# NORTHERN CALIFORNIA GEOLOGICAL SOCIETY

Website: www.ncgeolsoc.org



## MEETING ANNOUNCEMENT

**DATE:** **June 28, 2017**

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

**TIME:** **6:30 – 7:00 p.m.: Social; 7:00 p.m.: Presentation**

**SPEAKER:** ***Matthew James, Professor of Geology and Paleontology, Sonoma State University***

**TOPIC:** ***Collecting Evolution: The Galapagos Expedition that Vindicated Darwin***

In 1905, eight sailor-scientists from the California Academy of Sciences set out on an 89-foot schooner from San Francisco for a scientific collection expedition in the Galapagos Islands. By the time they finished in 1906, they had completed one of the most important expeditions in the history of both evolutionary and conservation science. They brought back over 78,000 specimens, validating the ideas of Charles Darwin and laid the groundwork for foundational evolution texts like *Darwin's Finches*. Despite its significance, no longer treatment has appeared on this voyage, lost amongst discussion of Darwin's trip on HMS *Beagle*. In my new book *Collecting Evolution*, I tell the story of the 1905-06 Galapagos expedition in terms of why they went, what they did, and what it means today. I follow these eight young men aboard the schooner *Academy* to the Galapagos and back, and reveal their personal stories and groundbreaking success in historical context.

**Biography:** Matthew James is a Fellow of the California Academy of Sciences, and Professor of Geology and Paleontology at Sonoma State University in northern California. He has been writing about the Galapagos in historical, scientific, and research capacities for thirty-five years.

# *NCGS 2017 – 2018 Calendar*

**September 27, 2017 7:00 pm**
**Dr. Slawomir M. Tulaczyk, UC Santa Cruz**

***Glaciology and recent behavior of the West Antarctic ice sheet***

**October 25, 2017 7:00 pm**
**Megan Nguyen, UC Davis Center for Watershed Sciences**

***Title to be determined***

**November 29, 2017**
**Dr. Marjorie Schulz, USGS**

***Marine Terraces of California: Landscapes from the Waves***

## 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 at 141 McCone Hall on Thursdays at 4 pm for most of 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 Outreach Activity

A recent outreach event was held on May 21st at the El Cerrito Hillside Celebration. In addition to the NCGS rock and mineral display, Bill Motzer led a short geology walk at the quarry site (investigated by John Wakabayashi) from 2 to 3 pm.

**Outreach Events**

Using rocks and fossils from the Greater Bay Area we generate interest with the geological, biological and historical stories behind them and the connections between them. If you enjoy sharing your knowledge of geology with friends, family and others you will enjoy a day of doing this. No doubt.

Come and join us by helping to attend our booth! You may meet some interesting people; generate a youngster's interest in rocks and geology; help to raise our visibility; and may even re-learn some of our locally significant rocks and minerals! Our next event:

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

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

If you are interested in helping attend the NCGS booth, please contact Mark Petrofsky at 510-526-4944 or mpetrof@hotmail.com.

## Silent Auction at the June Meeting

There will be some field trip guides available for "Silent Auction" at the June Meeting, including some excellent titles. Bidding will start at $10 to $15. All proceeds will go to the NCGS field trip fund. Thanks to Paul Henshaw and Noelle Schoellkopf for organizing. At a minimum, the following guides will be available:

Geology of San Francisco & Vicinity: Field Trip Guidebook T105 by Clyde Wahrhaftig, July 1-7, 1989, AGU.

Late Cenozoic Geology in the North Bay Region: Field Trip Guide & References, T.L. Wright (ed.), May 16, 1992, NCGS.

Geology of the Mount Diablo Region: Field Trip Guide & References by R. Crane & C.A. Lyon, April-May 1994, NCGS.

The Franciscan Complex & the San Andreas Fault from the Golden Gate to Point Reyes, California: Field Trip & References, J.R. Kleist et al., May 1981, PS-AAPG vol. 51.

Geology of the Point Reyes Peninsula, Marin County, California by A.J. Galloway, 1997, California Division of Mines & Geology Bulletin 202.

Geology and Tectonics of the Gualala Block, Northern California: W.P. Elder (ed.), Oct 1998, SEPM Pacific Section.

Gualala River Watershed Literature Search & Assimilation by P. Higgins, ~1998.

Thermal Springs & Wells and Radiometric Ages of Rocks in the Santa Rosa Quadrangle, California: F.R. Kelley (compiled), 1979-1981, California Div Mines Geol.

Geology & Tectonics of the Southern Sacramento Valley and Adjacent Coast Ranges: E.M. Moores (Ed.), Oct 1993, NCGS.

Guide to the Monterey Formation in the California Coastal Area, Ventura to San Luis Obispo: C.M. Isaacs (Ed.), May 1981, PS-AAPG.

Itinerary for the U.S.-U.S.S.R. Cooperative Field Workshop: Granitic Batholiths by G.H. Brimhall & J.J. Ague, Fall 1990.

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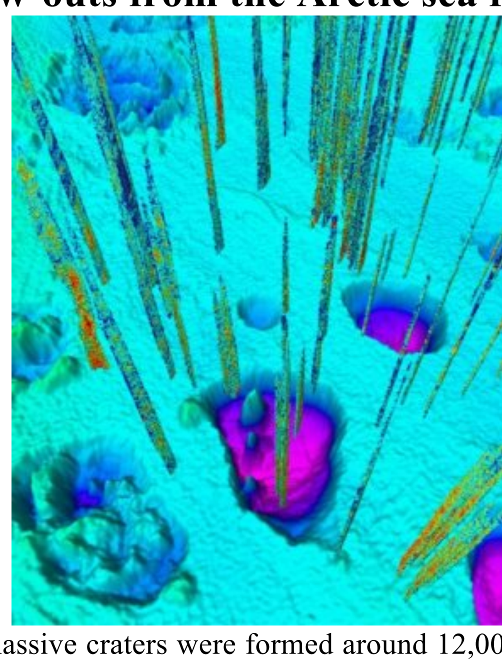
## Massive craters formed by methane blow-outs from the Arctic sea floor



The massive craters were formed around 12,000 years ago, but are still seeping methane and other gases.

*Illustration Credit: Andreia Plaza Faverola/CAGE*

Even though the craters were formed some 12,000 years ago, methane is still leaking profusely from the craters. Methane is a potent greenhouse gas, and of major concern in our warming climate.

"The crater area was covered by a thick ice sheet during the last ice age, much as West Antarctica is today. As climate warmed, and the ice sheet collapsed, enormous amounts of methane were abruptly released. This created massive craters that are still actively seeping methane " says Karin Andreassen, first author of the study and professor at CAGE Centre for Arctic Gas Hydrate, Environment and Climate.

Today more than 600 gas flares are identified in and around these craters, releasing the greenhouse gas steadily into the water column.

"But that is nothing compared to the blow-outs of the greenhouse gas that followed the deglaciation. The amounts of methane that were released must have been quite impressive."

**Siberian craters small in comparison**

A few of these craters were first observed in the 1990s. But new technology shows that the craters cover a much larger area than previously thought and provides more detailed imaging for interpretation

"We have focused on craters that are 300 meters to 1 kilometer wide, and have mapped approximately 100 craters of this size in the area. But there are also many hundred smaller ones, less than 300 meters wide that is" says Andreassen.

In comparison, the huge blow-out craters on land on the Siberian peninsulas Yamal and Gydan are 50-90 meters wide, but similar processes may have been involved in their formation.

The Arctic ocean floor hosts vast amounts of methane trapped as hydrates, which are ice-like, solid mixtures of gas and water. These hydrates are stable under high pressure and cold temperatures. The ice sheet provides perfect conditions for subglacial gas hydrate formation, in the past as well as today.

**Unbearable pressure builds up**

Some 2000 meters of ice loaded what now is ocean floor with heavy weight. Under the ice, methane gas from deeper hydrocarbon reservoirs moved upward, but could not escape. It was stored as gas hydrate in the sediment, constantly fed by gas from below, creating over-pressured conditions.

"As the ice sheet rapidly retreated, the hydrates concentrated in mounds, and eventually started to melt, expand and cause over-pressure. The principle is the same as in a pressure cooker: if you do not control the release of the pressure, it will continue to build up until there is a disaster in your kitchen. These mounds were over-pressured for thousands of years, and then the lid came off. They just collapsed releasing methane into the water column" says Andreassen.

**Similar processes are ongoing under ice sheets today**

Major methane venting events such as this appear to be rare, and may therefore easily be overlooked.

"Despite their infrequency, the impact of such blow-outs may still be greater than impact from slow and gradual seepage. It remains to be seen whether such abrupt and massive methane release could have reached the atmosphere. We do estimate that an area of hydrocarbon reserves twice the size of Russia was directly influenced by ice sheets during past glaciation. This means that a much larger area may have had similar abrupt gas releases in the overlapping time period " says Andreassen

Another fact to consider is that there are reserves of hydrocarbons beneath the load of West Antarctica and Greenland ice sheets today.

"Our study provides the scientific community with a good past analog for what may happen to future methane releases in front of contemporary, retreating ice sheets" concludes Andreassen.

**Story Source:** Materials provided by CAGE – Center for Arctic Gas Hydrate, Climate and Environment (The Arctic University of Norway, Tromso).

**Journal Reference**: K. Andreassen, et al. **Massive blow-out craters formed by hydrate-controlled methane expulsion from the Arctic seafloor**. *Science*, June 2017 DOII: 10.1126/science.aa14500.

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# Earliest human-made climate change took place 11,500 years ago

### The earliest geological indication of humans' impact on the environment discovered in the Dead Sea, Tel Aviv University researchers say

The vast majority of climate scientists agree that climate-warming trends over the past century have been due to human activities. A new Tel Aviv University study has uncovered the earliest known geological indications of human-made climate change from 11,500 years ago. Within a core sample retrieved from the Dead Sea, researchers discovered basin-wide erosion rates dramatically incompatible with known tectonic and climatic regimes of the period recorded.

"Human impact on the natural environment is now endangering the entire planet," said Prof. Shmuel Marco, Head of TAU's School of Geosciences, who led the research team. "It is therefore crucial to understand these fundamental processes. Our discovery provides a quantitative assessment for the commencement of significant human impact on the Earth's geology and ecosystems." The results of the study were published in *Global and Planetary Change*.

The research was conducted by TAU post-doctoral student Dr. Yin Lu and in collaboration with Prof. Dani Nadel and Prof. Nicolas Waldman, both of the University of Haifa. It took place as part of the Dead Sea Deep Drilling project, which harnessed a 1,500-foot-deep drill core to delve into the Dead Sea basin. The core sample provided the team with a sediment record of the last 220,000 years.

The newly-discovered erosion occurred during the Neolithic Revolution, the wide-scale transition of human cultures from hunting and gathering to agriculture and settlement. The shift resulted in an exponentially larger human population on the planet.

"Natural vegetation was replaced by crops, animals were domesticated, grazing reduced the natural plant cover, and deforestation provided more area for grazing," said Prof. Marco. "All these resulted in the intensified erosion of the surface and increased sedimentation, which we discovered in the Dead Sea core sample."

**A natural laboratory in the Dead Sea**

The Dead Sea drainage basin serves as a natural laboratory for understanding how sedimentation rates in a deep basin are related to climate change, tectonics, and human-made impacts on the landscape.

"We noted a sharp threefold increase in the fine sand that was carried into the Dead Sea by seasonal floods," said Prof. Marco. "This intensified erosion is incompatible with tectonic and climatic regimes during the Holocene, the geological epoch that began after the Pleistocene some 11,700 years ago."

The researchers are currently in the process of recovering the record of earthquakes from the same drill core. "We have identified disturbances in the sediment layers that were triggered by the shaking of the lake bottom," Prof. Marco said. "It will provide us with a 220,000-year record -- the most extensive earthquake record in the world."

**Story Source:** Materials provided by American Friends of Tel Aviv University.

**Journal Reference**: Yin Lu, Nicolas Waldmann, Dani Nadel, Shmuel Marco. **Increased sedimentation following the Neolithic Revolution in the Southern Levant**. *Global and Planetary Change*, 2017; 152: 199 DOI: 10.1016/j.gloplacha.2017.04.003

# How X-rays helped to solve mystery of floating rocks in the ocean

### Experiments at Berkeley Lab show scientists how pumice can remain buoyant for years

*These are pumice stones.*
*Credit: UC Berkeley, Berkeley Lab*

It's true -- some rocks can float on water for years at a time. And now scientists know how they do it, and what causes them to eventually sink.

X-ray studies at the Department of Energy's Lawrence Berkeley National Laboratory (Berkeley Lab) have helped scientists to solve this mystery by scanning inside samples of lightweight, glassy, and porous volcanic rocks known as pumice stones. The X-ray experiments were performed at Berkeley Lab's Advanced Light Source, an X-ray source known as a synchrotron.

The surprisingly long-lived buoyancy of these rocks -- which can form miles-long debris patches on the ocean known as pumice rafts that can travel for thousands of miles -- can help scientists discover underwater volcano eruptions.

And, beyond that, learning about its flotation can help us understand how it spreads species around the planet; pumice is nutrient-rich and readily serves as a seafaring carrier of plant life and other organisms. Floating pumice can also be a hazard for boats, as the ashy mixture of ground-up pumice can clog engines.

"The question of floating pumice has been around the literature for a long time, and it hadn't been resolved," said Kristen E. Fauria, a UC Berkeley graduate student who led the study, published in Earth and Planetary Science Letters.

While scientists have known that pumice can float because of pockets of gas in its pores, it was unknown how those gases remain trapped inside the pumice for prolonged periods. If you soak up enough water in a sponge, for example, it will sink.

"It was originally thought that the pumice's porosity is essentially sealed," Fauria said, like a corked bottle floating in the sea. But pumice's pores are actually largely open and connected -- more like an uncorked bottle. "If you leave the cap off and it still floats ... what's going on?"

Some pumice stones have even been observed to "bob" in the laboratory -- sinking during the evening and surfacing during the day.

To understand what's at work in these rocks, the team used wax to coat bits of water-exposed pumice sampled from Medicine Lake Volcano near Mount Shasta in Northern California and Santa María Volcano in Guatemala.

They then used an X-ray imaging technique at the ALS known as microtomography to study concentrations of water and gas -- in detail measured in microns, or thousandths of a millimeter -- within preheated and room-temperature pumice samples.

The detailed 3-D images produced by the technique are very data-intensive, which posed a challenge in quickly identifying the concentrations of gas and water present in the pumice samples' pores. To tackle this problem, Zihan Wei, a visiting undergraduate researcher from Peking University, used a data-analysis software tool that incorporates machine learning to automatically identify the gas and water components in the images.

Researchers found that the gas-trapping processes that are in play in the pumice stones relates to "surface tension," a chemical interaction between the water's surface and the air above it that acts like a thin skin -- this allows some creatures, including insects and lizards, to actually walk on water.

"The process that's controlling this floating happens on the scale of human hair," Fauria said. "Many of the pores are really, really small, like thin straws all wound up together. So surface tension really dominates."

The team also found that a mathematical formulation known as percolation theory, which helps to understand how a liquid enters a porous material, provides a good fit for the gas-trapping process in pumice. And gas diffusion -- which describes how gas molecules seek areas of lower concentration -- explains the eventual loss of these gases that causes the stones to sink.

Michael Manga, a staff scientist in Berkeley Lab's Energy Geosciences Division and a professor in the Department of Earth and Planetary Science at UC Berkeley who participated in the study, said, "There are two different processes: one that lets pumice float and one that makes it sink," and the X-ray studies helped to quantify these processes for the first time. The study showed that previous estimates for flotation time were in some cases off by several orders of magnitude.

"Kristen had the idea that in hindsight is obvious," Manga said, "that water is filling up only some of the pore space." The water surrounds and traps gases in the pumice, forming bubbles that make the stones buoyant. Surface tension serves to keep these bubbles locked inside for prolonged periods. The bobbing observed in laboratory experiments of pumice floatation is explained by trapped gas expanding during the heat of day, which causes the stones to temporarily float until the temperature drops.

The X-ray work at the ALS, coupled with studies of small pieces of pumice floating in water in Manga's UC Berkeley lab, helped researchers to develop a formula for predicting how long a pumice stone will typically float based on its size.

The recent study triggered more questions about floating pumice, Fauria said, such as how pumice, ejected from deep underwater volcanoes, finds its way to the surface. Her research team has also conducted X-ray experiments at the ALS to study samples from so-called "giant" pumice that measured more than a meter long.

That stone was recovered from the sea floor in the area of an active underwater volcano by a 2015 research expedition that Fauria and Manga participated in. The expedition, to a site hundreds of miles north of New Zealand, was co-led by Rebecca Carey, a scientist formerly affiliated with the Lab's ALS.

Underwater volcano eruptions are not as easy to track down as eruptions on land, and floating pumice spotted by a passenger on a commercial aircraft actually helped researchers track down the source of a major underwater eruption that occurred in 2012 and motivated the research expedition. Pumice stones spewed from underwater volcano eruptions vary widely in size but can typically be about the size of an apple, while pumice stones from volcanoes on land tend to be smaller than a golf ball.

"We're trying to understand how this giant pumice rock was made," Manga said. "We don't understand well how submarine eruptions work. This volcano erupted completely different than we hypothesized. Our hope is that we can use this one example to understand the process."

Fauria agreed that there is much to learn from underwater volcano studies, and she noted that X-ray studies at the ALS will play an ongoing role in her team's work.

**Story Source:** Materials provided by DOE/Lawrence Berkeley National Laboratory.

**Journal Reference**: Kristen E. Fauria, Michael Manga, Zihan Wei. **Trapped bubbles keep pumice afloat and gas diffusion makes pumice sink**. Earth and Planetary Science Letters, 2017; 460: 50 DOI: 10.1016/j.epsl.2016.11.055.

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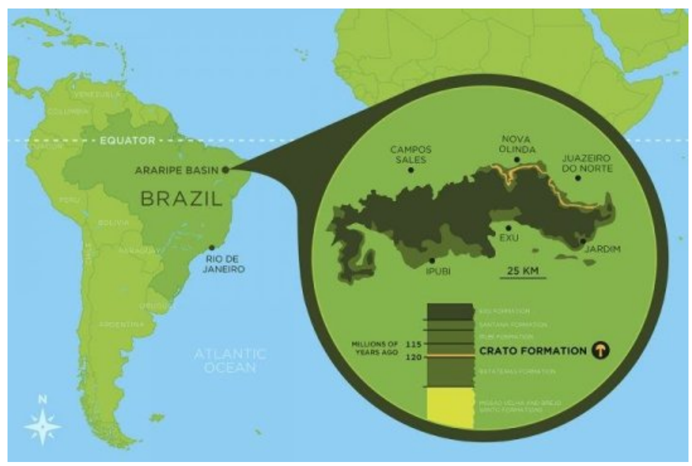
# World's oldest fossil mushroom found




The mushroom was uncovered in the Araripe Basin, in northeast Brazil, in a limestone layer called the Crato Formation.

*Credit: Graphic by Danielle Ruffatto*

Roughly 115 million years ago, when the ancient supercontinent Gondwana was breaking apart, a mushroom fell into a river and began an improbable journey. Its ultimate fate as a mineralized fossil preserved in limestone in northeast Brazil makes it a scientific wonder, scientists report in the journal *PLOS ONE*.

The mushroom somehow made its way into a highly saline lagoon, sank through the stratified layers of salty water and was covered in layer upon layer of fine sediments. In time -- lots of it -- the mushroom was mineralized, its tissues replaced by pyrite (fool's gold), which later transformed into the mineral goethite, the researchers report.

"Most mushrooms grow and are gone within a few days," said Illinois Natural History Survey paleontologist Sam Heads, who discovered the mushroom when digitizing a collection of fossils from the Crato Formation of Brazil. "The fact that this mushroom was preserved at all is just astonishing.

"When you think about it, the chances of this thing being here -- the hurdles it had to overcome to get from where it was growing into the lagoon, be mineralized and preserved for 115 million years -- have to be minuscule," he said.

Before this discovery, the oldest fossil mushrooms found had been preserved in amber, said INHS mycologist Andrew Miller, a co-author of the new report. The next oldest mushroom fossils, found in amber in Southeast Asia, date to about 99 million years ago, he said.

"They were enveloped by a sticky tree resin and preserved as the resin fossilized, forming amber," Heads said. "This is a much more likely scenario for the preservation of a mushroom, since resin falling from a tree directly onto the forest floor could readily preserve specimens. This certainly seems to have been the case, given the mushroom fossil record to date."

The mushroom was about 5 centimeters (2 inches) tall. Electron microscopy revealed that it had gills under its cap, rather than pores or teeth, structures that release spores and that can aid in identifying species.

"Fungi evolved before land plants and are responsible for the transition of plants from an aquatic to a terrestrial environment," Miller said. "Associations formed between the fungal hyphae and plant roots. The fungi shuttled water and nutrients to the plants, which enabled land plants to adapt to a dry, nutrient-poor soil, and the plants fed sugars to the fungi through photosynthesis. This association still exists today."

The researchers place the mushroom in the Agaricales order and have named it *Gondwanagaricites magnificus*.

**Story Source:** Materials provided by University of Illinois at Urbana-Champaign.

**Journal Reference**: Sam W. Heads, Andrew N. Miller, J. Leland Crane, M. Jared Thomas, Danielle M. Ruffatto, Andrew S. Methven, Daniel B. Raudabaugh, Yinan Wang. **The oldest fossil mushroom**. *PLOS ONE*, 2017; 12 (6): e0178327 DOI: 10.1371/journal.pone.0178327.

## A new twist on uranium's origin story

### Mineral deposits in Wyoming have revealed a new form of biologically produced uranium

Scientists sampled a 650-foot deep sediment core from roll-front uranium deposits at an unmined site at Wyoming's Smith Ranch Highlands. By characterizing the mineralogical and microbial composition of the sample, they discovered a new form of biologically produced uranium.

*Credit: Amrita Bhattacharyya*

Uranium, the radioactive element that fuels nuclear power plants and occurs naturally in the Earth's crust, is typically mined from large sandstone deposits deep underground. The uranium in these deposits, which are called roll fronts, has long been thought to form over millions of years via chemical reactions of sulfur and other non-biological compounds.

This widely accepted textbook geology is being challenged by Colorado State University biogeochemists in a new study published June 1 in *Nature Communications*. Thomas Borch, professor of soil and crop sciences with joint appointments in chemistry and civil and environmental engineering, and Amrita Bhattacharyya, a former postdoctoral researcher in Borch's lab, offer evidence for a new origin story for the uranium trapped underground in roll fronts. Bhattacharyya is the paper's first author, and is now a research fellow at Lawrence Berkeley National Laboratory.

"You know you might have a big story when you discover something that will result in people having to rewrite textbooks," Borch said. "Our results may introduce a paradigm shift in the way we think about ore genesis and mining -- from implications for human health, to restoration practices, to how mining companies calculate how much they can earn from a given site."

Conventional wisdom has told us that uranium within ore deposits is mostly found in the form of uraninite, a crystalline mineral. In recent years, scientists had uncovered new evidence that bacteria - living microorganisms -- could generate a different kind of reduced uranium that is non-crystalline and has very different physical and chemical properties. Borch, working on an unrelated experiment studying the composition of uranium at mined and unmined sites in Wyoming, surmised that this biogenic (of biological origin), non-crystalline uranium might occur naturally within ore deposits.

To find out, Borch's team analyzed samples from the Wyoming roll front, using new techniques including synchrotron radiation-based spectroscopy and isotope fingerprinting. They found that up to 89 percent of the uranium from their 650-foot-deep samples wasn't crystalline uraninite at all, but rather, a non-crystalline uranium that was bound to organic matter or inorganic carbonate. Most of the uranium they found in that unmined site is estimated to be 3 million years old, and formed via reduction by microorganisms - microbes that respire not on oxygen, but on uranium.

To verify their results, the team partnered with experts from the U.S. Geological Survey, Institute for Mineralogy at Leibniz University in Germany, and the Swiss Federal Institute of Technology in Lausanne, all of whom became paper co-authors.

Abundance of this biogenic non-crystalline uranium has implications for environmental remediation of mining sites, and for mining practices in general. For instance, biogenic non-crystalline uranium is much more likely to oxidize into a water-soluble form than its crystalline counterparts. This could impact the compound's environmental mobility and its likelihood for contaminating a drinking water aquifer, Borch said.

Borch says that most states require spent mines to be restored to pre-mining conditions. "In order to get back to pre-mining conditions, we had better understand those pre-mining conditions," Borch said. "The baseline may not be what we thought it was."

Though there is now strong evidence for microbial origins of roll-front uranium, what's less clear is whether the microbes making uranium today are the same as those that formed it in the Earth's crust 3 million years ago. "But we do know through isotopic fingerprinting that the uranium formed via microbial reduction," Borch said.

Borch's co-authors include Rizlan Bernier-Latmani, a scientist in Switzerland who developed the isotopic fingerprinting techniques to differentiate between uranium formed via microbial or chemical means.

Borch and colleagues hope to explore the origins of roll-front uranium deposits at other sites, in order to evaluate the global significance of their findings.

**Story Source:** Materials provided by Colorado State University.

**Journal Reference**: Amrita Bhattacharyya, Kate M. Campbell, Shelly D. Kelly, Yvonne Roebbert, Stefan Weyer, Rizlan Bernier-Latmani, Thomas Borch. **Biogenic non-crystalline U(IV) revealed as major component in uranium ore deposits**. *Nature Communications*, 2017; 8: 15538 DOI: 10.1038/NCOMMS15538.

## Lost ecosystem found buried in mud of southern California coastal waters

Shells from muddy sediment collected on the western Palos Verdes shelf off the coast of southern California. The shells are from the scallop Chlamys hastata.

*Credit: Courtesy of Prof. Susan Kidwell*

Paleontologists investigating the seabed off the coast of southern California have discovered a lost ecosystem that for thousands of years had nurtured communities of scallops and shelled marine organisms called brachiopods.

These brachiopods and scallops had thrived along a section of coast stretching approximately 250 miles from San Diego to Santa Barbara for at least 4,000 years. But they had died off by the early 20th century, replaced by the mud-dwelling burrowing clams that inhabit this seabed today. Paleontologists Adam Tomašových of the Slovak Academy of Sciences and

Susan Kidwell of the University of Chicago examine the lost ecosystem in a study published online June 7 in the *Royal Society Proceedings B*.

Evidence indicates that the brachiopod and scallop die-off occurred in less than a century. Because this community disappeared before biologists started sampling the seafloor, its existence was unknown and unsuspected. Only dead shells remain, permitting analysis by paleontologists.

"This loss unfolded during the 19th century, thus well before urbanization and climate warming," said Kidwell, the William Rainey Harper Professor in Geophysical Sciences. "The disappearance of these abundant filter-feeding animals coincided with the rise of livestock and cultivation in coastal lands, which increased silt deposition on the continental shelf, far beyond the lake and near-shore settings where we would expect this stress to have an impact."

Continental shelves, the submerged shoulders of the continents, are a worldwide phenomenon. They form a distinct environment separated by a steep slope from the much deeper and vaster expanse of ocean floor beyond, and provide key habitats for biodiversity and fisheries.

The seabed off southern California is one of the most thoroughly studied in the world, but in applying geologic methods to modern biological samples of the sea floor, Kidwell and Tomašových encountered unsuspected results. Today that seabed consists of soft sediments, where creatures such as segmented worms, crustaceans, molluscs, crabs and urchins feed on organic matter.

This is a fundamentally different ecosystem than the one that preceded it not so long ago, said Tomašových, who heads the Department of Paleoecology and Organismal Evolution at the Slovak Academy.

"The methods applied here provide crucial information on ecosystem response to natural and human pressures over otherwise inaccessible timescales," he said.

In pioneering these methods since the 2000s, Kidwell and her associates have fostered the field of conservation paleobiology. Their work has shown that misfits between live populations and the shells they leave behind on modern sea floors do not signal poor preservation. The differences instead indicate a recent ecological shift -- one usually driven by human activities such as pollution or sea-floor dredging.

Tomašových and Kidwell based their new study on the analysis of samples and data collected from multiple sources. They have conducted their own research on the sea floor off southern California, but they've also benefited from samples and monitoring data that other scientists have collected from the area since 1954.

Brachiopods and scallops, which prefer cold waters and a gravelly environment, range from the U.S.-Mexico border to the Gulf of Alaska. Tomašových and Kidwell eliminated climate warming as a likely culprit in their ecosystem collapse, given that large populations of brachiopods persist near Catalina Island, where water temperatures are similar to those of southern California's mainland coastal waters.

The paleontologists instead pointed to the dramatic changes that southern California's watersheds have undergone since 1769, after Spanish missionaries introduced cattle, horses and sheep to the area.

The researchers established the age of the brachiopods using a molecular dating technique called amino acid racemization. All of the 190 shells analyzed were more than 100 years old, and most were older than 200 years, indicating that the start of the population die-off coincided with the rise of livestock and cultivation on the nearby mainland.

Brachiopods and scallops have low tolerance for high levels of suspended sediment, leaving them vulnerable to the side effects of a regional economy that focused on cattle production from 1769 to the 1860s. During this time, much of modern-day Los Angeles and Orange counties were subject to unmanaged, open-range grazing. The economy shifted to agriculture in the late 19th century, but in the absence of soil conservation methods, the side effects on the coastal ocean would have continued unabated into the early 20th century.

"Extirpation was complete by the start of 21st-century urbanization, warming, bottom fishing and scientific surveys," Tomašových and Kidwell reported, emphasizing the value of combining many lines of historical evidence, especially the application of paleobiological methods to present-day ecosystems, to gain a fuller picture of recent biotic changes.

They further concluded that siltation derived from coastal land-use practices is an under-recognized ecological factor on continental shelves around the globe.

**Story Source:** Materials provided by University of Chicago.

**Journal Reference**: Adam Tomašových, Susan M. Kidwell. **Nineteenth-century collapse of a benthic marine ecosystem on the open continental shelf**.

*Proceedings of the Royal Society B: Biological Sciences*, 2017; 284 (1856): 20170328 DOI: 10.1098/rspb.2017.0328.

## Aftermath of supereruption shows Toba magma system's great size

Southward view of the northern third of the Lake Toba depression produced by the supereruption 74,000 years ago. *Credit: Photo by Shan de Silva; Image courtesy of Oregon State University*

The rare but spectacular eruptions of supervolcanoes can cause massive destruction and affect climate patterns on a global scale for decades -- and a new study has found that these sites also may experience ongoing, albeit smaller eruptions for tens of thousands of years after.

In fact, Oregon State University researchers were able to link recent eruptions at Mt. Sinabung in northern Sumatra to the last eruption on Earth of a supervolcano 74,000 years ago at the Toba Caldera some 25 miles away.

The findings are being reported this week in the journal *Nature Communications*.

"The recovery from a supervolcanic eruption is a long process, as the volcano and the magmatic system try to re-establish equilibrium -- like a body of water that has been disrupted by a rock being dropped into it," said Adonara Mucek, an Oregon State doctoral candidate and lead author on the study.

"At Toba, it appears that the eruptions continued for at least 15,000 to 20,000 years after the supereruption and the structural adjustment continued at least until a few centuries ago -- and probably is continuing today. It is the magmatic equivalent to aftershocks following an earthquake."

This is the first time that scientists have been able to pinpoint what happens following the eruption of a supervolcano. To qualify as a supervolcano, the eruption must reach at least magnitude 8 on the Volcano Explosivity Index, which means the measured deposits for that eruption are greater than 1,000 cubic kilometers, or 240 cubic miles.

When Toba erupted, it emitted a volume of magma 28,000 times greater than that of the 1980 eruption of Mount St. Helens in Washington state. It was so massive, it is thought to have created a volcanic winter on Earth lasting years, and possibly triggering a bottleneck in human evolution.

Other well-known supervolcano sites include Yellowstone Park in the United States, Taupo Caldera in New Zealand, and Campi Flegrei in Italy.

"Supervolcanoes have lifetimes of millions of years during which there can be several supereruptions," said Shanaka "Shan" de Silva, an Oregon State University volcanologist and co-author on the study. "Between those eruptions, they don't die. Scientists have long suspected that eruptions continue after the initial eruption, but this is the first time we've been able to put accurate ages with those eruptions."

Previous argon dating studies had provided rough ages of eruptions at Toba, but those eruption dates had too much range of error, the researchers say. In their study, the OSU researchers and their colleagues from Australia, Germany, the United States and Indonesia were able to decipher the most recent volcanic history of Toba by measuring the amount of helium remaining in zircon crystals in erupted pumice and lava.

The helium remaining in the crystals is a remnant of the decaying process of uranium, which has a well-understood radioactive decay path and half-life.

"Toba is at least 1.3 million years old, its supereruption took place about 74,000 years ago, and it had at least six definitive eruptions after that -- and probably several more," Mucek said. "The last eruption we have detected occurred about 56,000 years ago, but there are other eruptions that remain to be studied."

The researchers also managed to estimate the history of structural adjustment at Toba using carbon-14 dating of lake sediment that has been uplifted up to 600 meters above the lake in which they formed. These data show that structural adjustment continued from at least 30,000 years ago until 2,000 years ago -- and may be continuing today.

The study also found that the magma in Toba's system has an identical chemical fingerprint and zircon crystallization history to Mt. Sinabung, which is currently erupting and is distinct from other volcanoes in Sumatra. This suggests that the Toba system may be larger and more widespread than previously thought, de Silva noted.

"Our data suggest that the recent and ongoing eruptions of Mt. Sinabung are part of the Toba system's recovery process from the supereruption," he said.

The discovery of the connection does not suggest that the Toba Caldera is in danger of erupting on a catastrophic scale any time soon, the researchers emphasized. "This is probably 'business as usual' for a recovering supervolcano," de Silva said. It does emphasize the importance of having more sophisticated and frequent monitoring of the site to measure the uplift of the ground and image the magma system, the researchers note.

"The hazards from a supervolcano don't stop after the initial eruption," de Silva said. "They change to more local and regional hazards from eruptions, earthquakes, landslides and tsunamis that may continue regularly for several tens of thousands of years.

"Toba remains alive and active today."

As large as the Toba eruption was, the reservoir of magma below the caldera is much, much greater, the researchers say. Studies at other calderas around Earth, such as Yellowstone, have estimated that there is between 10 and 50 times as much magma than is erupted during a supereruption.

**Story Source:** Materials provided by Oregon State University.

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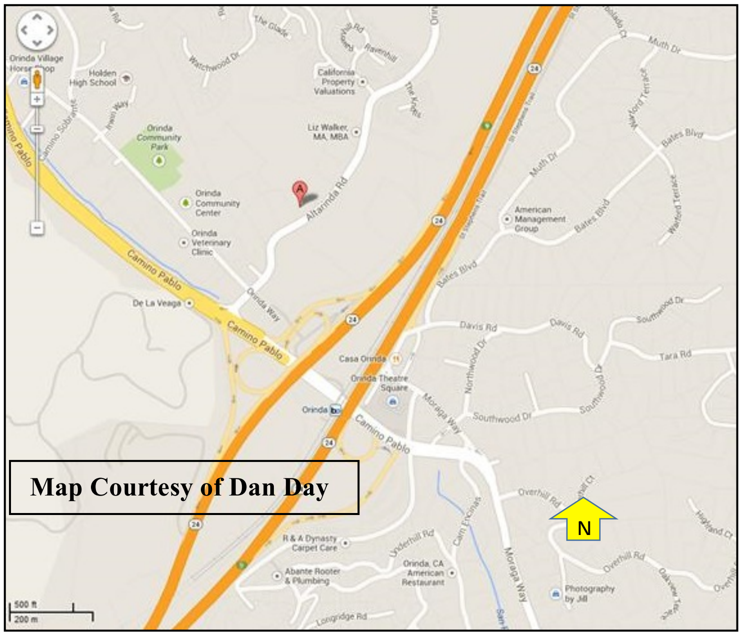


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