PITTSBURGH GEOLOGICAL SOCIETY

A Multi-scale View of the Yellowstone Volcanic System

Dr. Jamie Farrell

Research Assistant Professor & Chief Seismologist of the Yellowstone Volcano Observatory

University of Utah

March 16, 2022

MEETING TIMES

Social Hour	5:30 PM
Dinner	6:30 PM
Speaker	7:30 PM

DINNER COSTS

$35.00 regular member
$15.00 student member
$40.00 non-member

RESERVATIONS

Email your name and number of attendees to: pgsreservations@gmail.com

Or reserve and use PayPal: https://www.pittsburghgeologicalsociety.org/

MEETING LOCATION

Cefalo's Banquet & Event Center, Carnegie PA

COVID19 POLICY

See page 3 for current guidance.

Please RSVP by Wednesday, March 9

Speaker Abstract

Scientists and the general public have been fascinated by the Yellowstone volcanic system for decades. As computing systems have become faster and programming has become more sophisticated, combined with improved monitoring capabilities, our understanding of the Yellowstone Volcanic system has improved over time.

In this presentation, I will show how we image the Yellowstone volcanic system from the core-mantle boundary up to the surface. To do this, we take advantage of a multitude of data collected at different scales and over decades of time. This enables us to learn about the system at different spatial and temporal scales including learning about the 100s of kilometer-scale mantle plume that feeds the volcanic system and the meter-scale hydrothermal features that sit on the surface. In addition, since Yellowstone is such a dynamic place, we can look at changes in activity with time to learn more about how the volcanic system works and to better understand the related hazards and risks to the millions of people who visit each year.

Speaker Biography

Jamie Farrell received his B.S. in Geology from Utah State University in 2001; his M.S. in Geophysics from the University of Utah in 2007; and his Ph.D. in Geophysics from the University of Utah in 2014. His research has focused on the Yellowstone magmatic-tectonic system since 2003 when he organized a focused seismic and geodetic study of the Norris Geyser Basin at Yellowstone National Park. Since that initial study, Dr. Farrell has carried out several GPS and gravity campaigns in the Yellowstone backcountry and installed dedicated seismic systems around Old Faithful and Steamboat Geysers.

Dr. Farrell is currently a Research Assistant Professor in the Department of Geology and Geophysics at the University of Utah, as well as the Chief Seismologist for the Yellowstone Volcano Observatory. Recent research papers have included topics such as tomographic imaging of the Yellowstone magmatic system, in-depth analysis of Yellowstone seismicity and earthquake swarms, seismic and volcanic hazard and risk assessment of the Yellowstone region, seismic signals related to hydrothermal systems, and source characteristics of seismic events. Current research projects include continued analysis of Yellowstone seismicity, using ambient noise to better understand the velocity structure of the Yellowstone system, and continued analysis of earthquake swarm activity including its relationship to local uplift/subsidence signals.

Please note that PGS is monitoring the COVID-19 situation closely and will continue to modify our mask policy based on the recommendation of national and local experts. The US Centers for Disease Control and Prevention (CDC) currently recommends the following:

- Those who are not vaccinated should wear a mask indoors in all public places.
- Those who have a condition or are taking medications that weaken their immune system should wear a mask indoors in all public places.
- If you are fully vaccinated, to maximize protection from the Delta and Omicron variants and to prevent possibly spreading it to others, you should wear a mask indoors in public places if in an area of substantial or high transmission. Allegheny County is classified as an area of high transmission.

To best align with the recommendations of the CDC, PGS strongly recommends that meeting attendees wear a mask and maintain social distancing to protect other meeting attendees and themselves. Masks may be removed when eating or drinking; however physical distancing is encouraged for those times. Please note that some members in attendance may qualify as immunocompromised, or may be caregivers for those who are, regardless of vaccination status.

UPCOMING PGS MONTHLY MEETINGS

Meeting Date	*Scheduled Speaker*	*Presentation Topic*
April 20, 2022	19th Annual Student Research Night	
May 11, 2022	Jim McDonald Ohio Geological Survey	History of Structure Contour Mapping in the Appalachian Basin: 1870-1917

The Pittsburgh Geological Society welcomes six new members:

Grant R. Marts

Tiffani P. Marts

Ian McCombie, Student
California University of Pennsylvania

Madison D. Raviart, Student
California University of Pennsylvania

Melanie Stasik, Field Technician
Vibra-Tech Engineers

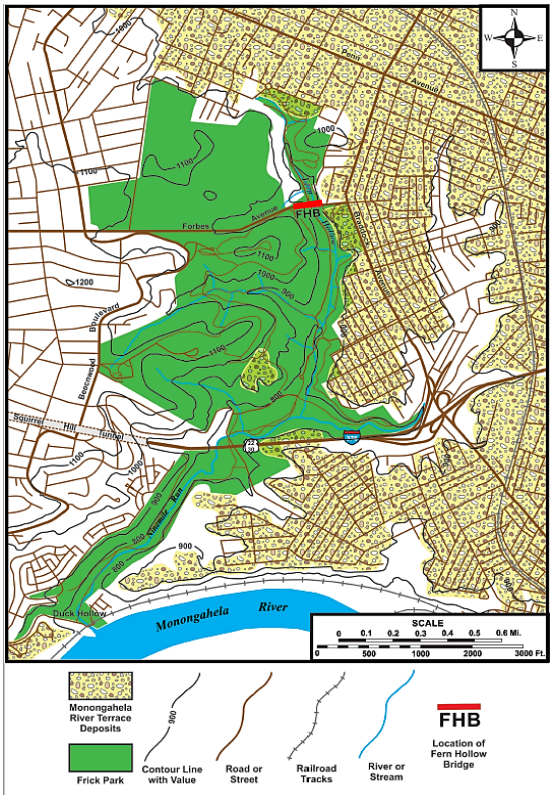
Michael R. Stoehr, PG, Assistant Project Manager/Geologist II
Rea Engineers & Consultants, Inc.

"To Cross a Bridge": Fern Hollow Bridge in Pittsburgh, A Geology Story

By Albert D. Kollar and Wendy T. Noe

This article about the geology of Fern Hollow in Frick Park was originally published as a blog article by the Carnegie Museum of Natural History. This extract is reprinted here courtesy of PGS members Albert Kollar and Wendy Noe. To read the full article and see many more illustrations, visit: https://carnegiemnh.org/to-cross-a-bridge-fern-hollow-bridge-in-pittsburgh-a-geology-story/

In the early morning of January 28, 2022, Pittsburgh's 52-year-old Fern Hollow Bridge collapsed into Fern Hollow Run of Frick Park. Thankfully, there were no fatalities. The event made local and national news. The now infamous bridge, which carried Forbes Avenue's vehicle and pedestrian traffic between Squirrel Hill and Regent Square, crossed a hollow that probably took over a million years to erode. The Fern Hollow Bridge owned by the City of Pittsburgh, was a steel rigid frame, a design in which the superstructure and substructure are rigidly connected to act as a continuous unit. The structure included three spans, with a total length of 447 feet (48.7 meters). Its road surface was 160 feet above (48.7 meters) Fern Hollow Run, and the bridge operated with a weight limit of 26 tons.



Pittsburgh, with 446 bridges within the city limits, has long been known as the City of Bridges. The title is appropriate because the tally far exceeds the number of bridges in Venice that cross the Italian city's network of canals as part of a lagoon system formed in the Holocene. Bridges are so common in Pittsburgh that for many residents it's a daily experience to both cross over and pass under a bridge. Understanding the origins of the landscape features in Pittsburgh that make hundreds of bridges a necessity requires background knowledge of two long and widely spaced periods of Earth's geologic history. Cyclothems sedimentation of limestone, sandstone, shale, and peat (coal) during the first period (the Pennsylvanian Period) helps explain why rock layers here appear (mainly in roadcuts, hollows and ravines) stacked in relatively flat layers while the erosional actions of water during the recent Ice Age (Pleistocene Epoch) impacted Pittsburgh's current landscape for bridge building. As a result of glacial fluctuations and continued erosional features, the landscape shifted from a gently rolling plain dissected by shallow, meandering stream valleys into broader, deeper valleys, hollows, and ravines.

In Frick Park, the strata exposed along the eastern flank of the ravine at the Fern Hollow Bridge consists of sediment deposited as the Carmichaels Formation. The oldest rock strata exposed along the floor of Fern Hollow is the Saltsburg Sandstone, a fluvial unit formed about 300 million years ago. Sedimentary rocks are, by nature, more prone to erode than igneous and metamorphic rocks, which don't occur in outcrop in western Pennsylvania except for some Jurassic dikes in Fayette County. Some estimates propose that it takes about a million years to erode approximately 164 feet (50 meters) of rock within the river valleys and hollows of this region. Assuming this estimate is valid, which might not be the case, the hollow created by erosion of Fern Hollow Run, and that of nearby Nine Mile Run, still took hundreds of thousands of years to form.

Every bridge crossing is a potential encounter with geology. This scientific discipline offers insight into the natural dynamics that shape landscapes through deposition of sediments, mountain building, and erosion, all factors that help account for the locations where our region's hundreds of bridges were built as transportation necessities.

PRESIDENT'S STATEMENT

The February virtual meeting was an absolute blast, Dr. David King led a marvelous discussion of stratigraphic units in Belize that formed from ejecta material from the end-Cretaceous Chicxulub impact! The thick boulder breccia beds and pebbly ashfall units that Dr. King showed us were an impressive reminder of just how powerful this extinction-level event was.

Though I absolutely enjoy the in-person conversation at our typical in-person meetings, it was really a nice change to hold a virtual meeting again, and particularly so since it was not forced by COVID. I strongly feel as though offering more virtual meetings in the future would be of a significant benefit to our members, particularly those that find attendance at in-person meetings either difficult or impossible and I look forward to exploring more ways to increase meeting access to the membership through exploring different venues and through offering more virtual options.

The February meeting also featured a drawing for a series of prizes for professional and student members in attendance. Thanks to the various board members and the PGS as a whole for donation of the prizes and congratulations to the winners!

Please remember that PGS is collecting registration requests for the virtual landslide field trip (free for members) authored by Jim Hamel and constructed by Brett McClinton. Please use the "contact us" form on the website to request access and note that a google account or gmail account will be required. Cost for registration is $30 for non-members. Our in-person landslide field trip is now full and registrants should have received their contact email from the organizers.

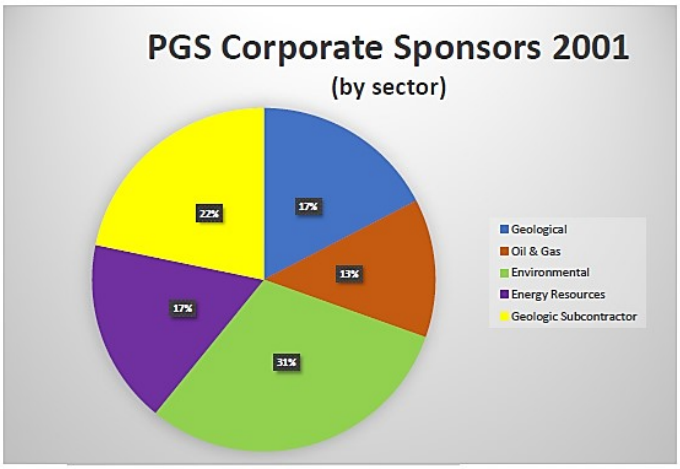
As a reminder to our student members, please be advised that applications for the Frank Benacquista scholarship will be accepted up to the deadline of May 3, 2022. See the "For students" section of the website for more information. And don't forget to submit your abstacts this month for the upcoming Student Research night. Instructions for that are also on the website.

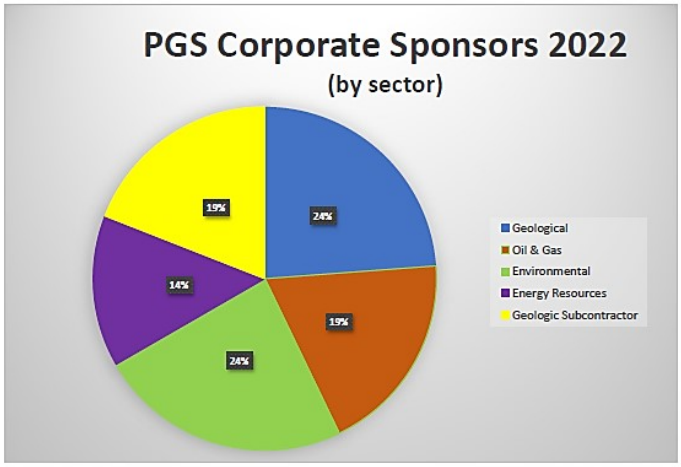
I'm looking forward to our March 16th in-person meeting featuring Jamie Farrell of Utah State University who will be providing a talk related to the geology of Yellowstone National Park. I hope to see you all there!

Dan

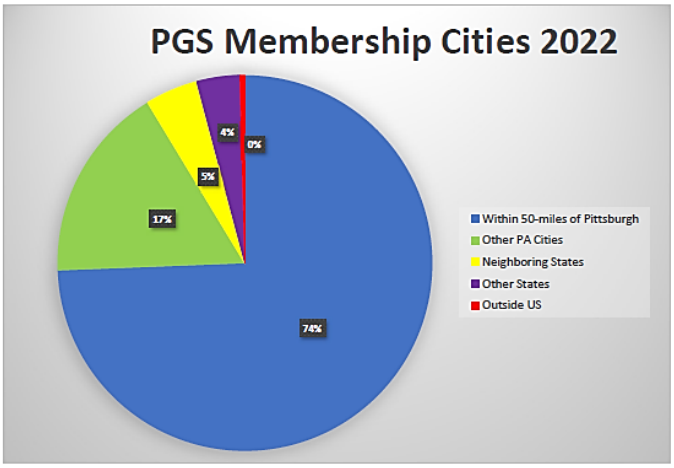
PGS MEMBERSHIP NEWS

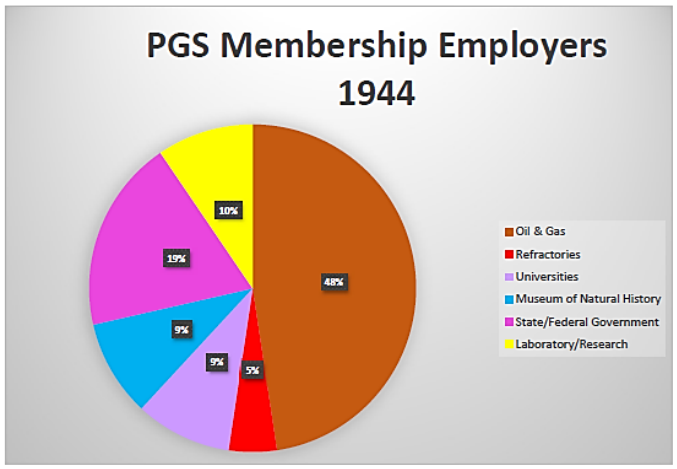
Pittsburgh Geological Society (PGS) historian Paul W. Garrett (deceased) opined how the society's original mission was to serve the professional interest of the oil and gas industries. Over the last half century, the society's demographics evolved by gaining new memberships from other geologic employment sectors, offering programs in the environmental, geotechnical, coal/mineral resources, educational outreach, and student night to its core mission. We present updated membership and corporate sponsors charts of the demographics that shows how PGS continues to be the leading regional geological society in the 21st century as the founding members envisioned.





Currently, PGS has 242 members and 21 corporate sponsorships. These totals reflect the continued support of the society by the core industries, educational and cultural institutions, and geological surveys of the region. Many industries employ recent graduates from regional colleges and universities.





One hundred and eighty members, or 74% of the membership, are Pittsburgh based. Forty-one members or 17% originate from other PA cities for a total of 91% from Pennsylvania. Of the remaining members, 5% are from states adjacent to Pennsylvania, 4% are from other states extending from Maine to California, and one member lives in New South Wales, Australia.

We want to thank John Harper for the membership database list.
Albert D. Kollar & Wendy T. Noe, Directors At Large

LOCAL GEOLOGICAL EVENTS

SOCIETY OF PETROLEUM ENGINEERS (SPE)

March 15, 2022 **11:00 AM – 1:00 PM**

"A Pioneering Technology to Mitigate Sand Production Using In-situ Metallic Bonding Oxidization"

April 5, 2022 **11:00 AM - 1:00 PM**

"Distinguished Lecture: Machine Learning Applications for Optimizing Real-Time Drilling and Hydraulic Fracturing" by Dr. Yuxing Ben, Senior Reservoir Engineer, Occidental Petroleum

For more information: https://connect.spe.org/pittsburgh/events/recentcommunityeventsdashboard

Cefalo's Banquet and Event Center, Carnegie, PA

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

March 31, 2022 **5:30 – 9:30 PM**

Joint Meeting with the Deep Foundations Institute (DFI) - An Evening with Geotechnical Industry Legend Tom Richards
Details and registration: https://www.asce-pgh.org/event-3618422

Engineers' Society of Western Pennsylvania, Oakland, PA

PENNSYLVANIA COUNCIL OF PROFESSIONAL GEOLOGISTS (PCPG)

March 29, 2022 **8:00 AM - 4:00 PM**

"Hydro-structural Methods in Bedrock Aquifer Characterization and Remedial Decision Making" (In-person Seminar, 405 minutes) by Thomas D. Gillespie P.G., Gilmore & Associates, Inc.

Details and registration: https://pcpg.org/event-4448953

Chester County Public Safety Training Campus, Coatesville, PA

April 19, 2022 **9:00 AM - 4:00 PM**

"Essentials of Borehole Geophysics with Field Demonstration" (In-person Workshop, 300 minutes) by Scott Wendling, P.G., Vice President, ARM Geophysics.

Details and registration: https://pcpg.org/event-4530196

3240 Schoolhouse Road, Middletown, PA

April 26, 2022 **1:00 - 2:00 PM**

"Factors affecting groundwater quality used for domestic supply in Marcellus Shale region of north-central and north-east Pennsylvania" by Charles "Chuck" Cravotta, PhD, P.G., Research Hydrologist/Geochemist, U.S.G.S. Pennsylvania Water Science Center (Webinar: 60 minutes)

Details and registration: https://pcpg.wildapricot.org/event-4653733

PITTSBURGH GEOLOGICAL SOCIETY
SPRING 2022 LANDSLIDE FIELD TRIP

Registration is now closed for the landslide field trip scheduled for March 26, 2022. Please be aware that parts of the trip are over rugged terrain and require climbing potentially slippery slopes. Participants should watch their email for further trip details.

PGS VIRTUAL LANDSLIDE FIELD TRIP ANNOUNCEMENT

Keep an eye out for our **Virtual Landslide Field Trip** and accompanying **Field Trip Guidebook**! Among others, this effort was fueled primarily by Dr. James Hamel, PGS Honorary Member and consulting geologist and engineer, and the Slippery Rock University team of Brett McClinton, Geography, Geology, and Environment Major, and Jeremiah Brown, Strategic Communications and Media. John Harper, PGS Honorary Member, edited the Guidebook.

This virtual experience examines the landslides along I-79 north of Pittsburgh between the Ohio River/Glenfield Borough area and the Mt. Nebo exit. Included are landslides on the nearby Western Pennsylvania Conservancy property along Toms Run Road and a discussion of the Kilbuck Township's infamous Walmart slide along PA Route 65. Watch our website for directions on how to access the Virtual Field Trip and Guidebook.

Pittsburgh Geological Society
Spring 2022 Student Field Workshop
Special 2-Day Event

Friday, April 8 & Saturday April 9
California University of Pennsylvania's SAI Farm

Have you wondered what you might be doing on that first job? Chances are you'll be assigned to a project that involves sampling wells and analyzing core logs.

Through this field experience, you will have the opportunity to work alongside experienced drillers and geological professionals from multiple companies and agencies.

Not only is this an excellent learning opportunity, it is your chance to ask all those questions regarding life after college and brush up on your networking skills!

What will you experience?

- Soil sampling using a drill rig
- Soil & Rock descriptions
- Basic sampling techniques
- Well installation basics
- Basic monitoring equipment
- Designing a drilling program

As with all field work, this will be a RAIN or SHINE event! The drilling process can be dusty, wet, and muddy, so leave the nice clothes and flip-flops behind. Only open to active students.

•Friday (4/8) Dinner Program: "Preparing for a Geoscience Career"
(A block of rooms has been reserved at a local hotel, less than a mile from the drill site.)

•Saturday (4/9) Drilling and Sampling Field Workshop
(Snacks and a lunch will be provided.)

Cost: $40 (Friday/Saturday) or $25 (Saturday only)

To Register, navigate to
https://www.surveymonkey.com/r/2022PGSDrilling

Direct questions to
Pgsreservations@gmail.com

Or contact Dr. Kyle Fredrick (CALU)
fredrick@calu.edu

PGS - AEG - ASCE STUDENT NIGHT IS APRIL 20

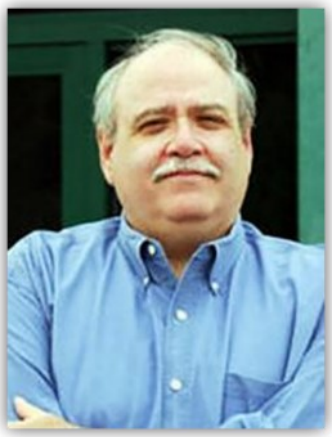
Students are invited to present college research projects at the **19th Annual PGS – AEG – ASCE Student Research Night on April 20, 2022**. If you have been conducting undergraduate or graduate research in any geological or geotechnical field, you can share your work in this virtual meeting with members of three regional professional scientific societies. All student presenters will receive official certificates of recognition. The three students chosen to give oral presentations will each receive awards of $100, while the three best poster presenters will each receive awards of $50.

The deadline for submitting abstracts for student research night will be March 16, 2022. Abstract submission forms and guidelines will be posted on the PGS website at: https://www.pittsburghgeologicalsociety.org/student-night.html.

DON'T FORGET TO ORDER YOUR PGS SWAG FOR SPRING!

Show off your PGS Membership at our society's spring events by purchasing a hoodie, t-shirt, or bumper sticker at the new PGS merchandise store. All proceeds support geology student participation in society meetings!

https://apparelnow.com/pittsburgh-geological-society-apparel



The Frank Benacquista Undergraduate Scholarship

The PGS Frank Benacquista Undergraduate Scholarship is an award of $500 to an undergraduate-level earth science student. This scholarship, created in honor of a long-time PGS member and student advocate, is intended to assist a student with college education costs and to promote student participation in the Pittsburgh Geological Society. Any student who is majoring in the earth sciences, is at least a sophomore, and attending a four-year accredited college or university in the Pittsburgh region is eligible to apply. The applicant must be a student member of PGS or must have applied for student membership at the time the application for the Frank Benacquista scholarship is submitted.

Required Materials

The full application must include the following:

- One-page resume
- Cover letter introducing yourself and elaborating on key points of your resume with a focus on activities outside of the classroom such as research projects, academic club service, or community involvement
- One-page essay describing your background, decision to pursue earth science, career goals, and academic objectives beyond the bachelor's degree (if any)
- Copy of your transcript (unofficial) and documentation that you are a current student. The requisite standard to apply is a minimum of 12 semester credits of earth science courses. Successful applicants should have a strong academic record that can be achieved through course work, research or service
- Letter of recommendation from a professor or another professional in the earth science field that provides information on your performance and activities in the classroom, in the department, or at an affiliated or non-affiliated institution. The letter should address your work ethic and your character in how you work and assist others in the classroom or field.

Scholarship Application Process

The application may be sent in digital form (email with attachments) to the current PGS President at harris_d@calu.edu. Follow these instructions when sending as an email:

- In subject line of email message, please type "PGS Scholarship, Your Last Name"
- Include a professional message to the President stating that you are submitting your application for the PGS Frank Benacquista Undergraduate Scholarship
- Attach all documents required as Word or PDF documents. Please make sure that each document is titled with your last name. For example: Jones Resume.pdf, Jones Essay.pdf

Application Deadline and Award Date

All applications must be received by **May 3, 2022**. The scholarship will be awarded at the first meeting of the Pittsburgh Geological Society in September, 2022.

Acceptable Fund Uses

Students may use the scholarship toward tuition fees, for field camp, to purchase equipment required for hands-on exploration as required by academic course work (e.g., rock hammers, hand lens), to attend geologic conferences, educational field trips, the PGS field trip, or the Field Conference of PA Geologists.

Basis of Awards

Awards will be based on the cover letter, recommendation letter, transcript, and the content and creativity of the essay as judged by the Scholarship Committee. The decision of the scholarship committee is final.

THE ORIGIN OF WESTERN PENNSYLVANIA PLACE NAMES

The Borough of Elderton, on US 422 in Armstrong County near the boundary with Indiana County, is located on a tract originally owned by Sarah Elder and called "Wheatfield" in the late 1700's. Her descendant Robert J. Elder laid out 41 town lots on 14 acres in 1822 and named it "New Middletown." The first building erected was a small tavern, of course! Elderton was incorporated as a borough in 1859. The Ebensburg and Butler pike (now US Route 422) was built through the town in 1865. It was the first good road through this part of Armstrong County.

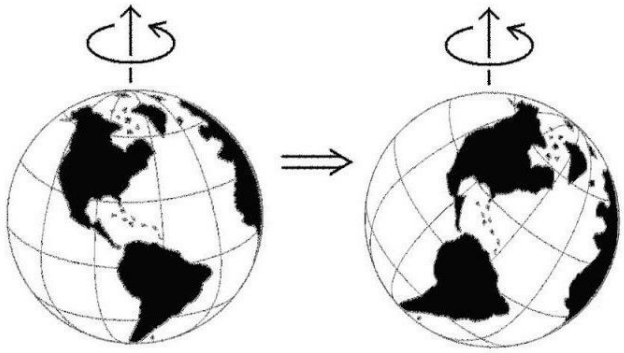
Portrait of Dr. David Alter, a resident of Elderton, PA, who invented numerous objects and processes, including the telegraph, telephone, and spectral analysis.

Arguably, Elderton's most famous citizen was David Alter (1807-1881), a prominent 19th century doctor, scientist, and inventor. In 1836, Alter invented the electric telegraph, one year before Samuel Morse did. Later, when he was interviewed about the discovery going unobserved by other inventors, he said, "I may say that there is no connection at all between the telegraph of Morse and others and that of myself . . . Professor Morse most probably never heard of me or my Elderton telegraph." He also developed a short-range telephone that was a precursor to Alexander Graham Bell's telephone, an electric clock, an electric buggy, a process for extracting oil from coal and shale, and spectrum analysis, the idea that every element has its own emission spectrum. This latter was a breakthrough development in spectroscopy.

DID YOU KNOW . . . ?

When you think of Earth revolving around the sun, or a globe sitting on a shelf, you tend to think it always has had that tilt of between 22º and 24º from the plane of the ecliptic. But this is not correct. As it turns out, Earth's crust tipped on its side and back again during the Late Cretaceous in an incident that is called true polar wander, or TPW (although some people have referred to it as a "cosmic yo-yo"). TPW occurs when the outer layers of a planet slide around its core, tilting the crust in one direction or another relative to its axis. There have been some scientists who predicted that TPW occurred on Earth in the Late Cretaceous, sometime between 145 and 66 ma ago, however this was intensely debated.

Now, new research strongly suggests TPW really did occur on Earth during that time period. The research team mapped the movement by examining magnetic-field data confined inside fossil bacteria in limestone deposits in Italy. The limestones, it turned out, were special, and very reliable, because the fossil bacteria had been



During the Late Cretaceous, the Earth's crust rotated about 12º on the liquid outer core and then back to its original position. The planet's axis and magnetic field remained the same, however.

replaced by magnetite. Some kinds of bacteria create chains of tiny magnetite crystals that naturally orient with Earth's magnetic field at the time of their creation. When these bacteria died and became fossilized during the TPW, the magnetite chains were locked in place. Then, as Earth's crust moved during TPW while its magnetic field remained in place, the magnetic

fossils embedded in the limestone could be used to determine how much the crust moved relative to the magnetic field over time.

The team found that the planet tilted 12° relative to its axis about 84 ma ago, and then returned to its original position over the next 5 ma. This is the most recent large-scale TPW documented to date, and it disputes the concept that Earth's axis has been mostly stable over the past 100 ma. If you imagine staring at Earth from outer space back then, it would have appeared as though Earth tipped on its side. But what actually happened was that the crust and mantle rotated around the liquid outer core as a single unit. This would not have resulted in any major tectonic activity or drastic changes to major ecosystems, however. It would have been a gradual process that would not have impacted the dinosaurs or other living things on the surface.

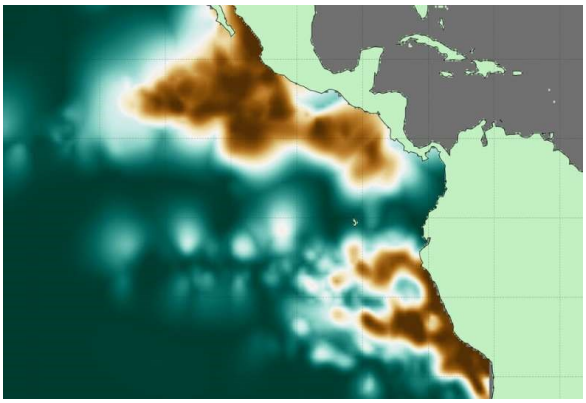
The planet's electromagnetic field would not have changed during the TPW because it is created by Earth's inner core, which would have stayed in place. As a result, only the geographic poles wandered while the magnetic poles remained in place or moved only slightly. The research team suggests that their findings now settle the dispute over whether Earth had a True Polar Wander event during the Cretaceous.

https://www.livescience.com/earth-tipped-on-side-and-back-again

Life is abundant almost everywhere in Earth's oceans, except in certain areas where O_2 is naturally deficient. In these areas, the water is habitable only for anaerobic species. These are oxygen-deficient zones, or ODZs, and although they constitute less than 1% of the oceans' total volume, they are an important source of nitrous oxide (N_2O). This gas, also known informally as laughing gas, is a potent greenhouse gas.

ODZs are large naturally occurring expanses of the ocean where marine microbes consume sinking phytoplankton; in the process, they also use up all the available surrounding's O_2. These areas just happen to occur in regions where ocean currents, which would normally replenish the water with O_2, don't pass through. Therefore, ODZs are relatively permanent, O_2-depleted waters that occur at depths ranging from 115 to 3,280 feet.

Recently, a team of scientists from MIT produced a detailed, 3D atlas of the world's largest ODZs. It provides high-resolution maps of the two major anaerobic zones in the tropical Pacific that reveal the volume, geographic extent, and depth variations of each ODZ, as well as smaller features such as ribbons of oxygen-rich waters that invade the depleted zones. The research required compiling, analyzing, and processing more than 40 years' worth of data, including almost 15 million measurements, to generate the maps. From these data, however, the research team was able to estimate the total volume of the two ODZs more precisely than any previous effort. One zone stretches out from the coast of South America and measures about 145,000 mi^3. The other zone, which lies off the coast of Central America, is approximately three times larger.



Map of the intensities of two oxygen-deficient zones in the eastern Pacific Ocean. Locations of consistently low O_2 concentrations (anaerobic waters) are shown in brownish colors and regions without low dissolved O_2 are shown in dark bluish green. Central and northern South America, as well as Caribbean islands, are shown in light green.

Although the atlas currently acts as a reference for where ODZs lie today, the team anticipates that other researchers will add to it with continued measurements in order to better track changes in the zones and predict how they may shift as the climate warms, when many people expect that the oceans will lose O_2. A detailed map of the two ODZs gives us a point of comparison for future changes.

The map construction wasn't easy, however. Over the past 40+ years, researchers have tried measuring the O_2 levels of the ODZs by dropping bottles over the sides of research vessels to

collect water samples. Unfortunately, since many of the bottles are made of plastic, and the plastic is full of O_2 that can leach out into the sample, any O_2 measurements overstate the actual values of the ocean. Rather than relying on measurements from bottle samples, the team examined data from sensors attached to the outsides of the bottles or integrated with robotic platforms that can change their buoyancy to measure water at different depths. These sensors measured a variety of signals to estimate the amount of O_2 dissolved in water. Best of all, the sensors recorded signals continuously as they descended through the water column. The researchers used the data not to observe O_2 at their true values, but rather to see how those values changed within the water column. This approach allowed them to identify anoxic waters, regardless of what a specific sensor reported. This has allowed them to observe the tropical Pacific's ODZs in far more detail than any previous measurements.

https://phys.org/news/2021-12-scientists-atlas-ocean-oxygen-starved.html

As reported in the December 2021 PGS Newsletter, extreme warming at the end of the Permian Period induced extreme changes in both the cyclicity of marine biogeochemistry and animal viability that led to the Permo-Triassic Extinction Event, the largest extinction in Earth's history. In that report, it was volcanism in Siberia and China that was implicated as the cause for the warming. However, volcanism cannot account for the various records of geochemical conditions that occurred. Assorted evidence indicated a 12.6° -18° F increase in the temperature of the sea surface over 39 ka, the development of anoxic waters containing sulfides, prolonged seafloor anoxia, and a decrease in the carbon isotopic signature recorded in carbonates.

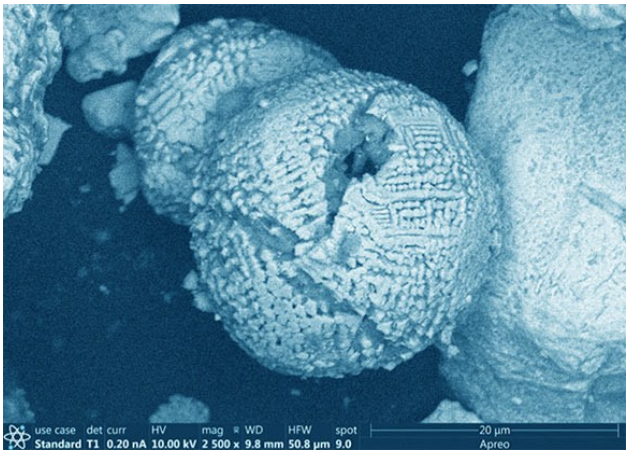
Until now, even though the extinction event had been studied in great detail, the processes that led to widespread loss of O_2 in Earth's oceans, and the subsequent biodiversity loss, have not been fully understood. According to a new study, the increased sea temperatures speeded up the metabolisms of oceanic microbes, thereby creating lethal conditions that affected life on Earth. As the photosynthesizing microbes and plants decomposed, other microbes quickly used up the O_2, leaving very little for larger organisms. Once the O_2 became insufficient to decompose organic material, microbes started to take in sulfate and produce H_2S, a gas that is poisonous to animals. These conditions became sustainable due to the release of nutrients during decomposition, which stimulated the production of more organic material, thereby helping maintain the toxic cycle.

The entire ocean didn't start out toxic, however. It began in the deeper parts of the water column. Then, as temperatures increased, the H_2S-rich anoxic zones became larger and even more toxic, progressing up the water column into the shelf environment where most marine animals lived, contaminating it and them. The expanding anoxia was detected through chemical signatures in sediment samples. Such examples from geologic time could be important lessons for understanding the processes that are challenging today's oceans, lakes, and streams. Although it would be scientifically risky to use the Permo-Triassic Extinction Event as an example of where today's climate changes will lead, this study does indicate that the ocean's response to higher CO_2 concentrations in the atmosphere might be underestimated.

http://www.sci-news.com/paleontology/toxic-microbes-end-permian-marine-mass-extinction-10382.html

Artist's concept of what the world might have looked like at the commencement of the Permo-Triassic Extinction Event.

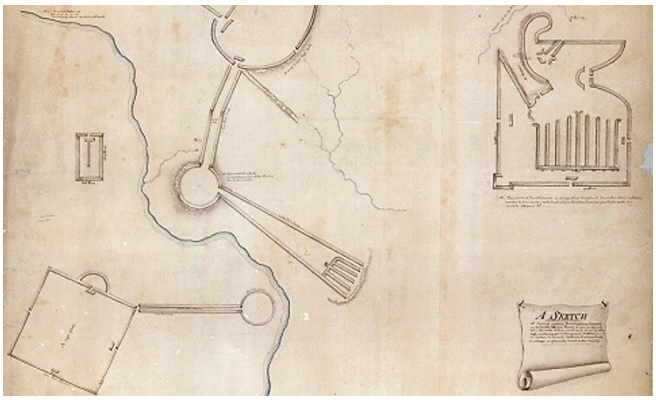
Archaeologists have been documenting an anomalously high concentration and diversity of meteorites, including iron, stony iron, and stony meteorites**,** at eleven Hopewell culture sites in the Ohio River Valley of three states. They've also found microspherules, iridium and platinum anomalies, and burned charcoal-rich habitation surfaces**,** leading to the conclusion that a catastrophic cosmic airburst from a comet or bolide occurred in the area at some time in the past. Using radiocarbon and typological dating, they have determined that the event occurred between 252 and 383 CE (1,699 to 1,567 years ago). Early Chinese astronomers documented 69 near-Earth comets, including Haley's, which came to within 0.09 astronomical units of Earth in 374 CE (1,646 years ago), a time when human communities and the resources they needed for survival would have been at a heightened risk of being destroyed by a comet airburst event.



SEM photo of microspherules from an archaeological site in Ohio that provide evidence of a cometary airburst over the Ohio River valley over 1,500 years ago.

The Hopewell people collected meteorites and forged metals from them into jewelry and pan flutes. The research team was able to identify the meteorites from concentrations of iridium and platinum they contained. The scientists also found a widespread charcoal layer suggesting the area was exposed to fire and extreme heat. Although the Hopewell people survived the event, it is believed that the astronomical event probably contributed to their cultural decline.

In addition to the physical evidence, the archaeologists used cultural clues left behind in the masterworks and oral histories of the Hopewell. For example, the Hopewell constructed a comet-shaped mound near the epicenter of the airburst at a site called the Milford Earthworks near Cincinnati, OH.



Portions of a land survey created by the U.S. Army Corps of Engineers in 1823 for an ancient Hopewell site known as the Milford Earthworks. The surveyor found Hopewell mounds standing 5-10 feet tall, including one in the shape of a comet.

Archaeologists are also aware of various post-Hopewell tribes with oral histories of the event. For example, Algonquin and Iroquoian tribes, who are descended from the Hopewell, relate the story of a calamity that befell the Earth, while Miami tribes tell of a horned serpent that flew across the sky and dropped rocks onto the land before plummeting into the Ohio River. The Shawnee have a tale of a "sky panther" that had the power to tear down forests, and the Wyandot recount a dark cloud that rolled across the sky and was destroyed by a fiery dart. The Ottawa talk of a day when the sun fell from the sky. When a comet hits Earth's thermosphere, it would explode like an atom bomb, much like what happened at the Tunguska event in Siberia in 1908.

http://www.sci-news.com/archaeology/hopewell-comet-10515.html

According to new research, supermountains formed twice during geologic time, first between 2 and 1.8 ga ago and a second time between 650 and 500 ma ago. Both mountain ranges rose during supercontinent formation, and the erosion of the ranges could be connected to the emergence of macroscopic organisms, including the radiation of early eukaryotes, the proliferation

Rapid erosion of supermountains has been suggested to have increased atmospheric oxygen and oceanic nutrients, both essential to life and evolution.

of chlorophyte algae, and the emergence of large, animal-like organisms. The researchers, from Australia and New Zealand, traced the formation of the supermountains throughout Earth's history using a combination of zircon and the rare earth element lutetium, found only in the roots of high mountains where they form under intense pressure. They found that the first supermountains formed during the assembly of supercontinent Nuna and the second during the amalgamation of Gondwana. It just so happens that there are links between these supermountain episodes and the two most important evolutionary periods in geologic time.

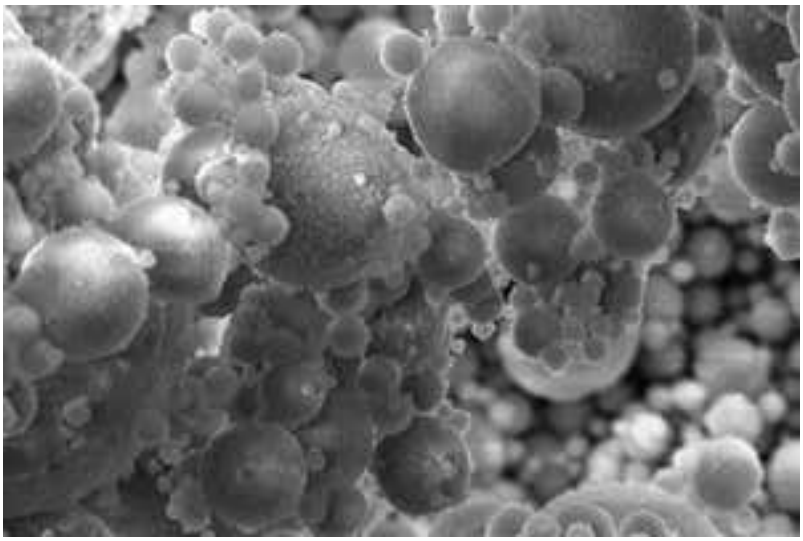
Nothing like supermountains exist today. If you can imagine the 1,500 mile-long Himalayas repeated three or four times you might get an idea of the scale of one. The formation of the Nuna Supermountain coincides with the probable appearance of eukaryotes, organisms that later gave rise to plants and animals. The formation of the Transgondwanan Supermountain coincides with the appearance of the first large animals 575 million years ago and the "Cambrian explosion" 45 million years later, when most animal groups appeared in the fossil record.

When the supermountains eroded they provided essential nutrients like phosphorous and iron to the oceans, supercharging biological cycles and driving evolution to greater complexity. They also might have boosted oxygen levels in the atmosphere. Researchers think atmospheric oxygen levels increased in a series of steps, two of which correspond with the supermountains. Erosion of the Transgondwanan Supermountain is associated with the largest increase in atmospheric oxygen in Earth's history, which was essential for the appearance of animals. Because there is no evidence of other supermountains forming at any stage between these two events, their existence made them even more significant. The slowing of evolution between the Nuna and Transgondwana Supermountain events has been attributed to the absence of any other supermountains during that period, resulting in the reduction in the supply of nutrients to the oceans.

http://www.sci-news.com/othersciences/geoscience/nuna-gondwana-supermountains-10521.html

The currently increasing importance of the supply of critical minerals and elements is propelling global discovery, innovation, and economic development. The term “critical minerals” refers to 17 rare earth materials such as scandium, yttrium, and neodymium that have different electronic and magnetic properties used in a variety of manufacturing. These and other elements like cobalt, nickel, and lithium that are vital to everyday technologies are recognized as critical to national and economic security.

The supply chain of these elements acts as an important economic driver capable of inciting incredible growth or causing crippling lack of productivity. Where broader supply chain problems have become universal, instability in the critical minerals market has the ability to cause even greater obstacles, damaging the production of everything from cell phones and laptops to ventilators and electric vehicles. Since China dominates global mining and processing of critical minerals, instituting a domestic industry for this supply chain is imperative.



Photomicrograph of tiny glass spheres in coal fly ash that contains rare earth elements.

Pennsylvania could meet this call to action and, as a matter of fact, might already have its first success to build on. Two years ago, the federal government funded a Penn State-led pilot consortium to produce rare earth minerals from coal waste. The consortium sought to identify and separate elements from waste using a self-contained, portable plant at a coal site near Hazelton, Luzerne County, PA. The project recovered rare earth oxides derived from anthracite coal waste material, successfully procuring minerals and remediating the contaminated land afterward. It confirmed that rare earths, in particular scandium, which is used in aerospace and renewable energy technology, was not only present in enough quantity to merit further exploration, but that it and other minerals could be satisfactorily produced.

Extracting elements through coal-waste remediation exemplifies an innovation capable of catalyzing a niche industry here in the coal fields of Pennsylvania. This is the kind of breakthrough that defines 21st-century economic development – ethical, strategic, readily accessible, and environmentally conscious. The timing of this economic development study into Pennsylvania’s critical mineral supply chain is perfect; with proper coordination between industry and government, Pennsylvania could entice significant investment.

Further due diligence, however, coupled with consequential action is required. A Pennsylvania government fact-finding hearing marked a significant step, and state economic development leaders can use that testimony to further create wider buy-in from the government and business community. In addition, expanded stakeholder engagement and further evidence from additional projects could be a significant step toward assembling an industry from the ground up.

The opportunity to create and grow a new industry is as unique as it is critical. Fostering an enabling environment for this industry’s early development would support both the national supply chain security and sustainability goals. In turn, this would afford the nation a formidable geopolitical advantage and Pennsylvania a rare opportunity for economic growth.

http://pge.libercus.net//.pf/showstory/20220122000 2/3

WEBSITE OF THE MONTH

https://www.msn.com/en-us/weather/topstories/12-out-of-this-world-images-of-earth-taken-by-landsat-satellites/ss-AASbzBL

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Fun Fact Having Nothing to Do with Geology

When you see a dog panting, it is regulating its body temperature, but this isn't their means of "sweating." Dogs actually sweat through their footpads.

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