PITTSBURGH GEOLOGICAL SOCIETY

April 21, 2021

Virtual Meeting Times

Board Meeting	6:00 PM
Poster Session	7:00 PM
Oral Presentations	7:30 PM

Pre-Registration is Required

To receive the Zoom link, PGS members and guests must RSVP at: pittsburghgeologicalsociety.org

PDH Certificates are Available

Attendees can receive an emailed PDH certificate at their request. Non-PGS members are asked to kindly donate $10 to either the Pittsburgh Geological Society Endowment Fund or the PGS Galey Fund for Students when they request a certificate on the PGS website.

Online Meeting Guidelines

All attendees are encouraged to join the meeting no later than 7:20 PM when announcements will be made. PGS requests all attendees to mute their own audio and video during the presentation to avoid disruptions and to lower bandwidth.

The 18th Annual Student Night

Virtual Poster Session (7:00 PM)
Virtual Presentations (7:30 PM)

Co-sponsored by the Association of Environmental and Engineering Geologists (Greater Pittsburgh Chapter) and the American Society of Civil Engineers Geo-Institute (Pittsburgh Chapter)

Generously supported by a donation from the Pennsylvania Council of Professional Geologists

Please RSVP by April 20 to receive the Zoom link.

STUDENT ORAL PRESENTATIONS

ASCE-Geo-Institute Judges' Selection for 2021

Characterizing the Development of the Subsidence Basin Formed under the Interstate-70 Alignment over Longwall Mining of the Tunnel Ridge Mine, Washington County, Pa

ROBERT MAXWELL WINN, University of Pittsburgh

Longwall coal mining is an underground mining method in which large rectangular 'panels' of coal are extracted. These longwall panels within the study area are approximately 1,200 ft in width and 10,000 ft in length and average 7.25 ft in extraction height. The void that is created by this extraction process allows the strata above to collapse into the mined area, producing a subsidence basin on the surface. The formation of this basin creates surface strains that can be hazardous to natural and human-made structures alike. In 2019, a longwall panel undermined a section of Interstate-70, which then caused impacts to the roadway. In some areas, over five feet of elevation drop and 1.5 feet of horizontal shifts occurred before ground movements finally settled. GPS and LiDAR surveys were utilized weekly to track the dynamic movements of the surface. By recording these movements, a comprehensive analysis of ground movements was made possible. These movements were then correlated to the impact on the surface. Additionally, this information was used to project what to expect in future undermining scenarios of the interstate. With a better understanding of the correlation between ground movements and surface damages, prediction of future impact to the roadway is possible. This presentation aims to introduce the methods used in this case study, and how they helped prepare for future undermining scenarios of Interstate-70.

PGS Judges' Selection for 2021

Variations in Produced Water Chemistry and Relation to Regional Geology and Production in the Marcellus Shale, Northcentral West Virginia

JONATHAN M. BRADY, West Virginia University

An investigation of 74 Marcellus Shale wells across northcentral West Virginia indicates changes in produced water chemistry and hydrocarbon production can be related to geologic conditions based on well logs and core data. Moving west to east from Harrison County to Taylor County, then north into Monongalia County, gamma-ray logs show increasing intensity, especially in the Middle and Lower Marcellus. Mineralogical X-Ray Diffraction from core data indicates increasing clay content moving west to east with associated decreases in quartz minerals. Produced water analyses show changes in barium, calcium, and strontium concentrations from west to east indicating volume changes in clay and carbonates, potentially in the form of carbonate cement, are occurring across the study area. The geological differences result in varying produced water behaviors. These behaviors are determined by reviewing multiple produced water analyses for individual wells for periods up to ten years. Total dissolved solids concentrations typically reach their maximum value during the second year of production after which areas in Harrison County show both increasing and decreasing concentrations over time, while areas in Taylor and Monongalia show almost exclusively decreasing concentrations over time. With total dissolved solids concentrations dropping below the maximum values, relative ratios of formation water versus fracturing fluid can be determined to characterize a well's behavior as it ages. Normalized, cumulative gas production for the wells show that the geologic differences observed in the produced water behavior are reflected in different production rates across the study area.

AEG Judges' Selection for 2021

LANDSLIDE INVENTORY AND BEDROCK SLOPE STABILITY FOR THE NORTH COVE AREA, MCDOWELL COUNTY, NORTH CAROLINA

MARGARET KROEHLER, Kent State University

In the Blue Ridge Mountains of western North Carolina, major storm systems can rigger hundreds of debris flows and other forms of slope movements. The research objective is to map slope movement hazards and evaluate the influence of bedrock on slope stability. The study area is in northern McDowell County where the North Fork Catawba River watershed forms a reentrant in the Blue Ridge Escarpment. An inventory map of >400 slope movements, and associated deposits, was created by digitally mapping the geomorphic features in ArcGIS using LiDAR-derived DEM (digital elevation model) maps, orthophotography, and satellite imagery. Field investigations were conducted to obtain soil and rock samples, to measure bedrock discontinuities, and to field-verify the digital map. Mapped slope movements are primarily slides and flows of earth or debris, with many areas characterized by repeated movements. The soils are poorly graded silty and clayey sands with some gravel. Direct shear tests on soil results in friction angles of 36º - 43º and cohesion of 261-584 psf, while results for soil-rock contact show friction angles of 30º -34º and negligible cohesion (<100 psf). Bedrock geology consists of Proterozoic basement gneisses and early Paleozoic metasedimentary rocks. Structural analysis of discontinuity data (723 measurements) shows the most significant discontinuities are high-angle (>70º) joint sets, including conjugate (NE-SW and NW-SE) joint sets, and low-angle (17º -25º) bedding and foliation. Kinematic analysis of the principal discontinuity sets suggests that toppling is the main mode of failure, while plane and wedge failures may occur if slopes are near vertical or are undercut.

STUDENT POSTER SESSION

Posters will be hosted on the PGS website. A password will be provided to meeting attendees the morning of the event so they can view the posters prior to the meeting. Poster presenters will briefly discuss their work from 7:00 PM to 7:30 PM.

Shaun Donmoyer, West Virginia University, "Effect of oxidative breakers on organic matter degradation, contaminant mobility and metals release in the Marcellus Shale"

Julia Jones, University of Pittsburgh, "Is the Caney Shale Formation Brittle or Ductile?"

Morgan R. Jones, California University of Pennsylvania, "Landslide Susceptibility Assessment Using ArcGIS Pro in Pike Run Watershed, Washington County, Pennsylvania"

Amber Netherton, California University of Pennsylvania, "Sunlight influence on dissolved Fe concentrations at Wingfield Pines"

Natalie Odegaarden, West Virginia University, "Vein Evolution and Intensity due to Kerogen Maturation in the Marcellus Shale"

Garrett Strittmatter, Indiana University of Pennsylvania, "How do Scotia Sea Diatoms Relate to Climate During the Last 30,000 Years?"

Rachel Yesenchak, West Virginia University, "Increasing accessibility of water quality data to identify impacts of shale gas drilling in West Virginia"

PRESIDENT'S STATEMENT

April is traditionally student month at PGS. During this month, we celebrate the successes of student researchers at our monthly meeting and provide a workshop for student members to learn valuable job-related field skills. Last year, after COVID hit, we were unable to offer this workshop or assemble together for student night.

Many of the geology graduates last year and to some extent this year will be graduating, not having the opportunity to have participated in field workshops, internships, and even in-person geology field camps. Some of the graduating senior geology students hope to begin their career as geologists, working in the environmental consulting industry, state or federal regulatory agencies, or the petroleum and natural gas energy sector. Others will choose to continue in their studies and begin graduate programs.

I have conducted an informal survey of graduating seniors over my 25+ years of teaching. Students overwhelmingly indicate that it has been the experiences both in and out of the classroom that they feel has prepared them the best to enter whatever path they have chosen. Students say that the out-of-classroom experiences, like internships and field courses, have given them a glimpse into the professional world, linking knowledge gained in the classroom to solving "real world" problems while helping them to enhance their interpersonal skills.

Unfortunately, 2020-2021, has left students with more virtual experiences than actual hands-on field work that commonly augments the classroom learning experience. Due to the COVID pandemic, many 2020 summer internships, geology field camps, and class field trips were canceled. This continued into Fall 2020. Many of the graduating seniors I have surveyed this year are less confident in having the skills needed to enter the professional workplace.

With any luck, things will begin opening back up later this year, with in-person field camps and field trips. In order to help the recent graduates develop the field skills needed to become qualified to enter the work force, more internships and on-the-job training experiences will be needed. Because of this I would encourage students to seek out internships that can provide them with the necessary training to catapult them into a successful post graduate career. To the professionals, if possible, please consider offering internship opportunities to the pandemic and post-pandemic graduates to help them acquire the essential skills needed.

One other way students can experience what the professional world of geology is like is by attending our outdoor drilling workshop to see how environmental sampling is done. The PGS Student Workshop will be held on April 24th at Slippery Rock University. See page 6 for details. Students, you should also remember to submit a scholarship application for the Frank Benacquista Student scholarship. More details about that can be found on page 9.

As always, I want to thank our corporate sponsors and the membership for your constant support and understanding during the past year. I would also like to thank the PGS board for their hard work and dedication to the society. Their commitment to the society is commendable and worth recognizing. Lastly, I would like to thank all the students that submitted abstracts for student night. This is truly a difficult time for all that have had to persevere and navigate the system during COVID.

Tamra

UPCOMING PGS MONTHLY MEETINGS

Meeting Date	*Scheduled Speaker*	*Presentation Topic*
May 19, 2021	Thomas Bardol, Seneca Resources	Oil and Gas Industry Talk

OTHER GEOLOGICAL EVENTS

Pennsylvania Council of Professional Geologists

April 14, 2021 **12:00 PM – 4:30 PM**

PCPG Virtual Annual Meeting and Education Sessions including talks on:

- Appalachian Acid Mine Drainage as a Source of Rare Earth Elements
- Cultivating a Diverse, Ethical, and Inclusive Professional Environment
- Rock Slope Investigation Along US 340 in Harper's Ferry, WV
- Land Recycling Program Update: Chapter 250 Rulemaking, Groundwater to Surface Water Modeling, & Risk Assessment Report Reviews
- The Ridge Run PFAS HSCA Site: A Case Study

For more information and to register: https://pcpg.org/event-4137494

April 20, 2021 **12:00 PM – 1:30 PM**

"Virtual Panel Discussion: Career Success Pathways for Students and Young Professionals" by Kristin M. Carter, P.G., C.P.G., Assistant State Geologist (Pennsylvania Geological Survey); David Crotsley, P.G., Senior Geologist (HDR Engineering, Inc.); Emily V. Glick, P.G., Senior Hydrogeologist (Tetra Tech, Inc.) and Tom Wagner, P.G., C.P.G., Geologist (Cabot Oil & Gas).

For more information: https://pcpg.org/event-4137507

Pittsburgh Area Petroleum Geologists

April 15, 2021 **12:00 PM – 1:00 PM**

"Digital Fluid Physics: Prediction of phase equilibria for several mixtures of CO2 with petroleum fluid systems" by Dr. Mohammad Kazemi of Slippery Rock University.

For more information and to register: https://www.papgrocks.org/meetings/upcoming-meeting

SPRING 2021
PGS STUDENT FIELD WORKSHOP
APRIL 24th
10:00 am – 4:00 pm

The Pittsburgh Geological Society is pleased to announce the 16th annual student field workshop! The event is a hands-on, practical demonstration of the tasks, knowledge, and skills of a typical early-career field geologist. Participating students will learn field skills commonly used in the environmental and geotechnical drilling fields and develop their approach to prepare for a career in geology and environmental sciences.

The costs of the Student Field Workshop are underwritten by the PGS Galey Fund for student education and by a generous donation from Wally and Susan Scott Phillips in memory of George O. Scott. Professional geologists from across the region have volunteered their time and talents to share with the next generation of geoscientists.

THIS YEAR'S FIELD WORKSHOP WILL BE HELD ON THE CAMPUS OF SLIPPERY ROCK UNIVERSITY OF PENNSYLVANIA.

Schedule

Saturday, April 24 (10 AM – 4 PM): Discussion on preparing for a career in the geoscientists. Field demonstrations and use of geotechnical and environmental field skills. Beverages will be provided, but due to Covid-19 safety guidelines, students should bring their own brown-bag lunch.

Registration

Cost: $15.00 for the 1-day field workshop. Due to COVID restrictions, space is limited to 18 students.

1. To reserve your workshop spot, email your name and university affiliation to **Dr. Tamra Schiappa** at tamra.schiappa@sru.edu. After your registration space has been confirmed, you will have until April 20th to submit a nonrefundable payment of $15 to hold it.
2. Payment can be made through PayPal. Payments received without a reservation and subsequent confirmation will be returned.

PGS AWARDS STUDENT RESEARCH IN EARTH SCIENCE AT THE PITTSBURGH REGIONAL SCIENCE AND ENGINEERING FAIR

On March 24, 2021, Carnegie Science Center held the annual Pittsburgh Regional Science and Engineering Fair at Heinz Field. PGS members Wendell Barner, Michael Bikerman and Daniel Gillies participated in judging of geoscience-related projects virtually. PGS sponsors two awards for the science fair, one for the Senior Division (High School) and one for the Intermediate Division (Middle School).

Intermediate Division

Adia Boccella (8th Grade) – Project: What Method is Most Effective in Preventing Soil Erosion?

Teacher: Andrea Shannon – Campus School of Carlow University

If you observe 5 half cut bottles of soil with different earthly objects on top and pour water on them, then you can see the plant object is more effective in keeping the soil in, because plants latch on to soil when you plant them and the soil combines together. Cut the five large soda bottles vertically from the top, leaving the entrance hole in place Lay each bottle on it's side Fill 4/5 empty bottles with soil Plant grass in the same soil and wait for it to fully grow Dig up the planted grass and put in bottle Line up each bottle and place on an elevated base Place 5 clean drinking cups under each bottle Gather leaves, rocks and algae from outside Place materials on top of 3/5 bottles filled with soil Leave one bottle of soil with nothing but soil on top of it Take a turn pouring clean water in each bottle and observe the water that came out into the cups.

Senior Division

Caleigh Cessna (12th Grade) – Project: Additional Crystallization of Submarine Volcanic Tephra

Teacher: Emily Hixson – Indiana Area Senior High School

This experiment focuses on the overall crystallization of submarine volcanic tephra. Submarine volcanoes differ from terrestrial volcanoes in that the material expelled from a submarine volcano goes through a sort of convection due to the feverish nature of the volcanic activity. This results in the tephra forcefully expelled from the area of activity to fall again and entangle with other tephra in various stages of melt. The tephra is not expelled far from its source due to the drag of water which limits its velocity. Some of the tephra will fall back into the volcano resulting in complexly crystallized pieces of tephra. The amount of crystallization within tephra is affected by many variables that correspond with the rate at which cooling occurs. It is known that volcanic rock's crystallization depends on its rate of cooling. What remains unknown is the significance of this crystallization and what may be told of the environment surrounding the volcano based on data collected from tephra. In this experiment, I have greatly explored the limited information about submarine volcanoes that have undergone tephra analysis. I have also completed my own analysis on tephra and plan to share my findings. It would seem possible to draw similarities between environments, this could contribute to our understanding of the effect submarine volcanoes have on their local ecosystem and extended geology.

EVENTS OF INTEREST TO PGS MEMBERS

The Geological Society of America®

GEOCAREERS

Professional Geologist Licensure Requirements: Tips for the Exam and How Certification will Help Your Career

Wed, Apr 14, 2021 1:00 PM - 2:00 PM EDT

Show in My Time Zone

About this Webinar:
This webinar will provide an overview of geology licensure qualification requirements in the United States. Having a license to practice geology is a requirement in the majority of U.S. states, Canada, and other countries. Learn about professional licensing requirements and how becoming licensed can influence your career opportunities and career success. Laurie Racca will present a discussion of the national licensing exams for geologists prepared by the National Association of State Boards of Geology (ASBOG). She will discuss the purpose of the license, qualification requirements (education, experience, exams), and the Geologist-in-Training Certificate. Shanna Schmitt will present a discussion on the ASBOG® Practice of Geology (PG) exam, including when to site for the exam, how to study, why being licensed is a great idea, and some advice for early career professionals. Jazzy Graham-Davis is a certified Geologist-in-Training in the state of California. They graduated with a BS in Geology in 2019 and passed the Fundamentals of Geology exam in Fall of 2020. They will be sharing their advice on the GIT process and the FG exam.

Speakers:
Laurie Racca, PG, Senior Registrar, California Board for Professional Engineers, Land Surveyors and Geologists
Jazzy Graham-Davis, GIT, Portland State University
Shanna Schmitt, PG, CPG, Minnesota Pollution Control Agency (MPCA)

Promotional Partners:
ASBOG (National Association of State Boards of Geology)
AGI (American Geosciences Institute)
AGU (American Geophysical Union)
GSA Environmental and Engineering Geology Division (EEGD)
GSA Hydrogeology Division

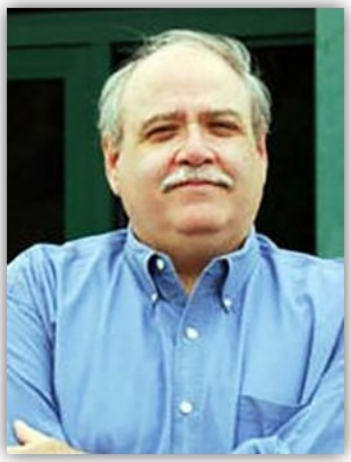
To register for this event, please visit:
attendee.gotowebinar.com/register/6840038060837900047

The Pittsburgh Geological Society welcomes two new student members:

Eric N. Sowers
University of Pittsburgh

Ellie G. Ruffing
California University of Pennsylvania

The Pittsburgh Geological Society is proud to announce



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.

Eligibility Requirements

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 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

Your application packet may be printed out and submitted by mail to:

Pittsburgh Geological Society
Attn: Scholarship Committee
P.O. Box 58172 Pittsburgh, PA 15209

The application may also be sent in digital form (email with attachments) to the current PGS President at tamra.schiappa@sru.edu. Follow these instructions if 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

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 or field trips, or to attend the PGS field trip, or to attend 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 will be final.

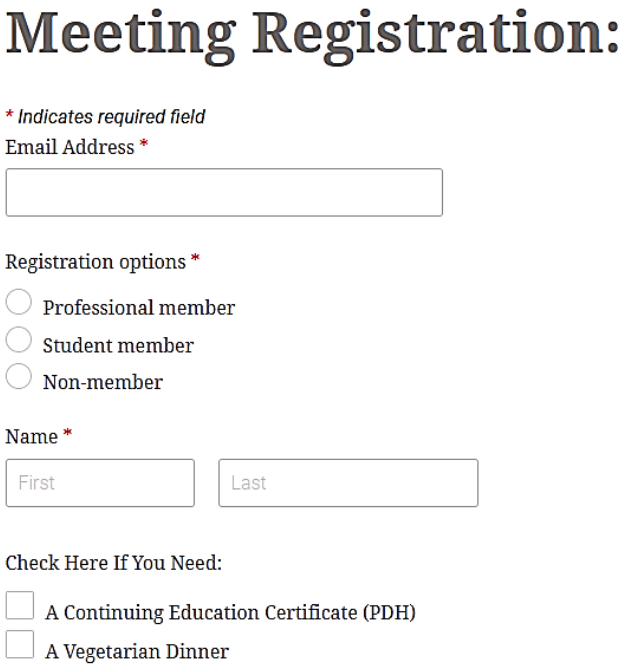
Application Deadline and Award Date

All applications must be received by May 1, 2021. The scholarship will be awarded at the first monthly meeting of the Pittsburgh Geological Society in September.

PROFESSIONAL DEVELOPMENT HOUR (PDH) CERTIFICATES

PGS issues one PDH unit for those professional geologists who attend our meetings and request a certificate. Virtual meetings complicate matters a bit. If you are a professional who needs PDH units for licensure, please be sure to enter your full name with the email address where you want the PDH certificate sent when registering to ensure accurate recordkeeping.

Don't forget to check the PDH box on the website form. →


Meeting Registration:

* Indicates required field

Email Address *

Registration options *

- Professional member
- Student member
- Non-member

Name *

First Last

Check Here If You Need:

- A Continuing Education Certificate (PDH)
- A Vegetarian Dinner

PGS NOMINATIONS & ELECTIONS LAST CALL FOR CANDIDATES

April is a good time to consider becoming more involved in the Pittsburgh Geological Society by serving as an officer or board member. Nominations and Elections Committee Chair Ray Follador is seeking non-student members who regularly join us at our Wednesday meetings to consider filling a position on our Board or as an officer. He will be looking to fill a ballot with qualified and energetic members by the April 21 meeting prior to our May 19 election.

Whether you have served in the past or have no previous experience, we welcome your interest and enthusiasm in supporting the society as either a Director-at-Large or an officer. If you are an active professional member of the Society and have an interest in being a candidate or know of a member that you think would be a good candidate, please contact Ray Follador, Nominations and Elections Committee Chair, at geodawg@comcast.net or (724) 744-0399. A list of all candidates will be announced at the April 21 PGS meeting with the election to be held by the May 19 meeting.

THE ORIGIN OF WESTERN PENNSYLVANIA PLACE NAMES

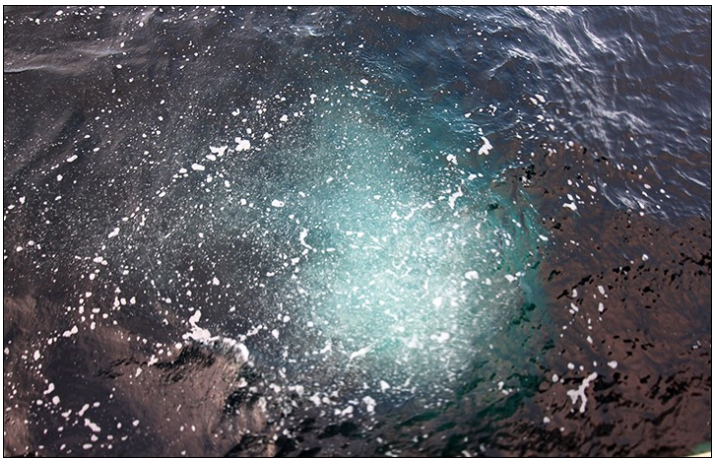
John Curry is considered to have been the first settler in what is now Marshall Township, Allegheny County, in the late 1700s, and the settlement that sprang up was called Brush Creek after the local north-flowing tributary of Connoquenessing Creek. Brush Creek was "downtown" for the rest of the rural township. As the community grew, several general stores, a post office, blacksmith shops, inns, some taverns, and a couple of livery stables became established there. Jonathan Ransom established a hotel in Brush Creek in 1845 and George W. Warren later served as the hotel keeper for many years. Warren and his family lived on a hill above what is now the Pennsylvania Turnpike. The "town" of Brush Creek was renamed Warrendale in their honor in 1907.

Pennsylvania Turnpike toll plaza at Warrendale, northern Allegheny County. When the Warren family lived on Warren Hill near here, the town was called Brush Creek.

Following the excitement over the Drake Well in Venango County in 1859, a group of farmers drilled on the Warren property in 1861, but after 190 laborious feet they gave up. Several more unsuccessful attempts were made in the ensuing years until 1887 when William Munhall and his partners finally discovered oil at 1,400 feet in the Hundred-foot sand of the Upper Devonian Venango Formation. Intense drilling followed, establishing the Brush Creek oil field as the largest in the township. And in 1878, I. C. White named the fossiliferous Pennsylvanian Brush Creek limestone for outcrops along the creek (not for the "town").

DID YOU KNOW . . . ?

An international team of scientists has discovered evidence that frozen methane deposits (hydrates) in the Arctic Ocean have started to be released over a wide area of the continental slope about 375 mi off the East Siberian coast. Arctic slope sediments contain huge quantities of frozen methane, which is a potent greenhouse gas, as well as other gases. High levels of CH_4 have been detected as deep as 1150 ft in the Laptev Sea near Russia. At one location at a depth of about 985 ft, they found CH_4 concentrations of up to 1,600 nanomoles/liter, 400 times higher than if the sea and atmosphere were in equilibrium. The intrusion of warm Atlantic currents into the east has been suggested as the probable cause of the instability.



Bubbling water in the East Siberia Sea is the result of melting hydrates on the continental slope of Siberia.

This has prompted some researchers to be concerned that it could have serious climate consequences because, in the first two decades after its release, CH_4 is 84 times more potent as a greenhouse gas than CO_2. The USGS lists Arctic hydrate destabilization as one of the four most serious potential settings of abrupt climate change. The research team noted that most of the gas bubbles were dissolving in the water, but CH_4 levels at the surface were four to eight times higher than would normally be expected and it was venting into the atmosphere. Although it is unlikely that this will have a major impact on global warming, it is important to note that the process has begun. The East Siberian slope hydrate system has been disturbed and the process will continue.

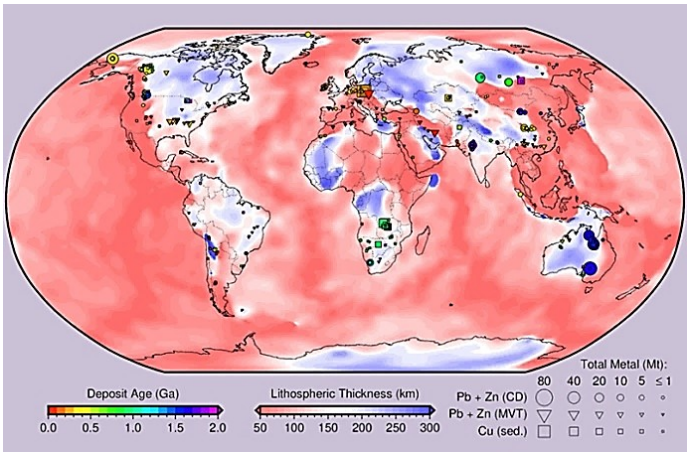
The team stressed that their findings were preliminary. Past detections of methane seeps are known to have been historic, but the team believes the current ones are new. This is based on an earlier study showing movement of the subsea permafrost between the early 1980s and 2015. The scale of hydrate release will not be confirmed until the team returns to the East Siberian coast, analyzes the data, and has their studies published in a peer-reviewed journal.

Still, the discovery of potentially destabilized slope hydrates raises concerns. The Arctic is ground zero in the debate about hydrate deposits. If releases eventually exceed a certain tipping point, they could increase the acceleration of global warming. Arctic temperatures are rising more than twice as fast as the global average, so the question of when (or whether) the melted hydrates will be released to the atmosphere has been a matter of considerable uncertainty in climate computer models.

https://www.theguardian.com/science/2020/oct/27/sleeping-giant-arctic-methane-deposits-starting-to-release-scientists-find

According to researchers from Australia, the US, and the UK, lithospheric thickness maps can be used in the search for deposits of essential metals such as lead, zinc, copper, and nickel. Although these metals occur in many rocks, they need to be concentrated into localized deposits in order to be exploitable. Some, like copper, can be found in large quantities only in volcanic deposits whereas sedimentary deposits typically provide the largest concentrations of the other exploitable metals with some deposits containing more than 10 megatons of metal. Thanks to the current advances in mobile and battery technology, along with the need to decarbonize the global economy, more of these giant deposits are greatly in need.

So, what can we do to find these deposits? The first hint came from northern Australia, where scientists noticed that a number of large zinc deposits lined up along an arc. They weren't sure what geological feature was connected to that shape, but by using improved models of how seismic waves travel through Earth's interior their work provided a new map of Australia's lithospheric thickness. It turns out that the arc of zinc deposits skirted the large craton underlying the west of the continent.



Productive Pb, Zn, and Cu mines line up with the edges of cratons, where thinning lithosphere made sedimentary basins perfect for metal precipitation.

This finding encouraged the researchers to investigate the geography of deposits and cratons in the rest of Australia, and then worldwide. In doing so, they found many similar juxtapositions of cratons and mineral deposits, and a statistical analysis confirmed that these were not due just to chance. It turns out that such locations provide a lot of conditions that facilitate the concentration of metals.

The process starts with an inland sea that becomes increasingly salty through evaporation. The shallowest parts of the sea are where the concentrations become so high that salts precipitate

out of the water and become deposits of gypsum, anhydrite, and halite. Seawater percolating through these rocks travels through faults into older rocks. If those rocks are oxidized, the brine becomes oxidized itself, allowing any metals in the rocks to dissolve into the brine. Then, as the brine percolates deeper, it gets hotter and begins to expand, which makes it less dense (more buoyant) to such an extent that it rises again. Then it cools just enough to start sinking again. This repeating cycle can keep the brine circulating through sedimentary layers for long periods of time, collecting metals as it flows. When the brine eventually passes through a reducing environment, some of the metals will precipitate out. Black shales, for example, provide the right conditions to allow the build-up of metal deposits.

Although cratons typically don't lend themselves to thinning or rifting, that kind of resistance makes their edges, places where the surrounding lithosphere is thinner, perfect for forming sedimentary basins. This usually takes a long time, which gives the brine more time to circulate, and the thickness of the craton's edge gives it a longer downward journey before temperatures get too high for the metal precipitation processes to work. These circumstances increase the volume of the deposit. The researchers are confident that they can provide an actual probability that a deposit exists, which is what companies need to make financial decisions. Beyond economics, their research also provides evidence for the stability and longevity of cratons.

https://eos.org/articles/cratons-mark-the-spot-for-mineral-bonanzas

There are many different kinds of diamonds, and many ways that they formed. Some formed as the carbon-rich environments of dying stars expanded and cooled billions of years ago. High-temperature and high-pressure environments in the Earth's mantle produced most of the diamonds we're familiar with as gemstones. And we know that 5 ka ago, a large meteorite struck some carbon-rich sediment on Earth and produced impact diamonds.

Although each of these kinds of diamonds differs in both composition and genesis, all are currently categorized as "diamond" by the International Mineralogical Association's (IMA) Commission on New Minerals, Nomenclature and Classification. This is the "bible" of mineralogy that dates to the 1800s when James Dwight Dana himself suggested a way to categorize minerals on the basis of idealized elemental compositions and crystal structure.

Many mineralogists find no problem with this, but for planetary scientists, geobiologists, paleontologists, and others trying to understand the historical context of minerals, this system leaves a lot of unanswered questions. So, some planetary scientists from the Carnegie Institute for Science recently teamed up with a professor in the Philosophy Department at Colorado University, Boulder to propose that scientists tackle this deficiency using what they call an evolutionary system of mineral classification. This system would include historical data and also reflect changes in the distribution and diversity of minerals throughout Earth history.

Quartz is not just SiO_2. Its rich history of formation and any subsequent modifications provides a wealth of information that could help scientists understand some of the mysteries of the Earth and the Solar System.

Every mineral specimen contains traces of its formation process that makes it unique. Quartz, for example, is defined as pure SiO_2, but there probably are no versions of quartz that are that simple. As such, the IMA approach to mineral classification – categorizing materials completely on the basis of obvious similarities and differences, regardless of how they were produced and what modifications they have undergone – involves grouping minerals with distinctly different historical origins while separating others that share a

common history. This approach doesn't work very well for historically-oriented geosciences such as planetary sciences where understanding the formation and development of planetary bodies is of particular importance. Differences in the history of a mineral's development are far more critical than the mere fact that a crystal qualifies as a specific named mineral because the conditions of its formation and subsequent modification are far more informative.

There is, as of yet, no universal theory of "mineral evolution", and creating such a classification system is challenging. The researcher's proposed solution would be based on historically revelatory, information-rich chemical, physical, and biological attributes of solid materials. Such a strategy would allow scientists to build a historical system of mineral kinds without regard to its underlying theoretical principles. Because they are durable and rich in information, minerals provide a wealth of data to understand Earth's origin and evolution. The researchers believe that by rethinking the way we classify minerals, it offers a new way to resolve the big, outstanding mysteries of Earth and the Solar System. Through their flaws and deficiencies, minerals have encapsulated the story of what has happened to them through deep time.

https://phys.org/news/2020-12-scientists-philosopher-team-categorize-minerals.html

Recent research has identified a subterranean magma "conveyor belt" that thrusted up to Earth's surface over millions of years. It was responsible for the longest expanse of super-volcano eruptions known. Shifts of the ocean floor created channels through which the magma flowed freely, resulting in an extensive period of eruptions that lasted from approximately 122 to 90 ma ago, a whopping 32 ma. Typical flows of this sort only last for one to five ma.

The eruptions occurred on the Kerguelen Plateau, which now lies at the base of the Indian Ocean on the Antarctic plate. The area is a large igneous province (LIP), an extensive accumulation of magma and lava. LIPs are of particular interest to geologists because of their links with mass extinctions, rapid climatic disturbances, and ore deposit formation. The researchers used argon isotope dating of samples of sea floor basalts to determine the spread and rise of the LIP as it sat above a mantle plume. Throughout the 32 ma interval of intense activity, the Kerguelen Plateau rose by about 7.87 in per year. Considering the size of the LIP, that equates to lava filling 184,000 Olympic-sized swimming pools every year.

The Kerguelen Plateau's unique configuration of a

Heard Island, one of two active volcanoes on the Kerguelen Plateau in the southern Indian Ocean.

mantle plume, combined with slow seafloor-spreading ridges channeling the magma upwards, accounted for the long and steady spate of super-volcanic activity. Other volcanoes typically stop erupting when temperatures fall and the channels become clogged by solidified magmas. At the Kerguelen Plateau, however, the mantle plume acted like a Bunsen burner that kept the mantle plastic and flowing. The rate of volcanic activity dropped significantly about 90 ma ago, but scientists aren't sure why. Volcanic activity continues today, but on a much smaller scale.

Studies like this are important because the more we can learn about how systems like this can form and stay active, the better we will be able to understand the interactions taking place below Earth's surface right now. It has implications for how geologists understand magmatism on Earth as well as on other planets.

https://www.sciencealert.com/a-huge-magma-conveyor-belt-fuelled-the-world-s-longest-burst-of-supervolcanoes

As every geologist, and most upper-level undergraduate geology students, knows, you can't get a geology degree without learning some form of geologic mapping. Attitudes toward geologic mapping vary greatly, from profound love to profound hatred, depending on the individual's taste for the processes involved in this basic and essential process. Since the days of William Smith, it has been widely recognized that learning how to map is an excellent way to learn the basics of the geological sciences, from how to identify rock types in the field to understanding structural geology. Geologic mapping also reinforces attributes of graduate-level education as well as the use of geology in professional life, from government surveys to economic mineral exploration.

Sadly, the number of geologists using the field mapping skills they learned in undergraduate school is declining, in part because of the increasing use of seismic and borehole data alone to generate cross-sections. This is in spite of the fact that field mapping, either used alone or in conjunction with other methods, often provides better insight into what actually occurs underground. Some lament the possibility that, as the practice of field mapping continues to decrease, there may come a time when mapping skills are lost to all but a few specialists.

Mapping has evolved over the years in connection with technology – our geological "ancestors" used horses to get to and study available outcrops; today we use drones to become familiar with large-scale landscape features that otherwise might not be seen at ground level. As technology continues to simplify many of mapping's more physical, and less pleasant, aspects (long hikes, hazardous climbs, poison ivy, dangerous wildlife), will it eventually eliminate the need for conventional geological mapping entirely? A quick look at a satellite image of an area might be able to answer questions that long days spent scratching heads at an outcrop cannot.

William Smith's geological map of Great Britain, the map that "changed the world."

Let's face it – there is certain information that can only be obtained by looking at a rock close up, such as the identification of different mineral components or the rock's deformational history. Exploration geologists, especially, are becoming increasingly worried about the apparent decrease in the mapping expertise of up-and-coming generations of geoscientists.

Why is this happening, especially since no geological discipline is complete without a map? In part because the number of colleges offering advanced-level geology has markedly decreased over the past few years, which in turn is the result of fewer students interested in taking up the subject. Concurrently, there has been a conspicuous shift away from fieldwork-focused college curricula thanks to increasing costs for both fieldwork and liability issues.

In addition, mineral resource exploration is trending away from regions with lots of outcrops and more toward regions with more cover. Increasing the number of geologists accomplished in mapping requires regular replenishing of skills to ensure that techniques learned in college will be retained. Industry funding for college-level mapping education would also be beneficial. Geological mapping may seem like an old-fashioned skill, but it is definitely NOT outdated as any student or professional GIS user will tell you. Although geological mapping skills are decreasing, they are far from being lost altogether. Many industries still appreciate the value of proficient field-mapping ability, and we can only hope that funding will eventually result. We need to guarantee that this science, this art, continues to be applied for the benefit of society as well as the science.

https://blogs.egu.eu/network/gfgd/2019/03/19/is-geological-mapping-becoming-obsolete/

Most of the major mass extinction events, and even some of the smaller biotic-turnover events, that occurred during the past 300 ma are connected to changes in Earth's natural carbon cycle. The end-Triassic mass extinction, for example, began after a volcanic eruption spewed CO_2 into the atmosphere, disrupting the carbon cycle. This created a chain reaction of environmental events, including acidification of ocean waters that affected delicate marine ecosystems and led to other unfavorable planetary changes. That extinction event resulted in the demise of about 76% of all marine and terrestrial species.

Recently, a team of researchers analyzed biomarkers extracted from rocks in the Bristol Channel of the UK and found that the end-Triassic mass extinction actually occurred later than previously thought. The researchers found evidence of ancient microbial mats, comparable to extant microbial mats in Shark Bay of Western Australia, where previous studies had suggested the extinction had taken place. The chemical signatures of the mat organisms complicated the rock record, leading previous researchers to date the extinction event to a time when, in fact, the microbes were actually flourishing.

Analyses of the biomarkers of microbial mats, such as these stromatolites, provide evidence that the end-Triassic mass extinction occurred later than previous thought.

The new research used a combination of sea-level changes, water-column freshening, and their analyses to reveal that the end-Triassic mass extinction occurred later than previously supposed. The research also showed that microbial mats played important functions in other mass extinction events, as well as a role in preserving the soft tissue of dead organisms and other remains of life under exceptional circumstances. The new findings also provide a warning for potential future mass extinction events on Earth. Knowing more about CO_2 levels during the end-Triassic mass extinction gives scientists important details that might help protect our environment and the health of our ecosystems for future generations.

http://www.sci-news.com/paleontology/end-triassic-mass-extinction-slightly-later-09070.html

Artist's conception of a Devonian tidal pool. Large tides in areas such as this might have played a large role in the evolution of air-breathing fish and early tetrapods.

Tides are a major element in the interactions between the marine and terrestrial environments and they play an important role in determining the environmental framework during the evolution of shallow marine and coastal organisms. Recent research suggests that large tidal ranges occurred from the Late Silurian 420 ma ago to the Late Devonian 380 ma ago and these might have promoted the evolution of air-breathing organs in bony fish and the development of weight-bearing limbs in early tetrapods.

Air-breathing organs in these early vertebrates would have assisted these animals with breathing in oxygen-poor tidal pools, which is where they most likely began as a species. Similarly, the evolution of strong weight-bearing limbs would have aided them with navigation from pool to pool within the intertidal zones as the tides rose and fell.

This is interesting because evidence collected from sediments such as tidal rhythmites, banded iron formations, and other tidal facies suggests that tidal ranges for much of the Earth's geologic history were fairly small. The Late Silurian and Early Devonian, when early tetrapods first appear in the fossil record, appear to be unusual in having large tidal ranges in some parts of the world.

The researchers used a dedicated tidal model and paleogeographic reconstructions from this geologic time range to explore the potential significance of tides in the evolution of bony fish and land vertebrates. They even changed model variables, such as ocean depth, but still got the same patterns of tidal ranges. Their results showed tidal variations larger than 13 ft in the vicinity of the South China block, the site believed to be where the origin and diversification of the earliest bony fish group occurred. This area has produced the earliest important fossils of this group so far.

The results of this study show a need for more detailed tidal simulations of the ancient Earth. The researchers suggest that their methodology could be used with a variety of paleogeographic reconstructions for other time periods to explore the tidal influence upon the origin and diversification of other early vertebrates. It is also possible it would assist in determining the role of tides in triggering marine extinction events.

http://www.sci-news.com/paleontology/large-tides-evolution-bony-fish-early-tetrapods-08991.html

PGS WEBSITE OF THE MONTH

https://www.usgs.gov/faqs/what-are-gas-hydrates?

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Fun Fact Having Nothing to Do with Geology

The Statue of Liberty was shipped to the US from France in 350 pieces. It took 4 months to reassemble it upon its arrival.

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