*TPG* is a publication of the American Institute of Professional Geologists

# THE PROFESSIONAL GEOLOGIST

VOLUME 59 NUMBER 2 APR.MAY.JUN 2022

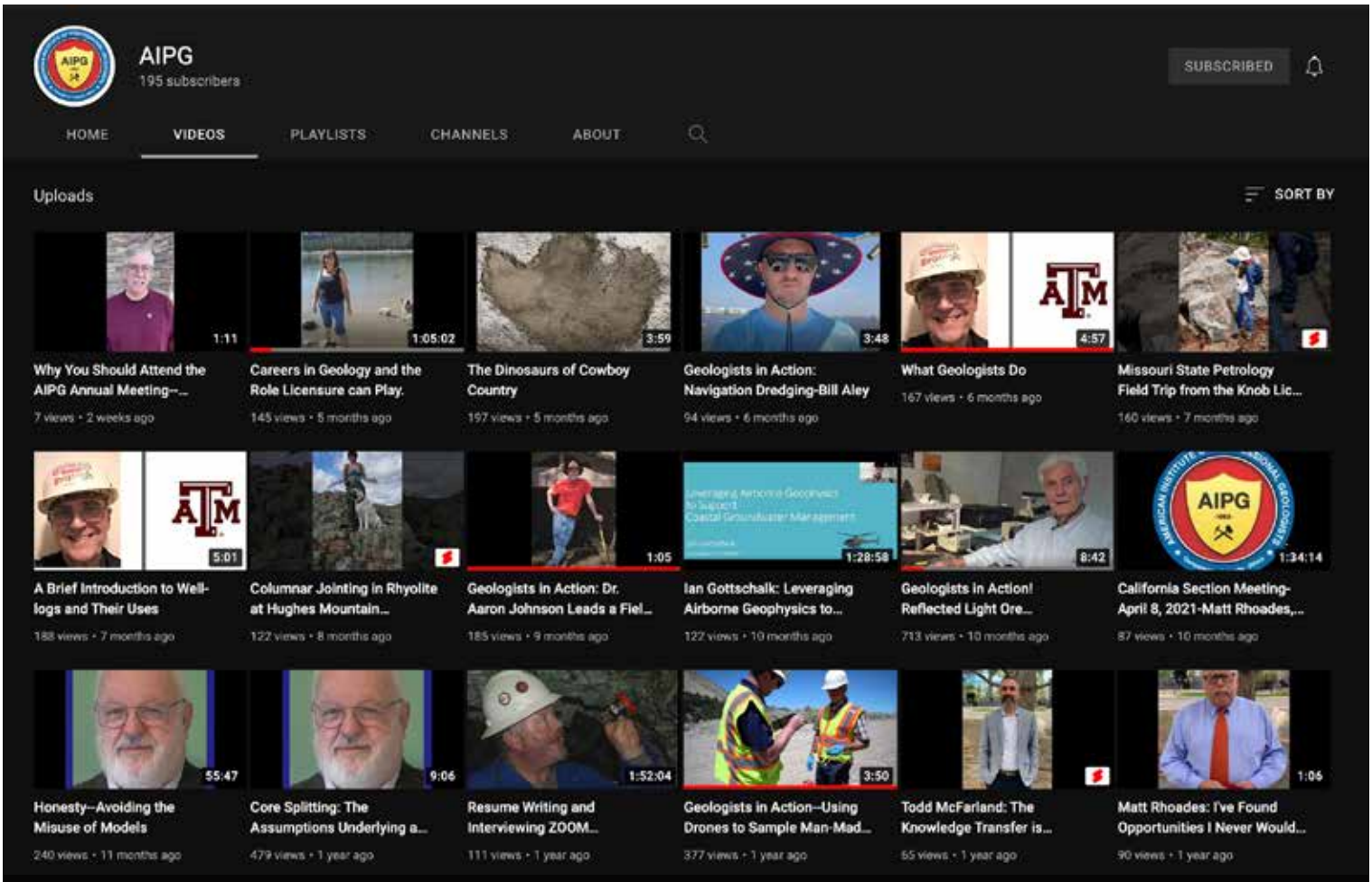
## Destination Marquette: National Conference

## Meet the National Officer Candidates

## From Outcrops to 3D Models and Printing

*Peer review*

## Feasibility of New Helium Well Development in the Holbrook Basin, Arizona

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# The Professional Geologist

Volume 59 Number 2 APR.MAY.JUN 2022


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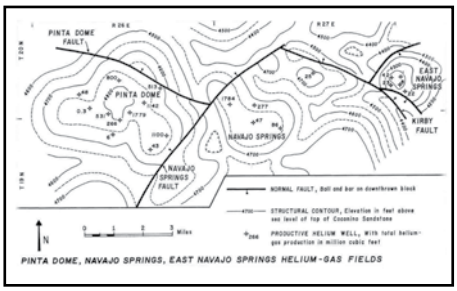


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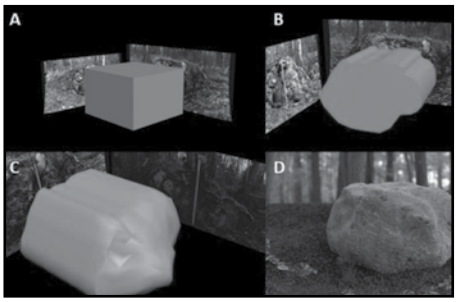


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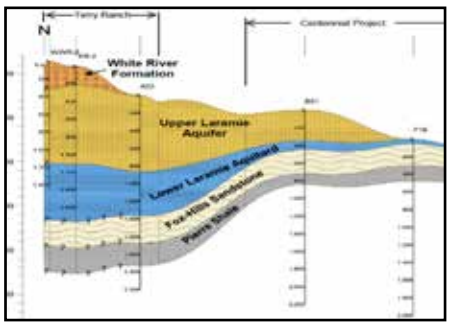


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On the Cover: Pictured Rocks National Lakeshore, Michigan. The rocks are 50-200 foot tall mineral stained sandstone cliffs. The mineral staining creates the beautiful colors. The Munising and Au Train formations date back as far as the Cambrian. Photo credit: Sara Pearson, CPG-10650.

**FEATURES**

## DEPARTMENTS



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

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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.


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# Geology: More than a Career!

# Member Challenge

**Adam W. Heft, CPG-10265**

As I write this, we are in the throes of winter here in the Midwest and have had several recent winter storms. Hopefully, the weather will begin to improve, and winter will relax its grip as we begin to move into spring. This edition of *TPG* contains a wealth of information about the near future of AIPG.

The Apr/May/Jun edition contains two things of primary interest to members: candidate information for this year's election of officers for the National Executive Committee and detailed information on the Annual Conference. Please remember to carefully review the bios and write-ups provided by the candidates and be sure to **VOTE** for the candidate that you feel will best serve AIPG for the coming term. This is just one small way you can be involved, but it is an important one, so be sure to take it.

This year's Annual Conference will be held in Marquette, Michigan. I won't dwell on this here, as there is detailed information elsewhere in this edition. That said, I hope you will attend, and I look forward to welcoming you there in August!

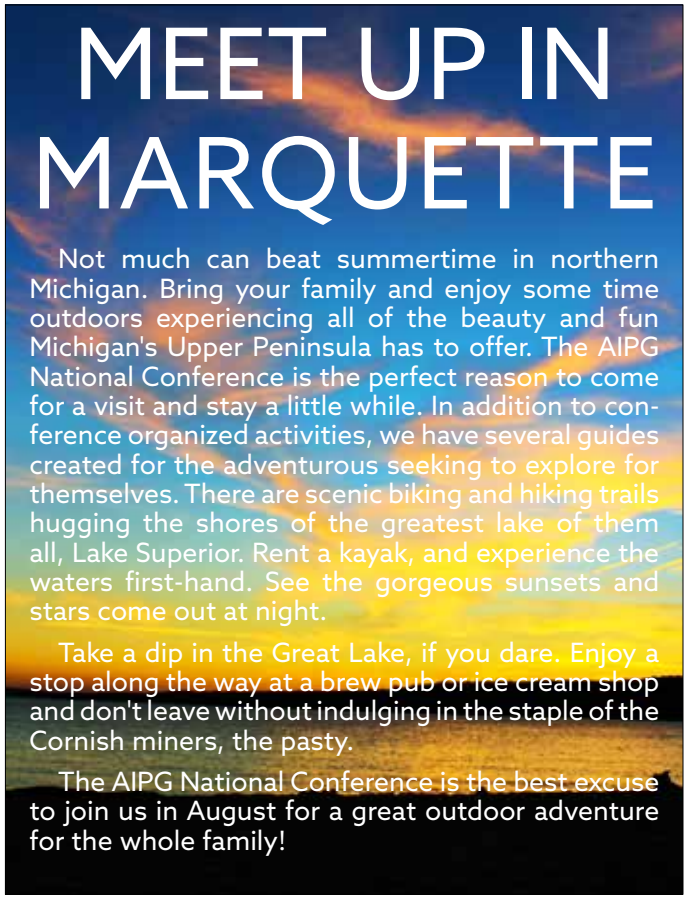
This edition also includes several articles I hope you will find interesting. They range from a peer-reviewed article on helium development in the Holbrook Basin to aquifer recharge at Terry Ranch. Have you heard of GigaPan technology? We have an article featuring photographic model construction of an outcrop using this new technology. Additionally, be sure to take a look at the article on competence, reasonableness and ethics while performing mineral evaluations, which counts towards ethics continuing education credits. There are even a few letters to the Editor, including one sharing a similar experience that relates to my last column on "Do the Rules Apply?". I encourage you to share your experiences as well. And of course, the usual columns that you've come to expect. There are several articles in the pipeline for future editions, but please keep them coming!

Virtually everyone reading this is a practicing geologist that is in the midst of their career, is in the beginning of their career, or is at the end of their career. This applies to students and professors as well; they have their classes, research, and field activities. And of course, our members span all aspects and specialties of geology.

This said, what do you do outside of your career and the required activities that go along with it that pertain to geology? I'm talking about your spare time, and/or something you do for fun. Do you volunteer at your child's school to give a presentation on geology or what a geologist does? Do you present some aspect of geology to the public, like Jim Howard has shown with his "Stealth Education" articles? Do you learn about some aspect of geology unrelated to your field of practice for your own edification? Or do you do something else?

My wife Sara and I plan vacations around meetings, particularly the AIPG Annual Meeting. We go see national and state parks in different parts of the country and learn about and experience the geology in those areas. Most recently, and in conjunction with the National Executive Committee meeting in Albuquerque in February, we took several days before the meeting to go to several parks, including White Sands, Guadalupe Mountains, Carlsbad Cavern, and Petroglyphs. We are considering going to Isle Royale following the Annual Meeting in Marquette in August.

While we were in New Mexico, the idea behind this article came to us, and we shot a couple of short video segments while in two of the parks talking about what we were seeing and learning about. Which brings us to a member challenge; how is geology relevant to you outside of your career? I challenge you to shoot your own video clip showing how geology is more than just a career, it is a lifestyle. They don't need to be very long, just long enough to show what it is you do. Send them to Headquarters, and they can be added to the collection of videos that are part of the AIPG YouTube Channel. I'm looking forward to seeing what you do!



# 2022 Conference Schedule - Marquette, Michigan

| Saturday, August 6, 2022 | |
|---|---|
| 7:30 am – 12:00 noon | Conference Registration |
| 8:00 am – 12:00 noon | AIPG Executive Committee Meeting |
| 9:00 am – 5:00 pm | AIPG Student/ECP Career Workshop |
| 12:00 noon – 1:00 pm | AIPG Luncheon |
| 1:00 pm – 4:00 pm | AIPG Advisory Board Meeting |
| 4:00 pm – 4:30 pm | AIPG 2022-2023 Joint Executive Committee Meeting & Business Meeting |
| 4:30 pm – 5:30 pm | AIPG Foundation Meeting |
| 5:00 pm – 6:30 pm | Student/ECP Networking Event with Professionals |
| 7:00 pm – 9:00 pm | 4th Annual AIPG Geo-Trivia Night |

| Sunday, August 7, 2022 | |
|---|---|
| 7:30 am – 5:00 pm | Conference Registration |
| 7:30 am – 5:00 pm | Field Trip – High-Grade Ni-Cu Eagle Mine and Mill |
| 7:30 am – 5:00 pm | Field Trip – Minerals & Falling Water |
| 7:30 am – 5:00 pm | Field Trip – Historic Iron Mining on the Marquette Range |
| 10:00 am – 4:00 pm | Exhibitor and Poster Set-up |
| 5:30 pm – 6:30 pm | WI Section Meeting |
| 5:30 pm – 8:00 pm | Foundation of the AIPG Silent Auction |
| 6:30 pm – 8:00 pm | Welcome Reception – Exhibit Area Open |

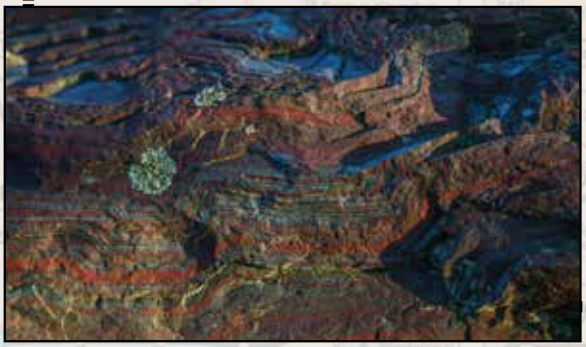
| Monday, August 8, 2022 | |
|---|---|
| 7:15 am – 8:00 am | Section Delegate Meeting |
| 7:30 am – 5:00 pm | Conference Registration |
| 8:00 am – 5:00 pm | Plenary Session/Technical Sessions |
| 8:00 am – 5:00 pm | Exhibits Open |
| 12:00 noon – 1:30 pm | Luncheon with Keynote Speaker |
| 6:00 pm – 8:30 pm | AIPG Awards Banquet |

All events take place at the
Northern Center at Northern Michigan University
540 West Kaye Avenue, Marquette, MI 49855

A shuttle will be provided to/from some area hotels to the University

Go to www.aipg.org and select 'Events' for additional information on the conference

*All pictures courtesy of Travel Marquette



| Tuesday, August 9, 2022 | |
|---|---|
| 7:30 am – 5:00 pm | Field Trip – Tilden Iron Mine and Mill |
| 7:30 am – 5:00 pm | Field Trip – Sandstone Cliffs and Glacial Features of the Pictured Rocks National Lakeshore (with boat tour) |
| 7:30 am Tuesday – 5:00 pm Wednesday | 2-Day Field Trip – Keweenaw Copper Mining and History |


# Geology: The Cornerstone of our Future

August 6-9 | Marquette, MI

## ALL-INCLUSIVE REGISTRATION PACKAGE

Includes: Full Registration + Welcome Reception + Technical Sessions + 2 Field Trips of your choice

Details: Executive Committee Meeting, Advisory Board Meeting, breaks, lunch, and reception with two complimentary beverage tickets Saturday, Geo-Trivia Night, Welcome Reception with two complimentary beverage tickets, Silent Auction, Technical Sessions/Short Course, Access to Exhibit Area, Monday Networking Breaks and Lunch, Awards Banquet with two complimentary beverage tickets, Choice of two Field Trips - one Sunday, one Tuesday (an additional $350 will be added for the Keweenaw Copper Field Trip and includes overnight lodging).

Member - $750

Non-Member - $850

Early Career Professional - $650

## TECHNICAL/NETWORKING REGISTRATION PACKAGE

Includes: Technical Sessions + Networking Activities + Awards Banquet (Monday Only)

Details: Technical Sessions/Short Course, Access to Exhibit Area, Networking Breaks, Lunch, Awards Banquet with two complimentary beverage tickets.

Member - $310

Non-Member - $410

## LODGING

FAIRFIELD INN & SUITES BY MARRIOTT
$219/NIGHT rate + taxes & fees available until 6/10/22 (mention AIPG)

COMFORT SUITES
$180/NIGHT rate + taxes & fees available until 6/6/22 (mention AIPG)

DAYS INN
$173.99/NIGHT + taxes & fees rate available until 6/6/22 (mention AIPG)

## FIELD TRIP REGISTRATION PACKAGE

Includes: 2 Field Trips of your choice + Welcome Reception + Awards Banquet

Details: Executive Committee Meeting, Advisory Board Meeting, Welcome Reception with two complimentary beverage tickets, Silent Auction, Access to Exhibit Area, Awards Banquet with two complimentary beverage tickets, Choice of two Field Trips - one Sunday, one Tuesday (an additional $350 will be added for the Keweenaw Copper Field Trip and includes overnight lodging).

Member - $410

Non-Member - $510

## A LA CARTE REGISTRATION

Full Member Registration - $425

Non-Member Registration - $510

Full Early Career Professional Registration - $325

Daily Registration (Saturday or Monday) - $275

Guest Full Registration - $250

Welcome Reception Only - $50

Awards Banquet - $77

Field Trips - $165 each

2-Day Field Trip - $450

Student Full Registration - $175

Student Career Day Only (Saturday) - $30

## For more information and registration

**https://aipg.org/page/2022NationalConference**

For the first time, AIPG is now offering package registrations. Looking for more to do in Marquette? The Michigan Section has created a series of self-guided tours. Michigan's newsletter magazine, *Geologically Speaking*, has several field guides in the past 8 issues. http://mi.aipg.org/newsletters.htm. They will also be available at the conference.

# Field Trips

## Historic Iron Mining on the Marquette Range

**Leaders: Bob Clark, Cliffs Shaft Museum & Barry C. James, Historian, Michigan History Center, Michigan Iron Industry Museum**

**Date:** August 7, 2022

**Time: 7:30 am - 5:00 pm**

**Attire/Accessibility: The stops on this trip will be indoors and on outdoor paved walkways. Some easy hiking may be required, depending on the outcrops of iron formation which are visited.**

We are visiting two museums along the historic Marquette Iron Range to learn about the history and development of the iron industry in Michigan's Upper Peninsula. The first stop is the Michigan Iron Industry Museum in Negaunee, overlooking the Carp River and the site of the first iron forge in the Lake Superior region. This museum, operated by the Michigan History Center, tells the story of Michigan's three iron ranges and the people who worked them. The museum grounds also include interpretive trails highlighting mining history of the area.

Lunch is at Jackson Park in Negaunee, developed at the site of the Jackson Mine, the first iron mine in the Lake Superior Region. The park is located adjacent to the Iron Ore Heritage Trail, a 24-mile trail which showcases the role of the iron ore mining industry to the State of Michigan.

Our last stop is the Cliffs Mine Shaft Museum, located in Ishpeming, a site on the National Register of Historic Places. The museum grounds are home to two historic headframes, which served as access to the underground mining operations. The museum also houses historical artifacts representing the local community during the mining era. Historical displays depict miners and past and present mines and operations, headgear and other safety equipment, and displays on blasting and diamond drilling equipment. A rock and mineral display features minerals from the local area, Michigan's Upper Peninsula, the Midwest and the world. The trip will include a guided tour of the museum, historic grounds, and general mining history of the Cliffs Mine.

*Photo credit: Bob Clark, Cliffs Shaft Museum*

# The High-Grade Cu-Ni Eagle Mine and Mill*

**Leader: Meagen Morrison – Community Relations at Lundin Mining and other Lundin Mining staff**

**Date:** August 7, 2022

**Time: 7:30 am - 5:00 pm**

***Limited to first 30 registrants**

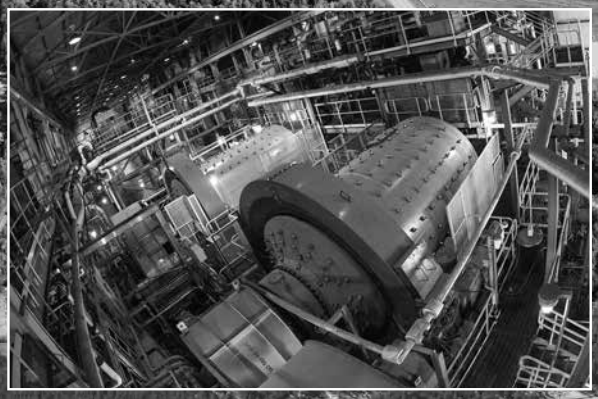
Attire/Accessibility: Participants will be required to wear appropriate clothing, including close-toed shoes. Hard hats, safety glasses, and safety vests will be required and provided by Eagle Mine, but participants may bring their own.

The trip will not include any strenuous hiking. The trip will visit several interior buildings, with short walks between buildings and outdoor areas of the surface facilities at the mine and mill sites.

Samples of the nickel-copper ore will be available for collecting in the coarse ore storage area.

The Eagle Mine is the only primary nickel mine in the United States. Lundin produces high-grade nickel and copper ore from an underground mine. Part one of the trip will include a tour of the surface facilities at the mine, including a presentation and discussion of the geology, mine operations, mining methods, and visits to the coarse ore storage area, wastewater treatment plant, and other surface facilities with an emphasis on the measures being used to protect the environment at the mine site. Ore samples will be available for collection from the ore storage area. Part two of the trip will visit the Humbolt Mill, where ore from the mine is delivered for processing. The processing includes conventional crushing, grinding, and floatation to produce separate nickel and copper concentrates. The mill is a historic iron mine milling facility, which was refurbished into the Eagle Mill. Participants of the tour will see the refining process of the ore, learn about the historic uses of the mill, and the brownfield redevelopment into its current use. The environmental permitting and development history will be discussed.

*Photo credit: Jen Heikkala, Lundin*




Geology:
The Cornerstone
of our Future

August 6-9 | Marquette, MI

## FOUNDATION OF THE AMERICAN INSTITUTE OF PROFESSIONAL GEOLOGISTS

# SILENT AUCTION FUNDRAISER

Annual Meeting Welcome Reception
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:

Barbara Murphy, CPG
Chairperson, Foundation of the AIPG
480-659-7131 (O)
602-809-2355 (C)
bmurphy@geo-logic.com

Adam Heft, CPG
Chairperson, AIPG 2022 National Conference
517-886-7400 (O)
517-488-8462 (C)
adam.heft@wsp.com

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

**THANK YOU FOR YOUR SUPPORT**

*The Foundation of the American Institute of Professional Geologists is a 501 (c) (3) public foundation, qualified to receive contributions in support of educational programs. Contributions and gifts-in-kind are tax-deductible.*

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## FEATURED AUCTION ITEMS

Eagle Mine Ore Specimen ● Seaman Museum World-Class Mineral Specimen ● Amethyst Cathedral
One-of-a-kind Michigan Rocks & Minerals ● and much more

# Minerals & Falling Water

**Leaders: David Adler, CPG, Mannik Smith Group, and Adam Heft, CPG, WSP**

**Date:** August 7, 2022

**Time: 7:30 am - 5:00 pm**

Attire/Accessibility: Closed-toed shoes or hiking boots. The trip will include a hike up a hill on an irregular pathway; the elevation gain is about 100 feet. Other portions of the trip involve hiking across rock, which may be slippery. The Champion mine dump piles may include unstable rock piles and should be treated with caution if climbed.

Samples of the material on the Champion mine rock piles will be available for collecting.

The first portion of the field trip features the natural beauty of the Upper Peninsula wilderness, the fascination of falling water, and the ancient bedrock geology of the Marquette area. Our first stop will be at the Dead River Gorge and the confluence of Reany Creek and the Dead River located just outside the city limits. Along the riverside trail through Dead River Gorge we'll see several scenic waterfalls, some of which are quite spectacular. The bedrock here is Lower Precambrian (Archean) metavolcanic rocks of the southern Canadian Shield. Before leaving this area, we'll also take a short walk up the narrow gorge of Reany Creek just upstream from the confluence to see 3 more waterfalls and numerous intervening cascades. The bedrock at Reany Creek is the Archean Compeau Creek Gneiss, consisting of intrusive igneous and metaigneous rocks. Our last stop is along Lakeshore Drive and the Marquette bike path where Whetstone Brook flows into Lake Superior, just a short walk from downtown Marquette. Here we'll see a very scenic unnamed waterfall known to locals but overlooked by waterfall guidebooks. The bedrock here is schistose and massive metabasalt, actinolitic and chloritic schist, and ellipsoidal greenstone of the Mona Schist Lower Member. Some of the best exposures of the ancient pillow basalts can be seen here. There will be great views of Marquette Harbor and the old Marquette ore docks.

The second portion of the trip will feature mineral collecting at the Champion mine rock piles. This mine began operating in 1867 and continued for 100 years. Total iron ore production from this location was in excess of 7 million tons of iron ore, making it one of the more prolific mines west of the Tilden/Empire mines near Marquette. Champion is within the staurolite zone of metamorphism. At least 75 different minerals have been identified at Champion. We will have the opportunity to look for and collect samples from the rock piles.

A final stop will be in the town of Ishpeming at Jasper Knob. Here, participants will be able to see a world-class example of banded iron formation that has been extensively deformed.

*Photo credit waterfall: Dave Adler, CPG-11377*

# Sandstone Cliffs and Glacial Features of the Pictured Rocks National Lakeshore

**Leader:** Robert Regis, PhD., Professor Emeritus of Geology, Northern Michigan University

**Date:** August 9, 2022

**Time:** 7:30 am - 5:00 pm

**Attire/Accessibility:** The trip will consist of easily-accessible waterfalls, overlooks, and a 2-hour boat trip on Lake Superior. No special instructions or clothing is required.

Pictured Rocks National Lakeshore, located approximately 30 minutes east of Marquette, is America's first National Lakeshore. The Park features 50 to 200-foot high sandstone cliffs that extend for more than 15 miles along the shoreline. Sea caves, arches, blowholes, turrets, stone spires, and other features have been sculpted from the cliffs over the centuries by waves and weather. The cliffs consist of Mid to Late Cambrian-aged Munising Formation and the Early Ordovician-aged Au Train Formation. The Munising Formation is a gray to white sandstone, representing a complex shoreline/shallow water environment that was influenced by river, wave, tidal, and wind processes. The Au Train Formation is a light brown to white dolomitic sandstone that lies above the Munising Formation. The name "Pictured Rocks" comes from the streaks of mineral stain that decorate the cliffs, formed when groundwater seeps out of cracks and trickles down the rock face. Red, orange, blue, green, brown, black, and white decorate the cliffs.

The best way to observe the sandstone cliffs is from Lake Superior, so this trip will include a 2¼-hour boat cruise along the cliffs to observe the cliffs and erosional features up close. Waterfalls are abundant in the area, and the trip will visit some of the easily-accessible falls, as well as learn about the complex glacial history of the area.

*Photo credit: Al Blaske, CPG-10529*

# Tilden Iron Mine and Mill

**Leaders:** Cleveland-Cliffs geology staff

**Date:** August 9, 2022

**Time:** 7:30 am - 5:00 pm

Attire/Accessibility: The trip will take place in an operating, open pit iron mine, as well as in a large industrial facility. Closed-toe shoes will be required, and steel-toe boots recommended. Safety vests and hard hats may be available from Cleveland Cliffs, but participants are encouraged to bring their own. Sample collection will be allowed in the iron mine, however, photographs are prohibited..

The Tilden Mine is an open-pit iron mine located near Ishpeming and operated by Cleveland Cliffs. Tilden's operations consist of an open pit truck and shovel mine, a concentrator that utilizes single stage crushing, milling, magnetite separation and floatation to produce hematite and magnetite concentrates. The concentrates are supplied to the on-site pellet plant, which produces marble-sized pellets which are transported by rail to port at Marquette. The open pit is over 2 miles long, 1/2 mile wide, and more than 1,200 feet deep.

Tilden extracts low-grade ore (taconite) from the Paleoproterozoic (~1,875 billion years) Negaunee Iron Formation. The Negaunee Iron Formation consists of a variety of iron rich rocks in the Marquette area, including carbonate iron-formation (iron carbonate and chert with minor magnetite), oxide iron formation (hematite or magnetite and chert), magnetite-banded iron formation (laminated magnetite and chert), hematite banded iron formation (laminated hematite and chert), silicate iron formation (iron silicate minerals and chert) and combinations of these types. The origin of the iron minerals in the Negaunee Iron Formation is a complex combination of primary sedimentary depositional, diagenetic, and metamorphic processes.

To make the ore usable, the iron formation is ground into powder and the iron minerals separated using magnetic and flotation techniques. The iron-rich powder is then mixed with water and clay into a slurry that is shaped into pellets, heated, dried, and shipped to steel mills. Crude ore is approximately 35% iron and is upgraded to 65% before pelletizing.

This trip will visit the operating Tilden open pit mine, as well as the processing facility where the ore is turned into pellets for shipment to steel mills throughout the Great Lakes region.

*Photo credit: Google Earth, 2022*


# Keweenaw Copper Mining and History

**Leaders: Dr. Theodore Bornhorst, Professor Emeritus, Geological and Mining Engineering and Sciences, Michigan Tech University**

**Date:** August 9-10, 2022

**Time: Two full days – The Keweenaw Peninsula (Houghton Michigan) is 100 miles from Marquette. An overnight stay in Houghton will be necessary.**

**Attire/Accessibility:** The trip will consist of walking on a variety of surfaces, including underground and on waste rock piles. Therefore, closed-toe shoes (hiking boots or shoes) are recommended.

The Keweenaw Peninsula is the location of a dormant billion-dollar native copper mining district. Mining began in 1845 and continued to 1968, and the mines of the region produced 11 billion pounds of refined copper. The copper deposits are unique, in that the metal is present in the native form, and not in the typical sulfide, carbonate, or oxide form. The copper deposits are contained within the Portage Lake Volcanic sequence, a series of rift-filling volcanic rocks with minor clastic sedimentary rocks.

This two-day trip will examine the geology and history of the mining district, examining the geology of the Portage Lake Volcanic series, as well as the mining and milling methods to liberate the copper, and the environmental impacts of decades of mining. The trip will include a visit to the Quincy Mine Steam Hoist, an underground tour of the Quincy Mine, a visit to the historic Quincy Smelter, and a visit to the Torch Lake area to observe reclamation efforts associated with mining waste products. The trip will also visit the Keweenaw National Historic Park visitors center in Calumet, to gain an understanding of the human aspect of the copper boom in the peninsula. Finally, the trip will include the world-famous A. E. Seaman Mineral Museum to observe the spectacular native copper and associated mineralization of the region. Time permitting, mine waste rock piles will be visited to see the geology and mineralogy of the famous Keweenaw native copper deposits. *Photo credit: Al Blaske, CPG-10529*

# Feasibility of New Helium Well Development in the Holbrook Basin, Arizona

**Jacob Smith, Professional Master (Mineral Exploration) and Barbara L. EchoHawk, Ph.D.**


## Abstract

Continued demand for helium has led to renewed interest in the development of helium resources in the Holbrook Basin, Arizona. This paper discusses the feasibility of developing these resources, including consideration of the marketability of helium and of potential resources in the Holbrook Basin.

Helium prices have gone up significantly in recent years. Cessation of Bureau of Land Management (BLM) auctions of U.S. helium reserves has left it to the private sector to provide helium for commercial buyers. Numerous applications in science and industry have also increased the demand for helium.

The Holbrook Basin, located on the Colorado Plateau, has seen discovery of high-concentration helium deposits and promising exploration results in the twentieth century. The Coconino Sandstone and the Supai Formation have historically been identified as the main helium reservoirs. Furthermore, little natural gas is present in the system, making refining easier.

Desert Mountain Energy announced in September, 2020 that they drilled two new wells in the Holbrook Basin, the State 10-1 and 16-1, yielding helium concentrations of ~7% and ~4%, respectively. These results, along with high demand for helium, make the Holbrook Basin a promising locality for further exploration and well development.


**Keywords:** Helium, Economic feasibility, Holbrook Basin, Desert Mountain Energy, Well Development, Exploration geology

## Introduction

The purpose of this paper is to discuss some aspects of the economic feasibility of development of helium resources in the Holbrook Basin, Arizona, and the potential for further exploration in the area. The Holbrook Basin is located in Northeastern Arizona and spans approximately 170 by 80 miles (Figure 1). Previous production in the area ceased in 1976, with much of the basin remaining unexplored for helium resources. Economics of helium production have also changed significantly in recent years, with the cessation of BLM auctions in 2018 opening more of the market to private suppliers (Mueller, 2020).

The economic feasibility of developing a resource is in part established by providing evidence of resource marketability and resource availability. To this end, we review 1) the economics of helium and its uses in industry and 2) the geology of the Holbrook Basin and its potential for helium deposits. Methods and costs for processing and transporting helium are briefly reviewed in the context of Desert Mountain Energy's plans for production. A review of past production and of Desert Mountain Energy's new wells in the region will help focus on the potential for future development of helium resources in the Holbrook Basin. It is important to note that a complete picture of economic feasibility requires addressing factors outside of supply and demand, such as technological feasibility. Feasibility of resource exploration and extraction/production depends heavily on processing and transportation technologies available.

## Economic Feasibility

Helium is a noble gas with an atomic number of 2, and is the second most abundant element in the universe (Mueller, 2020). It is inert, non-toxic, colorless, and odorless. Its boiling point (-268.9°C) and freezing point (-272.2°C) are the lowest of any element on the periodic table. Helium's physical and chemical properties make it essential to numerous medical, scientific, and industrial applications (Table 1).

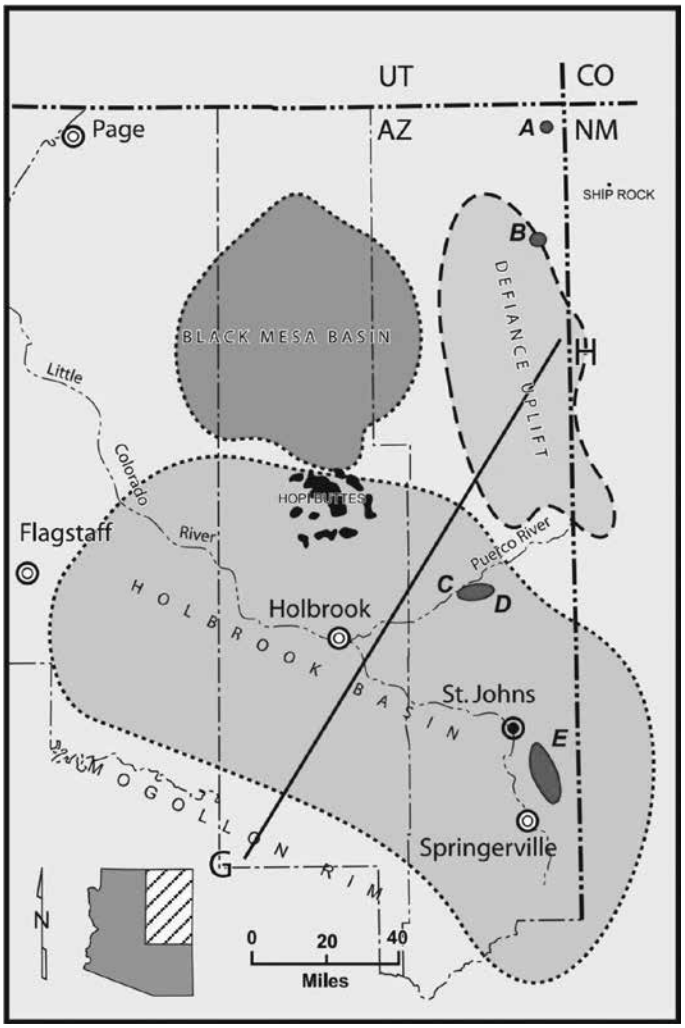


Figure 1. Regional map showing the location of the Holbrook Basin and areas where significant helium concentrations have been encountered in Northeast Arizona. A) Tohache Wash Field, B) Dineh-bi-Keyah Field, C) Pinta Dome Field, D) Navajo Springs Field, E) St. Johns-Springerville area (figure from Rauzi & Fellows, 2003).

The various applications for helium require different purities. Grades 5 and 6 (99.999% and 99.9999% helium by volume, respectively) are classified as research-grade helium (Mueller, 2020). Grade A helium is 99.997% pure. Grade 4 (99.99% pure) helium and lower are classified as balloon grade and are also used in air bags, heat-transfer applications, and leak detection. Crude helium is at least 50% pure and requires further refining for many commercial applications.

Because helium is extremely lightweight and non-reactive, it tends to float away once it enters Earth's atmosphere. This means that, despite it being the second most abundant element in the universe, concentrations of helium in Earth's atmosphere are extremely low (~5.2 parts per million (ppm)) (Mueller, 2020). There are two sources of terrestrial helium. The first is primordial $^{3}He$, which was created before the Earth's formation and was deposited during formation of the planet (Spencer, 1983; Xiong et al., 2020). The second type, $^{4}He$, continues to form from radioactive decay, primarily from unstable isotopes of uranium and thorium. $^{4}He$ makes up over 99.9% of helium found on Earth (Mueller, 2020). The ratio of $^{3}He$ to $^{4}He$, as well as other isotope data, can be used to help determine a source in helium exploration. Anomalously high $^{3}He$ in crustal rocks is found at basaltic hot spots and is thought to reflect an ultra-deep source of helium, perhaps seeping across the core-mantle boundary (Xiong et al, 2020). A higher proportion of $^{4}He$ points to a source fed by radioactive decay, typically produced from uranium- and thorium-bearing minerals in Precambrian granitic or metamorphic basement

**Table 1. Industrial uses and chemical properties of helium** (modified from Mueller, 2020).

| Relevant Properties | Examples of Related Applications |
|---|---|
| Lowest boiling point (-268.9°C) | Refrigerant, as in:<br>• Superconducting sensing systems and cryogenic research (Rauzi & Fellows, 2003)<br>• Magnets in medical MRI/NMR equipment<br>• Quantum computing systems |
| Second lightest element | Lift for balloons<br>Hard-drives |
| Smallest atomic radius (31 picometer) | Leak detection |
| Inert (chemically and radiologically) | Carrier gas (semiconductor manufacturing, gas chromatography)<br>Heat transfer medium in nuclear reactors |
| High thermal conductivity / specific heat | Gaseous cooling in fiber optics<br>Semiconductor manufacturing |
| Inert + lowest boiling point (-268.9°C) + lowest freezing point (-272.2°C) | Pressurizing/purging of liquid-fueled rocket tanks and other fluid-driven systems |
| Inert + high thermal conductivity + highest ionization potential | Shielding in gas metal/plasma arc welding |
| Low solubility | Deep sea diving gas<br>Surgical insufflation |
| High sonic velocity (972 m/s at 0°C) | Carrier gas for supersonic metal coating |
| Low index of refraction (n = 1.000036 at 0°C and 1 atm) | Solar telescopes<br>High-resolution microscopes |

rock (Spencer, 1983; Halford, 2018) and redistributed over time into overlying sedimentary strata..

## Resource Marketability

Helium is a non-renewable resource and cannot be replaced by other elements in a number of its applications (Mueller, 2020). For instance, helium is the only option for cryogenic applications that require extremely low temperatures (United States Geological Survey, 2021). Even where substitutions are possible, helium is often the optimal choice where technological advances take advantage of its unique physical and chemical attributes. For example, the medical field is finding a rapidly expanding array of new applications for helium (Berganza & Zhang, 2013), and the space industry continues to rely on helium in a variety of applications (Northon & Young, 2020).

Demand for helium has continued despite a sharp increase in price point over the past several years. This price increase can be seen in the results of the BLM auctions of helium from the Federal Helium Reserve from 2015 to 2019 (Figure 2). These auctions have now ceased, opening more of the market to private suppliers of helium (Mueller, 2020). In numerous applications, helium's unique chemical and physical properties mean that it cannot be substituted and is the only option, regardless of price (National Research Council, 2010). The National Research Council also projects global demand for helium will steadily grow by as much as three percent per year.

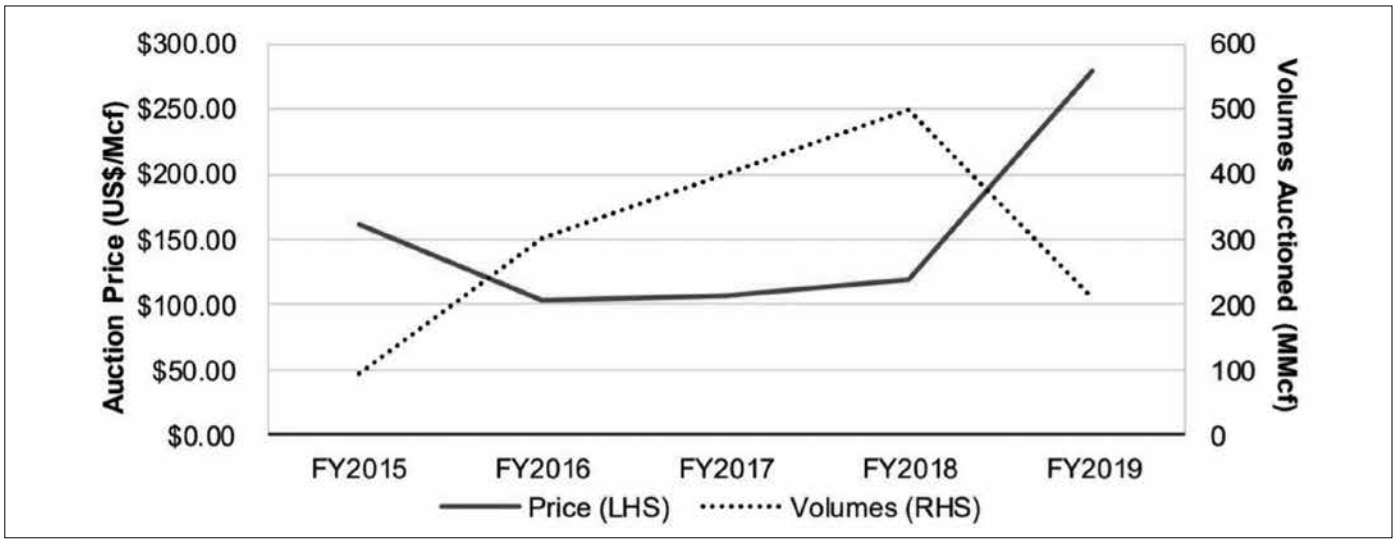


Figure 2. Sales of crude helium from the Federal Helium Reserve at BLM auctions, 2015-2019 (Mueller, 2020). LHS (left hand side) refers to the bid price (in dollars per thousand cubic feet (US$/Mcf), and RHS (right hand side) refers to the volumes offered at auction (in millions of cubic feet (MMcf) (figure from Mueller, 2020).

## Resource Availability

In the United States, helium is predominantly found in natural gas wells. Typically, concentrations of 0.3% or higher are considered economic to extract (Rauzi & Fellows, 2003). However, as natural gas prices have dropped and helium prices have skyrocketed, helium is being considered as a primary target for exploration (Mueller, 2020). Most exploration is conducted by helium exploration companies (for example, Desert Mountain Energy and Royal Helium based in Canada). The helium industries' largest buyers/refiners (Air Liquide, Linde, Air Products, and Praxair) have shown no interest in directly investing in production of helium assets, leaving the exploration work to the exploration companies (Mueller, 2020). It is important to note that helium is generally cheaper to process when natural gas is not present (Mueller, 2020). This makes the reservoirs in the Holbrook Basin particularly interesting for exploration, as the carrying gas consists primarily of nitrogen with little to no $CO_2$ and natural gas, depending on the well (Ballard, 2019; Rauzi & Fellows, 2003).

# Exploration Potential

## Geologic Setting

The Holbrook Basin is part of a regional northwest-plunging syncline that also includes the Black Mesa Basin (Figure 3). It is part of the Colorado Plateau and consists of sedimentary strata of Paleozoic and Lower Triassic age (Ballard, 2019). The Pennsylvanian to Permian target strata (the Coconino Sandstone and Supai Formation sandstones) are less than 4,000 feet below the surface and rest unconformably on Precambrian basement rocks. Gas samples from the Coconino Sandstone at Pinta Dome show that the likely source of helium is radioactive decay in shallow crustal basement rocks (Halford, 2018). This interpretation is based on isotopic signatures of $N_2$ and noble gases. Halford (2018) also found significant faulting in the area through geologic mapping and interpretation of closely spaced well logs. At Pinta Dome, these faults could aid in the transport of helium via advection from the Precambrian basement source to structural traps in the Coconino Sandstone.

## Exploration History

Helium in the Holbrook Basin was reported as early as 1927, based on the results of a non-productive oil test drilled to the Cambrian Tapeats Sandstone near Holbrook (Rauzi & Fellows, 2003). Helium at Pinta Dome was discovered in 1950, when a well drilled in search of oil produced a very high concentration (~8%) of helium transported primarily by nitrogen, with little natural gas present (Rauzi & Fellows, 2003). Rauzi and

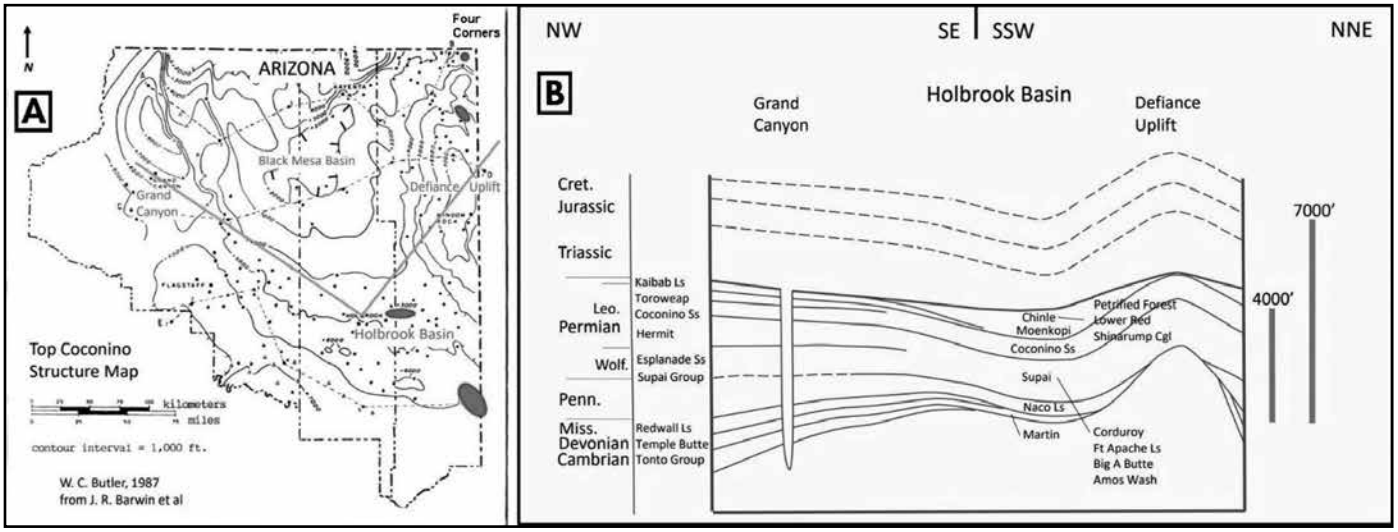


Figure 3. (A) Geologic map showing the Holbrook Basin and (B) cross section from the Grand Canyon across the Holbrook Basin to the Defiance Uplift (figure modified from Butler, 1987, and Ballard, 2019).

Fellows (2003) report that Kerr-McGee constructed a plant to process helium nearby in 1961, and that production began at Navajo Springs in 1964 and East Navajo Springs in 1969; the plant closed and fields were abandoned in 1976 due to falling helium prices and a drop in production. Over the lifespan of the wells, the Pinta Dome and surrounding fields produced over 700 million cubic feet (MMcf) of Grade A helium which, at today's value of ~$300 per thousand cubic feet (Mcf), would be worth approximately $210 million. Rauzi and Fellows (2003, p. 2) noted that, "the gas averaged 90 percent nitrogen, 8-10 percent helium, and 1 percent carbon dioxide." Figures 4 and 5 display a map of productive wells in the region and the simplified stratigraphy of the region, respectively.

Helium deposits in the Holbrook Basin result from the same general principles as conventional natural gas deposits: both require a source and migration, as well as a reservoir, trap, and seal. The primary differences occur at the beginning of the process. Helium sources are abiogenic rather than biogenic, and migration of $^4$He involves escape from host minerals as

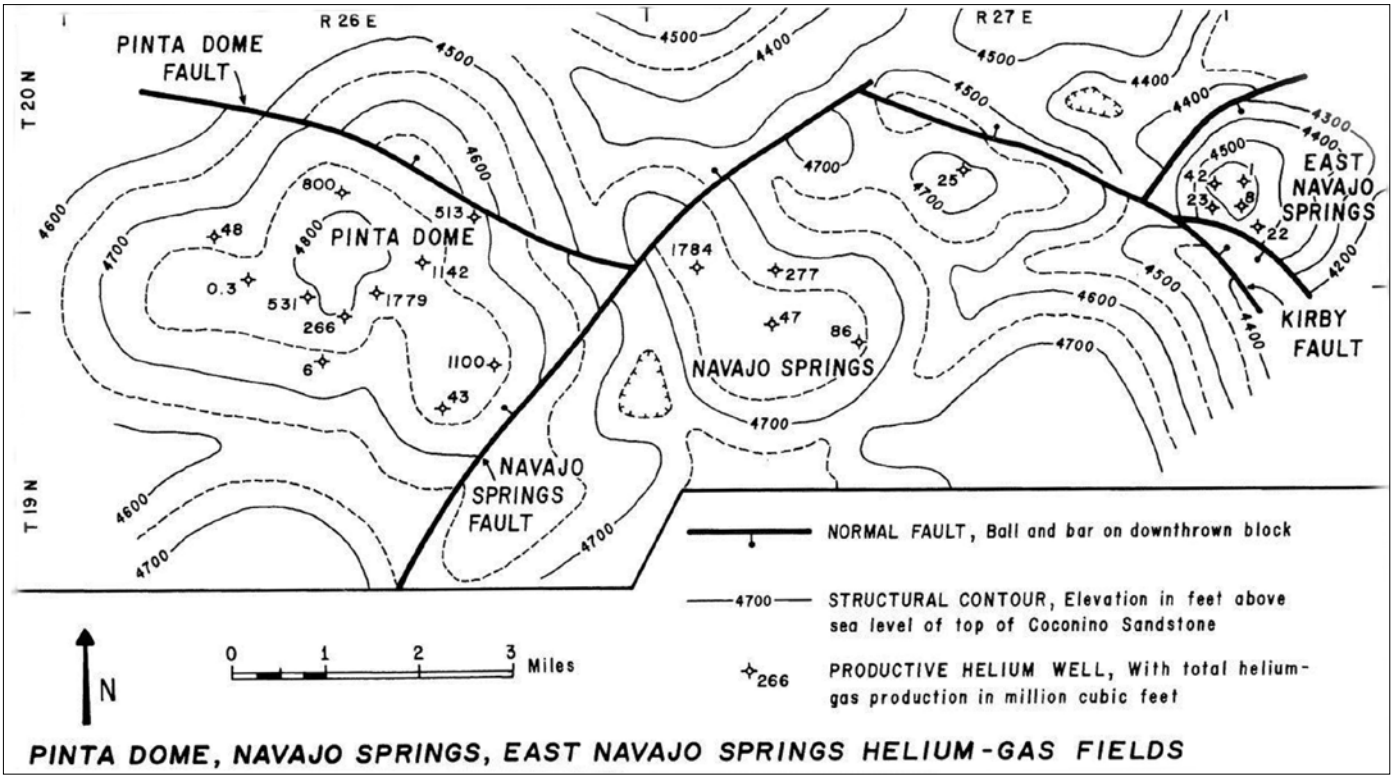


Figure 4. Regional map showing wells at Pinta Dome, Navajo Springs, and East Navajo Springs. Structural contours mark the top of the Coconino Sandstone (figure from Spencer, 1983).

| SYSTEM OR SERIES | | FORMATION | THICKNESS | LITHOLOGIC CHARACTERISTICS |
|---|---|---|---|---|
| Quaternary | | | | Alluvium, sand and gravel |
| Tertiary | | Bidahochi Formation | 0-180 ft. | Grayish-brown calcareous sandstone interbedded with silty mudstone and volcanic ash; bentonitic |
| | | UNCONFORMITY | | |
| Triassic | Upper | Chinle Formation | 650-850 ft. | Reddish-brown to grayish-blue mudstone and claystone with some silty sandstone; some limestone and gypsum in upper portion; siltstone and conglomeratic sandstone in lower portion |
| | | UNCONFORMITY | | |
| | Middle to Lower | Moenkopi Formation | 125-150 ft. | Brown to gray calcareous siltstone and mudstone; slightly gypsiferous; very silty |
| | | UNCONFORMITY | | |
| Permian | Lower | Coconino Formation | 250-325 ft. | Light gray to buff, fine- to medium-grained sandstone; loosely to firmly cemented with silica |
| | | UNCONFORMITY | | |
| Pennsylvanian? | | Supai Formation | 1,700? ft. | Reddish-brown sandstone, siltstone and mudstone; some dolomitic limestone; thick interbedded evaporitic sequence in upper portion |
| | | UNCONFORMITY | | |
| Precambrian | | | | Crystalline basement rocks |

Figure 5. General stratigraphy of the Pinta Dome area (figure from Spencer, 1983).

well as from the source rock (Mueller, 2020). Where porosity and permeability are sufficient, the Coconino Sandstone and parts of the Supai Formation could act as reservoirs for the helium (Ballard, 2019). The Coconino Sandstone is fine- to medium-grained and silica-cemented. In many areas, it is so close to the surface that it lacks an effective overlying seal (Ballard, 2019), so drilling to find deeper deposits in the underlying Supai Formation is necessary. Small anticlinal structures at Pinta Dome, Navajo Springs, and East Navajo Springs trap helium (Rauzi & Fellows, 2003), but facies changes between shales, carbonates, and sandstones may also create stratigraphic traps in depositional cycles within the Supai Formation (Ballard, 2019). For example, units such as tight dolomitic limestones make good seals, whereas others like porous sandstones are good reservoir rocks. Faults are thought to be the primary mechanism of transport for helium deposits to accumulate in both the Coconino Sandstone and the Supai Formation (Halford, 2018). Helium concentration also appears to be enhanced in structural and stratigraphic traps near deep-seated igneous intrusions (Rauzi & Fellows, 2003) that were emplaced in the Holbrook Basin ~8.5 to 6 million and ~4 million years ago (Arizona Geological Survey, 2021).

## Recent Helium Discoveries in the Holbrook Basin

After Kerr-McGee's cessation of exploration activity in 1976, further development of wells in the Holbrook Basin ceased until economic changes stirred interest in the region once again. Demand for helium has increased in recent years as supplies have decreased with the cessation of BLM auctions. The last public BLM auction occurred in August, 2018 with further availability of Federal Reserve helium limited to federal users (Mueller, 2020). Price increases with decreasing volumes auctioned through 2018 are also demonstrated in Figure 2. This created new opportunities for private suppliers of helium post-2018.

Desert Mountain Energy (DME), based in Vancouver, Canada, has access to much of the property in the Holbrook Basin outside the Pinta Dome region. Many of these areas have potential for untapped helium deposits, given that historic production focused mainly on the Pinta Dome, Navajo Springs, and East Navajo Springs fields. Structural mapping in tandem with stratigraphic knowledge gained from previous drilling in the area can help determine the best places for exploration and new wells.

Desert Mountain Energy announced the completion of two new wells in the Holbrook Basin, the State 10-1 and the State 16-1, in September, 2020. Significant helium deposits were found in both wells (Desert Mountain Energy, 2020). Analysis of gas from the State 10-1 showed concentrations of 7.1321% helium, 77.0837% nitrogen, 4.0183% $CO_2$, and 2.6512% methane and other minor gases. This gas was found when the company perforated five feet into a limey sandstone unit in the Pennsylvanian Supai Formation. Based on open-hole well logs, the productive zone may be as much as 28 feet thick. Well logs show a drop in porosity in the middle of the target section, which may require additional perforations to produce.

Analysis of gas from the State 16-1 showed concentrations of 4.0904% helium, 90.2742% nitrogen, 0.0063% $CO_2$, and 3.5535% methane and other minor gases. Five feet of sandstone in the Supai Formation was also perforated in this well, with the potential productive zone estimated to be 61 feet thick. Two very dense layers of dolomitic limestone impact the porosity as in the State 10-1 well, and will require additional perforations to enhance production.

Desert Mountain Energy plans to put these two new wells into production in late 2021 once it completes building a helium separation plant in Navajo County, Arizona. The plant will be within approximately one mile of the closest well. While the total cost of the helium separation plant is proprietary, construction of the plant is projected to save Desert Mountain

Energy over $7.5 million compared with other processing options (Robert Rohlfing, personal communication, 2021). The processing plant will use a combination of pressure swing adsorption and membrane technology to refine helium produced from the wells. The refining process is simplified by the low percentage of natural gas associated with the helium.

Refining helium at the plant will reduce transport costs and increase the value of the produced helium by providing industry with a more highly concentrated product. If production is successful, Desert Mountain Energy plans additional helium exploration in the Holbrook Basin. Based on the region's historic and current helium grades, further exploration may have significant growth potential and economic upside.

## Conclusions

This is an excellent time for exploration and production in the helium industry. Demand and price points are up, and cessation of the BLM's auctions of federal helium reserves has opened more of the market to private suppliers. Helium's unique physical and chemical properties make it essential to many industries and technologies. As a non-renewable resource, helium deposits are projected to further increase in value over time.

Northeastern Arizona's Holbrook Basin is among the most promising places identified for helium exploration. The 8-10% helium concentrations encountered in older fields within the basin are some of the highest recorded in the world. At 7.1321% (State 10-1) and 4.0904% (State 16-1), both of Desert Mountain Energy's new wells show helium concentrations an order of magnitude above economic levels (0.3%) for natural gas wells. In addition, the location is near potential buyers, and the processing plant planned by Desert Mountain Energy will help minimize midstream and downstream costs. Technology companies and high-tech industries that require helium in California, Texas, and throughout the region will likely find it advantageous and cost-effective to order from a local domestic supplier.

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# From Outcrops to 3D Models and Printing

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## Abstract

The collection of 3D information from geological media is fundamental for field geology, however it can be both time consuming and expensive. This report describes a new method for the collection of 3D information of outcrops using simple to use and inexpensive technology. GigaPan® systems can be used to take high resolution images of outcrops. These images can then be either left in 2D for additional description of the outcrop in the lab or processed in Autodesk 3ds Max® to create realistic 3D models of the outcrops, which can then be 3D printed. The collection of this data can allow for maximization of field time and may allow for additional analysis and descriptions in the lab. The ability to visit or revisit an outcrop without physically going there has implications for facilitating collaborative research projects and improving the learning outcomes of students.

**Keywords:** GigaPan®, photogrammetry, 3D modeling, 3D printing, Autodesk 3ds Max®

## Introduction

Collecting detailed 3D data from outcrops has been done since the advent of surveying methods and is one of the most fundamental skills in field geology. This data collection is typically completed using one of the two main data collection techniques: 1) direct topographic surveying or, 2) remote digital surveying. These methods all have their relative strengths and weaknesses in terms of field time requirements, computer processing requirements, accuracy and precision, and cost (Carrivick, et al., 2016). The products of these different surveying techniques may ultimately be used to create 3D models of landforms or landscapes which then could potentially be 3D printed. This paper focuses on remote digital surveying techniques.

We also discuss the further step of integrating outcrop scale 3D modeling using GigaPan® photogrammetry and Autodesk 3ds Max® 3D modeling in conjunction with 3D printing to help bring the outcrop back to the lab setting for additional analysis which can be tied to traditional geologic methods; this paper seeks to address this current gap.

## Background

### Remote Digital Surveying Techniques

Remote digital surveying techniques, which may be done remotely or in the field (Carrivick, et al., 2016), allow for the collection of more dense data more rapidly than direct surveying techniques. The three most common remote digital survey techniques are 1) photogrammetry, 2) laser scanning, and 3) structure from motion (SfM) (e.g. Carrivick, et al., 2016). Traditional photogrammetry has been used since the advent of cameras (Carrivick, et al., 2016). High resolution gigapixel photogrammetry requires the overlap of two-dimensional images all taken from a fixed location, ideally with a metric camera. This can allow for the construction of a three-dimensional feature. These photogrammetry techniques can also be completed using airborne or terrestrially based cameras (e.g. Carrivick, et al., 2016, and references therein). Photogrammetry is applicable at nearly all scales, from the micro to the macro scale (e.g. Carrivick, et al., 2016, and references therein).

For geologic surveying, laser scanning can be conducted by both airborne and terrestrially based methods (e.g. Carrivick, et al., 2016, and references therein). Laser scanning can be highly accurate and precise if the GPS connected to it is also accurate and precise (e.g. Carrivick, et al., 2016, and references therein). Laser scanning has the advantage over other remote digital survey techniques in that it can penetrate through vegetation to get to the true

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earth surface (e.g. Carrivick, et al., 2016, and references therein). However, laser scanning techniques are cost prohibitive and require specialized equipment (e.g. Carrivick, et al., 2016, and references therein).

Structure from motion is a special type of photogrammetry that removes the limitations of general photogrammetry and reduces the cost. SfM stitches two-dimensional images together, but does not depend on a metric camera nor does it depend on knowing the precise location of the camera (e.g. Carrivick, et al., 2016; Westoby, et al., 2012). SfM requires the movement of a camera to capture overlapping images for an object of interest. These images require a known scale and, from this, algorithms can be used to render a scaled three-dimensional object (e.g. Carrivick, et al., 2016; Westoby, et al., 2012). SfM can be done both using airborne and terrestrial methods (e.g. Carrivick, et al., 2016, and references therein). SfM is a cost-effective method of remote digital surveying techniques that yields fast, accurate and precise models that can be applied from the micro to macro scales (e.g. Carrivick, et al., 2016; Westoby, et al., 2012).

### GigaPan® Technology

A tool that has been used in the photogrammetry of geologic outcrops is the GigaPan® technology, but its full potential hasn't been explored yet (e.g. Biber, et al., 2018; Hana, et al., 2019; Lee, et al., 2019; Piatek, et al., 2012). GigaPan® is a robotic camera mount system on a tripod that generates high resolution panoramic photos that can cover a large area. This is accomplished by automating the process of taking many photographs (tens to thousands) over a relatively short period of time and stitching them together using the GigaPan® Stitch software.

### Autodesk 3ds Max® Software

Autodesk 3ds Max® is a leading software used in developing 3D models. This software is free to students and educators and is not computer resource intensive, which makes it attractive as a tool to use to create models of rocks and outcrops.

### 3D Printing from Photogrammetry and SfM

Additive printing of 3D geological models from SfM has not been greatly explored at the outcrop scale. 3D printing in geology has mostly been used for educational purposes using a mixture of photogrammetry and SfM techniques (e.g. Hasiuk, 2014; Ishutoz, et al., 2018; Squelch, 2017). It has also been used for modeling rocks for deformation and porosity studies using photogrammetry, SfM, and computed tomographic (CT) techniques (e.g. Betlem, et al., 2020; Ishutov, et al., 2015; Ishutov, et al., 2018).

Figure 1. The robotic camera system setup with the system mounted on a tripod. Note that tripod mounting of the system does not allow for overhead imaging.

### Field Location and Geologic History

The field study area is within the Hiawatha National Forest in Michigan's Upper Peninsula. This region is primarily underlain by early Silurian dolostones (Engadine and Manistique Groups) which form the Niagara Escarpment in the area (Sumrall and Larson, 2020).

The field location used in this study is a suspected knoll reef from the McKay Bay Member of the Bush Bay Formation (Engadine Group) and is located approximately 1.5 km north of the community of Pontchartrain Shores, MI (Mackinac County) at 0686550m E, 5101700m N, zone 16T. The McKay Bay Member is a generally white dolostone which is chert-free and contains numerous fossils and a relatively high porosity (Sumrall and Larson, 2020). Knoll reefs immediately east of this study area have been described (Johnson, et al., 1979). This possible knoll reef, and its paleontology and petrography, has received a preliminary description (Pearson, et al., 2019), and was found to contain numerous reef binders (stromatoporoids and stromatolites) and reef builders (mollusks, crinoids, and tabulate coral). This site was selected because it provides a relatively small and discrete rock body to test the methods proposed in this paper.

## METHODS

### Robotic Camera Setup

A GigaPan® Epic Pro mount with a Canon® 7T camera was used to collect images. A Canon 50mm F1.4 lens was used for its ability to operate in poorly lit sites. The robotic camera system was mounted on a fixed aluminum survey tripod with a flat head (Figure 1).

From a fixed point the robotic camera system scans and captures images which are organized by columns and rows. The columns and rows are defined when calibrating the image boundaries during panoramic setup. Noting row and column numbers for each panorama attempt is extremely important to correctly arrange the photos manually in the Gigapan® Stitch software. Each image was captured in JPEG and CR2 formats. CR2 files are based on the TIFF specification which collects significantly more data per image, which is useful in postediting.

During panorama calibration, multiple test shots with different shutter speeds were taken to find the correct light intake. The camera's light tempera-

Figure 2. The four sides of the knoll reef after being stitched together.
These four images were used to reconstruct a 3D model of the reef (Figure 3).

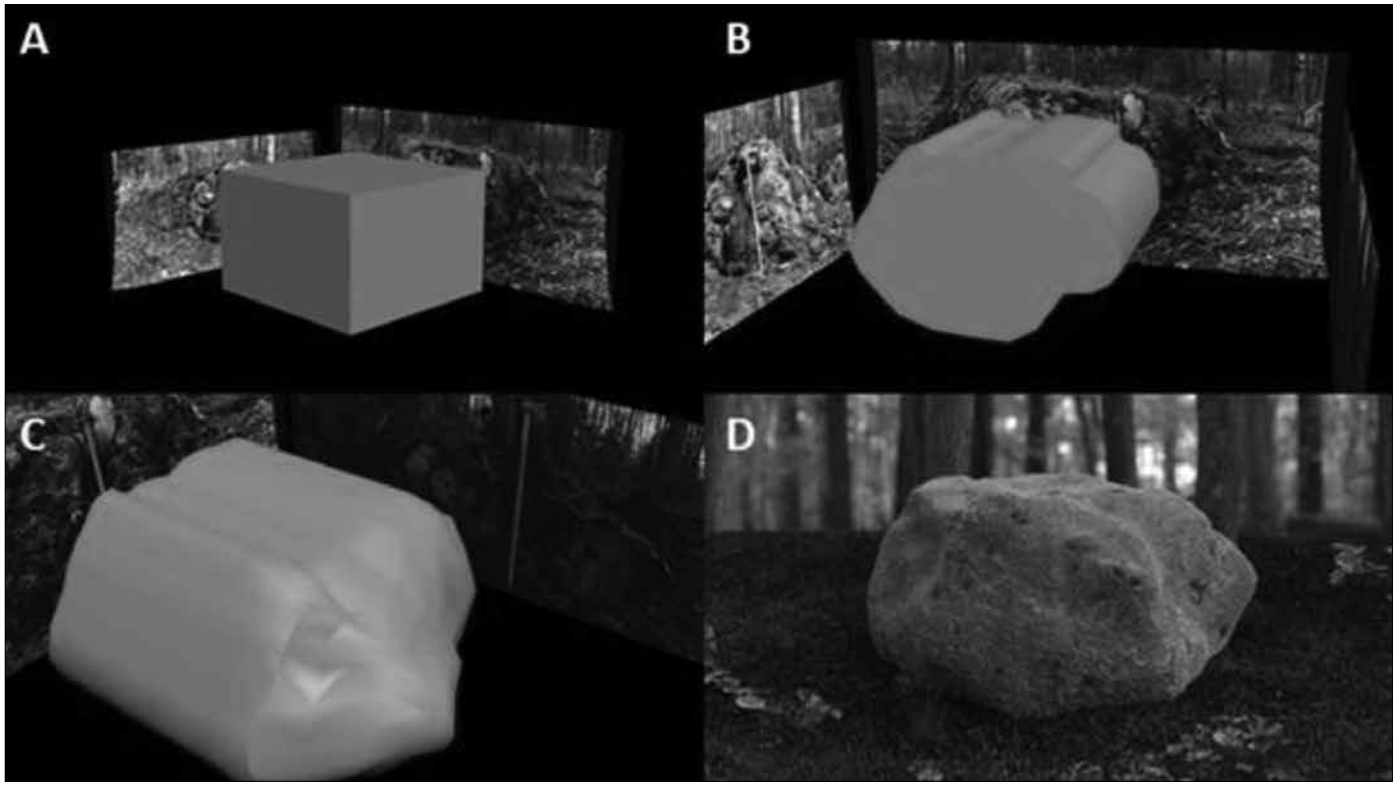


Figure 3. Construction of the 3D model of the knoll reef. A) The images of the four faces of the reef were superimposed on a blank cube. B and C) Sculpting of the cube based on the images allowed for its construction in 3D space. D) The final rendering of the reef based on sculpting from four images.

Figure 4: The four sides of the knoll reef 3D print at a scale of 60:1.

ture (k) and ISO was manually adjusted for each panorama to best match the white balance to the outside light at the time and to keep each image consistent for the stitching process. The images are manually arranged into rows and columns based on the specifications of the panorama boundaries when the image was taken. Once the image is stitched, it is automatically saved as a TIFF file.

The knoll reef was measured using tape measures and meter sticks to ensure that the exact size of the outcrop was maintained in the 3D modeling and printing. After measuring the knoll reef, it was photographed with the robotic camera system from four sides to allow for the development of a 3D model. Each side was made of 60 images which were individually stitched together. The top of the knoll reef was not photographed for this project as there was not a way to aerially mount the robotic camera system over the feature (Figure 1). The different sides of the knoll reef were then additionally processed as described below.

## Data Processing and 3D Modeling

While Photoshop® was not used for the panorama stitching process, it was used for editing. "Brightness/contrast" and "curve" adjustments were used to clean up dim lights and correct the photos' hue. The "shake reduction" filter automatically adjusted blurs with the smart detect and the "spot healing brush" tool was used to enhance anything the "shake reduction" might have missed. The edited panoramas were then converted from their original TIFF to JPEG format in Photoshop® to lower the risk of crashing within Autodesk 3ds Max®. These JPEG images were then converted into texture files and placed onto planes using texture mapping in order to accurately model the knoll reef.

The software's "create object" tool allows users to draw a wide variety of 3D geometric shapes, lights, and motion controls. A generic cube was initially used as a foundation to work with because of its easy manipulation, and because it has a large surface area. The JPEG panoramas were converted to a texture file and placed in this 3D space based on the cardinal directions they faced.

An "edit poly" modifier tool was the main modifier used to manipulate and distort the cube into the reef shape. This was done by adding and manipulating vertices around the object. Decreasing the distance between the vertices in the model to 0" by 0" will crash the software, requiring frequent saves. Measurements taken of the outcrop were used to ensure the size and scale of the 3D model. The "push / pull paint" deformation modifier tool was the last major modifier to cut down on sharp edges and smooth out rigid areas. Finally, the "turbosmooth" modifier tool was applied to make the results appear more natural.

For the final render a blue hue was added to the camera to make the background blur which provides an image for the background of the 3D model. A displacement map, which changes the geometry of the surface and patches tessellation, was added to the reef as a texture file. A cream grey dolomite rock texture was applied to the 3D model. The ground was formed with a basic green color and a small hill shape. For cosmetic purposes, a high dynamic range imaging map designed the background lighting, trees were grown using a basic tree material, and leaves and grass were created using bitmap images and their alphas (a technique to create low foliage trees and grass), and were placed on the planes – this editing had no impact on the actual 3D model, only providing a background for the 3D model to stand against.

## 3D Printing

A stereolithography STL file of the knoll reef which was readable by the

3D printer was created. A Mono Maker Select Plus® 3D printer with 1.75mm recyclable filament was used for this printing. The freeware Cura was used to import the STL file and allowed for scaling of the knoll reef model to fit within the bed of the printer. Painters tape was applied to the bed of the printer to help prevent warping. Before printing, the printer bed was levelled and heated. The knoll reef that was 3D printed was at a scale of 60:1 and took 6.5 hours to print.

## Results

### Knoll Reef

The knoll reef was photographed from 4 sides, with the individual sides stitched together (Figure 2). Each panorama was mounted on its own plane and rendered into a 3D model, as described above (Figure 3). The knoll reef was then 3D printed as a demonstration of proof of concept for this entire process (Figure 4).

## Discussion

### Strengths of this Method

In the field this method excels in that it is low cost and rugged. The cost of the robotic camera system, camera and lens, and tripod is relatively low compared to other remote digital surveying techniques (Carrivick, et al., 2016). These instruments are also rugged and can hold up well to field use. Finally, the ability of the robotic camera system to produce high resolution images allows this method to be used at a variety of scales. These reconstructed panoramas can be used as 2D surfaces or may be stitched together to allow for additional and supplemental analysis and description of the outcrops after the field work is complete.

The computer processing of the images into a 3D model is not resource taxing and can be completed with widely available software. The method also allows for the 3D printing of geologic outcrops which means that additional analysis of the rock body may be conducted after the field work is completed.

### Weaknesses of this Method

The main field limitation of a GigaPan® robotic camera system is the battery life of the camera and mount. The length of time required for the system to complete its photography can also be difficult in the field setting due to changes in light and shadows, as this process may take a long time to complete depending on the size of the panorama and the number of individual images required, up to hours; though this can be somewhat addressed through subsequent photo editing.

In the lab, the 3D printing of the model is restricted to the resolution and scale of the printer. In an ideal situation a larger printer with higher precision could be used to reconstruct a more precise model and additional features could be better integrated into the model with scaling (e.g. paleontological resources).

### Future Implications

The methods described in this paper potentially allow the user to maximize the time spent in the field describing rocks. With high resolution images, image-based stratigraphic columns may be constructed, reducing the amount of data that needs collecting in the field. The methods may also allow for greater collaborations as possible collaborators may not have to go to the field together and can instead together view and describe an outcrop digitally. While these methods will not replace the need for field-based research, they may facilitate greater collaborations along with deeper subsequent analysis of outcrops without necessarily requiring additional field work (e.g. McCaffrey, et al., 2005; Whitmeyer, et al., 2020).

These methods also have implications for the future of geoscience education: high resolution 2D and 3D models of outcrops could be used for lab instruction for students with mobility challenges or allow for students to interact with outcrops that are far removed from where they are (e.g. De Paor, 2016; Dolphin, et al., 2019; Ishutov, et al., 2018; Piatek, et al., 2012; Pringle, et al., 2004; Squelch, 2017). Neither this method nor ones similar to it will replace the need for field-based instruction, but they may meaningfully supplement it.

### Future Considerations

In the future this project and method should be expanded to additionally include imagery from the top of the structure of interest to allow its complete reconstruction. This will likely be best accomplished using an unmanned aerial vehicle. This project may also be expanded upon using a larger 3D printer which would allow for more detailed rendering of the outcrop when printed and possible integration of notable paleontological resources. Finally, the use of different file types may make this process more efficient or increase the precision of the intermediary and final products.

### Other Possible Technologies

There are other hardware and software options that can perform tasks similar to those performed as described. Clauss® and Canon® have comparable panoramic robotic head mounts for cameras. For stitching the images, software like PTGui is designed as a panoramic stitching application. Image processing programs like Adobe Photoshop® can be used to create the panoramas. There is an abundance of animation and modeling software that is capable of recreating the 3D models from the panoramic images. Unity and Adobe Dimensions are some of the more common computer graphics programs that can also be used.

## Conclusion

Moving from a geological site to a 3D printed model that fits in your hand is a lengthy process but not a laborious one. This paper reports on a way to complete this using inexpensive and rugged field instruments with minimal computing power required for data processing. Outcrops can be photographed and the images then used immediately in 2D space for additional description of the rock or outcrop in the lab setting, thereby maximizing field time, or the images can be processed to render an accurate 3D model of the outcrop which can then be 3D printed to allow for additional analysis and description.

The use of this method and others like it has implications for the future of geologic research and education. This method allows researchers to maximize their field time and to "revisit" the outcrop without leaving their lab. It also potentially allows for the improvement of student outcomes as they may now be able to interact with far-flung outcrops which consist of rocks available locally.

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This paper is dedicated to the memory of Logan Pearson.

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# Competence, Reasonableness, and Ethics when performing Mineral Valuations

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## Abstract

Mineral Evaluation services are diverse and include technical, physical, legal, economic, or other assessments of a mineral property. Mineral Valuation services are different from Mineral Evaluation services and provide an estimate of value of a mineral interest in terms of a monetary equivalent. A mineral valuation may include integration of results from evaluation services and valuation standards regarding these integrations may have competence, reasonableness, and ethical considerations. Competence requirements from three organizations describe the competence required when performing mineral valuations under their standards. Reasonableness is a defined term in most of these valuation standards. Consideration of classification and modifying factors in resource/reserves reports is necessary when the valuations include the consideration and application of the mineral resources/reserves reports in the assignment. Valuation standards generally look for valuers to apply recognized methods and techniques, avoid substantial errors of omission, and not make a series of errors that when combined affects the credibility of the valuation assignment.


**Keywords:** Competence, Ethics, Evaluation, Reasonableness, Valuation

Geologists are familiar with Technical Evaluation Services, and in many cases are designated as experts in specific disciplines of Technical Evaluation. Common Technical Evaluation services performed on mineral properties include:

1. Entitlement of mineral lands/interests/rights
2. Exploration and Sampling
3. Geologic and Resource Mapping
4. Technical Assessments
5. Scoping Studies
6. Preliminary Economic Analyses
7. Mineral Resources/Reserves Classifications
8. Permitting
9. Pre-Feasibility/Feasibility Studies
10. Mine Planning/Equipment Scoping/Design

Valuation Services differ from Evaluation Services, as Valuation Services provide an estimate of value of a mineral interest in terms of a monetary equivalent. Valuation Services require appraisal/valuation expertise, which is different from the expertise used in providing Evaluation Services. An individual that performs Valuation Services is typically known as an Appraiser in the United States, which is synonymous with the term Valuer used outside the United States. An Appraiser performs an Appraisal assignment, and the written product is an Appraisal Report. Similarly, a Valuer performs a Valuation assignment, and the written product is a Valuation Report.

## Competence with Mineral Valuation Assignments

The International Institute of Minerals Appraisers (IIMA) is a professional organization of qualified Members who specialize in the appraisal of properties containing minerals. Mineral valuation competence requirements are a baccalaureate or higher degree in geology, mining, or petroleum engineering, and at least one continuing education course in the valuation of minerals. Experience requirements include a minimum of five years of minerals valuation experience, after having satisfied the educational requirements. Like other valuation disciplines, there are also continuing education requirements.

The Society for Mining, Metallurgy & Exploration (SME) has a Registered Member Program for experts in specific disciplines, including Geology and Mineral Valuation. SME Registered Members that perform Exploration, Mineral Resource and Mineral Reserves reporting must follow the SME Guide for Reporting Exploration Results and Mineral Reserves. SME Registered Members that perform Mineral Valuations must follow the SME Standards and Guidelines for Valuation of Mineral Properties (Including Petroleum). Both documents are updated periodically. Registered Members must demonstrate expertise per discipline and have the following competence requirements:

- Applicant must possess a university degree from a U.S. accredited university or a recognized overseas university, and
- Applicant must have a minimum of seven (7) years of professional experience, of which at least 3 must have been in a position of responsibility, defined as one in which the individual was depended on for significant participation, management and decision making relevant to their respective area of competency, and
- Applicant must satisfy and demonstrate one of the following conditions:
    - Licensed or Certified in a state of the United States that is a member of the National Association of State Boards of Geology (ASBOG).
    - Certified by the American Institute of Professional Geologists (AIPG) as a Certified Professional Geologist.
    - Professional Engineer (PE) licensed or certified in a state of the United States, (PEng) licensed or certified in a province in Canada.
    - Professional Geologist (PGeo) in a province in Canada or
- The applicant will need three endorsements from three current SME Registered Members

The International Mineral Valuation Committee (IMVAL) publishes the International Mineral Property Valuation Standards Template, a standards and guidelines template created for the harmonization of International Mineral Valuation Codes and Standards. A valuer using the IMVAL Template as a valuation standard has competence considerations as follows:

"A Valuer must be able to demonstrate to the Commissioning Entity and those entitled to rely on a Valuation Report that the Valuer is sufficiently Competent to prepare or contribute to the Valuation Report. A Valuer must be clearly satisfied that they are able to face their professional peers and demonstrate Competence in the Valuation undertaken. Among other things, Valuers should assess their competence regarding the subject Mineral Property, the market in which the property would trade, and the purpose of the Valuation. See also IVS Framework, Section 50 Competence."

"A Valuer who is not personally Competent to undertake an aspect of a Valuation assignment must seek assistance from an Expert who is Competent in the applicable field or discipline necessary to address that aspect. Material assistance from Experts must be disclosed in the Valuation Report. See also IVS Framework, Section 50 Competence."

"The Valuation of Mineral Properties may require Competence in a wide range of disciplines. Depending on the nature of the Mineral Property to be valued, the Basis of Value to be applied, and the availability of currently relevant technical reports for the subject Mineral Property, an in-depth understanding may be needed in such specialized areas as geoscience; mining or petroleum engineering; metallurgy; water rights; environmental assessment; social aspects; regional geopolitics; micro and macro mineral economics; finance; taxation and government levies; property, mineral, and other applicable law; bulk transportation; and marketing. Therefore, in many cases, Valuers should retain Experts who are Competent in the vetting and development of certain technical information and development of Inputs used in the Mineral Property Valuation and the preparation of a Valuation Report. See also IVS Framework 50."

When other experts are utilized, both SME Registered Members (Valuation) or Valuers using the IMVAL Template have the same requirement for the valuer regarding other expert(s): "(b) Ensuring that any Expert(s) assisting with the review of information and the Valuation are appropriately qualified and experienced, that their assistance is disclosed in the Valuation Report, and that their consents are obtained for any description of their assistance in the form and context in which it appears in the report."

The responsibility of the valuer for the mineral valuation, report and work by other experts follows the Preamble of the AIPG code of ethics: "A Member shall not be relieved of an ethical responsibility…because the Member has delegated an assignment to a subordinate…"

## Reasonableness

"Reasonableness" is one of five key principles in the IMVAL template, defined as: "The Valuer must ensure the Reasonableness of the Valuation. Any Valuation, assumptions applied, and any method relied upon should be reasonable within the context of the purpose of the Valuation and the Basis of Value. A method applied to the subject Mineral Property should be within the expected capability and consideration of an assumed likely buyer or lessee of the property...".

The SME Valuation Standards currently do not identify Reasonableness as a principle but do require the valuer to be responsible for "Assessing the reasonableness of the relevant information, interpretations, discussions and conclusions, forecasts, and parameters used in the Valuation."

IMVAL's definition of Reasonableness contains three distinct components:

1. "…reasonable within the context of the purpose of the Valuation…" – the purpose of the valuation may define the level of scope of work/efforts necessary to perform the valuation. For example, a valuation assignment solely for the owner of a 50-year family run sand mine might be a far less rigorous valuation assignment compared to a development stage industrial minerals valuation that will be used by multiple parties for

litigation purposes. The level of scope and assumptions may also be substantially different in these two kinds of valuation assignments, as is the intended users/use.

2. "Basis of Value" - relates to the type and definition of the value opinion that is being rendered in the assignment. These types provide a specific definition and the considerations of the value. For example, Fair Market Value is a different type of value opinion than Fair Value, and likely produces a different value opinion. There can also be different definitions for each of these types based on assignment, law, or other factors.

3. "…within the expected capability and consideration of an assumed likely buyer or lessee…" - Using abstract or non-industry accepted valuation approaches and methods may not be considered reasonable, especially if the industry/market (buyers and sellers) would not have the capability (including via their valuers) to perform similar. Using abstract or non-industry accepted methods alone may not be considered reasonable. In some cases, if industry accepted methods were used as a primary value indicator, and abstract or non-industry methods can help illustrate the validity of the primary indicator, then it may be reasonable for the valuer to consider abstract/non-industry methods for support purposes.

AIPG's Ethics Code contains three rules that apply to IMVAL's Reasonableness principle:

1. *Rule 2.2.2 A Member shall not issue a false statement or false information which the Member knows to be false or misleading, even though directed to do so by an employer or client.*

2. *Rule 2.2.3 A Member shall avoid making sensational, exaggerated, and or unwarranted statements that may mislead or deceive members of the public or any public body.*

3. *Rule 3.3.2 A Member shall not give a professional opinion or submit a report without being as thoroughly informed as might be reasonably expected, considering the purpose for which the opinion or report is requested.*

Provided a valuer using the IMVAL Template is being reasonable in their valuation, then issues with the AIPG Ethics code that apply to the IMVAL Template are avoided.

Both IMVAL and AIPG consider the purpose for which the opinion or report is requested and recognize different intended users and uses of these assignments. Both organizations expect the valuer to be reasonable with their assignments.

## Mineral Resources/Reserves Standards and Mineral Valuations

Depending on the jurisdiction and valuation assignment, a mineral valuation may involve the consideration and application of mineral resources/reserves reporting standards. Two examples are the SME Guide for Reporting Exploration Information, Mineral Resources, and Mineral Reserves (The SME Guide) and the CRIRSCO International Reporting Template for the Public Reporting of Exploration Targets, Exploration Results, Mineral Resources and Mineral Reserves (CRIRSCO Template). Other jurisdictions may have their own mineral resources and reserves classification systems.

The SME Guide and CRIRSCO both contain standards for classification or mineral resources/reserves and included in these standards are modifying factors:

1. The SME Guide defines modifying factors as: "Modifying Factors are considerations used to convert Measured and Indicated Mineral Resources to Proven and Probable Mineral Reserves. These include, but are not restricted to, mining, processing, metallurgical, economic, marketing, legal, environmental, infrastructure, social, and governmental factors."

2. CRIRSCO defines modifying factors as: "Modifying Factors are considerations used to convert Mineral Resources to Mineral Reserves. These include, but are not restricted to, mining, processing, metallurgical, infrastructure, economic, marketing, legal, environmental, social and governmental factors."

Modifying factors in these resources/reserves standards apply to all levels of classification. An exploration stage property will typically have far less information on modifying factors than a development or production stage mineral property. Regardless, there may be attributes of the modifying factors for the mineral property that materially affect whether additional exploration and characterization efforts will lead to a viable and economic deposit. These modifying factors can materially affect the conclusions of the mineral valuation regardless of the degree of deposit delineation. Beck (2021) discusses this in detail regarding the financially feasible component of a Highest and Best Use Analysis on an undeveloped mineral property (p. 2). He also notes the high level of risk with undeveloped properties, stating that industry experience historically indicates that less than one percent of all "exploration projects" ever advance to a producing stage mine. Beck then presents two fundamental concepts: "1.) the mere presence of mineralization (i.e., a deposit), more than often not, does not equate to a mine; and 2.) It is highly probable that if an appraiser is to appropriately conclude that a property's HBU is "mining" (as of the effective date), then it is either already a mine, or at minimum, a latestage developmental project. If, however, in actuality, it is not an active mine or a late-stage developmental project as of the effective date, it is more likely that the mineral appraiser is valuing an undeveloped mineral-bearing property which may (or may not) be an exploration target, due to its implicit inability to pass the test of "financial feasibility" for a "mining" HBU. And that, in turn, is due to its inability to pass the test of "physically possible", simply because there exists, to date, no demonstrated mineral resource base" (Beck, 2021, p. 4).

## Compounding Effect of Mistakes or Ethical Errors in Valuation Assignments

Nobody is perfect and we all make mistakes. Valuation Standards recognize this and generally look for valuers to apply recognized methods and techniques, avoid substantial errors of omission, and not make a series of errors that when combined affects the credibility of the valuation assignment.

Valuation methods under the three traditional Approaches to Value (Cost, Market, Income) generally require data collection, analyses, comparisons, and calculations to derive an indicator of value. Calculations are typically based on multiple data points, and therefore the opportunity for a mathematical error or series of mathematical errors is always an apparent concern. However, there can be more substantial areas of concern in mineral valuation than just mathematical errors as discussed in the following paragraphs.

The court systems historically prefer Market Approach based methods, as the value is related to an actual transaction of an interest. Despite the court's preference and perceived comfort with using "actual transactions", there are substantial areas within the Market Approach where a valuer could be deemed incompetent and not in compliance with an Ethics Code if a series of mistakes or ethical errors occur.

The most comparable transaction to a subject mineral interest would ideally be an arm's length sale of the subject itself, on the effective date of analyses, between willing and knowledgeable independent parties each acting in their own best interest, under no duress, for cash consideration in the equivalent currency, and no special or creative financing. Naturally, this seldom occurs in the real world, and valuers thus try to find similar transactions to the subject interest and ideally make minimal adjustments to place the transactions on a comparable basis to the subject interest.

Mineral interest valuations utilizing transaction-based methods for certain types of minerals may require analyses of non-domestic mineral transaction data. International transaction based mineral valuations can be complex due to differences in currency, governments, policy, risk, and other factors. A valuer using non-domestic transactional data might not understand the nature of the data being utilized. Several examples of areas of concern are as follows:

Transaction Equivalence: Mineral project transactions may also include ownership/ownership interests in a business, Royalty and Development rights/costs, stock purchases, assumption of debt/obligations, bonus/installment payments, options, and/or complex purchase structures. If the mineral interest component cannot be isolated and determined in terms of cash equivalence, the transaction would be misleading.

Adjustments: The misapplication of a few transactional or property adjustments without support could cause a significant error, based on the methodology.

Stage of Development: A transaction of an undeveloped mineral resource is not a good comparable to a mineral reserve that is already in production. Beck discusses the inappropriate use of the Income Approach on properties that do not have mineral reserves or demonstrate financial feasibility (Beck, 2021, p.3). Similarly, using a transaction of a producing mineral reserve for an undeveloped mineral resource presents issues of comparability.

Technical Data: If the Subject Interest does not have the technical studies (resources/reserves, scoping, Preliminary Economic Analyses, pre-feasibility studies, feasibility studies, etc.) that are comparable (in quality and definitions) to the Transaction, then those transactions present comparability issues.

Country Risk: Countries and states or provinces have different "risks", and these risks are studied extensively by Intelligence Agencies, Governments, and many others. Not considering country, state, or provincial risk can have significant impacts to transactions if adjustments for risk are not considered.

Government/Law: Based on differences in Country Governments, law and policy may alter the concept of "equivalent" transactions. For example, a Sovereignty might grant a mining company the privilege to explore, finance and develop minerals, while the Mining company pays royalty and possibly other concessions to the Sovereignty. This could present a serious error in the valuation, if Governmental differences exist, but are not considered.

Valuation professionals should be aware of professional ethics and competence issues that might arise when working with transactional data to stay in compliance.

## Valuation Differences in Mineral Properties

Mineral Properties under the various mineral valuation standards are generally categorized into four stages of development:

1. Exploration properties - actively explored for mineral deposits/resource and economic viability has not been demonstrated
2. Resource properties - contains a mineral resource/economic viability has not been demonstrated
3. Development properties - demonstrated to be economically viable/not yet in production
4. Production properties - active mineral producing operation

Mineral valuation methodology is very dependent on the stage of development. Only a small percentage of mineral deposits/properties worldwide become producing and sustainable mineral properties. There are significant risks and unknowns associated with an undeveloped mineral property and supporting assessments and studies are performed to assess and characterize these risks.

Evaluation Services, which differ from Valuation Services, might evaluate an exploration or resource stage mineral property using preliminary inputs and consider an Income Approach Method to determine a Net Present Value (NPV) for a preliminary assessment of project viability and/or the decision to further develop. "Back of the envelope" calculations, based on known grades, potential mineralization extent, mineral prices and/or consideration of SME's or CRIRSCO's modifying factors are helpful to demonstrate if an exploration or resource stage mineral property has little or no mineral value/potential, and therefore mining is likely not the "highest and best use" of the mineral interest. However, this is not the same as a Mineral Interest Valuation for these stages of mineral properties.

Exploration and resource stage mineral properties typically have limited to no technical evaluation data, and the risk/benefit of producing and sustaining income has not been determined. These stages of mineral properties are typically

not valued using Income Approach methods that consider the present value of future benefits, as the risk/benefits and other factors are unknown or not well known. These stages of mineral properties are typically valued using Cost Approach methods based on actual expenditures and/or Market Approach methods that ideally use mineral interest transactions with similar physical, legal and economic characteristics, and similar stages of development.

Development and Production stage mineral properties typically have some to extensive technical evaluation data, and possibly actual production and income/expense data. These stages of mineral properties are often valued using Income Approach Methods, with consideration of risks and contingencies for valuation purposes. Market approach methods ideally using mineral properties with similar physical, legal and economic characteristics and similar stages of development might also be performed for these stages of mineral properties.

Each mineral commodity has different markets, factors and prices, and the concept of perceived risk and its impact on value follow through the stages of development. An unknown/undeveloped/suspected mineral property has the highest risk, and the lowest risk is with a long term, stable, producing mineral property with an extensive history of production and no known risks. Naturally, a buyer would pay less for a higher risk mineral property and more for a lower risk mineral property.

A knowledgeable buyer would still scrutinize an exploration or resource stage property that has some Technical Evaluation work, including exploration or resource stage properties with preliminary economic assessments and even with positive Net Present Value. While Technical Evaluation assessments may indicate viability and positive returns for these stages of mineral properties, there may be actual market transactions of exploration or resource stage mineral properties (with or without technical evaluation data) that may be comparable, but different in value. A thorough understanding of the risks, the Technical Data and other factors would then be necessary to determine if the mineral property warrants a premium in value compared to the market, or what a reasonable value would be compared to the observed transactions.

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# Nominations Invited for AGI/ExxonMobil Exploration Teacher Leadership Academy

The American Geosciences Institute (AGI) and ExxonMobil Exploration are currently recruiting teachers for the 14th Annual Geoscience and STEM Teacher Leadership Academy for K-8 teachers. The 2022 academy will begin with an introductory webinar in early July, with the main academy experience taking place virtually July 11, 12, 13, 18, and 19.

As in past years, during the Teacher Leadership Academy, K-8 teachers from around the country will be provided with:

- activities to refresh and enhance Earth science content knowledge,
- access to and guides for hands-on STEM (science, technology, engineering, and mathematics) activities,
- resources to develop professional development workshops,
- opportunities to network with other educators, and
- experiences to share with students in the classroom and with colleagues in professional development settings.

Selected will be up to 30 participants, each of whom is recognized by their school and/or school system as having potential as a teacher leader. Learn more about the Teacher Leadership Academy online.

For more information: https://www.americangeosciences.org/news/nominations-invited-agiexxonmobil-exploration-teacher-leadership-academy-1.

# The Secondary Science

**Aaron W. Johnson, MEM-2783**
**awj@aipg.org**

I recently learned that my niece has decided to study geology. I did not influence her decision. She came to geology the way so many of us do: by taking an introductory course as part of her general education requirement, and learning in that course that the rocks have stories to tell. She's learning to read the stories in the rocks and, by extension, learning to read Earth's history.

My niece's story mirrors my own. I sat in on a geology class while I was waiting to meet with the Dean of the College of Arts and Sciences as part of my effort to be readmitted to the University after failing dismally in my first attempt at higher education. The lecture was delivered by a retired United States Marine who had a dry wit and the rare ability to make a lecture in a massive hall seem as though it was directed to you, personally. The lecture was on volcanoes, and for 50 minutes, I was entranced. After the class was over, I walked down to the front of the class, introduced myself, told the professor, Dr. Tom Moeglin, that I was trying to get back into college and that if I was successful, I wanted to study Earth Science and I wanted him to be my advisor. Dr. Moeglin said, "If Bill Cheek lets you back in, come and see me." My meeting with Dean Cheek was successful, and I left campus that day with a major field of study and a course schedule.

Stories like mine and my niece's are commonplace among geologists. Our field is not given the same pride of place in secondary education as are the other sciences. Biology is required in every high school in America. In the school my kids attend, four years of high school biology is recommended. My kids will also take two years of high school chemistry, and a year of physics. To be fair, the chemistry and physics are not required; my kids have stated their respective interests in medicine and engineering and are taking courses to help them prepare to major in those fields when they go off to college. Still, earth science is not required. In most public schools, earth science is offered in junior high (generally to 8th grade students) and then forgotten. Students get no exposure to earth science for the rest of their high school career. Their next exposure is often when they take Introduction to Physical Geology as part of their General Education curriculum in college. There, very few will recognize that they want to learn to read the stories recorded in rocks. They will begin their journey to becoming a geologist.

I spent nine years teaching geology at a regional university with an enrollment of about 6,000 students. Each year, the incoming freshman class would make their way to campus for an early visit. As part of that visit, departments would provide a one-day introduction for students to faculty and programs, helping to acclimate the students to their new academic home. Our program was part of the Department of Natural Sciences and shared that introductory visit with biology, chemistry, and physics. Biology was always the largest group with more than 100 new majors each fall. Chemistry was generally the second largest and physics was close behind, primarily because of their emerging nanotechnology degree. Geology was always a distant last in terms of the number of new students. During my time at the university, we never had more than three students come to the campus as geology majors. The vast majority of students in our program, which had about 60 students majoring in geology, came from those introductory courses where they learned that rocks have stories to tell. It's not just anecdotal evidence: according to the American Geosciences Institute, more than 65% of students majoring in geology didn't become geology majors until after they started their post-secondary studies.

If it seems as if our field is at a disadvantage compared to the other hard sciences, it's because we are. The factors behind this disadvantage are varied. First, geology is a small field, especially compared to the number of jobs in biology (which includes pretty much all medicine) and chemistry. Second, geology is often viewed as a secondary science. We geologists use biology, chemistry, physics, and mathematics to better understand earth. I've heard more than one college administrator refer to geology, with disdain, as a "derivative science." Third, geology is inherently field-based because Earth is our laboratory. It's difficult to create a high-quality geology course of any kind without a field component. But field trips are expensive, especially when designed to provide access for all students. Finally, we face the inertia of an administrative system that is entrenched combined with public school faculty who often are over-worked and underpaid, leaving little time to make meaningful changes to curricula.

What does this mean for our field? It means that we have an opportunity to make meaningful change. We can become active in our local public schools, by speaking to science classes, by leading field trips, or by running for a spot on the local school board. We can reach out to colleges and universities to have a voice on campus, as AIPG does in so many places with our student chapters. Our professional organizations can work directly with colleges and universities to provide a better understanding of the skills and knowledge that geoscience companies value in new hires. We can reach out to local and national legislators to help raise awareness of the outsized importance of our profession relative to the number of working geologists in the United States. It is incumbent upon us to use our voices to spur a change in the way our field is perceived in secondary and higher education. We have an opportunity. We must have the vision and courage to seize it.

I wish each of you the very best this spring,

**Aaron**

# Challenges & Opportunities

**Matthew Rhoades, CPG-7837**
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Anyone who has ever spent any amount of time managing any type of endeavor is aware of the inherent 'challenges' in such endeavors. Whether you've been a task manger, project manager, program manager, group manager, study manager or a deputy to any of those roles, you are aware of the 'challenges' that can present themselves at any turn in the future. I learned quite a bit about 'challenges' early in my career as an alternative type of 'polite-speak' wherein you did not elect to relate all of the travails and setbacks you or your team experienced on your way to successful completion of the mission. Blind alleys, mis-directions, personnel calamities, fiscal shortcomings, technical failures and strained client relationships can all be grouped accordingly under the heading of 'challenge' as you and your team trod forward. Such challenges are inevitable as we continue to include human beings in all of our endeavors. More often than not, the 'challenges' are somehow rooted in our 'human-ness' and our varying ideas of what successful completion of any project looks like.

You would think from the paragraph above that all 'challenges' are inherently negative and somehow diminishing. I would posit the exact opposite. Challenges are character and skill-building events that are to be leveraged for all they are worth. Challenges are the very root of all technical and professional growth opportunities. As an example, I have long held the belief that any team in any sport experiences rapidly diminishing prospects of completing a season as an undefeated contender. Why? The underlying reason is that success is a very poor teacher. With each successful 'win', the coach has less and less to work with. We learn very little in success and we learn less and less with each continued success. Failure is the ultimate teacher for those that are willing to learn; those introspective few who are willing to walk away from a hairy setback to ponder what they could've done better or more completely to have perhaps guided the events in a different direction.

The AIPG is an aggregation of geologists; each with her or his own view of what professional success looks like. Within the Institute, we have our own definitions of what constitutes professionalism and professional conduct. We cannot define success for the individual, however. It is incumbent on that geologist to formulate their own ideas of what professional success will look and feel like. It is the mission of the Institute to provide as many conduits as possible for its members to divine success.

Within this context of challenges and opportunities, it is important to understand that growth, along with challenges, provides another valuable opportunity for personal and professional development. A philosopher much brighter than me once stated that, "You will be exactly the same person at this time next year as you are today, with exception of the books that you read, and the people that you meet." If there were plenty of opportunities to meet other geologists from all walks and learn from their experiences; wouldn't that pose a value in itself? That is one of the value propositions of AIPG; the opportunities to meet other geologists from all walks and learn from their experiences.

> "If there were plenty of opportunities to meet other geologists from all walks and learn from their experiences; wouldn't that pose a value in itself?

The ramblings above are meant to serve an important point. All of us members of AIPG need to attract and recruit new members to our ranks with the promise that we are here to advance their individual ideas of what success might look like for them individually. I have had my own circuitous career path that I don't think I would wish on anyone. Some others find it oddly enviable. With continued growth in our ranks, the potential for synergies becomes endless. If you know an individual or group of geologists that would benefit from joining AIPG, now is not the time to be shy. It is the time to have a direct, candid discussion about who we are and what we do.

**Answers on Page 34-35**

**Robert G. Font, CPG-03953**
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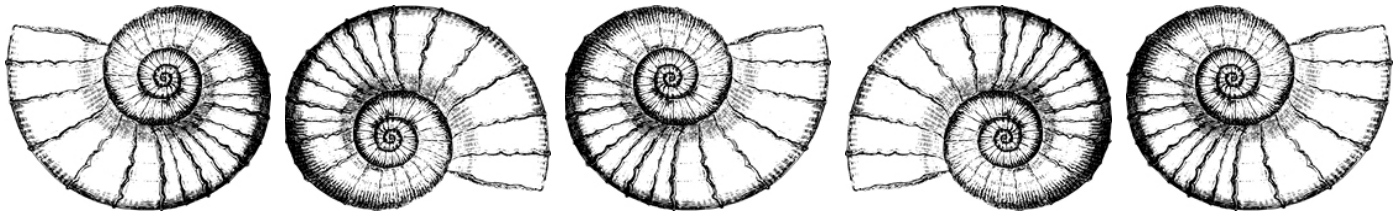
**1.** The chemical reaction $NaAlSi_3O_8 + 4½H_2O + H^+ \Rightarrow Na^+ + 2\ Si(OH)_4 + ½Al_2Si_2O_5(OH)_4$ is best described as an example of this earth process:

a) Diastrophism.
b) Metasomatism.
c) Diagenesis.
d) Dude, I flunked chemistry, but stay hydrated by drinking lots of $H_2O_2$.

**2.** At an outcrop we spot a "septarian." What have we found?

a) A type of concretion.
b) A plant-eating sauropod of the Late Cretaceous.
c) An ammonite showing septa or the walls separating its internal chambers.
d) A strange-looking 70+ year-old dude collecting rock samples.



**3.** In our field work we find a well-cemented sedimentary rock consisting of particles averaging 1 millimeter in diameter. What choice below would best describe this lithologic unit?

a) Sandstone.
b) Siltstone.
c) Conglomerate.
d) I can't answer this now, hombre. I'm looking for my "lost shaker of salt."

**4.** We have unearthed the skeletal remains of "dimetrodon" from a given rock formation. Which Series/Epoch or Stage/Age defines the geologic time frame of this stratigraphic unit?

a) Cisuralian.
b) Kimmeridgian.
c) Cenomanian.
d) This is a mean one, dude!

**5.** The "divergence" (div) of a vector field ($\hat{w}$) at a point describes the tendency of the field to expand or diverge from the point. "Divergence" is a scalar quantity. One area of application of "divergence" in the geological sciences concerns fluid flow. Consider a case of steady-state flow with velocity $\hat{\mathbf{w}} = \mathbf{x\hat{i}} + \mathbf{y\hat{j}}$

If div $\hat{\mathbf{w}} \neq 0$, what does this tell us about our fluid?

a) The fluid is non-Newtonian.
b) The fluid is compressible.
c) The fluid is incompressible.
d) Hey dude, I say let's drink this fluid! Sounds like aquavit to me. Skål!

**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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## The Responsibilities of and Restrictions on AIPG Officers and Officials

AIPG Officers and Officials include the members of the National and Section Executive Committees and members of the various National and Section Committees (both standing and ad hoc). The AIPG Policy on Advocacy (7/12/86) places limits on statements by AIPG Officers and Officials on behalf of the Institute acting in their official capacities. Specifically, the AIPG Policy on Advocacy states, "Public positions adopted by AIPG, and statements issued on its behalf, must be based on sound evidence and must reflect the opinions of its Members, consistent with an appropriate poll of Section or Institute Members." The AIPG Bylaws §6.3 Limitation of Authority specify that, "No Member or Adjunct shall have the authority to speak or act for the Institute, except by express delegation of authority from the Executive Committee or the President." The AIPG's Code of Ethics' provisions on honesty, diversity, and inclusiveness, and against harassment and discrimination (Standards 4.2, 4.3, and 4.4) can also apply to statements by officers and officials acting in their official capacities. An AIPG Member or Adjunct is speaking, writing, or acting for the Institute when Member's or Adjunct's official position is stated in the document, presentation, signature line, or otherwise made clear in the relevant document(s) and statement(s), for example, "John Doe, President of the Vermont Section, AIPG" or in a President's Letter or Editor's Comments in *The Professional Geologist* or a Section newsletter.

National and Section Presidents issue most of the documents and statements addressing official positions and policies. While such documents or statements can contain personal opinions, these opinions must be clearly identified as such and, if the opinion differs from an Institute or Section position or policy, that difference must also be clearly identified and the relevant Institute or Section position or policy stated as well. Those AIPG Members or Adjuncts acting in their official capacities should keep the foregoing precepts in mind. Jessica Davey's (then YP-413, now MEM-3242) article, "Addressing Bias and Ethical Issues in AIPG Communications," (*TPG*, Jul/Aug/Sep '19) provides an excellent discussion of these concepts including an example of an inappropriate statement by a Section officer.

## Rebuilding Restrictions After the Marshall Fire?

The December 30th urban wildfire in Superior and Louisville, Colorado made international TV news due to the spectacular pictures of burning homes.[1] The fire was named the Marshall Fire for the small hamlet just south of the city of Boulder where the fire started. The exact cause of the fire is still undetermined but the combination of 100+ mph winds (not that uncommon in the area), the lack of moisture for the preceding six months, and the ignition of fields of long, dry grass resulted in a large, rapidly moving fire front. A downed telecommunications line (unlikely), the burning of a shed on private property, and ignition by the burning underground coal are currently being examined as causes.[2] It may be that a combination of two or more of these origin points may be involved. Over 1,000 homes and some businesses were burned to their foundations within an area of over 6,000 acres.

Dr. Lauren Gifford, a geographer who focuses on climate policy, was interviewed on TV and expressed her anger and frustration that despite 15 years of urging action to reduce atmospheric $CO_2$ very little meaningful action has been taken despite increasing public support for $CO_2$ reduction. Various federal, state, and local government leaders including President Biden, Governor Polis, and others have promised that lasting help will be available when the burned subdivisions are rebuilt. This rebuilding could include meaningful steps in reducing fossil fuel use by prohibiting the use of natural gas for heating, cooking, and other uses in the rebuilt homes (natural gas is by far the most common heating method in the Colorado Front Range). In addition, requiring the use of fire-resistant exterior building materials would seem like a reasonable requirement. Reportedly, the use of fire-resistant exterior building materials would not materially alter reconstruction costs. Rebuilding with these restrictions would provide a significant demonstration of the viability of such restrictions. Will such re-building restrictions be required? Do you think they will be? If not, why?

One argument against the natural gas restriction is that home heating, cooking, and other home uses of natural gas represent only a minor amount of the $CO_2$ produced by burning fossil fuels each year and therefore would not represent a truly meaningful step in the reduction of annual $CO_2$ production. How strong an argument do you think this is? Your thoughts on the subject are welcomed.

*Continued on p. 36*

1. Marshall is located at the west end of the Boulder-Weld coal field that extends east through Superior and Louisville to Erie. Marshall has remained a hamlet due to the burning coal seams in the area.
2. The burning coal started a small fire in the area in 2006. A burning coal seam started a significant wild fire west of Glenwood Springs in 2002.

## Answers:

**1.** The answer is choice "c" or "Diagenesis."

Diagenesis defines all processes (mainly chemical) that sediments may undergo from deposition to lithification as they become rock (early phase diagenesis) and afterwards before they first experience metamorphism (late phase diagenesis or epigenesis).

The transformation of sodium plagioclase feldspar [albite or $NaAlSi_3O_8$] into a clay mineral [kaolinite or $Al_2Si_2O_5(OH)_4$] via chemical weathering is an example of diagenesis:

$$NaAlSi_3O8 + 4½\ H_2O + H^+ \Rightarrow Na^+ + 2\ Si(OH)_4 + ½Al_2Si_2O_5(OH)_4$$

Diastrophism is equivalent to tectonism or deformation of the earth's crust involving fracturing, faulting, folding and the reshaping of the earth's surface through rock movements and displacements. Diastrophism encompasses the deformation through which major features of the earth's crust are formed including continents, ocean basins, mountain belts, plateaus, rift valleys, etc.

Metasomatism is a metamorphic process or the chemical alteration of rocks by hydrothermal solutions or other fluids resulting in the replacement of one rock by another of different mineralogical and chemical composition. For example, in a stage of an ore-forming process, garnet may be replaced by quartz, calcite and magnetite as illustrated by the chemical formula shown below:

$$3Ca_3Fe_2Si_3O_{12} + 3HCO_3^- + 15\ H^+ \Rightarrow 3CaCO_3 + 9SiO_2 + 2Fe_3O_4 + 6Ca^{2+} + 9H_2O + O$$

Finally, I would not advise hydrating yourself with hydrogen peroxide ($H_2O_2$).

**2.** The answer is choice "a" or "A type of concretion."

"Septarian" concretions are nodules typically made of calcite, clay-rich carbonate material or iron compounds. The nodule is interlaced within by a network of cracks that are filled in with calcite or other mineral matter.

Sorry, no dinosaurs here.

Ammonites are cephalopods distinguished by their "septa" or the thin, dividing walls that separate the internal chambers of the shell.

A 70+ year-old dude is a "septuagenarian."

**3.** Given our possible choices, the answer is choice "a" or "Sandstone."

Please refer to the Wentworth Scale of sediment grain size shown below:

| Particle Size in millimeter | Wentworth class |
|---|---|
| >256 | Boulder |
| 64 to 256 | Cobble |
| 2 to 64 | Pebble to Granule |
| 1/16 to 2 | Sand |
| 1/256 to 1/16 | Silt |
| <1/256 | Clay |

**4.** The answer is choice "a" or "Cisuralian"; the oldest Series/Epoch of the Permian Period (see table below). Dimetrodon is an extinct genus of a non-mammalian synapsids (creatures more related to mammals than to reptiles or birds). The animal's most prominent feature was the large neural spine sail on its back formed by elongated spines extending from the vertebrae. As indicated, Dimetrodon lived during the Lower Permian, approximately 272–298 million years ago.

| Epochs of the Permian Period | Approximate time range in Mya |
|---|---|
| Lopingian | 251-259 |
| Guadalupian | 259-272 |
| Cisuralian | 272-298 |

"Kimmeridgian" refers to the middle Stage/Age of the Upper Jurassic Epoch. "Cenomanian" is the oldest Stage/Age of the Upper Cretaceous Epoch.

## Answers: *(cont.)*

**5.** The answer is choice "b" or "The fluid is compressible."

For an incompressible fluid the div $\hat{w} = 0$. This is not our case.

We do not know what the fluid is in this example or how viscosity changes with stress.

If a force is applied to a "compressible" fluid, its density changes. If a force is applied to an "incompressible" fluid, its density does not change (density change is negligible). A non-Newtonian fluid is one in which the viscosity can change under stress. Newtonian fluids have constant viscosity with varying velocities of flow.

In our specific case, what we know is that:

$\hat{w} = x\hat{i} + y\hat{j}$ (1)

Then,

$\text{div } \hat{w} = \partial w_1/\partial x + \partial w_2/\partial y + \partial w_3/\partial z$ (2)

Since our example is in 2-D the term $\partial w3/\partial z$ does not apply to equation (1), and we may rewrite (2) as:

$\text{div } \hat{w} = \partial w_1/\partial x + \partial w_2/\partial y$ (3)

Taking the partial derivatives of equation (1) with respect to x and y:

$\text{div } \hat{w} = 1+1 = 2 \neq 0$ (4)

Equation (4) shows that our fluid is not "incompressible." Thus, it is "compressible" and choice "b" is our best answer.

## Errata

Regarding question 2 in the January-February-March 2022 issue, it was pointed out to me that my answer was correct and properly explained, but that when I summarized the information in table form, the data for brass and bronze were flipped. The correction is shown below. My thanks to Cecia Bicknell, ECP-0417 and Pat Mulvany, PhD, RG, MEM-0658 for catching the misprint!

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

Robert Font, CPG-3953

*Continued from p. 33*

## Comments on Good CV Practice

As one progresses through one's professional career the information contained within a resumé or CV frequently changes. Your professional position changes; your employer changes; your educational qualifications, professional memberships, professional committee and/or officer status, address, other contact information, etc. all change over time. Although one may be a member of AIPG or similar professional association throughout one's career, the membership grade can change. Officer positions are generally only held for a year or two. Committee assignments may also be time limited. Membership in a professional association may only last a few years. Likewise, a state PG license may only be held for a few years.

One's CV must be regularly brought up to date to reflect one's current professional status. Each time a CV is updated, the CV should be dated. My review of many CVs shows that many are undated.[3] A CV attached to a Qualified Person's report prepared 10 years ago should be current as of the CP report's date. However, a 10-year-old CV cannot be simply copied and attached to a current report without review and updating. Failure to do so violates Standard 2.2 of the AIPG Code of Ethics, "Members shall be accurate, truthful, and candid in all communications with the public" and the three rules thereunder. Discipline for failure to keep your CV current can vary from an advisory or cautionary letter through membership suspension or expulsion from AIPG on depending on the facts and circumstances. In summary, keep your CV current and date it each time a change is made.

## Sealing draft documents

The Autumn 2021 Newsletter of the Texas Board of Professional Geologists presented the question, "Should I seal a draft document?" The TBPG's answer was, "No, draft documents should not be sealed according to TAC §851.156(k). However, the rule does state that preliminary documents need to be signed in the following way: "Preliminary documents released from their control shall identify the purpose of the document, the Professional Geoscientist of record and the Professional Geoscientist license number, and the release date by placing the following text or similar wording instead of a seal: "This document is released for the purpose of (Examples: interim review, mark-up, drafting) under the authority of (Example: Leslie H. Doe, P.G. 0112) on (date). It is not to be used for (Examples: construction, bidding, permit) purposes."

This question and answer recognize that draft reports are commonly sent to clients for their review for corrections and comments prior to finalization. As noted, Texas requires that such draft or preliminary documents should not be sealed but should include appropriate cautionary language. Other states may have different rules.

The last paragraph of AIPG's Policy on the Use of Professional Seals (amended 6/11/11) states, "AIPG recommends legal proscriptions against the making of changes to a document sealed by a professional geologist. If changes are required, either a new document incorporating the changes shall be prepared, or an addendum noting the changes shall be made. Each document, original, new, or addendum, is the professional responsibility of the document's author(s)." AIPG therefore does not support sealing or stamping draft reports sent to a client for review. The draft report should clearly indicate that it is a draft for review by specified parties only, that it is not final, and should not be sealed. Please share relevant experiences or additional comments on this issue.

## Limits on individual freedom

I first addressed this question in two topics in Column 179 (Oct/Nov/Dec '21). In the discussion of "Honesty and Trust," I commented in that column to the initial survey about planned attendance at the Annual Meeting in Sacramento stating, "AIPG will host its National Conference as an in-person-event experience where all individuals on-site, including attendees, guests, speakers, staff, and venue personnel, remain safe and comfortable throughout our event.' AIPG will have to trust that those attending the Annual Meeting will honestly disclose their vaccination status and wear masks, or not, as appropriate. Canon 1 of the AIPG Code of Ethics addresses honesty, personal integrity, and professional conduct. Canon 2 address protecting the public's health, safety, and welfare. Mask wearing in professional settings like professional meetings involves both these Canons."

The discussion about "Can an individual's freedom be limited?" addressed the issues presented in Adam Heft's (CPG-10265) Editor's Corner, "Are Rules Just Meant to be Broken?" in the Jul/Aug/Sep '21 *TPG*. Heft's question strikes me as an example of the "personal freedom to do whatever I want" versus "protection of the public's safety" conflict that has characterized debates over mandatory mask wearing during the Covid-19 pandemic. At their most basic level, all moral and ethical rules (and laws) place limits on an individual's right to do whatever he/she/they wants. My analysis in this discussion states "exceptions to these [moral rules] are generally *not* justified" (italics added here).

As I write this in early February, the debate over mask wearing and vaccination continues, particularly over mandates to wear masks and get vaccinated as a condition of employment in many instances. Early February data from the Center for Disease Control showed that overall, 76% of the whole population has received at least one dose and 65% are considered fully vaccinated. The low percentage of childhood vaccination is inconsistent with the generally stated desire that children return to in-classroom learning. A February 4th press release from UCHealth (University of Colorado Health Science) noted that "Omicron has peaked. Will the Covid-19 pandemic ever end?" As a result, mask mandates are falling around the country. But is this too soon? Many people think so and continue to wear masks in closed public places and require masking in their indoor places of business. Last summer when vaccines finally were generally available for adults in the US, many felt and hoped that the pandemic would soon be over and mask wearing dropped off significantly. Then the delta and subsequent omicron variants caused new surges in infections and the reimposition of masking and vaccination mandates.

Everyone agrees that mask-wearing is annoying and restricting for a variety of reasons. But wearing high-quality masks demonstrably helps prevent infections, so most people comply with the mandates. Even in places where masking mandates are being lifted,

3. I assess professional development logs for the Australasian Institute of Mining and Metallurgy. Submission of a current CV is part of the information required for the assessment.

50% of the people will continue to wear mask in indoor venues until the number of Covid-19 cases that the positivity-infection rate drop to much lower levels (<5% positivity). Many of those objecting to mandatory vaccinations (those with valid medical and religious objections excluded) and mask-wearing mandates see these mandates as impinging on their personal freedom to act as they see fit, which they view as a fundamental right, the freedom to individually do as they please. Many objectors are becoming increasingly vocal about their beliefs and impolite to those insisting on mandates. They could, incorrectly, point to Bernard Gert's fourth moral rule, "Do not deprive of freedom," as justification of their position.

> "Those citing "freedom" as the basis for their objections to mandates need to remember that their freedom is an act no more fundamental than my freedom from being negatively acted upon.

As regular readers of these columns know, I find Bernard Gert's analyses of morality as fundamental.[4] Gert (2004) states, "Common morality is the only guide for governing our behavior towards others that is based on nothing more the universal features of our common human nature such as our fallibility, rationality, and vulnerability." Gert (1998) defines, "Morality is an informal public system applying to all rational persons, governing behavior that affects others, and includes what are commonly known as moral rules, ideals, and virtues and has the lessening of evil or harm as its goal." The phrases "governing our behavior towards others" and "governing behavior that affects others" are key fundamental elements in discussions of morality and ethics.[5] As Gert (1998) points out, "Do not deprive of freedom" is "a [moral] rule prohibiting, limiting, or preventing the exercise of one's ability [or activities]." Gert continues, "the deprivation of freedom is also the deprivation of freedom from being acted on." "This is especially true with the disabling [e.g. becoming ill], if it is to be called that, is temporary." Gert is here pointing out that the rule in question could be viewed as violating Gert's third general moral rule, "Do not disable," or his fourth moral rule, "Do not deprive of freedom." Gert argues that which of these moral rules is being violated does not matter stating, "Undecidable cases are unimportant, because there are rules prohibiting taking away both." Spreading disease can cause at least loss of freedom or disability due confinement causes by sickness or quarantine.

It is here that Gert's phrases "governing our behavior towards others" and "governing behavior that affects others" are key fundamental parts of his definition common morality. Here is where the freedom from being acted upon becomes significant. Gert (2004) cites the example of intentionally touching someone who one knows does not want to be touched violates the "Do not deprive of freedom" rule. Here is where mandated mask wearing and vaccination, which are known to reduce the spread of an infection like Covid-19, are morally justified exceptions to the "Do not deprive of freedom" rule. Long-standing quarantine rules and the shunning of those believed to be carrying bubonic plague or lepers are classic examples.[6] You cannot morally deprive me of freedom from disease or temporarily disable me by passing me your germs. The mask wearing and vaccination mandates apply only to group settings. Those who remain in the privacy of their own homes can choose whether or not to get vaccinated and do not have to wear a mask, unless they can infect family members. The mandates affect behavior that affects others and serve to limit others' freedom from infection or from disability due to sickness. Mandates are morally justified by the "What harm is avoided by the moral rule's violation?" exception to the moral rules. Those citing "freedom" as the basis for their objections to mandates need to remember that their freedom is an act no more fundamental than my freedom from being negatively acted upon.

## Your contributions to future PE&P columns welcomed

PE&P Column #1 appeared in the November 1995 *TPG*. 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. 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–≈350 words. Longer discussions—≈650+ words—warrant being individual articles. Both shorter and longer contributions are welcome. 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.

4. Bernard Gert, 1998, *Morality: its nature and justification*, Oxford University Press, 408 p., and 2004, *Common morality: deciding what to do*, Oxford University Press, 179 p. The 1998 book is the philosophy professor's carefully worded, professional level statement while the shorter 2004 book presents Gert's ideas in a more readable form.

5. My personal distinction between morals and ethics is that morals, as Gert recognizes, are an informal and universally recognized system while ethics are formally written statements or codes like the AIPG Code of Ethics.

6. An exception to the "do not infect others" rule applied prior to the 1960s when children were encouraged to play with the neighbor kid who had mumps, measles, or chicken pox because getting these diseases as a child was not nearly as serious as getting them as an adult. The development of the measles, mumps, and rubella vaccines in the 1960s ended this practice that "boomers" remember.

# Candidate for AIPG National President-Elect

**Shanna Schmitt**
**CPG-11781**
***Roseville, Minnesota***

Hello from the North Star State! I'm honored to be nominated for AIPG President-Elect. I've been involved with AIPG in the Minnesota Section and at the National level since 2006, where I gained a broad perspective of the geoscience community. The geosciences are vital to the health and happiness of all Americans, and each of us should be advocates where and when we can.

Although in my idealistic youth, I wanted to save the rainforests, I now consider myself a pragmatic environmentalist. I want to see a more robust circular and sustainable economy for the minerals and resources we extract because I enjoy the benefits of things like continuous power, clean water, smart phones, and airplanes. I think all that is possible, and I believe that a professional, ethical, and diverse geoscience community are a very important part of the process.

In 2003, I began my career as a field geologist at Terracon where field work and data analysis formed a well-rounded basis for my future endeavors. Since 2006, I have worked at the Minnesota Pollution Control Agency (MPCA), where my work has focused on the cleanup and redevelopment of Brownfield and Superfund sites. My involvement and management of these projects includes technical reviews, timeline and budget management, technical guidance and policy writing, and collaboration with geoscientists and others to find practical and sustainable solutions.

As President-Elect, I will focus on growing membership, supporting members at every stage of their careers, and advocating for professional geoscientists in industry, the regulatory community, academia, state geological surveys, and wherever geoscientist are needed to promote a sustainable standard of living. I believe this emphasis is important for ensuring the success of AIPG's mission "to be an effective advocate for the profession of geology and to service its members through activities and programs that support continuing professional development and promote high standards of ethical conduct."

## Growing membership

This consists of attracting new members as well as keeping existing members by showing them the value of our membership. This includes:

- Maintaining the CPG program for members that need the certification to practice in the geological sciences, for those operating in states without licensure, and for members benefiting from our cooperative agreements with AIPG's sister societies.
- Encouraging the state sections to share and coordinate programs and ideas to create a more robust Institute.
- Continuing to provide member testimonials, in *TPG* and on our YouTube channel, discussing geoscience career paths, the importance of networking, and regulatory tips and tricks, will show the benefits of membership.
- Encouraging, promoting, supporting, and welcoming a diverse membership.

## Supporting members and sections

Supporting members in the various stages of their careers is an important benefit and can be strengthened by:

- Making events more accessible by using technology and more inclusive by promoting a welcoming atmosphere and experience.
- Soliciting new content for our online Geoscience Online Learning Initiative (GOLI) talks.
- Encouraging and helping sections develop short courses and field trips.
- Providing resources, including mentoring opportunities, for all of our members.

## Advocating for professional geoscientists

Professional geoscientists, licensed or certified, should be part of the processes for all public health and welfare policies and procedures. This includes professional geoscience involvement in situations such as:

- Public water supply well construction.
- Ore estimations for mining permits.
- Groundwater investigations at manufacturing facilities.
- Developing legislation for emerging contaminants.

I have a lot to contribute as President-Elect. If elected, my collaboration skills and work ethic will serve the Institute well. If you have questions for me as you're filling out your ballot, please feel free to contact me directly. You can email me at shanna.schmitt@state.mn.us and find me on LinkedIn. I appreciate this opportunity to give back to the Institute in a new way. AIPG's success is due to the extraordinary professionals that are our membership. Thank you for your consideration.

# Candidate for AIPG National President-Elect

**Brent Smith**
**CPG-11130**
***Worthington, Ohio***

Hello fellow AIPG members. I am honored by the opportunity to continue to lead AIPG at the National level. I would like to give thanks to the Nominating Committee for this opportunity, and, if elected will work hard to uphold the ideals of the organization as a leader and support the growth of AIPG. I feel that my experience, motivation, and strategic ideas make me the ideal candidate for the position of President-Elect. If elected, I will draw upon the skills I have developed during my professional career and tenure with the Ohio Section and AIPG National Executive Committee to deliver the same dedication and passion for geology and AIPG at a leadership level.

As a little bit of background, growing up, my dad was very involved at the state and national level with professional organizations similar to AIPG. I fondly recall many family vacations centered on his national conferences at locations around the United States, a tradition I am continuing with my own family. Unbeknownst to me, these educational opportunities and travels laid the groundwork for my future as a geologist. Trips to places such as Arizona, Colorado, Pennsylvania, Washington, and Wyoming revealed the physical world beyond the glacially scoured plains of the Midwest. From these experiences, I developed an understanding of both the diversity of the geologic world and the core professional and personal value of involvement in organizations such as AIPG. This continued in college, where my love for geology and the natural world was cemented in through the broad assortment of courses, encouraging professors, and, of course, frequent field trips to a myriad of geologically interesting places. Following college, I found my home in environmental consulting where I am continually motivated and challenged by the diverse array of projects and clients.

> “AIPG has had an integral role in my professional life.

AIPG has had an integral role in my professional life. I joined the Ohio Section Executive Committee in 2009 as a Member-At-Large based upon the recommendation of a coworker with whom I shared the sense of volunteerism and desire to “give back” to the profession. Since my initial recruitment, I have been involved with the Ohio Section of AIPG for over 13 years. During this time, I served in a broad range of roles leading up to my election as President for 2017. During these years, we worked diligently to improve how the Ohio Section operated with the primary purpose of providing value to our members and student chapters. Specific examples of my achievements within the Ohio Section include a modernization of the Treasurer’s position through implementing electronic banking and billing, and expansion of our sponsorship program for newsletters, meetings, and events. These efforts improved Section organization and added revenue that is still used to this day to subsidize member and student activities and provide student scholarships. Additionally, the most gratifying aspect of my experience at the Ohio Section has been my involvement with the student sections. One of the most important goals of our organization is to provide mentorship to our student chapters as they represent the future of our profession and membership base. The unbridled enthusiasm, optimism, natural curiosity, and scientific prowess of the students is inspirational and reminds us of why we got into geology in the first place. With the student chapters, I helped foster mentoring opportunities through the organization of field trips and activities, presentations, section meetings, and development of scholarship opportunities.

During the 2020 virtual annual meeting, I had the honor of being appointed as an Advisory Board Representative on the 2021 National Executive Committee and was reappointed for 2022 last fall in Sacramento. As an Advisory Board Representative I’ve deepened my understanding of the organization through my interactions with both National and Section leadership. My role on the 2022 Executive Committee will further that experience and allow me the opportunity to continue the work started by current leadership. Initiatives that I look to work on in 2022 and beyond include modernizing the way we communicate with current and potential members, evaluating current membership benefits, and continued support to foster growth of our student sections. I will also continue to assist with the planning process for the 2023 Annual Meeting to be held in the greater OH-IN-KY area. This opportunity represents a partnership of multiple regional sections in a combined effort that I am proud to be a part of. Regardless of the outcome of the election, I will continue listening to our members and developing initiatives that will foster membership and professional growth opportunities during the coming years.

In closing, I’d like to thank you for reading my message, and to leave you with the confidence that, should you elect me as President, I will execute my role with the same level of passion and effort that I have dedicated to the Ohio Section and my career.

# Candidate for AIPG National Vice President

**David Heidlauf**
**CPG-9365**
***Chicago, Illinois***

I am humbly honored to be nominated for the 2023 AIPG Vice President position. If elected, I commit to provide leadership and coordination to the advisory board and to support the initiatives of the 2023 AIPG President, Dawn Garcia. I believe my service on the National Executive Committee as Treasurer this last year and a half has provided me a solid foundation and understanding of the roles and responsibilities of the National Executive Committee, the important issues and challenges facing our organization, a working knowledge of our headquarters staff and incoming President. I view the continued service on the National Executive Committee as Vice President as a further opportunity to give back to the organization and profession that I believe in.

Being a member of AIPG has enriched my professional growth as an applied environmental hydrogeologist. My vision for AIPG is to spark, encourage, challenge the upcoming generation of applied geology professionals to meet the world's evolving challenges. Committed young geology professionals are needed to address responsible resource development with environmental stewardship in the context of an increasing world population, climate change, and finite resources.

> "Being a member of AIPG has enriched my professional growth as an applied environmental hydrogeologist.

My love for geology began with visiting the mountains and multiple national parks during summer family vacations as a kid. Like many, I did not go to college seeking to become a geologist, but quickly caught the bug my sophomore year with my first geology course in historical geology. I soon embarked on a path to equip myself for a career as a petroleum exploration geologist by completing a Bachelor's in geology, working on Oklahoma deep gas rigs and completing a Master's degree in clastic sedimentology.

Life circumstances, however, taught me a valuable lesson in the boom-and-bust cycle of our cherished vocation. My job prospects in the petroleum industry disappeared in late 1985 as my fiancée and I were finishing our graduate studies in geology. After a short active duty stint with the Army, I secured my first position as an environmental geologist in 1987 with no prior hydrogeology coursework. Early in my career I learned the tools of an environmental hydrogeologist through night courses, correspondence courses, short courses, conferences and on-the-job training. My career has entailed employment with four environmental consulting firms with a variety of diverse projects across the country.

I first joined AIPG in 1994 to gain the credentials of the certified professional geologist (CPG) registration and quickly came to value network of professional colleagues at other firms that I developed through attendance at our local Illinois/Indiana sectional meetings. Around twelve years ago I increased my engagement in AIPG at both the sectional and national meetings. Within my section, I joined our local board and have served as the field trip coordinator and am currently serving as the section's Vice President. Through my participation in national meetings since 2011; I have come to value a broader network of professional colleagues from many different sectors of our profession.

Having enjoyed a great education and employment as an applied geologist, I now want to focus some of my time investing in the future generation of geologists to support their education and employment as young professionals. Locally, I support and am engaged with my undergraduate geology department where my wife has served as an adjunct geology instructor for the last 23 years. As a recruiter of young geology professionals for my firm, I find it challenging that the current generation of students seem more attracted to policy-based environmental science versus more traditional hard geoscience programs. I also am concerned about the recent trend of many respected geology graduate programs of eliminating their Master's degree track. I have long viewed the Master's degree as the preferred applied geologist working degree. I am concerned that the current educational pipeline will be not adequate to supply the applied geological workforce needs of the future.

Looking forward, I believe AIPG should encourage responsible resource development, environmental stewardship, balancing energy types and needs with $CO_2$ footprint and client change and supporting access to life giving clean drinking water around the world. I believe these aspirational sustainability themes are many of the issues that the younger generation highly value and AIPG embracing these themes has the potential to make membership and participation in our organization more relevant and desirable to the next generation of applied geology professionals.

# Candidate for AIPG National Vice President

**Dennis Pennington**
**CPG-4401**
***Ambler, Pennsylvania***

From the beginning of my career, I have served the Institute in any way I could. AIPG is an important organization in promoting professionalism and integrity. I would like to continue to help AIPG in this complicated time with bringing experience and service to the National Executive Committee. Because my time as National President was cut short by a medical issue in 2000, I want to help with guiding AIPG through problems and making AIPG as strong as possible. It has been a pleasure working with the AIPG staff over the years. Regional programs, young professional development, membership development as well as making AIPG an important and desirable part of a career of any member are just some of the ways I feel I can contribute. By being involved at the national level, I can ensure development of new programs and continue with extending existing programs.

> “AIPG is an important organization in promoting professionalism and integrity.

**My experience is as follows:**

Past National President (2000), Pennsylvania Section President (two different terms); represented AIPG internationally in Europe and Canadian Council of Professional Geologists; organized several AIPG Pennsylvania regional meetings from 2014 through 2019; established an AIPG student chapter at Temple University; represented AIPG at booths at GSA meetings; and created AIPG national undergraduate scholarship program (2000). I am currently serving on AIPG education and other committees. I would appreciate your vote and look forward to serving you as Vice President if elected.

# Foundation of the American Institute of Professional Geologists In Appreciation of Generous Supporters in 2021

The Foundation of the American Institute of Professional Geologists is appreciative of the donations received during 2021. As for many, 2021 was 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 and to view the List of Donors for 2021.

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 H. Murphy, RG, CPG
Chairperson, Foundation of the AIPG

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

# Candidate for AIPG National Treasurer

**Bill Brab**
**CPG-11693**
***Richmond, Kentucky***

Looking back through previous *TPG* articles at examples of my predecessors' visions, what I found were some excellent parallels with my values and thoughts for what makes Geologists and AIPG unique in the professional realm among their peers. There are many admirable qualities across all ages and disciplines of our respective areas of geological expertise, but there are also equal or greater occurrences of (excuse the pun) faults amongst our peers and within our profession that rival the typical schoolyard. One of the reoccurring topics that many articles centered on was the need for continuing education (CE), especially after we leave academia and build our careers.

Stories during our Kentucky Section Executive Committee Meetings describe the difficulties encountered to pass legislation for PG Registration. A topic resurfaces frequently and usually coincides with the election of a new officer: why does Kentucky not require CE for Professional Licensure? Seasoned members that were active and involved with getting the bill before legislators recall having to yield the CE requirement to a small, but powerful, few geologists in an effort to prevent blockage of the bill. Why the resistance to CE?

The EPA Federal Register 2015 guidance concerning the disposal of Coal Combustible Residuals (CCR) waste is a citable example that should concern any geologist, stating that geologists are often considered less credible than engineers because of something as fundamental as the CE requirement and we are not seen as peers because are not held to rigorous standards:

*"EPA is not convinced that hydrologists or geologists licensed by a state are held to the same standards as a professional engineer licensed by a state licensing board. For example, it is unclear whether geologists are subject to the rigorous testing required by professional engineers or that state licensing boards can investigate complaints of negligence or incompetence..."*

I currently serve as Chairman of the Kentucky Board of Registration for Professional Geologists and am a Subject Matter Expert (SME) for the Council of Examiners that certify the ASBOG Exams. The credentials granting certification are present and solid; however, what would hold professional geologists accountable when compared to other professions is actively and continuously opposed and blocked from within our own ranks. This destroys our credibility and undermines our expertise in our respective disciplines.

Another resurgent topic that resonates with me is the need to increase AIPG membership to thrive as an organization. This requires both retention of enlisted members and efforts to bolster new membership through student chapters and new or young professionals in the active workforce. Efforts to maintain our existing numbers and at the same time attract new members has been problematic, languished attempts throughout my tenure as an active member of the organization have repeatedly shown what's being done isn't having the desired return. The primary solution is to globally target outreach and do more of it; however, there are underlying issues that complicate this even further which need to be carefully considered and addressed to maximize any efforts to increase outreach.

A recent AIPG focus on Diversity, Equity, and Inclusion (DEI) comes to mind as I ponder solutions to improve outreach. Specifically, I cannot help but notice the dominantly monotone demographic that represents our profession. Currently, there is excellent momentum by AIPG and other geological organizations, but coordinated and pragmatic efforts will be key to transitioning this into mainstream common practice. We as concerned advocates can issue statements and write letters easily enough, but advocacy requires both persistence and widespread support from more than a select few within our organization. Improvement requires that we work in both the professional realm with geologists already in the workforce and in partnership with academia to inform and enroll current students and recent graduates needed to fill the opening in both the AIPG and our workforce, regardless of gender, race, ethnicity, or background.

Students and young professionals need guidance, mentorship, and networking opportunities to assimilate into the profession and, optimistically, the membership. There is significant support and efforts covering these growth resources, but a central and organized system to aggregate these components would help expand their effectiveness. A database of professionals is now available that can be queried by prospective members and then paired with an individual mentor would be a valuable tool that could draw interest in the organization and endow new membership; however, the number of mentors in this database is very small. Workshops and training opportunities to improve communication skills, technical acumen, resume writing, and interview etiquette would provide skills beneficial to employers, and incentivize student participation and interaction in outreach resources hosted and supported by AIPG.

To consistently and continually defend attacks that threaten our profession, we need to support CE adoption and membership growth so we not only survive, but thrive. With this, we also need support from our colleagues as we face these hurdles to save the geological profession. As Treasurer, I would strive to introduce improvements and strengthen efforts that are already in place or under development, and seek to use my position, relatively young age, and proclivity for technology and data archiving to advance this mission.

# Candidate for AIPG National Treasurer

**Mark Schaaf**
**CPG-10732**
***Hanover, Maryland***

With pleasure and gratitude, I am honored to accept the nomination for the AIPG National Executive Committee Treasurer role for 2023 and 2024. Thank-you to the nominating committee for their endorsement.

Excited?? You bet!! Out of the gate, it has been a fun and fulfilling experience being involved with the people, the organization, and the work that makes AIPG the great professional organization it is. For several years now, I was hoping for an opportunity to give back to the geology profession and last year AIPG welcomed me with an opportunity on the National Advisory Board. I am also the AIPG representative for the Capitol Section.

> “Out of the gate, it has been a fun and fulfilling experience being involved with the people, the organization, and the work that makes AIPG the great professional organization it is.

My love for geology is a genetic thing – my dad was a mining engineer and exploration geologist. He got me involved with the adventures and excitement of geology-related opportunities when I was a teenager growing up in Canada. I was involved with geophysical surveys, splitting core, supporting sampling programs before I even understood or appreciated the broad expanse of geology. I somewhat reluctantly (feeling over-encouraged) enrolled into the Earth Sciences/Geology program at the University of Waterloo. And almost every summer I continued to expand my geology skills with various mineral exploration opportunities. I look back with absolutely no regrets. From Waterloo, I went on to the Mineral Exploration graduate program at Queen’s University in Kingston, Ontario. One of the graduate field trips was through the Great Basin. For weeks we visited two mines a day and on weekends we visited national parks of geological interest. I fell in love with Nevada – the raw, open geology. I was determined to find my first geology career opportunity in The Mining State! I worked three years out of Winnemucca, Nevada at the former Chimney Creek Mine. From there an opportunity emerged to work overseas. For over four years, I supported various mineral exploration projects in South America and Africa. In the late 1990s and early 2000s, I transitioned my geology background into environmental assessment and remediation – from searching for gold deposits to defining the extent of bedrock groundwater contaminant plumes. My geology career journey continues and looking back, it has provided so much. The “rear-view mirror” is screaming - NOW is the time to give back!

Finding my way to an active role in AIPG started with an underlying desire to both promote geology as a viable/needed career option and draw a few young STEM-centric students towards geology. I contacted AIPG initially in search of a “WHY GEOLOGY?” presentation to deliver at local high schools. I was also curious about AIPG’s support and guidance for geology students and young geology professionals. As I started to interact with AIPG, I became aware of the new AIPG mentoring program and have since greatly enjoyed the opportunities to support geology undergraduates with their career and/or graduate school decisions. I truly believe looking for and providing mentoring support to young geologists is a critical component to both strengthening the future of AIPG and attracting AIPG’s next generation of leadership.

There are so many important areas that AIPG is involved and supporting – from education to government policy, to climate change, energy, mineral exploration/development, resource management, conservation, many areas of research … all that on this planet never mind going beyond! I look forward to the opportunity to be involved with AIPG and support all fields of geology and the broader earth sciences.

If elected AIPG National Executive Committee Treasurer, I look forward to: ensuring AIPG finances remain strong to continue the AIPG mission; encouraging others to become active members in AIPG; supporting both responsible resource development and more North American based strategic mineral development; promoting appropriate environmental stewardship; endorsing the advancement of all energy types; and improving AIPG membership and participation for the next generation of geologists and other earth science professionals.

I very much look forward to the opportunity to serve and support AIPG, the Executive Committee and the membership at-large as the next AIPG National Executive Committee Treasurer. Thank-you for your time and consideration. Explore AIPG, there’s a lot to discover!

# Candidate for AIPG National Editor

**Adam Heft**
**CPG-10265**
***Portland, Michigan***

I was honored and pleased to be asked by the AIPG National Nominating Committee whether I would continue my service to AIPG by accepting a nomination to run for a second term as 2023 National Editor. I believe strongly in AIPG as an organization that supports professional geologists and has much to offer those of us who have selected this career. I am grateful for all the opportunities I have had to give back on both the section and national levels. I look forward to the opportunity to continue to serve on the National Executive Committee and would like to thank the Nominating Committee and the Executive Committee for approving my nomination.

> “I believe strongly in AIPG as an organization that supports professional geologists and has much to offer those of us who have selected this career.

During my 23 years as an AIPG Certified Professional Geologist, I have taken an active role as a leader and participant in both Michigan Section and National activities, because I enjoy the challenges and opportunities that this service provides. I plan to continue this practice for many more years in whatever capacity presents itself. During this time, I have met and got to know many members, and hope to meet many more of you in the years to come.

Over the last five years, and beginning with my service as National President, my primary message to members has been that Communication is key. I get this message out to members by serving as the current National Editor and will continue to do so if reelected for a second term. As you know, the Editor’s primary responsibility is the publication of *The Professional Geologist,* which I believe has improved in quality over the years; I hope to continue the improvement and relevance of this, our flagship publication during my tenure as Editor, and continue making these improvements in future editions. In order to do so, I would appreciate your input and feedback, whether positive or negative. Both aspects are important in the continual drive to improve.

AIPG has become increasingly diverse over the years I have been a member. There are increasing numbers of women, minorities, and students transitioning to Early Career Professionals than ever before, and this lends a new perspective to the organization and the focus it has. This is a good thing, but participation by these individuals is critical. There has been a wide variety of article types submitted for publication, from highly regarded seasoned professionals, to early career professionals and students who are just beginning to make their mark. Articles draw from traditional specialties of geology and newer, cutting-edge technologies that are applied to a variety of subjects, and I try to include them all. I strongly encourage all our members to write and submit at least one article for publication in The Professional Geologist. Your experiences and opinions are valuable and will help encourage others to participate as well.

I feel that my experience will continue to benefit AIPG. I look forward to continued commitment in making AIPG the best supporter of professional geologists. I anticipate the opportunity to continue to serve AIPG as your Editor and would be honored if you would consider voting for me. Please contact me if you have any questions; my email address is adam.heft@wsp.com. Thank you for your consideration.

# Candidate for AIPG National Editor

**Paul Pribyl**
**CPG-12099**
***Anchorage, Alaska***

I am grateful for the committee's nomination and the consideration by AIPG's members for the role of the 2023 and 2024 National Editor. My first significant exposure to AIPG and the functions of the Institute was through *The Professional Geologist* publication after becoming an Early Career Professional. I attended my first AIPG National Conference in 2013 and was able to meet colleagues from across the country and gain exposure to practicing geologists from many fields of study. I have continued to attend the National Conference as frequently as my responsibilities allow, look forward to reading each issue of *The Professional Geologist*, and enjoy everything AIPG has to offer. I am honored to be considered for this opportunity to give back to Institute and serve the members of AIPG.

One of the primary responsibilities of the Editor is the publication of *The Professional Geologist,* and I welcome the opportunity to contribute to this important publication. *The Professional Geologist* is a unique asset to our members as it is created by geologists for geologists. It is a tangible representation of the Institute and what it means to be a professional geologist within our society. This makes it critical to the Institute and all members of our profession, inside and outside of AIPG, to ensure that the publication maintains professionalism, integrity, ethics, and factual technical information. As Editor my primary goal would be to maintain the respected status of the publication that has been created through the countless hours and hard work of those that have come before, and I will work to maintain the credibility for those who will carry on the work in the future.

> "AIPG provides opportunities for professional support and mentorship, and *The Professional Geologist* provides an opportunity for our members to publish their work and ideas.

*The Professional Geologist* serves an important role as a forum in which members at all stages of their career are able to share knowledge, get to know fellow colleagues, and gain exposure to new and fascinating topics. I believe it is particularly valuable to members who would like to publish research or opinions, but may have never had the opportunity or were perhaps apprehensive to submit topics for publication. I recall being more than a little nervous when I submitted my first research paper for publication in a peer-reviewed journal. I am not sure I would have gone through with it if it wasn't for the support of my research mentor and partner. I was ecstatic when I received news that the paper had been accepted! The experience of getting work published creates an immense feeling of validation and motivation to continue forward with one's research and professional development. AIPG provides opportunities for professional support and mentorship, and *The Professional Geologist* provides an opportunity for our members to publish their work and ideas.

I strongly believe that advancement of the profession and individual development is dependent on dialogue among supporting and opposing views, exposure to new ideas, and the ability to learn from others. *The Professional Geologist* provides a venue for this to occur. It is a shared conversation that we are all welcome to join. If elected, I would work to make those who want to participate in the conversations surrounding our profession have the opportunity to do so. *The Professional Geologist* performs another important function of providing updates on the developments within AIPG and if elected I would look forward to working with the Executive Committee to ensure members stay well informed on the status of the Institute. Being a member of AIPG has been a rewarding experience, and I am ready to give my time, energy, and dedication back to help AIPG continue forward into the future. I greatly appreciate the opportunity to serve as the next Editor and would be honored if you would consider voting for me. I am motived to fulfill the responsibilities of the position and work to present the best representation of our profession and members through all of AIPG's publications. I can be contacted at ppribyl@dowl.com if there are any questions or concerns. Thank you for your time and consideration.

# Candidate for AIPG National Early Career Professional

**Bruno Abersold**
**ECP-0884**
***Enon Valley, Pennsylvania***

I would like to thank AIPG for this nomination for the position of Early Career Professional, as a part of the 2023 AIPG National Executive Committee. AIPG has provided plenty of support and growth opportunities throughout my undergraduate and graduate education. It has always been a goal of mine to mentor and cultivate future geoscientists and there would be no better organization to perform this under.

> "I found that speaking to geoscience professionals within AIPG is paramount to developing a career path, setting realistic goals, and knowing what to expect as a member of the workforce.

I was first introduced to AIPG during my sophomore year, where my department head took several students to a nearby AIPG meeting. From there, my cohort and I were convinced to start up our own student chapter, seeing plenty of opportunities to network, fundraise, and engage in scientific outreach. I found that speaking to geoscience professionals within AIPG is paramount to developing a career path, setting realistic goals, and knowing what to expect as a member of the workforce.

My experience within the student chapter helped develop many critical skills, such as event planning, work delegation, and interpersonal communication. Being a part of the student chapter played a major role for my acceptance into graduate school, as I met my thesis advisor at an AIPG meeting.

The students and early career professionals of AIPG need representation, which is the duty of Early Career Professional of the National Executive Committee. As a nomination for this position, I would work to promote geology as a science and profession, speaking for those who are at about the same level in their career. My vision for this position is to garner involvement in AIPG, helping students and other early career professionals. Connecting with students may provide opportunities to network, find internships, and promote the transition from education to the work force.

It seems to me that not enough attention is given to the importance of ASBOG GIT certification for current and potential student chapter members. Providing resources such as study materials and hands on training will be paramount for securing professional licensure. In my experience, education alone fails to impart just how important these steps are to become a full-fledged geologist. Online learning has grown exponentially in the last few years, making it possible to provide more opportunities than ever before. AIPG does an excellent job at hosting courses through the Geoscience Online Learning Initiative (GOLI), if elected I would work to promote awareness of GOLI to students and early career professionals.

One of the primary issues that students in geologic science face is a lack of opportunity. Many undergraduate programs are small and cannot provide the research experiences of larger universities, making it harder for these students to be competitive. These students would benefit greatly from the chance to contribute on projects, get published, or receive awards. Especially when they can cross between disciplines, like geographic information science and environmental science. Secondly, I think that there exists elitism and bias among research disciplines. At both universities I attended, I found that division exists based on several factors. Some research groups will clash based on funding availability, ethics, or perceived standards of education. This makes it difficult for students to think freely and speak their mind, in fear of retribution. Regardless of the moral or ethical implications, the students should never suffer from interdepartmental conflict. If elected, I'd make it a goal to promote small opportunities and advocate for interdisciplinary harmony.

To conclude, I am hopeful for the opportunity to become an Early Career Professional of the National Committee. My experience and educational background will be essential in communicating with my peers of AIPG. I appreciate the consideration and hope to be a powerful voice for the students and early career professionals. This would be a growing experience, that would provide plenty of avenues to serve and learn. AIPG is an organization in which one can find opportunity and develop both personal and professional connections, I am proud to be a member.

# Candidate for AIPG National Early Career Professional

**Brigitte Petras**
**ECP-0851**
***Campbell, Ohio***

Hello from the Buckeye State! As a member that has benefitted and continues to learn so much from this organization, I'm greatly honored to be nominated as a candidate for the Early Career Professional Representative. I look forward to all the contributions I can make to this professional scientific community using my enthusiasm and my previous AIPG experience to support the growth of AIPG. As a current Member-at-Large for the Ohio Section in 2022, I would apply this knowledge and experience to this national position.

My involvement with AIPG began in 2017 when I was a co-founder of a new AIPG Student Chapter at Youngstown State University (YSU) in Ohio. Since then, I was president of the YSU AIPG Student Chapter and implemented fundraisers, outreach events, joint geological field trips, and attended Ohio Section meetings and an annual AIPG conference. This was the first organization I was a part of that encouraged fellow students and myself to truly learn more about our profession, connect with professionals, and grow as geologists. I would like to ensure that other students across the nation are aware of the professional exposure that AIPG offers that could "open their eyes" and directly affect their careers.

I also had the privilege of presenting at my first professional conference at the AIPG National Conference, and my first publication was in *The Professional Geologist*. I'm incredibly grateful that AIPG provided a platform for me to communicate science and gain exposure with the professional review process. I want to educate students and young professionals of such opportunities that I was able to take advantage of as a member of AIPG. These recent experiences have also taught me technical and nontechnical skills, the power of connecting with other professionals, and so much more.

> "As an early career professional, I have found strength and insight through my connections with several mentors.

The Early Career Professional Representative acts as a conduit to student members, early career professionals, and the rest of the professional geology community. My goals in this role are to provide additional outreach to engage more students and young professionals to join and participate in AIPG, and to continue developing the Student Day and early career professional activities at the national conference in 2023. There are many current and emerging career opportunities as a geologist, so it's important to share these career pathways from the professionals themselves. My attendance in AIPG meetings also motivated me to sign up and pass the ASBOG Fundamentals of Geology exam. I would like to help educate others on the importance of this certification and provide a success roadmap for passing the exam.

As an early career professional, I have found strength and insight through my connections with several mentors. These great mentorships were essential to my professional growth and continue to help me immeasurably. I would like to provide other members the same opportunity by further developing AIPG's new mentorship program. Additional advocacy for mentors and mentees would strengthen this program.

In closing, my positive experiences as a member of AIPG inspires me to give back to this community. I want to reach out to students and young professionals to educate them on all the opportunities that AIPG has to offer. The field of geology is vast, and bringing geologists together to share experiences and ideas benefits everyone.

Thank you so much for your consideration. I would uphold the values and standards of AIPG and do everything I can to be the voice of students and early career professionals as Early Career Professional Representative. I am grateful for this opportunity to serve AIPG nationally, and I look forward to contributing to the professional development of its student members and early career professionals.

## CANDIDATE FOR AIPG NATIONAL 2023 PRESIDENT-ELECT

### Shanna Schmitt

**CPG-11781**
*Roseville, Minnesota*

**Statement of Purpose or Goals you have for AIPG:** As President-Elect, I will focus on growing membership, supporting members at every stage of their careers, and advocating for professional geoscientists in industry, the regulatory community, academia, state geological surveys, and wherever geoscientist are needed to promote a sustainable standard of living.

| Universities Attended | Degrees Granted | Dates |
|---|---|---|
| University of Minnesota - Twin Cities | B.S. Geology | 2003 |

| Company | Title | Dates |
|---|---|---|
| Minnesota Pollution Control Agency | Hydrogeologist | 2006-present |
| Terracon Consultants, Inc. | Field Tech/Staff Geologist | 2003-2006 |

| AIPG Activities | Dates |
|---|---|
| Minnesota Section Student Support Sub-Committee Chair | 2017-present |
| Minnesota Section Webmaster | 2015-present |
| National Executive Committee - Advisory Board Member | 2016, 2019, 2020 |
| Inter-Society Liaison - GSA Professional Development Committee | 2017-2020 |
| Presidential Certificate of Merit | 2018 |
| Section Leadership Award | 2018 |
| Minnesota Section President | 2016 |
| Minnesota Section Secretary/Treasurer | 2011-2014 |

## CANDIDATE FOR AIPG NATIONAL 2023 PRESIDENT-ELECT

### Brent Smith

**CPG-11130**
*Worthington, Ohio*

**Statement of Purpose or Goals you have for AIPG:** To change the way we connect with current and future members in order to foster growth and increase the value of membership. If elected, I will work hard to uphold the ideals of the organization as a leader and support the growth of AIPG.

| Universities Attended | Degrees Granted | Dates |
|---|---|---|
| The Ohio State University | B.S. Geology | 1994-1998 |

| Company | Title | Dates |
|---|---|---|
| Civil & Environmental Consultants, Inc. | Senior Project Manager | 2017-present |
| Burgess & Niple, Inc. | Geologist/Project Manager | 1999-2017 |

| AIPG Activities | Dates |
|---|---|
| National Executive Committee - Advisory Board Member | 2021, 2022 |
| Ohio Section Award of Honor | 2021 |
| Ohio Section Website Committee Chairman | 2018-present |
| Ohio Section Various Ad-Hoc Committees | 2009-present |
| Section Leadership Award | 2018 |
| Ohio Section Past-President | 2018 |
| Ohio Section President | 2017 |
| Ohio Section President-Elect/Treasurer | 2016 |
| Ohio Section Business Development Committee Chair | 2013-2015 |
| Ohio Section Treasurer | 2011-2016 |
| Ohio Section Member-At-Large | 2009-2010 |

## CANDIDATE FOR AIPG NATIONAL 2023 VICE PRESIDENT

### Dave Heidlauf

**CPG-9365**
*Chicago, Illinois*

**Statement of Purpose or Goals you have for AIPG:** I am committed to provide coordinated leadership to the AIPG Advisory Board and to support the initiatives of the AIPG 2023 President, Dawn Garcia.

| Universities Attended | Degrees Granted | Dates |
|---|---|---|
| Wright State University | Hydrogeology Coursework | 1989-1992 |
| Northern Illinois University | Environmental Coursework | 1987-1988 |
| Univ. Of Illinois - Champaign-Urbana | M.S. Geology | 1983-1986 |
| Wheaton College | B.S. Geology | 1978-1982 |

| Company | Title | Dates |
|---|---|---|
| ENVIRON/Ramboll | Principal | 2002-present |
| MWH | Supervising Hydrogeologist | 2000-2002 |
| Mittelhauser/Clayton | Senior Project Manager | 1989-2000 |
| CCJM | Environmental Geologist | 1987-1988 |
| US Army Reserves | Captain/Field Artillery | 1982-1992 |

| AIPG Activities | Dates |
|---|---|
| National Executive Committee - Treasurer | 2021-2022 |
| Illinois - Indiana Section Vice President | 2017-2022 |
| Illinois - Indiana Section Committee - Field Trip Coordinator | 2015-2017 |

## CANDIDATE FOR AIPG NATIONAL 2023 VICE PRESIDENT

### Dennis Pennington

**CPG-4401**
*Ambler, Pennsylvania*

**Statement of Purpose or Goals you have for AIPG:** Help establishment of regional meetings, expand early career development programs, increase membership, set up officer visitation program, and expand joint programs with other geological societies.

| Universities Attended | Degrees Granted | Dates |
|---|---|---|
| Villanova University | Water Resources Coursework | 1974-1975 |
| Penn State University | M.S. Geochemistry | 1971-1973 |
| State University at Potsdam New York | B.A. Geology | 1967-1971 |

| Company | Title | Dates |
|---|---|---|
| WVWA PA | Project Manager/Geologist | 2002-2017(retired) |
| National Environmental Tech PA | Owner/Senior Geologist | 1990-2002(sold business) |
| Soil Material Engineers | Northeastern Manager | 1986-1990 |
| SAIC | Vice President Waste Management | 1986 |
| SMC Martin | Manager Geological Services | 1983-1986 |
| International Exploration Inc. | Partner/Engineering Geology/Geophysics | 1979-1983 |
| Richard Cowan Associates | Manager Geological Services | 1976-1979 |
| Jack McCormick Associates | Program Manager | 1975-1976 |
| Sanders & Thomas | Project Geologist | 1973-1974 |

| AIPG Activities | Dates |
|---|---|
| Pennsylvania Section Executive Committee - President | 1999, 2018-2021 |
| Martin VanCouvering Memorial Service to the Institute Award | 2018 |
| Honorary Membership | 2015 |
| Volunteer various committees | 2002-Present |
| Ben H. Parker Memorial Distinguished Service Award | 2008 |
| National Executive Committee - President | 2000 |
| Various National Executive Committees | 1996, 1998, 1999, 2000 |

## CANDIDATE FOR AIPG NATIONAL 2023-2024 TREASURER

### Bill Brab

**CPG-11693**
*Richmond, Kentucky*

**Statement of Purpose or Goals you have for AIPG:** AIPG should assure that the profession of geology is appropriately aligned with current academic, professional, and societal issues. AIPG should also strive to bolster membership attrition through existing member retention and student member conversion. Finally, AIPG should evolve its amenities and reinforce its accreditation in science and society.

| Universities Attended | Degrees Granted | Dates |
|---|---|---|
| University of Kentucky | B.S. Geology | 2001 |

| Company | Title | Dates |
|---|---|---|
| AST Environmental, Inc. | Senior In-Situ Remediation Geologist | 2011-present |
| Environmental Probing & Drilling | Project Geologist | 2007-2011 |
| Environmental Probing & Drilling | Staff Geologist | 2002-2007 |

| AIPG Activities | Dates |
|---|---|
| Kentucky Board of Registration for Professional Geologists Member | 2017-present |
| Kentucky Section AIPG Treasurer | 2017-present |
| Kentucky Section AIPG Past President | 2015 |
| Kentucky Section AIPG President | 2014 |
| Kentucky Section AIPG President-Elect | 2013 |
| Kentucky Section AIPG Vice President | 2012 |

## CANDIDATE FOR AIPG NATIONAL 2023-2024 TREASURER

### Mark Schaaf

**CPG-10723**
*Hanover, Maryland*

**Statement of Purpose or Goals you have for AIPG:** To provide commitment and support to AIPG in its continuing support of geologists and other earth science professionals. Areas of interest include: (i) supporting and strengthening AIPG's financial health as a professional organization, (ii) AIPG's mentoring program (iii) broadening AIPG's online visibility and (iv) encouraging others to become active/contributing AIPG members..

| Universities Attended | Degrees Granted | Dates |
|---|---|---|
| Queen's University, Canada | M.S. Geology | 1990 |
| University of Waterloo, Canada | B.S. Geology | 1989 |

| Company | Title | Dates |
|---|---|---|
| Kleinfelder. | Senior Program Manager | 2005-present |
| Terracon | Project Manager | 2000-2005 |
| Golden Star | Senior Exploration Geologist | 1993-1998 |
| Goldfields | Mine Geologist | 1990-1993 |

| AIPG Activities | Dates |
|---|---|
| National Executive Committee - Advisory Board Member | 2022 |

## CANDIDATE FOR AIPG NATIONAL 2023-2024 EDITOR

### Adam Heft

**CPG-10265**
*Portland, Michigan*

**Statement of Purpose or Goals you have for AIPG:** My goals as Editor are to continue to communicate the state of the profession to members, remind members of the value of AIPG membership, and to keep The Professional Geologist relevant and timely.

| Universities Attended | Degrees Granted | Dates |
|---|---|---|
| Michigan State University | M.S. Geology | 1990-1993 |
| Central Michigan University | B.S. Geology and Earth Science | 1985-1990 |

| Company | Title | Dates |
|---|---|---|
| WSP USA | Senior Supervising Geologist | 2017-Present |
| Parsons Brinkerhoff | Senior Supervising Geologist | 2009-2017 |
| Fitzgerald Henne & Associates | Project Manager | 1994-2009 |
| Peterson Environmental Services | Field Geologist | 1993-1994 |

| AIPG Activities | Dates |
|---|---|
| Chairman of the 59th Annual Meeting | 2018-Present |
| National Past President | 2018 |
| National President | 2017 |
| National President-Elect | 2016 |
| Section Leadership Award | 2014 |
| Michigan Section Delegate to the Advisory Board | 2014 |
| National Secretary | 2010-2011 |
| National Advisory Board Representative | 2009 |
| Michigan Section Newsletter Editor | 2008-Present |
| Presidential Certificate of Merit | 2008 |
| Significant Contribution to the Section Award | 2007 |
| Chairman of the 44th Annual Meeting | 2004-2007 |
| Michigan Section Assistant Newsletter Editor | 1999-2007 |

## CANDIDATE FOR AIPG NATIONAL 2023-2024 EDITOR

### Paul Pribyl

**CPG-12099**
*Anchorage, Alaska*

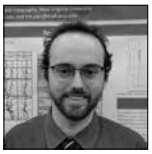
**Statement of Purpose or Goals you have for AIPG:** As Editor, I would seek to continue *TPG's* legacy as an open forum for geologists at all stages of their careers and keeping members informed of the Institute's activities. AIPG's publications are created with contributions from a diverse range of members and *TPG* is a tangible representation our profession. As such, I would seek to maintain the professionalism, integrity, ethics, and expertise presented within each publication as it is a reflection of our profession as a whole.

| Universities Attended | Degrees Granted | Dates |
|---|---|---|
| University of Nevada, Las Vegas | M.S. Geosciences | 2012 |
| University of Wyoming | B.S. Geology | 2010 |

| Company | Title | Dates |
|---|---|---|
| DOWL | Engineering Geologist | 2013-Present |
| Las Vegas Isotope Science Laboratory | Lab Technician | 2010-2012 |

| AIPG Activities | Dates |
|---|---|
| AIPG Member | 2013-Present |
| National Conference Attendance | 2013, 2015, 2016, 2019, 2021 |

## CANDIDATE FOR AIPG NATIONAL 2023-2024
## EARLY CAREER PROFESSIONAL



### Bruno Abersold

**ECP-0884**
*Enon Valley, Pennsylvania*

**Statement of Purpose or Goals you have for AIPG:** To further the reach of geologic science and advocate for educational opportunities in high school classrooms. For collegiate students, provide opportunities to learn applicable skills one may use in the work force.

| Universities Attended | Degrees Granted | Dates |
|---|---|---|
| West Virginia University | M.S. Geology | 2021 |
| Youngstown State University | B.S. Geology | 2019 |

| Company | Title | Dates |
|---|---|---|
| WSP/Golder | Assistant Consultant | 2022 |
| Tongass National Forest | Caves & Karst Remote Assistant | 4/2021-8/2021 |
| Keylogic | Energy Analyst Intern | 4/2020-8/2020 |
| West Virginia University | Graduate Research Assistant | 2019-2021 |
| Intertek, PSI | Engineering Tech | 4/2019-8/2019 |
| Clarence Smith Mineral Museum | Curator, Attendant | 2017-2019 |

| AIPG Activities | Dates |
|---|---|
| Youngstown State University Student Chapter Founding Member, Vice President and President | 2017-2019 |

## CANDIDATE FOR AIPG NATIONAL 2023-2024
## EARLY CAREER PROFESSIONAL

### Brigette Petras

**ECP-0851**
*Campbell, Ohio*

**Statement of Purpose or Goals you have for AIPG:** My goals in this role are to advocate for the profession of geology and contribute to the development of AIPG's student members and early career professionals. I would engage more students and young professionals to join and participate in AIPG and its activities, such as their mentorship opportunities. I look forward to developing the Student Day and early career professional activities at the national conference.

| Universities Attended | Degrees Granted | Dates |
|---|---|---|
| West Virginia University | M.S. Geology | 2019-2021 |
| Youngstown State University | B.S. Geology | 2014-2018 |

| Company | Title | Dates |
|---|---|---|
| Battelle Memorial Institute | Geologist | 2021-Present |
| Pure Earth Resources | Geologist | 2022 |
| Greenfields Environmental Corp. | Environmental Scientist | 2022 |
| West Virginia University | Graduate Teaching & Research Assistant | 2019-2021 |
| Pearl Oil & Gas | Geology Intern | 2019 |
| Cleveland Museum of Natural History | Geology Research Intern | 2017 |

| AIPG Activities | Dates |
|---|---|
| Ohio Section Member-at-Large | 2021-Present |
| *The Professional Geologist*, vol. 56, issue 1 | 2019 |
| Director's Award, AIPG National Student Poster Contest | 2018 |
| Youngstown State University Student Chapter President | 2018 |
| Youngstown State University Student Chapter Co-Founder | 2017 |

# Official AIPG 2022 Ballot National Officer Election

## President-Elect
President in 2024

☐ **Shanna Schmitt, CPG-11781**

☐ **Brent Smith, CPG-11130**

## Treasurer
Term of office 2023-2024

☐ **Bill Brab, CPG-11693**

☐ **Mark Schaaf, CPG-10723**

## Editor
Term of office 2023-2024

☐ **Adam Heft, CPG-10265**

☐ **Paul Pribyl, CPG-12099**

## Vice-President
Term of office 2023

☐ **Dave Heidlauf, CPG-9365**

☐ **Dennis Pennington, CPG-4401**

## Early Career Professional
Term of office 2023-2024

☐ **Bruno Abersold, ECP-0884**

☐ **Brigette Petras, ECP-0851**

**Name**

_____

**AIPG Member Number**

_____

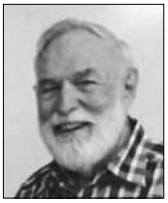
**Vote online or mail in this ballot**

# In Memoriam

## James W. Sansom Jr., CPG-02406

*Liberty Hill, Texas*

*January 15, 1937 - February 27, 2021*



**Member Since 1972**

*Text and photograph excerpted from the Dignity Memorial website...*

James Word Sansom Jr. was born in Austin, Texas on January 15, 1937, and lost his battle with Covid 19 on February 27, 2021. He received his Bachelor of Science Degree in Geology from UT in 1963. He was a lifetime member of the UT Ex-Students Association.

On August 12, 1961 he married Minnie Faye Edwards in Colorado City, Texas. They lived in Austin, and in the 1960's they had two sons, Alan and Marc Sansom.

He began his geological career with the Texas Highway Department in February 1962. During this time, Inner Space Cavern in Georgetown was discovered while he was supervising the drilling of the core holes for Interstate Hwy. 35 bridges. This discovery would be one of the highlights of his career. He loved taking students and groups through the cavern and telling the story of its discovery. In 1965 he worked for the Texas Department of Water Resources, now known as the Water Development Board. From 1980 until he retired from the State in 1989, he worked for the Texas Railroad Commission in their Surface Mining and Reclamation Division. After retiring from the State, Jim worked as an independent consulting geologist providing environmental geologic assessments for engineers, city and state agencies, and individuals. He loved being in the field and was a true field geologist.

He was an active member of the Austin Geological Society from 1965 until his death. He was also a member of the American Institute of Professional Geologists and the Association of Engineering Geologists. In 1996 he received the AIPG Public Service Award for his outstanding contributions to achieve a Registration Act for Geologists in the State of Texas and also the AEG award as the Outstanding Engineering Geologist in the Texas Section for his tireless effort for registration. In the past decade, Jim enjoyed volunteering with the UT Jackson School of Geosciences to help with their GeoForce educational program to encourage minority students to obtain careers in science, technology, engineering and math. He enjoyed working with the young students and staff of GeoForce and was excited with the success of those students.

## Stanley B. Shryock, CPG-02478

*Fredericktown, Missouri*

*September 13, 1937 - May 12, 2021*

**Member Since 1973**

*Text excerpted from the Follis and Sons Funeral Home website.*

Stanley Baron Shryock was born September 13, 1937, at Cornwall, Missouri the son of Stanley E. and Margaret (Dowd) Shryock and passed away on May 12, 2021 at Fredericktown at the age of 83 years.

Stanley was preceded in death by his parents, a brother Lee Shryock and his wife Judith Ann (Watkins) Shryock who he married on August 11, 1961.

## Ronald J. Krakowski, CPG-04378

*Edmond, Oklahoma*

*June 10, 1945 - June 10, 2021*

**Member Since 1978**

*Text and photograph excerpted from the Dignity Memorial website…*

Born in Detroit, Michigan on June 10, 1945, Ron was the youngest son of John and Carol Krakowski.

He is survived by his caring wife of almost 47 years, Diane; their three children: James Krakowski and wife Amy, Kara Vorderlandwehr and husband Jacob, and Kristin Kraham and husband James; adoring grandchildren: Allison, Jackson, Asher, Macy, Evelyn, and Harrison who each had a special bond with their grandpa; brother, John and his wife Patricia and their children; and a large extended family that he truly treasured.

As a geologist, Ron worked for numerous oil and gas companies in Houston, Michigan, and Oklahoma. He was an active member of the Oklahoma City Geological Society, serving as editor of the Shale Shaker for many years. Ron was also a member of the Oklahoma Mineral and Gem Society, most recently serving as president. Ron's passions included collecting rocks, minerals, books, and especially capturing special moments on camera.

## Kathryn A. West, MEM-0367

*Newark, Delaware*

*August 29, 1966 - July 28, 2021*

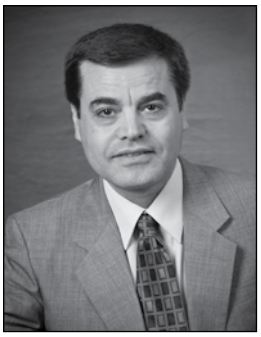
**Member Since 2003**

*Text and photograph excerpted from the Spicer-Mullikin Funeral Home website…*

Kathryn A. "Kathy" West, age 54, of Newark, DE, passed away on Wednesday, July 28, 2021.

Born in Wilmington, on August 29, 1966, she was a daughter of the late James C. and Elizabeth (Vaughan) West, Sr. Kathy graduated from Newark High School in 1984. She then attended Penn State University, where she earned her degree in Geo Science in 1988 and in 1993 obtained her Master of Science degree from Kent State University. Kathy made her career as a senior geologist at AECOM, since 2004.

She enjoyed traveling, especially visiting national parks and going to the beach. Kathy enjoyed photography and was a proud member of the Penn State Alumni Association. She was a collector of minerals, gems and stamps.



# Virtual Field Trips

**Rasoul Sorkhabi, Ph.D., CPG-11981**

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

The concept of virtual field trips is not new. Documentary films of natural features and geological sites have provided virtual field trips to the public since the 1950s, such as the *True-Life Adventures* (by Walt Disney Productions, 1948-1960), David Attenborough's nature documentaries as well as Iain Stewart's Earth documentary produced by BBC, and History Channel's *How the Earth Was Made* series.[1] However, virtual geology field trips (tours or travels)[2] (VGFTs) are more focused, systematic, detailed, and intended for geology students. The value of VGFTs has been heightened in the past two years because of travel restrictions caused by the Covid-19 pandemic, and it is expected VGFTs will retain their importance in the future as well because of its certain advantages as well as technological advances in producing them. Nevertheless, they cannot replace the actual geological field trips. Let's examine what virtual field trips are and what they can or cannot offer.

## Production: Site, Science, and Technology

VGFTs are a type of science documentary films, but unlike the documentary films which cover general themes (plate tectonics, volcanic eruptions, polar bears, etc.) for the general public, VGFTs are site specific, audience specific (geology students), and with in-depth knowledge coverage for education (not entertainment). The most critical aspect of VGFTs is their production, because the audience (viewers) have a passive participation (other than watching them attentively) and depend on what the producers inform and record. Like in-person field trips, VGFTs need logistical preparations and travel[3]; however, they also have their particular requirements in terms of equipment, content, planning, filming, editing, and production.

Site-selection, aside from accessibility, is related to the overall objective of the filming. The geological site should provide typical examples for geological features, rocks, minerals, fossils, stratigraphy, structures, and processes that students (viewers) should learn. The production of VGFTs involves both content (science) and filming (technology), and there should be close cooperation and coordination between these two teams in all stages of the project, from planning, traveling and filming to editing and final production.

Although VGFTs are essentially educational tools and should contain realistic views and factual information, the products should not be boring or monotonous. They should also be impressive, immersive, and entertaining so as to keep the audience attentive. VGFTs are audiovisual media, which means sound is as important as sight. In other words, the content of VGFTs includes both words and views, both of which should be carefully selected and integrated. A luxury that the production of VGFTs enjoys is that the producers can insert other pieces of information in the films such as history of the area, stories of previous investigators and works, illustrations to explain concepts and processes, multi-scale photographs, interviews with various expert geologists, and so forth.

Thanks to the digital revolution in recent decades, we now have access to drone image capture, 360-degree video cameras, and high-resolution imagery (down to 2-3 centimeters per pixel). LIDAR ("laser imaging, detection and ranging") technology offers digital 3D scans of outcrops; the imagery can be either land-based or airborne (attached to a flying aircraft).

## Pros and Cons

VGFTs have several advantages: (1) They save lots of traveling time and budget for both universities and students. (2) A large number of students (and even those who may not be able to travel) can watch and benefit from them. (3) Students can take VGFTs any time and any number of times. (4) VGFTs can include aerial imagery and other audiovisual information (for example, interviews with several experts) that may not be available to the actual field trip leaders.

What are the cons? (1) If you want to produce high quality VGFTs, upfront production costs are much higher (although distributed over the years of using the film, the costs may be reasonable.) (2) Students are not present in the field:

1. Sorkhabi, Rasoul (2020) Documentary films in geology education. *The Professional Geologist*, vol. 57, no. 1, pp. 44-45.
2. I am using the words trip, tour, and travel interchangeably. But they have subtle differences. Trip involves a shorter period of time and more likely a specific place. Tour involves visiting several sites (stops) and may also take a longer period of time. Travel involves both longer time and a larger area with various sites.
3. Sorkhabi, Rasoul (2022) Field work and field trips. *The Professional Geologist*, vol. 59, no. 1, pp. 38-41.

They cannot touch the rocks or collect samples; (3) Students will not be able to go beyond what they are shown, explore and map the outcrops or landscape for themselves, or ask questions in the field itself (This indeed limits the skills transfer necessary for training of geologists.) (4) Students will not have the adventure, excitement, or camaraderie of an actual field trip (a field camp or any other geological field trip is a memorable part of geology education – a memory which all geologists treasure throughout their lives).

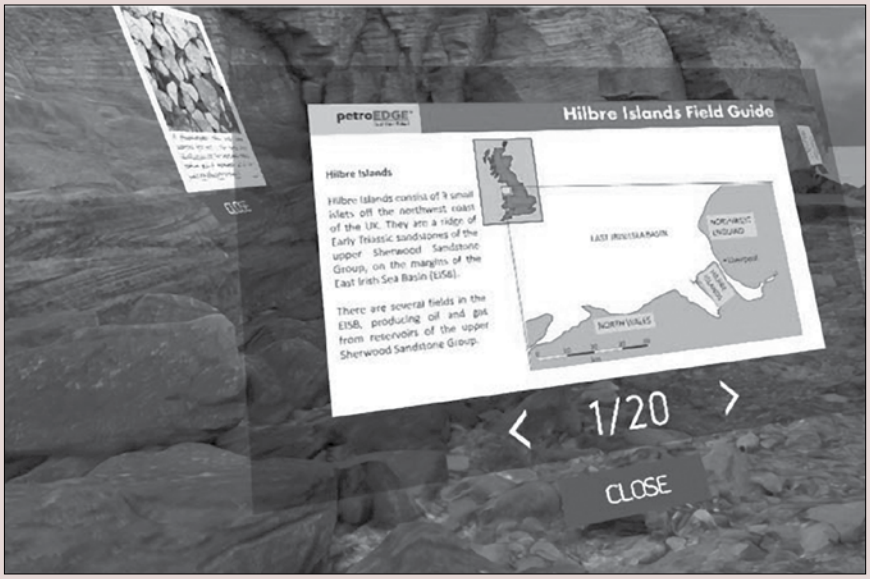
Considering the above statements, it is clear that VGFTs will never replace the actual, in-person field trips in geology education and training. However, they can be, in their own turn, a significant tool in the education and a supplementary part of field trip courses.

## A Growing Field

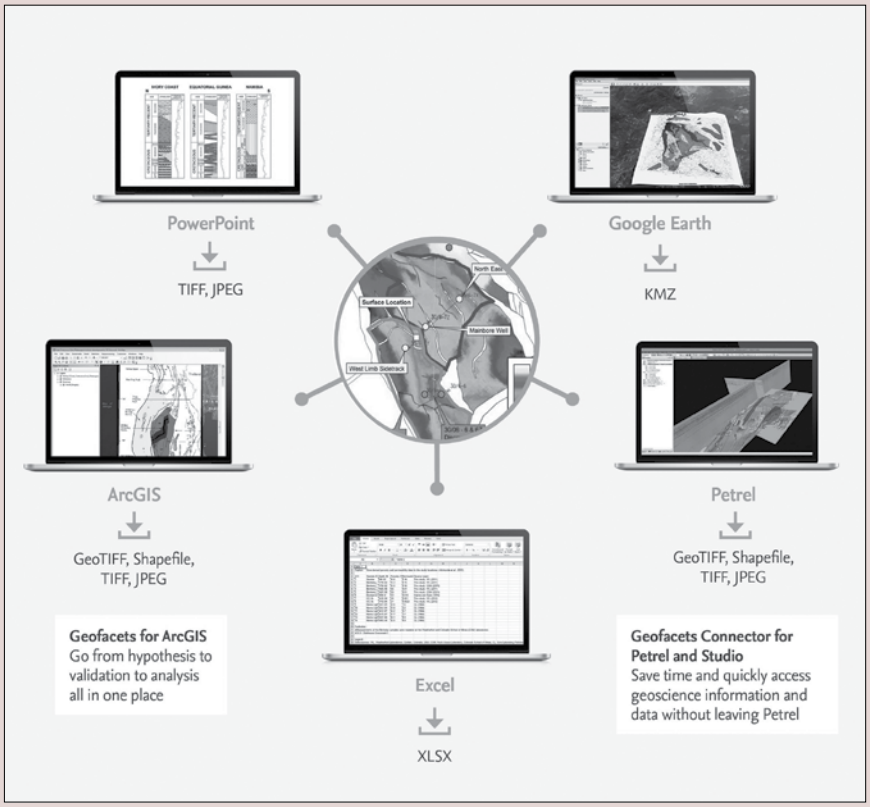
Given the technological advances and the fact many interesting geological sites have not been virtually documented, it is time for geoscience departments to embrace this rapidly growing field. Indeed, several companies are already offering VGFT videos and training packages or services and tools to help production of VGFTs. PetroEdge, a company located in Malaysia and Singapore, offers Virtual Reality Geology Field trips for the oil and gas industry. Geofacets (an Elsevier service) offers location-based geologic information and images (structural maps and cross-section, outcrop photographs, stratigraphic columns, geochemical data, etc.) that can be downloaded into GoogleEarth, ArcGIS and other map software packages. These data and images not only help with reconnaissance study of a geo-site but also with content production.

This 1940 quote from the British geologist Herbert Harold Read is almost a mantra in geology: "The best geologist is he [or she] who has seen the most rocks." It seems that we have entered an era in which "seeing" is both actual and virtual, one not necessarily replacing the other, but complementing each other. For example, students can watch a video-recording of the field trip to familiarize themselves before actually visiting the field. This would increase their learning and productivity in the field. The time for such hybrid field trips has come.

# Virtual Reality & Data Analysis Examples




Example of screenshot from PetroEdge Virtual Field Trip.
Image source:
https://www.geoexpro.com/articles/2019/03/virtual-reality-geology-field-trips.
Accessed Feb. 26, 2022.




Geofacets data integration workflow examples.
Image source: https://www.elsevier.com/solutions/geofacets, accessed Feb. 26, 2022.

**AIPG MEMBERSHIP TOTALS**

| | As of 3/4/2021 | 3/3/2022 |
|---|---|---|
| CPG / Active | 2,290 | 2,195 |
| CPG Emeritus Member | 553 | 586 |
| Honorary Member | 17 | 17 |
| Professional Member | 635 | 651 |
| Professional Member/Non-Practicing | 42 | 44 |
| Early Career Professional | 184 | 185 |
| Associate Member | 41 | 37 |
| Student Adjunct | 968 | 865 |
| **TOTALS** | **4,730** | **4,580** |











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

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

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**Adam Heft, CPG-10265,** *Editor*

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**OCT.NOV.DEC. - July 1, 2022**

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**Instructor:** Kitty Milliken, Ph.D., is a Senior Research Scientist for the University of Texas at Austin Bureau of Economic Geology. She received a B.A. in Geology at Vanderbilt University and completed both her M.A. and Ph.D. in Geology from the University of Texas. Dr. Milliken was the 2014-2015 President of the Society for Sedimentary Geology (SEPM).

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

## 2022 AIPG Member Photo Challenge

**Entries due 11/1/2022 -** see AIPG eNews for details

# MEMBER NEWS

**John Jens, CPG-06550, Alexandria, Virginia, Virginias Section**

John C. Jens, CPG 6550, was honored in a retirement ceremony at the Army Geospatial Center (AGC) in late January 2022 for more than 47 years of combined military and civilian service to the US Army and The Corps of Engineers. Mr. Jens was assigned as a geologist to the Army Geospatial Center for the last 27 years as an instructor and as a remote sensing and GIS expert on special mapping projects. His duties included contracting for these mapping services and overseeing the progress of the work.

For 20 years, Mr. Jens served on active duty in the U.S. Army in a variety of capacities the fields of military topography, terrain analysis, and geospatial intelligence. He wrote the Army's first topographic operations manual. Upon retirement from the U.S. Army, Mr. Jens joined the U.S. Army Corps of Engineers, Engineer Research and Development Center (TEC), now the Army Geospatial Center (AGC), as a Geologist. Mr. Jens is one of those rare team members that not only has seen our art and science evolve from paper and pencil to digital on-demand "mapping" capabilities to meet warfighter needs across all domains, but was also instrumental in its transition at various points.

Jens' wife, Sara Jens, AIPG Associate Member 0021, was also recognized for supporting her husband's career.

Mr. Jens received several awards for his services, some of which are listed below.

The Bronze Order of the De Fleury Medal presented by The Army Engineer Association recognizing the superior service and inspirational leadership of Mr. Jens in support of the Army to assure mobility, enhance protection, enable expeditionary logistics, and build capacity to provide Commanders with the freedom of action required for full-spectrum operations in an era of ongoing conflict. His efforts have significantly contributed to the overall readiness of the Army.

The Meritorious Civilian Service Medal and Certificate for exceptional meritorious service for outstanding achievement and exemplary performance while serving as Contracting Officer Representative and Acting Team Lead for the Terrain Generation Team, Warfighter Support Directorate.

A brass survey marker with his name, dates of service, and coordinates of the Army Geospatial Center.

Presidential Letter of Appreciation for Combined Service, as well as additional awards and mementos.

Among other section duties, Mr. Jens served as the section president of the Virginias Section of the AIPG in 2002 when the Virginia and West Virginia Sections were combined. He was instrumental in establishing and developing the section's first webpage. In the early 2000's, he was AIPG's representative to the American Geosiences Institute's (AGI) Environmental Geoscience Advisory Committee. He contributed an article to TPG in October 1996, Ruminations of a Military Geologist.

## LETTERS TO THE EDITOR

### Dear Editor,

In response to the article "Are We Becoming Like the Dinosaurs?" by Drew Diefendorf, I agree with Drew that AIPG has had a membership problem for years. I thought it was a mistake for AIPG, several years ago, to make the requirements for CPG more complicated. Until recently, I've been active with ASBOG, and the baseline for licensing is the minimum level of competence which is a score of 70 on the examinations. All the topics of professional practice are covered, so it is not unreasonable for petroleum geologists to be unfamiliar with technical details of mining geology, etc. But professional geologists should only work/consult in the areas in which they are competent.

In working to get licensing in Illinois, our greatest resistance was from the Illinois Society of Professional Engineers - mainly the Civil Engineers whose work laps over into geology. Our best answer to them was if they would let us do the geology, they wouldn't get sued for malpractice for messing up on the geology.

My thought is that AIPG needs a "Licensed Geologist" category and needs to operate in a fashion similar to that of the National Society of Professional Engineers. Several states already have groups that could join into AIPG with some delicate negotiations.

**William Dixon, (formerly) CPG-03659**

### Hi Adam,

An example to your article "Do Rules Apply" is illustrated by my experience with my family in 1997. In 1971 I found a great sheer face display of obsidian and snowflake obsidian at Yellowstone Park. The face was a vertical wall about 8 to 12 feet in diameter along a trail in the park. I didn't have a camera then but knew exactly where it was. In 1997 I took my family and three boys to the Park and wanted to show them the outcrop. It was cleaned out, a great disappointment. Visors now do not know it even existed. Made a big buildup for the kids to see. What a letdown; it was so beautiful.

Keep up the good work.

**Gary Dannemiller, CPG-05118**

### Dear Editor,

Really excellent summary of exploration tools and methods re: epithermal precious metal deposits by Mr. Wood! More like this, please.

**Jeffrey O. Keener, MEM-0777**

*Editor's Note: I'm happy to include articles our members like, but I need those articles to be submitted to me for publication. Please keep them coming!*

# Aquifer Recharge at Terry Ranch, CO: Model for Large-Scale Municipal Water Storage?

**William Hoyt, Ph.D., CPG-7015, Harold Evans, P.E., Adam Jokerst**

## Abstract

Since recent severe/extreme droughts and wildfires threaten sustainability of humans relying only on surface water reservoirs in the arid west, the strategy of storing water in underground aquifers by means of artificial recharge has become attractive. A pair of studies conducted by the Colorado Geological Survey in 2003 and 2004 took stock of the ground water resources in the State and assessed artificial recharge already being done, as well as its potential for the future. The advantages of aquifer storage and recovery (ASR), compared to surface reservoirs, include: 1) protection from surface contamination from watershed impacts such as wildfires, 2) prevention of evaporative loss from surface reservoirs (3 feet to over 6 feet of evaporation in an average year along the Front Range and eastern plains of Colorado), 3) ease and economy of obtaining permits for non-tributary water storage, 4) increased ability to store water that Greeley has access to and especially in years of excess supply, 5) feasibility of ASR within the context of Colorado Water Law, and many other benefits.

The City of Greeley, Colorado (population 110,997 in the 2020 Census) is 50 miles north of Denver, 50 miles south of Cheyenne, and 20 miles east of the Northern Colorado Front Range. Since the 2010 Census, Greeley has grown almost 20%; projections suggest Greeley's population may double by the year 2050. To increase and diversify Greeley's future water needs, the Water and Sewer Board and City Council unanimously approved the acquisition of an ASR project (the "Terry Ranch Project") for purposes of municipal water storage and retrieval of native water from the Late Cretaceous-age Upper Laramie Formation Aquifer. Depositional environments are characterized by fluvial sands and silts. Aquifer thickness in the Terry Ranch area is 800-1,000 feet, and its decreed volume of native groundwater 1.2 million acre-feet (which would add substantially to Greeley's water storage upon project buildout by the end of the 21st century). Extensive feasibility studies have been conducted at Terry Ranch in test wells to ascertain water quality and water quantity that could be produced from and recharged to the aquifer. The upper part of the aquifer (generally 200 feet to 600 feet below ground surface) would be the main "working" part of the formation because the hydraulic conductivity and pumping rate characteristics there are one or two orders of magnitude better than the lower part of the aquifer. The upper part of the aquifer is overlain by 400-500 feet of the Tertiary White River Formation, chiefly composed of fine-grained volcaniclastic sediments; the upper part of the aquifer is underlain by about 400 feet of the Laramie Formation aquiclude, comprised predominantly of silts and clays. The upper part of the aquifer is confined in the region of Terry Ranch.

Because ASR is a relatively new paradigm for large-scale municipal water storage in Colorado, those vested in the civil engineering of dams and spillways may be wary of such a strategy. On balance ASR is a viable and cost-effective strategy for large-scale water storage for a municipality like Greeley. Due to the implementation over many decades, and the cost-sharing by private interests it is a good investment for Greeley that does not cost as much as other strategies. Environmental impacts of ASR are more palatable than impacts of surface reservoirs.

**Keywords:** aquifer storage and recovery, water storage underground, surface reservoir disadvantages, wildfire, drought, water quality, environmental impacts, climate change, Terry Ranch.

## Introduction

One of the grand challenges facing humans and virtually all organisms on Earth has been the acquisition of adequate fresh water to sustain life. In the 21st century humanity increasingly struggles with providing water for increasing populations and a growing global economy. In the arid west of North America, the problem has come into sharper focus as wildfires engulf mountain watersheds and warmer temperatures stress water supplies at their source; the resultant damages and threats to surface water reservoirs have spurred water managers to seriously investigate subsurface aquifer storage and recovery as an alternative to enlarging and increasing the number of surface reservoirs. Though droughts and floods have always been a part of the geological and hydrological record, it behooves humans to seek better management strategies of both in the future.

This paper reviews one such strategy for large-scale municipal water storage that has recently been undertaken by the Water and Sewer Board and City Council of Greeley, Colorado. The initiative is called the Terry Ranch Project and is hosted in the Late Cretaceous Laramie Formation north of Greeley (Figure 1). Advantages of storing water via subsurface ASR versus surface reservoirs include:

1. Subsurface aquifers have no evaporative loss (surface reservoirs lose 3 feet to over 6 feet of evaporation in an average year along the Front Ranch and eastern plains of Colorado) and during droughts and warmer temperatures surface aquifers lose more;
2. The Terry Ranch subsurface aquifer is *non-tributary water* (not connected to rivers and therefore not "waters of the United States") and therefore the water may be used without consideration of the type or location of use;
3. Relative to surface reservoirs, permits from government entities for subsurface aquifer storage are relatively inexpensive, easy, and quick to obtain (prior to the Terry Ranch Project, Greeley spent 15 years and $19 million to obtain permits for a surface reservoir expansion project);
4. Subsurface aquifers do not remove the land surface from other uses (in this case bison grazing at Terry Ranch);
5. Subsurface aquifers are not affected by wildfires whereas surface reservoirs can be contaminated with black carbon and/or choked with soil erosion as a result of wildfires (the last few decades in Colorado and other western states have highlighted this serious vulnerability);
6. For the Terry Ranch project, the overall ***cost*** is about half that of a surface reservoir expansion because construction costs are less and because of a negotiated private financing plan (the current cost of a water tap fee to build a single-family house in Greeley ranges from $15,000 to over $20,000); and
7. With the unprecedented federal action to declare a water emergency on Lake Meade and Lake Powell, water supplies from the Colorado River Basin may dry up reservoirs and reduce agricultural and municipal water to many states in the Basin.

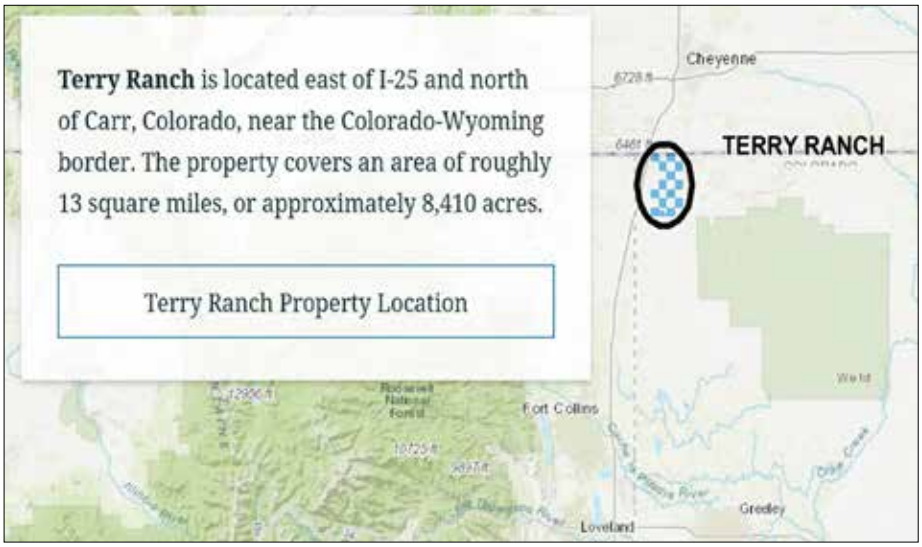


Figure 1. Terry Ranch, 85 miles north of Denver, would pump water, during times of drought, to Greeley from the Upper Laramie Aquifer; during times of excess water supply, injected water would be pumped back into the Aquifer. Full buildout of the project would be completed by 2100 thereby spreading the cost of the project out over many decades (modified from LRE Water, 2020).

The Colorado Geological Survey was charged in a pair of studies to publish a ground water atlas of Colorado and to assess the potential for artificial recharge in the subsurface aquifers of the state. The resultant 210-and 152-page reports identified and evaluated groundwater and aquifer recharge capacity and reported on 19 artificial recharge operations, with many more specific points of recharge (Topper and others, 2003; Topper and others, 2004). There are several natural aquifer recharge mechanisms that can replenish subsurface aquifers, but they typically act at such slow rates that replenishments are inconsequential on human time scales. For example, the fossil water that has been extracted from the Ogallala Formation (High Plains Aquifer) has depleted wells in most of the aquifer's eight-state extent, to the tune of drawdown of about two feet per year and natural recharge of only three inches per year (reported in Frankel, 2018). The damage to agricultural productivity in parts of the midcontinent and high plains has been catastrophic. Frankel also reports that agencies at the state and national level recognize that depletion of America's largest aquifer is an economic crisis in the breadbasket of the U.S. All over the west aquifers are in similar decline and many need recharging. Artificial recharge is a feasible answer, in part. Natural recharge to the Upper Laramie Aquifer is relatively minor compared to the aquifer volume, thus contributing to its non-tributary determination. The decree for the non-tributary groundwater allows Greeley to extract up to 1,212,100 acre-feet of the native groundwater. Use of native groundwater will augment use of injected water.

## Geologic, Hydrologic, and Water Quality of the Upper Laramie Aquifer

The Late Cretaceous sandy sediments of the mostly fluvial Laramie Formation are in the Cheyenne Basin of northeastern Colorado (Figure 2). The architecture of the Upper Laramie Aquifer and surrounding deposits is displayed in a pair of cross-sections in the vicinity of Terry Ranch, one north-south and the other west-east. The lines of the sections are displayed in Figure 3; the north-south section is displayed in Figure 4 and the west-east section is displayed in Figure 5. Examination of those sections shows the thickness of the Upper Laramie Aquifer in the Terry Ranch Project is 800-1,000 feet thick. Overlying sediments of the White River Formation are of Tertiary age and are mostly fine-grained volcaniclastics. The underlying Lower Laramie Aquitard is also mostly fine-grained with a considerable clay component. The fine-grained sediments above and below the Upper Laramie Aquifer act to prevent vertical migration of fluids, at least on human time scales. That means that contamination from above or below the Aquifer would be minimal and of little concern. In short, the aquifer is quite well protected. The White River Formation above averages almost 200 feet thick and the Lower Laramie Aquitard below averages about 600 feet thick.

The aquifer is divided into an upper unit and a lower unit, both about 400-500 feet thick (see Figures 4 and 5). The upper unit is the best working part of the aquifer because both pumping rate from the seven test wells (measured in gallons per minute) and hydraulic conductivity (measured in feet per day) are 10-100 times faster in the upper unit compared to the lower unit (LRE Water, 2020). That simply means that it will be much easier to pump water out of the upper unit (and recharge water back in).

The horizontal migration of water through the aquifer is very slowly down gradient to the east. In the unlikely event that polluted water finds its way into the aquifer west of Terry Ranch by way of natural recharge, it would take about 1,400 years to reach the project.

Water quality from the 7,000-plus samples collected from the seven test wells shown on Figure 3 is generally good. During due-diligence water testing, water quality studies largely focused on the condition of the native formation groundwater. However, we also conducted a pilot injection test to evaluate water quality of the blended water following injection and withdrawal. The pilot test injected approximately 150,000 gallons of Greeley's treated water, the quality of which is excellent, and stored that water in the aquifer for 24 and 72 hours prior to extraction. Blended water quality was good, and showed lower concentrations of metals (e.g., uranium) than the native groundwater. Manganese concentrations in the native formation waters are above the EPA limit in a few areas, but the resultant unpleasant taste can be mitigated by blending with other waters in the Greeley water system. There are also a very few samples in the native formation waters showing uranium levels above the EPA limit. Those are routinely removed to non-detect levels by ion exchange columns. Nevertheless, opponents of the Terry Ranch Project have cited the uranium in the water as reason enough to abandon the Project. But evidence of routine treatment success at removing uranium suggests that using uranium to discredit the project is simply a scare tactic. Some people are swayed by such tactics.


Figure 2. Terry Ranch is in the westernmost part of the Cheyenne Basin. In this view only the Northern Colorado extent of the Basin is shown; it does extend into Wyoming (modified from LRE Water, 2020).

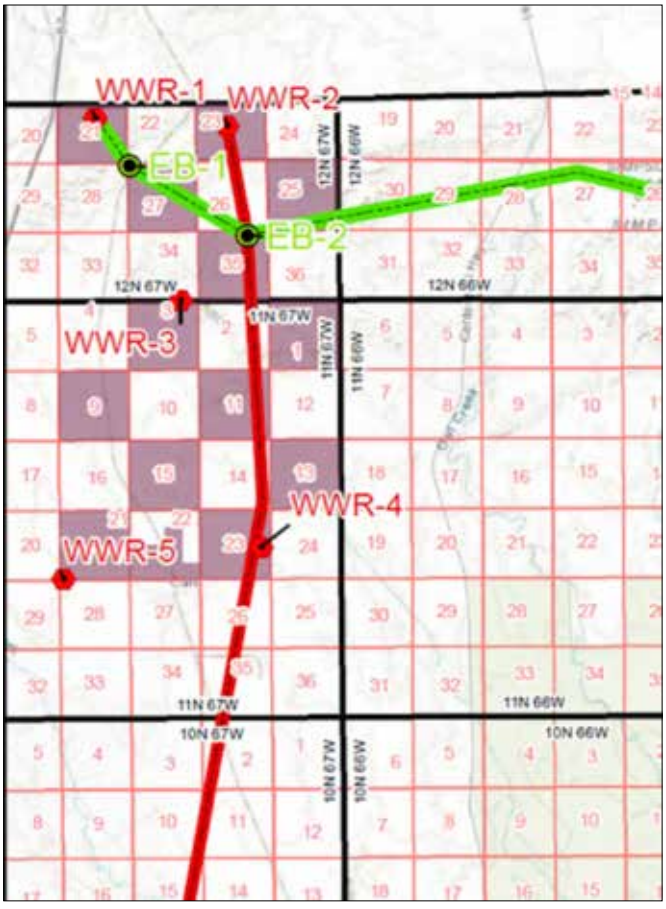


Figure 3. Lines of cross-section in the immediate Terry Ranch area. The north-south cross-section is shown in red and the west-east cross-section in green. Test well locations are shown by circles. The 13 square miles of the project area are colored in. Bison graze on the surface land now and in the future (modified from LRE Water, 2020).

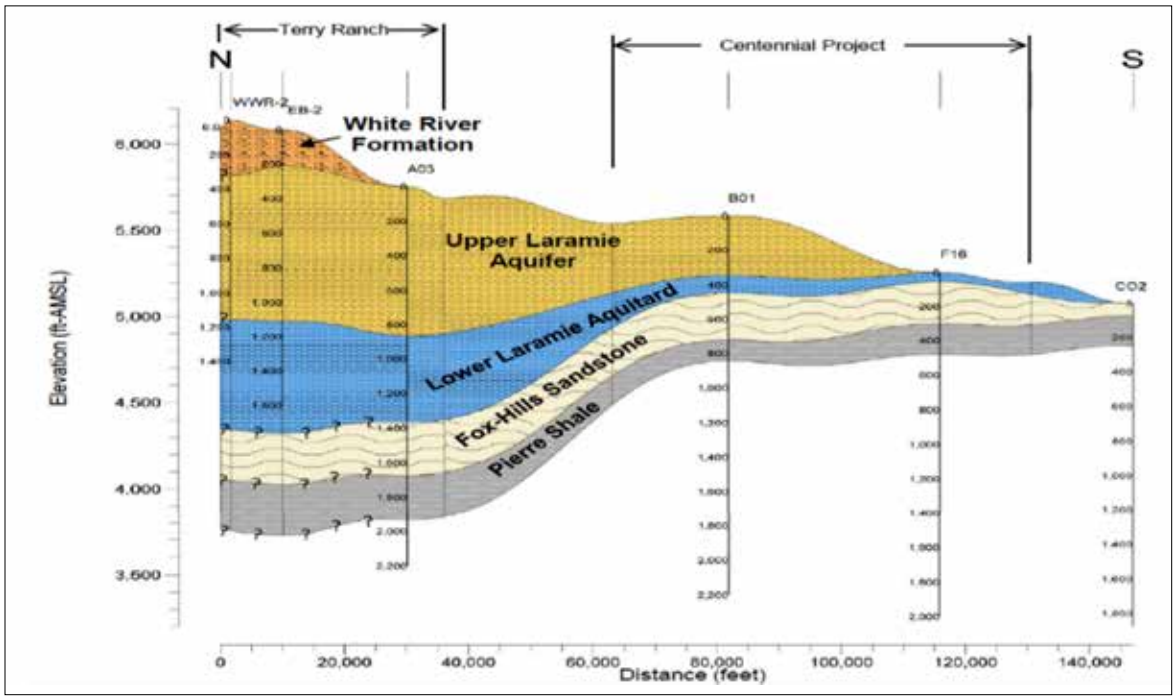


Figure 4. North-south cross-section showing the Upper Laramie Aquifer in yellow. It is thickest in the Terry Ranch area (800-1,000 ft. thick) and is the "working" part of the aquifer for water extraction and recharge. Test well locations are indicated at the top of the sections. All units thin to the south toward the Greeley Arch (modified from LRE Water, 2020).

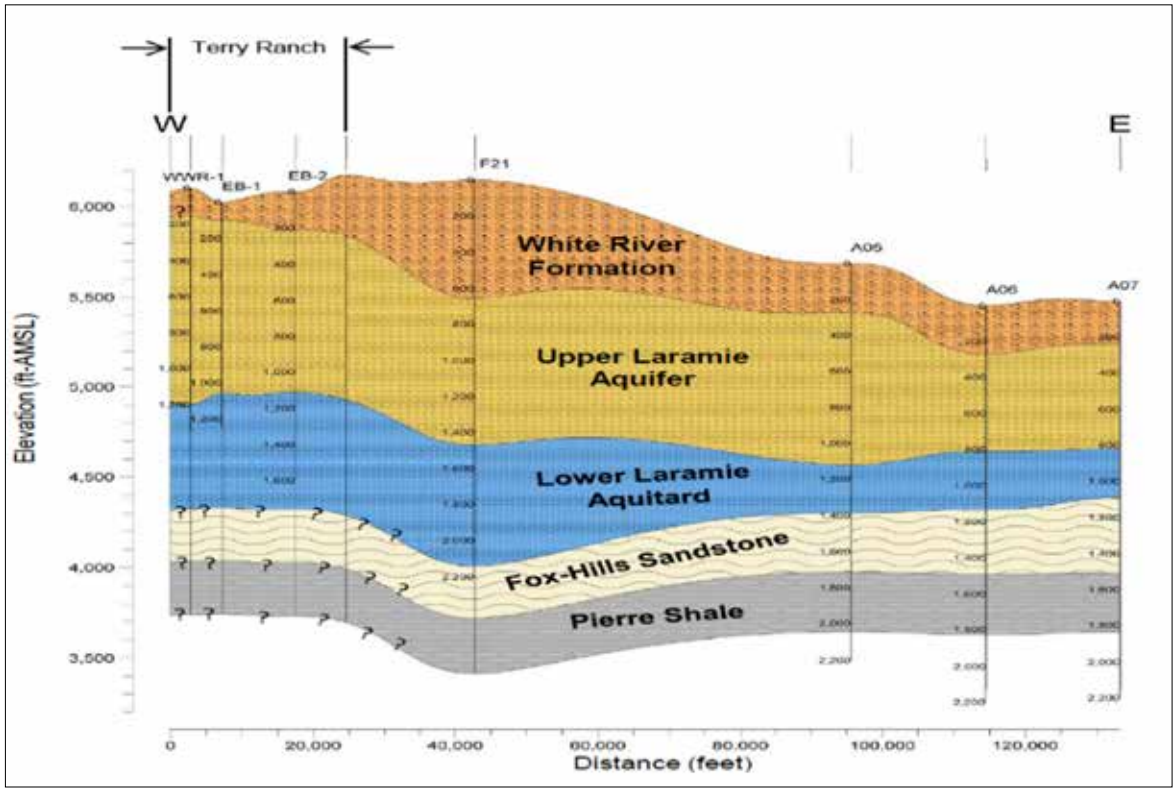


Figure 5. West-east cross-section showing the Upper Laramie Aquifer in yellow. The Aquifer gradually thins to the east (modified from LRE Water, 2020).

## Financing the Increasing Costs of Water

A novel approach to financing of the Terry Ranch Project has been laid out in a presentation delivered in November at the annual meeting of the American Water Resources Association (Jokerst, 2021). A private company owned the water and surface use rights and provided preliminary due diligence regarding water quantity and quality at the Terry Ranch site. Under the purchase arrangement, the company will receive Raw Water Credits redeemable in the future for raw water dedication due to Greeley from developers and homeowners – the payment in the form of water or cash due from developers to receive a water tap. Greeley gets the water and recharge rights in perpetuity for the 1.2 million acre-feet of water. Moreover, Greeley's buildout of the full capacity of the artificial recharge and recovery system will be phased between now and the turn of the 21st century, thereby avoiding large increases in water rates that a surface reservoir would invoke immediately. It is a creative and fiscally beneficial arrangement that appears to

be a win-win-win (for the city, the company, and the environment).

To sustain an ASR system for as long as possible, it is necessary (and required by the EPA) to only inject clean, treated water from the Greeley water system into the aquifer during the recharge cycle. This minimizes the potential for deleterious chemical reactions and sediment that could plug pore throats in the sandy/silty formations. But it also increases costs to do so. Combined with pumping costs, ASR projects can entail higher operational costs than traditional gravity-fed surface reservoir systems.

## Cultural Understandings and Collaborations a Groundwater Geologist Needs to Understand

During the next several decades of water acquisition in the west, increasingly complex and new water development schemes will require geologists involved in water development to collaborate across many sectors of society. Some of the skills and understandings necessary for projects like Terry Ranch are:

- This strategy is different from just collecting snowmelt runoff into surface reservoirs.
- Those who were good at building reservoirs and filling them from rivers are going to be wary of a new strategy (this is a new paradigm).
- Any project that involves any nuclear word or any nuclear substance (no matter how minute) will be fraught with fear and public opposition.

## Conclusion

Horace Greeley founded the Union Colony (Greeley) in 1869 with his urging "Go west young man". Though Horace did not originate the saying, it is often attributed to him. Ever since, the town has led the development and implementation of Colorado and western water law and policy. For example, in a dispute with Fort Collins, in 1874, the town of Greeley was able to establish the precedence for the doctrine of prior appropriation. That is, the person who put water to beneficial use first has the first priority to the water. This is also known as having the senior water right. That is the cornerstone of Colorado law. And Delph Carpenter, a lawyer from Greeley, authored the first draft of the Colorado River Compact. That agreement divides Colorado River water among states in the southwest and Mexico (Hobbs and Welsh, 2020). As such, Greeley has innovated the acquisition and management of water in the west and has always been forward-looking in its water strategies. A sophisticated scientific and engineering board (the Greeley Water and Sewer Board) informs the Greeley City Council of wise and pragmatic strategies to obtain water. Despite the careful analysis of the Terry Ranch ASR project and its high likelihood of success, a small group of opponents obtained enough signatures to force a vote on a change in the Greeley Charter and diminished influence of the water professionals who serve in the Greeley Water and Sewer Board. In November, Greeley citizens voted on two measures brought by opponents of the Terry Ranch Project. Those measures failed by large margins and so implementation of the Terry Ranch ASR Project continues.

The American Geosciences Institute (AGI) declared the 2021 Earth Science Week theme (Oct. 10-16, 2021) to be *"Water Today and for the Future"*. For practicing and future hydrogeologists to prepare for future water needs, it would be wise to learn as much as possible about aquifer storage and recovery. Terry Ranch is a great case study toward that end.

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