NORTHERN CALIFORNIA GEOLOGICAL SOCIETY

MEETING ANNOUNCEMENT

DATE: **April 26, 2017**

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

TIME: 6:30 p.m. social; 7:00 pm talk (no dinner) Cost: $5 per regular member; $1 per student or K – 12 teachers

SPEAKER: Dr. Mark Richards, UC Berkeley

Topic: "Triggering of the Largest Deccan Eruptions by the Chicxulub Impact"

or

"What Really Killed the Dinosaurs"

Biography: Mark Richards earned his BS in engineering at the University of Texas, Austin, and his MS in physics and PhD in geophysics from the California Institute of Technology. He was a postdoc at Australian National University and served on the faculty at the University of Oregon prior to moving to UC Berkeley in 1989. He served as Dean of Mathematical and Physical Sciences from 2002-2014 and also as Executive Dean of the College of Letters and Science from 2006-2014, before returning to full-time research and teaching in the Department of Earth and Planetary Science. Professor Richards is a geophysical modeler and observer, focusing on the effects of large- scale dynamic processes in the interiors of the terrestrial planets on surface phenomena ranging from plate tectonics to large-scale volcanism. Recently, Professor Richards and his colleagues have suggested that one of the largest volcanic eruptions in Earth history, the Deccan Traps of India, was accelerated by the impact in Yucatán, Mexico, and that both events may have contributed to the great Cretaceous-Tertiary mass extinction. Professor Richards is a Fellow of the American Geophysical Union and the California Academy of Sciences. He is also the PI for the NSF-funded California Alliance (Berkeley, Caltech, UCLA, Stanford) project promoting diversity at the graduate, postdoctoral, and professorial levels in the mathematical and physical sciences. He has won Berkeley's two highest awards for contributions to diversity, the Academic Senate's Leon Henkin Award and the Chancellor's Award for Institutional Excellence.

NCGS 2016 – 2017 Calendar

May 31, 2017 Dinner meeting 6:00 pm
(see reservation form on page 13; submit reservations by May 26!)

Dr. Greg Stock, National Park Service

The Rise and Fall of Sierra Nevada Glaciers

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

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Peninsula Geologic Society

PGS may be pulling back, as there is only one active officer remaining. For an update on the society's future, 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. This spring, remaining seminars will be held on Thursdays through May 4, at 4 pm at 141 McCone. The last two speakers are:

April 27: **John Valley, Univ of Wisconsin-Madison**

Hadean Zircons are not from Hell: SIMS & Atom Probe Studies of $^{207}Pb/^{206}Pb$, One Atom at a Time

May 4: **Marissa Tremblay, UC Berkeley**

Constraining Past Earth and Planetary Surface Temperatures Using Cosmogenic Noble Gases

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, at the CB&I (formerly Shaw E&I) offices at 4005 Port Chicago Hwy, Concord, CA 94520. The next board meeting has been scheduled for 8:30 to 11 am on Saturday, May 13. If you arrive much after 8:30, call Barbara Matz (415) 713-8482 or Mark Sorensen (925) 260-6942 to open the door.

NCGS Outreach Events

John Christian is leaving us but his legacy lives on. On March 28th Lora Teitler, Gary Proust and Mark Petrofsky took a collection of rocks and fossils to a Math, Science Night at Grant Elementary School in Richmond. The theme, as usual, was "Local Rocks and the Stories They Tell." John is taking his collection of local rocks with him but he provided a very representative substitute collection as well as helping for many hours getting it sorted, organized and filled out.

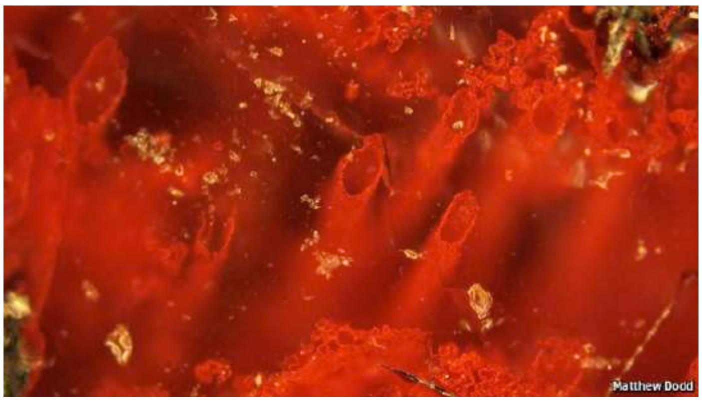
The next NCGS Outreach event will be at **Cal Day** on **Sat., April 22nd**. Let Mark Petrofsky know (mpetrof@hotmail.com; 510 526-4944) if you have time on that day to help out; you can also check out the other events on campus. Other upcoming events:

- May 21st at the El Cerrito Hillside Celebration (Bill Motzer, will also present at the quarry site investigated by Wakabayashi); and
- June 24th at New Almaden County Park in San Jose, Make-Like-a-Miner Day.

We also want to note John Christian's great contributions to NCGS since he joined us. I (editor) met John at the classic Franciscan outcrop in the Marin Headlands opposite the Golden Gate Bridge in 2004. Since then he has been a reliable and enthusiastic member who has served in several official roles, and has been tireless in promoting the NCGS at outreach events, as well as bringing some of his excellent rock, mineral, and fossil specimens to meetings. Good luck in Arizona, John!

A new fossil could push back the start of life on Earth

The putative fossils formed just a few hundred million years after Earth itself



SCIENTISTS have a pretty good idea of how the Earth formed: it condensed, around 4.6 billion years ago, from the same cloud of dust and interstellar gas that gave birth to the sun and the rest of the solar system. They are less sure how and when life got going. Last year a group of researchers found evidence for stromatolites—small, layered mounds produced by photosynthesizing bacteria—in rocks from Greenland that are 3.7 billion years old.

react-text: 400 Now, though, the date of life's debut may be pushed back even further. As they report in *Nature*, a group of researchers led by Dominic Papineau from University College London have found what they think is the signature of living organisms in rocks from Quebec that date back to between 3.8 and 4.3 billion years ago. Intriguingly, the sort of life that Dr. Papineau and his colleagues think they have found is very different from the sort that built the stromatolites. This suggests that even very early in its existence, Earth was hosting several different kinds of living organism.

The rock in question is a 3-kilometre-long swathe on the eastern shores of the Hudson Bay called the Nuvvuagittuq Greenstone Belt. It is mostly composed of pillow-shaped basalt, a type of rock formed when lava cools rapidly in seawater. When Dr. Papineau visited the formation in 2008 he found unusual reddish-colored outcrops of jasper, a type of quartz formed from compressed volcanic ash, that contained odd-looking veins and nodules. Closer examination revealed rings, between 50 and 100 microns (a millionth of a meter) across. That made him sit up: similar rosette-shaped features have been found in younger, but still ancient, rock formations from Biwabik, in Minnesota, and Løkken, in Norway. They are thought to have been formed when micro-organisms decayed and were fossilized.

But that evidence was not quite conclusive. Similar-looking structures can also be formed by non-living, geological processes. So Dr. Papineau gave the rock samples to Matthew Dodd, his PhD student, to look at. Within the veins and nodules of the jasper that intrigued his boss, Mr. Dodd found hollow tubes between 2 and 14 microns in diameter and up to 0.5mm long made of hematite, a mineralized form of iron oxide. Some of these filaments form networks anchored to a lump of hematite; others are corkscrew-shaped.

The team contends that these bear more than a passing resemblance to the networks of bacteria that live in hydrothermal vents—towering, crenellated structures that form in the deep ocean above the boundaries between tectonic plates, where superheated mineral-laden water spurts up from beneath the seabed. Well-preserved fossil remnants of these microbes have been found at many sites younger than Nuvvuagittuq, and they closely resemble the coiled and branching tubes that Dr. Papineau and his colleagues have found.

Such a find is doubly intriguing because hydrothermal vents are seen as a plausible candidate for the cradle of life. Microscopic pores in the rock might have served as natural cell walls, and the chemistry of the water could provide exactly the sort of energy gradient that a primitive living cell would have needed to go about its biochemical business. Although the sorts of bacteria apparently found by Dr Papineau and his colleagues are too complicated to reveal much about the very earliest organisms, the suggestion that hydrothermal vents have played host to life for so long is a strike in the theory's favor.

Bacteria to the future

The find—which will face fierce scrutiny from other paleobiologists—has other implications, too. Most living organisms, including those that built the stromatolites, ultimately derive their energy from photosynthesis, the process by which plants and some micro-organisms convert sunlight into sugar. The creatures that live around hydrothermal vents are fundamentally different: no sunlight penetrates so deep into the oceans, so the food chains of such ecosystems are based on reactions between the dissolved chemicals that well up from the crust.

If Dr. Papineau's fossils are as old as he thinks, that implies that Earth was, within a few hundred million years of its formation, already playing host to very diverse sorts of life. One of the biggest questions in science is whether life is an inevitable and common consequence of the laws of chemistry, or a lucky one-off confined to Earth alone. If life got going on Earth so quickly, and was able to diversify so rapidly, it suggests the same might have happened elsewhere, too.

Source: **The Economist**, Mar 4, 2017. The article appeared in the Science and Technology section of the print edition under the headline "The Living was Easy."

Ancient Earth's fingerprints in young volcanic rocks

Geochemical clues suggest that some rocks from Hawaii, Samoa may contain material formed during the planet's birth

A fountain of lava erupts from Hawaii's Kilauea Iki crater on Dec. 5, 1959. Two rock samples from this eruption contain geochemical anomalies that could date back 4.5 billion years, shortly after the Earth first formed. Credit: USGS/J.P. Eaton

Earth's mantle is made of solid rock that nonetheless circulates slowly over millions of years. Some geologists assume that this slow circulation would have wiped away any geochemical traces of Earth's early history long ago. But a new study led by University of Maryland geologists has found new evidence that could date back more than 4.5 billion years.

The authors of the research paper, published April 7 in the journal *Science*, studied volcanic rocks that recently erupted from volcanoes in Hawaii and Samoa. The rocks contain surprising geochemical anomalies -- the "fingerprints" of conditions that existed shortly after the planet formed.

The researchers are not yet sure how Earth's mantle preserved these anomalies. But the group's results suggest that some of these rocks contain material that survived through all of Earth's history -- and that the planet's interior may not be well mixed after all.

"We found geochemical signatures that must have been created nearly 4.5 billion years ago," said Andrea Mundl, a postdoctoral researcher in geology at UMD and the lead author of the study. "It was especially exciting to find these anomalies in such young rocks. We don't yet know how these signatures survived for so long, but we have some ideas."

The anomalous signatures are found in the ratios of key isotopes of two elements: tungsten and helium.

In the case of tungsten, which has many isotopes, the important ratio is tungsten-182 to tungsten-184. The heavier isotope, tungsten-184, is stable and has existed since the planet first formed. Tungsten-182, on the other hand, results from the decay of hafnium-182, which is highly unstable. All naturally occurring hafnium-182 decayed within the first 50 million years of Earth's history, leaving tungsten-182 in its place.

Tungsten and hafnium behaved very differently during the planet's first 50 million years. Tungsten tends to associate with metals, so most of it migrated to Earth's core, while hafnium, which tends to associate with silicate minerals, stayed in Earth's mantle and crust. Most of the rocks on Earth have a similar ratio of tungsten-182 to tungsten-184, and this ratio serves as a global baseline. Geologists can learn a lot from rocks with an unusually high or low amount of tungsten-182 -- which indicates how much hafnium-182 was present in the rock long ago.

"Nearly all of these anomalies formed within the first 50 million years after the solar system formed," Mundl said. "Higher than normal levels of tungsten-182 are seen in very old rocks that most likely contained a lot of hafnium long ago. But lower levels of tungsten-182 are rare, and resemble what we might expect to see deep beneath the surface, in or near the planet's metallic core."

Sure enough, Mundl and her colleagues observed an unusually low amount of tungsten-182 in some of the rocks from Hawaii and Samoa. On its own, the tungsten isotope ratio is interesting, but not enough to make any convincing conclusions. But the researchers also observed that the same rocks contain an unusual ratio of helium isotopes.

Helium-3 is extremely rare on Earth, and tends to show up in samples of rock that have not been melted or otherwise recycled since the planet first formed. Helium-4, on the other hand, can form from the radioactive decay of uranium and thorium. A higher than normal ratio of helium-3 to helium-4 typically indicates very old rocks that have not been significantly altered since the planet formed.

"Variations in the isotopic composition of helium have been long known, but have never been correlated with other geochemical parameters," said Richard Walker, professor and department chair of geology at UMD and a co-author of the paper. "Rocks with high helium-3 to helium-4 ratios have commonly been speculated to contain 'primitive' mantle material, but how primitive was not known. Our tungsten data show that it is very primitive indeed, with the source region most likely forming within the first 50 million years of solar system history."

Mundl, Walker and their co-authors suggest a few different scenarios that could have produced the tungsten and helium anomalies they observed in volcanic rocks from Hawaii and Samoa. Perhaps the volcanoes are drawing material from Earth's core, where the ratios are expected to favor low tungsten-182 and high helium-3.

Alternatively, the rocky outer surface of Earth might have formed in patches, with vast magma oceans in between. Parts of these magma oceans may have crystallized and sunk to the boundary between the mantle and the core, preserving the ancient tungsten and helium signatures.

"Each of these scenarios contain some inconsistencies that we can't yet explain," Mundl said. "But this is an exciting result that is sure to generate lots of interesting new research questions."

Story Source: Materials provided by University of Maryland.

Journal Reference: Andrea Mundl, Mathieu Touboul, Matthew G. Jackson, James M. D. Day, Mark D. Kurz, Vedran Lekic, Rosalind T. Helz, Richard J. Walker. **Tungsten-182 heterogeneity in modern ocean island basalts**. *Science*, 2017; 356 (6333): 66 DOI: 10.1126/science.aal4179.

Massive, computer-analyzed geological database reveals chemistry of ancient ocean

Julia Wilcots, a Madison native who was then at Princeton University, at a rock quarry in Shorewood Hills, Wisconsin. The layers at her head and chest level are both composed of different types of stromatolites. Credit: Shanan Peters, UW–Madison

A study that used a new digital library and machine reading system to suck the factual marrow from millions of geologic publications dating back decades has unraveled a longstanding mystery of ancient life: Why did the easy-to-see and once-common structures called stromatolites essentially cease forming over the long arc of earth history?

Stromatolites are contorted layers of sediment formed by microbes, and they are often found in limestone and other ancient sedimentary rocks deposited beneath oceans. "Geologists have known for a long time that stromatolites were abundant in shallow marine environments during the Precambrian, before the emergence of multi-cellular life" more than 560 million years ago, says Jon Husson, a post-doctoral researcher and co-author of a study now online in the journal *Geology*. "But, stromatolites are rare in the ocean today."

The new study measures the slide in stromatolite prevalence based on descriptions of rocks sifted from more than 3 million scientific publications.

"Paleontologists have largely attributed the decline in stromatolites to the evolution of animals, starting some 560 million years ago," says Shanan Peters, a professor of geoscience at University of Wisconsin-Madison and study first author. "Many multi-cellular animals, like snails, eat microbes. The evolution of these big microbe-grazing animals hit 'reset' on the stromatolite's world. Or so the story has gone."

The new study found a weak correlation between stromatolite occurrence and the diversity of animals, but a stronger link to seawater chemistry. "The best predictor of stromatolite prevalence, both before and after the evolution of animals, is the abundance of dolomite in shallow marine sediments," says Husson. Dolomite, a high-magnesium variety of carbonate, is harder to make than low-magnesium carbonate, and it forms today in only a narrow range of marine environments.

When the ocean water is super-saturated with carbonate, "that can make it easier for stromatolites to form," says Husson. "In Lake Tanganyika [Africa], there are stromatolites forming today, even though there are animals everywhere, snails and fish. The lake is super-saturated with carbonate, and it's begging to be precipitated. The microbes come along and help it to precipitate, and the result is an abundance of stromatolites." Elevated carbonate saturation can also help the formation of dolomite, thereby driving the correlation with stromatolites found in this study.

Measuring the prevalence of stromatolites through all Earth history is difficult because counting the number of stromatolites alone is not sufficient. You must also know how many rocks could potentially have stromatolites, but do not.

The big innovation of this study is the interplay of a new type of digital library and machine reading system called GeoDeepDive with a geological database called Macrostrat. Both were spearheaded by Peters at UW-Madison.

GeoDeepDive is a digital library built on high throughput computing technology that can "read" millions of papers and siphon off specific information. To date, the GeoDeepDive library contains more than 3 million scientific publications from all scientific disciplines; some 10,000 new published papers are added daily.

Macrostrat is a database describing the known geological properties of North America's upper crust, at different times and depths.

The massive computing capacity at UW-Madison's Center for High Throughput Computing and HTCondor system, the brainchild of UW-Madison computer scientist Miron Livny, powers GeoDeepDive. Combining the digital library with the geological database allowed the researchers to estimate, at different time periods, the percentage of shallow marine rocks that actually have stromatolites.

The study began in the summer of 2015, when the third author, Julia Wilcots, a Madison native who was then an undergraduate at Princeton, asked Peters for a summer project. Wilcots did not have to travel to see stromatolites, Peters says. "In Madison, we are sitting on top of rocks recording one of the biggest rises in stromatolite abundance -- at least during the age of animals."

Among 10,200 papers that mentioned stromatolites, "our program was able to extract 1,013 with a name of a rock unit, which enabled us to link stromatolite occurrences to Macrostrat," says Husson.

Scientists long ago observed that stromatolites started a long decline just before the start of the Cambrian era, but that decline represented a "fundamental question of paleobiology," Husson says. "Stromatolites are the oldest fossils that are visible to the naked eye. If you look at rock that is a billion years old, the chance for seeing evidence of life equals the chance of seeing stromatolites."

Beyond answering a fundamental question of Earth's history, the new study "allows us to do the kind of analyses that scientists used to only dream about, Peters says: 'If we could just compile all the published information on... anything!'

"Doing this study without GeoDeepDive would be all but impossible," Peters adds. "Reading thousands of papers to pick out references to stromatolites, and then linking them to a certain rock unit and geologic period, would take an entire career, even with Google Scholar. Here we got started with a talented undergrad working on a summer project. GeoDeepDive has greatly lowered the barrier to compiling literature data in order to answer many questions."

For centuries, "geologists have transferred hard-to-get information from the field to hard-to-get information in the literature," Peters says. "To achieve a broad-scale synthesis, you have to survey all of the published knowledge. There are new discoveries waiting in the scientific literature, if you can see the big picture and get all the data into one place."

Story Source: Materials provided by University of Wisconsin-Madison. Original written by David Tenenbaum.

Journal Reference: Shanan E. Peters, Jon M. Husson, Julia Wilcots. **The rise and fall of stromatolites in shallow marine environments**. *Geology*, 2017; G38931.1 DOI: 10.1130/G38931.1.

Ice age thermostat prevented extreme climate cooling

Credit: © JohanSwanepoel / Fotolia

During the ice ages, an unidentified regulatory mechanism prevented atmospheric CO_2 concentrations from falling below a level that could have led to runaway cooling, reports a study conducted by researchers of the ICTA-UAB and published online in *Nature Geoscience* this week. The study suggests the mechanism may have involved the biosphere, as plants and plankton struggled to grow under very low CO_2 levels.

Atmospheric CO_2 concentrations swung over a range of 100 ppm (parts per million, by volume) during the ice ages. The exact processes behind this variation have been difficult to pinpoint, but it is known that changes in the storage of carbon by photosynthetic organisms played an important role.

"When we took a close look at measurements from ice cores, we noticed that atmospheric CO_2 concentrations hovered close to 190 ppm during much of the past 800,000 years, but very rarely fell any lower," said Sarah Eggleston, a researcher at the Institut of Environmental Science and Technology (ICTA-UAB) and co-author of the study. "This was surprising, because it suggests that these very low CO_2 concentrations were quite stable. What's more, we know that CO_2 was often very high in the distant geological past, but we have no evidence that CO_2 concentrations were ever lower than 190 ppm."

"We know that, over hundreds of thousands of years, CO_2 is regulated by slowly reacting with exposed rocks" explained Eric Galbraith, lead author of the study and an ICREA professor at ICTA-UAB. "But this would be too slow to explain the stability during periods of only a few thousand years, as we see in the ice cores. So it must have been some other mechanism that kicked in at very low CO_2."

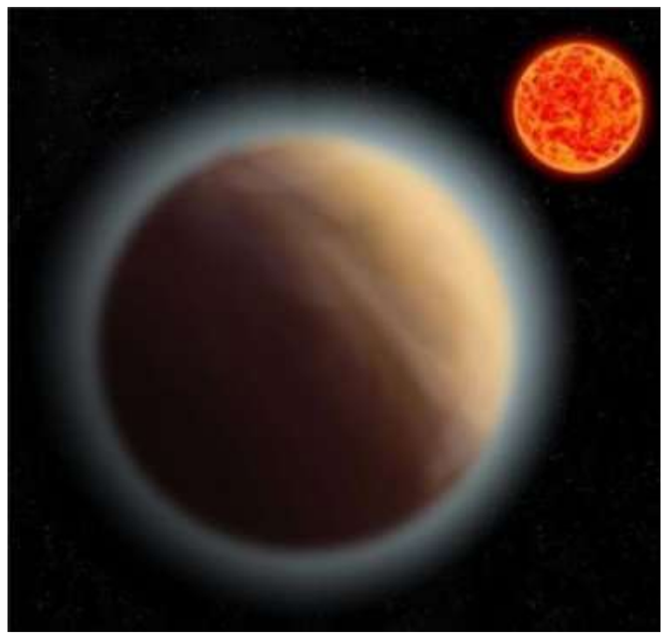
The authors suggest that it was most likely the biosphere that maintained habitable temperatures, since at very low CO_2 levels, plants and phytoplankton struggle to photosynthesize. Slower growth of these organisms would have meant less carbon in the soils and deep ocean leaving more in the atmosphere, and preventing CO_2 concentrations from falling further. This might have prevented extreme cooling that would have led to Earth freezing over as a 'snowball'.

However, the study did not reveal a corresponding regulation during the warm portions of the ice age cycles, suggesting that Earth does not have a similar mechanism to prevent rapid warming.

Story Source: Materials provided by Universitat Autonoma de Barcelona.

Journal Reference: E. D. Galbraith, S. Eggleston. **A lower limit to atmospheric CO2 concentrations over the past 800,000 years**. *Nature Geoscience*, 2017; DOI: 10.1038/ngeo2914.

Atmosphere detected around an Earth-like planet



Artist's impression of super-Earth planet GJ 1132b.

Credit: MPIA

Astronomers have detected an atmosphere around the super-Earth planet GJ 1132b. This marks the first detection of an atmosphere around an Earth-like planet other than Earth itself, and thus is a significant step on the path towards the detection of life outside our Solar System. The team that made the discovery, led by Keele University's Dr. John Southworth, used the 2.2 m ESO/MPG telescope in Chile to take images of the planet's host star GJ 1132. They were able to measure the slight decrease in brightness as the planet and its atmosphere absorbed some of the starlight while transiting (passing in front of) the host star.

Dr. John Southworth explains, "While this is not the detection of life on another planet, it's an important step in the right direction: the detection of an atmosphere around the super-Earth GJ 1132b marks the first time that an atmosphere has been detected around an Earth-like planet other than Earth itself."

Is there life out there?

Astronomers' current strategy for finding life on another planet is to detect the chemical composition of that planet's atmosphere, on the look-out for chemical imbalances which could be caused by living organisms. In the case of our own Earth, the presence of large amounts of oxygen is a tell-tale sign of life. Until these findings by Dr. Southworth's team, the only previous detections of exoplanet atmospheres all involved gas giants reminiscent of a high-temperature Jupiter.

Dr. Southworth says that while we're still a long way from detecting life on exoplanets, this discovery is the first step: "With this research, we have taken the first tentative step into studying the atmospheres of smaller, Earth-like, planets. We simulated a range of possible atmospheres for this planet, finding that those rich in water and/or methane would explain the observations of GJ 1132b. The planet is significantly hotter and a bit larger than Earth, so one possibility is that it is a "water world" with an atmosphere of hot steam."

Studying atmospheres

The planet in question orbits the very low-mass star GJ 1132 in the Southern constellation Vela, a distance of 39 light-years from Earth. The system was studied by a team led by John Southworth (Keele University, UK) and Luigi Mancini (currently at the University of Rome Tor Vergata), and including researchers from the Max Planck Institute for Astronomy (MPIA, Germany) and the University of Cambridge.

The team used the GROND imager at the 2.2 m ESO/MPG telescope of the European Southern Observatory in Chile to observe the planet simultaneously at seven different wavelength bands spanning the optical and near-infrared. As GJ 1132b is a transiting planet, it passes directly between Earth and its host star every 1.6 days, blocking a small fraction of the star's light. From the amount of light lost, astronomers can deduce the planet's size -- in this case only 1.4 times that of Earth.

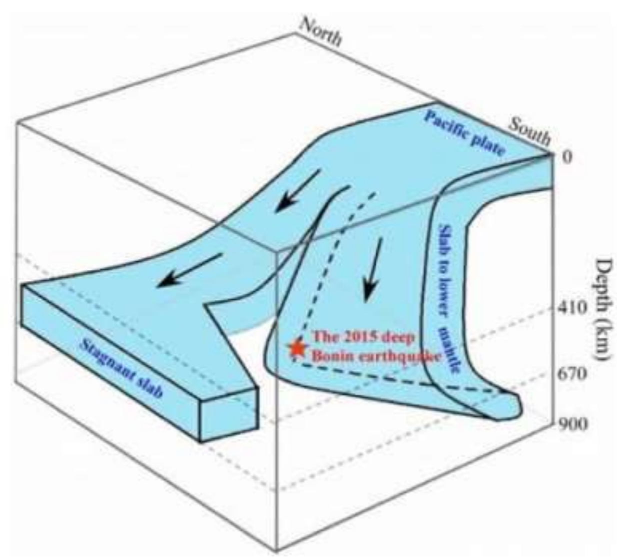
Crucially, the new observations showed the planet to be larger in one of the seven wavelength bands. This suggests the presence of an atmosphere that is opaque to this specific light (making the planet appear larger), but transparent to all the others.

The discovery of this atmosphere is encouraging. Very low-mass stars are extremely common (much more so than Sun-like stars), and are known to host lots of small planets. But they also show a lot of magnetic activity, causing high levels of X-rays and ultraviolet light to be produced which might completely evaporate the planets' atmospheres. However, the properties of GJ 1132b show that an atmosphere can endure this for billions of years without being destroyed. Given the huge number of very low-mass stars and planets, this could mean that the conditions suitable for life are common in the Universe.

This discovery makes GJ 1132b one of the highest-priority targets for further study by the current top facilities, such as the Hubble Space Telescope and ESO's Very Large Telescope, as well as the James Webb Space Telescope, slated for launching in 2018.

Story Source: Materials provided by Keele University. **Journal Reference**: John Southworth, Luigi Mancini, Nikku Madhusudhan, Paul Mollière, Simona Ciceri, Thomas Henning. **Detection of the Atmosphere of the 1.6 M ⊕ Exoplanet GJ 1132 b**. *The Astronomical Journal*, 2017; 153 (4): 191 DOI: 10.3847/1538-3881/aa6477.

Dissection of the 2015 Bonin deep earthquake



A schematic diagram of the subducting Pacific slab beneath the Bonin region. The red star denotes the hypocenter of the 2015 Bonin deep earthquake.

Credit: Dapeng Zhao

Researchers at Tohoku University's Department of Geophysics have been studying the deep earthquake which occurred on May 30, 2015, to the west of Japan's Bonin Islands.

The earthquake, which registered at about 670 km depth with moment magnitude (Mw) of 7.9, was the deepest global seismic event on record with M > 7.8. It was also an isolated event located over 100 km deeper than the main seismic zones recorded so far. The event has attracted great interest among researchers because high pressure and high temperature at such great depth make it unusual for earthquakes to generate there.

In the Izu-Bonin region, the Pacific plate is subducting northwestward beneath the Philippine Sea plate. To date, several studies have investigated the source location of the Bonin deep earthquake relative to the subducting Pacific plate. But there have been conflicting results because the mantle structure in and around the source zone is still unclear.

The Tohoku University team, led by Professor Dapeng Zhao, applied a method of seismic tomography to over five million P-wave arrival-time data recorded by world-wide seismic stations to determine a high-resolution mantle tomography beneath the Izu-Bonin region. The stations included those from the dense seismic networks in Japan and East China.

Seismic tomography (a method to image the three-dimensional structure of Earth's interior by inverting abundant seismic wave data generated by many earthquakes and recorded at many seismic stations) is an effective tool for investigating the three-dimensional structure of Earth's interior, in particular, for clarifying the morphology and structure of subducting slabs. Using that method, the team received clear images of the subducting Pacific slab as a high-velocity zone, and showed that the Bonin deep event occurred within the Pacific slab, which is penetrating the lower mantle. Moreover, its hypocenter is located just beside the eastern slab boundary to the ambient mantle within the mantle transition zone (a part of Earth's mantle between depths of approximately 410 and 670 km, separating the upper mantle from the lower mantle).

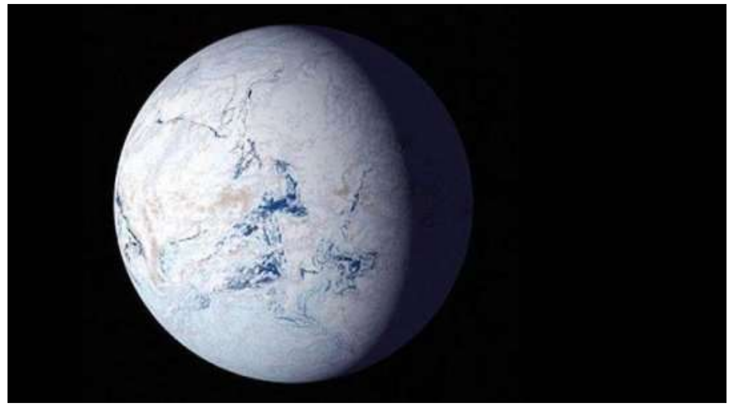
They also found that the Pacific slab is split at about 28° north latitude, i.e., slightly north of the 2015 deep event hypocenter. In the north, the slab is flat in the mantle transition zone. In the south, the slab is nearly vertical and directly penetrating the lower mantle.

The results suggest that this deep earthquake was caused by the joint effects of several factors. These include the Pacific slab's fast deep subduction, slab tearing, slab thermal variation, stress changes and phase transformations in the slab, as well as complex interactions between the slab and the ambient mantle. This work sheds new light on the deep slab structure and subduction dynamics.

Story Source: Materials provided by Tohoku University. **Journal Reference**: Dapeng Zhao, Moeto Fujisawa, Genti Toyokuni. **Tomography of the subducting Pacific slab and the 2015 Bonin deepest earthquake (Mw 7.9)**. *Scientific Reports*, 2017; 7: 44487 DOI: 10.1038/srep44487.

A perfect storm of fire and ice may have led to snowball Earth

Explaining a 'once-in-a-billion-year event'



About 700 million years ago, runaway glaciers covered the entire planet in ice. Harvard researchers modeled the conditions that may have led to this so-called 'snowball Earth. Credit: Image courtesy of NASA

What caused the largest glaciation event in Earth's history, known as 'snowball Earth'? Geologists and climate scientists have been searching for the answer for years but the root cause of the phenomenon remains elusive. Now, Harvard University researchers have a new hypothesis about what caused the runaway glaciation that covered Earth pole-to-pole in ice. The research is published in *Geophysical Research Letters*.

Researchers have pinpointed the start of what's known as the Sturtian snowball Earth event to about 717 million years ago -- give or take a few 100,000 years. At around that time, a huge volcanic event devastated an area from present-day Alaska to Greenland. Coincidence? Harvard professors Francis Macdonald and Robin Wordsworth thought not.

"We know that volcanic activity can have a major effect on the environment, so the big question was, how are these two events related," said Macdonald, the John L. Loeb Associate Professor of the Natural Sciences.

At first, Macdonald's team thought basaltic rock -- which breaks down into magnesium and calcium --

interacted with CO_2 in the atmosphere and caused cooling. However, if that were the case, cooling would have happened over millions of years and radio-isotopic dating from volcanic rocks in Arctic Canada suggest a far more precise coincidence with cooling.

Macdonald turned to Wordsworth, who models climates of non-Earth planets, and asked: could aerosols emitted from these volcanos have rapidly cooled Earth?

The answer: yes, under the right conditions.

"It is not unique to have large volcanic provinces erupting," said Wordsworth, assistant professor of Environmental Science and Engineering at the Harvard John A. Paulson School of Engineering and Applied Science. "These types of eruptions have happened over and over again throughout geological time but they're not always associated with cooling events. So, the question is, what made this event different?"

Geological and chemical studies of this region, known as the Franklin large igneous province, showed that volcanic rocks erupted through sulfur-rich sediments, which would have been pushed into the atmosphere during eruption as sulfur dioxide. When sulfur dioxide gets into the upper layers of the atmosphere, it's very good at blocking solar radiation. The 1991 eruption of Mount Pinatubo in the Philippines, which shot about 10 million metric tons of sulfur into the air, reduced global temperatures about 1 degree Fahrenheit for a year.

Sulfur dioxide is most effective at blocking solar radiation if it gets past the tropopause, the boundary separating the troposphere and stratosphere. If it reaches this height, it's less likely to be brought back down to earth in precipitation or mixed with other particles, extending its presence in the atmosphere from about a week to about a year. The height of the tropopause barrier depends on the background climate of the planet – the cooler the planet, the lower the tropopause.

"In very warm periods of Earth's history, volcanic cooling would not have been very important because Earth would have been shielded by this warm, high tropopause," said Wordsworth. "In cooler conditions, Earth becomes uniquely vulnerable to having these kinds of volcanic perturbations to climate."

Another important aspect is where the sulfur dioxide plumes reach the stratosphere. Due to continental drift, 717 million years ago, the Franklin large igneous province where these eruptions took place was situated near the equator, the entry point for most of the solar radiation that keeps Earth warm.

So, an effective light-reflecting gas entered the atmosphere at just the right location and height to cause cooling. But another element was needed to form the perfect storm scenario. After all, the Pinatubo eruption had similar qualities but its cooling effect only lasted about a year.

The eruptions throwing sulfur into the air 717 million years ago weren't one-off explosions of single volcanoes like Pinatubo. The volcanoes in question spanned almost 2,000 miles across Canada and Greenland. Instead of singularly explosive eruptions, these volcanoes erupted more continuously like those in Hawaii and Iceland today. The researchers demonstrated that a decade or so of continual eruptions from this type of volcanoes could have poured enough aerosols into the atmosphere to rapidly destabilize the climate.

"Cooling from aerosols doesn't have to freeze the whole planet; it just has to drive the ice to a critical latitude. Then the ice does the rest," said Macdonald. The more ice, the more sunlight is reflected and the cooler the planet becomes. Once the ice reaches latitudes around present-day California, the positive feedback loop takes over and the runaway snowball effect is pretty much unstoppable.

"It's easy to think of climate as this immense system that is very difficult to change and in many ways that's true. But there have been very dramatic changes in the past and there's every possibility that as sudden of a change could happen in the future as well," said Wordsworth. Understanding how these dramatic changes occur could help researchers better understand how extinctions occurred, how proposed geoengineering approaches may impact climate and how climates change on other planets.

"This research shows that we need to get away from a simple paradigm of exoplanets, just thinking about stable equilibrium conditions and habitable zones," said Wordsworth. "We know that Earth is a dynamic and active place that has had sharp transitions. There is every reason to believe that rapid climate transitions of this type are the norm on planets, rather than the exception."

Story Source: Materials provided by Harvard John A. Paulson School of Engineering and Applied Sciences. Original written by Leah Burrows. **Journal Reference**: F. A. Macdonald, R. Wordsworth. **Initiation of Snowball Earth with volcanic sulfur aerosol emissions**. *Geophysical Research Letters*, 2017; DOI: 10.1002/2016GL072335.

Steep rise of the Bernese Alps

View of the granite bastion north of Grimsel Lake with glacially polished granite surfaces being heavily dissected by morphological incisions. These furrows (see arrows) are all the result of steep fault zones, which originated at a depth of 20 kilometres. Due to uplift and erosion, they are recognisable today on the earth's surface as couloirs in the topography.
Credit: © M. Herwegh, Institute for Geology, University of Bern

The striking North Face of the Bernese Alps is the result of a steep rise of rocks from the depths following a collision of two tectonic plates. This steep rise gives new insight into the final stage of mountain building and provides important knowledge with regard to active natural hazards and geothermal energy. The results from researchers at the University of Bern and ETH Zürich are being published in the *Scientific Reports* specialist journal.

Mountains often emerge when two tectonic plates converge, where the denser oceanic plate subducts beneath the lighter continental plate into Earth's mantle according to standard models. But what happens if two continental plates of the same density collide, as was the case in the area of the Central Alps during the collision between Africa and Europe?

Geologists and geophysicists at the University of Bern and ETH Zürich examined this question. They constructed the 3D geometry of deformation structures through several years of surface analysis in the Bernese Alps. With the help of seismic tomography, similar to ultrasound examinations on people, they also gained additional insight into the deep structure of Earth's crust and beyond down to depths of 400 km in Earth's mantle.

Viscous rocks from the depths

A reconstruction based on this data indicated that the European crust's light, crystalline rocks cannot be subducted to very deep depths but are detached from Earth's mantle in the lower earth's crust and are consequently forced back up to Earth's surface by buoyancy forces. Steep fault zones are formed here, which push through Earth's crust and facilitate the steep rise of rocks from the depths. There are textbook examples of these kinds of fault zones in the Hasli valley, where they appear as scars in form of morphological incisions impressively cutting through the glacially polished granite landscape.

The detachment of Earth's crust and mantle takes place at a depth of 25-30 kilometres. This process is triggered by the slow sinking and receding of the European plate in the upper earth's mantle towards the north. In specialist terminology, this process is called slab rollback. The high temperatures at these depths make the lower crust's rocks viscous, where they can subsequently be forced up by buoyant uplift forces.

Together with surface erosion, it is this steep rise of the rocks from lower to mid-crustal levels which is responsible for the Bernese Alps' steep north front today (Titlis -- Jungfrau region -- Blüemlisalp range). The uplift data in the range of one millimetre per year and today's earthquake activity indicate that the process of uplift from the depths is still in progress. However, erosion on Earth's surface causes continuous ablation which is why the Alps do not carry on growing upwards endlessly.

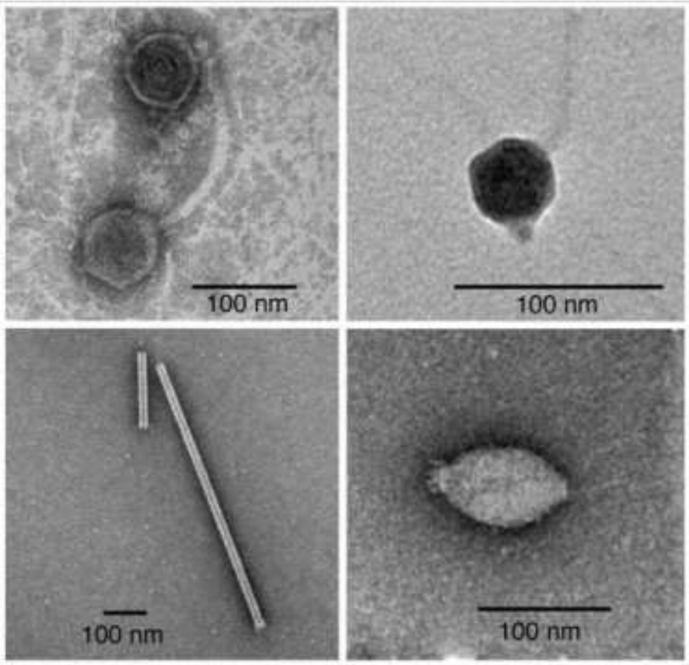
Important for natural hazards and geothermal energy

The analysis of the steep fault zones are not just of scientific interest though. The seismic, partly-still-active faults are responsible for the rocks weathering more intensively on the surface and therefore landslides and debris flows occurring, for example in the Halsi valley in the extremely steep areas of the Spreitlaui or Rotlaui. The serious debris flows in the Guttannen area are based, among other things, on this structural preconditioning of the host rocks. The leakage of warm hydrothermal water, which it is important to explore for geothermal energy and the 2050 energy policy, can be traced directly back to the brittle fracturing of the upper earth's crust and the seeping in of cold surface waters. The water is heated up in the depths and arrives at the surface again through the steep fault zones -- for example, in the Grimsel region. In this sense, the new findings lead to a deeper understanding of surface processes, which influence our infrastructures, for example the transit axes (rail, roads) through the Alps.

Story Source: Materials provided by University of Bern. **Journal Reference**: Marco Herwegh, Alfons Berger, Roland Baumberger, Philip Wehrens, Edi Kissling. **Large-Scale Crustal-Block-Extrusion**

During Late Alpine Collision. *Scientific Reports*, 2017; 7 (1) DOI: 10.1038/s41598-017-00440-0.

Viruses in the oceanic basement



These are various types of viruses observed in the basement fluids imaged using electron microscopy.

Credit: Olivia D. Nigro

A team of scientists from the University of Hawai'i at Manoa School of Ocean and Earth Science and Technology (SOEST) showed for the first time that many novel viruses are present in the fluids circulating deep in the rocky crust of the seafloor known as the ocean basement. Their recently published study also provides evidence that the viruses are actively infecting the many unusual microorganisms that live in the basement.

Viruses are often thought of as a nuisance because of the familiar diseases they cause -- common colds and the flu, for example. However, viruses infect every living thing on earth and viral infections have been one of the major creative forces that shape the nature of life on our planet. The first viruses likely originated at the dawn of life billions of years ago. Through relentless cycles of infections, viruses have helped drive the evolution of the diverse life found on our planet and their influence continues to this day.

"The ocean basement was one of the last major habitats on Earth for which we had no information on the number and types of viruses present," said lead author Olivia Nigro, post-doctoral researcher of oceanography. "The volume of water that moves under the seafloor through the ocean basement is enormous. Annually, it is equivalent to the flow of all the rivers on the planet combined." Hydrothermal vents and plumes, like those found in Hawaii at Lihi seamount, are the most spectacular evidence of that flow.

"Despite the massive scale of flow through the seafloor and its importance for understanding the chemical balance of our oceans, our view of the unusual microorganisms that live in this fluid and how they interact is still very sketchy," said Grieg Steward, oceanography professor and lead investigator for the project.

It is very challenging to get a clean sample of water from rocks buried under hundreds of feet of sediment at the bottom of the Pacific Ocean. To do this, the team took advantage of devices designed to plug holes drilled deep into the seafloor called Circulation Obviation Retrofit Kits, or CORKs. The bottom of the CORKs seal off the fluids in the basement and transport samples of that fluid to a sampling port that extends a few meters above the seafloor. The CORKs sampled were over 1.5 miles under the ocean and required an autonomous underwater vehicle to connect the sample vessels, open and close the valves, and return the samples to the surface.

The researchers used microscope and DNA analyses to count and characterize the viruses in the fluids and to detect viral DNA inside of cells. This pioneering work provided the first look at the diverse and unusual viruses infecting the microorganisms in warm basaltic crust, which forms the very foundation of the Hawaiian Islands. Surprisingly, many of them resemble the lemon- and rod-shaped viruses found in hot springs on land, like those in Yellowstone National Park, even though these two habitats are very far apart.

"One of the likely places for the origin of the first living cells and viruses was in hydrothermally active seafloor," said Nigro. "Analyzing viruses from this remote habitat helps us flesh out the deep branches on the virus family tree so we can better understand their origins, their contributions to the history of life, and how they influence the activities of microbial life in the crust."

Story Source: Materials provided by university of Hawaii at Manoa.

Journal Reference: Olivia D. Nigro, Sean P. Jungbluth, Huei-Ting Lin, Chih-Chiang Hsieh, Jaclyn A. Miranda, Christopher R. Schvarcz, Michael S. Rappé, Grieg F. Steward. **Viruses in the Oceanic Basement**. *mBio*, 2017; 8 (2): e02129-16 DOI: 10.1128/mBio.02129-16.

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 **

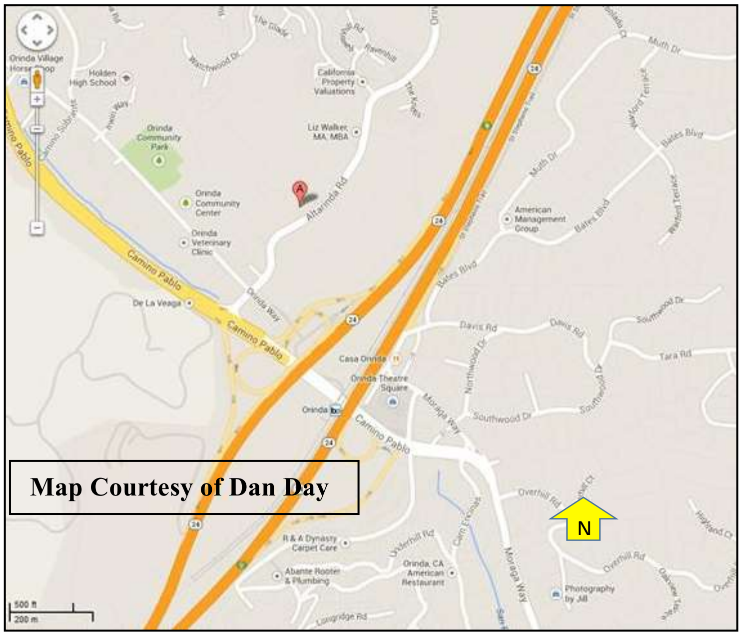
Name(s):____

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



Map Courtesy of Dan Day

Northern California Geological Society
c/o Mark Sorensen
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