NORTHERN CALIFORNIA GEOLOGICAL SOCIETY

Website: https://ncgeolsoc.org

MEETING ANNOUNCEMENT

DATE: **Wednesday, February 28, 2024**

LOCATION: **Orinda Masonic Hall**

TIME: **Social time: 6:30 to 7:15 pm; Program: 7:15 to 8:30 pm**

SPEAKER: ***Chris Bonds, California Department of Water Resources (DWR)***

TOPIC: ***"The California Aqueduct Subsidence Program (CASP)"***

Abstract:

The California State Water Project (SWP) consists of over 700 miles of aqueducts/canals, pipelines, and waterways, 21 dams, and 8 main power generating facilities that serve over 27 million people and irrigates over 750,000 acres of farmland and also provides flood control, power generation, recreation, and environmental stewardship functions.

Subsidence, or the sinking of land, has been documented throughout California for almost a century. Prior to the construction of the CA Aqueduct in the mid-1960s, portions of land nearby dropped between 20 and 30 feet. While rates of subsidence stabilized for a few decades after original construction, the CA Aqueduct has sustained an alarming and unprecedented increase in subsidence rates. In the three years of the drought from 2013 through 2016, areas of the CA Aqueduct sunk nearly three feet.

The CA Aqueduct is divided up into pools, which are roughly 10 miles long in the Central Valley. Each pool has an elevation fall of 2 to 4 feet, which is used to move the water. Changes to this profile, through subsidence, have caused decreases in the flow capacity of the system, as well as operational difficulties.

Groundwater pumping has long been understood as a primary cause of this alarming subsidence trend, which typically ramps up during drought periods. The effects of climate change are predicted to exacerbate this trend. In addition, the recent conversion of row crops (often fallowed in dry years) to orchards and vineyards (not fallowed in dry years) has resulted in more subsidence when surface water is unavailable during dry periods.

The impacts of subsidence on the CA Aqueduct are many, including increased water delivery costs, decreased reliability, and increased operations and maintenance.

The California Aqueduct Subsidence Program (CASP) is a significant DWR-SWP effort underway to help improve the resiliency of CA's

 (continued on last page)

NCGS 2023 – 2024 Calendar

March 27, 2024 7:15 pm (6:30 social hour)
Jessica Murray, U.S. Geological Survey
Inclusion of real-time Global Navigation Satellite System-based earthquake source characterization in the ShakeAlert earthquake early warning system to improve estimates of anticipated ground shaking and the alerts derived from them

April 24, 2024 7:15 pm (6:30 social hour)
Nicholas Swanson-Hysell, UC Berkeley
Chronostratigraphy of Miocene strata in the Berkeley Hills and the arrival of the San Andreas transform boundary

May 29, 2024 7:15 pm (6:30 social hour)
(Dinner meeting)
Libby Ives, Jet Propulsion Laboratory (NASA/Caltech)
Sedimentary geology of the Jezero crater western fan as seen by NASA's Mars Perseverance rover

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

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.

Invitation For New Officer Appointment

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

(1) The **Recording Secretary** shall attend and take notes at all Executive Committee board meetings (typically three times per year) and shall notify the members of proposed amendments to the Constitution and Bylaws.

(2) When any other membership-wide communication is required, assist other officers in sending out email and occasional postal communications. Note: Since NCGS has moved to a new web-based system for emails, sign-ups, and payments (RegFox), this will chiefly be a consulting role to help others such as the President, Newsletter Editor, Treasurer, Membership Chair, Program Chair, or Field Trip Chair, all of whom will be trained on sending out such messages directly.

(3) Maintain Google drive folders and access for our archive of past information.

(4) Maintain hard cc files (as backup) only for critical Society records.

(5) Serve as alternate check signer when neither Treasurer nor President is available.

Website News

From Andrew Alden, NCGS Website Manager/Social Media

Now that the website renovation is done, I'm starting to think about writing up some of our old field trips in my spare time. For instance, there's our memorable jaunt to Lake Tahoe in June 2011. Between the field-trip guide, my memories and my photos, I could have it done in . . . a while, let's say.

One easy thing I've done is to add photos to existing field-trip reports. The report on our memorable trip to the Coso geothermal area in March of 2008, for instance, was handicapped by military security restrictions, but I had pictures to add from outside the restricted area. See the upgraded report at https://ncgeolsoc.org/coso-geothermal-system/.

The next time you look over your own stash of field-trip photos, consider taking on a similar project. The joys and memories of field trips are a major reason why people join our society. And the next time you sort through your own stash of field-trip guides, check and see if it's already up on the website (https://ncgeolsoc.org/past-field-trips/). If not, we can digitize it for posterity!

K-12 GEOSCIENCE TEACHER OF THE YEAR AWARD FOR 2024 – $1,000

The Northern California Geological Society (NCGS) invites applications from candidates in Northern California for the 2024 K-12 Geoscience Teacher of the Year Award. Applications may be submitted by any K-12 teacher.

Applications should address teaching of units covering any of the earth or environmental sciences, including but not limited to mineralogy, petrology, economic geology, geomorphology, paleontology, hydrology, and planetary geology and are invited from physical science, earth science, and geology teachers.

The deadline for application submittal is **Saturday, March 2, 2024.**

The winner will receive a $1,000 award at a Northern California Geological Society dinner meeting in Orinda in late May 2024. Also, the awardee will be entered in the Pacific Section of the AAPG's competition, which has further benefits, and the winner of that award may subsequently be entered in the AAPG's national competition, which has substantial benefits. To apply, complete the application form, which is available on our website along with other relevant information:

https://ncgeolsoc.org/awards/

For any questions, contact Dr. Paul Henshaw at (925) 212-0402, or drphenshaw@comcast.net

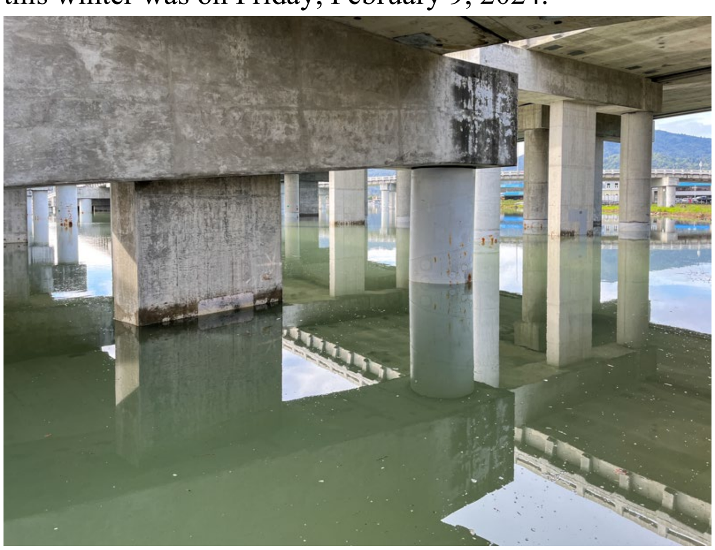
NCGS Photo of the Month

Photographing the King Tide near the Larkspur Ferry Terminal

by John Karachewski

The California Coastal Commission hosts the California King Tides Project. The following information is briefly summarized from the above website. While "King Tide" isn't a scientific term, it is used to describe the highest high tides of the year—one to two feet higher than average high tides. King Tides themselves are not related to climate change, but they allow us to experience and visualize what higher sea levels will be like over the next few decades. When you observe the King Tides, imagine seeing these tides (and the associated flooded streets, beaches, and wetlands) every day. Understanding what a King Tide looks like today will help us plan for future sea level rise.

On Friday, January 12, 2024, I took the following King Tide photos within a mile or two walk of the Larkspur Ferry Terminal in Marin County. The last King Tide for this winter was on Friday, February 9, 2024.



Above: Concrete reflections along the San Francisco Bay Trail near the Highway 101 and Sir Francis Drake interchanges. (GPS coordinates: 37.944003° -122.514603°)

Flooded benches along Corte Madera Creek with Mount Tamalpais in background. (GPS coordinates: 37.942211° -122.521317°)

Loss of a Dear Colleague

NCGS sends its condolences and deep appreciation to his wife Barbara and his family for the passing of our departed friend, colleague, and respected leader for many years, Dr. Ray Sullivan, on Saturday, January 13, 2024. An obituary will appear in a future newsletter.

The Northern California Geological Society's

RICHARD CHAMBERS MEMORIAL SCHOLARSHIPS

2023-2024 AWARDS

The NCGS is pleased to announce that it is awarding $2,000 scholarships to two graduate students pursuing research in northern California. The availability of the Richard Chambers Memorial Scholarship is announced to all Colleges and Universities having graduate programs in northern California. These scholarships are funded from the Richard Chambers Memorial Scholarship fund and donations made by NCGS members and others for scholarships. These two students were chosen from a collection of well-prepared applications made to the NCGS during the fall of 2023. Serving on the NCGS Scholarship Committee were Phillip Garbutt (chair), Andrew Alden, Don Medwedeff, Noelle Schoellkopf and Will Schweller.

The recipients are:

Eden Pikowski, CSU Chico, for a master's research proposal titled ***"Paleoecology of the hydrocarbon seeps***

of Blue Ridge, Colusa, County, CA". Project advisor is Dr. Robert Shapiro.

Evelyn H. Usher, for a master's degree research proposal titled: ***"Transition from Walker Lane deformation to Cascade Range faulting and volcanism within Lassen National Park".*** Project advisor is Dr. Michael Oskin.

UC Berkeley Earth & Planetary Science Weekly Seminar Series

In-person EPS Seminar talks have resumed for the semester and are scheduled through the academic year. On Thursday, February 29, 2024 at 3:45 pm, Junlin Hua, UT Austin will speak on ***The lithosphere-asthenosphere system and its interaction with the deep mantle*** 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 are scheduled through June. On February 29 at 6:00 PM, Dr. Sara McBride will speak on ***Using Communication Science to Communicate USGS Science.*** Check the website to join the live stream, at: www.usgs.gov/pls/. To be added to the email notification list for future USGS Public Lecture Series events, please email: wmcesic@usgs.gov.

2023-2024 NCGS Registration and Dues

A 21st Century Innovation Takes Hold

Following a successful pilot for 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. Upcoming meeting: **Saturday, May 18, 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.

Trilobites

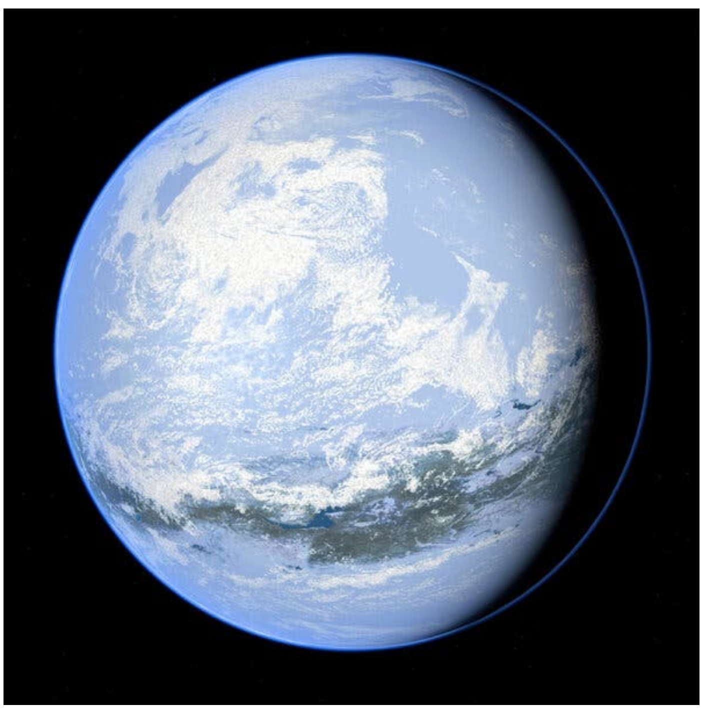
How Earth Might Have Turned into a Snowball

A team of scientists thinks the planet may have been thrust into its longest ice age because less gas leaked out of volcanoes.

New York Times - February 7, 2024
by Katrina Miller

Around 717 million years ago, Earth's humid landscapes and roiling blue waters transformed into a frigid, barren world. Scientists nicknamed this stage of geological history, and others like it, Snowball Earth.

What exactly froze the planet nearly solid has been a mystery, as has how it remained that way for 56 million years. On Wednesday, a team of researchers at the University of Sydney said they have it figured out. Earth's glaciation, they say, may have come from a global drop in carbon dioxide emissions, a result of fewer volcanoes expelling the gas into the atmosphere.



An artistic depiction of planet Earth mostly covered in snow with a slice of green peeking through in one area, during one of the planet's most severe ice ages. Credit...Simon Terrey/Science Source

Less carbon dioxide makes it more difficult for Earth's atmosphere to trap heat. If the depletion were extreme enough, they argued, it could have thrust the planet into its longest ice age yet.

The theory, published in the journal *Geology*, adds insight to the way geological processes influenced Earth's past climate. It may also help scientists better understand trends in our current climate.

"These days, of course, humans are having a large impact on CO_2 in the atmosphere," said Adriana Dutkiewicz, a sedimentologist at the University of Sydney who led the study. "But back in time, there were no humans, and so everything was basically modulated by geological processes."

There are many ideas about what turned Earth into a snowball. One popular theory suggests that minerals released by the weathering of igneous rock sucked enough carbon dioxide from the atmosphere to set off a deep freeze.

Perhaps that helped kick off a global glaciation, Dr. Dutkiewicz said, but it couldn't have kept Earth frozen for 56 million years on its own. "So there has to be another mystery mechanism that would have sustained the glaciation for that long," she said.

Dr. Dutkiewicz and her colleagues turned their eyes to volcanoes because of a newly available model of Earth's shifting tectonic plates. As the continents spread apart, they studied the changing length of the mid-ocean ridge — a chain of underwater volcanoes — predicted by the model.

The team then calculated the amount of volcanic gas emissions at the beginning of, and throughout, the ice age. Their results showed a drop in atmospheric carbon dioxide sufficient to initiate and sustain a 56-million-year glaciation.

A reduction in volcanic gas emissions has been proposed as an explanation for Snowball Earth before. But according to Dr. Dutkiewicz, this is the first time that researchers have proved that the mechanism was viable through modeled computations.

Dietmar Müller, a geophysicist at the University of Sydney and an author of the study, said the work was one way "to distinguish between alternative models for this very ancient part of Earth's evolution." If scientists know there was an ice age, Dr. Müller explained, "then we can say this one reconstruction model is perhaps more likely than the other one."

Of course, a model is still just that: a model. Without real-world data to back it up, the researchers can't rule out other possibilities. "One thing about geology, there are no definite answers," Dr. Dutkiewicz said. "But based on a combination of different lines of evidence, we can suggest that this is a very likely process."

Francis Macdonald, a geologist at the University of California, Santa Barbara, who was not involved in the work, said studies like this were important for learning about why climates fail. But he is hesitant to readily accept outcomes from models of the ancient seafloor, because there is little data revealing what Earth's oceanic crust was like at that time. "How do we actually test that?" Dr. Macdonald asked about the team's model. "I think it's a really big challenge."

Still, Dr. Müller thinks it is important to try to put bounds on the amount of volcanic gas emitted in the past, particularly when it comes to running climate models for the future. "Usually, that's the most uncertain parameter," he said.

Research like this can help scientists distinguish the influence of geological activity from human-induced climate change. But could a natural drop in volcanic emissions ever save us from the amount of carbon we have pumped into our atmosphere today?

"Unfortunately not," Dr. Dutkiewicz said. "We can study these ancient perturbations," she added, "but the human-induced change is a different kind of beast."

Katrina Miller is a science reporting fellow for The Times. She recently earned her Ph.D. in particle physics from the University of Chicago.

Editor's Note: We appreciate this contribution from Bill Motzer, Ph.D., an accomplished geochemist and longtime NCGS member.

Only at Oklo?

(Part 3)
by
Bill Motzer

Background:

The movie Oppenheimer recently received 13 Academy Award nominations for 2023, including best picture. The film had a brief scene describing Chicago Pile-1 or CP-1 in what was then believed to be the world's first self-sustained nuclear chain reaction. In Part 1 (November 2023 NCGS Newsletter) I described the story behind CP-1's nuclear reaction, which occurred on December 2, 1942, assembled under supervision of physicist Enrico Fermi. In Part 2 (January 2024 NCGS Newsletter), I noted the prediction and subsequent discovery of the ~1.8 billion year old (Ga) natural nuclear reactors in Gabon, West Africa (aka: the Oklo uranium deposits). These deposits were formed on the supercontinent Nuna (aka Columbia or Hudsonland) (Figure 1-3) which is theorized to have existed from about 2.5 to 1.5 Ga. So how did this unique natural reactor phenomenon come about? To understand this, we need to know something about the physical characteristics of these ore deposits. (Note: this is an updated version that appeared in the American Chemical Society California Section newsletter: The Vortex (Motzer, 2017).

The Oklo Ore Deposits:

The Oklo and adjacent Okelobondo mines consists of several mineralized zones containing uranium (U) mineralization in sandstone and conglomerate of the Francevillian Formation. These rocks, and their contained subsequent mineralization, were deposited in a deltaic-type sedimentary basin (aka: stratiform sedimentary deposits because they form continuous and "stacked" layers). The deposits also include shale beds and zones of organic materials probably derived from algal mats similar to stromatolites. However, some of the contained organic matter has been described as "asphaltic," possibly from hydrothermal activity produced by the reactors. Within these layers are mineralized zones ranging from about 5 to 8 meters in thickness with mineralization consisting primarily of the uranium oxide minerals such as uraninite/pitchblende (mostly UO_2, but due to oxidation variable proportions of U_3O_8 may occur). Deposition age has been determined to be about 1.74 (+0.20) Ga. Uranium sources are believed to have been from local upriver igneous alkali granite intrusives. Most uranium (and thorium) in such granites are generally dispersed in accessory minerals such as zircon ($ZrSiO_4$), monazite [$(Ce,La)PO_4$], and apatite [$Ca_5(PO_4)_3(F,Cl,OH)$], where uranium fits in the crystal latus.

Until the rise of free oxygen in the atmosphere to about one percent of present levels, uranium contained in the granitic rocks could not be mobilized. This may have occurred just about this time as around 1.8 Ga there was a sudden increase in atmospheric oxygen (Figure 2-3) as indicated by oxidized fossil soils dated about 2.1 Ga. Once mobilized, dissolved uranium concentrations were probably in the part per million (mg/L) range. Although uranium compounds generally are soluble in oxygenated waters, they are relatively insoluble in anoxic waters (Figure 3-3). Therefore, as the uranium-rich river water encountered a reduced environment, dissolved uranium precipitated out of solution as it crossed the oxidation/reduction front of the organic horizons. Anaerobic bacterial action may have also enhanced this process. Over a period of perhaps 200 million years, several thousand tons of uranium were deposited and concentrated in the algal mats. The Francevillian sedimentary rocks were then buried, consolidated, subsequently uplifted, and tilted about 45 degrees by tectonic forces to their present positions (Figure 4-3). During tectonic uplift fractures formed that were subsequently filled with uranium minerals, which probably exceeded 10 percent uranium. With a natural 235U content of about 3% (the approximate amount required for artificially enriched uranium used in most modern nuclear power plants) the nuclear reactions occurred within these enriched zones (Figure 5-3) and in the next article I'll described this process.

Figure 1-3: Schematic global representation for the Nuna supercontinent at about 1.8 Ga showing location of West Africa (no. 7).

Figure 2-3: [Oversize figure – definitely see Page 13!]

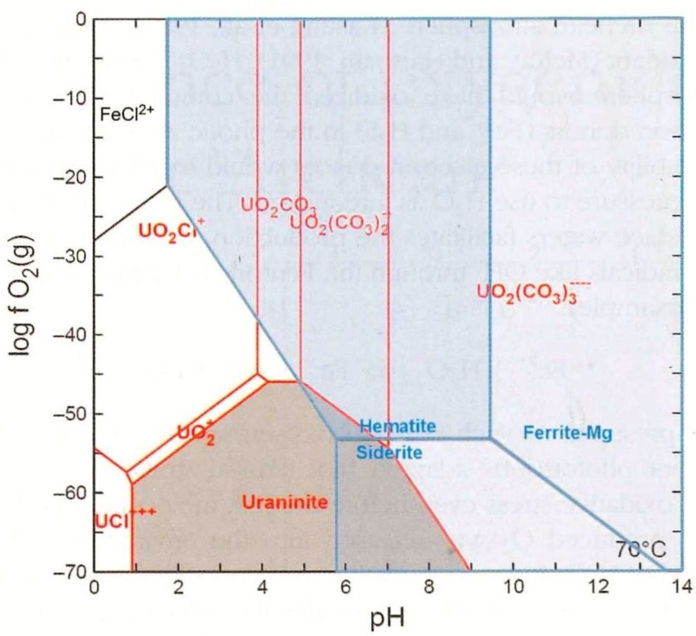


Figure 3-3: Phase diagram model for uranium (U) species (red lines) as a function of pH and fugacity or fO_2 (@ T = 70 °C with fCO_2 = 5 atm) and with major ion concentrations in modern seawater. A uranium activity of 10 nmol/L and iron (Fe) activity of 50 µmol/L were used to denote increased Fe solubility in a probable anoxic Archean ocean. Stability fields of Fe-species are overlain (separated by blue lines) with the stability fields hematite (Fe_2O_3), siderite ($FeCO_3$), and Mg-ferrite ($MgFe_2O_4$) in shaded blue. The predicted mobility of U occurs with increasing fO_2 while Fe, a potential neutron absorber, remains in the solid phase for a pH >5.8. Source: Coogan and Cullen (2009).

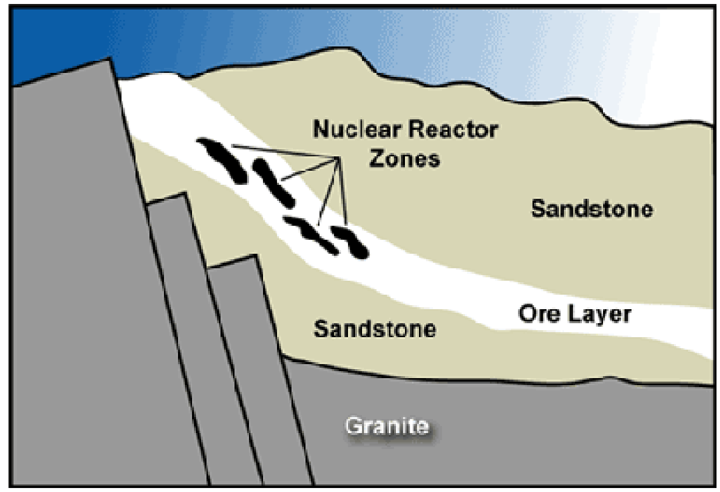


Figure 4-3: Schematic cross section of the Oklo uranium deposits and the natural nuclear reactors. Modified from https://commons.wikimedia.org/wiki/File:Gabon_Geology_Oklo.svg

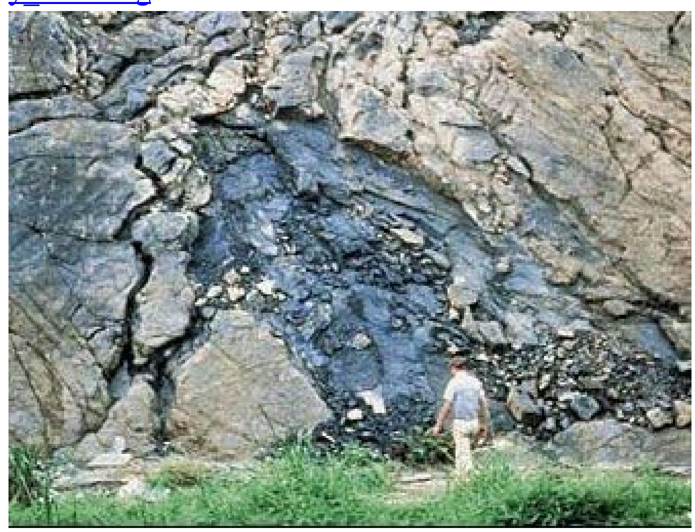


Figure 5-3: Fossilized reactor zone within the Oklo uranium deposit. Photo source same as Figure 1-3.

References:

Coogan, L.A. and Cullen, J,T., 2009, **Did Natural Reactors Form as a Consequence of the Emergence of Oxygenic Photosynthesis During the Archean**: *GSA Today*, v. 19, n.10, pp. 4-10.

Mitchell, R.N. and Evans, D.A.D., 2024, **The Balanced Billion**: *GSA Today*, v. 34, n. 2, pp.10-11.

Motzer, W.E., 2017, **Only at Oklo?** – Part 3: *The Vortex*, v. LXXIX, n. 2, pp. 6-7, www.calacs.org.

North China fossils show eukaryotes first acquired multicellularity 1.63 billion years ago

EurekAlert! January 24, 2024
Source: Chinese Academy of Sciences Headquarters

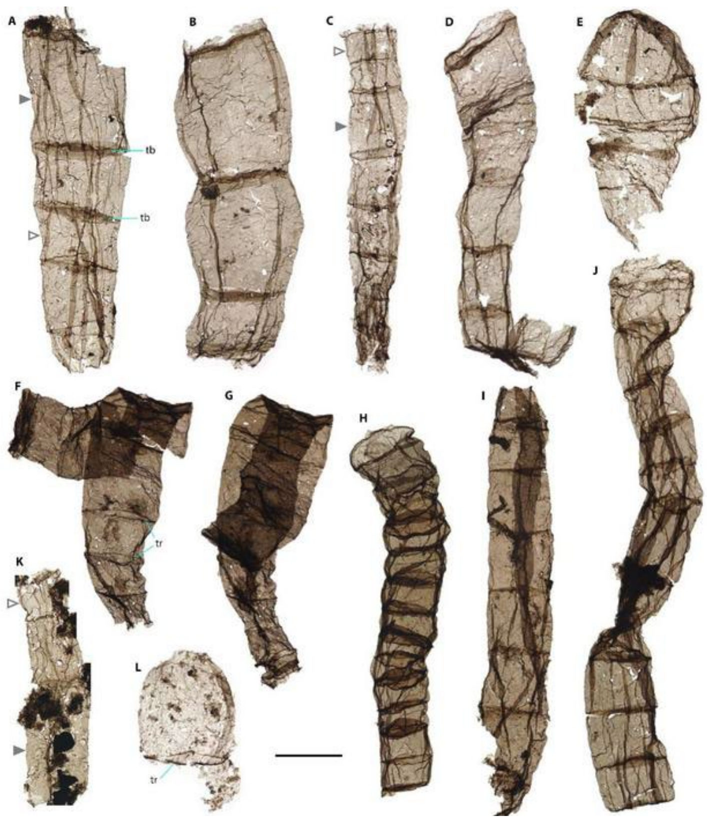


Image: Multicellular fossils from the late Paleoproterozoic Chuanlinggou Formation Credit: Miao Lanyun

In a study published in *Science Advances* on Jan. 24, researchers led by Prof. ZHU Maoyan from the Nanjing Institute of Geology and Palaeontology of the Chinese Academy of Sciences reported their recent discovery of 1.63-billion-year-old multicellular fossils from North China.

These exquisitely preserved microfossils are currently considered the oldest record of multicellular eukaryotes. This study is another breakthrough after the researchers' earlier discovery of decimeter-sized eukaryotic fossils in the Yanshan area of North China, and pushes back the emergence of multicellularity in eukaryotes by about 70 million years.

All complex life on Earth, including diverse animals, land plants, macroscopic fungi, and seaweeds, are multicellular eukaryotes. Multicellularity is key to eukaryotes acquiring organismal complexity and large size, and is often regarded as a major transition in the history of life on Earth. However, scientists have been unsure when eukaryotes evolved this innovation.

Fossil records offering convincing evidence show that eukaryotes with simple multicellularity, such as red and green algae, and putative fungi, appeared as early as 1.05 billion years ago. Older records have claimed to be multicellular eukaryotes, but most of them are controversial because of their simple morphology and lack of cellular structure.

"The newly discovered multicellular fossils come from the late Paleoproterozoic Chuanlinggou Formation that is about 1,635 million years old. They are unbranched, uniseriate filaments composed of two to more than 20 large cylindrical or barrel-shaped cells with diameters of 20–194 µm and incomplete lengths up to 860 µm. These filaments show a certain degree of complexity based on their morphological variation," said MIAO Lanyun, one of the researchers.

The filaments are constant, or tapered throughout their length, or tapered only at one end. Morphometric analyses demonstrate their morphological continuity, suggesting they represent a single biological species rather than discrete species. The fossils have been named *Qingshania magnifica*, 1989, a form taxon with similar morphology and size, and are described as being from the Chuanlinggou Formation.

A particularly important feature of *Qingshania* is the round intracellular structure (diameter 15–20 µm) in some cells. These structures are comparable to the asexual spores known in many eukaryotic algae, indicating that *Qingshania* probably reproduced by spores.

In modern life, uniseriate filaments are common in both prokaryotes (bacteria and archaea) and eukaryotes. The combination of large cell size, wide range of filament diameter, morphological variation, and intracellular spores demonstrate the eukaryotic affinity of *Qingshania*, as no known prokaryotes are so complex. Filamentous prokaryotes are generally very small, about 1–3 µm in diameter, and are distributed across more than 147 genera of 12 phyla. Some cyanobacteria and sulfur bacteria can reach large sizes, up to 200 µm thick, but these large prokaryotes are very simple in morphology, with disc-shaped cells, and are not reproduced by spores.

The best modern analogues are some green algae, although filaments also occur in other groups of eukaryotic algae (e.g., red algae, brown algae, yellow algae, charophytes, etc.), as well as in fungi and oomycetes.

"This indicates that *Qingshania* was most likely photosynthetic algae, probably belonging to the extinct stem group of Archaeplastids (a major group consisting of red algae, green algae and land plants, as well as glaucophytes), although its exact affinity is still unclear," said MIAO.

In addition, the researchers conducted Raman spectroscopic investigation to test the eukaryotic affinity of *Qingshania* from the perspective of chemical composition, using three cyanobacterial taxa for comparison. Raman spectra revealed two broad peaks characteristic of disordered carbonaceous matter. Furthermore, the estimated burial temperatures using Raman parameters ranged from 205–250 °C, indicating a low degree of metamorphism. Principal component analysis of the Raman spectra sorted *Qingshania* and the cyanobacterial taxa into two distinct clusters, indicating that carbonaceous matter of *Qingshania* is different from that of cyanobacterial fossils, further supporting the eukaryotic affinity of *Qingshania*.

Currently, the oldest unambiguous eukaryotic fossils are unicellular forms from late Paleoproterozoic sediments (~1.65 billion years ago) in Northern China and Northern Australia. *Qingshania* appeared only slightly later than these unicellular forms, indicating that eukaryotes acquired simple multicellularity very early in their evolutionary history.

Since eukaryotic algae (Archaeplastids) arose after the last eukaryotic common ancestor (LECA), the discovery of *Qingshania*, if truly algal in nature, further supports the early appearance of LECA in the late Paleoproterozoic—which is consistent with many molecular clock studies—rather than in the late Mesoproterozoic of about 1 billion years ago.

This study was funded by the National Key Research and Development Program of China, the National Natural Science Foundation of China, and the Innovation Cross-Team of CAS.

Journal: *Science Advances*

Magnetic data suggest the hazardous Seattle fault zone developed as the edge of the continent tore itself in two more than 50 million years ago, providing a possible new origin story for the fault

A new origin story for the deadly Seattle Fault

EurekAlert! February 6, 2024
Source: Washington Geological Survey, American Geophysical Union

WASHINGTON — The Seattle fault zone is a network of shallow faults slicing through the lowlands of Puget Sound, threatening to create damaging earthquakes for the more than four million people who live there. A new origin story, proposed in a new study, could explain the fault system's earliest history and help scientists improve hazard modeling for the densely populated region. The study was published in Tectonics, AGU's journal for research exploring the evolution, structure and change of Earth's crust and upper mantle.

The modern Seattle fault zone cuts directly through the densely populated Puget lowlands, including Seattle and its metro area. Fifty million years ago, the continent tore in two here, setting the geologic stage for the modern faults, according to a new Tectonics study. Credit: Washington Geological Survey.

The Seattle fault is active today because of forces exerted on the region from ongoing tectonic deformation both to the west and south, but that was not always the case. Washington in the Eocene looked different from today, with a coastline well east of where Seattle sits today and a chain of volcanic islands dotting the horizon offshore.

The study suggests that around 55 million years ago, that island chain was pulled toward the continent. As it ran into the North American plate, part of it went up and over the crust while the rest was sucked under it. Between these two parts, the crust would have been under great strain and torn. That ancient tear zone set the geologic stage for the modern Seattle fault, the study authors posit.

"It was a total surprise," said Megan Anderson, a geophysicist with the Washington Geological Survey and lead author of the study. "It wasn't something we were going for originally, but our results predict a major ancient fault where the Seattle fault is today."

A massive mystery

The Pacific Northwest lies just inland from the Cascadia subduction zone, where dense oceanic crust gets pulled under the continent. In 1700, a roughly 1000-kilometer (620-mile) rupture of the subduction zone created a massive quake between magnitude 8.7 and 9.2; smaller quakes shook the region throughout the 1900s and, most recently, during the 2001 Nisqually earthquake. The Seattle fault ruptured notably in 923-924 AD, based on local Indigenous oral traditions and geologic evidence along the Puget Sound shoreline.

Despite the region's seismic activity, scientists didn't begin to study the Seattle fault zone in earnest until the 1990s.

"There's a lot more uncertainty about the Seattle fault than, for example, the San Andreas fault," Anderson said. "The Seattle fault could generate something like a magnitude 7.2 earthquake, and we want to be prepared for it. There's still a lot to learn so that engineering geologists can do better simulations for earthquakes and understand the potential risks to our communities."

Previous work to determine the geometry of the Seattle fault at depth relied primarily on seismic data, which are sound waves traveling through and being reflected by underground layers of rock. The data revealed faults and geologic structures that seismologists and geologists interpreted differently. They knew the region hosted a major fault zone, but scientists had proposed different ways parts of the fault are connected, how deep it extends, and how steeply it cuts through the bedrock.

Anderson and her co-authors set out to test the existing hypotheses of the fault zone's geometry by mapping kilometers-deep bedrock across western Washington and building a more complete picture of the region's geologic structure. Gravity and magnetic fields vary across Earth's surface based on rocks' density and composition, so Anderson compiled those data for western Washington and paired them with seismic data. The researchers also collected rock samples from geologic formations that correspond to different parts of the ancient fault and mountain system.

The researchers used computer models to see which, if any, of the hypotheses matched up with the gravity, magnetic and seismic data. The gravity data did not show a complex pattern, but the magnetic data revealed a key secret seismic data missed: deep in the crust, the bedrock consistently alternates between being more and less magnetic, suggesting slanted layers of changing rock type. And in map view, features on either side of the Seattle fault zone angle away from each other; north of the Seattle fault zone, structures are angled north-northwest, while in the south, they're oriented north-northeast.

Those wonky orientations gave Anderson pause; they hinted at an ancient mountain range, but to check that, Anderson needed to match up the map-view data with deeper rocks. To connect the map view with known, deeper bedrock geology, Anderson modeled a vertical profile of rocks underground and found some of those structures dip at different orientations underground, too.

"These are all very different orientations," Anderson said. "It's very hard to do that unless there's a place where the structures get disconnected from each other and then restart."

Anderson had stumbled upon a new possible explanation for the Seattle fault zone's early history and why it's reactivated today.

A tear in the crustal continuum

The data suggested that about 55 million years ago, as the subduction zone pulled in a string of oceanic islands, the northern half of the island chain was subducted, but the southern half was added to the top of the crust, or obducted. Over a couple million years, as the islands were obducted, they crumpled into a fold-and-thrust mountain belt with topography similar to the Blue Ridge Mountains of Appalachia today.

The zone where the islands switched from being subducted to being accreted would have been under incredible strain and been ripped apart.

"It would have been this slow, ongoing tear, almost like the crust unzipping itself," Anderson said. "As this progressed, the tear fault got longer and longer."

And that "torn" region overlaps perfectly with the modern Seattle fault zone.

The intense tearing would have stopped after the islands were crunched into the continent, but the damage was done. The zone of intense tearing created fragmented, weakened crust, setting the geologic stage for the modern Seattle fault zone.

Beyond offering a possible explanation for why the fault zone exists, the study's results about the geometry of Washington's more ancient faults and geologic structures provide valuable details about the bedrock under and within the Seattle basin. This basin is filled with kilometers of looser sedimentary rock which make seismic ground shaking stronger, and the new data can help scientists make more accurate models of future ground shaking in the area.

Anderson is excited to use her findings to study western Washington's active faults next.

"This buried tectonic story was so much fun to discover, and now it will provide a great basis for getting back to answering our original questions about active fault geometry for the Seattle fault and other faults in western Washington," Anderson said.

Journal Reference: Anderson, Megan L., Blakeley, R.J., Wells, R.E., and Dragovich, A.G., **Deep structure of Siletzia in the Puget Lowland: Imaging an obducted plateau and accretionary thrust belt with potential fields.** *Tectonics*, 2023. DOI: 10.1029/2022TC007720.

Trilobites

A Fossilized Tree That Dr. Seuss Might Have Dreamed Up

The toilet brushlike specimen from a Canadian quarry hints at the evolutionary experiments that occurred during a 15-million-year gap in the fossil record.

Source: The New York Times, February 2, 2024

Sanfordiacaulis densifolia, a tree found in present day New Brunswick, Canada, was the result of earthquakes in a 352-million-year-old rift-lake system.Credit...Matthew Stimson

By Robin Catalano

In the ancient prehistory of Earth, there is a chapter that waits to be told known as Romer's gap. Researchers have identified a hiatus in the tetrapod fossil record between 360 million and 345 million years ago, after fish had begun to adapt to land and more than 80 million years before the first dinosaurs.

While mysteries remain about evolution's experiments with living things during that 15-million-year gap, a fossilized tree described in a new paper offers greater insights to some of what was happening during this period in nature's laboratory.

Named *Sanfordiacaulis densifolia*, the tree had a six-inch diameter with a nearly 10-foot-tall trunk composed not of wood, but of vascular plant material, like ferns. Its crown had more than 200 finely striated, compound leaves emanating from spiral-patterned branches that radiated 2½ feet outward. Robert Gastaldo, a geology professor at Colby College in Maine who is an author of the study, which was published Friday in the journal ***Current Biology***, compared it to "an upside-down toilet brush." Comically top-heavy, even Seussian, the tree most likely remained upright by intertwining its branches with those of neighboring trees.

"This is a totally new and different kind of plant" than had been found in the Late Paleozoic Era, said Patricia Gensel, a professor of biology at the University of North Carolina at Chapel Hill and another author of the paper. She added, "We typically get bits and pieces of plants, or mineralized tree trunks, from Romer's Gap. We don't have many whole plants we can reconstruct. This one we can."

Image

A reconstruction of *Sanfordiacaulis* with a simplified branching structure. Credit...Tim Stonesifer

The tree was unearthed near Valley Waters, New Brunswick, in an active private quarry within Canada's Stonehammer UNESCO Global Geopark. (A new fossil museum will open in the village later this year.) The area is part of the 350-million-year-old Albert Formation, a geological layer that has also yielded fossilized fish and trace fossils. Although partial fossils of the same tree species had previously been found, the new discovery represents the only such fossil whose trunk and crown were preserved together.

"It's very rare to find something this well preserved and unique," said Matt Stimson, an author of the study who works at the New Brunswick Museum and who first excavated *S. densifolia* with another study author, Olivia King of Saint Mary's University. "It's like finding a cactus in the middle of a Canadian boreal forest."

Trees with spongy, vascular-tissue trunks first appeared 393 million to 383 million years ago. Their woody counterparts entered the fossil record about 10 million years later. Trunks and stumps make up the bulk of arboreal fossils from 398 million to 327 million years ago, and have been found only in coastal wetland areas.

The quarry in Valley Waters was once a swampy, tropical ecosystem surrounding a rift lake, a deep water body running atop a fault zone. Its sediments were similar to those of modern-day Lake Victoria and Lake Tanganyika in East Africa. The bank containing the tree was sloughed off during a catastrophic earthquake, depositing the tree on its side at the bottom of the lake. Ensuing mudslides quickly buried the vegetation and snuffed out aquatic life. Sediments filled in around the leaves, three-dimensionally preserving the specimen, which falls somewhere on the evolutionary continuum between a woody tree and an enormous plant.

S. densifolia evolved during a time when the tiered forest-canopy structure was still developing, and plants were diversifying, Ms. King said. It probably lived below the tallest trees, such as the 100-plus-foot, scaly barked *Lepidodendron*, but above low-growing lycopods and mosses.

"The architecture of this tree suggests it was growing into this ecological niche of being in the mid canopy, trying to capture as much sunlight as possible with branches that extended out almost as long as the tree was tall," Ms. King said.

"It's an experiment in plant biology that was successful for some point in time, and then was not," Dr. Gastaldo said. "We don't see anything that looks like this in any of the forests we've been able to evaluate since then."

Journal: *Current Biology*

Ice cores provide first documentation of rapid Antarctic ice loss in the past

EurekAlert! (from AAAS), 8-Feb-2024
Source: University of Cambridge

Researchers from the University of Cambridge and the British Antarctic Survey have uncovered the first direct evidence that the West Antarctic Ice Sheet shrunk suddenly and dramatically at the end of the Last Ice Age, around eight thousand years ago.

The evidence, contained within an ice core, shows that in one location the ice sheet thinned by 450 meters — that's more than the height of the Empire State Building — in just under 200 years.

This is the first evidence anywhere in Antarctica for such a fast loss of ice. Scientists are worried that today's rising temperatures might destabilize parts of the West Antarctic Ice Sheet in the future, potentially passing a tipping point and inducing a runaway collapse. The new study, published in Nature Geoscience, sheds light on how quickly Antarctic ice could melt if temperatures continue to soar.

"We now have direct evidence that this ice sheet suffered rapid ice loss in the past," said Professor Eric Wolff, senior author of the new study from Cambridge's Department of Earth Sciences. "This scenario isn't something that exists only in our model predictions and it could happen again if parts of this ice sheet become unstable."

The Antarctic ice sheets, from west to east, contain enough freshwater to raise global sea levels by around 57 meters. The West Antarctic Ice Sheet is considered particularly vulnerable because much of it sits on bedrock that lies below sea level.

Model predictions suggest that a large part of the West Antarctic Ice Sheet could disappear in the next few centuries, causing sea levels to rise. Exactly when and how quickly the ice could be lost is, however, uncertain.

One way to train ice sheet models to make better predictions is to feed them with data on ice loss from periods of warming in Earth's history. At the peak of Last Ice Age 20,000 years ago, Antarctic ice covered a larger area than today. As our planet thawed and temperatures slowly climbed, the West Antarctic Ice Sheet contracted to more or less its current extent.

"We wanted to know what happened to the West Antarctic Ice Sheet at the end of the Last Ice Age, when temperatures on Earth were rising, albeit at a slower rate than current anthropogenic warming," said Dr Isobel Rowell, study co-author from the British Antarctic Survey. "Using ice cores we can go back to that time and estimate the ice sheet's thickness and extent."

Ice cores are made up of layers of ice that formed as snow fell and was then buried and compacted into ice crystals over thousands of years. Trapped within each ice layer are bubbles of ancient air and contaminants that mixed with each year's snowfall — providing clues as to the changing climate and ice extent.

The researchers drilled a 651-meter-long ice core from Skytrain Ice Rise in 2019. This mound of ice sits at the edge of the ice sheet, near the point where grounded ice flows into the floating Ronne Ice Shelf.

After transporting the ice cores back to Cambridge at -20ºC, the researchers analyzed them to reconstruct the ice thickness. First, they measured stable water isotopes, which indicate the temperature at the time the snow fell. Temperature decreases at higher altitudes (think of cold mountain air), so they were able to equate warmer temperatures with lower-lying, thinner ice.

They also measured the pressure of air bubbles trapped in the ice. Like temperature, air pressure also varies systematically with elevation. Lower-lying, thinner ice contains higher pressure air bubbles.

These measurements told them that ice thinned rapidly 8,000 years ago. "Once the ice thinned, it shrunk really fast," said Wolff, "this was clearly a tipping point — a runaway process."

They think this thinning was probably triggered by warm water getting underneath the edge of the West Antarctic Ice Sheet, which normally sits on bedrock. This likely untethered a section of the ice from bedrock, allowing it to float suddenly and forming what is now the Ronne Ice Shelf. This then allowed neighboring Skytrain Ice Rise, no longer restrained by grounded ice, to thin rapidly.

The researchers also found that the sodium content of the ice (originating from salt in sea spray) increased about 300 years after the ice thinned. This told them that, after the ice thinned, the ice shelf shrunk back so that the sea was hundreds of kilometers nearer to their site.

"We already knew from models that the ice thinned at around this time, but the date of this was uncertain," said Rowell. Ice sheet models placed the retreat anywhere between 12,000 and 5,000 years ago and couldn't say how quickly it happened. "We now have a very precisely dated observation of that retreat which can be built into improved models," said Rowell.

Although the West Antarctic Ice Sheet retreated quickly 8,000 years ago, it stabilized when it reached roughly its current extent. "It's now crucial to find out whether extra warmth could destabilize the ice and cause it to start retreating again," said Wolff.

Journal reference: Abrupt Holocene ice loss due to thinning and ungrounding in the Weddell Sea Embayment, *Nature Geoscience, Feb. 8, 2024*. DOI: 10.1038/s41561-024-01375-8.

Trilobites

This Ancient Fish Gave the Whole Ocean the Stiff Lower Lip

What paleontologists long believed were long spines on the aptly named *Alienacanthus* turn out to be an extended lower jaw.

New York Times, January 30, 2024
Source: Royal Society Open Science

By Jack Tamisiea

Some 375 million years ago, armored fishes ruled a watery world. Known as placoderms, these primitive jawed vertebrates came in all shapes and sizes, from small bottom-dwellers to giant filter-feeders. Some, like the wrecking-ball-shaped *Dunkleosteus*, were among the ocean's earliest apex predators.

An artist's reconstruction of *Alienacanthus*, a Devonian Period fish that has been a mystery since its discovery in Poland in 1957. Scientists say its pointed teeth were suitable to grasp live prey. Credit...Beat Scheffold and Christian Klug

Few of these ancient oddities were weirder than the aptly named *Alienacanthus*. Discovered in Poland in 1957, this Devonian Period fish was initially known for a set of large, bony spines. But the recent discovery of a fossilized *Alienacanthus* skull, described in a paper published Wednesday in the journal *Royal Society Open Science*, reveals that these spines were actually the fish's elongated lower jaw. Measuring twice as long as the rest of the fish's skull, this lower jaw gave *Alienacanthus* nature's most extreme underbite, and, perhaps, a stiff lower lip.

"It's still very alien looking so the name is very fitting," said Melina Jobbins, a paleontologist who studies placoderms at the University of Zurich and is an author on the paper.

Since its discovery in the 1950s, *Alienacanthus* is known only from a few fossils discovered in the mountains of central Poland and Morocco. During the Late Devonian Period, these areas were submerged coastlines on opposite ends of a vast sea separating northern and southern supercontinents. But many of these fossils are fragmentary and offer little detail on what this strange fish looked like. Over the past two decades, researchers have uncovered additional well-preserved *Alienacanthus* fossils in European museum collections. Dr. Jobbins teamed up with researchers from several of these museums to pool together the fossil bits and more accurately describe the ancient fish.

The Moroccan *Alienacanthus* skull fossil. Credit...Jobbins et al., The Royal Society.

The key to cracking this fishy enigma was a nearly complete *Alienacanthus* skull measuring more than two and a half feet that originated in Morocco and is currently in the collection of the University of Zurich's Palaeontological Institute. With the elements of the skull still articulated, the team realized that *Alienacanthus*'s oddly shaped spines were actually its lower jaw bones. This made the fish even stranger: When it closed its mouth, the placoderm resembled an upside-down billfish with a long, beaklike bottom jaw.

While fishes like swordfish and sawsharks wield dramatic upper-jaw protrusions, very few species possess elongated lower jaw protrusions. Today, this feature is seen only in a group of small fish called halfbeaks. But the relative length of *Alienacanthus*'s lower jaw was 20 percent greater than a halfbeak's. *Alienacanthus*'s jaw was also proportionally longer than similar structures seen in prehistoric sharks and porpoises, making the fossil fish the undisputed champion of the underbite.

The extended jaw may have helped *Alienacanthus* sift through sediment, which is how modern halfbeaks utilize their shovel-like jaws. Another hypothesis is that the prehistoric fish wielded its lower jaw to stun or injure prey.

Dr. Jobbins thinks the elongated jaw, which was studded with recurved teeth that extended well past where its top jaw ended, most likely served as a trap. "Basically it could invite prey in and then they can't get out because there's only one way to go," she said. *Alienacanthus*'s shorter upper jaw could move independently of the lower jaw and snap shut once a fish or squid was in too deep.

This snaggletoothed fish is an intriguing evolutionary oddball. As a placoderm, *Alienacanthus* belonged to the earliest groups of vertebrates to develop complex jaws. The fish provides a glimpse of just how extreme jaws could be right after the now-widespread feature originated.

Alienacanthus also represents one of the final chapters of placoderm evolutionary ingenuity. Within 15 million years of the appearance of *Alienacanthus*'s toothy mug, these armored fish were wiped out and replaced by sharks.

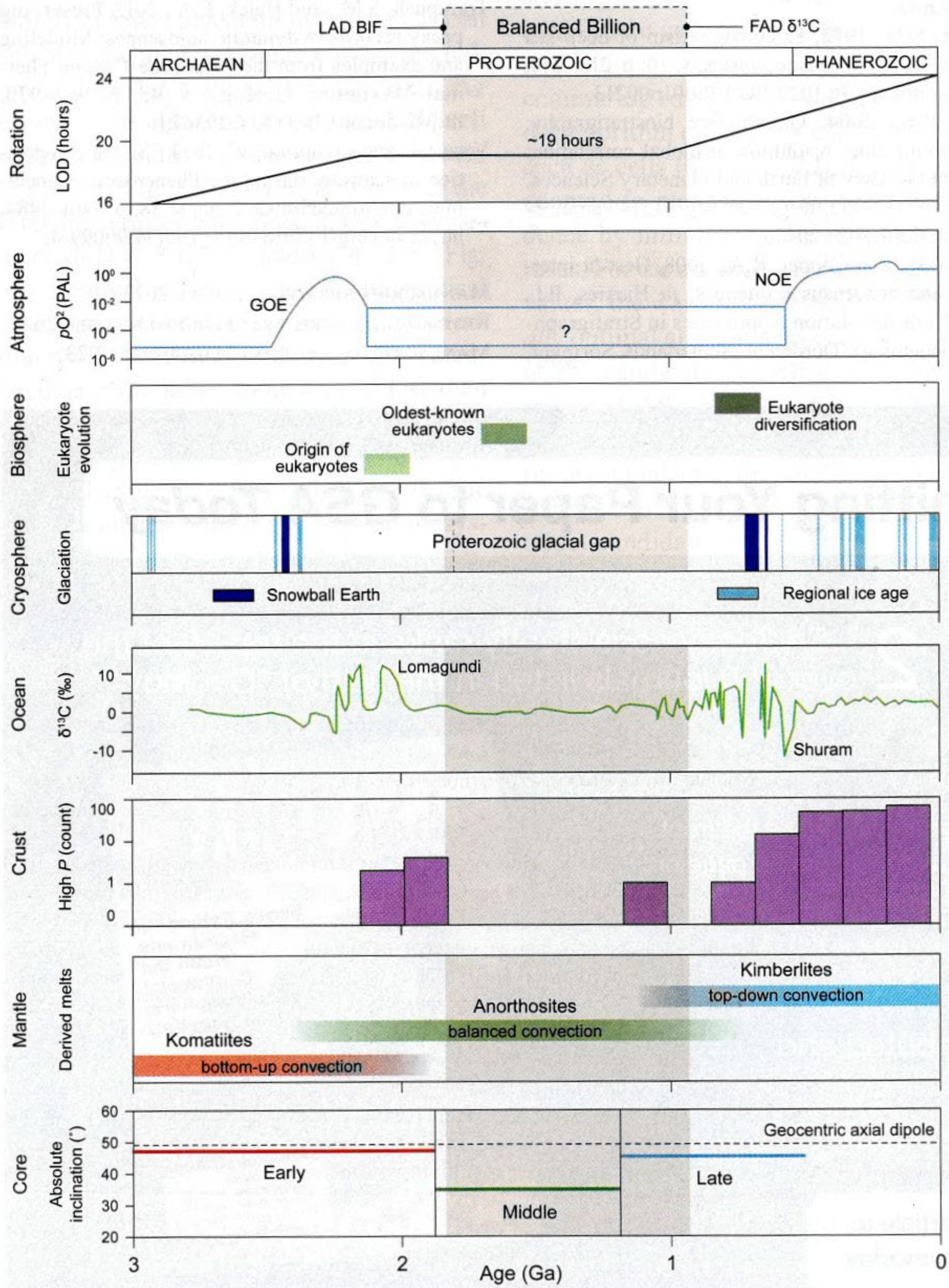
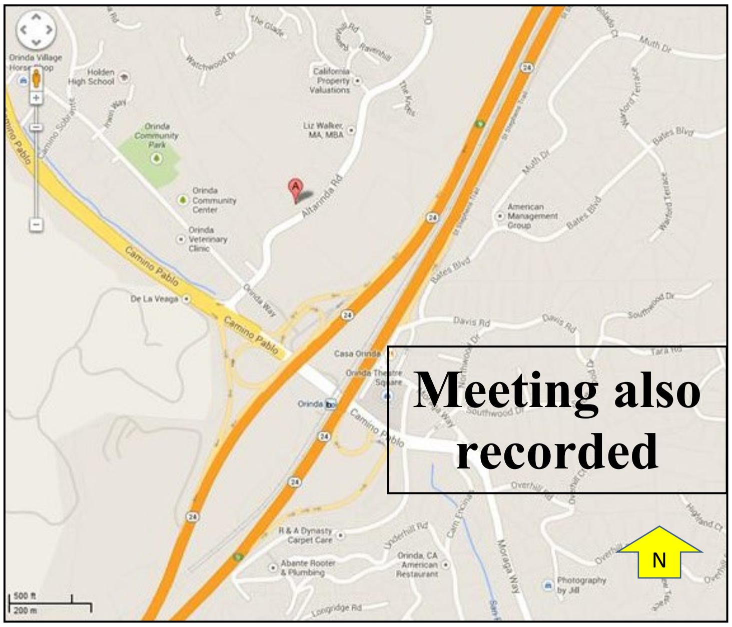


Figure 2-3 of the **Only at Oklo** article: Representative record events from the mid Proterozoic. Note that atmospheric oxygen levels increased beginning at about 2.5 Ga. Abbreviations: **LAD BIF** = last appearance of banded iron formation. **FAD $\delta^{13}C$** = first appearance of significant carbon isotope excursions. **LOD** = length of day. **GOE** = Great Oxidation Event. **NOE** = Neoproterozoic Oxidation Event. Source: Mitchell and Evans (2024).



water management systems and prepare for future needs. CASP consists of a series of strategic actions including a Subsidence and Groundwater Monitoring Project, a Subsidence and Groundwater Modeling Project, and other short- and long-term planning and remediation activities.

Biography:

Chris Bonds is a Senior Engineering Geologist (Specialist) with the California Department of Water Resources (DWR) in Sacramento. Since 2001, he has been involved in a variety of statewide projects including exploration, monitoring, modeling, policy, research, water transfers, and emergency response. Chris has over 31 years of professional experience in paleontology, geophysics, and environmental/engineering geology, within the private/public sectors, in California, Alaska, and Hawaii. Chris holds a master's degree in Geology from Cal State Los Angeles and is a Professional Geologist and Certified Hydrogeologist in California. In January 2021, Chris co-authored a book titled Geology of Sacramento, California which was published by the Association of Environmental & Engineering Geologists.

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