NORTHERN CALIFORNIA GEOLOGICAL SOCIETY

Website: www.ncgeolsoc.org

MEETING ANNOUNCEMENT

DATE: **October 25, 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: ***Megan Nguyen, Professor of Earth Sciences, University of California, Davis***

TOPIC: ***UC Davis Center for Watershed Sciences –Research Summary***

The Center for Watershed Sciences is California's leading academic institute in water management. As an interdisciplinary research unit of the John Muir Institute of the Environment, the Center combines the talents of biologists, geologists, engineers, economists, legal scholars and others to help understand and solve California's complex water problems. The Center conducts problem-solving research and syntheses on restoration and water resource management, mainly in California, but also nationally and internationally. This presentation will review a handful of ongoing projects including:

Childs Meadow's Project (Building Beaver Dam Analogs) - Launched in 2015, this experiment is designed to test whether artificial and natural beaver dams are effective meadow restoration tools for reducing climate-warming gases and increasing biodiversity. Beaver dams increase carbon storage by trapping sediment high in carbon and raising the water table, which expands the growth of riparian and aquatic vegetation. The project tests the effects of two meadow restoration treatments on carbon sequestration, hydrology and sensitive species — one section of meadow with the mock beaver dams and the other without the structures.

Nigiri Project/Knaggs Ranch (Salmon + Rice) - The Center is investigating harvested rice fields as potential salmon nurseries that could help boost struggling Central Valley populations. Experimental releases of young hatchery salmon on the Yolo Bypass near Sacramento indicate that parts of the 57,000-acre floodway could make productive rearing habitat at **(continued on back page)**

NCGS 2017 – 2018 Calendar

November 29, 2017 **7:00 pm**
Dr. Marjorie Schulz, USGS

Marine Terraces of California: Landscapes from the Waves

NCGS Silent Auction

We will hold a brief "silent auction" during the happy hour at our October meeting. Please send the description of any auction items to Noelle Schoellkopf (NoellePrince@sbcglobal.net; NSchoellkopf@slb.com), and copy Crystal Replogle (ctreplogle@gmail.com) and Barb Matz (barbara.matz@cbifederalservices.com), ahead of time for approval and to obtain a bid sheet.

The rules of the silent auction will be sent in a separate email form Crystal. Thanks for your participation!

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 has pulled back on their activities, but meetings are still being held, including one on October 17. For an update on the future of the society, go to http://www.diggles.com/pgs/#PGSfuture. For a list of planned and 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 (usually) on Thursdays at 4 pm for most of the academic year, from late August through early May. An interesting seminar coming up on October 19 is "The role of deep mantle buoyancy in driving plates: Evidence from the Pacific" by David Rowley of the University of Chicago. For an updated list of seminars, go to http://eps.berkeley.edu/events/seminars.

Welcome back, everyone! Now: *It's Renewal Time!* Our Year Runs From September to September. If you haven't already renewed, please use the Renewal Form in previous newsletter, or see the Treasurer at the 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 at this address at 8:30 am on Saturday, January 13, 2018.

Bay Area Geophysical Society: Upcoming Speakers

November 3, 2017: Qingkai Kong (UC Berkeley)

December 2017: John Connor and Fred Herkenhoff

January 2018: Artie Rodgers (LLNL)

Please check the society's website for time, location and topic: http://bayareageophysicalsociety.org/.

NCGS Outreach Events

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 events:

- Saturday, Oct. 28th – Cal State East Bay in Hayward. Event: 11 to 4; participation needed 10 to 5.
- Saturday, Nov. 11th – ATT Park in San Francisco for Bay Area Science Festival. Event: 10 to 4; participation needed 9 to 5.

If interested, please let Mark Petrofsky know, whether Yes, No, or Maybe for each date.

It will be fun, as usual. More, these are high attendance, high-energy events (at least the S.F. one is).

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

Bay Area Science

(http://www.bayareascience.org)

This website provides a free weekly emailed newsletter of an extensive listing of local science-based activities (evening lectures, classes, field trips, hikes, etc. – usually several per week).

Also, mark your calendars for the upcoming 7th annual Bay Area Science Festival, which returns October 26th – November 11th 2017. The Science & Health Education Partnership (SEP) at the UC – San Francisco (UCSF) is producing the festival alongside a core group of science institutions. The festival will provide a wide range of science & technology activities – lectures, debates, exhibitions, concerts, plays, workshops, etc. –at a variety of locations throughout the Bay Area.

Association of Engineering Geologists San Francisco Section

Meeting locations rotate between San Francisco, the East Bay, and the South Bay. Please check the website for current details. For information on monthly meetings as well as next year's congress, go to: https://online.wr.usgs.gov/calendar/.

Also, mark your calendar to join them for the 61st AEG Annual Meeting/13th IAEG Congress in San Francisco, California on September 17-21, 2018! AEG is partnering with the International Association of Engineering Geologists and the Environment (IAEG) to host the first ever Congress in the United States in IAEG's 54-year history.

USGS Evening Public Lecture Series

The USGS evening public lecture series events are free and are intended for a general public audience that may not be familiar with the science being discussed. Monthly lectures are usually scheduled for 7 pm on the last Thursday evening of the month throughout the year, but are commonly scheduled for the previous Thursday to accommodate speakers. On October 26, Steven M. Fortier will present a lecture titled "**Global Trends in Mineral Commodity Supplies?"** For more information on the lectures, and for a map of the location, go to: https://online.wr.usgs.gov/calendar/

Ancient humans left Africa to escape drying climate

The Lamont-Doherty Core Repository contains a unique and important collection of scientific samples from the deep sea. Sediment cores from every major ocean and sea are archived here.
Credit: Courtesy Lamont-Doherty Earth Observatory

Humans migrated out of Africa as the climate shifted from wet to very dry about 60,000 years ago, according to research led by a University of Arizona geoscientist.

Genetic research indicates people migrated from Africa into Eurasia between 70,000 and 55,000 years ago. Previous researchers suggested the climate must have been wetter than it is now for people to migrate to Eurasia by crossing the Horn of Africa and the Middle East.

"There's always been a question about whether climate change had any influence on when our species left Africa," said Jessica Tierney, UA associate professor of geosciences. "Our data suggest that when most of our species left Africa, it was dry and not wet in northeast Africa."

Tierney and her colleagues found that around 70,000 years ago, climate in the Horn of Africa shifted from a wet phase called "Green Sahara" to even drier than the region is now. The region also became colder.

The researchers traced the Horn of Africa's climate 200,000 years into the past by analyzing a core of ocean sediment taken in the western end of the Gulf of Aden. Tierney said before this research there was no record of the climate of northeast Africa back to the time of human migration out of Africa.

"Our data say the migration comes after a big environmental change. Perhaps people left because the environment was deteriorating," she said. "There was a big shift to dry and that could have been a motivating force for migration."

"It's interesting to think about how our ancestors interacted with climate," she said.

The team's paper, "A climatic context for the out-of-Africa migration," is published online in *Geology* this week. Tierney's co-authors are Peter deMenocal of the Lamont-Doherty Earth Observatory in Palisades, New York, and Paul Zander of the UA.

The National Science Foundation and the David and Lucile Packard Foundation funded the research.

Tierney and her colleagues had successfully revealed the Horn of Africa's climate back to 40,000 years ago by studying cores of marine sediment. The team hoped to use the same means to reconstruct the region's climate back to the time 55,000 to 70,000 years ago when our ancestors left Africa.

The first challenge was finding a core from that region with sediments that old. The researchers enlisted the help of the curators of the Lamont-Doherty Core Repository, which has sediment cores from every major ocean and sea. The curators found a core collected off the Horn of Africa in 1965 from the *R/V Robert D. Conrad* that might be suitable.

Co-author deMenocal studied and dated the layers of the 1965 core and found it had sediments going back as far as 200,000 years.

At the UA, Tierney and Paul Zander teased out temperature and rainfall records from the organic matter preserved in the sediment layers. The scientists took samples from the core about every four inches (10 cm), a distance that represented about every 1,600 years.

To construct a long-term temperature record for the Horn of Africa, the researchers analyzed the sediment layers for chemicals called alkenones made by a particular kind of marine algae. The algae change the composition of the alkenones depending on the water temperature. The ratio of the different alkenones indicates the sea surface temperature when the algae were alive and also reflects regional temperatures, Tierney said.

To figure out the region's ancient rainfall patterns from the sediment core, the researchers analyzed the ancient leaf wax that had blown into the ocean from terrestrial plants. Because plants alter the chemical composition of the wax on their leaves depending on how dry or wet the climate is, the leaf wax from the sediment core's layers provides a record of past fluctuations in rainfall.

The analyses showed that the time people migrated out of Africa coincided with a big shift to a much drier and colder climate, Tierney said.

The team's findings are corroborated by research from other investigators who reconstructed past regional climate by using data gathered from a cave formation in Israel and a sediment core from the eastern Mediterranean. Those findings suggest that it was dry everywhere in northeast Africa, she said.

"Our main point is kind of simple," Tierney said. "We think it was dry when people left Africa and went on to other parts of the world, and that the transition from a Green Sahara to dry was a motivating force for people to leave."

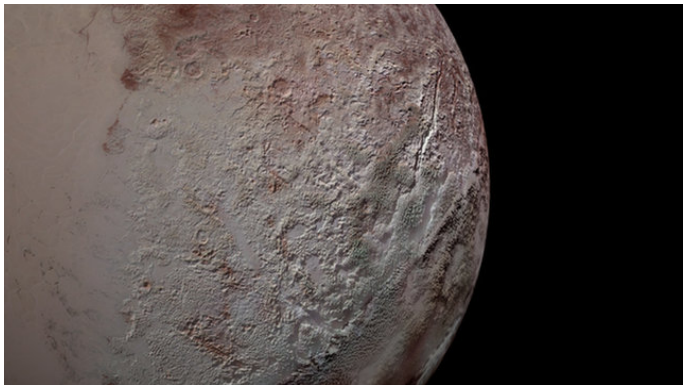
Story Source: Material provided by University of Arizona.

Journal Reference: Jessica E. Tierney, Peter B. deMenocal, Paul D. Zander. **A climatic context for the out-of-Africa migration**. *Geology*, 2017; DOI: 10.1130/G39457.1.

Pluto's 'Skyscrapers': What's Responsible for Dwarf Planet's Giant Ice Blades

Pluto's surface hosts blades of ice that soar to the height of skyscrapers — and researchers have narrowed down exactly how the dramatic features form

According to new research, the blades are made mostly of methane ice, and form similarly to (much shorter) spikes of snow and ice on Earth. When the New Horizons spacecraft flew by Pluto in July 2015, researchers observed an astonishing variety of terrains across the dwarf planet. Flat and cratered areas on the dwarf planet's surface point to its varied geological activity, composition and evolution over time.



The New Horizons mission that flew by Pluto in 2015 gathered this view of blades of ice on the dwarf planet's surface — many stretching as tall as skyscrapers. *Credit: NASA/JHUAPL/SwRI*

The jagged spikes targeted in this latest study form at the highest altitudes on Pluto's surface, near its

atmosphere, where methane is able to freeze out of the atmosphere — skipping straight from solid to gas without ever becoming liquid. When the climate is a bit warmer, parts of the methane ice sublimate away, heading straight back to gas form, according to the new study.

"When we realized that bladed terrain consists of tall deposits of methane ice, we asked ourselves why it forms all of these ridges, as opposed to just being big blobs of ice on the ground," Jeffrey Moore, a New Horizons team member and lead researcher on the new work, said in a statement. "It turns out that Pluto undergoes climate variation and sometimes, when Pluto is a little warmer, the methane ice begins to basically 'evaporate' away."

Penitentes forming at the southern end of the Chajnator plain in Chile reach a few feet in height, but are made through the same process of sublimation as Pluto's methane spikes. *Credit: Wikimedia Commons/ESO*

On Earth, such structures are called penitents, and stretch just a few meters in height in high-altitude regions along the planet's equator. Slight irregularities can turn into dramatic spikes of snow as the structures' surfaces concentrate sunlight toward certain regions, sublimating some parts faster than others and leading to longer and spikier forms.

The presence of penitentes on Pluto tell researchers more about how its surface and air temperature change over time, according to the statement, and the link between methane's presence and high elevations can help researchers map the dwarf planet's topography in places where they have lower-resolution views.

The bladed terrain on Pluto is observed to occur within latitudes 30° of the equator and are found almost exclusively at the highest elevations (> 2 km above the mean radius). Analysis indicates that these deposits of CH_4 preferentially precipitate at low latitudes where net annual solar energy input is lowest. CH_4 and N_2 will both precipitate at low elevations. However, since there is much more N_2 in the atmosphere than CH_4, the N_2 ice will dominate at these low elevations. At high elevations the atmosphere is too warm for N_2 to precipitate so only CH_4 can do so. We conclude that following the time of massive CH_4 emplacement; there have been sufficient excursions in Pluto's climate to partially erode these deposits via sublimation into the bladed shapes we see today. Blades composed of massive CH_4 ice implies that the mechanical behavior of CH_4 can support at least several hundred meters of relief at Pluto surface conditions. Bladed Terrain deposits may be widespread in the low latitudes of the poorly seen sub-Charon hemisphere, based on spectral observations. If these locations are indeed bladed terrain deposits, they may mark heretofore unrecognized regions of high elevation.

Story Source: Article by Sarah Lewin, Space.com Associate Editor, in September 27, 2017 edition.

Journal Reference: Jeffrey M.Moore, Alan D.Howard, Orkan M.Umurhan, Oliver L.White, Paul M.Schenk, Ross A.Beyera, William B.McKinnon, John R.Spencer, Kelsi N.Singer, William M.Grundy, Alissa M.Earle, Bernard Schmitti, Silvia Protopapa, Francis Nimmo, Dale P.Cruikshank, David P.Hinson, Leslie A.Young, S. AlanStern, Francesca Scipioni. Icarus, Volume 300, 15 January 2018, Pages 129-144.

Changes in Earth's crust caused oxygen to fill the atmosphere

New research has uncovered a direct link between changes in the earth's crust three billion years ago and the accumulation of free oxygen to the atmosphere

Scientists have long wondered how Earth's atmosphere filled with oxygen. UBC geologist Matthijs Smit and research partner Klaus Mezger may have found the answer in continental rocks that are billions of years old.

"Oxygenation was waiting to happen," said Smit. "All it may have needed was for the continents to mature."

Earth's early atmosphere and oceans were devoid of free oxygen, even though tiny cyanobacteria were producing the gas as a byproduct of photosynthesis. Free oxygen is oxygen that isn't combined with other elements such as carbon or nitrogen, and aerobic organisms need it to live. A change occurred about three billion years ago, when small regions containing free oxygen began to appear in the oceans. Then, about 2.4 billion years ago, oxygen in the atmosphere

suddenly increased by about 10,000 times in just 200 million years. This period, known as the Great Oxidation Event, changed chemical reactions on the surface of the Earth completely.

Smit, a professor in UBC's department of earth, ocean & atmospheric sciences, and colleague, professor Klaus Mezger of the University of Bern, were aware that the composition of continents also changed during this period. They set out to find a link, looking closely at records detailing the geochemistry of shales and igneous rock types from around the world -- more than 48,000 rocks dating back billions of years.

"It turned out that a staggering change occurred in the composition of continents at the same time free oxygen was starting to accumulate in the oceans," Smit said.

Before oxygenation, continents were composed of rocks rich in magnesium and low in silica -- similar to what can be found today in places like Iceland and the Faroe Islands. But more importantly, those rocks contained a mineral called olivine. When olivine comes into contact with water, it initiates chemical reactions that consume oxygen and lock it up. That is likely what happened to the oxygen produced by cyanobacteria early in Earth's history.

However, as the continental crust evolved to a composition more like today's, olivine virtually disappeared. Without that mineral to react with water and consume oxygen, the gas was finally allowed to accumulate. Oceans eventually became saturated, and oxygen crossed into the atmosphere.

"It really appears to have been the starting point for life diversification as we know it," Smit said. "After that change, the Earth became much more habitable and suitable for the evolution of complex life, but that needed some trigger mechanism, and that's what we may have found."

As for what caused the composition of continents to change, that is the subject of ongoing study. Smit notes that modern plate tectonics began at around the same time, and many scientists theorize that there is a connection.

Smit and Mezger published their findings in the journal *Nature Geoscience*. The research was funded by the Natural Sciences and Engineering Research Council.

Story Source: Materials provided by University of British Columbia.

Journal Reference: Matthijs A. Smit & Klaus Mezger. **Earth's early O2 cycle suppressed by primitive continents**. *Nature Geosceince*, 2017 DOI: 10.1038/ngeo3030.

Did life on Earth start due to meteorites splashing into warm little ponds?

Life on Earth began somewhere between 3.7 and 4.5 billion years ago, after meteorites splashed down and leached essential elements into warm little ponds, say scientists at McMaster University and the Max Planck Institute in Germany. Their calculations suggest that wet and dry cycles bonded basic molecular building blocks in the ponds' nutrient-rich broth into self-replicating RNA molecules that constituted the first genetic code for life on the planet.

The researchers base their conclusion on exhaustive research and calculations drawing in aspects of astrophysics, geology, chemistry, biology and other disciplines. Though the "warm little ponds" concept has been around since Darwin, the researchers have now proven its plausibility through numerous evidence-based calculations.

Lead authors Ben K.D. Pearce and Ralph Pudritz, both of the McMaster's Origins Institute and its Department of Physics and Astronomy, say available evidence suggests that life began when the Earth was still taking shape, with continents emerging from the oceans, meteorites pelting the planet -- including those bearing the building blocks of life -- and no protective ozone to filter the Sun's ultraviolet rays.

"No one's actually run the calculation before," says Pearce. "This is a pretty big beginning. It's pretty exciting. Because there are so many inputs from so many different fields, it's kind of amazing that it all hangs together," Pudritz says. "Each step led very naturally to the next. To have them all lead to a clear picture in the end is saying there's something right about this."

Their work, with collaborators Dmitry Semenov and Thomas Henning of the Max Planck Institute for Astronomy, has been published recently in the *Proceedings of the National Academy of Science*.

"In order to understand the origin of life, we need to understand Earth as it was billions of years ago. As our study shows, astronomy provide a vital part of the answer. The details of how our solar system formed have direct consequences for the origin of life on Earth," says Thomas Henning, from the Max Planck Institute for Astronomy and another co-author.

The spark of life, the authors say, was the creation of RNA polymers: the essential components of

nucleotides, delivered by meteorites, reaching sufficient concentrations in pond water and bonding together as water levels fell and rose through cycles of precipitation, evaporation and drainage. The combination of wet and dry conditions was necessary for bonding, the paper says.

In some cases, the researchers believe, favorable conditions saw some of those chains fold over and spontaneously replicate themselves by drawing other nucleotides from their environment, fulfilling one condition for the definition of life. Those polymers were imperfect, capable of improving through Darwinian evolution, fulfilling the other condition.

"That's the Holy Grail of experimental origins-of-life chemistry," says Pearce. That rudimentary form of life would give rise to the eventual development of DNA, the genetic blueprint of higher forms of life, which would evolve much later. The world would have been inhabited only by RNA-based life until DNA evolved. "DNA is too complex to have been the first aspect of life to emerge," Pudritz says. "It had to start with something else, and that is RNA."

The researchers' calculations show that the necessary conditions were present in thousands of ponds, and that the key combinations for the formation of life were far more likely to have come together in such ponds than in hydrothermal vents, where the leading rival theory holds that life began in roiling fissures in ocean floors, where the elements of life came together in blasts of heated water. The authors of the new paper say such conditions were unlikely to generate life, since the bonding required to form RNA needs both wet and dry cycles.

The calculations also appear to eliminate space dust as the source of life-generating nucleotides. Though such dust did indeed carry the right materials, it did not deposit them in sufficient concentration to generate life, the researchers have determined. At the time, early in the life of the solar system, meteorites were far more common, and could have landed in thousands of ponds, carrying the building blocks of life. Pearce and Pudritz plan to put the theory to the test next year, when McMaster opens its Origins of Life laboratory that will re-create the pre-life conditions in a sealed environment.

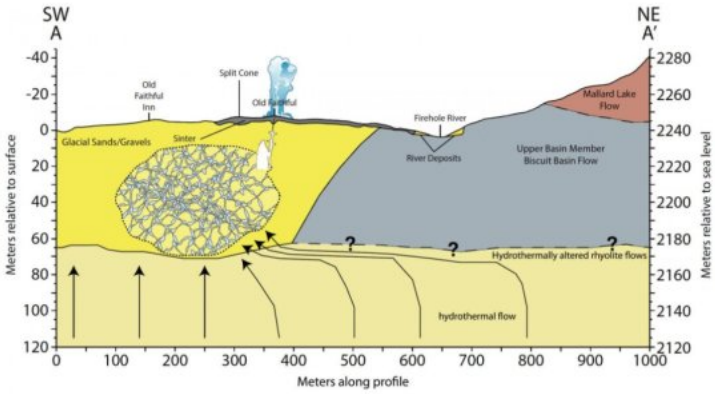
"We're thrilled that we can put together a theoretical paper that combines all these threads, makes clear predictions and offers clear ideas that we can take to the laboratory," Pudritz says.

Story Source: Materials provided by McMaster University.

Journal Reference: Ben K. D. Pearce, Ralph E. Pudritz, Dmitry A. Semenov, Thomas K. Henning. **Origin of the RNA world: The fate of nucleobases in warm little ponds**. *Proceedings of the National Academy of Sciences*, 2017; 201710339 DOI: 10.1073/pnas.1710339114.

Old Faithful's geological heart revealed

Dense seismograph network shows subsurface geyser plumbing structures



This is the model of Old Faithful's hydrogeological system suggested by the study's results.

Credit: Sin-Mei Wu

Old Faithful is Yellowstone National Park's most famous landmark. Millions of visitors come to the park every year to see the geyser erupt every 44-125 minutes. But despite Old Faithful's fame, relatively little was known about the geologic anatomy of the structure and the fluid pathways that fuel the geyser below the surface. Until now.

University of Utah scientists have mapped the near-surface geology around Old Faithful, revealing the reservoir of heated water that feeds the geyser's surface vent and how the ground shaking behaves in between eruptions. The map was made possible by a dense network of portable seismographs and by new seismic analysis techniques. The results are published in Geophysical Research Letters. Doctoral student Sin-Mei Wu is the first author.

For Robert Smith, a long-time Yellowstone researcher and distinguished research professor of geology and geophysics, the study is the culmination of more than a decade of planning and comes as he celebrates his 60th year working in America's first national park.

"Here's the iconic geyser of Yellowstone," Smith says. "It's known around the world, but the complete geologic plumbing of Yellowstone's Upper Geyser Basin has not been mapped nor have we studied how

the timing of eruptions is related to precursor ground tremors before eruptions."

Small seismometers

Old Faithful is an iconic example of a hydrothermal feature, and particularly of the features in Yellowstone National Park, which is underlain by two active magma reservoirs at depths of 5 to 40 km depth that provide heat to the overlying near-surface groundwater. In some places within Yellowstone, the hot water manifests itself in pools and springs. In others, it takes the form of explosive geysers.

Dozens of structures surround Old Faithful, including hotels, a gift shop and a visitor's center. Some of these buildings, the Park Service has found, are built over thermal features that result in excessive heat beneath the built environment. As part of their plan to manage the Old Faithful area, the Park Service asked University of Utah scientists to conduct a geologic survey of the area around the geyser.

For years, study co-authors Jamie Farrell and Fan-Chi Lin, along with Smith, have worked to characterize the magma reservoirs deep beneath Yellowstone. Although geologists can use seismic data from large earthquakes to see features deep in the earth, the shallow subsurface geology of the park has remained a mystery, because mapping it out would require capturing everyday miniature ground movement and seismic energy on a much smaller scale. "We try to use continuous ground shaking produced by humans, cars, wind, water and Yellowstone's hydrothermal boilings and convert it into our signal," Lin says. "We can extract a useful signal from the ambient background ground vibration."

To date, the University of Utah has placed 30 permanent seismometers around the park to record ground shaking and monitor for earthquakes and volcanic events. The cost of these seismometers, however, can easily exceed $10,000. Small seismometers, developed by Fairfield Nodal for the oil and gas industry, reduce the cost to less than $2,000 per unit. They're small white canisters about six inches high and are totally autonomous and self-contained. "You just take it out and stick it in the ground," Smith says.

In 2015, with the new instruments, the Utah team deployed 133 seismometers in the Old Faithful and Geyser Hill areas for a two-week campaign.

The sensors picked up bursts of intense seismic tremors around Old Faithful, about 60 minutes long, separated by about 30 minutes of quiet. When Farrell presents these patterns, he often asks audiences at what point they think the eruption of Old Faithful takes place. Surprisingly, it's not at the peak of shaking. It's at the end, just before everything goes quiet again.

After an eruption, the geyser's reservoir fills again with hot water, Farrell explains. "As that cavity fills up, you have a lot of hot pressurized bubbles," he says. "When they come up, they cool off really rapidly and they collapse and implode." The energy released by those implosions causes the tremors leading up to an eruption.

One scientist's noise is another scientist's signal

Typically, researchers create a seismic signal by swinging a hammer onto a metal plate on the ground. Lin and Wu developed the computational tools that would help find useful signals among the seismic noise without disturbing the sensitive environment in the Upper Geyser Basin. Wu says she was able to use the hydrothermal features themselves as a seismic source, to study how seismic energy propagates by correlating signals recorded at the sensor close to a persistent source to other sensors. "It's amazing that you can use the hydrothermal source to observe the structure here," she says.

When analyzing data from the seismic sensors, the researchers noticed that tremor signals from Old Faithful were not reaching the western boardwalk. Seismic waves extracted from another hydrothermal feature in the north slowed down and scattered significantly in nearly the same area suggesting somewhere west of Old Faithful was an underground feature that affects the seismic waves in an anomalous way. With a dense network of seismometers, the team could determine the shape, size, and location of the feature, which they believe is Old Faithful's hydrothermal reservoir.

Wu estimates that the reservoir, a network of cracks and fractures through which water flows, has a diameter of around 200 meters, a little larger than the University of Utah's Rice-Eccles Stadium, and can hold approximately 300,000 cubic meters of water, or more than 79 million gallons. By comparison, each eruption of Old Faithful releases around 30 m3 of water, or nearly 8,000 gallons. "Although it's a rough estimation, we were surprised that it was so large," Wu says.

The team is far from done answering questions about Yellowstone. They returned for another seismic survey in November 2016 and are planning their 2017 deployment, to begin after the park roads close for the winter. Wu is looking at how air temperature might change the subsurface structure and affect the propagation of seismic waves. Farrell is using the

team's seismic data to predict how earthquake waves might reverberate through the region. Smith is looking forward to conducting similar analysis in Norris Geyser Basin, the hottest geothermal area of the park. Lin says that the University of Utah's research program in Yellowstone owes much to Smith's decades-long relationship with the park, enabling new discoveries. "You need new techniques," Lin says, "but also those long-term relationships."

Story Source: Materials provided by Univ. of Utah.

Journal Reference: Sin-Mei Wu, Kevin M. Ward, Jamie Farrell, Fan-Chi Lin, Marianne Karplus, Robert B. Smith. **Anatomy of Old Faithful from subsurface seismic imaging of the Yellowstone Upper Geyser Basin**. *Geophysical Research Letters*, 2017; DOI: 10.1002/2017GL075255.

Early trilobites had stomachs, new fossil study finds

Remarkable Chinese specimens contradict previous assumptions about trilobite digestive systems and evolution

This photo is of a specimen of the trilobite Palaeolenus lantenoisi from the Guanshan Biota in southern Yunnan Province, China. Rarely are internal organs preserved in fossils, but this specimen shows the digestive system preserved as reddish iron oxides. The digestive system is comprised of a crop (inflated region at top of specimen), lateral glands, and a central canal that runs along the length of the body; the iron oxides that extend beyond the fossil are the remains of gut contents that were extruded during preservation. *Credit: © F. Chen*

Exceptionally preserved trilobite fossils from China, dating back to more than 500 million years ago, have revealed new insights into the extinct marine animal's digestive system. Published in the journal *PLOS ONE*, the new study shows that at least two trilobite species evolved a stomach structure 20 million years earlier than previously thought.

"Trilobites are one of the first types of animals to show up in large numbers in the fossil record," said lead author Melanie Hopkins, an assistant curator in the Division of Paleontology at the American Museum of Natural History. "Their exoskeletons were heavy in minerals, and so they preserved really well. But like all fossils, it's very rare to see the preservation of soft tissues like organs or appendages in trilobites, and because of this, our knowledge of the trilobite digestive system comes from a small number of specimens. The new material in this study really expands our understanding."

Trilobites are a group of extinct marine arthropods -- distantly related to the horseshoe crab -- that lived for almost 300 million years. They were extremely diverse, with about 20,000 species, and their fossil exoskeletons can be found all around the world. Most of the 270 specimens analyzed in the new study were collected from a quarry in southern Kunming, China, during an excavation led by Hopkins' co-author, Zhifei Zhang, from Northwest University in Xi'an.

Previous research suggests that two body plans existed for trilobite digestive systems: a tube that runs down the length of the trilobite's body with lateral digestive glands that would have helped process the food; or an expanded stomach, called a "crop," leading into a simple tube with no lateral glands. Until now, only the first type had been reported from the oldest trilobites. Based on this, researchers had proposed that the evolution of the crop came later in trilobite evolutionary history and represented a distinct type of digestive system.

The Chinese trilobite fossils, about 20 percent of which have soft tissue preservation, are dated to the early Cambrian, about 514 million years ago. Contradictory to the previously proposed body plans, the researchers identified crops in two different species within this material. In addition, they found a single specimen that has both a crop and digestive glands -- suggesting that the evolution of trilobite digestive systems is more complex than originally proposed.

The study backs up an earlier announcement made by a separate research team, which found evidence for the unusual crop and gland pairing in a single juvenile trilobite specimen from Sweden from the late Cambrian. But the Chinese material presents the oldest example of this complex digestive system in a

mature trilobite, wiping away doubts that the dual structures might just be part of the animal's early development.

"This is a very rigorous study based on multiple specimens, and it shows that we should start thinking about this aspect of trilobite biology and evolution in a different way," Hopkins said.

Story Source: Materials provided by American Museum of Natural History.

Journal Reference: Melanie J. Hopkins, Feiyang Chen, Shixue Hu, Zhifei Zhang. **The oldest known digestive system consisting of both paired digestive glands and a crop from exceptionally preserved trilobites of the Guanshan Biota (Early Cambrian, China)**. *PLOS ONE*, 2017; 12 (9): e0184982 DOI: 10.1371/journal.pone.0184982.

Dino-killing asteroid's impact on bird evolution

Human activities could change the pace of evolution, similar to what occurred 66 million years ago when a giant asteroid wiped out the dinosaurs, leaving modern birds as their only descendants. That's one conclusion drawn by the authors of a new study published in *Systematic Biology*.

Cornell University Ph.D. candidate Jacob Berv and University of Bath Prize Fellow Daniel Field suggest that the meteor-induced mass extinction (a.k.a. the K-Pg event) led to an acceleration in the rate of genetic evolution among its avian survivors. These survivors may have been much smaller than their pre-extinction relatives.

"There is good evidence that size reductions after mass extinctions may have occurred in many groups of organisms," says Berv. Paleontologists have dubbed this phenomenon the "Lilliput Effect" -- a nod to the classic tale *Gulliver's Travels*. "All of the new evidence we have reviewed is consistent with a Lilliput Effect affecting birds across the K-Pg mass extinction."

"Smaller birds tend to have faster metabolic rates and shorter generation times," Field explains. "Our hypothesis is that these important biological characters, which affect the rate of DNA evolution, may have been influenced by the K-Pg event."

The researchers jumped into this line of inquiry because of the long-running "rocks and clocks" debate. Different studies often report substantial discrepancies between age estimates for groups of organisms implied by the fossil record and estimates generated by molecular clocks. Molecular clocks use the rate at which DNA sequences change to estimate how long ago new species arose, assuming a relatively steady rate of genetic evolution. But if the K-Pg extinction caused avian molecular clocks to temporarily speed up, Berv and Field say this could explain at least some of the mismatch. "Size reductions across the K-Pg extinction would be predicted to do exactly that," says Berv.

"The bottom line is that, by speeding up avian genetic evolution, the K-Pg mass extinction may have temporarily altered the rate of the avian molecular clock," says Field. "Similar processes may have influenced the evolution of many groups across this extinction event, like plants, mammals, and other forms of life."

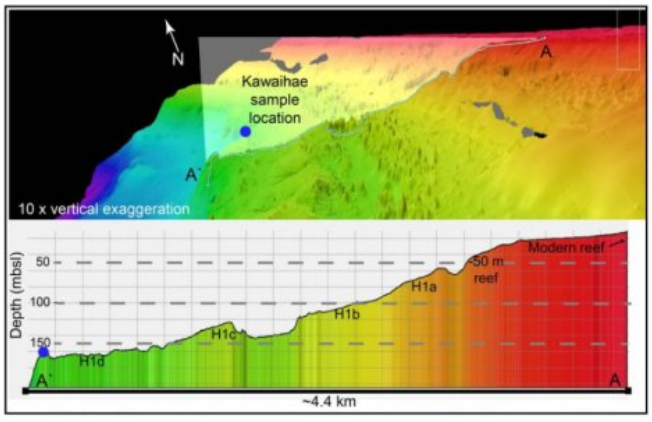
The authors suggest that human activity may even be driving a similar Lilliput-like pattern in the modern world, as more and more large animals go extinct because of hunting, habitat destruction, and climate change.

"Right now, the planet's large animals are being decimated -- the big cats, elephants, rhinos, and whales," notes Berv. "We need to start thinking about conservation not just in terms of functional biodiversity loss, but about how our actions will affect the future of evolution itself."

Story Source: Materials provided by Cornell University.

Journal Reference: Jacob S. Berv, Daniel J. Field. **Genomic Signature of an Avian Lilliput Effect across the K-Pg Extinction**. *Systematic Biology*, 2017; DOI: 10.1093/sysbio/syx064.

Did rapid sea-level rise drown fossil coral reefs around Hawaii?



This is a map showing the location of sample collection off of Kawaihae, Hawaii (blue sphere), and a slope profile (below) showing the backstepping

younger and shallower terraces overlaying the targeted reef terrace 150m below sea level. *Credit: Bathymetry data from Monterey Bay Aquarium Research Institute, and figure by Kelsey Sanborn, University of Sydney*

Investigations to predict changes in sea levels and their impacts on coastal systems are a step closer, as a result of international collaboration between the University of Sydney and researchers from Japan, Spain, and the United States.

Scientists globally are investigating just how quickly sea-level rise can occur as a result of global warming and ice sheets melting.

Recent findings suggest that episodes of very rapid sea-level rise of about 20m in <500 years occurred in the last deglaciation, caused by periods of catastrophic ice-sheet collapse as Earth warmed after the last ice age about 20,000 years ago. Lead author, PhD candidate at the Univ. of Sydney, Kelsey Sanborn, has shown this sea-level rise event was associated with "drowning" or death of coral reefs in Hawaii.

The results are published in leading geosciences journal *Quaternary Science Reviews*. The paper provides new evidence of a meltwater pulse (referred to as meltwater pulse 1-A), based on analysis of fossil coral reef samples from off the coast of Kawaihae, on the northwest of the Big Island of Hawaii.

Co-author Associate Professor Jody Webster, from the Geocoastal Research Group at the University of Sydney's School of Geosciences, said although this pulse was greater than current modelling predictions of sea-level rise over the next few hundred years, it provides an example of the risks rapid environmental change poses to our marine ecosystems.

"If we saw a sea-level rise in the future of a similar rate as this past event, it would likely devastate coral reefs and coastal systems," Associate Professor Webster said.

The fossil corals used in this study were collected by a team of technical rebreather scuba divers who dove down to 150 m below present sea level to access the fossil reef. At this depth, more than 130m deeper than where you could dive along their living shallow counterparts today, the divers recovered targeted shallow reef species that were alive over 14,700 years ago.

Lead author Ms Sanborn said this coral reef had been growing for thousands of years, during the initially gradual sea-level rise as the ice sheets of the last ice age began to melt.

"During the meltwater pulse, sea level rose more rapidly than the reef could grow, preventing the photosynthetic algae living within the corals from receiving enough sunlight. This caused the previously thriving fringing reef system to drown, and left it to be overgrown by deep-water algae and other marine life," she said.

Although uncertainty remains regarding how quickly coastal areas could be inundated around the world, understanding how these events occurred in the past are key to understanding the risks we face in the future.

"The fact that this meltwater pulse was large enough to drown a large, active Hawaiian reef system implies that extreme climate change and associated sea-level rise occurred quite rapidly," Ms Sanborn said.

This event is believed to have been brought about by catastrophic melting of the Greenland, and potentially also Antarctic, ice sheets.

"This may help us better predict the extent of future sea-level rise based on how vulnerable the Antarctic ice sheet is to collapse and melting," Ms Sanborn said.

The research was a collaborative effort between the U. of Sydney, the U. of Tokyo, the U. of Florida, the U. of Granada, the Monterey Bay Aquarium Research Institute, the U. of Hawaii, and the Association for Marine Exploration.

As part of the research, Ms Sanborn examined the evidence for reef drowning by identifying the coral reef species which grow within a specific depth range, and dating them using radiocarbon dating. Taking into account the sinking of the island due to its volcanism, the relative-sea level history of Kawaihae was reconstructed.

The findings suggest that this reef was rapidly drowned by the combined effects of sinking of the island and global sea-level rise. This is supported by other studies from around the world showing a rapid sea-level rise around 14,700 years ago.

Story Source: Materials provided by University of Sydney.

Journal Reference: Kelsey L. Sanborn, Jody M. Webster, Yusuke Yokoyama, Andrea Dutton, Juan C. Braga, David A. Clague, Jennifer B. Paduan, Daniel Wagner, John J. Rooney, John R. Hansen. **New evidence of Hawaiian coral reef drowning in response to meltwater pulse-1A**. *Quaternary Science Reviews*, 2017; 175: 60 DOI: 10.1016/j.quascirev.2017.08.022.

Carbon feedback from forest soils may accelerate global warming

After 26 years, the world's longest-running experiment to discover how warming temperatures affect forest soils has revealed a surprising, cyclical response: Soil warming stimulates periods of abundant carbon release from the soil to the atmosphere alternating with periods of no detectable loss in soil carbon stores. Overall, the results indicate that in a warming world, a self-reinforcing and perhaps uncontrollable carbon feedback will occur between forest soils and the climate system, adding to the build-up of atmospheric carbon dioxide caused by burning fossil fuels and accelerating global warming. The study, led by Jerry Melillo, Distinguished Scientist at the Marine Biological Laboratory (MBL), appears in the October 6 issue of *Science*.

Melillo and colleagues began this pioneering experiment in 1991 in a deciduous forest stand at the Harvard Forest in Massachusetts. They buried electrical cables in a set of plots and heated the soil 5° C above the ambient temperature of control plots. Over the course of the 26-year experiment (which still continues), the warmed plots lost 17 percent of the carbon that had been stored in organic matter in the top 60 centimeters of soil.

"To put this in context," Melillo says, "each year, mostly from fossil fuel burning, we are releasing about 10 billion metric tons of carbon into the atmosphere. That's what's causing the increase in atmospheric carbon dioxide concentration and global warming. The world's soils contain about 3,500 billion metric tons of carbon. If a significant amount of that soil carbon is added to the atmosphere, due to microbial activity in warmer soils, that will accelerate the global warming process. And once this self-reinforcing feedback begins, there is no easy way to turn it off. There is no switch to flip."

Over the course of the experiment, Melillo's team observed fluctuations in the rate of soil carbon emission from the heated plots, indicating cycles in the capacity of soil microbes to degrade organic matter and release carbon. Phase I (1991 to 2000) was a period of substantial soil carbon loss that was rapid at first, then slowed to near zero. In Phase II (2001-2007), there was no difference in carbon emissions between the warmed and the control plots. During that time, the soil microbial community in the warmed plots was undergoing reorganization that led to changes in the community's structure and function. In Phase III (2008-2013), carbon release from heated plots again exceeded that from control plots. This coincided with a continued shift in the soil microbial community. Microbes that can degrade more recalcitrant soil organic matter, such as lignin, became more dominant, as shown by genomic and extracellular enzyme analyses. In Phase IV (2014 to current), carbon emissions from the heated plots have again dropped, suggesting that another reorganization of the soil microbial community could be underway. If the cyclical pattern continues, Phase IV will eventually transition to another phase of higher carbon loss from the heated plots.

"This work emphasizes the value of long-term ecological studies that are the hallmark of research at the MBL's Ecosystems Center," says David Mark Welch, MBL's Director of Research. "These large field studies, combined with modeling and an increasingly sophisticated understanding of the role of microbial communities in ecosystem dynamics, provide new insight to the challenges posed by climate change."

"The future is a warmer future. How much warmer is the issue," Melillo says. "In terms of carbon emissions from fossil fuels, we could control that. We could shut down coal-fired power plants, for example. But if the microbes in all landscapes respond to warming in the same way as we've observed in mid-latitude forest soils, this self-reinforcing feedback phenomenon will go on for a while and we are not going to be able to turn those microbes off. Of special concern is the big pool of easily decomposed carbon that is frozen in Artic soils. As those soils thaw out, this feedback phenomenon would be an important component of the climate system, with climate change feeding itself in a warming world."

Story Source: Materials provided by Marine Biological Laboratory. Original written by DianaKenney.

Journal Reference: J. M. Melillo, S. D. Frey, K. M. DeAngelis, W. J. Werner, M. J. Bernard, F. P. Bowles, G. Pold, M. A. Knorr, A. S. Grandy. **Long-term pattern and magnitude of soil carbon feedback to the climate system in a warming world**. *Science*, 2017; 358 (6359): 101 DOI: 10.1126/science.aan2874.

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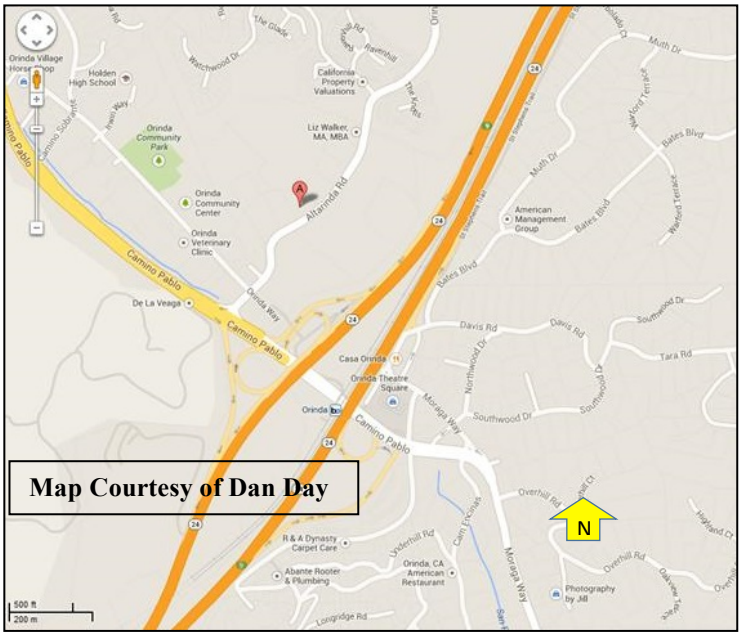

relatively little cost to farmers.

Cosumnes/McCormack Williamson Tract (Zooplankton, Fish) – Owned by The Nature Conservancy California, the island offers opportunities for restoration of of critical tidal freshwater marsh and floodplain habitat. There is also the potential that the island could be managed in such a way as to moderate flood flows in the North Delta.

Shasta River (Reconciliation Ecology) - Center scientists are investigating causes for the decline of salmon and steelhead in Shasta River, historically one of the most productive tributaries in the lower Klamath Basin. Researchers are developing approaches to restoring and sustainably managing this unique resource for both native fish and for irrigating local ranches and farms.

Biography: Megan Nguyen is Communications Coordinator for the Center for Watershed Sciences. She manages the center's new science communication outreach program, SPEAK (Scientists for Public Engagement And Knowledge). SPEAK is a workshop series that helps scientists make their research accessible, engaging, and influential. In addition to SPEAK, Megan also manages the watershed social media accounts, contributes to the California waterblog as well as producing her own written and video blog contributions. One of her most notable blog posts is the Yolo Bypass: the inland sea of Sacramento. Prior to her communications role, she was a junior specialist GIS researcher for the Center. Megan brought her creativity and critical thinking to CWS, where she continues to promote science outreach via tools such as interactive web maps and the development of virtual hikes using field data visuals.

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