NORTHERN CALIFORNIA GEOLOGICAL SOCIETY

Website: https://ncgeolsoc.org

MEETING ANNOUNCEMENT

DATE: **Wednesday, May 29, 2024 – Dinner Meeting**

LOCATION: **Orinda Masonic Hall**

TIME: **Social time: 6:00 to 6:45 pm; Dinner: 6:45 to 7:45; Program: 7:45 to 9 pm**

SPEAKER: ***Libby Ives, Postdoctoral Fellow, Jet Propulsion Laboratory, NASA / Caltech***

TOPIC: ***"Sedimentary geology of the Jezero crater western fan as seen by NASA's Mars Perseverance rover"***

Abstract:

The Mars 2020 Perseverance rover, NASA's most recent flagship Mars rover mission, landed in Jezero crater in February 2021. Mars 2020 is the first step of a multi-mission effort to return samples from Mars back to Earth. Perseverance's mission includes characterizing the geology and habitability of its exploration area, seeking signs of ancient life, collecting a cache of scientifically compelling, return-worthy samples, and preparing for future human exploration of Mars. During the first three years of its mission, Perseverance has traversed over 15 miles, captured innumerable images and geochemical measurements of the Martian surface, and collected 21 rock samples with high potential for biosignature preservation and/or to constrain the geologic history of Mars, 2 regolith samples, and 1 atmospheric sample.

Throughout roughly the second two years of its mission, Perseverance collected observations of and samples from the sedimentary rocks of the Jezero crater western fan. Before exploration by Perseverance, interpretations of these rocks based on high-resolution satellite images converged on the hypothesis that the sedimentary rocks in Jezero crater were deposited as a mud-rich, lacustrine delta. However, rover observations of these rocks seem to reveal a much more complex, dynamic, and coarse-grained depositional system than proposed from orbital data. This system evolved through time in response to both changes in lake level and changes in discharge and deposited a variety of sedimentary rock types in a stratigraphically complex succession.

In this talk, I will review major observations made by Perseverance of sedimentary rocks in the Jezero crater western fan, and what those rocks can tell us about the history of water on Mars, their potential for habitability, and the context for return sample science.

Biography:

Libby is a Postdoctoral Fellow on the Mars 2020 Science Team at the Jet Propulsion Laboratory in Pasadena, CA. At JPL, Libby is contributing to the Mars 2020 team by helping describe and interpret the geologic context

 (continued on last page)

NCGS 2023 – 2024 Calendar

June 26, 2024 **7:15 pm (6:30 social hour)**

Don Medwedeff, Consultant

Structure, Timing, and Western Extent of the Stockton Arch: Constraints on Neogene strike slip fault offset in the Diablo Range

September 25, 2024 **7:15 pm (6:30 social hour)**

John Karachewski

Icelandic Geoscapes

New Youtube Channel:

By vote of the Board in May 2023, we returned to in-person meetings only, as of 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 for which authors have given permission for this archiving will be accessible.

Message from the President

The NCGS Board today approved the following list of candidates to stand for election for the next fiscal year (2024-25) that begins on September 1. We will announce these at the annual dinner meeting on May 29th and ask for any additional nominations for interested members. The election will be held by voice vote at the June meeting on June 26th, our last meeting of this fiscal year. Please review these nominations and let us know if you are interested in having your name added to the ballot. Officers must be Active or Honorary Members in good standing.

President:	Jim O'Brient
President – Elect:	Tom MacKinnon
Past President:	Noelle Schoellkopf
Recording Secretary:	John Karachewski
Field Trip Coordinator:	Will Schweller
Treasurer:	Don Medwedeff
Program Directors:	Paul Henshaw, Greg Bartow
Membership Director:	Tom Barry
Newsletter Director:	Mark Sorensen
Webmaster/Social Media Director:	Andrew Alden

Dinner Meeting Details!

Dr. Libby Ives (JPL) will present "Sedimentary geology of the Jezero crater western fan as seen by NASA'S Mars Perseverance rover" at the annual NCGS dinner meeting on Wednesday, 29 May. Before you forget, please go to the link below to register. You are invited to bring a dessert to share! At the link, you'll also find a nice, quick preview of what awaits us in the evening's program. Remember to register by May 26 (revised deadline), as the Back Forty needs several days' warning for large food orders like ours. No walk-ins!

https://ncgs.regfox.com/ncgs-dinner-meeting-may-2024

We hope to see your there,
Greg, Paul, and John,
NCGS Program Chairs

Website News

From Andrew Alden, NCGS Website Manager/Social Media

I've reviewed our most recent weeks of traffic, now that the NCGS website has settled down. As a whole, each week the website gets from a few dozen to around 150 visitors, each of whom visits a little more than 2 pages. The home page accounts for about half of these page views. This level of traffic seems appropriate and doesn't cause me concern.

I would like the "News" column on the home page to have more activity, so today let me reiterate and expand upon what I said in April: All members are invited to send me tips of possible interest for posting, just as NCGS members supply Mark Sorensen with newsletter content--in fact I would prefer that people CC me when they send Mark tips. I can do things that complement the newsletter by posting items where they fit best, whether that's on the website or our Facebook page or our Twitter account. Help Mark and me build this kind of traffic with the aim of improving recruitment of new members.

Facebook traffic and Twitter traffic are minimal at this time. I post a few times a month, although I also promote NCGS on my own accounts. It seems that few NCGS members spend much time online, and I hope to change that by responding to comments promptly and encouraging conversation, both with you and with people online hearing about us for the first time.

Author (and geologist) D.J. Green to Appear at Orinda Books

Not many novels have an engineering geologist hero, but ***No More Empty Spaces*** does. Long-time AEG member and former Jahns Lecturer, Deb Green's (writing as D. J. Green) debut novel is available wherever books are sold, and she'll be in the Bay Area for an author event, in conversation with her publisher, Brooke Warner, in June.

Save the date, and join Deb at Orinda Books, 276 Village Square, Orinda, CA 94563, on Saturday June 22, 2024, at 2 PM!

Here's the link to register for this event (it's free, this just guarantees you'll get a seat):

https://www.orindabooks.com/event/d-j-green-author-no-more-empty-spaces-conversation-brooke-warner-publisher-she-writes-press

Email info@geologistwriter.com for more info. See you there!

NCGS Photo of the Month

This month we have a beautiful shot from member Steve Edwards. This picture combines geology and botany.

Serpentine Larkspur – *Delphinium uliginosum* is a rare serpentine endemic of the southern inner north coast ranges, confined to wet meadows, seeps, and stream sides. It is abundant at Bartlett Springs and in other wet meadows on Walker Ridge.

This photo is from a website developed by member Steven Edwards, Ph.D. and Director Emeritus of the Regional Parks Botanic Garden in Berkeley. The website is centered on California geology and plants. Steve has gathered some beautiful photographs of, among other things, wildflowers and petrographic thin sections – he secured some expert help from John Wakabayashi and Howard Day in interpreting thin sections. There are also essays on botany and conservation, poetry, and lithic replicas, landscapes, and animals.

You can find the site at http://californiageology.net, or it can be googled at californiawildflowers.net (which leads to the same site).

UC Berkeley Earth & Planetary Science Weekly Seminar Series

In-person EPS Seminar talks are off for the summer, but will presumably return in the fall for the academic year, on Thursdays at 141 McCone Hall. To join the department's email list, send an email to eps_frontoffice@berkeley.edu. 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 had been scheduled through June, but USGS is currently taking a pause on their Virtual Public Lecture Series. In the meantime, take a look at their archive for their past lectures, at https://www.usgs.gov/public-lecture-series.** 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 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 among those unable to use the electronic registration, you 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 Jim O'Brient at j.obrient @ comcast.net. Board meetings generally are on Saturday mornings in Jan., Apr./May, and Aug./Sep. The next meeting will be on **Saturday, September 7, 2024 at 9 a.m., by Zoom**.

A Great Website to Visit

Last year Dr. Ray Sullivan 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 worked, with some great photos and stories.

Did a magnetic field collapse trigger the emergence of animals?

Evidence suggests a weak magnetic field millions of years ago may have fueled the proliferation of life.

EurekAlert!, May 3, 2024
Source: University of Rochester

The Ediacaran Period, spanning from about 635 to 541 million years ago, was a pivotal time in Earth's history. It marked a transformative era during which complex, multicellular organisms emerged, setting the stage for the explosion of life.

But how did this surge of life unfold and what factors on Earth may have contributed to it?

Researchers from the University of Rochester have uncovered compelling evidence that Earth's magnetic field was in a highly unusual state when the macroscopic animals of the Ediacaran Period diversified and thrived. Their study, published in Nature Communications Earth & Environment, raises the question of whether these fluctuations in Earth's ancient magnetic field led to shifts in oxygen levels that may have been crucial to the proliferation of life forms millions of years ago.

According to John Tarduno, the William Kenan, Jr. Professor in the Department of Earth and Environmental Sciences, one of the most remarkable life forms during the Ediacaran Period was the Ediacaran fauna. They were notable for their resemblance to early animals—some even reached more than a meter (three feet) in size and were mobile, indicating they probably needed more oxygen compared to earlier life forms.

"Previous ideas for the appearance of the spectacular Ediacaran fauna have included genetic or ecologic driving factors, but the close timing with the ultra-low geomagnetic field motivated us to revisit environmental issues, and, in particular, atmospheric and ocean oxygenation," says Tarduno, who is also the Dean of Research in the School of Arts & Sciences and the School of Engineering and Applied Sciences.

Earth's magnetic mysteries

About 1,800 miles below us, liquid iron churns in Earth's outer core, creating the planet's protective magnetic field. Though invisible, the magnetic field is essential for life on Earth because it shields the planet from solar wind—streams of radiation from the sun. But Earth's magnetic field wasn't always as strong as it is today.

Researchers have proposed that an unusually low magnetic field might have contributed to the rise of animal life. However, it has been challenging to examine the link because of limited data about the strength of the magnetic field during this time.

Tarduno and his team used innovative strategies and techniques to examine the strength of the magnetic field by studying magnetism locked in ancient feldspar and pyroxene crystals from the rock anorthosite. The crystals contain magnetic particles that preserve magnetization from the time the minerals were formed. By dating the rocks, researchers can construct a timeline of the development of Earth's magnetic field.

Leveraging cutting-edge tools, including a CO_2 laser and the lab's superconducting quantum interference device (SQUID) magnetometer, the team analyzed with precision the crystals and the magnetism locked within.

A weak magnetic field

Their data indicates that Earth's magnetic field at times during the Ediacaran Period was the weakest field known to date—up to 30 times weaker than the magnetic field today—and that the ultra-low field strength lasted for at least 26 million years.

A weak magnetic field makes it easier for charged particles from the sun to strip away lightweight atoms such as hydrogen from the atmosphere, causing them to escape into space. If hydrogen loss is significant, more oxygen may remain in the atmosphere instead of reacting with hydrogen to form water vapor. These reactions can lead to a buildup of oxygen over time.

The research conducted by Tarduno and his team suggests that during the Ediacaran Period, the ultraweak magnetic field caused a loss of hydrogen over at least tens of millions of years. This loss may have led to increased oxygenation of the atmosphere and surface ocean, enabling more advanced life forms to emerge.

Tarduno and his research team previously discovered that the geomagnetic field recovered in strength during the subsequent Cambrian Period, when most animal groups begin to appear in the fossil record, and the protective magnetic field was reestablished, allowing life to thrive.

"If the extraordinarily weak field had remained after the Ediacaran, Earth might look very different from the water-rich planet it is today: water loss might have gradually dried Earth," Tarduno says.

Core dynamics and evolution

The work suggests that understanding planetary interiors is crucial in contemplating the potential of life beyond Earth.

"It's fascinating to think that processes in Earth's core could be linked ultimately to evolution," Tarduno says. "As we think about the possibility of life elsewhere, we also need to consider how the interiors of planets form and develop."

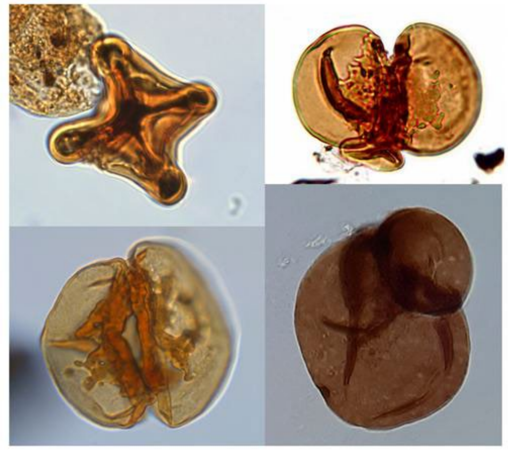
This research was supported by the US National Science Foundation.

Journal Reference: Near-collapse of the geomagnetic field may have contributed to atmospheric oxygenation and animal radiation in the Ediacaran Period, *Communications Earth & Environment.* DOI**:** 10.1038/s43247-024-01360-4. Publication Date: 2-May-2024.

Climate change and mercury pollution stressed plants for millions of years

Volcanic province drove mass-extinction and disturbance afterwards

EurekAlert! April 27, 2024
Source: Utrecht University



Examples of severely malformed and teratologic spores from Schandelah-1, and other locations (right top: Stenlille core, Denmark; left bottom: Pechgraben, southern Germany; right bottom: Prees-2 core, United Kingdom). fern spores (spores are 40 – 60 micrometers in size). Credit: Sofie Lindström (Geological Survey of Greenland and Denmark, Geus, Stenlille) and Bas van de Schootbrugge (others).

The link between massive flood basalt volcanism and the end-Triassic (201 million years ago) mass-extinction is commonly accepted. However, exactly how volcanism led to the collapse of ecosystems and the extinction of entire families of organisms is difficult to establish. Extreme climate change from the release of carbon dioxide, degradation of the ozone layer due to the injection of damaging chemicals, and the emissions of toxic pollutants, are all seen as contributing factors. One toxic element stands out: mercury. As one of the most toxic elements on Earth, Hg is a metal that is emitted from volcanoes in gaseous form, and thus has the capacity to spread worldwide. A new study in Nature Communications adds new compelling evidence for the combined effects of global warming and widespread mercury pollution that continued to stress plants long after volcanic activity had ceased.

An international team of Dutch, Chinese, Danish, British, and Czech scientists studied sediments from Northern-Germany in a drill-core (Schandelah-1) that spans the uppermost Triassic to lower Jurassic for microfossils and geochemical signals. A study of pollen and spore abundances revealed a profusion of fern spores showing a range of malformations, from abnormalities in wall structure to evidence for botched meiotic divisions, leading to unseparated, dwarfed, and fused fern spores. "Seeing the sheer amount and different types of malformed fern spores in sediment samples from a coastal lagoon, dating back 201 million years ago is truly astonishing. It means there must have been very many ferns being stressed," explains Remco Bos, a PhD candidate at Utrecht University and lead author of the study. "It is also not something we see regularly during other periods that also contain many fern fossils, making it a true signal connected to the end-Triassic mass-extinction event."

Deforestation and ferns

The results from Bos and co-authors confirm earlier work by co-authors Sofie Lindström (University of Copenhagen), Hamed Sanei (Aarhus University), and Bas van de Schootbrugge (Utrecht University), who previously produced similar data obtained from cores from Denmark and from nearby outcrops in Sweden. According to Sofie Lindström: "Ferns replaced trees across the extinction interval in response to dramatic environmental changes likely driven by heat stress, strongly increased monsoonal rainfall, and increased forest fire activity. Palynological results show that a pioneering fern vegetation spread across vast swaths of coastal lowlands in Northwestern Europe from Sweden and Denmark to Germany, France, Luxemburg, and Austria in response to widespread deforestation". Ferns are hardy plants, often colonizing disturbed environments, including newly formed volcanic islands or landscapes devastated by volcanism or wildfires. "What is extraordinary here is that the ferns that produced all these malformed spores in all these different sites, did not go extinct. While other plants went extinct, ferns were apparently robust enough to continue, which could also be related to their different mercury tolerance."

Climate variability

In this new study, Bos and co-authors show that the ferns, which took advantage of the dieback of forests, themselves were subjected to stress from Hg-pollution well beyond the immediate extinction interval. "We found four more intervals with high levels of Hg concentrations and high numbers of malformed spores in the 1.3 to 2 million years following the extinction interval," explains Remco Bos. This interval, known as the Hettangian, was a time of continuing adverse conditions in the oceans, with generally low diversities among marine invertebrates, such as ammonites and bivalves. On land, however, vegetation appeared to have recovered quicker. "We now show that this forest ecosystem continued to be perturbed repeatedly for at least 1.3 million years, but perhaps as long as 2 million years," Bos explains.

The four additional episodes of high Hg concentrations and high fern spore malformations were unlikely connected to later phases of Central Atlantic Magmatic Province volcanism. Instead, Bos and co-authors show that these periods correspond closely to the long eccentricity cycle, the major variation in the shape of Earth's orbit that moves Earth closer or further away from the Sun every 405 thousand years. During eccentricity maxima Earth moves closer to the Sun allowing for more sunlight to reach the Earth surface. As the Earth's atmosphere was already supercharged with carbon dioxide from the large-scale volcanism, this cyclic modulation of the climate system repeatedly triggered forest dieback, allowing for the renewed spread of pioneer ferns. As is shown by the correlation with high Hg contents, malformations in fern spores during these episodes were also the result of mercury poisoning. But where did this Hg come from?

Hg isotopes

A crucial data set was generated at Tianjin University (China) by Wang Zheng, a co-corresponding author and geochemist specialized in metal isotope studies, especially Hg-isotopes. Mercury has different stable isotopes that behave differently in the environment. During reactions in nature, for example the expulsion from volcanism, deposition from the atmosphere, and the uptake by organisms, Hg-isotopes can become fractionated, enriching one pool in heavier isotopes, and others in lighter isotopes. Sediments with elevated levels of Hg and malformed spores also show clear variations in Hg-isotopes. "Based on the Hg-isotope variations we were able to link an initial pulse in Hg enrichment at the Triassic-Jurassic boundary to the emission of mercury from flood basalt volcanism," Wang Zheng explains. "However, the four other pulses in mercury had a different isotopic composition, indicating they were mainly driven by Hg input from soil erosion and photochemical reduction."

Climate change and toxic pollution

The combined geochemical and microfossil data thus paint a picture of a much more complex and drawn-out sequence of events, starting with massive volcanism driving climate change and releasing toxic pollutants, followed by episodic pulses of disturbance in the aftermath of the extinction event lasting for at least 1.3 million years. Dr. Tomas Navratil from the Czech Academy of Sciences, a co-author on the paper and a specialist for modern-day mercury pollution, agrees with this scenario. "Our work on polluted sites in the Czech Republic does show evidence for episodic remobilization from forest soils, especially during hot summers, and in places that are more exposed to sunlight causing the photochemical reduction of mercury and re-release to the atmosphere of previously stored mercury".

"We know that mass-extinction events were complex and long-lasting events. Here we show that a mix of greenhouse warming and pollution led to continued ecosystem perturbation. Coastal ecosystems likely suffered the most by receiving large amounts of mobilized mercury from vast catchment areas. Eventually, the system recovered during the Sinemurian, when we see stable forested biomes appear. It is likely that by that time, Earth had cleaned up the mess, carbon dioxide levels went down, and mercury was buried for good in offshore marine sediments," Bos concludes.

Journal Reference: *Nature Communications.* Climate-forced Hg-remobilization associated with fern mutagenesis in the aftermath of the end-Triassic extinction. DOI: 10.1038/s41467-024-47922-0. Article Publication Date 27-Apr-2024.

Archaeology: Egyptian pyramids built along long-lost Ahramat branch of the Nile

EurekAlert! May 16, 2024
Source: University of North Carolina Wilmington

Thirty-one pyramids in Egypt, including the Giza pyramid complex, may originally have been built along a 64-km-long branch of the river Nile which has long since been buried beneath farmland and desert. The findings, reported in a paper in Communications Earth & Environment, could explain why these pyramids are concentrated in what is now a narrow, inhospitable desert strip.

The Egyptian pyramid fields between Giza and Lisht, built over a nearly 1,000-year period starting approximately 4,700 years ago, now sit on the edge of the inhospitable Western Desert, part of the Sahara. Sedimentary evidence suggests that the Nile used to have a much higher discharge, with the river splitting into several branches in places. Researchers have previously speculated that one of these branches may have flown by the pyramid fields, but this has not been confirmed.

The water course of the ancient Ahramat branch borders a large number of pyramids dating from the Old Kingdom to the Second Intermediate Period, spanning between the third dynasty and the thirteenth dynasty. Credit: Eman Ghoneim

Eman Ghoneim and colleagues studied satellite imagery to find the possible location of a former river branch running along the foothills of the Western Desert Plateau, very near to the pyramid fields. They then used geophysical surveys and sediment cores to confirm the presence of river sediments and former channels beneath the modern land surface, indicating the presence of a former branch, which they propose naming 'Ahramat' (meaning 'pyramids' in Arabic). The authors suggest that an increased build-up of windblown sand, linked to a major drought which began approximately 4,200 years ago, could be one of the reasons for the branch's migration east and eventual silting up.

The discovery may explain why these pyramid fields were concentrated along this particular strip of desert near the ancient Egyptian capital of Memphis, as they would have been easily accessible via the river branch at the time they were built. Additionally, the authors found that many of the pyramids had causeways which ended at the proposed riverbanks of the Ahramat branch, which they suggest is evidence the river was used for transporting construction materials.

The findings reiterate the importance of the Nile as a highway and cultural artery for ancient Egyptians, and also highlight how human society has historically been affected by environmental change, according to the authors. Future research to find more extinct Nile branches could help prioritize archaeological excavations along their banks and protect Egyptian cultural heritage, they add.

Journal Reference: The Egyptian pyramid chain was built along the now abandoned Ahramat Nile Branch, *Communications Earth & Environment,* 16-May-2024. DOI: 10.1038/s43247-024-01379-7.

Lake tsunamis pose significant threat under warming climate

EurekAlert! (from AAAS), 2-May -2024
Source: Seismological Society of America

The names might not be familiar—Cowee Creek, Brabazon Range, Upper Pederson Lagoon—but they mark the sites of recent lake tsunamis, a phenomenon that is increasingly common in Alaska, British Columbia and other regions with mountain glaciers.

Triggered by landslides into small bodies of water, most of these tsunamis have occurred in remote locations so far, but geologist Bretwood Higman of Ground Truth Alaska said it may just be a matter of time before a tsunami swamps a more populated place like Portage Lake near

Whittier, Alaska.

When he estimates where the risk of an Alaskan lake tsunami is highest, Portage Lake "is pretty much at the top of my list," Higman said.

The most active portion of the instability at Portage Glacier, looking down on Portage Lake and a tour boat in the distance. Credit: Bretwood Higman

Other sites in Alaska where the risks of lake tsunamis coincide with human activity and infrastructure include Eklutna, Seward, Valdez, Juneau, Grewingk Lake in Kachemak Bay State Park and Index Lake near Glacier View.

At the Seismological Society of America (SSA)'s 2024 Annual Meeting, Higman discussed the importance of assessing sites like Portage Lake for the possibility of lake tsunamis, in part by using distinctive seismic signals connected to landslides.

"There are some cases where there are dramatic and very distinctive precursory seismic signals that precede a catastrophic landslide, sometimes by as much as days," Highman noted. "If we could get to the point where we understood these and knew how to detect them, they could be really useful."

Higman calls lake tsunamis "an emerging, climate-linked hazard." The geological conditions that underlie the events in places like Alaska are usually similar. Higher temperatures melt the glaciers that buttress the walls of the valley that cradles the shrinking glacier. Without the glacier in place to hold them up, the valley walls are more prone to landslide, either into an existing body of water or a new lake created by the glacier melt. In other areas, warming conditions are weakening permafrost that may be important to the stability of slopes above lakes.

"This is something that historically has been a pretty rare event, but in the last few years there have been a really surprising number of these," said Higman.

The 2020 Elliot Creek tsunami in a glacial valley in British Columbia, for instance, featured a landslide measuring 18 million cubic meters in volume and a tsunami runup of more than 100 meters.

Forest and salmon habitat were the main casualties of that tsunami, but Higman and his colleagues are looking at these remote but dramatic events to find ways to prepare for tsunamis in places with more infrastructure. "There are places where we see the same kinds of geologic instability that preceded these other events, but there are a lot of people exposed," said Higman.

Higman said there are some parallels between the tectonic faults that seismologists usually study and "the behaviors that we're seeing in the failure surface of these very large landslides," suggesting that they also offer one way to study fault dynamics in miniature.

Rock solid evidence: Angola geology reveals prehistoric split between South America and Africa

EurekAlert! May 1, 2024
Source: Southern Methodist University

An SMU-led research team has found that ancient rocks and fossils from long-extinct marine reptiles in Angola clearly show a key part of Earth's past – the splitting of South America and Africa and the subsequent formation of the South Atlantic Ocean.

With their easily visualized "jigsaw-puzzle fit," it has long been known that the western coast of Africa and the eastern coast of South America once nestled together in the supercontinent Gondwana — which broke off from the larger landmass of Pangea.

The research team says the southern coast of Angola, where they dug up the samples, arguably provides the most complete geological record ever recorded on land of the two continents moving apart and the opening of the South Atlantic Ocean. Rocks and fossils found date back from 130 million years ago to 71 million years.

"There are places that you can go to in South America, for instance, where you can see this part of the split or that part of it, but in Angola, it's all laid out in one place," said Louis L. Jacobs, SMU professor emeritus of Earth Sciences and president of ISEM. Jacobs is the lead author of a study published in The Geological Society, London, Special Publications.

"Before this, there was not a place known to go and see the rocks on the surface that really reflected the opening of the South Atlantic Ocean, because they're now in the ocean or eroded away," Jacobs said.

Angola rocks and fossils tell the whole story

Africa and South America started to split around 140 million years ago, causing gashes in Earth's crust called rifts to open up along pre-existing weaknesses. As the tectonic plates beneath South America and Africa moved apart, magma from the Earth's mantle rose to the surface, creating a new oceanic crust and pushing the continents away from each other. And eventually, the South Atlantic Ocean filled the void between these two newly-formed continents.

Scientists have previously found evidence of these events through geophysics and well cores drilled through the ocean floor.

But these tell-tale signs have never been found in one place, or been so clearly visible for anyone to see, said study co-author Michael J. Polcyn, research associate in the Huffington Department of Earth Sciences and senior research fellow, ISEM at SMU.

"It's one thing for a geophysicist to be able to look at seismic data and make inferences from that," he said. "It's quite another thing to be able to take a school field trip out to the rock formations, or outcrops, and say this is when the lava was spreading from eastern South America. Or this was when it was a continuous land."

Essentially, Angola presents the opportunity for someone to easily walk through each phase of this geologically significant chapter in Earth's history.

"That gives Angola major bragging rights," Jacobs said.

Jacobs, Polcyn and Diana P. Vineyard – who is a research associate at SMU – worked with an international team of paleontologists, geologists and others to analyze both the rock formations they found in eight different locations on the coast and the fossils within them.

Fieldwork in Angola's Namibe Province began in 2005. At that time, the research team recognized particular types of sediments, which gave them a good indication of what the western coast of Africa had been like at various stages millions of years ago. For instance, fields of lava revealed volcanic outpourings, and faults or breaks showed where the continents were being rifted apart. Sediments and salt deposits showed ocean flooding and evaporation, while overlying oceanic sediments and marine reptiles showed completion of the South Atlantic Ocean.

Paleontologists, meanwhile, discovered fossils in Angola from large marine reptiles that had lived late during the Cretaceous Period, right after the Atlantic Ocean was completed and while it grew wider.

By bringing together experts from a wide range of fields, "we were able to document when there was no ocean at all, to when there was a fresh enough ocean for those reptiles to thrive and have enough to eat," Vineyard said.

Many of the ancient fossils are currently on display at the Smithsonian's National Museum of Natural History "Sea Monsters Unearthed: Life in Angola's Ancient Seas" exhibit, which was co-produced with SMU – a nationally-ranked Dallas-based private university.

Angolan researchers – Nair de Sousa, a geoscientist and energy consultant at the African Circular Business Alliance, and Pedro Claude Nsungani, a geology professor at the Universidade Agostinho Neto – also played a key role in this research.

Journal Reference: *Geological Society London Special Publications*, 8-Mar-2024. Article Title: **The Atlantic jigsaw puzzle and the geoheritage of Angola.**

Making batteries takes a lot of lithium. Some could come from Pennsylvania oil-and-gas wastewater

EurekAlert! May 15, 2024
Source: University of Pittsburgh

Most batteries used in technology like smart watches and electric cars are made with lithium that travels across the world before even getting to manufacturers. But what if nearly half of the lithium used in the U.S. could come from Pennsylvania wastewater?

A new analysis using compliance data from the Pennsylvania Department of Environmental Protection suggests that if it could be extracted with complete efficiency, lithium from the wastewater of Marcellus shale gas wells could supply up to 40% of the country's demand.

Already, researchers in the lab can extract lithium from water with more than 90% efficiency according to Justin Mackey, a researcher at the National Energy Technology Laboratory and PhD student in the lab of Daniel Bain, associate professor of geology and environmental sciences in the Kenneth P. Dietrich School of Arts and Sciences.

The US Geological Survey lists lithium as a critical mineral, (although, as Mackey was quick to point out, lithium is an element, not a mineral). The designation means the U.S. government wants all lithium to be produced domestically by 2030, and so the search for sources has intensified. Currently, much of it is extracted from brine ponds in Chile. Then it's shipped to China, where it's processed.

There are lithium mining operations in the U.S., but, Mackey said, "This is different. This is a waste stream and we're looking at a beneficial use of that waste."

Finding lithium in the wastewater in Marcellus shale wasn't a surprise: Researchers had analyzed the water recycled in hydraulic fracking and knew that it picked up minerals and elements from the shale. "But there hadn't been enough measurements to quantify the resource," Mackey said. We just didn't know how much was in there." Thanks to Pennsylvania regulatory requirements, the research team was able to figure it out. They published their results in the journal *Scientific Reports*.

Companies are required to submit analyses of wastewater used in each well pad, and lithium is one of the substances they have to report, Mackie said. “And that’s how we were able to conduct this regional analysis.”

Meeting 30% to 40% of the country’s lithium needs would bring the country much closer to the 2030 requirements. But there’s lithium-rich wastewater outside of the state’s boundaries, too. “Pennsylvania has the most robust data source for Marcellus shale,” Mackey said, “But there’s lots of activity in West Virginia, too.”

The next step toward making use of this lithium is to understand the environmental impact of extracting it and to implement a pilot facility to develop extraction techniques.

“Wastewater from oil and gas is a burgeoning issue,” Mackey said. “Right now, it’s just minimally treated and reinjected.” But it has to potential to provide a lot of value. After all, he said, “It’s been dissolving rocks for hundreds of millions of years — essentially, the water has been mining the subsurface.”

Journal Reference: *Scientific Reports.* **Estimates of lithium mass yields from produced water sourced from the Devonian-aged Marcellus Shale**. 27-Mar-2024. DOI: 10.1038/s41598-024-58887-x. Article Publication Date: 16-Apr-2024.

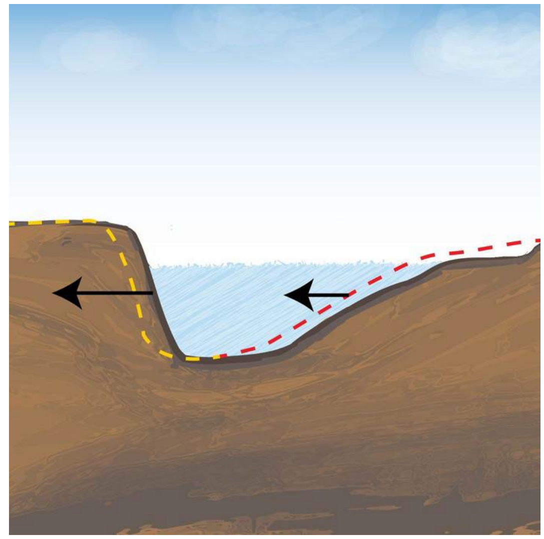
Managing meandering waterways in a changing world

UC Santa Barbara researchers connect sediment load to migration rate in meandering rivers worldwide

EurekAlert! April 24, 2024
Source: University of California - Santa Barbara

Just as water moves through a river, rivers themselves move across the landscape. They carve valleys and canyons, create floodplains and deltas, and transport sediment from the uplands to the ocean.

A new paper out of UC Santa Barbara presents an account of what drives the migration rates of meandering rivers. The two authors compiled a global dataset of these waterways, analyzing how vegetation and sediment load effect channel movement. “We find a global-scale trend between the amount of sediment that rivers carry and how quickly they’re migrating, across all variables,” said lead author Evan Greenberg, a doctoral student in the Department of Geography.



Erosion pulls the steep bank over at the same time as deposition pushes the sand bar on the opposite side. together, they move the river bend to the left. Credit: Matt Perko

Their results, published in the journal *Earth and Planetary Science Letters*, contrast with previous work that emphasized the stabilizing effect of vegetation. In this paper, the researchers highlight how the activity of meandering rivers emerges from the interplay between sediment deposition and bank stabilization by vegetation. Some of the world's most important waterways are meandering rivers, so properly understanding their behavior is crucial to managing these natural phenomena in a changing world.

Two forces, called bar push and bank pull, act on a river bend. Bar push is caused when deposition on the inside of a bend forms a sandbar, which pushes the curve outward. At the same time, erosion on the opposite bank pulls the bend even farther outward. Sediment load has a stronger effect on the former, while the stabilizing presence of vegetation has more influence on the latter.

Scientists have proposed various hypotheses as to which factor exerts a stronger influence on meander migration. “This is a pretty contentious topic and keeps going back and forth,” said senior author Vamsi Ganti, Greenberg’s advisor and an associate professor in the geography department.

To investigate these dynamics, Greenberg and Ganti collated existing measurements of river migration rates and added data from approximately 60 additional rivers. Altogether, they compiled data on 139 meandering rivers across the globe, spanning different regions, climates, sizes and vegetation regimes. The researchers modeled each river channel as a series of line segments using satellite imagery. They could then track how these segments shifted over time to measure the river’s migration.

The leading paradigm was that vegetation slows down this migration by stabilizing the outer bank against erosion.

This contrasted with experimental evidence suggesting that sediment load could be an influential factor. Bank pull is stronger in unvegetated rivers, but as Greenberg and Ganti discovered, these tend to have higher sediment supply as well, making it difficult to distinguish the relative contributions of the two processes.

But Greenberg and Ganti's analysis revealed a clear trend: Migration was faster for rivers that carried a lot of sediment relative to their size. The model also showed vegetation slowing down river migration, as suggested by previous studies. However, the effect was much more modest, with unvegetated rivers migrating four times faster than similar-sized counterparts, rather than the 10-fold increase reported by some of their colleagues. This suggests that bar push has a stronger influence on meandering rivers than bank pull.

That said, river behavior flows from the confluence of the two processes. "You can't have one dominate the other in a meandering river," Ganti said. "If you don't have enough sediment supply, bank pull will outpace bar push, and you'll end up with a braided river. And so it's really the balance between the bar push and the bank pull that creates these stable meandering rivers."

Dams provide a ready-made case study for investigating the contributions of these two mechanisms, since the structures trap sediment but scarcely affect vegetation. When the authors looked at the movement of three North American rivers above and below notable dams, they found that migration rates slowed downstream, where the river was starved of sediment. They could now be certain that sediment load was driving bend migration.

Greenberg is further investigating the effect dams have not just on meandering rivers, but on all the types of rivers that have floodplains. "We want to know what dams are doing to the migration of rivers," he said.

Many of the world's most important waterways are meandering rivers, and hundreds of millions of people live along their floodplains, Ganti said. "So knowing how rivers move is important for managing the risks that come with bank migration.

In previous papers, Ganti has documented how sea-level rise and changes in sediment supply could affect river dynamics in the future. The results paint a picture of more active, less predictable rivers, especially when combined with more extreme weather and changing land use. For instance, scientists predict that many rivers will see increased sediment supply. "More sediment means that rivers can do more stuff," he remarked.

Ganti plans to broaden the scope of their model. While geographers and Earth scientists have historically focused on meandering rivers, the majority of the planet's waterways are wandering, multi-threaded rivers, he said. He and Greenberg are working on quantifying river mobility in general, across the many categories of rivers. Ideally, they want to develop a model that can describe a river's migration as it changes type along the entirety of its length, from headwater to sea.

Journal Reference: *Earth and Planetary Science Letters,* 15-May-2024. Article Title: **The pace of global river meandering influenced by fluvial sediment supply.** DOI: 10.5281/zenodo.7271700.

Warming climate is putting more metals into Colorado's mountain streams

Copper, zinc and sulfate concentrations have doubled over the past three decades in metal sulfide-rich watersheds, with the greatest increases seen at high altitudes

EurekAlert! April 23, 2024
Source: American Geophysical Union

Iron oxides stain the bed of Upper East Mancos River in southwestern Colorado, an alpine stream affected by acid rock drainage. Concentrations of zinc, copper and sulfate have doubled in the last three decades in Colorado's high-altitude streams, like the Upper East Mancos, where groundwater flows through bedrock rich in metal sulfides, according to a new study that linked the trend to climate change.

Credit: Andrew Manning

Warming temperatures are causing a steady rise in copper, zinc and sulfate in the waters of Colorado mountain streams affected by acid rock drainage. Concentrations of these metals have roughly doubled in these alpine streams over the past 30 years, a new study finds, presenting a concern for ecosystems, downstream water quality and mining remediation.

Natural chemical weathering of bedrock is the source of the rising acidity and metals, but the ultimate driver of the trend is climate change, the report found.

"Heavy metals are a real challenge for ecosystems," said lead author Andrew Manning, a geologist with the U.S. Geological Survey in Denver. "Some are quite toxic. We are seeing regional, statistically significant trends in copper and zinc, two key metals that are commonly a problem in Colorado. It's not ambiguous and it's not small."

The study was published in Water Resources Research, AGU's peer reviewed journal for original research on the movement and management of Earth's water.

Although the mechanism coupling warming temperatures to increased sulfide weathering is still an open research question, the new results point to exposure of rock once sealed away by ice as a top suspect, Manning said. The sudden appearance of "rusting Arctic rivers" flowing out of regions of thawing permafrost in the last couple of years is likely the same process, magnified.

Colorado is riddled with patches of bedrock rich in metal sulfides. Shiny iron sulfide, familiar to many Coloradans as fool's gold, or pyrite, is the most common of these sulfide minerals, but copper, zinc and other metal sulfides are also common.

Exposure to air oxidizes the metal sulfides in bedrock, releasing the metals into groundwater, which flows into surface streams. Rusty red deposits in streambeds are distinctive signs of iron sulfide oxidation. Sulfides also acidify the water, which can accelerate weathering. Some alpine streams sampled were found to have a pH as low as 3 or 4.

The study drew on 40 years of water chemistry data, taking final samples from all sites in 2021, from 22 headwater streams in 17 watersheds that are naturally acidic and metal-rich enough to limit aquatic plants and animals. Sampling sites were above 3,000 meters (10,000 feet) elevation and included a mix of pristine, untouched areas and places that had been mined historically, but left alone for 50 to 100 years.

"The key point is no recent mining or remediation work has been done," Manning said. "These watersheds have just been sitting there responding to nothing other than the climate."

Warming, drying mountains

Mountain streams were sampled from mid-July to November, spanning the late summer and fall low-flow period. Long-term records of flow volume from nearby stream gauges show streamflows have been dwindling with warming temperatures and smaller snowpacks, suggesting smaller water volumes could explain the higher metal concentrations.

But Manning and his colleagues found less water could only account for half the effect they observed. To reach the concentrations they were seeing, the mountains had to be putting metals and sulfate into streams at a faster rate.

As these metal-rich mountain streams flow down into larger rivers, the effect of the extra metal load is diluted, the researchers noted.

"I don't think this is a big red flag for major metropolitan or agriculture users way downstream at lower elevations," Manning said, "but some of our mountain communities get their water only a short distance down from these mineralized streams." To help mitigate the water quality risk, managers could benefit from advance knowledge of what metals are entering the stream, and where and how fast they are increasing, Manning said.

More metals and acidity in these mountain streams could also impact decisions about where to invest limited funds for remediation of those that have been altered by historical mining, and where to stock fish to benefit tourism.

Local case, global pattern

Colorado's watersheds are a dramatic case because of the unusual abundance of bedrock metal sulfides, Manning said, but scientists are observing more subtle rising sulfate concentrations in mountain streams around the world. The new study is the first to statistically connect accelerated sulfide weathering to rising temperatures on a large scale across an entire region.

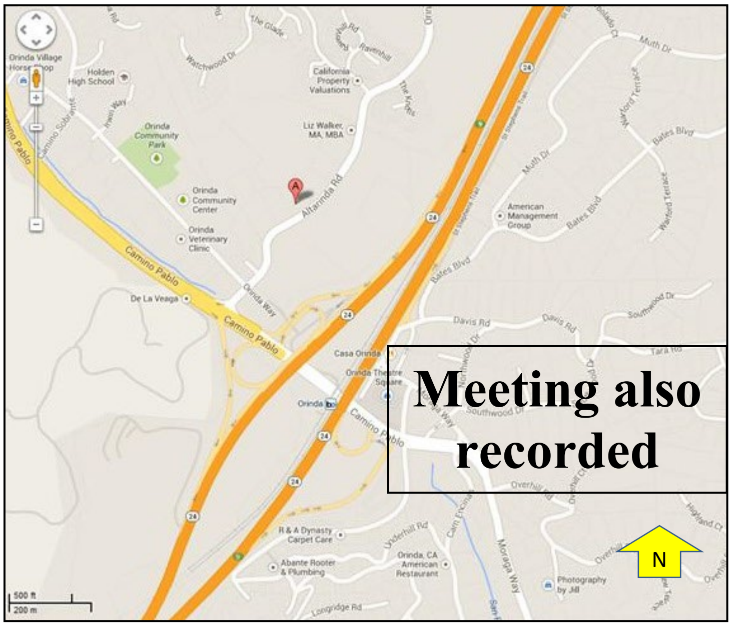
The study found the biggest gains in metal loads in the highest, coldest mountain streams. Manning said this pattern points to thawing underground ice. Colorado's highest elevations have annual average temperatures close to zero degrees Celsius (32 degrees Fahrenheit), putting them right at the boundary conditions for permafrost. Some peaks have warmed past the freezing threshold since 1980.

"Ice is like armor. Melt it and you create windows for groundwater to get into rock that has not seen water and oxygen for millennia, and it will begin to oxidize quite quickly," Manning said.

Other possible mechanisms are falling water tables exposing fresh rock to air and melting rock glaciers releasing pockets of concentrated metals stored in the ice. Wetlands accumulate metals and may release a burst when water returns after dry periods. The study did not find a correlation between rates of rising metal concentrations and the presence of wetlands, rock glaciers or factors linked to falling water tables, although these could be playing a role in other regions. But all these possible mechanisms are consequences of climate change.

"There's just no other logical explanation than this is a changing climate signal," Manning said. "Nothing else would reach all these watersheds universally."

Journal Reference: *Water Resources Research*, 2-Apr-2024. Article Title: **Climate-Driven Increases in Stream Metal Concentrations in Mineralized Watersheds Throughout the Colorado Rocky Mountains, USA.** DOI: 10.1029/2023WR036062.



(Continued from Page 1)

of sedimentary rocks in Jezero crater using data collected by the Perseverance rover. Libby is a geologist, clastic sedimentologist, geomorphologist, and geologic mapper who developed her expertise by studying a diverse suite of sedimentary systems, landscapes, and depositional processes on Earth. This work was primarily conducted through field observations of such field sites as modern glaciers in Iceland, Quaternary glacial deposits of the northern United States, Cenozoic marine sediments of Baffin Bay, and Paleozoic successions in Argentina, Australia, and Antarctica. Libby earned her Ph.D. Geosciences (2021) from the University of Wisconsin – Milwaukee, an M.S. Geology (2016) from Iowa State University, and a B.S. Earth Science (2013) from Northern Michigan University.

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