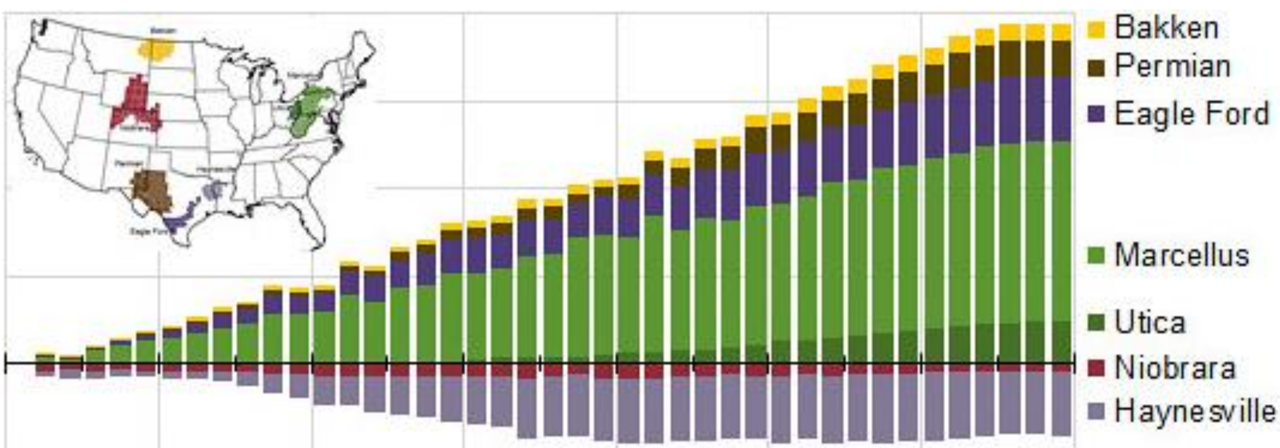
PITTSBURGH GEOLOGICAL SOCIETY

Creating Giants: Insights into the depositional and diagenetic pathways that created two of the most prolific unconventional reservoirs in the U.S. - the Ordovician Utica Shale/Point Pleasant Limestone and the Devonian Marcellus Shale



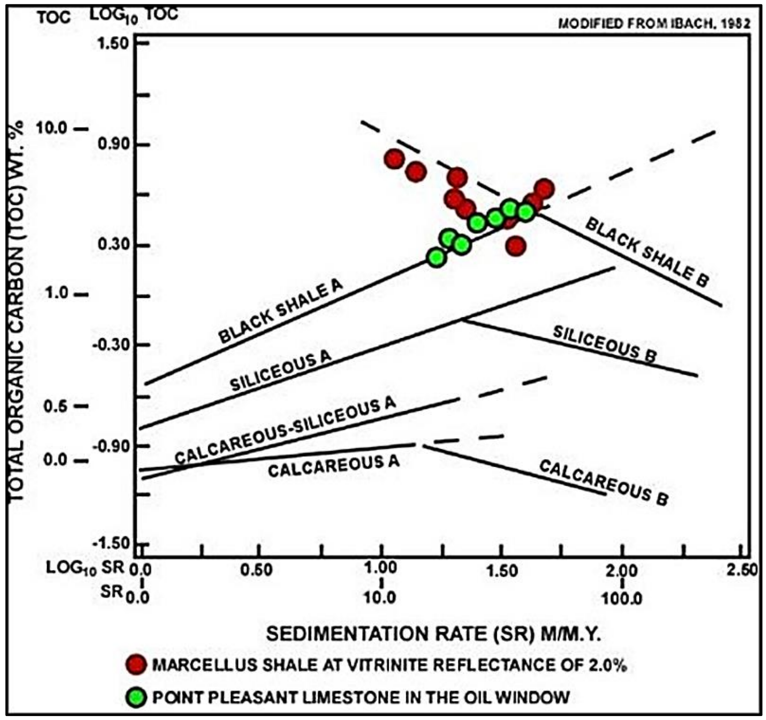
Speaker: David (Randy) Blood
President, DRB Geological Consulting

Meeting to be held via Zoom on May 13, 2020, at 7:30 PM.

Information on how to register and log in will be sent to PGS members via email. Please log in by 7:15 PM to avoid possible disruptions during the presentation.

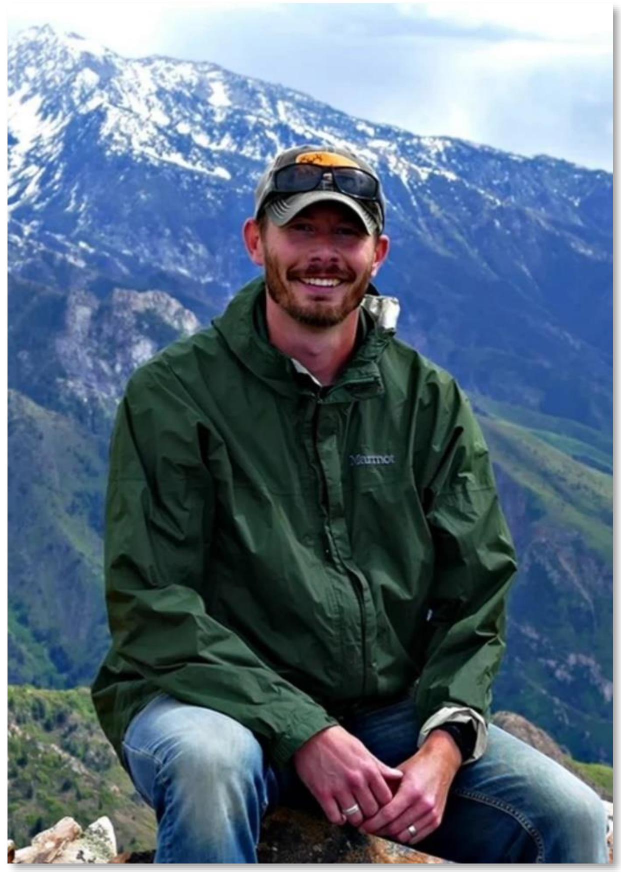
Speaker Abstract

Appalachian Basin “shale gas” has become a significant component of U.S. natural gas production. Indeed, the EIA reports that the Devonian Marcellus Shale and Ordovician Utica/Point Pleasant accounted for 85% of the U.S shale gas production growth since 2012. While these two shale plays display similar production mechanisms (organic matter-hosted pores are the major source of porosity), the conditions under which these deposits accumulated were markedly different, and should be considered when exploring and identifying sweet spots. Vertical chemostratigraphic profiles and pyrite morphology trends were developed on core retrieved from both formations. The Marcellus exhibits enrichments in redox sensitive trace elements, a framboid population detailing abundant small, <5 µm framboids, with subordinate large framboids, and occasional bioturbation. These observations suggest that sediments accumulated under dominantly anoxic to euxinic bottom waters that were occasionally subjected to periods of (dys)oxia.



The high total organic carbon content of the Marcellus Shale is largely the result of increased preservation due in part, to favorable oxygen-depleted conditions, while concentration was controlled by dilution from clastic influx. Conversely, the Point Pleasant comprises mudstones and marls largely devoid of redox sensitive trace elements, minimal pyrite, a paucity of iron, and a number of in situ shell bed horizons. These observations suggest the Point Pleasant accumulated under oxic to dysoxic bottom water conditions. Further, the lack of iron, a biolimiting nutrient, and lower preservation potential due to oxidation of organic matter, yielded a formation of lower organic carbon concentration, where preservation occurred by rapid burial. It is noteworthy that, despite the lower organic carbon content, locally the Point Pleasant hosts a pore pressure gradient far in excess of that observed in the Marcellus. While expulsion fractures, including Mode I vertical catagenic fractures, are common to the Marcellus, they are infrequent to absent in the Point Pleasant study area. One explanation is that the pressure needed to overcome the compressive stress carried by higher modulus, carbonate-rich sediments was never achieved, thus limiting fracturing and hydrocarbon expulsion and preserving its high pressure. Conversely, stress build-up from pore pressure resulting from hydrocarbon generation in lower modulus, more clay-rich Marcellus sediments exceeded the tensile strength of the rock causing it to fracture and release hydrocarbons, subsequently lowering reservoir pressure.

Speaker Biography



Randy (David) is a geologist and petrophysicist, and the president of DRB Geological Consulting. Based in the greater Pittsburgh area he works on many aspects of the Utica/Point Pleasant petroleum system and the Marcellus Shale including basin scale depositional trends, depositional environments, organic and inorganic geochemistry, and litho- and stratigraphic analysis as they relate to reservoir development and wellbore placement. His current interests including evaluation of subtle sedimentary features within mudstones and how they affect hydrocarbon transport, drilling, and completions.

Before starting DRB Geological Consulting, Randy worked for Chesapeake Energy and EQT Production evaluating their unconventional assets, defining horizontal landing zones, and using inorganic geochemistry data to model facies, estimate rock mechanics, and help solve wellbore stability issues. While with Pure Earth Resources, he evaluated numerous unconventional and conventional plays across the United States, Canada, and Europe including the U.K. and Spain. He has authored a number of publications on unconventional reservoirs, and given over 50 presentations at technical meetings, symposia, and invited lecture programs for which he has received numerous awards, including two PGS Awards for the Best Paper on Appalachian Geology at both the 2017 and 2018 Eastern Section AAPG annual meetings.. Randy holds a B.S. degree in Geology from SUNY Fredonia (2003), and an M.S. degree in Geology from the University at Buffalo (2006).

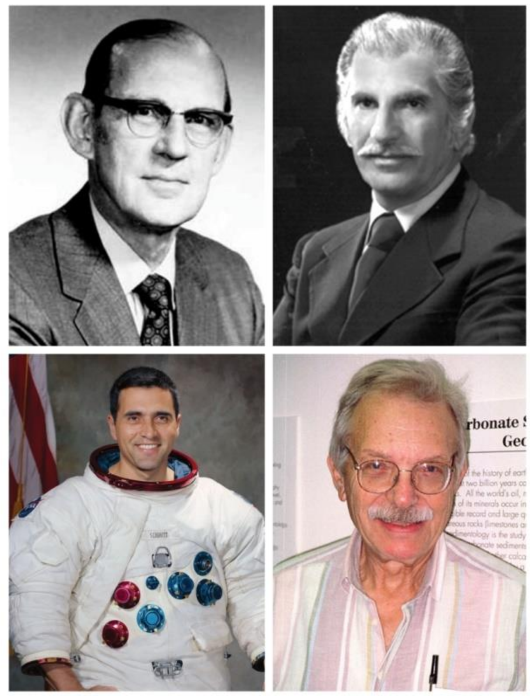
State Registration Board for Professional Engineers, Land Surveyors and Geologists

Due to the current coronavirus pandemic, social distancing guidance from the Federal and State government and remote work is making it difficult for Professional Engineers, Land Surveyors and Geologists to issue final or complete documents to clients, where Professional Engineers, Land Surveyors and Geologists might interpret existing regulations to require a physical stamp and signature. The Department of State is providing this notice to clarify that all licensees of the State Board of Professional Engineers, Land Surveyors, and Geologists may utilize electronic/digital signatures and seals until such time that Governor Wolf determines that the statewide emergency proclamation may be lifted. Electronic/digital signatures and seals affixed during this statewide emergency shall be recognized as originals notwithstanding the end of the current statewide emergency

The Story of Our Later Years

In celebration of our 75th Anniversary, the April and May issues of our newsletter will include a two-part retelling of our society's history as documented by John Harper, PGS Counselor.

Since its inception, the Pittsburgh Geological Society has provided a well-rounded set of programs for the geological community of western Pennsylvania and adjacent areas. PGS meetings continued to feature many nationally and internationally recognized experts. Some of the more prominent who have spoken since the mid-1950s included Harold R. Wanless, Robert R. Berg, Michael T. Halbouty, Robert N. Ginsburg, Hollis D. Hedberg (who was also a long-time PGS member), Francis G. Stehli, C. Blain Cecil, Robert L. Bates, Scott W. Tinker, and Apollo 17 astronaut Harrison Schmitt, the first geologist on the moon.



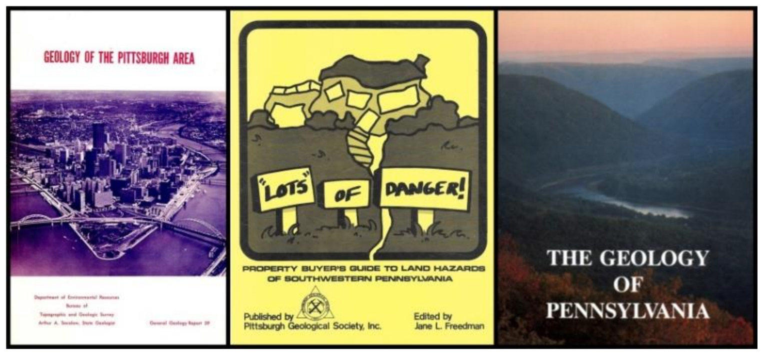
Some of the famous geologists who spoke at PGS meeting since the mid-1960s included, clockwise from top left, Robert L. Bates, Michael T. Halbouty, Robert N. Ginsburg, and Harrison Schmitt.

Today's meetings typically draw somewhat fewer attendees than during the first 10 years of PGS, but average attendance has been relatively constant since 1970. Joint meetings typically have the highest numbers of attendees. The recent January 2020 joint meeting with the Pittsburgh Chapter of the American Society of Civil Engineers (ASCE) and the Association of Environmental and Engineering Geologists (AEG), for example, drew an astonishing 170 attendees. Since 1979, the September PGS meeting has been designated the *Walter R. (Dick) Wagner, Jr. Memorial Meeting*, devoted to Appalachian geology of Pennsylvania and adjacent states. This meeting honors the late Dick Wagner, a Pennsylvania Geological Survey employee and very active – one might say essential – long-time PGS member who passed away in 1975. In 2003, April meetings were designated as Student Night and organized as joint meetings with AEG and ASCE. These meetings are devoted to giving college students the opportunity to present their research to the Society and vie for financial awards.

Between the mid-1950s and mid-1960s, meetings were held in various venues, including the Hotel Webster Hall in Oakland (now an apartment building), the Schenley Park Hotel (now the William Pitt Union at the University of Pittsburgh), the cafeteria and libraries of Carnegie Institute of Technology (now Carnegie Mellon University), the University Club on the Pitt campus, and even at the Y.W.C.A. downtown. In the mid-1960s, meetings mostly occurred at the Howard Johnson Motor Lodge (now the Quality Inn University Center) in Oakland until February 1969 when they switched to Duquesne University's Mellon Hall of Science. Shortly afterward, PGS moved its meetings to the former Terrace Restaurant in Parkway Center #3 in Green Tree (now occupied by a home healthcare service). This venue lasted as the Society's home for almost 30 years, until September 1999 when PGS moved to Foster's Restaurant in Foster Plaza #10, also in Green Tree. Finally, in January 2019, PGS moved to its current site in Carnegie where meetings are held in an old church that was renovated and repurposed as Cefalo's Banquet & Event Center.

Monthly meetings have not been PGS's only offering to the geological community from the beginning. In addition to the monthly programs, PGS has also sponsored or co-sponsored:

- Field trips typically, but not always, of one-day duration, meant to broaden the understanding of local and regional geology. The Society strives to run at least one spring or autumn field trip annually;
- Occasional short courses for professionals including such topics as: geostatistics, engineering geophysics, sandstone and carbonate exploration methods, geophysics, and GIS;
- Annual workshops for students devoted to preparing them for careers in the geosciences;
- Judges for regional science fairs, currently called the Covestro Pittsburgh Regional Science & Engineering Fair. PGS has been supporting science fairs since the 1950s;
- Regional meetings of the Northeastern Section of GSA and the Eastern Section of AAPG;
- Special publications such as *Geology of the Pittsburgh Area* (1970), *"Lots" of Danger: Property Buyers Guide to the Geology of Southwestern Pennsylvania* (1977), and the hugely popular 888-page *The Geology of Pennsylvania* (1999);

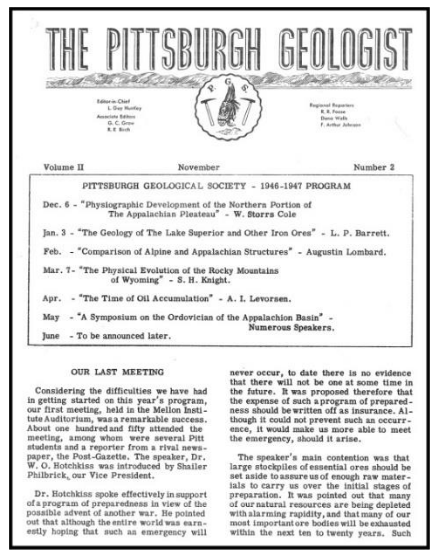


- Awards and recognitions. PGS currently has three awards that it bestows, including:
  - ✓ Two awards for middle and high school students at the annual science and engineering fairs, consisting of a check and a certificate for quality projects dealing with earth science topics;
  - ✓ The *Walt Skinner Award*, given occasionally since 1987 to honor those members who have provided exceptional service to the Society and to the geological community at large. As of May 2020, the list of Walt Skinner Awardees, including deceased, numbered 17. The names of all award winners will be listed in the 2019-2020 Membership Directory;
  - ✓ The *PGS Award for the Best Paper on Appalachian Geology*, awarded annually at the Eastern Section AAPG Annual Meeting.

When PGS became a formal society in April 1945, the governing body consisted of a Council that included the President, Vice President, Secretary, Treasurer, and seven (later, six) general Councilors. The structure of this governing body lasted until November 1973 when the Society became legally incorporated as a 501(c)(3) (not-for-profit) organization, requiring a Corporate Seal, and giving PGS tax-exempt status. The Constitution and By-Laws were overhauled and the Council was redesignated as the Board of Directors. The Board currently includes the immediate Past President, President, Vice-President, Secretary, Treasurer, one or more Counselors, and six Directors-at-Large who hold two-year terms in a staggered fashion so that three Directors are elected each year. Officers and Directors have always been elected from a broad cross-section of the professional membership. Other formal PGS positions include the Newsletter Editor, Webmaster, Historian/Archivist, Student Representative, and AAPG Delegate. These positions, appointed by the Board, are non-voting members who are encouraged to participate in Board meetings to offer advice and discussion. PGS also has a selection of committees, both standing and ad hoc, that do much of the day-to-day work of the Society. There currently are nine standing committees: Awards, Audit, Communications, Continuing Education, Finance, Membership, Nominations and Elections, Outreach, and Program. Each consists of a Chairperson and designated committee members. The President is an ex officio member of all committees. Occasionally, the Board will create an ad hoc committee charged with a specific tasks and functions for a relatively short time. When that task has completed, the chairperson submits a brief report describing the results and the committee is disbanded.

The three membership categories established by the Founders – Member, Student, and Associate – evolved over the years. In 1970, in celebration of the Society's 25th Anniversary, 18 members, mostly Founders, who had maintained active membership through the years, were named Honorary Life Members. This category later morphed into the Honorary Member category, established to venerate those members who had been actively involved with PGS for a substantial number of years. The list of Honorary Members continues to grow. As of May 2020, the Society had honored 51 members, most of them now deceased. Their names will be listed in the 2019-2020 Membership Directory. Associate membership was eliminated in 1990 and anyone in that category was granted full Member status. Two additional categories were created in the past 40 years: Corporate Member in 1982 for any corporation or organization that supports the Society, and Recent Graduate Member in 2014 for any Student Member choosing to maintain membership for the year following graduation. All current members, with the exception of Students and Recent Graduates, are eligible to vote and to run for any position on the Board of Directors. Although total PGS membership has waxed and waned from year to year, it has not changed significantly in the past 75 years. Early membership in PGS typically was between 150 and 200. During the 1960s and 1970s it averaged between 150 and 250. Average membership since the 2000-2001 program year has averaged 233 in all membership categories, only 61 more than the 172 members the Society had in its first year. Much of that increase is due to the increase in Student membership since the 1960s.

The Society's connection to the membership has always been the newsletter. Originally called *The Pittsburgh Geologist*, the newsletter's name lasted until the mid-1960s when it became known simply as the PGS newsletter. For 25 years, the one- or two-page newsletter was printed on a mimeograph machine, stuffed into envelopes, addressed by hand or on a typewriter, and posted using stamps. In January 1970, PGS began to employ commercial printing companies to print the newsletter, an arrangement that served the Society's needs for the next 30+ years. Envelopes were still hand-addressed and stuffed, but the advent of a postage meter cut down on some of the toil. In 1978, the newsletters were merely folded, stapled, and adorned with printed address labels, thereby saving the added cost of envelopes. Because of the expense of printing and mailing, the newsletter was rarely more than four pages long until September 2013 when email replaced printed newsletters and allowed the editor to expand the amount of information included in it. Now, the newsletter commonly 10 to 20 pages in full color.



THE PITTSBURGH GEOLOGIST

Volume II — November — Number 2

PITTSBURGH GEOLOGICAL SOCIETY - 1946-1947 PROGRAM

Dec. 6 - "Physiographic Development of the Northern Portion of The Appalachian Pleateau" - W. Storrs Cole

Jan. 3 - "The Geology of The Lake Superior and Other Iron Ores" - L. P. Barrett.

Feb. - "Comparison of Alpine and Appalachian Structures" - Augustin Lombard.

Mar. 7- "The Physical Evolution of the Rocky Mountains of Wyoming" - S. H. Knight.

Apr. - "The Time of Oil Accumulation" - A. I. Levorsen.

May - "A Symposium on the Ordovician of the Appalachion Basin" - Numerous Speakers.

June - To be announced later.

OUR LAST MEETING

Considering the difficulties we have had in getting started on this year's program, our first meeting, held in the Mellon Institute Auditorium, was a remarkable success. About one hundred and fifty attended the meeting, among whom were several Pitt students and a reporter from a rival newspaper, the Post-Gazette. The speaker, Dr. W. O. Hotchkiss was introduced by Shailer Philbrick, our Vice President.

Dr. Hotchkiss spoke effectively in support of a program of preparedness in view of the possible advent of another war. He pointed out that although the entire world was earnestly hoping that such an emergency will never occur, to date there is no evidence that there will not be one at some time in the future. It was proposed therefore that the expense of such a program of preparedness should be written off as insurance. Although it could not prevent such an occurrence, it would make us more able to meet the emergency, should it arise.

The speaker's main contention was that large stockpiles of essential ores should be set aside to assure us of enough raw materials to carry us over the initial stages of preparation. It was pointed out that many of our natural resources are being depleted with alarming rapidity, and that many of our most important ore bodies will be exhausted within the next ten to twenty years. Such

First page of the November 1946 *The Pittsburgh Geologist,* as PGS's newsletter was called for the first 20 years.

In December 1992, the Pennsylvania Legislature revised Act 23 of 1945, the Engineer and Land Surveyor Registration Law, to include the registration of geologists. The legislation went into effect a year later requiring all practicing geologists in Pennsylvania to be registered by the Pennsylvania State Registration Board for Professional Engineers, Land Surveyors and Geologists, unless considered to be exempt under Section 5. The act was emended in 2010 to clarify mandatory continuing education requirements. All licensed Professional Geologists and Professional Engineers (PGs and PEs) are required to complete at least 24 professional development hours (PDHs) of training during the two years between license renewals. PGS provides the additional service of issuing PDH certificates to PGs and PEs who attend meeting presentations, short courses, and field trips. As a result, the Corporate Seal's primary purpose now is to stamp PDH certificates, thus ensuring their legitimacy.

PRESIDENT'S STATEMENT

Altering History

If we look at human history, nothing has killed more people than infectious disease. Covid-19 has shown us how vulnerable we are, and the response to the outbreak was simple,-- shelter in place to stop the spread. The response united scientists around the world as they began using cutting-edge research to sequence the coronavirus genome to develop vaccines and medications and to educate the public. However as of right now, the most effective method for protecting the population is to self-isolate. Self-isolation gives people plenty of time to reflect and the ways this pandemic will alter history is undeniably mind numbing.

Since the virus showed up on the global stage, oil prices have plummeted, dropping below zero in one day, along with a wildly fluctuating stock market. Businesses have closed and millions of people are unemployed. All schools are ending the academic year virtually. Organizations canceled their professional conferences and popular programs, and live music events have been curtailed. It is not the first time that oil prices have dropped, or the unemployment numbers escalated, but somehow this feels different. Maybe it is because I am older, isolated, and have more time to ponder the impacts. When this is over, what will life be like? Will we continue as we did before the stay at home orders?

It is certain that the increased use and dependency on technology will continue, some individuals may never return to their office spaces and working remotely may become more of the norm. Our health care system will likely see some much-needed improvements and we may even see more support for universal health care.

Individuals are developing new "normal" habits. Some will be hygiene related, like frequent hand washing, disinfecting surfaces and wearing a mask in crowded spaces. Another new norm -- perhaps renewed communications with family and friends. People have realized the benefits that a sense of community can bring by coming together sharing compassion and spreading kindness. What could have turned into a bad situation, like major rioting, protesting and looting in the streets, has turned into communities expressing appreciation to those serving on the front lines, caring for elderly neighbors and increasing donations to food banks. This is not to say there have been no protests, as there have been for various reasons likely spurred on by politicians and radical/fringe groups. But in my mind, compassion and love will prevail.

On the forefront of my uneasiness, however, is what education will look like in the future. Will education and teachers finally get the attention that they have been needing? The education system in our country has been neglected for years. Maybe now, with millions of school children forced to learn from home while parents are also trying to work, money will be invested to update the educational system and teachers will get the respect and pay they deserve. Hopefully, back up plans will be put into place and the way we educate will become that much better. New modalities are improving the way we transmit content material, and students are becoming, or are forced to become, self-learners.

What cannot be replaced is the field component of our science. This is essential in any geoscience curriculum. As much as I am saddened at not being able to offer that to my students this semester, I can't help but think that the way we conduct field work will improve. People have the time not only to develop new technologies but also to learn to use them, such as the operation of drones and applications to

(Continued on next page)

improve data acquisition. I also think that forcing students to be self-learners will benefit society by improving the critical thinking, problem solving and communications skills of graduating seniors.

Dissemination of the improvements in our understanding of Earth has always been presented at professional society meetings. Will these meetings continue, and if so, how will they look? As far as PGS meetings, I hope that we will be able to resume our monthly face-to-face meetings in September, sharing laughter, conversation and a good meal. For now, we will host the last meeting of the program year via Zoom on May 13th. This is by no means ideal, but it is a way to bring our community back together to share for a moment in the commonality that unites us. For now, we will continue to follow the stay at home orders and make the best of these times. What the future will bring is anyone's guess. What is certain, however, is that we are altering history in ways we may never realize.

Stay well, be safe and please keep an eye out for an invitation to join us via Zoom on May 13th.

Tamra

Nominations & Elections

The nomination period for officer and board candidates for the upcoming PGS election closed on April 15th, 2020. I am pleased to announce this year's slate of candidates as follows:

President:	Tamra Schiappa
Vice President:	Daniel Harris
Secretary:	Diane Miller
Treasurer:	Kyle Fredrick

Director at Large (Two Year Term):

Brian Dunst	Raymond Follador
Mary Ann Gross	Albert Kollar
Nancy Slater	

All eligible voting members of the Society will be receiving their ballot sometime shortly after the mailing of the May Newsletter. ***Due to the current Covid-19 circumstances we <u>STRONGLY URGE</u> that all ballots be cast via <u>EMAIL</u>***. If you are unable to vote electronically an alternate mailing directive will be noted on the ballot. Please remember, the May 13th Society meeting will be virtual so there will be no opportunity to cast your ballot at the meeting as some of you have traditionally done.

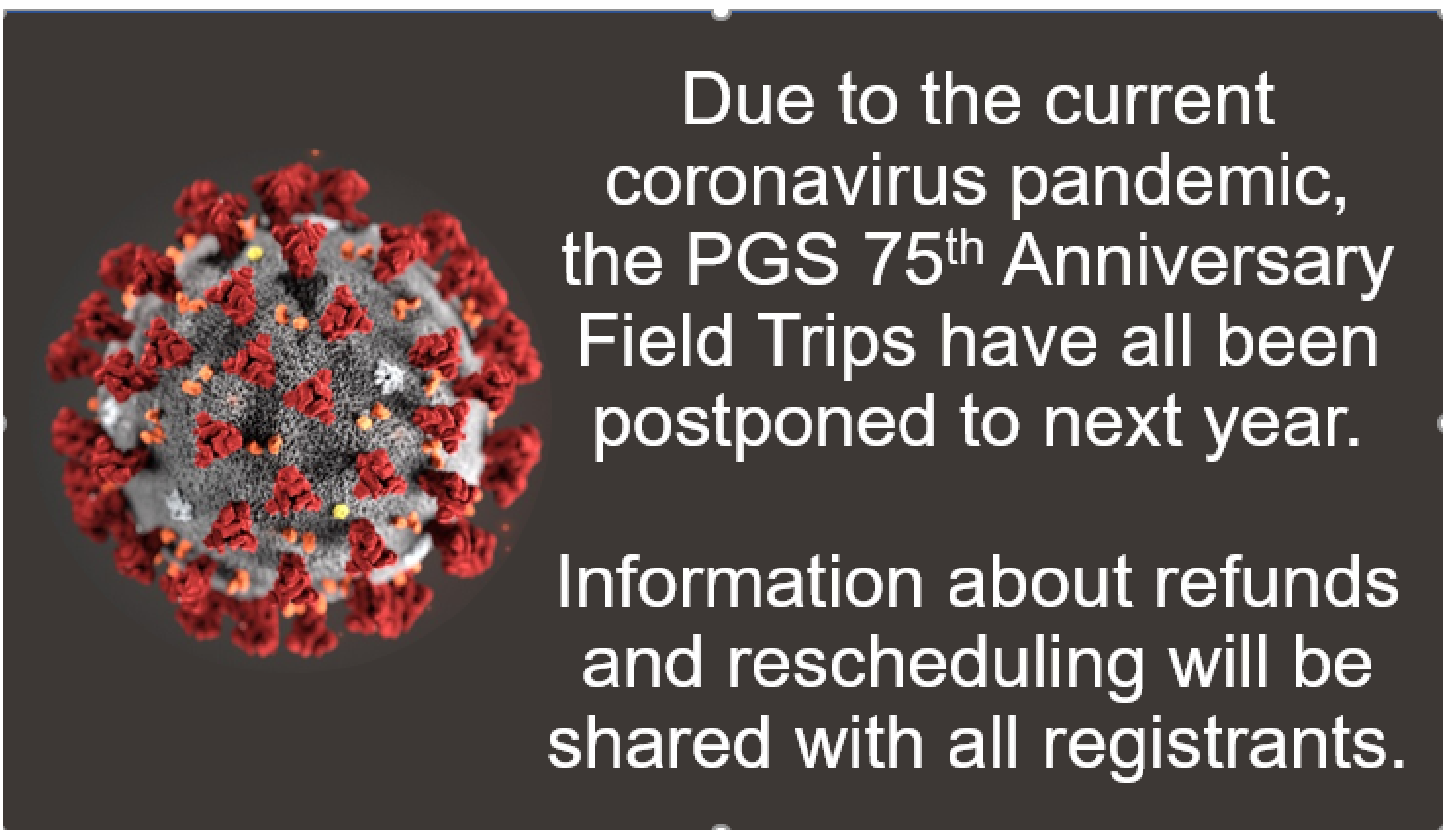
Stay safe. Stay healthy.

Ray Follador
Chair – Nominations & Elections Committee

A Eurypterid Walks Into a (Sand) Bar …..

A large eurypterid walks out of a stream onto a sand bar in what will one day become Elk County, Pa., leaving behind a set of tracks that will be on display at the Carnegie Museum of Natural History in Pittsburgh 320 million years later. Read more about this specimen in a fascinating article written by PGS members John Harper and Albert Kollar, along with Kay Hughes of Mount Holyoke College in the Winter 2019 issue of Pennsylvania Geology, available free to download from this site:

http://www.docs.dcnr.pa.gov/cs/groups/public/documents/document/v49n4.pdf



THE ORIGIN OF WESTERN PENNSYLVANIA PLACE NAMES

As if it weren't already obvious, the town of Braddock, about 10 miles up the Monongahela River from downtown Pittsburgh, was named for Major General Edward Braddock, the British officer and commander-in-chief for the Thirteen Colonies at the start of the French and Indian War. Braddock commanded a disastrous expedition against the French-occupied Ohio River Valley in 1755 at an area known as Braddock's Field. During a battle when his troops attempted to cross the river where the town now stands, Braddock was mortally wounded and his troops were soundly defeated. This Battle of the Monongahela was a key event at the beginning of the French and Indian War.

Historical photo of the Braddock Public Library, the first library in the United States built with the generosity of steel magnate Andrew Carnegie.

The Lenape Indians, ruled by Queen Allequippa, originally inhabited the area now occupied by the town of Braddock. In 1742, John Fraser and his family established the area at the mouth of Turtle Creek as the first permanent English settlement west of the Allegheny Mountains. The town was incorporated as a borough in 1867 and, in 1873, Andrew Carnegie built the Edgar Thompson Steel Works on the site of Braddock's Field. The plant, which is still in operation, was one of the first in the US to use the Bessemer process in making steel. Braddock is also historical in being the location of the first of the more than 1,600 libraries Carnegie had built in the country.

DID YOU KNOW . . . ?

PITTSBURGH GEOLOGICAL SOCIETY 1945 - 2020

Looking back 75 years ….

The last meeting of PGS's first program year, 1944-1945, was held May 28, 1945 in the clubrooms of the Engineers Society of Western Pennsylvania in the William Penn Hotel (now the Omni William Penn). It was a symposium on the continuing wartime activity (VE Day, May 8, 1945, had not yet occurred when the announcement went to press) of the U. S. Geological Survey in the Ohio-Pennsylvania-West Virginia area, especially concerned with a detailed study of the Berea Sandstone and its equivalents. Discussion was led by three distinguished USGS geologists, Dr. James F. Pepper, David F. Demarest, and Dr. Gordon Rittenhouse.

Gordon Rittenhouse (1910-1974), was born in Chicago where he attended public school and graduated from the University of Chicago with a bachelor's degree in 1932, a master's degree in 1933, and a Ph.D. in 1935, all in the field of geology.

Portrait of Gordon Rittenhouse, one of three speakers who led a discussion of U.S. oil interests in Alaska at the May 1945 PGS meeting.

While still a student, he joined a field party led by Francis Pettijohn to northwestern Ontario where he was introduced to both Pleistocene varved clays and Archean sedimentary and volcanic rocks of the region. The varved clays became the subject of his master's thesis, the establishment of a 1,600-year varve chronology of northwestern Ontario, and led to his first two scientific papers. The Archean rocks, a thick sequence of sediments and volcanic flows, became the subject of his doctoral thesis, the first study of these rocks in any significant detail. In the words of Francis Pettijohn, his memorialist, "This early work, done without any grant support, with no remuneration other than the joy of discovery, and under often adverse conditions, arduous canoe travel, sweaty portages, difficult bush traverses accompanied by hordes of black flies and mosquitoes, camping without benefit of air mattress, sleeping bag, Coleman stove, or the modern dehydrated foods tested the mettle of the field geologist."

Following his Ph.D. in 1935, Gordon went to work with the research arm of the Soil Conservation Service. Although originally tasked with designing and establishing a laboratory for analysis of alluvial sediments, he quickly became involved instead in field work, particularly measuring the rate of gully erosion and excessive alluvial sedimentation due to aggravated erosion. He played a major role in establishing the criteria for distinguishing between those and older sediments, being the first to recognize that abundant soil concretions served to recognize older deposits in places where no buried topsoil occurred. He also studied Rio Grande sediments in New Mexico to determine their source, resulting in the concept of "hydraulic equivalence" for comparing sand grains differing in density.

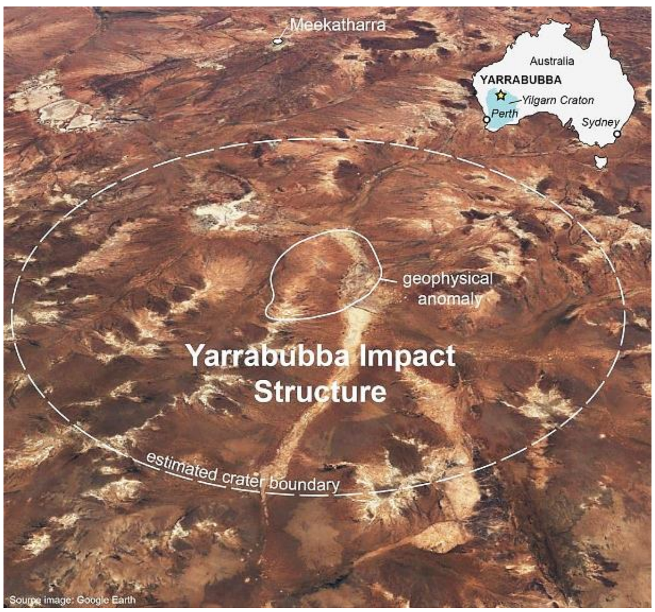
In 1943, Gordon transferred to the USGS's Fuels Section in Morgantown, WV, where he applied sedimentary petrology to the study of Appalachian Basin rocks in order to determine favorable areas for oil and gas exploration. This led him into the study of petroleum geology where he excelled in subsurface geology, sample and core logging, sand-body geometry, and stratigraphic traps. At the end of WWII, while retaining his USGS appointment on a part-time basis, he became an Associate Professor of Geology at the University of Cincinnati where he excelled at imparting to his students the necessity of careful observation, honest and objective appraisal of the facts, using alternative hypotheses, and formulating criteria to obtain a definitive answer to any problem. He taught them to use petrology to reconstruct the total history of the rock.

In 1947, Gordon resigned from the USGS to become a consultant on sedimentation and sedimentary petrology. In 1951, he was employed by the Shell Oil Company until he retired in 1973. While at Shell, he worked in Tulsa as a consultant on special problems, in Denver as a senior geologist, and in Houston as a geological manager in the Exploration and Research Division, a consultant to the Exploration and Production Research group, and Consultant to the Head Office in Exploration. During his employment, he contributed papers to several AAPG symposia, including one of the most complete classifications of stratigraphic traps on record, dealing with the form and geometry of sandstone bodies. He also became interested in oil-field brines and in the effects of diagenesis on compaction and pore-space reduction in oil sands.

Gordon was active in a variety of professional organizations, including:

- Fellow of the Geological Society of America, 1944; Associate Editor, 1963 to 1970
- Member of the American Association of Petroleum Geologists, 1946; member of the Research Committee, 1957 to 1958
- Vice-president of the Society of Economic Paleontologists and Mineralogists, 1948; President, 1958; Councilor, 1959 to 1960; and Honorary Member, 1972
- Member of the Geological Domain Committee of the American Petroleum Institute, 1956 to 1964; Chairman, 1963 to 1964; member of the Government Liaison Committee, 1965 to 1973
- Member of the Pittsburgh Geological Society
- Member of the Rocky Mountain Association of Geologists
- Member of the Houston Geological Society
- Member of the Gulf Coast Association of Petroleum Geologists
- Member of the International Association of Sedimentology.

Many of the major events in geologic history involved a bolide impact, yet despite the long history of meteorite and comet impacts on Earth, finding unequivocal evidence for such collisions can be hard to find. Even the largest impact craters tend to disappear over time due to erosion, sedimentation, and tectonic activity. Yarrabubba crater in Western Australia, approximately 45 miles in diameter, was discovered in 2003 but all that's visible today is a small red hill at the area's center, known as Barlangi Hill. The rocks that form this hill hold minerals containing valuable information about the impact's age. The mineral grains were subjected to smashing, melting, and recrystallizing to, among other things, monazite and zircon, by the impact.



The estimated shape of the Yarrabubba impact crater in Western Australia. The structure might be part of the oldest known impact crater on Earth.

Now, those minerals contain neoblasts that researchers have dated with U-Pb to reveal the bolide impacted approximately 2.229 ga. This date puts the Yarrabubba impact at the end of one of the global "Snowball Earth" ice ages in the Precambrian. After establishing the age, the researchers ran computer simulations of an impact big enough to create a 45-mile-wide crater on a continent-size glacier. The results showed that the crash would have instantaneously vaporized huge amounts of ice, potentially releasing enough water vapor to equal about 2% of that currently in Earth's atmosphere.

Water vapor is a powerful greenhouse gas, so it is possible that injecting that much water vapor into the atmosphere could have helped warm the planet, triggering the end of the "Snowball Earth" period that occurred roughly 2.2 billion years ago. It's only a hypothesis at this point, however, a hypothesis that relies on a pretty big "if." Questions remain, such as how long the water vapor would have remained in the atmosphere and how much of a warming effect it would have had. Also, there is no certainty that an ice sheet covered Western Australia at the time of impact. Impact sites that are even older than Yarrabubba probably exist, and studying those could fill in more gaps in our understanding of the planet's geologic past, so it is just a matter of finding them. More climate research will also be necessary to better understand what actually happened.

https://www.livescience.com/worlds-oldest-meteor-crater-yarrabubba.html

On the subject of "still yet again another report" on the end-Cretaceous extinction, a group of scientists from Europe and the US has weighed in with what they claim is the definitive answer as to whether a bolide impact or colossal volcanism initiated the demise of the dinosaurs 66 million years ago. Their conclusion: it was the asteroid. The team's analysis of ocean sediments supposedly indicates that the Deccan Traps volcanism in India at the end of the Cretaceous did not change the climate enough to drive the extinction. Although volcanoes can spew enormous volumes of gases into the atmosphere that can both cool and warm the planet, and although the Deccan Traps certainly spewed tens of thousands of cubic miles of molten rock onto the land surface over thousands of years, the team claims there is a mismatch in both the effect and timing of the volcanism's influence.

When the end-Cretaceous asteroid hit what is now Chicxulub, Mexico, the impact supposedly hit with the energy equivalent of 10 billion Hiroshima bombs.

This information came from foraminiferan shells collected in core samples from the North Atlantic seafloor. Forams are well known indicators of ocean temperature and chemistry, so by studying the compositions of their shells, the scientists could study in great detail the environmental changes that occurred in the run-up to the extinction event. What they found was that the only way they could get their climate model simulations to match the observed temperature changes indicated by the forams was to have the volcanism completed and stilled a couple of hundred thousand years before the impact event, which they suggest occurred exactly contemporaneous with the extinction.

Scientists recently established that the bolide impacted rocks rich in sulfur, which, when it was vaporised and ejected into the high atmosphere, would have led to a rapid and deep cooling of the climate over a relatively short period, making life a struggle for all sorts of plant and animal life. The fossil record shows that the dinosaurs, apart from birds, couldn't get beyond the stressful environmental changes. In contrast, the mammals could and rose to the prominence they enjoy today. Now, if only someone could figure out how birds survived!

https://www.bbc.com/news/science-environment-51150001

We all know the Earth's inner core is very hot and under immense pressure. Did you also know it was snow-capped? According to new research, the snow is composed of tiny particles of iron that fall from the molten outer core and pile on top of the inner core, creating piles up to 200 miles thick that cover the inner core. Although this might seem like an alien winter wonderland, the scientists from China and the US who did the research said it is similar to how rocks form inside volcanoes with the core acting like a magma chamber.

The Earth's core can't be sampled, of course, so it can only be studied by seismic waves. However, there were abnormalities between the scientist's recent seismic wave data and the values they expected based on the current model of the Earth's core. The waves move more slowly than expected as they passed through the base of the outer core, and they move faster than expected when moving through the eastern hemisphere of the top inner core. This can be explained, suggests the team, by proposing the iron snow-capped core. In the early 1960s, a researcher had proposed that a slurry layer exists between the inner and outer core, but that hypothesis died because of the prevailing knowledge about heat and pressure conditions in the core environment.

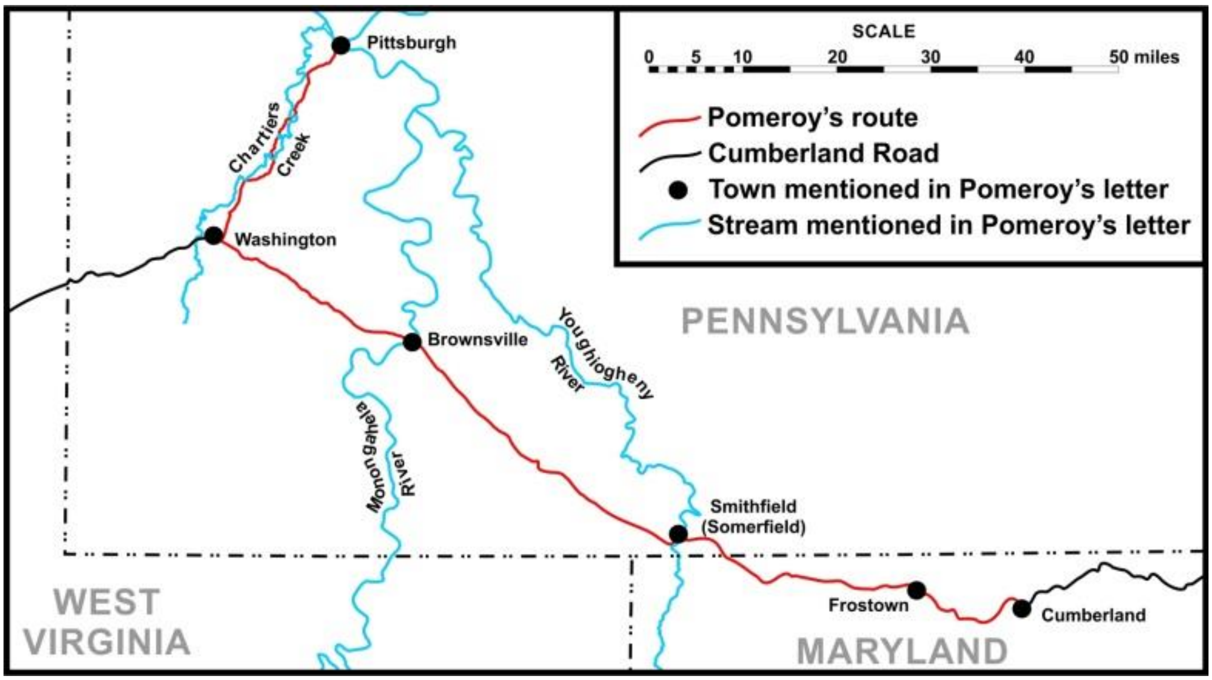
More recent data from experiments on core-like materials, however, found that crystallization was possible, and that about 15% of the lowermost outer core could be made of iron-based crystals that eventually fall from the liquid outer core and settle on top of the solid inner core, a distance of several hundred miles. A variation in snow pile size, such as thinner in the eastern hemisphere and thicker in the western, would explain the change in seismic velocity.

Snow at the Earth's Core? Geez – what would Edgar Rice Burroughs think?

The team compared the "snowing" of iron particles with a similar process that happens inside magma chambers closer to the Earth's surface involving minerals crystalizing out of the melt and sticking together. In magma chambers, the compaction of the minerals creates what's known as "cumulate rock." In the Earth's core, the compaction of the iron contributes to the growth of the inner core and shrinking of the outer core. The boundary between the outer and inner core is not a smooth surface. The irregularities probably affect the thermal conduction and the convections of the core. Since the core influences phenomena that affect the entire planet (e.g., generating the magnetic field and radiating heat that drives the movement of tectonic plates), learning more about its composition and behavior might assist in better understanding how those other processes work.

https://www.sciencedaily.com/releases/2019/12/191219162350.htm

In 1831, Samuel Wyllys Pomeroy published a letter, titled Remarks on the Coal Region between Cumberland and Pittsburgh, and on the Topography, Scenery, &c. of that Portion of the Alleghany Mountains, in the American Journal of Science and Arts (AJSA), v. 21, p. 342-347. Pomeroy (1764-1841), who was a descendant of both one of the original trustees of Dartmouth College and the Colonial Secretary of Massachusetts and Connecticut, had moved to Ohio and purchased land along the Ohio River in what is now Meigs County in 1804. His property included most of the coal-bearing land along the river for several miles, as well as abundant deposits of salt, building stone, fireclay, and glass sand. As such, Pomeroy, who eventually founded the Pomeroy, Sons & Company coal venture, was well acquainted with these mineral resources. The area was incorporated as the Village of Pomeroy and became the Meigs County Seat at the time of his death.



Map of parts of Maryland, Pennsylvania, and West Virginia showing Pomeroy's route from Cumberland to Pittsburgh.

Pomeroy traveled the Cumberland Road (now US Route 40) from Maryland to Washington, PA, then north to Pittsburgh. His descriptions of the geography and geology are interesting, given the embryonic state of knowledge in 1831. In describing the Ridge and Valley Province, he wrote, "I would here remind you, that some of the ridges of this stupendous chain, including their adjuncts, are designated by local names. For instance, the mountain over which the ascent commences, is called Shavers, in Maryland: the same ridge in Pennsylvania is known as Wills, where the next ridge is designated the Great Alleghany, which divides the waters that run into the Potomac from those that feed the Father of Rivers [Mississippi River]; and stretching across the state to Virginia, it reassumes its former cognomen."

He described the coal mined on the east side of Savage Mountain in Maryland: "I observed its combustion for some hours in a grate in the reading room of the inn at Hagerstown, and also in a smith's forge. The fracture and general characters very much resemble those of the coal from several localities on James' river in Virginia; it is equally fragile, and if large pieces are laid lightly on the grate, it burns with more flame; but the small coal cakes and stops the ventilation. Its specific gravity appears rather to exceed that of the Virginia coal: an intelligent smith stated that it was a strong coal, but contained considerable sulphur that often proved destructive to his iron; and appeared grateful for the information that, I could assure him on unquestionable authority, that a little salt sprinkled occasionally on the fire when well ignited, would protect the metal from the effects of sulphur." Pomeroy examined the coal with "a strong lens" but was unable ". . . to detect any organic vegetable remains or impressions." The coal mined on the west side of the mountain, in contrast, was considered much better quality. When the coal was mined, ". . . basins are formed in the under stratum of rock, from which it becomes necessary often to drain the water, which is however no difficult job, as it only requires a narrow trench to be cut through the slate, and perhaps a few inches into soft sand-stone that forms the pavement, from which is a fall some hundreds of feet."

Pomeroy found the road over the mountains reflected ". . . great credit on the engineers; the contour is admirable, and must be highly valued by geologists, as it presents a profile section across the whole range . . . The sandstone strata which are almost constantly in sight from the base of Shavers to near the greatest altitude of the Savage, incline 15° or 20°, as well as I could judge in passing rapidly – the dip opposite the setting sun in the middle of November. From thence it declines by gradations hardly perceptible to near the western base, and there becomes horizontal, like all the strata far beyond the Ohio. . . There are several varieties of sandstone; the most common has a yellow or ferruginous tinge, – the layers are of sufficient thickness for all the masonry on the whole line of road, and for this purpose it has been used in the numerous bridges, culverts and embankments, which are constructed with skill; but the cement has entirely failed, owing probably to substituting loam for sand, which appears to be rare in these regions; I have never been able to discover a pebble, or a handful of silex except in the beds of water courses, or that which is coherent in the sandstone, on any of these mountains, – the soil being a fine friable loam."

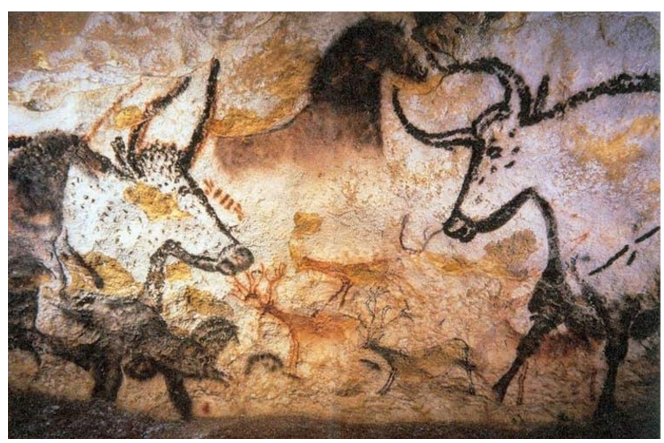
"The quality of the coal continues to improve till we reach the Youghiogeny [sic]. . . The coal on this stream justly deserves the reputation of superiority to any in this whole region. I examined a large heap at Smithfield*, where we crossed the Youghiogeny [sic], and could not find a single piece that was not beautifully iridescent throughout and exceeded, in richness of tints, those elegant specimens of anthracite which I viewed in [AJSA editor Benjamin Silliman's] cabinet; perhaps the fracture being cubical may have displayed them to more advantage; the same distinctive mark of the rainbow attaches to the coal on the banks of the stream till it falls into the Monongahela."

After a brief mention of Laurel Hill and Chestnut Ridge, Pomeroy continued: "The national road crosses the Monongahela at Brownsville, sixty miles (following the stream) above Pittsburgh. This village is founded on a bed of coal, of a quality superior to that of Pittsburgh; the precipitous banks directly opposite, present the first limestone in strata which I met with, but no coal is near, nor is any limestone found on the Brownsville side, unless in thin layers high above the coal. From this to Washington, Penn., the country becomes more level, and the coal banks are less frequent. There we turned off the national road to Pittsburgh, distant twenty six miles. The banks of Chartier's creek, which we crossed three or four times, are full of fine coal, which is hauled six miles to supply the borough of Washington and its neighborhood."

Pomeroy ended his letter with a statement with a forecast of the future of the coal industry in the Greater Pittsburgh Area that you could argue predated one of the main concepts of Lord Kelvin's On the Age of the Sun's Heat by 31 years, i.e., ". . . the sun and the bituminous coal of Western Pennsylvania will burn out together."

*The town was later renamed Somerfield. It was demolished and submerged in 1946 with the flooding of Youghiogheny Reservoir. Nothing remains but a campground, recreation area, and boat ramp bearing the town's name.

A question has long puzzled anthropologists and archaeologists - why did humans take so long to invent civilization? Modern Homo sapiens, us, first appeared about 250 to 350 ka, but our first steps towards civilization, such as harvesting and domesticating crops, have only occurred since about 10 ka; the first civilizations only appeared 6.4 ka. Ninety-five percent of our species' history



Our human ancestors hunted wild cattle, horses, deer, and other megafauna wherever they went for over 300,000 years. Then 10,000 years ago, they developed agriculture instead of subsisting on hunting. Why?

occurred before we started farming, creating large settlements, or organizing complex political hierarchies. We had survived in small nomadic bands by hunting and gathering for thousands of years. Then, around 10 ka, we transitioned from hunter-gatherers to plant harvesters, then cultivators, then city dwellers. And this transition began only after the Ice Age megafauna (e.g., mammoths and mastodons, giant ground sloths, giant deer) went extinct.

The reasons humans began to practice farming remains uncertain, but the disappearance of animals we supposedly depended on for food may have forced our culture to change. Early humans certainly were intelligent enough to farm. All groups of modern humans are equally intelligent, which suggests that our cognitive abilities evolved before the populations separated about 300 ka and changed very little afterwards. If our ancestors weren't farmers, it's because something in their environment kept them from developing that technology. Either that or they just didn't need to do it.

Sure, the end of the last glacial period 11.7 ka probably made farming easier. Temperatures were higher, there were longer growing seasons, more rainfall, and longer-term climate stability, all of which made more areas suitable for cultivation. But there were many such warming events between glacial periods of the last 325 ka, and farming didn't occur during any of those events. Although human migration might have contributed, people occupied most parts of the world long before farming began. Human migration preceded plant domestication by tens of thousands of years.

Farming has many disadvantages compared with a nomadic hunting lifestyle, not the least of which is being tied to the land and having to wait months for your food to develop. So, why become farmers at all? Some people insist it is because we were too good at what we did and hunted our food sources to extinction. Everywhere humans went, the larger animals, the megafauna, eventually disappeared. It may be that overhunting game caused the hunter-gatherer lifestyle to become less viable, and pushed people to harvest and eventually cultivate plants. Civilization might not have been born out of a drive to progress, but rather as a result of an ecological catastrophe that forced people to abandon their traditional lifestyles.

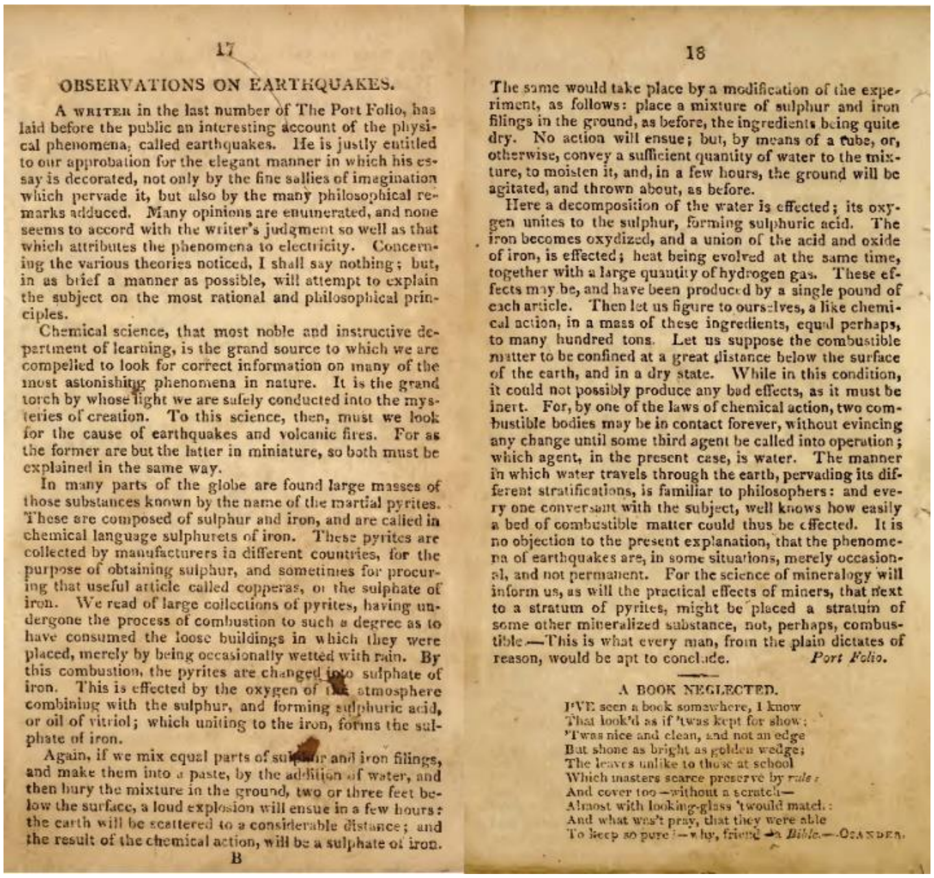
So, with the old way of life no longer viable, humans would have been forced to innovate. This allowed human populations to expand. Eating plants rather than meat is a more efficient use of land, so farming can support more people in the same area than hunting. People could settle permanently, build settlements, then civilizations. Our ancestors probably would have continued hunting horses and mammoths forever if they hadn't been so good at it that they probably wiped out our own food supply. They invented agriculture and civilization most likely because they had no choice. Agriculture was a desperate attempt to fix things when they took more than the ecosystem could sustain. If this is an accurate interpretation of events, our Ice Age hunter-ancestors created the seeds of our modern world, not because they saw a brighter future, but because of an ecological catastrophe. To the climate skeptics in the crowd – does this sound familiar?

http://theconversation.com/how-the-extinction-of-ice-age-mammals-may-have-forced-us-to-invent-civilisation-128799

It should be noted that not all of our geological "ancestors" were on the right track when they published the results of their studies, nor even of their imaginations. The following is from an essay called, "Observations on Earthquakes" published in Cramer's Pittsburgh Almanack, for the Year of Our Lord 1813. The author of the essay, who most likely was Zadok Cramer himself, wrote under the pseudonym Port Folio:

"Chemical science, that most noble and instructive department of learning, is the grand source to which we are compelled to look for correct information on many of the most astonishing phenomena in nature. It is the grand torch by whose light we are safely conducted into the mysteries of creation. To this science, then, must we look for the cause of earthquakes and volcanic fires. For as the former are but the latter in miniature, so both must be explained in the same way.

"In many parts of the globe are found large masses of those substances known by the name of the martial pyrites, These are composed of sulphur and iron, and are called in chemical language sulphurets of iron. These pyrites are collected by manufacturers in different countries, for the purpose of obtaining sulphur, and sometimes for procuring that useful article called copperas, or the sulphate of iron. We read of large collections of pyrites, having undergone the process of combustion to such a degree as to have consumed the loose buildings in which they were placed, merely by being occasionally wetted with rain. By this combustion, the pyrites are changed into sulphate of iron. - This is effected by the oxygen of the atmosphere combining with the sulphur, and forming sulphuric acid, or oil of vitriol; which uniting to the iron, forms the sulphate of iron.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OBSERVATIONS ON EARTHQUAKES.

A WRITER in the last number of The Port Folio, has laid before the public an interesting account of the physical phenomena, called earthquakes. He is justly entitled to our approbation for the elegant manner in which his essay is decorated, not only by the fine sallies of imagination which pervade it, but also by the many philosophical remarks adduced. Many opinions are enumerated, and none seems to accord with the writer's judgment so well as that which attributes the phenomena to electricity. Concerning the various theories noticed, I shall say nothing; but, in as brief a manner as possible, will attempt to explain the subject on the most rational and philosophical principles.

Chemical science, that most noble and instructive department of learning, is the grand source to which we are compelled to look for correct information on many of the most astonishing phenomena in nature. It is the grand torch by whose light we are safely conducted into the mysteries of creation. To this science, then, must we look for the cause of earthquakes and volcanic fires. For as the former are but the latter in miniature, so both must be explained in the same way.

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Again, if we mix equal parts of sulphur and iron filings, and make them into a paste, by the addition of water, and then bury the mixture in the ground, two or three feet below the surface, a loud explosion will ensue in a few hours: the earth will be scattered to a considerable distance; and the result of the chemical action, will be a sulphate of iron.

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The same would take place by a modification of the experiment, as follows: place a mixture of sulphur and iron filings in the ground, as before, the ingredients being quite dry. No action will ensue; but, by means of a tube, or, otherwise, convey a sufficient quantity of water to the mixture, to moisten it, and, in a few hours, the ground will be agitated, and thrown about, as before.

Here a decomposition of the water is effected; its oxygen unites to the sulphur, forming sulphuric acid. The iron becomes oxydized, and a union of the acid and oxide of iron, is effected; heat being evolved at the same time, together with a large quantity of hydrogen gas. These effects may be, and have been produced by a single pound of each article. Then let us figure to ourselves, a like chemical action, in a mass of these ingredients, equal perhaps, to many hundred tons. Let us suppose the combustible matter to be confined at a great distance below the surface of the earth, and in a dry state. While in this condition, it could not possibly produce any bad effects, as it must be inert. For, by one of the laws of chemical action, two combustible bodies may be in contact forever, without evincing any change until some third agent be called into operation; which agent, in the present case, is water. The manner in which water travels through the earth, pervading its different stratifications, is familiar to philosophers: and every one conversant with the subject, well knows how easily a bed of combustible matter could thus be effected. It is no objection to the present explanation, that the phenomena of earthquakes are, in some situations, merely occasional, and not permanent. For the science of mineralogy will inform us, as will the practical effects of miners, that next to a stratum of pyrites, might be placed a stratum of some other mineralized substance, not, perhaps, combustible.—This is what every man, from the plain dictates of reason, would be apt to conclude. *Port Folio.*

A BOOK NEGLECTED.

I'VE seen a book somewhere, I know
That look'd as if 'twas kept for show;
'Twas nice and clean, and not an edge
But shone as bright as golden wedge;
The leaves unlike to those at school
Which masters scarce preserve by *rule*:
And cover too—without a scratch—
Almost with looking-glass 'twould match:
And what was't pray, that they were able
To keep so pure?—why, friend—a *Bible*.—OSANDER.

Pages 17 and 18 of Zadok Cramer's Pittsburgh Almanack, 1813, showing the essay by "Port Folio" on earthquakes.

"Again, if we mix equal parts of sulphur and iron filings, and make them into a paste, by the addition of water, and then bury the mixture in the ground, two or three feet below the surface, a loud explosion will ensue in a few hours; the earth will be scattered to a considerable distance; and the result of the chemical action, will be a sulphate of iron. The same would take place by a modification of the experiment, as follows: place a mixture of sulphur and iron filings in the ground, as before, the ingredients being quite dry. No action will ensue; but, by means of a tube, or, otherwise, convey a sufficient quantity of water to the mixture, to moisten it, and, in a few hours, the ground will be agitated, and thrown about, as before.

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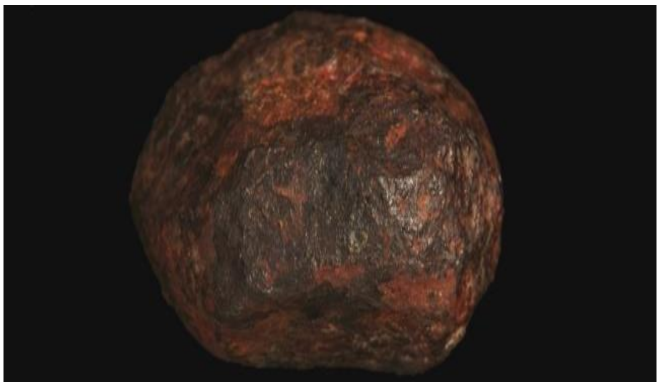
https://archive.org/details/cramerspittsburg1813amer/mode/2up

A meteorite found a few miles from the town of Wedderburn, Australia, in 1951 has been studied for decades, but researchers from California just found something entirely new. The Wedderburn meteorite, which had been donated to the Geological Survey of Victoria and now resides at the Melbourne Museum, contains edscottite, a rare form of iron-carbide mineral with a chemical formula Fe5C2 that had never before been found in nature.

Since the Wedderburn meteorite was first discovered, numerous research teams have



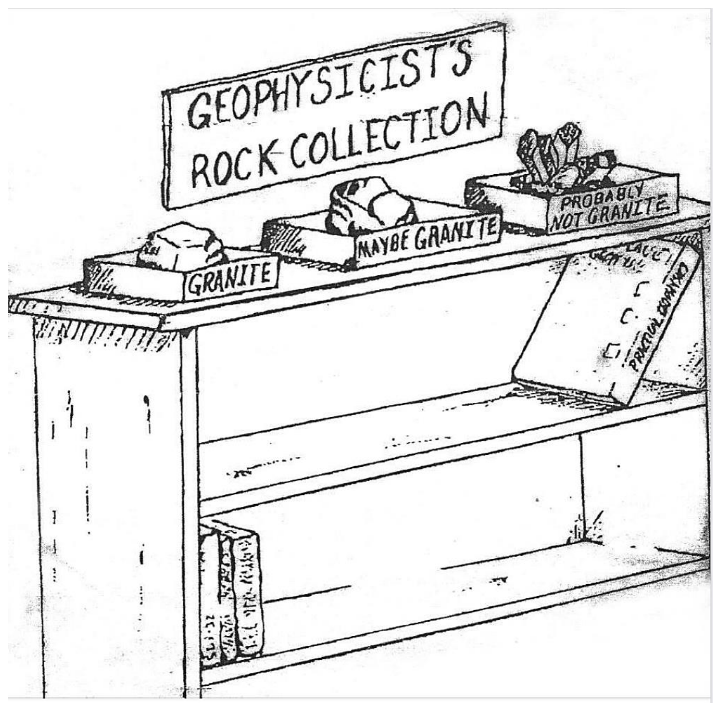
Scientists have discovered a new mineral they named edscottite, which was lodged inside a meteorite found in central Victoria, Australia

examined and sampled it. In fact, only about one-third of the original specimen remains intact. The other two-thirds has been removed in a series of slices that were extracted to analyze its composition. The analyses indicated traces of gold and iron, as well as rarer minerals such as kamacite, schreibersite, taenite, and troilite. As such, the Wedderburn meteorite has been classified as belonging to one of the rarest sub-groups, known as 1AB sLH, of iron-nickel meteorites. It has one of the highest nickel contents of any meteorite, around 24%. Now we know it also contains edscottite.

Named in honour of meteorite expert and cosmochemist Edward Scott from the University of Hawai'i, edscottite is important because it had never been found in nature, only as a synthesis produced during iron smelting. (Of the 500,000 to 600,000 minerals that can be produced in the lab, fewer than 6,000 have been found to occur in nature.) Now that it has been found in nature, it is an officially recognized mineral by the International Mineralogical Association.

No one knows for certain how a sliver of natural edscottite found its way to Wedderburn, but according to a planetary scientist from the Australian National University it could have formed in the heated, pressurized core of an ancient planet. If that planet suffered some kind of cataclysmic event, such as collision with another celestial body, and been blasted apart, the fragmented chunks of the planet would have been flung across time and space. Then serendipity came into play, with one chunk of that older planet ending up as a 7.4-ounce meteorite found just outside a small mining town in rural Australia.

https://www.sciencealert.com/scientists-have-discovered-a-mineral-never-before-seen-in-nature



(Cartoon shared by our friends at the Pennsylvania Council of Professional Geologists, and published in the newsletter with sincere apologies to our other friends in the Geophysical Society of Pittsburgh.)

PGS WEBSITE OF THE MONTH: https://earthquake.usgs.gov/earthquakes/map/

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Fun Fact Having Nothing To Do With Geology

When quicklime (CaO) is heated to 2400°C it emits an intense glow. Before the invention of electric lights, quicklime was used as a lighting source for theater productions. That is where the phrase "in the limelight" originated.

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