

NORTHERN CALIFORNIA GEOLOGICAL SOCIETY



Website: www.ncgeolsoc.org

NCGS OFFICERS

President:

Will Schweller
willschweller@yahoo.com

President-Elect:

Greg Bartow, CA Dept Parks & Rec
gregbartow@yahoo.com

Past President:

Phil Reed, Retired
philecreed@yahoo.com

Field Trip Coordinator:

Stefano Mazzoni
mazzonigeoscience@gmail.com

Treasurer:

Barbara Matz, Shaw Group, Inc.
barbara.matz@cbifederaleservices.com

Program Director:

John Karachewski, Department of
Toxic Substances Control
cageo@sbcglobal.net

Scholarship Chair:

Phil Garbutt, Retired
plgarbutt@comcast.net

K-12 Program Chair:

Open

Membership Chair:

Tom Barry, tomasbarry@aol.com

NCGS Outreach Chair:

Open

NCGS Newsletter Editor:

Mark Sorensen, Gilbane Federal
msorensen64@earthlink.net

NCGS Website Editor:

Mark Detterman, Alameda County
Env Health, mdetter1@gmail.com

Recording Secretary & Social Media:

Crystal Replogle, Asbestos TEM Labs
creplogle@gmail.com

COUNSELORS

Don Lewis, Retired
donlewis@comcast.net

Ray Sullivan, Emeritus,
San Francisco State University
rays.rock@gmail.com

Noelle Schoellkopf, Schlumberger
nschoellkopf@slb.com

MEETING ANNOUNCEMENT

DATE: May 31, 2017

LOCATION: Orinda Masonic Center, 9 Altarinda Rd., Orinda
(see map on back page)

TIME: 6:00 – 6:45 p.m.: Social; 6:45 – 8:00 pm: Dinner;
8:00 – 9:00 pm: Presentation. Cost: \$25/person.

If you're not yet registered, complete & submit the registration form provided on Page 13, to be received by May 26.

SPEAKER: *Dr. Greg Stock, National Park Service*

Topic: The Rise and Fall of Sierra Nevada Glaciers

[from the National Geographic Society website]: Glaciers are more than a playground for skiers and climbers; they are significant to the world, and it's vital to pay attention to what's happening to them. For 85 years, the park service has conducted annual surveys of the Lyell and Maclure Glaciers. The results of the most recent studies are shocking. The glaciers have lost about 80 percent of their surface area.

"The reason glaciers are good indicators of climate change is because they are simple. Snowfall and temperature are the only two things that control a glacier's health. So if you have less snow or warmer temperatures, the glaciers are going to retreat," explains Greg Stock, a Yosemite National Park glaciologist.

In Yosemite, the Lyell and Maclure Glaciers form the headwaters of the Tuolumne River, providing drinking water to more than two million people in the Bay Area. Once the glaciers disappear, the ecosystems downstream are bound to change. In other places in the world, like China, Bolivia, and the Alps, melting glaciers provide a significant source of freshwater for large communities. Globally, the loss of glaciers means many communities will lose their water source.

"The other part," Stock says, "is more philosophical. Glaciers were foundational in creating this landscape that's so famous. When the glaciers disappear, we'll lose the physical links to the past and the tangible link to the past study of glaciers from John Muir on—the hundreds of people involved in studying these glaciers over a century and a half."

Biography: Dr. Greg Stock is the first-ever Park Geologist at Yosemite National Park. He has B.S. and Ph.D. (U.C. Santa Cruz) degrees in geology and earth science, and (continued on back page)

NCGS 2016 – 2017 Calendar

June 28, 2017

7:00 pm

Dr. Matthew J. James, Sonoma State University

Collecting Evolution:

The Galapagos Expedition that Vindicated Darwin

NCGS Field Trips

The following potential field trips are in a preliminary planning stage:

- Geology of Devil's Slide
- Pt. Sal Ophiolite in Santa Barbara Co,
- Convergent Margin Tectonics across Central California Coast Ranges - Pacheco Pass
- Tuscan Formation volcanic mudflow deposits, Cascade foothills

Peninsula Geologic Society

PGS may be pulling back on their activities, as there is only one active officer remaining. For an update on the future of the society, go to <http://www.diggles.com/pgs/#PGSfuture>. For a list of past meetings, abstracts, and field trips go to <http://www.diggles.com/pgs/>. The PGS has also posted guidebooks for downloading, as well as photographs from recent field trips at this web address. Please check the website for current details.

UC Berkeley Earth & Planetary Science Weekly Seminar Series

Interesting seminars are presented in many weeks at EPS throughout the academic year, generally from late August through early May. For an updated list of seminars, go to <http://eps.berkeley.edu/events/seminars>.

Have you renewed your NCGS membership this year? Our year runs from September to September. If you haven't already renewed, please use the Renewal Form on page 13 of the November newsletter, or see the Treasurer at the next meeting, at registration time.

NCGS members are invited to attend any of our **NCGS Board meetings** held quarterly throughout the year (except for summer), generally in September, January, and May, and generally at the CB&I (formerly Shaw E&I) offices at 4005 Port Chicago Hwy, Concord, CA 94520. The next board meeting will occur in September.

NCGS Spring 2017 Outreach

by Bill Motzer, Mark Petrofsky, and Mark Sorensen

April 15, 2017: New Almaden Quicksilver County Park Hike and Field Trip

New Almaden Park, in Santa Clara County southwest of San Jose, is the site of one of the largest mercury mining areas in the Coast Ranges. The hike/field trip was hosted by Jim Jacobs, with American Institute of Professional Geologists (AIPG) Student's Chapters at U.C. Davis and Sonoma State University. Bill Motzer led the field trip on the Historic Trail with two park docents – Mike Cox and Mike Boulland: both experts in the park's mines and mining history. Mark Sorensen represented NCGS. After the hike we visited the Casa Grande Museum just north of the park to see mercury ore specimens (cinnabar) and historic relics collected and preserved from the mines.



New Almaden: Group photo with field trip participants right to left: Mark Sorensen (NCGS), Mike Boulland (Park Docent), Joe Jacobsen (AIPG Sonoma State Univ.), Bill Motzer (AIPG and NCGS), Mike Priestaf (Weiss Assoc.), Jim Jacobs (AIPG), Mike Cox (Park Docent), and Steven Mok and Michaela Gnos (AIPG UC Davis). Photo taken at historic mining equipment display outdoor exhibit.

April 22, 2017: Cal Day at U.C. Berkeley

At the annual Cal Day, NCGS hosted a booth and table on the patio behind McCrone Hall displaying our Bay area and California rock and mineral collection. Mark Petrofsky has taken the lead as *Outreach Coordinator* from John Christian who had moved to Phoenix and donated 90% of the rocks to NCGS. Mark was assisted by Bill Motzer, Greg Croft, Phil Garbutt, and Will Schweller. The morning was quiet, but the afternoon was hopping.

Future outreach events will be on:

- May 21st at the El Cerrito Hillside Celebration (Bill Motzer, will also lead a short geology

walk at the quarry site (investigated by John Wakabayashi) from 2 to 3 pm; and

- June 24th back at New Almaden County Park in San Jose, *Make-Like-a-Miner Day*.

Some other future events are: Lafayette Library, S.F. Mineral and Gem Show and the Bay Area Science Festival.



Cal Day: Right to left: Mark Petrofsky, Bill Motzer, and Greg Croft.

California fossils, stone tools may rewrite New World human history



Retired San Diego Natural History Museum Paleontologist Richard Cerutti (L) and Curator of Paleontology and Director of PaleoServices, Dr. Tom Demere, compare mastodon bones salvaged at the Cerutti Mastodon site in San Diego County, California, U.S., in this handout photo received April 26, 2017. San Diego Natural History Museum/Handout via REUTERS

By Will Dunham | WASHINGTON

In what may be one of the most significant discoveries ever in archeology in the Americas, researchers on Wednesday said stone tools and broken mastodon bones unearthed in California show humans had reached the Americas by about 130,000 years ago, far earlier than previously known.

The researchers called five rudimentary tools -- hammerstones and anvils -- discovered in San Diego County alongside fossil bones from the prehistoric elephant relative compelling evidence, though circumstantial, for the presence of either our species or an extinct cousin like Neanderthals.

San Diego Natural History Museum paleontologist Tom Deméré said until now the oldest widely accepted date for human presence in the New World was 14,000 to 15,000 years ago, making the San Diego site nearly 10 times older.

The finding would radically rewrite the understanding of when humans reached the New World, though some scientists not involved in the study voiced skepticism.

"If the date of 130,000 years old is genuine, then this is one of the biggest discoveries in American archeology," University of Southampton paleolithic archeologist John McNabb, who was not involved in the research and called himself "still a little skeptical."

No human skeletal remains were found. But the stone tools' wear and impact marks and the way in which mastodon limb bones and molars were broken, apparently in a deliberate manner shortly after the animal's death, convinced the researchers that humans were responsible. They performed experiments using comparable tools on elephant bones and produced similar fracture patterns.

"People were here breaking up the limb bones of this mastodon, removing some of the big, thick pieces of mastodon limb bones, probably to make tools out of, and they may have also been extracting some of the marrow for food," said archeologist Steven Holen of the Center for American Paleolithic Research in South Dakota.

U.S. Geological Survey geologist James Paces used state-of-the-art dating methods to determine that the mastodon bones, tooth enamel, and tusks were 131,000 years old, plus or minus about 9,000 years.

Some skeptics suggested alternative explanations about the material excavated beginning in 1992 at a freeway construction site, suggesting the bones may have been broken recently by heavy construction equipment rather than by ancient humans.

'HARD TO ARGUE'

The researchers defended their conclusions, published in the journal *Nature*. "It's hard to argue with the clear and remarkable evidence that we can see in all of this material," said archeologist Richard Fullagar of Australia's University of Wollongong, calling the conclusions "truly incontrovertible."

Our species, *Homo sapiens*, first appeared in Africa about 200,000 years ago and later spread worldwide. Timing of the New World arrival has been contentious. Genetic data suggests it was roughly 23,000 years ago, though archeological evidence is lacking.

The researchers said the humans at the site could have been *Homo sapiens* or an extinct species such as Neanderthals, already known to have lived in Siberia, or Denisovans, known from only scant remains.

Holen said humans may have walked from Siberia to Alaska on a now-gone Bering Sea land bridge or perhaps traveled by boat along the Asian coast, then over to Alaska and down North America's western coastline to California. "It's a huge deal if it's true," McNabb said.

But McNabb wondered whether there was anything in the chemistry of the soil or ground water that might have affected the way the date of the material was calculated, and whether anything else could have produced the impact and damage patterns on the material other than humans.

(Reporting by Will Dunham; Editing by Sandra Maler)

Source: Article from Reuters website (Reuters.com), Science News section, April 26, 2017.

2 Tennessee Cases Bring Coal's Hidden Hazard to Light

By Tatiana Schlossberg, April 15, 2017

GALLATIN, Tenn. — The hulking Gallatin Fossil Plant sits on a scenic bend of the Cumberland River about 30 miles upstream from Nashville. In addition to generating electricity, the plant, built in the early 1950s by the Tennessee Valley Authority, produces more than 200,000 tons of coal residue a year. That coal ash, mixed with water and sluiced into pits and ponds on the plant property, has been making its way into groundwater and the river, potentially threatening drinking water supplies, according to two current lawsuits.

Coal ash, the hazardous byproduct of burning coal to produce power, is a particularly insidious legacy of

the nation's dependence on coal. Unlike the visible and heavily regulated airborne emissions from power plant smokestacks, coal ash is largely unseen unless there is a major spill and, until recently, far less effectively regulated.

More than 100 million tons of coal ash is produced every year, one of the nation's largest and most vexing streams of toxic waste. The hazardous dust and sludge — containing arsenic, mercury, lead and other heavy metals — fill more than a thousand landfills and bodies of water in nearly every state, threatening air, land, water and human health.

The Gallatin power plant is facing citizens' complaints and two major lawsuits over its handling of coal ash. One suit, filed in 2015 by an environmental advocacy group in federal court, says the utility violated the Clean Water Act by allowing toxic leaks from its coal ash disposal ponds. A second, also filed in 2015, by the state's attorney general and its environmental enforcement agency, asserts that the Tennessee Valley Authority broke state pollution laws and endangered public health.

The state case is scheduled to go to trial this year; in the federal case, which went to trial at the end of January, the parties were scheduled to file proposed findings of fact on Friday.



Pipes that carry coal ash to the stilling ponds at the Gallatin plant, about 30 miles upstream from Nashville.

Credit: Joe Buglewicz for The New York Times

A new rule regulating the monitoring, safe storage and disposal of coal ash went into effect in 2015. This past week, however, Scott Pruitt, the administrator of the Environmental Protection Agency, said in a letter to a Minnesota environmental official that the agency would reconsider the rule and delay the 2018 compliance deadline for states.

The plant is among the Tennessee Valley Authority's fleet of power stations, which have used fossil fuels, nuclear energy, and renewable sources like hydropower to bring reliable electricity to parts of seven states across the Southeast. The authority, created in 1933 as part of President Franklin D. Roosevelt's New Deal, provides 99.7 percent of Tennessee's electricity.

The Gallatin plant, like all others that burn coal, produces a steady and difficult-to-control stream of coal ash. Its disposal poses problems across the country, but particularly in the Southeast, which is highly dependent on coal for electricity.

"Gallatin is in many ways the worst site we've seen," said Frank Holleman, a senior lawyer with the Southern Environmental Law Center, the nonprofit legal organization that filed the federal lawsuit on behalf of two state conservation groups. The group has filed several other suits claiming environmental harm from improper handling of coal ash in other states.

Mr. Holleman said vigorous federal enforcement of laws governing coal ash disposal was crucial because utilities like the Tennessee Valley Authority, which are responsible for managing coal ash storage, held so much political sway at the state level. He said that support for protecting water supplies from coal ash contamination cut across party lines and that efforts by the Trump administration to curb enforcement would be opposed even by residents who had voted for the president.

"We have to hope and pray that, regardless of any official's political outlook, they can recognize that coal ash does not wear a political button," he said.

Officials from the state's attorney general's office and Department of Environment and Conservation declined to comment for this article because of the continuing litigation. But in court filings, the state identified at least 10 places where unpermitted and illegal seepage from Gallatin's coal ash ponds may have occurred, and said the utility's own reports showed that the groundwater around the site was contaminated with heavy metals at levels exceeding state health standards.

On March 14, the Tennessee Valley Authority filed a motion in state court seeking to have the case dismissed, since, it argued, all seepage from the coal ash ponds is legally permitted by the state.

Coal ash gets far less attention than toxic and greenhouse gas emissions from power plants, but it has created environmental and health problems — every major river in the Southeast has at least one coal

ash pond — and continuing legal troubles and large cleanup costs for the authority and other utilities.

The Gallatin site is pockmarked with ponds that serve as storage for millions of tons of coal ash slurry. As at other sites in the region, these ponds were built on top of karst, porous limestone prone to cracks and sinkholes that can let poisonous ash seep into groundwater and threaten drinking water — in this case, possibly affecting more than a million people.

At other sites in the Southeast, coal ash ponds were built out into rivers, making them vulnerable to spills or dam collapses.

Even though coal use is declining in the United States, it is still the second-biggest source of greenhouse gas emissions, according to the federal Energy Information Administration, and coal ash is one of the largest waste streams in the country.

Coal is used to generate power almost everywhere, but problems associated with coal ash and coal ash slurry disproportionately affect low-income and minority communities, experts say.

The environmental law center that brought the federal suit does not claim a civil rights violation on behalf of the downstream residents whose water was polluted. But Beth Alexander, one of the center's lawyers, and her colleagues have outlined what they say is decades-long neglect of the coal ash issue. From 1970 to 1978, coal ash from one of the Gallatin slush ponds seeped into the groundwater and made its way to the Cumberland River beyond, the center's lawyers and several scientists say. The slow-motion coal slurry spill totaled 27 billion gallons, more than 100 times the size of the Deepwater Horizon oil spill.

The Tennessee Valley Authority denied that amount of coal ash water had entered the river (though it did acknowledge some historical contamination during a recent site visit). Walter Kutschke, an engineer for Aecom, an engineering firm contracted by the authority, confirmed the 27 billion-gallon figure, however, under cross-examination.

While the plant's history is not at issue in the current trial, lawyers for the environmental law center cited it in arguing that smaller coal ash leaks were still occurring at Gallatin.

The authority has had more recent challenges in dealing with coal ash: In 2008, an ash pond dike at its Kingston Fossil Plant in eastern Tennessee collapsed, releasing just over a billion gallons of coal ash water into the Emory River, which flows into two other rivers, including the Tennessee.

The slurry released in that spill, which has been called the largest environmental disaster of its kind, buried 300 acres of land in toxic sludge. That sludge was taken to an unlined landfill in Alabama, just outside a predominantly African-American community, prompting challenges under federal civil rights law.

The spill helped spur the E.P.A. to create new rules regulating coal ash storage, and the Tennessee Valley Authority has begun to comply by draining and capping many of its ash ponds and storing future coal ash in dry landfills.

Gallatin's coal ash problems do not approach the scale of earlier disasters, but people and communities are still affected. The City of Gallatin, which gets its drinking water from the river, at a spot about a mile downstream from the plant, said in a 2014 report that the coal plant represented a threat to its water supply.

John Kammeyer, the Tennessee Valley Authority's vice president for civil projects, who manages its coal ash storage, said the state had acknowledged the issue of seepage from coal ash ponds, which is allowed in certain circumstances. "If we thought we were doing anything unsafe or untoward, we wouldn't do it," Mr. Kammeyer said.

Source: *New York Times* website. A version of this article appeared in print on April 16, 2017, in the Climate section on Page A11 of the New York edition with the headline: Hidden Peril Of Coal Ash To the Water Many Drink.

Jurassic drop in ocean oxygen lasted a million years

Dramatic drops in oceanic oxygen, which cause mass extinctions of sea life, come to a natural end -- but it takes about a million years.



The Pacific Ocean. Credit: Copyright Michele Hogan

Dramatic drops in oceanic oxygen, which cause mass extinctions of sea life, come to a natural end -- but it takes about a million years.

The depletion of oxygen in the oceans is known as "anoxia," and scientists from the University of Exeter have been studying how periods of anoxia end.

They found that the drop in oxygen causes more organic carbon to be buried in sediment on the ocean floor, eventually leading to rising oxygen in the atmosphere which ultimately re-oxygenates the ocean.

Scientists believe the modern ocean is "on the edge of anoxia" -- and the Exeter researchers say it is "critical" to limit carbon emissions to prevent this.

"Once you get into a major event like anoxia, it takes a long time for the Earth's system to rebalance," said lead researcher Sarah Baker, a geographer at the University of Exeter. "This shows the vital importance of limiting disruption to the carbon cycle to regulate the Earth system and keep it within habitable bounds."

The researchers, who also include Professor Stephen Hesselbo from the Camborne School of Mines, studied the Toarcian Oceanic Anoxic Event, which took place 183 million years ago and was characterized by a major disturbance to the global carbon cycle, depleted oxygen in Earth's oceans and mass extinction of marine life.

Numerical models predicted that increased burial of organic carbon -- due to less decomposition and more plant and marine productivity in the warmer, carbon-rich environment -- should drive a rise in atmospheric oxygen, causing the end of an anoxic event after one million years.

To test the theory, the scientists examined fossil charcoal samples to see evidence of wildfires -- as such fires would be more common in oxygen-rich times. They found a period of increased wildfire activity started one million years after the onset of the anoxic event, and lasted for about 800,000 years.

"We argue that this major increase in fire activity was primarily driven by increased atmospheric oxygen," said Baker. "Our study provides the first fossil-based evidence that such a change in atmospheric oxygen levels could occur in a period of one million years."

The increase in fire activity may have also helped end ocean anoxia by burning and reducing the amount of plants on land.

This is because plants can help to erode rocks on the land that contain nutrients needed for marine life -- therefore with fewer plants, fewer nutrients are

available to be carried to the sea and used to support marine life in the oceans.

Less marine life -- that would use oxygen to breathe -- would mean less oxygen being used in the oceans, and could therefore help the oceans to build up a higher oxygen content, ending anoxia.

It may therefore be essential to maintain the natural functioning of wildfire activity to help regulate the Earth system in the long-term, the researchers say.

The charcoal sediment tests were carried out at Mochras in Wales and Peniche, Portugal. The research was funded by the Natural Environment Research Council (NERC).

Story Source: Materials provided by University of Exeter.

Journal Reference: Sarah J. Baker, Stephen P. Hesselbo, Timothy M. Lenton, Luís V. Duarte, Claire M. Belcher. **Charcoal evidence that rising atmospheric oxygen terminated Early Jurassic ocean anoxia.** *Nature Communications*, 2017; 8: 15018 DOI: 10.1038/ncomms15018.

Earthquakes can make thrust faults open violently and snap shut

Experiments reveal a new mechanism that could explain the source of a destructive feature of the 2011 Tohoku earthquake

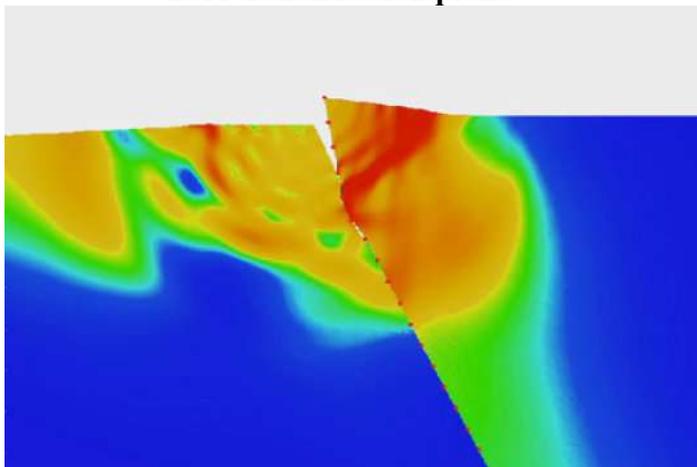


Illustration based on computer model shows how the hanging wall (right) of a thrust fault can twist away from the foot wall (left) during an earthquake.

Credit: Harsha Bhat/ENS

It is a common trope in disaster movies: an earthquake strikes, causing the ground to rip open and swallow people and cars whole. The gaping earth might make for cinematic drama, but earthquake scientists have long held that it does not happen.

Except -- it can, according to new experimental research from Caltech.

The work, appearing in the journal *Nature* on May 1, shows how the earth can split open -- and then quickly close back up -- during earthquakes along thrust faults.

Thrust faults have been the site of some of the world's largest quakes, such as the 2011 Tohoku earthquake off the coast of Japan, which damaged the Fukushima nuclear power plant. They occur in weak areas of the earth's crust where one slab of rock compresses against another, sliding up and over it during an earthquake.

A team of engineers and scientists from Caltech and École normale supérieure (ENS) in Paris have discovered that fast ruptures propagating up toward the earth's surface along a thrust fault can cause one side of a fault to twist away from the other, opening up a gap of up to a few meters that then snaps shut.

Thrust fault earthquakes generally occur when two slabs of rock press against one another, and pressure overcomes the friction holding them in place. It has long been assumed that, at shallow depths the plates would just slide against one another for a short distance, without opening.

However, researchers investigating the Tohoku earthquake found that not only did the fault slip at shallow depths, it did so by up to 50 meters in some places. That huge motion, which occurred just offshore, triggered a tsunami that caused damage to facilities along the coast of Japan, including at the Fukushima Daiichi Nuclear Power Plant.

In the *Nature* paper, the team hypothesizes that the Tohoku earthquake rupture propagated up the fault and -- once it neared the surface -- caused one slab of rock to twist away from another, opening a gap and momentarily removing any friction between the two walls. This allowed the fault to slip 50 meters.

That opening of the fault was supposed to be impossible.

"This is actually built into most computer models of earthquakes right now. The models have been programed in a way that dictates that the walls of the fault cannot separate from one another," says Ares Rosakis, Theodore von Kármán Professor of Aeronautics and Mechanical Engineering at Caltech and one of the senior authors of the *Nature* paper. "The findings demonstrate the value of experimentation and observation. Computer models can only be as realistic as their built-in assumptions allow them to be."

The international team discovered the twisting phenomenon by simulating an earthquake in a Caltech facility that has been unofficially dubbed the "Seismological Wind Tunnel." The facility started as a collaboration between Rosakis, an engineer studying how materials fail, and Hiroo Kanamori, a seismologist exploring the physics of earthquakes and a coauthor of the Nature study. "The Caltech research environment helped us a great deal to have close collaboration across different scientific disciplines," Kanamori said. "We seismologists have benefited a great deal from collaboration with Professor Rosakis's group, because it is often very difficult to perform experiments to test our ideas in seismology."

At the facility, researchers use advanced high-speed optical diagnostics to study how earthquake ruptures occur. To simulate a thrust fault earthquake in the lab, the researchers first cut in half a transparent block of plastic that has mechanical properties similar to that of rock. They then put the broken pieces back together under pressure, simulating the tectonic load of a fault line. Next, they place a small nickel-chromium wire fuse at the location where they want the epicenter of the quake to be. When they set off the fuse, the friction at the fuse's location is reduced, allowing a very fast rupture to propagate up the miniature fault. The material is photoelastic, meaning that it visually shows -- through light interference as it travels in the clear material -- the propagation of stress waves. The simulated quake is recorded using high-speed cameras and the resulting motion is captured by laser velocimeters (particle speed sensors).

"This is a great example of collaboration between seismologists, tectonicists and engineers. And not to put too fine a point on it, US/French collaboration," says Harsha Bhat, coauthor of the paper and a research scientist at ENS. Bhat was previously a postdoctoral researcher at Caltech.

The team was surprised to see that, as the rupture hit the surface, the fault twisted open and then snapped shut. Subsequent computer simulations -- with models that were modified to remove the artificial rules against the fault opening -- confirmed what the team observed experimentally: one slab can twist violently away from the other. This can happen both on land and on underwater thrust faults, meaning that this mechanism has the potential to change our understanding of how tsunamis are generated.

Story Source: Materials provided by California Institute of Technology. Original written by Robert Perkins.

Journal Reference: Vahe Gabuchian, Ares J. Rosakis, Harsha S. Bhat, Raúl Madariaga, Hiroo

Kanamori. **Experimental evidence that thrust earthquake ruptures might open faults.** *Nature*, 2017; DOI: 10.1038/nature22045.

Paleontologists identify new 507-million-year-old sea creature with can opener-like pincers

Discovery points to origin of millipedes, crabs and insects among other species



This specimen of *Tokummia katalepsis* shows a number of strong legs on the left partially protruding from the body, the shape of the bivalved carapace and dozens of small paddle-like limbs below the trunk at the lower right. This nearly complete fossil was chosen as the main reference for the new genus *Tokummia* and new species *katalep*.

*Credit: Photo courtesy of Jean-Bernard Caron;
Copyright: Royal Ontario Museum*

Paleontologists at the University of Toronto (U of T) and the Royal Ontario Museum (ROM) have uncovered a new fossil species that sheds light on the origin of mandibulates, the most abundant and diverse group of organisms on Earth, to which belong familiar animals such as flies, ants, crayfish and centipedes. The finding was announced in a study published today in *Nature*.

The creature, named *Tokummia katalepsis* by the researchers, is a new and exceptionally well-preserved fossilized arthropod -- a ubiquitous group of invertebrate animals with segmented limbs and hardened exoskeletons. *Tokummia* documents for the first time in detail the anatomy of early "mandibulates," a hyperdiverse sub-group of arthropods which possess a pair of specialized appendages known as mandibles, used to grasp, crush and cut their food. Mandibulates include millions of

species and represent one of the greatest evolutionary and ecological success stories of life on Earth.

"In spite of their colossal diversity today, the origin of mandibulates had largely remained a mystery," said Cédric Aria, lead author of the study and recent graduate of the PhD program in the Department of Ecology & Evolutionary Biology at U of T, now working as a post-doctoral researcher at the Nanjing Institute for Geology and Palaeontology, in China. "Before now we've had only sparse hints at what the first arthropods with mandibles could have looked like, and no idea of what could have been the other key characteristics that triggered the unrivaled diversification of that group."

Tokummia lived in a tropical sea teeming with life and was among the largest Cambrian predators, exceeding 10 cm in length fully extended. An occasional swimmer, the researchers conclude its robust anterior legs made it a preferred bottom-dweller, as lobsters or mantis shrimps today. Specimens come from 507 million-year-old sedimentary rocks near Marble Canyon in Kootenay national park, British Columbia. Most specimens at the basis of this study were collected during extensive ROM-led fieldwork activities in 2014.

"This spectacular new predator, one of the largest and best preserved soft-bodied arthropods from Marble Canyon, joins the ranks of many unusual marine creatures that lived during the Cambrian Explosion, a period of rapid evolutionary change starting about half a billion years ago when most major animal groups first emerged in the fossil record," said co-author Jean-Bernard Caron, senior curator of invertebrate paleontology at the ROM and an associate professor in the Departments of Ecology & Evolutionary Biology and Earth Sciences at U of T.

Analysis of several fossil specimens, following careful mechanical preparation and photographic work at the ROM, showed that Tokummia sported broad serrated mandibles as well as large but specialized anterior claws, called maxillipeds, which are typical features of modern mandibulates.

"The pincers of Tokummia are large, yet also delicate and complex, reminding us of the shape of a can opener, with their couple of terminal teeth on one claw, and the other claw being curved towards them," said Aria. "But we think they might have been too fragile to be handling shelly animals, and might have been better adapted to the capture of sizable soft prey items, perhaps hiding away in mud. Once torn apart by the spiny limb bases under the trunk, the mandibles would have served as a revolutionary tool to cut the flesh into small, easily digestible pieces."

The body of Tokummia is made of more than 50 small segments covered by a broad two-piece shell-like structure called a bivalved carapace. Importantly, the animal bears subdivided limb bases with tiny projections called endites, which can be found in the larvae of certain crustaceans and are now thought to have been critical innovations for the evolution of the various legs of mandibulates, and even for the mandibles themselves.

The many-segmented body is otherwise reminiscent of myriapods, a group that includes centipedes, millipedes, and their relatives. "Tokummia also lacks the typical second antenna found in crustaceans, which illustrates a very surprising convergence with such terrestrial mandibulates," said Aria.

The study also resolves the affinities of other emblematic fossils from Canada's Burgess Shale more than a hundred years after their discovery. "Our study suggests that a number of other Burgess Shale fossils such as Branchiocaris, Canadaspis and Odaraia form with Tokummia a group of crustacean-like arthropods that we can now place at the base of all mandibulates," said Aria.

The animal was named after Tokumm Creek, which flows through Marble Canyon in northern Kootenay National Park, and the Greek for "seizing." The Marble Canyon fossil deposit was first discovered in 2012 during prospection work led by the Royal Ontario Museum and is part of the Burgess Shale fossil deposit, which extends to the north into Yoho National Park in the Canadian Rockies. All specimens are held in the collections of the Royal Ontario Museum on behalf of Parks Canada.

The Burgess Shale fossil sites are located within Yoho and Kootenay national parks in British Columbia. The Burgess Shale was designated a UNESCO World Heritage Site in 1980. Parks Canada is proud to protect these globally significant paleontological sites, and to work with leading scientific researchers to expand knowledge and understanding of this key period of earth history. New information from ongoing scientific research is continually incorporated into Parks Canada's Burgess Shale education and interpretation programs, which include guided hikes to these outstanding fossil sites.

Story Source: Materials provided by University of Toronto.

Journal Reference: Cédric Aria, Jean-Bernard Caron. **Burgess Shale fossils illustrate the origin of the mandibulate body plan.** *Nature*, 2017; DOI: 10.1038/nature22080.

Cold extermination: One of greatest mass extinctions was due to an ice age and not to Earth's warming



Permian-Triassic boundary in shallow marine sediments, characterised by a significant sedimentation gap between the black shales of Permian and dolomites of Triassic age. This gap documents a globally-recognised regression phase, probably linked to a period of a cold climate and glaciation. Credit: © H. Bucher, Zürich

Earth has known several mass extinctions over the course of its history. One of the most important happened at the Permian-Triassic boundary 250 million years ago. Over 95% of marine species disappeared and, up until now, scientists have linked this extinction to a significant rise in Earth temperatures. But researchers from the University of Geneva (UNIGE), Switzerland, working alongside the University of Zurich, discovered that this extinction took place during a short ice age that preceded the global climate warming. It's the first time that the various stages of a mass extinction have been accurately understood and that scientists have been able to assess the major role played by volcanic explosions in these climate processes. This research, which can be read in *Scientific Reports*, completely calls into question the scientific theories regarding these phenomena, founded on the increase of CO₂ in the atmosphere, and paves the way for a new vision of Earth's climate history.

Teams of researchers led by Professor Urs Schaltegger from the Department of Earth and Environmental Sciences at the Faculty of Science of the UNIGE and by Hugo Bucher, from the University of Zürich, have

been working on absolute dating for many years. They work on determining the age of minerals in volcanic ash, which establishes a precise and detailed chronology of Earth's climate evolution. They became interested in the Permian-Triassic boundary, 250 million years ago, during which one of the greatest mass extinctions ever took place, responsible for the loss of 95% of marine species. How did this happen? for how long marine biodiversity stayed at very low levels?

A technique founded on the radioactive decay of uranium.

Researchers worked on sediment layers in the Nanpanjiang basin in southern China. They have the particularity of being extremely well preserved, which allowed for an accurate study of the biodiversity and the climate history of the Permian and the Triassic. "We made several cross-sections of hundreds of metres of basin sediments and we determined the exact positions of ash beds contained in these marine sediments," explained Björn Baresel, first author of the study. They then applied a precise dating technique based on natural radioactive decay of uranium, as Urs Schaltegger added: "In the sedimentary cross-sections, we found layers of volcanic ash containing the mineral zircon which incorporates uranium. It has the specificity of decaying into lead over time at a well-known speed. This is why, by measuring the concentrations of uranium and lead, it was possible for us to date a sediment layer to an accuracy of 35,000 years, which is already fairly precise for periods over 250 million years." Ice is responsible for mass extinction

By dating the various sediment layers, researchers realized that the mass extinction of the Permian-Triassic boundary is represented by a gap in sedimentation, which corresponds to a period when the seawater level decreased. The only explanation to this phenomenon is that there was ice, which stored water, and that this ice age that lasted 80,000 years was sufficient to eliminate much of marine life. Scientists from the UNIGE explain the global temperature drop by a stratospheric injection of large amounts of sulfur dioxide reducing the intensity of solar radiation reaching the surface of Earth. "We therefore have proof that the species disappeared during an ice age caused by the activity of the first volcanism in the Siberian Traps," added Urs Schaltegger. This ice age was followed by the formation of limestone deposits through bacteria, marking the return of life on Earth at more moderate temperatures. The period of intense climate warming, related to the emplacement of large amounts of basalt of the Siberian Traps and which we previously

thought was responsible for the extinction of marine species, in fact happened 500,000 years after the Permian-Triassic boundary.

This study therefore shows that climate warming is not the only explanation of global ecological disasters in the past on Earth: it is important to continue analyzing ancient marine sediments to gain a deeper understanding of Earth's climate system.

Story Source: Materials provided by Université de Genève.

Journal Reference: Björn Baresel, Hugo Bucher, Borhan Bagherpour, Morgane Brosse, Kuang Guodun, Urs Schaltegger. **Timing of global regression and microbial bloom linked with the Permian-Triassic boundary mass extinction: implications for driving mechanisms.** *Scientific Reports*, 2017; 7: 43630 DOI: 10.1038/srep43630.

Large Sections of Australia's Great Reef Are Now Dead, Scientists Find



Severe bleaching last year on the northern Great Barrier Reef affected even the largest and oldest corals, like this slow-growing Porites colony.

Credit: Terry Hughes et al./Nature

SYDNEY, Australia — The Great Barrier Reef in Australia has long been one of the world's most magnificent natural wonders, so enormous it can be seen from space, so beautiful it can move visitors to tears. But the reef, and the profusion of sea creatures living near it, is in profound trouble.

Huge sections of the Great Barrier Reef, stretching across hundreds of miles of its most pristine northern sector, were recently found to be dead, killed last year by overheated seawater. More southerly sections around the middle of the reef that barely escaped then are bleaching now, a potential precursor to another

die-off that could rob some of the reef's most visited areas of color and life.

“We didn't expect to see this level of destruction to the Great Barrier Reef for another 30 years,” said Terry P. Hughes, director of a government-funded center for coral reef studies at James Cook University in Australia and the lead author of a paper on the reef recently published as the cover article of the journal *Nature*. “In the north, I saw hundreds of reefs — literally two-thirds of the reefs were dying and are now dead.”

The damage to the Great Barrier Reef, one of the world's largest living structures, is part of a global calamity that has been unfolding intermittently for nearly two decades and seems to be intensifying. In the paper, dozens of scientists described the recent disaster as the third worldwide mass bleaching of coral reefs since 1998, but by far the most widespread and damaging.

The state of coral reefs is a telling sign of the health of the seas. Their distress and death are yet another marker of the ravages of global climate change.

If most of the world's coral reefs die, as scientists fear is increasingly likely, some of the richest and most colorful life in the ocean could be lost, along with huge sums from reef tourism. In poorer countries, lives are at stake: Hundreds of millions of people get their protein primarily from reef fish, and the loss of that food supply could become a humanitarian crisis.

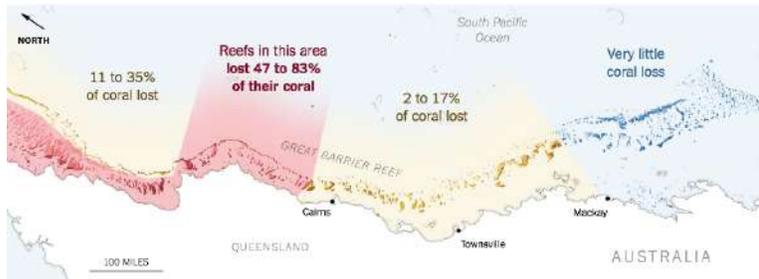
With this latest global bleaching in its third year, reef scientists say they have no doubt as to the responsible party. They warned decades ago that the coral reefs would be at risk if human society kept burning fossil fuels at a runaway pace, releasing greenhouse gases that warm the ocean. Emissions continued to rise, and now the background ocean temperature is high enough that any temporary spike poses a critical risk to reefs.

“Climate change is not a future threat,” Professor Hughes said. “On the Great Barrier Reef, it's been happening for 18 years.” Corals require warm water to thrive, but they are exquisitely sensitive to extra heat. Just two or three degrees Fahrenheit of excess warming can sometimes kill the tiny creatures.

Globally, the ocean has warmed by about 1.5 degrees Fahrenheit since the late 19th century, by a conservative calculation, and a bit more in the tropics, home to many reefs. An additional kick was supplied by an El Niño weather pattern that peaked in 2016 and temporarily warmed much of the surface of the planet, causing the hottest year in a historical record dating to 1880.

Bleaching indicates that corals are under heat stress, but they do not always die and cooler water can help them recover. Subsequent surveys of the Great Barrier Reef, conducted late last year after the deadline for inclusion in the Nature paper, documented that extensive patches of reef had in fact died, and would not be likely to recover soon, if at all.

Professor Hughes led aerial surveys that found that 67



percent of the corals had died in a long stretch north of Port Douglas, and in patches, the mortality reached 83 percent. By luck, a storm stirred the waters in the central and southern parts of the reef at a critical moment, cooling them, and mortality there was much lower — about 6 percent in a stretch off Townsville, and even lower in the southernmost part of the reef

NOTE: Individual reefs within each region lost different amounts of coral. Numbers show the range of loss for the middle 50% of observations in each region. Source: ARC Centre of Excellence for Coral Reef Studies

But an Australian government study released last week found that over all, last year brought “the highest sea surface temperatures across the Great Barrier Reef on record.”

Only 9 percent of the reef has avoided bleaching since 1998, Professor Hughes said, and now, the less remote, more heavily visited stretch from Cairns south is in trouble again. Water temperatures there remain so high that another round of mass bleaching is underway, the Great Barrier Reef Marine Park Authority confirmed last week.

The Australian government has tried to combat these local threats with its Reef 2050 plan, restricting port development, dredging and agricultural runoff, among other risks. But Professor Hughes’s research found that, given the high temperatures, these national efforts to improve water quality were not enough.

“The reefs in muddy water were just as fried as those in pristine water,” Professor Hughes said. “That’s not good news in terms of what you can do locally to prevent bleaching — the answer to that is not very much at all. You have to address climate change directly.”

With the election of Donald J. Trump as the American president, a recent global deal to tackle the problem, known as the Paris Agreement, seems to be in peril. Australia’s conservative government also continues to support fossil fuel development, including what many scientists and conservationists see as the reef’s most immediate threat — a proposed coal mine, among the world’s largest, to be built inland from the reef by the Adani Group, a conglomerate based in India. “The fact is, Australia is the largest coal exporter in the world, and the last thing we should be doing to our greatest national asset is making the situation worse,” said Imogen Zethoven, campaign director for the Australian Marine Conservation Society.

Australia relies on the Great Barrier Reef for about 70,000 jobs and billions of dollars annually in tourism revenue, and it is not yet clear how that economy will be affected by the reef’s deterioration. Even in hard-hit areas, large patches of the Great Barrier Reef survived, and guides will most likely take tourists there, avoiding the dead zones.

The global reef crisis does not necessarily mean extinction for coral species. The corals may save themselves, as many other creatures are attempting to do, by moving toward the poles as the Earth warms, establishing new reefs in cooler water. But the changes humans are causing are so rapid, by geological standards, that it is not entirely clear that coral species will be able to keep up.

Coral reefs are sensitive systems, built by unusual animals. The corals themselves are tiny polyps that act like farmers, capturing colorful single-celled plants called algae that convert sunlight into food. The coral polyps form colonies and build a limestone scaffolding on which to live — a reef.

But when the water near a reef gets too hot, the algae begin producing toxins, and the corals expel them in self-defense, turning ghostly white. If water temperatures drop soon enough, the corals can grow new algae and survive, but if not, they may succumb to starvation or disease.

Even when the corals die, some reefs eventually recover. If water temperatures stay moderate, the damaged sections of the Great Barrier Reef may be covered with corals again in as few as 10 or 15 years.

Within a decade, certain kinds of branching and plate coral could be extinct, reef scientists say, along with a variety of small fish that rely on them for protection from predators.

Source: New York Times article by Damien Cave and Justin Gillis, March 15, 2017 Climate section.

NORTHERN CALIFORNIA GEOLOGICAL SOCIETY



NCGS DINNER MEETING Wednesday May 31, 2017
Orinda Masonic Center, 9 Altarinda Road, Orinda, CA

The Rise and Fall of Sierra Nevada Glaciers

Dr. Greg Stock, National Park Service

(Reservations are required by May 26, 2017; Limit 100 persons)
We are sorry, but we will not be able to accommodate “walk-ins”

The NCGS is pleased to host this *special dinner meeting* with **Dr. Stock**. This annual event will be catered by *Back Forty Texas BBQ* and consist of *Pork Ribs and BBQ Chicken, Tossed Green Salad, BBQ Beans, and Fresh Corn Cobettes*. A *deluxe veggie burger* is available upon request (see below). *Dessert will include assorted cookies and brownies. Wine will also be served.*

Dr. Greg Stock is the first-ever Park Geologist at Yosemite National Park. He has B.S. and Ph.D. (U.C. Santa Cruz) degrees in geology and earth science, and was a researcher at the University of Michigan prior to accepting the job at Yosemite in 2006. Greg's research interests are primarily in geomorphology, and include glacial erosion, river dynamics, and hillslope processes such as rock falls and debris flows.

*******Dinner Logistics*******

Social Hour: 6:00 – 6:45 pm; **Dinner:** 6:45 – 8:00 pm; **Presentation:** 8:00 – 9:00 pm
Cost: \$25/person

*****✂*******Registration*******

Name(s): _____

E-mail: _____

Phone (day): _____ Phone (cell) _____

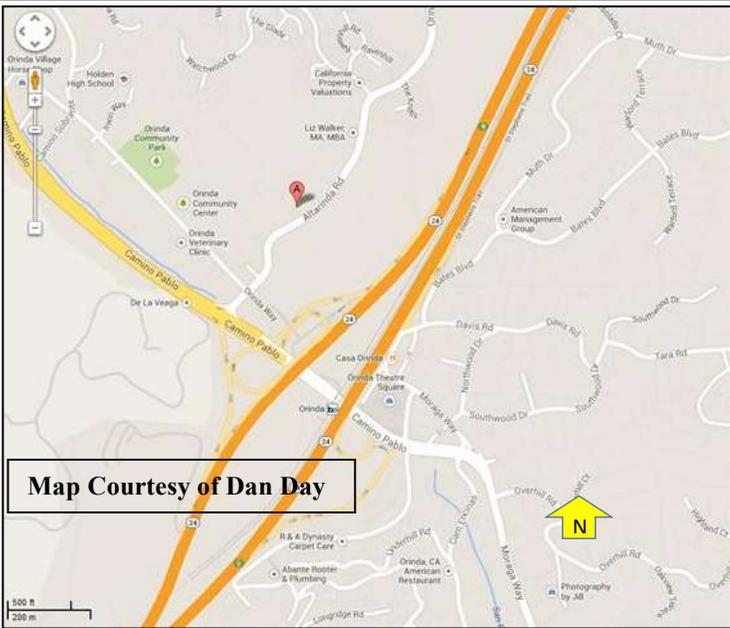
Check one per person: Regular Dinner: ____ Vegetarian: ____ # Attending _____ Check Amount: _____

Please clip and mail this registration form with a check made out to NCGS to:

Barbara Matz, 803 Orion #2, Hercules CA 94547

Questions: e-mail barbara.matz@cbifederalservices.com; Phone: (415) 713-8482

was a researcher at the University of Michigan prior to accepting the job at Yosemite in 2006. Greg's research interests are primarily in geomorphology, and include glacial erosion, river dynamics, and hillslope processes such as rock falls and debris flows.



Northern California Geological Society
c/o Mark Sorensen
734 14th Street, #2
San Francisco, CA 94114

Would you like to receive the NCGS newsletter by e-mail? If you are not already doing so, and would like to, please contact Tom Barry at tomasbarry@aol.com to sign up for this free service.