Geologically Speaking

A Michigan Section AIPG Publication

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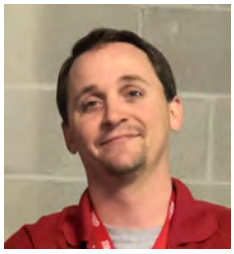

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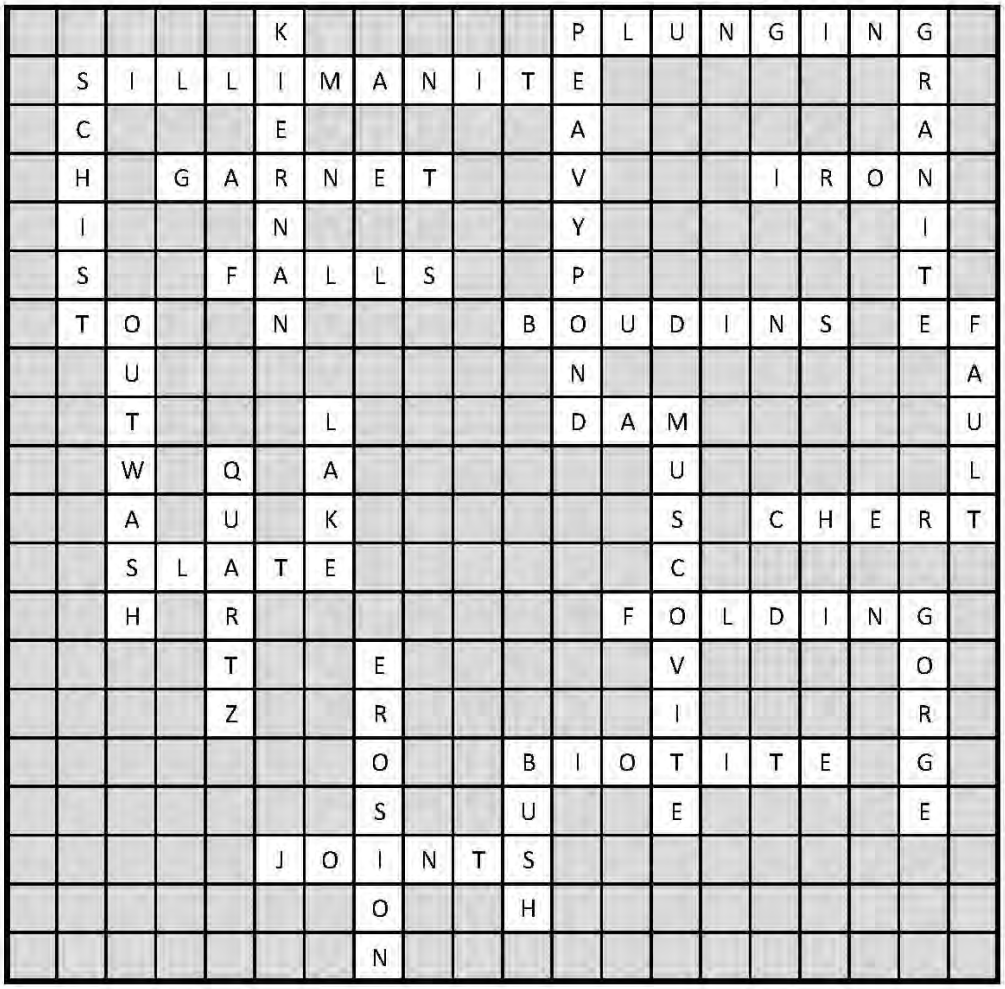
Geology Crossword #3 Solution



Across

2 Plumbers action
4 Highest metamorphic grade
5 Semi precious gem
6 County or element
7 Topples
8 Letter addressee
10 Extensional deformation feature
11 Out of or like
14 Inpoundment feature
17 var. silica
18 Michigamme rock
19 Compressional deformation feature
22 Black mica
23 Doobie

Down

1 Ultramafic sill
2 Man-made lake
3 Felsic intrusive rock
4 Mid-range metamorphic
9 Glacial deposit
12 Geological break
13 Water body
15 $KAl_2[(OH,F)_2 \mid AlSi_3O_{10}]$
16 Residual magma fluid
20 To stuff oneself
21 Material reduction
22 A shrubbery

From the President's Desk

The Holidays are over and it is the start of another year, hopefully not quite as crazy as last! I, as you, have missed our periodic Section meetings where we can socialize face to face, enjoy a beverage together, discuss what is new, and reminisce about times past. Although our virtual meetings and seminars have been great, it is just not the same. Hopefully the time when we can meet in person as a group is not too far off!

Periodically throughout past years, I have been asked to present geology related topics to the public for both for work and on my own time. Public libraries and schools are the most common places. Presentations like these tend to be a little more relaxed than those work related, which may deal with such things as hydraulic fracturing, and a lively discussion of the rules and laws that govern. I enjoy talking to kids; they have such a genuine affinity for rocks in general and geology as a science. My most frequent presentation subject is the geology of Michigan. I can incorporate our mining history, formation of the Great Lakes, and the tropical climate that gave rise to hexagonaria.

With the health conditions that have impacted all of us since March, all of these events have been unfortunately canceled. I enjoy these events very much and really miss them. Whether it is a group of 3rd graders in school, or a summer afternoon at a small library where Grandma and Grandpa bring the grandkids to listen to some old dude talk about rocks. I bring in larger specimens of banded iron, copper, coral heads, … for people to touch and feel. Generally I feel the participants enjoy themselves, hopefully something was learned by all.

The reason I bring this up, is that the general public does not have an understanding of what we as geologists do as a profession. Who better to tell the story than a geologist? Whether we are prospecting for mineral deposits, exploring for oil/gas, or remediating the environment, the role geologists play in our society is incredibly important!

There is a great deal of opportunity for us, as professional geologists, to reach out to the public and explain what we do, and present the geological sciences in a manner that can be understood. When things become more "normal", think about arranging a presentation to your child's class, your grandchild's class, the local library, or maybe a senior home. Many areas have local rock clubs and they are always open for new members, especially geologists. Share your knowledge and tell people what it is to be a geologist!

Great resources are readily available. Geology in Michigan , EGLE- Oil, Gas and Mineral Division, https://teachearthscience.org/, Teach Earth Science, and https://www.usgs.gov/science-support/osqi/yes/resources-teachers/online-lectures, U.S.G.S, are only a few sites.

I am not one who generally enjoys being in front of a crowd, as you will see throughout the year, but I really enjoy talking to folks about rocks and geology. If we geologists do not tell our story, then who will?

I am looking forward to a busy year as 2021 Section President! Please feel free to contact me with any questions or comments you may have throughout the year.

Be Safe, Stay Healthy!

Bill

Students - Reminder

Don't Forget: Your student Chapter Reports are due by May 1 each year. Send a copy to Dorothy Combs at National at aipg@aipg.org and to Adam Heft at adam.heft@wsp.com.

Celebrating Women and Minorities in the Geosciences:

Dr. Mona Liza Sirbescu, CMU Faculty

Some of you may know me, but for those of you who do not… Hello! I'm Mellisa Powers-Taylor, the 2021 Michigan Section Vice President, and I have been working as a geologist for the past almost six years. My journey into geology began about 10 years ago when I started my undergraduate program at Wayne State University. As a younger female geologist, I feel privileged to have had the opportunity to be surrounded by such a diverse group of geologists, environmental scientists, and environmental engineers. I've known that the field of geology and the geosciences in general have been dominated by white males for decades, but I have been witnessing the turning point where more and more women and minorities are becoming engaged and taking on careers in the geosciences. I was extremely fortunate to have gone to college in Detroit, which was a melting pot of all different kinds of people with all different types of backgrounds. My geology classes had men and women, Caucasian, Middle Eastern, African American, Asian, African, Dutch-Canadian, etc. My 2013 undergraduate field camp class was the first in that field camp's 100 year history to have more women attendees than men. In 2015 when I entered the workforce, the office I worked in was dominated by women scientists, engineers, and CAD technicians.

Amy Hoeksema, the 2020 Michigan Section Past President, inspired me to begin this article series. As I have gotten to know Amy over the last few years as a mentor and friend, we have talked at length about the importance of diversity in the field of geology. She has shared with me the stories of her early career as a woman in the field of geology and the challenges she faced early on because of men who thought the field was no place for a woman. Together, Amy and I embarked on a mission to meet women and minorities in geology and the geosciences who are making a positive impact to the profession, and inspiring others to join us in exploration of the earth. Our goal is to share their stories and honor their hard work and dedication. We hope that their stories will inspire and motivate others. Our work as geologists is important for tackling some of the world's most important issues. Diversity within our field can bring about new ideas for tackling these problems we face.

I first learned about Dr. Mona-Liza Sirbescu from a former professor of mine from Wayne State, Dr. Lawrence Lemke, who is now the Chair of the Earth Science Department at Central Michigan University. Dr. Lemke spoke so highly of Dr. Sirbescu's academic background, her passion for her students at Central Michigan, and her dedication to inspiring the next generation of geologists. I knew she would make a great candidate for this article series based on her accomplishments as a professor at Central Michigan University. I admittedly knew little of her personal background, including where she was from, other than what I could gather from her curriculum vitae that was shared with me by Dr. Lemke. So I walked into

the discussion with an expectation of getting to know a University Professor but walked away with a glimpse into the fascinating life Dr. Sirbescu has lived. As the Michigan Section Executive Committee liaison to the CMU Student Section, I really look forward to getting to know Dr. Sirbescu, learning more about her life story, and working with her and her students from Central Michigan over the next few years.

Amy and I began our discussion with Mona with the most basic question – What inspired you to become a geologist? Mona described the area of Romania where she grew up as rural with tall hills. She loved exploring and a normal summer activity as a child included collecting fossils and rocks washed downstream to the area near her house by a local stream. While exploring with her younger brother and a couple of other kids when she was around the age of 9 or 10, she discovered a layer of lignite coal in the bed of a small stream in the small town of Beceni, Romania where she lived. They also found thin layers of gypsum in the crest of a nearby hill. In this area she collected coal samples, gypsum crystals, and gastropod and bivalve fossils. Some of her twinned gypsum crystals were later placed on display in the Mineralogy department at Bucharest University, and she still uses one of the gypsum specimens she brought with her to Central Michigan for teaching today. Her love of exploration and the abundance of geology to explore sparked her interest in geology in very early childhood and high school. Later, in college Mona found out that the formations surrounding her home town are an upper Miocene sequence deposited in the foothills of the Eastern Carpathian Mountains. The region was part of the "Parathetys" basin closing during collisional tectonics between Africa and Eurasia. The Mediterranean Sea – Black Sea – Caspian Sea, etc. are today's remnants. Professors at Bucharest University confirmed her coal samples, gypsum crystals, and bags of nice fossils (gastropods and bivalves).

In 1980's Communist Romania, a college education was free, but following college, a person was placed into a job directly related to their degree. In the early days of college, Mona's interests in drawing and art steered her towards applying to the architecture institute. When her application was rejected to the Architecture Institute, she applied to the geology school and was a top candidate on their list.

Women were treated equally in Communist Romania. Occupational paths had less to do with gender and more to do with ability. In the 1980's, her geology program was made up of about a 50/50 split of men and women, and she had both men and women as professors at her University in Romania. Her department as a whole at the time had somewhere between 60-80 professors. Mona

did not experience mistreatment or gender bias while studying geology during her undergraduate program, unlike what she would later experience coming to the United States in the mid 1990's.

Within the first week of school, students were taken into the field for two weeks for courses. She was completely fascinated by her geology courses from the beginning. "The first field trip was in the Apuseni Mountains, Transylvania (Western Romania) and included visits to several active mines, extinct volcanic structures, metamorphic terrains, and even a gold museum in Brad City. "I was in love with minerals at first sight! That early field trip and the first courses including Physical Geology, Cartography and Topography, and Introduction to Earth Physics connected perfectly to my childhood experiences including my early geologic "explorations" and a powerful 7.2 Magnitude (Richter) earthquake of March 4, 1977." Initially she had an interest in paleontology, which led to her first project to research fossils. Before even taking a paleontology class, Mona worked on a project with her Physical Geology lab instructor, Mrs. Sagatovici, where she helped with fossil collection, cataloguing, and size measurement. This lead to her first co-authored publication in a Romanian journal! She discovered her "irreversible passion" for Mineralogy in her sophomore year. "I remember being involved with a team project on placer gold, then sketching crystals for a crystallographic atlas of Romania that Prof. Emil Constantinescu was putting together, and several other interesting projects." Mineralogy is still her research focus today.

Communism in Romania ended in 1989, the same year that Mona completed her undergraduate degree in Geology. Her senior thesis was on molybdenum-REE mineralization associated with the Ditrau alkaline intrusion, Eastern Carpathians. Following the completion of her undergraduate degree, Mona worked for one year as a field geologist in Romania and for a couple more years as an Assistant Professor for Bucharest University, Ro-

mania and Bucharest Ecological University, Romania. The end of Communism opened up many opportunities for information sharing from publications around the world. For the first time, Mona was able to read research from Western Scientific Journals. She developed a desire to work on advanced mineralogy at a rigorous quantitative level. There was a lack of analytical facilities in Romania and after receiving two ads for graduate schools in the United States (Duke University and State University of New York (S.U.N.Y) at Binghamton), she decided to apply. She was accepted to geology programs at both Duke University and S.U.N.Y at Binghamton. She ultimately chose S.U.N.Y because she had received their acceptance first and had already started communications with their geology department and their office dedicated to international students. She said that this is a decision she has never regretted.

Mona came to the U.S in 1993 and has called the U.S her primary residence ever since. On the day of our interview, Mona shared that she was becoming a citizen of the United States that very week. She was excited to be able to vote in her very first election!

Mona received her master's degree in Geology from S.U.N.Y. Mona described the differences in attitudes towards women at the time and there was a stark contrast between the two countries. At S.U.N.Y – Binghamton none of her professors were women. She described feeling isolated a bit by the male faculty, and she did not feel welcome in some groups. Although some made her feel unwelcomed, her advisor Dr. Jenkins was both fair and caring. During her graduate studies, she encountered few minorities in the program. The diversity she did see came by way of international students studying in the U.S.

Her programs, and the industry, were still male dominated when she received her Ph.D. from the University of Missouri-Columbia in 2002 and began teaching at Central Michigan University in 2001. Although many in the field had a deep respect for the contributions of women, minorities, and foreigners, some still held that old boys club attitude to the field and looked down on the work of others.

Mona shared an example of a time when she experienced blatant gender bias towards her and her work during a presentation she was giving. She described a packed session room where very few women were seated among predominantly white-haired, white men. Mona was the only woman presenter and was the last to present during the special topic session of that day. To make the setting a little more tense, some very important names in petrology and geochemistry were seated in the audience. All of the previous presenters of the day were given simple introductions with the presentation title and presenters name. Mona was given a "special" introduction that not only stated her name and presentation title, but also questioned the core strategy of her research and clearly attempted to discredit the presentation before it had even started. Mona described those moments by saying "As the convener's words cut like knifes and it was time for me to step up on the podium, my heart was going fast, my eyes were quickly drying up some tears, but my mind was laser focused (or so I thought). I spontaneously redesigned my presentation as a series of rebuttals. Apparently, I defended quite well our thesis. I received many congratulations and encouragements and eventually I learned to beam with confidence again. Still, after all these years, a bit of bitter taste remains, just enough to fuel my deliberate mentoring of cohorts of students (about 50% female) with their research projects and teach them to give confident, well-prepared research presentations."

These negative past experiences of gender and foreigner bias, feelings of isolation, moments of disrespect, and feelings she would not want others to experience have crafted Dr. Sirbescu into the outstanding educator she is today. Her initial experiences in New York as a master's student allowed her to know what it meant to feel like an outsider and gave her an advantage to connect with students who may feel like they are different.

Dr. Lemke shared the following about Mona when nominating her for the 2020 AIPG Michigan Section Out-

standing Educator Award; it truly sums up how her past experiences have allowed her to become such a compassionate and influential educator:

> "Equally important, and comparatively rarer, is Professor Sirbescu's attention to the affective needs of her students. She shows care and respect for them in a myriad of small but important ways. In her classes, for example, she learns all of her students' names. This may seem simple, but it fosters a sense of belonging and mutual respect that permeates her classroom learning environment."

One challenge that is acknowledged by academics and professionals alike is engaging more minorities in the geosciences. Other industries are identifying that lack of diversity and the Nasdaq has even recently proposed to require more than 3,000 companies on its stock exchange to improve boardroom diversity by appointing at least one woman and at least one minority or LGBTQ+ person to their boards. Greater diversity can lead to broader perspectives, a greater pool of ideas, and overall stronger unity within an organization by bringing people of different backgrounds to the table. It is this drive for stronger diversity in organizations that push our Universities to seek out ways to bring in and motivate groups of students who may not otherwise look towards the geosciences.

To give more minorities an opportunity to develop an interest in fields which they might not otherwise explore, universities like Central Michigan are developing programs to engage underrepresented communities early. When asked why she finds diversity in the classroom so important, Mona responded "Our mission is to train and educate new generations of geoscientists who will have to tackle increasingly complex issues: diminishing resources, climate change, and environmental inequality. Addressing these issues require ingenuity of geoscientists of diverse perspectives and with broad backgrounds. Unfortunately, Earth Sciences are the least diverse STEM discipline." Central Michigan University is currently working on boosting the diversity of undergraduate students in the Earth Sciences by teaching short summer classes to kids from underrepresented communities; reaching out to high school counselors to introduce them to various geoscience career paths and; partnering with community colleges; and involving minority students in research and encouraging them to continue with graduate school.

The journey Dr. Sirbescu has been on since childhood has allowed her to become an advocate for inclusivity and diversity within our field. The adversity she has faced has molded her into an outstanding educator and role model for her students. She is able to build connections with her students and help them overcome whatever challenges they may face. We thank you, Dr. Sirbescu, for all that you do and all that you have done.

Illustrations of Successful Contaminated Site Management Partnerships with an EPA and State Funded Cleanup Action

By Charles W. Graff, Senior Geologist, Environment, Great Lakes, and Energy

This article is a summation of the PowerPoint presentation given during Michigan Environmental Compliance Week on September 24, 2020 hosted by the Department of Environment, Great Lakes, and Energy (EGLE). The site chosen for this presentation was the Ott/Story/ Cordova Superfund site located north of Muskegon, Michigan (Figure 1). This is one of the legacy sites here in Michigan, meaning that it has been identified as a source of contamination for many years and is still undergoing remediation. Many consulting and drilling firms have worked at the site through the years, perhaps you belong to one of these.

Take Away Points from this Article

- What are important aspects of contaminant site management?
- How does developing a good Conceptual Site Model (CSM) help provide the tools necessary for good site management?
- How developing a good partnership team promotes progress toward successful site management and cleanup.

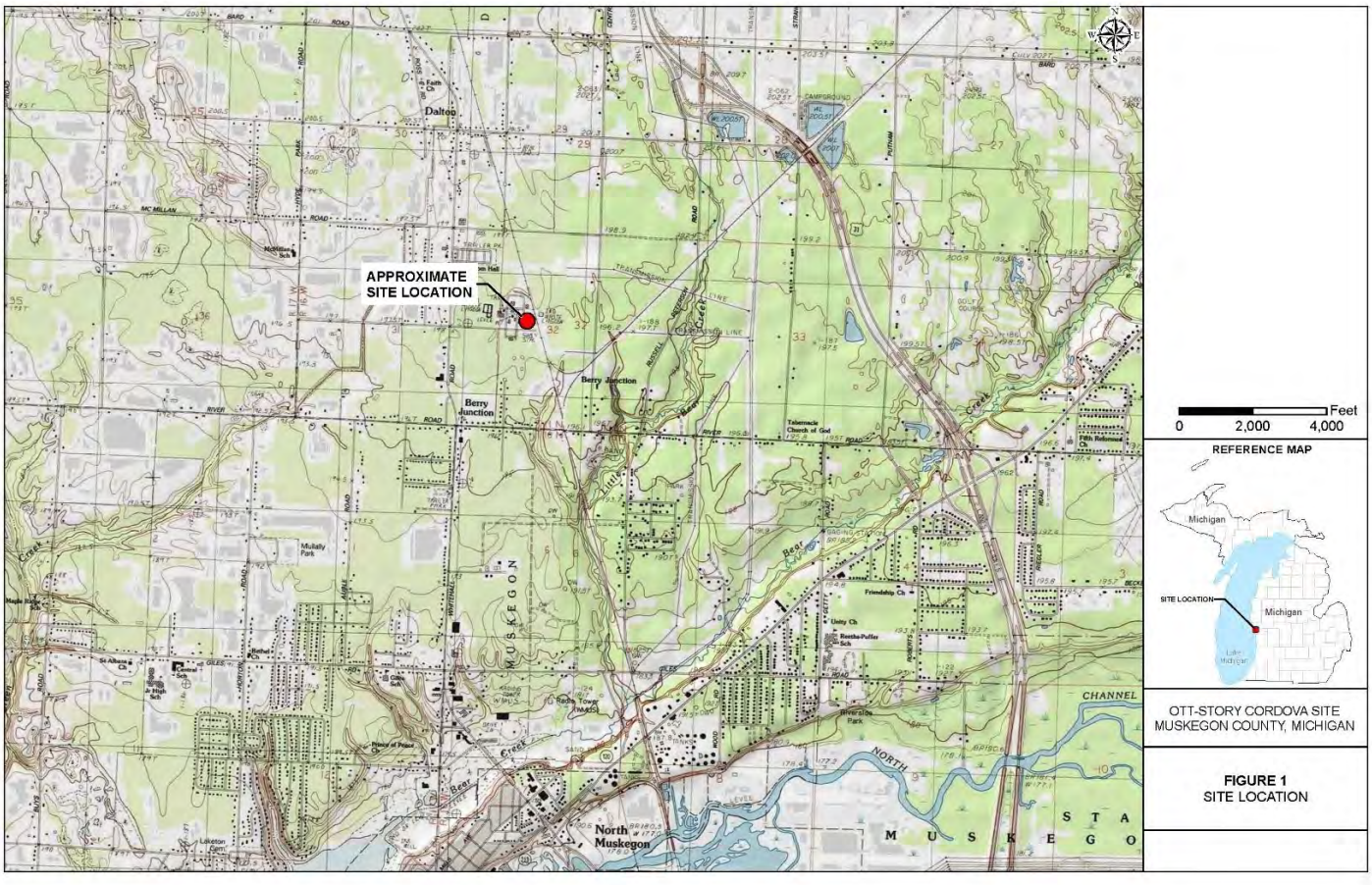


Figure 1: Site location map. Diagram by TetraTech.

History

The history of the site begets its name. Ott Chemical was started in 1957 and operated until 1972, when it was purchased by Story Chemical. Story operated until 1977 when they went out of business. Cordova Chemical purchased the site from bankruptcy but performed no opera-

tions there. The site produced specialty synthetic organic chemical intermediaries for the pharmaceutical and agricultural industry: herbicides, pesticides, dyes, and chemicals for industrial purposes. Site practices were sloppy with frequent releases of phosgene gas and leaking pipes. Chemicals were spilled and dumped around most buildings in use at the site. Liquid waste products and off-spec chemical batches were also sent to on-site waste lagoons, or placed into drums and allowed to leak out until empty. When Cordova took over, 55-gallon drums filled with hazardous waste were stacked 3 to 4 drums high and many had begun to leak their contents (Figure 2). The site covers 20 acres overall. This site was placed on the National Priorities list in 1982, officially making the Ott/Story/Cordova location a Superfund site.

Figure 2: MDNR Photo, circa late 1970s.

Resulting Environmental Impact

Over 20 years of operations resulted in the contamination of the shallow soils in the plant area (Figure 3) and the unconfined and semi-confined aquifers with a groundwater contaminant plume one mile long, three quarters of a mile wide, and up to 150 feet deep. The site geology consists of essentially beach sands with some lacustrine silt and clay layers that separate the unconfined and semi-confined aquifers. The base of the aquifer consists of an extensive clay layer. The plume that migrated to the southeast was discharging to an unnamed tributary and downstream Little Bear Creek (a designated trout stream). Whatever was disposed of on site has been detected in the plume. Both surface water bodies were considered devoid of life and the adjacent trees were all dead. Downgradient residential water wells were impacted by the plume with residents receiving bottled water for several years until a new potable water line was installed to service these homes. Over 8,000 cubic yards of soil and sludge, and approximately 10,000 drums of waste were removed from the site. Nearby dump sites also received drums and waste during site operations, one of which became the Duel and Gardner Superfund site.

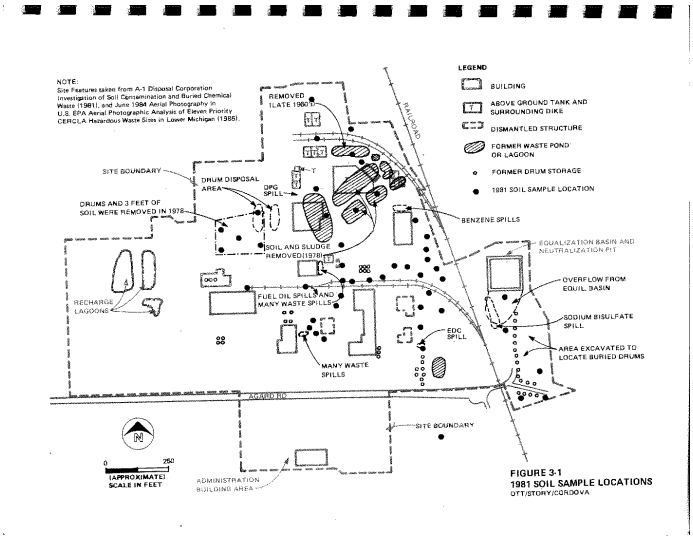


Figure 3: U.S. EPA Remedial Investigation Document.

Figure 4: U.S. EPA aerial photograph, circa 1996.

The Superfund Process and Remedial Actions Taken by the Partners at the Ott/Story/Cordova (O/S/C) Site

Cordova worked with the State of Michigan and the Environmental Protection Agency (EPA) to begin site cleanup and disperse any salvageable equipment still at the site as well as paying for the water supply line in 1982. Several investigations were performed at the site in attempts

to delineate the soil and groundwater contamination. Records of Decision (RODs) were written to codify the site issues and resolutions/chosen remedial action goals. A site remedy was chosen, designed, and installed by the Army Corps of Engineers (ACE) and consultants, with input and oversight by EPA, and DNR (EGLE). In early 1996, the groundwater treatment plant was fully functional (Figure 4) and put on line with nine extraction wells pumping contaminated groundwater to the plant: eight from the upper aquifer, and one from the semi-confined aquifer.

Ongoing Activities

There are monthly partnering meetings to evaluate system operation and maintenance (O&M), treatment effectiveness, and likely changes needed (Figure 5). Through

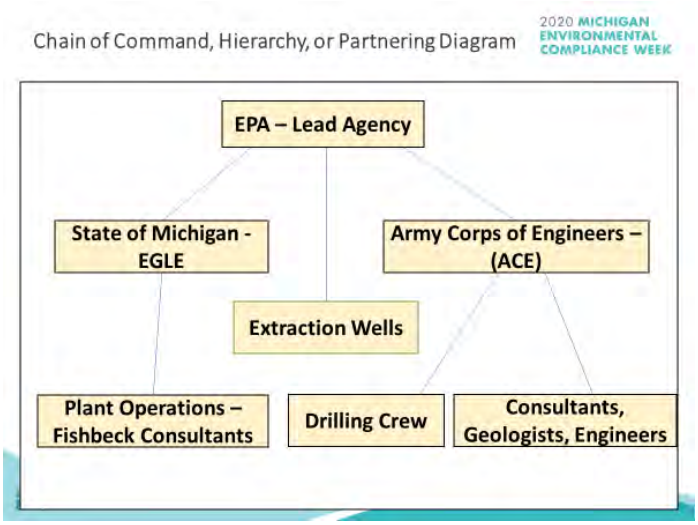


Figure 5: EGLE diagram, chain of command.

time, additional extraction wells have been added with the operation of 12 high-capacity extraction wells, pumping

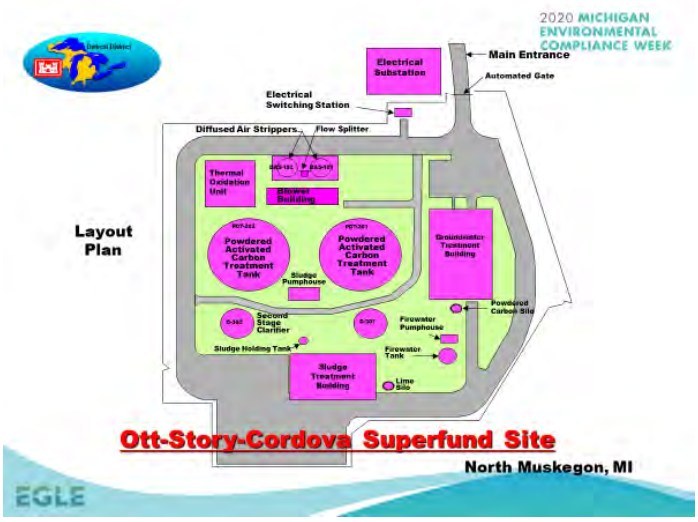


Figure 6: ACE site diagram.

from 40 to 100 gpm each. The groundwater treatment plant (GWTP) has a treatment capacity of up to 900 gpm, currently operating at ~650 gpm 24/7 (Figure 6). The State of Michigan took control of the GWTP in February of 2011, as mandated by Federal law, with an O&M cost of about $1.8 million per year. The extraction wells are currently being evaluated under an EPA contract with the ACE and a consultant. Once they are deemed fully functional, the State will also take over their O&M as well. Replacement and new extraction well installations are planned.

Additional Actions Were Deemed Necessary

During monthly meetings, it became apparent that the source area must be delineated for treatment so the pump and treat remedy could be more effective and be completed in a shorter timeframe. EPA retained a consultant to address this issue. They worked with the Agencies to develop a work plan and implement a source area investigation. This work began in 2014 with HRSC: high resolution site characterization. Development of a valid Conceptual Site Model (CSM) is the single most important activity for ensuring that sound site management decisions, including remedy selection and design, are made. HRSC helped make this possible and the CSM was updated with the new site information (Figures 7 and 8).

Figure 7: Tetra Tech Phase IV Downgradient model.

The HRSC began with a membrane interface probe (MIP) investigation near the assumed western edge of the source area. The MIP reconnaissance work was not as effective as planned; so, the investigation work was switched to the WaterlooAPS (advanced profiling system). It allows collection of groundwater samples along the aquifer soil column while collecting hydraulic pressure data continuously, which provides relative hydraulic conductivity (IK) values. Groundwater sampling is very flexi-

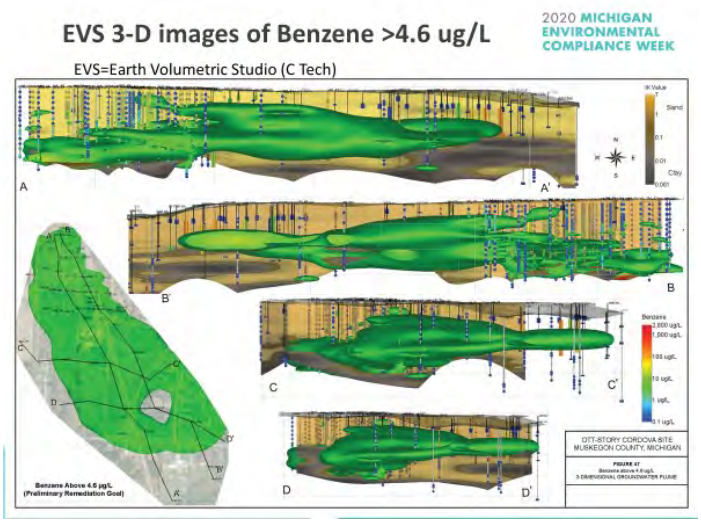


Figure 8: Tetra Tech diagram.

ble within the aquifer with this system. Numerous groundwater samples were collected for VOC and SVOC analyses at on-site laboratories (Figure 9). Quick turnaround was possible and essential for guiding continuing fieldwork. The on-site lab at O/S/C was invaluable for this work, especially analyses for SVOCs.

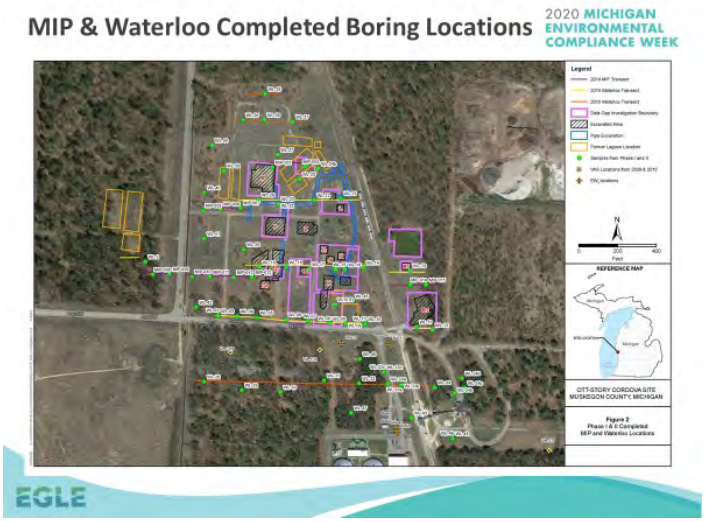


Figure 9: Tetra Tech diagram.

An Updated CSM

The updated CSM allows a better evaluation of what the source area consists of and how best to plan for the most appropriate remedial actions to effectively clean it up. It is easier to hit a target when you know where it is located. Likewise, the CSM provides all partners with a clear understanding of what they are dealing with; all partners have the same perception of the site conditions. This agreement makes it easier to make forward progress and not waste time on conflicting opinions based on an inadequate data set. The site partners are working with consultants on a Focused Feasibility Study to shorten the time required to clean up the site, and a ROD will soon follow.

Current Site Activities

Additional actions at the site have been evaluated through the years during the monthly meetings and routine calls apart from those meetings, as necessary. The age of the treatment plant is necessitating the upgrade of many treatment train components. EGLE is currently working with Fishbeck consultants to most effectively implement upgrades and replacements to bring portions of the system up to modern standards of operation (computer systems and electronics). Onsite operators are continually repairing and optimizing the operations at the plant and in the laboratory. For example, they evaluate the operation of the extraction wells and take measures to keep them operating effectively to maintain capture while also keeping the GWTP effectively treating the contaminated groundwater waste stream.

Major modifications were evaluated and discussed between the parties, which requires significant coordination on many fronts. One such item was the repainting of the treatment system at the site, which included all the piping and tanks; essentially every painted surface (Figure 10). This effort also detected other problems with the tanks, one of which was erosion of the very bottom of the powdered activated carbon treatment tank walls that was revealed during routine sand blasting that cut through the steel tank walls; this should not be possible. Further investigation brought this issue to light, and it was dealt with during the repainting effort. The team is working well to address these many issues. We keep each other up-to-date with the progress on these issues in our monthly meetings, which are now calls since COVID-19 hit.

Figure 10: EGLE photo.

Geophysics in the Time of Covid-19

By Breauna Murray, Wayne State University Student Chapter President 2020/2021

For myself and many students across the nation, this year has been a unique time of adjustment to online-only university life. While some universities went back to campus in the fall, Wayne State continued to require virtual classes. As someone who previously lived in the geology lab, being home all day on the computer has been mentally exhausting. Student social life has been severely impacted as well, with in-person extracurricular activities suspended this fall. As the president of the Student Chapter of AIPG at Wayne State, this presents a challenge of maintaining a sense of community while keeping physically distanced. We have found a sense of normality with biweekly online meetings by having guest speakers, and some fun ones as well. Some of these include a fun jeopardy game night, a bad scientific movie Netflix party, etc. It's not quite the same to see friends over a Zoom call, but for now it's all we have.

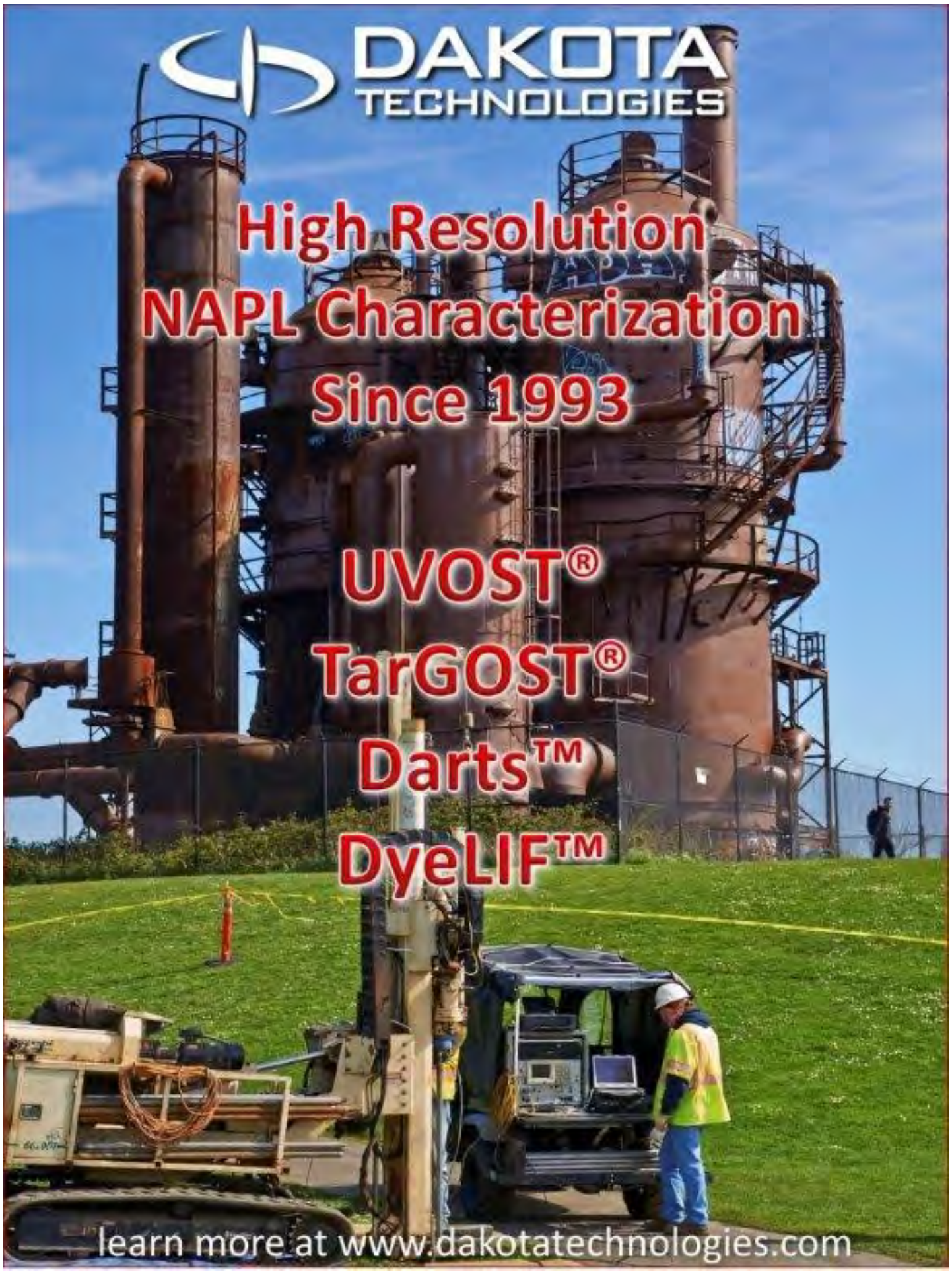
While lectures have been moved online, Wayne State allows some hands-on lab and field classes to meet in person—socially distanced, with masks on. This new normal took some adjustment too, but these labs have been a real silver lining. One of these field classes is Environmental and Applied Geophysics, taught by Prof. Scott Burdick. Although the lectures and discussion groups have been online-only, the class has gathered in person on a few occasions (apparently always during bad weather) to make measurements with geophysical equipment. These field sessions have allowed us to get real experience in designing and conducting our own geophysical surveys.

Benediktas Gaskevicius, Devon Jesiel, Jonas Sikah, Breauna Murray, Benjamin Moyer, Paul Manion, Scott Burdick, Hannah Monear, Denada Planaj. Photo provided by Breauna Murray.

Professor Scott Budick setting up the geophysical equipment. Photo provided by Breauna Murray.

As a class, we carried out two surveys around Detroit. The first was a ground penetrating radar survey of an archaeological site. The site, the former town center of Hamtramck, Michigan, is being excavated by an archaeology field course lead by Krysta Ryzewski of the Department of Anthropology, in partnership with the Hamtramck Historical Museum. Prof. Ryzewski and her students are investigating this site for artifacts and traces of past structures to understand how this immigrant community grew and developed during the last half of the 19th century and first half of the 20th. Our class staked out a 7 x 34-meter grid and pushed the lawnmower-like GPR around it to locate waste pits, utilities, and the foundations of the historical police and fire departments and the Nut House bar.

Article continues on page 23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The Pegmatite Puzzle: Insights from Mineral Intergrowth Textures

Editor's Note: This article was also included in the Jan/Feb/Mar 2021 edition of The Professional Geologist.

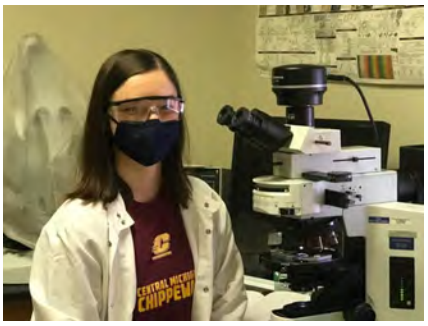

Figure 1: Emily Yoder in the lab with the Olympus research microscope/camera used to take images of thin section samples and document qualitative observations. Photo by Dr. Mona Sirbescu, 2020.

My name is Emily Yoder and I am currently a junior at Central Michigan University, double majoring in Geology and Geography (Geographic Information Science concentration). I have been a student member of AIPG since Spring 2019 and am currently the CMU Student Chapter Secretary. During my sophomore year, I became involved in undergraduate research on mineral intergrowths in pegmatites with Dr. Sirbescu. My favorite parts of research have been learning new concepts and research methods, as well as growing as a writer. This past spring, I wrote a proposal for CMU's Undergraduate Summer Scholars Program scholarship and grant, and was incredibly honored to receive this funding for my research for Summer 2020. My current goal is to attend graduate school to study volcanology, so I am thankful for this opportunity to learn important skills for my future. I highly recommend becoming involved in undergraduate research for any students who are considering it and am glad to be able to share my research here!

Pegmatites are intrusive igneous rocks of granitic composition with unique textural features. Notably, they can have coarse crystals of 2.5 cm to over 10 m in length and special mineral intergrowth textures. The cooling rate of pegmatites is debated because extrapolating the slow cooling rates for common intrusive igneous rocks to the coarse crystals found in pegmatites suggests an incredibly long duration of crystallization, perhaps as long as the age of the Earth. Some theories suggest that pegmatites formed by a long, slow cooling process. However, other models of pegmatite crystallization use geologic and experimental evidence to show that cooling actually occurs far more rapidly and at unusually low (undercooled) temperatures. As a familiar example, pure water can be placed in a freezer and undercooled to a temperature far below its freezing point and remain a liquid, then crystallize to unusual ice needles within seconds. Similarly, pegmatite-forming magma may cool below its typical crystallization temperature when it intrudes much colder host rocks (the freezer) and crystals with unusual textures may grow rapidly. While typical granites form around 700°C, studies have proposed that crystallization in pegmatites may occur as low as 400°C.

The key to solving this pegmatite puzzle may be found in a skeletal intergrowth between quartz and tourmaline, which has been the focus of the research I am currently working on with Dr. Sirbescu at CMU. We are studying samples from the granitic Emmons pegmatite in Oxford County, Maine. Emmons is about 260 Ma, rich in exotic lithium-cesium and tantalum minerals, and zoned, meaning mineralogy and texture varies distinctly from the outer edge of the pegmatite to its core. Crystallization begins at the outermost zones in contact with the surrounding host rock. The quartz-tourmaline intergrowth is found in the hanging wall zone, where tourmaline up to 45 cm long

Figure 2: Comb texture tourmaline (black) from the wall zone of the Emmons pegmatite; growth direction shown by yellow arrows. Photo by Dr. Mona Sirbescu, 2018.

has grown towards the core, perpendicular to the host rock. This oriented 'comb texture' is especially visible in the field (Fig. 2). From these more ideal (euhedral) crys-

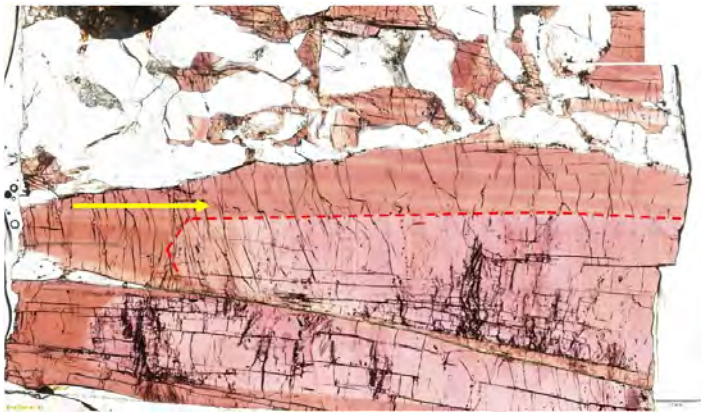

Figure 3: Quartz (white) and tourmaline (pink/brown) intergrowth shown in thin section (200 µm thick); note the larger central tourmaline and the smaller branches intergrown with quartz; tourmaline growth direction shown by yellow arrow and one boundary between growth zones shown by red dotted line (photo by Emily Yoder, 2020).

Article continues on page 31...

2020 Michigan Section Awards

Each year, the Michigan Section gives out a number of awards in several categories at its Annual Meeting. Not all award categories receive nominations; this year, awards given included Longevity, Outstanding Regulator, Outstanding Educator, and Student Posters. This year's meeting was held via Zoom the evening of December 3, 2020 because of Covid-19 restrictions.

Longevity Awards:

Longevity awards were awarded to individuals for having reached the following milestones in AIPG membership:

10 Years: David Adler, CPG-11377; John Bacon, CPG-11389; Nathaniel Hehir, CPG-11378; Curtis Lichy, CPG-11342; Scott Martin, MEM-1929; Robin Osborn, CPG-11427; and Mark Theobald, MEM-1948.

15 Years: Charles Bush, CPG-10894; Daniel Cassidy, CPG-10867; Dale Elliott, AS-0031; Erin Hart, CPG-11135; Thomas Hernick, CPG-11355; Jon Hirschenberger, MEM-0788; Bradley Hoare, MEM-0785; Jason Iseler, CPG-10871; Jason Lagowski, CPG-10944; Mack Carolyn, CPG-10399; Craig Marlow, AS-0033; and Heston Stein, CPG-10873.

20 Years: Allan Blaske, CPG-10529; Brian Burke, CPG-10546; Robert Lint, CPG-10548; William Mitchell, CPG-10486; Steven Murray, CPG-10542; Nikolas Rogers, MEM-0044; Thomas Sampson, CPG-11393; and Timothy Woodburne, CPG-10532.

25 Years: Maureen Allen, CPG-09502; Jeffrey Goedtel, CPG-09640; Daniel Hendrix, CPG-09560; Alan Hinks, CPG-09469; Douglas Hull, CPG-09567; Thomas Kinney, CPG-09552; Patrick Lynch, CPG-09514; Jamie Matus, CPG-09516; Robert Schulz, CPG-09618; Michael Tuckey, CPG-09540; and James Wilson, CPG-09656.

30 Years: James Brode, CPG-07869; James Dexter, CPG-07844; Marc Florian, CPG-07785; Craig Savage, CPG-08052; and Daniel Townsend, CPG-07810.

35 Years: Christopher Peters, CPG-06913.

On behalf of the Michigan Section Executive Committee, thank you for your support and your years of membership. We hope you will continue to be active and participate in Section events for many years to come!

Outstanding Regulator:

This year, Melissa Kendzierski from the EGLE RRD Gaylord District Office, received nominations from five individuals (Ranty Rothe, Christiaan Bon, Amy Pitts, Heidi Pixley, and Elaine Pelc) for outstanding regulator. Here are some excerpts from those nominations:

"She takes on and volunteers for a lot of extra work. She serves on TAPS teams, committees, testing databases and work processes, and voluntarily chaired the hiring committee for a Geologist position in 2018 and again in 2019 for an EQA position. She is a critical thinker and brings up issues that some of us never think about. She thinks outside the box and shares solutions when she sees a problem or issue. When Melissa tells me something I know I can take it to the bank."

"Melissa has a wide breadth of expertise and an unmatched attention to detail. She completes extremely thorough reviews of Part 201 and Part 213 reports and is an excellent communicator of compliance information to the regulated community. She also serves as a Gaylord point of contact for an impressive number of topics: due care, baseline environmental assessments, and background concentrations. She does this with tenacity and determination."

"I have never worked with a public servant as dedicated to their profession as Melissa Kendzierski. I can say without hesitation that she loves being a geologist and loves working in the RRD of EGLE. I can't think of a question that I've asked her in the past 20 months that she hasn't been able to answer regarding Michigan's geology or RRD regulations. She has an ability to recall project details from years ago, details that are at times critical to current project completion."

"Her knowledge of the statutes, rules, criteria, guidance documents, internal policies & procedures are exceptional. As a Geologist by degree, Melissa has helped me on numerous sites … Melissa works well professionally with not only internal colleagues but also outside par-

ties, consultants, contractors, media, and the general public. Gaylord is lucky to have this Outstanding Regulator on our Team.

"Melissa is an articulate and pragmatic regulator in that she sends a clear and consistent message to the regulated communities she works with while also willing to work with them to achieve favorable outcomes. It is a fine balancing act that I believe she has mastered."

Outstanding Educator:

Dr. Mona Sirbescu. Photo excerpted from CMU Department of Earth & Atmospheric Sciences website.

For 2020, the Nominating Committee received two nominations for outstanding educator. This year, Dr. Mona Sirbescu of Central Michigan University was selected as the recipient of this award. She is the current student chapter faculty sponsor for the CMU Student Chapter of AIPG. Dr. Sirbescu was nominated by Department Chair Dr. Larry Lemke. His nomination follows:

"After joining Central Michigan University in 2001, Dr. Mona Sirbescu compiled an impressive record of excellence in teaching and undergraduate student mentorship. She has been honored many times for her exceptional teaching. In 2006, she received the CMU College of Science and Engineering outstanding teaching award. In 2019, she was put forward as Central Michigan University's nominee for the Michigan Distinguished Professor of the Year Award. And in 2020, she received a CMU Excellence in Teaching Award – Central Michigan University's highest honor for its instructors.

"I first met Mona (and several of her students) twelve years ago at a Geological Society of America meeting in Denver. We quickly recognized a shared interest in undergraduate education and pedagogy and struck up a conversation on field-based education (essential to geology!) that continued through subsequent GSA meetings, the 2014 Summit on the Future of Undergraduate Geoscience Education, and on to this very day. Now, as Chair of Earth and Atmospheric Sciences at CMU, Mona is my colleague and I have seen first-hand how she embodies the characteristics of an Outstanding Educator in every way. She brings her extensive knowledge of igneous processes directly into her classroom. Her lessons are intentional and engaging, and her teaching materials are inventive and thoughtfully designed. She is a kind and inspiring role model who has mentored dozens of undergraduates and published more than 30 papers and abstracts with them. She takes her students into the field (literally) on field trips that engage and motivate them to learn more geology. On campus, her door is literally always open, and our students never hesitate to enter it.

"Professor Sirbescu is a generous and appealing role model who inspires her students with kindness and enthusiasm. As a professor, she leads by example – never shying away from the hard work of preparing new lessons or grading assignments thoroughly to give students the valuable feedback they need to progress. Her approach to her students' cognitive advancement is rigorous and her attention to students' personal and professional growth is unmatched.

"In the classroom, Professor Sirbescu regularly receives outstanding evaluations from her students, despite demanding excellence in their performance and awarding lower grades than most of the other professors in her department. Dr. Sirbescu respects her students' time by engaging them fully in meaningful exercises that are skillfully prepared with intentional learning objectives. Finally, she respects her students' potential by setting high expectations for their performance. This contributes to the formation of a growth mentality, where students become comfortable stretching their academic skill sets while taking responsibility for their own learning.

"Equally important, and comparatively rarer, is Professor Sirbescu's attention to the affective needs of her students. She shows care and respect for them in a myriad of small but important ways. In her classes, for example, she learns all her students' names. This may seem simple, but it fosters a sense of belonging and mutual respect that permeates her classroom learning environment. After the semester ends, she continues to nurture that relationship with her students, providing formal advising and informal coaching to help them succeed. What is more, she maintains contact with many of the alumni from our department and they regularly keep her updated on their professional and academic accomplishments – a clear testament to the lasting relationships she has formed with them.

"For these reasons and many more, I am proud to nominate Dr. Mona Sirbescu for an AIPG Outstanding Educator award! "

Student Poster Contest Recipients

This year, four students submitted posters for the annual student poster contest. Because all four posters were for the graduate category, no undergraduate poster award was made this year. Since two of the students were M.S. students, and the other two were Ph.D. students, the Executive Committee decided to shift the awards for this year to first place and runner up for each M.S. and Ph.D.

categories.

For the 2020 poster contest, each student was judged by a panel of six individuals. Points were awarded to each student out of a possible 100 points; the scores from each judge were averaged to obtain a ranking score for each student.

Jackie Kleinsasser of the University of Michigan presented her research poster called "Sulfur speciation in dacitic melts as a function of magmatic redox conditions." Jackie was an entrant and winner with a different poster last year. Jackie's poster presentation took first place in the Ph.D. category, and she will receive $1,000.

Maria Mustafa of the University of Michigan presented "Non-traditional stable isotopic assessment of the evolution of the Mina Justa Iron oxide-copper-gold (IOCG) Deposit, Peru." Maria was also an entrant and winner with a different poster last year. She was the runner-up for the Ph.D. category, and will receive $500.

Nolan Gamet of Michigan Technological University presented his research on "Distribution of Trace Elements in Spodumene: Insights From Preliminary P-XRF Results." Nolan's presentation took first place in the M.S. category, and he will receive $1,000.

Ross Helmer of Western Michigan University presented "Characteristics of PFAS Contaminated Sites in Michigan." Helmer was the runner-up for the M.S. category, and will receive $500.

Article continues from page 17.

For the second survey, our class teamed with researchers from the Wayne State University Healthy Urban Waters Initiative and the Michigan Department of Environment, Great Lakes, and Energy to characterize the geology beneath a former gas station. Our colleagues were investigating the movement of volatile organic compounds (VOCs) through the complex urban environments, a critical subject since VOCs in groundwater have been linked to adverse birth outcomes. Starting from their well logs, our goal was to map out potential flow pathways beneath the site. Using geophones and a hammer source, we collected seismic data to estimate the depth of the clay aquitard layer in the upper ten meters and search for sand lenses and urban detritus that would allow for VOC transport. It was nice work on a cold fall day—set the metal strike plate, swing the hammer eight times to average out the vibrations from the nearby auto plant, check the data on the monitor, move to the next spot. For the following class period, it was back online to interpret the data and create a model of the subsurface.

Reading closet to farthest:: Breauna Murray, Denada Planaj, Benjamin Moyer, Hannah Monear, Paul Manion, Jonas Sikah, Devon Jesiel. Photo provided by Breauna Murray.

Unfortunately, after COVID-19 cases spiked in mid-November, a planned third survey to measure resistivity at the gas station site has been cancelled. All the same, I'm very glad we were able to have the hands-on experience we did, not only because we learned real-world skills, but also because it brought some sense of normalcy. While it doesn't begin to erase everything causing stress on my shoulders, it certainly makes it a little better. During this stressful semester, it may not be much, but I'll take what I can get.

Did You Know?

This article is intended to remind members of various aspects of AIPG and benefits of membership. If there is something you would like to see featured in this column, please contact the Editor…

The AIPG Code of Ethics states:

CANON 1. General Obligations

Members shall be guided by the highest standards of personal integrity and professional conduct.

STANDARD 1.1

Members shall pursue honesty, integrity, loyalty, fairness, impartiality, candor, fidelity to trust, inviolability of confidence, and honorable conduct as a way of life.

Rule 1.1.1 By applying for or by continuing Membership in the Institute, a Member agrees to comply with and uphold this Code of Ethics.

STANDARD 1.2

Members shall separate facts and observations from interpretations. Members should acknowledge the complexities and uncertainties of Earth systems and state what is unknown in addition to what is known.

CANON 2. Obligations to the Public

Members shall uphold the public health, safety, and welfare in the performance of professional activities, and avoid even the appearance of impropriety.

STANDARD 2.1

Members shall observe and comply with the requirements and intent of all applicable laws, codes, and regulations.

Rule 2.1.1 A Member shall not knowingly participate in any illegal activities, or knowingly permit the publication of his or her reports, maps, or other documents for illegal purpose.

Rule 2.1.2 A Member shall neither offer nor make any illegal payment, gift, or other valuable consideration to a public official for the purpose of influencing a decision by such official; nor shall a Member accept any payment, gift, or other valuable consideration which would appear to influence a decision made on behalf of the public by the Member acting in a position of public trust.

Rule 2.1.3 If a Member becomes aware of a decision or action by an employer, client, or colleague which violates any law or regulation, the Member shall advise against such action, and when such violation appears to materially affect the public health, safety, or welfare, shall advise the appropriate public officials responsible for the enforcement of such law or regulation.

STANDARD 2.2

Members shall be accurate, truthful, and candid in all communications with the public.

Rule 2.2.1 A Member shall not knowingly engage in false

Section Website Reminders

The Michigan Section has created a database of geologic photographs on our website. Please submit photographs that you are willing to share to Adam Heft at adam.heft@wsp.com. Don't forget to include your name and a short explanation of what the photograph depicts. The photographs will be uploaded to the website periodically.

If you have suggestions on other items that should be included on the History page, please let a member of the Section Executive Committee know.

Minerals for Sale!

Long-time Michigan mineral collector and dealer, Bill Micols, is selling his lifetime collection of material. Bill is in Milford. For additional details, please see the full-page flyer on the following page.

SALE

50 year life time collection

Private museum with thousands of specimens;

MINERALS, FOSSILS, ARTIFACTS, CARVINGS, JEWELRY, ASIAN ANTIQUES, ETC.

From the collections of William J. Micol, Milford, MI… Can be contacted at 1-248-842-1705 APPOINTMENT ONLY
BEST PRICES GUARANTEED!!!

or deceptive advertising, or make false, misleading, or deceptive representations or claims in regard to the profession of geology or which concern his or her own professional qualifications or abilities or those of other geologists.

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.

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.

STANDARD 2.3

Members should participate as citizens and as professionals in public affairs.

Rule 2.3.1 A Member acting in a position of public trust shall exercise his or her authority impartially, and shall not seek to use his or her authority for personal profit or to secure any competitive advantage.

STANDARD 2.4

Members should promote public awareness of the effects of geology and geological processes on the quality of life.

Where in Michigan?

The October 2020 edition of *Geologically Speaking* featured a photograph of boudins in the Michigamme Slate. The outcrop is located on the east side of M-95 just north of County Road 601 near Republic. The Michigamme Formation is Precambrian age. No one correctly identified the photograph.

This edition of *Geologically Speaking* features a new photograph **at right** - not the photo on the cover page. The first person to correctly identify what the photograph depicts (feature name, location, formation, and age) will win AIPG swag! Submit your entry to the editor; only one per person per issue please.

Don't forget to check out the feature article "Geology in America" in this issue (as well as the last two editions) that presents a geologic feature of interest as a mini field guide. One of the best parts about being a geologist is field trips, and we are hoping that in your travels around the state or country you include these featured spots as a stop. Why not incorporate them into a family vacation or bring friends who may not be geologists and share these locations that make Michigan unique? We hope you enjoy reading about it, and more importantly, go see it in person! We invite you to share unique geologic features that you know about and submit a "mini field guide" to share with our members in future editions.

Regulatory Roundup

Happy New Year! We are looking forward to 2021 and hoping it will bring relief from the pandemic and a return to more in-person activities. As we kick off the new year, there are a few new things to report in the regulatory arena including federal guidance on per- and polyfluoroalkyl substances (PFAS), Michigan's announcement of PFAS standards for five additional compounds and more.

If there is one thing we promote through this column, it is to encourage professionals like you to provide your insight and experience in the process of regulatory rule making and policy. We encourage professionals to share their knowledge on topics to help inform the development of regulations and policies to ensure that sound science is part of the process and decision-making considerations. We try to highlight them here.

Just such an opportunity is currently available with the recent Federal Register publication on Interim PFAS Destruction and Disposal Guidance. The Environmental Protection Agency opened the public comment period for this document on December 22, 2020. The comment period closes on February 22, 2021.

In December 2020, the Michigan Department of Environment, Great Lakes, and Energy (EGLE) announced the addition of five more PFAS compounds to be regulated as clean-up and drinking water maximum contaminant levels. In the October Regulatory Roundup message, we reported the promulgation of drinking water criteria for seven PFAS compounds effective August 3, 2020.

As of December 21, 2020, EGLE is now applying the new standards to the Part 201 Environmental Remediation program as generic clean-up criteria. The table below depicts the criteria.

Gongwer news service reported on December 21, 2020 the addition of these compounds to PFOS and PFOA being regulated in groundwater by the department. The following is an excerpt from this article.

> "Scientific evidence supports designating these PFAS as hazardous substances due to their potential to pose unacceptable risks to public health and the environment," Mike Neller, EGLE's Remediation and Redevelopment Division director, said in a statement Monday. "These five PFAS, as documented during EGLE's development of state drinking water standards, have the ability to cause adverse health effects. Therefore, it is appropriate for us to identify these PFAS as hazardous substances under Part 201."
>
> Mr. Neller went on to say that EGLE had received a large amount of feedback on the set levels, and the results are the best efforts of the department to regulate the chemicals while still complying with processes described within Part 201.
>
> Lisa Wozniak, executive director of the Michigan League of Conservation Voters, praised the additions of the five chemicals to the state's regulatory authority in a statement Monday.

PFAS	CAS Registry Number	State Drinking Water Standard	
		ng/L	µg/L
Perfluorooctanoic acid (PFOA)	335-67-1	8	0.008
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	16	0.016
Perfluorononanoic acid (PFNA)	375-95-1	6	0.006
Perfluorohexane sulfonic acid (PFHxS)	355-46-4	51	0.051
Perfluorohexanoic acid (PFHxA)	307-24-4	400,000	400
Perfluorobutane sulfonic acid (PFBS)	375-73-5	420	0.420
Hexafluoropropylene oxide dimer acid (HFPO-DA)	13252-13-6	370	0.370

> "We have some of the strongest standards for PFAS in the country, but now we must focus on testing for and cleaning up these toxic chemicals in our groundwater," Ms. Wozniak said. "We look forward to working with EGLE and state officials as we strive to ensure all Michiganders have clean water that is free from toxic contaminants."

Regulation of these levels, effective December 21, will remain in effect throughout the Administrative Procedure Act rulemaking process.

News releases, program information, and MI Environment, the Department's blog, are also accessible via the homepage. During these times of great uncertainty, we recommend visiting the homepage frequently to find the latest information and Departmental activities.

Be sure to stay safe, follow CDC guidelines, and observe social distancing practicing.

Proposed Rules

Natural Resources and Environmental Protection Act, PA 451 of 1994, as amended, bill search

Safe Drinking Water Act, PA 399 of 1976, as amended, bill search

Invitation to Our Members!

Do you have a case study to share?

The Michigan Section AIPG promotes knowledge sharing and would like to feature case studies from projects where others may benefit from successes as well as lessons learned. We feel as professionals that learning from each other is a great opportunity that AIPG offers our members. AIPG offers connection with other professionals and their experiences in the work we do every day. This case study represents what we would like to offer more to our members, not only as a way to solve problems, but unify us as professional geologists. Additionally, do you have a suggestion for other types of information to share that would be of interest to our membership?

Please send your case studies and suggestions for future publication in upcoming editions of *Geologically Speaking* to the Editor.

Article Continues from Page 19

tals, tourmaline continues to branch out into anhedral shapes, with each individual crystal like a tree and its branches. What is puzzling is that the tree "trunk" and branches are in optical continuity, so they are a single tourmaline crystal, best viewed in thin sections (Fig. 3). Quartz intergrows with the skeletal tourmaline branches. As they grow simultaneously from the magma, the two minerals seem to be competing for space.

Both tourmaline and quartz can also trap microscopic fluid and melt inclusions, which are an important source of data related to the pegmatite's original environment of formation. As a mineral grows, melt and/or fluid can become trapped in small spaces caused by imperfections in the mineral. Upon cooling, the trapped melt crystallizes into microcrystals within the tiny cavity, while the fluid separates into an aqueous liquid and CO_2 gas bubble and

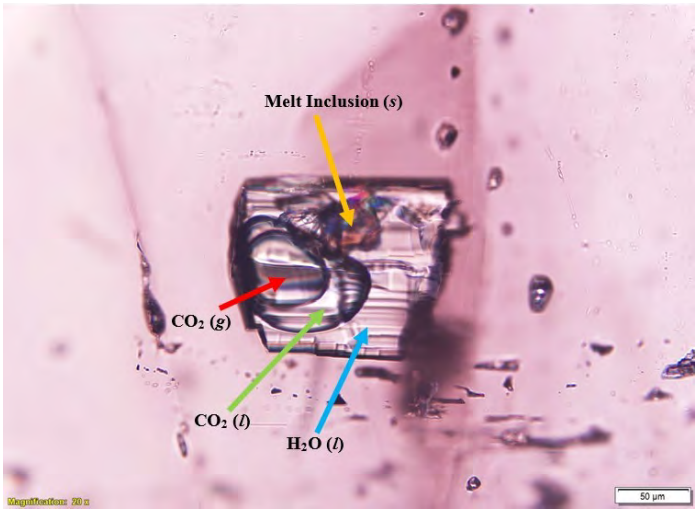

Figure 4: In tourmaline, a fluid inclusion with three phases: liquid water (blue arrow), liquid CO2 (green arrow), gaseous CO_2 (red arrow); also note small crystal (melt) inclusion (orange arrow). Photo by Emily Yoder, 2020.

may also precipitate daughter crystals (Fig. 4). Melt inclusions are significant because they indicate when melt was present during crystallization and may give clues about the melt's composition. Numerous fluid and melt inclusions are well-preserved in Emmons tourmaline and quartz, which is a good evidence that the minerals were growing rapidly (at disequilibrium). My objective is to extract information from these inclusions about the composition, pressure, and temperature conditions during rapid crystallization of the pegmatite.

Tourmaline is especially important in my study because (1) its widening shape clearly indicates direction of growth from its point of attachment towards its branching intergrowth with quartz, and (2) single crystals have growth zones indicated by color variations under the microscope (Fig. 3). These color bands are an important indicator of the stages of crystallization and can reveal the relative timing of fluid and melt inclusions. For example, trails of inclusions that cut across growth zones were formed later than inclusions that stop at the edge of a growth zone, similar to the cross-cutting principle used for relative dating.

After initial qualitative observations, we started collecting microthermometric data to understand the temperature and pressure conditions during the pegmatite's formation. Microthermometry consists of measuring temperatures at which phase changes take place in fluid inclusions during freezing-heating cycles on a microscope stage. For the Emmons samples, I carefully monitored the inclusions as I froze the samples down to about –100°C and heated them up to about 350°C. Essentially, the temperature data we obtained allows us to estimate the composition and density of the fluid trapped in the bubbles, as well as the temperature/pressure conditions during quartz -tourmaline crystallization. We can correlate this data with the locations of inclusions and propose a model for the pegmatite's formation.

Currently, we are processing the raw fluid inclusion microthermometric data and have already found on average 415°C trapping temperatures for an estimated pressure of 300 MPa. That is very low, indicating that the pegmatite magma was highly undercooled in the hanging wall. Going forward, we are planning to collect qualitative and quantitative data from a continuous sequence of samples from the pegmatite border towards the core, in order to understand whether the processes and conditions were changing during crystallization. We hope to solve the puzzle of these unusual textures and present this research at a 2021 national or international conference.

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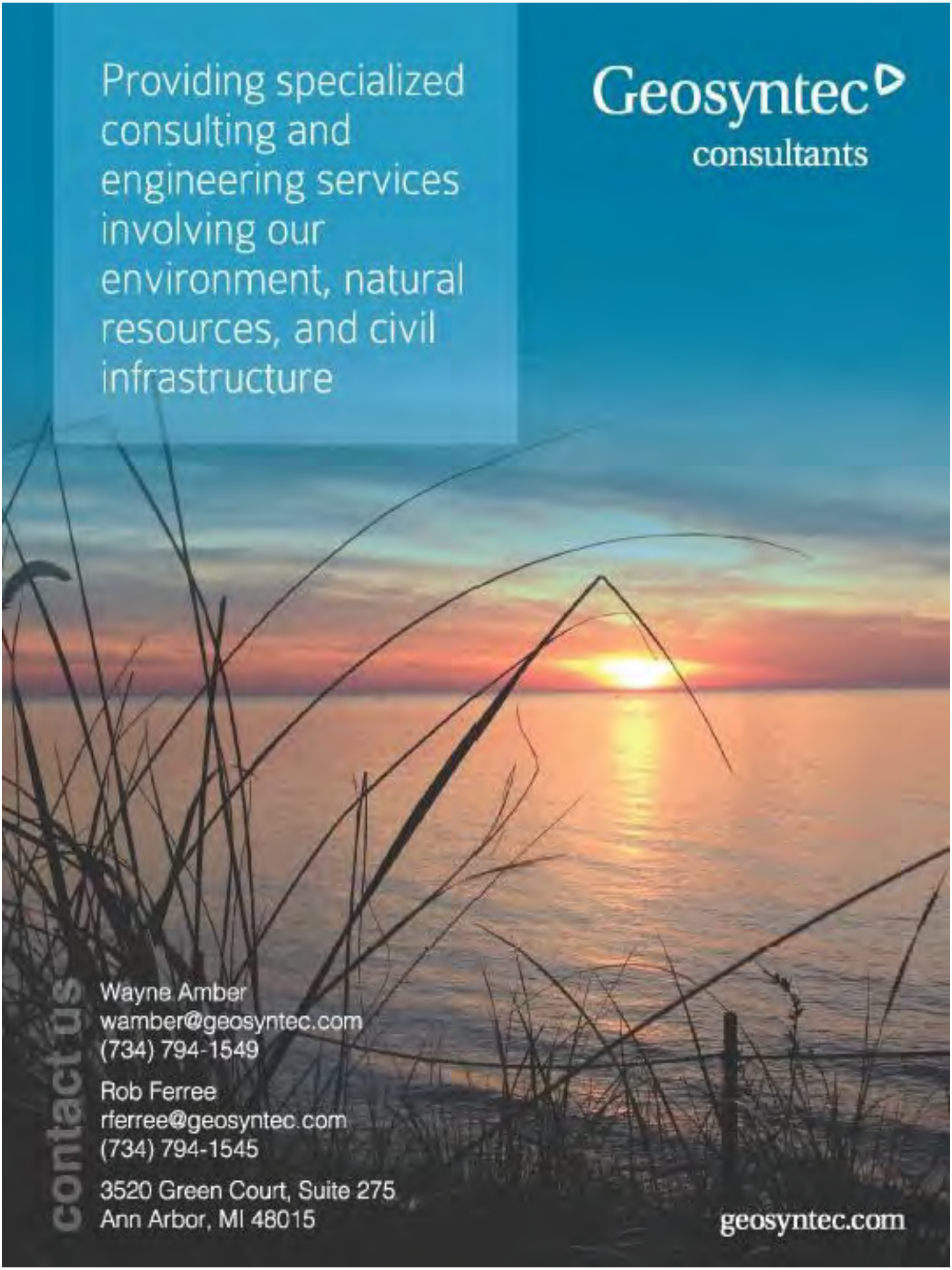
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Geology in America – Crater of Diamonds State Park

By Allan Blaske, CPG

Latitude: 34°01'58"N; Longitude: 93°40'13"W

Sections 21 and 28, T8S, R25W, Pike County

Directions

Crater of Diamonds State Park is located at 209 State Park Road, in Murfreesboro, Arkansas.

From Little Rock, Arkansas, take Interstate Highway 30 (I -30) west for approximately 107 miles to Exit 30 at Hope, Arkansas. Continue north-northwest along US Highway 278 for 24 miles. At Nashville, Arkansas, continue straight onto Arkansas Highway AR-27 (N. Mine Street). Follow AR-27 for approximately 13 miles to Murfreesboro. At the traffic circle, stay right (south) onto Washington Avenue (AR-301). Follow Washington Avenue for approximately two miles to the park entrance road at the sign (State Park Road). Signs are present along the interstate, on the state highways, and in Murfreesboro to lead you to the park.

Figure 1: Sign at the entrance to Crater of Diamonds State Park. Photo by Allan Blaske.

Introduction

What does a geologist do when stuck in northeast Texas for a work assignment with nothing to do? You find something geologically interesting to explore! Unfortunately, northeast Texas does not offer anything of geologic interest (sorry, but it is true!). I found myself in this situation in November 2020 and knew exactly where I was going to spend my day off. I have always wanted to visit this location but have never been to this part of the United States. It is not really on the way to anything, but since I was within a three hour drive, I figured I might not ever be any closer.

You have probably heard the stories on the news about someone finding a diamond at an Arkansas park. Every few years someone finds a large one and the story makes a brief appearance on a national news outlet. Most recently, in September 2020, a nine-carat brown diamond was found, the size of a small marble!

The Crater of Diamonds State Park is located in southwest Arkansas, just to the southeast of the town of Murfreesboro, Pike County, in Arkansas (Figure 1). The park is the world's only diamond-bearing site open to the public. For $10, you can dig for diamonds – and keep what you find! The park is located approximately 40 miles north of interstate highway 30, 60 to the northeast of Texarkana, Arkansas, and approximately 100 miles southwest of Little Rock, Arkansas (Figure 2). The park

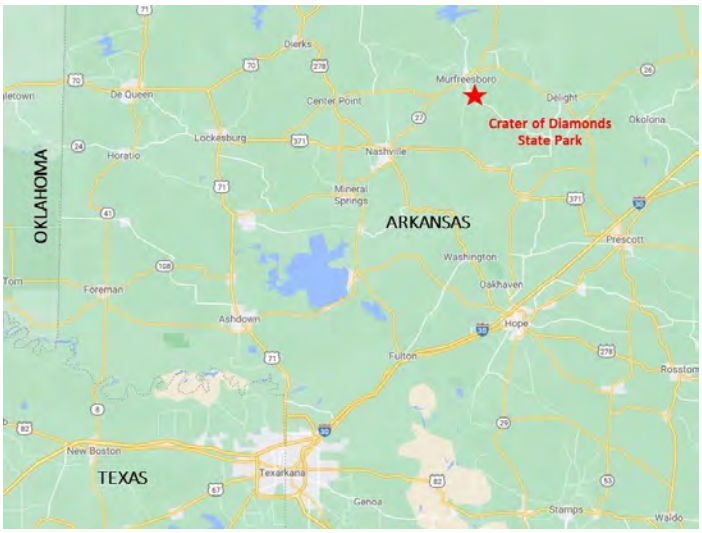

Figure 2: Location of Murfreesboro and Crater of Diamonds State Park. (modified from Google maps) .

features a 37.5-acre plowed field where you can search for diamonds. The park is over 900 acres, and other amenities include a visitor center, diamond discovery center, walking trails, picnic sites, a campground, gift shop, café, and even a water park (Figure 3). At the visitor center, you can view real diamonds found in the park and interact with exhibits illustrating the area's unique history and geology. At the Diamond Discovery Center,

Figure 3: Aerial view of Crater of Diamonds State Park. (From Hanson, W. D., Howard, J. M., and Clardy, B. F., 2007).

you can learn more about rocks and minerals found at the park and how to search for diamonds using various techniques. Park staff provide identification or rocks and minerals found at the park, as well as diamond mining demonstrations and other interpretive programs.

History

The first diamond was found in 1906 by John Huddleston, a farmer who owned a portion of the diamond-bearing crater at that time. Soon after the first diamond was found, a "diamond rush" created a boomtown atmosphere around Murfreesboro. After 1906, several attempts at commercial diamond mining failed. The only significant yields came from the original surface layer, where erosion over a long period of time had concentrated diamonds. During the Second World War, the U.S. government took over the mine and granted a contract to extract diamonds. Diamonds were found, but the mine was not successful. From 1951 to 1972, the crater hosted several private tourist attractions. In 1972 the property was sold to the State of Arkansas for $750,000. The tourist operation continued as the centerpiece of Crater of Diamonds State Park. In the 1990s, a consortium of diamond companies was allowed exploration rights at the park, but studies indicated that the deposit is sub-economic. Figure 4 shows a historic mine shaft structure from previous operations.

Geology

Crater of Diamonds State Park is just south of the Ouachita Mountains and along the northern margin of the West Gulf Coastal Plain. The oldest rock unit in the area surrounding the park is the Pennsylvanian-age Jackfork Sandstone. The sandstone beds dip steeply to the south. Overlying the sandstone are Cretaceous sedimentary rocks, including limestones with some shale, sandstone, and gypsum. They represent sediments that were deposited in shallow water on the northern margin of the Cretaceous seas. These rocks dip gently to the south and have been eroded by local rivers and streams. Figure 5 is a geologic map of the area around the park.

Figure 4: Historic mine shaft building from the Ozark Diamond Mine in the diamond search field. Photo by Allan Blaske.

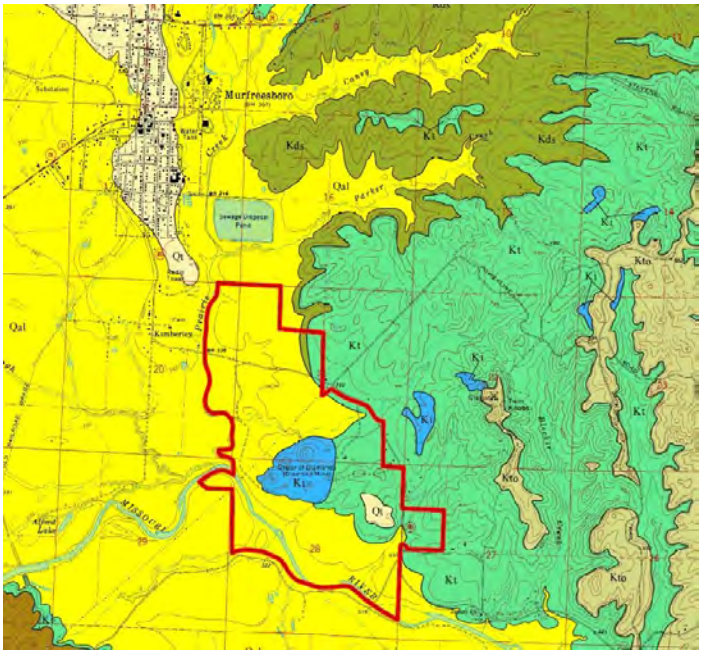

Figure 5: Geologic map. State park outlined in red. Lamproite diatreme bodies are represented in blue. Green colors represent Cretaceous sedimentary rocks, and yellow is quaternary alluvium. (modified from Hanson, W. D., Howard, J. M., and Clardy, B. F., 2007) .

Along the coastal margin, about 100 million years ago, several explosive volcanic eruptions occurred, resulting in the emplacement of diamond-bearing rocks known as the Prairie Creek Diatreme. Other, smaller diatremes of similar origin and composition are present in the area surrounding park.

The rock within the diatreme is a lamproite. Lamproite is an ultrapotassic and somewhat aluminum-poor mantle-derived volcanic rock, which includes forsteritic olivine, phlogopite, richterite, leucite, sanidine, diopside, and a variety of rare potassium-, barium-, titanium-, and zirconium-rich oxides and silicates. Lamproites form from partially melted mantle at depths greater than 93 miles. The volcanic eruption brought xenoliths and xenocryst dia-

monds from the peridotite or eclogite mantle regions where diamonds form.

The lamproite within the Prairie Creek Diatreme have been divided into several rock types, based on textural and depositional differences. These include magmatic lamproite, pyroclastic lamproite, and maar epiclastics. Figures 6a and 6b are a map and cross section of the diatreme.

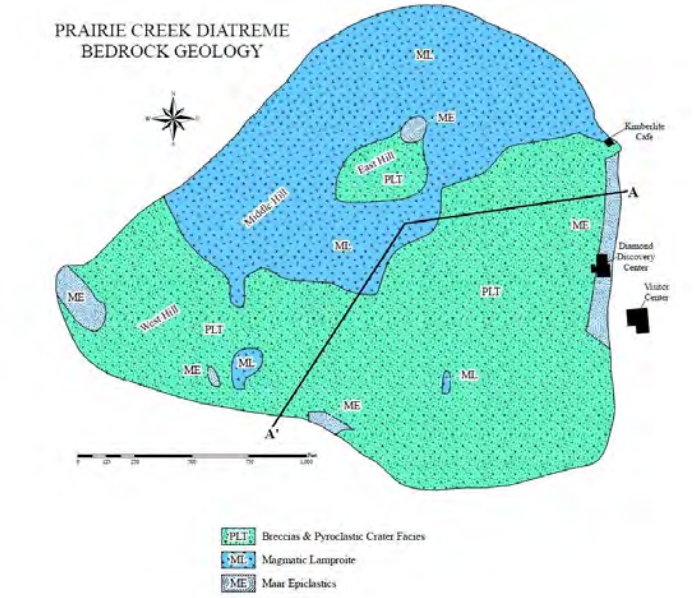

Figure 6a: Plan map of the lamproite diatreme, showing various volcanic units. (From Hanson, W. D., Howard, J. M., and Clardy, B. F., 2007).

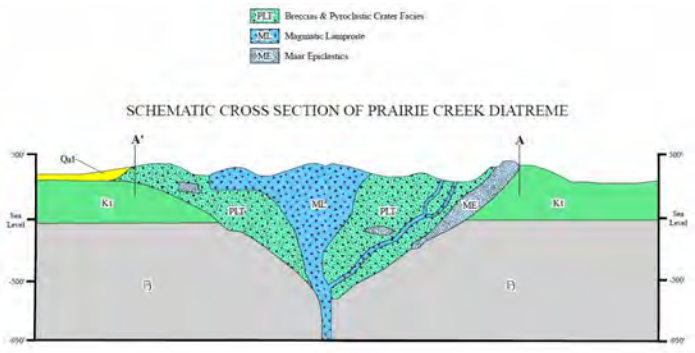

Figure 6b: Cross-sectional representation of the lamproite diatreme, showing various volcanic units. (From Hanson, W. D., Howard, J. M., and Clardy, B. F., 2007).

The magmatic lamproite was originally termed peridotite by early investigators and later hypabyssal olivine lamproite and pyroxene (diopside) madupitic lamproite by recent workers. The rock is a magmatic non-explosive phase material. The rock consists of crystals and crystal fragments of olivine, in various stages of alteration to serpentine, set in a fine matrix of poikilitic phlogopite, diopside, magnetite, and perovskite. Magmatic lamproite may contain xenoliths of rocks from the mantle and crust, brought along by its rapid movement to the earth's surface. The magmatic lamproite contains only very few micro-diamonds.

The pyroclastic lamproite was originally termed kimberlite by early workers simply because it contained diamonds. Pyroclastic lamproite is further subdivided into two field identifiable types: lamproite lapilli tuff and lamproite breccia tuff. These units are the source of the diamonds now found in the soil. These rocks weather rapidly because most of the minerals composing them formed at great depth and are unstable at surface temperatures and pressures. The weathered material (now soil) is a gray to green-gray clay. The lamproite lapilli tuff is fine-grained ash that was formed by the initial explosion and settled as air fall material. Phlogopite mica is present in all samples, often a major component. The lamproite breccia tuff is composed of fragments of lamproite and other rocks that were both shattered during rapid transport to the surface and the initial near surface explosive emplacement event. Olivine was a major component, now mostly altered to serpentine. Some breccia fragments of lamproite still contain glassy olivine crystals, only having marginal alteration. In hand specimen, the rock is dark brownish with scattered yellow, tan, or whitish spots of serpentine after olivine set in a fine-grained matrix.

The maar epiclastic rocks were originally described as quartz-bearing tuffs. They formed by admixture of uncemented Cretaceous sands and clays with the lamproite lapilli and breccia tuff units.

Diamonds

Diamonds originated in the mantle as part of the early formation and crystallization of the earth and were brought to the surface by the explosive eruption of the lamproite. Mineral inclusions within the diamonds indicate an age of approximately 3 billion years. The formation of the pipe itself has been dated from local stratigraphy as upper Early Cretaceous (approximately 106 million years). Most diamonds found at the park have suffered some dissolution by the lamproite matrix and transporting fluids, and perhaps even breakage and dissolution effects. This is due to the fact that diamonds are not stable at pressures and temperatures other than those in the mantle where they formed. The lamproite body is

Figure 7: Diamonds from Crater of Diamonds State Park. Yes, these were found in the park! Diamonds found at the park and historic displays can be seen at the Visitor Center. (Photo from Crater of Diamonds State Park website) .

uneconomical for large-scale mining. However, the rocks within the diatreme have been weathered to a depth of 40 feet or more, and this weathering has somewhat concentrated the diamonds in the upper portions of the pipe (now soil), where they can be found by visitors to the park.

Searching for Diamonds

More than 33,000 diamonds have been found by park visitors since the Crater of Diamonds became a state park in 1972, including the 40.23-carat Uncle Sam, the largest diamond ever unearthed in the U.S. This equates to more than 600 finds per year. Most diamonds found are the size of a match head, or about 0.2 carats. Diamonds found in the park are generally white, brown, and yellow (Figure 7). The search area is plowed periodically to help loosen the surface soil and promote diamond finds (Figure 8).

Figure 8: Diamond search field. Note the furrowed surface from periodic plowing, and the washing pavilion in the center distance. Hopeful diamond seekers already searching! Photo by Allan Blaske.

Several techniques can be used to locate diamonds. Some people slowly wander the plowed surface, searching for diamonds laying on the surface. This technique works best after the field has been plowed and after recent rains. Searchers look in low areas and small ravines where gravel accumulates after rains.

Screen sets are available for rental at the park, or you can purchase from private vendors outside the park or bring your own. I brought my own double-screen setup – an upper screen (1/4-inch mesh) to remove large rocks, debris, and maybe a huge diamond, and a lower screen (window screen) to wash the gravel. You can bring also shovels, pails, wagons, and other tools, but no power tools are allowed. Many people also use a saruca, a small, round screen used to concentrate the heavy minerals.

Some use the dry screening technique, where you simply sift soil from the field through your screen set. Most people, however, use the wet screening technique. The park contains two pavilions which contain water-filled troughs and tables. You simply dig up material from the field, and screen it through your screen set, using the water to remove the fine silt and clay soil. With the proper technique, gravel can be washed and graded in the lower screen so that the heavier mineral grains are concentrated to the center of the screen. The screen is then flipped onto a table, and if lucky, a diamond will be in the center of the gravel pile (Figure 9). If you were not lucky enough to find a diamond in your screened gravel, you can take up to five gallons of screened material home with you so that you can continue your search.

Where do you dig to find a diamond within the 37½-acre search field? It is completely random! There are makers in the field where large, historic diamonds have been found. But previous finds are no indication of future

Figure 9: Screened and washed gravel. Are there any diamonds in here? Photo by Allan Blaske.

finds. Because the surface material in the field is deeply weathered bedrock and has been repeatedly plowed, the diamonds are randomly distributed through the field. Some search for areas with more abundant gravel which has been washed by rainwater, but others dig holes several feet deep, thinking that “this is the spot”! The only predictor of success is a lot of hard work (dig and screen lots of material) and a good bit of luck!

Conclusion

It was a perfect fall day (sunny and 70 degrees). Unfortunately, I did not find a diamond during my brief visit (about five hours) to the park (and no one sifting around me did either). But I sifted about a dozen buckets of soil and brought home about 4 gallons of sifted gravel to continue the search! (I just know there is a diamond in there somewhere!). I learned something new about the unique lamproite rocks which originated in the mantle (how cool is that?!), crossed something off my bucket list, and had a great time! I highly suggest a visit if you are ever in this part of the United States!

References

Hanson, W. D., Howard, J. M., and Clardy, B. F., 2007, Geology of the Crater of Diamonds State Park and Vicinity, Geologic Map State Park Series, DGM-SPS-003, Arkansas Geological Survey.

Howard, J. M. and Hanson, W. D., 2008, Geology of the Crater of Diamonds State Park and Vicinity, Pike County Arkansas; Arkansas Geological Survey, State Park Series 03 (SPS-03).

Crater of Diamonds State Park Website:

https://www.arkansasstateparks.com/parks/crater-diamonds-state-park

Crater of Diamonds State Park Wikipedia Website:

https://en.wikipedia.org/wiki/Crater_of_Diamonds_State_Park

WANTED!

We want YOU! to serve as our next Section Screening Chairperson. Our current Screening Chair, Dave Regalbuto, will be stepping down after nearly 20 years of service as chairman on June 30, 2021.

Position Requirements:

- **Must be a CPG** in good standing
- Must maintain all application materials in strict confidence
- Work with other members of the Screening Committee
- Report to the National Screening Committee and the Section Executive Committee

Dave estimated that he handled two to four applications per year, and each required about two hours to:

- Check/verify the applicants employment history, adequacy of geologic coursework, and completion of requisite degree and academic hours.
- Qualitatively evaluate the adequacy of the applicant's description of their work history, with respect to career progression, the depth and quality of their work as verified by their sponsors and supervisors, and most importantly the application of geologic knowledge and principals during their work history.
- Communicate and collaborate with the other (2) section screeners to return completed screening evaluations back to the national committee.

If you are interested in serving as the next Michigan Section Screening Chairperson, please email Bill Mitchell, 2021 President.

Welcome New Members

The Michigan Section is continuing to grow. Please welcome the following new CPGs, Professional Members, Early Career Professionals, Associate Members, and Students:

Gwendolyn Drake, SA-10850; Samara Graft, MEM-3260; Isaac Hinz, SA-10869; Christopher Konen, ECP-0729; Zach McCurley, MEM-3237; Ashley Miller, ECP-0736; John Owens, ECP-0719; Chase Schepke, ECP-0727; Mary Shalifoe, SA-10887; Jordin Simone, SA-10845; Garett Smith, ECP-0714 .

To each of our new members, welcome to our Section. We encourage you to attend Section meetings and other events. You are also invited to provide information for the Member's Corner articles.

Member's Corner

The Member's Corner includes information about the Section's membership. This is your chance to provide information on where you are and what you are doing. Simply send the information to the Editor for inclusion in this section.

No Member's Corner articles were received for this edition of *Geologically Speaking*.

Interesting Geology Links

The Editor has received links to various interesting geology-related sites. Some of the more interesting links are included here. If you have any links to geology-related sites that you would like to share, please forward them (with a citation, if applicable) to the Editor.

Thanks to Mark Francek of Central Michigan University for sharing via the "Earth Science Site of the Week" emails. This edition features a few "fun" links

Iceberg Calving Wave: https://www.youtube.com/watch?v=HB3K5HY5RnE.

Five Icebergs Flipping Over: https://www.youtube.com/watch?v=hxy-0zpJwxs

Earth's Most Destructive SuperVolcanoes: https://www.youtube.com/watch?v=LVtNvJPU1wY

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The A.E. Seaman Mineral Museum in Houghton, Michigan

By David Adler, CPG

The A.E. Seaman Mineral Museum in Houghton, Michigan showcases world class mineral specimens from the Great Lakes region and around the world. The museum features the largest public exhibit and finest collection of Great Lakes minerals and the premier collection of Michigan minerals. It is the official Mineral Museum of Michigan and is the unofficial Mineral Museum of the Great Lakes Region. The museum's stated mission is to promote education about minerals and their relevance to society through its collections, exhibits, and educational resources.

The Seaman Museum's collection includes approximately 50,000 mineral specimens, of which about 4,000 are on display. The collection includes iconic specimens of Michigan native copper and silver, porcelaneous datolite (found only in the Keweenaw Copper District), Lake Superior agates, Michigan amethyst, and over 100 other minerals from the copper deposits of the Keweenaw Copper District in the western Upper Peninsula. The world-record holding 19-ton Lake Copper specimen, a native copper slab retrieved from Lake Superior in 2001, is on display in an outdoor pavilion exhibit on the museum grounds. There is also an informative rock garden on the grounds and satellite mineral displays that are open to the public at several locations in Michigan. The museum's nationally and internationally recognized mineral collection includes the University of Michigan collection, co-owned by the museum and the University of Michigan.

The A.E. Seaman Museum is located at 1404 E. Sharon Avenue on the south side of the Michigan Technological University (MTU) campus in Houghton (see Figure 1). The Thomas D. Shaffner Exhibit Hall and the adjoining museum gift shop are open from 9:00 AM - 5:00 PM Monday through Saturday. The museum is owned and

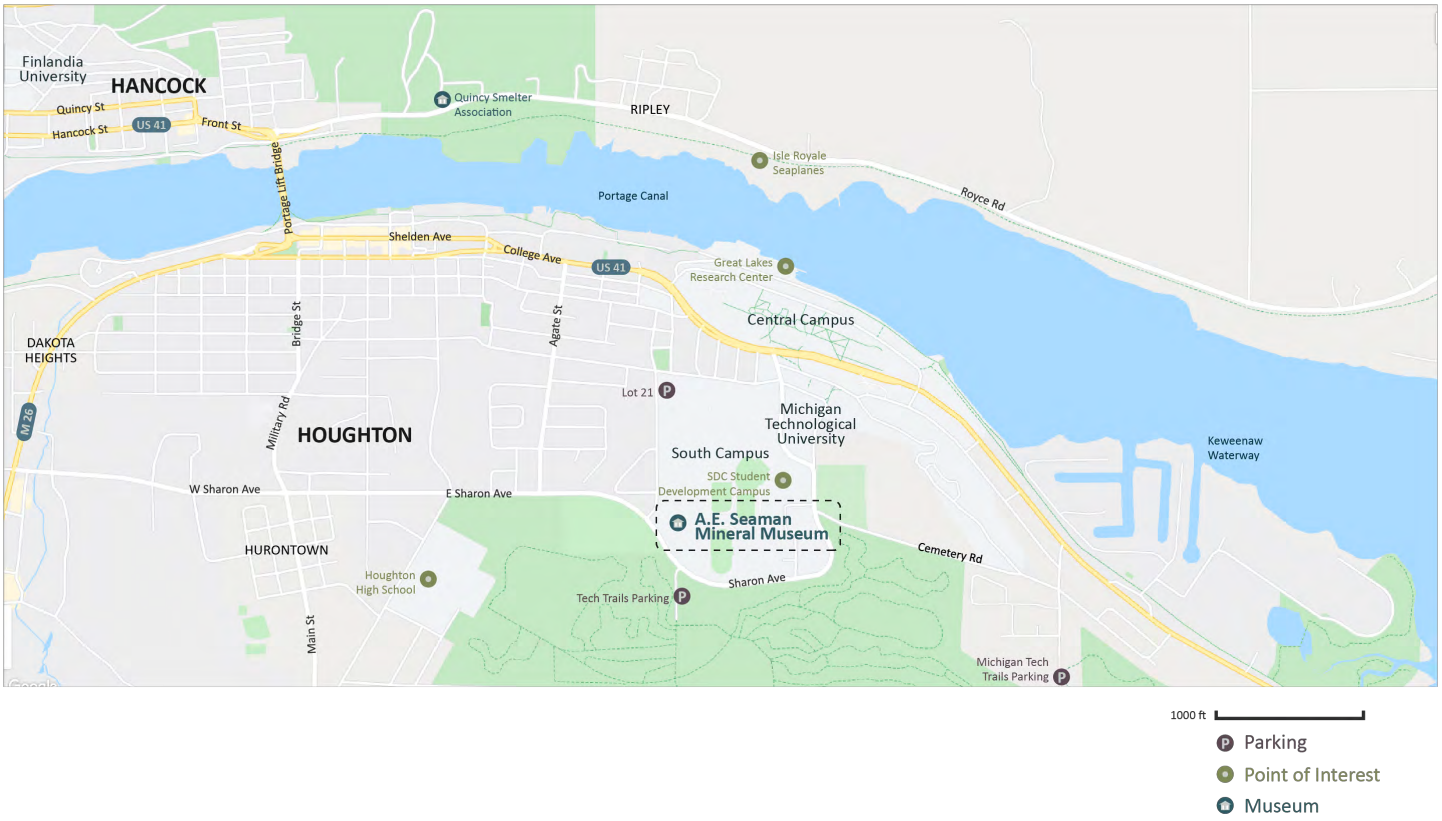

Figure 1: Museum Location. Source: Source: https://www.google.com/maps/@47.1169538,-88.5549888,15z?h|=en-US.

operated by MTU. Visitors are advised to check the museum's website (museum.mtu.edu) or call in advance (906-487-2572) for additional information regarding visiting protocols.

The area that is now the MTU south campus was the site of some of the early copper mining ventures in the 19th century, beginning in the 1850s. It seems only fitting that the current site of the A.E. Seaman Mineral Museum was once one of the early copper mines. The museum grounds overlie two 19th century mine shafts that were long forgotten and rediscovered in 2010 during construction of the museum at its present location. More on that to follow.

Museum History

The history of both MTU and the A.E. Seaman Mineral Museum are inextricably linked to the unique native copper deposits of the Keweenaw Peninsula of Michigan. Copper mining began there thousands of years ago by indigenous Americans using stone and wood tools. The copper diggings left behind by the ancient indigenous miners, whose identity and origins remain unknown, became the basis for the mining rush that began in the 1840s, largely through the pioneering exploration work of Dr. Douglas Houghton, the first Professor of Geology, Mineralogy, and Chemistry at the University of Michigan and the first State Geologist after Michigan achieved statehood in 1837. A life size oil painting of Dr. Houghton from the 1870s is prominently displayed in the main museum building.

The extensive native copper deposits in Keweenaw, Houghton and Ontonagon counties were worked extensively from the 1840s into the second half of the twentieth century and were the primary source of copper for the U.S. from about 1880 to 1910. MTU was founded in 1885 as the Michigan Mining School under Michigan Public Act 70. The school was established by the State of Michigan to train mining engineers to operate the local copper mines. The Michigan Mining School, subsequently renamed the Michigan College of Mines, trained nationally and internationally recognized mining engineers. The name was changed to Michigan Technological University in 1964. Today, MTU is one of the leading engineering and science education and research institutions in the country. MTU's Department of Geological and Mining Engineering and Sciences offers undergraduate and graduate degree programs in Geology, Geological Engineering, Mining Engineering and Applied Geophysics.

Public Act 70 called for "… obtaining and establishing a complete collection of minerals from the Upper Peninsula …" The mineral collection that would become the A.E. Seaman Mineral Museum began in the late 19th century by professors A. E. Seaman and G.A. Koenig and mining geologist L.L. Hubbard. The museum was officially founded in 1902 and moved into Hotchkiss Hall in 1931. The museum was named for Professor Arthur Edmond Seaman, its first curator, in 1932. In 1976, the museum moved to the fifth floor of the Electrical Energy Resources Center (EERC) building in the central MTU campus. It moved to its current location on the MTU south campus in 2011. The museum was designated as the official Mineral Museum of Michigan by the Michigan Legislature in 1991.

The 5th floor of the EERC building was intended as a temporary home for the museum. Construction of the current permanent location on the MTU south campus began on October 23, 2010. On November 3, 2010, a mine shaft was discovered directly beneath the location of the west wall of the museum building while preparing the west wall foundation. Subsequent research revealed that this mine shaft was the main F shaft on a native copper deposit known as the Mabbs Vein (Bornhorst, 2018). Subsequent attempts to plug the F Shaft resulted in discovery of a second shaft just south of the F shaft. The second shaft was suspected to be an unnamed ventilation shaft of the Mabbs Mine (see Figure 2).

Figure 2: Mabbs Vein Copper Mine shafts discovered during construction of the new museum building in 2010. The F Shaft is in the left foreground; the ventilation shaft is in the background. Source: Bornhorst, 2018, Figure 7A.

Construction of the museum was temporarily suspended until mitigation measures could be developed and implemented to ensure the structural integrity of the new museum building. During implementation of the mitigation measures, a third circular opening approximately two feet in diameter was discovered just north of the F shaft. This opening appeared to be connected to a larger underground opening extending northward underneath what is now the museum parking lot. The third opening is believed to be the top of an unnamed stope extending upward from the 1st level of the Mabbs Mine (Bornhorst, 2018).

The Mabbs Vein

Subsequent research by the museum director, Dr. Theodore J. Bornhorst, determined that mining on the Mabbs Vein began in 1864 and continued intermittently into the mid-1870s, led by brothers John and Austin Mabbs. In 1865 a 2,300-pound mass of native copper was recovered from the main F shaft at a depth of 70 feet below the surface (Bornhorst, 2018). Barrel and stamp copper were also recovered from the Mabbs Vein. Yearly copper production from the Mabbs Vein mine ranged from approximately 30,000-800,000 lbs. of native copper. Total production of Mabbs Vein copper is estimated to be on the order of 1.6 million to 2 million pounds (Bornhorst, 2018). The Mabbs Vein copper production was small in comparison to the historic production of the Keweenaw amygdaloid lode and conglomerate lode mines, especially production from the Quincy Mine in Hancock (amygdaloid) and the Calumet and Hecla Mine (conglomerate) in Calumet.

The Mabbs Vein is now an integral part of the history of the A.E. Seaman Mineral Museum. Today, the location of the main F shaft is near the west side of the museum entrance. A manhole along the sidewalk in front of the museum marks the location of the unnamed stope. The location of the ventilation shaft underlies the southwest corner of the museum gift shop. The location of the museum on top of the 19th century Mabbs Vein copper mine workings is a fitting tribute to the museum's linkage to the copper mining legacy of the Keweenaw Peninsula.

19-Ton Lake Copper Specimen

Just as you enter the museum grounds from E. Sharon Ave., you'll see a gazebo-like structure on your right. This is the Copper Pavilion (see Figure 3). Inside is the world record Lake Copper specimen, a 19-ton slab of pure native copper. The Lake Copper was discovered in 1991 by local divers Bob Barron and Don Kauppi on the floor of Lake Superior in Great Sand Bay, located between Eagle River and Eagle Harbor in Keweenaw County. The Lake Copper was lying horizontally in approximately 30 feet of water. It is believed to have been attached to a nearby vertical vein in the Lake Shore Trap Basalt host rock (Bornhorst and Barron, 2017). The vein exhibits native copper mineralization.

Figure 3: The Copper Pavilion and the World-Record 19-ton Lake Copper Slab recovered from Lake Superior in 2001. Photo provided by Dr. John Jaszczak, Director and Curator of the A.E. Seaman Museum.

The floor of Lake Superior off Great Sand Bay is owned by the State of Michigan. Initial attempts to secure a permit to recover the Lake Copper slab were unsuccessful. However, after Mr. Barron became an employee of the A.E. Seaman Mineral Museum in 1996, an agreement was reached between the Michigan Department of Natural Resources (MDNR) and MTU, whereby the MDNR would retain ownership of the Lake Copper slab and put it on permanent loan to the museum. The Lake Copper was recovered from the floor of Lake Superior in 2001 using a barge-mounted crane provided by the US Army Corps of Engineers (see Figures 4 and 5).

Figure 4: Recovery of the 19-Ton Copper Slab from Lake Superior in 2001. Photo provided by the A.E. Seaman Museum.

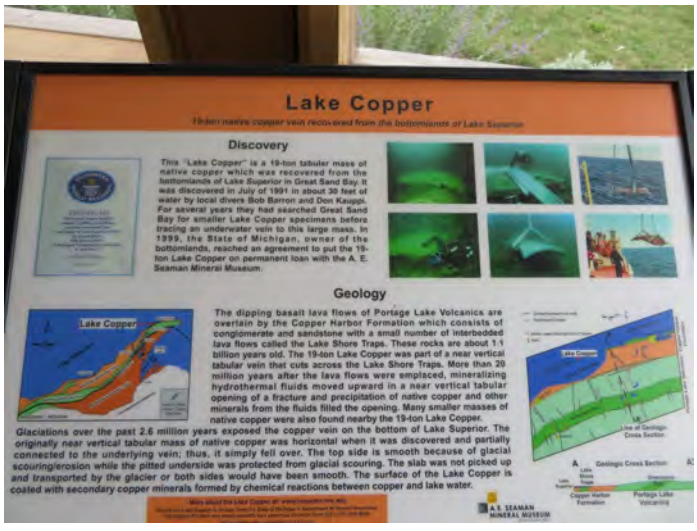

Figure 5: Lake Copper Educational Resource. Photo provided David Adler.

Following recovery, the Lake Copper slab was taken to the Quincy Mine Hoist Association hoist building at the Quincy Mine workings in Hancock for temporary exhibit. In 2015, the Lake Copper was moved to the A.E. Seaman Mineral Museum where it is on permanent display on the museum grounds in the Copper Pavilion, made possible by a generous donation. Both the A.E. Seaman Mineral Museum and the Quincy Mine workings are Keweenaw Heritage sites affiliated with the Keweenaw National Historic Park under the Keweenaw Heritage Sites program.

The Michigan Mineral Alliance

The University of Michigan, founded in 1817, had a significant mineral collection originally established in 1838. This collection, consisting of approximately 15,000 specimens, is part of a long and distinguished history of mineralogical research at the University of Michigan. More recently, the collection was not actively curated or exhibited. Its existence was threatened by financial pressures and shifting trends in research.

The A.E. Seaman Mineral Museum, on behalf of MTU, entered into negotiations with the University of Michigan to preserve the U-M collection. In April 2015, those negotiations, led by Dr. Bornhorst, culminated in the creation of the Michigan Mineral Alliance, a unique perpetual legal agreement between MTU and the University of Michigan whereby the U-M mineral collection can be preserved in the public trust where it will continue to benefit future generations.

The Michigan Mineral Alliance resulted in co-ownership of the U-M collection by MTU and the University of Michigan. The Seaman Museum assumed responsibility for the collection's care and management, and actively curates the collection and exhibits specimens in the Thomas D. Shaffner Exhibit Hall on the MTU south campus in Houghton and at satellite exhibits located at the University of Michigan in Ann Arbor and elsewhere. The Michigan Mineral Alliance preserves the legacy of the University of Michigan collection and ensures its availability for public display.

The University of Michigan collection includes many specimens collected from the late 18th century to the early 1900s, including the only suite of specimens collected by Douglass Houghton (1809-1845). Dr. Houghton was Michigan's first State Geologist (1837-1845). He is renowned for his exploration and geological survey of the upper peninsula that resulted in the first mining boom in American history in the mid-1840s. Dr. Houghton organized the State of Michigan's first geological survey and served as mayor of Detroit in the early 1840s. He perished in a Lake Superior shipwreck near Eagle River in 1845 at the age of 36.

Some examples of the world-class mineral specimens from the U-M collection, now preserved and made available for public display by the A.E. Seaman Mineral Museum through the Michigan Mineral Alliance, are shown in Figures 6 and 7.

Figure 6: Hemimorphite ($Zn_4Si_2O_7[OH]_2 \cdot H_2O$) After Calcite ($CaCO_3$) - Joplin, Missouri. From the University of Michigan Collection. Photo provided by the A.E. Seaman Museum.

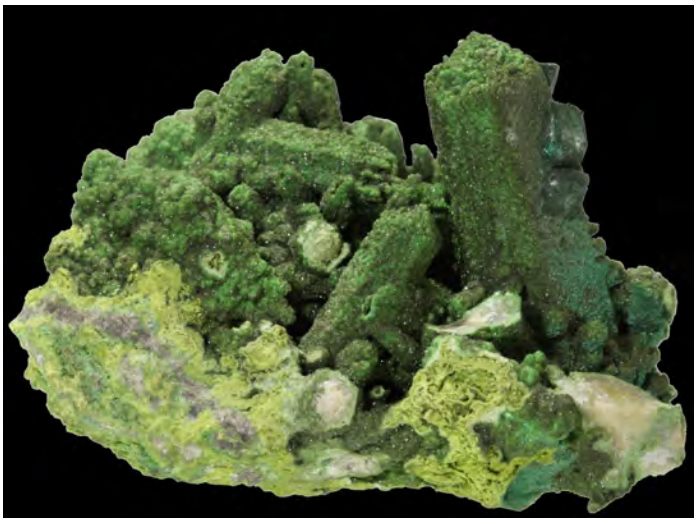

Figure 7: Bayldonite ($PbCu_3O\{AsO_3OH\}_2\{OH\}_2$) Over Mimetite ($Pb_5\{AsO_4\}_3Cl$) with Malachite ($Cu^{2+}{}_2\{CO_3\}\{OH\}_2$) after Azurite ($Cu^{2+}{}_3\{CO_3\}_2\{OH\}_2$) - Tsumeb, Namibia. From the University of Michigan Collection. Photo provided by the A.E. Seaman Museum.

Collection Highlights

The A.E. Seaman Mineral Museum features outstanding specimens from Michigan and the Great Lakes region. There is a seemingly endless supply of highlight specimens. The finest specimens from the Keweenaw Copper District are on display, including crystallized native copper and silver (see Figures 8 and 9), copper/silver "half breeds", copper sculls from the conglomerate lodes, crystallized copper inside translucent calcite crystals, chlorastrolite (Isle Royale Greenstone – the State Gem of Michigan), Lake Superior agates and amethysts, and porcelaneous datolite.

Datolite ($Ca_2B_2Si_2O_8\{OH\}_2$) is a hydrous calcium boro-

Figure 8: Crystallized Native Copper from the Phoenix Mine in Keweenaw County, Michigan. Photo by Dr. Christopher Stefano and Dr. John Jaszczak. Provided by Dr. Jaszczak.

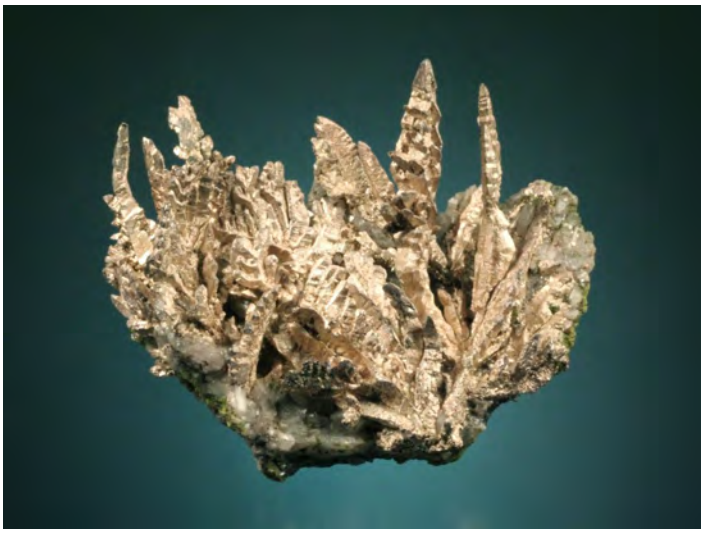

Figure 9: Crystallized Native Silver. Photo provided by the A.E. Seaman Mineral Museum.

silicate that occurs as a secondary mineral in cavities in basalt lavas and similar rocks. It is commonly associated with zeolites, prehnite, apophyllite, and calcite (Hurlbut and Klein, 1977). The porcelaneous variety of datolite is rare, occurring only on the Keweenaw Peninsula of Michigan. Porcelaneous datolite occurs as nodules in the basalts of the Precambrian Portage Lake Volcanics and in the Lake Shore Trap Basalts. The outer surface of porcelaneous datolite nodules has a distinctive texture that has been described as “fossilized cauliflower”. When the nodules are cut open, they reveal an astonishing variety of spectacular colors, and when polished they often become stunningly beautiful specimens that are highly prized (see Figure 10). The rarest of the rare porcelaneous datolites are the yellow specimens found in the High Rock Bay area of Keweenaw County near Keweenaw Point at the very edge of mainland Michigan (see Figure 11). Porcelaneous datolite nodules the size of small boulders have been found in some of the Keweenaw copper mines and in areas where the basalts outcrop.

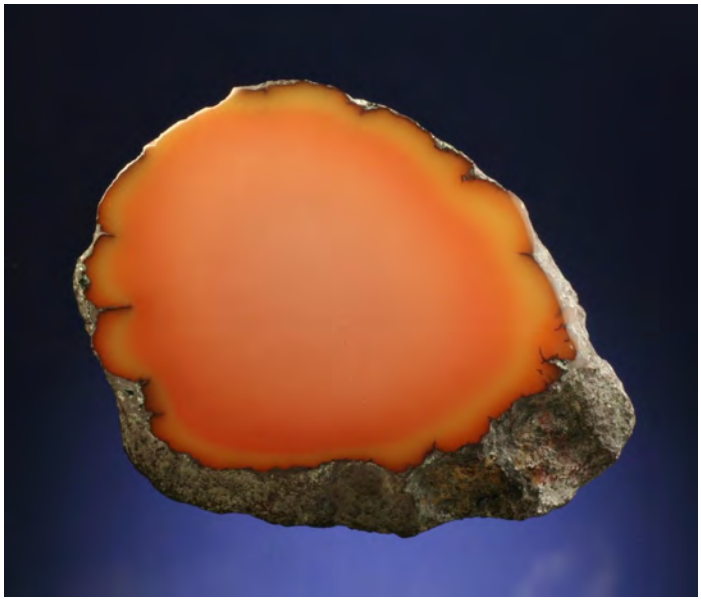

Figure 10: Porcelaneous Datolite from the Quincy Mine in Hancock (Houghton County), Michigan. Photo provided by the A.E. Seaman Mineral Museum.

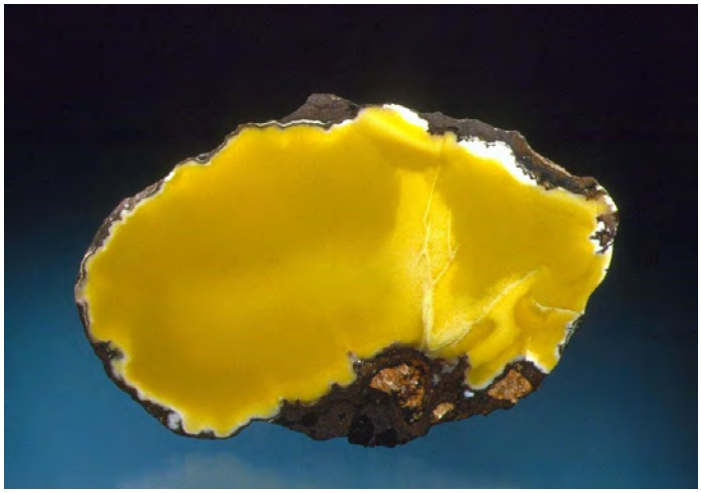

Figure 11: Porcelaneous Datolite from High Rock Bay in Keweenaw County, Michigan. Photo provided by the A.E. Seaman Mineral Museum.

Agate is a microcrystalline variety of Quartz (SiO_2) with alternating layers of chalcedony having different colors and porosity (Hurlbut and Klein, 1977). The Lake Superior area is well known for its distinctive agates. They occur primarily as amygdules in basalts. When the basalts weather, the harder and more resistant agates are released and can often be found on Lake Superior beaches and in gravel pits. Agates from different locations within the Lake Superior region have distinctive colors and textures, many of which are on display at the Seaman Museum. Two excellent examples of Lake Superior agates from the Seaman Museum collection are shown in Figures 12 and 13. Imagine the thrill of discovery felt by the fortunate individual who found the beautiful agate shown in Figure 12. Copper-bearing agates like the one in Figure 13 from the Kearsarge amygdaloid lode are exceedingly rare.

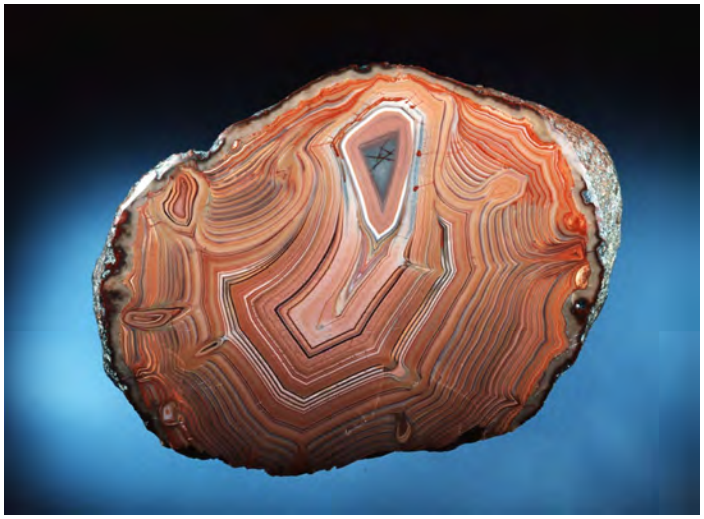

Figure 12: Lake Superior Agate from Keweenaw Point in Keweenaw County, Michigan. Photo taken and provided by Dr. John Jaszczak, Director and Curator of the A.E. Seaman Mineral Museum.

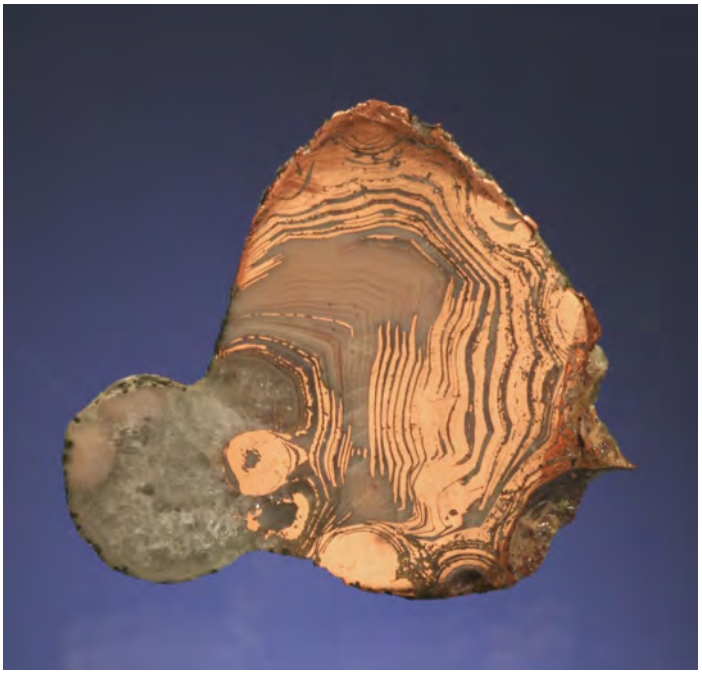

Figure 13: Copper-Bearing Agate from the Wolverine #2 Copper Mine in Houghton County, Michigan. Photo taken and provided by Dr. John Jaszczak, Director and Curator of the A.E. Seaman Mineral Museum.

The Seaman Museum also features minerals from Michigan's Iron Ranges (Marquette, Menominee, and Gogebic). Some of the many Michigan Iron Range specimens on display at the museum are shown in Figures 14 and 15. The unusual hematite specimen in Figure 14 came from the Newport-Bonnie Mine located in the Ironwood, Michigan area in the Gogebic Iron Range. The Newport-Bonnie Mine operated from 1886 to 1950 and extracted iron ore primarily from hematite (Fe_2O_3) and goethite ($Fe^{3+}O\{OH\}$). The minerals shown in Figure 15 include Romanèchite ($\{Ba,H_20\}_2\{Mn^{4+},Mn^{3+}\}_5O_{10}$), Hollandite ($Ba\{Mn^{4+},Mn^{2+}\}_8O_{16}$), and Cryptomelane ($K\{Mn^{4+},Mn^{2+}\}_8O_{16}$), each of which are manganese accessory minerals from the Marquette and Gogebic Iron Ranges.

Figure 14: Hematite (Fe_2O_3) From The Newport-Bonnie Mine in Gogebic County, Michigan. Photo by David Adler.

Figure 15: Romanèchite from the Lucy Mine (Marquette Range), Hollandite from Ironwood (Gogebic Range), and Cryptomelane from the Geneva Mine (Gogebic Range). Photo by David Adler.

There is much more to the Seaman Museum than just displays of Michigan and Great Lakes region minerals. The museum's collection includes thousands of beautiful mineral specimens from locations throughout the U.S. and around the world. Many of these specimens are breathtaking and quite unique. There are far too many to display at any one time, let alone to do justice to within the short confines of this article. Nonetheless, the specimens in Figures 16-18 provide a feel for what's in store for the visitor.

Calcite ($CaCO_3$) is one of the most common and widespread minerals in the earth's crust. It is the primary constituent of limestones and marbles, and is often found as a hydrothermal mineral in veins, lodes, and replacement deposits of a great variety of metallic mineralizations (Heinrich, 2004). The most common polymorph of calcite is Aragonite. Although common and widespread in its oc-

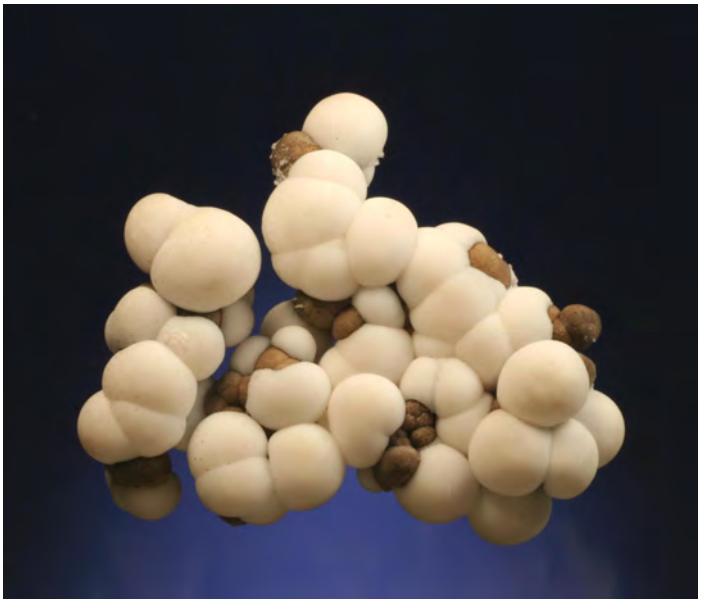

Figure 16: Aragonite ($CaCO_3$) from Chetco, Curry County, Oregon. Photo provided by the A.E. Seaman Mineral Museum.

currence, there is nothing common about the exquisite concretionary Aragonite spheroids displayed in the unusual specimen from Oregon in Figure 16.

Azurite ($Cu^{2+}{}_3\{CO_3\}_2\{OH\}_2$) is a hydrous copper carbonate supergene mineral formed by weathering of copper sulfide minerals in veins and lodes (Heinrich, 2004). It occurs in the oxidized portions of copper veins associated with malachite, cuprite, native copper, and iron oxides (Hurlbut and Klein, 1977). Azurite specimens are noted for their rich blue colors, often contrasted by the green shades of Malachite. The Azurite specimen in Figure 17 is from the Bisbee, Arizona copper mining district, an area famous for beautiful Azurite and Malachite specimens. This specimen is from the collection of the late Dr. E. William Heinrich (1918-1991). Dr. Heinrich was a professor of Geology and Mineralogy at the University of Michigan and was Curator of the U-M mineral collection. Among his many professional publications is the *Mineralogy of Michigan* book originally published in 1976 and updated and revised by Dr. George Robinson (former Curator of the Seaman Museum, now with the Department of Geology at St. Lawrence University in Canton, New York) in 2004. Dr. Heinrich donated his extensive collection of rocks and minerals to the Seaman Museum.

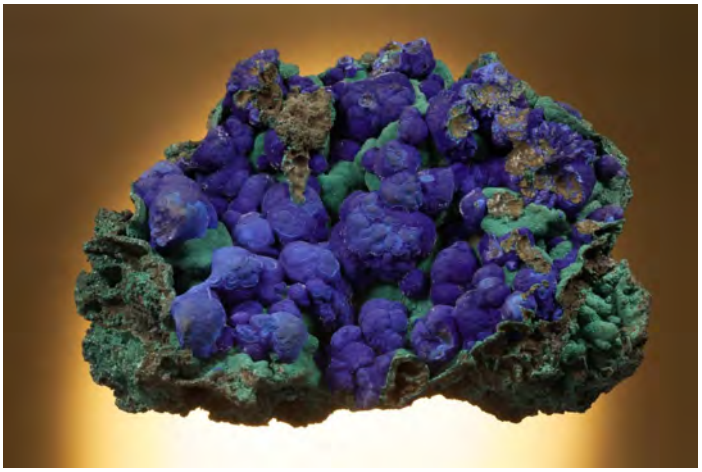

Figure 17: Azurite ($Cu^{2+}{}_3\{CO_3\}_2\{OH\}_2$) from Bisbee, Cochise County, Arizona . Photo provided by the A.E. Seaman Mineral Museum.

Crocoite ($PbCrO_4$) is a rare lead chromate mineral deposited from hydrothermal fluids. The element chromium was first extracted from Crocoite in 1798 by Louis-Nicholas Vauquelin. He produced chromium oxide (CrO_3) in 1797 by mixing Crocoite (also known as Siberian red lead) with hydrochloric acid (HCl). In 1798 he isolated elemental chromium metal by heating chromium oxide in a charcoal oven (It's Elemental, 2020). The Crocoite specimen shown in Figure 18 is from the Adelaide Mine in Dundas, Tasmania. Both silver and lead have been extracted historically from the Dundas mining district. The red, orange, and yellow Dundas "jackstraw" Crocoites known for their brilliant colors and luster were discovered in gossan overburden during exploration for lead and silver. The Dundas Crocoites were found in association with Cerussite ($PbCO_3$) in the oxidation zone of lead orebodies where ultramafic minerals were present as a source of chromium.

Figure 18: Crocoite (PbCrO4) from the Adelaide Mine in Dundas, Tasmania. Photo by David Adler.

Educational Resources

The museum's vision statement includes the following elements addressing education:

- Improve the educational content of exhibits while maintaining visual appeal
- Improve the educational content of exhibits through revision of the layout of exhibits
- Create exhibits that encourage learning about minerals
- Pursue scholarly activities that lead to publications in recognized mineralogical and

geological literature
Increase open-access educational publications on the museum's website
Provide satellite exhibits in the Great Lakes region and temporary exhibits at regional and national mineral shows
Develop public awareness through the museum's website and other relevant media
Support the educational and outreach activities of MTU

To fulfill these goals, the museum maintains open access (free) publications of interest on its website. These publications cover topics of interest such as Great Lakes Geology and Michigan mining history. The museum's website also contains a listing of publications by the museum staff, and information about books of interest, including books that can be purchased at the museum gift shop or online.

The museum's outreach program includes satellite displays in Marquette, Calumet, Ann Arbor, and Copper Harbor. In addition, mineral specimens from the museum's collections are displayed at national and regional mineral shows, and mineral specimens are offered to the attending public through silent auctions. Museum staff give informative lectures and presentations at some of the shows. Staff-led group tours of the museum are also available.

Many of the mineral exhibits at the museum include educational displays. Topics covered include: Michigan Basin minerals, low temperature hydrothermal minerals, banded iron formations and ancient stromatolites, magmatic minerals, contact metamorphic minerals, oxidation zone minerals, mineral colors, and many more. There are educational displays about the Geology and history of the Mabb's Vein and the 19-ton Lake Copper slab, as well as displays about float copper. One of the exhibits in the museum displays specimens, including rare copper "skulls", from the famous conglomerate copper lodes, and describes how the conglomerate lode ores were formed (see Figure 19). The outdoor garden and Copper Pavilion also provide educational displays. One of the interesting features of the rock garden is an 1860s era mining kibble that was used to move ore in the 19th century mines (see Figure 20).

Figure 19: Conglomerate Copper Lode Display. Photo by David Adler.

Figure 20: Rock Garden and 1860s Era Mining Kibble. Photo by David Adler.

Gift Shop

The museum gift shop offers a variety of specimens for sale including amethyst and citrine crystals, amethyst and quartz geodes, malachite, celestine, jasper, picture sandstone, pyrite, lapis lazuli, labradorite, rhodochrosite, septarian nodules, Brazilian agates, and ammonites. The gift shop also offers jewelry, various items made from Rose Quartz, Onyx, Orthoceras, Lapis Lazuli, and Malachite as well as bookends made from native copper ores. There are also books and other publications on Michigan Geology, rocks and minerals, collecting, Geology of the Great Lakes region, etc. for sale. Of special interest to collectors and mineral enthusiasts is a cabinet of special, high quality mineral specimens for sale, some of which are museum quality. They make great gifts. Prices are very reasonable considering the quality of the specimens.

Museum Staff

Dr. John Jaszczak succeeded Dr. Bornhorst as Museum Director and Curator on July 1, 2020. Dr. Jaszczak served as Adjunct Curator of the museum from 1992 to 2020 and as Interim Curator in 2013. He is a Professor of Physics at MTU and an Affiliated Professor of Materials Science and Engineering. Dr. Jaszczak has also served

as Associate Dean for undergraduate education in the MTU College of Sciences and Arts and as Interim Chair of the MTU Chemistry Department.

The accomplishments of Dr. Jaszczak are too numerous to fully mention here. His interest in minerals began at a young age and continues to this day. He is an expert in the field of crystallography. Dr. Jaszczak's areas of interest include crystal growth, the mineralogy of natural graphite, minerals from the Merelani Hills of Tanzania, and mineral photography. In 2016, the new mineral Jaszczakite ($[Bi_3S_3]$ $[AuS_2]$) was named after Dr. Jaszczak in honor of his research on the complexities of the morphology and structure of natural graphite.

Dr. Jaszczak is ably assisted by Patrice Cobin, Associate Museum Manager. Ms. Cobin has Bachelor of Arts degrees in Geology and History from Mount Holyoke College and a Master of Science degree in Geology from MTU. She earned her MS degree as a Peace Corps Masters International student and volunteer in Guatemala. Ms. Cobin manages the day-to-day operations of the museum and gift shop. She also develops educational materials and assists Dr. Jaszczak with exhibit displays and the museum's collection catalogue.

In addition, the museum employs MTU student interns. Two of the MTU AIPG Student Chapter officers work part time at the museum while pursuing undergraduate degrees in Geology and Geological Engineering. The museum staff is dedicated to the concept of continuous improvement through additions to the museum's collection and upgrades to its exhibits, displays, and educational resources.

The A.E. Seaman Museum at MTU has much to offer to Geologists and non-Geologists of all ages. It's a place where some of earth's most spectacular geologic treasures can be experienced firsthand in a warm and friendly atmosphere. There are educational experiences around every corner of the museum. The gift shop is a great place to acquire specimens of your own or as gifts for others. It's also a great place to come in and get out of the cold if you should happen to find yourself in Houghton during the winter months. Even if you have no interest in minerals, a visit to the museum will be worth your while. Who knows where it could lead.

Acknowledgments

Special gratitude is extended to Dr. John Jaszczak and Ms. Patrice Cobin of the A.E. Seaman Mineral Museum for information and photographs they provided for this article. Ms. Jenny Hamel provided invaluable assistance in preparation of the figures. The author also wishes to acknowledge the many contributions made by Dr. Theodore Bornhorst, whose dedication, leadership, and commitment to excellence have made the Seaman Museum the world class institution it is today.

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Consider Submitting an Article for TPG!

Adam Heft, Michigan Section's Newsletter Editor, has been elected National Editor of *The Professional Geologist (TPG)* for 2021-22.

I would like to thank all of you who voted in this year's National election and helped me to attain the position of Editor.

Starting now, I encourage ALL of our members to consider submitting a technical or professional article or opinion piece for publication. The deadline for submittal is two months before the start of the quarter for which the TPG edition is published. Thus, February 1 is the deadline for the Apr/May/Jun edition.

Please submit your articles of no more than 3,200 words in MS Word format to Dorothy Combs at National Headquarters at aipg@aipg.org. All graphics (photos, figures, or tables) should be submitted in .jpg, .tiff or other standard format at 300 dpi. Please ensure your graphics are clean and easy to read to make things easier for the editorial staff. Complete information on submitting an article may be found on National's website at: https://aipg.org/page/TPGInformation.

I'd like to encourage our members to consider submitting an article related to Michigan geology in advance of the Annual Meeting that will be held in Marquette in 2022.

ASBOG Exam Update

Twenty-four individuals took the ASBOG FG exam at Central Michigan University last Friday, October 2nd. Registration is now open for the next exam, which will be administered on March 19, 2021. Relevant dates for taking the exam this March are:

- January 14 – apply to CMU
- January 24 – register with ASBOG
- March 19 – FG exam at CMU

Details are available at: se.cmich.edu/asbog and will be provided in the next edition of *Geologically Speaking*.

Member Input Sought

The Section Executive Committee is seeking input from members on a variety of topics. Do you have any suggestions regarding speakers/presentation topics that you would like to hear? What about field trips or other events? Some place you'd like to see us go, or something you think the membership would enjoy doing? Then make your voice heard; please send your suggestions to one of the members of the Executive Committee; any of the six members would be glad to hear from you. AIPG is your organization. Please help keep it relevant and interesting for all by participating.

Support our Sponsors!

The Section Executive Committee would like to remind its members to support the companies advertising in this publication. Consider working with these companies, and when you speak with their representatives, let them know that you saw their ad in the Michigan Section's *Geologically Speaking*.

Annual Meeting Planning

The Michigan Section AIPG will be hosting the 2022 Annual Meeting in Marquette on August 6-9, 2022. The planning committee is growing but needs your help! The committee is co-chaired by Adam Heft and Sara Pearson. If you are interested in helping with the planning of the 2022 Annual Meeting or would like to be on the planning committee, please email either Adam or Sara at adam.heft@wsp.com or pearsons@michigan.gov.

As one of the most active AIPG Sections, Michigan wants to have an exciting program and a highly successful Annual Meeting with many attendees. If you have any suggestions or ideas that will make the 2022 Annual Meeting one to remember, please pass them along.

Look for periodic updates on the status of the Annual Meeting planning in future editions of *Geologically Speaking*!

Update Your Information!

Please be sure that you continue to receive the Section's *Geologically Speaking* publication and other announcements. Submit an updated e-mail address to Adam Heft at adam.heft@wsp.com. If you move or change places of employment, don't forget to send your new contact information to both the Section and to National. If you are not receiving announcements directly from the Editor, it is because your email address is not up to date with the Michigan Section.

Please help the Editor by making sure that your email address doesn't bounce when the next announcement is sent. And be sure to cc Dorothy Combs, National AIPG Membership Director at aipg@aipg.org when you update your contact information. Thank you!

Coming Events

RESCHEDULED:

June 14-16, 2021: Michigan Section's 10th Annual Environmental Risk Management Workshop: "The Data Tell the Story" at the Ralph A. MacMullan Conference Center, Roscommon, Michigan.

October 23-26, 2021: Rescheduled 57th Annual AIPG Meeting to be held in Sacramento, California. The Role of Geoscientists for Resiliency, Sustainability and Opportunities in a Changing Environment. The meeting venue will be the Hilton Sacramento Arden West.

August 6-9, 2022: 58th Annual AIPG Meeting to be held in Marquette, Michigan. See article in this edition of *Geologically Speaking* regarding meeting planning.

Remediation and Risk Management Series - Conceptual Site Models 101, January 27, 2021 (12:00 to 1:00 p.m. EST)

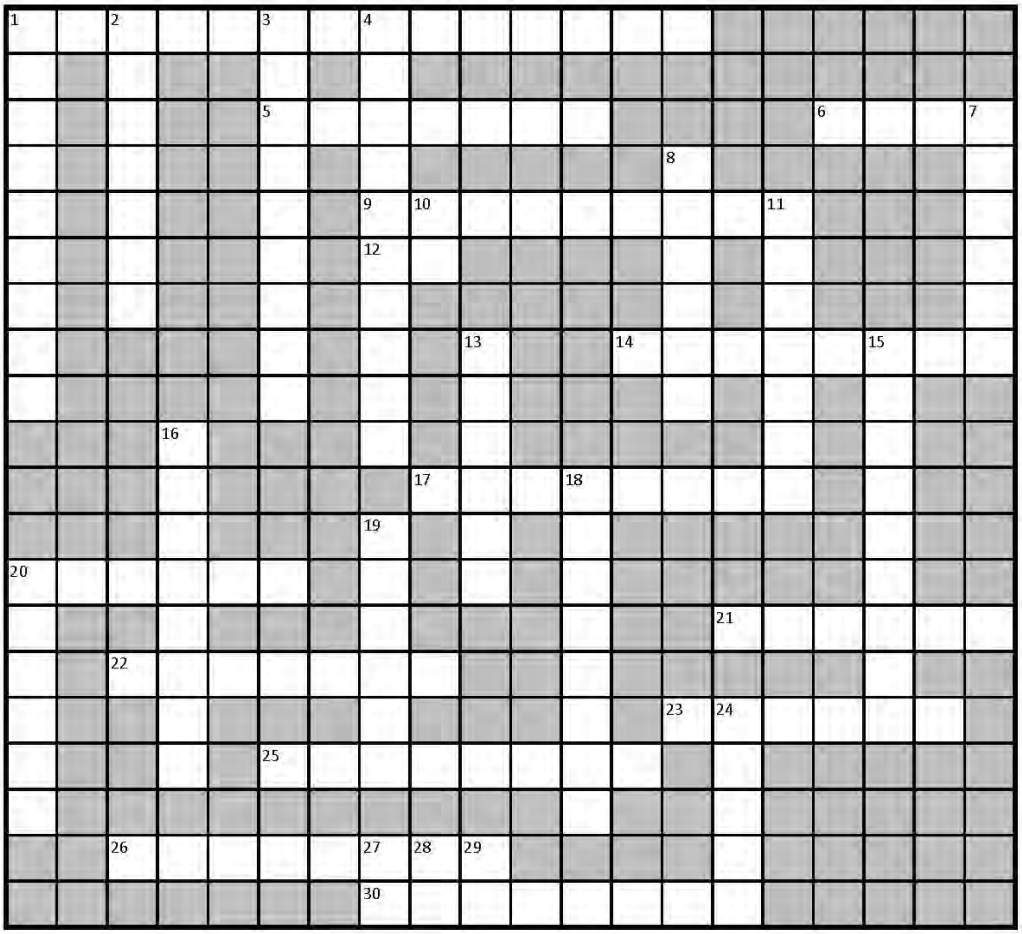
Conceptual site models (CSMs) are a written or pictorial representation of an environmental system and the biological, physical, and chemical processes that determine the transport of contaminants from sources through the environmental media to environmental receptors within the system. Learn what this means from a regulators perspective and how CSMs play a role in the review of compliance submittals. The webinar will review CSM basics, as well as information and tools that may be available for CSM construction. Every contaminated site has a story to tell, so know your audience and write a great script.

Speaker Biography: Aaron Assmann is an Environmental Quality Analyst for the Remediation and Redevelopment Division in the Grand Rapids Office managing Part 201, 213, State Funded and Brownfield Sites/Facilities. Aaron attended Alma College (BS) and the University of Michigan (MS). Before joining EGLE in 2017, Aaron worked in the Alaskan oilfields as an Environmental Advisor.

How to attend the Online Webinar:

To attend the online webinar register at https://attendee.gotowebinar.com/register/16509579260218380. After registering, you will receive a confirmation email containing information about joining the webinar.

Geology Crossword #4



Across

1 Michigan State Gem
5 Blue, copper carbonate hydroxide
6 Moh's scale 1 mineral
9 Gray-black iron oxide mineral
12 As 10 down
14 Granitic mineral
17 Mineral for writing
20 Fertilizer component
21 Preservative
22 Moh's scale 10 mineral
23 A prominent knob
25 Calcium borosilicate mineral
26 Often satin spar
30 Yooperlite mineral

Down

1 Strontium sulfate
2 Very low-grade coal
3 Fine grained massive gypsum
4 Semi-precious borosilicate
7 Keweenaw native metal
8 Argentum
10 Auric
11 Green metamorphic mineral
13 Common magma residual fluid
15 Green sorosilicate mineral
16 Fe_2O_3
18 Green calcium aluminum silicate mineral
19 semi-precious gemstone
20 Iron sulfide
24 Often found on beaches
27 Islamic state, abr.
28 Not too or 2
29 Education, abr.

*The solution to this geology crossword will be included in the next edition of *Geologically Speaking*.