NORTHERN CALIFORNIA GEOLOGICAL SOCIETY

MEETING ANNOUNCEMENT

DATE: **September 28, 2016**

LOCATION: **Orinda Masonic Center, 9 Altarinda Rd., Orinda**

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: **Rick Wilson, Senior Engineering Geologist, California Geological Survey – Tsunami Program**

Topic: Addressing California's Tsunami Hazard

California faces tsunami threats from both local and distant sources. North of Cape Mendocino, large earthquakes on the Cascadia Subduction Zone have the potential of causing tsunamis greater than 50 feet high as they travel onshore. For areas south of Cape Mendocino, smaller offshore reverse and thrust faults as well as submarine landslides are also capable of creating moderate to large local tsunamis which could impact adjacent coastal communities. All of California's coastal communities face a legitimate distant-source threat capable of producing tsunamis of 20 to 30 feet for portions of the central coast and 10 to 15 feet for southern California. These tsunami threats overall put over 300,000 coastal residents and millions of coastal visitors at risk on a daily basis.

Recent tsunamis, primarily the February 27, 2010 Chilean event and the March 11, 2011 Japan event, have been wake-up calls for emergency managers, harbormasters, and other coastal planners. These two events have resulted in inconsistencies in coastal evacuation and response, and caused over $100M in damages to 27 harbors in California.

An overview of the tsunami hazard and vulnerability of California will be summarized. Results from new hazard analyses and new planning tools being developed by the state will be presented. How these new tools address preparedness, response, mitigation, and recovery will also be discussed.

Biography: Mr. Rick Wilson is a Senior Engineering Geologist with the California Geological Survey who has worked for over 25 years in the geologic and seismic hazard fields, much of it with the state Seismic Hazard Mapping Program. For the past ten years, Mr. Wilson has been the Science Coordinator for the State of California Tsunami Preparedness and Hazard Mitigation Program, a program

NCGS 2016 – 2017 Calendar

October 26, 2016 7:00 pm
Dr. Brian Collins, U.S. Geological Survey

Processes of exfoliation-induced rock falls: recent studies from California's Sierra Nevada

November 16, 2016 (one week early) 7:00 pm
Dr. Julia Sigwart, Associate Professor and UCMP Visiting Scholar

Two Miles Underwater: A Voyage to the Bottom of the Sea

NCGS Field Trips

Field trips 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

For an updated list of 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 weekly at EPS throughout the academic year, generally from late August through early May. Seminars are held Thursdays at 4 pm at 141 McCone. Fall speakers are listed and include Peter Molnar, but titles are not yet available.

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.

Important NCGS note:

We are searching for a new secretary!

Our current secretary, Dan Day, has served superbly for many years, and needs a break. Something about moving out of state – to Oregon! We wish him well and thank him for his many years of service to NCGS in several different roles. If you are interested in taking on the secretary position, or know someone who is, please contact a member of the Nominating Committee (Ray Sullivan, Tom Barry, and Mark Sorensen) or the President by email or at the next meeting.

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 not yet been scheduled, but will likely be in early- to mid-January 2017.

Dr. M. Lee Allison (1948 - 2016)

(Editor's Note: We thank John Christian for contributing this information and the references cited herein.)

The author of the best state government geology blog and the head of the Arizona Geological Survey, Dr. M. Lee Allison, died at the age of 68 following a fall off a ladder in Tucson. Formally the head state geologist in Kansas and Utah, he was a tireless advocate for the dissemination of accurate geological information to the general public and governmental agencies using entertaining methods.

The most poignant tribute was written by geologist and geological novelist, Sarah Andrews, who gave a talk to NCGS in 2006. She said that Allison had great integrity. Allison resigned as the head Utah State Geologist because the state did not want to let him talk about the earthquake hazards found underneath a planned state building. In sympathy with Allison's plight Andrews created a character in her book based on Allison. Here is her article: https://speakingofgeoscience.org/2016/08/29/in-appreciation-m-lee-allison-1948-2016/

Here is a link to Allison's Arizona Geology blog. I wish that California could have a similar high quality blog. http://arizonageology.blogspot.com/

Allison also hosted the interesting monthly, Arizona Mining Review, sponsored by the Arizona Geological Survey on YouTube: https://www.youtube.com/playlist?list=PLLkn9lzbK_rcCj38_m1nlt7MweBLuiNT

Here is a good article about Allison from the Arizona Daily Star: http://tucson.com/news/state-geologist-s-death-devastating-as-agency-moves-to-ua/article_b979e877-c8a0-5eb1-b29f-9daa310e32f5.html

Like Rodney Dangerfield, geologists get no respect including Lee Allison. In this article, Allison points out results of valid geological studies that go against the public and governmental preconceived notions. For example, uranium mining near the Grand Canyon will cause little additional uranium flowing through the Colorado River since 40 to 60 tons of naturally occurring uranium already do so. See: http://www.earthmagazine.org/article/down-earth-lee-allison

NCGS members in the news!!

See the link below. It includes Ray Sullivan offering his informed opinion about the tilting apartment tower in downtown SF! We watched it at the board meeting. (See what you're missing when you don't come!)

The high-end San Francisco apartment that can't stand straight - CBS News

http://www.cbsnews.com/news/high-end-san-francisco-apartment-cant-stand-straight/

Member Contribution

(Editor's Note: We thank John Christian for contributing this poem and photographs.)

Here is a parody of Robert Frost's "The Road Not Taken" that points out my rock and fossil collecting philosophy. Roads are good to take you to the areas that few people search, the hillsides and the creek beds. Remember, I like to leave no stone unturned.

The Roads Not Taken

by John Christian

Two roads diverged in a rocky wood,
And not sorry to travel either one
And being an adventurer, long I stood
And looked up the nearby creek bed as far as I could
To see the rocks glistening in the sun.

I took the downstream side, as just as fair,
And having perhaps the better rocks
Because it was fossil rich and wanted wear;
Paleozoic creatures preserved there
stood out in massive limestone blocks.

The up and downstream sides equally lay
In rocks no one had collected.
Oh, I kept the upstream side for another day,
Knowing fossils that occurred that way,
should not be left uninspected.

I shall be telling this with never a sigh
Somewhere ages and ages hence:
Two roads diverged in a wood, and I—
I took the creek bed nearby,
And that has made all the difference.

Here are some of my creek bed finds. The first one is a Cretaceous *Encodus* sp. fish found in the Atco Chalk near Dallas, Texas. The second one is a 60 pound slickenside in volcanic Moraga Formation rock found in Orinda, California.

'Anthropocene': Potential new geological time interval

Date: August 29, 2016

The Working Group on the 'Anthropocene' (AWG), which includes University of Leicester geologists, will provide its summary of evidence and its provisional recommendations on a potential new geological time interval at the 35th International Geological Congress in South Africa between 27 August -- 4 September.

This international scientific body (that includes the University of Leicester geologists Jan Zalasiewicz, Mark Williams and honorary chair, the British Geological Survey geologist Colin Waters, and archaeologist Matt Edgeworth), has been active since 2009, analysing the case for formalization of the Anthropocene, a potential new epoch of geological time dominated by human impact on the Earth. The AWG is about to present its preliminary findings and recommendations at the International Geological Congress in Cape Town, at the same time indicating the range of voting opinion within the group on the major questions surrounding the Anthropocene. It will also map out a route towards a formal proposal on formalization, and indicate work that still needs be done to effect this.

Majority current opinion on the group indicates the following:

• The Anthropocene concept, as articulated by Paul Crutzen and Eugene Stoermer in 2000, is geologically real. The phenomenon is of sufficient scale to be considered as part of the International Chronostratigraphic Chart, more commonly known as the Geological Time Scale.

• Majority AWG opinion is for assignation as an Epoch/Series. This option is preferred over either a lower rank (e.g. Age/Stage, i.e. as a subdivision of the Holocene) or a higher rank such as a Period or Era. In such a step, and in common with all other geological time units, the Anthropocene would comprise both a 'pure time' unit (an Anthropocene Epoch) and an equivalent unit of strata (an Anthropocene Series).

- If the Anthropocene is adopted as an Epoch, this would mean that the Holocene has terminated, but that we remain within the Quaternary Period and Cenozoic Era.

• Human impact has left discernible traces on the stratigraphic record for thousands of years -- indeed, since before the beginning of the Holocene. However, substantial and approximately globally synchronous changes to the Earth System most clearly intensified in the 'Great Acceleration of the mid-20th century. The mid-20th century also coincides with the clearest and most distinctive array of signals imprinted upon recently deposited strata.

• Hence, the mid-20th century represents the optimal beginning of a potential Anthropocene Epoch (and, simultaneously, the base of the Anthropocene Series).

• Changes to the Earth System that characterize the potential Anthropocene Epoch include marked acceleration to rates of erosion and sedimentation, large-scale chemical perturbations to the cycles of carbon, nitrogen, phosphorus and other elements, the inception of significant change to global climate and sea level, and biotic changes such as unprecedented levels of species invasions across the Earth. Many of these changes are geologically long-lasting, and some are effectively irreversible.

• These and related processes have left an array of signals in recent strata, including plastic, aluminum and concrete particles, artificial radionuclides, changes to carbon and nitrogen isotope patterns, fly ash particles, and a variety of fossilizable biological remains. Many of these signals will leave a permanent record in the Earth's strata.

• The Anthropocene beginning might conceivably be defined by a Global Standard Stratigraphic Age (GSSA), i.e. a numerical age that can be expressed as a calendar date such as 1945. Or more, conventionally it could be defined by a Global boundary Stratotype Section and Point (GSSP), which is more colloquially a 'golden spike', and is a physical reference point in strata at one carefully selected place. Majority opinion on the AWG is to seek and choose a candidate GSSP, as this is the most familiar and widely accepted method of defining geological time units.

• The AWG has already begun the process of identification of potential GSSPs, by initial analysis of the general environments in which the best combinations of stratigraphic signals may be found (e.g. undisturbed lake or marine sediments, annually banded coral skeletons, polar snow/ice layers, speleothems and so on).

• This will lead to selection of sites for sampling and further analysis, to provide full descriptions of relevant signals in the strata, a process that we hope will lead to the identification of one or more suitable candidate sites for a GSSP. We would hope to complete this process over the next 2-3 years.

• This would then form the basis for the preparation of a formal proposal, to our immediate parent body, the Subcommission on Quaternary Stratigraphy (SQS), on defining a formal Anthropocene unit. If the SQS recommends this by supermajority vote, the proposal will go on to its parent body, the International Commission on Stratigraphy (ICS) to be voted on, with any vote in favor still needing to be ratified by the

Executive Committee of the International Union of Geological Sciences (IUGS).

• If all of these conditions can be fulfilled, then the Anthropocene would become a formal part of the Geological Time Scale.

Results of AWG Vote (35 members):

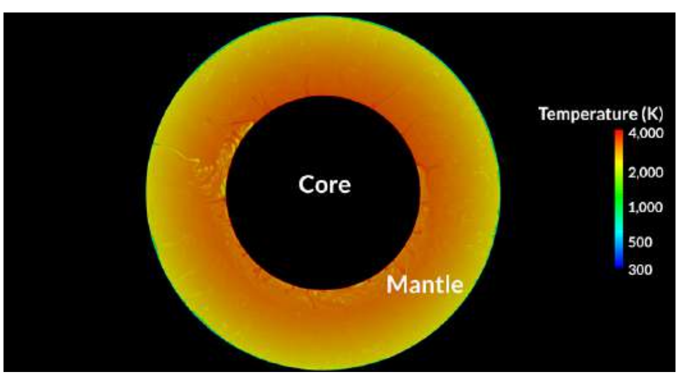
- Is the Anthropocene stratigraphically real? For: 34, Against: 0, Abstain: 1
- Should the Anthropocene be formalised? For:30, Against: 3, Abstain: 2
- Hierarchical level of the Anthropocene? Era: 2, Period: 1.5, Epoch: 20.5, Sub-epoch: 1, Age: 2, Sub-age: 0, None: 1, Uncertain: 3, Abstain: 4
- Base/beginning of the Anthropocene? ~7ka: 0, ~3ka: 1.3, 1610 Orbis: 0, ~1800: 0, ~1950: 28.3, ~1964: 1.3, Diachronous: 4, Uncertain: 0, Abstain: 0
- GSSA .v. GSSP? GSSP: 25.5, GSSA: 1.5, Uncertain: 8
- What is the Primary Signal? aluminum: 0, plastic: 3, fuel ash particles: 2, carbon dioxide concentration: 3, methane concentration: 0, carbon isotope change: 2, oxygen isotope change: 0, radiocarbon bomb spike: 4, Plutonium fallout: 10, Nitrate concentration / nitrogen isotope change: 0, Biostratigraphic: extinction/ assemblage change: 0, Other (lead, persistent organic pollutants, technofossils): 3, Uncertain: 2, Abstain: 6.

Story Source: The above post is reprinted from materials provided by University of Leicester.

Reference: University of Leicester. "'Anthropocene': Potential new geological time interval." ScienceDaily. ScienceDaily, 29 August 2016. <www.sciencedaily.com/releases/2016/08/160829094255.htm>.

Plate tectonics just a stage in Earth's life cycle: Simulation shows crust to stop shifting in 5 billion years

Thomas Sumner, *Science News*



TECTONIC TIMETABLE: Plate tectonics will grind to a halt in a few billion years, researchers predict. A computer simulation calculated how heat flows through a planet's interior, including this snapshot during a period of active plate tectonics.

Earth's plate tectonics could be a passing phase. After simulating rock and heat flow throughout a planet's lifetime, researchers have proposed that plate tectonics is just one stage of a planet's life cycle.

In the simulation, the Earth's interior was too hot and runny at first to push around the giant chunks of crust, researchers report in the June *Physics of the Earth and Planetary Interiors*. After the interior cooled for around 400 million years, tectonic plates began shifting and sinking, though the process was stop-and-go for about 2 billion years. The simulation suggests that Earth now is nearly halfway through its tectonic life cycle, says study coauthor Craig O'Neill, a planetary scientist at Macquarie University in Sydney. In around 5 billion years, plate tectonics will grind to a halt as the planet chills.

The long delay before full-blown plate tectonics hints that the process could one day begin on currently stagnant planets, says Julian Lowman, a geodynamicist at the University of Toronto who was not involved in the research. "There is a possibility that plate tectonics could start up on Venus if conditions were right," he says.

Plate tectonics regulates a planet's climate by adding and removing carbon dioxide from the atmosphere. This climate control helps maintain Earth's habitability. Plate movement is driven by heat flow through the planet's interior. Simulating that heat flow requires complex calculations. Previous simulations were simplified and typically considered only snapshots of Earth's history and missed how plate tectonics evolves over time.

O'Neill and colleagues simulated Earth's full tectonic life span, starting with the planet's formation around 4.5 billion years ago and looking ahead to around 10 billion years in the future. Even using a supercomputer and simulating only a two-dimensional cross section of the planet, the calculations took weeks.

The new timeline suggests that Earth's plate tectonics is just a midpoint in the planet's evolution between two stagnant states. Planets with different starting temperatures than Earth's follow different trajectories, the team found. Colder planets may exhibit plate tectonics throughout their history while hotter planets could go for billions of years without plate tectonics.

Just because a planet currently lacks plate tectonics doesn't make it uninhabitable, O'Neill says. Life potentially appeared on Earth as early as around 4.1 billion years ago (Science News Online: 10/19/2015), a time when the new simulation suggests that Earth lacked full-blown plate tectonics. "Stagnant planets, depending on when they are in their history, can be equally likely of supporting habitable conditions" as planets with plate tectonics, O'Neill says.

Story Source: Science News Magazine issue: Vol. 189, No. 13, June 25, 2016, p. 8.

Journal Reference: C. O'Neill et al. A window for plate tectonics in terrestrial planet evolution? *Physics of the Earth and Planetary Interiors*. Vol. 255, June 2016, p. 80. doi: 10.1016/j.pepi.2016.04.002.

Proxima b is in host star's habitable zone, but could it really be habitable?

Artist's impression of the planet orbiting the red dwarf star Proxima Centauri. *Credit: ESO*

The world's attention is now on Proxima Centauri b, a possibly Earth-like planet orbiting the closest star, 4.22 light-years away. The planet's orbit is just right to allow liquid water on its surface, needed for life. But could it in fact be habitable?

If life is possible there, the planet evolved very different than Earth, say researchers at the University of Washington-based Virtual Planetary Laboratory (VPL) where astronomers, geophysicists, climatologists, evolutionary biologists and others team to study how distant planets might host life.

Astronomers at Queen Mary University in London have announced discovery of Proxima Centauri b, a planet orbiting close to a star 4.22 light-years away. The find has been called "the biggest exoplanet discovery since the discovery of exoplanets."

Rory Barnes, UW research assistant professor of astronomy, published a discussion about the discovery at palereddot.org, a website dedicated to the search for life around Proxima Centauri. His essay describes research underway through the UW planetary lab -- part of the NASA Astrobiology Institute -- to answer the question, is life possible on this world?

"The short answer is, it's complicated," Barnes writes. "Our observations are few, and what we do know allows for a dizzying array of possibilities" -- and almost as many questions.

The Virtual Planetary Laboratory is directed by Victoria Meadows, UW professor of astronomy. UW-affiliated researchers include Giada Arney, Edward Schwieterman and Rodrigo Luger. Using computer models, the researchers studied clues from the orbits of the planet, its system, its host star and apparent companion stars Alpha Centauri A and B -- plus what is known of stellar evolution to begin evaluating Proxima b's chances.

Relatively little is known about Proxima:

• It's at least as massive as Earth and may be several times more massive, and its "year" -- the time it takes to orbit its star -- is only 11 days

• Its star is only 12 percent as massive as our sun and much dimmer (so its habitable zone, allowing liquid water on the surface, is much closer in) and the planet is 25 times closer in than Earth is to our sun

• The star may form a third part of the Alpha Centauri binary star system, separated by a distance of 15,000 "astronomical units," which could affect the planet's orbit and history

• The new data hint at the existence of a second planet in the system with an orbital period near 200 days, but this has not been proven

Perhaps the biggest obstacle to life on the planet, Barnes writes, is the brightness of its host star. Proxima Centauri, a red dwarf star, is comparatively dim, but wasn't always so.

"Proxima's brightness evolution has been slow and complicated," Barnes writes. "Stellar evolution models all predict that for the first one billion years Proxima slowly dimmed to its current brightness, which implies that for about the first quarter of a billion years, planet b's surface would have been too hot for Earth-like conditions."

Barnes notes that he and UW graduate student Rodrigo Luger recently showed that had modern Earth been in such a situation, "it would have become a Venus-like world, in a runaway greenhouse state that can destroy all of the planet's primordial water," thus extinguishing any chance for life.

Next come a host of questions about the planet's makeup, location and history, and the team's work toward discerning answers.

• Is the planet "rocky" like Earth? Most orbits simulated by the planetary lab suggest it could be -- and thus can host water in liquid form, a prerequisite for life

• Where did it form, and was there water? Whether it formed in place or farther from its star, where ice is more likely, VPL researchers believe it is "entirely possible" Proxima b could be water-rich, though they are not certain.

• Did it start out as a hydrogen-enveloped Neptune-like planet and then lose its hydrogen to become Earth-like? VPL research shows this is indeed possible, and could be a viable pathway to habitability

• Proxima Centauri flares more often than our sun; might such flares have long-since burned away atmospheric ozone that might protect the surface and any life? This is possible, though a strong magnetic field, as Earth has, could protect the surface.

Also, any life under even a few meters of liquid water would be protected from radiation.

Another concern is that the planet might be tidally locked, meaning one side permanently faces its star, as the moon does Earth. Astronomers long thought this to mean a world could not support life, but now believe planetwide atmospheric winds would transport heat around the planet.

"These questions are central to unlocking Proxima's potential habitability and determining if our nearest galactic neighbor is an inhospitable wasteland, an inhabited planet, or a future home for humanity," Barnes writes.

Planetary laboratory researchers also are developing techniques to determine whether Proxima b's atmosphere is amenable to life. "Nearly all the components of an atmosphere imprint their presence in a spectrum (of light)," Barnes writes. "So with our knowledge of the possible histories of this planet, we can begin to develop instruments and plan observations that pinpoint the critical differences."

At high enough pressures, he notes, oxygen molecules can momentarily bind to each other to produce an observable feature in the light spectrum. "Crucially, the pressures required to be detectable are large enough to discriminate between a planet with too much oxygen, and one with just the right amount for life.

As we learn more about the planet and the system, we can build a library of possible spectra from which to quantitatively determine how likely it is that life exists on planet b."

Our own sun is expected to burn out in about 4 billion years, but Proxima Centauri has a much better forecast, perhaps burning for 4 trillion years longer.

"If Proxima b is habitable, then it might be an ideal place to move. Perhaps we have just discovered a future home for humanity. But in order to know for sure, we must make more observations, run many more computer simulations and, hopefully, send probes to perform the first direct reconnaissance of an exoplanet," Barnes writes. "The challenges are huge, but Proxima b offers a bounty of possibilities that fills me with wonder."

Proxima Centauri b may be the first exoplanet to be directly characterized by powerful ground- and space-based telescopes planned for the future, and its atmosphere spectroscopically probed for active biology. The research was funded by the NASA Astrobiology Institute. "Whether habitable or not," Barnes concludes, "Proxima Centauri b offers a new glimpse into how the planets and life fit into our universe."

Story Source: The above post is reprinted from materials provided by University of Washington. The original item was written by Peter Kelley.

Journal Reference: "Proxima b is in host star's habitable zone, but could it really be habitable?" *ScienceDaily*, 29 August 2016. <www.sciencedaily.com/releases/2016/08/160829155336.htm>.

Some islands started in diamond-bearing regions under continents, geochemists say

Journeys spanning thousands of miles, billions of years

Crystals of the mineral olivine, taken from Grand Comore Island in the Indian Ocean, have a calcium-to-aluminum ratio similar to that of fluids found in diamonds. This suggests that both materials have a common source. *Credit: Courtesy Yaakov Weiss/Lamont-Doherty Earth Observatory*

The raw materials of some volcanic islands are shaped by some of the same processes that form diamonds deep under the continents, according to a new study. The study asserts that material from diamond-forming regions journeys nearly to earth's core and back up to form such islands, a process that could take two and a half billion years or longer -- more than half of earth's entire history. The research challenges some prevailing notions about the workings of the deep earth, and their connections to the surface. The study, led by researchers at Columbia University's Lamont-Doherty Earth Observatory, appears this week in the scientific journal *Nature*.

In line with the theory of plate tectonics, scientists believe that many islands far out in the oceans are the product of mantle plumes -- hot spots of material welling up from the vast region below earth's thin crust to erupt on the ocean floor. Examples include the Hawaiian and Galápagos chains. Prevailing thought says the raw material is recycled ocean crust made of the volcanic rock basalt that has been shoved down, or subducted, under the lighter rocks of the continents. This material is then thought to sink as far as 1,800 miles to the mantle's boundary with earth's core, then rise back up.

The new study leaves this basic story intact, but adds an intriguing chapter for some lavas with peculiar compositions known as "HIMU," meaning high μ, the Greek letter geochemists use as shorthand for the ratio of uranium to lead. The solid rocks of the continents stick down into the mantle like teeth set in gums. Thin ocean crust subducting under them often drags along carbon-rich limestone, a common ocean-floor sedimentary rock. Once near the continental roots, some of that carbon gets expelled as a fluid, interacting with and altering rocks there. A hundred miles or more down, this process forms diamond, a pure crystalline form of carbon that sometimes reaches the surface in rapid, explosive eruptions. The new study says chunks of the altered roots may also drop off and sink, to later re-emerge as part of an island-forming eruption.

The key to the finding: a connection between the chemistry of tiny bits of carbon-rich fluids, or inclusions, trapped within diamonds, and that of the lavas that form the HIMU islands. Diamond inclusions comprise the original carbon-rich fluid from which the diamond crystallized, and this fluid contains dozens of other elements that form characteristic abundance patterns. A defining characteristic of the fluids: a high ratio of calcium to aluminum. On the islands studied, the researchers found similarly high calcium-to-aluminum ratios in olivine, a mineral that crystallized from the magmas. They compared the abundance patterns of 28 other elements in the lavas, from cesium to lutetium, and found that the patterns also matched those within diamond inclusions. The conclusion: the diamonds and the lavas came from the same stuff. "It's not every day that new observations force us to completely rethink a concept that has been accepted for decades," said coauthor Cornelia Class, a Lamont-Doherty geochemist.

"Trace elements are the fingerprints of geologic processes," said lead author Yaakov Weiss, a Lamont-Doherty geochemist who studies diamond inclusions. "The key link is that carbon-rich fluids in diamonds that formed 100 miles below the surface and magmas that welled up from 1,800 miles down have the same unique chemical signatures. We can look at diamonds as time capsules, as messengers from a place we have no other way of seeing." Weiss last year published a study concluding that inclusions showed ancient seawater was involved in the formation of some diamonds.

The scientists analyzed HIMU lavas from the Cook-Austral islands in the south Pacific, and Grand Comore island, in the Indian Ocean. Most samples were taken by coauthor Takeshi Hanyu of the Japan Agency for Marine-Earth Science and Technology, who has previously studied the Cook-Austral rocks. (Another HIMU island, which the team did not study, is the Atlantic Ocean's St. Helena, where Napoleon was imprisoned following his downfall.) All of these islands formed 20 million years ago or less, meaning that while they themselves are geologically young, their source material is extremely ancient.

The findings are bolstered by previous research from others showing that diamond inclusions and HIMU lavas both contain unique combinations of isotopes of the element sulfur that were common in earth's atmosphere before 2 billion years ago, after which respiration from photosynthetic algae caused oxygen to accumulate in the air. This shows that the material for both diamonds and HIMU lavas came from the surface long ago.

"The idea that the subcontinental mantle contributes significantly to mantle plumes has been around for over 30 years, but never found general acceptance," said coauthor Steven Goldstein, also a geochemist at Lamont-Doherty. "While this is likely not the last piece to the HIMU puzzle, it signals a major shift in our view of deep earth dynamics."

One thing the study does not suggest: that diamonds might be found on oceanic islands. They might have been present in the continental root at the start of its journey, but would have been destroyed along the way.

The study was partly funded by the U.S. National Science Foundation.

Story Source: The above post is reprinted form materials provided by Lamont-Doherty Earth Observatory, Columbia University.

Journal Reference: Yaakov Weiss, Cornelia Class, Steven L. Goldstein, Takeshi Hanyu. Key new pieces of the HIMU puzzle from olivines and diamond inclusions. *Nature*, 2016; DOI: 10.1038/nature19113.

New study identifies next faults to fail along California-Nevada border

A handful of faults lining the border of California and Nevada may be near the point of rupture, according to a new study assessing earthquakes in the region as far back as 1,400 years ago.

Scientists report in a new study that earthquakes in a fault network east of the Sierra Nevada Mountains are not random, but are likely triggered from stress bestowed by past earthquakes. This same type of stress has built up in six faults near Death Valley, California, and Reno, Nevada, according to the new research.

These faults could be the next among their network to generate a moderate to major earthquake, according to the new study published in *Tectonics*, a journal of the American Geophysical Union. Rupture on these faults is not imminent and the new study does not specify when an earthquake might occur.

"The spatial distribution of earthquakes in this region is not a random process," said Alessandro Verdecchia, a geologist at the Ludwig Maximilian University of Munich, Germany, and lead author of the new study. "If we model these stress changes, we can see if a fault may be prone, perhaps ready, to produce an earthquake."

The Pacific and North American plates meet to form a series of faults along the western edge of the United States. In some sections, like along the San Andreas Fault, the plates' boundaries move past each other quickly and in easily discerned patterns. Faults like these have been studied extensively and the earthquakes they produce can be tracked to specific locations. These plate boundaries are referred to as localized because movement is confined to a small area near the plate boundary.

East of the San Andreas Fault, however, another section of the plates' boundaries slips past each other in a very different way. There, along the California-Nevada border, is a network of many smaller, slower-moving faults. Unlike localized plate boundaries, movement along this section of the plates' boundaries is diffused over a wider area. As a consequence, this fault network produces earthquakes occurring much farther apart in time and space. Because they interact in complex ways and less is known about them, these faults are generally more difficult to study, according to Verdecchia.

Looking at a map of the region's past earthquakes, Verdecchia suspected there may be a pattern. Previous studies looked closely at earthquakes along the California-Nevada border, but many focused on a smaller timescale or fewer events. The new study, however, assessed all of the region's tremors from 587 CE to 1954, a period comprising nearly 1,400 years of geological history.

Using data from previous studies, the study's authors built a three-dimensional model of the fault network's geometry. They used historical measurements to track how the region's earthquakes had interacted over the centuries. The authors found most of the events shared a link: Coulomb stress. Coulomb stress refers to the transfer of stress along a fault. To picture Coulomb stress, imagine rubbing the heels of two cleated shoes together. Stress accumulates where the spikes meet and unloads when they finally push past each other.

Stress is unloaded similarly during earthquakes. But that stress doesn't disappear — it moves to and accumulates in new places by traveling along a fault. Some of the stress is transferred instantaneously, like during an earthquake. Other stress is transferred much more slowly, usually over a long period following an earthquake. To study where previous earthquakes have struck and figure out when and where they might rupture again, the study's authors said it's important to consider both types of Coulomb stress.

Verdecchia and his coauthors used their model to understand where Coulomb stress traveled between earthquakes. They found more than 80 percent of the earthquakes in the region happened in areas where the increase in stress was high, leading them to conclude that faults in the region with high stress increases could be the next to produce earthquakes.

While the majority of the faults in the study network have accumulated Coulomb stress, six of those faults have reached roughly the average stress level of 30 bars needed to trigger a moderate to major earthquake, according to the new study. Because those active faults haven't produced an earthquake in more than 1,000 years, Verdecchia suspects they may be the next to fail, though their failure is not necessarily imminent nor does the new study predict when an earthquake might occur.

"If we can say a fault has accumulated 30 bars, then its number is very close to an average stress drop for a large earthquake," Verdecchia said. "That means that fault may be ready to produce a large earthquake."

Most of the next-to-fail faults, like the Black, White and Hunter Mountain fault zones, are in or near Death Valley, California. There are no densely populated areas nearby. But tourist destinations like Bishop, Big Pine and Mammoth lakes, which harbor a few thousand people, do stand near the fault zones, according to Verdecchia.

Further north, the Pyramid and Honey Lake fault zones stand closer to Reno, Nevada, which is home to more than 200,000 people. Honey Lake is roughly 96 kilometers (60 miles) from Reno, while Pyramid Lake is less than 64 kilometers (40 miles) away.

Verdecchia said the same method used in the new study has been used to examine faults in other areas of the world, though only in regions with detailed records of past earthquakes. He warns earthquake prediction in general is a distant enterprise, saying far too many uncertainties, like the lingering mysteries of earthquake mechanics, remain. “The real challenge now is to try to minimize those uncertainties,” he said.

-by Brendan Bane, an intern at American Geophysical Union’s (AGU’s) public information department.

Journal Reference: Alessandro Verdecchia, Sara Carena. **Coulomb stress evolution in a diffuse plate boundary: 1400 years of earthquakes in eastern California and western Nevada, USA.** Tectonics, 8 August 2016**.** **DOI:** 10.1002/2015TC004091.

New genus of bacteria found living inside hydraulic fracturing wells

'Frackibacter' one of dozens of microbes forming sustainable ecosystems there, study finds

Ohio State University researchers and their colleagues have identified a new genus of bacteria living inside hydraulic fracturing wells. These jars contain samples of "produced water fluids" -- the fluid that is collected at the surface of a hydraulic fracturing well after fracturing -- from wells in Marcellus and Utica shale formations. The fluids are orange because they contain large amounts of iron that oxidizes when the fluids are brought to the surface. By analyzing the genomes of microbes in the water, the researchers are piecing together the existence of microbial communities inside the wells.

Credit: Photo by Rebecca Daly, courtesy of The Ohio State University.

Researchers analyzing the genomes of microorganisms living in shale oil and gas wells have found evidence of sustainable ecosystems taking hold there -- populated in part by a never-before-seen genus of bacteria they have dubbed "Frackibacter."

The new genus is one of the 31 microbial members found living inside two separate fracturing wells, Ohio State University researchers and their colleagues report in the Sept. 5 online edition of the journal *Nature Microbiology*.

Even though the wells were hundreds of miles apart and drilled in different kinds of shale formations, the microbial communities inside them were nearly identical, the researchers discovered.

Almost all the microbes they found had been seen elsewhere before, and many likely came from the surface ponds that energy companies draw on to fill the wells. But that's not the case with the newly identified *Candidatus Frackibacter*, which may be unique to hydraulic fracturing sites, said Kelly Wrighton, assistant professor of microbiology and biophysics at Ohio State.

In biological nomenclature, "Candidatus" indicates that a new organism is being studied for the first time using a genomic approach, not an isolated organism in a lab culture. The researchers chose to name the genus "Frackibacter" as a play on the word "fracking," shorthand for "hydraulic fracturing."

Candidatus Frackibacter prospered alongside the microbes that came from the surface, forming communities in both wells which so far have lasted for nearly a year.

"We think that the microbes in each well may form a self-sustaining ecosystem where they provide their own food sources," Wrighton explained. "Drilling the well and pumping in fracturing fluid creates the ecosystem, but the microbes adapt to their new environment in a way to sustain the system over long periods."

By sampling fluids taken from the two wells over 328 days, the researchers reconstructed the genomes of bacteria and archaea living in the shale. To the researchers' surprise, both wells -- one drilled in Utica shale and the other drilled in Marcellus shale -- developed nearly identical microbial communities.

In addition, the two wells are each owned by different energy companies that utilized different fracturing techniques. The two types of shale exist more than a mile and a half below ground, were formed millions of years apart, and contained different forms of fossil fuel. Yet one bacterium, *Halanaerobium*, emerged to dominate communities in both wells.

"We thought we might get some of the same types of bacteria, but the level of similarity was so high it was striking. That suggests that whatever's happening in these ecosystems is more influenced by the fracturing than the inherent differences in the shale," Wrighton said.

Wrighton and her team are still not 100 percent sure of the microbes' origins. Some almost undoubtedly came from the ponds that provide water to the wells, she said. But other bacteria and archaea could have been living in the rock before drilling began, *Candidatus Frackibacter* among them.

Shale energy companies typically formulate their own proprietary recipes for the fluid they pump into wells to break up the rock and release oil or gas, explained Rebecca Daly, research associate in microbiology at Ohio State and lead author of the *Nature Microbiology* paper. They all start with water and add other chemicals. Once the fluid is inside a well, salt within the shale leaches into it, making it briny.

The microorganisms living in the shale must tolerate high temperature, pressure and salinity, but this study suggests that salinity is likely the most important stressor on the microbes' survival. Salinity forces the microbes to synthesize organic compounds called osmoprotectants to keep themselves from bursting. When the cells die, the osmoprotectants are released into the water, where other microbes can use them for protection themselves or eat them as food. In that way, salinity forced the microbes to generate a sustainable food source.

In addition to the physical constraints in the environment, the microbes also must protect themselves from viruses. The researchers reconstructed the genomes of viruses living inside the wells, and found genetic evidence that some bacteria were indeed falling prey to viruses, dying, and releasing osmoprotectants into the water.

By examining the genomes of the different microbes, the researchers found that the osmoprotectants were being eaten by *Halanaerobium* and *Candidatus Frackibacter*. In turn, these bacteria provided food for other microbes called methanogens, which ultimately produced methane.

To validate their findings from the field, the researchers grew the same microbes in the lab under similar conditions. The lab-grown microbes also produced osmoprotectants that were converted into methane -- a confirmation that the researchers are on the right track to understanding what's happening inside the wells.

One implication of the study is that methane produced by microbes living in shale wells could possibly supplement the wells' energy output.

Wrighton and Daly described the amount of methane produced by the microbes as likely minuscule compared to the amount of oil and gas harvested from the shale even a year after initial fracturing. But, they point out, there is a precedent in a related industry, that of coal-bed methane, to use microbes to greater advantage.

"In coal-bed systems they've shown that they can facilitate microbial life and increase methane yields," Wrighton said. "As the system shifts over time to being less productive, the contribution of biogenic methane could become significantly higher in shale wells. We haven't gotten to that point yet, but it's a possibility."

In the meantime, research led by co-author Michael Wilkins, assistant professor of earth sciences and microbiology, has used genomics information to grow *Candidatus Frackibacter* in the lab and is further testing its ability to handle high pressure and salinity.

Story Source: The above post is reprinted from materials provided by the Ohio State University. The original item was written by Pam Frost Gorder.

Journal Reference: Rebecca A. Daly, Mikayla A. Borton, Michael J. Wilkins, David W. Hoyt, Duncan J. Kountz, Richard A. Wolfe, Susan A. Welch, Daniel N. Marcus, Ryan V. Trexler, Jean D. MacRae, Joseph A. Krzycki, David R. Cole, Paula J. Mouser, Kelly C. Wrighton. Microbial metabolisms in a 2.5-km-deep ecosystem created by hydraulic fracturing in shales. *Nature Microbiology*, 2016; 1: 16146 DOI: 10.1038/nmicrobiol.2016.146.

A tenth of the world's wilderness lost since the 1990s

Credit: Liana Joseph

Researchers reporting in the journal Current Biology show catastrophic declines in wilderness areas around the world over the last 20 years. They demonstrate alarming losses comprising a tenth of global wilderness since the 1990s -- an area twice the size of Alaska and half the size of the Amazon. The Amazon and Central Africa have been hardest hit.

The findings underscore an immediate need for international policies to recognize the value of wilderness areas and to address the unprecedented threats they face, the researchers say.

"Globally important wilderness areas -- despite being strongholds for endangered biodiversity, for buffering and regulating local climates, and for supporting many of the world's most politically and economically marginalized communities -- are completely ignored in environmental policy," says Dr James Watson of the University of Queensland in Australia and the Wildlife Conservation Society in New York. "Without any policies to protect these areas, they are falling victim to widespread development. We probably have one to two decades to turn this around. International policy mechanisms must recognize the actions needed to maintain wilderness areas before it is too late. We probably have one to two decades to turn this around."

Watson says much policy attention has been paid to the loss of species, but comparatively little was known about larger-scale losses of entire ecosystems, especially wilderness areas which tend to be relatively understudied. To fill that gap, the researchers mapped wilderness areas around the globe, with "wilderness" being defined as biologically and ecologically intact landscapes free of any significant human disturbance. The researchers then compared their current map of wilderness to one produced by the same methods in the early 1990s.

This comparison showed that a total of 30.1 million km2 (around 20 percent of the world's land area) now remains as wilderness, with the majority being located in North America, North Asia, North Africa, and the Australian continent. However, comparisons between the two maps show that an estimated 3.3 million km2 (almost 10 percent) of wilderness area has been lost in the intervening years. Those losses have occurred primarily in South America, which has experienced a 30 percent decline in wilderness, and Africa, which has experienced a 14 percent loss.

"The amount of wilderness loss in just two decades is staggering" Dr Oscar Venter of the University of Northern British Colombia. "We need to recognize that wilderness areas, which we've foolishly considered to be de-facto protected due to their remoteness, is actually being dramatically lost around the world. Without proactive global interventions we could lose the last jewels in nature's crown. You cannot restore wilderness, once it is gone, and the ecological process that underpin these ecosystems are gone, and it never comes back to the state it was. The only option is to proactively protect what is left."

Watson says that the United Nations and others have ignored globally significant wilderness areas in key multilateral environmental agreements and this must change.

"If we don't act soon, there will only be tiny remnants of wilderness around the planet, and this is a disaster for conservation, for climate change, and for some of the most vulnerable human communities on the planet," Watson says. "We have a duty to act for our children and their children."

Story Source: The above post is reprinted form materials provided by Wildlife Conservation Society.

Journal Reference: Watson et al., **Catastrophic Declines in Wilderness Areas Undermine Global Environment Targets**. Current Biology, 2016 DOI: 10.1016/j.cub.2016.08.049.

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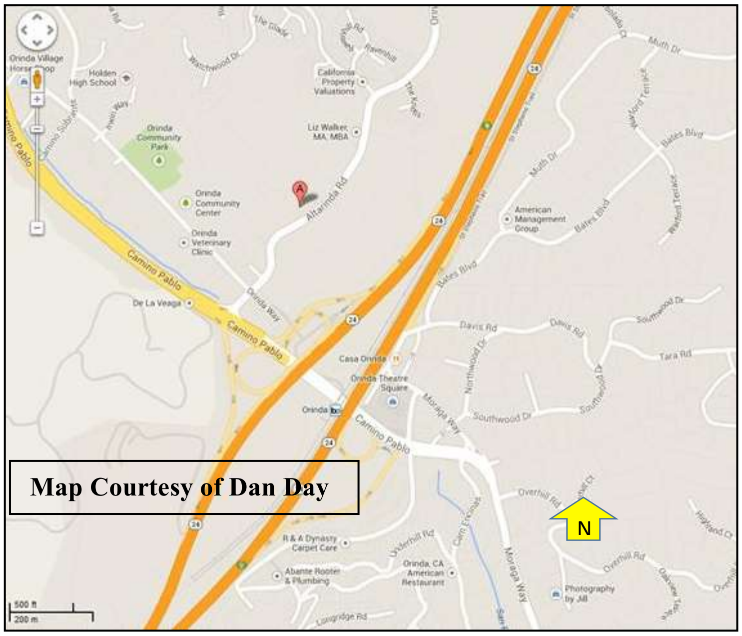

Map Courtesy of Dan Day

headed by the California Governor's Office of Emergency Services. Mr. Wilson is also the state Science Representative on the Coordinating Committee of the National Tsunami Hazard Mitigation Program (NTHMP), a partnership between federal and state governmental agencies designed to reduce the impact of tsunamis through hazard assessment, warning guidance, and mitigation. More recently, Mr. Wilson has been working on new planning tools to help ports and harbors improve tsunami response activities, and provide background information for making harbor improvements. These tools have been integrated into national NTHMP guidance for other states to use. For his tsunami planning work, Mr. Wilson was the recipient of the 2015 Andy Lee Award for Extraordinary Public Service for State Activities from the Floodplain Management Association.

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