

NORTHERN CALIFORNIA GEOLOGICAL SOCIETY



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MEETING ANNOUNCEMENT

DATE: Wednesday, October 25, 2023

LOCATION: [Orinda Masonic Hall](#)

TIME: [Social: 6:30 to 7:15 pm; Program: 7:15 to 8:30 pm](#)

SPEAKER: *L. Dismore (Diz) Swift, Chevron
(Retired)*

TOPIC: *“Climate Change – Evidence and
Possible Tipping Points”*

Abstract:

Since the Fourth Report of the Intergovernmental Panel on Climate Change in 2007, the scientific evidence for human caused climate change has become incontrovertible. In spite of warnings and many promises to address climate change since then, the two major greenhouse gases – CO₂ and methane – are still rising, reaching levels not seen since the Paleocene-Eocene. Most of the generated heat is being taken up by the oceans; they have absorbed 90% of the heat. Warming oceans affect atmospheric and ocean currents with resulting weather-related changes. This year, 2023, has seen extreme weather, record and near record lows in both Arctic and Antarctic sea ice, the highest recorded surface sea temperatures in the North Atlantic and Caribbean, and many, many record temperatures and heat waves. Although exacerbated by El Nino, the heat is well outside the range of that effect alone.

The inexorable increase in global temperature is leading to dangerous changes, some irreversible in the human time frame. These so-called “tipping points” include accelerating loss of ice sheets in Greenland and Antarctica, slowing or even collapse of the Atlantic Meridional Overturning Circulation (AMOC), and thawing of permafrost in the Northern Hemisphere, which releases methane and carbon dioxide, setting up a cycle of increasing greenhouse gases.

The warming climate is causing changing weather patterns, agricultural disruption, extinctions, migrations of people and animals, and political instability. The US Defense Department has long recognized climate change as a defense threat multiplier. The interrelationships are complex and difficult.

What do we do? A very big obstacle in the U.S. is how climate change has become political. But the economic argument against action is false. Putting off action just raises the costs. Further, California has shown we can reduce greenhouse gases and at the same time grow our economy. We

NCGS 2023 – 2024 Calendar

October 25, 2023 7:00 pm

Linda Dismore Swift, Chevron (Retired)

Climate Change: Evidence and Possible Tipping Points

November 15, 2023 7:00 pm

Jeff Unruh, Lettis Consultants International Inc.

Seismic Hazard Evaluation of the West Tracy Fault at Byron, CA, for State Water Infrastructure

January 31, 2024 7:00 pm

Pallav Sarma, Tachyus Corporation

Physics Embedded Machine Learning for Modeling and Optimization of Mature Oil Reservoirs

February 28, 2024 7:00 pm

Chris Bond, CA Department of Water Resources

DWR's California Aqueduct Subsidence Program (CASP) - addressing ongoing groundwater pumping induced subsidence while developing solutions and funding sources to proactively preserve the aqueduct's ability to deliver water for the next 75 years

March 27, 2023 7:00 pm

Jessica Murray, U.S. Geological Survey

Inclusion of real-time Global Navigation Satellite System-based earthquake source characterization in the ShakeAlert earthquake early warning system to improve estimates of anticipated ground shaking and the alerts derived from them

April 24, 2023 7:00 pm

Program TBD

May 29, 2023 7:00 pm

Program TBD – Dinner Meeting

June 26, 2023 7:00 pm

Program TBD

Announcing Return to In-Person Meetings and New Youtube Channel:

By vote of the Board in May 2023, we are returning to in-person meetings only, starting with the September 2023 meeting. We will still record the meetings to Zoom for archiving on our new YouTube channel, @NCGS1000 (which you can access now by typing in the entire name @NCGS1000 into the search bar for Google or YouTube). This is where recently recorded talks can be accessed a few days after each meeting, or past talks recorded since September 2022 can be reviewed at any time. Only talks

where authors have given permission for this archiving will be accessible.

NCGS Officers Follow-Up

As you probably know, in June NCGS approved the slate of nominated officers to serve for 2023-2024. All these officers can always use extra help, and this is a good way to learn the ropes. Please contact Jim O'Brien if you have any interest in serving in any of the Officer or Committee roles. We would also like to acknowledge Chris McGuffin, who continues to help us with the audio-visual set-ups for our meetings.

Invitation For New Officer Appointment

Due to the recent resignation of our Secretary, Steve Self, for personal reasons, we are looking to appoint a new secretary to fill the rest of Steve's elected term (through August 31, 2024) and potentially to stand for re-election next June. Please contact President Jim O'Brien or Past President Noelle Schoellkopf if you are interested or have a candidate to suggest. The duties are few, but vitally important to the society:

- (1) The **Recording Secretary** shall attend and take notes at all Executive Committee board meetings (typically three times per year) and shall notify the members of proposed amendments to the Constitution and Bylaws.
- (2) When any other membership-wide communication is required, assist other officers in sending out email and occasional postal communications. Note: Since NCGS has moved to a new web-based system for emails, sign-ups, and payments (RegFox), this will chiefly be a consulting role to help others such as the President, Newsletter Editor, Treasurer, Membership Chair, Program Chair, or Field Trip Chair, all of whom will be trained on sending out such messages directly.
- (3) Maintain Google drive folders and access for our archive of past information.
- (4) Maintain hard cc files (as backup) only for critical Society records.
- (5) Serve as alternate check signer when neither Treasurer nor President is available.

Website News

From Andrew Alden, NCGS Website Manager/Social Media

Earlier this month, our nceolsoc.org domain was transferred to our new provider, WordPress.com. In the

process, our previous design, created for us by Courtney Pasco in the mists of last decade, has been abandoned and the site completely rebuilt. I've renamed hundreds of files on a rational basis, making the site much easier to work with backstage. The website is now much snappier to load, less wasteful of screen space, and simpler to navigate.

I will be adding details, such as photos, to more of the pages. The site will be easy to modify, and I welcome feedback from all NCGS members. Expect bulletins from me often in upcoming newsletters.

I want to thank the NCGS Board for their advice, support and forbearance as I tinkered with the old and new systems. Don Medwedeff was especially helpful as a sounding board and experimenter in preparation for this move, and once we had our plans worked out, he coordinated with Will Schweller and others to set up our new online payment and reservation system, which is independent of the website.

Thanks,
Andrew

NCGS Photo of the Month

Ray Sullivan provided this photo of a dramatic scene from the NCGS field trip to Calaveras Dam in October 2014.



New publication on Oakland's Geologic Story

"In Deep Oakland: How Geology Shaped a City, published in May by Heyday Books, longtime NCGS member Andrew Alden (our June speaker) takes an attentive and affectionate look at Oakland "from the ground down." Deep Oakland weaves together three different histories of this Bay Area city: the Quaternary history of tectonics and glacial cycles that constructed and maintains Oakland's landscape, the late

Phanerozoic history of California recorded in Oakland's surprisingly diverse rocks, and the Holocene history of human interactions with this geological setting. Three different civilizations -- Indigenous, Spanish and Anglo-American -- have managed and exploited Oakland's geological resources, and adjusted to the site's constraints, in distinctive ways. Andrew seeks not only to awaken East Bay citizens to the secrets in their home landscape, but also to tempt local geologists with textbook features waiting in their own back yard. The latter topic will be his focus in his presentation at our June meeting.

Deep Oakland is available at many local bookstores as well as the usual online sources. Use the discount code "OAKLAND" for a discount from the Heyday Books website (<https://www.heydaybooks.com/catalog/deep-oakland/>).

That catalog page features this blurb by Doris Sloan, among others: "In this vivid account of Oakland's exceptionally rich geology, Andrew Alden weaves together historical and geological tales in elegant non-technical language that will tempt you to explore Oakland's beautiful landscape from the Bay margins to the crest of the hills."

UC Berkeley Earth & Planetary Science Weekly Seminar Series

In-person EPS Seminar talks have resumed for the semester and are scheduled through early December. On Thursday, October 26, 2023 at 3:45 pm, Michelle Muth of the University of Washington will speak on *The Influence of Sulfur on Magmatic Evolution* at 141 McCone Hall. Send an email to eps_frontoffice@berkeley.edu to join the department's email list. For updated listings of upcoming seminars, go to <https://eps.berkeley.edu/seminars-courses/eps-seminars>.

For the Rockhounds

For links to upcoming rock and mineral shows, go to www.cfmsinc.org/shows.

USGS Evening Public Lecture Series

The USGS evening public lecture series events are free and are intended for a general public audience that may not be familiar with the science being discussed. Pre-Covid, talks were held at USGS; the talks are now online. Talks are scheduled through November. On October 19 at 6:00 PM, Hon Ip, Research Geophysicist at the USGS Diagnostic Virologist, will speak on

Zombies?? Or the workings of a federal science laboratory - The National Wildlife Health Center.

Check the website to join the live stream, at: www.usgs.gov/pls/. To be added to the email notification list for future USGS Public Lecture Series events, please email: wmcesic@usgs.gov.

2023-2024 NCGS Registration and Dues

A 21st Century Innovation Takes Hold

Following a successful pilot for this August's field trip, NCGS is converting from last century's check-based system for membership renewal, field trip registration, and dinner meeting registration, to an electronic system. The system is hosted by RegFox, which is a fee-per-use system, with no software or internet costs to the NCGS. The fees per registration, which are 2.99% + \$0.99 per registration (or \$1.71, \$2.49, or \$3.24 for 1, 2, and 3-year registrations, respectively), will be covered by the NCGS.

To cover these new fees and increased costs for hall-rental, mailings, web-hosting, and insurance, the board-approved an increase in dues beginning September 1st to \$25 annually for membership and \$25/annually for surcharge for paper mailing.

All registrations will be accessed via this link: <https://NCGS.regfox.com/ncgs-landing>. This brings up an electronic version of the legacy NCGS Membership page (see attached figure). This page will always be active and a link to it will be included in the Newsletter and sent annually to members whose renewal date has arrived. Funds received are directly deposited in the NCGS account and membership details are immediately available to the Membership Secretary for recording.

Registration for Field Trips or the Annual Dinner Meeting will be accessed from the tabs above the Membership Renewal form. These tabs will be grayed out when inactive and highlighted when active. The electronic system is particularly effective for these time-sensitive reservations, as trip availability and dinner commitments are instantaneously updated for both organizers and attendees.

Final Note: If you are those unable to use the electronic registration can contact me (Don M.) via mail at 146 Roan Drive, Danville, CA 94526.

Regards,
Don Medwedeff
NCGS Treasurer

WE'RE ON FACEBOOK!

CHECK OUT THE MOST RECENT POST:

@NCGEOLSOC

ALSO, VISIT TWITTER @NORCALGEOSOC

NCGS Board Meetings

Board meetings (online for now) are open to all NCGS members. If you'd like to attend, please contact President Noelle Schoellkopf at NoellePrince @ sbcglobal.net. Board meetings generally are on Saturday mornings in Jan., Apr./May, and Aug./Sep. Upcoming meeting: **Saturday, January 13, 2024 at 9 a.m., by Zoom.**

A Great Website to Check Out

Dr. Ray Sullivan has recently completed an excellent website – see <http://raysullivangeologist.com/>. As many of you know, Ray was a longtime professor of geology at San Francisco State University as well as serving in multiple positions with other societies and organizations, and with NCGS as president, program chair, field trip leader and counselor, and co-editor of the Mount Diablo volume recently published with the Geological Society of America. The website has a biography, list of journal and book publications, and a list of projects on which he's worked, with some great photos and stories. Check it out!

Science and technology | When mammals attack

A spectacular new fossil shows a mammal making a meal of a dinosaur

The two animals were interrupted during a fight to the death

Source: *The Economist*, Jul 12th 2023



A fight, interrupted.

Image: Gang Han

That dinosaurs ate the mammals that scurried beneath their feet is not in doubt. Now an extraordinary fossil newly described in *Scientific Reports*, unearthed by a team led by Gang Han at Hainan Vocational University of Science and Technology in China, shows that sometimes

the tables were turned.

The fossil—dated to about 125m years ago, during the Cretaceous period—was formed when a flow of boiling volcanic mud engulfed two animals seemingly locked in mortal combat. The one on top is a ferret-like mammal known as *Repenomamus robustus*. The animal below is a herbivorous relative of Triceratops known as *Psittacosaurus lujiatunensis*. Animal interactions such as this are exceptionally rare in the fossil record.

One possibility is that the mammal was scavenging something already dead, rather than hunting live prey. These days it is uncommon for small mammals to attack much larger animals. But it is not unheard of. Wolverines, for instance, occasionally take caribou. And Dr Han and his colleagues point out that scavengers typically leave tooth marks all over the bones of the animals. The dinosaur's remains show no such marks. There is also a chance the fossil could be a fake. Many of the most convincing forgeries have come, as this one did, from China—though Dr Han and his colleagues argue that the complex and entwined nature of the skeletons makes that unlikely, too.

Assuming it is genuine, the discovery serves as a reminder that not all dinosaurs were enormous during the Cretaceous and not all mammals were tiny. From nose to tail, the dinosaur is just 1.2 meters long. The mammal is a bit under half a meter in length. Despite being half the size, the mammal has one paw firmly wrapped around one of its prey's limbs, and another pulling on its jaw. It is biting down on the dinosaur's chest, and has dislodged two of its ribs. Before they were interrupted, it seems that the mammal was winning.

Past climate warming driven by hydrothermal vents

New study shows volcanism 56 million years ago released more methane than thought

ScienceDaily, August 3, 2023

Source: Helmholtz Centre for Ocean Research Kiel (GEOMAR)

An international drilling expedition off the Norwegian coast led by Christian Berndt, Professor of Marine Geophysics at GEOMAR Helmholtz Centre for Ocean Research in Kiel, and Sverre Planke, Professor of Marine Geophysics at the University of Oslo, confirms the theory that methane emissions from hydrothermal vents were responsible for global warming about 55 million years ago. The study, published in the journal *Nature Geoscience*, shows that the vents were active in very shallow water depth or even above sea level, which would

have allowed much larger amounts of methane to enter the atmosphere.

About 55 million years ago, the Atlantic Ocean was born. Until then, Europe and America were connected. As the continents began to move apart, the Earth's crust between them ruptured, releasing large volumes of magma. This rift volcanism has led to the formation of large igneous provinces (LIPs) in several places around the world. One such LIP was formed between Greenland and Europe and now lies several kilometers below the ocean surface. An international drilling campaign led by Christian Berndt from the GEOMAR Helmholtz Centre for Ocean Research in Kiel, Germany, and Sverre Planke from the University of Oslo, Norway, has collected extensive sample material from the LIP, which has now been evaluated.

In their study, published in the journal *Nature Geoscience*, the researchers can show that hydrothermal vents were active at very shallow depths or even above sea level, which would have allowed much larger quantities of greenhouse gases to enter the atmosphere than previously thought.

"At the Paleocene-Eocene boundary, some of the most powerful volcanic eruptions in Earth's history took place over a period of more than a million years," says Christian Berndt. According to current knowledge, this volcanism warmed the world's climate by at least five degrees Celsius and caused a mass extinction -- the last dramatic global warming before our time, known as the Paleocene-Eocene Thermal Maximum (PETM). Geologists have not yet been able to explain why, as most modern volcanic eruptions cause cooling by releasing aerosols into the stratosphere.

Further studies of the Karoo large igneous province in South Africa revealed an abundance of hydrothermal vents associated with magmatic intrusions into the sedimentary basin. This observation among others led to the hypothesis that large amounts of the greenhouse gases carbon dioxide and methane could have entered the atmosphere through hydrothermal venting. "When our Norwegian colleagues Henrik Svensen and Sverre Planke published their results in 2004, we would have loved to set off immediately to test the hypothesis by drilling the ancient vent systems around the North Atlantic," says Christian Berndt. But it wasn't that easy: "Our proposal was well received by the Integrated Ocean Drilling Program (IODP), but it was never scheduled because it required riser drilling, a technology that was not available to us at the time."

As the research progressed hydrothermal vent systems were discovered that were within reach of riserless drilling. Thus, the drilling proposal was resubmitted, and

the expedition could finally begin in autumn 2021 -- 17 years after the first proposal was submitted.

Around 30 scientists from 12 nations took part in the IODP (now the International Ocean Discovery Program) research cruise to the Vøring Plateau off the Norwegian coast on board the scientific drilling ship "JOIDES Resolution." Five of the 20 boreholes were drilled directly into one of the thousands of hydrothermal vents. The cores obtained can be read by scientists like a diary of the Earth's history. The results were compelling.

The authors show that the vent was active just before the Paleocene Eocene Thermal Maximum and that the resulting crater was filled in a very short time, just as the global warming began. Quite unexpectedly, their data also show that the vent was active in a very shallow water depth of probably less than 100 meters. This has far-reaching consequences for the potential impact on the climate. Christian Berndt: "Most of the methane that enters the water column from active deep-sea hydrothermal vents today is quickly converted into carbon dioxide, a much less potent greenhouse gas. Since the vent we studied is located in the middle of the rift valley, where the water depth should be greatest, we assume that other vents were also in shallow water or even above sea level, which would have allowed much larger amounts of greenhouse gases to enter the atmosphere."

As far as today's climate warming is concerned, there are some interesting conclusions to be drawn from the cores. On the one hand, they do not confirm that the global warming at that time was caused by the dissolution of gas hydrates -- a danger that has been much discussed in recent years. On the other hand, they show that it took many millennia for the climate to cool down again. So the Earth system was thus able to regulate itself, but not on time scales relevant to today's climate crisis.

Journal Reference: C. Berndt et al. **Shallow-water hydrothermal venting linked to the Palaeocene–Eocene Thermal Maximum.** *Nature Geoscience*, 2023; DOI: 10.1038/s41561-023-01246-8.

Science and technology | What the bones tell

Saber-tooth tigers and dire wolves were in trouble before they vanished

Bones recovered from tar pits suggest both animals were becoming badly inbred

Source: The Economist, Jul 19th 2023

Along with the mammoth and the dire wolf, the saber-tooth tiger was a casualty of the Quaternary Extinction, a die-off that happened between 50,000 and 10,000 years ago that seems to have affected big animals in particular.

Exactly what caused the extinction is still a matter of debate. (Two popular possibilities are a warming in the climate, and the arrival of humans.) A new paper by Hugo Schmökel, a veterinary surgeon at the Evidensia Academy, a veterinary college in Sweden, and his colleagues, suggests that, for both the saber-tooth tiger and the dire wolf, inbreeding played a part.

Dr Schmökel arrived at that conclusion after examining bones from the Rancho La Brea tar pits in Los Angeles. These are gold mines for paleontologists because they were death traps for the animals of the day. Rainwater can accumulate on top of the tar. A large herbivore, like a mastodon or giant sloth, that ventured in for a drink would risk becoming ensnared. Its subsequent attempts to free itself would attract predators, which would take advantage of its distress and attack—but then become trapped themselves. As a result, Rancho La Brea contains bones from thousands of animals.

That allows for statistical studies that cannot be done anywhere else. Dr Schmökel examined 834 saber-tooth-cat femurs dated to between 12,000 and 10,000 years ago. Around 6% had defects suggestive of a bone disease known as osteochondrosis dissecans. This is caused by small fragments of bone underlying the cartilage in a joint dying and breaking loose. It causes joint pain, loss of motion, and becomes crippling in old age. An analysis of 266 dire-wolf femurs found that 2.6% likewise had defects indicative of the disease.

Several things, including diet and injury, can cause osteochondrosis dissecans. But one of the biggest predisposing factors is genetics. Indeed, though the disease is rare in wild animals today, it is common in domesticated dog breeds that have been heavily inbred. Around 9% of border collies, for instance, suffer from it. But inbreeding is not always a consequence of human interference. In the wild, it is usually a consequence of a shrinking population in which fewer and fewer mates are available with every passing generation.

That suggests both the saber-tooth tigers and the dire wolves were locked in a miserable downward spiral. Not only were their populations already shrinking, but the disease caused by the resulting inbreeding would have made it harder for the remaining individuals to survive, especially as they got older. It is impossible, at least for now, to discern what led these animals to become inbred in the first place. But the evidence from the tar pits suggests they were on a genetic knife's edge for thousands of years before they finally succumbed.

Why Venetians are pondering raising their entire city

A €5.5bn flood barrier has bought only a temporary reprieve

Source: *The Economist*, May 24th 2023



Waiting for a boost.

Image: AP

The relief in the City of Canals is palpable. For centuries, regular high tides—*acqua alta* to the locals—have flowed through Venice, submerging walkways, flooding buildings, and stopping boats from passing under its many bridges.

For most of the city, at least, that is no longer the case. In operation since last year, after nearly two decades under construction, a giant piece of hydraulic engineering called the Experimental Electromechanical Module—known by its Italian acronym MOSE—now protects Venice and its lagoon. In a city where waders were as easy to buy as postcards and ice cream, most people can now go about their business without consulting tide charts. Property prices are up, especially for flats and shops on the ground floor.

Or at least, they are for now. Although MOSE is up and running, there are questions about how long the barrier will last. The flood-defense scheme was designed to serve for a century. But Hermes Redi, the director-general of Consorzio Venezia Nuova (CVN), the Venetian engineering consortium that built it, fears that, thanks to a combination of climate change and the gradual sinking of the city itself, its useful lifespan might be just half as long.

MOSE is made up of 78 hinged steel floodgates that run for 1.6km along the sea floor beneath the three inlets to the Venetian lagoon. When a high tide begins, machines that consume enough electricity to power “a small town”, as a technician puts it, compress air that is blasted into each floodgate. As seawater is forced out, the floodgates rise into nearly vertical positions. The resulting barrier holds back the Adriatic until the tide retreats.

That sinking feeling

For all its technological whizzyness, the system has downsides. Cost is one. Mr Redi reckons each raising of the barrier costs about €150,000 (other estimates are higher). Maintenance costs add up, too. Sand must be cleared from the machinery. Each floodgate is designed to be removed every five years for defouling. Last year, when MOSE was used 36 times, the operating cost was more than €70m (\$76m).

The barrier also disrupts maritime traffic, causing protests from both fishermen and the big container ships that call at Marghera, a busy port in the lagoon. Antonio Revedin of the North Adriatic Sea Port Authority says a delay can cost an individual cargo ship €80,000 a day—though a system of locks, due to come online later this year, should help.

There are environmental issues, too. Most of Venice’s sewage flows into its canals. As Luigi Tosi, a geologist with Italy’s National Research Council (CNR), puts it, a lagoon that is sealed off too often would become “first a bathtub, then a sewer”. All that means that MOSE is only used when tides exceed 110cm. That means that some low-lying parts of the city, including St Mark’s square, still flood.

Rising sea levels will make those downsides more apparent as the barrier is raised more and more frequently. One paper, published in 2021, predicted a rise in water levels of between 32 and 110cm in the Venetian lagoon by 2100, depending on how sharply the world cuts its carbon emissions.

What is needed, then, is a plan to extend the system’s life. Dr Tosi is among those who think that seawater could be the answer as well as the problem. They propose to pump seawater underground, and in doing so to raise the land. That may seem outlandish but, in principle, it is merely the reversal of something that has already happened. Between the 1940s and 1970s the extraction of groundwater for use by industry caused Venice to sink by about 15cm. Pietro Teatini, a hydraulic engineer at Padua University, points out that there is precedent from the oil-and-gas industry, which has shown that storing gas in underground reservoirs can lift the land above.

The area’s geology is promising. Its sandy subsoils should be relatively expandable. Those sandy layers are capped with watertight clay which would prevent injected seawater seeping upwards to contaminate freshwater aquifers.

Giuseppe Gambolati, a semi-retired hydraulic engineer at Padua University, thinks it should be possible to achieve a rise of 25cm across the entire city within a decade. His proposal calls for drilling three test wells. If those reveal no show-stopping problems, then the full job would involve a dozen wells 600 to 800 meters deep around the city. Dr Gambolati reckons the city could be raised for something like 2% of MOSE’s €5.5bn construction cost.

Maintaining the uplift, by continual pumping of water, might cost 5% as much as the flood barrier's operating expenses.

For now seawater injection remains just an idea. But if something is not done, then the rising waters may eventually force more drastic changes. Dario Camuffo, who studies both the environment and Venice's cultural heritage at CNR, says one option would be simply to abandon the city's ground floors. Raised pavements could allow people to enter buildings on the story above. Another, he says, is that prized structures might be taken apart for reassembly elsewhere. Mr Redi worries that Venice's lagoon may need to be permanently cordoned off from the sea with a dike. For a city proud of its maritime heritage, that might be seen more as a humiliation than an adaptation.

Carbon dioxide -- not water -- triggers explosive basaltic volcanoes

ScienceDaily, August 7, 2023

Source: Cornell University

Geoscientists have long thought that water -- along with shallow magma stored in Earth's crust -- drives volcanoes to erupt. Now, thanks to newly developed research tools at Cornell, scientists have learned that gaseous carbon dioxide can trigger explosive eruptions.

A new model suggests that basaltic volcanoes, typically located on the interior of tectonic plates, are fed by a deep magma within the mantle, stored about 20 to 30 kilometers below Earth's surface.

The research, which offers a clearer picture of our planet's deep internal dynamics and composition, with implications for improving volcanic-hazards planning, will publish August 7, 2023 at 3:00pm ET in the Proceedings of the National Academy of Sciences.

"We used to think all the action happened in the crust," said senior author Esteban Gazel, the Charles N. Mellows Professor in Engineering in the Department of Earth and Atmospheric Sciences, in Cornell Engineering. "Our data implies the magma comes directly from the mantle -- passing fast through the crust - driven by the exsolution (the process phase of separating gas from liquid) of carbon dioxide.

"This completely changes the paradigm of how these eruptions happen," Gazel said. "All volcanic models had been dominated by water as the main eruption driver, but water has little to do with these volcanoes. It's carbon dioxide that brings this magma from the deep Earth."

About four years ago, Gazel and Charlotte DeVitre, Ph.D. '22, now a postdoctoral researcher at University of California, Berkeley, developed a high-precision carbon

dioxide densimeter (which measures density in a tiny vessel) for Raman spectroscopy (a device that examines scattered photons through a microscope).

The natural samples -- microscopic-sized carbon dioxide rich bubbles trapped in crystals emanating from the volcanic eruption -- are then measured via Raman and quantified applying the newly developed densimeter. Essentially, the scientists are examining a microscopic time capsule to provide a history of the magma. This new technique is critical for near real-time precise estimations of magma storage, tested during the 2021 eruption in Las Palmas, in the Canary Islands by Gazel's group.

Further, the scientists developed methods to assess the effect of laser heating on carbon-dioxide rich inclusions (found swathed in the crystals), and to accurately assess melt inclusion and bubble volumes. They also developed an experimental reheating method to increase accuracy and properly account for carbon dioxide trapped as carbonate crystals inside the bubbles.

"The method of development and instrument design were challenging, especially during the height of the pandemic," Gazel said.

Using these new tools, the scientists scrutinized volcanic deposits from the Fogo volcano in Cabo Verde, west of Senegal in the Atlantic Ocean. They found a high concentration of volatiles in the micro-sized melt inclusions encased within the magnesium-iron silicate crystals. The higher amount of carbon dioxide enclosed in the crystals suggested that the magma was stored tens of kilometers below the surface -- within the Earth's mantle.

The group also discovered that this process is connected to the deep mantle source that supplies these volcanoes. This implies that eruptions such as Fogo's volcanic flareups start and are fed from the mantle, effectively bypassing storage in the Earth's crust and driven by deep carbon dioxide, according to the paper.

"These magmas have extremely low viscosities and come directly from the mantle," DeVitre said. "So here, viscosity and water cannot play the common roles that they do in shallower and/or more silicic (rich in silica) volcanic systems. Rather at Fogo volcano the magma must be driven up fast by the carbon dioxide and this likely plays a significant role in its explosive behavior. This is a major step in our understanding of the controls on basaltic explosivity."

Comprehending magma storage helps best prepare society for future eruptions, said Gazel, who is also a faculty fellow at the Cornell Atkinson Center for Sustainability. "As deep magma storage will not be detected by ground deformation until the melt is close to surface," he said, "this has important repercussions to our understanding of volcanic hazards. We need to understand the drivers of

these eruptions. The only way to see these processes now is by observing earthquakes, but earthquakes don't tell you exactly what's happening."

Said Gazel: "With precise measurements that tell us where eruptions start, where magmas melt and where they are stored -- and what triggers the eruption -- we can develop a much better plan for future eruptions."

Journal Reference: Charlotte L. DeVitre, Esteban Gazel, Ricardo S. Ramalho, Swetha Venugopal, Matthew Steele-MacInnis, Junlin Hua, Chelsea M. Allison, Lowell R. Moore, Juan Carlos Carracedo, Brian Monteleone. **Oceanic intraplate explosive eruptions fed directly from the mantle.** *Proceedings of the National Academy of Sciences*, 2023; 120 (33) DOI: 10.1073/pnas.2302093120.

Enhanced chemical weathering: A solution to the climate crisis?

ScienceDaily, August 29, 2023

Source: Johannes Gutenberg Universitaet Mainz

Could blending of crushed rock with arable soil lower global temperatures? Researchers study global warming events from 40 and 56 million years ago to find answers.

The Earth is getting hotter and consequences have been made manifest this summer around the world. Looking back in geological history, global warming events are not uncommon: Around 56 million years ago, during the period known as the Paleocene-Eocene Thermal Maximum (PETM), the temperatures rose by an average of 5 to 8 degrees Celsius. This development was most likely linked to increased volcanism and the associated release of masses of carbon dioxide into the atmosphere. The higher temperatures persisted for about 200,000 years. Back in 2021, Professor Philip Pogge von Strandmann of Johannes Gutenberg University Mainz (JGU) had already investigated the effect that eventually led to global cooling and climatic recovery after the PETM warming.

In short: Rainwater combined with the atmospheric carbon dioxide, resulting in carbonic acid that caused enhanced weathering of rock, thus releasing calcium and magnesium. Rivers then transported the calcium, magnesium, and carbonic acid into the oceans where the calcium, magnesium -- and also the carbon dioxide -- came together to form insoluble limestone. "In other words, there is a feedback effect that helps control the climate. High temperatures accelerate the chemical rock weathering process, reducing the levels of carbon dioxide in the atmosphere, allowing the climate to recover," said Pogge von Strandmann.

Climate required twice as long to regenerate 40 million years ago

Climate warming occurred again 16 million years after the PETM during the Middle Eocene Climatic Optimum or MECO. Although volcanic activity resulted in the discharge of roughly the same amounts of carbon dioxide into the atmosphere as during the PETM, it took far longer for the climate to restabilize. The warming effect lasted for an immense 400,000 years, twice as long as in the PETM. Why was recovery so slow during that period?

In searching for an answer, Pogge von Strandmann and co-authors, including first author Alex Krause, began analyzing 40-million-year-old oceanic carbonates and clay minerals to compare the results with those for similar 56-million-year-old examples. "Just as during the PETM, there was also intensified weathering and erosion in the MECO. However, there was far less exposed rock on the Earth's surface 40 million years ago. Instead, the Earth was extensively covered by a global rainforest the soil of which largely consisted of clay minerals," explained the researcher. In contrast with rock, clay does not weather; in fact, it is actually the product of weathering. "So despite the high temperatures, the widespread clay soil prevented rocks from being effectively weathered, a process known as soil shielding," the geoscientist pointed out.

Enhanced weathering for climate protection

How can we use this knowledge in today's world? "We study paleoclimates to determine whether and how we can positively influence our present climate. One option might be to boost the chemical weathering of rock. To help achieve this, we could plough finely crushed rock into our fields," said Pogge von Strandmann. The fine-grained particles of rock would erode rapidly, resulting in the binding of atmospheric carbon dioxide, thus enabling the climate to recuperate. Negative emissions technologies (NETs) such as this involving the absorption of carbon dioxide are the subjects of intense research across the globe. At the same time, however, if the weathering results in the formation of clay, the effects of the process would be significantly less efficient, as Pogge von Strandmann has discovered. Clay retains the calcium and magnesium that would otherwise be delivered to the ocean. The carbon dioxide would continue to flow into the oceans, but it would not be bound there and would be able to escape back into the atmosphere. In this case, the weathering effect would have next to no influence on the climate.

If the rock particles fully dissolve as a result of weathering, the enhanced weathering concept would turn out to be 100 percent efficient. However, if all the weathered materials were turned into clay, this would in its turn completely nullify the effect. In reality, the actual outcome would probably be somewhere between the two extremes: While there was enhanced erosion of rock in the

PETM so that the climate normalized more rapidly, clay formation was predominant during the MECO. The extent to which the crushed rock dissolves and how much of it is preserved as clay depends on a range of local factors, such as the globally pre-existing levels of clay and rock. So in order to establish whether the process of enhanced weathering is a viable approach, it would first be necessary to find out how much clay is formed during the weathering process at each potential location.

The corresponding research paper has recently been published in *Nature Geoscience*. Also involved in the project were researchers at University College London and the University of Essex in the UK as well as Utrecht University in the Netherlands.

Journal Reference: Alexander J. Krause, Appy Sluijs, Robin van der Ploeg, Timothy M. Lenton, Philip A. E. Pogge von Strandmann. **Enhanced clay formation key in sustaining the Middle Eocene Climatic Optimum.** *Nature Geoscience*, 2023; 16 (8): 730 DOI: 10.1038/s41561-023-01234-y.

Oldest fossil human footprints in North America confirmed

Two new lines of evidence support the 21,000 to 23,000-year age estimate of the footprints first described and dated in 2021

ScienceDaily, October 5, 2023
Source: U.S. Geological Survey

Summary: New research reaffirms that human footprints found in White Sands National Park, NM, date to the Last Glacial Maximum, placing humans in North America thousands of years earlier than once thought. In September 2021, scientists announced that ancient human footprints discovered in White Sands National Park were between 21,000 and 23,000 years old. This discovery pushed the known date of human presence in North America back by thousands of years and implied that early inhabitants and megafauna co-existed for several millennia before the terminal Pleistocene extinction event. In a follow-up study, researchers used two new independent approaches to date the footprints, both of which resulted in the same age range as the original estimate.

The 2021 results began a global conversation that sparked public imagination and incited dissenting commentary throughout the scientific community as to the accuracy of the ages.

"The immediate reaction in some circles of the archeological community was that the accuracy of our dating was insufficient to make the extraordinary claim

that humans were present in North America during the Last Glacial Maximum. But our targeted methodology in this current research really paid off," said Jeff Pigati, USGS research geologist and co-lead author of a newly published study that confirms the age of the White Sands footprints.

The controversy centered on the accuracy of the original ages, which were obtained by radiocarbon dating. The age of the White Sands footprints was initially determined by dating seeds of the common aquatic plant *Ruppia cirrhosa* that were found in the fossilized impressions. But aquatic plants can acquire carbon from dissolved carbon atoms in the water rather than ambient air, which can potentially cause the measured ages to be too old.

"Even as the original work was being published, we were forging ahead to test our results with multiple lines of evidence," said Kathleen Springer, USGS research geologist and co-lead author on the current *Science* paper. "We were confident in our original ages, as well as the strong geologic, hydrologic, and stratigraphic evidence, but we knew that independent chronologic control was critical."

For their follow-up study, the researchers focused on radiocarbon dating of conifer pollen, because it comes from terrestrial plants and therefore avoids potential issues that arise when dating aquatic plants like *Ruppia*. The researchers used painstaking procedures to isolate approximately 75,000 pollen grains for each sample they dated. Importantly, the pollen samples were collected from the exact same layers as the original seeds, so a direct comparison could be made. In each case, the pollen age was statistically identical to the corresponding seed age.

"Pollen samples also helped us understand the broader environmental context at the time the footprints were made," said David Wahl, USGS research geographer and a co-author on the current *Science* article. "The pollen in the samples came from plants typically found in cold and wet glacial conditions, in stark contrast with pollen from the modern playa which reflects the desert vegetation found there today."

In addition to the pollen samples, the team used a different type of dating called optically stimulated luminescence, which dates the last time quartz grains were exposed to sunlight. Using this method, they found that quartz samples collected within the footprint-bearing layers had a minimum age of ~21,500 years, providing further support to the radiocarbon results.

With three separate lines of evidence pointing to the same approximate age, it is highly unlikely that they are all incorrect or biased and, taken together, provide strong support for the 21,000 to 23,000-year age range for the footprints.

The research team included scientists from the USGS, Lawrence Livermore National Laboratory, the National Park Service, and academic institutions. Their continued studies at White Sands focus on the environmental conditions that allowed people to thrive in southern New Mexico during the Last Glacial Maximum and are supported by the Climate Research and Development Program | U.S. Geological Survey and USGS-NPS Natural Resources Protection Program.

Journal Reference: Jeffrey S. Pigati et al. **Independent age estimates resolve the controversy of ancient human footprints at White Sands.** *Science*, 2023 DOI: 10.1126/science.adh5007.

Two out of three volcanoes are little-known. How to predict their eruptions?

ScienceDaily, August 31, 2023

Source: Université de Genève

What is the risk of a volcano erupting? To answer this question, scientists need information about its underlying internal structure. However, gathering this data can take several years of fieldwork, analyses and monitoring, which explains why only 30% of active volcanoes are currently well documented. A team from the University of Geneva (UNIGE) has developed a method for rapidly obtaining valuable information. It is based on three parameters: the height of the volcano, the thickness of the layer of rock separating the volcano's reservoir from the surface, and the average chemical composition of the magma. These results open new prospects for identifying volcanoes that present the greatest risk and are published in the journal *Geology*.

The Earth is home to some 1,500 active volcanoes, yet we only have accurate data for 30% of them. This is due to the difficulty of observing their "fuel," the famous magma, which is rich in information. This molten rock is first generated at a depth of between 60 km and 150 km in the Earth's mantle, whereas the deepest human boreholes generally only reach a depth of around ten kilometers, preventing direct observation. The production rate of magma in the Earth's deep crust beneath a volcano determines the size and frequency of future eruptions.

This lack of data is a danger as more than 800 million people live close to active volcanoes. Therefore, in many regions, there is no basis on which to assess the risk a given volcano poses and the extent of the protective measures to be taken -- the evacuation perimeter, for example -- in the event of a suspected eruption.

Three key parameters

Geochemical and geophysical analysis methods are regularly used by scientists to monitor volcanoes, but it

can take decades to gain an in-depth understanding of how a specific volcano works. Thanks to recent work by the team of Luca Caricchi, full professor at the Department of Earth Sciences of the UNIGE Faculty of Science, it is now possible to obtain valuable information more rapidly.

This method uses three easy-to-measure parameters: the height of the volcano, the thickness of the rocks separating the volcano's "reservoir" from the surface, and the chemical composition of the magma released over its eruptive history. The first can be determined by satellite, the second by geophysics and/or chemical analysis of minerals (crystals) in the volcanic rocks, and the third by direct sampling in the field.

A "snapshot"

By analyzing existing data on the volcanic arc of the Lesser Antilles, a well-studied archipelago of volcanic islands, the UNIGE team has highlighted a correlation between the height of volcanoes and the rate at which magma is produced. "The highest volcanoes produce the biggest eruptions on average during their life. In other words, they can erupt a greater quantity of magma in a single event," explains Oliver Higgins, a former doctoral student in Luca Caricchi's group and first author of the study.

Scientists have also found that the thinner the Earth's crust beneath the volcano, the closer its magma reservoir is to the surface, and the more thermally mature the volcano is. "When the magma rises from depth, it tends to cool and solidify, which halts its ascent. But when the supply of magma is large, magma retains its temperature, accumulates in the reservoir that will fuel a future eruption, and 'eats away' at the Earth's crust," explains Luca Caricchi, the second and last author of the study.

Identifying the volcanoes most at risk

Finally, the researchers observed that the average chemical composition of magma that has already erupted is an indicator of its explosiveness. "High levels of silica, for example, indicate that the volcano is fed by a large quantities of magma. In this case, there is a greater risk of a large, explosive eruption from that volcano," explains the researcher.

Together, the three parameters identified by the UNIGE team produce a "snapshot" of a volcano's internal structure. They enable an initial assessment of the hazard associated with poorly studied volcanoes, without the need for major technical and financial resources. This method can be used to identify the active volcanoes that are most likely to produce a large-scale eruption, and that require increased surveillance.

Journal Reference: Oliver Higgins, Luca Caricchi. **Eruptive dynamics reflect crustal structure and**

Science and technology | Choosing a fingerprint

A Canadian lake could mark the start of humanity's geological epoch

Plutonium, carbon and plastic mark a new phase in Earth's history



Image: Dan Clark/United States Fish and Wildlife Service via NYT/Redux/eyevine

One way to view the history of science is as a repeated puncturing of humanity's claims to be special. In scientific terms *Homo sapiens* is an oddly hairless species of ape that has existed for 200,000 years—an eyeblink in Earth's 4.5bn-year history.

For the past couple of decades, though, some scientists have been arguing that perhaps humans do deserve a bit of special recognition after all. In 2000 Paul Crutzen, a Dutch meteorologist and chemist, suggested that human influence over Earth was sufficiently profound that its effects would remain visible in the geological record for millions of years. For that reason, he argued, it was time to bring down the curtain on the Holocene—the current geological epoch, which has lasted for the past 12,000 years or so—and ring in a new one: the Anthropocene.

The idea quickly caught on. In 2016 the Anthropocene Working Group (AWG), an appendage of the International Union of Geological Sciences (IUGS), voted in favor of adopting it in principle. And on July 11th it suggested a precise geological feature, dating back to the 1950s, that could mark the Anthropocene's beginning. The committee recommended bestowing the honor upon sediments laid down at the bottom of Crawford Lake, a flooded sinkhole about 20 miles from Toronto.

The beginning of the Holocene was marked by a natural warming of the climate and the retreat of the world's ice sheets. The idea behind the Anthropocene is that human activity has disturbed the planet on a similarly grand scale. Humans have boosted the concentration of carbon dioxide in the atmosphere by about half in the past 250 years, to

its highest level in around 3m years. That spike will be clearly visible to geologists 100,000 years from now, assuming any exist, and may have delayed the start of the next ice age by tens of thousands of years.

There are markers besides climate change, too. Microplastics in oceans and rivers are laying down sedimentary layers of chemicals never seen before in nature. Nitrogen fertilizers have altered the balance of chemical isotopes in peat bogs. The world is in the midst of a mass extinction. At the same time shipping and air travel have scattered much of the remaining flora and fauna far from where they evolved. Both the extinction and the redistribution will be visible when what is alive today joins the fossil record of the past.

The IUGS's rules say that geological transitions must be marked not just by a particular event, but by a specific alteration in a specific geological feature. (For instance, the start of the Edicarian period, 635m years ago, is defined by a visible change in a band of exposed rocks in southern Australia.) The AWG's announcement marked the end of a years-long search for a suitable marker for the Anthropocene. Scientists examined sites from the estuaries of San Francisco to the sediment beneath Vienna's main square, before settling on Crawford Lake.

The lake has several advantages. Every summer, as the surface waters warm, flakes of calcium carbonate precipitate out and drift to the bottom. There they form regular white bands amid the sediments, much like age rings in trees. The sediments themselves lie deep enough that they remain undisturbed by the wind and waves above. They therefore contain records, in date order, of everything from CO₂ concentrations to particles of plutonium from the explosions of nuclear weapons, the first of which happened in 1945.

Indeed, the AWG has proposed that the subsequent spike in plutonium—an element which was vanishingly rare before the atomic age—should serve as the “primary marker” for the beginning of the Anthropocene. Not everyone is convinced, for plutonium is unstable. The isotopes that the AWG have in mind have half-lives of 6,500 and 24,000 years, meaning almost all the plutonium will be gone within 200,000 years. Dissidents suggest that fly ash from fossil-fuel combustion would make a better alternative. Like plutonium, it is not something that the planet has seen before. And unlike plutonium, it will, if left undisturbed, hang around in the rocks for many millions of years to come.

This article appeared in the Science & technology section of the print edition under the headline "Choosing a fingerprint"

An enormous—and unexpected—lump of granite has been found on the Moon

The discovery sheds light on lunar history, and suggests how other moons might be explored

Source: The Economist, July 12th 2023

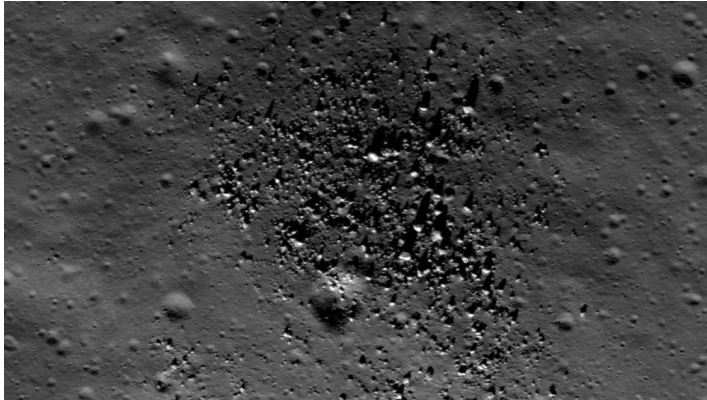


Image: NASA/GSFC/Arizona State University

In “2001: A Space Odyssey”, Stanley Kubrick and Arthur C. Clarke imagined a monolith buried beneath the surface of the Moon which turned out to be an alien artefact that set humankind on a path to the stars. The “batholith” that has been discovered below Compton-Belkovich, a volcanic-looking set of features on the far side of the Moon, hardly promises that. But it sheds some interesting light on the Moon’s past, and shows the power of a new way of peering into the crusts of other planets.

A batholith is a geological formation created when a vast quantity of molten rock rises through a planet’s crust, spreading out sideways as it does so. On Earth, these batholiths are composed mostly of granite; the rocks of Yosemite, for example, are parts of the Sierra Nevada batholith uncovered and spectacularly sculpted by subsequent erosion.

The Compton-Belkovich batholith is also made of granite, which is what gave it away. Granite is richer in thorium than other igneous—that is, once molten—rocks, such as basalt, and thorium is radioactive. Its decay heats the granite that hosts it. Measurements of microwave emissions made by the first two Chinese satellites to orbit the Moon, Chang’e 1 and Chang’e 2, allowed a team of scientists led by Matthew Siegler and Jianqing Feng of the Planetary Science Institute in Tucson, Arizona and Southern Methodist University in Dallas, Texas to calculate how much heat was being given off by rocks under the surface at Compton-Belkovich.

Assuming that the thorium was present at the sort of concentrations typically seen in granite allowed the scientists to calculate a likely shape for the source. Their best guess, published in Nature last week, was that there

is one smallish hot blob, maybe 10-20km across and a few kilometers deep, balanced on top of a much bigger, deeper one that might be 50km across and go down for tens of kilometers.

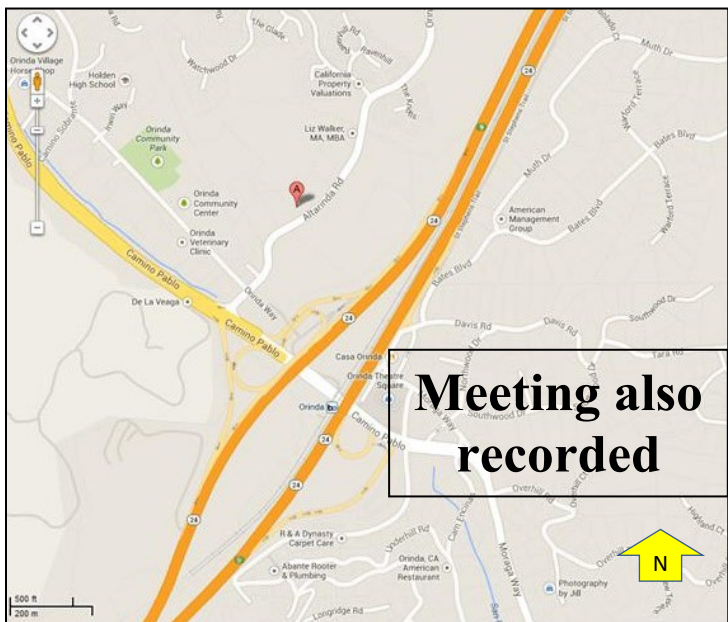
This suggests interesting goings-on in the depths of the Moon of a sort not previously recognized. Igneous rocks are made through a sort of geological distillation. When rocks far below the surface are heated, some components melt more easily than others; when the molten rock solidifies its mineral make-up is not the same as that of the original parent.

To turn rock from the mantle of Earth, or the Moon, into basalt requires just one cycle of distillation; basalt thus created makes up the solid crust under the oceans of Earth and the smooth lava plains of the Moon. To make granite, though, requires a number of separate distillations (which is what gives it high thorium concentrations). On Earth this is easily arranged; the collisions of tectonic plates provide lots of opportunities. On the placid, plateless Moon there is no such mechanism, and it has been easy to assume that basalt is for the most part all the planet has to offer. The granite batholith suggests something new at play. Perhaps the rocks in the area were unusually rich in water. Perhaps pulses of heat from below made them melt and freeze repeatedly.

The lunar discovery suggests that similar microwave measurements might provide novel insights into the innards of other planets. That this has not been tried before is due to a preconception. Satellites orbiting Earth use microwave receivers to measure water in the atmosphere. Because the solar system’s other rocky planets do not have watery atmospheres, such instruments have not been sent to them.

But when China launched Chang’e 1 and 2 its aim was to show that it could do science round the Moon, not necessarily to do the best such science. Dr Siegler thinks the microwave antennae were put on board simply because they had been shown to work and there were no more suitable instruments to hand. Now they have proved their worth, he hopes to see the designers of future spacecraft take note. One target where they might come in handy would be the moons of Jupiter, where their sensitivity to heat and moisture might be a useful addition to other sub-surface probes. Fans of “2001” will remember that its monolith spurred a new mission to Jupiter. Maybe the batholith will, too.

This article appeared in the Science & technology section of the print edition under the headline “Beneath the far side of the Moon.”



need to educate the public so constituents will not continue to vote for those holding back action. All of us need to act – and especially – vote climate.

Biography:

Diz Swift began her geology career during her Peace Corps tenure, ultimately publishing the glacial geology of Tierra del Fuego. She worked briefly for Lamont-Doherty in structural, but chose igneous petrology for her PhD at the University of Washington. She joined Chevron in minerals exploration, focusing on platinum, gold, and diamonds. During her Chevron career she moved through a variety of professional and management positions, ending in a key role for the Chevron-Texaco merger.

After retirement from Chevron, Swift returned to her geology roots to study climate change and advocate for action. She lectures widely on climate science, action and policy, including five years as a guest lecturer at the NYU Stern Business School. She began learning about government and policy as a Berkeley Public Works

Commissioner and with the League of Women Voters. She is currently Director of Natural Resources for the League of Women Voters of California where she advocates with the League for climate and related legislation. She founded and is co-chair of the national League of Women Voters Climate Interest Group with 1600 members spearheading grass-roots climate action in nearly all 50 states. Still interested in igneous petrology, she is also working on the petrogenesis and emplacement history of a sapphire-bearing lamprophyre in Montana.

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