PITTSBURGH GEOLOGICAL SOCIETY

December 15, 2021

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

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

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

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

MEETING LOCATION
Cefalo's Banquet & Event Center, Carnegie PA

COVID19 POLICY
See page 3 for current guidance.

Taking Earth Science to Higher Levels: a Tour of the Himalaya

MSU PhD student, Bibek Giri, standing on a lateral moraine with Cho Oyu in the background. Gokyo Valley, Nepal

Mary Hubbard, Ph.D.

Department of Earth Sciences
Montana State University

Please RSVP by Wednesday, December 8

Speaker Abstract

The Himalaya is the world's highest example of active continental collision and continued convergence between two continents. Mountain building has largely consisted of the stacking of faulted slices of what was the former passive margin of the Indian continent. In this presentation we will tour this range from the Ganges plains to the south to the Tibetan plateau in the north. Many unanswered questions exist relating to the initial collision and the subsequent deformation, metamorphism, and intrusion along the Himalayan mountain belt.

This mountain range is the home to many cultures through the countries of Pakistan, India, Nepal, and Bhutan. These people have been living with the constant threat of natural disasters that include earthquakes, landslides, and flooding. We will view these hazards and their connection to the active mountain building processes.

Note – The December PGS Meeting is our annual Friends and Family event, with a program designed to be interesting to geologists and non-geologists alike.

Cho Oyu, Mighty Mountain - photograph by Mary Hubbard.

Speaker Biography

Mary Hubbard is a Professor of Geology in the Department of Earth Science at Montana State University. Her research interest is in understanding the processes that result in mountain belts. This work has taken her to the Rocky Mountains, the Appalachians, the Western Alps (Europe), the Southern Alps (New Zealand), several places on the African continent and to the Himalaya.

Dr. Hubbard earned a Bachelor's degree at the University of Colorado and a PhD at MIT. Following graduate school she held a NATO-funded post-doctoral position at the Eidgenössische Technische Hochschule (better known as ETH) in Zurich, Switzerland. Prior to her current position she taught at the University of Maine, Kansas State University, and Utah State University. She has also served as a Department Head, a College Dean, and a Vice Provost for Global Engagement.

Collaborating with local scientists in host countries is a priority for her work. In 2019, she co-led a geology research team on a National Geographic Expedition to the Mt. Everest area in Nepal to study the climate record in this extreme environment. Outside of her profession, Mary has interests in photography, music, travel, hiking, and cross-country skiing. And she is an active Rotarian.

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

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

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

UPCOMING PGS MONTHLY MEETINGS

Meeting Date	***Scheduled Speaker***	***Presentation Topic***
January 19, 2022	Todd Halihan, University of Oklahoma	Electrical Hydrogeology: A Picture is Worth 1000 Wells
February 16, 2022	David King, Auburn University	Chicxulub Crater Geology
March 16, 2022	Jamie Farrell Utah State University	Geology of Yellowstone
April 20, 2022	19th Annual Student Research Night	
May 11, 2022	TBA	Oil and Gas Industry Topic

The Pittsburgh Geological Society welcomes several new members:

Janet J. Folajtar, Senior Project Geologist (retired)

Denali L. John, Student Member

Slippery Rock University

Tyler J. Newell, Geologic Specialist

American Geotechnical and Environmental Services, Inc.

Justin T. Petricko, Environmental Technician
Atlas Technical Consultants

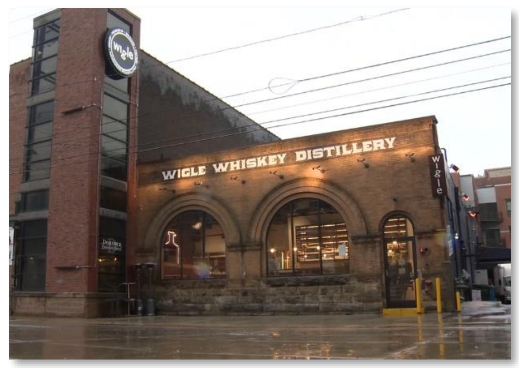
PRESIDENT'S STATEMENT

It was great seeing you all again at the November meeting and I hope you all have had a chance to relax over the subsequent holiday and reconnect with friends and family.

The November meeting featured a great talk by Dr. Thomas Anderson that included an incredible amount of detail regarding large scale tectonic processes and was followed by the usual thoughtful discussion. Dinner was also wonderful as always!

This past month featured less in the way of announcements, but they are still summarized below:

- PGS is organizing a tour of the Wigle distillery to take place on Saturday, December 18th from 4:30 to 5:30 PM. The tour will include tasting and an explanation of the Pittsburgh Whiskey Rebellion. Tickets are $25 and are available on a first-come first-serve basis. Information regarding how to reserve tickets will be distributed via email to the membership and will be announced on the website.



- If the event goes well and is enjoyed by the membership, we intend to offer other similar events including tours of other Pittsburgh distilleries or perhaps microbrew tours. Suggestions are welcome, so if you have any ideas for social gatherings in the Pittsburgh region I would welcome them at our December meeting.

- PGS is also exploring options to increase the accessibility of our monthly meetings, including virtual attendance, speaker recordings, or alternate venues. We want to reach as many geologists in western PA as possible and are discussing ways to make it happen.

I'm looking forward to our December talk that will feature a tour of the Himalaya provided by Dr. Mary Hubbard from Montana State University. Remember that this meeting is our annual friends and family event with a talk designed to be of interest for a diverse audience including non-geologists.

I hope to see you all there and drive safe!

Dan

LOCAL GEOLOGICAL EVENTS

PENNSYLVANIA COUNCIL OF PROFESSIONAL GEOLOGISTS (PCPG)

December 7, 2021 **1:00 - 2:00 PM**

"Using Petrologic, Geochemical, and Structural Analyses to Unravel the History of the Ultramafics of Southeastern Pennsylvania" by Ryan Kerrigan, PhD, Dept. of Energy & Earth Resources, University of Pittsburgh at Johnstown (Webinar: 60 minutes)

Details and registration: https://pcpg.org/event-4474564

EASTERN SECTION AAPG LUNCH & LEARN

December 9, 2021 **12:00 – 1:00 PM**

"How the humanities can teach us to improve our interpretation skills; Geosteering techniques from examples in several basins" by Chad Koury, Koury Geosteering (Free Zoom webinar)

Registration: https://us06web.zoom.us/webinar/register/WN_0KvxRurURwCiW7NxdumviA

OILFIELD CHRISTMAS BALL

December 16, 2021 **6:00 PM – 10:00 PM**

This holiday gathering is jointly sponsored by the American Association of Drilling Engineers (AADE), the Geophysical Society of Pittsburgh (GSP), the Pittsburgh Association of Petroleum Geologists (PAPG), and the Society of Petroleum Engineers (SPE). Semi-formal attire is requested. Food service begins at 7:15 PM. Attendance is limited so please register early to secure your seats.

Cefalo's Banquet Center, Carnegie PA 15106

Details and RSVP link: https://aade.app.neoncrm.com/np/clients/aade/event.jsp?event=12&

PGS VIRTUAL LANDSLIDE FIELD TRIP ANNOUNCEMENT

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

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

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

2021 WINNERS OF THE FRANK BENACQUISTA SCHOLARSHIP

PGS is delighted to announce that two geology students from the tri-state area submitted equally meritorious applications for the Frank Benacquista Memorial Scholarship. The Officers and Board of Directors unanimously decided to award scholarships to both of these deserving applicants. We wish them the best in their studies this year and in their future career opportunities.

Ellie Ruffing is currently a junior Geology student at California University of Pennsylvania. She is a Dean's List student and a member of both the Biology and Geology student organizations on her college campus, allowing her to meet professionals in a wide variety of scientific fields. In her work with the geology club, Ellie has also given back to her community through organizing and participating in volunteer highway cleanups. Her professors note that Ellie has shown an exceptional focus on her career preparation, with a clarity of purpose rare in her fellow students. These accomplishments are even more impressive when one realizes that Ellie maintains a part-time job throughout the school year in addition to her studies and extra-curricular activities.

Austin Keirs is a senior at Slippery Rock University working towards a BS in Environmental Geoscience, with a geology concentration. He is currently president of his university's Sigma Gamma Epsilon geologic honorary society and their Geography, Geology, and the Environment club. Austin has attended the PGS Drilling Workshop, as well as a Field Investigations in the Geosciences course where he studied local and regional Pennsylvania geology while learning how to keep detailed and accurate field notes. He is currently working on a research project to apply GIS and remote sensing techniques to study vegetation changes in arid regions of the United States. Austin plans to go on to graduate school and pursue a career in the geosciences.

THE ORIGIN OF WESTERN PENNSYLVANIA PLACE NAMES

Ellwood City's Fall Fest & Car Cruise is a fun day filled with vendors, kids' activities, live music, and a car cruise with more than 700 cars.

The Borough of Ellwood City, in Lawrence (mostly) and Beaver counties, was founded in 1892 by Henry Watters Hartman, a developer and industrialist from Beaver Falls. It was named for Isaac L. Ellwood, one of the inventors of barbed wire. Prior to being founded, the area was mostly farmlands, although a town named Hazel Dell existed, which has since become known as the neighborhood of North Side. Ellwood City suffered from the Depression of 1894 until R. C. Stiefel came to town with a patent for seamless tubing, and a few years later the town was heavily engaged in the international steel industry. Ellwood City grew rapidly after that, with immigrants from Europe bringing economic success and ethnic diversity to the region.

Unfortunately, the demise of US Steel's Ellwood division in the 1980's devastated Ellwood City's economic base and the town began a gradual decline in both population and job opportunities. To help fight back, the borough began having annual festivals at Ewing Park in 1986, and this began to grow until eventually there were 200+ vendors and 25,000+ visitors. Today, it is called the Ellwood City Fall Fest and Car Cruise. Ellwood City is constantly adapting to the demands of the 21st century, and all the while it is maintaining its ethnic heritage.

DID YOU KNOW . . . ?

Researchers from the U.S. and Austria analyzed remnants of Archean asteroids more than 2.5 ga old and demonstrated the effects of their collisions with Earth to show that the strikes not only took place more often than previously thought, but that they might have affected O_2 levels in the atmosphere.

When large asteroids or comets struck the early Earth, their energy melted and vaporized rocky materials in the Earth's crust. The researchers hypothesized that small droplets of molten rock from the impact called impact spherules would condense, solidify, and fall back to Earth as round sand-size particles distributed around the planet. These glassy spherules accumulated over time in thin layers in the Earth's crust, ranging in age from about 2.4 to 3.5 ga old that are now marker horizons of those impacts.

New spherule layers have been identified recently in drill cores and outcrops, so the number of known impact events has been increasing.

Currently established impact models underestimated the number of Late Archean spherule layers, suggesting that there were as many as 10 times more impacts than previously thought.

Artist's concept of the early (Archaean) Earth being bombarded by large asteroids and comets.

In addition, the researchers found that the cumulative impactor mass was an important O_2 sink, which suggested that early bombardment could have delayed oxidation of Earth's atmosphere (the abundance of O_2 in Earth's atmosphere is due to a balance of production and removal processes). This agrees with the geological record, which indicates that Earth's O_2 levels in the Early Archean varied but stayed relatively low. Impacts by bolides larger than 6 miles in diameter might have contributed to this because the limited O_2 present in Earth's early atmosphere would have been chemically consumed by impact vapors, resulting in reduced abundance.

At about 2.4 ga ago, near the end of the period of bombardment, Earth went through a major shift in surface chemistry triggered by the rise of atmospheric O_2 (the Great Oxidation Event), which is attributed to changes in the oxygen production-sink balance. Many people believe this allowed for an increase in O_2 production as well as a decrease in gases capable of removing O_2, either from volcanic sources or through their gradual loss to space. Over time, collisions became less frequent and too limited to significantly alter post-Great Oxidation Event O_2, allowing Earth to sustain life as we know it.

http://www.sci-news.com/othersciences/geoscience/archean-asteroid-impacts-10192.html

An international team of researchers recently analyzed 535 permafrost and lake-sediment samples spanning the past 50 ka across the Arctic that included a large-scale environmental DNA study of Pleistocene plant and mammal communities. Their results included the real reason why wooly mammoths went extinct.

People have argued vehemently over the last 100 years about this. Many blamed humans for their demise because, although mammoth populations and their ancestors lived for approximately 5 ma through many changes in climate, when humans began living among them the mammoths didn't survive for long. According to this circumstantial evidence, therefore, it was humans hunting the mammoths, not climate change, that drove the animals to extinction.

The research team, however, were able to prove that it was not just the changing climate that was problematic for the mammoths, but the increasing speed of it. The animals were incapable of adapting quickly enough when the Late Pleistocene landscape dramatically transformed and their food became scarce. As the climate warmed, trees and wetland plants replaced the mammoth's grassland habitats. The team also pointed out that there were many animals at that time that were a lot easier to hunt and kill than a giant woolly mammoth, which could grow to the height of a double decker bus. Humans are puny by comparison.

Three wooly mammoths wander the snow-covered hills, searching for succulent patches of grass that are their favorite food.

Herds of mammoths, as well as reindeer and woolly rhinoceroses, thrived in the cold and snowy conditions. That was due to the fact that, despite the cold, lots of vegetation in the form of grass, flowers, plants, and small shrubs was still available to keep various species of animals alive. All of this was suitable for forage for the herbivorous mammoths, who probably used their tusks to shovel the snow aside. They also likely used their trunks to uproot tough grasses. Mammoths were as big as they were because they needed huge stomachs to digest the grass. They could travel a distance during their lifetime equal to traveling around the world two times; the fossil record indicates they lived on all continents except Australia and South America.

The researchers also sequenced the DNA of 1,500 Arctic plants for the first time, allowing them to draw globally significant conclusions about the timing of mammoth extinction. Previously, paleontologists thought mammoths began to go extinct at the end of the Pleistocene, about 12 ka ago. The new research team found that mammoths actually survived into the Holocene in different regions of the Arctic for far longer than realized. Decreases in population and genetic diversity of mammoths caused them to become smaller and smaller over time, making it even harder for them to survive. As the ecosystem changed, the biomass of the vegetation was reduced to the point where it could no longer sustain herds of mammoths. The researchers were able to show that when the climate changed, specifically in respect to precipitation, it directly drove this change in the vegetation. They concluded that humans had no impact on the demise of the mammoths at all.

http://www.sci-news.com/paleontology/rapid-climate-change-woolly-mammoths-10187.html

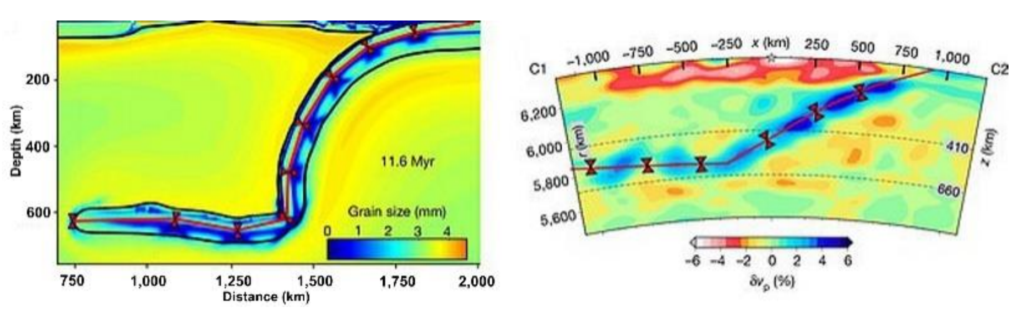
As we're all aware, tectonic plates bend as they sink into the mantle at subduction zones, and the weight of cold, dense ocean crust sinking into the mantle drags the rest of the plate behind it. Logic predicts that the subducting slabs must remain intact during their descent, or they would not be able to keep dragging the attached crusts with them. Yet geophysical evidence indicates that the plates are destroyed.

Now a new study by a research team from Switzerland has resolved these two suppositions by showing that plates are only significantly weakened as they sink and concludes that the plates also become segmented instead. The team reached this conclusion by running computer simulations exploring the impact of all the different geological forces that affect subducting oceanic crust. Previously, geophysicists lacked a truly comprehensive model of plate tectonics. The new model incorporated various plate-weakening mechanics, even including data on how rock grains are altered in the deep mantle. The new model showed that, as a tectonic plate enters the mantle, the fine-grained structure along its underside changes, leaving it weakened and allowing the plate to pinch at the weakest points. The plate is abruptly bent downwards, causing it to crack at these points. This leaves the plate essentially intact but segmented. The descending slab can therefore continue to pull the rest of the plate despite becoming distorted.

The team also experimented with running their simulations with a hotter mantle, mimicking the conditions that would have been seen in the early Earth. Under these conditions, the segmented plate segments only succeeded in traveling a few miles into the mantle before breaking off, suggesting that early Earth subduction may have occurred intermittently. This led the team to speculate that modern plate tectonics may have begun only within the last billion years, although one team member noted that there are good arguments for plate tectonics being much older than that.

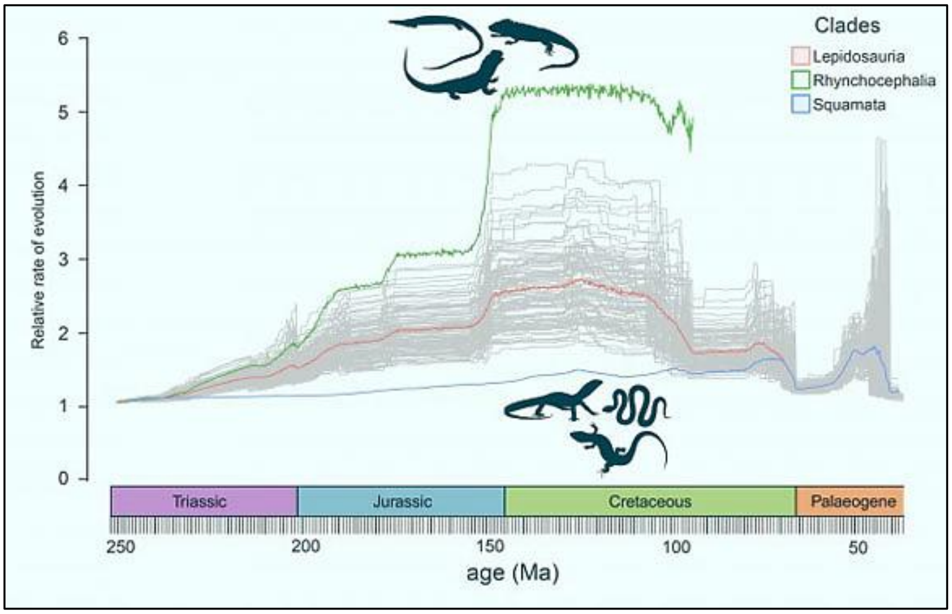
The new simulations suggest that subduction might be more sensitive to the temperature of the mantle than originally thought, which could lead to interesting new avenues of discussion. Researchers plan to study the same phenomena using 3D models and also explore what their models might be able to tell us about the occurrence of earthquakes at subduction zones.

https://www.dailymail.co.uk/sciencetech/article-10203819/Geology-Sinking-tectonic-plates-bend-enter-mantle-like-slinky-snake.html



A new model of plate subduction (left) predicted a scenario resembling observations of the Pacific plate subducting under Japan (right).

The moral of Aesop's fable of The Hare and the Tortoise is "Slow and steady wins the race." Now, according to a new study of Lepidosauria, the reptile suborder that includes lizards, snakes, amphisbaenians (worm lizards), and tuatara, this isn't always the case. The researchers found Aesop got it wrong, at least for this group. There are more than 10,000 lepidosaur species today, and much of their recent success is a result of fast evolution in favorable circumstances.



Rates of evolution for Squamata (lizards and snakes – blue line) and Rhynchocephalia (green line) were much lower for about 200 million years. Then the rates flipped about 50 million years ago.

Lepidosaurs originated during the Early Mesozoic about 250 ma ago, and since then they have split into two major groups, the squamates, including modern lizards and snakes, and the rhynchocephalians represented today by a single species, (*Sphenodon punctatus*) the tuatara. The team had expected to find slow evolution in rhynchocephalians, and fast evolution in squamates. What they found was the exact opposite. They looked at the rate of change in body size in the early reptiles and found that some groups of squamates evolved quickly in the Mesozoic, particularly the ones with specialized lifestyles – like the marine mosasaurs. Rhynchocephalians, however, were much more consistent in evolving quickly. Their average rates of evolution were significantly faster than those for squamates, at nearly twice the background rate of evolution. This was totally unexpected.

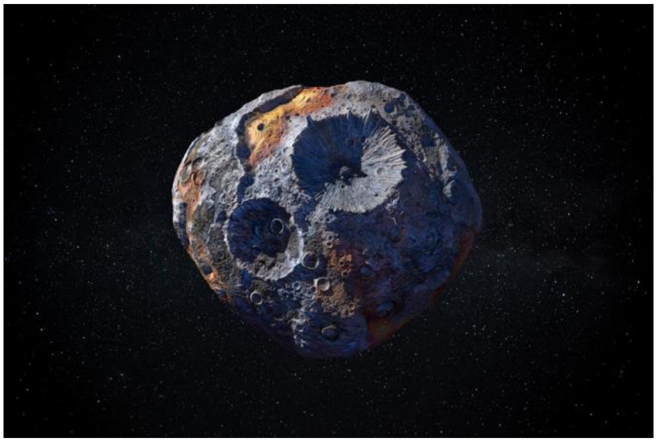
All of the modern groups of lizards and snakes originated and began to diversify in the later Mesozoic, and although they lived side-by-side with the dinosaurs they most likely did not engage with them ecologically. The early lizards were mainly quite small and fed on bugs, worms, and plants. For most of the Mesozoic, the rhynchocephalians were the innovators and the fast evolvers. When the dinosaurs became extinct, both the rhynchocelphalians and squamates experienced losses, but the squamates were able to bounce back and diversify in the Tertiary. Rhynchocephalian diversification dropped quite dramatically well before the end of the Mesozoic, and the whole dynamic changed after that.

The new study confirms a controversial proposal the famous paleontologist George Gaylord Simpson made by in his 1944 book *Tempo and Mode in Evolution*. Simpson looked at the fundamental patterns of evolution in a framework of Darwinian evolution and recognized that many fast-evolving groups like the rhynchocephalians belonged to unstable groups that were probably adapting to rapidly changing environments. So the rhynchocephalians are representative of Aesop's hare and the squamates represent the tortoise.

Since Charles Darwin's time, biologists have wondered if big groups of many species resulted from fast evolution over a short time or slow evolution over a long time. Perhaps the new study has shed some light on the question. In some cases, species can stabilize and survive well, but in many cases, they go extinct as fast as new ones emerge. In other cases, as Simpson predicted, slowly evolving species might also be slow to go extinct, which could end up being a more successful strategy in the longer term.

http://www.sci-news.com/biology/fast-evolution-10254.html

Thanks to Jeff Bezos and Elon Musk, the age of private space travel has arrived. What about the broader commercial space industry, though? “Space mining” has been mentioned for many years, mostly in science fiction novels and movies, but the hype has pretty much peaked thanks to the realization that the technology to obtain rare-Earth metals from distant asteroids is still a way off.



NASA believes the large metallic asteroid 16 Psyche, could be ideal for space mining

That has not stopped NASA’s plans to launch what it calls its “Psyche” mission next year. The mission will be an attempt to visit a large asteroid called 16 Psyche, which is situated in the asteroid belt between Mars and Jupiter. This asteroid is thought to be largely metallic and so would be ideal for space mining. At this time, NASA plans merely to orbit and document the asteroid when its spacecraft reaches it in 2026. Located about 230 million miles from Earth, 16 Psyche is the largest metal-rich body in the solar system, about 140 miles wide. It is believed to be made of iron and nickel. Astronomers think it is the leftover core of a planet that failed during formation.

Meanwhile, researchers have recently discovered two metal-rich near-Earth asteroids (NEAs) named 1986 DA and 2016 ED85 that could one day be mined as well. These space rocks are estimated to be 85% metal and 15% silica, and 1986 DA alone is thought to contain enough iron, nickel, and cobalt to exceed Earth’s reserves. By comparison to 16 Psyche, 1986 DA and 2016 ED85 are tiny – just a few miles wide – but they are also thought to be the result of the cores of developing planets being destroyed early in the Solar System’s history. They are far closer to Earth than 16 Psyche, so they should be better targets for mining.

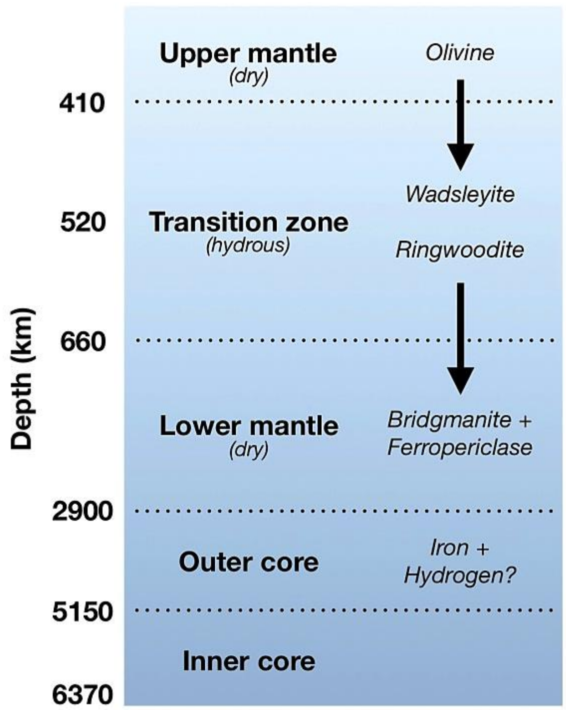
In addition, it is possible that the researchers have discovered additional metal-rich asteroids. By studying the orbits of 1986 DA and 2016 ED85 they identified four possible asteroid families in the main asteroid belt where 16 Psyche resides. They think the two NEAs are probably fragments from a larger metallic asteroid in the main belt. It’s also possible that some of the iron and stony-iron meteorites found on Earth could have also come from that region in the Solar System as well.

https://www.forbes.com/sites/jamiecartereurope/2021/10/19/the-age-of-space-mining-just-got-closer-as-scientists-discover-two-asteroids-whose-precious-metals-would-exceed-global-reserves/?sh=6c570edd713b

Scientists recently detected the deepest known earthquake, which occurred 467 miles below the Earth's surface, much deeper than previous quakes. That depth means the quake occurred in the lower mantle where seismologists expected earthquakes to be impossible because, under extreme pressures, rocks are more likely to bend and deform than they are to break with a sudden release of energy. Minerals, however, don't always behave exactly the way we expect them to behave. Even at pressures where they should transform into less quake-prone states, they might linger in old configurations, so just because they SHOULD change doesn't mean they WILL change. What the earthquake may reveal, then, is that the boundaries within Earth are vaguer than we give them credit.

The earthquake, which was first reported in June 2021, was a minor aftershock to a 7.9-magnitude quake that shook the Bonin Islands off mainland Japan in 2015. Researchers detected the quake using Japan's Hi-net array of seismic stations, the most powerful system for detecting earthquakes in current use. Because the quake was small and couldn't be felt at the surface, sensitive instruments like Hi-net were needed to detect it. Although the findings appear to be reliable, the depth of the quake still needs to be confirmed by other researchers. Thus, the quake is something of an enigma.

The vast majority of earthquakes originate within the Earth's crust and upper mantle. The rocks in the crust are cold and brittle and when they undergo stress they tend to break, releasing energy like a coiled spring. Deeper in the crust and upper mantle, as far down as 249 miles, the rocks are hotter and under higher pressures, making them less prone to break. Earthquakes can happen there, however, when high pressures affect pore fluids in the rocks, forcing the fluids out and making the rocks prone to brittle breakage. Even before the 2015 Bonin aftershock, quakes had been observed down to about 420 miles, but seismologists have long wondered how those quakes could occur. The rocks' pores have been squeezed shut and fluids are no longer a trigger mechanism.



Phase transformations of olivine moving through the upper mantle, transition zone, and lower mantle.

The problem has to do with the ways minerals behave under pressure below 249 miles. Much of the mantle is composed of olivine. At about 249 miles down, the pressures cause the olivine atoms to rearrange into the mineral wadsleyite. Another 62 miles down, the wadsleyite rearranges to form ringwoodite, and then again at about 423 miles deep the ringwoodite breaks down into bridgmanite and periclase (we know this because of lab experiments that recreate the extreme pressures and temperatures needed to make these changes. In addition, because seismic waves move differently through different mineral phases, geophysicists can detect these changes by looking at seismograms of large earthquakes). That last mineral transition marks the upper/lower mantle boundary. As olivine transforms into its higher-pressure phrases, it becomes less brittle, so earthquakes should not happen.

As it turns out, however, researchers have found that olivine mineral phases aren't nearly so neat and clean. Under certain conditions, and with enough pressure, olivine skips the wadsleyite phase and goes straight to ringwoodite, allowing the mineral to break instead of bend. But the Bonin earthquake originated at 467 miles down, in a spot that should be in the lower mantle. It is possible, because the area is a subduction zone, that the upper/lower mantle boundary isn't exactly where it is expected to be. The researchers, therefore, suggest the subducting slab might have settled onto the lower mantle firmly enough to subject the rocks there to an enormous amount of stress, generating enough heat and pressure to cause a very unusual break.

Or perhaps it has to do with minerals behaving in an odd manner. Because the continental crust being subducted is much cooler than the surrounding rock, the minerals there might not be warm enough to complete the phase changes they are supposed to at a given pressure. Perhaps olivine, which should be under enough pressure to transform into a non-brittle phase, is too cold because of a slab of "cool" continental crust all around it. Under these circumstances, it might remain olivine. Thus, an earthquake could originate in the lower mantle because it's just not as hot down there as we expect it to be. Essentially, if the lower mantle rock material is cool enough to build up sufficient stress to release it as an earthquake, it's also cool enough for the olivine to retain its olivine structure.

Whatever caused the lower mantle earthquake, it is unlikely to occur very often because only about half of Earth's subduction zones experience deep earthquakes, and the kind of large quake that occurred prior to the lower mantle quake happens only every two to five years on average.

https://www.livescience.com/deepest-earthquake-lower-mantle

WEBSITE OF THE MONTH:

https://earthobservatory.nasa.gov/images/146342/phenomenal-faults-and-folds

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Memberships: For information about memberships, please write PGS Membership Chair, PO Box 58172, Pittsburgh PA 15209, or e-mail jharper.pgs@gmail.com. Membership information may also be found at our website: www.pittsburghgeologicalsociety.org.

Programs: If you would like to make a presentation at a PGS meeting or have a suggestion for a future speaker, contact Pete Hutchinson, Program Chair at pjh@thggeophysics.com.

Newsletter: To contact the Newsletter Editor, Karen Rose Cercone, with questions or suggestions for articles, job postings or geological events, please email kcercone@iup.edu.

Facebook: Follow the PGS at https://www.facebook.com/PittsburghGeologicalSociety

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Fun Fact Having Nothing to Do with Geology

December should be called "National Unwholesome Month" because snacks celebrated in December include pie, cotton candy, chocolate brownies, cocoa, cookies, and cupcakes.

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