# PITTSBURGH GEOLOGICAL SOCIETY

**April 17, 2019**

**Poster Session 6:00 PM**

**Dinner 7:00 PM**

**Student Talks 8:00 PM**

**Dinner costs**
$30.00 per person
$10.00 student member

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

You can also reserve and pay via PayPal at:
https://www.pittsburghgeologicalsociety.org/

**NEW LOCATION**
Cefalo's Banquet & Event Center, Carnegie PA

# The 17th Annual Student Night

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

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

**Deadline for Reservations: Wednesday, April 10.**

# STUDENT ORAL PRESENTATIONS

## *ASCE Judges' Selection for 2019*

### HYDROGEOLOGY OF SLIPPERY ROCK UNIVERSITY

RUSSO, NICHOLAS, Department of Geology, Geography and the Environment, Slippery Rock University, Slippery Rock, PA 16057

Slippery Rock University's campus is an intensively developed environment, presenting a highly disrupted hydrogeological setting. The goal of this research project was to develop a concise hydrogeologic assessment of the campus. Well logs from previous production wells and recent irrigation wells, as well as data from shallow wells installed for a hydrogeological laboratory, were compiled. These wells perforate the Pennsylvanian-aged Allegheny and Pottsville groups, from the Kittanning Sandstone to the Mercer Shale and Coal. The Homewood Sandstone is the premier aquifer beneath the campus. Aquifer parameters were determined by pump tests performed on the production wells in the 1960s and the 1970s. Since the wells perforated multiple formations, the values of transmissivity and storage coefficients determined are composites for a stratigraphic packet consisting of the Kittanning Sandstone, Vanport Limestone, and the Clarion and Homewood Sandstones. The storage coefficients for this stratigraphic sequence range from $1*10^{-4}$ to $8*10^{-4}$, indicating confined conditions. The transmissivities present a range of values from 1,000 to 13,000 gpd/ft. The specific capacity for the wells spans a range of values from 1 to 15 gpm/ft, as determined with pumping rates that ranged from 30 to 110O gpm. Slug tests were completed on the hydrogeological laboratory wells to determine the hydraulic conductivity of the screened interval of the wells. Using the Hvorslev method, hydraulic conductivity values of $1.02*10^{-3}$ cm/s to $7.51*10^{-4}$ cm/s were calculated indicating a fine grained sandstone. We have assembled a campus map, structure contours, and a fence diagram in order to better convey the hydrogeology of campus.

## *AEG Judges' Selection for 2019*

### POINT PLEASANT PRODUCED WATER CHARACTERIZATION: AN ANALYSIS OF PAST PRODUCTION AND PREDICTION OF FUTURE PRODUCTION

WILSON, VICTORIA N. Department of Geological and Environmental Sciences, Youngstown State University, Youngstown OH 44555

This research characterizes rates of produced water for the Point Pleasant Formation unconventional play of eastern Ohio and provides a means of predicting future produced-water volumes through 2022. The research utilizes Ohio Department of Natural Resources Division of Oil and Gas Resources (ODNR DOGRM) unconventional production reports for 2011 through the first quarter of 2017. These periodic reports were used to select a representative sample of producing wells from across the Point Pleasant play.

The combination of individual water production characteristics for sixty selected wells combined with a spatial analysis of production from these wells provides a basis for distinguishing between a northern production region and a southern production region. These two regions closely correspond to an industry recognized normal pressured zone in the north and an over-pressured zone in the south. Composite production decline plots for each region provide a basis for predicting future water production.

The findings show percent decline in the northern region of 69% percent in the first four quarters as compared to 63% decline for the southern region over the first four quarters. After four years of production, the percent declines are essentially indistinguishable at 96% and 95%. The composite production decline curves provide a means of predicting water production for the first twenty-eight quarters of production (seven years) of any given well within each respective region. The findings can also be used to plan for additional UIC wells and produced water treatment facilities.

## *PGS Judges' Selection for 2019*

### BODY MASS ESTIMATIONS OF THE PROTOCERATOPS AND TRICERATOPS

CAMARDA, NICOLE, Geoscience Department, Indiana University of Pennsylvania, Indiana, PA 15705

In ornithischian dinosaurs, on three separate occasions, a rare locomotor shift occurred where whole groups transitioned from bipedal to quadrupedal. Ceratopsians, a subgroup within Ornithischia, made this transition at the beginning of the Late Cretaceous. Previous studies have looked at changes in muscle attachments, skeletal anatomy, ornamentation, etc. to document the locomotive change. Recent research has used volumetric techniques to determine body mass and Center of Mass (CoM). In bipedal organisms, CoM must be located over the hind feet for upright posture. In contrast, quadrupeds are not constrained to CoM location. CoM is usually shifted more towards the anterior in quadrupeds to create a balanced posture between its front and hind limbs. Therefore, body mass and CoM are fundamental to understanding locomotive behavior.

The current research uses convex hulling, a previously ground-proofed volumetric body mass estimation technique, to compare two different stages of this locomotor transition. We analyzed *Protoceratops*, an early, small ceratopsian dinosaur closer to the transition than previously studied, and then compared it to *Triceratops*, a larger and later appearing ceratopsian. The volume of the convex hull was implemented in the mass estimation equation and associated MatLAB script described in Sellers et. al, 2012. *Triceratops* and *Protoceratops* are the first taxa of many in a larger study to determine the exact phylogenetic location of this transition from bipedal to quadrupedal ceratopsians. Our preliminary conclusions show high error in mathematical calculations. Going forward we will be able to correct these errors by segmenting the skeletal anatomy into smaller portions.

# STUDENT POSTER SESSION

*6:00 to 7:00 PM*

**NUTRIENT AVAILABILITY AND RECYCLING RATES OVER MARINE ISOTOPE STAGE 31 IN THE ROSS SEA, ANTARCTICA**

BRENNER, ROCK, Geoscience Department, Indiana University of Pennsylvania, Indiana, PA 15705

**ACCUMULATION OF MACRO AND MICROPLASTICS IN LAKE ERIE SEDIMENT**

CHEEK, ALEXANDRA, Department of Earth Sciences, California University Of Pennsylvania, California PA 15419

**CONTINUATION OF ESTABLISHING A BASELINE OF SELECT SHORELINE PHYSICAL FEATURES ON SAN SALVADOR, BAHAMAS**

CRAY, STEVE and MIKETA, RACHEL, Department of Geological and Environmental Sciences, Youngstown State University, Youngstown OH 44555

**IDENTIFYING THE EFFECTS OF HISTORIC DEFORESTATION ON THE DEPOSITION OF ALLUVIAL SEDIMENTS ALONG THE CLARION RIVER**

DEVINE, COLE, EWING, JAKE, and LARSON, AVERY, Department of Biology and Geosciences, Clarion University, Clarion PA 16214

**FRAGILARIOPSIS KERGUELENSIS: A QUANTITATIVE INTERPRETATION OF DIATOM GROWTH AND NUTRIENT RECYCLING**

FURLONG, HEATHER, Geoscience Department, Indiana University of Pennsylvania, Indiana, PA 15705

**DRONE ASSISTED INVESTIGATION OF DUNE FIELD MORPHOLOGY IN THE WHITE RIVER BADLANDS, SOUTH DAKOTA**

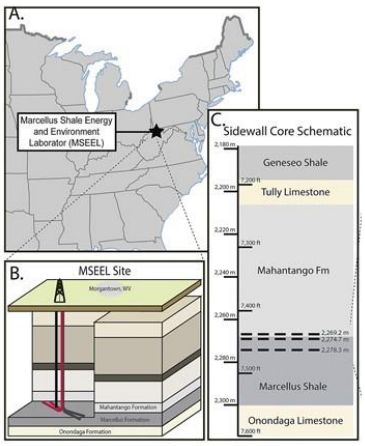
KRAMER, HENRY, Department of Geology, Geography and the Environment, Slippery Rock University, Slippery Rock, PA 16057

# PGS MEETING LOCATION

A reminder that the Pittsburgh Geological Society has moved its monthly meetings for spring to **Cefalo's Banquet and Event Center** in Carnegie PA. Please note that for this facility, your dinner reservations must be made by **Wednesday of the week prior to the meeting**.

Directions: Take Parkway West to Exit 65 for Carnegie. If exiting from westbound lanes, use the left exit ramp (marked Heidelburg) to Lydia Street. Follow Lydia Street for four blocks until it ends at Washington Avenue. Cefalo's Banquet Center (a former church) will be directly across from you. Overflow parking is along side streets and across the street from the site.


## Preview of the Next PGS Meeting




New Dinner Location: Cefalo's Restaurant in Carnegie

Next month's PGS meeting will be held on May 15, 2019.

**The role of geochemistry in unconventional resource development**

**Dr. Shikha Sharma**

Associate Professor/Associate Chair Geology

Director, IsoBioGeM Laboratory

Dept. of Geology & Geography

West Virginia University

# PRESIDENT'S STATEMENT

April has become the month we honor the student membership. The drilling workshop starts off the month and it ends with student night.

This is an exciting time for students since many are preparing for graduation and these opportunities help to prepare them for the next stage in their career. The drilling workshop will introduce them to life as a field geologist and student night gives them the opportunity to improve upon their communication skills. The professional members have dedicated hours toward mentoring and organizing these opportunities and the student members benefit both professionally and personally.

When I think back about my undergraduate years, I wish that opportunities that involved the professional community were there to mentor me and provide opportunities to learn about tools of the trade. Having exposure to a drill rig prior to graduating may have eliminated my apprehension of the unknown. And who knows - my career may have taken a different path. I commonly suggest to students that they should become a PGS member and to take advantage of all the society has to offer. The most common response is why, why should I join?

My response may be a canned one, but there are many benefits to joining and being part of a professional organization. Here are a few of my reasons and responses. Joining provides members with a competitive advantage because they become active, informed members of their discipline. Many members join with the hopes that they will be kept up-to-date on advances in technologies, important industry trends, or new legislation. Joining a professional association is a win-win situation for students. They are not only networking with professionals, but are being praised for taking the initiative to make it to a meeting and learn about their field of interest. Most of the PGS members enjoy speaking to students and truly want to mentor potential new recruits as they transition into the work force. Other benefits include: learning about internships or potential jobs, getting a discounted rate at professional conferences (and PGS dinners!), and learning valuable field and communication skills from the professional mentors and presenters. I am sure there are other benefits, but these are the ones that commonly come to mind.

Please remember that these benefits don't end after you graduate. Maintain your membership and participate in the meetings. You're experience and knowledge of the industry will be helpful to share with the new student members. I am sure there is information that you wished you had known when searching for or beginning your new job. Come back and share that with the students as they begin to apply for positions. We hope that the graduates this year will maintain their membership, help mentor, and, who knows - maybe even seek out a leadership position while supporting future PGS initiatives.

I want to express my sincere appreciation to the Pennsylvania Council of Professional Geologists (PCPG) for their generous donation in support of student night! Their sponsorship highlights the commitment that the professional societies have to provide topnotch opportunities for students.

I also want to thank all the corporate sponsors. Without their contributions we would not be able to offer the many opportunities for students as well as their reduced dinner costs.

*Tamra*

## LOCAL GEOLOGICAL EVENTS

**SOCIETY OF PETROLEUM ENGINEERS**

April 18, 2019 (lunch meeting)

"Stop, Drop And Circulate, An Engineered Approach To Coiled Tubing Intervention in Horizontal Wells" by SPE Distinguished Lecturer Charles Pope, Devon Energy

***Cefalo's Banquet Center, Carnegie PA***

**PITTSBURGH ASSOCIATION OF PETROLEUM GEOLOGISTS**

April 18, 2019 (Student Night)

"Geology of Mudstones" by Dr. Amy Weislogel, West Virginia University.

***Cefalo's Banquet Center, Carnegie PA***

**SOCIETY OF WOMEN ENVIRONMENTAL PROFESSIONALS**

April 27, 9:00 AM – 12:00 PM

North Park Volunteer Day

**North Park Ranch House, Allison Park PA**

**PENNSYLVANIA COUNCIL OF PROFESSIONAL GEOLOGISTS**

"More than a Data Table: Get More from Your Groundwater Data Using MS Excel" (see details on page 10).

**Regional Learning Alliance, Cranberry PA**

**GEOPHYSICAL SOCIETY OF PITTSBURGH**

June 5, 2019

"1st Annual Appalachian Basin Geophysical Symposium" (see details on page 11)

**NOAH's Event Center, Canonsburg, PA**


**The Pittsburgh Geological Society is delighted to welcome the following new student members:**

**From California University of PA:**
Danica R. Pils
Jenna M. Theis

**From Clarion University:**
Dawn L. Badtorff
Abigail M. Beckwith
Cole R. Devine
Kevin A. Venesky
Ryan S. Maitland
David J. McKnight, IV
Alexis L. Robison

**From Slippery Rock University:**
Cody D. Brown

## THE PITTSBURGH GEOLOGICAL SOCIETY ENDOWMENT FUND

*Established May 8th, 2014 through the*

COMMUNITY FOUNDATION
*Serving the Heart of Western Pennsylvania*

# UPCOMING EVENTS OF INTEREST TO MEMBERS OF PGS


*URTEC is coming to Pittsburgh for a one-day workshop in the heart of the Appalachian Basin. While operators are still pushing the boundaries of the Utica play, the Marcellus is firmly established and optimization is the name of the game. This multi-disciplinary event will cover a broad range of topics from geologic characterization, inter-lateral spacing, proppant and perforation designs, and production best practices. Come hear from industry and academic professionals, make new connections and learn current best practices to maximize your production.*

**Horizontal Targeting Strategies and Challenges: Examples from the Marcellus Shale, Appalachian Basin, USA**

Randy Blood - DRB Geological Consulting

**Far-Field Tectonic Controls on Deposition of the Ordovician Utica/Point Pleasant Play, Ohio Using Core Logging, Well Logging, and Multi-Variate Analysis**

Julie Bloxson - Stephen F. Austin State University

**Marcellus Shale Energy and Environment Laboratory Results: Improved Subsurface Reservoir Characterization And Engineered Completions**

Tim Carr - West Virginia University

**Laser Induced Breakdown Spectroscopy An Emerging Spectroscopic Technique For Shale Rock Characterization**

Jinesh Jain - USDOE National Energy Technology Laboratory

**Facies, Depositional Environments, Chemostratigraphy, and Reservoir Quality of the Middle Devonian Marcellus Formation, Appalachian Basin, Northeastern Pennsylvania**

Lucy Ko - Bureau of Economic Geology

**Topical Luncheon***

Shawn Bennett – Office of Fossil Energy

Topical luncheon ticket is included with registration to the workshop.*

# UPCOMING EVENTS OF INTEREST TO MEMBERS OF PGS

North American
COALBED METHANE FORUM

Home | Conference | Board Members | Book/Presentations | History | Links | News | Contact

## SPEAKERS

**Keynote Speaker - April 17, 2019**

Our keynote luncheon speaker will be Shawn Bennett, Deputy Assistant Secretary for Oil and Natural Gas for the U.S. Department of Energy.

READ HIS BIO

**Other speakers include:**

- Tim Carr, West Virginia University: Fossil fuel in our present and future energy mix
- Steve Schatzel/assistant, NIOSH: Natural gas well stability near active longwall mining.
- Ira Pearl, Montauk Energy: Methane: Landfill to Market.
- David Reistenberg, Advanced Resources International: Update on CO2 Sequestration: Gas composition to maintain injectivity while sequestering CO2 in different ranks of coal.
- Dr. Qin He, St. Francis: Theory of CO2 Sequestration and methane production
- Nathan Roberts, Halliburton: Mitigating lost production in child well completions because of parent well frac hits.
- Dr. C Eble, Kentucky Geological Survey: Future of coal in Kentucky and surrounding areas
- Kristian White, Steptoe & Johnson: Legal update in CBM production
- Jon Kelafant, ARI: Update on Worldwide and U.S. CBM/CMM Activities

## CONFERENCE LOCATION/ACCOMMODATIONS

**Hilton Garden Inn Pittsburgh/Southpointe**

4000 Horizon Vue Drive, Canonsburg, Pennsylvania 15317

Tel: 1-877-666-3243

Hotel web site

## UPCOMING EVENTS OF INTEREST TO MEMBERS OF PGS

# More than a data table: Get More From Your Groundwater Data Using MS Excel (435 mins.)

When April 30, 2019
8:00 AM - 4:30 PM

Location Regional Learning Alliance, 850 Cranberry Woods Drive, Cranberry Twp., PA

Spaces left 10

**Registration**

- Member – $209.00
  Registration closes April 24 or when sold out.
- Non-Member – $299.00
  Non-member registration closes April 17, or when sold out. To save $90 on the cost of this event, return to home page and Join PCPG.

VISA MasterCard DISCOVER AMERICAN EXPRESS OFFLINE

Be sure your browser settings allow pop-up windows. System automatically emails receipt upon payment completion. If online payment transaction is unsuccessful, enrollment record is discarded.

Register

**Maximum Enrollment: 25**

Regional Learning Alliance
850 Cranberry Woods Drive DIRECTIONS
Cranberry Twp., PA

8:00-8:30 Registration and AM Refreshments
12:00 Lunch Provided
4:30 Adjourn/Complete Course evaluation and pick-up certificate of attendance.

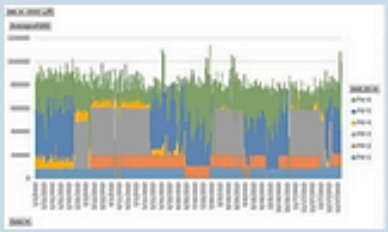
**Professional Development Conversion**
DE, SC 60 mins. = 1 CEU
PA 50 mins. = 1 PDH

**Instructor**
Steven Sayko, P.G. (Services Environmental, Inc.)

**Level: Intermediate/Advanced**

Download Agenda

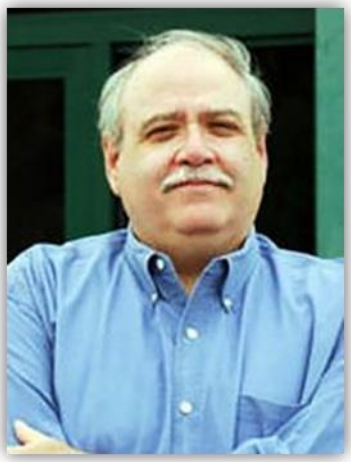
**Important:** To get the most from this class, please come prepared. Past classes using the attendee's computers have encountered difficulties opening files and running software. There will be no one-on-one IT support in class to address hardware or software issues. Before the class, please check that your computer will open the example worksheets and will run without attachment to your company network. **See additional requirements below.**



**Overview:** Geologists and Environmental Professionals collect lots of site data and typically use Microsoft Excel to prepare attractive report tables. Excel has the power to enable you to get more from your data than attractive tables. The objective of this course is to demonstrate how Excel can be used to explore your data and better understand site conditions using groundwater data from actual investigations. Approximately 40% of the class will be hands-on working with Excel. Effectively presentation of data will also be discussed. The case history examples are based on the instructor's 30-year career as a hydrogeologist.

## UPCOMING EVENTS OF INTEREST TO MEMBERS OF PGS

*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 is final.

## Application Deadline and Award Date

All applications must be received by May 1, 2019. The scholarship will be awarded at the first meeting of the Pittsburgh Geological Society in September.

## 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 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 17 meeting prior to our May 15 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 17 PGS meeting with the election to be held at the May 15 meeting.

## THE ORIGIN OF WESTERN PENNSYLVANIA PLACE NAMES

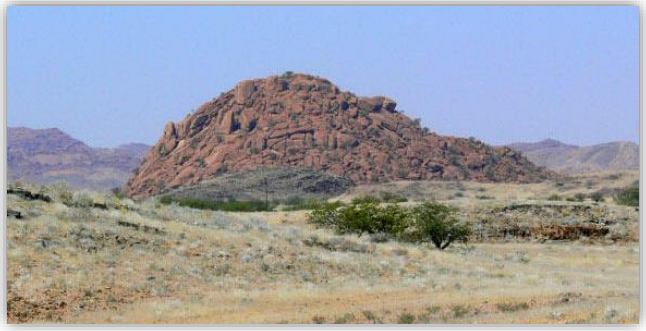
During the French and Indian War, George Washington traveled extensively throughout what is now Fayette County and became very familiar with the land. When land became available for purchase, he bought a tract of flat land along the Youghiogheny River, declaring it "as fine a land as I have ever seen, a great deal of rich meadow; it is well watered and has a valuable mill seat." The mill, completed in 1776, encouraged other businesses to follow. Eventually, the town of New Boston sprung up and Washington drew up plans for the streets to be laid out in the shape of a wagon-wheel. He never saw his dream come to fruition - it was not until after he died and his estate sold the land in 1814 that the town was laid out using Washington's plans.

**Aerial photo of Perryopolis showing the wagon-wheel shape of the town center as envisioned by George Washington.**

At that time, it was renamed Perryopolis in honor of Admiral Oliver Hazard Perry who won the famous victory of Lake Erie during the War of 1812. The wagon-wheel shape of the town center is very distinctive in aerial photography. What drew Washington's attention to the area, the flatness of the land, is due to Perryopolis and its environs lying within a cut-off meander of the Youghiogheny River. This meander was abandoned sometime before or during the early Pleistocene. The soil is derived from the Carmichaels Formation, which consists mostly of alluvial and lacustrine deposits. The lowest material, deposited by the ancient Youghiogheny, is coarse. Above and often interbedded with this are large rock clasts, fragments of the bedrock the river encountered on its trip through the Allegheny Mountain Section. Fine, laminar clays indicate deposition in the quiet waters of the Pleistocene Lake Monongahela.

# DID YOU KNOW . . . ?

Our colleagues to the south recently made an interesting discovery. During explorations in Namibia in southern Africa, Dr. Graham Andrews and a team of geology students from West Virginia University stumbled upon some fascinating geomorphic features. The desert land is basically flat, but there are scattered hills with long, steep slopes here and there. After examining the hills, the team quickly realized they were drumlins, which typically occur as teardrop-shaped hills formed by glaciers. Since some of the team had grown up in glaciated territory, they were sure that's what they were looking at. The rocks formed during the Late Paleozoic, a time when southern Africa was covered by an ice sheet, something people from that part of the world already knew. No one had ever mentioned the drumlins, however.



**Namibia's Late Paleozoic drumlins were formed by fast-moving ice streams.**

The team used morphometrics to determine if the drumlins showed any patterns that would reflect regular behaviors as the ice carved them. Normal glaciers grow and melt in sequential patterns but they don't move very much. The team found large grooves, glacial striations, on the drumlins, however, indicating that the ice was moving at a fast pace. The grooves are the first evidence of an ice stream in southern Africa during the late Paleozoic, approximately 300 million years ago (Late Pennsylvanian or Early Permian). The team's findings confirm that southern Africa was located over the South Pole at that time. The drumlins and their grooves also provide another connection between southern Africa and South America, showing the two continents were joined.

**http://www.sci-news.com/geology/paleozoic-ice-age-namibia-06882.html**

Most of us are familiar with the wonderful natural rock formations that occur with some abundance in the American west – Monument Valley, Arches National Park, etc. These and others like them occur in some of the most desolate areas on the planet. Such features that probably are not so familiar occur in the African country of Chad. There is an extraordinary series of natural formations that were shaped by the elements over thousands of years but have rarely been visited because of their remoteness. They are so exceptional that UNESCO granted them World Heritage Site status in 2016.

The geological formations are located on the Ennedi Plateau in the Sahara Desert, in an area about 5000 feet above sea level that is as large as Switzerland. The rocks of the plateau formed as sand deposited during the Paleozoic Era when ocean waters covered what is now the Sahara. Long after the water receded, the sandstone was sculpted by the desert winds. Among the features of the Ennedi Plateau are towers, pillars, bridges, and arches. A multitude of gorges and deep valleys created a labyrinthine aspect as well.

Some of the geological features are pillar-shaped with large rocks caps which resemble gigantic mushrooms, and there are spherical rocks perched on narrow fingers of sandstone. Although only one of many rock arches on the plateau, the Aloba Arch, at almost 350 feet high, is the world's largest natural arch. The plateaus also features the Mississippian-age Gweni-Fada meteorite impact crater, which is 8.6 miles wide.

**One of the isolated Ennedi rock formations sculpted by Saharan winds the Ennedi Plateau of Chad.**

And as if the spectacular geological formations aren't famous enough, the plateau also is the location of an estimated 8000 examples of petroglyphs created up to 8 ka. The images, made by a pastoralist people who once thrived in the area, give us a glimpse into the Sahara's lush environment before climate change turned it into a desert. The plateau also currently has a unique ecosystem. Freshwater occurs in desert ponds called gueltas that have allowed many unique

**Petroglyphs from Manda Guéli Cave, Chad.**

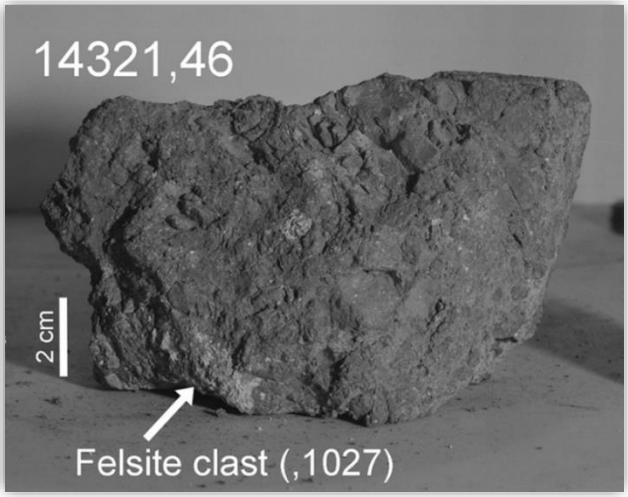
species to survive in the Sahara, including many that went extinct elsewhere. Anyone wishing to visit the plateau needs to know that it is quite remote and, although there are guided tours, the tourist industry in Chad is underdeveloped due to poverty, conflict, and banditry.

**https://www.ancient-origins.net/ancient-places/ennedi-0011416**

Over the past few months, DID YOU KNOW . . . ? has featured some stories about Earth's oldest known rocks, typically Precambrian stromatolitic rocks from Greenland and Australia. This is another such story, but it is unique in that the oldest rock was found in the last place anyone would have thought to look for it - in samples of rock from the Cone Crater on the Moon, brought back to Earth by Apollo 14 astronauts in 1971.

This is not part of the "Moon was once a part of Earth" story. According to an international team of scientists, there is very good evidence that the rock, a 2-gram piece of quartz, feldspar, and zircon (felsite) embedded in a larger chunk of rock called "Big Bertha," originated on Earth. The mineralogy of the specimen commonly occurs on Earth, but it is very rare on the Moon. In addition, chemical analysis suggests that the specimen formed in Earth-like temperatures in an Earth-like oxidized system. The team determined that if, in fact, the specimen had formed on the Moon, the Moon had conditions never before inferred from lunar samples.

Which leaves a loaded question – if it was, indeed, formed on the Earth, how did it get to the Moon? The team has that covered as well. They suggest it was launched off Earth about 4 ga when an asteroid or comet slammed into the young (roughly 540 ma) planet, sending rock fragments flying off into space. The Moon was about 3 times closer to Earth at that time so it was in a better position for some of this debris to end up there. More detailed analysis using the zircon indicated the rock formed around 4 to 4.1 ga at a depth of about 12.4 miles below Earth's surface. Once it reached the Moon, additional impact events probably partially melted and buried it around 3.9 ga. It finally reached the surface again around 26 ma when an impact event created the Cone Crater. And there it remained until an astronauts picked it up 48 years ago.




**Apollo 14 breccia 14321, "Big Bertha." This sample has a mass of 9 kilograms and is up to 23 centimeters across. The felsite clast is the "terrestrial" item of interest.**

Okay, it is possible the rock formed on the Moon. The conditions for that to have occurred, however, are very unlikely. It would have to have formed 18 to 44 miles below the surface in a very unusual oxidizing magmatic environment where the oxygen levels would have needed to be much higher than anything measured or speculated to have occurred

4 ga. It is much more likely, given the known and speculated terrestrial conditions at that time, that it formed on Earth. Only serendipity accounts for its return. How do we determine its origin for certain? Find more specimens either among those already returned, or plan more expeditions to our nearest neighbor.

**https://www.sciencealert.com/earth-s-oldest-rock-may-have-been-found-it-was-um-on-the-moon**

Scientists have known for years that many early dinosaurs were covered in feathers, but the feathers were not used for flight. Most likely they evolved for warmth and/or for display, to attract mates. But no one knows when or how feathered dinos took flight. Recent findings, however, provide molecular evidence that key proteins in feathers allowed the feathers to become lighter and more flexible over time. Combine that with major anatomical changes such as lightweight or, later, hollow bones and flightless feathered dinosaurs found themselves airborne.

**Artist's rendering of *Anchiornis*, a feathered dinosaur. Feathers probably evolved long before dinosaurs took flight and became birds.**

All modern land vertebrates have keratins – the proteins that make up fingernails, beaks, scales, hair, and feathers. In humans and other mammals, hair, skin, and nails are composed of α-keratins that form 10 nanometer-wide filaments. In crocodiles, turtles, lizards, and birds, β-keratins form the even narrower, more rigid filaments that build claws, beaks, and feathers. Over the past decade scientists have used the genomes of dozens of living bird and reptile species to deduce a phylogenetic tree of these animals based on how their β-keratins changed over time. Their revelations include an interesting fact – modern birds have lost most of their α-keratins, but the β-keratins in their feathers have become more flexible, thanks to some missing amino acids that make claws and beaks rigid. This suggests the transition from flightlessness to flight required both changes to have taken place.

More recently, a team of paleontologists from China and North Carolina have shown this directly by analyzing the α- and β-keratins in a handful of exceptionally preserved fossils from China and Mongolia. They designed separate antibodies to bind to identifying segments of various α- and β-keratin proteins preserved in the fossilized feathers of five Jurassic and Cretaceous species. The antibodies were labeled with fluorescent tags that light up whenever they bind to their targets.

The research revealed that the feathers of *Anchiornis,* a crow-sized Late Jurassic feathered dinosaur that predated the first recognized bird, *Archaeopteryx*, by 10 ma, likely had some, though not all, of the molecular characteristics of modern bird feathers. The feathers lit up to indicate they contained the flexible truncated β-keratin typical of modern birds. *Anchiornis* had even more α-keratins, however, which are largely absent from bird feathers today. Add to that the structural differences revealed by electron microscope analysis and it is highly unlikely that *Anchiornis* feathers would have been suitable for flight. Instead, the fossils indicate an intermediate stage in the evolution toward flight feathers.

The fossilized feathers from a small Early Cretaceous flightless dinosaur called *Shuvuuia* revealed that it lacked α-keratins like modern birds. Unlike *Anchiornis*, though, its feathers were still made up of the larger, more rigid β-keratins. This suggests the transition of feathers to flight was an

evolutionary mosaic that required both the mutations that eliminated most α-keratins and gave rise to the flexible truncated β-keratins. Taken together with modern genetic evidence, the new findings suggest that the β-keratin gene was duplicated many times in the genomes of some dinosaurs during the transition to flight. As the dinosaurs evolved, some of the extra copies mutated into the truncated form that made flight possible. That allowed *Archaeopteryx* to fly during the Late Jurassic, and also gave rise over time to all the sparrows and condors living today.

**https://www.sciencemag.org/news/2019/01/fossil-feathers-reveal-how-dinosaurs-took-flight**

In the space of only decades, Antarctica has lost trillions of tons of ice, and at an alarming rate. As if that were not bad enough, a huge cavity has been found growing at the bottom of the Thwaites Glacier under West Antarctica that scientists say is about 2/3 the area of Manhattan almost 985 feet high.

**The Thwaites Glacier in Antarctica.**

The Thwaites has been dubbed the "most dangerous glacier in the world." It is enormous, representing the estimated 277 billion tons of ice Antarctica loses every year. Researchers say the cavity would at one time have been large enough to hold some 15.5 billion tons of ice. Worse yet, the researchers say it lost most of this ice volume over the last three years alone. For years they suspected that Thwaites was not tightly attached to the bedrock beneath it. And now, thanks to a new generation of satellites, they can see the details.

As part of NASA's Operation IceBridge, and with the addition of data supplied by German and French scientists, the researchers discovered the cavity using ice-penetrating radar. According to the readings, the void is only one problem with the complex pattern of retreat and ice melt that's taking place at Thwaites Glacier where portions are retreating by as much as 2,625 feet per year. The complex pattern the new readings reveal don't fit with current ice sheet or ocean models. Instead, they suggest scientists have more to learn about how water and ice interact with one another in the Antarctic environment.

Although researchers are still learning new things about the ways ice melts at the Thwaite Glacier, the cavity represents a simple scientific actuality – the size of a cavity under a glacier plays an important role in melting. The more heat and water that get under the glacier, the faster it melts. Inasmuch as the Thwaites Glacier accounts for about 4 percent of global sea level rise today, were it to melt entirely, global sea level could rise about 2 ft.

That's only the beginning, however; the Thwaites Glacier actually keeps neighbouring glaciers and ice masses farther inland from getting to the ocean and melting. If it disappeared, the consequences would be castastrophic. Nobody knows how long Thwaites will stay. That's why scientists now embarking on a major expedition to learn more about it. This is among the most important scientific research being conducted in the world today. In fact, the Thwaites Glacier is almost the entire story of global sea-level change during the next century

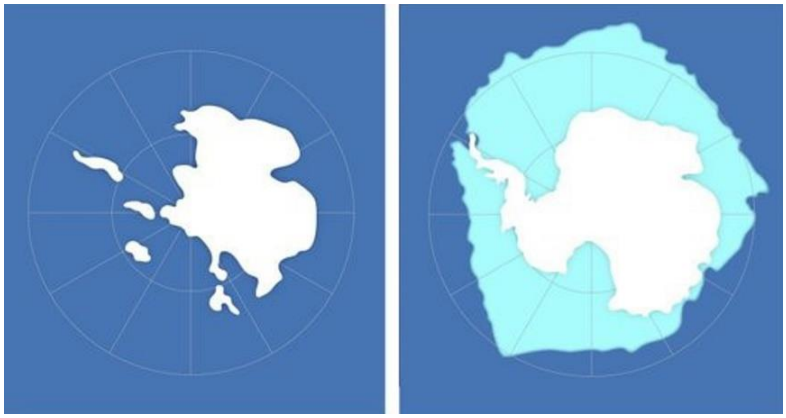
**https://www.sciencealert.com/giant-void-identified-under-antarctica-reveals-a-monumental-hidden-ice-retreat/amp**

And speaking of Antarctica, as global levels of greenhouse gases rise and warm the planet, the continent's ice will become more vulnerable to astronomical-scale cycles, particularly the tilt of our planet is as it rotates on its axis. Over the course of about 40,000 years, Earth's axis tilts back and forth. The tilt is currently about 23.4$^{o}$, but it can be as little as 22.1$^{o}$ or as much as 24.5$^{o}$. The tilt governs when and where sunlight hits the globe, so it can influence climate

Now, new research suggests that, over the past 30 ma of geological history, Antarctica's ice sheets

responded most strongly to the Earth's tilt when the ice extended into the oceans and interacted with warm water currents that increased melting. The effect of the tilt reached its acme when $CO_2$ reached levels over 400 ppm, suggesting that the global climate will become more sensitive to tilt in the near future if we don't get $CO_2$ under control. The prospect of high $CO_2$ and high tilt angle could be especially bad for the ice covering Antarctica.

The researchers used data from various sources in their analyses. For example, the calcareous shells of benthic foraminiferans provide a continuous record of the chemistry of the oceans and atmosphere. Sedimentary cores drilled around Antarctica provided another source of climate history because they provide records of glacial history through the sediment left behind.



**Maps of Antarctica. Left: During the Mid-Miocene about 12 ma. Notice the lack of sea ice. Right: Antarctica today showing the extent of sea ice.**

Using data from both sources, the researchers determined that the first large ice sheets on Antarctica formed 34 ma when $CO_2$ ran 600 to 800 ppm and most of the ice was continental and not in contact with the sea (year-round sea ice became the norm only 3 ma, when $CO_2$ levels fell below 400 ppm). Antarctica's ice advance and retreat were relatively insensitive to the planet's tilt at that time. Between about 24.5 ma and about 14 ma, atmospheric $CO_2$ dropped to between 400 and 600 ppm and the ice sheets advanced more often into the sea, but there wasn't very much floating sea ice. During this time, the planet became quite sensitive to the tilt of Earth's axis. Then, between 13 ma and 5 ma, $CO_2$ levels dropped as low as 200 ppm. Floating sea ice became more prominent and sensitivity to the Earth's tilt declined.

The researchers aren't certain why this change in sensitivity to obliquity occurs. They suspect the reason involves the contact between the ice and the ocean. During times of high tilt, the polar regions warm and the temperature differences between the equator and the poles become less extreme, altering wind and current patterns and ultimately increasing the flow of warm ocean water to Antarctica's edge. When ice is mostly continental, this warm-water flow doesn't reach the ice, but when the ice sheets are in contact with the currents, the flow of warm water matters a lot. Although floating sea ice can block some of the flow, thereby decreasing the ice sheet's tendency to melt, when $CO_2$ levels are high enough that floating sea ice melts, warm-water currents can do their thing. Thus, Earth's tilt seems to matter the most at such times, times such as occurred between 24.5 million and 14 million years ago. Now that atmospheric $CO_2$ have exceeded 400 ppm, it is possible the sea ice will falter and we will begin to experience a world that hasn't existed for tens of millions of years.

**https://amp.livescience.com/64507-antarctica-ice-melt-earth-tilt.html**

Paleoanthropologists know that Denisova cave, located at the foot of the Altai mountains in southern Siberia, was home to Neanderthals and Denisovans for thousands of years, but they were never sure about when or how long these groups remained there. Now, a pair of recent studies traced the paleohistory of human occupation at the cave, showing who lived there and when, including a suspected period of time when the two now-extinct species occupied the cave together. The new research suggests the Denisovans, regarded as a sister species to Neanderthals, lived in the cave for a longer period than Neanderthals, starting around 287 ka. Neanderthals didn't arrive at the site until about 140 ka, and possibly shared the space with the Denisovans for thousands of years, providing further evidence that Neanderthals and Denisovans interbred.

Paleoanthropologists had been carefully sifting through Denisova cave for the last 40 years, finding and cataloguing various animal and Neanderthal bones. Then, in 2010, they discovered the finger bone of a previously unknown human species – the Denisovans. This new species obviously were related to Neanderthals, but not much else about them was known, other than that they also lived at the cave (***Homo sapiens***, surprisingly, don't seem to have utilized the cave). Determining a timeline of events, such as when the cave was first occupied and by whom, has proven difficult. The cave is very large and has complex layers of sediment. The

**The entrance to Denisova Cave in southern Siberia.**

cave's stratigraphy encompasses both the Siberian Middle Paleolithic period (between 340 ka and 45 ka) and the Initial Upper Paleolithic period (roughly 45 ka to 40 ka). Since radiocarbon dating is good for only about 50,000 years, the scientists have had to use less reliable dating methods that lead to unconvincing or controversial timelines.

To get around this problem, an international, multidisciplinary team of researchers spent the past five years analyzing bones and artifacts found in the cave. They used multiple dating techniques, both well-established and cutting-edge, as well as statistical techniques to date thousands of items at the site, allowing them to piece together the most accurate and detailed timeline to date of human occupation at the site. Stimulated luminescence, which indicates the last time a mineral grain like quartz was exposed to sunlight helped date the cave sediments, and therefore the artifacts found in them. This provided dates for 103 sediment deposits spanning 280,000 years of cave history.

These data showed that Denisovans first occupied the cave around 287 ka, and continued to live in the cave until around 55 ka. Neanderthals arrived at the cave around 193 ka and continued to live there up until around 97 ka, overlapping the Denisovian occupation by 96,000 years. Although it's possible the two species didn't share the space concurrently, recent evidence of a hybrid archaic hominin suggests they probably did. The hybrid, called Denisova II, a girl with a Denisovan father and a Neanderthal mother, lived in the cave 90 ka Along with other evidence, this suggests the two species interbred regularly.

A second recent study offered new dates for Neanderthal and Denisovan fossils using multiple techniques such as radiocarbon dating and uranium-series dating to date thousands of bone fragments and artifacts. The oldest Denisovan fossil suggests this group was present at the site as early as 195 ka, while all Neanderthal fossils, including Denisova II, were dated to between 80 ka and 140 ka. The youngest Denisovan fossil was dated to between 52 ka and 76 ka. The fact that Neanderthals and Denisovans were both present at times greatly complicates disentangling which humans were responsible for which elements of the paleoanthropology. It is possible that sediment DNA studies will eventually help to better map their presence in the cave.

**https://gizmodo.com/neanderthals-and-denisovans-shared-a-siberian-cave-for-1832195445/amp**

A new study by geologists from the University of Alberta has determined that the cobalt deposits in the Democratic Republic of Congo (DRC), one of Earth's largest cobalt-mining regions, are as much as 150 ma younger than previously thought. Cobalt is a critically important metal because of its use as a component in rechargeable lithium-ion batteries. Cobalt enables rechargeable batteries to stock energy without overheating. It is a strategic metal for the technological revolution, critical in efforts to face and remediate climate change. Because of this use, it is a hot commodity on the international market, creating steep competition.

Most known large cobalt deposits are located in developing or poverty-stricken regions in Central Africa, and as such, exploration can be mired in human rights, geopolitical, and sustainability issues. The researchers used a new, rhenium-osmium dating system to examine the rich cobalt deposits in the DRC. This indicated that cobalt and copper mineralization occurred between the Ediacaran and Lower Ordovician (610 ma and 470 ma), during a period of mountain building and deformation.

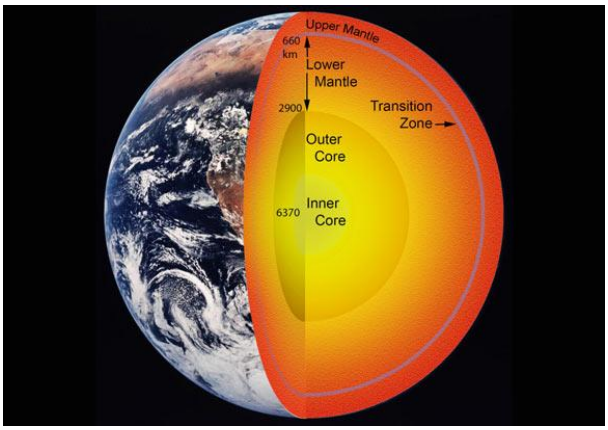
**A cobalt mine in the Democratic Republic of Congo.**

This places formation of the deposits 100 ma to 150 ma more recently than originally thought. Now geologists can target specific regions for exploring known cobalt deposits and discovering new ones. The biggest value of this research is opening the possibility of finding more prospective areas worldwide for sources of cobalt. This background information helps exploration geologists develop ideas of where and where not to look.

**https://www.sciencedaily.com/releases/2018/12/181212134424.htm**

There is a new hypothesis about the thermal evolution of Earth that might explain why the upper mantle was cool enough to produce diamonds in the Archean Eon (4 to 2.5 ga), rather than just graphite. A research team from Queensland and Ireland looked at the magnesium oxide levels in thousands of 2.5 ga or older volcanic rocks collected from around the world. Their analysis contradicts the conventional belief that the Earth's mantle was a lot hotter than it is in today. Although the mantle produced about 2.5 to 3 times the current amount of heat, most geologists believed that the whole mantle was significantly hotter until the end of the Archean Eon, about 2.5 billion years ago. The team's research, however, indicates that is only half right. The LOWER mantle was significantly hotter, sure, but the UPPER mantle was no hotter than it is today. And the upper mantle matters most because it produced the magma that became the volcanic rocks we see around the planet.

The question, therefore, is not how much heat the Earth is producing, but how warm it was in the planet's interior. The assumption has been that there was more heat; therefore, it was hotter. What the researchers showed instead is that the Earth was producing more heat but was also expelling it at the same time. Their cool-upper-mantle theory would help explain the formation of diamonds, most of which were formed during the Archean, and which should have been just lumps of graphite if the upper mantle was too hot.




**The Earth's upper mantle was much cooler than previously thought during the early Precambrian.**

The hypothesis also answers a long-standing question about the movement of tectonic plates: if the upper mantle had been much hotter 2.5 ga, then the oceanic plates would have been thicker and difficult to move under each other. A cooler upper mantle, which would have been churning hot magma from the lower mantle upwards towards the surface to release the heat, explains how the plates would have moved fast and collided with each other. Understanding the thermal evolution of the Earth is critical to understanding many aspects of our planet, such as the evolution of the atmosphere, the emergence of land, and the evolution of life.

**http://www.sci-news.com/geology/earths-cool-upper-mantle-theory-07030.html**

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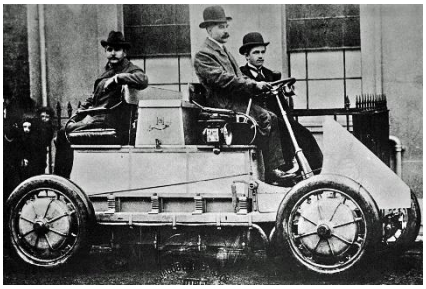
### *Fun Fact Having Nothing to Do with Geology*

*Ferdinand Porsche, founder of the Porsch automobile company, designed the first hybrid gasoline-electric vehicle in 1900 when he was 25 years old. He called it the Lohner-Porsche Semper Vivus. It had two generators paired with gasoline engines that formed a single charging unit, supplying electricity to wheel-hub motors and batteries simultaneously.*



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