courses to take and come across geology/geosciences. The students and parents maybe remembered something about earth sciences from middle school, but nothing after that. That told him, and later me, that could be a prime reason why enrollment numbers are decreasing.

That experience made me think it was a Florida thing but have since learned that it is an issue across the nation. Which seems to make sense because there aren't enough geoscientists being graduated to replace the retiring geologists. Again, this is where working with NESTA and ABET and Geo-ACTS will be a huge help.

Recently, I met with several department directors from the Orange County (FL) Public Schools (OCPS) to discuss how we can get earth sciences into the high school curriculum. During that meeting, I learned that OCPS has elective classes in environmental sciences, and quite a lot of what is taught is in the geoscience realm. Perhaps a simple name change would allow the students to remember geosciences.

I am encouraged because when I talked with the school board chairwoman, she immediately understood the need for geologists in Florida, especially in the water sector. It took only two days for her staff to contact me to schedule a meeting.

A couple of weeks ago, I met Florida State Representative Doug Bankson at an event and because he had mentioned something about the environment during his presentation, I talked with him during the dinner and told him about the lack of geoscience education in Florida. He was immediately interested and gave me his card and asked me to call his office and set up a meeting.

I did, and we met in his district office. I went to the State Representatives webpage and learned that he is on the Student Academic Success subcommittee and Career and Workforce subcommittee. Now I know why he was so interested! He asked what he could do to help, and I answered that we need to let students know that there are many career opportunities in the geosciences in Florida and across the nation and world. I might've been too eager because he jokingly called me a "geoscience evangelist!"

Recently, I was fortunate to attend a University of Central Florida football game and Florida Lt. Governor Jay Collins and his wife, Layla, were there. I talked with him for few minutes and mentioned geoscience education, which I do with every elected official I meet, and learned that he is interested in education in general and that Layla is a committee woman on the Florida State Board of Education. I did some "geoscience evangelizing" and she said one of her sons is extremely interested in fossils and does a lot of fossil hunting. Her suggestion was for me to find high schools that have international baccalaureate programs and give presentations to them. I'll do that and keep in contact with her, as well as Representative Bankson.

That's my story about the things I want to work on and continue the efforts of previous Executive Committee members and the advisory committee members.

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. Thank you for being a member of the AIPG and Happy New Year!



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

1. We are documenting the presence of sedimentary structures in our study area and encounter “lebensspurren.” What have we found?
 - a) A type of trough crossbedding.
 - b) Sedimentary structures created by living organisms that include burrows, borings, trails, tracks and coprolites.
 - c) Asymmetric ripple marks with gentle up-current slopes and steeper down-current slopes formed by flowing water or wind moving in a generally-uniform direction.
 - d) Lobes, bulges and lumps that form along bedding planes and which hang down from the upper sedimentary layer into the lower one.
 - e) Star graduate student at D.U.M.B. University says: Easy one, dude; it’s the sound a family of lebens makes when purring!

 2. “Trottoir” refers to:
 - a) A narrow (sidewalk-like) intertidal, reef buildup separating the sea from the shoreline.
 - b) A Cretaceous land-dwelling tortoise.
 - c) A gently-sloping surface produced by wave erosion that extends far into the sea (or lake) from the base of a wave-cut cliff.
 - d) A sodium-rich, non-marine evaporite mineral refined into soda ash with chemical formula $[Na_2CO_3 \cdot NaHCO_3 \cdot 2H_2O]$.
 - e) A bunch of dudes riding on trotting horses.

 3. “Albian” relates to:
 - a) The Proterozoic Eon or youngest division of the Precambrian.
 - b) The youngest or uppermost stage or age of the Lower Cretaceous Period.
 - c) The oldest or earliest stage or age of the Late Cretaceous Period.
 - d) The oldest or earliest stage or age of the Lower Cretaceous Period.
 - e) Man, it’s either a dude from Albany, NY, or one from Albania.
-
4. “Graptolites” were colonial, filter-feeding organisms that lived from Cambrian time to the end of the Cretaceous.
 - a) True.
 - b) False.

 5. A roughly linear relationship has been established between two geologic parameters in your field study area. What is the equation of the line of best fit in your X-Y plot, if the line contains the points (0, -1) and (5, 1)?
 - a) $Y = 4.0X + 1$
 - b) $Y = 0.4X - 1$
 - c) $Y = 4.4X - 1$
 - d) $Y = 44X + 1$
 - e) Dude, you and your equations! Exasperating!



Using Midland Valley MOVE to analyze near-surface geology for construction and hydrogeologic applications

Mark J. Abolins (Professor, Geosciences Department, Middle Tennessee State University), Kristie Linstead, Andrew Gibson, Meredith Bryson, and Hannah Jones

PE Limited donates licenses for their Midland Valley MOVE structural geology software (PE Limited, 2025) to universities for academic use. Although Midland Valley MOVE and similar software packages are typically used to investigate macroscale structure at depths commonly targeted in hydrocarbon exploration and development, these software packages can be used for a variety of applications, including the investigation of near-surface structure for groundwater exploration (e.g., De Donatis et al., 2007) and construction. This Fall, Middle Tennessee State University (MTSU) undergraduates will use Midland Valley MOVE software to investigate structures at depths of 17 to 81 m which is within the range typically targeted in groundwater exploration in carbonates within the U.S. (Degnan et al., 2021). These educational activities built on institutional experience with use of the software to analyze near-surface mesoscale folds at a construction site during Spring 2021.

In 2021, four MTSU Geosciences master's students (Andrew Gibson, Meredith Bryson, Hannah Jones, and Kristie Linstead) used Midland Valley MOVE software to create structure contour maps (Fig. 1) and cross sections through mesoscale folds at depths less than 50 m beneath the U.S. Army Corps of Engineers Chickamauga Lock construction site in Tennessee. The Chickamauga lock and dam were originally built on the Tennessee River in 1940, and lock replacement is in progress. To support the graduate student project, the Nashville District provided data from 145 boreholes within the 35 x 180 m lock.

One of the former master's students, Andrew Gibson, works in the oil and gas industry as the Measurement While Drilling Coordinator for Total Directional Services, LLC, but the others work in other fields. Nonetheless, Kristie Linstead (Jacobs) and Hannah Jones (Consolidated Nuclear Security) acknowledge that computer literacy and sophisticated software play an important role in their sub-fields. Kristie notes that computer literacy is needed for many careers in remedial investigations. For example, Jones uses

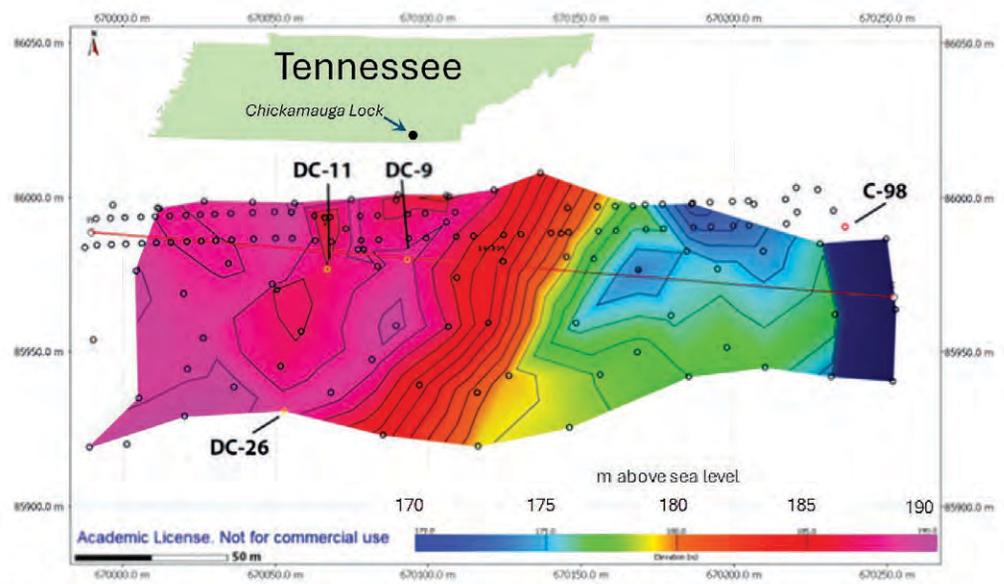


Fig. 1. Elevation of top of Late Ordovician Tyrone Limestone. Structure contour map generated in MOVE. Contour interval: 1 m.

OpenGround to create soil boring logs, groundwater sampling logs, and well construction diagrams. GIS is used to create heat maps to display plumes of contamination, and GIS is used to create cross sections to show well transects and HPT and slug testing logs to show permeability and groundwater reactivity.

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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

Two suggestions for students and early career professionals

Create and use an individual professional email address: As one moves from undergraduate school to graduate school or the first of what will likely be a number of different jobs over your career, your school and/or job email will change over time. In order for professional colleagues and organizations to keep track of you, I urge you to establish an individual professional email address that you can use for all personal correspondence with your professional colleagues and organizations throughout your career. I had a conversation with a colleague at the Annual Meeting who didn't have a consistent professional email address and thus was having trouble keeping up with various professional organizations and others. She has a personal email address for her personal contacts, which is perfectly reasonable. The same logic applies to having a consistent individual email for professional use.

Important non-geoscience courses/skills for professional practice: There are three non-geoscience skills that you will need to advance in your professional career. The first skill is the ability to write well and clearly. Did you have a college course whose academic purpose was writing skill? Mine, English 2, was a seminar focused on a subject of particular interest to the presenting professor. While one picked a subject that sounded interesting, the academic focus of the course was on writing several papers. The second skill is public speaking. During our careers we will have to give presentations to our employers, to our clients, and to our professional associations. Speech courses are offered at college and help cover a distributive requirement. They require

you to give speeches of various types to the class. An alternative to a speech class is participating in Toastmasters International, a nonprofit organization that helps people improve their public speaking and leadership skills through clubs around the world. The third crucial non-geoscience subject is basic accounting. Basic accounting courses are usually available through community colleges and are frequently taught by practicing CPAs. Basic business finance requires a knowledge of double-entry bookkeeping, P&L statements, and balance sheets. Project management requires keeping track of income and expenses.

Areas where technology doesn't work

Guanella Pass between Georgetown and Grant west of Denver is a very popular road for leaf peepers and for access to Mt. Bierstadt, one of Colorado's 14ers. It is a narrow road with limited parking, and the local police are aggressively ticketing and towing illegally parked cars. One problem for those whose cars are towed is that there is no cell phone service at the top of the pass and it is sporadic in other parts. This example serves as a reminder that there are lots of places where the technology on which too many of us have become dependent doesn't work. Old fashioned maps and magnetic compasses still work fine in such areas. Geoscientists generally understand and use maps. We need to remind the general public of their usefulness.

Introduction to this column's AI topics

The use of Artificial Intelligence (AI) is a hot topic these days and was addressed in talks and discussions at the AIPG Annual Meeting in St. Louis. The following discussions of various AI use issues reflect the

interest in AI use and misuse. Interestingly, the first two articles in the October 2025 issue of *PCWorld* are "Microsoft's Windows future is built on AI, voice, cloud, and context" and "I don't need AI in Windows." The contrast between these two articles reflects the primary issues with AI.

AI Ethics Recommendations for the geoscience community

The Task Group on Artificial Intelligence (AI) in the Geosciences of the Commission on Geoethics of the International Union of Geological Sciences (IUGS) issued a paper, *Artificial Intelligence (AI) Ethics Recommendations for the geoscience community*, on September 26, 2025.¹ The article states, "Statistical and machine learning approaches have supported geosciences for decades and the rapid adoption of frontier and generative AI have introduced new risks and amplifies existing ones." The article identifies eight themes with recommendations "to address ethical issues and concerns. These are: *Use AI Responsibly; Promote Transparency and Explainability; Consider Bias and Fairness; Obtain Informed Consent, Protect Personal Data; Practice Participatory Design and Community Engagement; Advocate for Environmental Protection; Integrity in Science, Publishing and Education; and Consider Geopolitics.* A simple practical one-page summary is presented for AI Ethics in the Geosciences, supported by a rich discussion of each theme with illustrative geoscience specific examples and reflective questions." The one-page quick-look geoscience ethics guide is included on page 8 that is worth reviewing.

I urge readers to download and read the whole 38-page report.

1. <https://www.geoethics.org/ai-ethics-recommendations>.

One page quick-look AI Ethics guide for geoscience

Virtue Ethics Lens: These recommendations are not just rules, but reminders to act with responsibility, humility, justice, foresight, and integrity. Ask yourself: *What would a good and wise geoscientist do?*

<p>1. Use AI Responsibly</p> <ul style="list-style-type: none"> Peaceful use of Geoscience AI should not be used to harm people or ecosystems. AI should be treated as a tool to support a geoscientist's judgment, not replace it. Human oversight is mandatory where geoscience impacts people and ecosystems. 	<p>2. Promote Transparency and Explainability</p> <ul style="list-style-type: none"> Research conducted with AI needs to be open, traceable and reproducible. Non-commercial models, training data, code & test sets should be open-source. Use explainable AI techniques to quantify uncertainty in black-box models and make limitations very clear. Use Retrieval Augmented Generation (RAG) to link Gen AI answers to sources.
<p>3. Consider Bias and Fairness</p> <ul style="list-style-type: none"> Use diverse, representative AI training datasets. Intervene where biases may impact the rights of marginalised / indigenous communities. No censorship in international facing geoscience AI outside the exceptions in the UN Declaration of Human Rights. Free web/cloud hosted AI tools aid fairness, but open-source tools best protect equity and data sovereignty. 	<p>4. Obtain Informed Consent, Protect Personal Data</p> <ul style="list-style-type: none"> Consent to use personal data of any kind must be sought. Use opt-out mechanisms with providers when uploading sensitive data to hosted AI, or don't use them at all. Advocate for on-premise, / secure AI tools. Build AI systems with privacy-by-design, opt-in required for data use (e.g. model training).
<p>5. Practice Participatory Design and Community Engagement</p> <ul style="list-style-type: none"> Where AI outputs using earth science data (especially at scale using remote sensing data) impacts local indigenous communities – they must be meaningfully engaged <i>"nothing about us without us"</i>. Adopt the CARE framework for indigenous data governance. 	<p>6. Advocate for Environmental Protection</p> <ul style="list-style-type: none"> Geoscience institutions should support initiatives (e.g., UNEP) on AI's environmental costs and provider accountability. Advocate for sustainable practices (e.g. energy-efficient algorithms, renewable-powered data centres). Proactively look for opportunities where geoscience AI can aid env. protection.
<p>7. Integrity in Science/Education</p> <ul style="list-style-type: none"> LLMs can help refine your writing, but avoid 'cut and paste', use <i>your own voice and your own ideas</i>. Disclose and acknowledge all AI use. Gen AI can be <i>"more about persuasion than truth"</i>. Be sceptical, check outputs and verify sources. LLMs can help as a coding assistant but not a replacement for learning how to code. Live explanations / oral defense can help reduce overreliance. 	<p>8. Consider Geopolitics</p> <ul style="list-style-type: none"> International scientific / geoscientific institutions should remain neutral and avoid endorsing cloud/web-hosted geoscience Big Data & AI platforms that centralise data, as this risks eroding data sovereignty, trust, and reinforcing inequities ('algorithmic colonisation'). Military ties in peaceful geoscience AI projects must be declared, ensuring informed consent for participation.

Sleuth unearths citation, authorship issues at earth sciences journal

Retractionwatch.com issued an article, *Sleuth unearths citation, authorship issues at earth sciences journal*. "Carlos Conforti Ferreira Guedes, a geology professor at the Federal University of Paraná in Brazil,

came across a paper in the *Journal of South American Earth Sciences* earlier this year (2025) with irrelevant, and in some cases nonexistent, references.

"Made-up citations can indicate the use of generative AI in crafting the paper – but another detail caught his attention as particularly odd: The researchers on the paper, a study on the transformation of

the Brazilian coastline, all listed affiliations in India. Guedes reached out to one of the editors-in-chief of the journal at the time, Andres Folguera, on March 10 to notify the journal about the issues.

"As Guedes and his colleagues noted in a May 19 blog post on the Brazilian Association for Quaternary Studies (ABEQUA) website, 'there were no citations of work conducted in Brazil or by researchers who had previously worked in the region.'

"According to the August 3 retraction notice, the authors 'were asked to comment upon the presence of these references in their work and acknowledged that the references were not correct.'"

I urge those interested in the details to download the article from retractionwatch.com.

The dangers of using Chat GPT and AI Bot recordings

An article, "Deeply personal Chat GPT conversations leaked into Google searches," in the September '25 issue of *PCWorld*, p. 11-12, warns that "Anything powered by a large language model is generally fed right back into it for more training." While the article focused on personal information that could be searched by Google, the concern should be equally valid for sensitive corporate or client information that is posted somewhere in your personal computer or company data files. According to the article, OpenAI's co-chief security officer stated, "the ability of search engines to index shared posts has been removed." This is a reminder to be very careful when using AI.

Mark J. Howell's article "AI Bots are joining your calls" in the Jul/Aug/Sep *TPG*, p.17, provides another warning about AI, in this case recordings of conversations you may have on Zoom, Teams, or similar programs. These recordings, what Howell calls "AI Bots," may be loaded into the searchable databases that form the backbone of AI technology. Because of the sensitive nature of many of these calls for both personal and business reasons, be very careful about how they are used. Howell ends his article with the statement that he uses AI, including in the preparation of his article. However, his warning to be careful stands.

False 'geofacts' and promotion of bad policies

Members of the public can and do use AI to produce articles/papers on various topics. These articles/papers can contain false 'geofacts' that are then used to promote bad public policies. When we read such faulty geoscience information that is contained within such an article/paper, we need to

call out the misinformation to the author and publisher. This should occur whenever such misinformation is used regardless of whether we agree or disagree with the proposed policy.

In summary, AI can provide useful tools to do a wide range of tasks. Users of current versions of Microsoft Word (in Microsoft 365) will have noticed that AI-driven grammar checks are now part of a program most of us use. But grammar checkers demonstrate that we must evaluate the AI-generated help. Sometimes it is correct and sometimes it is incorrect. The user must make choices. More complex AI programs provide greater challenges but no less need for the user, not AI, to be in charge.

Using the net and AI to develop a test of student thinking

A colleague who teaches Rocks 1 told me about an exercise she used to test her students' ability to review, critique, and

think about different articles on the same topic, some generated by AI, some not. The question asked was what parts of what articles are correct, what parts are incorrect, and why?

As another exercise example, in 1842 Charles Darwin published a monograph, *The Structure and Distribution of Coral Reefs, Being the first part of the geology of the voyage of the Beagle, under the command of Capt. Fitzroy, R.N. during the years 1832 to 1836.* Darwin's theory, although missing some important underpinning, has been supported by modern findings including the observation that part of atoll formation involves crustal sinking as the site of formation moves away from a spreading center. An early and a very worthwhile reading paper (even today) is, *History of Ocean Basins*, by H.H. Hess (1962) in *Petrologic studies, a volume in honor of A.E. Buddington*, Geological Society of America, addresses this issue. Hess began with these words: "The birth of the oceans is a matter of conjecture, the subsequent his-

tory is obscure, and the present structure is just beginning to be understood. Fascinating speculation on these subjects has been plentiful, but not much of it predating the last decade holds water." John McPhee has observed that these two sentences may be among the funniest comments ever made in a serious scientific paper. Ask students to read and comment on both papers. What is right, what is wrong, and what additional information is required by both papers? Among other things, reading these two papers illustrates that fact that older papers can provide important and useful information that supports our current understanding of a topic.

Another topic for students to explore is in *Basin and Range*, 1982,² John McPhee sums up his exploration of sea floor spreading (plate tectonics) with the following sentence: "The summit of Mt. Everest is marine limestone." Why is this an apt summary? How did the survey of India lead to the hypothesis of isostasy? What are the problems with this hypothesis?

2. Basin and Range is the first of McPhee's books compiled into *Annals of a Former World*, 2000.

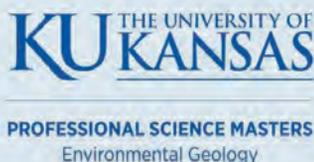


Advance your Career with a Professional Science Master's in Environmental Geology

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.

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- 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 “Sedimentary structures created by living organisms that include burrows, borings, trails, tracks and coprolites.” The term “Lebensspuren” translates into “traces of life.”

Choice “a” could refer to festoon cross bedding. Choice “c” refers to “current ripple marks.” Choice “d” is the definition of “load casts.” “Load casts” form when denser, wetter sediment slumps down into a less-dense layer below.

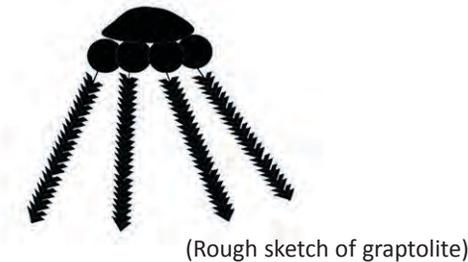
2. The answer is choice “a” or “A narrow (sidewalk-like) intertidal, reef buildup separating the sea from the shoreline.”

Sorry, no Cretaceous land-dwelling tortoise here. Choice “c” describes a “wave-cut platform.” Choice “d” defines “trona ore.”

3. The answer is choice “b” or “Albian”, or “The youngest or uppermost stage or age of the Lower Cretaceous Period.” Choice “c” is the “Cenomanian.” Choice “d” is the “Berriasian.” Sorry, the Proterozoic does not apply here.

Mesozoic Era	
Cretaceous Period	
Upper Cretaceous (Youngest to oldest)	Lower Cretaceous (Youngest to oldest)
<i>Maastrichtian</i>	<i>Albian</i>
<i>Campanian</i>	<i>Aptian</i>
<i>Santonian</i>	<i>Barremian</i>
<i>Coniacian</i>	<i>Hauterivian</i>
<i>Turonian</i>	<i>Valanginian</i>
<i>Cenomanian</i>	<i>Berriasian</i>

4. The answer is “b” or “False.” Graptolites lived from Cambrian time to Carboniferous time.



5. The answer is choice “b” or “ $Y = 0.4X - 1$.” The proof follows:

$$Y = mX + b \quad (1)$$

$$m = (Y_2 - Y_1) / (X_2 - X_1) \quad (2)$$

From points (0, -1) and (5, 1) we may write:

$$m = [1 - (-1)] / (5 - 0) \quad (3)$$

$$m = 2/5 = 0.4 \quad (4)$$

Once we have “m” we can use the point (5, 1) to substitute into (1) and solve for “b”:

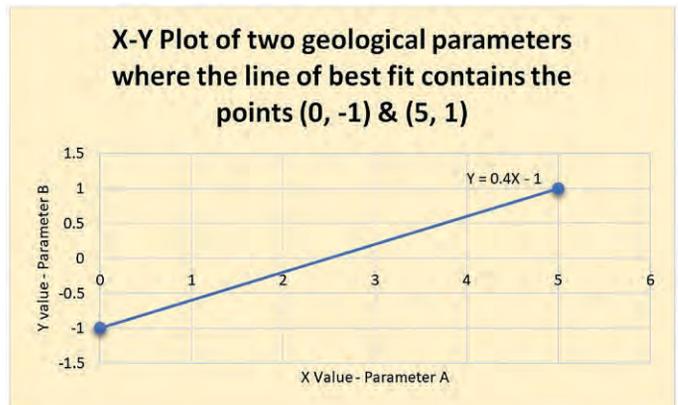
$$1 = 0.4(5) + b \quad (5)$$

$$b = 1 - 2 = -1 \quad (6)$$

Thus, from (1):

$$Y = 0.4X - 1 \quad (7)$$

Equation (7) is our answer and corresponds to our choice “b”.



Layered Vapor Intrusion Mitigation: Field Insights on Integrating SSD Systems and Vapor Barriers

Robert C. Carvalho, P.G. CPG-10588

The Importance of Vapor Intrusion Strategies

Vapor intrusion (VI) is a critical consideration in the redevelopment of brownfields, the reuse of landfills, and the reuse and construction of contaminated sites. As expectations for long-term indoor air quality protections rise—both from regulators and the public—relying on a single mitigation method isn't sufficient. Today's best practices call for layered systems that combine sub-slab depressurization (SSD), passive or active venting, and vapor barriers to block and remove harmful vapors before they enter occupied structures.

According to the EPA's Community Guide to Vapor Intrusion Mitigation (<https://sempub.epa.gov/work/HQ/401625.pdf>), several mitigation options are available for both new and existing buildings. These include:

- **Installing vapor barriers**, such as geomembranes or sprayed-on materials, beneath the slab, to prevent vapor entry.
- **Passive venting systems**, which use subsurface venting layers in combination with vapor barriers to enable vapors to dissipate into the outdoor air.
- **Active sub-slab depressurization (SSD)**, in which a blower and suction pit system pulls vapors from beneath the building and vents them safely outside.

Integrating these system components creates a robust, multi-barrier defense against vapor intrusion. This layered methodology ensures durability, performance, and redundancy across a wide range of soil types, contamination levels, and structural footprints. This approach not only aligns with evolving EPA guidance but also reflects a growing industry standard that prioritizes long-term protection and adaptability in real-world conditions.

Start with the Site: Evaluating Risk and Selecting SSD Systems

Every site requires a tailored strategy. Factors such as vapor source type, soil permeability, building footprint, and occupancy type influence the selection of the system.

Passive SSD systems (SSDS) may be sufficient for small, stable retail projects. But for high-volume footprints like warehouses,

schools, or institutional buildings, active SSDs are typically required to establish and maintain sub-slab negative pressure. EPA guidance affirms this trend, recommending active systems for buildings where long-term reliability is essential.

Vapor mitigation system design begins early in the development process to ensure the system can manage site-specific vapor levels and protect occupant safety. Our typical approach combines subsurface venting infrastructure with a robust vapor barrier, addressing both vapor transport and intrusion pathways as part of a unified mitigation system tailored to each project's risk profile.

Low-Profile Venting: Efficient and Scalable

On large projects, minimizing trenching saves time and cost. Low-profile venting systems allow gas collection across the entire slab footprint without the need for deep or disruptive excavations

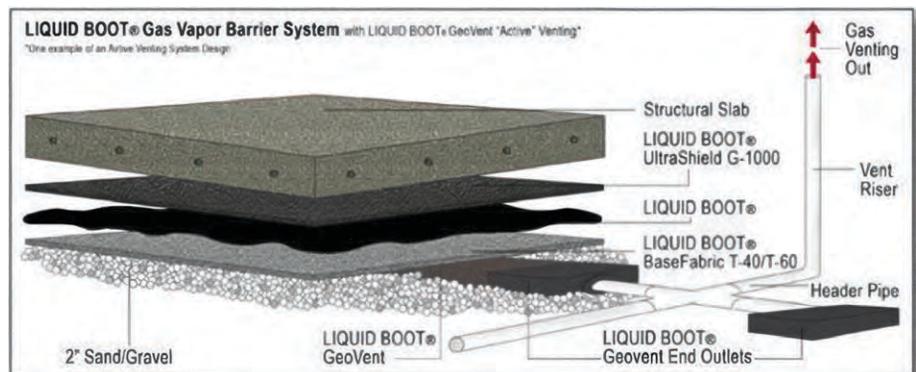


Figure 1. Layered vapor intrusion mitigation system with GeoVent low-profile venting beneath a spray-applied vapor barrier. Gases are routed through vent risers for active SSD. Photo courtesy of CETCO.

that would be required for standard sub-slab pipe installations. These systems are highly compatible with vapor barriers and can be activated post-construction if necessary, offering flexibility as site conditions evolve.

Integrating Vapor Barriers and SSDs

The EPA's Citizens' Guide clearly outlines the role of vapor barriers as a primary line of defense. Spray-applied systems or sheet-based geomembranes help physically block the vapor intrusion pathway.

The correct installation sequence is critical:

- Place venting layer and header piping
- Install reinforced base fabric (for spray-applied membranes)
- Apply vapor barrier: spray-applied or sheet layer

Case Study: 1 Million Square Foot Warehouse, Northeast U.S.

A recent EAI project involved a 1-million square foot brownfield redevelopment for a warehouse facility development. Crews



Figure 2. Low-profile venting installed in the field. This design reduces the need for deep trenching while supporting sub-slab depressurization systems (SSDs) as part of a layered vapor intrusion mitigation approach.



Figure 3. Spray-applied vapor barrier installation at the grade beam and slab interface. This monolithic application ensures full coverage and chemical resistance, sealing vapor intrusion pathways around footings, utility penetrations, and critical slab transitions.

- Add protective top sheet (for spray-applied membranes)
- Install blower systems for active SSDS where applicable
- Perform QA/QC testing before pouring the concrete slab

A certified installer will ensure that every transition and penetration is sealed using manufacturer-approved techniques and verified via smoke testing.

Lessons from the Field: Where Systems Fail (and How to Prevent It)

Barriers and SSDS can underperform if not supported by rigorous field practices. Common problems we’ve seen include:

- Late-stage slab penetrations made without sealing
- Barrier damage from rebar, tools, or foot traffic
- Rushed work without proper curing, testing, or inspection

To counteract these issues, we conduct mandatory pre-slab coordination, use protective mats over installed membranes, and test every section prior to pour. These practices mirror the EPA’s recommendations for building-specific QA/QC.

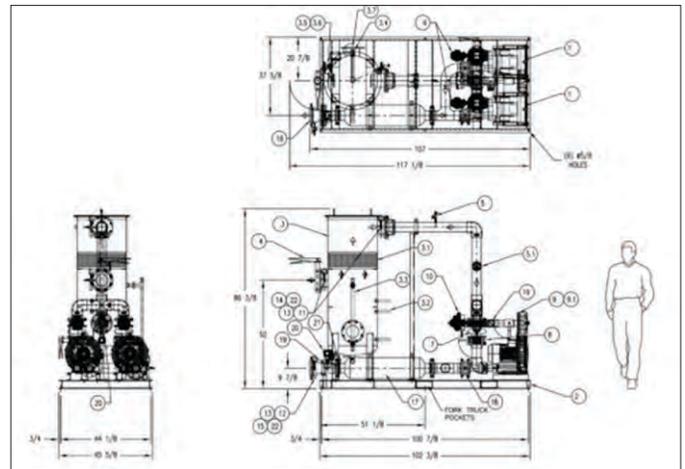


Figure 4. Blower system schematic showing dual-blower setup with piping connections and integrated controls.

installed multiple active SSD blower skirts, over 20,000 linear feet of low-profile venting, and a full spray-applied barrier system. Installation took place through winter, requiring close attention to environmental conditions and curing. Our quality control team conducted phased smoke testing across every slab section, with all phases passing on the first attempt.

To ensure both vapor barriers and SSDS deliver reliable protection, we implement QA/QC procedures immediately following installation—before slab pour or final cover-up. These include smoke testing to verify membrane seals and detect preferential pathways, tracer gas testing to assess sub-slab airflow, and thorough visual inspection of all seams, penetrations, and wall terminations. These procedures align with best practices, verified in guidelines like the ITRC Vapor Intrusion Mitigation Post-Installation Fact Sheet (<https://vim-1.itrcweb.org/post-installation-fact-sheet/#Smoke-and-Tracer-Gas-Testing>), which identifies these methods as high-impact tools for verifying the integrity and performance of both active and passive mitigation systems.

Robust Vapor Mitigation: Active Venting and Vapor Barriers for Real-World Performance

Mitigation is no longer just about compliance—it’s about durability and adaptability. EPA guidance and public outreach both point to the value of combining active venting with vapor barriers and long-term QA/QC for sites such as landfills, brownfields, and redevelopment sites.

By treating mitigation as a system—not just a product—teams can deliver performance that holds up under real-world stress, seasonal variation, and evolving site use. Whether the building is a healthcare clinic, school, warehouse, or commercial space, the goal remains the same: protect indoor air with reliable, proven strategies backed by data, experience, and guidance from the field.

About the Author

Robert Carvalho holds a Bachelor of Science in Geology from Hofstra University and is a Certified Professional Geologist (CPG). He has over 30 years of experience managing and directing a wide range of environmental projects as the President and CEO of EAI, Inc. <https://www.eaienviro.com/>.

Casting for Data:

Where Fieldwork Meets Fishing Trips



Mark Nickels, Elena Muir, Dr. Joe C. Yelderman, Jr.

My graduate research at Baylor University was conducted in the Brazos River Alluvium Aquifer where I investigated surface water and groundwater interactions. Since I needed to measure groundwater levels for an extended period, several water level data loggers were deployed in selected wells using 1/16th-inch galvanized steel cable. This cabling was looped through the data logger, crimped, and secured to the casing. The thought process being that a strong connection would be dependable for data collection.

Approximately a month after deployment, my advisor, Dr. Joe Yelderman, and I returned to the first study site to check on the data loggers and collect data. We found the first data logger with no issues and recovered the data. Our luck started to take a turn for the worse with the second well when we discovered that the steel cable had corroded and was approximately 1/10 of the original thickness. Only a couple of the smaller steel strands remained connected to the data logger, and they were black and brittle. Upon further investigation we were able to disaggregate the steel in our hands and considered it a miracle that we successfully recovered the logger with the data.

Following the trip to the field, we attempted to determine the cause of the rapid degradation of the steel cabling and assumed that due to the heterogenous nature of the aquifer, that specific well was contaminated with an unknown substance. This assumption would soon lead to dire consequences. Approximately 10 weeks after

deploying loggers at the second study site, Elena Muir, another graduate student from my lab, and I returned to collect data. We visited two wells at the second study site: a large irrigation well with limited access due to a turbine pump and an empty 16-inch casing with three steel plates welded to the top.

When we were pulling the cable up in the irrigation well, we noticed that it was suspiciously light as we approached the end where the data logger was attached and there was also a marked difference in the brittleness of the cable where it was submerged. To our collective shock the data logger was missing and there were signs of corrosion with a dark black coating and in several instances a white slimy crust (with the appearance of a calcium deposit) on the cable.



Figure 1. The open casing well at the second study site with three metal plates welded on top.



Figure 2. The cable that pulled from the open casing with no datalogger attached due to corrosion.

The results were the same at the second well with the open casing. After taking a moment to worry about the state of my project's budget since I just lost \$3,400 worth of equipment, we returned to Baylor to take on the daunting task of informing Dr. Yelderman. Thankfully, he was shocked more than angered and was extremely gracious, so I only had to endure some mild teasing which was a tolerable outcome.

Once I emotionally recovered, Elena and I set off into the field on October 15th with renewed determination to recover the lost equipment. After some words of encouragement, and an edict to not lose any more data loggers, Dr. Yelderman sent us to the field with the promise that after a few hours of actively attempting to

retrieve the data logger we would call him so he could coax us to continue trying. On the drive to the study site we formulated a plan of action and decided that the open casing well would be our best shot at a successful retrieval due to its accessibility when we compared it to the irrigation well.

Upon our arrival at the well in the middle of a recently plowed field, we set to work unloading our retrieval tools: a reel of fishing line, hooks and weights to create a length of fishing line with a treble hook and a weight similar to what one would use for catfish. After dragging the hook on the gravel approximately 60 feet down at the bottom of the casing the line weighted, and I pulled it up. With a failed first attempt, and the sun rising higher in the humid Central Texas sky, Elena and I felt the heat as the temperature rose to 95°F. The lack of shade made this task particularly grueling, and since we could only deploy one line at a time, lest we hook ourselves, Elena was primarily relegated to a safety partner and moral support. After a few hours, we had successfully retrieved several pounds of what used to be well casing which was now pieces of porous rusted iron. At that point, we concluded that despite our best efforts we had to admit defeat. I asked Elena to call Dr. Yelderman so we could request permission to end our fishing expedition and when she put him on speaker, I decided to give it one last shot and dropped the line. After a few more attempts something weighted the line, and I carefully pulled it up while talking with my advisor on the phone. To our shock I had hooked the top of the data logger!



Figure 3. The successful retrieval of the data logger from the bottom of the open casing.

With the logger in hand and after several excited yells, we retrieved the data and even saw the moment in the data when the water level rose three feet within one sample interval when the cable broke and were able to adjust for it going forward.

While the exact cause of the cable failure has not been positively determined, it seems likely that there was a biogeochemical reaction. The aquifer has relatively low dissolved oxygen, moderate pH and high salinity. Many farmers in the area also commonly lubricate their irrigation wells with oil that gets into the casing and provides a source of organic carbon. Due to these conditions, it is possible that bacteria feed off this source of organic carbon for cellular respiration using first the minimal dissolved oxygen, then the nitrates from fertilizer before utilizing dissolved iron, accelerating the dissolution of any solid iron, such as steel cables and well casing.

For the remainder of the study, I utilized a chemically resistant cord made of Kevlar which held up in the local aquifer conditions. Considering the biogeochemistry of the conditions that your equipment may need to tolerate is vital for successful research and would have saved us thousands of dollars and arguably, more importantly, avoided data gaps. From this experience there are lessons in biogeochemistry that could be explored, discussions about proper materials for anoxic conditions, but most importantly, a lesson about perseverance in the field. Mistakes will be made, issues will be encountered, and if we learn to share them, we can all become better.



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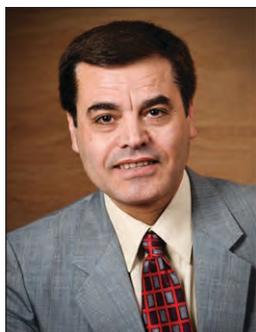


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Geology Study Guides

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



In a previous article¹, I introduced some popular geology books written for the public. This article is a report from another bookshelf of my library – a shelf I call “Geology Guidebooks” that I have collected over the years, initially for my own learning as a geology student and later for my own review as a teacher (each book has its own “flavor” in words, pictures and focus). These books offer what may be called crash courses, review courses, or self-study courses on geology at a knowledge level between high school and college education. I am listing some of these books that may help geology students and teachers, as well as professional geologists interested in a fast-based review of this subject. These are also great books as birthday or Christmas presents to friends who are interested in minerals, rocks, fossils and other “Earth-lore.” Of dozens in my library, I have selected 14 recent books listed under four categories.

General Geology

1. **Geology for Dummies**, by Alecia M. Spooner (John Wiley & Sons, New York, 2020, second edition), 400 pages with black-and-white illustrations and engaging prose. Part of the so-called “Dummies” book series, but these books are for “the Curious” minds.
2. **Planet Earth** (“Beginners’ Guides”) by John Gribbin (Oneworld, Oxford, UK, 2012), 175 pages, prose-based overview of geology.

Illustrated Geology

3. **The Rough Guide to Earth**, Martin Ince (Rough Guides, London, 2007), 294 pages, profusely illustrated. A comprehensive, introductory coverage of Earth science.
4. **Geology**, by Mark A.S. McMenamin (“Smithsonian Science 101” series) (Collins, New York, 2007), 218 pages with lots of color photographs. Great gift book.
5. **How the World Works: Planet Earth**, by Anne Rooney (Sirius, London, 2020), 208 pages with lots of color illustrations. Great gift book.
6. **Geology**, by Frank H.T. Rhodes with illustrations by Raymond Perlman (“A Golden Guide from St. Marin’s Press,” New York, 2001). 160 pages, pocket size. “Fully illustrated. Authoritative. Easy-to-use.”
7. **Smithsonian’s Earth: The Definitive Visual Guide**, by Douglas Palmer, Robert Dinwiddie, John Farndon, Michael Allaby, David Burnie, Clint Twist, Martin Walters, and Tony Waltham (DK Publishing, London 2013), 528 pages, large format and illustrated. This is one of my coffee table books

1. Sorkhabi, Rasoul (2023) How to refresh your geology. *The Professional Geologist*, vol. 60, no. 4 (October- December), pp. 40-42.

Course Reviews and Self-Test Books

8. **Earth Science: Cliffs Quick Review** by Scott Ryan (Cliffs Notes, Lincoln, Nebraska, 2019, second edition), 240 pages with black-and-white illustration. Great book for course review.
9. **Geology: A Complete Introduction** ("Teach Yourself" series), by David Rothery (Teach Yourself publishers, Oxford, UK, 2016), 384 pages with black-and-white illustrations.
10. **Geology: A Self-Teaching Guide**, by Barbara Munck "Self-Teaching Guides" (John Wiley & Sons, New York, 2001), 328 pages with black-and-white illustrations and self-test questions at the end of each chapter.
11. **Barron's Earth Science: The Easy Way**, by Allan D. Sills (Barron's Educational Series, New York, 2003), large-format 378 pages with black-and-white illustrations and self-test quizzes at the end of each chapter. More on physical geology, Earth's history is not covered.

12. **Let's Review Earth Science**, by Edward J. Denecke, Jr. ("Barron's Review Course Reviews") (Barron's Educational Series, New York, 2021), 800 pages with black-and-white illustrations and review questions at the end of each chapter. It also has a companion: Barron's Regents Exams and Answers. If you want to test your knowledge of geology, try this one.

Field Guide Geology

13. **The Field Guide to Geology**, by David Lambert and the Diagram Group (Checkmark Books, New York, 2007, second edition), 304 pages with lots of illustrations. (I usually assign this book to my students to read and write a report to get extra points in the class).
14. **A Field Manual for the Amateur Geologist: Tools and Activities for Exploring Our Planet**, by Alan M. Cvancara (John Wiley & Sons, New York, 1995), 334 pages with black-and-white photographs and bibliography at the end of each chapter.

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Under the Graduation Lights:

Joining the Ranks of Professionals

Isaac E. Pope, SA-9950

Graduations are around the corner. It is around this time of year that a wave of excitement begins to slowly build up to the big day. Of course, there is still another semester of cram studying, exams, and haggling with classmates over those infamous group projects. Yet, you begin to see the light at the end of the tunnel. A prize not yet in hand but fully in sight.

These are the months of reflection. You may not fully realize it now, but you have truly come a long way from where you started. Regardless of whether you always knew geology was for you or if you discovered it later in the journey, you have passed some significant hurdles to join the ranks of a privileged few who dedicate their lives to the study of our Earth. It is a life of continual learning, and as such perhaps you feel daunted at how much remains to learn. I can assure you: the distance you have already come has prepared you like few others ever will to tackle the breadth of engineering, applied, or fundamental questions awaiting you.

It is also at this time you are preparing to embark on a new chapter of your story. Even if you head to graduate school, you are no longer simply a “student.” You are joining the professional community, a pantheon of individuals trained and qualified to address a variety of challenges in the world beyond the textbook. With this rank of professional, you are about to enjoy several privileges and responsibilities. Perhaps the most surprising to me was the transformation from understudy to peer. No longer are you simply an apprentice; now you are qualified to stand upon your own two feet. You will still have supervisors and mentors to answer to, but to many more you will be seen as a professional capable of solving questions independently. Be mindful of what you say – you might be surprised how much more weight a stray comment or criticism now carries!

With your newly minted graduation, you will also act as a representative to broader society of our professional community. Unless you actively engage in community outreach, you may be surprised at how little most of our society understands seemingly intuitive

issues in Earth Science. Most people will only ever become familiar with the dangerously little they learn in primary school, and only a few of those will take entry level classes in college. Instead, most perceptions are built around what they see in the news or social media. In case you have not had the time to keep up with either during your studies, allow me to catch you up: most of the content out there is not positive. As is widely known, news media prioritizes startling or upsetting stories that sell, and it is these stories, such as the latest oil spill or high-casualty natural disaster, that will frame most individual’s ideas on Earth Science. As a geoscience professional, you have the opportunity to represent and offer new perspectives into these broader issues.

Not long ago, I myself was told (loosely paraphrased) “you always hear about people in said scientific field, but you rarely ever know one for yourself.” Chances are, as a new professional, you may be the sole representative for the geoscience and geoenvironmental professional community for many people in your life. Be prepared to hear some of the toughest questions facing our society, be grounded in the latest information available, and be willing to share so that more will learn to value the contribution of geoscientists and geoenvironmental engineers.

Finally, as you approach graduation, it is not too soon to embark on this journey. For myself, I sported the AIPG stole at graduation. Not only will you stand out from the crowd for being one of the few who will wear a geoscience-themed graduation stole, you will also be one of the few to truly adopt a forward-looking mindset. You will find that most people enjoy only part of the true excitement of graduation. Many treat it as a time to “rest on one’s laurels,” and celebrate their past endeavors. However, for the geoscience professional, you are doing far more than simply graduating. You don the honor of joining the ranks of professionals. With the AIPG stole, you carry the promise of us all, the promise to speak and do with “competence, integrity, and ethics.” You certainly have come a long way toward competence. Congratulations, soon to be graduates!

WSP USA Supports AEG St. Louis Chapter and AIPG Students at UCA “Down for That” Outreach at the University of Missouri

Luke Ducey, CPG-12317

On November 4th, 2025 Everett Litton, PE, ENV SP and Luke Ducey, GIT, CPG of WSP USA visited the University of Missouri in Columbia to give a presentation as part of the Underground Construction Association’s (UCA) “Down for That” university initiative and the AEG Mizzou Student Chapter outreach. The event drew around 40+ students studying civil and geotechnical engineering as well as geology, all eager to learn more about the underground construction and tunneling industry.

Everett and Luke presented on the *Design and Construction of the Lower Meramec Tunnel (LMT)*, a major infrastructure project serving the St. Louis region. The discussion highlighted the complex geotechnical considerations, data collection, and reporting that goes into large tunnel projects as well as the teamwork going into a project of this size.

In addition to the technical overview, the presentation emphasized career pathways in underground engineering, environmental and geology with the importance of professional societies like AEG, AIPG and UCA, and the many benefits of getting involved early through student memberships and scholarship opportunities. Several Mizzou professors even offered extra credit for attending the session, which helped drive strong engagement and turnout.

Students were highly interactive throughout the presentation, asking thoughtful questions about tunneling design, project logistics, and real-world applications. The session wrapped up with Shakespeare’s Pizza, brought in from a local favorite, and a brief tour of the Mizzou campus, including a stop at the historic Columns on Francis Quad.

It was a rewarding experience to connect with such motivated students and share insights into an industry that blends geology, engineering, and innovation below the surface. The WSP Team, AEG St. Louis Chapter, local AIPG and UCA members are proud to support initiatives that educate and inspire the next generation of professionals in underground construction.



Luke and Everett Presenting about LMT to Mizzou students.



Luke and Everett of WSP at the Mizzou Quad.



Luke Presenting about LMT to Mizzou students.

Geoscience Gold: AIPG Members

Editors note - As we started last year, we are including a member listing in *TPG*. The names are organized alphabetically by section and membership category, and I am pleased to see so many responses this year of members who want to be listed. Hopefully, next year there will be even more. If you don't see your name on the list, be sure to opt-in for next year to proudly showcase your membership and demonstrate what it means to exemplify the Gold Standard of the Geosciences!

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In Memoriam

David L. Gross., CPG-02568

Urbana, Illinois

November 20, 1943 - September 17, 2025

Member Since 1973

Obituary and photo obtained from *The News-Gazette* website...

He was born in Springfield on Nov. 20, 1943, to parents Carl and Shirley Gross. A graduate of Beardstown High School and Knox College, he earned his Ph.D. in geology from UIUC in 1969. The Illinois State Geological Survey became his professional home for over 30 years. He was instrumental in creating the field of Environmental Geology, publishing early research on the bottom sediments of Lake Michigan. His work focused on fitting people into the physical environment. He was very passionate about scientific research and the ISGS.



While at Knox College, he met Claudia Cole; they married at First Unitarian Church in St. Louis in 1966. He became a Unitarian, a Cardinal fan and a cat parent. She accepted his love of boats and even learned to sail. From 1965, they made their home in Champaign-Urbana and cheered for the Illini, especially the volleyball team. The arrival of sons, Oliver and Alexander, completed the family as they embraced parenthood.

Always the traveler, David researched geology throughout Illinois and beyond, spending a field season in Antarctica. Travels took them to much of the U.S., especially Minnesota, spending time at Camp Unistar each summer for 40 years. For 25 years, David served as a counselor for youth week teaching sailing, mentoring teenagers and making lifelong friends. He loved sailing in nearby Illinois lakes, but especially in Minnesota in summer and the Florida Keys in winter.

In his retirement years, David became a banker serving as chairman of a community bank in Western Illinois. Travels continued, especially cruising in both Europe and North and South America. The family grew with daughters-in-law and four perfect grandchildren; David's favorite name was "Grandpa."

David served AIPG as an Advisory Board member in 1980.

David is survived by Claudia, his wife of 59 years; sons, Oliver (Kerri Skrudland) of Springfield and Alexander (Jamie) of Marathon, Fla. His grandchildren are Michelle (Justin) Welever of Plant City, Fla., Megan Gross of Marathon, Fla., and Benjamin and Samantha Gross of Springfield. He is also survived by his sister, Susan Conner of Springfield and several nieces and nephews.

David lived a long and good life, accomplishing most of his goals. We are very privileged to have known and loved him. We are especially grateful to all his colleagues, friends and family who have blessed us with their affection.

Edwin "Ed" Via, CPG-06349

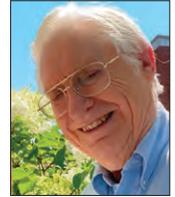
Richmond, Virginia

January 19, 1936 - May 28, 2025

Member Since 1983

Obituary and photograph provided by Ed's wife, Sandy Via.

Edwin "Ed" Via, 89, of Richmond VA, passed away peacefully at home on May 28, 2025 after a long illness.



Ed was born in Martinsville VA on January 19, 1936. He was one of 11 high school seniors who graduated in 1954 from Drewry Mason High School in Martinsville. He and his brother Banks were raised on their parents' farm where he worked during summers and harvest times. He earned a BS (1959) and an MS (1962) in Geology from Virginia Tech where he was a member of the Corps of Cadets. He worked for the Virginia Department of Highways for three years after graduating from college. He then worked for 17 years with Lone Star Industries as chief geologist at the corporate headquarters, New York City. In 1982 he became a geological consultant. He was a lifetime member of AIPG. His travel as a geologist took him to many countries outside the USA, especially in South America.

After his retirement, Ed enjoyed family trips and celebrations, attending school programs of children and grandchildren, membership in the LLI (Lifetime Learning of Chesterfield), and outings with several other informal groups of friends including the "Valentine" group, composed of his Virginia Tech roommates and their spouses. He was a member of a group of friends who enjoyed breakfasts and lunches at the Apothecary, McDonalds, Bojangles, Hardees, and the Brickhouse Diner. Ed's search for the "perfect biscuit" as well as the "perfect tomato" continued for years.

Ed also enjoyed trips to the Blue Ridge Mountains, the Great Smoky Mountains, Williamsburg, Smith Mountain Lake, Harrisonburg, Virginia Beach, and the Outer Banks.

Travel with his wife Sandy was enhanced through a partnership between the Virginia Community College System and Brightpoint Community College (formerly John Tyler Community College), where Sandy taught for 19 plus years, and similar colleges in the UK. Through this exchange, Sandy met Maggie Wood, who taught at Queen Mary's College, Basingstoke, Hampshire, UK and her husband John. This friendship led to 22 years of travel for the four, who enjoyed trips both in the UK and USA, as well as extending travel to other family members. Visits to the UK included England, Scotland, and Wales as well as repeat visits to their beloved Cornwall and the Lake District. When Maggie and John visited from "Across the Pond," the four enjoyed trips out west, Route 66, the Smoky Mountains, National Parks, the Southeast Coast, the Mississippi River, the Northeast, as well as local sites in Richmond.

Ed's achievements and interests were many: Eagle Scout, avid reader, rock collector, poet, proud owner of his 1989 Camry, farmer at heart, generous friend, Hokie, dear husband, Dad, Brother, Uncle, and Grandpa. He was an associate member of Central Baptist Church, Richmond VA where he enjoyed music, special programs, church dinners around the table with dear friends, and Central's informal "parking lot" services during the pandemic. Church members recall his "laughter, kindness, wisdom, generosity, and unwavering support. His spirit will remain a guiding force, reminding us of the power of love, compassion, and togetherness." He will be missed by all who knew and loved him.

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.

Keith August Diegel, SA-9007

Los Lunas, New Mexico

September 8, 1983 - May 5, 2025

Member Since 2017

Obituary written and photo provided by close friend and fellow geologist, Nicholas (Nico) Harrison (ECP-0839).



Keith passed away suddenly and unexpectedly on May 5, 2025

Keith was born September 8, 1983, in Albuquerque, New Mexico to Thea and August Diegel Jr., who preceded him in death.

Keith spent his childhood in Stephentown, New York. His father's work as a jeweler first introduced him to the wonders of geology, as he became fascinated by the hidden stories within each stone-an interest that would eventually become the driving force of his life.

Having completed his GED, Keith went to work in retail, becoming a night manager at Albertson's and an order filler at a Walmart Distribution Center.

His passion for rocks and minerals and keen natural intelligence prompted his friends and family to observe that a man with his gifts and passions belonged on a university campus instead of a warehouse. Keith would later remark that it was when his stepsons stopped asking him for help with homework that he decided to go back to school. Thus, at the age of thirty, he set foot on a college campus for the first time and enrolled at University of New Mexico-Valencia.

Pursuing his A.S. in mathematics, his decision to go back to school was validated by the hard work and quick mind which led him to complete his associate's summa cum laude in 2016, having earned UNM V's Alberta Flores scholarship and a Phi Theta Kappa scholarship.

In 2017, Keith transferred to New Mexico Institute of Mining and Technology, pursuing a B.S. in Earth Science. Over the next two-and-a-half years, he worked assiduously to pass his classes with high enough grades to retain the scholarships which sustained his academic career, while remaining a devoted husband and father who would take the bus between his home in Los Lunas and the Tech campus in Socorro, and who balanced his commitments to academia with those to his family.

Despite the age difference between him and most of his fellow students, Keith's friendly, outgoing and compassionate nature, along with a sense of humor which made his hearty baritone laugh recognizable a mile away, enabled him to bond easily and form deep and lasting friendships with classmates not much older than

his stepsons, and he had a large and varied group of friends which constantly seemed to grow.

It was at Tech that Keith was first introduced to AIPG, and in the fall of 2017 he helped to found the Tech student chapter, serving as its vice president for two years and helping to bring in guest speakers and recruit new student members. Keith also served as vice president and treasurer of Tech's student chapter of the Society of Economic Geologists.

Keith participated in research with several Earth and Environmental Science faculty and NM Bureau of Geology and Mineral Resources staff-during his time at Tech, on subjects including aqueous hydrogeochemistry, subsurface mapping and modeling, speleogenesis, and critical minerals. He held jobs on campus including as an associate at the Bureau's Mineral Museum, a data assistant in the Bureau's Geologic Information Center, and a student GIS analyst. His hard work, intelligence, good humor and friendly attitude endeared him to his supervisors and coworkers.

Keith graduated with high honors in December 2019, on the Dean's list and as a Tech Scholar, along with receiving numerous other merit-based scholarships. He was intensely proud of being the first college graduate in his family.

He embarked on a M.S. in Mineral Engineering at Tech but left the program in the fall of 2020 to take a job with Green Geophysics, installing and interpreting results from magnetotelluric equipment in remote field sites for a federally funded subsurface imaging project. He also obtained an M.S. in Geology through Ohio University's online program, completing it with a 3.34 GPA.

Mineral exploration was always Keith's biggest area of interest in geoscience, as evidenced by his rock collection which his wife often pleaded with him to curtail the growth of, due to space limitations. It was truly the beginning of a career Keith had long dreamed of when he began work as an ore control geologist, first with America's Gold & Silver at the Relief Canyon Mine in Nevada, then for three years with Sibanye-Stillwater at their platinum workings in Montana.

At the time of his death, he had just started a position with The Doe Run Company in Viburnum, Missouri. Throughout his career, his family remained his top priority. He brought them with him when he moved between jobs, and when away on overnight work trips he would constantly talk about how much he missed his wife. When asked how work was going, Keith was fond of repeating the saying, "Love what you do, and you'll never work a day in your life."

In addition to his parents, Keith was preceded in death by his grandparents and his uncle John Diegel. Keith is survived by his wife Kenya, (step)sons Nethaniel and Christopher Astorga, daughter Iliana Diegel, granddaughter Skylar and various family members. A Celebration of Life was held on September 13th at the Westside Family Chapel in Los Lunas, New Mexico. Contributions in his memory may be made to the Geological Society of America Foundation.

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