TPG is a publication of the American Institute of Professional Geologists

THE PROFESSIONAL GEOLOGIST

VOLUME 59 NUMBER 3 JUL.AUG.SEP 2022

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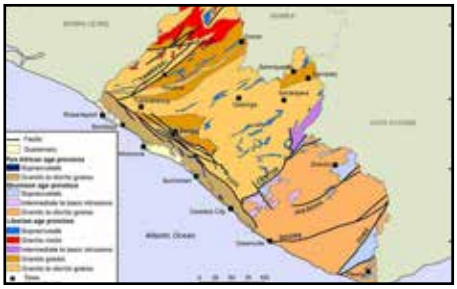

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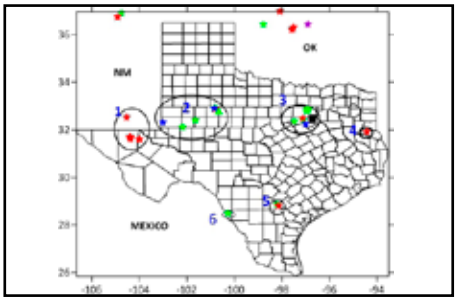

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On the Cover: The ore dock in Marquette's Lower Harbor. Originally the 6th Dock, called the Duluth, South Shore, and Atlantic Dock, it was constructed in 1931 and closed in 1971 with the simultaneous closing of the Tracy Mine, from which ore shipped from the dock was primarily mined. Almost 24 million tons of iron ore were shipped from this dock; peak capacity was in 1969 with 1.6 million tons. Information excerpted from https://www.upmatters.com/news/the-ore-dock-its-past/. Photo credit: Sara Pearson, CPG-10650.

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

The mission of the American Institute of Professional Geologists (AIPG) is to be an effective advocate for the profession of geology and to serve its members through activities and programs that support continuing professional development and promote high standards of ethical conduct.

The Professional Geologist (USPS 590-810 and ISSN 0279-0521) is published quarterly by the American Institute of Professional Geologists,1333 W. 120th Avenue, Suite 211, Westminster, CO 80234-2710. Periodicals Postage Paid at Denver, Colorado and additional mailing offices.

POSTMASTER: Send address changes to *The Professional Geologist*, AIPG, 1333 W. 120th Avenue, Suite 120, Westminster, CO 80234-2710

Subscriptions for all Members and Adjuncts in good standing are included in annual membership dues. Subscription prices are $20.00 a year for Members' additional subscriptions and $30.00 a year for non-members for 4 issues (for postage outside of the U.S. add $10.00). Single copy price is $5.00 for Members and $8.00 for non-members. Claims for nonreceipt or for damaged copies are honored for three months.

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

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

What Do High Standards of Conduct Apply to?

Adam W. Heft, CPG-10265

Spring has finally sprung here in mid-Michigan, and we are getting some warm (even a few hot!) days, although the potential for frost remains for a couple more weeks. Yes, I know – as you are reading this, we are already well into summer. Some of you are probably wishing for some of our mild spring weather at this point…

The Jul/Aug/Sep *TPG* edition contains several contributions by regular contributors, including a piece on Liberian geology and water resources, several opinion pieces, and a peer-reviewed article. I hope you enjoy them. We also have this year's AIPG scholarship awardees' essays for your reading pleasure. Ten undergraduates and one graduate made the cut at the national level and two additional undergraduates received section-sponsored scholarships. One big and very noticeable change for this edition is… FULL COLOR! The cost of printing in full color has come down substantially, and it is now economical to have the print copy of *TPG* in full color going forward.

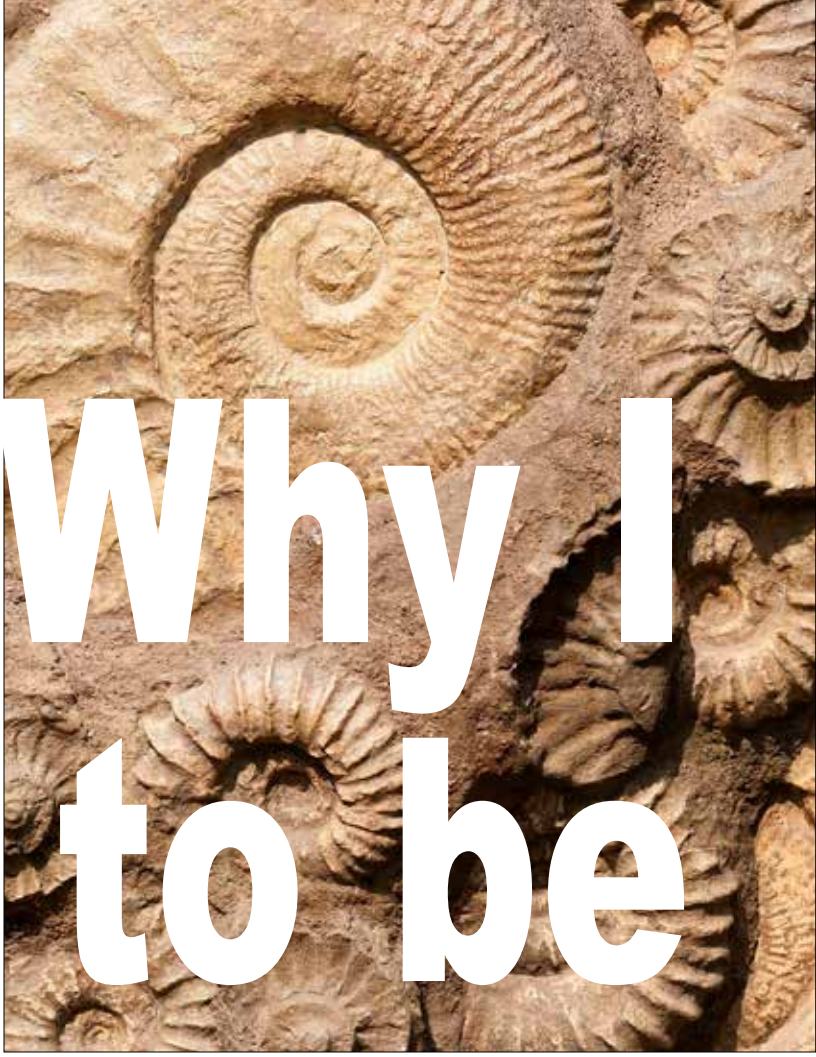
I'm hoping that our members are reading this column, and of course, the rest of *TPG*; there is a lot of good information in it. Did anyone see my last column where I asked members to share their experiences that were similar to what I included in the Jan/Feb/Mar edition on "Do the Rules Apply?" I was hoping for one or more Letters to the Editor outlining their experiences. It isn't too late; please consider sharing – I'd like to hear from you! In a similar vein, I tossed out a member challenge on how you consider geology to be more than just a career, it's a lifestyle. Did anyone send in a video clip to headquarters to include for the AIPG YouTube channel? Let's start accumulating those; with several thousand members, we ought to be able to get at least a few of those up every month. This will be good outreach to students and the general public to help them understand what it is that we do, both on and off the job.

For this column, I'm going to touch on a different topic. As you all know, as AIPG members, and particularly as CPGs, we are held to a high standard of conduct and professionalism. Our three pillars are "Competence, Integrity, and Ethics"; these are included in our bylaws and on our organization's logo. They are the basis for our actions; both for things we do, and things we must not do. I would argue that our professional actions should also include going above and beyond the everyday. In this case I would suggest that it could include passing along knowledge in the case of seasoned professionals, and a willingness to absorb that knowledge by those just getting started in their careers. What better way to do this than by mentoring? And this could be in an informal setting rather than just a formal one-on-one mentor-mentee situation. A good way to accomplish this would be by submitting articles for publication for *TPG*. We have enough members that if each individual were to write just one article (technical, educational, or opinion piece), we would have no shortage of them!

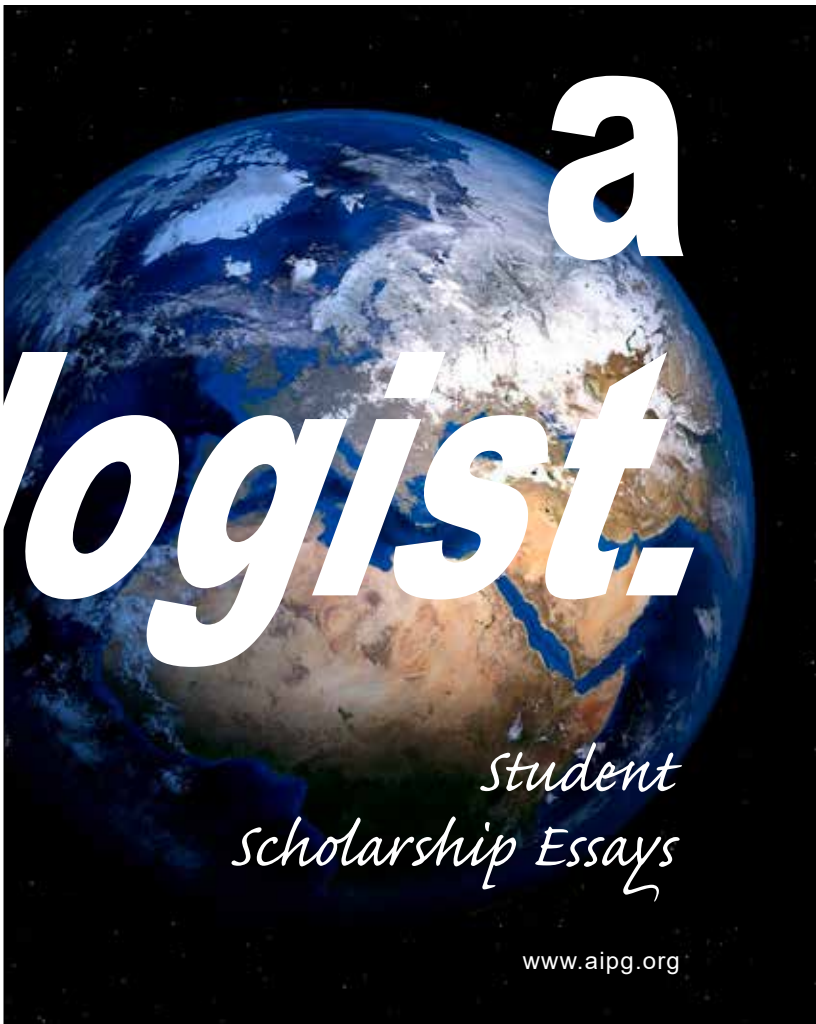
That said, and going back to my original point about our being held to a high standard of professionalism, shouldn't that apply to our publications too? I think it should. This means that when an article (of whatever type) is submitted, care should be taken to ensure that if follows our publication guidelines. The article should be based solidly on facts (unless it is an opinion piece) and include any caveats in the data so it is clear to the reader what is and is not included as the basis for the article – the same as we should be doing in our professional careers and reports we generate.

Another thing that our members can do is to volunteer as an Associate Editor. We are in need of seasoned professionals with solid writing skills in all specialty fields of the geosciences to help out by reviewing articles, particularly those that are submitted for peer-review. I encourage you to consider serving in this capacity; the time commitment is not that great, and not every edition of *TPG* includes a technical article in every field of the geosciences. And the more people that step up to help in this capacity, the lighter the load for everyone!

So please consider upping your professionalism by submitting articles, reviewing them, or passing your knowledge to others by mentoring. This will help strengthen AIPG, encourage others to join the organization, and will make for a better publication.



Why I want to be a Geologist.



Student Scholarship Essays

AIPG National is proud to announce that we have awarded 10 $1,500 scholarships to students pursuing geology degrees and careers. Two additional $500 scholarships, sponsored by the Indiana-Illinois Section, were also given. Scholarships are funded by national and the Foundation of the AIPG. As part of their scholarship application, we asked undergraduate students to write an essay themed "Why I want to be a Geologist." We are sharing their essays here.

We also awarded one William Siok graduate scholarship funded by the Foundation of the AIPG to students pursuing their graduate level degrees. We asked graduate students to write an essay focusing on a single theme of their choice, and explain how the profession of geology, over the coming decade, should best contribute to addressing a problem for the well-being of the public. They were asked to explain (1) Why their theme choice is significant and (2) How professionals educated in geology are essential to contributing successfully to addressing the problem. We are sharing these in this edition as well.

We are so proud of our student members and excited to see what they will bring to the future of the geosciences.

Congratulations students!

Benjamin Bugno

SA-11362

Illinois State University

Illinois-Indiana Section

My passion for science came young, as I was a motivated child wanting to learn the ins and outs of our central belonging and place in time on this planet that seemed too good to be true. I remember being fascinated by so many things growing up, such as dinosaurs, volcanoes, earthquakes, and the ocean. I grew fond of the natural sciences more than any other science, dreaming of one day working outside and being able to experience places and activities that an average person may not be able to in their lifetime. As well as learning in the classroom, I also was strongly involved in my local Boy Scouts of America troop which not only allowed me to grow as a young individual and learn much about my intrinsic values, but also to become more curious about our planet and its many unique characteristics. I was fortunate enough through my teenage years to travel with my parents and see many of the National Parks that make up the landscape across our country. My passion for the outdoors that stemmed from my experiences in Boy Scouts and traveling, along with my record of being an ideal student, first lead me to pursuing a career in education. I was accepted into the College of Geology, Geography, and the Environment at Illinois State University in Fall of 2018 with the intent to earn a degree in Earth and Space Science Education. My first collegiate exposure to Geology was an Environmental Geology course where we discussed the impacts of beach erosion, groundwater contamination, flooding hazards, and water quality on everyday human life. I grew fond of the idea of working towards researching the human impact on our world as well as the impact it has on us. I decided to switch from my current major into Geology, my future plans being researching water quality. Shortly after this, I was able to be admitted into an internship at the Lab for Environmental Analysis as part of the Surface Water Assessment Team at Illinois State University for the Summer of 2021. While working for this internship, I assisted graduate students of the Hydrogeology program at Illinois State in their studies relating to their theses. This included sampling from two lakes in central Illinois, filtering these samples, and collecting data used to compare to a remote sensing drone. My internship also gave me the opportunity to create and carryout my own undergraduate research project that I was able to present at the annual meeting of the Geological Society of America in October of 2021. Through my experiences with working for the lab, I learned about the aspects that went into research and lead me to strive to pursue a career in my newfound interests.

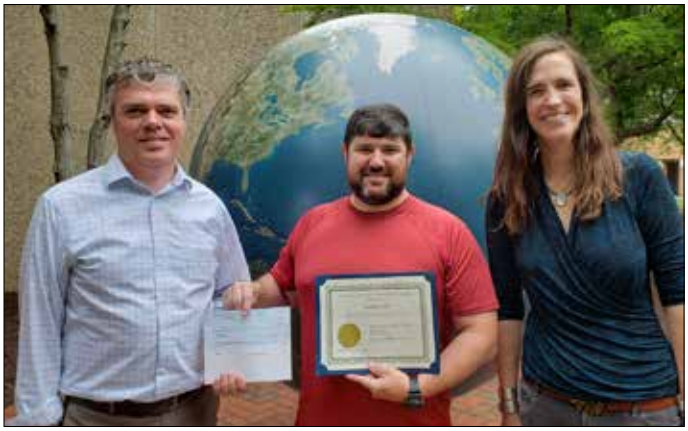
What makes Geology so intriguing is the interdisciplinary aspect of the science. One can always find something that they like about Geology because so much research from varying fields goes into understanding bigger concepts. Biology, Chemistry, Physics, Engineering, and Mathematics all help make up how we build our spatial and temporal understanding of the Earth. Although I have a firm idea of the path I want to take in the future, that doesn't necessarily mean my mind won't change tomorrow because of an experience I was a part of today. We are constantly learning new things that pique the interest of individuals that allows for the further advancement of our collective knowledge. I'm honored to have met many intelligent individuals. that dedicate their lives to further advance our understanding of the past, present, and future, and I hope to one day be an individual who helps solve the issues that affect us. I hope to study surface and groundwater quality and how they are affected by humans and other environmental factors. Geology is the greatest science there is because of the research that leads us to bettering our societal practices so we can safekeep the world we were blessed to be given. I'm excited to be working in a field of study that may be overlooked on a large scale. When someone turns on their faucet, I doubt they ever question, "Where is this water coming from? How clean is my water?" Having such a pivotal role in a system that relies on the advancement of science fulfills my goals in life and leads me to continue to take my education seriously and strive to take opportunities as they come, as those opportunities that I have taken in the past have led me to where I am now. The reason why I want to be a Geologist is because I want to give back to the place we call home and enjoy a career where I am immersed in unique experiences. Geologists are necessary for our society to function, and I hope that I can find a field of study where I can make a difference in other's lives.

Justin Coley

SA-11292

UNC Charlotte

Carolinas Section



Associate Professor David Vinson, Ph.D. Justin Coley, and Professor Martha Cary Eppes, Ph.D.

I am a non-traditional student who has returned to school to complete undergraduate and graduate degrees in the fields of Geology and Earth Science. I am coming back to school from the accounting profession. I am also a Marine Corps combat veteran. I have always enjoyed working and being outdoors, and value environmental conservation and stewardship. The physical sciences are something that I grew up around, and was encouraged in, as the son of a chemistry and physics teacher.

Physical geology was a science elective for me when I was working through my first degree. I really enjoyed the class, and was always amazed with the information that can be gleaned from a rock. It is staggering how far back in time we can look by studying geologic settings. I want to work in the sort of incredible landscapes we were seeing pictures of every day in class. I should have known then that this was the perfect fit for me.

Geology touches and/or affects everything from the deepest parts of the Earth to the outer solar system and beyond. Its interdisciplinary combination of chemistry, physics, and math and the geologic ramifications with respect to biology, ecology and engineering is very interesting to me. The range of geology's applications and the consequences it holds for economic development and the environment means it provides many different opportunities for work and study. I am returning to school from the business world, where my typical day involved long hours in an office setting. The work I was doing was demanding but had no tangible results, and was not personally rewarding to me. I am making this change to do something that has tangible benefits to the world around me, and that gives me a chance to be more hands on while still using critical thinking skills. It would be rewarding to me to get to study and build things that are useful to people, and create a better world and environment.

Since making this change, I have often been asked, "Why geology? What will you do with it?" My ultimate goal is licensure as a professional geologist, and to end up in a role focused on environmental geology and hydrology. I am most interested in subsurface hydrology and geology that affect the movement and availability of water and related contaminant transport. I am also interested in surface hydrology and biogeochemical processes in riparian areas. I find the science of water and lithosphere interaction not only interesting, but also vital for society, especially in light of the effects of global warming, groundwater depletion, and land subsidence. These are the reasons I want to be a Geologist.

“ I am making this change to do something that has tangible benefits to the world around me, and that gives me a chance to be more hands on while still using critical thinking skills."

Zephyr Girard

SA-11352

UC Santa Barbara

California Section

As far back as I can remember, I have been drawn to nature. After high school I was unsure of what I wanted to study in college and instead opted to take a few years off from school to explore the world and find something I was passionate about. Following my love for the outdoors, I spent 18 months in the Colorado Rockies working as a snowboard instructor and spent two winters snowboarding almost every day and summers hiking, biking and camping in the surrounding mountains. When I left Colorado, I missed the intensity and adventure of the Rockies so I saved money from my earnings from a summer job and took a three month trip to Southeast Asia where I explored ancient temples, attended museums to learn different histories of the region and hiked through stunning canyons and mountains. My trip culminated in a two week trek through the Nepal Himalayas up to the basecamp for Annapurna I, the tenth tallest mountain in the world. I was struck by the dramatic peaks and valleys and was amazed to learn that these massive mountains are still growing due to the active collision between the Eurasian and Indian tectonic plates. When I returned from my trip I committed to studying Global Studies at UC Santa Barbara to continue learning about different cultures, languages and histories.

I was first introduced to geology in the winter quarter of my first year of college in "Introduction to Physical Geology," a class I chose somewhat randomly to fulfill my general education science requirement. My professor was an energetic

British geophysicist and his passion for earth science shone through as he taught us the "greatest hits" of geology. While in my global studies classes I learned the opinions of my professors on abstract geopolitical dynamics, my geology class took us out into the mountains of Santa Barbara to touch (and taste) the very rocks we had studied all quarter. We learned about what the local exposed surface rocks tell us about the unique tectonic history and changes in sedimentary environments over the past 165 million years. Geology helped me understand the majesty I had sensed in the Himalayas less than a year prior, and I developed a deeper sense of reverence for the power the Earth has to form and shape our environments through geological processes.

After my first geology class I was hooked, and in Spring quarter I loaded up my schedule with more geology classes, including a four night field trip in the Eastern Sierras. Through informational hikes around lakes and volcanoes the professor managed to tie together the orogenic events that formed the present day Sierra Nevadas, the complex hydrological history of Southern California and the ongoing extension of the Basin and Range Province. This trip introduced me to real world applications of geology in geohydrology, and I quickly realized that geology can help answer many of the most important questions we face today: about sustainability, resource management, human impacts on the environment and natural hazards. Geology was giving me a new lens through which to see the natural world but also a newfound sense of optimism that applied geology could help solve the crises I worried most about. This past summer I started working as an independent undergraduate researcher in a Biogeochemistry lab in my department that focuses on the interaction of sulfur with organics in the environment. I work with two other undergraduates and Dr. Morgan Reed Raven evaluating the storage of agricultural biomass in marine anoxic basins as a carbon dioxide sequestration method. We are in early stages and far from even thinking about large-scale implementation but my experience in the lab has strongly motivated me to attend graduate school after I graduate next Spring to continue to research creative ways to use natural geological, chemical and biological processes to solve real problems. This work has introduced me to the interdisciplinary and collaborative nature of geology, and I am constantly amazed by the interactions between the complex, intricate geological and biological processes happening all around us.

I want to be a geologist because understanding how our environments are formed connects me to nature in the deepest way I can imagine. It has taught me that even the most seemingly mundane places have rich, complex geological histories to learn from. Geology has also given me lessons that apply to my everyday life; like how just as an ordinary river slowly carves out magnificent rock formations and canyons, the small steps I take toward my goals everyday also compound and someday I will reach them and beyond. I am truly captivated by this science and I am excited to continue learning about the world around me for the rest of my life.

Julianne Gonzalez

SA-11293

University of Florida
Florida Section

I struggle when contemplating why I do almost anything, burdened with a hyper-active "what is the point?" part of the brain. So, naturally, I keep tabs on the moments that quiet those questions: hanging out with my cat, singing in the car, and connecting to nature. But as we all come to realize… There are only so many passions you can pursue as a career.

I have always loved to learn as a *part* of life, but it was not until I began studying geology that learning deepened my love *for* life. Somewhere along the way, school stopped being the thing I wished I could forget about- it became all I wanted to think about. This is because it was no longer just school, it wasn't just for the grades and merit, it was something more. What that is, exactly, is something that I can't quite articulate. Maybe I'm just not a writer, but I think language hasn't measured up to the grand processes of the natural world. Through my eyes at least, the sun just shines differently on nature, and understanding nature always deepens the awe that it inspires.

The first time I fell in love with a rock, I was young. It was Christmas and my grandpa had gifted me a quartz geode with a hammer to bash it open. That geode lived in my display of shells and shark teeth I had collected over the years, which I now realize proved my instinctual fascination with earth science. Cut to 10 years later and it's simple; I was born to be the friend who won't stop telling you geology facts as you try to take a peaceful walk outdoors.

I want to be a geologist because I never have to wonder if what I'm studying matters. Of course it matters, because it just is. It is and it always will be. I want to be a geologist because I love getting to know the world around me; I am yet to find a greater reward to learning than walking outside, looking around, and understanding a little bit more of the 'why' of where we are. Being outdoors reinstills the drive and inspiration it takes to work diligently in the classroom or lab, and what I learn indoors reinstills the wonder and excitement

that accompanies the outdoor work so beautifully. I don't only want to learn, however. I also want to ask questions, make interpretations, and ponder new ideas. Luckily for me, I imagine that geologists will never run out of questions to ask.

I know that I want to be a geologist because every new experience I gain in geology makes me want to continue working and learning. Even the most painstaking moments in my academic career, in retrospect, have continued my drive to become a geologist. Every new lab method I learn makes me excited for the next, and each new outcrop I see leaves me wanting more. The most disappointing aspect of my choice to study geology is that I can't explore every topic within it! One thing I appreciate the most in geology is the subtopics; almost every greater cause someone wants to work towards in their life requires geologists, from fighting climate change to advancing new technologies. No matter how unsure I am of what area of the industry intrigues me the most, I can still be sure that I want to be a geologist.

Education and careers in geology represent the perfect storm of my interests. I am passionate about Earth, in both its former and future states, I love science and scientific communication, I find creating art to be cathartic, and nothing makes me feel better than being outdoors. Studying geology allows me to learn about natural processes, analyze scientific results, create visual maps and graphs, and conduct field work in stunning locations. I am confident in my aspiration to be a better geologist, and proud of the one that I am already.

McKenzie Miller

SA-11294

UNC at Charlotte

Ohio Section

When I was a kid, we didn't have cable. We did have a box set of the original Star Wars movies. Our neighbors thought it was strange that a five-year-old girl loved the space-action saga. My parents fortunately ignored this and fostered my fascination with the movies' strange worlds: from desert and ice planets to lush forests to volcanic hellscapes…these foreign sights were larger than life to my Ohio born eyes. My dad, a carpenter, watched PBS's Nova religiously. He encouraged me to join in. To my delight, the Star Wars worlds were real, right here on Earth! Even better, there were these unfathomably smart scientists who figured out how these exotic places came to be. The documentary geologists in their polar garb, riding helicopters over volcanoes and donning white coats in high tech labs were as spectacular and distant as adventure heroes in a film.

Inspired, I recreated extinction events with my dinosaur figurines in the sandbox. I made it my business to search my backyard creek tirelessly for the Ohio state fossil, Isotelus. Fistfuls of crinoids, bryozoa and brachiopods collected along my warpath adorn the horizontal surfaces in my childhood home to this day.

My five year old self had a geology dream, but unfortunately, peer pressure and the woes of adolescence robbed me of it shortly thereafter. Though my parents continued to nurture my tomboyish affinity for playing barefoot in the dirt with camping trips, I grew self conscious of my seemingly unorthodox passions. I couldn't find other girls who wanted to play with dinosaurs or go fossil hunting. Maybe I'm not supposed to like these things, I thought. By high school, Earth science had completely fallen off my radar. The Indiana Joneses of the science world were people I was destined to watch from afar.

During college applications, I saw a scholarship that included a month-long backpacking trip in the Wind River Range the summer before freshman year. The pull of the mountains, to explore and wonder "how did these rocks get like this?" was irresistible. I got the scholarship, signed up for a load of premed classes, then got on a plane to Wyoming. For a whole month, living and breathing glacially carved cirques, scrambling over scree slopes and hunting for the smoothest granite glacial erratic to cook dinner on lit my imagination on fire. I returned east to Charlotte, North Carolina to reluctantly start premed classes.

As I slogged through general education requirements and started thinking about internships and research, I pondered what really interests me. I realized I had no idea how my newfound weekend backpacking playground, the Appalachians, were formed. I didn't know why Charlotte has salt and pepper granodiorite bedrock while Cincinnati's is fossiliferous limestone. These questions bothered me. How could I live in these places and not understand the ground beneath my feet? Searching for answers, I registered for GEOL 101.

It was love all over again, reading my textbook with the same fascination I once applied to Nova nights as a kid. For every answer, there were ten new questions. If you kept questioning, there was no limit to how deep you could dive in geology. Hooked on the pursuit of answers, I officially switched majors and skimmed through the faculty research going on at my school. Lo and behold, the swashbuckling, exploring geologists of documentaries had offices just feet from my dorm. With one geology class under my belt, I naively approached a researcher who'd been to Antarctica.

Can I go next time?

Well, not quite yet. But I could do a simple outcrop mapping project in Charlotte. My curiosity to learn how dramatic tectonic stories can be unraveled from the subtlest clues in the rock record led me to more and more questions. Always in pursuit of "how this landscape come to be," I now find myself on the path to becoming a geologist. In just a couple years, this question led to thin section point counts on Antarctic

rocks, presenting at GSA, a mineral exploration internship in Nevada, and now a semester doing geochronology research in France. I can't imagine myself doing anything else.

One day in Nevada, I overlooked the open pit mine with another intern. A couple of senior geologists explained the beautiful rats' nest of folds and faults to us. The conversation turned to how they'd gotten into geology. The other three remarked that they'd all been inspired by a geologist family member. I smiled inwardly. My parents' quiet encouragement of my childhood curiosity is my geology origin story. The prospect of grad school now looms, exciting rather than daunting. It's thrilling, starting out in this field is so rife with questions in need of some intrepid geologist to go bushwhacking into the unknown to answer. Why not me?

Sebastian Pérez-López

SA-11373

Stanford University

California Section

Assistant Professor Mathieu Lapôtre and Sebastian Pérez-López

For me, being a geoscientist has always come hand-in-hand with being Chilean. My favorite childhood memories are of hiking the Andean volcanoes with my cousins, exploring open-pit quartz mines with my grandparents, and staring at the Milky Way in the Atacama Desert. My perception of geoscience's power and importance grew as I watched the relief events for the destructive 2010 Chilean earthquake and tsunami, witnessed the world unite to rescue the 33 trapped Chilean miners, and celebrated the first images of planetary formation from Chile's ALMA telescope. I'd like to think that every Chilean is born with a little bit of geoscience in them.

My parents took a different route, however, and instead chose to become life-scientists. Growing up as the child of two biologists, dinner table conversations swirled with talks of the newest microbial developments and breakthroughs in viral studies. Holidays were celebrated with a flurry of microbiologists and neuroscientists, and on special days I would get to join my parents and watch them work behind the lab bench. The topics covered always fascinated me, but as I grew older I caught myself wondering what was going on with the things that weren't alive — we were learning so much about the living world, but what questions could we answer about the natural world?

My curiosity turned into action when I was ten years old hiking through the Atacama with my grandfather. I remember walking idly alongside him when I caught a glimpse of a dirty, beat-up piece of quartz poking out from the sand. When we got back home, I sacrificed my own toothbrush to scrub off all the dirt until its pristine crystal structure was unmistakable — I couldn't understand how nature made something so perfect! By the time I entered college, I was knee-deep in my obsession with Earth Sciences and was certain that I wanted to be a geoscientist. I spent all my time wrapping my head around the beautiful crystal structure of minerals, mathematical perfection of planetary orbits, and absurdity of geologic timescales. Little did I know that as I moved through my undergraduate coursework, I was going to be exposed to the best thing about being a geologist — how fun the work inherently is. I will never forget my first field experience in Death Valley, where I learned how to take strikes and dips, cook out of the back of a truck, and how incredible a career in the geosciences could truly be. I am lucky that as a future geologist it will be my job to spend time outdoors and probe our planet to better understand where we live.

There's a quote that goes something like "Find a job you enjoy doing, and you will never have to work a day in your life…" and to be quite honest, I think I'm on track to do just that. I couldn't think of a better career!

"I will never forget my first field experience in Death Valley, where I learned how to take strikes and dips, cook out of the back of a truck, and how incredible a career in the geosciences could truly be."

Mackenzie Rutherford

SA-10979

Miami University

Ohio Section

Ohio Section President Robert Andrews, CPG-11975 and Mackenzie Rutherford.

In the summer of 2019, I ventured 788 miles away from home to be a missionary in Panama City, Florida, hoping to find clarity as to what I wanted for my future. Through the heat, the sea of strangers, and the hard manual labor, I realized that what I wanted to do was the exact same thing as what led me there: helping people. When I returned to Miami in the Fall, I hoped to find more direction and found myself falling in love with my Mineralogy class on day one. I was suddenly learning about the amazing discovery that William Henry Bragg and William Lawrence Bragg had made together – a discovery that created the basis for which 28 Nobel Peace Prizes have been awarded. Bragg's equation ($ny=2d\sin\theta$), though it appears to be simple, it impacted our understanding of crystal structures and created solutions to much bigger issues. The Braggs made everything click for me and demonstrate the major reason why I want to be a Geologist: I want to study something bigger than myself that leads to solutions that help others.

To me, success in the field is not only the ability to climb along the rocks and take samples, but coming back and sharing the information you have found with the community, whether it be a strike and dip, a study into extreme precipitation events utilizing speleothems, or engineering pathways to safe water sources. The general public relies on our research and ability to communicate what we find in order to make informed decisions regarding their day-to-day life or politically. It is essential to take good data that can be shared in a way that the general population can understand what's going on in the world around them and how it affects them, particularly with historically excluded groups of people (Hispanic, Black, and American Indian/ Native Alaskan). These groups often end up in geographical locations that are affected heavily by climate change; yet these people are extremely underrepresented in the field. Through my senior thesis project on diversity in the earth sciences and the State of Ohio's K-12 curriculum, I hope to begin something that will become much bigger and ultimately create equal education opportunity within the earth sciences.

"I want to study something bigger than myself that leads to solutions that help others."

Living in extraneous conditions as a missionary taught me to not only be adaptable but has shown me the importance of perseverance, which are essential to achieving my big goals. I have learned how imperative it is to be innovative and patient when creating solutions. You must be willing to learn from your failures to make progress. I have applied this to everything I have accomplished in college, from designing a sustainability garden that represents the cultural values of an indigenous group, to determining whether I'm looking at a thrust or normal fault while mapping at 8000ft. in elevation, or designing a national website that promotes diversity and provides educational resources regarding earth sciences for high school teachers to use in their classroom (and that's just the tip of the iceberg). Each and everything I have accomplished has been thanks to my ability to persevere and work with others in a way that allows me to learn from them.

When it comes to learning, I value what others can contribute and often look for opportunities to share my own knowledge. For this reason, I have assisted Miami's Mineralogy lab through an undergraduate teaching assistantship. Not only have I gained teaching experience, but I have learned to utilize new programs that are useful to my own learning. Perhaps one of my favorite experiences at Miami was participating in the 28th Rochester Mineral Symposium as a technical speaker. In this session, I spent 20 minutes teaching and interacting with the audience regarding miller indices. One of the attendees said that my session inspired him to open his old Mineralogy textbook again. Seeing how I inspired others to learn was extremely rewarding.

I have always been driven by my curiosity for learning and my want to contribute by utilizing my skills in communication, leadership, and creativity. At Miami, I made it a priority to be a representative for the student body through positions in councils that pertain to diversity, sustainability, and student success, along with leadership positions that enhance other students' experience. My education has provided me with essential skills; however, I have only scratched the surface. I look forward to creating change, starting with the State of Ohio, and I am eager to continue my education by pursuing a PhD in hopes of further enhancing and learning new problem-solving skills that will ultimately lead me to what inspired me to begin with: studying something bigger than myself that is groundbreaking and inspiring, just as the Braggs did. I'm ready to be the change.

Cassia Snyder

SA-10521

Indiana University – Purdue University at Indianapolis

Illinois-Indiana Section

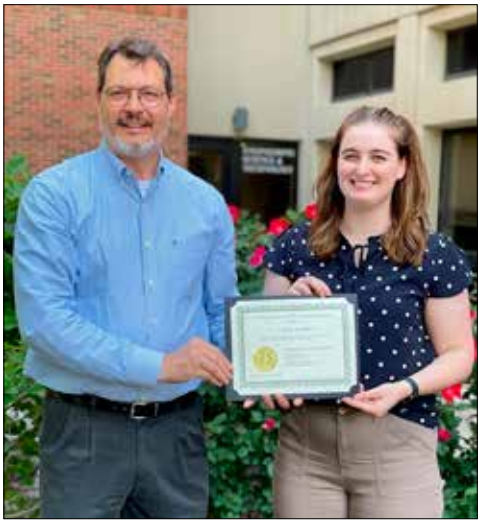
Without a foundation of geologic knowledge, humanity cannot be fully comprehended. For some people, this may seem like a blanket statement, but for me it is reality. Only by comprehending Earth's geological past will we be able to comprehend everything there is to know about humans. At the end of the day, we would not exist without our planet. Everything we have is derived from Earth, from our food and water to our technologies.

Throughout geologic time, the planet has gone through many changes. Understanding these changes and how they relate to human life and the rest of the universe is the job of a geologist. As geologists, we study the evolution of Earth's conditions across time to write the history for Earth and life. The chapters of our planet's story are inscribed in layers of rock beneath our feet, from accretion to how we, humans, managed to form and develop. Our layer, the Anthropocene, may cause irreversible damage to our planet.

We live in an egocentric world that is slowly deteriorating from our misuse of the planet's materials. Climate change is in full swing, the planet has been depleted of its resources and our society's actions are inadequate. Why do I want to be a geologist? To do something about it.

My interest in geology is anything but linear. As a child, I didn't grow up playing with rocks in the backyard or with my hands in the dirt, that may be tell-tale signs that a child will grow up to be a geologist. In fact, I don't think my parents ever knew what I was going to do with my life. Instead, we were worried about when I was playing in my next soccer game or swimming in my next meet. I was enjoying my childhood, as any kid should.

It wasn't until high school that I realized that I cared what I was learning about and began exploring my choices. I focused on swimming competitively and chose the classes I was interested in. I was motivated to succeed in the pool as much as in the classroom, but I realized I needed direction. I needed to figure out where I was going and what I would be studying. My family and I knew I had potential as a high-level swimmer. I was a nationally ranked athlete in Canada and was being recruited by U.S. universities.



Illinois-Indiana Section Board Member Shane Schmidt, CPG-11332 and Cassia Snyder.

Up until this point, I had not thought about a degree path. I was focused on swimming but didn't really know what I wanted to do with my life. I knew I wanted to love my future career and continue swimming, so I started thinking about the classes I enjoyed the best. As I began to narrow this down, I knew it would be in the science field. I loved chemistry, environmental science, physical geography, and anything to do with natural disasters. Then it clicked, I wanted to study geology.

It wasn't until my introductory geology class in university that something changed. It was the first time where every piece of information in a class was interesting to me. I was engaged with the material in and out of the classroom. I finally felt like this is where I was supposed to be. The more geology classes I took and the more my professors inspired me, the more invested I became. So here I am, with a staunch desire to use my geological studies and research to bring about positive change.

Finding my purpose has been so important to me because I want to make a difference in my lifetime. Through my studies, I want to contribute to the scientific community and better understand how geology can tell a larger story. When I look at a rock, for instance, I see it as a piece of history while others simply see it as a rock. Where did it come from? How did it get here? Under what conditions did it form? What did Earth look like during its creation? I want to inspire others to study geology and learn that Earth's story is here to be discovered.

Furthermore, I want to be a geologist to help educate the world about the Earth's environmental crisis. To our planet, we have a duty, an obligation, to do better. The future of humanity rides on our shoulders and I want to be a part of the solution. I want to be part of the reason that our chapter in the geologic storybook does not end. For this, I have dedicated my life to geology.

Zachary Tenney

SA-10982

Casper College

Wyoming Section

"I hope that I may be able to help other people learn about the natural history of Earth and how studying Earth's past has allowed us to further advance society."

My first interest in geology was initiated when my father took a job as a geologist for a uranium exploration company. He took me out into the field with him a few days while he was logging the exploration wells. Even though I hardly understood anything about what he was doing and why, it sparked my curiosity about the history of the earth. A couple years after going out with my dad into the field, he took my siblings and me on a geology field trip to Alcova Lake, giving me my first experience of collecting fossils. Another source of my interest in geology came from my grandfather who was an independent petroleum geologist here in Casper, Wyoming. He had many different rock samples in his office at my grandparents' house and outside of their house there were a lot of large boulders my siblings and I would play on, further increasing my curiosity about geology and the history of Earth.

Two years after my grandfather passed away, I had the opportunity to take some classes at Casper College as a high school student. The first college class I took was physical geology and in subsequent semesters, I took classes from several different departments, but I came back to geology since it piqued my interest more than anything else. I took a class on paleontology in the field which focused on collecting fossils from numerous periods of time throughout Wyoming's geologic history. I absolutely fell in love with collecting fossils, from trilobites and crinoids to dinosaurs and mammals. Since I enjoyed that class so much, I took the Geology of Wyoming class which had a focus on geologically-related natural disasters such as earthquakes, landslides and volcanoes. That class also had a field trip that went up to Jackson and Yellowstone where we looked at the potential hazards of an earthquake along the Teton Fault and an eruption of the Yellowstone hotspot. Following that semester, I took the paleontology lecture class and the paleontology field trips class again. It was after taking this class that I decided to become a geologist.

Since I had already taken several introductory geology courses, I had a head start and was able to begin taking several more advanced geology courses and electives such as mineralogy, petrology, geophysics, geomorphology, sedimentology and stratigraphy from Casper College. I also got a job within the geology department and reorganized the department's extensive library in addition to becoming a teaching assistant and mechanic for the lapidary class held for students and community members. Along with the lapidary lab, another class is held for going out and collecting Wyoming gemstones and minerals such as rubies, jade, labradorite, beryl and more from sites scattered throughout Wyoming. With every class I took, I fell more in love with geology and the history of the earth, thoroughly enjoying every aspect of it, from plate tectonics to mineralogy.

During the summer break after I started my geology program, the paleontology professor, Dr. Kent Sundell, offered myself and a couple other students a job to collect and preserve fossils. In this job I had the privilege of participating in several projects including hunting for Oligocene mammals out of the White River Formation, excavating a tyrannosaur tracksite with several individuals, and extracting some new, undescribed, late Cretaceous ceratopsian dinosaurs out of the Mesa Verde Formation. In addition to teaching me how to collect fossils, my professor has shown me how to search for water wells using resistivity equipment to locate aquifers and assess the potential economic value of gravel quarries. These experiences have fueled a greater interest in economic geology and searching for the vital resources that are used everyday in our technologically advanced society.

I am very thankful for the opportunities that my professors have given me to learn about geology outside of the classroom and in the field. From collecting fossils and gemstones, to searching for economically viable mineral deposits, and to writing research papers about the earth's history, I have enjoyed every aspect of geology. The amount of time that my teachers and mentors have invested in me has greatly impacted me. I would like to get the chance to give back to the geology community by continuing my education and going for a masters degree or a doctorate in geology. Once I have finished my education, I am seriously considering a career in teaching after working in the industry for a few years. With experience in the petroleum or mining industry, I will be able to give students some practical advice about economic geology and help them to prepare for their own careers in geology. I hope that I may be able to help other people learn about the natural history of Earth and how studying Earth's past has allowed us to further advance society.

Donovan Vitale

SA-11158

Western Michigan University

Michigan Section

Associate Professor Stephen Kaczmarek, Ph.D., Donovan Vitale, Department Chair Heather Petcovic Ph.D., and Michigan Section Past President Bill Mitchell, CPG-10486.

Ever since I was young, I have had a great appreciation for nature; specifically, I was fascinated by its beauty, its fragility, and the balance these properties had. This fascination along with my deep curiosity have served as guiding forces within my life. Early on they manifested as an interest in Earth science, they later molded into an interest in environmental science, and have most recently developed into an interest in geology with a backbone of environmentalism. I believe that studying and understanding geology serves as the key to solving many man-caused environmental issues. By understanding geology and more specifically earth systems we can understand the way human actions have impacted our planet, we can understand how Earth spreads and moves the pollutants we produce, and most importantly, we can find the ways to reverse and reduce negative human impacts on our planet. Ultimately, I want to be a geologist because I want to better understand how our Earth works. I want to understand the complex systems and cycles it exhibits and I want to find a way for humans to exist on this planet without pushing these systems into disarray.

There are two main geologic fields that really interest me and fuel my desire to be a geologist: hydrogeology and geologic carbon sequestration. For me, both fields possess a beautiful balance between geology and environmental science; furthermore, both fields have the potential to make big changes and benefit humanity on a large scale.

With hydrogeology, I am really interested in using Geographic Information Systems (GIS) to understand and predict the rate and direction of groundwater contamination. For the last two years, I have worked for the Michigan Geologic Survey's Triage Project. This project aims to revise and add to Michigan's water well database. By accurately entering well logs, contamination maps and geologic cross sections can be created. These maps show the direction that groundwater and surface water would flow based off the area's topography and interpolated static water level. These maps would serve as great tools in contamination clean up; being able to predict and quickly clean up contaminants is of great importance for public health and safety. Ideally, when a possible contamination site (such as a landfill) is built, these contamination maps and models could be produced proactively. This would allow for contamination clean up plans to also be created proactively! A system like this would greatly improve public safety and peace of mind all thanks to a solid understanding of geology!

As for geologic carbon sequestration, I took a sedimentology & stratigraphy class this semester and fell in love with this topic. The basic idea is that carbon dioxide can be captured from our atmosphere, altered to a supercritical state, and injected into porous reservoirs. Once within these porous reservoirs, the supercritical carbon dioxide is stored by a combination of physical and chemical methods. This CO_2 can be safely stored for thousands of years! A good reservoir for geologic carbon sequestration must be porous, overlain by a layer of low impermeability, and have a lithology that promotes chemical trapping. These parameters leave a large range of geologic formations as plausible reservoirs for carbon sequestration. Consequently, I believe that geologic carbon sequestration is an effective and viable method for reducing the amount of carbon dioxide in our atmosphere. Geologic carbon sequestration serves to keep air clean and reduce global climate changes produced by the excessive release of man-made carbon dioxide. As a geologist, I would love to study geologic formations and find the most optimal locations for carbon sequestration. I think that effective and optimal use of carbon sequestration, early on, is necessary for carbon sequestration to gain traction and expand as a combatant against excessive atmospheric CO_2.

Section Sponsored Scholarships

Emily Coffin

SA-11346

Purdue University

Illinois-Indiana Section

To be honest, being strictly a geologist is not something I want to be. Does anyone want to strictly be a geologist? Of all the people I have met throughout my academic and professional career thus far, I have not met anyone who wants to be only a geologist. Let me explain why geology is of course going to be a part of my career, but also why geology by itself is not in my realm of professionalism.

Being an Environmental Geoscience major at Purdue has given me the opportunity to explore the relationship between geology and the field I want to really be involved in after I graduate, which is environmental and sustainable engineering. With these two disciplines of engineering comes all sorts of aspects of geology, which I was initially scared wouldn't be

the case because I enjoy learning both of these subjects and using them in application situations.

Let me explain why, however, I'm not majoring in Environmental Engineering, since it must come across that I have a serious need to be in the engineering field. Well, I simply just didn't want to learn about theories and methods of engineering, but instead wanted to gain hands-on experience in the classes so I would be prepared for internships and other future employment opportunities after I graduate. Also, I didn't get accepted into the engineering program… which is okay because I originally applied for Environmental Geoscience and Purdue anyways, but was swayed to change my major in my application process by someone who's an engineering graduate from Purdue. This person told me that engineering from Purdue looks great on resumes for employers, which I'm not going to disagree with. Purdue has an amazing engineering program and historically always has, which is why I recently decided to tackle a Sustainability Engineering minor. However, not getting accepted into engineering was honestly the greatest thing to happen to me in terms of my academic career at Purdue. Purdue has an equally amazing EAPS and geoscience program that is shaping me into being an amazing geoscientist/geologist… or something similar.

In my sophomore year, I realized that I can do many of the same tasks as environmental engineers and possibly be hired as one. This realization actually came true once I was hired as an environmental/staff engineer/scientist intern at Weaver Consultants Group. My past experience being an Arborist intern for Bartlett Tree Experts really appealed to the hiring manager. So much so that my hiring manager told me that I would be very useful towards projects involving arboriculture, tree identification, and phytoremediation. This position is going to give me the opportunity to collect samples for soil, groundwater, and vegetation in the field and take it to a lab to test for possible exposure to toxic chemicals. This is done for company building additions, abandoned buildings or parking lots, and waterways, parks, and agricultural fields. Specifically for building additions and abandoned buildings, if the condition of these are deemed to be poor, other tests will be conducted for VOCs and all other indoor air pollutants. I will also have the opportunity to drill into property grounds and detect for toxic waste near pipelines and work in the office's geotechnical lab to construct topographic maps, gaining skills in AutoCAD, needed to conduct these tests. Even though I was hired as an engineering intern, I want to put emphasis on the scientist title as well in my internship position. I enjoy the fact that I can be noticed as both a scientist and engineer. This can only widen my horizons in terms of the career paths I can take. In addition to my tasks as this intern, I will also write up Phase I and II Environmental Assessments, templates produced by the EPA, for these company assessments and condition check-ups, where I will be co-author and be titled as the Staff Scientist alongside a Geologist, Project Manager. This will give me the opportunity to also utilize my minor in Environmental Politics and Policy by conducting environmental evidence for these assessments and coming to my own conclusions whether these companies should continue with their plans to add to their already-maintained infrastructure and build more infrastructure on another property for company improvement.

I am being shaped into becoming the very specific environmental/sustainable/geological engineer I want to be. I have dreams and ambitions to work for the EPA and work on projects involving phytoremediation, and groundwater and atmospheric cleanliness and remediation, while enforcing environmental policy for sustainable energy usage, clean drinking water, and food security – the main issues this world is facing. Geology is a strong topic in my life and these are the reasons why this discipline will reign in my professional career… but I still don't want to strictly be only a Geologist.

Katelyn Snodgrass

SA-11341

Indiana University - Bloomington

Illinois-Indiana Section

Since middle school, I knew with confidence that I wanted to become a scientist. I remember looking out the window on long car rides, wondering why the world looks the way it does. I grew up in rural Indiana, allowing me to hike in wooded areas, observing the rocks, flora, and fauna of the backwoods region that I called home. In addition to developing in this setting, my father was employed by a limestone quarry an hour away from where we lived. He would come home late in the evenings covered in lime dust, exhausted from his laborious and low-paying blue-collar position. As a young girl, I wasn't aware of the details of my father's job or it's significant impact on people's everyday lives. The quarry he worked at provided building materials for people nationwide, primarily utilizing Indiana's wealth of limestone deposition. This sparked my interest in economic geology, as the resources that the earth naturally conjures via its complex processes have profound and vital applications for everyday life. Whether it be limestone for building materials, platinum group element-enriched malachites, or emeralds for jewelry, I became passionate about learning for the purpose of sustainable resource acquisition, utilization, and protection at Indiana University.

In addition to my childhood motivations, my experiences in college have affirmed my desire to pursue geology as a profession. Attending a college larger than my hometown provided a large culture shock and slight intimidation. My rural, underfunded high school fell short of preparing me for the intensity of college courses and the prestige of academia resulted in imposter syndrome that was only eased by my involvement in the Women in STEM Living-Learning Center on IU's campus. There, I learned about the struggles of fellow women pursu-

ing careers in male-dominated STEM fields and learned valuable skills such as salary negotiation, knowing strengths, and time management. I also received academic support via tutors that were employed by the center to help with my chemistry and math courses. Along with this obstacle, rigorous hiking field trips revealed the implications that my heart condition had on my physical abilities. This resulted in trips to my cardiologist and conditioning on an inclined treadmill to gradually increase my endurance. The discouragement caused by my health issues and background converted to motivation to succeed. I still receive encouragement from the Women in STEM Living-Learning Center and condition daily to prepare for the mandatory field course at the Judson Mead Geologic Field Station in Cardwell, Montana. In the future, I hope to encourage others who are interested in pursuing geology who have demographic and health disadvantages with my story of persistence.

Over the summer of 2021, I had the privilege of learning outside the classroom in Dr. Shelby Rader's Metal Isotopes Laboratory at IU. In this lab, I prepared and analyzed samples from the New Rambler Mine in Albany County, Wyoming via ICP-MS. These samples were found to contain an odd abundance of the rare and valuable platinum group elements, which are important for electronics and catalytic converter manufacturing. This experience significantly reduced any trace of doubt that I wasn't meant for the field of geology and taught me about data analysis and sample preparation in a clean laboratory. Most importantly, this summer initiated my interest in applying for graduate school to be able to pursue economic geology research as a career.

Due to the financial barriers of being a dependent of a single mother who also supports my chronically ill brother with his medical bills, I am grateful for this scholarship opportunity presented by the AIPG. I agree with AIPG's promotion of geology as a career, especially in this time of accelerating climate change and instability. The advancement of this rewarding field is vital in many respects in order to care for the planet, and I hope that with financial aid, I can one day contribute and encourage others to pursue similar paths.

Christopher C. Matson

SA-11369

Colorado School of Mines

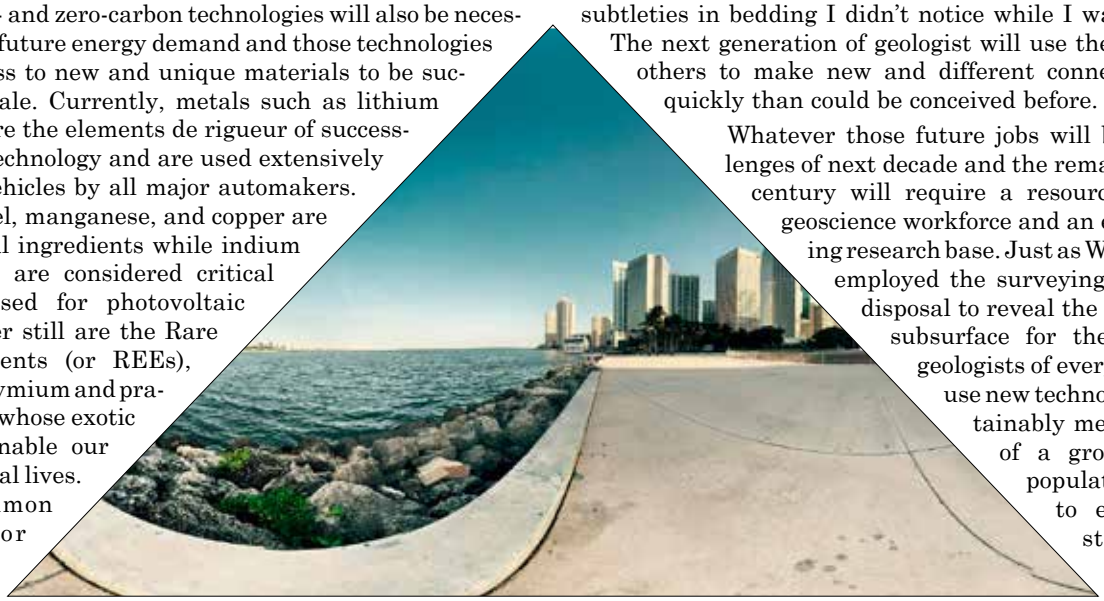
Colorado Section

Colorado Section Past President Jessica Davey, MEM-3242, Christopher Matson, and Professor Stephen Sonnenberg, Ph.D., CPG-6201.

Graduating from the University of Montana with a BS in Geology in 2007, I held many assumptions about what the next decade would bring for my geology career. Though never explicitly stated to me, I assumed that innovation and discovery in the oil and gas industry would gradually diminish and virtually end long before I could comfortably retire. However, given my interest in sedimentary systems, I was readily employable as a petroleum geologist but convinced I needed to broaden my skillset as much as possible to facilitate a future career change. After graduate school my pessimism was proven unfounded. Exactly ten years after graduating, I would find myself working in the oil and gas industry riding the explosive growth of unconventional source rock plays.

Technologies may evolve rapidly to meet market demands, but rarely upend entire industries overnight. The jobs of professional geologists in 2032 are mostly extant today, the result of the same evolutionary innovation pressure. Such is true with the energy transition active today. Since 2018, interest in and capital for new strategies to capture and monetize carbon and other greenhouse gases have skyrocketed. The tools and techniques of today's geologists borne from our need to characterize petroleum systems are again in demand to realize the ambitions of a "net-zero" future and the de-carbonization of energy systems. Such is the case with commercial geothermal projects where many petroleum geologists in transition are bringing their toolbox of play-based exploration techniques to geothermal systems. Extensive basin modeling from petroleum exploration has created robust geothermal gradient maps throughout the world and, using de-risking strategies developed in the oil and gas industry, the commercial viability of geothermal electricity generation away from hydrothermal hotspots and proximal to population centers is ever increasing.

Other low- and zero-carbon technologies will also be necessary to meet future energy demand and those technologies require access to new and unique materials to be successful at scale. Currently, metals such as lithium and cobalt are the elements de rigueur of successful battery technology and are used extensively in electric vehicles by all major automakers. Cobalt, nickel, manganese, and copper are also essential ingredients while indium and gallium are considered critical materials used for photovoltaic films. Scarcer still are the Rare Earth Elements (or REEs), such as neodymium and praseodymium, whose exotic properties enable our modern digital lives. The common denominator of these elements is the rarity of ore bodies that contain sufficient concentrations for economic viability. Also in need will be minerals that can spontaneously mineralize carbon from the atmosphere such as olivine and pyroxene. However, as evocative as careers in space mining may be, we will need to find ready supplies closer to home and the next decade will see increased exploration to meet the demand for these critical minerals.



The geologists coming into their careers by 2032 will likely have learned as much in the virtual world as in-person. Though no replacement for a first-hand field trip, students are now more than ever able to visit outcrops the world over via virtual reality (VR). The extraordinary perspective of VR is almost tailor made for the three-dimensional nature of our profession. VR geology educators will take their classes swimming through 3D seismic volumes and accelerate time to watch plates collide and follow facies transitions during subduction. With VR, I've visited sites I had only seen in illustrations and even noticed subtleties in bedding I didn't notice while I was in-person. The next generation of geologist will use these tools and others to make new and different connections more quickly than could be conceived before.

Whatever those future jobs will be, the challenges of next decade and the remainder of this century will require a resourceful, skilled geoscience workforce and an ever-expanding research base. Just as William Smith employed the surveying tools at his disposal to reveal the extent of the subsurface for the first time, geologists of every decade will use new technologies to sustainably meet the needs of a growing global population aspiring to ever greater standards of living.

Teaching Field Geology Online

Maria Carmencita B. Arpa, PhD, ECP-0450

Strict lockdowns were implemented in the city of Manila during surges of COVID-19 cases. The university where I teach is in the old district of the city. For several terms during the pandemic the university implemented online delivery of classes. Many students who stayed in dormitories within the city went home to their respective provinces. Online delivery could be difficult for any course, but it is a problem I think for teaching geology, especially field geology. Field geology is one of the most anticipated courses in the geology curriculum. Its online delivery disappointed not only students, but also teachers who must find a way to teach it online. How should I teach a class online that has lab materials located outdoors, and a course objective that states: "students should be able to demonstrate field observations, geologic mapping, sampling, and interpretation of geologic data"? We had to utilize and practice a lot of imagination.

There are many tools online to help – Google Earth (including street view), YouTube videos, satellite imageries, and the virtual microscope [1]. Combined with providing students field data accumulated through years of practicing geology, the class got through. Though there was a promise made that we would put all the learnings to practice when face-to-face classes are allowed.

Teaching laboratory or field courses requires, among others, these basic objectives: data analysis, problem solving, creativity, teamwork, communication, instrumentation including use of software, and design whether of an experiment or field plan. Here I list some of the activities, which I think, and hope, were effective. The first exercise required them to do a site investigation of their current location. This included activities such as determining pace factor, map orientation and use of transit compass for triangulation and north orientation. Part of the exercise is doing research on the geology of the area and hazard assessment. The information available will vary depending on location, such that a student living in a highly urbanized area will have limited information to gather. There are many aspects to observe, such as signs of expansive soils, nearby outcrops, the presence of wells in the community, and nearby bodies of water. Some students made a hazard assessment of their area, gathering available ground rupture, liquefaction, landslide, and volcanic hazard maps.

An activity that I liked was planning and reporting a detailed field itinerary. Here I gave a hypothetical five-day field assignment that would sample rocks in the Tongariro National Park [2] in New Zealand (Figure 1). The points to sample were assigned, and options on where to stay, such as suggested base and camping sites, was provided. They had to make a detailed schedule of daily activities including routes to take, time during sampling stops, field gear and materials to bring, and group member task assignments. For this activity, Google Earth (and Street View) was most useful, and I added photos of outcrops for the assigned stops. Each group then gave an oral report in Zoom. I was surprised at the details that the students provided. Some included getting a sampling permit from the NZ Department of Conservation,

Figure 1. Target sampling stops and possible camp locations within Tongariro National Park for a hypothetical fieldwork. Photos of outcrops, Tephra sequence 2 shown here as an example, were provided to students.

a risk analysis for the activities, and quarantine time upon arriving in New Zealand.

Modern methods in geologic mapping are shifting more towards interpretation of imageries [3]. A series of activities for igneous, sedimentary, and metamorphic environments involved construction of photo-geologic maps using topographic maps as base and Synthetic Aperture Radar (SAR) imageries for interpretations (Figure 2). The activity utilized GIS software. The interpretation was easier for volcanic terrain, especially for the Philippine setting, but was harder for metamorphic terrain for any environment except for large metamorphic belts. For this activity, ground truthing was really missed.

Measurements of strike and dip of structures were refreshed to students by video demonstration and available videos on YouTube. Student activity was limited by the fact that not all students owned a transit compass and they do not have access to university materials. Many used a digital compass app in their cellphones combined with some creativity. Petrology and petrography were reviewed from the use of the virtual microscope and photos of rocks and outcrops provided by the instructor. For a final project, I gave them data from a previous mapping project. The activity included reinterpretation of borehole logs, drafting of geologic cross-sections, revision of a geologic map [4], and a final long report.

In the end, I was able to assess course outcomes from oral exams, reporting, and written submissions. The effectiveness of these activities compared to actual field activities can only be assessed when they do actual fieldwork. But I think the positive result of the online delivery is an encouragement of creativity, imagination, and an eagerness for putting what they have learned to practice.

About the Author

Maria Carmencita B. Arpa, PhD is a faculty member at the School of Civil, Environmental and Geological Engineering, Mapua University, Manila, Philippines.

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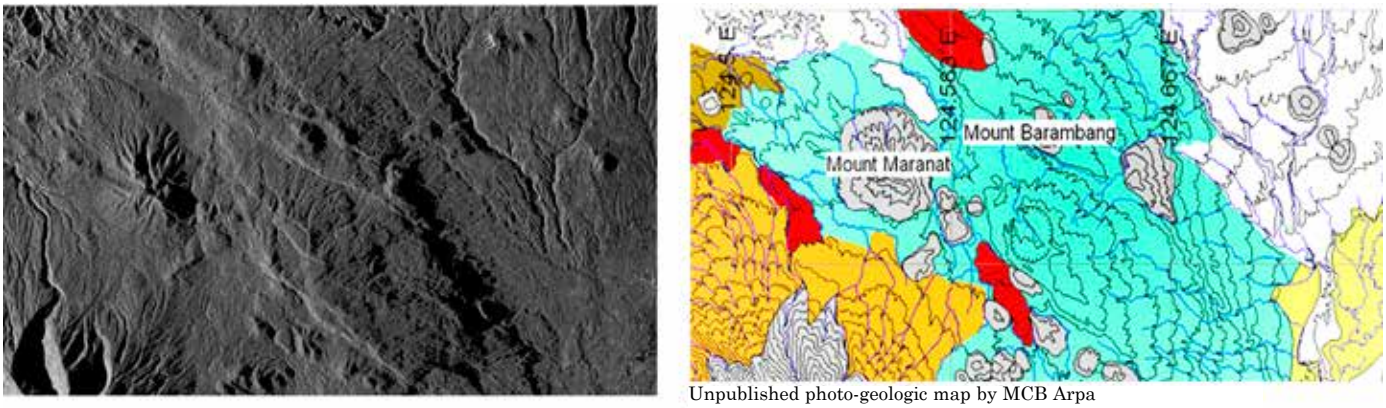

Unpublished photo-geologic map by MCB Arpa

Figure 2. SAR imagery of an area in Mindanao, Philippines (left) and a photo-geologic map of the same area (right). Features interpreted are cones and domes (gray), lava flow (red), and pyroclastic deposits (orange).

WANTED:

Used, older water level data loggers for sea level rise research

Project Details: https://paytanlab.ucsc.edu/people/james-jim-jacobs/

Contact: Jim Jacobs, CPG-7760
(cell: 510-590-1098) jaajacob@ucsc.edu

Liberian Geology and Water Resources

Barney P. Popkin

Figure 1. Location map of Liberia (CIA, 2021).

I wrote this article based on my public-private partnership water-resources work with a British economist and a Philippine water resources specialist in Liberia in 2016 (Prattle, 2017), my 2021 literature review of over 200 articles and interviews with over 12 colleagues, and my December 2021-January 2022 revisit for a Liberian water, sanitation, and health proposal (USAID/ Liberia, 2021). It summarizes my thoughts on the water-resources challenges and potential solutions for Liberia. Because it was during the rainy season, we saw first-hand the extensive rainfall for which coastal Liberia is well known. Many of my observations were reinforced by articles in Bloomberg, The Liberian Observer, and other publications.

Background, History, and Setting

The Republic of Liberia (aka "The Land of the Free") is in Western Africa. It borders the North Atlantic Ocean to the west, and lies between Sierra Leone, Guinea, and Cote D'Ivoire at 6^0 30" North, 9^0 30" West. Slightly larger than Virginia, Liberia covers about 111,369 km^2 (96,320 as land, 15,049 as water bodies). See Figure 1 for a location map.

Liberia has a hot and humid (tropical) climate. It has winters with hot days and cool nights; summers are wet and cloudy with frequent heavy showers. Its terrain is mostly flat to rolling coastal plains rising to undulating plateau and low northeastern mountains. The mean elevation is 242 m and its peak elevation 1,447 m. The country has abundant natural resources in fisheries, iron, timber, diamonds, gold, and hydropower, traditional banana, cassava, rice, rubber and emerging palm oil and cocoa exports, and potential petroleum development.

Liberia's capital Monrovia receives over seven meters of annual rainfall, the highest in any national center. Its drinking water is provided by systems common in developing countries (VITA, 1964). Its citizens' earned incomes are the lowest in Africa (CIA World Facts Books of gross domestic product per capita). Its water is otherwise provided by public kiosks, shallow hand-dug wells, deeper drilled boreholes, captured spring and river water, delivered vendor water-filled jerrycans and tanks, government agency pipelines, traditional rooftop rainwater harvesting and cistern storage, and even capture of air-conditioning condensate (Figures 2 through 6). Per the Church of Latter-Day Saints (2022), approximately 7,000 boreholes have been estimated, many of which are inoperable, seasonally dry, and occasionally salty.

Liberia has abundant water supplies that have been improved but not maintained in both rural and urban areas so that 40 percent of the population has access to potable water. Surface water is abundant, and groundwater reserves are ample and regularly replenished by the country's heavy rainfall (Hadden, 2006). Unfortunately, the country doesn't have a local cadre of professional water-resources managers, engineers, technicians, craftsmen, or equipment manufacturers and suppliers, so it depends on foreign personnel and imported equipment which are very expensive.

Table 1 summarizes Liberian land use. Note only 30 km^2 of Liberia are irrigated. Its dominating latosol sols (loams to sand) are very well drained with high infiltration rates (Reed 1951; Hadden 2006, requiring excessive fertilization and soil amendments to make them productive for commercial agriculture.

Liberia is one of the world's least developed countries (UNDP, 2020). The World Bank Atlas (2020) categorized Liberia as a "lower-income developing country" in 2019 based on its low gross domestic product per person.

Table 1. Summary of Liberian land use.

Land Use	Percent		Agricultural land types	Percent
Agricultural	28		Arable land	5.2
Forest	48		Permanent crops	2.1
Other	27		Permanent pasture	20.8

Transparency International (2020) scored Liberia as 28 out of 100 percent (Corruption Score 18/100, where 1/100 is highest corrupt percent) with a rank of 137 out of 198 countries (Corruption Rank 168/198, where 198 is most corrupt country). According to Transparency International, Liberia's Global Corruption Barrier, 47% of its population thought corruption increased, and 53% of its population thought public service users paid a bribe in the previous 12 months. Corruption, bribery, cronyism, nepotism, fraud, looting, kidnapping, theft, customs delays and exorbitant shake-down fees, widespread illiteracy, and low life-expectancy are commonplace.

More than half of Liberia's 5.2 million people live in coastal urban areas, with about one third within 80 km of its rain-rich capitol. The country has high population growth, low life-expectancy, large infant and maternal mortality and high emigration. It suffers from high infectious disease rates, from food and water (bacterial and protozoal diarrhea, hepatitis A, and typhoid), and vector borne diseases which breed in contaminated waters (malaria, dengue, yellow fever).

Liberia had a recent 14-year civil war which killed over 250,000 Liberians. It continued internal political and cultural conflicts, transitioning from dictatorship to democracy, very high malnutrition, and debilitating disease epidemics as HIV/AIDS, Ebola, and COVID-19. Prior to the recent civil war which ended in 2003, its physical infrastructure, including water supply was stronger. Culturally, epigenetic transformations occurred whereby war survivors tend to live day-by-day and view both themselves and others as potential prey (Bedawi, 2020).

Liberia rarely experiences serious flooding, although streets and roads are routinely flooded for short periods during storms. Its major natural hazards are March-December dust-laden Harmattan winds from the Sahara and seawater intrusion. Several water-stressed environmental issues plague the country: pollution of coastal waters from oil residues and sewage; pollution of rivers from agricultural chemicals; industrial runoff; and open burning and dumping of garbage.

Liberia's Atlantic coastline is an important natural economic resource for its fisheries and attractive tourism. It is characterized by lagoons, mangrove swamps, and river-deposited sand bars. The country's inland small grassy plateau supports limited agriculture. Because there is no ongoing or long historic record of rainfall, evaporation, runoff, surface water storage, groundwater regime, water use and related items, it is not possible to provide a water balance for Liberia. Budyko (1956) provided a general water balance per year for all of Africa as: 67cm precipitation, 51cm evaporation, and 16cm runoff. L'vovich (1945) provided a distribution of annual runoff for the Atlantic coast of Africa as: 14.0 inches as runoff.

Physiographic Regions Detail

According to the Republic of Liberia, there are three major physiographic regions of Liberia in parallel with the coast as described below:

- **The Coastal Plains.** The Coastal Plains are about 350 miles (560 km) long and extend up to 25 miles

Figure 2. Liberian women water gatherers filling up at a new drinking water kiosk (WSUP, 2017).

Figure 3. Family filling water jugs from shallow, open hand-dug water well, Newport Street, Monrovia (Popkin, 2016).

Figure 4. Monrovia water-vendor boys filling up jerrycans (Popkin, 2016).

Figure 5. Fresh-water delivery truck, Monrovia (Popkin, 2016).

Figure 6. Three rainwater storage tanks from rooftop water harvesting at The Cape Hotel, Monrovia (Popkin, 2016).

(40 km) inland. They are low and sandy, with miles of beaches interspersed with bar-enclosed lagoons, mangrove swamps, and a few rocky promontories.

- **The Rolling Hills.** Parallel to the Coastal Plains is a region of rolling hills some 20 miles (32 km) wide with an average maximum elevation of about 300 feet (90 meters); a few hills rise as high as 500 feet (150 meters). It is a region suitable for agriculture and forestry.
- **The Dissected Plateau.** Behind the Rolling Hills, most of the country's interior is a dissected plateau with scattered low mountains ranging from 600 to 1,000 feet (180 to 305 meters) in elevation; some mountains rise to 2,000 feet (600 meters).

Drainage and Flooding Detail

According to the Republic of Liberia:

- There are only two major lakes in Liberia – Lake Shepherd in Maryland County and Lake Piso in Grand Cape Mount County, with Piso being the larger of the two. Both of them are situated along the Atlantic Ocean, with Lake Piso characterized by a vast expanse of wetlands and lowland forest vegetation.
- The Mano and Morro rivers in the northwest and the Cavalla in the east and southeast are major rivers and form sections of Liberia's boundaries. Other major rivers include the Lofa in the north and St. Paul, St. John, and Cestos rivers southward, which all flow perpendicular to the coast. The Farmington River is a source of hydroelectric power. Waterfalls, rapids, rocks, and sandbanks occur frequently in upstream sections of most rivers, inhibiting river traffic, and limiting navigation inland to short distances. During the rainy season there is often severe temporary street flooding in the coastal plains because of inadequate, destroyed, or poorly maintained drainage networks.

According to the Republic of Liberia, four types of soil are found in Liberia. Latosols of low to medium fertility occur in rolling hill country and cover about three-fourths of the total land surface.

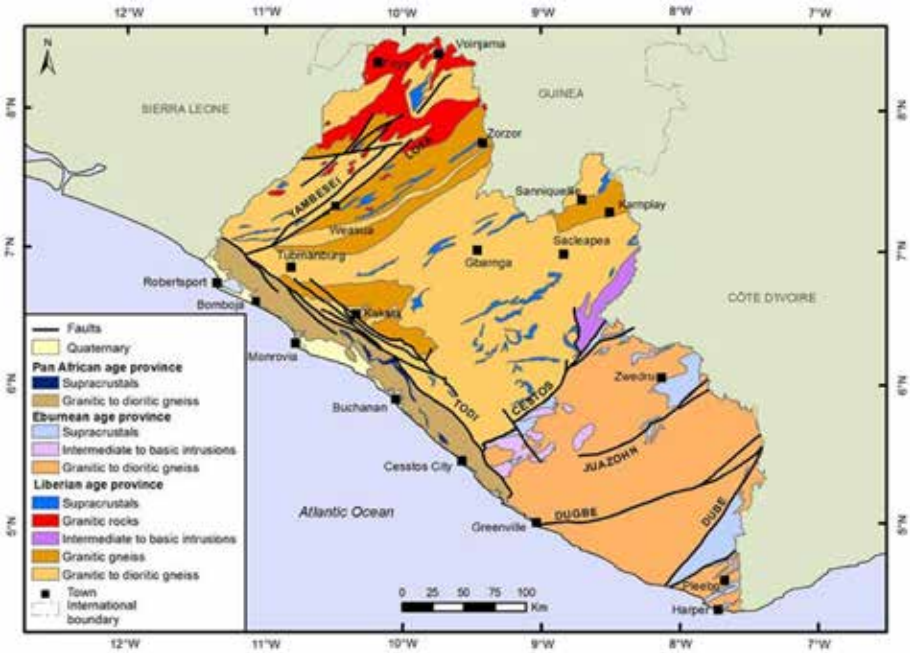

Figure 7. Geologic map of Liberia (Liberian Geological Survey, undated).

Shallow, coarse lithosols, in the hilly and rugged terrain, cover about one-eighth of the land. Infertile regosols, or sandy soils, are found along the coastal plains. Highly fertile alluvial soils represent a small percentage of the land area and are utilized largely for agriculture.

Water Resources

According to the Republic of Liberia (undated):

- Liberia is endowed with abundant water resources, but the proper management and planning of these remain crucial to meeting the national priorities and goals and reducing conflicts between competitive uses. This problem is further compounded by various administrative, technical and political problems, particularly the poor state of the Liberian economy after 14 years of civil strife.
- Generally, groundwater is available and can be exploited in most parts of the country in quantities needed for rural water supply, which relies on dug wells and to some extent on drilled boreholes. Data from the rural water supply program indicate that the depth to the water table in shallow wells can be less than one meter. Drilled boreholes can be as deep as 100 meters. However, reliable data on borehole yields and data on water quality from both surface and groundwater are scarce.
- Domestic sewage, however, causes many problems as the only conventional sewerage system, which was already poorly functioning before the civil crisis is out of operation. Some sewage water is collected by vacuum trucks and disposed of into lagoons and other water bodies. In some areas there are indications that water quality is deteriorating due to mining, logging, farming and industrial activities.

Groundwater

According to the Desert Research Institute: Due to the lack of available borehole data, it is difficult to infer depths to the (porous-media) water table, and depths to fresh bedrock throughout the country. Nonetheless, several past reports which include borehole data have made initial estimates. In a 2011 report titled "An initial estimate of depth to groundwater across Africa," The authors, Bonsor and Macdonald, estimate the water table depth to be approximately 7-25 m, and the saturated aquifer thickness to be less than 25 meters in Liberia.

An independent 2014 study that only analyzed borehole data from Lofa County, Liberia examined depth to bedrock as a contour of mantle thickness.

The study found that the depth to bedrock rarely exceeded 25 m and had an average depth of roughly 7 m, these values are in range with Macdonald's estimates. Based on effective porosity and saturated aquifer thickness total groundwater storage has been estimated to be 86 cubic kilometers with a large range of 25-333 km^3 (Macdonald et al 2012).

In other words, most of Liberia is underlain by impermeable bedrock which supplies haphazard groundwater through fractures, although there are thin alluvial deposits along the coast and inland rivers which supply dependable shallow porous-media groundwater.

Earthwise provides information on the hydrogeology of Liberia, summarized as follows: Groundwater occurs in unconsolidated, sedimentary, and igneous regimes.

The Unconsolidated Aquifer consists of Quaternary coastal and alluvial sediments, that are moderately to highly productive where boreholes yield water at 0.5 to 3 liters/ second (LPS; 8 to 48 gallons per minute (GPM)) or higher. These waters from unconsolidated rocks are "fresh," generally below 300 mg/L (ppm) total dissolved solids (TDS) and soft; generally below 60 mg/L (ppm) calcium carbonate hardness.

The Sedimentary Aquifer consists of Laterite and Cretaceous/Devonian materials; where the laterite has low water productivity, and the Cretaceous/Devonian rocks are coastal sandstones which yield as much as 1.4 LPS (22 GPM). The Igneous Aquifer consists of Mesozoic igneous intrusive rocks from which

Table 2. Liberian water problems, damage, and potential remedy.

Problem	Damage	Potential Remedy
Water Resources Supply Issues		
Lack of effective national water collection, data analysis, construction, and management	Decision-making process with inadequate information	Establish and fully fund a transparent, non-political, independent national agency with appropriate authority to include data collection and evaluation; construction and operation & maintenance; procurement; analytical testing; management; procurement and contracting; auditing; and administration branches
Increased overland stormwater drainage and flooding	Loss of life, property, livelihoods, and lost water for potential use	Fund, develop, implement, monitor, evaluate, operate, and maintain a practical national stormwater drainage and flood control program
Water Shortages	Health and safety stresses	Improve drinking water availability and sanitation through planning and implementation of practical programs; promote community-based water management entities; especially overseen by women
Water Resources Degradation Issues		
Increased agricultural pollution to water resources	Degraded water resources	Promote integrated pest management and slowly released fertilizers
Increased petroleum and industrial pollution to water resources	Degraded water resources	Promote: aboveground and underground leaking tank testing and remediation, double tank enclosures, and leak-detection systems; and hazardous materials and waste management reduction programs
Increased sewage pollution to water resources	Degraded water resources	Promote concrete-enclosed septic tanks, "honey-wagon" tank pump-outs, transportation to, and disposal in designated treatment facilities
Increased flooding from slopes and terraces	Soil erosion	Install rock gabions, canvas curtains, geotextiles, and re-vegetation; capture and release rooftop rainwater and stormwater; divert floodwaters for enhanced groundwater recharge through recharge basins and caissons
Rising sea level	Seawater intrusion; salinization of coastal and riverine surface and groundwater and soil; human resettlement; habitat and livelihood destruction; reduced agricultural productivity	Install an inland perimeter of a groundwater barrier of flood waters and treatment wastewater through recharge basins and caissons

there is little information but overall water productivity is likely to be low. Finally, the Basement Aquifer consists of Precambrian rocks where test boreholes between 80 and 100 m deep in Buchanan and 44 and 63 m deep in Zwedru have produced specific capacities of 0.25 to 2.60 cubic meters per hour per meter, and 24.5 to 7.60 cu m/ hour/ m, respectively from weathered and fractured rock. These waters from sedimentary, igneous, and Precambrian rocks are generally "fresh" and "soft" unless derived from laterites and carbonates which make such waters iron-aluminum rich from laterites and calcium-magnesium rich from carbonates.

Notable Successes in the Liberian Water Sector

Most successes are achieved through generous international donors, banks, philanthropists, and charities. These include improvement in water sector master planning and mapping; electricity and water availability; installation of many new water points (drinking water fountains), water kiosk (water-fountain bays); improved water delivery schemes, and COVID-19 hand-washing stations; expansion of water services; water financing and credit; and upgraded wastewater treatment plants. Some of these water systems from wells, springs, and rivers include sedimentation basins, slow-sand filtration, granular chlorination, and pumping by hybrid solar/ diesel/ battery. Major contributors have been very helpful in establishing these systems.

Further Degradation in the Liberian Water Sector

Several issues have intensified, including rising urban crowding, squalor, and decay in Monrovia; increasing bacteriological contamination of vendor-supplied drinking waters; rising seawater levels; and increased coastal erosion at The Hotel Africa near Monrovia, Monrovia's West Point, and Buchanan (150 km southeast of Monrovia), and other coastal communities. In addition, poor governance, the small percentage of income-earning women, and foreign-financed infrastructure (haphazard water supplies, sewers as well as roads, bridges, energy, fire, and public safety) hamper Liberia's development and contribute to degradation of its water sector, including needed energy, fire-fighting, and public security.

Conclusions and Recommendations

The water availability situation in Liberia is dire although there is an abundant freshwater supply from rainfall, runoff, and groundwater. Several reasons behind the availability problem include poverty, illiteracy, lack of leadership and finance, and poor governance. Table 2 summarizes my suggestions for remedy on the previous page.

About the Author

Barney P. Popkin is a geologist, hydrologist, soil scientist, and water/ wastewater, solid/ hazardous waste, and environmental manager. He has worked in these fields for over 50 years in over 30 U.S. states and as many developing countries. Mr. Popkin contributed over 100 articles to several U.S. and European journals.

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Texas Temblors and the Balcones Fault Zone

Stephen Pierce, CPG-08726

Introduction

My EQ-1 seismometer detected 29 earthquakes in Texas between 2011 and 2021, as shown in Figure 1. These quakes measured between Richter magnitudes 2.6 and 4.4 and ranged from 9,800 to 49,212 ft (2,988-15,000 m) in focus (depth). The observed seismic events have been determined by checking their timing and apparent magnitude against USGS and IRIS earthquake websites.

The EQ-1 seismometer (shown in Figure 2) is a pendulum seismograph designed to detect only vertical motion. Therefore, it can detect longitudinal waves (P-waves), transverse waves (S-waves), and Rayleigh waves. It has limited sensitivity. An earthquake with a Richter magnitude of 2.6 located in Dallas, Texas 30 miles or 48 km from the EQ-1 will register, but an earthquake of magnitude 3 located in West Texas 300 to 440 miles (600 to 700 km away) will not be recorded. A protected cover (not shown in Figure 2) is required to shield the instrument from air currents.

Seismic Activity

Earthquakes produce seismic energy in the form of (1) body waves and (2) surface waves.

Body Waves

Primary (P-waves). These are longitudinal (compressional) waves similar to sound waves in air. They are the fastest waves. They travel between 2.4 and 4.3 miles/sec (3,860-6,920 meters/sec) in near surface rocks and much faster in deeper, more dense rocks (Plummer et al, 2005).

Secondary or shear (S-waves). The particle motion in these waves is perpendicular to propagation. These waves travel slightly slower than P-waves; between 1.2 and 3.1 miles/sec (1,930-4,990 meters/sec) in near surface rocks and much faster in deeper, more dense rocks (Plummer et al, 2005).

Surface Waves

Rayleigh waves. The surface waves travel like ocean waves, but cause the ground to move in an elliptical path opposite in sense to that of the propagation direction. Their velocity is about 0.92 times the velocity of an S-wave. They are the slowest waves and potentially the most destructive. In addition, their longer wavelengths are easier to detect.

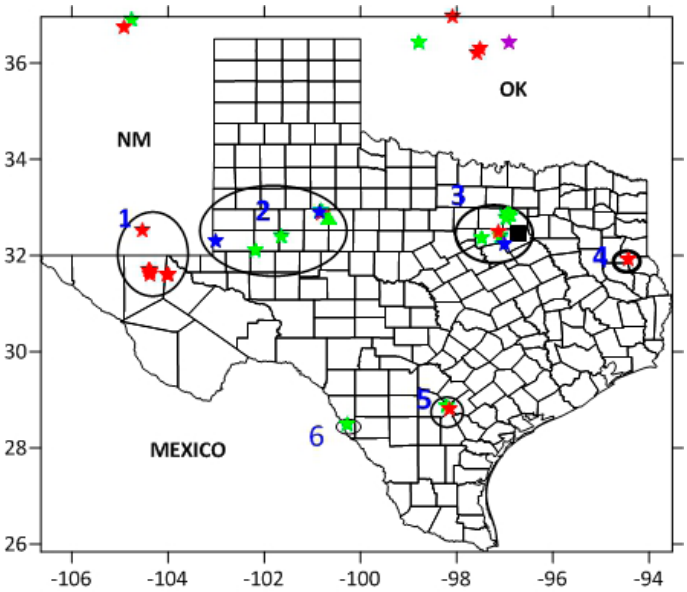

Figure 1. Texas earthquakes. Blue = Richter Magnitude 2 – 2.9; green = 3 – 3.9; red = 4 – 4.9; purple = 5 – 5.9. Seismometer is located by the black square in area 3. Earthquakes in New Mexico (NM) and Oklahoma (OK) are shown for regional control.

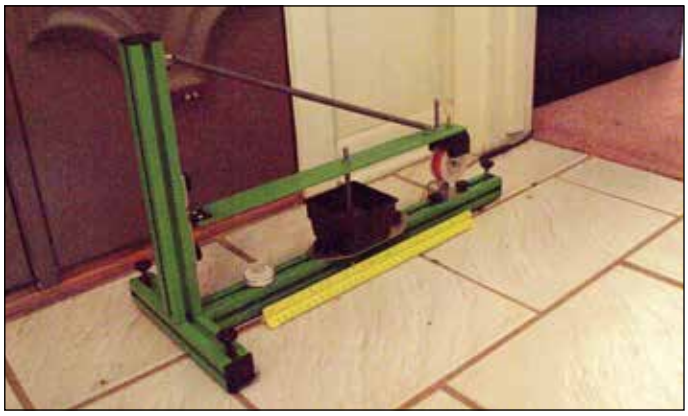

Figure 2. EQ-1 seismograph with yellow 12" ruler for scale.

Texas Temblors

The temblors recorded by the EQ-1 are not randomly located. They appear to be located in six separate areas: (1) west Texas, (2) south of the Panhandle, (3) Dallas area, (4) East Texas,

Table 1. Magnitudes and Depths of Texas Temblors Recorded by EQ-1 in 2010-2021

AREA (as numbered on Figure 1 map)	NUMBER	RICHTER MAGNITUDE	FOCUS (Depth) feet, (meters)
West Texas (1)	8	3.1-4.4	11,154-36,089 ft (3,400-11,003 m)
South Panhandle (2)	9	3.5-4.4	9,842-32,808 ft (3,000-10,000 m)
Dallas (3)	8	2.6-3.6	10,498-49,212 ft (3,200-15,000 m)
East Texas (4)	1	4.1	16,404 ft (5,000 m)
South Texas (5)	2	3.3	16,404 ft (5,000 m)
Rio Grande (6)	1	3.3	11,154 ft (34,000 m)

(5) South Texas, and (6) Rio Grande Valley (numbered areas shown on Figure 1).

As can be observed from Table 1, the magnitudes of the quakes are small, and all are shallow (less than 98,208 ft or 30 km). The strongest earthquake ever recorded in Texas was one with a 4.7 magnitude in 1923 in the El Paso area of West Texas (Frohilch and Davis, 2002).

Table 2. Earthquake Magnitude

RICHTER	DESCRIPTION	MERCALLI	DESCRIPTION
2-2.9	Very Minor	I - II	Felt by some indoors
3-3.9	Minor	III	Felt indoor
4-4.9	Light	IV - V	Felt by most – slight damage
Adapted from Plumer et al, 2005.			

As shown on Table 2, earthquakes with origins in Texas have Richter magnitudes that are not very dangerous. The most probable cause of a devastating quake in Texas would be a major earthquake with its epicenter outside the state. Frohlich and Davis, (2002) asked what would happen if another major quake of Richter magnitude 8 like the one in the winter of 1811-1812, that struck New Madrid, Missouri were to occur. What effect would it have on the high-rise buildings in Dallas, located about 422 miles (679 km) southwest of New Madrid?

Origin of Temblors

Temblors in Texas have two known causes: one natural and the other artificial.

Natural earthquakes. These events are primarily tectonic in origin. But other processes that may generate temblors include landslides. Tectonic quakes have occurred in West Texas and there is a possibility that the Balcones Fault Zone near Dallas may show residual activity.

Artificial earthquakes. These events include artificial landslides, filling of water reservoirs, quarrying, and oil field activities including 'fracking and deep injection of fluids. As of January 2021, the Texas Railroad Commission has recorded 166,529 active oil wells and 84,668 active gas wells. As can be seen from Figure 3, areas of earthquake activity coincide with many oil and gas fields. Most drilling ranges in depths from 9,000 to 36,000 ft (2,750-9,500 m). In a list of Texas temblors occurring from 1847 to 2002, oilfield activity (mainly fluid injection) is given as the most probable cause of 10 earthquakes in areas of known petroleum drilling, (Frohlish and Davis, 2002.) The USGS defines deep wells as those drilled deeper than 15,000 ft. There are many wells drilled in the Permian basin with depths greater than this (Dyman, et al., 1990).

Unknown. Many unknown seismic events (UKSE's) have been recorded by the EQ-1. These events are short lived (a couple of minutes maximum), have a small amplitude, and unique characteristics. I presume they are from human activity somewhere near Dallas. Additionally, these events have never been mentioned in the USGS or IRIS websites.

Texas Temblors

West Texas (Group 1) and Southern Panhandle (Group 2)

The EQ-1 detected tectonic activity and oil field activities that have caused 17 earthquakes. These earthquakes had Richter magnitudes between 3.5 and 4.4, and depths varying from 14,763 to 30,183 ft (4,499 to 9,199 m). See Areas 1 and 2 on Figure 1. An example of a seismogram is Event 440 shown in Figure 4, and whose location is shown in Figure 5. This temblor occurred on December 28, 2021 at 1:55:43 GMT. It had a Richter magnitude of 4.3 and a focus of 25,590 ft (7,799 m). It is likely that it is related to oilfield activity.

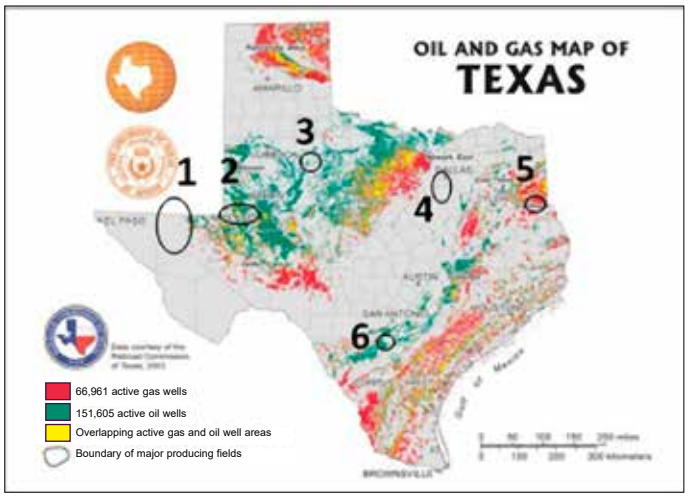

Figure 4. Event 440 earthquake in the Texas Panhandle. Time is in minutes on the x-axis and amplitude is on the y-axis.

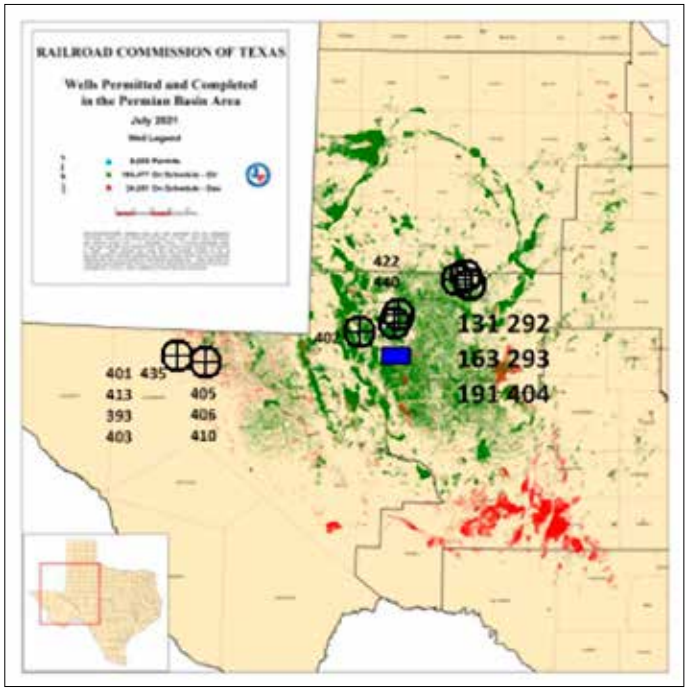

Figure 5. Earthquake events in West Texas and the Panhandle. Circles are earthquakes recorded from the EQ-1. Event 440 has a blue rectangle under the circle. The green areas are oil fields and red areas are gas fields. The map is from the Texas Railroad Commission website.

Major oil and gas fields are located in the Permian Basin and adjacent areas in West Texas. Earthquakes in the southern Panhandle may be due to drilling activities in the Permian Basin. Average Richter magnitudes are 3.95 and depths are 22,965 ft (6,999 m). The westernmost group of temblors on Figure 5 are in my West Texas Group (Group 1 on Figure 1) and may be of tectonic origin due to active faulting (Figure 6) associated with the Rio Grande Rift.

As shown in Figure 6, earthquakes are associated with numerous faults likely associated with the rift. The rifting began some 29 to 25 million years ago (NSF-Earthscope).

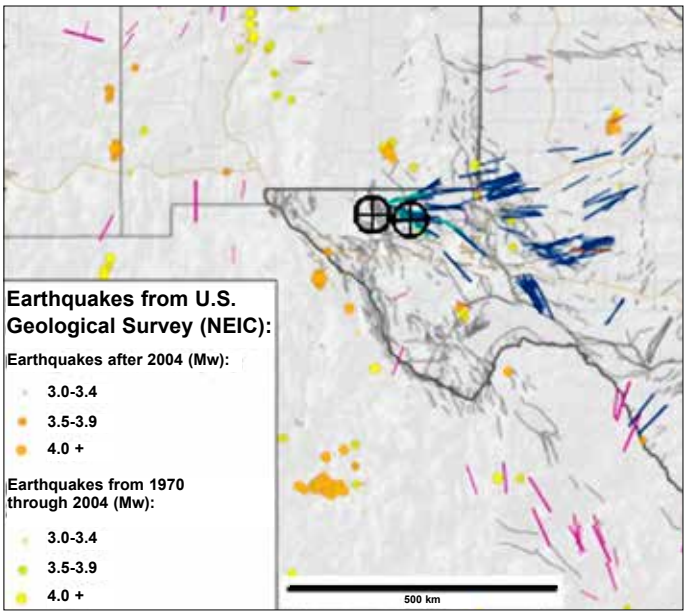

Figure 6. Earthquakes in West Texas. The base map is from the USGS website. Circles are in West Texas (Group 1 on Figure 1).

Dallas Area and the Balcones Fault Zone (Group 3)

In the Dallas area, eight earthquake events are recorded (86, 101, 107, 172, 253, 254, 261, and 264). The locations and presence of these temblors presents an interesting question. Dallas is located in what is considered a tectonically quiet region. What is the origin of these quakes? Could they be the result of natural tectonic movements or are they of manmade origin? West of Dallas in Tarrant County, there has been much drilling activity in the Fort Worth Basin. However, In the Dallas/Ellis/Johnson counties area there is no known oil field activity.

Could there be residual seismic activity on the Balcones Fault Zone (BFZ)? The BFZ consists mainly of normal faults downthrown to the Gulf of Mexico, (Figure 7). The northern termination of the BFZ is located northeast of Dallas County, as shown on Figures 7 and 8. As can be seen in Figure 8, Ellis/Dallas/Johnson counties are located on the western margin of the fault zone. Movement of the BFZ occurred mainly during the Tertiary (Nance, et al, 1994).

As can be seen from Figure 7, there are two parallel fault zones. The Mexia-Talco Fault Zone is parallel to and located east of the Balcones Fault Zone. The BFZ strikes northeast through southeast Tarrant County, western Dallas County, western Ellis County, and central and eastern Johnson County.

Figure 8 shows suggested fault trends as recorded from the EQ-1and structural trends (Reaser et al, 1990) in Dallas/Ellis/Johnson counties. The northeast-southwest trend of these faults is consistent with those mapped in Ellis County by Dutton, et al, 1994 for the Department of Energy. The temblors shown have Richter magnitudes varying from 2.6 to 4.1 and depths of focus from 10,498 to 49,212 ft (3,200-15,000 m). In addition to the field work of Reaser, et al and Dutton et al, Nance et al, 1994 confirmed the presence of the Balcones Fault Zone.

As a result of construction activities of the Department of Energy in the western/central parts of Ellis County on the

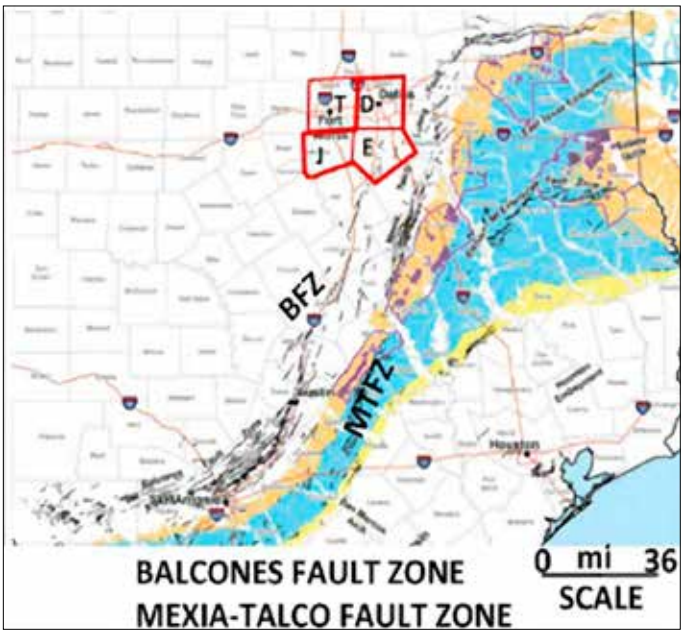

Figure 7. Balcones Fault Zone showing locations of Dallas County (D), Ellis County (E), Johnson County (J), Tarrant County (T). Black lines are outcrop segments of the Balcones Fault Zone (BFZ). Also shown is the Mexia-Talco Fault Zone (MTFZ). The map is from Wikipedia.

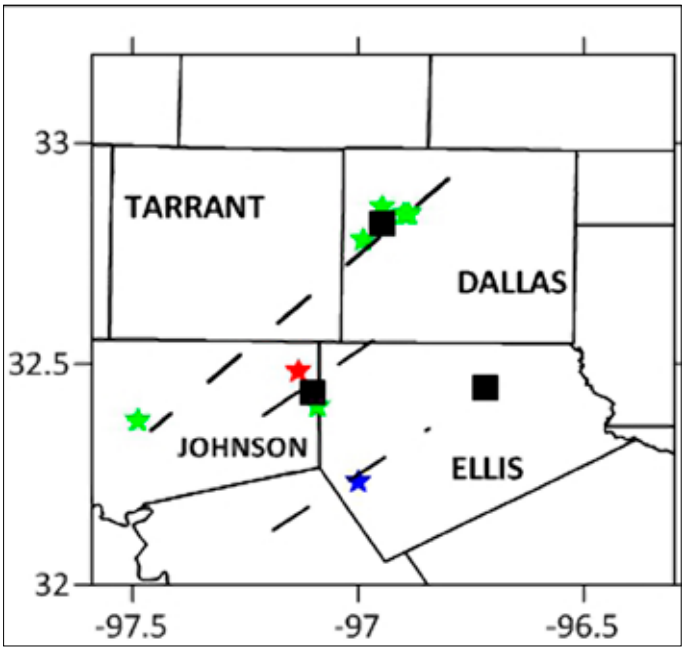

Figure 8. The Texas counties where the nearby earthquakes have occurred. Blue star earthquake magnitude 2 -2.9, green 3 – 3.9, and red 4 - 4.9. The black square to left is the town of Venus, the central square is Irving, and the right square is my home seismometer.

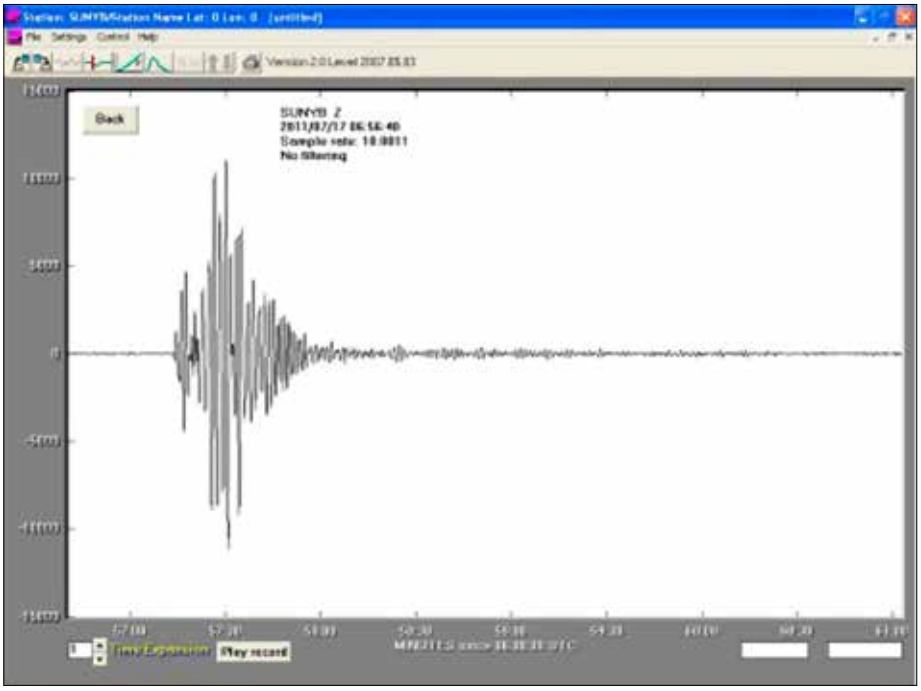

Figure 9. Event 101 earthquake near Venus about 25 mi from EQ-1 seismograph. The date was July 17, 2011 at 06:57:59 GMT. Time in minutes is the x-axis and wave amplitude is the y-axis.

Late Cretaceous Austin chalk, the BFZ has been thoroughly examined (Nance, et al, 1994).

As shown in Figure 7, Dallas, Ellis, and Johnson counties are within the Balcones Fault Zone. In figure 8, interpretation of seismic data from the EQ-1 suggests earthquakes appear to have a northeast-southwest strike consistent with the fault zones. Observation of surface faults again suggests northeast-southwest striking faults. Faults mapped near the SSC site had throws from 20 to 100 ft (Reaser and Collins, 1988).

Although most authorities agree the Balcones Fault Zone is most likely dormant or extinct, some think the fault zone had small movements occurring as late as the Pleistocene. In addition to the above seismic data, in 1934 a minor earthquake on a fault in northeast Texas/southwest Oklahoma (Flawn, 1970) may have occurred on the Balcones Fault Zone. Historical data from 1893, 1902, and 1934 in addition to my seismic data suggests continuing residual activity on the Balcones Fault Zone, (Bureau of Economic Geology, 2021.). See Figures 9, 10, 11, and 12 for seismograms of temblors thought to be on the BFZ.

East Texas (Area 4)/ South Texas (Area 5)/ Rio Grande (Area 6):

A few temblors have been recorded from East Texas (1), South Texas (2), and the Rio Grande Valley (6). As can be seen from Figure 3, they may be associated with oil/gas activities.

Unknown Seismic Events (UKSE's)

Many unknown seismic events have been recorded. These are apparent seismic events that are not correlated to known earthquakes, and their seismic signatures do not resemble those of earthquakes. These show up regularly and appear to

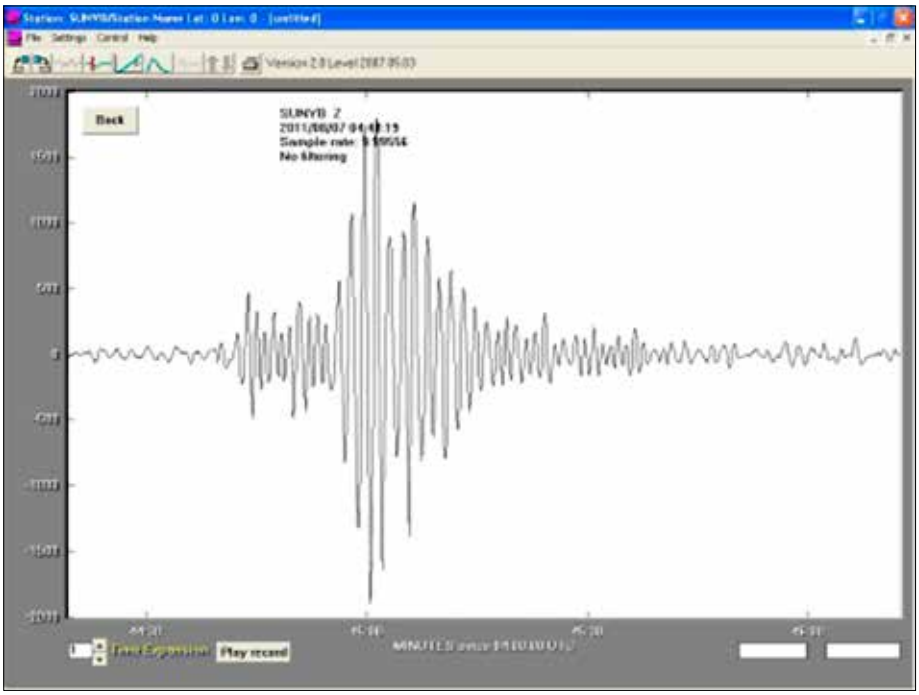

Figure 10. Event 107 earthquake near Irving, Texas on August 7, 2011 at 04:44:41 GMT. Time in minutes is the x-axis and wave amplitude is the y-axis.

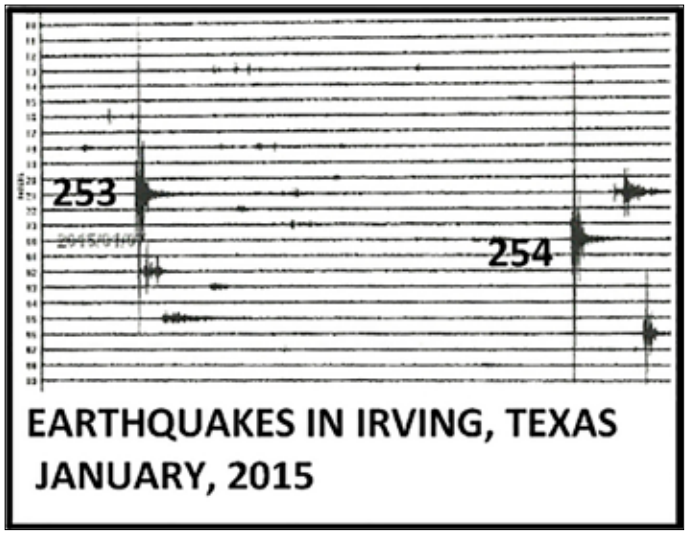

Figure 11. Earthquake events 253 and 254, near Irving on January 6, 2015 at 6:21:00 GMT and on January 7, 2015 at 00:52:00 GMT, respectively. Magnitudes are 3.5 and 3.6, respectively. Depths are 16,404 ft (5,000 m). Note other quake events. Time in minutes is the x-axis and wave amplitude is the y-axis. Earthquake events 253 and 254 suggest a possible earthquake and aftershock with the epicenter located in Irving.

be artificial seismic events. When compared with the USGS/IRIS earthquake websites they do not appear to correlate with any recorded seismic event. In order to determine the location of an earthquake it requires a minimum of two seismographs and preferably more. However, since the velocity of P and S waves are known, the distance from the seismograph can be determined by using time verses distance plots, Braile, 2007. My determination of S-waves is not always reliable. However, about 10 percent can be determined. From my data I have estimated that Event 471 is located about 35 miles from my seismograph, as shown on Figure 13. In general, these UKSE's occur from 25 miles to 145 miles (40 km to 233 km) away from my seismograph.

Conclusions

As observed on the EQ-1 seismometer, Texas temblors have modest Richter magnitudes varying from 2.6 to 4. Many temblors, especially those in the Panhandle, may be related to oil field activity. However, residual tectonic activity on the Balcones Fault Zone may have produced some of the temblors observed on my EQ-1 seismometer. Historical data from 1893, 1902, and 1934 in addition to my seismic data suggests continuing residual activity on the Balcones Fault Zone.

Lastly, many unknown seismic events (UKSE's) were also recorded. The origin of these events is a mystery although they are most likely associated with

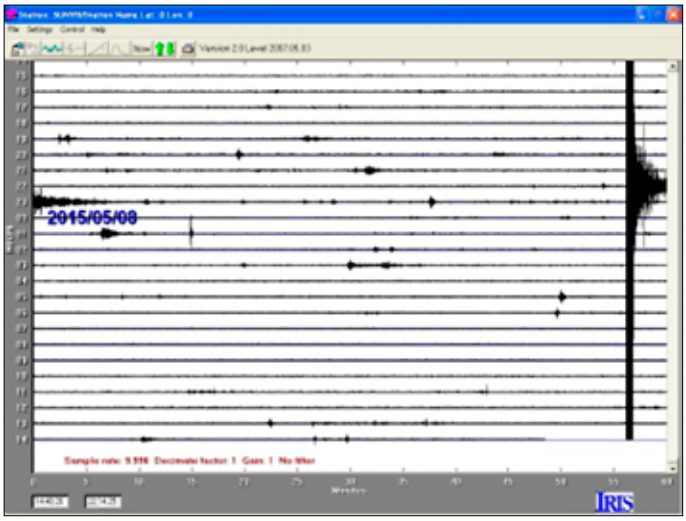

Figure 12. Event 264 near Venus, Texas on May 7, 2015 at 23:00:59 GMT. Magnitude 4.0, depth 10,500 ft. about 28 mi. from seismometer. Time in minutes is the x-axis and wave amplitude is the y-axis.

human activity. They have unique seismic signatures of short durations and small amplitudes.

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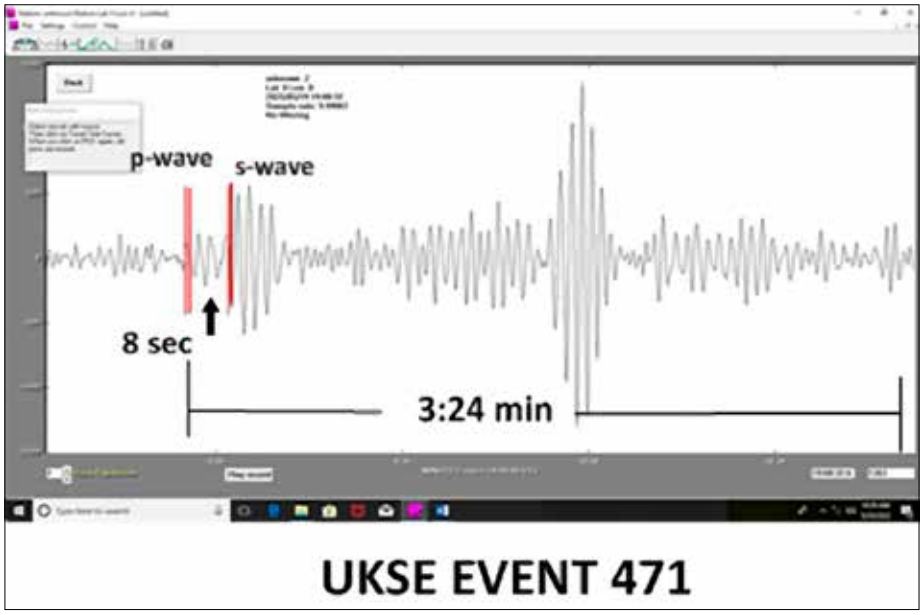

Figure 13. UKSE event 471. Estimated location is about 35 miles from my seismograph.

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Study Shows Ground Heat Hazards Can Be Harmful to Man's Best Friend

Paul F. Hudak, Department of Geography and the Environment, University of North Texas

Dog walking is an important form of human-animal interaction in urban and suburban settings worldwide. Healthy effects of walking dogs are well established. Owning and walking dogs contributes to physical, mental, and emotional health, while providing an important form of social support (Cutt et al. 2007).

While ample research demonstrates the benefits of dog walking, fewer studies document adverse outcomes, including those affecting dogs. Potentially harmful situations include over exertion, salt in cold areas, and extreme temperatures (Bender 2019), which can lead to dehydration and potentially stroke (Foley 2015; Hall et al. 2020), as well as damage to paws, including abrasion, chapping, cracking, sores, blisters, and burns (VMBS 2015).

Two case studies in Texas, one in a built environment and another in a natural setting, illustrate potential ground heat hazards when walking dogs on warm days. In the first case, temperatures of four different ground surfaces—concrete, grass, chip seal, and tar—were measured along a street in a suburban neighborhood. The study involved two morning and two afternoon surveys of 30 sampling locations where all four materials were present. Air temperatures, typical of the study area in summer, ranged from 78.0°F in the morning to 96.1°F in the afternoon. Ground surfaces reached much higher temperatures, exceeding 150°F, in the afternoon surveys. Median temperatures were highest in tar, followed by chip seal, concrete, and grass. The second case involved shallow lake water and various types of mud, sand, cobbles, rock fragments, and grass along a nature trail. Air temperatures ranged from 74.7°F at 8:00 a.m. to 92.5°F at 6:00 p.m. Ground temperatures varied considerably with material and time of day, ranging from 76.4°F at gray cobbles and beige rock at 8:00 a.m. to 125.7°F at brown sand at 4:00 p.m. Over the day, temperatures were highest at brown sand and lowest in water and moist sand.

Summer heat can create hazardous ground surface conditions that pet owners need to consider. Professor Paul Hudak with the Department of Geography and the Environment at the University of North Texas submitted a

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The Student: Work of A Fine Craftsman

Isaac Pope, SA-9950

Who doesn't like awards? There may be the odd one of us who may dislike the fanfare and limelight, but there is nary a person who would not at the very least be tickled at the idea of being recognized for their work. As illustrious as recognition may be, the question always remains: what is it that builds the work and life of an exemplary student? What process or factors contribute to sculpting a student whose work catches the eyes of those around them and become recognized by their peers and mentors? As I complete my essay as a nominee for the Outstanding Student Award at my college, I have been pondering lessons from when I served as a student representative of the college's Outstanding Student Award committee last year.

Every year, a handful of students are nominated as the shining stars of the graduating class for their work showcasing tenacity, character, and academic excellence on campus. These students come from a wide range of backgrounds and experiences, yet each have overcome specific challenges to become some of the most distinguished students. Grades and mastery of demanding coursework are only the beginning for these students, who have furthermore learned dedication and key leadership skills through their service not only on campus but throughout their community. In the midst of such a competitive cohort, what could possibly make the finalists stand out from the crowd?

As I read through the dozen essays, what I saw shocked me. Some students clearly invested considerable effort into their essays, while others completed little more than the bare minimum. While this may be expected in any group – even among the best – the strength of the essay was not random. Indeed, those students who had the strongest recommendations tended to have the strongest essays. If a professor left only a few comments on the nomination form, the student would likely apply minimal effort, while if one or more professors wrote glowing recommendations, the students would write incredible stories of their journey. Was it the praise that gave students confidence in their essays?

Consider this: *none of the students ever saw the nominators' comments, yet those comments were the best indicator of the strength in the student essays!* How could this be? As I considered the essays, I slowly began to realize that what truly set these students apart from all others was that they had been refined through fire. Those students who wrote the strongest essays had nominators who actually knew them and their every strength and weakness. For the past two years, those professors had invested in those students and pushed them beyond what many might consider possible, yet through it all the students had grown stronger, more refined, and more confident. Rather than going about the normal college routine, these students had invested in pursuing a journey towards becoming stronger students and leaders under the guidance of vigilant mentors, and it was that journey, with its many joys and setbacks, that had instilled within them a confidence no ordeal could dampen. That is the reason these students had such strong essays: the students had learned to rise to the occasion, no matter the circumstance.

> **"In the midst of such a competitive cohort, what could possibly make the finalists stand out from the crowd?"**

That year, several students were honored with the Outstanding Student Award, and it was well earned. Each student was an example of dedication, perseverance, and passion refined through hard work and the guiding words of their mentors. These mentors had helped sculpt raw talent and enthusiasm into a fine work of art, free to grow and brighten their corner of the world. When I reflect upon my own journey, I see the overwhelming importance of a strong network of family, friends, and mentors who help shape my mindset and push me beyond who I am today. With perseverance, hard work, and dedication, what exciting opportunities now lie before us! Even while we climb towards unforeseen horizons, let us pause to remember upon whose shoulders we now climb. Anyone care to join me in writing some thank-you notes this evening?

Qualified Professional Judgment

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In 2009, a colleague and I along with a student from Northwest Missouri State University traveled to Scotland and Ireland to create a study-abroad field course for geology students at NWMSU. We worked our way from Dublin, to Edinburgh, around the Scottish Highlands and back to Belfast. From there we went along the north coast of Ireland, all the way to Galway in the west, before heading back to Dublin. It was a fantastic work trip and based on our fieldwork, we created a 17-day field course that started in Edinburgh and ended in Dublin. Along the way students learned to use a Brunton Compass at Siccar point, studied the Buchan and Barrovian metamorphic series, saw evidence of the opening of the Atlantic Ocean, and studied world class Flysch sedimentation in western Ireland. We also immersed ourselves in the culture, visiting archeological sites, attending a performance at the Abbey Theater and, of course, enjoying a pint or two in a local pub in the evenings. In 2012, during one such visit to a pub, I had an experience that would drive home to me the importance of professional organizations like AIPG.


Donegal, Ireland

We were in Donegal in the northwest of Ireland. It had been a long day and following our evening meal, I headed into a local pub (I believe it was The Reel Inn) to have a well-earned end of the day beverage and to begin grading student field assignments from that day. I sat down with a fresh pint of 'the black stuff' as Guinness was called by the locals and opened student field books to begin grading and giving feedback on the day's field notes. As I sat, two gentlemen sat at a table next to mine. I noted they were there, but paid little attention, becoming focused on my task. After about 30 minutes, one of the men touched my shoulder and asked if I was a geologist. He apologized for reading over my shoulder but had noticed that the work I was assessing seemed to be geologic in nature. I replied that I was and that I was co-leading a field course for students. He inquired after my area of expertise, and I replied that I was an economic geologist with expertise in carbonate-hosted base metal deposits. I responded that my Ph.D. work had been in the Irish zinc-lead ore field and that I had done a little bit of work in Mississippi Valley-type deposits as well. I could see that his interest was piqued, and he asked if he and his partner could buy me a drink and bend my ear about a project they were pursuing. Never one to turn down a pint, I agreed.

The two gentlemen gave me the 10,000-foot overview of their project. It was a gold project located near an Irish National Heritage Site. They had what they believed was good data, some from drilling and some from surface sampling, and had several assays indicating a grade that would be well above their inferred minimum cut-off grade for mining. They felt they had enough information to make an ore reserve calculation that could be used to help them procure investment dollars to move the project forward. The gentlemen asked if I had any experience making such calculations. I replied that I did, but in carbonate-hosted base metals rather than igneous-associated hydrothermal gold mineralization. The gents assured me that the two types of deposits were similar enough that the calculations would be similar and that my experience would be sufficient for the project. This is where I became uneasy. I had a small amount experience doing some consulting on an epithermal gold project in Canada and I knew that there was an enormous difference between the two types of deposits. I immediately became uneasy because I began to feel a bit of pressure from the two men. Still, I agreed to review their data after I finished grading. We agreed to meet later that evening.

I finished grading and began to look at the information they had provided. There were assays, core logs, chip logs, descriptions of surface samples, and maps showing the total surface area that appeared to be altered. The more I looked at the information, the more convinced I became that the data were inadequate to perform any kind of assessment as to the size, grade, and overall tonnage of ore that might be present in what I could only think of as a prospect. There was no information as to the type of mining that might be used to exploit the deposit, nor any information on the type of processing that might be used to liberate gold from the ore. I had no way to make any kind of estimate of ore grade and tonnage.

The two gentlemen returned at about 10:30 that evening and I informed them that my experience was not sufficient to make calculations as to tonnage, grade, or value of potential ore within this prospect. I went on to state that I felt their data was inadequate and that it would be premature to make any kind of assessment at this time. They were disappointed

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Are You Working On Anything Cool?

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In the last few months, I have talked with more geologists, one-on-one, than I ever have in such a short period of time. I am loving the experience. Part of it is due to my responsibilities as the 2022 President, but another part of it is simply my inquiring mind wanting to know what geologists are doing professionally. In the last quarter, I have given several presentations and attended a few conferences. With all of that inter-activity, I never fail to ask other geologists, "Are you working on anything cool?" Quite often, the knee jerk answer is "No, nothing special." However, invariably, people quickly reflect and then talk about something cool they are involved with. This has included new instrumentation, new remediation or exploration approaches, new equipment, new roles, new webinars, new teams, new part of the country where they are working, etc., etc. You get the idea. I really believe this is the fun stuff that we get to talk about whenever we get together. I am not asking for company or trade secrets. I really don't care who the client is or any of the specifics. In round about terms, however, all of us are working on projects or programs that have a certain cool element to them. Almost all of us have a treasure trove of 'cool' project experiences that we could share with others.

I have had technical discussions with other geologists that went on for more than half an hour before I even learned their name. I have been invited out to project sites, collecting sites, mine sites, remediation sites, and manufacturing sites simply by virtue of striking-up a discussion about whatever is cool about someone's job. One attribute that I think that all of us geologists share in our wiring diagrams is that we all readily gravitate to the cool factor of any given endeavor. Field trips and learning opportunities are all about what's new and what's cool. We all have timesheets and expense reports to prepare and submit, but I have yet to meet a geologist who bragged about his or her attention to detail on an expense report. Quite the opposite. New direct-push technology, three-dimensional modeling, UAVs, GIS and all sorts of field instrumentation keep the cool factor moving up the curve.

One of the things that initially drew me to geology was that all of the textbooks had lots of pictures in them (be sure to read the captions) and I am very much a visual learner. At the nexus of GIS and three-dimensional modeling, geologic interpretations are becoming increasingly more robust while becoming more detailed. Gone are the days of simple, black-and-white cartoon cross-sections and block diagrams. A highly detailed conceptual model, built on a healthy dataset literally propels the project forward. In short, our work products are becoming cooler. I can give you one very clear example of our work products getting more and more cool (cooler and cooler?). In the Roadside Geology book series (I'm a big fan), each successive State edition has so much more information in each and the maps and graphics are much more detailed and well-presented than each previous edition. They are becoming really cool and indispensable.

There is no doubt in my mind that you are currently working on some project that includes at least a modicum of cool factor. Maybe it's just a cool locality; down the road from a state park or National Monument. Lots and lots of projects have cool geology; that's a given. Our project results are now being compiled into really exceptional graphics where full-color excellence is quickly becoming the norm. Geologists of all stripes are rapidly evolving in their ability to compile thought-provoking technical graphics. In short, our communication tools are improving drastically. But, back to the cool factor.

As geologists, we all benefit when we are in the mix with other geologists talking about the cool stuff that's keeping them engaged. We need to not only engender this type of dialogue, but to also keep it going. In the future, ask another geologist if they are working on anything cool. It's an easy question and it is important. It is even more important that you do this if that geologist doesn't belong to AIPG. It is important, because they will readily recognize that their wiring diagram is like our wiring diagram and AIPG is the place where they will fit in well and really belong.

Cheers, Matt

Answers on Page 36

Robert G. Font, CPG-03953
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1. Which of the terms given below describes a condition where rapid changes of pressure in a liquid lead to the formation of small, vapor-filled cavities in locations where the pressure is relatively low?

a) Thixotropy.
b) Sublimation.
c) Cavitation.
d) Fufutropy.

2. Frosted sand grains are characteristic in this depositional environment:

a) Paludal.
b) Glacial.
c) Eolian.
d) Dude, if you drink frozen margaritas while vacationing at the beach, you are bound to find some frosted sand grains in your drinking cup…

3. This famous geoscientist is known for his invention of a precise method to measure gravity, which led to the measurement of gravity at sea and to the discovery of gravity anomalies above the ocean floor:

a) Charles Edward Dutton.
b) Felix Andries Vening Meinesz.
c) Robert Sinclair Dietz.
d) Oswald Chesterfield Cobblepot.

4. A series of consolidated-undrained triaxial tests have been conducted on the normally consolidated Weald Clay. The relationship between water content (w), minor principal stress (P_3) and major principal stress (P_1) at failure is given in the table below. Based on this data, what would we expect the deviatoric stress to be at a water content of 17.5%?

Water content w (%)	Major principal stress P_1 (psi)	Minor principal stress P_3 (psi)
23.10	47.0	30.0
20.7	94.0	60.0
18.3	188.0	120.0

a) Deviatoric stress = 83.25 psi
b) Deviatoric stress = 73.66 psi
c) Deviatoric stress = 60.98 psi
d) Deviatoric what? OK, Dude, you really need to come down to Earth! Repeat after me: This column in the *TPG* is about geoooooloooooogy, not quantum mechanics.

5. (Question submitted by David M. Abbott, Jr., CPG-04570) -- The fossil accumulations in the Burgess Shale in Yoho National Park in eastern British Columbia, the Quarry Museum outside of Vernal, UT in Dinosaur National Monument, and the La Brea Tar Pits in western Los Angeles are known as?

a) Catastrophic flood deposits.
b) Turbidite deposits.
c) Lagerstätten.
d) A real jumble of fossils; who needs German?

Extra credit: *What well-known building is across the street from La Brea Tar Pits?*

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

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

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Indian Law and ESG Governance: geoscientists are likely the first boots on the ground

Proposed or initiated operations on lands subject to a variety of claims by indigenous groups including reservation lands, archeological sites, religious sites, and/or lands formerly occupied by an indigenous group can result in all sorts of costs, delays, potential lawsuits, etc. I use "indigenous group" because the interested group may or may not be a recognized tribe in the US and recognized tribes can include members from two or more separate tribes or related groups; it's complicated. Problems with indigenous groups in other countries have their own complicated issues. While natural resources entities historically have had the most interactions with indigenous groups, other entities that use, manage, or alter lands for development, utility transmission lines, reclamation, new reservoirs or aqueducts, or other activities can and will become involved with indigenous groups. ESG (environmental, social, and governance) policies are now disclosure issues for all public companies on a worldwide basis. The social part of ESG clearly includes relations with affected indigenous groups.

The Mining and Metallurgical Society of America sponsored a one-hour webinar, *#3 A look under the hood at: Indian law and ESG governance*, on February 11, 2022. Carolyn Loder addressed mineral rights and tribal engagement and Maureen Upton addressed the growing scope and seriousness of ESG issues. The webinar was a real eye-opener for me. I had no idea of the complexities of working with Native American indigenous groups. Upton's remarks noted the increasing numbers of NGOs and others are looking for and demanding more than nice sounding (greenwashing) statements in ESG disclosures. Specific programs and actions are being demanded and examined. This webinar is available online at https://www.youtube.com/watch?v=OfnqlzZCmgY. I urge you to watch it.

The importance of the increasing sensitivity to ESG statements and activities on lands of interest to Native American or other indigenous groups to geoscientists is that geoscientists are commonly the first boots on the ground for a project. As such, geoscientists will be asked by interested parties about what is going on and what is proposed. Geoscientists should be sensitive to all questions and comments and do their best to alert their employers or clients about potential issues and problems so that they can be addressed at an earlier and, hopefully, less confrontational stage.

Take a moment to effect change

Contributed by Sara Pearson, CPG-10650: The health and safety moment has become a common way for organizations to start meetings whether they are in the office, virtual, or standing around the tailgate. As anyone who has sat through health and safety training courses has heard, it is very easy to become so familiar with tasks and equipment so that we don't think about the potential dangers. Being on "autopilot" is when injuries are most likely to happen. The regular routine of holding a quick five-to-10-minute health and safety discussion at the beginning of meetings encourages mindfulness and ultimately saves money, prevents injuries, and improves productivity.

What if this approach were used for another very important topic? What if it were used to increase awareness and promote diversity and inclusion? Diversity, equity, and inclusion have come to the forefront in recent years in many organizations including AIPG. AIPG has committed to diversity, equity, and inclusion through amendments to the Code of Ethics and formation of committees dedicated to the topic at the National and section levels. What if we took this one step further and started out meetings with a brief discussion about diversity and inclusion?

Jessica Davey, MEM-3242 and I were invited by the Minnesota Section to give a presentation about AIPG's Code of Ethics in March to help satisfy the requirements for ethics training for professional geologists. We chose to not only focus on the Code, but also the most recent amendments about diversity, inclusion, and implicit bias. The presentation was interactive featuring small group discussions that allowed for more sharing of thoughts, perspectives, and examples. One example given during our discussion that a participant gave was about their organization's addition of a diversity, inclusion, and equity moment at the beginning of meetings much like the health and safety moments. I was very impressed and found this to be an innovative approach to keeping a focus on this important topic and effect change one step at a time. What steps have you or your organization taken to effect change and raise awareness?

Honesty and trust, Part 2 Practice

This discussion of honesty and trust began in Column 179 (Oct/Nov/Dec '21). There I cited "the normal assumption that people are honestly telling us about their education, experience, competencies, and all manner of other things. Only in certain circumstances is verification of some sort required." "In our interactions with strangers, most of us default to assuming that we are being told the truth, that is, we assume that strangers are honest unless there are dramatic red flags, and not always then. We have illusions that others are being as transparent as we believe ourselves to be. And we do not understand the importance of the context in which the stranger is operating and so fail to understand what the stranger is communicating." Malcom Gladwell's 2019 book, *Talking to*

Continued on p. 36

Answers:

1. The answer is choice "c" or "Cavitation."

Thixotropy describes the property of some substances becoming less viscous when subjected to an applied stress. This is typical in some gels that become temporarily fluid when shaken. Thixotropic behavior also occurs in some clays, such as the problematic "quick clays." This type of behavior leads clays with flocculated fabrics to lose strength when disturbed or remolded.

Sublimation is the process of conversion from a solid state to a gaseous one without passing through a liquid phase. In the hydrologic cycle snow and ice may change into water vapor directly without first melting into water.

If any of you find out what "fufutropy might be, do let me know!

2. The answer is choice "c" or "Eolian."

The abrasional effect or sandblasting impact of sand grains transported via saltation causes sedimentary particles in eolian environments to have a frosted sheen (patina). Thus, sand grains in eolian environments are characteristically frosted due to their texture.

Sand is not the typical sediment type found in paludal (swamp) environments.

Heterogenous, unsorted sedimentary particles of all sizes (from boulders to clay) are transported as glacial till.

3. The answer is choice "b" or the Dutch geophysicist and geodesist "Felix Andries Vening Meinesz" (1877-1966).

The American geologist-seismologist Charles Edward Dutton (1841-1912) is credited with (best known for) the concept of isostasy.

The American marine geologist-geophysicist and oceanographer Robert Sinclair Dietz (1914-1995) along with Harry Hammond Hess are best known for the theory of seafloor spreading published in 1960-1961.

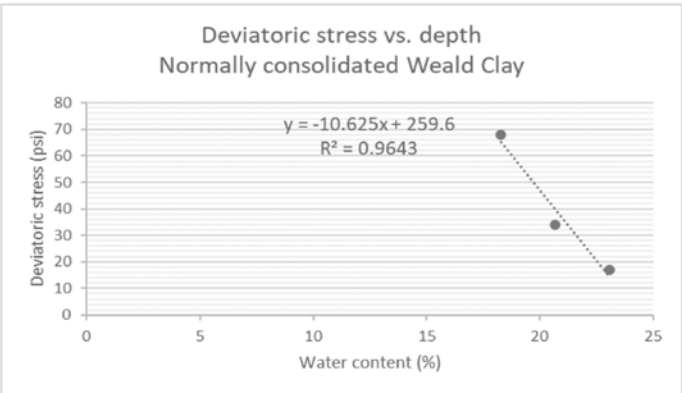
Sorry, Oscar Chesterfield Cobblepot is no geoscientist; he happens to be the infamous "Penguin" and archrival of "Batman" as introduced by DC Comics (starting in 1939).

4. The answer hinges on our understanding of what we mean by "deviatoric stress." In this example it is choice "b" or "Deviatoric stress = 73.66 psi."

Note that P_3 is the confining pressure and P_1 is the axial pressure added to the confining stress. Thus, the deviatoric stress is the difference between these values or P_1-P_3. In other words, the deviatoric stress is that which deviates from the hydrostatic. In our example:

Water content w (%)	Deviatoric stress P_1-P_3 (psi)
23.1	17.0
20.7	34.0
18.3	68.0

The relationship is plotted in the graph shown below:



Based on a linear regression analysis and the corresponding equation for the line of best fit, we can extrapolate that at a water content of 17.5% the deviatoric stress should approach 73.66 psi. The linear trend has a coefficient of correlation ($\sqrt{R^2}$) of approximately 0.98.

5. The answer is choice "c" or "Lagerstätten."

Extra credit: *The LA County Museum of Art.*

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Marquette, Michigan
August 7, 2022 from 6:30 – 9:00 pm

Cash Bar and Auction Preview 5:30 pm

The Foundation of the American Institute of Professional Geologists will hold a silent auction at the AIPG Welcome Reception on Sunday, August 7th starting at 6:30 pm at the Exhibit Area in the Northern Center. **We hope you will consider a donation (such as mineral/rock specimen, books, antique or historic items, artwork, jewelry, maps, or other items of interest) to the silent auction to raise funds in support of the Foundation for AIPG programs, scholarships, internships, and various initiatives.** We also encourage you to consider bidding on items at the auction. Bring your checkbook!

Adam Heft and the AIPG Michigan Section have kindly volunteered to organize the silent auction on behalf of the Foundation.

We also appreciate some advance notification to help us plan for the numbers and types of donations. Please bring items to the annual meeting registration desk prior to the silent auction OR you may ship them to Adam Heft prior to August 1st. Include a copy of the 2022 Silent Auction Donation Form with your donated item. Please consider donated item size and travel safety regulations. The winning bidder will need to transport the item. Please send a copy of the completed donation form to me in advance and also include a copy with your donated item(s).

If you have any questions or need additional information about the Foundation and/or silent auction, please contact:

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We look forward to seeing you at the Silent Auction for an evening of fun and friendship and an opportunity to support the Foundation of the AIPG.

Barbara Murphy
Chairperson, Foundation of the AIPG

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Continued from p. 35

> **“ Professional integrity demands that you stick to your position even when it costs you a job. While the cost may be significant, it is likely to be far less than the potential liability.**

Strangers: what we should know about the people we don't know is something we all should read.

This topic came to mind from a recent experience of some colleagues. A new client was referred to them by a former client. The new client asked them in writing to value the damages resulting from the interaction of the production of the new client's gas well with a neighboring secondhand gas storage facility. The new client promised to send a retainer check, which never happened. About two weeks later, after my colleagues had generated a bill approaching $20,000, the new client phoned telling my colleagues to forget the project. The new client also took the position that attempts to collect the outstanding consulting bill would be viewed as extortion. Subsequent inquiries by my colleagues revealed that although the new client was referred by a former client, the former client didn't know the new client. Among the new client's credentials was claimed membership in the American Institute of Petroleum Geologists. There is no such organization. Further digging uncovered lawsuits indicating that the new client was pursuing an apparently long-standing fraudulent business practice.

It is clear that a bit of prior investigation of the new client's credentials would have raised significant red flags. We all default to an assumption that other people are being honest. Unfortunately, this assumption is sometimes wrong. A little checking doesn't take much time and could have helped prevent my colleagues being out about $20,000 in consulting fees.

Certification and sealing liability issues

When you sign a professional report using your AIPG Certification number, AIPG CPG Seal, a state license, or other professional credential you are assuming liability for the professional contents of that report. Those CPGs signing S-K 1300, NI 43-101, or similar reports as a qualified person potentially face liabilities of hundreds of millions of dollars to investors if your opinions are found to be false and misleading in a securities lawsuit. The amount of liability for other types of professional reports may be smaller but no less financially ruinous. The certificates or statements of professional qualifications and designating the parts of a report for which you are professionally responsible are particularly important parts of these documents. If such a qualification certificate is drafted by an employer or client, review it very carefully. There might be language saddling you with liability for the employer's, client's, or other's activities. Corporate lawyers are looking out for the company's best interests, not yours. If there is problematic language, don't sign the report until you've discussed and resolved the problem, potentially with the advice of your own lawyer. Your signed and sealed report may be something the employer or client needs to close a deal, particularly closing a stock offering. That fact is your very powerful stick in the situation. Professional integrity demands that you stick to your position even when it costs you a job. While the cost may be significant, it is likely to be far less than the potential liability.

This is an important topic and does not contain any specific examples of problem professional qualification certificates. I do know from personal experience that telling a client that the reverse circulation drilling they hoped would support claimed existence of gold reserves did not support that conclusion is a very uncomfortable situation. Reverse circulation drilling for gold, particularly when the water table is intersected in the hole, is notorious for having high-grade assays at the bottom of the holes due the dense (≈19 g/cc) gold particles falling through the circulating fluid to the bottom of the hole. Informing the client of this fact was not pleasant but necessary. If you have examples of being pressured to assume unjustified liability in professional qualification certificate or in a professional report, please contribute it. The details can be in generic form.

Should a “Reasonableness” standard be added to the AIPG Code of Ethics?

Column 179 (Oct/Nov/Dec'21) posed this question. I published a paper on this subject, “Applying the Reasonableness Standard Early in a Property Evaluation” for the 2022 SME Annual Meeting, Salt Lake City Preprint 22-004, 3 p. An abstract of this paper is currently available on SME's website and next year the full paper will be posted on OneMine. Those interested in obtaining a copy should send me an email. **John Manes'** (CPG-11742) related paper, “Competence, reasonableness, and ethics when performing mineral valuations” is in the Apr/May/Jun'22 *TPG*.

Mineral exploration provides an example of the use of reasonableness. Mineral exploration is a process of examining prospects, selecting the most promising, and rejecting the less promising. The examinations are largely geoscientific, geology, geochemistry, geophysics, and sampling. Most prospects don't pan out. The potential quantity of mineralization is too small, or the grade is too low. But there are other reasons for rejection, such as the inability to obtain needed mineral rights. Exploration financing fluctuates and when funding is reduced, less promising or less advanced projects are dropped. One or more deleterious elements, such as a radioactive element being present in one or more minerals in the deposit, or the presence of asbestiform minerals are examples. The increasingly important ESG (environmental, social, governmental) issues often arise early in a project's life. The exploration geologist with the first boots on the ground is often the first to learn about such issues, which may or may not be significant. There may be problems with too much water, or too little. All of these other reasons are varieties of modifying factors used in the major mineral resource and mineral reserve classification systems. Some parts of these classification systems suggest that modifying factors are only applicable after a mineral resource has been delineated. Indeed, a reasonably well-delineated deposit's size and grade/quality

distribution are required before effective mine and processing plant design can occur. But the *reasonable prospects for economic extraction* phrase in the definition of "mineral resources" in the JORC Code (2012), SME Guide (2017), SEC, CRIRSCO (2019), and similar classification systems clearly indicates that application of a modifying factor such as those listed above are and should be applied to a prospect's evaluation as soon the materiality of the particular factor to the prospect becomes apparent.[1] The SME Guide's (2017) paragraph 34 states: "Public Reports of Exploration Results should contain sufficient information to allow a considered and balanced judgment of their significance. Reports should include relevant information such as effective date, exploration context, type and method of sampling, sampling intervals, relevant sample locations, distribution, dimensions and relative location of all relevant assay and physical data, data aggregation methods, *land tenure status, plus information on any of the other criteria listed in Table 1 of the SME Guide that are material to such an assessment"* (emphasis added). The CRIRSCO (2019) Template's paragraph 6.5 states, "Reports must include relevant information such as exploration context, type and method of sampling, relevant sample intervals and locations, distribution, dimensions and relative location of all relevant assay data, methods of analysis, data aggregation methods, *land tenure status plus information on any of the other criteria listed in Table 1 that are material to an assessment"* (emphasis added). The Table 1 referred to in both Codes is a checklist of assessment and reporting criteria that includes all the modifying factors. Other statements in the classification systems reinforce this conclusion.

The proposed general Reasonableness standard would be: "The author(s) of geoscience reports or presentations must ensure the Reasonableness of all contained conclusions and recommendations. 'Reasonableness' means that other qualified and experienced geoscientists with access to the same information would consider the author(s)' interpretations and conclusions to be with a reasonable range of variation. Any standards used, assumptions applied, and any method relied upon should be reasonable within the context of the purpose of the report or presentation. Any method applied in the subject report or presentation should be within the expected capability and consideration of an assumed likely reader of the report or presentation."

The purpose of a Reasonableness standard is to assure that any geoscience reports or presentations reflect a realistic assessment of the purposes of report or presentation, particularly from the perspective of the assumed reader of the report or presentation. Conceptually, while several reports on the same topic would be expected to have varying conclusions, the Reasonableness standard would help ensure that the variance of a particular report is not significantly different from similar reports unless thoroughly justified differences are scientifically based and well presented. What do you think? Please contribute your comments and suggestions regarding the need for a reasonableness standard.

"The proposed general Reasonableness standard would be: "The author(s) of geoscience reports or presentations must ensure the Reasonableness of all contained conclusions and recommendations.

Rebuilding restrictions after the Marshall Fire?

I asked this question in column 181 (Apr/May/Jun/'22). Since I wrote the question, Boulder County has tightened new construction regulations to increase resistance to fires spreading from adjacent areas and buildings. However, due to projected building cost increases stemming from these new rules, efforts have been made to exempt reconstruction of homes burned in the Marshall fire from these restrictions. This reaction to the new rules is not surprising. Some people will build to the new standards and others will not.

Your contributions to future PE&P columns welcomed—reminder #2

People regularly tell me that this column is the one thing they read in each *TPG* issue. I also realize that I will not be able to compile this column forever. I know many of you are interested in professional ethics and practice issues. Some have questions and some have developed proposed answers. **Sara Pearson's** contribution to this column, "Take a moment to effect change," is an excellent example. I invite you to contribute to this column by addressing a topic of interest to you. You will receive full credit for your contribution. For those of you who must document PDH time, being able to cite something you've published provides solid evidence of your interest in and time spent on professional ethics.

Each column is a collection of several, usually unrelated, topics. Topic lengths vary from 2–3 paragraphs to a page or more of Times New Roman on standard paper and margins. The topics in this column vary between ≈250–≈450 words. Longer discussions—≈1,650+ words—warrant being individual articles. Both shorter and longer contributions are welcome from all membership grades and ages. Please write up your topic and send it in as it occurs to you. Thank you in advance.

1. JORC Code, 2012, Australasian Code for reporting of identified mineral resources and ore reserves (the JORC Code 2012 edition): https://www.jorc.org/docs/JORC_code_2012.pdf; SME Guide, 2017, SME Guide for reporting exploration information, resources, and reserves (the SME Guide): SME Guide for Reporting - Society for Mining, Metallurgy & Exploration (smenet.org); CRIRSCO Template, 2019, International reporting template for the public reporting of exploration targets, exploration results, mineral resources and mineral reserves: https://crirsco.com/docs/CRIRSCO_International_Reporting_Template_November_2019.pdf.

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The Foundation of the American Institute of Professional Geologists is appreciative of the donations received during 2021. As for many, the year 2021 was still a challenging time and the Foundation board members are very thankful for these many contributions, and especially for some very generous ones, to support the Foundation's programs. The Foundation is proud to be able to serve AIPG and the geosciences by providing financial support for scholarship programs, student workshops, and other endeavors in support of AIPG and the geosciences.

Be sure to check the web site www.aipg.org/foundation for additional information about the Foundation.

The Foundation is a 501(c)(3) organization. Contributions are tax deductible.

We thank our many individual members and corporate donors for their generous support of the Foundation. All contributions, no matter the amount, are greatly appreciated.

Thank you!

Barbara Murphy, CPG
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Last summer Kenny Richard, (pronounced Ri-shard, as in French), died of a stroke in Bangor, Maine. We had worked in mineral exploration in northern Maine during the late 1980's as geo-techs searching for VMS-type base metal deposits for Chevron Resources. We weren't the best of friends but we always made it out of the woods at the end of the day. I've never thought of Kenny without thinking of the following.

We were working on paper company lands northwest of Houlton, Maine cutting soil grids, soil sampling, and doing HLEM geophysics in what were still large stretches of unpopulated paper company forestlands. It was winter so we used snowmobiles, Sandvik brush axes, extended soil augers, and snowshoes. The weather was usually clear and cold and hovered around 0°F, sometimes warmer, often times much colder. The days were short with dusk arriving early. I was young, probably in the best shape of my life, and enjoyed working in the woods.

The project area was accessed by the St. Croix Rd. There was no logging along the road that winter so most of it remained unplowed. We were able to drive into a camp (in Maine a woods cabin or cottage is called a camp) at Mile 1. We'd arrive with sleds in tow and unload the sleds and geophysical equipment. We were using two long track Arctic Cats that rode like tanks. Great for hauling gear and use on trails but not so much good in the woods or hauling them out of a snowbank. We would sled in from Mile 1 with the equipment on a trailing dogsled followed by one of us on the second sled for safety. So it went for 10 to12 days on and 2 to 4 days off that winter.

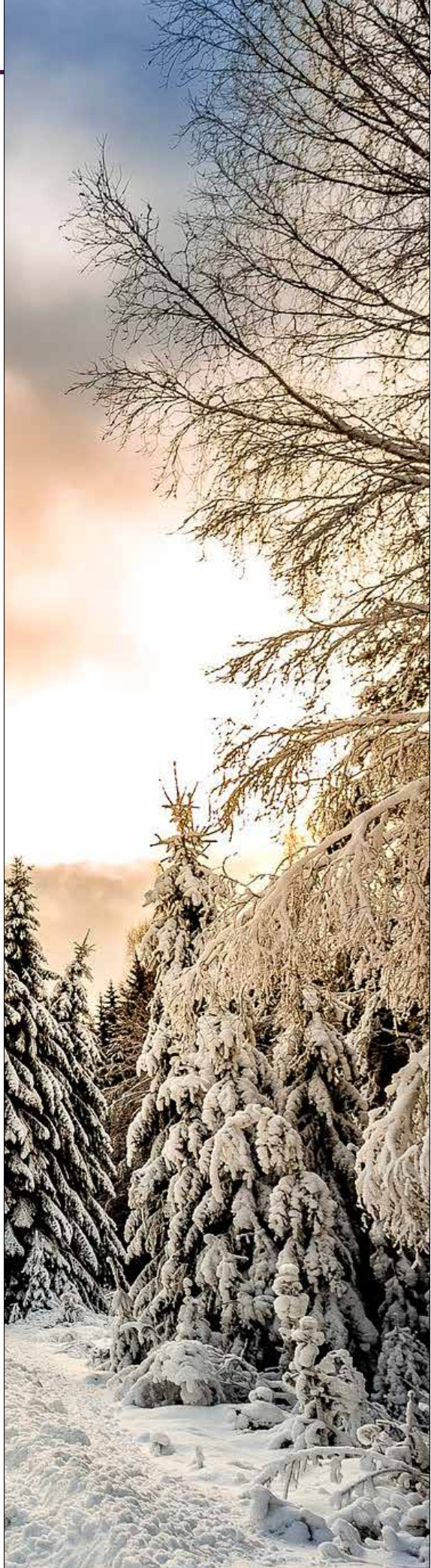
Until one morning when we couldn't get one of the sleds started. Instead of wasting a day hauling it back to town to rent another we used one sled with one guy standing behind the gear laden dogsled like a musher. The grid we had cut was accessed at Mile 14. We unloaded, unwound the cable, hooked up the transmitter and hoop, snowshoed in, and started the HLEM survey. It always seemed that I was the one with the hoop and it was no different that day.

The day was spent lugging the hoop and pulling 800 ft. of cable and Kenny up and down through bog and over rhyolite ridges. Up one line 100 feet at a time, bushwhacking to the next line, and back down the line trying to time the end of the day as close to the sled as possible. We made it back before dark, unhooked, re-wound, and loaded the sled back up and headed back to the truck.

The sled ride back was cold and crisp with tears forming in my eyes and my breath freezing on the inside of my wool pull down mask. The silhouette of Mount Katahdin in the southwest stood out black in the orange sky with the sun setting. The day was short, but we had been on the move all day because of the cold. So, I felt pretty spent as the endorphins kicked in standing on the back of the sled listening to the whine and catching whiffs of its exhaust. I was good and tired and was just looking forward to getting out of the cold.

We were almost halfway back when Kenny pulled off under the Mile 9 sign hanging over the side of the logging road. I thought he had turned off the machine but the way he was quizzically looking at the sled dashboard and turning the key made me wonder. A queasy feeling flowed out of my gut stoking anxiety. As I walked toward him from the back of the dogsled, he lifted his head and said, "you filled this up with gas, didn't you?" I said, "Ah no, I thought you did."

The Holy #&@$'s started flying and thus began one of the longer nights of my life. Nothing accusatory because we were both at fault. The fuel gauge must have stuck, and we never noticed. We



worked our way quickly toward resignation as we strapped the snowshoes back on.

We followed the sled track back. At some point over the first mile, we took the snow shoes off and discovered if we stayed on the sled track we didn't sink that much and walking wasn't that difficult. The first few miles were easy. The night was clear and cold, and a big silver moon was out making the snow glow white. I ate snow and cough drops while trying to keep up with Kenny. That was a chore. Kenny played hockey some nights after work and was in better shape than I.

By Mile 3 I was feeling it and suggested we build a fire and take a break. He said, "the hell with that, keep walking, only a couple miles to go!" He coaxed me on over the next couple of miles until we rounded that last corner and saw the truck. How beautiful was that crappy tan pick-up. How great and sturdy a feeling to walk on solid road. Kenny grabbed the keys from the wheel well, unlocked the doors, and started the truck. Only it didn't start. The battery was dead.

"The Holy #&@$'s started flying and thus began one of the longer nights of my life"

"Are you effin' serious!?" one of us must have said.

So, we walked another mile to the main road. This is still not the most populated portion of the state and houses were pretty spread out. Luckily the first door we knocked on was a welcoming one. Warmth and the smell of dinner flowed out from inside. I quickly explained our circumstances and we were soon invited in.

The husband told us not to worry, the wife offered food and drink, and more children than I had first noticed just stared. We stood and soaked in the warmth. We were looking for a jump start.

Soon a small man in a large diesel pick-up arrived. He said very little but for some reason had a casserole with him that he offered us. A lasagna to be exact.

We politely declined but after he jump started our pick-up he placed it in the back seat without a word.

The next day we rented a sled, bought some gas, and retrieved the Arctic Cat. What was basically a very long walk after a long days' work in very cold weather was due to carelessness. The office down in South Portland was surprised that we had went out in the first place because it was around -20°F that night.

And the moral of the story? That two sleds are always better than one.

Man's Best Friend, continued from p. 30

paper to *TPG* sharing the results of two case studies evaluating daytime surface temperatures on various ground settings to determine what potential harm could result from walking your dog.

Ground temperatures reached hazardous levels in both built and natural settings. Dry, non-vegetated, dark surfaces reached the highest temperatures, up to 151.1^{o}F in the built environment. Such high temperatures are potentially dangerous to dogs. Mammalian skin cannot tolerate lengthy exposure to temperatures above 111°F (Wohlsein et al. 2016). Additionally, hot surfaces along walking paths compound health risks associated with high air temperatures and humidity levels. Walkers should avoid inflicting possible harm to dogs by closely monitoring them, avoiding hot surfaces during warm conditions, and avoiding hot weather altogether. On warm days, other coping strategies include walking over moist earth or through shallow water and finding shade when available.

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Executive Director, continued from p. 32

(one of the two appeared to be visibly angry) but went on their way. I never saw the two again.

I think back on this experience often. I don't believe the two men were grifters, though they might well have been. I think they simply felt they had a good project but did not have the geological knowledge and experience to bring that project forward. I later found out they were lawyers, not geologists, and that they had approached several geologists in a similar fashion. In retrospect, had I chosen to attempt to assess the potential value of the deposit, the results could have been disastrous.

It occurs to me that experiences like this are one of the reasons AIPG exists. Our CPG credential combined with your experience allows you to act as a Qualified Person for mineral reporting. In addition, AIPG's continuing education webinars and GOLI courses provide a sound basis for geologists to know when they can or cannot be a QP for a specific deposit type. The result is robust protection for investors, geologists, and companies that engage in the extractive industries. Your continued support for AIPG will allow us to continue to offer a globally accepted and respected certification and to provide continuing education with respect to public reporting on ore deposits and mining projects.

Thank each of you for your continued support of AIPG. I wish all of you the best this summer.

Aaron

Geosites and Field Trips

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Any location on Earth that offers some geologic information is, in principle, a geosite. However, following George Orwell's famous phrase that, "All animals are equal but some animals are more equal than others," some geosites are scientifically more informative, scenically more impressive, historically better known, rare or unique, or simply valuable but fragile. Such geosites are often destinations for geotourism by the public or field trips by geology students, teachers and researchers. Geosites can be used for "place-based education"[1] (teaching and learning in place) or "case-based curriculum"[2] (using case studies to teach geologic processes). There is no official list of geosites, and my effort to compile a relatively comprehensive catalogue is still an ongoing project. But, in this article, I share the views of several authors and organizations.

An Inventory of Geosites

One of the books I have tremendously enjoyed reading is Richard Fortey's *Earth* (2004).[3] Fortey is a British paleontologist. In 2002, he was awarded a chair in public understanding of science at the University of Bristol and this gave him an opportunity to teach plate tectonics and geologic processes using some real-world examples. The result was his 2004 book, in which the following areas are prominently featured: Mount Vesuvius in the Bay of Naples, Hawaiian Islands, Iceland, the European Alps, the Appalachian-Caledonian orogens, Deccan Traps of India, and the San Andreas Fault and the Grand Canyon in the southwestern USA.

Michael Wysession of Washington University in St. Louis has given a series of 36 lectures, published in video-recordings as "The World's Greatest Geological Wonders" by The Great Courses (Course No. 1712, 2013). The geological wonders described by Wysession (2013) are given in Table 1.

A more recent book, *The Geotraveller*[4] (2021) by Roger Scoon of Rhodes University in South Africa, describes 17 areas as "famous geosites and of historical interest." These areas are limited to North America, Europe and Africa (Asia, Australia and Antarctica are excluded). The chapters in the book were first written as "The Geotraveller" column for the *Geobulletin*, a quarterly publication of the Geological Society of South America. These 17 geosites described in Scoon (2021) are listed in Table 2.

Geological surveys and geological societies in various countries and states offer valuable information, field guide books, and maps to geosites. Their websites and publications are best sources to consult on local geosites. In the US, since 1972, Mountain Press publishing company has published the popular *Roadside Geology* series (for 33 states, so far). These illustrated books are written by local expert geologists. In 2012, Mountain Press published *101 American Geo-sites You've Gotta See* by the retired geologist Albert Dickas.[5] These selected geosites in the 50 US states are listed in Table 3.

Earth (formerly *Geotimes*), a magazine published by the American Geoscience Institute, used to publish "Travels in Geology" feature articles from 2003 until the magazine's cessation in 2019. These articles are available online.[6]

During the Earth Science Week 2014, The Geological Society, London, announced a list of 100 Great Geosites across the UK and Ireland.[7] These geosites fall into ten categories: Landscape, industrial/economic importance, historical/scien-

1. Smeken, S. (2017) Place-based education in geoscience: theory, research, practice, and assessment. *Journal of Geoscience Education*, vol. 65, pp. 542-562.
2. Goldsmith, D.W. (2011) A case-based curriculum for introductory geology. *Journal of Geoscience Education*, vol. 59, pp. 119-125.
3. Fortey, R. (2004) *Earth*. Harper Collins, London; Knopf, New York, 444 p.
4. Scoon, R.N. (2021) *The Geotraveller: Geology of Famous Geosites and Areas of Historical Interest*. Springer Nature Switzerland, 452 p.
5. Dickas, A.B. (2012) *101 American Geo-sites You've Gotta See*. Mountain Press, Missoula, MN, 264 p.
6. http://www.geotimes.org/Travels.html and https://www.earthmagazine.org/bysubject/
7. https://www.geolsoc.org.uk/100geosites

Table 1. The World's Greatest Geological Wonders according to Wysession (2013)

Country, Continent or Ocean	Geosite
Greece	Santorini Volcano
Japan	Mt. Fuji
Pacific	Galapagos Rift
Africa	East Africa Rift Valley: Red Sea to Mount Kilimanjaro
Canada	Burgess Shale
USA	Grand Canyon, Arizona
Asia	Himalayas
India and Bangladesh	Ganges Delta
Brazil	Amazon Basin
Argentina	Iguazu Falls
USA	Mammoth Cave National Park, Kentucky
Mexico	Cave of Crystals, Chihuahua
Vietnam	Ha Long Bay
USA	Bryce Canyon, Utah
Australia	Uluru/Ayers Rock
USA	Devil's Tower, Wyoming
Antarctica	Antarctica
USA	Columbus Glacier, Alaska
New Zealand	Fiordland National Park
Gibraltar	Rock of Gibraltar
Canada	Bay of Fundy (high tides)
USA	Hawaiian Islands
USA	Yellowstone National Park (geysers)
Indonesia	Kawah Ijen Volcano (acid lake)
Iceland	Iceland (hotspot)
Maldives	The Maldives (beaches and hotspot islands)
Jordan	Dead Sea (saline lake)
Bolivia	Salar de Uyuni (salt flats)
South Africa	Namib/Kalahari Deserts (sand dunes)
Eygpt	Siwa Oasis
Arctic Circle	Auroras
USA	Meteor Crater, Arizona

Table 2. Selected Geosites in North America, Europe and Africa described in Scoon (2021)

Location	Geosite
USA: Southern Utah	Canyonlands National Park and Monument Valley (Mesozoic)
USA: Eastern Utah	Arches National Park and Dinosaur National Monument (Mesozoic)
USA: California	Yosemite National Park (Mesozoic, Miocene-Recent)
USA: Wyoming	Yellowstone National Park (Pliocene-Quaternary)
Canada	National Parks of the Rocky Mountains (Mesozoic-Cenozoic)
Uganda	National Parks, River Valleys and Lakes (Proterozoic & Cenozoic)
Tanzania	Lake Natron and Ngorongoro Conservation Area (Proterozoic & Cenozoic)
Italy	Mediterranean Basins, Aeolian Islands and Mount Etna Volcano (Pliocene-Quaternary)
Italy: Southern	Neapolitan Volcanoes including Vesuvius National Park (Quaternary)
Greece	Hellenic Volcanic Arc: Methana, Milos, and Santorini (Quaternary)
Greece	Peloponnese and Zakyanthos (Mesozoic-Cenozoic)
Greece	Hellenic Volcanic Arc: Methana, Milos, and Santorini (Quaternary)
Turkey: Western	Gallipoli Peninsula National Park, Troy, Assos, Pergamum, Ephesus, Denizli Basin (Mesozoic-Cenozoic)
Turkey: Southwest	Parmukkale, Hierapolis (Pliocene-Quaternary)
Turkey: Central	Cappadocia (Pliocene-Quaternary)
England	Lake District (Paleozoic)
Greenland	Skaergaard Intrusion (Eocene)
South Africa	Eastern Bushveld Complex (Proterozoic)

tific importance, educational, adventurous, human habitation, coastal, outcrops, folding/faulting, and fire/ice. These categories also indicate the varied nature and function of geosites in general.

An impressive book entitled *Four Billion Years and Counting: Canada's Geologic Heritage* prepared by the Canadian Federation of Earth Science provides information about fascinating geosites in Canada (published by Nimbus, 2014).

Early this year in India, a group of geoscientists called Guardians of Geoheritage[8] (hosted by Lucknow-based Society

8. https://geoheritage.in/initiatives/ and https://geoheritage.in/unofficial-registry/.

Table 3. 101 American Geosites in the 50 US states according to Dickas (2012)

State	Geosites
Alabama	(1) Wetkumpa Crater
Alaska	(2) Exit Glacier
Arizona	(3) Meteor Crater; (4) Monument Valley
Arkansas	(5) Prairie Creek Pipe
California	(6) Wallace Creek; (7) Racetrack Playa; (9) Devils Postpile; (10) Rancho La Brea; (11) El Capitan
Colorado	(12) Boulder Flatirons; (13) Interstate 70 Roadcut; (14) Florisseant Fossil Beds
Connecticut	(15) Dinosaur Trackway
Delaware	(16) Wilmington Blue Rocks
Florida	(17) Devil's Millhopper
Georgia	(18) Stone Mountain
Hawaii	(19) Kiluaea Volcano
Idaho	(20) Borah Peak; (21) Menan Buttes; (22) Great Rift
Illinois	(23) Valmeyer Anticline
Indiana	(24) Hanging Rock Klint
Iowa	(25) Fort Doge Gypsum
Kansas	(26) Monument Rocks
Kentucky	(27) Ohio Black Shale; (28) Mammoth Cave; (29) Four Corners Roadcut
Louisiana	(30) Avery Island
Maine	(31) Schoodic Point
Maryland	(32) Calvert Cliffs
Massachusetts	(33) Purgatory Chasm
Michigan	(34) Nonesuch Potholes; (35) Quincy Mine; (36) Grand River Ledges
Minnesota	(37) Sioux Quartzite; (38) Thomson Dikes; (39) Soudan Mine
Mississippi	(40) Petrified
Missouri	(41) Elephant Rocks; (42) Grassy Mountain Nonconformity
Montana	(43) Chief Mountain; (44) Madison Slide; (45) Butte Pluton; (46) Quad Creek Quartzite
Nebraska	(47) Ashfall Fossil Beds; (48) Scotts Bluff; (49) Crow Creek Marlstone
Nevada	(50) Sand Mountain; (51) Great Unconformity
New Hampshire	(52) Flume Gorge
New Jersey	(53) Palisades Sill; (54) White Sands
New Mexico	(55) Carlsbad Caverns; (56) Ship Rock; (57) State Line Outcrop
New York	(58) American Falls; (59) Taconic Unconformity; (60) Gilboa Forest
North Carolina	(61) Pilot Mountain
North Dakota	(62) South Kildeer Mountain
Ohio	(63) Hueston Woods; (64) Bick Rock; (65) Kelleys Island
Oklahoma	(66) Interstate 35 Roadcut
Oregon	(67) Mount Mazama; (68) Lava River Cave
Pennsylvania	(69) Drake's Folly; (70) Hickory Run; (71) Delaware Water Gap
Rhode Island	(72) Beavertail Point
South Carolina	(73) Crowburg Basin; (74) Mount Rushmore; (75) Mammoth Site; (76) Pinnacles Overlook
Tennessee	(77) Reelfoot Scarp
Texas	(78) Enchanted Rock; (79) Capitan Reef; (80) Paluxy River Track
Utah	(81) Upheaval Dome; (82) Checkboard Mesa; (83) San Juan Goosenecks; (84) Salina Canyon Unconformity; (85) Bingham Stock
Vermont	(86) Whipstock Hill
Virginia	(87) Great Falls; (88) Natural Bridge; (89) Millbrig Ashfall; (90) Catoctin Greenstone
Washington	(91) Mount St. Helens; (92) Dry Falls
West Virginia	(93) Seneca Rocks
Wisconsin	(94) Roche-A-Cri Mound; (95) Van Hise Rock; (96) Amnicon Falls
Wyoming	(97) Green River; (98) Devils Tower; (99) Fossil Butte; (100) Steamboat Geyser; (101) Specimen Ridge

of Earth Scientists) have launched an online Geoheritage Register that proposes 25 geoheritage sites in India as well as the list of 32 national geological monuments declared by the Geological Survey of India.

Geoheritage and Geoparks

The concept of geosites is closely related to geoconservation, geoheritage and geoparks. These terms are yet to enter geology dictionaries, but they are areas of research, writing, and activism.

In June 1991, the First International Symposium on the Conservation of Our Geological Heritage was held in Digne, France. Since then, "geoheritage" has drawn much attention. In 2009, Springer launched a journal entitled *Geoheritage*.[9]

The US National Park Service[10] defines geoheritage sites as follows:

"Geologic Heritage encompasses the significant geologic features, landforms, and landscapes characteristic of our Nation which are preserved for the full range of values that society places on them, including scientific, aesthetic, cultural, ecosystem, educational, recreational, tourism, and other values. Geoheritage sites are conserved so that their lessons and beauty will remain as a legacy for future generations."

The US National Park Service also identifies geoheritage sites located on public lands, natural landmarks, heritage areas and the national register of historical places in the USA.

Geological Society of America in its Position Statement on Geoheritage gives the following description: "Geoheritage is a generic but descriptive term applied to sites or areas of geologic

9. https://www.springer.com/journal/12371.
10. www.us-parks.com/geology/geologic-heritage-in-the-national-parks.html.

features with significant scientific, educational, cultural, or aesthetic value. They serve public interest, critical to advancing knowledge about natural hazards, groundwater supply, soils processes, climate and environmental changes, evolution of life, energy and mineral supplies, and other aspects about the nature of the earth."[11]

The Switzerland-based International Union for Conservation of Nature (IUCN) has also been active in the area of geoheritage sites. They have published several major reports, which can be downloaded from their website.[12] In 2013, IUCN formed Geoheritage Specialist Group to provide advice on geodiversity in relation to protected areas and their management, including caves and karst.[13]

In 2015, the American Geoheritage & Geoparks Advisory Group[14] was founded with support from the US Geological Survey, US National Park Service, and US National Academies, Board on International Scientific Organization, and the US National Committee for Geological Sciences.

Geological Society of Australia has published "Geological Heritage Policy" and has "Heritage Matters" column in its quarterly magazine *The Australian Geologist*.[15]

A global initiative to document and preserve geological heritage sites is UNESCO's Global Geoparks Network founded in 2004 in collaboration with the International Union of Geological Sciences (IUGS). In the same year, the first International Conference on Geoparks was held in Beijing (this conference has been held every two years in various countries). Since 2005, 177 geosities in 46 countries have been designated as geoparks by UNESCO.[16] There are global and national geoparks. According to UNESCO, global geoparks are "single, unified geographical areas where sites and landscapes of international significance are managed with a holistic concept of protection, education and sustainable development."

Geopark is essentially a Eurasian concept, and the vast majority of geoparks are located in Europe and Asia. A major book published recently on this topic is *Global Geographical Heritage, Geoparks and Geotourism: Geoconservation and Development*, edited by R.B. Singh, D. Wei, and S. Anand (Springer, 2021).

Summary

Geosites are popular places for both geotourism and geology education and field trips. There are various ways of defining important geosites. Some have international fame (Everest, Mt. Fuji, Grand Canyon, and so forth). Some enjoy historical significance for science (e.g, Hutton Unconformity at Siccar Point in Scotland). Some pose geological wonders (e.g., Cueva de los Cristales or Cave of Giant Crystals in Chihuahua, Mexico). Some are famous for their rich fossils or minerals. Many of the names used in the geologic time scale come from places where the formations for these particular periods or stages were first studied; for example, Ediacaran (from the Ediacara Hills of Australia), Jurassic (from the Jura Mountains between France and Switzerland), and Cretaceous (from the chalk deposits in the Paris Basin). Many geosites are located in geoparks, national parks or other wilderness areas. In any case, geosites are our geological heritage and vulnerable to over-tourism and careless field trips; they need protection. Before visiting any geosite, it is helpful to read online materials or guide books or watch documentary films. Prior knowledge enhances your field trip and visit.

11. https://www.geosociety.org/gsa/positions/position20.aspx.
12 https://www.iucn.org/commissions/world-commission-protected-areas/about/geoheritage/geoheritage-resources-and-links
13. https://www.iucn.org/commissions/world-commission-protected-areas/our-work/geoheritage
14. https://www.americasgeoheritage.com/geoheritage/
15. https://www.gsa.org.au/Public/Geoheritage/Public/Geoheritage/Geoheritage.aspx
16. https://en.unesco.org/global-geoparks/list

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JAN.FEB.MAR. - November 1, 2022

APR.MAY.JUN. -February 1, 2023

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

Professional Development
AGI Webinar Series:

Geologic Names and Usage: A Guide to Stratigraphic Nomenclature

CEUs: 0.10

Stratigraphic nomenclature is the system of proper names given to specific stratigraphic units, which provides a universal language essential for all scientific publications. Consistent and effective communication in the geosciences requires systematic use of stratigraphic nomenclature. The importance of consistent stratigraphic nomenclature as a means of effective geologic communication has been recognized since the USGS established the Geologic Names Committee (GNC) in 1899 to evaluate and address issues of nomenclature. This course is designed to provide a review of geologic names usage and stratigraphic principles that serve as a foundation for professionals and students to improve geoscience communication among all industries.

Instructor: Randall Orndorff is a Research Geologist for the U.S. Geological Survey, Florence Bascom Geoscience Center. Mr. Orndorff is internationally recognized for his work in geologic mapping, stratigraphy, and structural geology and was appointed Secretary General for North and Central America for the Commission for the Geologic Map of the World. He has been a Commissioner representing the USGS on the North American Commission on Stratigraphic Nomenclature since the late 1990's and is Chair of the USGS Geologic Names Committee. Randall has published on many geology subjects, including stratigraphy, regional geology, structural geology, and karst, and has published 29 geologic maps. Also, Randall has 15 years of experience in project and program management for the National Cooperative Geologic Mapping Program (NCGMP) as Associate Program Coordinator and the Eastern Geology and Paleoclimate Science Center (EGPSC) as Director.

To watch this webinar, go to:
https://www.americangeosciences.org/goli/SEPM001

LETTERS TO THE EDITOR

Dear Editor,

It was a real pleasure to participate in the zoom-based AIPG town hall meeting yesterday. Nothing replaces in-person dialog, but the format of remote dialog is a wonderful way to get together in lieu of the former. To my point. The subject of field camp arose. It appears that field camp, which in my personal opinion is a needed basic in geology education, has become less available to undergraduate students and often, we were told yesterday, not required by many collegiate institutions for completion of a bachelor's degree in geology.

One of my college professors in the mid 1970s told we then, young skulls of mush, "He or she who sees the most outcrops – wins". The professors at Southwest Missouri State University gave their personal time to make outcrops available to the students. Each spring, winter and fall, lengthy and distant field trips were available, not to mention nearly every weekend a short excursion to the more local rocks. A class consisting of 90% field trips to much of Missouri, Oklahoma and Northeast Arkansas was offered and taken by most students. This particular class was very taxing to the students' other classes due to the requirement to be gone from campus for some time. Then each summer was the crowning achievement for the juniors soon to be seniors as they packed the vans and trailers and headed off to Vernal, Utah not very far from Dinosaur National Monument for three weeks of mapping those folds, faults, anticlines and synclines and measuring the highly visible stratigraphy. Packing up our tents (not one day in a hotel or dormitory) and kitchen we traveled to Salt Lake City and spent a few days in the rather magnificent Wasatch Range. Now the tough part – the part that really challenged we students. We traveled to Gold Hill, an actual mining ghost town in the Basin and Range on the Utah – Nevada border, some 70 miles south of Wendover, Nevada. The wind blew so hard and so often that we set up our tents inside the abandoned buildings for added security from the forces of weather. Each day for three weeks we walked many miles and mapped our way through those jumbled masses of rocks as we looked down upon the distant salt flats. The students at SMSU had many opportunities to see the rocks in person.

I firmly believe that experiences in the field – especially that tough two months in the deserts of Utah, was the catalyst to turn on my figurative mental lightbulb, the ah-ha moment in my education. I do not believe that I could have functioned as a professional geologist for over 40 years without each and every one of those field experiences, especially field camp.

I personally have a hard time imagining an adequate substitute for seeing the rocks in person in one's geological education. Perhaps this is due to when my education took place and the technology available at the time. In essence – to see the rocks then – one had to go to the rocks.

John L. Bognar, CPG-08341

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Editor's Note: The following was submitted to Cristie Valero at AIPG headquarters in early March, 2022…

Three weeks ago, I had a "Duh Moment" when I was in the field in south Florida looking at a limestone mine. This is a new mine and there were stockpiles of several gradations of aggregates. One of the piles had the owner excited because the rock was much harder than the limestone. I was tossed a piece that is about 1.25-inches across (see photo 1) by the plant manager and was asked "What is this rock?" He said this is much harder than the limestone and it should work as a wear surface on bituminous pavement. So, I took the hand specimen and rolled it in my fingers (spit on it too) and told the fellow he had a calcarenite composed of essentially beach sand cemented with calcium carbonate. He wanted more explanation, and he was correct in that the calcarenite should be a durable wear course stone.

The rock piece is small, and the sand grains are all a medium to fine silica making it hard for the fellow to visualize the makeup. So, to improve the visuals for my discussion I took a 2X photo close-up of the piece (the spit had dried) with my iPhone. Photo two is that image. The simple trick was to open the picture and zoom in. The client could see the silica grains and some darker heavy minerals, so we had a good field lecture. He asked how much calcium carbonate cement was in the rock (a DOT aggregate test)? I guesstimated maybe 20-25% and it turned out to be 26% based on the laboratory assay.

What was best of all was returning to the office wherein I sent the photo to my desktop. I saved the image as my screen saver on my 32-inch monitor. A beautiful view of a 1.25-in rock picked up in the field magnified 2X and blown up to 32 inches (probably a 100X enlargement) that is nice to view.

I am now retiring my hand lens for the second time. The first time was about 45 years ago.

Dr. Thomas Herbert, CPG-02551

Common Geometric Shapes of Geological Features and Landscapes

Robert Font, CPG-3953

Abstract

The geometric configuration, 3-D morphology and cross-profile of geological features and landscapes are important in our understanding of their geneses and significance. They can also relate to specific geological environments. A few examples are summarized herein including geometric shapes found in the field that can be described in terms of absolute value functions, quadratic functions, and closed conic sections.

Keywords: Absolute value functions and V-shaped cross profiles, quadratic functions and U-shaped parabolic shapes, closed conic sections and elliptical shapes, chevron folds, young stream landscapes, open folds, mature-stream landscapes, glacial valleys, rounded clasts, boudins, planar shapes, spherical shapes with circular cross sections, hexagonal and pentagonal prisms, faults and joints, ooids, columnar basalt.

Discussion

What geologic features could be represented by the basic mathematical functions expressed below?

$y = 2\ |x|$ (1)

$y = x^2$ (2)

$x^2/9 + y^2/4 = 1$ (3)

Equation (1):

The geometric shape illustrated in equation (1) is an example of an absolute value function with the general equation

$y = m\ |x-h| + k$ (4)

In equation (4), the vertex occurs at (h, k), and "m" is the slope of the sides. The details and graph pertinent to equation (1) are shown in Figure 1. Note that since the value of "m" is positive, the graph of the function opens upward.

In which geological settings would we expect to find the overall geometric shape as indicated in equations (1) and (4)? Examples could relate to the profiles of following features:

- A chevron syncline (Figure 2) with tight hinges and straight limbs resulting from compressive stresses affecting alternating beds of different ductility contrast and/or composition. As indicated in Fig. 2, for chevron anticlines the value of "m" is negative.
- The V-shaped valley of a young mountain stream with plenty of down-cutting power and no flood plain (Figure 3).

y = m |x-h| + k
y = 2 |x|
(h,k) = (0,0)
"m" = 2

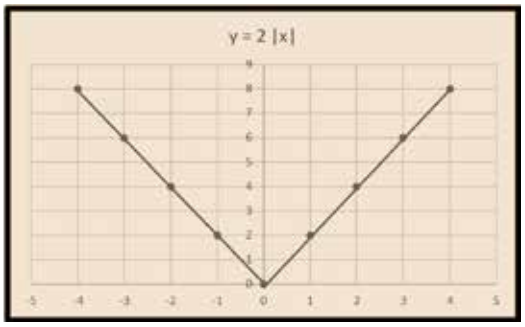

Figure 1. Equation $y = 2\ |x|$ has the general form $y = m\ |x-h| + k$.

Erosional structures, such as the remnants of the volcanic peak shown in Figure 4.

Equation (2):

Equation (2) is a quadratic function and the equation of a parabola. The general equation of a parabola is:

$y = a(x-h)^2 + k$ (5)

Note that in equation (5), (h, k) give us the coordinates of the vertex, and "a" determines how wide or narrow the parabola is. The specific attributes and graph related to equation (2) are illustrated in Figure 5.

In which geological landscapes would we expect to see the type of geometrical configuration depicted in equations (2) and (5)? Example of parabolic shapes are found in the profiles of:

Open synclinal folds.

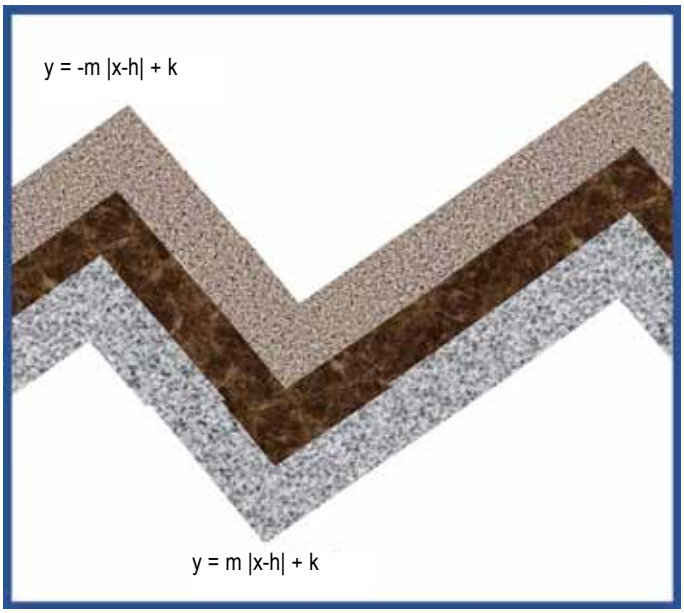

Figure 2. The profile of chevron folds are approximated by the equations of the absolute value functions.

Figure 3. V-shaped valley of young streams. Example from Maui, Hawaii and northern New York.

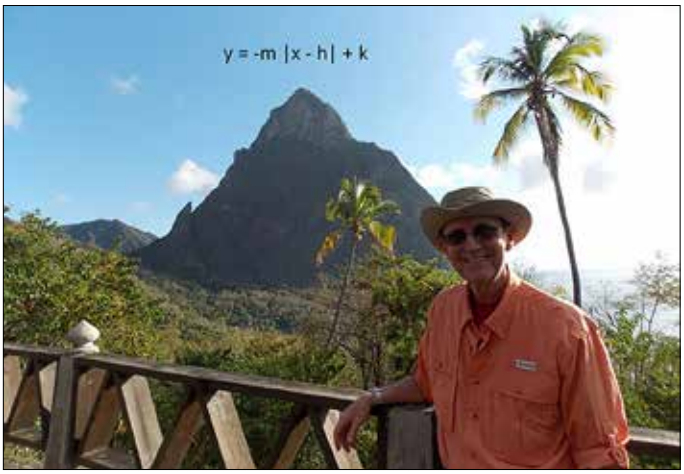

Figure 4. Petit Piton in St. Lucia is a dacite volcanic peak. The island is known for the two adjacent peaks, Gros Piton and Petit Piton. Note that the current geometric profile of the Petit Piton can be approximated by the equation y = -m |x-h| + k.

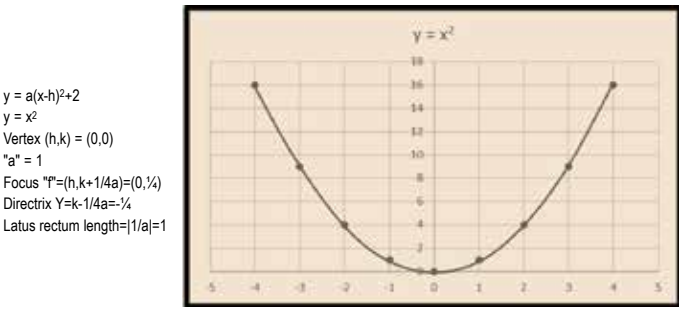

Figure 5. Equation $y = x^2$ has the general form of $y = a(x-h)^2 + k$; the equation of a parabola.

Figure 6. A classic U-shaped valley near Glacier Bay, Alaska.

Mature stream and glacial U-shaped valleys (Figure 6).

Cross profiles of glacial valleys worldwide have been described by Dr. Rebecca Coles in her work at the University of Sheffield in the U.K.

Equation (3):

Equation (3) is the equation of an ellipse (closed conic section) of general form:

$$(x-h)^2/a^2 + (y-k)^2/b^2 = 1 \qquad (6)$$

The graph of the ellipse for equation (3) and the related specifications are shown in Figure 7.

Examples of geologic features of the form given in equations (3) and (6) may be found in:

Clastic sediment that has undergone erosion transport (Figure 8).

Boudins (Figure 9).

Boudins of similar proportions to the ellipse of equation (3) have been described by Dr. Haakon Fossen in Norway.

Additional common geometrical forms:

Various additional common geometrical forms apply to other geological settings and features.

Faults (Figure 10), for example, can be represented by the equation of a plane:

$$a(x-x_o)+b(y-y_o)+c(z-z_o) = 0 \qquad (7)$$

In (7), a, b, and c are the components of the normal vector to the plane and (x_o, y_o, z_o) is a point that lies on the plane.

$(x-h)^2/a^2+(y-k)^2/b^2=1$
$x^2/9+y^2/4=1$
Center (h,k) = (0,0)
Maximum axis length = 2a = 2 $\sqrt{9}$ = 6
Minimum axis length = 2b = 2 $\sqrt{4}$ = 4

Foci are at f=(h±c.k), where
$c^2=a^2-b^2$ and $c=\sqrt{(3^2-2^2)}=\sqrt{5}$,
so that f=(± $\sqrt{5}$,0)

Vertex V=(h±a,k)=(±3,0)
Co Vertex V_{co}=(h,k±b)=(0,±2)

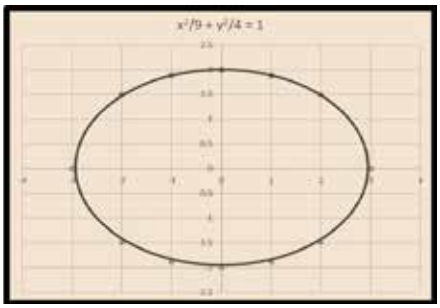

Figure 7. The equation $x^2/9 + y^2/4 = 1$ has a general form of $(x-h)^2/a^2 + (y-k)^2/b^2 = 1$.

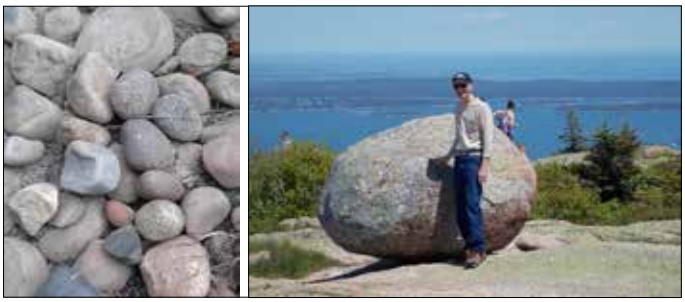

Figure 8. Rounded (quasi-elliptical or quasi-spherical) sillicic cobbles in Texas indicate long transport distance from the locality where the sediment originated. The quasi-elliptical boulder is found in the area of Acadia National Park in Bar Harbor, Maine.

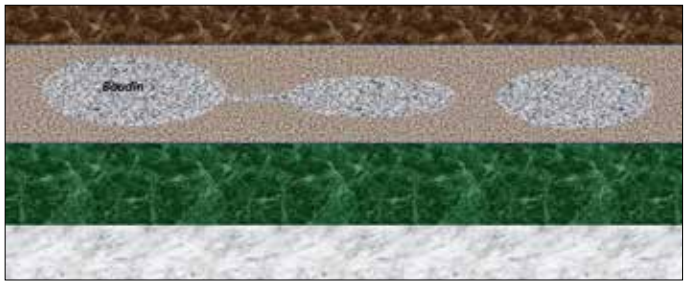

Figure 9. Roughly-elliptical structures may be found in the sausage-shaped boudins formed by extension where a competent or rigid rock unit is stretched within a less-competent or more ductile layer. Boudins or similar proportions to that of the equation $x^2/9+y^2/4=1$ are described in Norway by Dr. Haakon Fosson, where the boudin is composed of amphibolite and the more ductile strata are made up of quartz-rich schist.

Spherical geometric forms with circular cross-sectional shapes can be expressed by the general equation:

$$(x-h)^2 + (y-k)^2 + (z-l)^2 = r^2 \qquad (8)$$

In (8), (h, k, l) is the center of the sphere and "r" is its radius.

Ooids, for example, developing in warm, agitated, shallow marine waters, are typically spherical or quasi-spherical grains formed by concentric layers of $CaCO_3$, Fe_2O_3, [FeO(OH)], SiO_2, or $Ca,Mg(CO_3)_2$.

Another illustration of a common geometric shape involves hexagonal and pentagonal prisms that may form in columnar basalt, such as the ones seen at the Giant's Causeway in Northern Ireland (Figure 11). The prisms have volumes and surface areas as shown in the equations illustrated in figure 11.

Figure 10. Normal fault and related feather joints as seen in the Lower Eagle Ford of Texas.

Figure 11. Columnar basalt, Giant's Causeway, Northern Ireland.

Conclusion

Common geometric shapes are seen in geological landscapes and cross-profiles. Some are associated with specific geological environments. These geometric shapes may provide us with insights of the genesis and composition of geological features, as well as the erosional processes and tectonic history which are characteristic of certain geologic regions.

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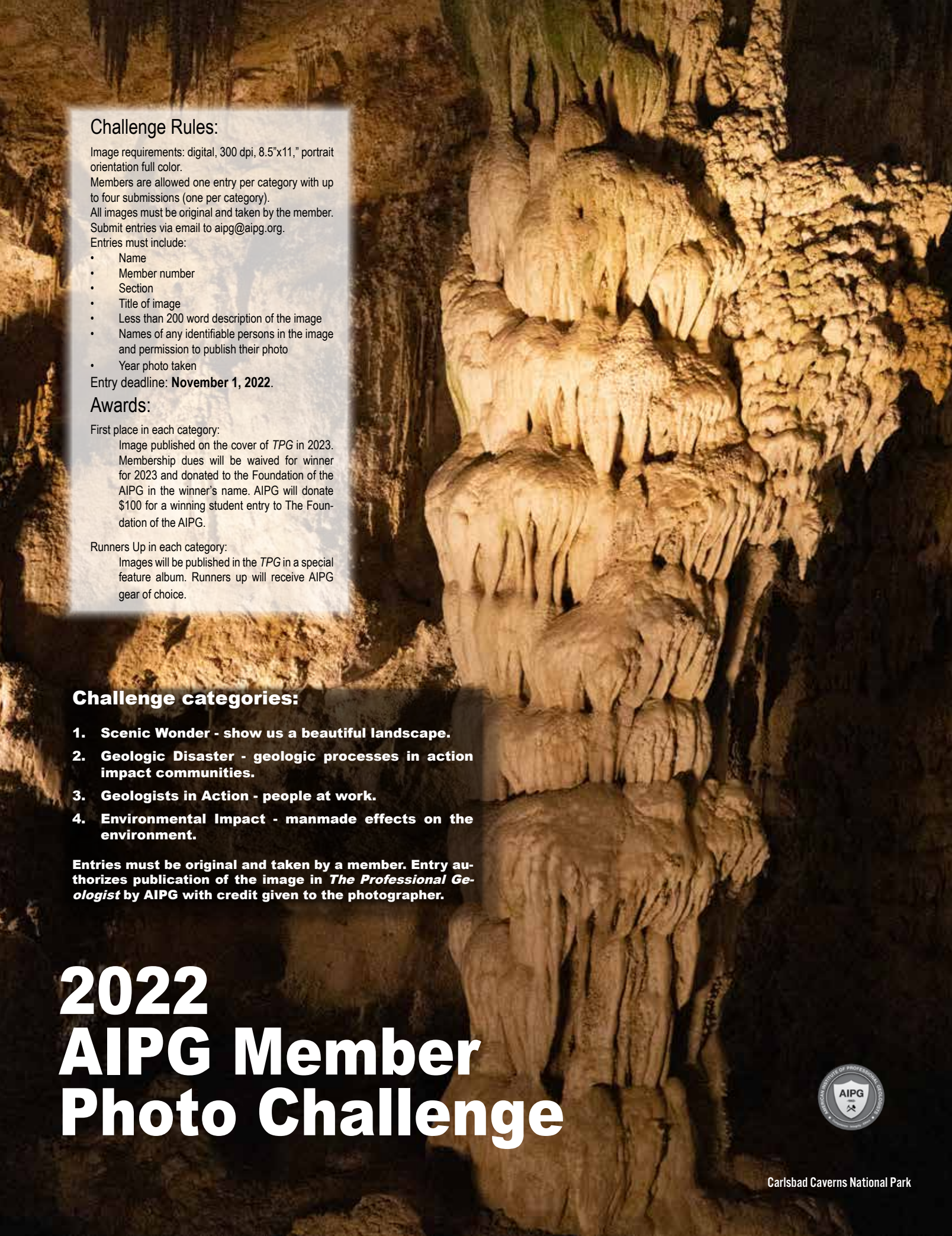

Challenge Rules:

Image requirements: digital, 300 dpi, 8.5"x11," portrait orientation full color.
Members are allowed one entry per category with up to four submissions (one per category).
All images must be original and taken by the member.
Submit entries via email to aipg@aipg.org.
Entries must include:

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

Entry deadline: **November 1, 2022**.

Awards:

First place in each category:

Image published on the cover of *TPG* in 2023. Membership dues will be waived for winner for 2023 and donated to the Foundation of the AIPG in the winner's name. AIPG will donate $100 for a winning student entry to The Foundation of the AIPG.

Runners Up in each category:

Images will be published in the *TPG* in a special feature album. Runners up will receive AIPG gear of choice.

Challenge categories:

1. **Scenic Wonder - show us a beautiful landscape.**
2. **Geologic Disaster - geologic processes in action impact communities.**
3. **Geologists in Action - people at work.**
4. **Environmental Impact - manmade effects on the environment.**

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

2022 AIPG Member Photo Challenge

Carlsbad Caverns National Park