NORTHERN CALIFORNIA GEOLOGICAL SOCIETY

- - NO MEETING for JUNE 2020 - -

Due to Covid-19 Pandemic Concerns

As you may have anticipated, we will have to cancel our June NCGS meeting as well. We hope and trust that everyone will practice social distancing and will remain safe, especially in any inside spaces outside the home. Until we can meet again as geologists should, we'll continue to publish newsletters to help us all to try and stay somewhat current on developments in our beloved field. In the body of the newsletter we have our normal collection of geology news summaries.

The society's board of directors met recently, and determined that we will attempt to meet in the fall, either virtually via online conferencing or in person. The former appears more likely, and please stay tuned as our normal September date (the 4th Wednesday) approaches. We'll also have to wait to decide on whether we will be able to organize a reprise of the excellent field trip on Mount Diablo that was led last fall by Don Medwedeff and Will Schweller. In the meantime, be safe!

NCGS 2019 – 2020 Calendar

Tentative – subject to change

September 30 **7:00 pm**

No speaker yet scheduled; meeting may be online

October 28 **7:00 pm**

(Meeting may be online)

Jared Gooley, Stanford University (Ph.D. candidate)

Tectonic evolution of the central California margin as reflected by detrital zircon composition in Mt. Diablo region

THE 75th ANNIVERSARY VOLUME OF THE NORTHERN CALIFORNIA GEOLOGICAL SOCIETY: THE REGIONAL GEOLOGICAL SETTING OF MOUNT DIABLO

The following table summarizes the contributions to the Volume scheduled to be published by the Geological Society of America in December 2020. The editors are Ray Sullivan, Doris Sloan, Jeff Unruh, and David Schwartz.

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NCGS 75th Anniversary

It's been 75 years since the NCGS began as an outgrowth of a genial gathering, over brews, of geologists from a variety of mostly petroleum exploration companies, in Rio Vista in 1944. Please join us in 2019 as we celebrate this landmark anniversary, and come to as many of our events as you can! We are progressing toward completion of the release ***The Regional Geologic Setting of Mount Diablo*** in a special publication of the GSA.

NCGS member contributions to the publication of this volume are very welcome

Members can simply send a check or online donation to the GSA Foundation and ask that it go to the Publications Fund. In addition to that, they will need to identify the book project. There is a spot in the

online donation system where they can specify details about their donation. If they simply write "Mt. Diablo" the funds will get to where they need to. If sending a check, please write "Pubs Fund Mt. Diablo" on the memo line.

Online Learning with American Geosciences Institute

With many geoscience programs now needing to quickly shift to online teaching, the American Geosciences Institute (AGI) wants to make sure all faculty are aware of the 29 modules in the free-to-take Geoscience Online Learning Initiative (GOLI) platform, which is a joint effort of AGI, AIPG, SEPM, and ASBOG. GOLI courses range in duration from 1 to 10 hours in length, addressing a range of geoscience topics and skills from writing in the geosciences to geoethics to advanced environmental geochemistry, among others. These modules are ready to go and available for your students right now.

GOLI courses are always free-to-take. If a student wishes to earn continuing education credits for successfully completing the course and apply them towards licensing or other professional needs, they have the option to pay a nominal fee. Please visithttps://goli.americangeosciences.org.

If you have any questions regarding GOLI, feel free to email goli@americangeosciences.org.

Currently available GOLI courses, among others:

An Introduction to Professional Writing for Geoscience Careers
Telling your Geoscience Story with Story Maps
Professional Geologist Licensure Requirements and the ASBOG National Geology License Examinations
Fundamentals of Professional Ethics: Elements and Examples
Tracking the Global Supply of Critical Materials
Desalination as a Source of Fresh Water
Techniques for Developing High Resolution LNAPL Conceptual Site Models
Converting Membrane Interface Probe Sensor Results into VOC NAPL Distribution Information

Streetcar 2 Subduction Geological Field Trips Using Google Earth

Streetcar 2 Subduction is a collection of geological field trips that take users to some of the world-class geological sites of the San Francisco Bay Area. In 1979, Clyde Wahrhaftig created a geology tour of the San Francisco Bay Area, which was updated and published by American Geophysical Union(AGU) as "A Streetcar to Subduction and Other Plate Tectonic Trips by Public Transport in San Francisco" in 1984. Forty years later, as part of AGU's Centennial, the "Streetcar" tours have been revised, with new trips added, and old exposures that have vanished removed, taking what once was a print book and turning it into a digital experience through Google Earth.

Streetcar 2 Subduction is designed for anyone to explore the geology of the San Francisco Bay area with their phone or cellular enabled device and the Google Earth App. The experience is modular and can take anyone from a few hours to a few days depending on how many trips and stops they would like to make. Many of the trips are accessible through public transportation, but a few outlying trips are best reached by driving. The trip can also be explored by those at home through their internet browser, at:

https://www.agu.org/learn-and-develop/learn/streetcar2subduction/streetcar2subduction

NCGS Outreach Opportunities

There are no announcements for NCGS outreach this month, but keep an eye on this space, and for emails that may come from Crystal Replogle, our recording secretary. The outreach group had a successful day interfacing with students at last fall's science fair at California State East Bay.

WE HAVE A FACEBOOK GROUP! FIND US ON FACEBOOK @NCGEOLSOC AND TWITTER @NORCALGEOSOC

Check out our updated NCGS Website at http://ncgeolsoc.org/**.** We have posted many older field trip guidebooks for free downloading, and we describe the process for purchasing newer guidebooks. The website includes a list of upcoming meetings, information on our scholarship program, a list of useful web links, and list of NCGS officers.

UC Berkeley Earth & Planetary Science Weekly Seminar Series

Interesting seminars are presented at 141 McCone Hall on Thursdays (usually) at 3:45 pm for most of the academic year, from late August through early May. There are no talks listed for spring 2020, but to monitor progress on this topic and any new listing of

seminars, go to http://eps.berkeley.edu/events/seminars.

NCGS Board Meetings

The next NCGS Board of Directors meeting will likely occur in late August or September, and will be held online as a **Zoom meeting**. Board meetings are open to all NCGS members. Please contact Tom MacKinnon if you'd like to attend, at tom.mackinnon@comcast.net. (Under normal circumstances, Board meetings are generally held on Saturday mornings in January, April/May, and September.)

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. Normally held at Rambo Auditorium, 345 Middlefield Road, Menlo Park, the only current information is that there will be **no evening public lectures through Spring 2020**. For more information on the lectures, and for a map of the location, go to: https://online.wr.usgs.gov/calendar/.

Renewed your membership?

Welcome to a new decade – but now is the time to check your membership status. **Please see page 13** for a blank registration form, and mail it in as indicated, or drop it off with Barbara Matz at the check-in desk at the next meeting.

2023 GSA Cordilleran Section Meeting Coming to Sacramento

John Wakabayashi has informed us that the 2023 GSA Cordilleran Section Meeting will be in Sacramento. John plans to lead a Mt Diablo Field trip for that meeting – his trips are great, so mark your calendars!

Discovery of ancient super-eruptions indicates the Yellowstone hotspot may be waning

ScienceDaily, June 3, 2020
Source: Geological Society of America

Grand Prismatic Spring
Credit: © gottsfam / stock.adobe.com

Throughout Earth's long history, volcanic super-eruptions have been some of the most extreme events ever to affect our planet's rugged surface. Surprisingly, even though these explosions eject enormous volumes of material -- at least 1,000 times more than the 1980 eruption of Mount St. Helens -- and have the potential to alter the planet's climate, relatively few have been documented in the geologic record.

Now, in a study published in Geology, researchers have announced the discovery of two newly identified super-eruptions associated with the Yellowstone hotspot track, including what they believe was the volcanic province's largest and most cataclysmic event. The results indicate the hotspot, which today fuels the famous geysers, mudpots, and fumaroles in Yellowstone National Park, may be waning in intensity.

The team used a combination of techniques, including bulk chemistry, magnetic data, and radio-isotopic dates, to correlate volcanic deposits scattered across tens of thousands of square kilometers. "We discovered that deposits previously believed to belong to multiple, smaller eruptions were in fact colossal sheets of volcanic material from two previously unknown super-eruptions at about 9.0 and 8.7 million years ago," says Thomas Knott, a volcanologist at the University of Leicester and the paper's lead author.

"The younger of the two, the Grey's Landing super-eruption, is now the largest recorded event of the entire Snake-River-Yellowstone volcanic province," says Knott. Based on the most recent collations of super-eruption sizes, he adds, "It is one of the top five eruptions of all time."

The team, which also includes researchers from the British Geological Survey and the University of California, Santa Cruz, estimates the Grey's Landing super-eruption was 30% larger than the previous record-holder (the well-known Huckleberry Ridge Tuff) and had devastating local and global effects. "The Grey's Landing eruption enameled an area the size of New Jersey in searing-hot volcanic glass that instantly sterilized the land surface," says Knott. Anything located within this

region, he says, would have been buried and most likely vaporized during the eruption. "Particulates would have choked the stratosphere," adds Knott, "raining fine ash over the entire United States and gradually encompassing the globe."

Several similar deposits may coexist in a succession, presenting a challenge to distinguish and correlate individual deposits. Successions of similar-looking ignimbrites occur along the track of the Yellowstone hotspot throughout southern Idaho, so the researchers developed a robust approach to distinguish and regionally correlate individual units by combining trace element and mineral chemistry (lead ages in zircon), paleomagnetic data, and detailed field characterization. Critically, any one correlation technique proved insufficient in isolation.

Both of the newly discovered super-eruptions occurred during the Miocene, the interval of geologic time spanning 23-5.3 million years ago. "These two new eruptions bring the total number of recorded Miocene super-eruptions at the Yellowstone-Snake River volcanic province to six," says Knott. Within a single cluster, super-eruption recurrence rates were on the order of ~300–500 k.y. This means that the recurrence rate of Yellowstone hotspot super-eruptions during the Miocene was, on average, once every 500,000 years.

By comparison, Knott says, two super-eruptions have -- so far -- taken place in what is now Yellowstone National Park during the past three million years. "It therefore seems that the Yellowstone hotspot has experienced a three-fold decrease in its capacity to produce super-eruption events," says Knott. "This is a very significant decline."

These findings, says Knott, have little bearing on assessing the risk of another super-eruption occurring today in Yellowstone. "We have demonstrated that the recurrence rate of Yellowstone super-eruptions appears to be once every 1.5 million years," he says. "The last super-eruption there was 630,000 years ago, suggesting we may have up to 900,000 years before another eruption of this scale occurs." But this estimate, Knott hastens to add, is far from exact, and he emphasizes that continuous monitoring in the region, which is being conducted by the U.S. Geological Survey, "is a must" and that warnings of any uptick in activity would be issued well in advance.

This study, which builds on decades of contributions by many other researchers, grew out of a larger project investigating the productivity of major continental volcanic provinces. Those with super-eruptions are the result of colossal degrees of crustal melting over prolonged periods of time, says Knott, and therefore have a profound impact on the structure and composition of Earth's crust in the regions where they occur.

Because studying these provinces is vital to understanding their role in shaping our planet's crustal processes, Knott hopes this research foreshadows even more revelations. "We hope the methods and findings we present in our paper will enable the discovery of more new super-eruption records around the globe," he says.

Journal Reference: Robert S. Coe, Simon Tapster, David R. Finn, Marc K. Reichow, Michael J. Branney, Thomas R. Knott. Discovery of two new super-eruptions from the Yellowstone hotspot track (USA): Is the Yellowstone hotspot waning? *Geology*, 2020; DOI: 10.1130/G47384.1.

Long Limbs Helped Propel T. Rex Up the Dinosaur Food Chain

The apex predator wasn't a quick runner because of its heft, but its lanky limbs ensured it could amble efficiently for hours.

Source: New York Times, May 23, 2020

By Katherine Kornei

T. rex, expert power-walker.
Credit...George Etheredge for The New York Times

Surviving in the Cretaceous wasn't a sprint, it was a marathon. And Tyrannosaurus rex was built to amble for hours, new research reveals. That attribute might have helped propel the carnivore to the top of the food chain, researchers suggest.

A study published earlier this month in PLOS One showed that some dinosaurs were particularly efficient walkers because of their long hind limbs. Thanks to their lanky legs, T. rex didn't need to eat as much as its brethren, and could therefore get away with hunting less frequently, the team concluded.

To understand the biomechanics of long-extinct animals, scientists rely on fossilized bones and footprints. These records reveal information about a creature's bone and muscle structure and its stride, all of which affect its ability to run. But identifying who is fleet of foot solely from imprints or a pile of bones is challenging. In 1976, Robert McNeill Alexander, a British zoologist, proposed that a dinosaur's maximum running speed depended on its stride length and hip height. But that idea has been revised over time.

"Once you get to big animals, limb length doesn't really dictate speed," said John Hutchinson, a biologist at the Royal Veterinary College in London who was not involved in the research. In recent years, scientists have realized that long legs will only get you so far — body mass also plays a role. Elephants tower above thoroughbreds, but there's a reason the Kentucky Derby is run with horses.

"Physics won't let you go any faster" once you get too heavy, said Alexander Dececchi, a paleontologist at Mount Marty College in South Dakota. "Your muscles can't get you to accelerate fast enough."

To more accurately estimate dinosaur running speeds, Dr. Dececchi and his colleagues amassed measurements of hind limbs and published body mass estimates for 34 dinosaur specimens. For each of the specimens — ranging from a tiny Archaeopteryx, a birdlike creature weighing half a pound, to a 20,000-pound T. rex — Dr. Dececchi and his collaborators compared calculations of running speed.

A comparison of the hindlimbs of small therapods, top, and large therapods, bottom.

Credit...Dr. Thomas Richard Holz, adapted from silhouettes from Phylopic.org

The researchers determined that dinosaurs weighing less than a few hundred pounds were actually faster according to the calculations that used their body mass compared with the calculations that didn't. In other words, smaller dinosaurs weren't slowed by their heft.

But the situation changed for animals larger than about 2,000 pounds — those dinosaurs moved considerably slower, according to the equations that included their mass compared with those that just included stride length and hip height. For behemoths like Tyrannosaurus, that difference was significant: 18 miles per hour versus 45 miles per hour.

That schism left Dr. Dececchi and his colleagues wondering about the evolutionary advantage of lanky limbs for a massive dinosaur. "Their legs are longer than would help them for speed," Dr. Dececchi said. Maybe those limbs allowed the animals to amble more efficiently, the team hypothesized. Dinosaurs like Tyrannosaurus walked about 10 miles per day, previous research has suggested.

Dr. Dececchi and his collaborators analyzed groups of dinosaurs with very similar masses but different leg lengths. For each animal, they estimated how much energy it would expend to move at a slow walk. They found that Tyrannosaurus used between 1 and 35 percent less energy than other related dinosaurs.

"That potentially gave them a big advantage," said Eric Snively, a biologist at Oklahoma State University who was not involved in the research. "The amount of energy you use in a day will dictate how much food you have to eat."

A Tyrannosaurus could get away with eating several hundred fewer pounds of meat each year than its brethren, Dr. Dececchi and his colleagues calculated. (That's about one Ornithomimus, a beaked dinosaur that resembled a large ostrich.) Because the carnivores typically hunted in packs, that savings added up to tons less meat that needed to be hunted. Less frequent hunting no doubt helped preserve the animals' health.

"Every hunt runs a risk of injury," Dr. Dececchi said. Staving off bodily harm might have helped ensure the evolutionary success of Tyrannosaurus, he said.

"It may have been one of the traits that allowed them to become so successful."

Earth's Tectonic Plates Could Be 1 Billion Years Older Than We Thought

Source: ScienceAlert
Date Published: 29 May 2020

By David Nield

© NASA images by Reto Stöckli, based on data from NASA and NOAA

Scientists are constantly learning more about the tectonic plates shifting across our planet's surface. According to new research, it turns out those plates have been around on Earth for longer than we originally thought – about a billion years longer, in fact.

These giant slabs of rock sit in the Earth's crust just above the mantle, and we can see the results of their shifting and crunching all around us, from the formation of mountain ranges to earthquakes and volcanic activity.

The new study is based on new geochemical models of the early Earth that use the element argon (Ar) as a measure. As argon is too heavy to leave our atmosphere, we can use it as a way of peering back in time through the planet's history.

In this study, the authors present a new model of coupled crust-mantle-atmosphere evolution to constrain the growth of continental crust with atmospheric $^{40}Ar/^{36}Ar$. Argon-40 is radiogenic, derived from the decay of potassium-40 in the Earth's crust. Argon gas is released as part of continental growth caused by subduction (one plate pushing down on another), a key indicator of tectonic plate activity. As argon accumulates, it can be tracked back to the radioactive decay of potassium in the planet's crust and mantle, and then to tectonic movement.

The model is the first to combine argon degassing with the thermal evolution of Earth in a self-consistent manner and to incorporate the effect of crustal recycling and reworking using the distributions of crustal formation and surface ages.

The study's results suggest that the history of argon degassing favors rapid crustal growth during the early Earth. The mass of continental crust, highly enriched in potassium, is estimated to have already reached >80% of the present-day level during the early Archean. The presence of such potassium-rich, likely felsic, crust has important implications for tectonics, surface environment, and the regime of mantle convection in the early Earth.

"Our model is the first to investigate the full effects of crustal evolution, including both crustal recycling and reworking, on the degassing history of Earth," write the researchers in their paper.

Accounting for that crustal recycling (where crust gets eroded then carried back underground) as well as the creation of new continental crust was one of the key considerations for the researchers. Their model suggests the tectonic plate network was in place more than 4.4 billion years ago, way beyond most previous estimates.

Assessing the geological history of Earth is a tricky business though. We're not exactly sure what's happening in terms of tectonic activity today, let alone billions of years ago, but the argon measurements could be our best bet yet for dating tectonic plate movement.

"Because of the peculiar characteristics of argon, we can deduce what has happened to the solid Earth by studying this atmospheric argon," says planetary scientist Jun Korenaga, from Yale University. "This makes it an excellent bookkeeper of ancient events."

It's not the only piece of evidence that's come to light recently that tectonic plates have been in place longer than 3 billion years or so, which is the current understanding. Studies of magnetism in ancient rocks in Australia and South Africa have already been pushing the date back by a few hundred million years.

Peering back through time like this is an important way of figuring out just how life on our planet got started. The shift from molten, flowing rock to hard crust is a crucial one not just for the study of the early Earth but for early lifeforms too.

As the researchers behind the latest study note, we still don't have a definitive answer as to when this shift to tectonic plates happened – but the suggestion that they're much, much older than we thought is undoubtedly worthy of further investigation, no matter how challenging it is.

"Understanding when plate tectonics started on Earth has long been a fundamentally difficult problem," says Korenaga. "As we go back deeper in time, we have fewer geological records."

The research has been published in *Science Advances*.

New ancient plant captures snapshot of evolution

ScienceDaily, May 4, 2020
Source: Stanford's School of Earth, Energy & Environmental Sciences

In a brilliant dance, a cornucopia of flowers, pinecones and acorns connected by wind, rain, insects and animals ensure the reproductive future of seed plants. But before plants achieved these elaborate specializations for sex, they went through millions of years of evolution. Now, researchers have captured a glimpse of that evolutionary process with the discovery of a new ancient plant species.

The fossilized specimen likely belongs to the herbaceous barinophytes, an unusual extinct group of plants that may be related to clubmosses, and is one of the most comprehensive examples of a seemingly intermediate stage of plant reproductive biology. The

new species, which is about 400 million years old and from the Early Devonian period, produced a spectrum of spore sizes -- a precursor to the specialized strategies of land plants that span the world's habitats. The research was published in *Current Biology* on May 4.

"Usually when we see heterosporous plants appear in the fossil record, they just sort of pop into existence," said the study's senior author, Andrew Leslie, an assistant professor of geological sciences at Stanford's School of Earth, Energy & Environmental Sciences (Stanford Earth). "We think this may be kind of a snapshot of this very rarely witnessed transition period in evolutionary history where you see high variation amongst spores in the reproductive structure."

A major shift

One of the most important time periods for the evolution of land plants, the Devonian witnessed diversification from small mosses to towering complex forests. The development of different spore sizes, or heterospory, represents a major modification to control reproduction -- a feature that later evolved into small and large versions of these reproductive units.

"Think of all the different types of sexual systems that are in flowers -- all of that is predicated on having separate small spores, or pollen, and big spores, which are inside the seeds," Leslie said. "With two discrete size classes, it's a more efficient way of packaging resources because the big spores can't move as easily as the little ones, but can better nourish offspring."

The earliest plants, from between 475 million to 400 million years ago, lacked reproductive specialization in the sense that they made the same types of spores, which would then grow into little plantlets that actually transferred reproductive cells. By partitioning reproductive resources, plants assumed more control over reproduction, according to the researchers.

The new species, together with the previously described plant group Chaleuria of the same age, represents the first evidence of more advanced reproductive biology in land plants. The next example doesn't appear in the fossil record until about 20 million years later.

"These kinds of fossils help us locate when and how exactly plants achieved that kind of partitioning of their reproductive resources," Leslie said. "The very end of that evolutionary history of specialization is something like a flower."

A fortuitous find

The researchers began analyses of the fossils after they had been stored in the collections at the Smithsonian National Museum of Natural History for decades. From about 30 small chips of rock originally excavated from the Campbellton Formation of New Brunswick in Canada by late paleobotanist and study co-author Francis Hueber, they identified more than 80 reproductive structures, or sporangia. The spores themselves range from about 70 to 200 microns in diameter -- about a strand to two strands of hair. While some of the structures contained exclusively large or small spores, others held only intermediate-sized spores and others held the entire range of spore sizes -- possibly with some producing sperm and others eggs.

"It's rare to get this many sporangia with well-preserved spores that you can measure," Leslie said. "We just kind of got lucky in how they were preserved."

Fossil and modern heterosporous plants primarily live in wetland environments, such as floodplains and swamps, where fertilization of large spores is most effective. The ancient species, which will be formally described in a follow-up paper, has a medley of spores that is not like anything living today, Leslie said.

"The overarching story in land plant reproduction is one of increased division of labor and specialization and complexity, but that has to begin somewhere -- and it began with simply producing small spores and big spores," Leslie said. "With these kinds of fossils, we can identify some ways the plants were able to do that."

Co-authors of the study are from Brown University, the University of North Carolina -- Chapel Hill and the University of Sheffield.

Journal Reference: Nikole K. Bonacorsi, Patricia G. Gensel, Francis M. Hueber, Charles H. Wellman, Andrew B. Leslie. A novel reproductive strategy in an Early Devonian plant. *Current Biology*, 2020; 30 (9): R388 DOI: 10.1016/j.cub.2020.03.040.

New study reveals cracks beneath giant, methane gushing craters

ScienceDaily, June 4, 2020
Source: CAGE - Center for Arctic Gas Hydrate, Climate and Environment

A paper published in Science in 2017 described hundreds of massive, kilometer -wide, craters on the ocean floor in the Barents Sea. Today more than 600 gas flares are identified in and around these craters, releasing the

greenhouse gas steadily into the water column. Another study, published the same year in PNAS, mapped several methane mounds, some 500m wide, in the Barents Sea. The mounds were considered to be signs of soon-to-happen methane expulsions that have created the said craters.

The most recent study in Scientific Reports looks into the depths far beneath these craters in the ocean floor and reveals the geological structures that have made the area prone to crater formation and subsequent methane expulsions.

"It turns out that this area has a very old fault system -- essentially cracks in bedrock that likely formed 250 million years ago. Craters and mounds appear along different fault structures in this system. These structures control the size, placement, and shape of the craters. The methane that is leaking through the seafloor originates from these deep structures and is coming up through these cracks." according to Malin Waage, a postdoc at CAGE, Centre for Arctic Gas Hydrate, Environment and Climate, and the first author of the study

Cutting edge 3D seismic technology

The deep origin of craters and mounds was discovered using cutting edge 3D seismic technology which can penetrate deep into the ocean floor, and help scientists visualize the structures in the hard bedrock underneath.

"Our previous studies in the area hypothesized that climate warming and the retreat of the ice sheet some 20,000 years ago, caused the gas hydrates beneath the ice to melt leading to abrupt methane release and creating craters."

Gas hydrates are a solid form of methane, among others, that is stable in cold temperatures and under pressure, which an enormous ice sheet provides. As the ocean warmed up, and the pressure of the ice sheet lifted, the methane ice in the seafloor melted and thus the craters were formed.

"This study, however, ads several layers to that picture, as we now see that there has been a structural weakness beneath these giant craters, for much longer than the last 20,000 years. Deep below the seafloor, the expansion of gas and release of water build up a muddy slurry which eventually erupted through the fractures and caused seafloor collapses and craters in the hard bedrock. Think of it as a building: A roof of a building can cave in if the ground structure is weak. We believe that this is what happened in the crater area after the last glaciation." says Waage.

The Barents Sea is poorly understood

The exploration of petroleum resources in the Barents Sea is a hot topic in Norway and beyond as the area is a part of a vulnerable Arctic ecosystem. But the area's geological system is poorly understood.

"Our 3D survey covered approximately 20 percent of the entire crater area. We believe that it is important to understand if similar fault systems exist in the larger context of the Barents Sea because they potentially could pose a threat to marine operations."

Some of the questions that scientists, society and the industry does not know the answer to are: Will these weak structures lead to unpredictable and explosive methane release? Can such release and related geohazards be triggered by drilling? And can the gas reach the atmosphere in case of abrupt blow-outs, adding to the greenhouse gas budget

"There is still very much that we don't know about this system. But we are currently collecting and analyzing new data in the Barents Sea, dominated by similar crater structures. This can help us map in bigger detail the fault systems and associated weakness. " says Waage.

Journal Reference: Malin Waage, Pavel Serov, Karin Andreassen, Kate A. Waghorn, Stefan Bünz. Geological controls of giant crater development on the Arctic seafloor. *Scientific Reports*, 2020; 10 (1) DOI: 10.1038/s41598-020-65018-9.

Today's atmospheric carbon dioxide levels greater than 23 million-year record

ScienceDaily, June 1, 2020
Source: Geological Society of America

A common message in use to convey the seriousness of climate change to the public is: "Carbon dioxide levels are higher today than they have been for the past one million years!" This new study by Brian Schubert (University of Louisiana at Lafayette) and coauthors Ying Cui and A. Hope Jahren used a novel method to conclude that today's carbon dioxide (CO_2) levels are actually higher than they have been for the past 23 million years.

The team used the fossilized remains of ancient plant tissues to produce a new record of atmospheric CO_2 that spans 23 million years of uninterrupted Earth history. They have shown elsewhere that as plants grow, the relative amount of the two stable isotopes of carbon, carbon-12 and carbon-13 changes in response to the amount of CO_2 in the atmosphere. This research, published this week in Geology, is a next-level study measuring the relative amount of these carbon isotopes in fossil plant materials and calculating the CO_2

concentration of the atmosphere under which the ancient plants grew.

Furthermore, Schubert and colleagues' new CO_2 "timeline" revealed no evidence for any fluctuations in CO_2 that might be comparable to the dramatic CO_2 increase of the present day, which suggests today's abrupt greenhouse disruption is unique across recent geologic history.

Another point, important to geological readers, is that because major evolutionary changes over the past 23 million years were not accompanied by large changes in CO_2, perhaps ecosystems and temperature might be more sensitive to smaller changes in CO_2 than previously thought. As an example: The substantial global warmth of the middle Pliocene (5 to 3 million years ago) and middle Miocene (17 to 15 million years ago), which are sometimes studied as a comparison for current global warming, were associated with only modest increases in CO_2.

Journal Reference: A. Hope Jahren, Brian A. Schubert, Ying Cui. A 23 m.y. record of low atmospheric CO_2. *Geology*, 2020; DOI: 10.1130/G47681.1.

World's oldest bug is fossil millipede from Scotland

ScienceDaily, May 28, 2020
Source: University of Texas at Austin

A 425-million-year-old millipede fossil from the Scottish island of Kerrera is the world's oldest "bug" -- older than any known fossil of an insect, arachnid or other related creepy-crawly, according to researchers at The University of Texas at Austin.

The findings offer new evidence about the origin and evolution of bugs and plants, suggesting that they evolved much more rapidly than some scientists believe, going from lake-hugging communities to complex forest ecosystems in just 40 million years.

"It's a big jump from these tiny guys to very complex forest communities, and in the scheme of things, it didn't take that long," said Michael Brookfield, a research associate at UT Austin's Jackson School of Geosciences and adjunct professor at the University of Massachusetts Boston. "It seems to be a rapid radiation of evolution from these mountain valleys, down to the lowlands, and then worldwide after that."

The research was recently published in the journal Historical Biology. Brookfield led the study with co-authors including Elizabeth Catlos, an associate professor in the Jackson School's Department of Geological Sciences, and Stephanie Suarez, a doctoral student at the University of Houston who made improvements to the fossil dating technique used in the study when she was an undergraduate at the Jackson School.

The team found that the ancient millipede fossil is 425 million years old, or about 75 million years younger than the age other scientists have estimated the oldest millipede to be using a technique known as molecular clock dating, which is based on DNA's mutation rate. Other research using fossil dating found that the oldest fossil of a land-dwelling, stemmed plant (also from Scotland) is 425 million years old and 75 million years younger than molecular clock estimates.

Although it's certainly possible there are older fossils of both bugs and plants, Brookfield said that the fact they haven't been found -- even in deposits known for preserving delicate fossils from this era -- could indicate that the ancient millipede and plant fossils that have already been discovered are the oldest specimens.

If that's the case, it also means both bugs and plants evolved much more rapidly than the timeline indicated by the molecular clock. Bountiful bug deposits have been dated to just 20 million years later than the fossils. And by 40 million years later, there's evidence of thriving forest communities filled with spiders, insects and tall trees.

"Who is right, us or them?" Catlos said. "We're setting up testable hypotheses -- and this is where we are at in the research right now."

Given their potential evolutionary significance, Brookfield said that he was surprised that this study was the first to address the age of the ancient millipedes.

Suarez said a reason could be the difficulty of extracting zircons -- a microscopic mineral needed to precisely date the fossils -- from the ashy rock sediment in which the fossil was preserved. As an undergraduate researcher at the Jackson School, Suarez developed a technique for separating the zircon grain from this type of sediment. It's a process that takes practice to master. The zircons are easily flushed away when trying to loosen their grip on the sediment. And once they are successfully released from the surrounding rock, retrieving the zircons involves an eagle-eyed hunt with a pin glued to the tip of a pencil.

"That kind of work trained me for the work that I do here in Houston," Suarez said. "It's delicate work."

As an undergraduate, Suarez used the technique to find that a different millipede specimen, thought to be the oldest bug specimen at the time, was about 14 million years younger than estimated -- a discovery that stripped

it of the title of oldest bug. Using the same technique, this study passes the distinction along to a new specimen.

The research was funded by the Jackson School, the Max Kade Foundation and DFG Scientific Instrumentation and Information Technology.

Journal Reference: M. E. Brookfield, E. J. Catlos, S. E. Suarez. Myriapod divergence times differ between molecular clock and fossil evidence: U/Pb zircon ages of the earliest fossil millipede-bearing sediments and their significance. *Historical Biology*, 2020; 1 DOI: 10.1080/08912963.2020.1761351.

Erosion of ozone layer responsible for mass extinction event

ScienceDaily, May 27, 2020
Source: University of Southampton

Researchers at the University of Southampton have shown that an extinction event 360 million years ago, that killed much of the Earth's plant and freshwater aquatic life, was caused by a brief breakdown of the ozone layer that shields the Earth from damaging ultraviolet (UV) radiation. This is a newly discovered extinction mechanism with profound implications for our warming world today.

There have been a number of mass extinctions in the geological past. Only one was caused by an asteroid hitting the Earth, which was 66 million years ago when the dinosaurs became extinct. Three of the others, including the end Permian Great Dying, 252 million years ago, were caused by huge continental scale volcanic eruptions that destabilized the Earth's atmospheres and oceans.

Now, scientists have found evidence showing it was high levels of UV radiation which collapsed forest ecosystems and killed off many species of fish and tetrapods (our four limbed ancestors) at the end of the Devonian geological period, 359 million years ago. This damaging burst of UV radiation occurred as part of one of the Earth's climate cycles, rather than being caused by a huge volcanic eruption.

The ozone collapse occurred as the climate rapidly warmed following an intense ice age and the researchers suggest that the Earth today could reach comparable temperatures, possibly triggering a similar event. Their findings are published in the journal Science Advances.

The team collected rock samples during expeditions to mountainous polar regions in East Greenland, which once formed a huge ancient lake bed in the arid interior of the Old Red Sandstone Continent, made up of Europe and North America. This lake was situated in the Earth's southern hemisphere and would have been similar in nature to modern day Lake Chad on the edge of the Sahara Desert.

Other rocks were collected from the Andean Mountains above Lake Titicaca in Bolivia. These South American samples were from the southern continent of Gondwana, which was closer to the Devonian South Pole. They held clues as to what was happening at the edge of the melting Devonian ice sheet, allowing a comparison between the extinction event close to the pole and close to the equator.

Back in the lab, the rocks were dissolved in hydrofluoric acid, releasing microscopic plant spores (like pollen, but from fern like plants that didn't have seeds or flowers) which had lain preserved for hundreds of millions of years. On microscopic examination, the scientists found many of the spores had bizarrely formed spines on their surface -- a response to UV radiation damaging their DNA. Also, many spores had dark pigmented walls, thought to be a kind of protective 'tan', due to increased and damaging UV levels.

The scientists concluded that, during a time of rapid global warming, the ozone layer collapsed for a short period, exposing life on Earth to harmful levels of UV radiation and triggering a mass extinction event on land and in shallow water at the Devonian-Carboniferous boundary.

Following melting of the ice sheets, the climate was very warm, with the increased heat above continents pushing more naturally generated ozone destroying chemicals into the upper atmosphere. This let in high levels of UV-B radiation for several thousand years.

Lead researcher Professor John Marshall, of the University of Southampton's School of Ocean and Earth Science, who is a National Geographic Explorer, comments: "Our ozone shield vanished for a short time in this ancient period, coinciding with a brief and quick warming of the Earth. Our ozone layer is naturally in a state of flux -- constantly being created and lost -- and we have shown this happened in the past too, without a catalyst such as a continental scale volcanic eruption."

During the extinction, plants selectively survived, but were enormously disrupted as the forest ecosystem collapsed. The dominant group of armored fish became extinct. Those that survived -- sharks and bony fish -- remain to this day the dominant fish in our ecosystems.

These extinctions came at a key time for the evolution of our own ancestors, the tetrapods. These early tetrapods are fish that evolved to have limbs rather than fins, but still mostly lived in water. Their limbs possessed many fingers and toes. The extinction reset the direction of their evolution with the post-extinction survivors being

terrestrial and with the number of fingers and toes reduced to five.

Professor Marshall says his team's findings have startling implications for life on Earth today: "Current estimates suggest we will reach similar global temperatures to those of 360 million years ago, with the possibility that a similar collapse of the ozone layer could occur again, exposing surface and shallow sea life to deadly radiation. This would move us from the current state of climate change, to a climate emergency."

The remote locations visited in East Greenland are very difficult to access, with travel involving light aircraft capable of landing directly on the tundra. Transport within the vast field area was by inflatable boats equipped with outboard motors, all of which had to fit in the small aircraft.

All field logistics was organized by CASP, an independent charitable trust based in Cambridge specializing in remote geological fieldwork. Mike Curtis, Managing Director of CASP says: "We have a history of assisting research geologists such as John Marshall and colleagues to access remote field areas and we are particularly pleased that their research has proved to have such potentially profound implications."

Journal Reference: John E. A. Marshall, Jon Lakin, Ian Troth, Sarah M. Wallace-Johnson. UV-B radiation was the Devonian-Carboniferous boundary terrestrial extinction kill mechanism. *Science Advances*, 2020; 6 (22): eaba0768 DOI: 10.1126/sciadv.aba0768.

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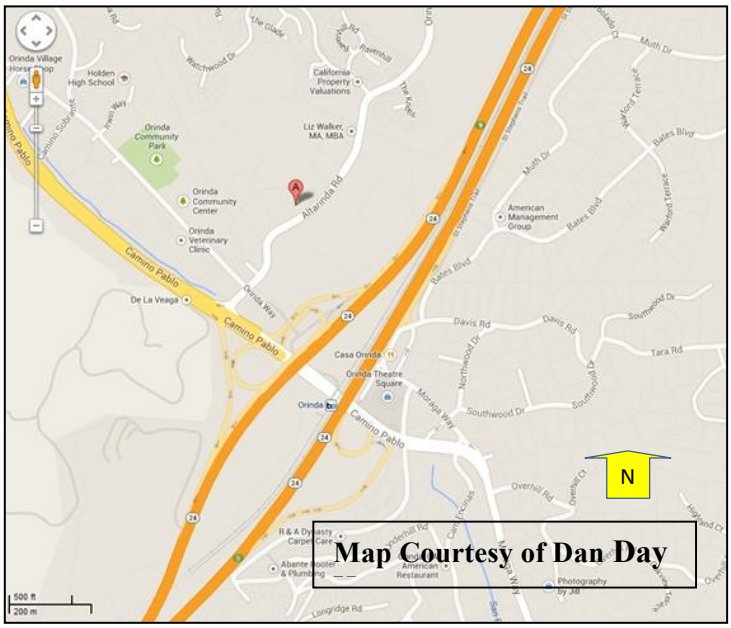

Map Courtesy of Dan Day

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