Career Paths: Forest Service
Aquifer Vulnerability Mapping

Peer review
Lost Secrets of Epithermal
Gold Exploration

Understanding the Need for Injection Wells
in the United States
Photo Contest Results

The 2021 AIPG Member Photo Challenge officially ended on November 1, 2021. The entries were evaluated against the criteria for the four photo categories. All of the entries were for the Scenic Wonder category and each featured stunning scenery. After some tough deliberations, two tied for first place. This edition features, Yellowstone Abstract, by the Northeast Section’s Guy Swenson, CPG-7574, one of the two winners of the 2021 Photo Challenge; the other winner, Joe Kurtak, CPG-11359 from the Alaska Section whose image titled A HooDoo Landscape, will be featured in the Oct/Nov/Dec 2022 edition. Congratulations to our winners and runners up! Thank you for sharing your images! AIPG is hosting the photo contest again this year. See page 15 for contest rules.

Runner Up

Pliocene Oyster Reef, Etchegoin Formation, Central California.
Rick Bowersox, CPG-6309, Kentucky Section

This photo was taken May 27, 2004, in the Kreyenhagen Hills, Kings County, central California. This locality is about 7 km southwest of the town of Avenal, which is located on the western edge of the Kettleman Hills oil field. I was a PhD candidate at the University of South Florida at the time, and took this photo during my last trip to California to collect Pliocene Etchegoin Formation fossils and measure section for my dissertation (2006) research. With me was my middle daughter, Alexandra, as field assistant. I was working in the northwest San Joaquin Basin because of the good stratigraphic exposures and my familiarity with the section from a prior 25-year career in the oil industry headquartered in Bakersfield, California. The reef is a steeply dipping (~70° northeast) 1-meter thick bed that is part of the basin-margin strata near the base of the Etchegoin, thus near the base of the Pliocene section, and is composed of well-cemented shells of Ostrea atwoodii. These oysters lived during a climatic period very similar to what is now coming.

Runner Up

A Beautiful Vista of Mount Oxford from Mount Belford, two mountain summits of the Collegiate Peaks in the Sawatch Range of the Rocky Mountains of North America.
Bryant Butler, ECP-0732, Ohio Section

We began our journey on the Missouri Gulch Trail located in the San Isabel National Forest at 4:00 am MST. We hiked almost 20 miles in total due to a mudslide washing out a 1/4 mile of Elk Horn Pass. Being from Ohio overcoming the elevation was a daunting task and made for an arduous hike. The reward for our hard work was far greater than the hardship, reaching the summits of Mt. Oxford, Mt. Belford and Missouri Mountain.
On the Cover: Photo Challenge Winner: Scenic Wonder: Guy Swenson, CPG-7574, from the Northeast Section. Yellowstone Abstract. This is an image of part of the wall of the Grand Canyon of the Yellowstone River. The Grand Canyon of the Yellowstone is known for the wonderful colors of the canyon walls caused by hydrothermal alteration of the rocks, captured the sedimentary rock textures and diagenetic oxidation along Lake Powell that tell stories from the past.

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Do the Rules Apply?

Adam W. Heft, CPG-10265

Greetings everyone, and welcome to 2022! I hope that everyone had a great holiday season, and a Happy New Year! Here is hoping that 2022 is a better year than 2021, and that we are finally able to put the Covid-19 pandemic behind us.

As you know, the Jan/Feb/Mar edition of TPG is the annual Student Edition. This year, I am pleased to offer several articles by and of interest to students. Articles include a technical article on aquifer vulnerability mapping in California, a tale of other skills needed during a field season in Canada by a long-time member, geophysics applications for cemetary mapping, and more. I have also included an introduction letter and a sneak peak of the field trips that will be part of this year’s Annual Meeting that will be held in Marquette on August 6-9, 2022.

While we have had more articles for this years’ Student Edition than the past couple of years, I am planning to make a change for 2023. Since the Mar/Apr/May edition typically includes the essays for the student winners of the AIPG national scholarships, it makes sense to me to push the Student Edition back one issue to the second quarter instead of having it be the first quarter edition. I would be interested in your feedback on this subject as a Letter to the Editor; please send me an email at adam.heft@wsp.com and let me know your opinion. If there are no overriding reasons for keeping the Student Edition as the Jan/Feb/Mar issue, the change will be made for 2023.

After attending the 2021 Annual Meeting in Sacramento, California at the end of October, my wife and I spent a week and a half sightseeing in several of the California National Parks, including Yosemite, Pinnacles, Muir Woods, and Point Reyes. One of the things that struck me during that time (other than the incredible scenic beauty of the parks) was the total disregard for park rules by many individuals with whom we shared our time.

One of the simplest examples was observed again and again throughout the parks was the disregard for posted signs. At many of the scenic overlooks, signs clearly state “Please stay on the trail.” Leaving the trails causes sensitive vegetation that is being reestablished to be trampled. This also is posted around some of the Giant Sequoias, which are also protected by fencing so the roots of these great trees are not damaged. Although it seems difficult to believe that something that simple can damage or kill something that large, there have been other instances (one I’m aware of in Michigan) where a very large old tree was killed by having its roots trampled and worn down by countless people seeking to have their pictures taken in front of the big tree.

Another instance I observed was while on a hike in Yosemite and involved the breaking of the cardinal rule while in a National Park: take nothing but pictures; leave nothing but footprints. We had hiked to the top of the Upper Yosemite Falls one day and had stopped to rest while heading down when we were passed by a group of four young individuals. At first, I did not realize what I was seeing, which was a stick coated in the distinctive greenish tree moss tied to the bottom of one of the individuals’ backpack. By the time I did, they had gone on past us and were out of earshot. Fortunately, we caught up with them a short time later when they had stopped to rest on the way down. I was hesitant to confront a group of others, but felt I needed to remind them that it wasn’t ok to collect souvenirs from within a National Park. After all, being a geologist with all that rock around… who’d miss one? So, since I was able to resist temptation, and was playing by the rules, everyone else should too, right? Rather than scolding them or telling them to put it back, I took a different approach – “you know, if that is tree moss you have there, and one of the park rangers sees you with it, you’d be in a lot of trouble…” They seemed quite surprised by that: “Oh really? I didn’t know that!” They thanked me for telling them as we went on past them. When they caught up to us and passed us about half an hour later (oh the energy of those much younger!) the stick and moss were no longer tied to the backpack. Whether they got rid of the item, or merely hid it securely in their pack, I have no idea, and didn’t feel I needed to ask.

Then there are the countless examples on the highways of people driving waaay over the speed limit. This is a case of more than just five to 10 mph over; it is being passed like we were standing still. And it doesn’t seem to matter what the road conditions are like either: straight and dry, wet, ice and snow covered, or curvy with hills and blind corners. Then there are the ongoing news stories about shootings, mayhem, and the like. Apparently, many people today feel that the rules are meant for someone else, or “I’ll follow them if it doesn’t inconvenience me too much.”

Some of you will recall the article I wrote last year about the individuals at Laughing Whitefish Falls climbing over the fence and all over the face of the cascade. At the time, I had thought that the symptoms of “The Rules Don’t Apply to Me!” were limited to a few inconsiderate individuals. But now, it seems this is a more widespread problem than I originally believed.

It seems that the best we can do is to lead by example, and offer information to those willing to listen; we can’t coerce others to do something they won’t do themselves, and could be taking a risk with our own safety if we do. What are your thoughts, and what do you do in similar situations?
Have you ever been at a store or a restaurant and suddenly caught a glimpse of someone you thought you knew before realizing it was not them at all? This occasionally obnoxious habit is a result of the amazing filing cabinet nature of your brain. In less than a second, your senses distill the essence of the faces around you and compares them to hundreds of images locked within your brain until a likely identity is selected. This little feat is an efficient means to quickly evaluate friends versus potential threats, though the occasional mistake could be embarrassing!

Though our brains are particularly attuned to recognizing faces, this is not unlike our own investigations in the field. Every time we gaze upon a landform or peer into a hand sample, we are instinctively comparing what we are observing to what we already know or have seen. Indeed, how many hours I have spent pouring over the details of a new sample and comparing it to my past experiences! It always amazes me how often my mentors will reflect “studying such a site certain years ago” after seeing photographs from my recent investigations. It seems that what we have seen in the past becomes an integral part with how we approach Earth’s mysteries in future endeavors.

Conversely, this habit of seeing what we have already experienced may cut deeper than one might imagine. Because our experiences define how we conduct our investigations, the human brain can easily slip into disciplinary bias, as well illustrated by the controversy on the origin of the Mima Mounds in the Puget Lowland (Pope, 2021). Ellipsoidal mounds up to 2 m high and found along prairies in the thousands, the Mima Mounds of the Puget Lowland have incited debate for over a century, which has fueled many warring models on the mounds’ formation (Washburn, 1988). These models have only proliferated from the continued study of similar “Mimalike mounds” across North America and beyond. Proposed causes range from permafrost, droughts, fossorial rodents, and
even earthquakes, yet adherents to each hypothesis tend to cluster in specific disciplines. For example, Quaternary geologists prefer glacial processes, geographers and biologists blame rodents, Midwest geologists propose droughts, and Northwestern geologists court the dreaded Cascadia earthquakes, each model being based upon the experiences from which the observer draws upon to reach a conclusion.

This sort of disciplinary bias has long been noted by the famed physicist Thomas Kuhn in the book, *The Structure of Scientific Revolutions*. Kuhn describes “normal science” as collection of data within the framework of an overarching paradigm which gives meaning to the data. Without the paradigm, certain questions would never be asked, and data would be pointless without a box in which to place them in reference to the whole. Kuhn suggests that not only do different paradigms ask different questions but observe different things – in a sense, two battling paradigms live in two distinct worlds, each contextualizing different data to different reference points. However, the paradigms may hold some overlap in understanding the Earth, but they will maintain a degree of incommensurability or incomparability due to existing in two practically separate universes. The differences may extend so far that adherents to each model may speak different “languages” from those of alternative ideas, making understanding between models a challenge to say the least. All this from a simple human precondition!

Even so, such disciplinary bias may not be the poison it appears to be. As Kuhn demonstrates, scientific development in many fields has been predicated upon this predisposed commitment to paradigm. Because a given paradigm will include predictions and shortcomings specific to that paradigm, research within that paradigm will be guided by questions distinct from that of other disciplines. Over time, data would be uncovered by means inconceivable by other paradigms, thereby broadening the scope of knowledge in an arena. As such, disciplinary bias represents an effective tool for probing Earth’s mysteries, but it is merely a means to an end. The challenge, therefore, remains upon the investigator to consider the entirety of the data rather than solely the sliver of knowledge attained through their own studies.

Commitment to a paradigm is natural – it is but a means for connecting to a world far more intricate than conceivable by the human brain. As such, it is our responsibility to expand our experience so that we can better interface with the breadth of data becoming available to the geologic community. Continuing to see more geology will force us to broaden our experience by confronting us with new mysteries. While sharpening our observational skills, this would help prevent us from becoming “small-minded” by relating each new experience to the limits of our past studies. With our current rollercoaster year, being small-minded is the last thing we want! Now, go explore the outdoors!

**Suggested Reading**


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**Students!**

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**National scholarship deadline is February 1, 2022.**
Lost Secrets of Epithermal Gold Exploration

John Wood, CPG-10580

Abstract
Successful epithermal gold exploration can be greatly enhanced with a fundamental knowledge of geothermal processes and resulting vein mineralogy, textures, geochemistry, and alteration zonation. Building a 3D model of favorable structure and vein attributes can be used to identify fluid pathways and visualize new target opportunities. This can greatly reduce the timeline to discovery, exploration costs, and is essential for sustained success.

Keywords: Epithermal, Gold Exploration, Discovery Methodology, Mineral Zonation, Fluid Pathways

Introduction
Most large epithermal gold districts occur in areas where hydrothermal fluids were active over large areas, often saturating rock volumes more than 100 km$^3$. They occur in areas of high heat flow along major crustal structures, plate margins, grabens, rifts, and regional fault zones. They form where meteoric water can circulate to great depths within major structures over extended periods of time, often exceeding millions of years. Geothermal drilling encounters open fault structures at depths greater than 2 km that are held open by fluids under extremely high pressure. Open structures become less abundant deeper in the earth due to lithostatic load and tectonic pressures which tend to squeeze openings closed. Fluid inclusion measurements indicate formation temperatures below 350°C and pressures less than 1 kilobar (100 MPa), with few exceptions. Geothermal well “blow-outs” mimic natural fault movement, releasing pressure on the hydrothermal system. These high-pressure fluids often exsolve a gas phase, create breccia bodies from explosive hydrofracking, deposit vein material and flash rapidly to the surface, sometimes moving upward hundreds of meters in minutes. Epithermal veins are often upper-level manifestations of deeper higher-temperature disseminated deposits, stockwork zones, replacement deposits and other types of gold deposits.

Structure
Epithermal gold districts are generally strongly controlled by structure in brittle host rocks. Most districts display a major trend of vein orientations formed during a tectonic event that created open structures. In major districts there is often more than one structural trend and sometimes a complex structural fabric is mineralized. Favorable structural trends can change dramatically at depth where fluids passed through deep paleostructural environments. Networks of ore-bearing structures, especially in transform-like fault systems, often contain weakly mineralized faults connecting ore-structures. These “link” structures were largely closed during mineralization and may off-set major veins. Link structures can distract the explorer from recognizing ore structures in a broadly mineralized fault network. Post-mineral structures may appear mineralized where later events or supergene processes deposit younger mineral assemblages. Almost any structure existing prior to mineralization can be a potential ore host. Host structures are rarely open for long distances (>1 km) or depths (>0.5 km) and most exhibit multiple small ore shoots controlled by open lenses along the structure. Fault movements tend to create larger openings closer to the surface. Deeper structures often display smaller, more complex ore shoots where openings were held open by breccia zones, bedrock pinch zones, bends, oblique faults or hanging wall structures. Even relatively impermeable looking structures may have been receptive elsewhere.
in a district. An early priority of district exploration should be to map the limits of the hydrothermal system, create a 3D model of important structures and trends, and categorize the district architecture.

**Alteration**

Rock alteration occurs when hydrothermal fluids are in disequilibrium with host rocks. In deep high-temperature systems, fluids are often in equilibrium with host rocks and even in areas of high-grade gold deposition, alteration may be very subtle. This may seem counterintuitive, but at high temperatures elements are disassociated and form few reactive compounds. High pressure keeps dissolved gases in solution and fluid reactivity is often low. A slow-moving gold-bearing fluid of this type may not significantly alter calcareous rocks, andesite, or low-iron strata, but leach small quantities of carbonate and other elements along fractures and deposit large quantities of gold in structural traps or reactive beds. As fluids move to the surface, pressure decreases, and fluid flow is less restricted. As temperatures drop below 300°C, acid and alkaline compounds form, and fluids become progressively more reactive. Reactive beds may display strong alteration, while adjacent beds appear unaltered. When epithermal fluids enter structures within 1 km of the surface, they will generally depressurize and exsolve vapor phases. Abundant H₂S vapor often condenses to form strongly acidic fluids (Scher, et al., 2013). This can create extensive advanced argillic (clay and illite) alteration zones that form at the top of a depressurizing hydrothermal system (Thompson and Thompson, 1996). Veins at this horizon often represent the end point of fluid transport and gold deposition. The largest and most intense alteration zones are controlled by proximity to the surface, host rock reactivity, quantity of open structures, availability of heat and meteoric water and sulfuric acid formation. Host rocks are often destroyed beyond recognition and it can be impossible to recognize multiple pulses of prograde mineral deposition overprinted by late hypogene, retrograde and vapor phase alteration. Large surface alteration zones help geologists locate favorable districts for gold exploration but can make locating productive structures difficult. Gold deposition will often exhibit progressively lower intensities of alteration with depth. Mineralogical and textural characteristics change with depth due to changes in fluid chemistry and depositional conditions experienced along their pathway to the surface. Vapor stage alteration is often rich in volatile elements above the paleo-water table, which can include phreatic breccias, abundant fluid inclusions, quartz and opal veins, and extensive alteration. This transitions downward into chalcedony veins and a dramatic reduction in host rock alteration.

Below the level of ground water saturation, open structures may host numerous fault-controlled reservoirs and gold veins at multiple elevations. Paleo-water tables can be recognized by their position as an elevation control at the top of ore shoots. They exhibit a topographic high over the ore zone due to fluid upwelling, which slopes gently downward away from orebodies. Vapor streaming often extends a hundred meters above the paleo-water table and may deposit large volumes of sulfate minerals (with 4-12% sulfur), coarse silica, jarosite and volatile minerals and metals directly above ore deposits. These horizons often display unique vein textures, mineralogy and geochemical attributes at similar elevations and can be an important tool to improve discovery rates for deep veins. (Figure 1).

Adding this “tops of veins” signature to the 3D model adds another tool that can help visualize favorable depositional environments and elevations indicative of hidden deep orebodies. Multiple levels of elevation-controlled gold deposition can

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**Figure 1. Mineral and Geochemical Zonation Section. Based on the Mariana Central Vein, Cerro Negro, Argentina.**
extend cumulatively to more than 2 km in depth, where open space becomes minimized. The depth of exploration potential is only limited by the loss of environments and mechanisms that can trigger gold deposition; usually where vein attributes indicate temperatures greater than 400°C. Gold exploration potential is always much greater below boiling and vapor phase horizons, and host rock alteration is rarely directly proportional to gold endowment.

**Fluids**

Natural meteoric waters generally start as rainfall and often undergo chemical changes as groundwater. The major fluid types are hosted by carbonate strata and crystalline rocks, which results in two chemical end members, alkaline carbonate-bicarbonate and weakly alkaline to acid sulfide-sulfate fluid systems (Freeze and Cherry, 1979). Most epithermal gold deposits form from weakly to moderately saline meteoric water within one pH unit of neutral (Renders and Seward, 1989). This water circulates down deep penetrating structures into areas of high heat flow and metal availability. Fluids circulating through large volumes of carbonate-rich or igneous host rocks are often buffered by host rock chemistry and resist chemical changes in deep environments. This may aid fluids in collecting gold, dissolved metals and other constituents and transporting them for greater distances without fluid-rock reactions. Hot water is an excellent solvent and may source metals and other constituents from active igneous activity and leaching country rocks. Deep epithermal fluids may mix with fluids of magmatic origin, connate water, basin brines and other sources. Fluids will evolve as they migrate to the surface, react with new host rocks, both leach and concentrate elements, and deposit minerals as physical and chemical conditions reduce the fluids’ capacity to transport components.

**Depositional Conditions**

Many mechanisms can initiate gold deposition from hydrothermal fluids. Physical processes often disrupt fluid flow and chemical equilibrium, thereby destabilizing gold-bearing metal complexes and reducing gold solubility. Gold deposition can be triggered by pressure changes, sulfidation, wall rock reactions, vapor loss, rapid cooling, fluid mixing, fluid boiling and other mechanisms (Benning and Seward, 1996). Reactive rocks, open structures and other physical features often localize ore bodies. In volcanic fields gold veins often form from sulfidation, where sulfur reacts with iron minerals like amphibole, biotite, and magnetite to form pyrite, which initiates gold deposition (Arribas, 1995). Where iron is present in solution banded pyrite veins may form. The same vein in low-iron rock may be barren of gold. Classic “high sulfidation” systems have fluids extremely high in sulfur, but in unreactive host rocks may form low sulfidation gold veins with abundant sulfates depositing at higher elevations. At deep levels, where fluids move and evolve slowly in low fracture environments, wall rock reactions, sulfidation, carbonate or silica replacement often trigger gold deposition. As fluids move to the surface, lithologies become less important and structures host epithermal veins. In high pressure environments, relatively small drops in fluid pressure when entering open fractures can cause episodic cooling and gold deposition. In areas of tight structures there may be many levels of gold deposition corresponding to broken zones. The pressure drop from deep levels to the surface can be substantial. Multiple levels of open structures can result in several elevation-controlled horizons of gold deposition before near-surface boiling takes place. Once gold is in hydrothermal solution, deposition will occur within the most favorable host rocks and depositional environments. Lacking favorable reactivity in host rocks, brittle rocks and
structural traps like anticlinal folds tend to be the best depositional environments. Almost any rock can be a good structural host for a gold-bearing vein.

A hydrothermal system depositing vein material will form fluid inclusions, at least on a microscopic scale. If you visualize a rapidly solidifying soft gel of silica, carbonate, or coagulating colloidal silica forming opal, it is easy to visualize inclusions and vapor bubbles getting trapped in vein material. Fluids squeezing into a large void experience a rapid pressure drop, vapor loss, a coincident (>20°C) temperature drop, and commonly deposition of vein material with fluid inclusions. Fluid inclusion data, even normalized for pressure, probably underestimates reservoir temperature, since inclusions form after a cooling episode. Inclusions are often abundant where fluids enter the base of large open structures. This effervescence can cause vapor streaming upward in the structure. Fluid inclusions are also abundant in areas where boiling took place at the top of the paleo-water table. Gold deposits often form above deep zones of fluid inclusions and below near-surface boiling horizons (Figure 2, previous page). Where gold deposits extend to great depths, fluid inclusions can be helpful in mapping temperature, pressure, and chemical gradients (Bodnar, R.J., and Beane, R.E., 1980).

At deep levels, gold deposits are often relatively small and strung along fluid pathways in structures, favorable stratigraphy, folds, and breccia structures that have triggered gold deposition. Fold traps often host short, rootless veins in the axial part of the fold. Depositional conditions and fluid pathways can be traced between gold deposits using vein textures, gangue mineralogy, and zonation as indicators. Figure 2 is a guide meant to give the exploration geologist a general orientation of geologic process and mineralogy. Fluid pathways are rarely vertical, and a new discovery may be a kilometer down gradient and lateral from a surface target.

**Mineralogy**

As gold-bearing fluids follow structures and permeable formations toward the surface, areas of fluid destabilization cause deposition of gold, gangue minerals and alteration mineral assemblages. On a district scale, mineralogy and vein textures may be quite different over a 2 km elevation range but form specific patterns of zonation related to fluid changes and evolution. These give clues to temperatures, elevations, oxidation states, and mechanisms of gold deposition, and give vectors to fluid pathways and favorable gold depositional horizons. Mineral textures and polymorphs may be controlled as much by the mechanics of deposition as temperature and pressure. There are many classic textures in epithermal veins, and most are related to rapid and cyclical mineral deposition in open structures as indicated by fine-grained minerals, banding, colloform and botryoidal textures. Base metal sulfides, often as sulfosalts, are common in epithermal veins. These are far removed from intrusion-related base metals and rarely represent a base to district gold mineralization. Carbonate and quartz textures, polymorphs and pseudomorphs, and paragenesis are indicative of the depth, temperatures, and sequence of vein formation. Mineralogy and vein textures can allow an estimate of the general proximity to a gold deposit. When added to 3D models, these attributes can give vectors to the best exploration targets by identifying favorable structure, elevations, and optimum gold depositional environments.

There are many types of materials which can occur as veins and fracture filling. Carbonate, chalcedony, and adularia (KAlSi3O8) are common precipitates from alkaline fluids. Buddingtonite (NH4AlSi3O8) may be more common than most people realize since it looks like adularia. Barite, albite, phosphates, alunite, and more exotic minerals may be important vein components. Carbonate is common in high temperature veins and is often first to deposit in large open structures. Field observations indicate bladed and “angel-wing” textured calcite is probably a rapid deposition texture and is often followed by chalcedony replacement. Siderite (FeCO3) is a common precipitate from CO2 and sulfide-rich fluids at temperatures below 200°C (Wood et al., 1987). Chlorite forms from 200°C to 350°C (Cathelineau, 1988). Silica solubility is strongly temperature dependent, with quartz depositing above 350°C and other polymorphs depositing at lower temperatures (Marshall, 1980). Many veins exhibit complex banding, solution, replacement, and void filling textures. We are trained to think of opal, chalcedony and bladed calcite as forming at low temperatures, but they are not strictly temperature dependent (Fournier, 1985). Opal can be relatively high temperature and replace areas of permeable volcanic rock. In some districts, chalcedony veins zone outward and upward into opal, indicating alkaline fluid conditions were turning acid and oxidizing, often triggered by release of H2S. The acidification of fluids can result in a silica colloid and formation of opal. There is usually a corresponding drop in gold grades at this chalcedony-opal transition zone. The upper parts of bonanza grade ore shoots in the Sleeper vein at the Sleeper Mine, Nevada contained opal, electrume, and adularia bands just below the zone of boiling (Wood, 1988). Opal is generally barren and is often distal to the gold depositional environment. Opal is best identified visually, can dehydrate, exhibit desiccation cracks and will crystalize to very-fine microlites of alpha-cristobalite, identifiable by X-ray analysis (Nash, Utterback and Saunders, 1989).

Paleo-thermometers and barometers of depositional conditions are common and mineralogical studies of gangue minerals have been extensive. Marcasite (FeS2) precipitates at a pH <5 and temperatures below 240°C, with H2S2 (aq.) present at the site of deposition (Murowchick, 1992). It is unstable at prolonged temperatures above 160°C, tending to go back into solution or invert to pyrite (Nash, et al., 1989). Epidote (Ca2(Al,Fe+2)3Si3O12(OH)) may form in gold-bearing structures at temperatures exceeding 230°C and is susceptible to replacement by calcite in CO2-rich fluids (Thompson and Thompson, 1996). The common silver minerals argentite and acanthite (Ag2S) often combine with gold in solution and precipitate at temperatures from 25°C to 350°C, where acanthite is the common polymorph below 177°C; Cerargyrite (AgCl) forms from precipitation of chloride complexes at pH <6, within a temperature range of 50°C to >350°C (Gammons and Barnes, 1989). Realgar (AsS) and orpiment (As2S3) have been shown to melt in hydrothermal solutions at 307°C and 312°C respectively (Barton, 1969). Identification of gangue minerals and a little research can result in considerable enlightenment of geologic process and new exploration concepts.

**Conclusions**

Making 3D models and tables of important geologic attributes is a valuable exploration tool to aid gold discovery and is essential for sustained success. When viewed spatially, the network of mineralized structures, epithermal vein textures,
and mineralogic and geochemical gradients provide a map of fluid pathways. These can be traced from the surface through deeper, ever changing levels of gold depositional environments, often to depths exceeding 2 km from the paleosurface. Understanding geologic processes helps the explorer visualize controls on gold mineralization, develop multiple working hypotheses, expand exploration methodologies, and create new discovery skills. Compiling a table of prioritized targets based on favorable attributes is a key component to success. As pieces of the puzzle are identified and assembled, pieces that do not fit are contemplated until they can be satisfactorily resolved. It is always best to start with targets you understand, easy tests and “low-hanging fruit”, and accumulate more information on complex and theoretical targets. Before abandoning poorly mineralized districts, make sure the best environments for gold deposition have been considered and tested.

References Cited
Bright and early on a dark and rainy Monday morning at the 2021 American Institute of Professional Geologists National Conference, 15 Section Delegates gathered to share their geology heart stories.

The individual geoscience journeys were all uniquely different, but there were common gateways for all the meeting participants:

- Grade school exposure to outdoor exploration
- Introduction to geology by a passionate geoscience professor
- Invitation to a geology field trip or event

The delegates unanimously agreed to encourage their Sections to:

- Provide geoscience learning opportunities to their local elementary schools
- Provide recognition to teachers and professors that have inspired geoscience students
- Expand event invitations to non-member groups and individuals

The delegates also agreed to advise National to do the same. A couple of these geology heart stories are listed below:

Name: **Brent Smith**, VAP CP, WV LRS, PG
Licensed in Alabama, Indiana, Kentucky, and Texas
Section: Ohio
Company: Civil & Environmental Consultants, Inc.

“Growing up with an Engineer for a Dad I was fortunately exposed to a lot of Math and Science. My parents, seeking the best possible public education, enrolled me in various alternative learning schools with a focus on math and science. In high school, I enrolled in the Columbus Public Schools Battelle Youth Science Program, which was one of the first AP programs in the state. Through this I was exposed to advanced chemistry, physics, calculus, and computer science in high school.

Moving on to college, I knew I wanted to be a scientist, but was unsure of what field I wanted to go into. I didn’t really see myself as a physicist or chemist, so I declared a biology major just to have some direction. In spring of my freshman year, I enrolled in an Honors Program geology course taught by Dr. Kenneth Foland, a geologist specializing in isotope dat-

ing, among other things. In contrast to the normal “rocks for jocks” 101 courses most students are exposed to, Dr. Foland’s course and the accompanying textbook, Understanding Earth, presented a summary of all aspects of the geologic sciences. The possibilities of a career seemed endless and needless to say I was hooked. Through the following years the foundation of my career as an environmental geologist developed through courses on hydrogeology, environmental geology, and glacial geology, along with the normal geology curriculum.

Following receipt of my bachelor’s degree I was intent on working and was given a great opportunity to be a field geologist by a local engineering firm. I was fortunate to work on a wide variety of projects and within several state and federal regulatory programs in those earlier years, cutting my teeth on brownfield investigations, landfill groundwater monitoring projects, and more complicated RCRA projects. Now, 22 years later, I continue to be inspired and challenged by an ever-growing number of environmental projects. Now, my focus is to assist clients with the assessment, clean-up, and reuse of impair properties, also known as “brownfields”. Through this I am able to help repair the mistakes of prior industry and ensure that human health and the environment is protected in the process. While my job now involves so much more than geology (chemistry, statistics, business, to name a few) I never lost sight of my passion for understanding our beautiful planet and doing my part to protect it.”

**Christine Lilek, CPG-10195**
Name: **Jessica Davey**, AIPG MEM-3242  
M.S.-Global Energy Management, University of Colorado Denver  
B.S.-Applied Geology, Metropolitan State University of Denver  
Section: Colorado  
Company: Desert Mountain Energy Corporation

“I grew up in an entrepreneurial family and had a strong business foundation from an early age. I had always wanted to be a paleontologist and geologist from a very young age, which was most likely a result of growing up on the Front Range in Colorado. My parents influenced me to go into either business or medicine (their ideas of the only paths to success in life) when I graduated high school.

My mom and I owned a green building supply store in Denver, and she decided to retire. I chose not to buy her interest out and, with the support of my husband, I went back to college to earn my degree in geology. I graduated in 2016 with my B.S. in Applied Geology from Metropolitan State University of Denver and went on to graduate school, earning my M.S. in Global Energy Management from the University of Colorado’s Business School.

I was lucky to get a position with a petroleum consulting firm in Denver where I was immersed in international projects in a very fast paced environment. I recently was offered a position as Vice President of Land and Board of Directors with Desert Mountain Energy Corp., a startup helium operator, where I get to work on exciting exploration geology as well.

I look forward to continuing in my field of geology because I am passionate about providing energy in a responsible way to support U.S. energy independence.”

We would love to hear your HEART geology story. If you are interested in sharing, please email me at clilek5959@gmail.com.

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**Garbage In, Garbage Out**

**William J. Elliott, CPG-04194**

The point is, in this complex and ever-moving and changing surface of our Earth, it is important to remember that assumptions, conclusions, and recommendations are the responsibility of the human geologist/geomorphologist and not that of the digital computer.

Garbage in, Garbage out is a common slang expression in today’s modern digital world. When over-used, however, the meaning and intent of this phrase tends to lose its impact.


“Probably no one questions the need for more quantitative work in geomorphology. All science is becoming more quantitative and it is inevitable, as well as desirable, that this trend extend to geomorphology. *It should be kept in mind, however, that the conclusions drawn from mathematical calculations are no better than the data and assumptions upon which they are based.*” (Thornbury, 1969, p. 14). Emphasis is mine.

The last sentence is what caught my eye when I was browsing through looking for a section describing typical geomorphic features of landslide terrain/terrane. I struck out, but I thought it worth repeating the wisdom of those who have gone before us.

The point is, in this complex and ever-moving and changing surface of our Earth, it is important to remember that assumptions, conclusions, and recommendations are the responsibility of the human geologist/geomorphologist and not that of the digital computer. It is good to remember that our computers are nothing but tools to be used as an aid, not as an answer to complex questions that must be answered, usually without all the pieces of the puzzle, but with critical thinking.

**Reference**

My name is Grace Ojala, and I am currently a senior at Michigan Technological University pursuing dual bachelor’s degrees in Geophysics and Anthropology. At face value, it may seem to be a strange combination of degrees — one is a physical science while the other is a social science. However, the two intersect and complement each other in exciting ways within the discipline of archaeology.

Archaeology, a branch of anthropology, is the study of past human cultures by examining the material artifacts they have left behind—and usually, these artifacts are buried underground. Geophysics is the study of the Earth using the principles of physics, and it is used to learn about the structures and objects that are underground. The ability provided by geophysics to learn about what is under the Earth’s surface without excavation is revolutionizing archaeology.

One of the areas where geophysics is revolutionizing archaeology is in the branch of cemetery studies. To properly care for a cemetery, it is necessary to know who is buried in the cemetery, and where. However, older historic cemeteries may not have grave markers for every person buried in the cemetery. In some cases, any trace of a cemetery may no longer exist, or may have never existed. The problem then is, how to locate unmarked graves without trespassing into the ethically gray area of digging up human remains.

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GPR works by detecting contrasts in relative permittivity, also referred to as dielectric constant. If a person has been interred in a metal casket or with some other large metal artifact, GPR can easily detect the metallic object because it has an extremely high relative permittivity compared to the surrounding soil. GPR can also detect the air voids created by intact coffins or caskets, because air has a much lower relative permittivity compared to the surrounding soil. Even when the casket has collapsed and there is no longer a detectable air pocket, GPR can still detect the disturbance in the soil profile caused by the interment (Conyers, 2006). Overall, GPR is an efficient, high-resolution technique for locating unmarked burials.

This combination of efficiency and high-resolution results is why I chose to use GPR as a part of my senior capstone project mapping the Hecla Cemetery, a historic cemetery located in Calumet, Michigan. The Hecla Cemetery was established in the 1880s by the Calumet & Hecla Mining Company for the company’s Catholic workers. It was used by the company until 1900, when it was leased by the Sacred Heart Catholic Church until 1931. No one knows how many people were buried at the cemetery, but members of the Houghton-Keweenaw County Genealogical Society (HKCGS), the society that maintains the cemetery, have determined from various sources that at least 800 people were interred there. However, this is likely a low estimate. Adding to the uncertainty, a few families later moved some of the burials to a nearby cemetery, and again, the number of those moved is unknown (HKCGS, 2021). Overall, an accurate number of people buried at the cemetery is not available, and estimates are a rough approximation at best.

Many of the grave markers once in the cemetery have disappeared, having been lost to undergrowth or destroyed by vandals. Because the last traces of the burials are disappearing, the HKCGS feels a sense of urgency for determining the locations of burials within the cemetery. At the least, they would like to mark the locations of those interred there, even if their names and stories are unknown. This project of mapping the cemetery and locating burials within the cemetery is the focus of my senior project.

The first part of the project has involved mapping the cemetery with Ruth Gleckler, a member of the HKCGS, using...
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Thank you.

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Craig Savage, CPG-8052

MY wife, Brooke, and I love to go bass fishing. We’ve been on nearly all the publicly accessible lakes in Oakland County, and have made special trips to several great Michigan fisheries, including Lake St. Claire, Long Lake near Alpena, and Mullet Lake near Cheboygan. All in search of catching a “personal best” or PB.

We take turns having the better day, with her besting on the largest smallmouth bass, crappie, and walleye, and me besting her on largest largemouth bass, northern pike, and bowfin. We are in the summer to fall transition now, and the fishing is wildly variable – on Labor Day weekend, we caught 30-40 fish on Saturday and only 4-5 between us on Monday. This past Sunday we headed out to our home waters, Commerce Lake in Commerce Twp. The morning temperatures were cool but promised to warm to 82 degrees by afternoon. I decided to wear a long white sleeve sun-blocking fishing shirt with black and yellow design features. These shirts provide a little warmth but are thin enough to breath and allow cooling even in warmer weather. Always the sharp-dressed man, I needed a hat that matched my ensemble. My normal go to hats didn’t make the grade – a Red Stripe hat from Jamaica, a dark green hat with a fish skeleton on it, a blue camo American flag hat, a blue trout fishing hat, etc. Then I came across the black, yellow, and white AIPG hat sitting at the bottom of the stack. Hmmm...almost a perfect match. I tried it on, and Brooke said I looked “cute,” so my decision was made. After all, you can’t look like a bum when getting fish slime all over yourself.

We set out and an unusual thing happened...I caught the first fish. It wasn’t big, but Brooke almost always catches the first fish and I come on strong later in the day. Today was different. I started hauling in fish after fish at regul-
global positioning system (GPS) technology to record the locations of grave markers such as headstones, base stones, and sunken grave shafts. I have imported these GPS coordinates into an online map along with pictures of the grave markers and transcriptions of the headstone inscriptions. The resulting product is a map of all of the known grave markers, with pictures of each marker as well as archival material collected by the HKCGS linked directly to each point on the map.

However, this step only addresses known burials. But what about unknown burials, those lost to time? That is where GPR comes in. Under the direction of Dr. Tim Scarlett, a professor of archaeology and anthropology at Michigan Tech, I have performed two GPR surveys at the Hecla Cemetery using a Sensors & Software Noggin GPR system with a center frequency of 500 megahertz. The first survey was in an area that was strongly suspected to contain unmarked burials. The second was in an area less likely to contain burials, but one which is a high-traffic area for pedestrians.

The first survey, an 8 by 10-meter grid with traverse lines every 0.2 meters, was completed in June 2021. It revealed one GPR anomaly that is very suggestive of an unmarked burial, given its depth (six feet below the surface) and orientation (long axis is oriented east-west). A second anomaly is also suggestive of being one or more burials given its depth (about four and a half feet deep) and large size. Finally, GPR has located an anomaly that is very close to the surface (within a foot) that may indicate buried headstones.

The second survey, an 8 by 12-meter grid also with traverse lines every 0.2 meters, was completed in October 2021, and the data is still being analyzed. However, the final map of the Hecla Cemetery will include imagery from both GPR surveys, so that the locations of known burials can be compared with the GPR results. This overlay may provide clues about the spatial arrangement of the cemetery, which would further indicate where more unmarked burials are located.

Further work is needed to validate the initial GPR results, including performing a GPR survey in an area known to have burials. Doing such a survey would provide a model for comparing the results from a known burial with a suspected burial. Additionally, collecting more archival material, such as a plot map of the cemetery, would be valuable for matching GPR results with burials.

Overall, an initial GPR survey of only a small portion of the Hecla Cemetery has proven that GPR is both useful and effective for locating unmarked burials at this cemetery. There is potential for many more unmarked burials to be found, all without having to perform any actual excavation. Even in this small cemetery, GPR, a geophysical technique, is greatly improving archaeological outcomes and is aiding in preserving this historic cemetery.

References
Understanding the Need for Injection Wells in the United States: The Challenges Faced and the Avenue to Success

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Abstract

With the world-wide movement forward to reduce carbon emissions through carbon capture, utilization, and storage, the injection of carbon dioxide (CO₂) into the subsurface will continue to strengthen the need for Class VI injection wells. Additionally, the need for both Class I and Class II injection wells will continue to be one of the safest and most environmentally friendly methods for disposing of billions of gallons of industrial and oilfield fluid wastes.

Site selection, geologic characterization, and area of review evaluation all need to be undertaken prior to submittal of any application for a Class I, Class II, or Class VI injection well. Proper evaluation and assessment of these factors can dramatically reduce problems that may arise later in the application process that could potentially impact or deny an injection well project.

A number of regulatory and technical challenges face an applicant looking to drill and complete a Class I, Class II, or Class VI injection well. These challenges can include changes in regulations or guidance on the state or federal level that increase the time frames for issuance of an injection permit and the technical issues such as injection-induced seismicity that can require additional technical assessment and submittal of additional technical data to alleviate the risk of seismic activity.

Injection wells will continue to be a viable, economic, and environmentally sound method of disposal of wastes from the environment and protection of groundwater. With the increased interest in carbon sequestration and government incentives such as the carbon tax credits, Class VI injection will continue to grow in the future as a viable method for elimination of excess carbon dioxide from the environment.

Keywords: Carbon Capture, Utilization, and Storage; Class I Injection Wells; Class II Injection Wells; Class VI Injection Wells; Geosequestration; Injection Wells; Underground Injection

Introduction

With the world-wide movement forward to reduce carbon emissions through geosequestration, injection of carbon dioxide (CO₂) for storage will continue to strengthen the need for injection wells. Additionally, injection wells will remain as one of the safest and environmentally sound method for disposing of industrial and oilfield fluid wastes. In particular, the removal of Per- and Polyfluoroalkyl Substances (PFAS) from the environment and the geologic sequestration of carbon dioxide (CO₂) from the atmosphere through injection into the subsurface will continue to be a priority in the U.S. for years to come. Injection of these wastes into the subsurface for disposal or storage will continue to be a critical link in safely eliminating these wastes from the environment.

U.S. EPA divides injection wells into six different classes. Injection well classification ranges from Class I to Class VI.

- Class I – Industrial and Municipal Waste Disposal
- Class II – Oil and Natural Gas Waste and Enhanced Oil Recovery
- Class III – Solution Mining of Minerals
- Class IV – Shallow Hazardous and Radioactive Injection Wells (BANNED)
- Class V – Non-hazardous Fluid injection into or above Underground Sources of Drinking Water (USDWs)
- Class VI – Geologic CO₂ Sequestration

According to U.S. EPA’s 2019 state and tribal lands Class I through Class VI injection well inventories, there is a total of 741,702 injection wells in the United States (U.S. EPA 2020). This paper will focus primarily on the Class I, Class II, and Class VI injection wells. These types of injection wells allow for the disposal of billions of gallons of wastes thousands of feet below the ground surface for geologic isolation with multiple layers of steel casing and cement to ensure protection of drinking and ground waters in a safe and environmentally sound method.

History of Underground Injection

The initial use of injection wells in the United States began in the 1930s to dispose of the brine (“saltwater”) produced as a byproduct of the oil and gas industry or to re-inject fluids or gas into depleted oil reservoirs for secondary oil recovery operations. By the 1950s, the chemical industry used injection wells for the disposal of industrial waste to remove these wastes from the surface waters and the environment. In the mid-2000s, interest was renewed in injection as a viable method for the permanent storage of CO₂ deep within the subsurface, a practice referred to as geosequestration.

Today, there are projects developed around the world for carbon capture, utilization, and storage (CCUS) and these injection projects are primarily regulated in the United States by the U.S. Environmental Protection Agency (U.S. EPA) as Class VI injection wells. Class VI injection is a viable method being utilized to help reduce CO₂ within the environment by injecting millions of metric tons of CO₂ into the subsurface for storage. With the recent release of their PFAS updated action plan, U.S. EPA is making aggressive and unprecedented efforts to address PFAS in the environment. The U.S. EPA regulates the injection of PFAS as Class I injection. Class I injection is an environmentally sound method for removing PFAS from the surface environment and injecting it thousands of feet below the surface for disposal.
Class VI injection wells are used exclusively for the geosequestration of CO₂ and this new classification of injection wells was established by U.S. EPA in December of 2010. The Class VI rules established minimum technical criteria to protect USDWs from the long-term subsurface storage of CO₂. North Dakota received primacy of its Class VI program in April of 2018 and several other states are currently pursuing Class VI primacy. The Department of the Treasury, Internal Revenue Service (IRS) implemented Section 45Q within the tax code on October 3, 2008, under Section 115 of Division B of the Energy Improvement and Extension Act of 2008 to provide a tax credit for CO₂ geosequestration. On June 2, 2020, the IRS issued a notice of proposed rulemaking in the Federal Register for setting regulations for the sequestration of CO₂ (Federal Register 2020). Currently, 45Q allows for a CO₂ tax credit for enhanced oil recovery storage tax of $35/ton and a CO₂ tax credit of $50/ton for saline reservoir storage.

**Site Selection, Geologic Characterization, and Area of Review Evaluation**

Site selection and geologic evaluation and assessment are critical components in the development of a successful injection well project and should be completed at the initiation of the project. Selection of the optimal location, identifying higher capacity geologic reservoirs, and performing a preliminary area of review (AOR) evaluation are critical steps prior to the application process.

Site selection for commercial injection wells typically requires a viable road network for easy site access for trucking of the waste fluids. So ideally, proximity to state highways or interstate highways is essential for commercial disposal operations. Additionally, the site must be chosen based on regulatory setbacks that dictate required distances from various environmental receptors such as streams, water bodies, wetlands, and water wells; known archaeological sites; and other improvements such as existing disposal wells, residential structures, or public and commercial buildings. As such, avoidance of densely populated areas is recommended.

Knowledge of local geologic conditions and regional changes in geology is very important in selecting the optimal injection interval. Typically, geologic
characterization involves review and assessment of existing open hole geophysical logs and well records to clearly identify potential injection intervals and confining layers so as to ensure that injected fluids are confined to the permitted injection intervals. Figure 3 (page 19) is a snip from an open hole geophysical log, which includes a gamma ray, compensated density-neutron, and resistivity tools, that is used to perform a geologic assessment of a potential injection interval. Additionally, the presence of non-permeable confining zones (which serve as barrier to fluid flow) both above and below the injection interval is required to ensure that injected fluids are confined to the permitted injection interval and prevent migration of injectate into USDWs. Regional or site-specific geologic factors, such as karst geology or deep USDWs, may be present and such scenarios require additional engineering controls to mitigate the associated risks.

A preliminary AOR assessment determines if there are other wells within the AOR that penetrate into or through the proposed injection interval and might provide a conduit for injected materials to migrate out of the permitted injection interval. This AOR evaluation is critical in determining the viability of an injection well project. An AOR for Class II injection wells can have a fixed 1/4- to 1-mile radius around the proposed Class II well location or require a calculated AOR based on the zone of endangering influence (ZOEI). The AOR of a Class I injection well can be based on a fixed radius or on a ZOEI calculation. For Class VI injection wells, the AOR delineation approach involves a computational/numerical modeling effort that appropriately represents the area in which USDWs may be endangered by injection operations, as specified by the Class VI rule requirements (U.S. EPA 2018). Defining the AOR then allows for the determination of any existing well penetrations within the AOR that might require corrective action to ensure injection fluids cannot migrate out of zone and potentially contaminate the USDWs. Corrective action can be accomplished by several different methods:

- Remedial cementing of existing wells,
- Monitoring of problem wells—more frequent testing, visual observations, or a systematic monitoring program,
- Plugging or re-opening and re-plugging of inadequately plugged wells, and
- Submittal of a corrective action plan prior to commencement of injection operations.

**Regulatory and Technical Challenges**

There are a number of regulatory and technical challenges facing an applicant wanting to permit a Class I, Class II, or Class VI injection well. Some states do not have primacy of their UIC program, so the initial application process would be through a U.S. EPA regional office. However, even in those states without primacy, it is likely that some type of an additional application process and permitting through a state agency will also be required. In a situation where a proposed oil and natural gas injection well is proposed on federal land, a second application process through BLM will be required.

Permitting challenges associated with Class I, Class II, and Class VI injection wells can include the following:

- An applicant may need to address permitting and regulatory requirements with multiple federal and state agencies;
- The loss of in-house experience and technical expertise in state and federal regulatory programs has led to longer lag times in permit reviews and permit issuance; and
- Changes to regulatory requirements and the addition of new regulations and guidance can lead to additional technical challenges and concerns for an applicant.

In addition, some regulatory concerns require specific technical considerations.
that need to be addressed. Those may include the following:

- Seismic Concerns: The term “induced seismicity” is defined as seismic events associated with man-made activities such as surface and underground mining, geothermal energy, oil and gas operations, dams and artificial lakes, underground nuclear tests, groundwater extraction, and underground injection (Tomastik and Arthur, 2015). The majority of injection wells in the U.S. do not pose a hazard for induced seismicity; however, injection-induced seismicity has been known to occur when critically stressed and optimally oriented faults slip due to changes in pore pressure or subsurface loading effects from injection operations (StatesFirst 2017). These injection-induced seismic events occur predominantly within the Precambrian basement rocks. Based on these concerns, the best practice is to avoid injecting into or near these critically stressed basement faults or injecting into reservoirs directly in contact with the Precambrian basement where these faults exist. In attempts to mitigate risks of injection-induced seismicity, both the states and the Federal government have established additional regulatory requirements to address injection-induced seismicity, including the following:
  - Performing seismic risk assessment as a part of the application process;
  - Reducing injection rates and maximum allowable surface injection pressures;
  - Seismic monitoring and mitigation planning;
  - Performing Fault Slip Potential (FSP) Analysis; and
  - Conducting additional downhole testing such as advanced geophysical logging, modeling, step-rate testing, and pressure fall-off testing and analysis.

- Well Interference: Typically, Class IID injection wells are spaced far enough apart to prevent well interference and buildup of the pore pressure within the injection interval reservoir. Class I injection wells are normally spaced close together as they are commonly associated with an industrial facility and not a commercial operation, so they typically do not inject large volumes of fluid or have pore pressure buildup issues. Class VI injection wells are the newest injection well type and injection of large volumes of CO₂ for CCUS will require a large area in comparison to CO₂ injection for enhanced oil recovery. The competition for the pore space between these types of injection wells will become more critical of an issue as new development of areas for CCUS and Class I disposal continues to increase.

- Mineral Rights: Mineral rights issues can complicate injection well planning and title of the proposed injection site needs to be thoroughly researched prior to commencement of a project.

- Enhanced Preliminary Assessments: Class I and Class VI injection wells already required enhanced geologic assessments and increased area of review evaluations, but Class IID injection well applications in some states are now seeing expanded requirements for detailed geologic investigations, enlarged area of reviews, and oil and gas production evaluations to protect correlative rights issues.

- Injection-Induced Seismicity: Additionally, some state primary programs have implemented changes to well construction and design to Class IID injection wells to further protect USDWs and to help alleviate potential injection-induced seismicity.

- Public and Media Concerns: Public and media concerns regarding injection wells across the U.S. continue to increase and an applicant should anticipate protests that can lead to public hearings and even civil litigation.

Summary and Conclusions

Class I, Class II, and Class VI injection wells will continue to be needed as a viable, economic, and environmentally sound method of disposal of billions of gallons of wastes from the environment, and for the protection of USDWs. Continued changes in regulatory requirements and guidance results in additional technical challenges that an applicant will face in permitting these types of injection wells in the U.S. With the recent concerns about PFAS in the environment and the need to eliminate it from the surface and groundwaters of the U.S., Class I injection will be one of the viable solutions in the disposal of PFAS wastes now and into the future. With the increased interest in carbon sequestration and government incentives such as the carbon tax credits, Class VI injection will continue to grow in the future as a viable method for elimination of excess CO₂ from the environment.

References


Geology in the Forest Service: A Rewarding Career Path

Sabrina M. Kohrt, Limaris R. Soto, Mark R. Nelson - CPG-9698

Abstract
The US Department of Agriculture Forest Service (Forest Service) minerals and geology program encompasses various geological sub-disciplines under a larger umbrella. Experts within the minerals and geology program strive to provide professional advice across all levels of the Agency to ensure — in collaboration with counterpart agencies — that current and future generations of Americans have access to mineral and geological resources foundational to infrastructure, safety, scientific advancements, technology, and other social needs. In all its work, program staff promote environmental stewardship and ecosystem management to sustain the viability and productivity of National Forest System (NFS) lands.

Forest Service geologists work at all levels of the organization, from remote district offices located on National Forests across the country to Forest Service Headquarters in Washington, DC. Forest Service geologists conduct the following types of work:

- Geological resources, hazards, and services
- Leasable resources and reserved and outstanding rights
- Locatable minerals, salable minerals, and abandoned mine lands
- Interdisciplinary environmental analyses in support of forest and project planning

The Forest Service minerals and geology program upholds the larger mission of the Forest Service, which is to sustain the health, diversity, and productivity of the nation’s forests and grasslands to meet the needs of present and future generations. The Forest Service manages 193 million acres of public lands in the United States spanning from Maine to California, Alaska, and Puerto Rico. About 150 geologists are employed in the Forest Service, and their work varies based on the needs of the specific national forest or national grassland and the type of mineral, energy, or geological resources present. The Forest Service is an agency of approximately 30,000 employees situated within the United States Department of Agriculture. The work of the Forest Service has evolved since the agency’s inception in 1905, however, our work continues to reflect the aspiration of the first Forest Service Chief, Gifford Pinchot, to manage the national forests for “the greatest good to the greatest number of people for the longest time.”

Numerous opportunities are available for students to explore a geology career in the Forest Service. These opportunities include the GeoCorps America Program, a public-private partnership between the Geological Society of America and federal government agencies including the Forest Service, and internship opportunities through the Forest Service Resource Assistants Program and the USDA Pathways Program.

Geological Resources, Hazards, and Services
Forest Service geologists administer and protect geological resources and assess geological hazards on NFS lands. Geological resources are natural features or areas with unique geological attributes that support multiple uses of NFS lands and/or provide important scientific and educational value. Active management of such geological resources is merited to preserve their values as significant landscape elements held by the agency in the public trust. Geological resources directly and indirectly support recreation, watershed sustainability, and sensitive ecosystems. These include cave and karst features, groundwater, and paleontological resources, among others. Geological hazards are hazardous phenomena of natural origin that arise from geological conditions or processes such as...
landslides, rock falls, debris flows, avalanches, floods, earthquakes, volcanoes, tsunamis, land subsidence, and naturally occurring hazardous minerals and gases such as asbestos and radon that have the potential to impact human health, safety, and infrastructure.

Laws and regulations require special designation, management, and/or protection of geological resources such as groundwater, caves, and paleontological sites. More than 2,300 caves have been designated as significant, more than 90,000 sensitive groundwater dependent ecosystems (GDEs) have been inventoried, greater than 1,000 areas with other designated significant geological features have been identified, and nearly 1,000 paleontological resource sites have been inventoried on NFS lands. These diverse resources are distributed across the nation on every national forest and grassland. These resources are managed to protect their cultural, educational, scientific, recreational values, and to protect and enhance groundwater resources to maintain the availability of water for people and ecosystems. During 2021, Forest Service geologists conducted management activities addressing almost 700 geological resources and over 200 geological hazards.

**Leasable Resources and Reserved and Outstanding Rights**

On national forests and grasslands with leasable resources or reserved and outstanding rights, Forest Service geologists administer mineral development and reclamation in accordance with laws, regulations, and agency policy. Leasable minerals include federally owned oil, gas, geothermal resources, coal, and phosphate. Leasable minerals also include hardrock minerals such as copper and lead, where they occur on acquired NFS lands. Forest Service geologists work closely with the Bureau of Land Management in managing leasable resources. Reserved and outstanding rights occur on lands with federal surface estate and private, or non-federal mineral estate. Much of the NFS land in the eastern United States was acquired by the federal government under the Weeks Act of 1911. On many of these lands, the federal government acquired only the surface estate whereas the underlying mineral estate remains in private ownership. On NFS lands with reserved and outstanding rights, the owner of the mineral estate has a right to develop their minerals as long as they comply with applicable requirements for protection of the surface.

Roughly 4 million acres of NFS lands (about 2%) are leased for oil and gas, coal, geothermal energy, or other mineral commodities, which ultimately contributes approximately $5 billion per year to the nation’s economy. Leasable and reserved and outstanding mineral development on NFS lands supports rural economies and contributes to our country’s energy needs. During 2021, the Forest Service administered 2,300 existing and proposed leasable mineral operations (mostly oil and gas) along with almost 1,000 reserved and outstanding mineral operations.
CAREER PATHS - US FORESTRY SERVICE

Locatable Minerals, Salable Minerals & Abandoned Mine Lands

Many NFS lands in the western United States are open to mineral entry under the General Mining Law of 1872. These lands are open to prospecting, exploration, and development of locatable minerals. Although amended significantly over its history, the General Mining Law has been in effect for almost 150 years. Mining activities conducted under the General Mining Law have supported development of many of the major mineral producing districts in the United States both from the perspective of providing metals to support our country’s growing infrastructure, manufacturing base, and defense, and supporting population and development of the western United States. However, these mining activities also caused an environmental legacy of tens of thousands of abandoned mines on NFS lands, particularly at mines that were developed prior to the advent of modern mine reclamation and environmental laws.

Forest Service geologists work to administer and manage current and proposed locatable minerals development on NFS lands in accordance with modern mine reclamation and environmental laws. This work includes detailed evaluation of proposals submitted by project proponents, interdisciplinary analysis of the likely effects of mining on the environment, calculation and administration of mine reclamation bonds, and compliance inspection and permit administration during mine exploration, development, production, and reclamation.

NFS lands host important deposits of critical minerals necessary to support alternative energy development and modern communications and defense technologies such as rare earth elements, cobalt, platinum group metals, antimony, tungsten, uranium, and vanadium. NFS lands also host important deposits of copper, lead, zinc, gold, silver, copper, and molybdenum, which are widely consumed in the United States. During 2021, the Forest Service administered 1,500 existing and proposed locatable minerals operations.

Salable minerals are another category of geological materials that are widely produced from NFS lands located across the United States. Salable minerals are common variety rocks and minerals that are used for construction materials, agricultural amendments, and other uses. Examples include road gravel, aggregate for use in concrete, riprap used for erosion control, landscape rock, building facia, and soil conditioners and amendments used in agriculture. Forest Service geologists evaluate and administer salable mineral production to support needs of other government agencies, commercial users, the public, and “in-service” use maintaining Forest Service roads across the country. The Forest Service administered approximately 1,200 new and existing contracts for salable minerals in 2021.

Forest Service geologists also participate in evaluation and reclamation of abandoned mines including mines developed in accordance with the General Mining Law and other types of abandoned mines. In the western United States, abandoned metal mines developed under the General Mining Law are more common, whereas abandoned coal mines are more common on NFS lands in the eastern United States. Both physical hazards such as open adits, shafts and legacy surface infrastructure, and environmental hazards such as metals contamination, acid rock drainage, and radiological hazards are present on NFS lands. The Forest Service operates an Abandoned Mine Land (AML) safety closure program, which addresses physical hazards on abandoned mine lands, and a program that remediates environmental hazards associated with abandoned mines in accordance with the federal Comprehensive Environmental Response, Compensation and Liability Act. During 2021, the Forest Service mitigated 185 AML sites.

Interdisciplinary Environmental Analyses in Support of Forest and Project Planning

The Forest Service manages each national forest or national grassland in accordance with a management plan, and the Forest Service conducts environmental analyses prior to conducting or approving projects on national Forest Service lands. Management Plans are developed in accordance with the National Forest Management Act (NFMA) of 1976 and project environmental analyses are conducted in accordance with the National Environmental Policy Act (NEPA) of 1969. Both NFMA and NEPA require that planning and environmental analyses utilize an interdisciplinary process.

Most Forest Service geologists participate on interdisciplinary teams assessing the potential effect of proposed plans or projects on the environment. For example, during environmental analysis of a proposed timber sale, a Forest Service geologist may analyze the potential effects of road construc-
tion on slope stability, the effects of timber removal on GDEs such as springs and fens, or the effect of the proposed project on mineral resource production. During forest planning, the geologist’s role on the interdisciplinary team may be to analyze the distribution of geological resources within the forest, and to evaluate the effects of various proposed prescriptions for forest management on those resources. The opportunity to participate on interdisciplinary teams contributing to forest, grassland, and project planning is an interesting and rewarding aspect of Forest Service geologist’s work.

Geology and Minerals Training Office

As the previous sections illustrate, the work of Forest Service geologists is varied, and Forest Service geologists require a broad knowledge of both geological processes and the regulatory context in which that knowledge is applied. The Forest Service operates a training program to supplement the knowledge that students learn at a college or university with additional information required to excel in management and administration of geological resources, hazards, and services; leasable resources and reserved and outstanding rights; locatable minerals, salable minerals and abandoned mine lands; and interdisciplinary environmental analyses in support of forest and project planning.

The Geology and Minerals Training Office (GMTO) works in partnership with subject matter experts from the Forest Service and partner agencies to deliver training addressing all programs administered by the Forest Service minerals and geology program. GMTO delivers both in-person and blended learning opportunities for employees including webinars, instructor training, classroom lectures, and field visits to sites such as oil and gas wells, areas of reclamation, caves, geologic hazards, areas affected by wildfire, and abandoned mines.

Interested in a Career as a Forest Service Geologist?

There are many opportunities to get involved with the minerals and geology program and the Forest Service. The information presented below are opportunities to start a career with the federal government.

GeoCorps

The GeoCorps America Program is a public-private partnership between the Geological Society of America (GSA) and federal government agencies including the Forest Service that operates through official agency agreements. The program places all levels of geoscientists – with a focus on students, recent graduates, and underrepresented groups in the sciences – into temporary positions on public lands throughout the United States. The GeoCorps America Program offers paid ($15/hour), cost-efficient summer opportunities to emerging geoscientists that leverage agency capacity to conduct geologic work.

Since 2000, the GeoCorps program has partnered with the Forest Service through its Minerals and Geology Management program to support geoscience-related projects on national forests, grasslands, and offices with over 350 participants fulfilling critical research needs. The GeoCorps Program is an effective way of providing scientific expertise and innovative solutions for managing geologic resources. The project areas include geoscience and related subjects such as geology, hydrology, geologic hazards, paleontology, speleology, cartography and GIS, soils, and many others. Projects can last from 10 weeks to 52 weeks, but most projects last 12 weeks during the summer. Positions for the summer of 2022 will be advertised between December 1, 2021 and February 2, 2022; visit the GeoCorps homepage at: www.geosociety.org/geocorps.

Examples of GeoCorps projects include: 1) assisting in an ongoing spring inventory and monitoring project to verify the map locations of developed and undeveloped springs and reservoirs on active grazing allotments of one of the national forests and 2) Using LiDAR data analysis to effectively map karst features and provide guidance for buffers around caves, sinkholes, and springs on national forests.

Students and recent graduates who are interested in participating in GeoCorps America may apply online at www.geosociety.org/geocorps between December 1, 2021, and February 2, 2022. For questions about the program, contact Lima Soto at limaris.soto@usda.gov or Matt Dawson at mdawson@geosociety.org.

Internships

Resource Assistants Program

There are many opportunities for internships with the Forest Service. The Forest Service offers a Resource Assistants Program (RAP) which is a paid internship that offers real world experience and application in the fields of conservation, natural and cultural resources, environmental management, and
lar time intervals. Brooke, on the other hand, was struggling, even though we were in the same boat, using the same gear and baits (Ned rigs), and fishing the same structures and drop-offs. While I was steadily reeling them in, none were bigger than about 1.5 pounds. Then, 1-2 hours into our outing, I made a cast to a weedy drop off and almost immediately felt the violent tug on the line that let me know a monster was attached to the other end. I saw the brief flash of the creature’s broadside through the clear water, and it looked too big to be a bass. My first thought was “uh oh, I caught a pike or snagged a turtle or carp, and my line is going to break off.” As I fought the beast and got it closer to the boat, I saw it was indeed a bass, but a smallmouth rather than the largemouth I’d been catching all day to that point. After a prolonged battle, I was able to get the fish close to the boat and Brooke dutifully netted it for me. It was a huge fish by our standards - prior to this day, the biggest smallmouth we’d caught were in the 3.5-pound range, and those were in big lakes known for being great smallmouth fisheries. This fish was 20-inches end to end and weighed 3 pounds, 13 oz., a personal best for me and a little bigger than Brooke’s largest catch.

We went on to fish another couple of hours with me catching more large-mouth bass and Brooke continuing to struggle. I probably caught 20 fish that day. We were using the same baits, the same hooks, similar fishing line and rod/real combos, and the same techniques. One would think that we would have similar success on any given day, but I had the better outing by a long shot on this day. The only difference that makes any sense to me is…the hat. If you are going to go fishing, and want to have a great outing, make sure to wear an AIPG hat, T-Shirt, or sweatshirt. They are fish magnets and are available at the AIPG Store. Go to https://aipg.org/store/ListProducts.aspx?catid=720476&ftr= to see what is currently available.

The program includes mentoring from Forest Service staff, a paid weekly stipend that offers housing and travel, health insurance, and eligibility for RAP direct hire authority and noncompetitive hiring eligibility for two years after successful completion of the program. The direct hire authority gives the participant the ability to compete for Forest Service jobs against those that have special hiring authority or are already a Forest Service employee. Each participant must complete 960 hours of satisfactory service and obtain an associate degree or higher to become eligible for the hiring authority.

USDA Pathways Program

Pathways is a paid employment program that offers different kinds of opportunities for students and recent graduates. There are three pathways programs in the USDA: The Internship Program, Recent Graduate Program, and Presidential Management Fellows Program. The internship program offers paid work experience for students in high school or an accredited college or university. To apply, visit usda.usajobs.gov and type “Student Trainee” in the search tab. Create a USAJOBS account and then sign up for notifications on the jobs of your interest. All applications are accepted through USAJOBS.

The Pathways Recent Graduate Program is for those who have recently graduated from an accredited college or university. Chosen applicants will be placed in a one-year career development program. Program applicants who successfully complete the Pathways Program may be eligible for temporary or permanent service jobs. The applicant must apply two years from the date educational requirements are completed.

The third program that Pathways offers is the Presidential Management Fellows Program. This program provides leadership development for pre-qualified applicants. This highly competitive program provides a two-year appointment with the USDA with eligibility for permanent hire after completion of the program. For more information, visit pmf.gov.

Conclusions

Being a part of the Forest Service minerals and geology program contributes to the sustainable development of geological and mineral resources and stewardship of the environment. Our work contributes to the national mineral supply chain, provides critical minerals needed for alternative energy and modern technology, protects clean water for people and healthy ecosystems, promotes public safety by identifying and managing geological hazards, supports recreational use and research of caves and karst, and preserves the rich history of paleontological resources. The Forest Service recruits well-educated, talented, and passionate geologists to fulfill these duties and support wider Forest Service goals of promoting diversity, equity, and inclusion, and mitigating the effects of climate change. As a Forest Service geologist, you will sharpen your problem-solving skills and navigate difficult questions both in minerals and geology and the agency’s role within it. Both daily work and long-term projects are vital, meaningful, and impactful in sustaining the health and diversity of our nation’s forests and grasslands. Each position will vary but all connect to a web of opportunities for personal growth, training, professional and long-term career development, and contribution to the critical work of the Forest Service.

Browse Minerals and Geology related careers with the Forest Service at USAJOBS.gov.
In the Fall of 2021, in-person meetings resumed as the impacts of the global COVID pandemic began to ease. If the pandemic revealed anything to us, it is that geologists thrive when we are able to meet with other geologists, share a meal and/or a beverage, and make the connections with our colleagues that help us to sustain our personal and professional lives. Geologists, maybe more than most other professionals, thrive on interactions with our peers. We are at our best when we are with people.

In October 2021, AIPG hosted our first post-pandemic Annual Meeting. The meeting was a bit smaller than usual. We endured the ‘bomb cyclone’ and the ‘atmospheric river’ that dropped five inches of rain on Sacramento and forced changes to our field trips. Still, the meeting was a tremendous success, largely because of the people that put in the time, effort, and energy to pull everything together in spite of the uncertainty associated with the pandemic. People like the Organizing Committee, (Steve Baker, Jim Jacobs, Mehmet Pehlivan, Gary Pischke, Bill Motzer, Mark Rogers, Katrina Simms, and Danielle Torres) who met dozens of times and devoted themselves to building a meeting in the face of countless challenges. People like Cathy Duran and Wendy Davidson, who worked tirelessly with the host hotel to ensure that the meeting spaces were first-rate, and to organize the food, beverage, and lodging services that we have come to expect. People like AIPG President Nancy Wolverson, who kept a large group focused and on task, so that we were able to put our best foot forward.

Our ability to pull off this meeting is a testament to the skill, dedication, and focus of our people.

Our members are the strength of AIPG. We have members in every state and in more than 50 countries around the world. Our membership is broad, our areas of expertise are varied, and the importance of the role that AIPG members play in shaping the future of our profession cannot be overstated. What YOU do makes a difference. You are our best advertisement. You are our best tool to recruit the next generation of geologists to support AIPG.

Our primary focus this year and in the future is on increasing the membership of AIPG. You, our members, will play a critical role in meeting our membership goals. You can provide us with insight into the value of your membership. You can take a leadership role in AIPG and bring your experience and skill to the table to help us chart a path forward. You can recruit your colleagues or share the value of your AIPG membership with the decision makers in your company or with the movers and shakers in your field of practice. There are numerous ways to support and promote AIPG. I hope that each of you can find a way that works for you, and that you will help us continue to move AIPG forward.

Wishing you a great winter,

Aaron
I am writing this in November, having just distilled the lessons learned at the annual Executive Committee meeting and annual conference in Sacramento a few weeks ago. One of the key lessons learned in Sacramento was that there are many members willing to help and volunteer their time toward keeping an active, growing membership within AIPG and growing its diversity along the way.

As a member of this Institute for more than 30 years, I’ve witnessed many changes in the overall make-up of our membership. Some of them have certainly been for the better, while other changes rankle an old Luddite like me. While taking the good with the bad, we are forced to recognize the facts on the ground that society is changing and we must change with it. Across the board, various state sections reported low activity rates and low participation due to the pandemic. It is my hope that we can quickly put the pandemic in the rear view mirror and get on to the task at hand – growing our membership.

Membership

The slow drip of declining membership numbers has been ongoing for nearly a decade. Now is the time to fix that faucet and reverse that trend. We are all very fortunate that reversing that trend is actually a simple, straightforward matter involving skills and capabilities that we already possess as accomplished professionals. Communication is the key. Most of us work in companies, organizations or agencies that are populated with many other geologists. They may have similar backgrounds as you in terms of years of professional experience since graduation. Your cohort – the people who you work with professionally – are the very best people to extend a little outreach to and query them if they might have an interest in AIPG. We are not talking about selling timeshares here, so the discussion ought to be pretty relaxed.

One of the most frequent objections that I encounter is when an individual tells me she is already registered in (fill in the blank) state. That is a simple enough objection, but it tells you an awful lot about how that individual views their profession and their career path. Will their future clients always be in that state alone? Has registration at the state level allowed them to network with accomplished professionals from all over the country? Does that state registration allow them to mentor junior geos or perform community outreach in a substantive way? The answer is almost always ‘no’. My basic argument is that you will get out of your career what you put into it. You will reap what you sow.

Most employers encourage their employees to take continuing education courses and to grow themselves professionally however they can. Most employers will reimburse an individual willing to improve themselves and perhaps, more importantly, add new initials after their name. It is simple recognition of a willingness to stretch yourself professionally and grow above and beyond your current circumstances.

In communicating with our co-workers about the benefits of AIPG, it is best to shrink it down to a few key points – national accreditation and recognition, added professionalism, networking opportunities, field trips, travel. Those can be distilled into a two-minute ‘elevator pitch’ about ‘why AIPG?’. Those individuals interested in their career advancement are quick to respond favorably. I have witnessed it myself several times.

I know of several firms where each of the geologists working there is expected to become a CPG as soon as they are able.

The point to all of this ‘sales’ talk is that each of us is working in a ‘target rich’ environment every day when it comes to looking for new members. AIPG members work for all of the largest consulting firms in the nation, along with some rather large Federal agencies and State agencies. We don’t have to go wandering far afield to find geologists to join AIPG; they are right down the hall or around the corner from where we are working right now. I urge you to talk to your peers and put your ‘elevator pitch’ into your own words to reflect your own values.

I know of several firms where each of the geologists working there is expected to become a CPG as soon as they are able. They see the value in the added professionalism and it communicates a larger message to the public. Many of us manage groups or projects where there are a number of geologists working together. Creating a large group of in-house CPGs communicates an altogether different value system to the public and to the competition. Many, many years ago, I worked for a Novato, California-based environmental consulting firm that wanted all of their geologists registered in California just as soon as they met the criteria. The firm became national, then multi-national, but still prized their California registrations. Only a handful of us went on to become CPGs.

There is a national trend toward fuller employment for geologists and times are good for talking about career paths.

Continued on p. 35
1. This famous early-day geologist is known for his landmark work on ichthyological classification and glaciology:
   a) Charles Lyell.
   b) George Cuvier.
   c) Alfred Wegener.
   d) Louis Agassiz.
   e) Pepé le Pew.

2. This metal alloy is composed mainly of copper and zinc, with possible minor amounts of tin, lead and iron:
   a) Pewter.
   b) Bronze.
   c) Brass.
   d) 60/40 Solder.
   e) Alloy there, dude! I have metal teeth and I glitter when I smile....

3. One indicator of climate change throughout geologic time relates to the shells created by Neogloboquadrina pachyderma. Which statement below is correct?
   a) These marine, planktonic foraminifera develop shells that coil to the left in colder temperatures and to the right in warmer temperatures.
   b) These marine, planktonic foraminifera develop shells that coil to the right in colder temperatures and to the left in warmer temperatures.
   c) These marine, benthonic foraminifera develop shells that coil to the left in colder temperatures and to the right in warmer temperatures.
   d) These marine, benthonic foraminifera develop shells that coil to the right in colder temperatures and to the left in warmer temperatures.
   e) Dude, thinking about this question is making my brain shrivel and coil from left to right and right to left...

4. In your seismic interpretation work you identify a “bright spot.” What is the possible significance of this find?
   a) The NMO correction has not yet been applied in the seismic processing phase affecting the sharpness of the Fresnel Zone.
   b) You have possibly located a zone just above the crest of a porous reef.
   c) You have located a possible reservoir with a hydrocarbon-water contact.
   d) You must quickly put on your sunglasses to protect your eyes.
   e) You realize that the workday is quickly ending, so your mood is not so gloomy after all.

5. In geophysical and geo-mechanical applications the concepts of the gradient of a scalar field and the divergence of a vector field become important. We also now that the divergence of the gradient is the Laplacian \( \nabla^2 = \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2} \). In one dimension the Laplacian becomes \( \frac{\partial^2}{\partial x^2} \). If this value is zero \( \nabla^2 = \frac{\partial^2}{\partial x^2} = 0 \), then:
   a) The function is parabolic.
   b) The function is exponential.
   c) The function is linear.
   d) Dude, the function stinks as far as I am concerned.
   e) Dude, you have outdone yourself, again!
Unethical Submission of an Article to More than One Publication

Raphael Ketani, CPG-9003, wrote AIPG pointing out the publication of two similar articles with similar authors in early 2021 and asking “Is this situation ethical?” This topic discusses why the answer to Ketani’s question is “Yes.” The articles are:


Ethical issues

The AIPG Code of Ethics (2019) does not address publishing issues. On those infrequent occasions when publishing issues have arisen, AIPG has looked to the publishing ethics guidelines of GSA and the American Geophysical Union (AGU) (PE&P column 164, Oct. 2017). As a result of this case, Adam Heft (current) and John Berry (immediate past) AIPG Editors are drafting some publication guidelines for AIPG that will appear in a future edition of TPG.

The GSA’s Ethical Guidelines for Publication (Ethical Guidelines) contain the following points in Section 3.1

3. Authors and Co-authors

3.1. Manuscripts should contain original, new results, data, ideas and/or interpretations not previously published or under consideration for publication elsewhere (including electronic media and databases).

3.3. Authors should inform the Editor of related manuscripts under consideration elsewhere and provide copies if requested.

Both the GSA Today article and TPG article present new ideas or concepts for presenting a capstone undergraduate field course. Whether the articles constituted a scientific publication or informational news is debatable. A “journalistic” summary version of the manuscript was published as a press release issued on August 25, 2020 by the South Dakota School of Mines and Technology. A manuscript was sent to the Journal of Geoscience Education in August 2020 and about August 26th a response stated that the manuscript was “not up to the standards of a scientific research journal in its current form. … specifically citing a lack of outcomes and quantitative data to support effectiveness of the mode of instruction.”

“(1) The practical importance of the information in the article for those people who needed to start planning for field camps to be held this summer.

“(2) The urgency to get it out in time for people who could use the information to actually use it.

“(3) The fact that I received an undertaking that it would not be the same article as that to be published by GSA, although it would contain the same useful information.”

Berry would like it to “be on the record that I did not submit the article for peer review, and nor was it flagged in TPG as a ‘Peer Reviewed Article,’ which is our practice. And I also accept some responsibility for not asking to see what was submitted to GSA. In hindsight, I should have been more proactive in making sure this situation did not arise. If I had allowed [publication] to go ahead at all I would probably have lopped off a good bit of text and insisted that readers be directed for more detail to the forthcoming GSA article.” Berry did not see a copy of the GSA Today article prior to the initiation of this ethical inquiry in August 2021. Regardless of one’s opinion on the scientific versus informational news character of these articles, they contain new ideas or concepts warranting publication with the geoscience community.

Answers:

1. The answer is choice “d” or “Louis Agassiz” (1807-1873).

   Charles Lyell (1797-1875) is best known as the author of “Principles of Geology” and for his assertion that the Earth was shaped by the same natural processes still in operation today. Lyell’s view was termed “uniformitarianism” by the philosopher William Whewell.

   George Cuvier (1769-1832) is sometimes referred to as the “father of paleontology.” Cuvier is known for establishing extinction as a fact and for proposing that species now extinct had been wiped out by recurring, periodic catastrophic floods. He was, thus, a proponent of “catastrophism.”

   Alfred Wegener (1880-1930) is best known for the “theory of continental drift.”

   Pepé le Pew is the famous cartoon character or “la moufette amoureuse.”

2. The answer is choice “c” or “Brass.”

   Bronze is mainly copper with tin and possible minor amounts of zinc and lead.

   Pewter is mostly tin with possible minor amounts of copper, antimony and bismuth.

   A 60/40 Solder consists of 60% tin and 40% lead. The table below illustrates the approximate composition of these alloys:

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<th>Bronze</th>
<th>Brass</th>
<th>Pewter</th>
<th>60/40 Solder</th>
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<tbody>
<tr>
<td>Main elements</td>
<td>Cu ~ 56%</td>
<td>Cu ~ 87%</td>
<td>Sn ~ 85-99%</td>
<td>Sn ~ 60%</td>
</tr>
<tr>
<td>and weight %</td>
<td>Zn ~ 37%</td>
<td>Sn ~ 7%</td>
<td>Pb ~ 40%</td>
<td></td>
</tr>
<tr>
<td>Secondary elements</td>
<td>Sn ~ 2%</td>
<td>Zn ~ 4%</td>
<td>Cu, Sb, Bi</td>
<td></td>
</tr>
<tr>
<td>and % weight</td>
<td>Pb ~ 1%</td>
<td>Pb ~ 2%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fe ~ 1%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. The answer is choice “a” or “These marine, planktonic foraminifera develop shells that coil to the left in colder temperatures and to the right in warmer temperatures.”

   Foraminifera are single-celled, mostly marine animals. Most of the foraminifers live on or within the seafloor sediment (benthic). A smaller percentage float or drift in the water column at various depths (planktonic). Most foraminifers are less than 1 millimeter in size, but some can be as large as 20 millimeters. *Neogloboquadrina pachyderma* is a planktonic specimen and it is useful as a climate indicator.

4. The answer is choice “c” or “You have located a possible reservoir with a hydrocarbon-water contact.”

   Commonly, “bright spots” and “flat spots” are reflectors generated from contacts of petroleum bearing reservoirs over water-bearing zones. They are normally produced by gas-water contacts. Occasionally, they fail to reveal the presence of commercial deposits of hydrocarbons, since they may be ghosts of old fluid contacts. Flat spots result from rapid velocity increase as waves come out of a gas zone into a water-bearing zone. The flat spot appears as a high amplitude reflector or “bright spot.” By contrast, the reflecting horizon above the gas sand may show a polarity reversal.

   “Dim spots” occur when a positive reflector locally changes polarity. “Dim spots” may occur over the crest of porous reefs due to the lower velocity encountered.

   The statement as phrased in choice “a” does not make much sense (see below):

   NMO is a processing step to remove the time shift due to the offset between source and receiver. The process corrects the traces to zero offset. NMO is removed using “RMS” (root mean square) velocities.

   The “First Fresnel Zone” is defined as the portion of a reflector from which the reflected energy can reach a geophone within the first one-half wavelength of the first reflected energy. Contributions from this zone add constructively to produce the “reflection.” The radius of the “Fresnel Zone” is: 
   \[ R = (\lambda Z/2)^{1/2} = (VZ/2f)^{1/2} \]
   where \( \lambda \) is wavelength, \( Z \) is the vertical depth to the reflection point from the shot/receiver point, \( V \) is velocity and \( f \) is frequency.
Whether the two articles are considered to be substantially the same despite their differences also is debatable. The *GSA Today* article consists of 5,494 words including the abstract and references but not the title or authors’ names and affiliations. The *TPG* article consists of 1,522 words, has no abstract or references, and without the title, the authors’ names and affiliations, or the printed pull quote. But do the similarities between the two articles outweigh the obvious and substantial differences between them? The similarities between the articles and the timing of the submissions are sufficient to raise questions about the applicability of Ethical Guidelines 3.1 and 3.3. This is sufficient for an affirmative answer. Ethical conclusion: the submission of two very similar articles at the same time to different publications is at the very least a violation [of Ethical Guideline 3.3], at least in spirit.

Berry’s first two reasons for publishing the *TPG* article present an interesting ethical point. Does the practical importance of the articles’ information and need to disseminate that information widely and prior to an upcoming field camp season constitute an allowable violation of the rule against simultaneous publication? Bernard Gert’s *Common Morality: deciding what to do* describes the common moral rules which must be obeyed by all people with respect to all other people at all times. One such rule is “Do not cause pain.” However, as with all the moral rules, exceptions are morally allowed; for example, in this case, surgeons performing lifesaving or life-enhancing operations. Gert provides a series of questions that must be answered in order to identify a morally justified violation of a moral rule. Gert’s final question is “Are you willing to publicly acknowledge and accept the consequences of the violation?” Although AIPG knew of the submission to GSA, GSA was not informed the subsequent submission of a similar article to *AIPG* and should have been. One of the problems in this case is that not all the articles’ authors were talking to each other. Co-authors need to agree on where an article, or similar, related articles are published. As a general principle, the same or similar material should not be sent to more than one publisher at a time without disclosing this fact and the reasons therefore to all with whom a submission has been made or discussed. In this case, GSA Ethical Guidelines for Publication 3.1 and 3.3 were violated.

**Examples of the Publication of Similar Material that are not Ethical Violations**

Three situations present examples in which the publication of the same or similar material would not violate the GSA Ethical Guidelines for Publication. The first case was the Bringing the field to students during Covid-19 and beyond article published in the March-April GSA Today. This article was authored by someone independent of the authors of the articles discussed here. While it addresses field camp issues during Covid-19, the complete independence of the author(s) and their organizations is clear and GSA published them as separate, independent articles.

In the second case, consider a hypothetical series of articles submitted simultaneously reporting on the discovery of a new lagerstatten in Utah. The hypothetical titles of the articles are:

- Discovery of a Mid-Cretaceous Lagerstatten in Eastern Utah: general geology and structure
- Discovery of a Mid-Cretaceous Lagerstatten in Eastern Utah: descriptions and identification of the animals found
- Discovery of a Mid-Cretaceous Lagerstatten in Eastern Utah: bone taphonomy
- Discovery of a Mid-Cretaceous Lagerstatten in Eastern Utah: detailed stratigraphy

While these four articles are clearly related and will share some locational and other introductory material, the focus of each article differs. While some authors’ names may appear on the author list for more than one article, the order of their appearance will probably differ. The reference list in each article will likely contain references to the other articles. It is likely that these four articles would be submitted to the same publication, but this is not required. If different articles are submitted to different publications, all relevant publications should be informed of the fact (Guideline 3.3).

3. Ethical rules are like moral rules, but they are formally written down.

**Answers: (cont.)**

5. The answer is choice “c” or “The function is linear.” In one dimension the Laplacian is expressed as:

\[ \nabla^2 = \frac{\partial^2}{\partial x^2} \]

and corresponds to the curvature. Thus, when:

\[ \nabla^2 = \frac{\partial^2}{\partial x^2} = 0 \]

the function is linear and the value at the center of any interval is the average of its limits (or extremes). In 3-D if the Laplacian is zero

\[ \nabla^2 = \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2} = 0 \]

the function is harmonic. Harmonic functions are of great importance in our geophysical and geo-mechanical studies.
The third case involves the reprinting of articles. When articles are reprinted, the fact of reprinting is noted in the article and the permission of the original publisher must be obtained. Various professional organizations have published reprint volumes of significant papers on a particular topic originally published in the organization’s main journal, for example, the AAPG’s Reprint Series. And there is the wonderful collection, Adventures in Earth History: being a volume of significant writings from original sources on cosmology, geology, climatology, oceanography, organic evolution, and related topics of interest to students of Earth history from the time of Nicolas Steno to the present, selected, edited, and with introductions by Preston Cloud: 1970, W.H. Freeman and Company, 992 p., a collection of 83 foundational papers.

Lone worker field work safety—Daniel Robinson

Field work safety has been the subject of several PE&P columns: 113 (Jan ’08), 115, 116, 162, and specifically lone worker safety in the July 2020 TPG with Phil Reimer’s article, Safety of lone field workers in the urban environment, and PE&P column 175. The Gabby Petito missing person case in September raised complaints that only blonde, blue-eyed, Helen of Troy-type victims draw national attention while missing persons of color or Native Americans are ignored.

The case of Daniel Robinson, a hydrologist with Matrix New World Engineering of Tempe, AZ, for the past 2-3 years was a highlighted example of an ignored missing person of color in the national news in late September. Robinson has been missing since June 23, 2021. On July 21st a rancher found Robinson’s Jeep rolled over and on its side in a ravine. The officials said Robinson’s cell phone, wallet, keys, and some clothes were found at the scene. A private investigator hired by Robinson’s father noted that the airbag controller module (ACM) showed the airbags in the vehicle were deployed in the moment it was an accident, another person had been able to summon help. Was cell service available in the area? In many field areas, it is not. A lot of us have had near misses while working alone. We’ve been lucky but should more be done to assure the safety of field work? Review the previous columns and articles on this topic and contribute your thoughts.

Ethics questions #5—what do you think?

Column 178 (Jul/Aug/ Sep ’21) presented the following three slightly different money-raising efforts. Are they ethically the same or different? What is your opinion about them? If there are differences, explain them. Please send me your thoughts.

Situation 1: an AIGP student chapter wants to raise money by selling geologically related t-shirts. It has asked its Section’s ExCom for permission to solicit Section members by sending an email to members and by placing an ad in the Section’s newsletter.

Charles Wm. Dimmick, CPG-3886, responded: “Situation one does not raise any ethical questions for me.”

Situation 2: a senior Section officer has published a book on a geologic aspect of the Section’s state that is intended to have a broad audience. The senior Section officer will receive all the profits from the sale of the book. The Section officer has asked the Section’s ExCom for permission to solicit Section members by sending an email to members and by placing an ad in the Section’s newsletter.

Charles Wm. Dimmick, CPG-3886, responded: “Situation two bothers me, particularly the sending of the e-mail. The ad would be OK if the author pays for it.”

Situation 3: an AIGP Section plans to raise money by assembling and selling a book of field trips within the Section’s state. The field trips book will include some field trips that the Section has published, and other field trips published by others.

Charles Wm. Dimmick, CPG-3886, responded: “Situation three lacks an important piece of information. Does the Section have written permission to publish the field trips previously published by others?” Dimmick is correct that written permission to republish the field trips is required from the trip’s author(s) and publishing organization. Obtaining both permissions is both courteous and thorough.
I remember my first exposure to geology, and fossil and mineral collecting in Wyoming with one of my aunts. What a great time we would have, and how exciting she made this experience. Those experiences have been repeated many times throughout my career! Can it get any better than walking on pillow lavas in Cyprus or walking across the Mid-Atlantic Ridge in Iceland (while also enjoying the geothermal waters in the ridge!). How about mapping the Moho in Newfoundland? Maybe mapping nickel and platinum group element deposits in the Archean greenstone belt of northern Quebec? Wait, there is also the excitement of installing a groundwater well for a public water supply in a confined aquifer with a 27-foot positive head and a free flow of 1,000 gallons per minute (gpm) (see TPG volume 41, no. 2, pages 2 – 6, 2004)! Maybe identifying the location and drilling an 850 gpm well in fractured crystalline bedrock? These are just a few of the geological experiences that I have had over the past few decades. 

Well, this article is not about these great experiences. Instead, it is about the other, non-geological experiences that we are often faced with as geologists, especially when we are working in remote areas of the world. Our academic training or work experience does not prepare us for these events. Rather, we need to have additional training and experience in other areas to round out our education. An important one of these areas is teamwork, while a second is first aid. Now there are certainly other important areas, but for now let’s take a look at how these two were of paramount importance during one particular summer of field work in the Ungava Peninsula of northern Quebec.

The nickel and platinum group element deposit that we were mapping and drilling is located approximately 1,110 miles (1,800 km) north of Montreal, Quebec. This location represents one of the finest high grade and, at that time, largely undeveloped nickel reserves in the world. We are only able to do our field work from approximately mid-July through early September. So, we had a very short six-week window for nice weather (and solar flares). I was the Party Chief that summer and was accompanied by another geologist and several camp support staff. We also had a helicopter and crew. Below is a recent picture of Raglan, our camp, along with a picture of the Mercedes-Benz Unimog vehicle that we had at the camp (Does it look familiar? The same vehicles are used in the Jurassic World movies).

To set the stage, I've included an aerial photo of the Pingualuit Crater (formerly the New Quebec Crater). It is just over two miles in diameter and rises approximately 520 feet above the tundra. The age of this impact structure is estimated to be 1.4 million years old (Pleistocene). This circular impact structure is an important part of this article. The crater

Pingualuit Crater (formerly New Quebec Crater).
is very impressive to view from the air, and a notable feature is that the lake within the crater is completely isolated from all streams and rivers (there are even some odd-looking trout in the lake). As such, the water within the lake is all from precipitation (i.e., rain or snow). Evaporation is the principal mechanism for loss of water. The rim is very wide and can easily accommodate tents and field equipment. Pingualuit Crater is located approximately 30 miles (50 km) south of our camp.

Starting the last week of July, equipment and personnel from the University of Montreal were arriving at our camp. They were on their way to the Pingualuit Crater as part of a research project. Because they had no way to get to the crater, we shuttled them to the rim of the crater and helped set up their camp. We also provided them with a two-way radio so that we could be in communication with them and arranged for twice daily schedule checks to ensure all was going well. There were a total of 18 persons in the research party, one of whom was the 11-year-old son of their research leader. We dubbed this group the “Crater People.”

The following is an account that I was asked to write for the company’s publication (Falconbridge Miner Incidents Vol. VII, No. 4, August 1988).

“The rain and windstorm of August 7–9, 1988 was the worst of the field season and particularly severe on August 8, when the wind speed was clocked at 100 mph (160 km per hour) by the Ministere de Energies et Ressources at Akulivik, near the northwestern tip of Quebec. At Raglan that day, loose debris, and empty fuel drums were being picked up and hurled through the air for tens of feet before dropping back to the ground. In addition, the main sleeping and eating building was in near constant motion and plexiglass storm windows were being bowed several centimeters by the high winds. The Viking helicopter had to be secured to the ground with full drums of JetB fuel.”

Field work had proceeded as usual on August 7. We watched as storm clouds developed off to the southwest and moved slowly eastward during the course of the day. As we had seen this type of cloud development from the southwest before, we were not too concerned, but nevertheless kept an eye on it. The rain did not begin until around 7 p.m., and as before, the wind direction was from the southwest. As the evening progressed, the wind direction began to shift and swing around to the south, southeast, then finally to the east. During this period, the wind speed was estimated at 20–25 mph and the rain turned briefly to snow before changing back to rain. Sometime around 10 p.m. we had a thunder and lightning storm which lasted about an hour. It may have lasted longer, but I fell asleep. I was awakened at midnight to the dripping of water in my room. The strong east wind was driving the rain through the small gaps around the window. I moved the paperwork from my desk below the window and made sure the leaks were not too bad and went back to sleep. At 1 a.m. there was a knock on my door and everyone else’s to tell us to move our valuables away from the window. Some of us were jolted awake while getting out of bed when we stepped in cold rainwater that had begun to collect in our rooms! Soon, all were scrambling around with mops to clean up the water. Most of us got back to bed around 3 a.m.
During our morning radio transmission with the Crater People, they informed us that all was well, but they were a little damp. As the morning progressed, the wind direction changed back to the southwest and the wind speed increased to about 60 mph. At approximately 11 a.m., I suggested we contact the Crater People to check on their status. We could not reach them. We tried unsuccessfully for the balance of the morning and early afternoon to make contact with them. At 4:15 p.m., Bradley First Air in Iqaluit (a major communications center previously named Frobisher Bay on Baffin Island) informed us that the University of Montreal group had put out a “MAYDAY” and had lost their camp in the storm.

The Rescue…

With the help of Bell Frobisher, Raglan got through by radio at 5 p.m. that evening to the Crater People, who advised us that their tents had blown away and all their materials (stoves, heaters, clothes) had been scattered, and that the condition of the people was good except for four who were showing signs of hypothermia. All took refuge against a wall of rocks.

The Royal Canadian Mounted Police and Canadian Armed Forces were notified, and over the next 19 hours, all parties were kept informed by radio transmission. Because of the severe weather conditions, there was no way for either of the government agencies to mount a rescue operation. It was up to the Raglan Camp to perform the rescue of the Crater People.

Raglan staff set about devising a rescue plan which would involve either two four-wheel-drive Mercedes-Benz track-type vehicles (Mobil 1) that would take six hours to reach the crater, or the helicopter, which could not attempt a rescue in such inclement weather. Mobil 1 left at 5:45 p.m. that evening and made over half the trip but had to turn back because the amount of rain that fell made driving conditions treacherous over the permafrost tundra. Moreover, the vehicles could not cross the swelling Povungnituk River. The Raglan helicopter was on standby all evening, but at 9 p.m. had to cancel a rescue attempt due to the high winds and darkness. Meanwhile, the Crater People, each with a sleeping bag, had separated into two groups of nine and gathered on the lee side of two large boulders for the night. Their only protection from the storm was by covering themselves with a tarp, and they had fuel oil to be used only for emergency heating purposes. The four persons suffering from exposure were in stable condition, and Raglan kept in touch with the group throughout the night.

At 7:11 a.m., word came that the condition of one of the Crater People suffering from exposure was worsening. Due to the reported worsening condition of the Crater People and the slightly improving weather conditions, I decided to mobilize the helicopter to attempt a rescue. Weather conditions were not good: winds were from the south-southwest at 35–40 mph with gusts of 50 mph, and visibility was poor. Nonetheless, the final green light to fly was given by the helicopter pilot, and after contact with First Air Iqaluit, the helicopter took off at 7:47 a.m. from Raglan camp for the Crater. We had removed all the seats from the helicopter except for the pilot and co-pilot seats in case people were too ill and had to be placed on the helicopter floor. At 8:34 a.m., the helicopter picked up the Crater People needing the most assistance: four adults and the 11-year-old boy. At 9:02 a.m., the first group arrived back at Raglan, cold and shaken by the ordeal but happy to be rescued. Raglan contacted Frobisher Hospital just in case and spoke to a doctor about the condition of each of the people. Throughout that morning of August 9, the Raglan helicopter crew made four trips to the Crater to rescue all 18 people. By noon, all the Crater People were safely back at Raglan camp.

In a letter to the company, the Associate Dean of Research at the University of Montreal thanked the Raglan staff for their warm reception, hospitality and rescue (the Crater People stayed at Raglan camp for two weeks while recovering from their ordeal)…"which is a concrete demonstration of the support of Canadian industry to Canadian university research."

I am sure that many of us who have spent time in the field in remote areas have been involved in non-geological situations that required other types of training. I often think of this particular experience and wonder what the outcome would have been if we did not have a helicopter available or if I was not able to convince the pilot to “give it a try and I will fly with you.” The pilot told me that he would give it a go, but that I would not be able to convince the pilot to "give it a try and I will fly with you.”

Thank you for allowing me to share this experience with you.

President’s Message, continued from p. 27

and career advancement. The fact that the nation is intent on 'pivoting' towards a larger green energy portfolio boxes well for all geologists. This includes geologists in commodities, environmental studies and permitting, and alternative energy. There are more geologists working in environmental fields than ever before, and the demand continues to grow. With the addition of geospatial analysis, high-resolution site characterization and commonplace three-dimensional modeling, opportunities in the geosciences are diversifying. Firms today are hiring for positions that did not exist just five to ten years ago. The notion that fossil fuels might soon be going the way of the buggy whip is over-hyped and oversold. With continued high demands, there will be steady employment in fossil fuels for the foreseeable future.

The time is right, the market is right, and the opportunities to grow our membership are abundant. I ask that you check your own professional surroundings. See if you could make a difference and talk to co-workers and colleagues that you would like to see join AIPG. I think that you will be surprised by the response. A lot of geos out there are looking for a competitive edge in their career and a ‘CPG’ after their name conveys an added measure of professionalism. If you could talk to a few people between now and this time next year, it would have a measurable impact on the AIPG headcount. Please show your support for AIPG and do it demonstrably.
MENTORING MATTERS

Mark Schaaf, CPG-10723

Recently I shared some thoughts in TPG (Thinking About Geology, Apr/May/June 2021 TPG, p.52) supporting the pursuit of a career in geology or more broadly, the Earth Sciences. As part of that TPG publication I noticed an article by Hays Slaughter (Staying Strong and Motivated during the Covid-19 Pandemic, Apr/May/June 2021 TPG, p.9). What happened from there is a great example regarding our collective AIPG mentoring efforts. Specifically, how easy it can be, the differences we can make, and the opportunities we can create for the next generation—all from just openly sharing our experiences, our life stories, and our turning-point decisions.

I enjoyed Hays’ article and decided to send him a note indicating my appreciation for his sharing, time, and effort. Hays article took me back to reminiscing my student days—the adventures, the struggles, the decisions. It only took a few minutes to find Hays’ email address in the AIPG directory. In my email note I offered to discuss and map out with Hays the options after finishing his undergraduate degree. Hays responded to my email, appreciated the feedback, and indicated he was interested in some guidance in the next part of his next career or further education options.

As with many young geologists when finishing their undergraduate degrees, Hays was navigating the decision of more education (a master’s program) or jumping into the working world. But first there was the decision of what area of geology to pursue. This is typically the biggest challenge for young student geologists. I shared my two main career experiences in international mineral exploration and more “home-based” environmental remediation consulting.

In our first three calls we covered a lot of ground (pros and cons, economic considerations, employment security factors, lifestyle differences, etc.) but the work and research were for Hays to complete. At the end of each call Hays had a list of items to investigate and think over. The progression went like this—Hayes decided to pursue a master’s degree, then selected mineral exploration (min-ex), and began researching min-ex master’s programs. At this point, we needed additional help as I was more familiar with Canadian schools and less with U.S. based schools/programs. It’s been a while and so much has changed/evolved.

I turned Hays onto the AIPG member directory to find an AIPG geologist active in mineral exploration, Hays took it from there and a new adventure evolved.

A Successful Mentoring Partnership

Hays Slaughter, SA-10132

I appreciate the opportunity to share this story. It has been a huge development in my young career, and I hope it encourages other students and young geology professionals to network within AIPG to benefit their career path decisions and career growth. Reaching out to CPGs for guidance provided insight and motivation in making both career and on-going education decisions. The experienced career advice I obtained through AIPG was imperative in making my next decisions. Also, the more geologists connect and expand their networks both within and between generations, the stronger AIPG will grow as an organization.

Once Mark guided me to the AIPG member directory, I was able to identify several min-ex geologists. I sent emails requesting input and ideas regarding schools that offer min-ex master’s programs. The process took a quick turn when I connected with a geologist running an exploration project in Alaska. The project manager was interested in my resume as he appreciated my pursuit for information concerning mineral exploration. I reached out to Mark Schaaf, who reviewed my resume before sending my response. I accepted the employment opportunity, and it has been incredible to work as an entry level exploration geologist in the beautiful state of Alaska. The geologic knowledge that I have attained in the field has been a huge benefit for my career as a young geologist, providing applied perspective to my undergraduate geology courses.

The toughest part of the decision was my not returning to school this past fall to complete my geology degree. The break from school was a big deal for both me and my parents but in the end, it was just too great an opportunity to pass up. My project manager recalled similar challenges when starting his career and this prompted his offering the opportunity to join his exploration team in Alaska. He was also inspired by my student involvement with AIPG, demonstrating my commitment to geology as both a career and life passion.

Three things I took from the mentoring experience include: decisions in life are ultimately mine to make; open mentoring dialogue provides clarity and career-decision stress relief; and, life is a journey not a pre-written script, so search, find, and discuss opportunities when they arise!

By the time of publication, I will have spent three tours of work (approximately 16 weeks) on an exploration project, where I have experienced summer, fall, and winter in Alaska. Through my experience, I’ve met and worked with a great team of professional geologists. I have learned so much “applied” geology, experienced the unfathomable northern lights, lived in, and traveled through some of the most beautiful wilderness.

And again, I can’t emphasize enough to the geology students and early professionals—network AIPG, identify a mentor, search and explore for the right opportunities, and develop your options! Explore Geology!
Are We Becoming Like the Dinosaurs?

Drew Diefendorf, CPG-3598

The Apr/May/Jun 2021 issue of TPG presents several discussions about future trends relating to the geosciences and AIPG’s future. Of particular interest are the President’s Message and the formation of the Ad hoc Membership Committee. Of concern are the decline in AIPG membership and AIPG’s effectiveness in communicating with geoscience students as well as the public.

AIPG membership has been in decline, not just for years, but for decades as shown in Figure 1 of Dr. Howard’s article on page 39 of that edition of TPG. The last real growth was back in the 1980s with the explosion in environmental jobs and the need for certifications and professional licensing. Since that time, most National office candidates have included the need to increase membership as a primary goal.

That membership increase hasn’t happened, and it isn’t going to happen unless we accept the inevitable changes taking place in the geosciences and adjust AIPG’s focus to the future. The Institute was formed predominantly by professionals in the petroleum and mining industries. AIPG can partially blame itself for what Dr. Howard refers to as the “storm of negativity” toward that segment of the profession. As a professional society we faltered badly on the issues of climate change and have not kept up with the changes in the needs and scope of today’s geoscientists.

I do not agree with some members that the geosciences are in decline. They are going through a paradigm shift and are becoming more diverse and inclusive. Our current slate of National Candidates is a good example. Not one of the eight is employed in the petroleum or mining industry.

According to AGI’s 2020 employment survey only four percent of new geoscience graduates were headed into the petroleum work force. This doesn’t mean that geoscience is dying and can’t be something to excite young minds and provide future career paths. We need to grasp the full depth of what is now called Earth Systems Science (ESS). Yes, geoscience departments are going through major changes in curricula and staffing, and there is much angst from the “old school” faculty members as the emphasis moves away from some traditional courses.

The Geological Society (London)(Smelror, M., 2020) predicts that by 2058 we will enter the Green Stone Age. All corners of the Earth will be fully mapped and we will have a handle on all of the Earth’s resources. But the geosciences will hardly be dead. We will need to manage our energy and mineral resources as well as develop a better understanding of the Earth System. Some undergraduate programs will still maintain courses in Structural Geology, Stratigraphy, Paleontology and Economic Geology. We have been a professional society for 58 years. We can survive to reach 2058 and beyond if we focus on the changes around us and develop more applicable curricula.

I suggest to the Ad Hoc Membership Committee that all members, along with the AIPG Executive Committee read the appropriate sections of AGI’s 2021 174-page report Vision and Change in the Geosciences (Mosher and Keane, 2021). It should be enlightening in terms of membership, outreach and mentoring.

One positive outcome of the COVID pandemic is that it has awakened the public to the benefits of science to the common good. The miracle of CRISPR has been an inspiration to those in the life sciences. To quote Walter Isaacson “....we have entered a third, more momentous era, a life-science revolution. Children who study digital coding will be joined by those who entered a third, more momentous era, a life-science revolution. The miracle of CRISPR has been an inspiration to those in the life sciences. To quote Walter Isaacson “....we have entered a third, more momentous era, a life-science revolution. Children who study digital coding will be joined by those who study genetic code” (Isaacson, 2021). As with the life sciences, perhaps the geosciences can inspire students of all genders and races to take up an exciting geosciences path toward solving our planetary problems.

AIPG has the opportunity to provide a unique mentoring role in this objective. The first step is a simple paradigm shift that can be enacted by AIPG immediately. Change the name of the society to the American Institute of Professional Geoscientists. No change in acronyms; still AIPG, no stomping on others professional turf. We can still have Certified Professional Geoscientists. The good news is that AIPG’s motto of “Competence, Integrity and Ethics” couldn’t be more appropriate in these days of fake news, cherry picked data, and misguided and misleading statements from many supposed professionals including those in the geosciences.

The image of a geoscientist doesn’t have to be that of a fedora-wearing Jeep jockey tearing down a dusty road. AIPG has an opportunity to strengthen its image in the public eye and to promote its standards to the new breed of geoscientists. And if we don’t make these changes, we will become like the dinosaurs.

References


Field Work and Field Trips

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 Saint Ronan’s Well, a novel set in a fashionable resort hotel in the Scottish Borders and written in 1823 by Walter Scott, Meg Dodds, the peevish and observant landlady of Cleikum Inn, refers to her geologist guests with these words: They “run uphill and down dale, knapping the chucky stanes [stones] to pieces wi’ hammers, like sae mony road-makers run daft [like so many road-makers gone crazy], to see how the world was made.” Geologists worked like road construction workers, or at least that was the public perception of geological field work.

Geology is essentially a field-based science. Even before the emergence of the modern geology in the late 18th and early 19th centuries, geology was rooted in mining and exploration of minerals, metals, and gemstones. The founding fathers of geology too based their ideas and theories on field observations. The Hutton Unconformity at Siccar Point near Edinburgh is a well-known case. This field observation indeed provided a critical benchmark for the modern geology. On a personal level also, many geologists choose this field because of their passion for the outdoors. Field trips and field work are huge attractions for geology students, even though most geologic work, from laboratory analyses to interpretations and report writing, is conducted in urban buildings and air-conditioned offices. Field work still remains an essential component of geologic education and research, and if history is any clue, it will always remain so. The reason is simple: No matter how sophisticated our laboratory experiments and computer simulations are, samples should come from nature, and computer models should be validated by field observations and the experiment that Earth has already run and is recorded in rocks. Field work and field trips are conducted either for specific research projects by established geologists, as part of geologic education and training, or for the purpose of entertainment (the so-called geo-tours). Although the focus of this article is the educational field trips, the information, procedures, and recommendations given in this article are largely applicable to the other categories as well.

Field work in geology ranges from one-day field trips for undergraduate students through “field method” and “field camp” courses for geology-major graduates to extensive field work, mapping, sample collection and trips to remote areas necessary for writing Master’s or PhD’s dissertations. Nevertheless, in all of these levels, certain procedures, preparations, check-lists, and guidelines ensure the safety and success of field work and field trips.

Field Work Objectives

Perhaps the first important task in preparing for field work is to define its specific objectives. Is it a short field trip to show some geologic features to students or an extended field trip to teach geologic mapping? Is it intended mainly to collect samples for a specific analytical work or does it involve new mapping? More importantly, what questions do we want answer from undertaking the field trip and field work? In other words, we simply do not go out there to observe or sample everything or haphazardly. We need to have a clear idea about the problems we want to resolve. Defining our objectives also helps to determine other factors involved in field work: Places to visit, length of time, sampling and measurement strategies, and whether the field work involves extensive or limited field mapping, the type of lithologies (sedimentary, plutonic, volcanic, or metamorphic), structural geology (on various scales of observation), geomorphologic investigations, environmental or engineering geology, mineral exploration, geochemical sampling (of rocks, soil, or fluids), and geophysical surveys.

Before the Field Trip

Once the objectives are defined, the locations for the field trip can be planned. In fact, field work begins in the office before actually going to the field. This involves (1) a reconnaissance desktop survey of the area in terms of its geology, terrain, weather conditions, logistics, safety and so forth, and (2) preparations including field gear (see Table 1 on page 40 for a check-list) and travel arrangements.

Before the field trip, it is necessary to read travel guidebooks (and online information), fossil and rock collection guidebooks, previous geologic reports about the area, and examine the maps carefully for deciding the possible field stops. Field trip and fieldwork, like driving, traveling and any other business, has its own possible risks, and every member of the field trip should have proper insurance. International field trips also require passports and visas. Leave your field trip itinerary with your employer and family.

Safety During the Field Trip

Safety and success of a field trip requires leadership, coordination, and communication. It is important to have one or two field trip leaders who are senior, experienced, and knowledgeable about the area. The headcounts, names, and contact information of the field trip members should be listed and used...
for checking their whereabouts at all times, especially before moving from one stop to another.

Some landscape features and locations are particularly risky and should be assessed carefully when conducting the fieldwork. These include: rock cliffs, loose rocks, slippery slopes, high mountain trails (prone to snow avalanches or rock falls), mines, caves, quarries, rivers, seaside tides, wildlife and toxic plants. Depending on the field trip length and terrain conditions, it is necessary to choose suitable base camps and home bases, and plan for food, night sleep, bathrooms, and team gathering. The nearest towns with medical facilities must also be identified and documented for emergency. In short, safety should be the most important consideration during the entire field trip.

At the end of each day, review the field work done, and discuss the following day’s field work.

The Ethics and Art of Sampling

The “core” of the geologic fieldwork consists in outcrop visits, mapping, taking measurements, and sample collection. Indeed, field work is the best opportunity for students to gain hands-on experience on reading and using (or making) geologic maps, identifying rocks and structures, taking geologic measurements, collecting samples, and studying their geology textbook in nature.

Sample collection is not a “grab and run” procedure. There is much ethics and art to sample collection and other tasks in field work that students should learn.

Let’s talk about ethics and good etiquette first. Consider fieldwork and sample collection a kind of privilege rather than a right taken for granted. If the field stop or sampling point is not on permitted public lands (say, they are on private lands or national parks), proper permission (preferably in advance) should be obtained before visiting. Otherwise, it will be trespassing and illegal collection. Moreover, even if you have access to an outcrop, be considerate of other geologists (or perhaps yourself or your students) who may visit the site in the future. Do not be destructive; leave your footprint and “hammer print” at the minimum. Actually, some outcrops are “geo-heritage” – rare, endangered, scenic, or for educational and geo-tour sightseeing. These should be treated with utmost care.

The following rules should be followed for meaningful outcrop measurements and sample collections:

1. Proper documentation of the location (precise coordinates, altitude, photography, marking on the map).
2. Proper documentation of the sample or the measurement, including lithology or other sample type, strike and dip, field relations, and stratigraphic position (as much as possible).
3. Each sample should be properly wrapped (say, with paper) and bagged (in calico cloth bags or polythene bags) with its label (name and number, date, sample type, and location). For liquid samples take plastic or glass bottles. Samples should not be mixed or cross-contaminated.
4. Samples should be representative of the entity we intend to study. For instance, a specimen from a local dike is not representative of the plutonic body. It should be recorded what entity each specimen represents.
5. Samples should be collected from original (in-situ) places (not fallen from the outcrop) and from fresh surfaces (not weathered surfaces).
6. Sample volume should be sufficient for the intended analyses. An intact rock chip (for thin section) and about 200 grams for geochemical and micropaleontological studies may be sufficient; however, for geochronological analyses, which may require mineral separation, 1-2 kilogram may be necessary.
7. Some studies may require “oriented” samples (with strike and dip marked on the sample).

After the Field Trip

Fieldwork is only the beginning. After the field trip is over, collected samples should be prepared for specific analyses (thin-section petrography, micropaleontology, geochemistry, etc.); field data should be tabulated, organized and interpreted; and photographs, maps and figures should be finalized for presentation and reporting. An excellent report indicates the success of the fieldwork.

Nowadays, a whole suite of computer word processing, tabulation, and graphic design software packages (AppleWorks, Microsoft Office, and Adobe Products) provide excellent tools for preparing reports, and every student and scientist should master these digital tools.

Even after the fieldwork, research project and reporting are over, we should save the entire data, maps, figures, and report, and keep the samples catalogued and properly stored in boxes and drawers for future reference or use. Who knows; some field areas may not be feasible in the future, and our legacy field samples, maps and data may be highly valuable for science.

Digital Developments

Field work in geology has gone through changes over time. In the 19th and early 20th centuries, for example, “gentlemen geologists” used to wear their best suits, ties, hats, and boots for field trip. Many classic geologic provinces were mapped by men on horsebacks. You can find photographs of those field trips in historical archives and books, and laugh at or sigh for those old days. Many of those old-day geologists were fine sketchers (and even landscape painters).

Since the 1990s, rapid developments in digital technologies have revolutionized the procedures and the very nature of geologic field work. The Internet offers worldwide information on places, people, weather, events, documents, and so forth. Services like Google Earth, ArcGIS Online, OneGeology,
Geological Globe of the World, and Rockd App offer interactive maps. Cameras, maps of all sorts, geologic compass, and GPS apps installed in smart/mobile phones and tablet computers have greatly advanced fieldwork procedures, documentation, and data storage. When using smart/mobile phones consider the online coverage of your provider and whether GPS Apps can function offline. Drones and lidar mapping now offer precision terrain measurement and imaging. Digital field geology and mapping is an evolving area.1

Table 1. Kit for Geologic Field Work

<table>
<thead>
<tr>
<th>Field Gear</th>
<th>Personal Gear</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Transportation Vehicle (sturdy, reliable and safe)</td>
<td>33 Duffel/backpack/rucksack</td>
</tr>
<tr>
<td>2 Topographic Map (and map holder, case or tube)</td>
<td>34 Field Clothing (proper for the climate) including wind/rain outfit and reflective vest</td>
</tr>
<tr>
<td>3 Geologic Map (and map holder, case or tube)</td>
<td>35 Sun hat, sun glasses, and sun screen</td>
</tr>
<tr>
<td>4 Travel Guidebook</td>
<td>36 Hard Hat</td>
</tr>
<tr>
<td>5 GPS or GPS App on your mobile phone or tablet</td>
<td>37 Gloves</td>
</tr>
<tr>
<td>6 Altimeter (or GPS)</td>
<td>38 Boots</td>
</tr>
<tr>
<td>7 Compass (Brunton or Silva) or Geologic Compass App on your mobile phone or tablet</td>
<td>39 Garbage Bags</td>
</tr>
<tr>
<td>8 Protractor and Ruler</td>
<td>40 Water and Water bottles</td>
</tr>
<tr>
<td>9 Measuring Tape</td>
<td>41 Watch with Calendar (or Smartphone)</td>
</tr>
<tr>
<td>10 Jacob Staff (for measuring stratigraphic thicknesses)</td>
<td>42 Sleeping bag and Tent (if necessary)</td>
</tr>
<tr>
<td>11 Calculator (or its app on your smartphone or tablet)</td>
<td>43 Small Towel/Washcloth</td>
</tr>
<tr>
<td>12 Camera (or high-resolution camera on your mobile phone or tablet)</td>
<td>44 Mobile Phone (with good online coverage), Radio Phone (Walkie Talkie) or Satellite Phone</td>
</tr>
<tr>
<td>13 Photo Scale</td>
<td>45 Flashlight</td>
</tr>
<tr>
<td>14 Grain-size Card</td>
<td>46 Hygiene Kit: Toothbrush, Toothpaste, Water Purifier, Insect Repellent, etc.</td>
</tr>
<tr>
<td>15 Mineral Hardness Set</td>
<td>47 Small First-aid Kit</td>
</tr>
<tr>
<td>16 Hand lens or magnifying loupe (10x)</td>
<td></td>
</tr>
<tr>
<td>17 Munsell Color Chart</td>
<td></td>
</tr>
<tr>
<td>18 HCl (diluted to 10%) in acid dropper bottle</td>
<td></td>
</tr>
<tr>
<td>19 Binocular</td>
<td></td>
</tr>
<tr>
<td>20 Field Notebook</td>
<td></td>
</tr>
<tr>
<td>21 Stationaries: Pens, Pencils, Magic pens, etc.</td>
<td></td>
</tr>
<tr>
<td>22 Drawing Board/ Clipboard</td>
<td></td>
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<tr>
<td>23 Rock Hammer</td>
<td></td>
</tr>
<tr>
<td>24 Cold Chisel</td>
<td></td>
</tr>
<tr>
<td>25 Portable Rock Coring Drill (if necessary for sampling)</td>
<td></td>
</tr>
<tr>
<td>26 Hand Brush (for cleaning outcrop)</td>
<td></td>
</tr>
<tr>
<td>27 Shovel, Trowel, Spade or Scoop (for sampling soft sediments)</td>
<td></td>
</tr>
<tr>
<td>28 Pocket/Swiss knife</td>
<td></td>
</tr>
<tr>
<td>29 Gold Pan</td>
<td></td>
</tr>
<tr>
<td>30 Sample Bags (of proper size and material) and Bottles (for liquids) with Labels</td>
<td></td>
</tr>
<tr>
<td>31 Boxes or bags for samples</td>
<td></td>
</tr>
<tr>
<td>32 Adhesive Tapes</td>
<td></td>
</tr>
</tbody>
</table>

Field Methods

Geology major students need to take a course in “Field Methods” to be able to do field work. There are a large number of books on geologic mapping and field geology. One of the earliest and most influential books was Field Geology by Frederick Henry Lahee, first published


in 1916 with the sixth edition in 1961. Lahee (1884-1968) was from Texas and worked for Sun Oil Company from 1917 until his retirement in 1955. Another standard book is *Geology in the Field* by Robert R. Compton (1985, a thoroughly revised version of his 1962 *Manual of Field Geology*). Compton (1922-2015) was from California and was a professor of geology at Stanford from 1944 till 1981 when he took an early retirement in order to devote his life to landscape painting. Compton’s artistic skills are apparent in his book with hand-drawn illustration of all the figures. A more recent and comprehensive publication is *Geological Field Techniques* edited by Angela L. Coe (2010).


Field trips are probably the most exciting parts of a geologist’s career; they are fun for students as well. Every field work is unique because of its specific objectives, terrain conditions, available resources, and individuals undertaking it. The information given above is obviously incomplete and should be supplemented with the needs and requirements of each field trip.

---

Robert J. Weimer, CPG-0098
Boulder, Colorado
September 4, 1926 - April 25, 2021

Member Since 1964

The following information was obtained from the Monarch Society website, and supplemented with AIPG information.

Robert J. Weimer died of natural causes on 25 August 2021 at Frasier Meadows Retirement Community in Boulder, Colorado. He was 94 years old.

An internationally known geologist, Bob distinguished himself in a seven-decade career as an outstanding teacher, influential researcher, and innovative explorationist.

Bob was born in Glendo, Wyoming, on 4 September 1926. In 1944, at age eighteen, he joined the US Navy’s officer training program, where he studied engineering at USC until the end of the War. After being discharged in 1946, Bob enrolled at the University of Wyoming, where he received his BA (1948) and MA (1949) degrees in geology. While in college, Bob met his life partner, Ruth Adams, a journalism student, and campus leader who became the secret ingredient in Bob’s success. Bob and Ruth married in September 1948 and remained married until her death in May 2017.

From 1949 to 1951, Bob worked with Union Oil in several locations in the Four Corners area. He took a leave of absence to attend Stanford University, completing his PhD in the 2½ years covered by the amount of funding remaining from his G.I. Bill. He returned to work with Union Oil for 1½ years in Wyoming and Montana, and then began working as a consulting geologist in late 1954.

As an explorationist, Bob broke new ground at age 32 with his innovative discovery of the Patrick Draw Field in southwest Wyoming in 1959. This discovery launched a decade of petroleum exploration in the Rockies and nationwide, where companies searched for similar kinds of previously unrecognized or ignored stratigraphic traps. Later, in 1973, Bob applied the same concepts to help discover the Spearhead Ranch Field in the southwestern portion of the Powder River Basin in northern Wyoming.

While Bob was identifying new techniques to locate petroleum fields, he also pursued his lifelong dream of becoming a teacher. In 1957, he was hired as a professor at the Colorado School of Mines. In this role, Bob became well-known in the Rocky Mountain geologic community:

As an academic, Bob chose to research areas that were not only economically productive, but also physically close to CSM and Denver. This made it easy for local geologists to visit the outcrops that Bob studied and apply Bob’s concepts to their companies.

At the same time, Bob published several papers that quickly became standard references and the starting point for understanding the regional framework of the Upper Cretaceous...
IN MEMORIAM

Bob Karnauskas, CPG-04804
Berlin, Wisconsin
October 5, 2021

Member Since 1980


The following information was provided by Tim Norris and Bob’s family...

Robert (Bob) Karnauskas of New Berlin, Wisconsin, died on Tuesday, October 05, 2021. He is survived by his loving wife Marnee, daughter Mandy (Claudio Delgado) Karnauskas, and grandchildren Aleah and Leandro, the apples of his eyes.

Born in Chicago, Bob received a B.A. degree in Geology and a M.S. degree in Hydrology and Water Resources Management from the University of Wisconsin-Madison. In 1977, Bob began his long career in the environmental consulting industry. Following stints at Warzyn Engineering, Roy F. Weston, The Mark Group Engineers & Geologists, and Simon Hydro-Search, Bob decided to lead a new organization becoming the founding President of Natural Resource Technology (NRT).

From 1993 until 2007, Bob led NRT, growing the company to over 50 employees during his leadership. Bob drove efforts

strata. Local companies applied this framework extensively, thus leading to major productive petroleum discoveries.

As a teacher, Bob used his experience in industry to bring an applied perspective to classes. His students learned not just geologic theory, but also pragmatic operational concerns. For this reason, many of Bob’s students credit his tutoring for their successful careers.

Bob was influential not only for the quality of his teaching, but also for the number of students he taught. In his 60-year tenure at CSM, Bob personally taught more than one thousand students; many of them took Bob’s “Principles of Stratigraphy” class that was required for all geology, geophysics, and petroleum engineering majors. A significant number of those students found employment in the Rocky Mountain geo-community, thus allowing them to build lifelong ties with Bob.

Furthermore, during the summers of 1971 through 1988, Bob also taught continuing education courses for industry groups. A significant portion of the Denver geo-community cycled through these courses, further strengthening Bob’s influence in local industry.

Bob served as CSM Geology Department Chair from 1964 to 1969 and held the inaugural Getty Chair from 1978 until his retirement in 1983. For the next 30 years, Bob remained active both as an emeritus professor at CSM, and as a geo-consultant in the Denver area. Among other duties, he meticulously described the rocks along the west side of the CSM campus; this work later evolved into an educational “walking geology” trail.

In addition to local pursuits, Bob also traveled and taught extensively around the world. For example, he taught as part of a Fulbright Program at the University of Adelaide in 1967, then returned to Australia several times to teach short courses. He also taught at the University of Calgary (1970), and at the Institute of Technology of Bandung in Indonesia in 1975. These trips were life-changing experiences for both Bob and his family and led to many lasting friendships in numerous countries.

Bob’s strong feelings for professionalism led to extensive work for many geologic and engineering professional associations. He was a Charter Member of AIPG. He did extensive service for the local Rocky Mountain Association of Geologists, and was recognized with Honorary Membership (1969), Scientist of the Year (1982) and Legend (2003). In addition, he served as President for two international geologic groups--SEPM (Society of Sedimentary Geology) and AAPG (American Association of Petroleum Geologists)--and served as a Distinguished Lecturer for both the AAPG and SEG (Society of Exploration Geophysicists). Bob was also honored to receive many awards during his distinguished career, including:

- AIPG’s Ben H. Parker Memorial Distinguished Service Medal (1986)
- Election to the National Academy of Engineering (1992)
- Distinguished Alumni from the University of Wyoming (1994)
- SEPM Twenhofel Award (1995)
- Honorary memberships with several groups

While Bob was building his career, he and Ruth raised their family on Lookout Mountain near Golden, Colorado. In his 55 years there, Bob served many volunteer roles, including President of his community and Chair of the local water committee. With his geologic expertise, he found the best locations to drill water wells in Mount Vernon Country Club. To this day, that water still fills the taps for Mount Vernon’s 100 households, swimming pool, and restaurant in the community. He also served as President of the Northwoods Conservancy Foundation, and a board member at the Foothills Art Center. As part of a family of homesteaders, he cherished the landscapes of the Rockies, and spent substantial time with family and friends in the outdoors hunting, fishing, backpacking, camping, skiing, rafting, and coaching baseball.

Bob is survived by one sister, Joyce; three sons, Tom, Paul (Laurie), Carl (Kathy); four grandchildren, Dan (Natalya), Lou (Sydney), Rudy (Lisette), Kate (Zach); and two great-grandchildren (Roslyn, Lenna). He was preceded in death by his wife Ruth and son Loren.

To summarize a life well-lived: Bob represented the very best of his profession. He understood that in exploration geology, the line between success and failure is infinitesimally thin, and he maintained the humility that is borne from that understanding. His professional service was driven by his deep gratitude for the opportunities that came his way.

Bob was more than an outstanding geologist: he was also a valued friend and colleague to many. He mentored hundreds of geologists in an informal, yet effective and lasting way. He was extremely generous in sharing his time, resources, and enthusiasm with members of his profession and his community. He relished guiding young people to discover the wonders of the geologic world and helping every person he encountered to feel truly special. Sometimes, in odd moments, one could hear Bob quietly crooning his favorite Louis Armstrong song, “I’m Just a Lucky So-And-So.” He will be sorely missed.

Proudly: Robert (Bob) Karnauskas, CPG-04804

The following information was provided by Tim Norris and Bob’s family...

Robert (Bob) Karnauskas of New Berlin, Wisconsin, died on Tuesday, October 05, 2021. He is survived by his loving wife Marnee, daughter Mandy (Claudio Delgado) Karnauskas, and grandchildren Aleah and Leandro, the apples of his eyes.

Born in Chicago, Bob received a B.A. degree in Geology and a M.S. degree in Hydrology and Water Resources Management from the University of Wisconsin-Madison. In 1977, Bob began his long career in the environmental consulting industry. Following stints at Warzyn Engineering, Roy F. Weston, The Mark Group Engineers & Geologists, and Simon Hydro-Search, Bob decided to lead a new organization becoming the founding President of Natural Resource Technology (NRT).

From 1993 until 2007, Bob led NRT, growing the company to over 50 employees during his leadership. Bob drove efforts
to address the environmental issues posed by legacy manufactured gas plants throughout Wisconsin. His energy to address legacy manufactured gas plants and find effective solutions for his clients would become the core business at NRT for years to come. Bob was also instrumental in the investigation and eventual remediation of the Fox River in Wisconsin.

Bob semi-retired in 2007 but continued mentoring NRT colleagues and contributing to the organization up until his passing. Bob truly believed everyone within the organization played a key role in its success, and having satisfied employees was always a top priority. Under his direction, NRT has enjoyed numerous accolades for NRT’s rapid growth over the years, including awards from the Metropolitan Milwaukee Association of Commerce, Zweig White, the Milwaukee Business Journal Book of Lists, and others. Despite all the growth accolades, the recognition that Bob took greatest pride in were those for being named among the most “Family Friendly” and “Best Companies to Work For” in Southeast Wisconsin. NRT was awarded the Milwaukee Business Journal’s “Beyond the Paycheck” Award under Bob’s leadership, which honors companies on a wide variety of categories including work-life balance. Bob said that receiving these types of awards was one of his greatest accomplishments and validated his employee-first, family friendly leadership style.

Colleagues have many great memories of Bob through the years, most notably his custom of saying “I love this business” at the times when the team was working hard to meet a deadline. His long career in environmental consulting and leadership at NRT makes it clear that he meant it. His passion and energy were contagious and led to many great and rewarding projects.

Although having the challenges of starting and running a new company, Bob always gave back through his participation and leadership in professional organizations, and his support for his employees to do the same. Bob held several volunteer leadership roles in his career, all with the mission of contributing to the improvement, quality, and advancement of the geology profession. A state-licensed geologist in Wisconsin, Indiana, Illinois, and Minnesota, Bob was a longtime member of AIPG, serving as President of the Wisconsin Section of AIPG from 1994 to 1996. He also served on the AIPG Membership Screening Board for the Wisconsin Section from 1981 to 1983 and again from 1990 to 1994.

Bob actively participated in advisory committees with Wisconsin Department of Natural Resources colleagues in advancing policy and advancing technical regulatory development initiatives for environmental protection. He was Secretary of the American Institute of Hydrology from 1987 to 1989. From 1998-2006, Bob was appointed by the State of Wisconsin to serve as Vice Chair of the Hydrology Section for the Examining Board of Professional Geologists, Hydrologists, and Soil Scientists. He also served as Secretary of the Wisconsin Groundwater Association from 1994 to 1996.

Over his career, Bob authored 29 technical publications and presentations in topics including groundwater contamination assessment, regulatory policy issues, UST technology assessments, and environmental risk management.

His interest in protecting the environment led him to several activities outside of environmental consulting as well. Bob was a board member of the River Revitalization Foundation, a non-profit foundation whose mission is to establish a parkway along the Milwaukee, Menomonee, and Kinnickinnic Rivers in Milwaukee. He also taught sustainability courses at Carroll University in Waukesha, Wisconsin. Bob was an avid sailor and active member of the South Shore Yacht Club in Milwaukee as well, helping the Club become certified as a Wisconsin Clean Marina.

Never a stranger to anyone, Bob enjoyed sitting around his backyard firepit, having conversations with friends and family over Jameson Irish Whiskey. Bob will be dearly missed by his family, friends, and former colleagues.

Anthony R. Wagner, CPG-09844
Jacksonville, Florida
April 5, 1955 - October 3, 2021

Member Since 1996

The following information was excerpted from the Dignity Memorial funeral home website...

Anthony was born in Springfield, Ohio on April 8, 1955, the son of Richard N. Wagner and Barbara (Huffman) Wagner. Tony graduated from North High School in 1973 and received a bachelor’s degree in Geology from the University of Colorado, Boulder in 1977.

Tony spent much of his career working for CH2M Hill as a Geologist. His work with them took him and his family from Tennessee to Alaska and then to Jacksonville, Florida. He was greatly fulfilled throughout his career and was proud to be a part of that company. After his retirement, he found a new passion in substitute teaching. He was a loved and caring teacher and was highly sought after for his positive attitude and thoroughness.

Tony loved anything to do with water. He was an avid swimmer his entire life, and a dedicated athlete on swim and football teams throughout his childhood and high school. He obtained his scuba certification when he was 16, and later met his wife, Patty, on a scuba diving trip in Ft. Lauderdale, FL.

He is survived by his wife Patty of 33 years, son Matt and his wife April and granddaughter Peri of Colorado Springs, CO, son Thomas of Jacksonville, FL, son Sam of Denver, CO, brother Mike of Springfield, OH and many nephews, cousins, aunts and uncles.

Honoring our members and their careers is important to AIPG. Every member has contributed to the field in one way or another. Help us honor their memory and let them be an inspiration to all of us who can carry on the legacy of their work and pay it forward to the next generations. Be sure to notify headquarters of the passing of a member, and we welcome sharing stories about that person and their career.

aipg@aipg.org
Comments on proposed rule: Modernization of Property Disclosures for Mining Registrants

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

Adam Heft, CPG-10265, Editor
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As humans, we’re all biased. The question is not ‘are we biased’, the question is ‘what are our biases’. We unconsciously infer things about people all the time. We do it at work on a daily basis. The challenge is that our biases are rarely blatant. Our biases may surface as subtle micro-behaviors that we often don’t notice. In this course, we’ll learn more about bias and what we can do to control and counteract our biases. This course will cover some of the ways our brains demonstrate these biases so we can better understand and recognize them, and we will invite participants to discuss ways they can overcome situations where they observe or feel bias.

To watch this webinar, go to:
https://goli.americangeosciences.org/courses/course-v1:AIPG+AIPG015+2021/about

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aipg@aipg.org
On behalf of the Michigan Section, I cordially invite you to attend the 2022 Annual Conference in Marquette on the beautiful shores of the world’s largest freshwater lake. This year’s meeting theme is “Geology: The Cornerstone of our Future”. Geology plays a significant role in today’s society and will become ever more important in the years to come. Our reliance on basic resources and building materials such as sand and gravel for roads, limestone for concrete, iron for structural purposes, and other base metals for electronics and other applications will not diminish; rather, it will become a greater concern as existing deposits are depleted or rendered inaccessible.

The ever-increasing number of applications of rare earth elements has created a greater demand on extraction and several of these elements will be needed in ever greater quantities to assist in the transition to a reduced carbon emission future. Geologists will be needed to identify, quantify, and yes, help with extraction of these mineral deposits.

A reliable source of clean freshwater is a basic necessity for life, and the onset of climate change is impacting these resources. Changing climate patterns mean that widespread areas may become stricken with drought. This will mean that significant depletion of groundwater aquifers and surface water reservoirs will occur in these areas as withdrawals exceed natural replenishment. This is already affecting agricultural practices and driving migration of human populations to areas where this precious resource may be found, resulting in conflict and/or political unrest. In addition, anthropogenic activities have contaminated some water resources and have made these resources locally unusable or require expensive treatment.

Join us this August as we explore these topics during the Annual Conference. This is the earliest that the conference has ever been held and is a perfect time to be in Michigan’s Upper Peninsula. Northern Michigan offers fantastic opportunities for exploration and time away from the daily routine. I invite you to bring your family along for a vacation – there are plenty of opportunities to enjoy the great outdoors – hiking, biking, kayaking, boating, swimming, and fishing, to name only a few.

We are planning several exciting field trips – who doesn’t love field trips? Take a trip back in time to see what historic iron mining life was like at the Michigan Iron Industry Museum and Cliffs Mine Shaft Museum or see modern mining at the open pit Tilden Mine and Mill (the largest operating iron mine in Michigan). Another trip will explore hard rock mining and reclamation of a formerly contaminated tailings pond. The future of mining looks very different from that of yesterday. Michigan has one of the leading state-of-the-art mining operations at the Eagle Mine and Mill. See how the Eagle project was able to shift the perception of past mining experiences that resulted in environmental damages to showcase how mining could be conducted while ensuring that environmental protections are in place. Don’t forget the jaw-dropping beauty of Cambrian rock cliffs reaching skyward from the edge of the great Lake Superior along the Pictured Rocks National Lakeshore! We are also planning to conclude with a two-day trip to the Michigan copper country to view historic copper mines, tailing piles, the Seaman Mineral museum, and stamp sands left from the mining process.

On behalf of the members of the Michigan Section and the planning committee, I look forward to welcoming you in person to Marquette.

Adam Heft, CPG-10265
2022 Annual Meeting Chairman
Pictured Rocks National Lakeshore, located approximately 30 minutes east of Marquette, is America's first National Lakeshore. The Park features 50 to 200-foot high sandstone cliffs that extend for more than 15 miles along the shoreline. Sea caves, arches, blowholes, turrets, stone spires, and other features have been sculpted from the cliffs over the centuries by waves and weather. The best way to observe the sandstone cliffs is from Lake Superior, so this trip will include a three-hour boat cruise along the cliffs to observe the cliffs and erosional features up close.

The Eagle Mine (operated by Lundin Mining) is an underground, high-grade nickel and copper mine located in western Marquette County; it is the nation’s only primary nickel mine. Participants will have a tour of the surface workings, including the ore storage area (where samples of the high-grade ore may be collected!) and the state-of-the-art reverse osmosis water treatment plant used to purify water from operations as well as all precipitation on the mine site and more.

This trip will visit two museums along the historic Marquette Iron Range to learn about the history and development of the iron industry in Michigan's Upper Peninsula. The Michigan Iron Industry Museum, operated by the Michigan History Center, tells the story of Michigan's three iron ranges and the people who worked them. The trip will include a guided tour of the Cliffs Mine Shaft Mine Museum, historic grounds, and general mining history of the Cliffs Mine.
Building an Aquifer Vulnerability Map in Southern California using GIS and the DRASTIC Model

Michael Roberts, SA-9536

Abstract
An important aspect of groundwater management is understanding exactly where the groundwater is under threat of contamination. Using the DRASTIC (Depth to water, net Recharge, Aquifer media, Soil media, Topography, Impact of vadose zone and hydraulic Conductivity) (Babiker, et al., 2005) pesticide model with geographical information system (GIS) software a map can be drawn that shows where an aquifer is most vulnerable to certain chemical contaminants. One of these contaminants modeled well by the DRASTIC pesticide model is nitrate of the form found in common fertilizers. This paper describes an effort to build a DRASTIC model for vulnerability to nitrate, covering a two-county region in southern California. In addition, another DRASTIC model will be examined in order to better understand the methods, weaknesses, and flexibilities of DRASTIC models.

Introduction
Water is possibly as integral to life on earth as carbon. With all the Earth’s inhabitants depending on water for survival, it is important to maintain the cleanliness of our sources. A good step toward prevention of contamination is to determine where an aquifer is most likely to become contaminated, and then to focus on those locations. To find these areas of relative vulnerability, several approaches have been developed. The United States Environmental Protection Agency (EPA) developed a model known as the DRASTIC model for determining vulnerability based on a set of geological properties of the region. The DRASTIC model was built in such a way that when GIS software was later developed, the model was easy to implement and use with these new tools. The model was developed to be a general case that could be altered and fit to the circumstances of many sites. One adopter of the DRASTIC model was the state of Florida who created the Florida Aquifer Vulnerability Assessment (FAVA). The geology of Florida is dominated by carbonate rock. Because of its low elevation, high humidity, lengthy coast and high water table, a highly eroded karst system has formed. This allows for easy subsurface water flow and therefore easy spread of contamination (Arthur et al., 2007).

The DRASTIC Model
Developed by the United States EPA in 1985, the DRASTIC model is used to determine an aquifer’s susceptibility to contamination. A common application of the DRASTIC model is to plot the chemistry of water or soil samples to a map, usually using geographical information systems (GIS) software, in order to determine where in a region the aquifer is susceptible to damage. The original 1985 model is somewhat dated, but many use it as a starting point for their own vulnerability models to this day.

Each of the parameters above was given a weight (5, 4, 3, 2, 1, 5, 3). The weights were derived from a number of real studies across a wide variety of settings to fit most circumstances. The most significant weights are the depth of the aquifer and the impact of the vadose zone. More clearly, the best shield to an aquifer is being far below layers of rock. Naturally, the effectiveness of the vadose zone (the unsaturated rock above
the aquifer) is driven by the depth of the aquifer and therefore the thickness of the vadose zone. Net recharge is the following variable in terms of significance in the DRASTIC model. The more water that an aquifer has flowing through it, the higher the chance that some of that water is contaminated.

The parameters next in importance are Aquifer media and Hydraulic conductivity. In the same way that vadose zone impact is a direct result of aquifer depth, hydraulic conductivity is a function of aquifer media. Hydraulic conductivity is the ease with which water moves through a medium. In the case of the sedimentary rocks that hold our aquifers, the most important factor of hydraulic conductivity is pore space, which is also part of the sedimentary rock classification scheme. Soil media are less effective than aquifer media. Soil type affects how much water penetrates the surface. Lastly, there is Topography. This refers to the slope of the ground above the aquifer. The steeper the slope, the less likely that rainwater remains in place long enough to penetrate the soil. The DRASTIC model has been used in a variety of settings around the world and has proven itself as an effective starting from which to build a strong regional model that can be tuned to a specific setting.

The FAVA

A demonstration of how DRASTIC models can be built using the same framework but can also be altered to better fit the challenges of a region can be found in the FAVA. In Florida, there is a high water table, and the bedrock is highly weathered carbonate. The landscape of Florida is pockmarked with sinkholes that give unobstructed access to the aquifer. The state has very little elevation change, aside from those sinkholes. The minimal change in elevation means that the topography is even less significant than in the base model, in which karst features are not represented at all. This setting has significant divergences from the assumptions made in the DRASTIC model. In order to track their state’s aquifers better, a new model, the FAVA, was created.

The official FAVA was selected from a set of models made with different techniques. A semi-empirical model, as well as a fuzzy-logic model were considered and rejected. Instead, the FAVA is built on weight of evidence (WofE) analysis. Like the DRASTIC model, WofE considers a wide variety of data that vary in significance. WofE employs training points, or measured data, in order to determine which of the evidential themes is most likely to influence an outcome, in this instance, contamination of an aquifer. Weights were determined for and applied to evidential themes. The weighted themes were applied to the training points, spatial data were added, and a series of map layers, like those in figure 1, were made (Arthur, et al., 2007).

Figure 1. Evidential themes and their generalizations based on WofE weights analysis: A, soil hydraulic conductivity; B, binary classification of soil hydraulic conductivity; C, closed topographic depressions; D, binary classification of karst-feature density (Arthur, et al., 2005).
were calibrated with real contamination data from 148 training points to determine the evidential themes that were most likely to predict correct outcome. Those most effective were soil hydraulic conductivity, karst features, thickness of aquifer confinement, and hydraulic head difference between water table and potentiometric surface: these were used as input in the FAS FAVA mode (Arthur, et al., 2007). This deviates quite far from the original DRASTIC model’s parameters. Both models agree that the most influential evidential theme is what lies above the aquifer. Depth of the aquifer is a parameter in both models, and the FAVA included a separate parameter for the thickness of the confining unit. Soil hydraulic conductivity was another addition to the FAVA. Where the DRASTIC model downplays the effect of soil type, the FAVA considers high soil hydraulic conductivity a strong predictor of contamination.

Study Area

Kern and San Luis Obispo Counties are in southern California, north of Los Angeles and Santa Barbara. Over 1,000,000 people live in these two counties, which contain just over 8,100 mi². The Los Padres National Forest runs through San Luis Obispo County. The Sierra Nevada Mountains pass through the east side of the region. The region contains three different aquifer systems; the Central Valley aquifer system in the middle, the Coastal Basin aquifers on the Pacific coast, and the Basin Fill aquifers to the east side. The two largest cities in the region are San Luis Obispo in San Luis Obispo County, and Bakersfield in Kern County. Land in these two counties is used for agriculture, as well as for industry and residence.

Methods and Data

Budget and time constraints mean that not all DRASTIC variables are complete and well tested. Priority has been given to variables that have been reported as highly important to similar studies. Soil hydraulic conductivity was highly important to both the FAVA (Arthur, et al., 2007) and the model built for Kakamigahara Heights (Babiker, et al., 2005). Topography was also added to the model as this was important in the original DRASTIC model, and has since seen validation (Babiker, 2005), (Neshat, 2017). In the case of nitrate pollution, land use has also shown itself to be an important factor. Where there is agriculture, the fertilizer used causes diffuse contamination over wide areas of land (Babiker, 2005). Depth of the aquifer and recharge are also important factors.

These values have been applied to representative map layers in Groundwater Ambient Monitoring & Assessment (GAMA) tool, but at the time of writing, that has not been completed. Until that calibration is completed, the Modified Pesticide DRASTIC model’s weights and ranges have been used (Brindha et al., 2015).

Depth of Aquifer

The depth of the aquifer is a simple measure of the difference in elevation between the water table and the ground surface. The depth used for this model was the depth field given by the Groundwater Stations Enterprise Water Management. A surface showing the depth to the water table was made using that depth as a z-value during IDW interpolation. This is a very simple method, but it is brief and effective and clear, and those are key priorities.
Recharge

Recharge is based on the precipitation in the area. This information was obtained from the California Nevada River Forecast Center. Originally data for the month of September were used because fertilizer is applied then. This resulted in a uniform low score across the entire study area, which reflects the low precipitation in the southwestern United States.

Soil Media

Information on the soils was obtained from the USDA Soil Survey. The hydraulic class of the soils was used to determine their unweighted value in the model. The hydraulic class is related to the sorting and grain sizes of the soil (NRCS, 2009), which is the trait scored in the Pesticide DRASTIC model (Brindha, 2015). Group A soils were given a score of 9.5, group B soils were given a 7, group C got a 4, and group D soils were scored at 2. A, B, and C also had classes split with D, which were given a value half the aforementioned value. Lower scores indicate soils that are more likely to produce runoff. This doesn’t affect total contamination in the regional hydrology, but it displaces many contaminants before they can infiltrate into the aquifer, thus lowering local aquifer contamination.

Topography

Topographical data was not a challenge to locate. The United States Geological Survey (USGS) offers free 30-second aerial imagery of almost all the United States. The DEMs for the study area were downloaded and converted to a single layer displaying the percent slope. This was reclassified categorically to better see regional trends. Low slopes are a strong indicator of vulnerability because they allow for more infiltration in the area to carry a greater amount of contaminant into the aquifer.

Land Use

In the case of Nitrate contamination, land use is especially important because nitrates do not occur naturally in high enough concentrations to cause ecological concern. (Babiker, et al., 2005). Human impact from agriculture and lawn care is required for harmful amounts to accumulate.

The Model

Once the layers were made, calculation of the final values was a simple process.
AQUIFER VULNERABILITY

matter. The DRASTIC model is a linear combination of the variables multiplied by their weight; a higher score means higher relative vulnerability. In the abridged model presented here, land use was the strongest indicator of aquifer vulnerability. Topography was also a very strong indicator of vulnerability. Soil medium was not as strong an indicator of vulnerability as topography but was stronger than depth to aquifer. Recharge from precipitation was the least important of the variables controlling pollution. This also influences the impact of aquifer depth. With low recharge, less contaminant makes it into the aquifer at any depth, making this measurement less helpful than it might have otherwise been.

Conclusions and Recommendations

The findings here matched the established literature quite well. Although the scope of the model here was limited, aquifer media and hydraulic conductivity having been ignored, the model still does a good job of predicting where contamination is likely to occur. Although serious statistical analysis has not been performed, it appears as though the most effective variables match up with those of Babiker, 2005 and of Arthur, 2007 (as applicable).

References


Students!
Submit your research projects for publication to TPG. You may submit articles any time of year. If you have questions, contact editor Adam Heft at adam.heft@wsp.com.
Geoscience student progress during the pandemic, August 2021

University students may be the population in society to experience the most variability in experiences during the pandemic. We are monitoring experiences of geoscience students during the pandemic, including how advising is being conducted, impacts on degree progress, and students’ intent to continue in their degree programs.

Advising

Student advising was primarily done via online only formats through May 2021, after which multiple modalities for student advising became more common. With the start of the Fall 2021 term and return to in-person classes in August 2021, online only advising was reported by 31% of respondents whereas a combination of in-person and online advising was reported by 35% of respondents.

Degree progress

Since March 2021, more than half of students reported impacts to their degree progress. By August 2021, 64% of students reported delays in tasks related to their thesis, dissertation, or capstone projects, and nearly one-quarter of students indicated that the design of their thesis, dissertation or senior capstone project had been changed. In addition, by August 2021, 20% of students indicated they had deferred their thesis or dissertation defense, and 16% of students indicated they had deferred graduation.

Most geoscience students were able to take required courses for their major during the 2020-2021 academic year. However, 28% of departments reported that 10% or more continuing students were unable to take required courses in the 2020-2021 academic year, and 14% of departments reported the same for graduating students. Furthermore, 57% of departments indicated that up to a quarter of students delayed their graduation to complete their degree requirements.

More than half of departments indicated that continuing and graduating students were unable to take field courses and courses with field components. Topics commonly mentioned as being unable to take included field methods (mapping, field skills, cross-sections, measurement, etc.), mineralogy, sedimentology, structural geology, environmental science, and lab methods.

The above information is an excerpt from the AGI Geoscience Currents data brief dated November 1, 2021. To read the data brief in full go to: https://www.americangeosciences.org/geoscience-currents/geoscience-student-progress-during-pandemic-august-2021.
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