NORTHERN CALIFORNIA GEOLOGICAL SOCIETY

MEETING ANNOUNCEMENT

DATE: **June 22, 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: **Jerome (Jerry) De Graff, U.S. Forest Service**

Topic: Fire, Earth & Rain: Emergency Response for Wildfire-Induced Landslide Hazards

The Jahns Distinguished Lectureship, established in 1988, is sponsored by the Association of Environmental and Engineering Geologists and the GSA Engineering Geology Division. Its purpose is to provide funding for distinguished engineering geologists to present lectures at colleges and universities in order to increase awareness of students about careers in engineering geology. The lectureship is named in honor of Dr. Richard H. Jahns (1915- 1983), an engineering geologist who had a diverse and distinguished career in academia, consulting and government. The main talk being offered by Mr. De Graff is "Fire, Earth & Rain: Emergency Response for Wildfire-Induced landslide Hazards".

Wildfire is a unique natural hazard because it poses immediate threats to life and property as well as creating conditions that can lead to subsequent debris flows and accelerated rock fall. This is a significant problem in the western U.S. where large wildfires have become more frequent since the mid-1980s. Limiting the impact of these post-fire geologic hazards requires determining their likelihood and location within the burned area. A rapid assessment is needed to ensure mitigation measures can be implemented prior to an initiating rainfall event.

Biography: During most of his 36 years in the US Forest Service, Jerry De Graff served in positions of either an environmental or engineering geologist on National Forests in Utah and California. In those capacities, he collected and interpreted geologic information needed for sustainable development, multiple-use management of natural resources, and emergency response. Jerry acted as the in-house geologist providing information on geomorphic processes, groundwater conditions, and other geologic conditions. During his last 6 years, he was a Forest Service On-Scene Coordinator for Superfund-type issues and responses at abandoned mines and other Forest Service sites in California. Since retiring from government service February 2014, Jerry continues his geology career teaching graduate courses for the Department of Earth & Environmental Science at CSU-Fresno, acting in

NCGS 2015 – 2016 Calendar

September 28, 2016 **7:00 pm**
Rick Wilson, California Geological Survey

Addressing California's Tsunami Hazard

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**

To Be Determined

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. For an updated list of seminars, go to http://eps.berkeley.edu/events/seminars.

Reminder: *It's Past 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, at the CB&I (formerly Shaw E&I) offices at 4005 Port Chicago Hwy, Concord, CA 94520. The next board meeting is scheduled for 8:30 am to noon on **Saturday, September 10, 2016**.

New Law Puts the Squeeze on the Arizona Geological Survey

Arizona state services at risk include a program to map Earth fissures; the state's earthquake-monitoring network; and the Survey's mineral resources program

A new law that consolidates the Arizona Geological Survey within the University of Arizona at Tucson could result in dramatic cuts to state geological services, according to the Survey and some industries that rely on its capabilities. However, Arizona governor Doug Ducey's office maintains that the cost-cutting action benefits taxpayers while building on synergy between the Survey and the university.

The action, part of broader budget legislation Ducey signed into law in May, calls for the Survey to vacate its current quarters by 30 June and move into space 75% smaller, but the law does not provide funding for the Survey for fiscal year (FY) 2017, which begins on 1 July.

The University of Arizona has agreed to provide the Survey with the equivalent of the Survey's FY 2016 state appropriation of $941,000 for the upcoming fiscal year, after which the Survey would need to become entirely self-supporting, according to Lee Allison, Arizona state geologist and director of the survey. Allison serves as a member of the *Eos* editorial advisory board. At risk is funding for mapping, hazard monitoring, and other services.

Reduction in Services

Since 2011, the Survey received $5.36 million from the state while entrepreneurially raising an additional $35.8 million through external research grants and contracts, according to a Survey document, which notes that the Survey had 27 employees earlier this year.

Allison applauded the University of Arizona for agreeing to replace state funds for the Survey for the coming year. However, he told *Eos* that the grant and contract funding that the Survey has raised on its own to support its state services now "will mostly go to the university to support [its] services, resulting in a 40%–50% reduction of those [Survey] functions and the staff that carried them out." He said that concerns about the Survey's future have prompted 20% of its staff to take other jobs. Allison also has notified another 25% of staff of pending layoffs.

Governor's Office Defends Action

The consolidation language, which was in the final state budget package approved in May, reflects a strategic way to cut the budget while taking advantage of synergies between the Survey and the university, according to Dan Scarpinato, spokesman for Arizona governor Ducey. He said the consolidation is a cost-efficient "net positive" for the Survey and the clients it assists and for the university.

– Excerpt of article written by Randy Showstack, Staff Writer for EOS. For the full article see the story source at the EOS website: https://eos.org/articles/new-law-puts-the-squeeze-on-the-arizona-geological-survey#.V1HXsma_Jrk.email

Journal Citation: Showstack, R. (2016), New law puts the squeeze on the Arizona Geological Survey, *Eos, 97,* doi:10.1029/2016EO053643. Published on 03 June 2016.

Methane-producing Microbes in California Rocks

The Cedars, shown here, is a small, isolated set of springs flowing out of a large patch of red rock from Earth's mantle in Sonoma County, California. The Cedars is one of the few easily-accessible sites of serpentinization on land. Credit: Lukas Kohl

A team of scientists report in a new study that they have found evidence of hardy, methane-producing microbes in water that surfaces from deep underground at The Cedars, a set of freshwater springs in Sonoma County.

It is the first time scientists have proven that these kinds of methane-producing microbes, which thrive in harsh environments, live anywhere outside of the deep sea. The new finding could offer clues into how early microbes could have lived on Earth billions of years ago and if they might be present on other planets like Mars, according to scientists in the field.

The new study also shows the newly-discovered microbes are likely capable of using carbon dioxide to produce methane -- a finding that could have implications for future carbon sequestration projects being proposed in areas similar to The Cedars, said Lukas Kohl, a biogeochemist at Memorial University of Newfoundland in St. John's, Newfoundland and lead author of the new study published in the Journal of Geophysical Research -- Biogeosciences, a journal of the American Geophysical Union.

If the microbes convert carbon dioxide injected into the ground into methane -- a potent greenhouse gas -- it could offset the benefit gained by carbon sequestration, he said.

"As our technology's expanding, we're able to look outside of the box a little to capture some of these groups [of microbes]," said Matt Schrenk, a microbiologist at Michigan State University in East Lansing, Michigan, who was not involved in the study. "As we're beginning to look into some of these natural environments [deep underground], our view of the microbial world, and of life in general, is really expanding."

Serpentinization, a process where water reacts with rock to create a green stone called serpentine, is common on the ocean floor. In the process, byproducts of the reaction, including methane, hydrogen, and heat, are released. The Cedars--a small, isolated set of springs flowing out of a large patch of red rock from Earth's mantle -- is one of the few easily-accessible sites of serpentinization on land.

Communities of microbes have been detected at many serpentinization sites across the globe, including in oceanic vents and sites deep underground. These harsh, high-pH environments have few organic molecules for organisms to feed on. These hardy microbes likely use the byproducts of serpentinization as an energy source, according to the study's authors. Until the new study, however, the only sites known to host microbes that released methane as a waste product were deep underwater, Schrenk said.

Previous analysis of water from The Cedars suggested some of the methane found in the springs could have come from microbes. To confirm the microbes could produce the methane at The Cedars, the study's authors took water samples from the springs and exposed the samples to different conditions in the laboratory.

In one group of samples they killed any living microbes. In these samples, they did not detect any additional methane being produced. The samples with live microbes, however, produced significant amounts of methane. In some cases, the live-microbe vials contained 650 percent more methane than vials with dead microbes. The scientists were also able to trace the methane, and determine that it had been produced by microbes, rather than as a product of serpentinization. The new study, combined with previous data, suggests a

significant portion of methane in water at The Cedars likely comes from the microbes living there.

The new findings also suggest the microbes can convert carbon dioxide into methane. Some scientists have proposed injecting carbon dioxide from the air into rocks like those at The Cedars. The carbon dioxide interacts with the rock and water to form a solid carbonate that can sequester carbon underground indefinitely and keep it out of the air. But if the microbes convert the injected carbon dioxide to methane and release it into the atmosphere, it would defeat the purpose of sequestration, Schrenk said. "If some of that [sequestered] carbon dioxide is converted to an even more potent greenhouse gas, we're really in trouble," he said.

The new study also sheds light on how microbes could have used the energy and chemicals from serpentinization to survive on early Earth when the atmosphere contained less oxygen and fewer organic molecules, said William Brazelton, an astrobiologist at the University of Utah in Salt Lake City who was not involved with the study. Further, the methane they released could have had an impact on the environment and the Earth's evolution, he added.

The discovery of the methane-producing microbes at The Cedars also gives hope to those searching for life on Mars, Brazelton said. Some surveys of the Martian atmosphere have found methane, which was thought to be a product of serpentinization. This study shows the methane could be a product of both serpentinization and microbes, Brazelton said.

Story Source: The above post is reprinted from materials provided by American Geophysical Union.

Journal Reference: Lukas Kohl and others. **Exploring the metabolic potential of microbial communities in ultra-basic, reducing springs at The Cedars, CA, USA: Experimental evidence of microbial methanogenesis and heterotrophic acetogenesis**. Journal of Geophysical Research: Biogeosciences, 2016; 121 (4): 1203 DOI: 10.1002/2015JG003233

Human Didn't Wait on Melting Ice to Settle the Americas

The steppe bison had much larger horns than modern bison. Radiocarbon dating and DNA analysis of bison fossils enabled researchers to track the migration of Pleistocene steppe bison into an ice-free corridor that opened along the Rocky Mountains about 13,000 years ago.

For most of the last ice age, enormous glaciers covered western Canada. And yet people still managed to cross deep into the Americas from their settlements in western Alaska. How did they do it? Archaeologists once thought a narrow strip of land opened up between the glaciers, allowing them passage. But others suspect the migrants hopped down the Pacific coast in boats long before that happened. Now, a new study of bison fossils offers the most precise date yet for the opening of the ice-free corridor: 13,000 years ago. Combined with evidence of earlier occupations in the lower 48, it suggests the corridor could not have been the first route people took into the New World.

"This is the first strong empirical data indicating when that corridor was viable," says Michael Waters, an archaeologist at Texas A&M University, College Station. "It's indirect evidence, but it's still strong evidence."

The opening date has loomed large in debates about the settling of the Americas. Researchers long thought that Clovis hunters, identified by their distinctive "fluted" spear points marked with long, shallow grooves, followed game south through the corridor more than 13,000 years ago, when their tools begin to show up in the continental United States. Recently discovered evidence of earlier human habitation in the Americas suggested they may have used a different, more ancient route. But hard data on the corridor were virtually nonexistent. Geoscientist Duane Froese and archaeologist Jack Ives, both at the University of Alberta, Edmonton, in Canada, were disappointed when they reviewed the literature a few years ago. "It [hadn't] really moved much in the last 20 years," Froese says.

So Froese and Ives set out to find when the corridor became habitable using a new tool: bison fossils. Bison were already in North America when the glaciers began to grow, and the ice separated their populations into northern and southern branches. During that time, southern bison experienced a dramatic die-off, shrinking to just a few closely related individuals. When the population began to grow again, they all had very similar genes. In particular, their mitochondrial DNA—genes in the power plants of cells, passed down only from the mother—was basically identical. By the time the ice sheets receded thousands of years later, "bison in the south all look the same, and bison in the north look different," says Beth Shapiro, an evolutionary biologist at the University of California, Santa Cruz. So to tell which group a bison fossil belonged to, all she had to do was sequence its mitochondrial DNA. Finding a

southern bison in the north or a northern bison in the south would indicate that the animals were successfully traversing the ice-free corridor. Radiocarbon dates from collagen in the fossils could reveal exactly when that had happened.

Northern and southern bison were mingling within the ice-free corridor by about 13,000 years ago, the team reports online today in the *Proceedings of the National Academy of Sciences*. That's right around the first appearance of Clovis points. But it's well after a handful of sites dated to the pre-Clovis period, including Page-Ladson in Florida, where archaeologists recently discovered a 14,500-year-old stone biface.

Still, the corridor may have been important for people on the move. "It may not have been Highway 1" into the New World, Ives says. "But it was Highway 2." By the time bison were able to pass through the corridor, he says, humans were already living south of the ice sheets, presumably after traveling down the Pacific coast by boat. "When those ice masses parted, human groups that had been separated for maybe a thousand or even few thousand years would have had a chance to get back in touch with each other," Ives says—just as the bison appear to have done.

Intriguingly, the researchers found more southern bison using the corridor to move north than northern bison coming south, perhaps because the lower reaches of the corridor became passable while the north was still frozen. If that's case, it's likely people did the same, flipping the traditional script about the corridor on its head. "We've always historically looked at the corridor as the way that people migrated from Alaska down into the interior of the United States," says Waters, who excavated Page-Ladson and several other pre-Clovis sites. "But now, we're seeing that it's the complete opposite. It's actually a corridor by which people are traveling back up to the north." That could explain why fluted points in northern Alaska appear to be younger than those discovered in the lower 48, Ives says: It's likely that Clovis technology developed in the south, and people carried it north.

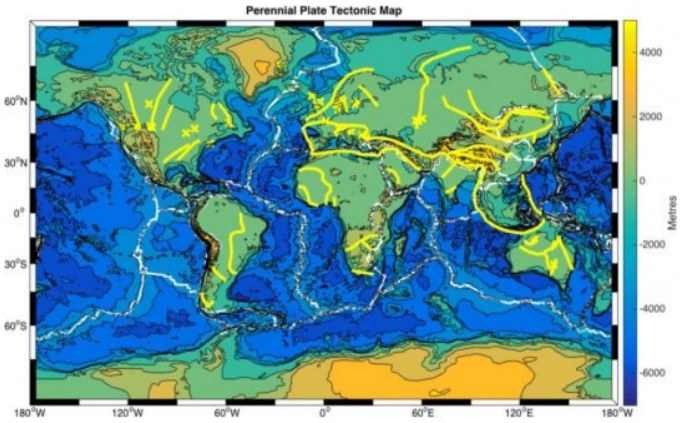
Some researchers remain skeptical, however, including Clovis expert Gary Haynes, an archaeologist at the University of Nevada, Reno. He cautions against extrapolating the bison data to humans. "It sets a date for the opening of this corridor to big, gregarious, herding animals, but I don't know if it necessarily sets a date for the very first movement of humans," he says. People could have been moving through the corridor long before it was capable of hosting the kind of extensive grassland bison depend on, perhaps by following and hunting less ecologically demanding waterfowl, he says. "It's tantalizing evidence, but it's not the slam-dunk kind of evidence."

Researchers agree that the bison data offer only an upper limit on the habitability of the ice-free corridor; it's possible that people could have used it before the bison. "It would be great to have solid evidence of humans," whether through bones or trace amounts of ancient DNA left behind in sediment cores, Shapiro says. "Maybe this [study] will reignite some of the interest in the corridor region, and help people who have other types of expertise or are collecting other types of data to really start focusing on this area again."

Story Source: The above post was written by Lizzie Wade, and published at the website of ***Science*** magazine at http://www.sciencemag.org/news/2016/06/humans-didn-t-wait-melting-ice-settle-americas.

Journal Reference: DOI: 10.1126/science.aaf5768.

Deep "Scars" from Ancient Geologic Events Play Role in Current Earthquakes



A proposed perennial plate tectonic map. Present-day plate boundaries (white lines), with hidden ancient plate boundaries that may reactivate to control plate tectonics (yellow lines). Regions where mantle lithosphere heterogeneities have been located are given by yellow crosses. *Credit: Russell Pysklywec, Philip Heron, Randell Stephenson*

Super-computer modelling of Earth's crust and upper-mantle suggests that ancient geologic events may have left deep 'scars' that can come to life to play a role in earthquakes, mountain formation, and other ongoing processes on our planet.

This changes the widespread view that only interactions at the boundaries between continent-sized tectonic plates could be responsible for such events.

A team of researchers from the University of Toronto and the University of Aberdeen have created models indicating that former plate boundaries may stay hidden deep beneath the Earth's surface. These multi-million-year-old structures, situated at sites away from existing plate boundaries, may trigger changes in the structure

and properties at the surface in the interior regions of continents.

"This is a potentially major revision to the fundamental idea of plate tectonics," says lead author Philip Heron, a postdoctoral fellow in Russell Pysklywec's research group in U of T's Department of Earth Sciences. Their paper, "Lasting mantle scars lead to perennial plate tectonics," appears in the June 10, 2016 edition of *Nature Communications*.

Heron and Pysklywec, together with University of Aberdeen geologist Randell Stephenson have even proposed a 'perennial plate tectonic map' of the Earth to help illustrate how ancient processes may have present-day implications.

"It's based on the familiar global tectonic map that is taught starting in elementary school," says Pysklywec, who is also chair of U of T's Department of Earth Sciences. "What our models redefine and show on the map are dormant, hidden, ancient plate boundaries that could also be enduring or "perennial" sites of past and active plate tectonic activity."

To demonstrate the dominating effects that anomalies below the Earth's crust can have on shallow geological features, the researchers used U of T's SciNet -- home to Canada's most powerful computer and one of the most powerful in the world -- to make numerical models of the crust and upper-mantle into which they could introduce these scar-like anomalies.

The team essentially created an evolving "virtual Earth" to explore how such geodynamic models develop under different conditions.

"For these sorts of simulations, you need to go to a pretty high resolution to understand what's going on beneath the surface," says Heron. "We modeled 1,500 kilometers across and 600 kilometers deep, but some parts of these structures could be just two or three kilometers wide. It is important to accurately resolve the smaller-scale stresses and strains."

Using these models, the team found that different parts of the mantle below the Earth's crust may control the folding, breaking, or flowing of the Earth's crust within plates -- in the form of mountain-building and seismic activity -- when under compression.

In this way, the mantle structures dominate over shallower structures in the crust that had previously been seen as the main cause of such deformation within plates.

"The mantle is like the thermal engine of the planet and the crust is an eggshell above," says Pysklywec. "We're looking at the enigmatic and largely unexplored realm in the Earth where these two regions meet."

"Most of the really big plate tectonic activity happens on the plate boundaries, like when India rammed into Asia to create the Himalayas or how the Atlantic opened to split North America from Europe," says Heron. "But there are lots of things we couldn't explain, like seismic activity and mountain-building away from plate boundaries in continental interiors."

The research team believes their simulations show that these mantle anomalies are generated through ancient plate tectonic processes, such as the closing of ancient oceans, and can remain hidden at sites away from normal plate boundaries until reactivation generates tectonic folding, breaking, or flowing in plate interiors.

"Future exploration of what lies in the mantle beneath the crust may lead to further such discoveries on how our planet works, generating a greater understanding of how the past may affect our geologic future," says Heron.

The research carries on the legacy of J. Tuzo Wilson, also a U of T scientist, and a legendary figure in geosciences who pioneered the idea of plate tectonics in the 1960's.

"Plate tectonics is really the cornerstone of all geoscience," says Pysklywec. "Ultimately, this information could even lead to ways to help better predict how and when earthquakes happen. It's a key building block."

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

Journal Reference: Philip J. Heron, Russell N. Pysklywec, Randell Stephenson. Lasting mantle scars lead to perennial plate tectonics. *Nature Communications*, 2016; 7: 11834 DOI: 10.1038/ncomms11834.

Slowing of landslide flows reflects California's drying climate

Merged data from on-the-ground measurements, aerial photography, satellite imagery and satellite-radar imaging have unveiled an unexpected geological consequence of northern California's ongoing drought.

Initially, University of Oregon scientists were perplexed by new satellite data that indicated that trees and rocks atop 98 slow-moving landslides in northern California's Eel River Basin were no longer flowing at historical rates seen between 1944 and the turn of the century. Many of the formations, they could see, had barely moved in the last three years.

"We realized that this slowing down of the landslides was a massive signature of California's drought," said Joshua Roering, a professor in the UO Department of Geological Sciences. "Finding this was an accident. We didn't set out to connect our research to climate. We discovered this by being frustrated by the data."

The research, led by Roering's postdoctoral researcher Georgie L. Bennett, is detailed in a paper accepted for publication in the journal *Geophysical Research Letters*. The findings, she said, are important to scientists monitoring landslides worldwide, including at similar sites she has visited in Italy.

Many Eel River Basin landslides have been slowly moving for thousands of years. The new study shows that the landslides, based on the 10 most-scrutinized landslides, slowed by half twice between 2009 and 2015, a period when the region experienced unprecedented drought.

Rates of historical movement vary by the size and depth of individual formations, Roering said, adding that, in general, the landslides had averaged "a few feet" annually. Small landslides are more sensitive to seasonal periods of rainfall and drought, while larger landslides more likely average out impacts from climate variability, the researchers found.

"Landslides move highways and make things really difficult for engineers all over the western U.S., and all over the world," Roering said.

Understanding the interior plumbing of landslides, especially how moisture affects "the conveyor belt" that keeps them moving along the surface is vital to maintaining safety and for projecting conditions that may indicate a catastrophic collapse that could dam a river or destroy a highway, he said.

"The landslide outflows we studied are typical in many places in the world," said Bennett, now a postdoctoral research associate with the U.S. Forest Service and Colorado State University. "This paper is important to helping understand how landslides respond to rainfall, and it provides data that should eventually help in terms of forecasting how landslides will respond to climate change. Smaller outflows are more sensitive to increasing or declining amounts of precipitation."

The study area covered an 86-square-mile stretch along the 200-mile-long river, which meanders through the coastal mountain range from just north of California's wine country to near Fortuna, where it meets the Pacific Ocean.

Data collection on such a scale had not been done before, Roering said. "The difference here is the amount of data we looked at," he said. "People have been putting equipment on landslides and watching them for years—long before GPS and lasers. We were able to do this on a massive scale. This was a systematic look at the whole landscape—what it's doing—not just of one feature."

Researchers found that the rocks and soil have dried substantially, based on groundwater data gathered at one of the locations. The current lack of moisture, Roering said, means there is no longer enough lubrication to allow for movement.

This summer, his team, in collaboration with a team led by UO seismologist Amanda Thomas, will place 80 small seismometers in various locations on one of the landslides. The project aims to locate the underlying water table.

"A question now is how much water will it take, and how long will it take to get water down the depths at the base of these sliding surfaces to reduce the friction and get them to start moving again," Roering said. "The site we will be instrumenting should help us better understand the structure and plumbing of landslides.

Data merged in the research came from manual measurements of movement based on tracking trees as they surfed on the surface of earthflows between aerial photographs from 1944 to 2006 and from automatic measurements obtained through satellite pixel tracking from high-resolution imagery spanning 2009-2015. The satellite tracking was validated using the remote sensing technology interferometric synthetic aperture radar (InSAR).

Bennett, who soon will join the faculty at the University of East Anglia in England, compared the data on landslide movement from 1944 onward with an index of drought known as the Palmer Drought Severity Index.

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

Journal Reference: *Geophysical Research Letters*, DOI: 10.1126/sciadv.1501538.

Appalachian Coal Ash Richest in Rare Earth Elements

The Roxboro Steam Station, a four-unit, 2,422-megawatt coal-fired Duke Energy plant in Semora, N.C., is one of the largest power plants in the United States. It began operation in 1966, with additions in 1973 and 1980. Credit: Heileen Hsu-Kim, Duke University

A study of the content of rare earth elements in U.S. coal ashes shows that coal mined from the Appalachian Mountains could be the proverbial golden goose for hard-to-find materials critical to clean energy and other emerging technologies. In the wake of a 2014 coal ash

spill into North Carolina's Dan River from a ruptured Duke Energy drainage pipe, the question of what to do with the nation's aging retention ponds and future coal ash waste has been a highly contested topic.

One particularly entrepreneurial idea is to extract so-called "critical" rare earth elements such as neodymium, europium, terbium, dysprosium, yttrium and erbium from the burned coal. The Department of Energy has identified these globally scarce metals as a priority for their uses in clean energy and other emerging technologies. But exactly how much of these elements are contained in different sources of coal ash in the U.S. had never been explored.

Researchers from Duke University measured the content of rare earth elements in samples of coal ash representing every major coal source in the United States. They also looked at how much of these elements could be extracted from ash using a common industrial technique.

The results, published online on May 26 in the journal Environmental Science and Technology, showed that coal from the Appalachian Mountains contains the most rare earth elements. However, if extraction technologies were cheap enough, there are plenty of rare earth elements to be found in other sources as well.

"The Department of Energy is investing $20 million into research on extraction technologies for coal wastes, and there is literally billions of dollars' worth of rare earth elements contained in our nation's coal ash," said Heileen Hsu-Kim, the Mary Milus Yoh and Harold L. Yoh, Jr. Associate Professor of Civil and Environmental Engineering at Duke.

"If a program were to move forward, they'd clearly want to pick the coal ash with the highest amount of extractable rare earth elements, and our work is the first comprehensive study to begin surveying the options," Hsu-Kim said.

The researchers took coal ash samples from power plants located mostly in the American Midwest that burn coal sourced from all over the country, including the three largest sources: the Appalachian Mountains, southern and western Illinois, and the Powder River Basin in Wyoming and Montana. The content of rare earth elements was then tested using hydrofluoric acid, which is much stronger and more efficient than industrial methods, but is too hazardous to use on a large scale.

The results showed that ash collected from Appalachian Mountain coal has the highest amount of rare earth elements at 591 milligrams per kilogram (or parts per million). Ash from Illinois and the Powder River Basin contain 403 mg/kg and 337 mg/kg, respectively.

The researchers then used a common industrial extraction technique featuring nitric acid to see how much of the rare earth elements could be recovered. Coal ash from the Appalachian Mountains saw the lowest extraction percentages, while ash from the Powder River Basin saw the highest. Hsu-Kim thnks this might be because the rare earth elements in the Appalachian Mountain coal ash are encapsulated within a glassy matrix of aluminum silicates, which nitric acid doesn't dissolve very well.

"One reason to pick coal ash from the Appalachian Mountains would be for its high rare earth element content, but you'd have to use a recovery method other than nitric acid," said Hsu-Kim, who also holds an appointment in Duke's Nicholas School of the Environment. "For any future venture to begin an extraction program, the recovery method will need to be tailored to the specific chemistry of the coal ash being used."

The Duke researchers also tried "roasting" the coal ash with an alkali agent before dissolving it with nitric acid. Even though the process hadn't been optimized for recovery purposes, the tests showed a marked improvement in extraction efficiency.

"The reagents we used are probably too expensive to use on an industrial scale, but there are many similar chemicals," said Hsu-Kim. "The trick will be exploring our options and developing technologies to drive the costs down. That way we can tap into this vast resource that is currently just sitting around in disposal ponds."

Story Source: The above post is reprinted from materials provided by Duke University. The original item was written by Ken Kingery.

Journal Reference: Ross K. Taggart, James C. Hower, Gary S. Dwyer, Heileen Hsu-Kim. **Trends in the Rare Earth Element Content of U.S.-Based Coal Combustion Fly Ashes**. Environmental Science & Technology, 2016; DOI: 10.1021/acs.est.6b00085

Hydrothermal vents, methane seeps play enormous role in marine life, global climate

A lush community of vibrant red tube worms grows on a black smoker chimney in the ASHES hydrothermal field.

The tube worms, which are hosted in white housings about the diameter of a person's small finger, are intergrown with brown palm worms. Credit: Courtesy of University of Washington, NSF/Ocean Observatories Initiative/Canadian Scientific Submersible Facility

The hydrothermal vents and methane seeps on the ocean floor that were once thought to be geologic and biological oddities are now emerging as a major force in ocean ecosystems, marine life and global climate.

However, even as researchers learn more about their role in sustaining a healthy Earth, these habitats are being threatened by a wide range of human activities, including deep-sea mining, bottom trawling and energy harvesting, scientists say in a report published in *Frontiers in Marine Science*.

Researchers from Oregon State University first discovered these strange, isolated worlds on the ocean bottom 40 years ago. These habitats surprised the scientific world with reports of hot oozing gases, sulfide chimneys, bizarre tube worms and giant crabs and mussels -- life forms that were later found to eat methane and toxic sulfide.

"It was immediately apparent that these hydrothermal vents were incredibly cool," said Andrew Thurber, an assistant professor in the OSU College of Earth, Ocean and Atmospheric Sciences, and co-author on the new report.

"Since then we've learned that these vents and seeps are much more than just some weird fauna, unique biology and strange little ecosystems. Rather than being an anomaly, they are prevalent around the world, both in the deep ocean and shallower areas. **They provide an estimated 13 percent of the energy entering the deep sea, make a wide range of marine life possible, and are major players in global climate.**"

As fountains of marine life, the vents pour out gases and minerals, including sulfide, methane, hydrogen and iron -- one of the limiting nutrients in the growth of plankton in large areas of the ocean. In an even more important role, the life forms in these vents and seeps consume 90 percent of the released methane and keep it from entering the atmosphere, where as a greenhouse gas it's 25 times more potent than carbon dioxide.

"We had no idea at first how important this ecological process was to global climate," Thurber said. "Through methane consumption, these life forms are literally saving the planet. There is more methane on the ocean floor than there are other forms of fossil fuels left in the oceans, and if it were all released it would be a doomsday climatic event."

In reviewing the status of these marine geological structures and the life that lives around them, a group of researchers from 14 international universities and organizations have outlined what's been learned in the past four decades and what forces threaten these ecosystems today. The synthesis was supported by the J.M. Kaplan fund.

These vents and seeps, and the marine life that lives there, create rocks and habitat, which in some settings can last tens of thousands of years. They release heat and energy, and form biological hot spots of diversity. They host extensive mussel and clam beds, mounds of shrimp and crab, create some prime fishing habitat and literally fertilize the ocean as zooplankton biomass and abundance increases. While the fluid flows from only a small section of the seafloor, the impact on the ocean is global.

Some of the microorganisms found at these sites are being explored for their potential to help degrade oil spills, or act as a biocatalytic agent for industrial scrubbing of carbon dioxide.

These systems, however, have already been damaged by human exploitation, and others are being targeted, the scientists said. Efforts are beginning to mine them for copper, zinc, lead, gold and silver. Bottom trawling is a special concern, causing physical disturbance that could interfere with seeps, affect habitat and damage other biologic linkages.

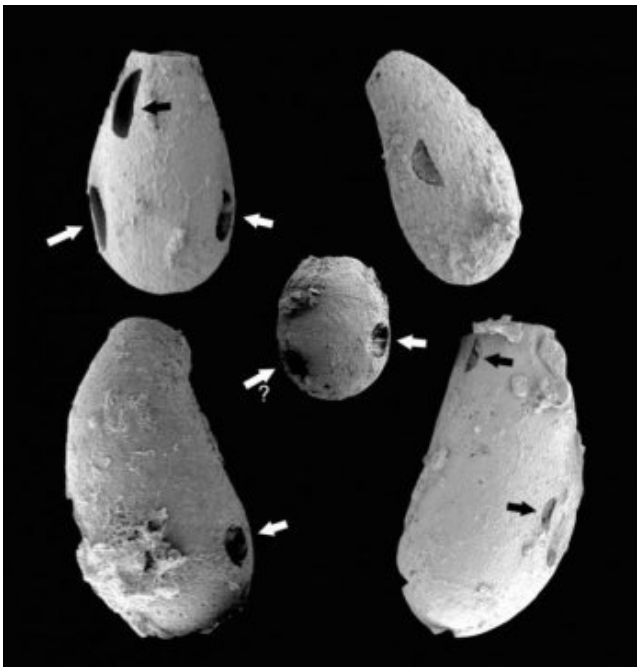
Oil, gas or hydrate exploitation may damage seeps. Whaling and logging may interfere with organic matter falling to the ocean floor, which serves as habitat or stepping stones for species reliant on chemosynthetic energy sources. Waste disposal of munitions, sewage and debris may affect seeps.

The range of ecosystem services these vents and seeps provide is just barely beginning to be understood, researchers said in their report. As many of these habitats fall outside of territorial waters, vent and seep conservation will require international collaboration and cooperation if they are going to continue to provide ecosystem benefits.

Story Source: The above post is reprinted from materials provided by Oregon State University.

Journal Reference: Lisa A. Levin, Amy R. Baco, David A. Bowden, Ana Colaco, Erik E. Cordes, Marina R. Cunha, Amanda W. J. Demopoulos, Judith Gobin, Benjamin M. Grupe, Jennifer Le, Anna Metaxas, Amanda N. Netburn, Greg W. Rouse, Andrew R. Thurber, Verena Tunnicliffe, Cindy Lee Van Dover, Ann Vanreusel, Les Watling. **Hydrothermal Vents and Methane Seeps: Rethinking the Sphere of Influence**. *Frontiers in Marine Science*, 2016; 3 DOI: 10.3389/fmars.2016.00072

Tiny 'vampires': Paleobiologist finds evidence of predation in ancient microbial ecosystems



Half-moon shaped holes (black arrows) and circular holes (white arrows) in 780--740 million-year-old fossils of shell-forming amoebae from the Chuar Group of the Grand Canyon, Arizona. Holes are approximately 15 to 35 micrometers in size: shells are 75 to 150 micrometers in length. Credit: Susannah Porter

Vampires are real, and they've been around for millions of years. At least, the amoebae variety has. So suggests new research from UC Santa Barbara paleobiologist Susannah Porter.

Using a scanning electron microscope to examine minute fossils, Porter found perfectly circular drill holes that may have been formed by an ancient relation of Vampyrellidae amoebae. These single-celled creatures perforate the walls of their prey and reach inside to consume its cell contents. Porter's findings appear in the *Proceedings of the Royal Society B*.

"To my knowledge these holes are the earliest direct evidence of predation on eukaryotes," said Porter, an associate professor in UCSB's Department of Earth Science. Eukaryotes are organisms whose cells contain a nucleus and other organelles such as mitochondria. "We have a great record of predation on animals going back 550 million years," she continued, "starting with the very first mineralized shells, which show evidence of drillholes. We had nothing like that for early life -- for the time before animals appear. These holes potentially provide a way of looking at predator-prey interactions in very deep time in ancient microbial ecosystems."

Porter examined fossils from the Chuar Group in the Grand Canyon -- once an ancient seabed -- that are between 782 and 742 million years old. The holes are about one micrometer (one thousandth of a millimeter) in diameter and occur in seven of the species she identified. The holes are not common in any single one species; in fact, they appear in not more than 10 percent of the specimens.

"I also found evidence of specificity in hole sizes, so different species show different characteristic hole sizes, which is consistent with what we know about modern vampire amoebae and their food preferences," Porter said. "Different species of amoebae make differently sized holes. The Vampyrellid amoebae make a great modern analog, but because vampirelike feeding behavior is known in a number of different unrelated amoebae, it makes it difficult to pin down exactly who the predator was."

According to Porter, this evidence may help to address the question of whether predation was one of the driving factors in the diversification of eukaryotes that took place about 800 million years ago. "If that is true, then if we look at older fossil assemblages -- say 1 to 1.6 billion years old -- the fossilized eukaryote will show no evidence of predation," Porter said. "I'm interested in finding out when drilling first appears in the fossil record and whether its intensity changes through time."

Porter also is interested in seeing whether oxygen played a role in predation levels through time. She noted that the microfossils those organisms attacked were probably phytoplankton living in oxygenated surface waters, but like vampyrellid amoebae today, the predators may have lived in the sediments. She suggests that those phytoplankton made tough-walled cysts -- resting structures now preserved as fossils -- that sank to the bottom where they were attacked by the amoebae.

"We have evidence that the bottom waters in the Chuar Group in that Grand Canyon basin were relatively deep -- 200 meters deep at most -- and sometimes became anoxic, meaning they lacked oxygen," Porter explained. "I'm interested to know whether the predators only were present and making these drill holes when the bottom waters contained oxygen," Porter added. "That might tie the diversification of eukaryotes and the appearance of predators to evidence for increasing oxygen levels around 800 million years ago.

"We know from the modern vampire amoebae that at least some of them make resting cysts themselves," Porter said. "A former student of mine joked we should call these coffins. So one of our motivations is to see if we can find these coffins in the fossil assemblage as well. That's the next project."

Story Source: The above post is reprinted from materials provided by University of California, Santa Barbara. The original item was written by Julie Cohen.

Journal Reference: Susannah M. Porter. **Tiny**

vampires in ancient seas: evidence for predation via perforation in fossils from the 780–740 million-year-old Chuar Group, Grand Canyon, USA. *Proceedings of the Royal Society B: Biological Sciences*, 2016; 283 (1831): 20160221 DOI: 10.1098/rspb.2016.0221.

Underwater "Lost City" Found to Be Geological Formation

The ancient underwater remains of a long lost Greek city were in fact created by a naturally occurring phenomenon -- according to joint research from the University of East Anglia and the University of Athens (Greece). Credit: University of Athens

The ancient underwater remains of a long lost Greek city were in fact created by a naturally occurring phenomenon -- according to joint research from the University of East Anglia (UK) and the University of Athens (Greece).

When underwater divers discovered what looked like paved floors, courtyards and colonnades, they thought they had found the ruins of a long-forgotten civilization that perished when tidal waves hit the shores of the Greek holiday island Zakynthos.

But new research published today reveals that the site was created by a natural geological phenomenon that took place in the Pliocene era -- up to five million years ago. Lead author Prof Julian Andrews, from UEA's School of Environmental Sciences, said: "The site was discovered by snorkelers and first thought to be an ancient city port, lost to the sea. There were what superficially looked like circular column bases, and paved floors. But mysteriously no other signs of life -- such as pottery."

The bizarre discovery, found close to Alikanas Bay, was carefully examined in situ by the Ephorate of Underwater Antiquities of Greece. Archaeologist Magda Athanasoula and diver Petros Tsampourakis studied the site, together with Prof Michael Stamatakis from the Department of Geology and Geoenvironment at the University of Athens (UoA). After the preliminary mineralogical and chemical analyses, a scientific research team was formed, composed of UoA and UEA staff.

The research team went on to investigate in detail the mineral content and texture of the underwater formation in minute detail, using microscopy, X-ray and stable isotope techniques. Prof Andrews said: "We investigated the site, which is between two and five meters under water, and found that it is actually a natural geologically occurring phenomenon.

"The disk and doughnut morphology, which looked a bit like circular column bases, is typical of mineralization at hydrocarbon seeps -- seen both in modern seafloor and paleo settings. "We found that the linear distribution of these doughnut shaped concretions is likely the result of a sub-surface fault which has not fully ruptured the surface of the sea bed. The fault allowed gases, particularly methane, to escape from depth.

"Microbes in the sediment use the carbon in methane as fuel. Microbe-driven oxidation of the methane then changes the chemistry of the sediment forming a kind of natural cement, known to geologists as concretion.

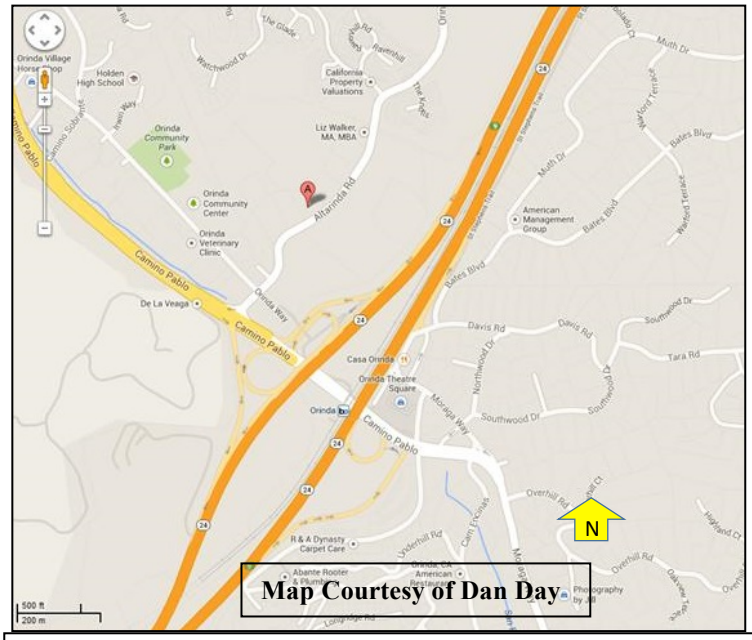
"In this case the cement was an unusual mineral called dolomite which rarely forms in seawater, but can be quite common in microbe-rich sediments. These concretions were then exhumed by erosion to be exposed on the seabed today. This kind of phenomenon is quite rare in shallow waters. Most similar discoveries tend to be many hundreds and often thousands of meters deep underwater.

"These features are proof of natural methane seeping out of rock from hydrocarbon reservoirs. The same thing happens in the North Sea, and it is also similar to the effects of fracking, when humans essentially speed up or enhance the phenomena."

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

Journal Reference: J.E. Andrews, M.G. Stamatakis, A. Marca-Bell, C. Stewart, I.L. Millar. **Exhumed hydrocarbon-seep authigenic carbonates from Zakynthos Island (Greece): Concretions not archaeological remains**. *Marine and Petroleum Geology*, 2016; 76: 16 DOI: 10.1016/j.marpetgeo.2016.05.022

Editor's Note: Recall Mel Erskine's **excellent field trip to the cold seeps in Paleocene rocks of the Panoche Hills** (eastern flank of the Coast Range, north Of Coalinga), on October 29, 2005.



Map Courtesy of Dan Day

editorial and related capacities for various professional journals, and being active in professional organizations.

Jerry has been active in professional organizations, notably the Geol Society of America (GSA) and the Association of Environmental & Engineering Geologists (AEG). He joined GSA in 1972, was made a Fellow in 1983. In addition to holding the chairmanship and other leadership positions in GSA's Engineering Geology Division, Jerry received their Meritorious Service award in 1997 and in 2011; honored to receive their Distinguished Practice Award in 2004. Jerry joined AEG in 1980 and chaired their Committee on Landslides from 1984 to 1995; received presidential citations in 1995 and 2013 in appreciation for his service to AEG. Jerry is presently vice-Chair of the San Joaquin Valley Chapter in AEG's Sacramento Section.

A native of the Finger Lakes region of upstate New York, Jerry graduated from State Univ. of New York-Geneseo with a BS in Education/Earth Science in 1967. During the last five years while an instructor at the Strasenburgh Planetarium (Rochester, NY), he realized he was too interested in what was beneath his feet to continue talking about what was happening among the stars. So Jerry and his wife moved west where he earned an MS in Geology from Utah State University in 1976. A job offer from the US Forest Service after a year as a USU researcher seemed more attractive than his original goal of returning east to teach in a community college, so he took it and never looked back. He has authored or co-authored more than 60 contributions to journals, books, and proceedings volumes. With Dr. Robert B. Johnson, he co-authored the textbook, **Principles of Engineering Geology**, which was awarded GSA's E.B. Burwell Jr. Memorial Award in 1989 and AEG's Claire P. Holdredge Award in 1990. In 2010, Jerry received the annual AEG publication award for the paper "The formation and persistence of the Matthieu landslide-dam lake, Dominica, W.I.", published in the journal **Environmental and Engineering Geoscience**.

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