PITTSBURGH GEOLOGICAL SOCIETY

Annual Joint Meeting with the Greater Pittsburgh Chapter of the Association of Environmental and Engineering Geologists and with the Pittsburgh Chapter of the ASCE Geo-Institute.

January 19, 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/

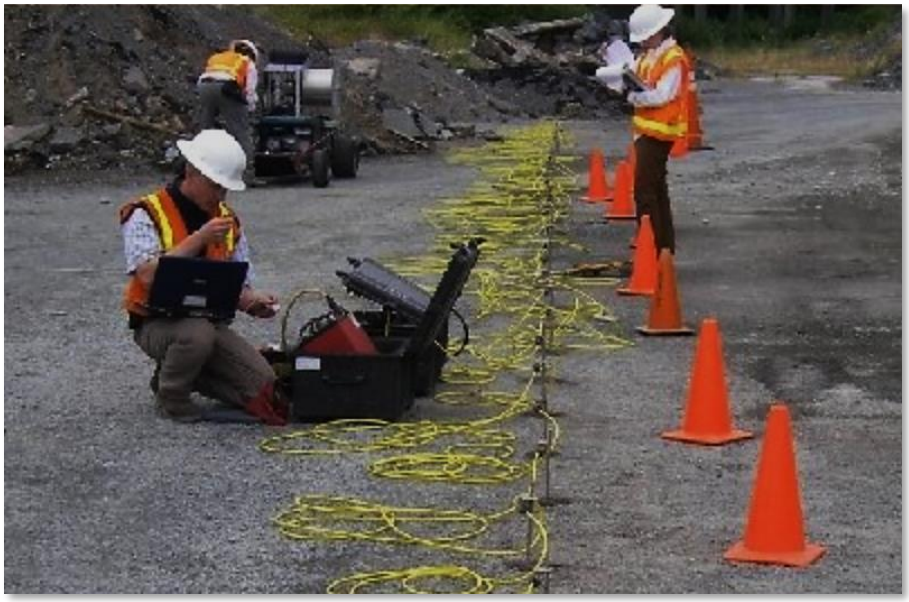
MEETING LOCATION

Cefalo's Banquet & Event Center, Carnegie PA

COVID19 POLICY

See page 3 for current guidance.

Electrical Hydrogeology: A Picture is Worth 1,000 Wells



Todd Halihan, Ph.D., P.Gp.

Sun Company Clyde Wheeler Chair in Hydrogeology, School of Geology, Oklahoma State University

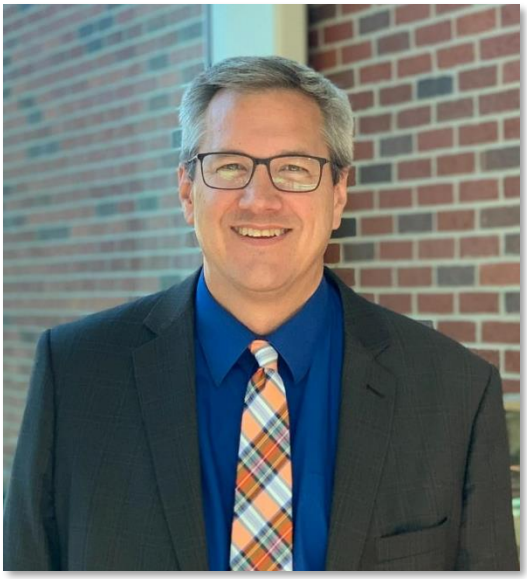
Please RSVP by Wednesday, January 12

Speaker Abstract

The science of hydrogeology was developed by creating conceptual models of the subsurface based on chemical or physical hydrogeology principles. Numerical and analytical modeling significantly added to the science. These modeling concepts provided a better understanding of ways to sample and test the subsurface.

Now, the ability to collect high density electrical data on an academic and commercial basis has allowed us to make several new advancements in the science. This talk will look at how electrical data can allow us to evaluate water supply or contaminant transport problems. Examples will include water supply and contaminants in karst domains, as well as contaminated sites affected by microbial activity.

Speaker Biography



Dr. Todd Halihan, Ph.D., P.Gp., is a Professor of Geology at Oklahoma State University and Chief Technical Officer for Aestus, LLC. Dr. Halihan's professional interests center in subsurface characterization and sustainable water supply. He has been an associate editor for Ground Water and has served as the Secretary-Treasurer of the U.S. Chapter of the International Association of Hydrogeologists. He served as the Chair of the Hydrogeology Division and the South-Central Section of the Geological Society of America. He also served on the Oklahoma governor's Coordinating Council on Seismic Activity.

Dr. Halihan has worked on over 200 different research and commercial sites in over 30 U.S. states and overseas. His international research work has occurred in Australia, Brazil, Iraq and Mexico along with a number of other countries on a commercial basis. He has also spent a significant amount of time in his home state of Oklahoma evaluating the Arbuckle Group of carbonates and associated springs.

Dr. Halihan is the recipient of the Karin and Robert J. Sternberg Award for Excellence, the Partners in Conservation Award from the U.S. Department of Interior, and the Sterling L. Burks Award for environmental research. He was the 2018 National Ground Water Association's McEllhiney Lecturer. He is also a professional driller in the state of Oklahoma and a PADI divemaster. He has provided input to stories on CBS, Fox News, NPR, CNBC, Popular Science, the New Yorker and the New York Times.

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***
February 16, 2022	David King, Auburn University	Chicxulub Crater Geology
March 16, 2022	Jamie Farrell Utah State University	Geology of Yellowstone
April 20, 2022	19th Annual Student Research Night	
May 11, 2022	TBA	Oil and Gas Industry Topic

The Pittsburgh Geological Society welcomes several new members:

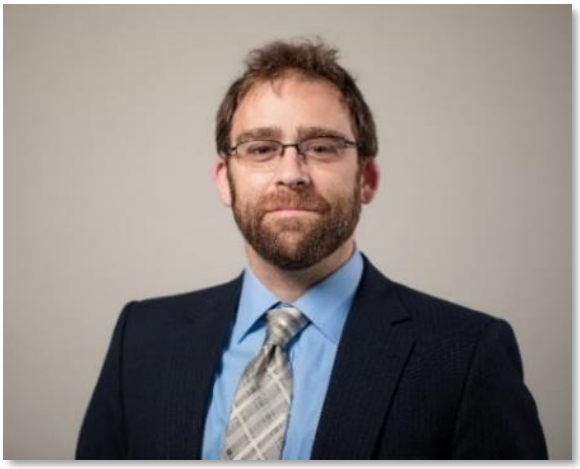
Tom Mueller, GISP, Geospatial Technology Professor
California University of PA

Stephen Pesch, PG, Project Manager
KU Resources, Inc.

Hunter L. Klobucar, Recent Geology Graduate
Co-Founder of Fish-Gods.

Derek A. Hoffman, Student Member
Slippery Rock University

PRESIDENT'S STATEMENT



Thanks to everyone that attended the December special partners meeting, I certainly enjoyed the amazing photography and story of the Himalayas. I particularly liked the personal accounts of the perils of field work in remote areas.

Also, thanks to those that were in attendance at our social event the Saturday following the meeting. The Wigle tour and tasting event was a success and those that were in attendance were treated to some local spirits and the story of the whiskey rebellion in Pittsburgh. It was a wonderful evening and we hope to organize similar events at other distilleries or local breweries in the future. I hope to see you there!

The December meeting had little in the way of announcements as we wrap up 2021. I'm hopeful that things will continue to improve in 2022 as we press onward through the pandemic. Though inconveniences persist, I'm grateful that we have been able to return to our in-person meetings so far and am looking forward to the second half of our program year.

The board is also working on plans to increase access to lectures through video recordings to be hosted on the website and through consideration of alternate venues, perhaps to be used for special seasonal events. Announcements regarding these new opportunities are forthcoming and will continue to be distributed at meetings, via the newsletter, and through special email announcements, so please continue to monitor all of these avenues of communication for updates.

As always I'm looking forward to our upcoming meeting to take place on January 19th, 2022. This meeting will feature Todd Halihan of the University of Oklahoma with a Hydrogeology talk titled "Electrical Hydrogeology: A Picture is Worth 1,000 Wells."

I hope you all have had a safe and happy holiday and I hope to see you at the upcoming meeting!

Dan

LOCAL GEOLOGICAL EVENTS

SOCIETY OF PETROLEUM ENGINEERS (SPE)

February 3, 2022 **11:00 AM - 1:00 PM**

"Unified Well Spacing and Completion Design for Unconventionals – A Physics and Data-Driven Approach" by Walter C. Dobbs III, P.E., International Reservoir Technologies, Inc.

For more information: tinyurl.com/5dw4yvbf

Cefalo's Banquet and Event Center, Carnegie, PA

PENNSYLVANIA COUNCIL OF PROFESSIONAL GEOLOGISTS (PCPG)

January 11, 2022 **1:00 - 2:00 PM**

"Pennsylvania Perspectives on CCUS and the Energy Transition" by Kris Carter, PG, Assistant State Geologist, DCNR Bureau of Geological Survey (Webinar: 60 minutes)

Details and registration: https://pcpg.org/event-4595125

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

"Act 2 Overview" by Mike Maddigan, Program Manager, Land Recycling Program, PA Department of Environmental Protection (Webinar: 60 minutes)

Details and registration: https://pcpg.org/event-4597777

February 16, 2022 **1:00 - 2:00 PM**

"Dust Suppression with Appalachian Basin Oil and Gas Produced Water: Efficacy and Water Quality" by Nathaniel Warner, PhD, Assistant Professor, Civil and Environmental Engineering Department, The Pennsylvania State University (Webinar: 60 minutes)

Details and registration: https://pcpg.org/event-4616235

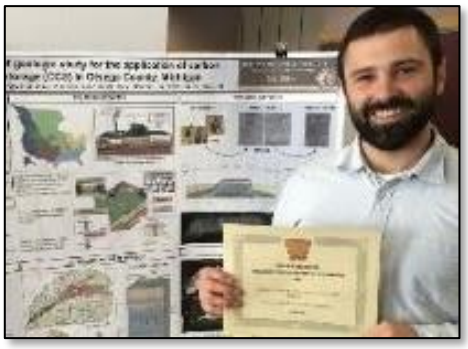
March 29, 2022 **8:00 AM - 4:00 PM**

"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

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.

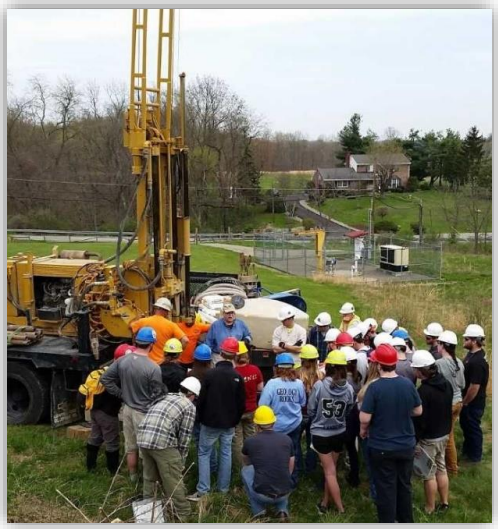
The deadline for submitting abstracts for student research night will be March 16, 2022. Abstract submission forms and guidelines will be posted on the PGS website at: https://www.pittsburghgeologicalsociety.org/student-night.html.

PGS STUDENT FIELD WORKSHOP IS BACK!

Dates: April 8 & 9, 2022 (rain or shine)
Location: California University of Pennsylvania SAI Farm

Friday Evening Program with Dinner

Networking and Preparing for a Geoscience Career – Advice from Working Professional Geologists. Held at the hotel where rooms will be reserved for those who want to stay near the field site/



Saturday Drilling and Sampling Field Workshop

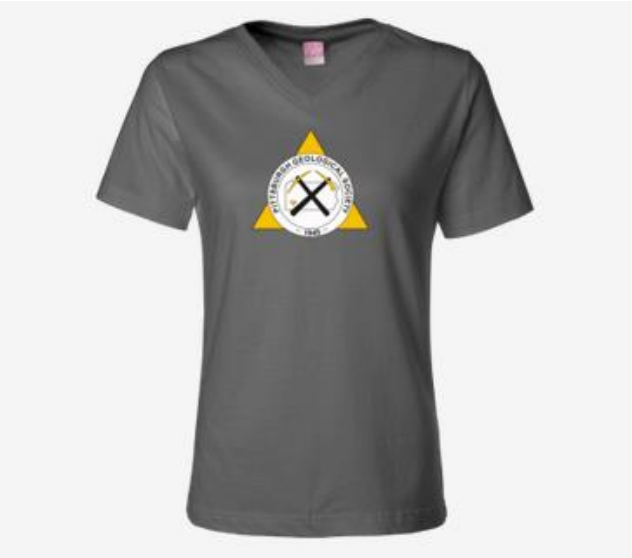
You will experience soil sampling using a drill rig, basic sampling techniques, soil & rock descriptions, well installation basics, use of basic monitoring equipment and design of a drilling program. Light Breakfast and Lunch will be provided.

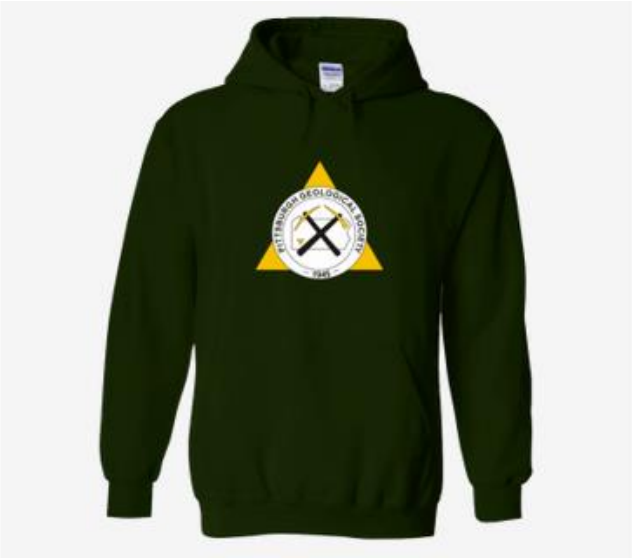
More information about how to reserve you spot will be provided in future newsletters. In the meantime, you can direct any questions to Kyle Fredrick at fredrick@calu.edu with "PGS Drilling Workshop" in the subject line.

PGS NOW HAS ITS OWN ONLINE MERCHANDISE STORE!

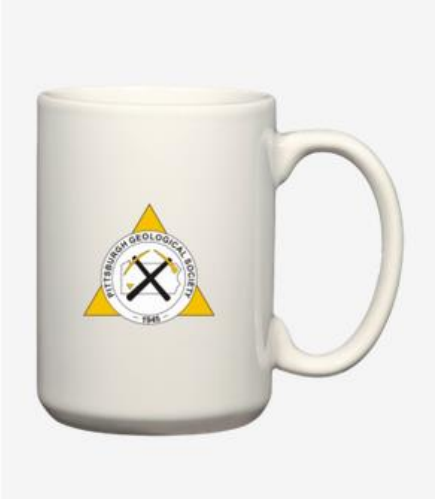
PGS Secretary Diane Miller has arranged for our society to have an on-line store where we can purchase PGS-branded goods.

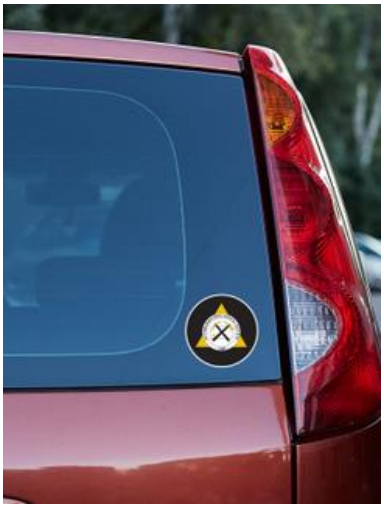
https://apparelnow.com/pittsburgh-geological-society-apparel

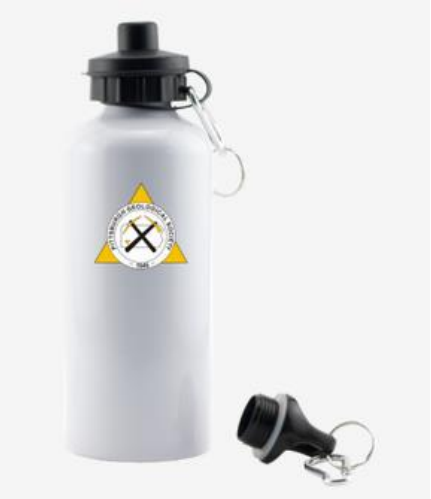




There are many styles of shirts, sweatshirt, polo shirts and hoodies available in your choice of size and color. You can also check out the hats, mugs, water bottles, bags, blankets, and car stickers, all with the PGS logo prominently displayed.







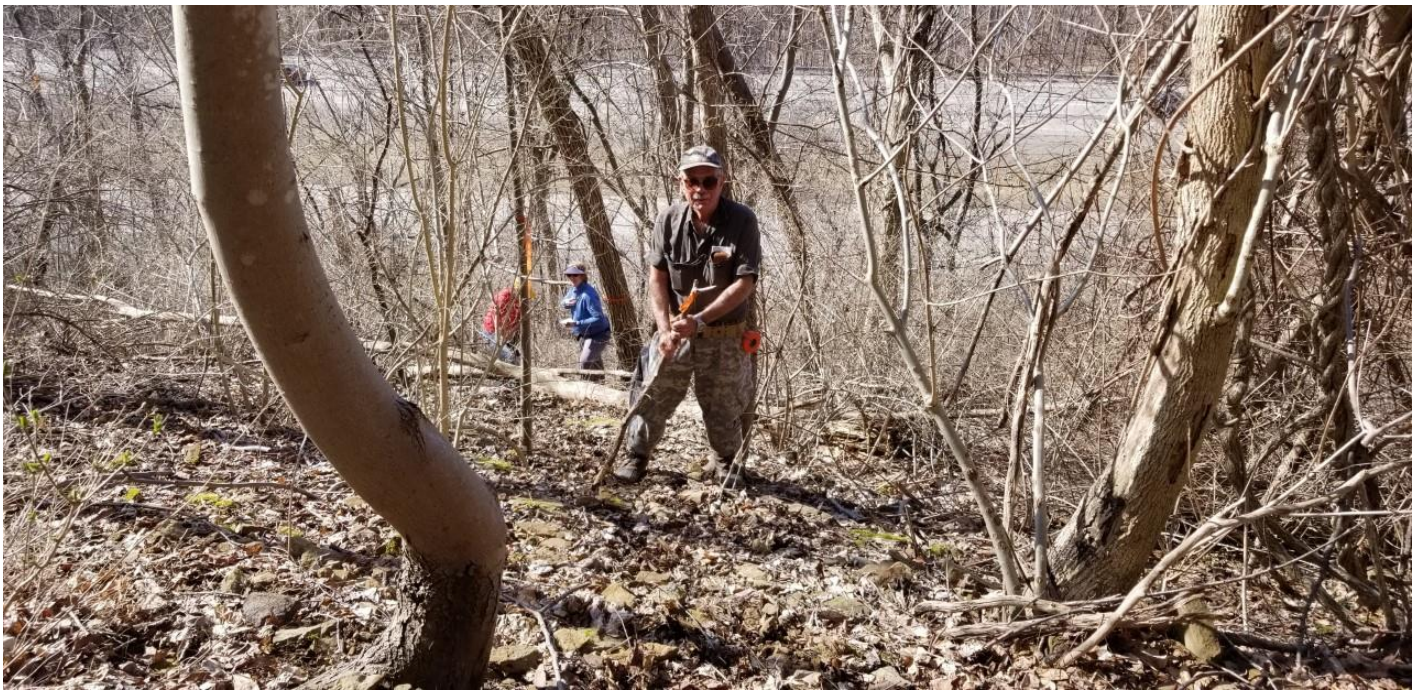
Best of all, the profits go to the Galey Fund, which helps offset the cost of meals for student members. So proudly wear, carry, or display your affiliation with the best geological society in western Pennsylvania and know that you are also helping to support student participation in our nine annual meetings.

PGS VIRTUAL LANDSLIDE FIELD TRIP ANNOUNCEMENT

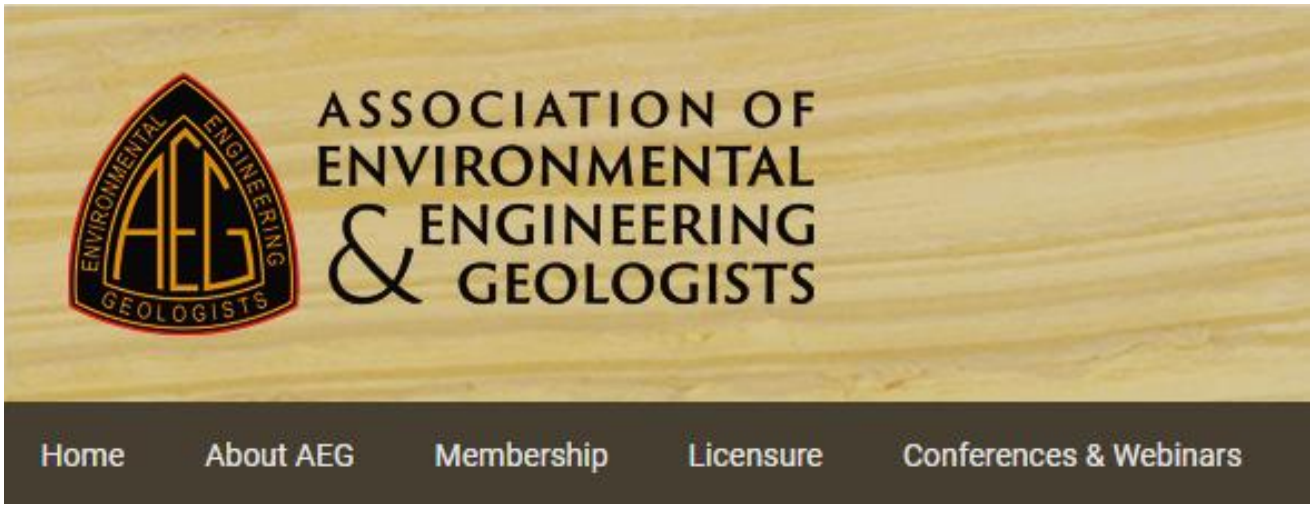
After months of work, PGS is ready to announce the soon-to-be released **Virtual Landslide Field Trip** and accompanying **Field Trip Guidebook**! Among others, this effort was fueled primarily by Dr. James Hamel, PGS Honorary Member and consulting geologist and engineer, and the Slippery Rock University team of Brett McClinton, Geography, Geology, and Environment Major, and Jeremiah Brown, Strategic Communications and Media. John Harper, PGS Honorary Member and retired from the PA Geological Survey, 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.

Directions will be forthcoming on how to access the Virtual Field Trip and Guidebook. It is hoped the actual field trip will run in early spring 2022. Keep an eye on the PGS web site and future newsletters to learn more.



OTHER EVENTS OF INTEREST TO PGS MEMBERS



ASTM E1527-21 Phase I Environmental Site Assessments - Industry Update

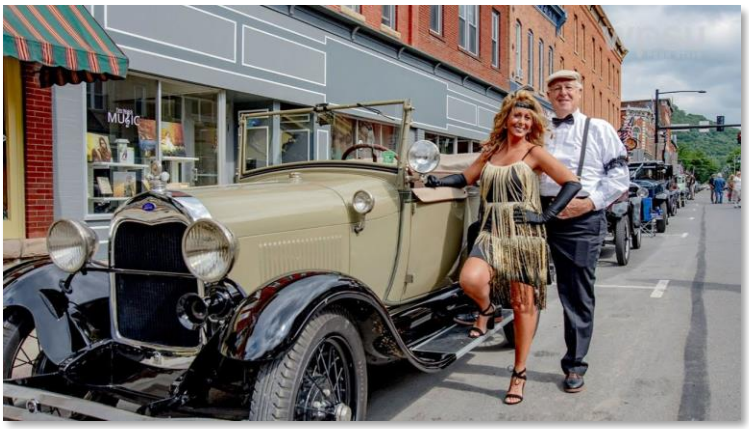
Tuesday, January 25, 2022
11:00 AM - 12:00 PM EST
Category: Webinars

ASTM E1527-21 Phase I Environmental Site Assessments - Industry Update
Join us for a webinar on January 25,2022 at 11:00 AM EST.
Cost:
Free for AEG members / $20 for Non-Members
Members register here
Non-Members Register Here
Speaker: Julie Kilgore
The primary standard utilized for conducting All Appropriate Inquiries, or Phase I Environmental Site Assessments, has recently been updated. The ASTM E1527-21 was published in November 2021, and environmental consulting firms across the country are evaluating internal procedures to ensure compliance with meet the new standard. Julie Kilgore, chair of the ASTM E1527 task force, will share insights about industry practices that led to the revisions, and discuss options for implementation while EPA formalizes its reference to E1527-21

Registration Link for AEG Members:
http://aeg.memberclicks.net/message2/link/6ef9f986-7eff-4b0d-8ff3-79ee8c0c2954/1

Registration Link for Non-AEG Members:
http://aeg.memberclicks.net/message2/link/6ef9f986-7eff-4b0d-8ff3-79ee8c0c2954/2

THE ORIGIN OF WESTERN PENNSYLVANIA PLACE NAMES



Coudersport has an annual festival to celebrate the life and legend of Elliot Ness, the famous lawman who put mobster Al Capone in jail. Ness was a resident of Coudersport at the time of his death in 1957.

The present site of the Borough of Coudersport, the county seat of Potter Counter, consisted of only 90 acres when it was surveyed by Francis King in July and August, 1807. The town was named in honor of Monsieur Jean Couderc, a member of the Amsterdam banking company that had lent funds to the Ceres Land Company for the survey. The town was settled shortly afterward as a port on the Allegheny River, thus becoming Couder's Port.

The borough was chartered by an act of the Pennsylvania Legislature, February 7, 1848, and the surrounding area, now known as Susquehannock State Forest, made Coudersport a major lumber center in 1880. By 1920, however, the town's lumber boom was over and other industries had taken over. The Coudersport and Port Allegany Railroad Station, Coudersport Historic District, and Potter County Courthouse are listed on the National Register of Historic Places.

Arguably, the most popular tourist attraction is the Ice Mine, which freezes with ice in the summer and the ice melts in the winter. Legendary lawman, Elliot Ness (of The Untouchables fame), spent the final two years of his life in Coudersport. The town hosts a one-of-a-kind festival to celebrate the life and career of the famous lawman. The festival was designed to entertain and educate the public by reliving the Roaring '20s with captivating activities and attractions, and drawing visitors to Potter County to join in on the fun.

DID YOU KNOW . . . ?

On Christmas Day in 1839, a 17-year-old named Ellen Sewall received gifts from two suitors, including a pale pink opal and a collection of poems. Within a year, she had rejected marriage offers from both John and Henry David Thoreau, but she kept their gifts. Miss Sewall would remain friends with Henry David Thoreau for the rest of her life.

About 10 years after their first meeting, Henry sent the young woman, now going by the married name of Osgood, a box designed to hold rocks and minerals. The box and its collection of specimens is currently housed at the Concord Museum where, for many years, it had been classified as the property of Ellen's husband, Joseph Osgood, a minister and education reformer. It was actually Ellen's collection, representing her lifelong interest in geology and her friendship with the Henry David Thoreau.

Portrait of Ellen Sewell Osgood, geology enthusiast and good friend of Henry David Thoreau.

It also offers a glimpse into how middle-class women pursued education beyond the classroom, and a passion for science, during the 19th century. Women were rarely able to participate in

professional scientific communities or contribute to natural history museums at that time. Instead, they found alternative ways to study science by creating collections at home or participating in informal networks centered on obtaining and exchanging objects.

Ellen Osgood became interested in geology as a teenager. Starting at 13, she attended the Roxbury Female Academy in Massachusetts studying a wide range of subjects. While young men often received a classical education, young women were more likely to receive basic training in science, considered a "girl's subject" at that time. It took a few additional decades for science to become a more male-dominated field.

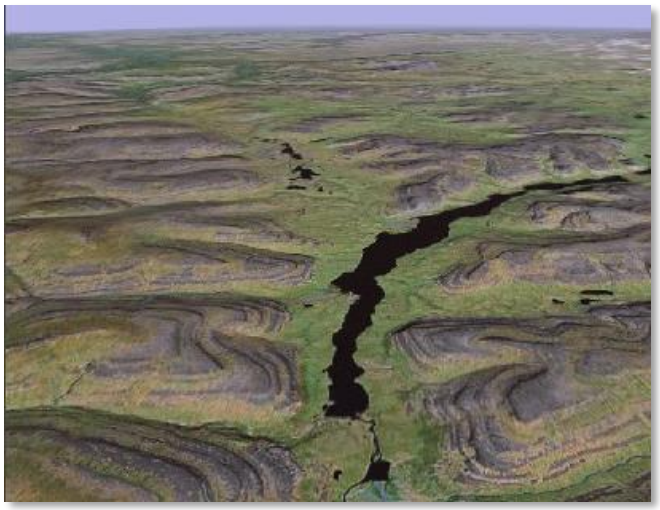
Although astronomy and experimental chemistry were fascinating to the young Ellen, it was natural history that especially interested her. She collected, dried, and pressed flowers, and spent hours browsing the academy's cabinet of geological specimens. Inspired by the cabinet of minerals, she decided to start her own collection. Suitors, including her future husband, sent specimens for her collection to demonstrate their continued interest and admiration in her.

After marrying Joseph Osgood, Ellen continued to stay in touch with Thoreau. At some point, perhaps during an 1850 trip, he gave the family a handmade mahogany box that had individual compartments carefully crafted to hold Ellen's mineral collection. Today, the box and its specimens provide evidence of her ongoing interest in geology and her collection's growth throughout her lifetime. Each compartment houses at least one rock or mineral labeled with a name, location, and, in some cases, the initials of the person who collected it. They include numerous examples of quartz, granite, porphyry, and other kinds of rocks and minerals commonly found around New England.

Although the specimens are not particularly rare, Ellen prized them and delighted in sharing her interest in geology with her children. At some point, the pink opal John Thoreau presented to her in 1839 became separated from the other rocks and minerals and now resides at the Huntington Library in San Marino, California. The fact that Ellen Osgood's collection survives intact is notable as part of her lifelong friendship with the Thoreaus and acts as an example of how women of the time managed to pursue their interests in science.

https://www.smithsonianmag.com/history/in-19th-century-new-england-this-amateur-geologist-created-her-own-cabinet-of-curiosities-180979083/

For decades, geologists have been trying to figure out what caused the end-Permian mass extinction, the largest extinction event in Earth history, which occurred about 252 ma ago. The current view is that it was the result of global warming, but what caused that has never been resolved. There is evidence that the warming was preceded by volcanic winter, a long, global cold spell created by volcanic activity that destabilized the planet's ecosystems. Life on Earth came dangerously close to a terminal collapse when nearly 85% of the species on the planet vanished, supposedly when lava oozed across what is now Siberia (Siberian Traps) in a series of eruptions that pumped enough CO_2 and CH_4 into the atmosphere to raise global temperatures and starve the oceans of oxygen.



The Siberian Traps are about 3 million cubic miles of volcanic basalt layers that erupted at the end of the Permian, forming a series of steps. They represent part of the possible cause of the end-Permian mass extinction.

A new study suggests that the Siberian Traps aren't the only eruptions to blame for the end-

Permian extinction. Unusual levels of copper and mercury occur embedded in ash layers at the mass extinction boundary in southern China. The ash layers are also rich in sulfur, hinting at explosive volcanism in the region. The explosive eruptions, which were distinct from the oozing Siberian eruptions, were catastrophic enough that the ensuing ash cloud probably foreshadowed the beginning of volcanic winter, a rapid period of global cooling that the researchers think may have preceded the warming caused by the Siberian Traps. Material from the eruptions would have been carried around the globe by stratospheric winds, creating global effects on climate.

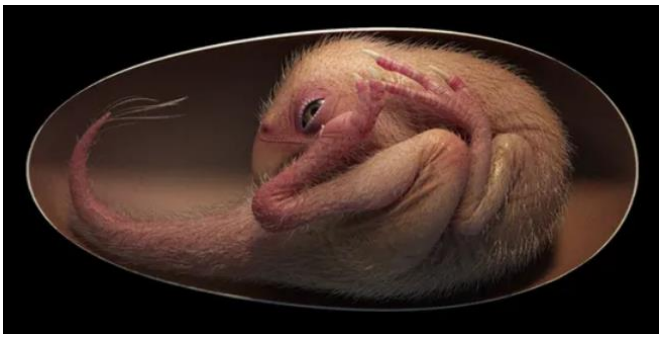
The geology also indicates that the ash clouds are correlative with large, local extinctions of land-based life. That, in turn, infers that the explosive eruptions were large enough to have a severe impact on the biosphere. If this new research is accurate, it suggests that the end-Permian extinction could have been caused by a “one-two punch” of geologic activity as organisms were stressed with a rapid period of cooling followed by a long period of warming that they were incapable of surviving.

https://www.newscientist.com/article/2298056-worlds-largest-mass-extinction-may-have-begun-with-volcanic-winter/

A fossilized dinosaur egg that failed to hatch 66 ma ago was found to have an embryo inside that was curled up in a way that links it to modern-day birds. The egg was found in 2000 in Ganzhou, Jiangxi Province in southern China by Yingliang Group, a company that mines stones. The specimen was placed in storage and only examined when the company began building the Yingliang Stone Nature History Museum in 2010. Museum staff found the fossil and noticed bones within the egg. Scientists discovered the embryo, which they named "Baby Yingliang."

Dinosaur embryos are some of the rarest fossils, and most are found incomplete with the bones dislocated. By contrast, “Baby Yingliang” is well-preserved and allows researchers to study dinosaur growth and reproduction.

The embryo is classified as an oviraptorosaur, part of the therapod group and closely related to birds. Therapods were carnivorous dinosaurs with small forelimbs that walked on two feet, like other creatures in that group, such as the *Tyrannosaurus rex* and the velociraptor.



Artist’s reconstruction of an oviraptorosaur dinosaur embryo just before hatching.

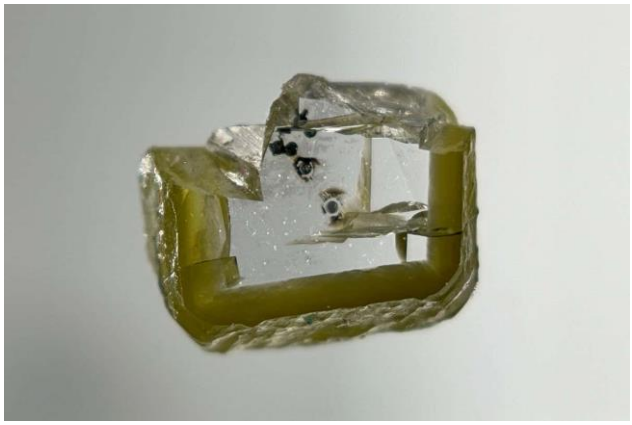
A distinct feature of the embryo was its tucked-up pose, with the feet on the side of its head and its back against the shell. Modern birds stay in the same type of tucked position before hatching. This particular species of dinosaur did not fly, making it the first time the tucking position has been observed in a non-avian animal. The findings suggest modern-bird hatching practices may have come from nonflying dinosaurs.

https://www.usatoday.com/story/news/world/2021/12/21/dinosaur-embryo-found-fossilized-egg/8988395002/

Since we can only physically examine Earth beneath the surface to a limited depth through drill cores and such, the best we can do is use specialized instrumentation to speculate on the character of much of the planet deep beneath our feet. Every now and then, however, Earth expels information from deep within itself that helps us determine what’s going on down there. For example, we sometimes find flawed diamonds with inclusions or embedded samples of some of the world's more exotic minerals.

One of the more unusual such examples occurred recently when a diamond was found in the mine at Orapa, Botswana, with an inclusion of a naturally occurring calcium silicate mineral from the lower mantle still preserving its high-pressure form

despite having traveled more than 410 miles from below the Earth's surface. Geologists are excited. Direct sampling of the otherwise inaccessible lower mantle in this way could fill in many knowledge gaps in the chemical composition and variability of the entire mantle.



A diamond from a mine in Botswana holds tiny inclusions of Davemaoite, a new mineral formed at high heat and pressure deep in the lower mantle.

The inclusion, named davemaoite, is a $CaSiO_3$-perovskite mineral that confirms 50-year-old hypotheses of its existence. Calcium silicates such as wollastonite exist naturally at relatively low-pressure in various structures. Wollastonite forms breyite, the second most abundant inclusion found in deep Earth diamonds, under intermediate pressure. But it has been suggested that there is another way breyite might form. Under the enormous pressures found in Earth's lower mantle, from 500 to about 2,060 miles deep, the atoms arrange themselves into the cubic perovskite structure. This structure typically reverts to another form once the pressure decreases, which might account for how some of the breyite inclusions in diamonds originated.

Synthetic CaSiO3 reverts to glass once the intense laser pressure used to form it is relieved. This is what makes davemaoite geochemically interesting. The crystal shape and the pressure that creates it, force together elements that generally aren't found together in nature. It turns out that davemaoite also hosts potassium, uranium, and thorium in its structure, which means davemaoite's abundance influences how much heat occurs in the deep mantle. The mineral's heat and distribution then determine how Earth's deep crust is recycled, where heat anomalies arise, and the state of the magma at the base of the mantle. The daveaoite sample was confirmed through synchrotron X-ray diffraction to have the predicted structure.

Laser mass spectrometry revealed that almost half of the davemaoite's calcium has been replaced by other elements, primarily potassium. The research team suspect this may have helped preserve its structure along with the residual pressure still found in the diamond. The mineral's low level of titanium and high level of potassium indicate that it formed within the hot, high-pressure depths of the lower mantle. Davemaoite has been officially recognized as a new natural mineral by the Commission of New Minerals, Nomenclature, and Classification of the International Mineralogical Association.

https://www.sciencealert.com/a-diamond-caught-and-preserved-the-deepest-rare-earth-mineral-science-has-ever-examined

Planetologists have known for years that the Moon was subjected to a barrage of asteroids 3.9 ga ago, about 500 ma after the Moon was formed, but the origin of this bombardment remained unclear. What was the origin of this bombardment and where did the asteroids come from? Scientists came up with two hypotheses: 1) these bodies could represent the leftover material from the main phase of Earth's formation that hit the Moon with continuously decreasing frequency; or 2) about 3.9 ga ago, instabilities in the orbits of the gas giant planets led to a sudden sharp increase in impacts from asteroids and comets from the outer solar system.

Now, researchers at Münster University in Germany have used very precise isotope measurements of lunar rocks to discover that it was due to continuous impacts of asteroids left over from the main phase of the Earth's formation. The team examined lunar rocks that were formed during the bombardment 3.9 ga ago that contain tiny metal globules consisting of material from the impactor asteroids. By studying the isotopic composition of these metal globules, they could determine where in the solar system the asteroids originated. They focused on the elements ruthenium and molybdenum because these

elements show systematic changes in their isotopic composition depending on where they were formed in the solar system.

Their research showed that the same bodies that

Isotopic evidence from metal globules in moon rocks from the Mare Imbrium indicate that the lunar impact craters are due to continuous bombardment of leftover asteroids from the main phase of the earth's formation.

formed the Earth and Moon were responsible for the bombardment of the Moon, and the lunar impact craters are due to a continuous bombardment of leftover asteroids from the main phase of the Earth's formation. This allows scientists to discount a sudden increase in the impact rate by bodies from the outer solar system.

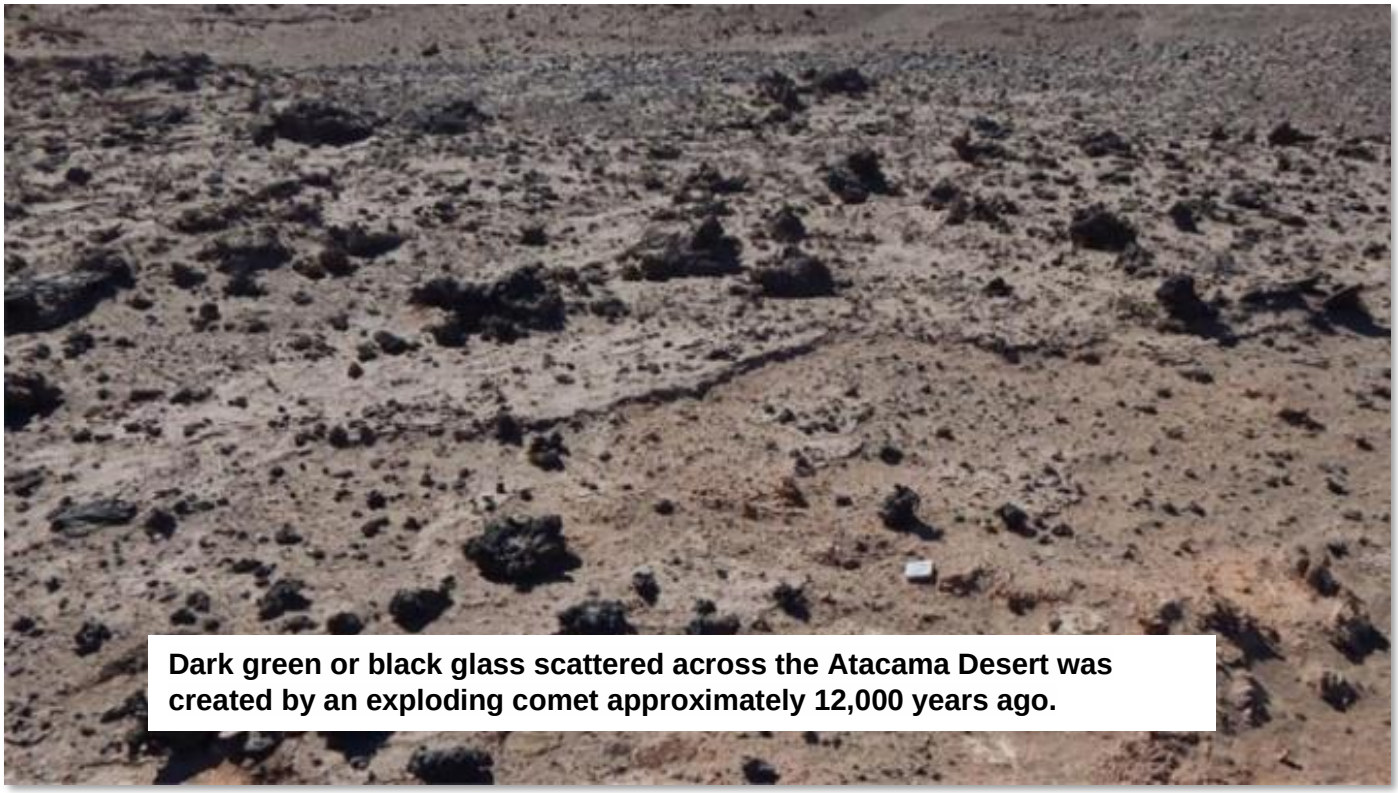
Why is there a clustering of 3.9 ga ages? It had been suggested that this was due to the majority of lunar rocks studied so far being from the Mare Imbrium in the north-central Earth-facing side of the moon. Theoretical calculations suggest the orbits of the gas giants changed at some point in the early history of the solar system, scattering many bodies from the outer solar system inwards where they collided with the inner planets, including Earth and the Moon. This event, however, apparently took place earlier than previously supposed, because there is no evidence of impacts by asteroids or comets from the outer solar system in the lunar rocks. The change in the orbits of the gas giant planets probably took place during the main formation phase of the rocky planets in the first 100 ma or so of the solar system, which agrees well with recent dynamic models. The new study also demonstrates that the Earth-like rocky planets incorporated water-rich bodies from the outer solar system relatively early in their formation, creating the conditions for the emergence of life prior to 3.9 ga ago.

https://phys.org/news/2021-11-planetologists-heavy-bombardment-moon-billion.html

Chile's Atacama Desert has been used to replicate alien environments like Mars for films and documentaries. The Atacama is the driest desert region on Earth, with incredibly little precipitation or moisture of any kind. Researchers have long been interested in it, and suggest it was the site of an ancient comet explosion strong enough to create large slabs of glass.

About 12 ka ago, intense heat turned the desert's sandy soil into vast areas of glass, extending for 46.6 miles, but no one was certain what caused it. The patchy desert glass contains miniscule fragments of minerals found in meteorites. These minerals are identical to particles collected by NASA's Stardust mission, which sampled a comet known as Wild 2. Researchers are confident that the minerals found in the Atacama Desert are leftovers from a comet similar to Wild 2 that exploded over the desert sands and melted them, the first clear evidence of glasses on Earth created by thermal radiation and winds from a fireball exploding above the surface.

Comet Wild 2, whose dusty trail through space was sampled by NASA's Stardust mission.



Dark green or black glass scattered across the Atacama Desert was created by an exploding comet approximately 12,000 years ago.

Such a dramatic effect on such a large area is indicative of a truly massive explosion. The fields of dark green or black glass stretch across an area east of the Pampa del Tamarugal plateau, located between the Andes Mountains and the Chilean Coastal Range. Although volcanic activity can create this kind of glass, there is no evidence that the Atacama glass formed that way. A previous hypothesis for the origin of the glass was that the area once hosted grassy wetlands, and if those ancient grasses burned in widespread wildfires it may have created the glass.

The glass is too complicated, however, to have originated in that way. In close-up it appears the glass pieces had been twisted, folded, rolled and thrown while they were still molten, which would only be possible with an airburst explosion that unleashed winds rivaling those of tornadoes.

Chemical analysis of the glass revealed zircons that thermally decomposed to form baddeleyite crystals, a change that can only occur when temperatures increase above 3,000^{o}F, much higher than what can be generated by grass fires. Other minerals found by analysis of the glass were cubanite and troilite, which were found in the Wild 2 comet and in meteorites. These provide really powerful evidence that the glass is the result of a cometary airburst.

The researchers now want to focus on dating the glass to determine its exact age and probable size of the comet, but the current estimate of 12 ka ago is supported by the date when large mammals disappeared from the area. Although it is too early to confirm if there was a causal connection between the two events, the researchers suggest this cometary explosion did occur at about the same time as when the megafauna disappeared. There's also a possibility that early inhabitants who had just arrived in the region were around to witness the event.

https://www.cnn.com/2021/11/03/world/atacama-desert-glass-comet-scn/index.html

The Smithsonian Museum of Natural History in Washington, D.C. houses many fossils, including some plant fossils that are nearly 100 ma old. These particular plant fossils are of leaves that fell off a tree at about the same time that *Tyrannosaurus rex* and *Triceratops* roamed prehistoric forests. Despite its age, one of the leaves is instantly familiar. It is a ginkgo leaf, recognizable by it's a unique shape because it really hasn't changed much in all those millions of years.

What is really special about ginkgo trees is not that they look pretty much the same after so many years, but that their fossils often preserve actual plant material rather than simply an impression in rock. That thin sheet of organic matter might be key to understanding the ancient climate system as well as the possible future of our warming planet. Ginkgo is a unique time capsule. It is hard to imagine that these “living fossils” decorating our streets and parks grew in forests at the same time as the dinosaurs, and that they are almost unchanged for the past 200 ma.

The reason scientists are studying them is to understand what they can tell us about the future. They want to understand how the planet has responded in the past to large-scale changes in climate, how ecosystems have changed, how ocean chemistry and sea levels changed, how forests worked. Of particular interest to scientists are "hothouse" periods when CO_2 levels and temperatures were significantly higher than today. One such period occurred during the Late Cretaceous 100 to 66 ma ago, before the dinosaurs went extinct. Learning more about ancient hothouse climates also gives scientists valuable data to test the accuracy of climate models for predicting the future.

A fossil ginko leaf (top) and Recent one (bottom). Comparisons of fossil and Recent ginko leaves could help determine what our climate will be like in the future.

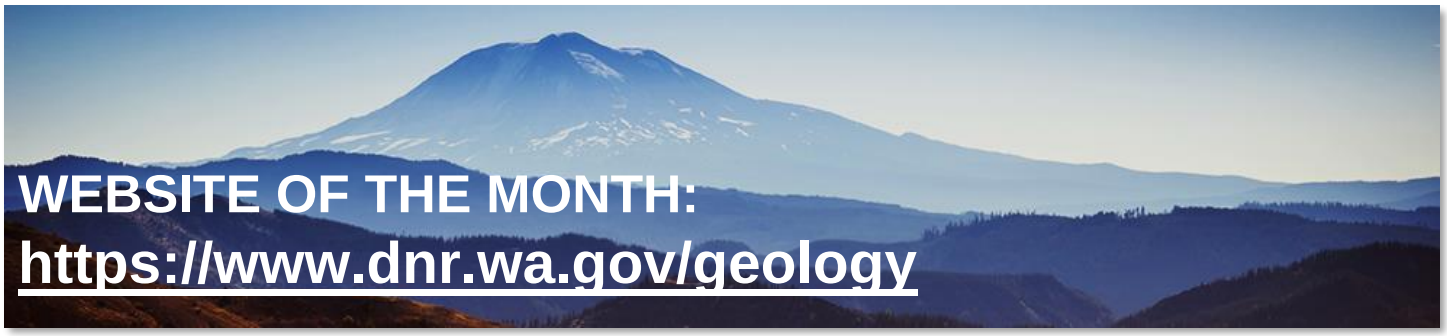
Unfortunately, climate information about the distant past is limited. Oxygen trapped in Pleistocene ice allows scientists to study ancient CO_2 levels, but the ice only goes back about 800 ka. That's why fossil ginkgo leaves in museum collections are so important. They allow paleobotanists and climate scientists to hop across millennia to the 19th century when the Industrial Revolution started changing the climate.

The leaf shapes of fossil and modern ginkos are virtually identical. One key difference that can be viewed with a microscope is how the leaf has responded to changing atmospheric CO_2. The leaf’s stomata, the tiny pores on a leaf's underside that take in CO_2 and exhale water, allow the plant to transform sunlight into energy. These change with climatic conditions. When there's a lot of CO_2 in the air, the plant needs fewer pores to absorb the carbon it needs. When CO_2 levels drop, the leaves produce more pores to compensate. We know the global average level of CO_2 in today’s atmosphere is about 410 ppm, and what the leaf looks like as a result.

Thanks to museum collections, paleobotanists know what Victorian era ginkgo leaves looked like before Earth’s atmosphere grew warmer. They also want to know what the stomata in fossil ginkgo leaves can tell us about the atmosphere 100 ma ago. This requires a codebreaker, a sort of Rosetta Stone, to help them decipher what the Late Cretaceous atmosphere looked like. One experiment exposes ginko trees in open-topped enclosures of plastic sheeting to rain, sunlight, and changing seasons so they experience natural cycles, then the researchers pump CO_2 into each enclosure and monitor the results. Some of the trees are grown at current CO_2 levels, whereas others are grown at significantly elevated levels, approximating levels in the past and, possibly, the future. If there is a match between what the leaves in the experiment look like and what the fossil leaves look like, it will give the researchers a rough guide to the ancient atmosphere.

The researchers are also studying what happens when trees grow in super-charged environments, and they found that more CO_2 makes them grow faster. If plants grow very quickly, they are more likely to make mistakes and be more susceptible to damage, which should be detectable in fossil specimens.

https://www.ksl.com/article/50228093/fossil-leaves-may-reveal-climate-in-last-era-of-dinosaurs



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Fun Fact Having Nothing to Do with Geology

Some snails have about 25,000 teeth.

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