Granite State Geologist

The Newsletter of the Geological Society of New Hampshire,
Summer Edition – June 2022 – Issue No. 117
Newsletter Editor: jlambert@nobis-group.com **Website:** http://www.gsnh.org/

In this issue:

MESSAGE FROM THE PRESIDENT

Hello Friends,

I hope you are well. I announced at the April 21st dinner meeting that there will not be a GSNH field trip this summer. We had planned on collaborating with the Northeastern Friends of the Pleistocene, but logistically things just didn't work out. Their trip was planned for three days (June 3-5). Having 50+ GSNH members join 50+ NEFOP members for one day in the field, well you can see how well that might go. If you have ideas for a field trip next year (with a capable and willing leader), please let a Board member know.

I am aware that many GSNH members rely on the annual field trip to earn continuing education credits toward Professional Geologist license renewal. There are several alternatives for low or no-cost training to secure credits. One that I'm familiar with is internet-based training offered by the Interstate Technology and Regulatory Council (ITRC). This organization describes itself as "a state-led coalition working to reduce barriers to the use of innovative air, water, waste, and remediation environmental technologies and processes. ITRC produces documents and training that broaden and deepen technical knowledge and expedite quality regulatory decision making while protecting human health and the environment." In 2018 and 2019, I was designated as the NH Point of Contact for ITRC's State Engagement Program. This honor rotates among technical staff of the NH Department of Environmental Services, Waste Management Division on a two-year basis.

ITRC organizes teams of technical experts to produce what they call "Tech-Reg Documents". Most of these work products focus on contaminated site investigation and remediation. ITRC is on the forefront in developing guidance for emerging contaminants

and has released numerous fact sheets, “explainer” videos and Youtube training modules regarding Per- and Polyfluoroalkyl Substances (PFAS). These reference materials are the go-to source of information on this subject for regulators and the regulated community.

Many of the recently completed Tech-Reg documents are not actual documents, as ITRC has adopted a web-based approach of disseminating information. Recent ITRC Team projects have expanded beyond contaminated site clean-up, with guidance covering topics such as Stormwater Best Management Practices and Preventing and Managing Harmful Cyanobacterial Blooms. ITRC’s recently-updated guidance on topics such as Light Non-Aqueous Phase Liquid (petroleum releases) and Characterization and Remediation of Fractured Rock may be very useful for professional geologists working in New Hampshire.

ITRC offers internet-based training presented by the experts who developed the Tech-Reg guidance. The schedule for upcoming live webinars, as well as past presentations that are available for on-line viewing or download, is listed on the USEPA Contaminated Site Clean-Up Information (CLU-IN) website. This website also provides links to webinars presented by Federal agencies and contractors. The website index currently lists 899 archived seminars. I’m sure that you can find a topic that interests you.

One challenge that has been the subject of ITRC’s State Engagement Program efforts is how to lessen the impact of the increasing rate retirements among environmental professionals. ITRC recently announced an Early Career Professional Program. You might check this out if the topic interests you.

I hope you enjoy the summer by exploring the geology of the Granite State! Tom

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GSNH T-Shirts Available!

We have a few GSNH T-shirts still available – no XL, and we have just a couple in size L and a few more M and S sizes left. Send in your order before they’re gone! T-shirts will be shipped to you. See order form on second to last page (right before the renewal form).

Front (left photo) and back (right photo) of GSNH t-shirt.

Have You Renewed your Membership?

If you have already renewed your 2022 GSNH membership, thank you! If not, please consider renewing. With your membership, you get a discount on dinner meetings (which will happen at some point!) and field trips, information of upcoming events of interest to the geological community, voting privileges at Society business meetings, and automatic subscription to this newsletter! Membership dues also help to support outreach for the greater community.

See the last page of this newsletter for a membership renewal application.

New Hampshire Geological Survey Update

By Shane Csiki, State Geologist and Director, June 2022

Summer is now upon us . . . which means 'tis the season for field work here at NHGS! First, on the geologic mapping front, Josh Keeley, Mike Howley and Rebecca LeCain have already been out in the field with some of our geologic mappers, including Woody Thompson (Josh) and Dyk Eusden (Mike and Rebecca). Josh will be headed up to Pittsburg and into Canada in mid-June to spend field time with Dave Converse and Canadian colleagues on the Indian Stream Area bedrock mapping project. Josh will also be mapping, as a co-author, the Mount Moosilauke (with Thom Davis) and Shelburne (with Woody Thompson) surficial quadrangles this summer.

NHGS continues to work with USGS geologic mapping program staff on the rollout of new mapping geodatabase standards (Geologic Mapping Schema, or GeMS). As part of this conversion, we have been asked to develop some form of peer review process for our geologic mapping products. This is a positive development, given identification of this need in the feedback from the NHGS stakeholder survey a few years ago. Given limited staff and a similarly limited pool of geologists who know the intricacies of New Hampshire geology, we are going to have a trial run this summer of a "collaborative peer review" process, which we recently developed. This will be based on a series of field conferences (one per mapped quadrangle) where the mapper, all of NHGS' core staff, and other mappers and external geologists who sign up to attend a quadrangle's field conference, meet on site and discuss the mapper's findings. The idea is that the mapper will then work to incorporate results of the field discussions into their mapping product. Then, once the maps are submitted to NHGS, the attendees of the field conferences will participate in a second, interactive online discussion about the map products with the ability for each mapper to incorporate received feedback into their maps before complete submittal of the map and GeMS geodatabase to USGS. This summer's field conferences for late July

and early August have been scheduled. If you have an interest in participating in this process, feel free to reach out to me (Shane.J.Csiki@des.nh.gov), and we can provide you more info. As other states are working to figure out how to establish similar peer review requirements, USGS has expressed interest in NHGS' development and trial of this process. So, stay tuned!

Mike Howley continues to work on enhancements of the statewide NHGS Groundwater Level Monitoring Network. This is a critical tool to evaluate statewide groundwater conditions, particularly in the event of a drought, as evidenced during the past 2 years. Mike is finalizing a contract that will lead to needed replacements for three wells in our network – in Colebrook, Concord and Franklin.

The recent Friends of the Pleistocene field trip led by Daniel Tinkham, Bob Newton, Woody Thompson, Brian Fowler, and John Brooks and co-sponsored by NHGS was a great success. New field evidence in Sandwich and Tamworth was presented for localized northeast-flowing ice along the southern edge of the White Mountains and around the northern side of the Ossipee Mountains. New discussions about the style of deglaciation of New Hampshire ensued.

Summer 2022 interns Finn Callahan and Vaneesa Franciosa conducting a stream crossing assessment in Sullivan.

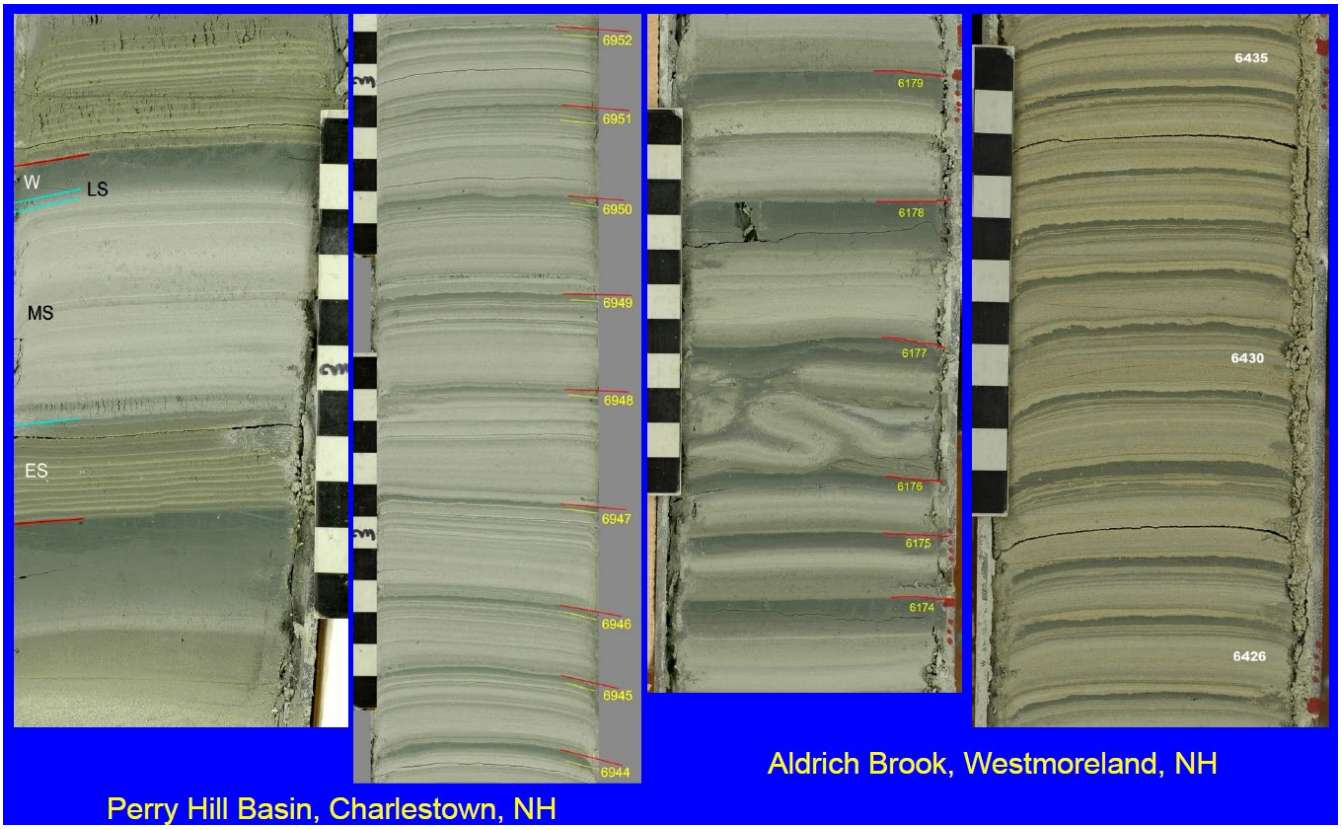
On the stream crossing assessment front, we welcome Brian Hauschild to NHGS, and are happy to have him on board. He is responsible for many of the data management components of the statewide stream crossing initiative. Brian, a New Hampshire native and UNH graduate, comes to us after working on similar issues for the U.S. Forest Service in Oregon. In addition, our summer interns have recently arrived! Four interns have been hired to perform field assessments, primarily in the Monadnock Region. Two interns have also been hired to perform quality control review of incoming data from 10 field interns hired through UNH as part of an NHDES-funded initiative that works to complete assessment work in the state. As usual, we have another outstanding group of interns and they have hit the ground running, and are already adding data to the statewide culvert dataset. This dataset is a critical tool to prioritize stream crossing replacements, particularly with the potential for infrastructure funding available. Completion of statewide data collection, in support of prioritizing the funding of infrastructure upgrades is an NHDES priority. NHGS is working closely and collaboratively with NHDES Wetlands Mitigation program staff, including Lori Sommer and Cheryl Bondi, to complete this assignment.

As always, if you have any questions or suggestions for NHGS, feel free to reach out to any staff member at any time.

April 2022 Meeting Presentation Recap

We had our spring GSNH meeting via Zoom on April 21, 2022. Professor Jack Ridge of Tufts University gave a presentation on the deglaciation of New England and its relation to climate: the fusion of varves, radiocarbon ages, paleomagnetism and critters in lakes. Professor Ridge gave a short introduction to varves, which are deposited in a distinctive annual sequence with a “winter” non-melt season (allows clays to settle out) and “summer” or melt seasons with multiple micro-graded events. Varves can be studied to produce a continuous, high resolution, calibrated, terrestrial chronology of declaciation and to develop a regional climate record. The long, deep, and narrow lakes of eastern New York, Vermont, New Hampshire, and western Massachusetts have thick varve deposits.

In a post-glacial environment, varves are thicker when ice recession is fast (more melting) and thinner when ice recession is slow or readvancing. The climate changes noted in the varve record studied in New England appear to be similar to and are likely synchronous between the southeastern Laurentide Ice Sheet in western New England and Greenland at sub-century scale, suggesting that the southeast Laurenditde ice sheet and North Atlantic have the same climate variation.



Examples of New Hampshire varves from the presentation.

You can see past varves of the month at the North American Glacial Varve Project:
https://eos.tufts.edu/varves/default.asp

Rainbow Pyrite

From Earth Science Picture of the Day, March 29, 2022.
Photographer and Summary Author: Allen Steinburg
https://epod.usra.edu/blog/2022/03/rainbow-pyrite.html

Rainbow pyrite (next page) is the trade name for Pyrite Druzy and a non-Quartz species of gemstone. These colorful rock specimens are valued for their rainbow-like iridescence caused by differential refraction and diffraction of light. Historically, this metallic looking rock was extracted in Russia, however, the former 1870 abandoned Shipman pyrite mine in Ontario, Canada is proving to be another source for rainbow pyrite along with uncommonly large octahedral pyrite crystals. Photo taken on November 10, 2021.

Shipman Mine Ontario, Canada Coordinates: 44.53750,-75.79694

Related Links

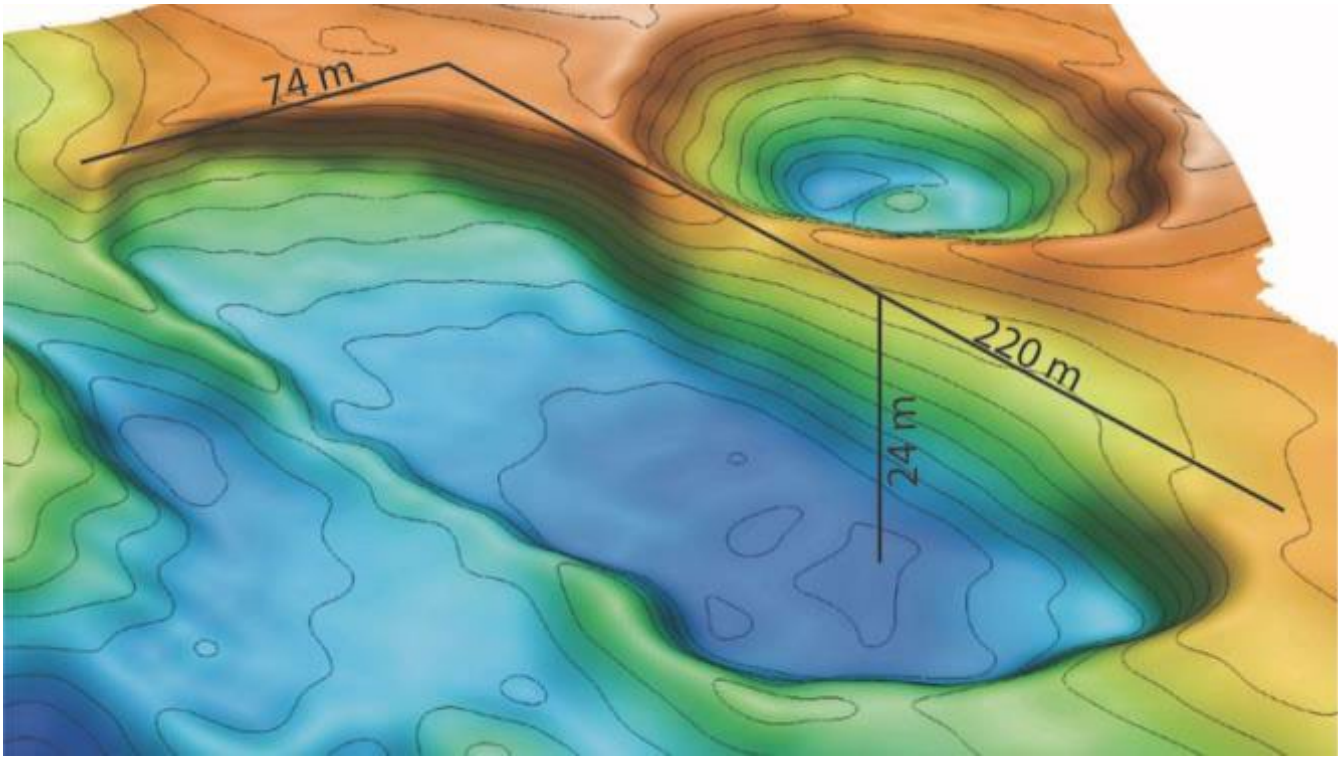
- Pyrite Crystal
- Iron Pyrite Cubes

Student Links

- More Information about Pyrite

Sinkholes as big as a skyscraper and as wide as a city street open up in the Arctic seafloor

By Jeanna Bryner, March 17, 2022. From Live Science.
https://www.livescience.com/sinkholes-opening-arctic-seafloor



Repeated surveys with MBARI's mapping AUVs revealed dramatic changes in seafloor bathymetry from the Arctic shelf edge in the Canadian Beaufort Sea. This sinkhole developed in just nine years. (Image credit: Eve Lundsten © 2022 MBARI)

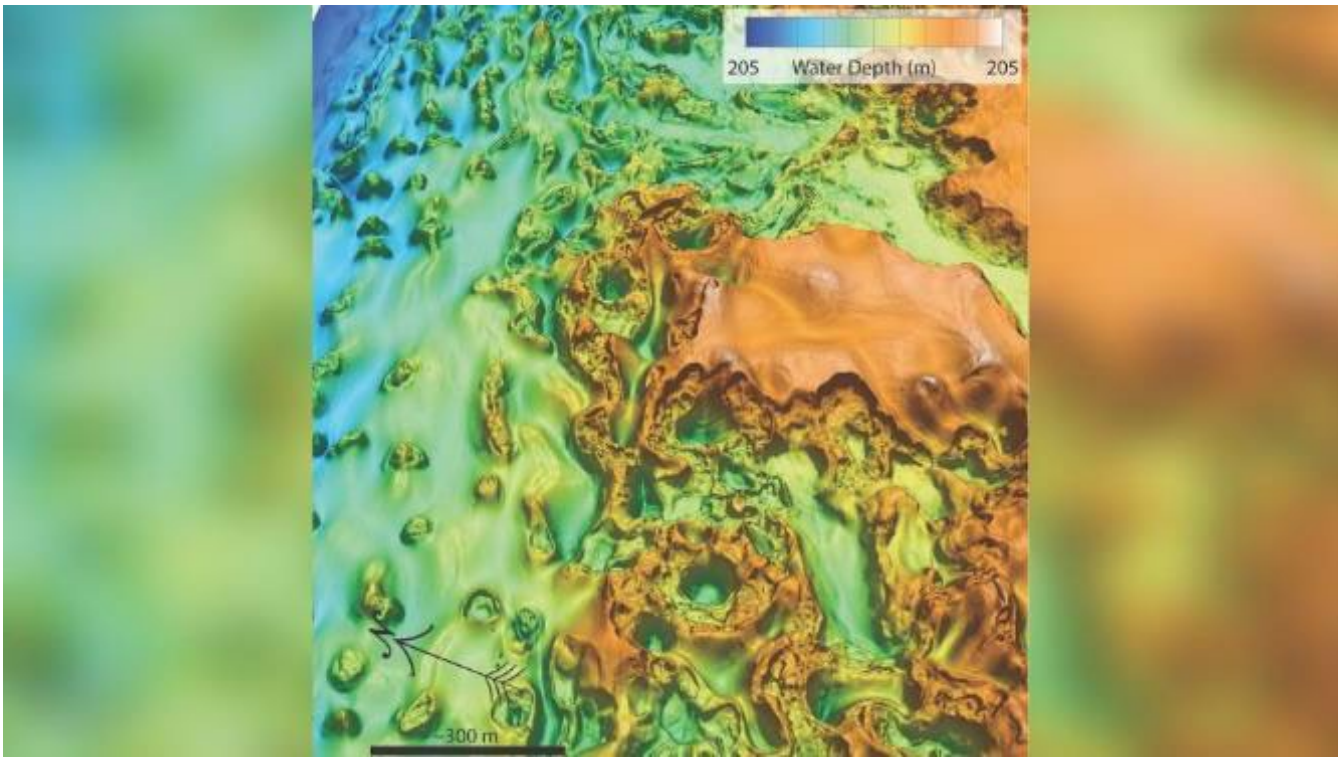
Giant "sinkholes" — one of which could devour an entire city block holding six-story buildings — are appearing along the Arctic seafloor, as submerged permafrost thaws and disturbs the area, scientists have discovered.

But even though human-caused climate change is increasing the average temperatures in the Arctic, the thawing permafrost that's creating these sinkholes seems to have a different culprit — heated, slowly moving groundwater systems.

The Arctic permafrost at the bottom of the Canadian Beaufort Sea has been submerged for about 12,000 years, since the end of the last ice age, when meltwater from glaciers blanketed the region. Until now, the frozen seafloor had been hidden from scientists' peering eyes. This remote part of the Arctic has only recently become accessible to researchers on ships as climate change causes the sea ice to retreat, the researchers said.

Mapping the seafloor

With access to the area, the study researchers relied on both ship-based sonar and an autonomous underwater vehicle (AUV) to complete high-resolution bathymetric surveys of the Canadian Beaufort Sea.



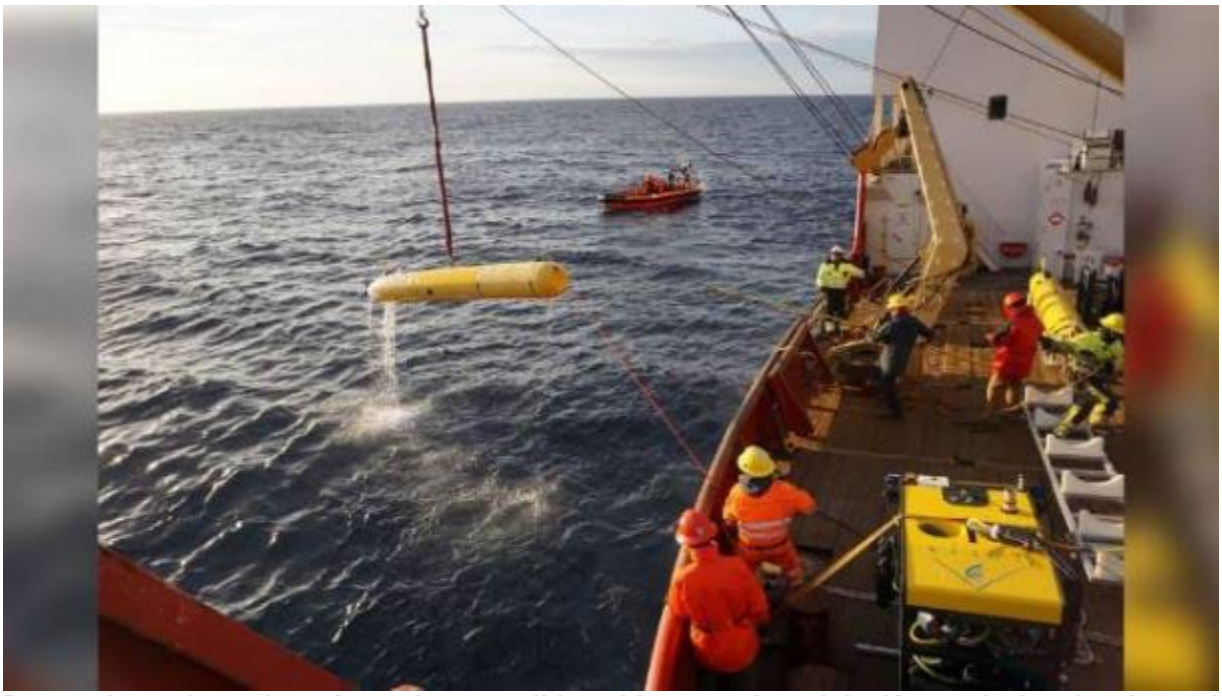
MBARI's mapping AUVs detailed the unusually rough seafloor terrain along the edge of the continental shelf in the Canadian Arctic. (Image credit: Roberto Gwiazda © 2017 MBARI)

"We know that big changes are happening across the Arctic landscape, but this is the first time we've been able to deploy technology to see that changes are happening offshore too," Charlie Paull, a geologist at Monterey Bay Aquarium Research Institute (MBARI), said in a statement. "While the underwater sinkholes we have discovered are the result of longer-term, glacial-interglacial climate

cycles, we know the Arctic is warming faster than any region on Earth," added Paull, who co-led the research with Scott Dallimore from the Geological Survey of Canada and Natural Resources Canada, with an international team of researchers.

When the researchers first started undertaking seafloor surveys in the region in 2010, they focused on the shelf edge and slope in the Canadian Beaufort Sea. About 110 miles (180 kilometers) from the shore, they spotted a 59-mile-long (95 km) band of unusually rough terrain along the seafloor. That stretch of seafloor once marked the edge of the Pleistocene permafrost during the last ice age. The team wondered what was causing the rugged nature of the ocean bottom.

To understand how this roughness evolved over time and what might be causing it, the team conducted three more surveys, using AUVs in 2013 and 2017 and then ship sonar in 2019. These snapshots of the same areas over time showed the emergence of steep-sided and irregularly shaped depressions. The largest sinkhole-like crater is a whopping 738 feet (225 meters) long, 312 feet (95 m) wide and 92 feet (28 m) deep, the researchers said.



Researchers plan to launch another expedition, this one onboard the Korean icebreaker Argon (shown here) for further research on the thawing permafrost under the Canadian Beaufort Sea. (Image credit: Roberto Gwiazda © 2017 MBARI)

Collapsing floor

Here's how the researchers propose the circular holes are forming: As gradual warming thaws the permafrost beneath the Arctic Shelf, an area that was once filled with a solid (frozen ground) becomes fluid. The surface material then collapses into that liquid-filled void; these seafloor collapses happen intermittently over time, the researchers said.

In some areas, where the discharge of this warm groundwater is more limited, the seawater on the floor stays cold enough that any groundwater percolating up refreezes once it's reached near-surface sediments. That frozen sediment expands, heaving upward to form little conical mounds called pingos. These frozen mounds interrupted by the sinkholes are responsible for the unusual roughness that the researchers first spotted in their surveys.

The surveys also showed that the sinkholes are expanding over time. "The continued enlargement of some depressions observed over multiple surveys indicates that the development of these depressions is part of on-going processes," the researchers wrote in their research article published online March 14 in the journal Proceedings of the National Academy of Sciences.

As for the cause, the researchers said that slow changes in climate related to the ending of the last ice age — which have been occurring for thousands of years — are the likely culprits that started the cycle. Once the submerged permafrost begins to melt, the heated groundwater from that melted permafrost inches upward along the bottom of the still-frozen permafrost, leading to more thawing of those sediments above. The process continues in this way to give birth to lots of divots.

What's Your Board Been Doing?

The GSNH Board of Directors met on Thursday, June 16th via zoom. The primary topic was preparing for the October dinner meeting, which will be in person! For the October meeting:

- The cost of dinner will be partially subsidized by NHGS.
- We will have elections for Board of Directors positions (see page 19 for details).
- See Dates to Remember (page 33) for presentation details. More details to come!

Other matters discussed at the meeting:

- Potential field trip topics for summer 2023
- Membership report: 126 active members, please see the end of this newsletter if you are interested in applying for, or renewing membership.
- Future dinner meeting locations, including the possibility that January meetings should be online due to weather concerns.

The next board of Directors meeting will be in September; please reach out to a board member if you'd like to attend.

Archive – Inside Kawah Ijen's Crater

From Earth Science Picture of the Day, June 04, 2022.
Photographer and Summary Author: João Manuel Pires dos Santos
https://epod.usra.edu/blog/2022/06/archive-inside-kawah-ijens-crater.html

The photo above was taken inside the crater of Kawah Ijen volcano on the island of Java, Indonesia. This colorful landscape is one of the most inhospitable places in the world. At upper left sulfuric gases can be seen venting from fractures in the crater. The lake partially filling the crater has a pH of 0.5 -- considered to be one of the most acidic bodies of water in the world. Photo taken on September 13, 2014.

Photo Details: 28mm focal length; f/8 aperture; 1/8 sec. exposure; ISO 200.

Kawah Ijen, Indonesia Coordinates: -8.05899, 114.23892

Related Links

- Sulfur Mining in the Kawah Ijen Volcano Crater

Student Links

- GLOBE Teacher's Guide - Hydrosphere

Earth Observatory

- Acid Lake in Java

Stanford researchers' explanation for formation of abundant features on Europa bodes well for search for extraterrestrial life

By Danielle Torrent Tucker for Stanford News Service. Published April 19, 2022.
https://news.stanford.edu/press/view/43397

Europa is a prime candidate for life in our solar system, and its deep saltwater ocean has captivated scientists for decades. But it's enclosed by an icy shell that could be miles to tens of miles thick, making sampling it a daunting prospect. Now, increasing evidence reveals the ice shell may be less of a barrier and more of a dynamic system – and site of potential habitability in its own right.

Ice-penetrating radar observations that captured the formation of a "double ridge" feature in Greenland suggest the ice shell of Europa may have an abundance of water pockets beneath similar features that are common on the surface. The findings, which appear in *Nature Communications* April 19, may be compelling for detecting potentially habitable environments within the exterior of the Jovian moon.

"Because it's closer to the surface, where you get interesting chemicals from space, other moons and the volcanoes of Io, there's a possibility that life has a shot if there are pockets of water in the shell," said study senior author Dustin Schroeder, an associate professor of geophysics at Stanford University's School of Earth, Energy & Environmental Sciences (Stanford Earth). "If the mechanism we see in Greenland is how these things happen on Europa, it suggests there's water everywhere."

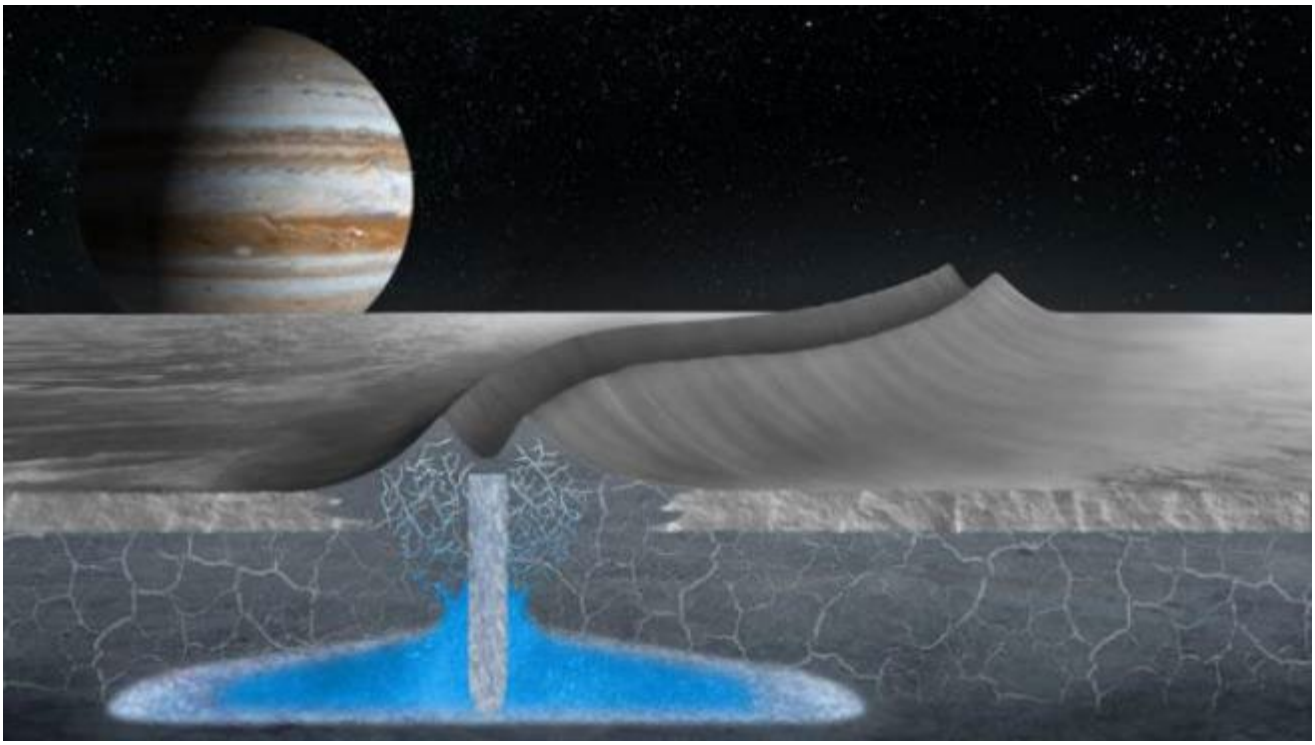
A terrestrial analog

On Earth, researchers analyze polar regions using airborne geophysical instruments to understand how the growth and retreat of ice sheets might impact sea-level rise. Much of that study area occurs on land, where the flow of ice sheets is subject to complex hydrology – such as dynamic subglacial lakes, surface melt ponds and seasonal drainage conduits – that contributes to uncertainty in sea-level predictions.

Because a land-based subsurface is so different from Europa's subsurface ocean of liquid water, the study co-authors were surprised when, during a lab group presentation about Europa, they noticed that formations that streak the icy moon looked extremely similar to a minor feature on the surface of the Greenland ice sheet – an ice sheet that the group has studied in detail.

“We were working on something totally different related to climate change and its impact on the surface of Greenland when we saw these tiny double ridges – and we were able to see the ridges go from ‘not formed’ to ‘formed,’ ” Schroeder said.

Upon further examination, they found that the “M”-shaped crest in Greenland known as a double ridge could be a miniature version of the most prominent feature on Europa.



This artist’s conception shows how double ridges on the surface of Jupiter’s moon Europa may form over shallow, refreezing water pockets within the ice shell. This mechanism is based on the study of an analogous double ridge feature found on Earth’s Greenland Ice Sheet. (Image credit: Justice Blaine Wainwright)

Prominent and prevalent

Double ridges on Europa appear as dramatic gashes across the moon’s icy surface, with crests reaching nearly 1000 feet, separated by valleys about a half-mile wide. Scientists have known about the features since the moon’s surface was photographed by the Galileo spacecraft in the 1990s but have not been able to conceive a definitive explanation of how they were formed.

Through analyses of surface elevation data and ice-penetrating radar collected from 2015 to 2017 by NASA’s Operation IceBridge, the researchers revealed how the double ridge on northwest Greenland was produced when the ice fractured around a pocket of pressurized liquid water that was refreezing inside of the ice sheet, causing two peaks to rise into the distinct shape.

“In Greenland, this double ridge formed in a place where water from surface lakes and streams frequently drains into the near-surface and refreezes,” said lead study author Riley Culberg, a PhD student in electrical engineering at Stanford. “One way that similar shallow water pockets could form on Europa might be through water from the subsurface ocean being forced up into the ice shell through fractures – and that would suggest there could be a reasonable amount of exchange happening inside of the ice shell.”

Snowballing complexity

Rather than behaving like a block of inert ice, the shell of Europa seems to undergo a variety of geological and hydrological processes – an idea supported by this study and others, including evidence of water plumes that erupt to the surface. A dynamic ice shell supports habitability since it facilitates the exchange between the subsurface ocean and nutrients from neighboring celestial bodies accumulated on the surface.

“People have been studying these double ridges for over 20 years now, but this is the first time we were actually able to watch something similar on Earth and see nature work out its magic,” said study co-author Gregor Steinbrügge, a planetary scientist at NASA’s Jet Propulsion Laboratory (JPL) who started working on the project as a postdoctoral researcher at Stanford. “We are making a much bigger step into the direction of understanding what processes actually dominate the physics and the dynamics of Europa’s ice shell.”

The co-authors said their explanation for how the double ridges form is so complex, they couldn’t have conceived it without the analog on Earth.

“The mechanism we put forward in this paper would have been almost too audacious and complicated to propose without seeing it happen in Greenland,” Schroeder said.

The findings equip researchers with a radar signature for quickly detecting this process of double ridge formation using ice-penetrating radar, which is among the instruments currently planned for exploring Europa from space.

“We are another hypothesis on top of many – we just have the advantage that our hypothesis has some observations from the formation of a similar feature on Earth to back it up,” Culberg said. “It’s opening up all these new possibilities for a very exciting discovery.”

Giant ‘dragon of death’ with 30-foot wingspan unearthed in Argentina

By Jennifer Nalewicki, May 24, 2022. From Live Science:
https://www.livescience.com/death-dragon-pterosaur-in-argentina

Researchers in Argentina have unearthed the largest pterosaur species ever found in South America. Dubbed "dragon of death" by paleontologists, two giant flying reptiles were discovered in the Plottier Formation, an outcrop located in the province of Mendoza.

The aptly named Thanatosdrakon "dragon of death" pterosaur was a flying reptile that lived alongside dinosaurs during the Cretaceous period. (Image credit: Courtesy of Leonardo D. Ortiz David)

The two specimens' wingspans measured approximately 23 feet (7 meters) wide and 30 feet (9 m) wide, respectively. Researchers confirmed that they are azhdarchids, a family of pterosaurs that lived during the end of the Cretaceous period (approximately 146 million to 66 million years ago).

"Azhdarchids were known for their very large skulls — sometimes larger than their bodies — as well as their hyper-elongated necks and short, robust bodies," Leonardo D. Ortiz David, lead author of a new study describing the enormous pterosaurs and coordinator general of Argentina's Laboratory and Museum of Dinosaurs in Mendoza, told Live Science in an email.

The scientists identified the pterosaurs as two individuals in the species *Thanatosdrakon amaru*. This is the sole species in the genus, which means "dragon of death," in Greek. The species name,

"amaru," translates as "flying serpent" from the Indigenous Quechuan language and refers to Amaru, a two-headed Incan deity, the study authors reported.

Researchers determined that the two pterosaurs died at the same time and that one was not yet fully grown. But the scientists can't say for sure if the two animals represent part of a family group.

"There is no indication in the fossil remains of a degree of parental relationship," Ortiz David said. "However, it can be confirmed that both specimens are of different sizes, and that the smaller one is a juvenile-subadult, and that they were together when they died more than 86 million years ago."

Paleontologist Leonardo D. Ortiz David stands next to a life-size reconstruction of Thanatosdrakon at the Laboratory and Museum of Dinosaurs at the National University of Cuyo in Mendoza, Argentina. (Image credit: Courtesy of Leondardo D. Ortiz David)

The fossils were found during excavations for a civil construction project about 500 miles (800 kilometers) outside Mendoza's capital city (also named Mendoza). Ortiz David and his team were supervising the dig when they discovered fossil fragments within floodplain deposits. Mendoza, where Aconcagua, the highest mountain in the Americas, is also located, is well known among paleontologists for other important dinosaur discoveries, including that of the giant sauropod *Notocolossus*, one of the largest dinosaurs in the world, in 2016. (Ortiz David's research group made that discovery as well.)

"The [*Thanatosdrakon*] fossils were in different states of preservation; some of them were complete, such as both humeri [large arm bones], syncarpals [fused foot bones] and dorsal vertebrae," he said. "Others were fragmentary, including the phalanges [toe bones], ulna, radius [forearm bones], femur [upper leg bone] and pelvis."

This photo shows part of a *Thanatosdrakon* radius, or forearm bone, where it attaches to the shoulder. (Image credit: Courtesy of Leonardo D. Ortiz David)

Ortiz David said that the team's discovery of fossils in such good condition was surprising, because pterosaur bones are fragile, and fossils are usually found in tiny pieces.

"From the beginning, two facts caught our attention: The first was the size of the remains and their preservation in three dimensions, an unusual condition in this group of vertebrates; the second was the amount of remains found at the site, since large-giant pterosaurs are only known from fragmentary remains (with some exceptions)," he said. "The description of new specimens is always important for vertebrate paleontology, as they shed light on the different groups being studied. In this particular case, 3D elements of large pterosaurs are scarce, making *Thanatosdrakon* an excellent case study."

The fossils are currently housed in the Laboratory and Museum of Dinosaurs at the National University of Cuyo in Mendoza. To help preserve the specimens, museum experts made casts of the different fossils on a 1-to-1 scale; the casts are on display at the museum.

The researchers' findings will be published in the September 2022 issue of the journal Cretaceous Research.

Call For Nominations – GSNH Board

Several positions on the Board of Directors have terms expiring this year, and voting will take place in October 2022. These include the following: President, Society Vice President, Council Vice President, Secretary, and three Member-at-Large positions.

GSNH Needs You!

Two positions are term-limited and expiring in 2020, so the Board is particularly looking for the candidates for Member-at-Large (two positions):

If interested in joining the Board of Directors, please contact a member of the Nominating Committee:
Julie Spencer (julie.spencer@comcast.net)
Wayne Ives (christopher.w.ives@des.nh.gov)

For more details about all the positions, see http://www.gsnh.org/gsnh-constitution-and-bylaws.html.

Archive – Upheaval Dome

From Earth Science Picture of the Day, March 19, 2022.
Photographer and Summary Author: Steven Schimmrich
https://epod.usra.edu/blog/2022/03/archive-upheaval-dome.html

The panorama above shows Upheaval Dome in Canyonlands National Park, Utah as viewed from the Overlook Trail. Upheaval Dome is an odd appearing structure in an area of otherwise flat-lying sedimentary rocks. While originally believed to be a deeply eroded uplift dome from the intrusion of a salt diapir (salt dome), evidence now indicates its origin as an ancient meteorite impact structure.

The lighter color rock at center is the Permian White Rim Sandstone of the Cutler Group, the prominent cliff faces are resistant Jurassic Wingate Sandstone, and in between lie the more easily eroded Triassic Moenkopi and Chinle Formations. Evidence suggesting that this is an impact structure include the orientation of the folds and faults surrounding the structure, the finding of shocked quartz in the vicinity, and seismic reflection data indicating fractured rock below the structure and the absence of a salt dome. Photo taken on June 7, 2010.

Photo details: Panasonic Lumix DMC-FZ50 camera; 35-400 mm zoom lens (f/2.8-3.7); automatic exposure; panorama created from seven images stitched together with Hugin 2011.0.0 Panoramic Photo Stitcher.

Upheaval Dome, Utah Coordinates: 38.43473, -109.95138
Related Links

- Mesa Arch
- Steven's website
- Utah Geology

Earth Observatory

- Zion Canyon
- Salt Domes on Melville Island

Krypton Isotopes Provide New Clues to Planets' Pasts

By Carolyn Wilke, Eos. Published May 4, 2022.
https://eos.org/articles/krypton-isotopes-provide-new-clues-to-planets-pasts

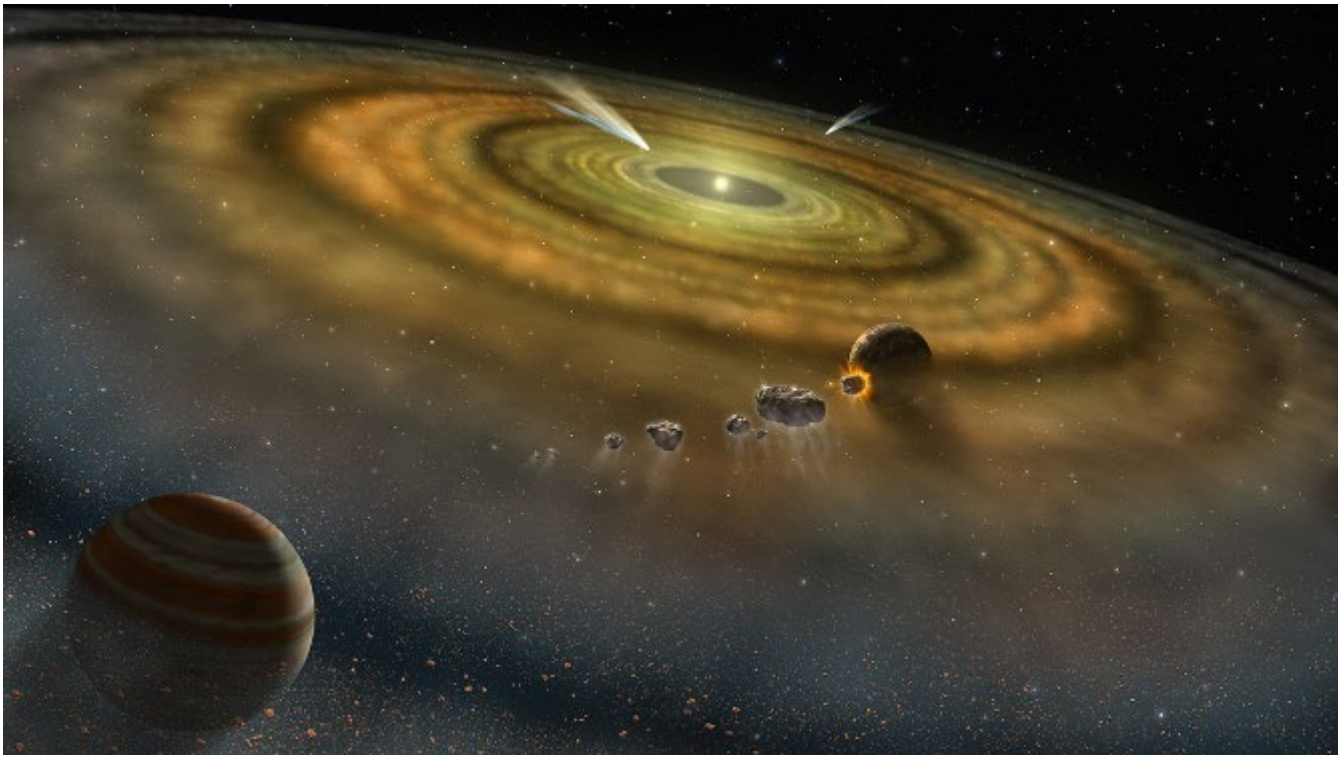
To host life, our home planet needed some key ingredients: carbon, nitrogen, and water. Information on where these crucial chemical entities came from, and when, isn't so clear. To search for clues, researchers look to noble gases, particularly neon, argon, krypton, and xenon, as tracers.

Now, improved experimental techniques have made it easier to untangle underutilized krypton isotopes in gas trapped in rocks, which may provide new hints about the pasts of Earth and other planets.

Planets' Shrouded Pasts

Billions of years ago, a swirling cloud of dust and gas started forming our solar system. Out of this cosmic hurricane, the Sun and the planets were born.

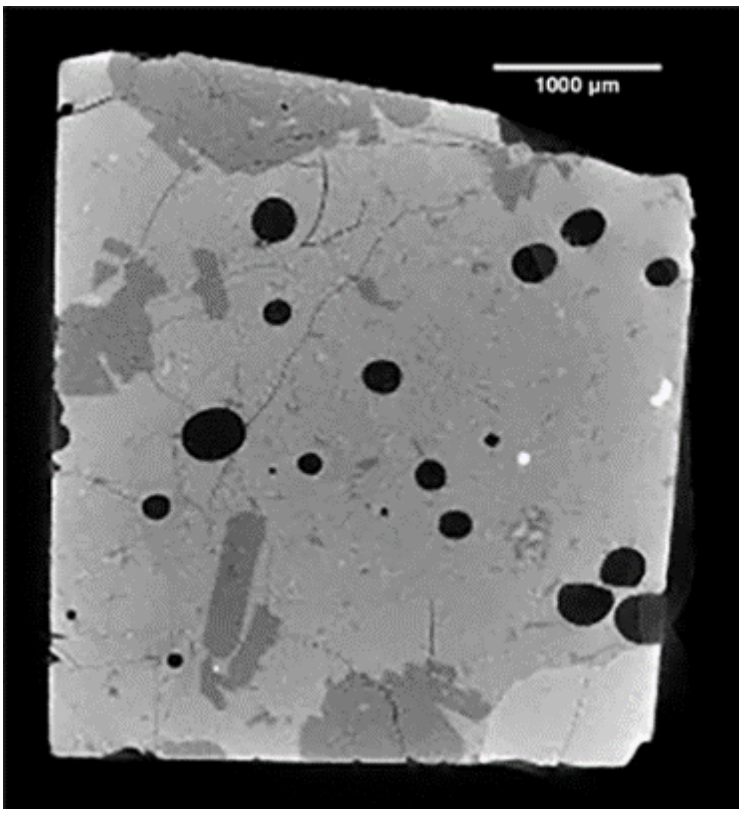
Exactly how the rocky planets (including Earth) took shape is still up for debate. In one scenario, planetary building blocks called planetesimals snatched up pebbles in their vicinities, also stashing carbon, nitrogen, water, and noble gases—stuff that planetary scientists call volatiles. In another scenario, planets grew mostly from planetesimals bashing into each other, the force of collisions melting rock and ejecting volatiles, which were replenished later. Or planets may have gained girth through a mix of these two models. Planetary scientists generally agree that there was one major and final impact with early Earth around 4.5 billion years ago that formed the Moon.



An artist's impression offers a view of planet formation: Close to the star, dust particles grow into planetesimals and Earth-like planets. Farther away, gas accretes onto planetary cores to create Jupiter-like giants. Credit: NASA/FUSE/Lynette Cook

To peer into Earth's past, researchers examine samples from the mantle that contain noble gases, some of which were delivered during Earth's formation. These samples include basalts that form at ocean ridges and from undersea volcanic eruptions. When the lava cools, forming these rocks, it traps gases from the mantle.

Unlike the stuff of life, noble gases are reticent elements, steering clear of biological processes and chemical reactions on Earth. Researchers can look to ratios of certain noble gas isotopes that have stuck around since their delivery as signposts for volatiles' sources, such as comets, meteors, the solar nebula, and solar wind.



This cross section shows gas bubbles in basalts in an image taken by a technique called X-ray microtomography. Credit: Sandrine Péron

Researchers have been doing this kind of work for decades. But “krypton has been one of the most underutilized noble gases,” said Michael Broadley, an isotope geochemist at the University of Lorraine in France who was not involved in the new research. “There’s been very little work done using krypton to determine the origin of volatiles.”

Somewhat tricky to track, krypton isotopes occur at low abundances and are difficult to separate from other noble gases. The name krypton means cryptic, said Sandrine Péron, a geochemist at ETH Zürich in Switzerland. “So it is kind of hidden…it was difficult to detect.”

Popping Rocks

Péron, then at the University of California, Davis, and her colleagues have come up with new techniques to improve the analysis of samples with tiny amounts of krypton.

When “you’re looking at a little bit of rock with a little bit of gas from the mantle in it, the big problem is air contamination,” said Greg Holland, a geochemist at the University of Manchester in the United Kingdom who was not part of this new work. Noble gases from the atmosphere can swamp the subtle signals of mantle gases.

To avoid air contamination, Péron's team progressively crushed rocks formed from eruptions beneath glaciers in Iceland and from under the ocean in the Galápagos. As the scientists popped bubbles in the basalts, they checked for atmospheric contamination, which is easily detected from the neon isotopic signature. Whenever bubbles' gases looked contaminated, they disposed of the gas. By keeping the gas when the neon isotopic composition was close to the mantle's, the researchers enriched the sample's mantle-derived krypton prior to analysis. Also, by splitting the process that separates the noble gases into two steps, the team upped their ability to isolate krypton isotopes from other noble gases.

Having the ability to measure krypton isotopes precisely is really useful, said Guillaume Avice, a planetary scientist at the Institut de Physique du Globe de Paris in France who was not involved in the new study. "It's a new tool…that you can use to build this story" of Earth's formation, he said.

One reason krypton isotope analyses are useful is that the isotopic signatures in different sources are easy to tell apart. Péron and colleagues saw that their mantle samples' krypton signatures mostly aligned with those of certain meteorites thought to have been incorporated into proto-Earth around the time of the Moon-forming impact. And because the mantle's krypton isotope signature doesn't match that of the atmosphere, another source had to have brought some of Earth's volatiles, the authors reported last year in *Nature*.

With this combination of techniques, Péron and colleagues have gotten the best insight yet into the deep mantle's composition, Broadley said. The study has also "opened a lot of questions, especially about the relationship between Earth and the meteorite records." Because the heaviest krypton isotope didn't match the meteoric source, it may require another source to explain it, the authors reported. Reanalyzing the old meteorites with the new methods may help explain the mismatch, Avice said, as could sampling more meteorites.

Beyond Earth

Péron and her colleagues are currently analyzing krypton isotopes in Martian meteorites, which may provide insights into where Mars's volatiles originated and why Earth and Mars are so different today.

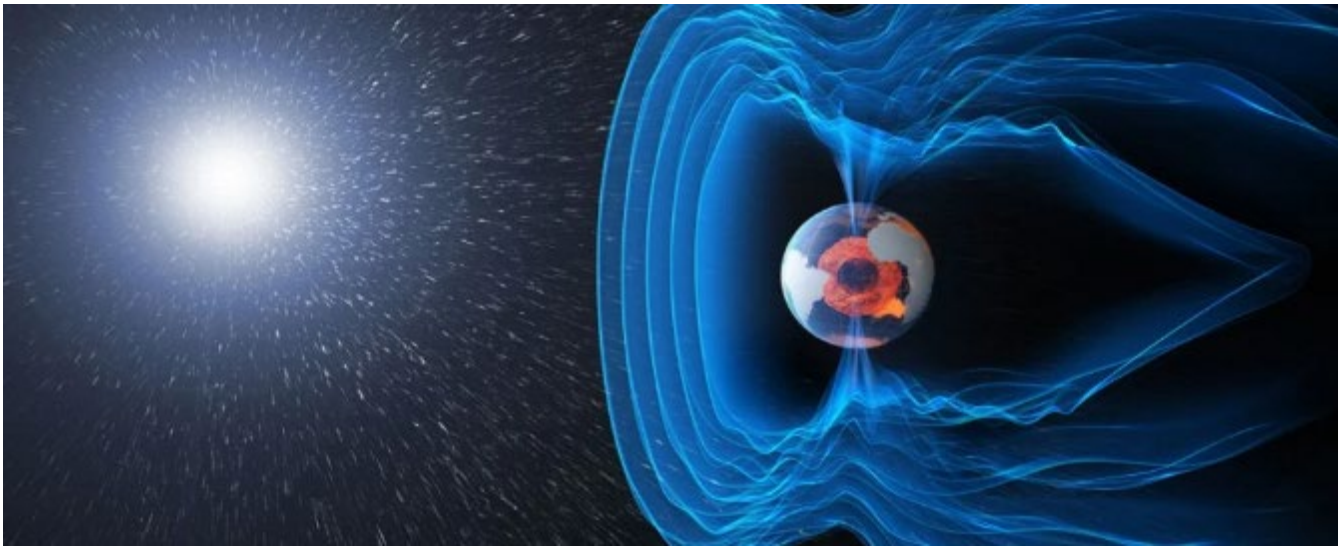
Venus presents another mystery. Similar in size and close in proximity, Earth and Venus are like twins, Broadley said. But scientists don't know how their paths to planethood and sourcing of volatiles compare. NASA's DAVINCI+ mission is slated to surveil Venus's noble gases. An understanding of the noble gases in Venus's atmosphere and a comparison with Earth will give us really fundamental insight into why Earth became habitable, he said.

With such tiny amounts of krypton isotopes, Péron said, we can learn more about the evolution of Earth and the solar system.

Citation: Wilke, C. (2022), Krypton isotopes provide new clues to planets' pasts, *Eos, 103,* https://doi.org/10.1029/2022EO220226. Published on 4 May 2022.

Earth's Magnetic Poles Probably Won't Flip After All, Scientists Predict

By Mike McRae, June 8, 2022. From ScienceAlert: https://www.sciencealert.com/a-9-000-year-old-timeline-of-our-planet-s-magnetic-field-shows-why-we-shouldn-t-panic



ESA/ATG medialab

Our planet's protective shell isn't quite what it used to be. Over the past two centuries its magnetic strength has taken a nosedive, and nobody has the foggiest idea why.

At the same time, a concerning soft-spot in the field called the South Atlantic Anomaly has blistered over the Atlantic ocean, and has already proven problematic for delicate circuitry on orbital satellites.

Both of these troubling observations fuel concerns that we might be seeing signs of an imminent reconfiguration that would turn the compass points all topsy-turvy in what's known as a magnetic pole reversal.

But researchers behind a new investigation modelling the planet's magnetic field in the recent past warn that we shouldn't be too hasty in assuming that's going to happen.

"Based on similarities with the recreated anomalies, we predict that the South Atlantic Anomaly will probably disappear within the next 300 years, and that Earth is not heading towards a polarity reversal," says geologist Andreas Nilsson from Lund University in Sweden.

Not any time soon, at least. So for now we can breathe easy.

Still, if our geological history is anything to go by, it's likely the flowing lines of our planetary magnetic field will eventually point the other way around.

What such a reversal would mean for humanity isn't clear. The last time such a monumental event occurred, a mere 42,000 years ago, life on Earth seemed to go through a rough period as a rain of high-speed charged particles ripped through our atmosphere.
Whether we humans noticed – perhaps responding by spending a bit more time sheltering – is a matter of speculation.

However, given today's reliance on electronic technology that could be vulnerable without the protection of a magnetic umbrella, even the most rapid of field reversals in the foreseeable future would leave us exposed.

So geologists are keen to know which wiggles, wobbles, and wanderings in the field herald catastrophe, and which imply business as usual.

Much of what we know of the magnetic field's history comes from the way its orientation forces particles in molten materials to line up before being locked in place as they solidify. Digging through layers of mineralized arrows provides a fairly clear record of which way the compass pointed throughout the millennia.

Similarly, pottery artifacts from archaeological sites can also provide a snapshot of the field in more recent times, capturing its direction in clay before firing.

In the new study, researchers from Lund University and Oregon State University reconstructed a detailed timeline of our planet's magnetic shell stretching back towards the last ice age, by analyzing samples of volcanic rocks, sediments, and artifacts from around the world.

"We have mapped changes in the Earth's magnetic field over the past 9,000 years, and anomalies like the one in the South Atlantic are probably recurring phenomena linked to corresponding variations in the strength of the Earth's magnetic field," says Nilsson.

With thousands of years of perspective, it quickly becomes clear the South Atlantic soft-spot isn't completely out of the ordinary. Starting around 1600 BCE, a similar geological change took place, lasting some 1,300 years before evening out once more.

Assuming the same basic mechanics are at work, it's likely the current patch of weakening will soon regain strength and fade away without ending in global reconfiguration. It's even likely the magnetic field as a whole will bounce back to a vigor we haven't seen since the early 19th century.

This isn't proof against a reversal occurring soon, however – just new evidence suggesting we shouldn't interpret present anomalies of diminishing strength as strong signs of a polar flip.

In some ways, that's good news. But it leaves us in the dark on exactly what such a massive geological process will look like in the scale of a human lifetime.

Having detailed records like this one goes a long way towards building a clearer picture, so maybe if the worst happens, we'll be prepared for it.

This research was published in *PNAS*.

Earth Science Week 2022

Earth Science week will be October 9-15 this year. The theme will be “Earth Science for a Sustainable World”. The Earth Science week website (https://www.earthsciweek.org/) includes educational resources and events for educators, students, the press, and the general public, including a free Earth Science Week Toolkit. At press time, it’s a bit early for events to be posted, but the website does list national events including Geoscience Congressional Visits Days, National Fossil Day with the National Park Service, the Great Central U.S. ShakeOut, and more.

The most recent Earth Science Week update as of press time (May 2022) provides links to other geoscience updates, including more educational resources and the results of the recent “Status of Recent Geoscience Graduates 2021” report. Check it out!

June Legislative Committee Report by Tom Fargo

Below is a list of 2022 NH General Court (House and Senate) Bills that are potentially relevant to members of the Geological Society of New Hampshire. This table lists bills identified by keyword searches completed on December 14, 2021, repeated on June 10, 2022.

Bill No.	Title	Bill Description	
Key Word "**Environ**"			
HB-398	making an appropriation to the department of environmental services for funding eligible wastewater projects	This bill, held over from 2021, appropriates to the NHDES the sum of $5,735,248 for the fiscal year ending June 30, 2023 and $6,919,115 for the fiscal year ending June 30, 2024, which is nonlapsing, for the purpose of funding eligible wastewater projects under RSA 486.	Passed by both Hose and Senate, signed by Governor
HB-412	making an appropriation to the department of environmental services for the purpose of funding public water system projects	This bill, held over from 2021, appropriates to the NHDES the sum of $500,000 for the fiscal year ending June 30, 2023 and $500,000 for the fiscal year ending June 30, 2024, which is nonlapsing, for the purpose of funding public water system projects eligible for state and/or federal assistance.	Laid on the Table by the Senate on March 24, 2022. In the second year of a term, this usually means the bill is dead. However, the Senate may still advance the bill.
HB-1452-FN	renaming the department of environmental services the department of environmental protection and assigning the department oversight of private drinking water wells.	This bill enables the Department of Environmental Services to enter private property to inspect and sample private wells and also changes the name of the "Department of Environmental Services" to the "Department of Environmental Protection" Note: The FN designation indicates the bill contains a fiscal note describing the impact of the bill on the State budget. In this case the cost was described as an indeterminable increase in expenses to the Department.	Referred to Interim Study by the House on February 16, 2022. In the second year of a term, this usually means the bill is dead. However, a Committee work session is scheduled for June 22, 2022.
HB-1546-FN	enabling the commissioner of the department of environmental services to adopt rules relative to airborne PFAS in certain circumstances	This bill states: By January 1, 2023 and annually thereafter, the commissioner shall consider peer-reviewed studies of the acute, chronic, mutagenic, reproductive, or developmental health effects in humans as a result of inhalation exposure to an individual per and polyfluoroalkyl substance, and whether to establish or modify any classification or ambient air limit for such individual per and polyfluoroalkyl substance by adopting rules in accordance with the provisions of RSA 541-A.	Passed by the House and Senate. Awaiting Governor action.
SB-455	requiring the commissioner of the department of environmental services to adopt ambient	This bill states: By January 1, 2023, the commissioner shall, in consultation with the commissioner of the department of health and human services and interested parties, initiate rulemaking	Voted Inexpedient to Legislate by the Senate on February 16, 2022. Bill Killed.

	groundwater quality standards for certain per and polyfluoroalkyl substances	to adopt ambient groundwater quality standards for perfluorobutanoic acid (PFBA), perfluoroheptanoic acid (PFHpA); and perfluorodecanoic acid (PFDA) Note: these are PFAS compounds for which AGQS have not been adopted.	
Key Word "**Water**"			
HB-135	requiring parties responsible for pollution of a drinking water supply to be financially responsible for certain consequences of that pollution	This bill, held over from 2021, states: Whenever the commissioner finds a public or private corporation, individual, partnership, or other entity has violated the provisions of this chapter, any rules in force hereunder, or any condition in a permit issued under this chapter, then: 1. The entity shall connect any residence or business affected by such violation to a commercial or municipal water supply; 2. The entity shall supply drinking water to the affected residence or business until a connection to commercial or municipal water supply is made. The entity shall pay the owner of the residence or business affected by the violation a monthly sum based on the average water usage and billing of comparable residences or businesses	Voted Inexpedient to Legislate by the Senate on January 5, 2022. Bill Killed.
HB-335	requiring bottled drinking water sold to the public to meet the same maximum contaminant levels established for public drinking water	This bill., held over from 2021, requires: 1) manufacturers of bottled water shall only utilize a source of water that complies with the requirements in rules adopted under RSA 143:6. 2) All sources of bottled water in New Hampshire that began service on or after August 8, 1997 shall be approved by the department of environmental services in accordance with RSA 485:3, XI. 3) All products shall comply as to composition, labeling, conditions of manufacture, transportation, storage, handling, and sale with existent statutory provisions relating thereto and with rules adopted under this chapter. 4) All bottled water manufactured in the state shall comply with requirements specified in departmental rules adopted under RSA 143:6, and the maximum contaminant levels established under RSA 485.	Voted Inexpedient to Legislate by the House on January 5, 2022. Bill Killed.
HB-478	relative to treatment of PFAS contaminants in the drinking water of the Merrimack Village Water District	This bill, held over from 2021, formally requests that Saint Gobain commit to the following: 1) Provide for the design, installation, operation, maintenance and monitoring of all water treatment system(s) necessary to effectively treat and remove PFC contamination from all affected public water systems. 2) Retain the services of a qualified professional engineer to design the treatment system(s) necessary to effectively treat and remove PFC contamination from all affected public water	Referred to Interim Study by the Senate on April 27, 2022. In the second year of a term, this usually means the bill is dead.

		systems; 3) Provide for the necessary long term operation, maintenance, and monitoring of the installed treatment systems	
HB-1167	establishing a maximum contaminant level for perfluorinated chemicals in surface water.	This House bill proposes to set the following maximum contaminant levels in surface waters: (a) Perfluorooctanoic acid (PFOA): 12 parts per trillion. (b) Perfluoroctanesulfonic acid (PFOS): 15 parts per trillion. (c) Perfluorohexanesulfonic acid (PFHxS): 18 parts per trillion. (d) Perfluorononanoic acid (PFNA): 11 parts per trillion. (e) Perfluorobutyrate (PFBA): 7 parts per trillion. (f) Perfluorobutanesulfonic acid (PFBS): 1000 parts per trillion. (g) The total contaminant levels of subparagraphs (a) through (f): 20 parts per trillion.	Referred to Interim Study by the House on March 11, 2022. In the second year of a term, this usually means the bill is dead. However, a Committee work session is scheduled for June 22, 2022.
HB-1185	relative to treatment of water contaminated with perfluorinated chemicals.	Key provisions: 1) A wastewater treatment plant may require any industrial or commercial facilities or septic haulers contributing discharge to its plant to test such discharge to determine the level of PFAS in the discharge. 2) A wastewater treatment plant may refuse discharge from an industrial or commercial facility or septic hauler that has reported a level of PFAS in its discharge above the level the wastewater treatment plant determines to be acceptable. 3) A municipality or other governmental entity owning or controlling a waste treatment facility may fine discharge producers for providing discharge containing a level of PFAS above the level the wastewater treatment plant has determined to be acceptable.	Passed with amendment by the House and Senate. Awaiting Governor action.
Key Word "**Waste**"			
SB-380-FN	relative to solid waste rules and landfill containment tests	This bill, held over from 2021, This bill adds duties to the solid waste working group relative to solid waste plans and disposal sites. These new duties include: 1) Review and make recommendations regarding municipal solid waste plans and implementing the prohibition of any landfill in the state from accepting waste from a municipality that does not have a solid waste management plan. 2) Review and make recommendations regarding the development of a solid waste disposal site evaluation committee or better defining alternative site analysis in RSA 149-M:9	Passed by both Hose and Senate, signed by Governor
SB-396-FN	relative to solid waste management	This bill, held over from 2021 enables the NHDES to enter into a written agreement with the applicant [for a landfill permit] for the department to retain, at the applicant's expense, an independent licensed professional engineer or hydrogeologist to assist the department in determining what information is necessary to render the application technically complete, assessing during the technical review of the application whether it meets the requirements for approval in this chapter	Passed by both Hose and Senate, signed by Governor

		and the rules adopted under RSA 149-M:7, and ensuring that the department processes the application in a timely manner as required by this section. The applicant's failure to enter into such an agreement may be grounds to deny the application.	
HB-1420-FN	prohibiting the issuance of new landfill permits until the state's solid waste plan is updated.	Requires the Department of Environmental Services shall not issue a permit for the construction of a new facility unless the department makes a positive determination that the permit application is consistent with the state's solid waste plan that has been updated consistent with the requirements of RSA 149-M:29.	Passed with amendment by the House and Senate. Awaiting Governor action.
HB-1121	relative to new solid waste sites	Requires applications for permits to construct and operate a new privately-owned solid waste landfill shall submit evidence to the department of environmental services that the applicant is in compliance with all insurance and surety bonding requirements of the state and federal government. The applicant shall also provide evidence to the jurisdictions in which it will be located, and all adjacent jurisdictions, that the applicant qualifies for and will obtain a surety bond against any and all damages caused to individuals and businesses located within those jurisdictions as a result of operation of the solid waste landfill.	Referred to Interim Study by the House on February 16, 2022. In the second year of a term, this usually means the bill is dead.
Key Word "Professional" as potentially related to Geologists			
HB-1019	establishing a committee to study the replacement of certain professional licenses with mandatory minimum liability insurance requirements.	This bill would establish a committee to study the replacement of certain professional licenses with mandatory minimum liability insurance requirements. The members of the committee shall be as follows: (a) Three members of the house of representatives, appointed by the speaker of the house of representatives. (b) Three members of the senate, appointed by the president of the senate.	Referred to Interim Study by the House on March 15, 2022. In the second year of a term, this usually means the bill is dead.
Key Word "Soil"			
HB-1547-FN	relative to per fluorinated chemical remediation in soil and procedures for certain hazardous waste generators	This bill: I. Requires the commissioner of the department of environmental services to adopt rules relative to perfluorinated chemical remediation in the soil. II. Clarifies language describing certification requirements for certain hazardous waste generators. III. Makes an appropriation to the PFAS remediation loan fund.	Passed by the House and Senate. Awaiting Governor action.

Key word searches with no returns: **geology, mineral, rock**

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DATES TO REMEMBER

Please check online or the contact info below to confirm the status of these events. The list is current as of publication date but may change.

June 25-26, 2022 – **Gilsum Rock Swap 2022**. Gilsum Elementary School and Community Center, 640 Route 10, Gilsum, NH. https://gilsum.org/rockswap/

July 15-16, 2022 – **Seek the Peak Adventure Expo** to benefit Mount Washington Observatory. https://secure.qgiv.com/event/stp2022

July 30-31, 2022 – **41st Annual Champlain Valley Gem, Mineral and Fossil Show**. Champlain Valley Exposition, Blue Ribbon Pavilion, 105 Pearl Street, Essex Junction, Vermont. http://www.burlingtongemandmineralclub.org/show.html

August 12-14, 2022 – **2022 East Coast Gem, Mineral & Fossil Show**. Better Living Center, Eastern States Exposition, 1305 Memorial Ave, West Springfield, Massachusetts. https://www.mineralshowslld.com/fall-east-coast-show/

August 27-28, 2022 – **Capital Mineral Club Gem, Mineral & Jewelry Show**. Everett Arena, 15 Loudon Road, Concord, New Hampshire. https://www.capitalmineralclub.org/minshows.php

September 12-13, 2022 – **NGWA Groundwater in Fractured Rock Conference**. Burlington, Vermont. https://www.ngwa.org/detail/event/2022/09/12/default-calendar/22sep5017

September 15, 2022 – **GSNH Board of Directors Fall Meeting**

September 17, 2022 – **New England Mineral Association Mineral Tailgate Sale**. Rain date September 18. The tailgate sale will be held at the Havey Quarry, Levine, Road, Poland, Maine from 9AM to 4PM. Contact Jeff (jmorris7@maine.rr.com) to request to be a vendor and Jan (nemineralinfo@gmail.com) to sign up as a volunteer. http://www.nemineral.org/me_events/

October 9-15, 2022 – **Earth Science Week** – more information will be available closer to October; see https://www.earthsciweek.org/ and blurb on page 26 for details.

October 13, 2022 – **GSNH dinner meeting** – In Person at Makris! Nathanial Kitchel will give a presentation entitled “Facing the Forest: Human Adaptations Across the Pleistocene-Holocene Transition in Northern New England”. Details to follow.

January 19, 2022 – **GSNH dinner meeting** – Details TBD.

Looking for some continuing ed credits? Some webinar series are below:

- clu-in.org compiles webinars of interest to EPA and the environmental community here: https://clu-in.org/training/#upcoming
- The geoscience online learning initiative (GOLI) has several webinars and short courses: https://www.americangeosciences.org/workforce/goli

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__ Other:

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Make checks payable to **"Geological Society of New Hampshire."** Note that GSNH dues are not deductible as a charitable contribution, but may be deductible as a business expense. Please return this completed application form with any necessary corrections and a check for the appropriate dues to the GSNH at the address above. The Society's membership year runs from January 1 to December 31.

Signature: _____ Date: _____