NORTHERN CALIFORNIA GEOLOGICAL SOCIETY

MEETING ANNOUNCEMENT

DATE: **February 26, 2014**

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

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

SPEAKER: **Tess Menotti, PhD Candidate, Department of Geological and Environmental Sciences, Stanford University**,

Moving Targets – Petroleum System Modeling in Central California

Central California is a region rich with unique and intriguing geological features, as well as an abundance of wealth in hydrocarbon resources. But some of these geologic features also complicate our ability to model the region's basin histories, predict additional petroleum reserves, and explain the accumulations we see today. This presentation will explore the challenges in modeling the Salinas Basin, where two of California's noteworthy geological traits exist. First, this Neogene basin's history is profoundly impacted by strike-slip tectonism, manifested as basin-scale oblique-slip faults and related compressional folds. Secondly, stratigraphy is dominated by the ubiquitous biosiliceous Monterey Formation, which primarily comprises thermodynamically unstable forms of silica, making it prone to diagenetic alteration. The progressive, tectonically-driven evolution of the basin shape and the unstable nature of its sedimentary fill require an integrated and dynamic approach in assessing the burial and petroleum system history. We present a new method that integrates three-dimensional basin modeling with strike-slip fault motion. We will also present one- and two-dimensional burial history models that incorporate silica diagenesis. Wellbore, outcrop and seismic reflection data constrain the basin model parameters and boundary conditions. These numerical models align with conceptual models of basin history, and are self-consistent with inorganic and organic calibration indicators.

Biography: Tess Menotti is a PhD candidate in the Geological & Environmental Sciences Department at Stanford University under advisor Professor Steve Graham. Her interests lie in exploring the interplay of tectonics and petroleum system development. Her current research investigates the integration of strike-slip tectonism and silica diagenesis in modeling the Salinas Basin, California. Tess is a Pennsylvania-native, with a B.S. in Geosciences from Penn State University, and prior work experience in the shale gas play of the Appalachian Basin.

NCGS 2012 – 2013 Calendar

March 26, 2013
Tom MacKinnon, Consultant
Revisiting the Monterey Formation

April 30, 2014
Stephen D. Reynolds, California Geological Survey,
Reclamation of the abandoned Spenceville Copper Mine

May 28, 2014
DINNER MEETING; TBA

June 25, 2014
Jason Utas, PhD Candidate at UCLA; Meteorites

Peninsula Geologic Society
Upcoming meetings

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.

Bay Area Science

This website provides a free weekly emailed newsletter consisting of an extensive listing of local science based activities (evening lectures, classes, field trips, hikes, and etc). Go to: http://www.bayareascience.org/

Association of Engineering Geologists San Francisco Section
Upcoming Events

Meeting locations rotate between San Francisco, the East Bay, and the South Bay. Please check the website for current details. To download meeting details and registration form go to: http://www.aegsf.org/.

Seeking Member Write-Ups

Have you recently gone to, or seen an interesting geologic feature, event, or…? Let us know! NCGS would like to diversify the content of the newsletter and we want to make sure you know that your articles are welcome. There may be some editing for length, content, or grammar, but we want to welcome your articles.

70th Anniversary of NCGS
Don Lewis

This year marks the seventieth anniversary of the Northern California Geological Society. The Society was founded in 1944 by a group of petroleum geologists, mudmen, and well logging representatives and early membership was mainly petroleum industry-oriented people with some academic and government geoscientists mixed in. Over the years, particularly in the last two decades, membership has evolved into a diversified mix of environmental, geotechnical, engineering, petroleum, and mineral geoscientists, with some representation from the academic community and government organizations.

The very first meeting was held in Sacramento in January, 1944, with the speaker being one John W. Thomas of Standard Oil Company of California, showing slides of "A Trip through Saudi Arabia". Some 60 people attended this ground-floor meeting and enjoyed the show. For several years most meetings were held in Sacramento and at Foster's Bar in Rio Vista. Foster's was the premier meeting place for petroleum types in northern California back then. Foster's Bighorn is still there, still alive and well with a room full of big game trophies.

By the late forties, few geologists were left in the Sacramento Valley and the meetings migrated to San Francisco, where they stayed until 1985, featuring dinner meetings at first and then becoming luncheon talks, often attended by over 100 people. In the fall of 1985, after Chevron's domestic exploration staff decamped for Concord, the meetings moved to the East Bay and returned to being evening affairs, albeit without dinner, at a variety of venues. In January, 1999, we finally found our current home and format in Orinda.

Our famous, nameless newsletter evolved in January, 1997, from mere meeting announcements to essentially its present format. Since the beginning, Dan Day and now Mark Detterman have for all these years intrepidly produced nine issues per year, every year. Exactly when our website was born is lost in the ether but for the last several years Mark has also kept that up and running.

We'll be including tidbits from our first seventy years in the newsletter this spring. If you want to see an entertaining and more thorough rendition of NCGS history, see "Short History of Northern California Geological Society" by Ottmar Kotick (1976), AAPG bulletin, v. 60, p. 988-992. Copies of this paper will available at NCGS meetings. Kotick got a couple of the early details wrong but no matter.

2013-2014 RICHARD CHAMBERS MEMORIAL SCHOLARSHIP

The Northern California Geological Society is pleased to announce its RICHARD CHAMBERS MEMORIAL SCHOLARSHIP recipients for 2013-2014. The scholarship is named for former NCGS member Richard Chambers who provided a bequest to the society. Two $ 1,000 are provided to students pursuing the Masters degree and one $2,000 is provided for a student pursuing a Doctorate Degree.

Recipients of the **2013-2014 Richard Chambers Memorial Scholarships at the Masters Degree level** are **Kevin M DeLano**, a student at Central Washington University. Kevin's research is *Geologic mapping in the northern Eastern California Shear Zone, California: testing a kinematic and geometric fault slip transfer model.* His thesis advisor is **Dr. Jeffrey Lee**. The other RCMS recipient at the Masters Degree level is **Edween Hernandez**, a student at California State University, Fullerton. Edween's research is *A Multidisciplinary Study of the Paleozoic to Modern Fauna Transition, Favret Canyon, Augusta Mountain, West-Central Nevada.* Her thesis advisor is **Dr. Phil Armstrong**.

Receiving the **2013-2014 Richard Chambers Memorial Scholarship at the Doctorate level** is **Emily A. Orzechowski**, a student at the University of California, Berkeley. Her research is *Paleoecological reconstruction of the Last Interglacial Maximum (~130 Kya) in California using uranium-thorium dating and geochemical temperature proxies on Late Pleistocene fossiliferous terraces*. Emily's advisor is **Dr. Seth Finnegan**.

The Northern California Geological Society **received nineteen outstanding applications** for the 2013-2014 Richard Chambers Memorial Scholarships.

Richard Chambers Memorial Scholarship application information is sent to all colleges and universities in California, Arizona, Nevada and Oregon that offer advanced degrees in September and November of each year.

The Early Days of NCGS

Don Lewis

I must not have enough to do (not what I tell my wife) so I've been looking through the old NCGS files. This is fun and maybe you'll enjoy some tidbits also.

The very first meeting was in Sacramento in January, 1944. In a memo to all members in March, 1945, Al Solari, the second NCGS Chairman (not called President for another ten years), said "At the last meeting an assessment of fifty cents was made on all members present. This is the first assessment since that made at the original meeting of the society in January, 1944." Then, "All members who have not paid are asked to enclose fifty cents in coin when returning this letter." Back then, all the members were referred to as men and the society's clerical work was done by secretaries (remember them?).

In June of 1944 members of the fledgling society were invited to a Sacramento meeting of ASCE to hear a talk by Thomas P. Pendleton, Chief Topographic Engineer of the USGS. In those early years, the NCGS meetings were mainly in Sacramento. His talk was on the new technique in making topo maps, i.e., from aerial photographs.

In a letter to Mr. Pendleton, the following chairmen of the Departments of Geology were given: Stanford - Eliot Blackwelder; Cal - N. L. Taliaferro; UCLA - U. S. Grant IV; USC - Thomas Clements; Pomona - A. O. Woodford; and Caltech - John Buwalda. These names ring any bells with you old-timers?

In April, 1945, Dr. Fred Bullard was the first AAPG Distinguished Lecturer to talk to the NCGS. He spoke on "Paricutin, Mexico's Newest Volcano", advertised as illustrated with Kodachrome slides and moving pictures. In a pencil summary of 1945 by E. M. Curry, Secretary, there are disbursements noted, among them $2.00 for 100 reply postcards, $8.00 for hotel and meal expenses for Dr. Louderback and $3.00 for Dr. Bullard's hotel room.

Cost of the March 23, 1945, dinner meeting was $1.45 per plate, including tip. Charge for a room at the Engineers Club in San Francisco for an evening meeting was $2.50. For 1945, the Society's cash balance after meeting expenses varied from $0.68 to 11.72. In early 1946, paid membership was around 55, the Society had a deficit of $21.60, and it was decided that dues were necessary for the first time and assessed at $2 per year. Considering 70 years of inflation, our current dues of $15 are a fabulous bargain!

California Federated Mineral Societies

In case you were not aware, but the Northern California Geological Society became a member of the **California Federation of Mineralogical Societies** several years back in order to provide liability coverage to NCGS functions, including field trips. The CFMS is largely a federation of mineral and gem societies in California, but as a member of NCGS you are also a member of the CFMS. Recently a short article was written for the Concord Mineral and Gem Society (NCGS had a table at their recent show, as shown by photos in last month's NCGS newsletter) to help explain what the CFMS. A copy of that article is reprinted here for your information and education. The CFMS website is: http://www.cfmsinc.org/ in case you want to explore the CFMS further.

THE HEARTBEAT OF CFMS

By Jennifer Haley, CFMS 2014 President

Often I am asked what CFMS is and what we are here for. When Terry asked me to write an article about it, I said "yes" in a heartbeat. There is so much I could write about the California Federation of Mineralogical Societies. Perhaps the best place to start is to give you some historical background.

Mineral clubs were formed in America as early as 1885, when the interest in the earth sciences really began blossoming. The first California club was formed in 1931 by the Mineralogical Society of Southern California in Pasadena. That club is still active today. In

June 1935 a "Mineral Day," was held at the San Diego Exposition. Several representatives of various clubs met there (in those days that meant a good handful) to organize a state organization of mineral societies, and in January 1936 CFMS held their first convention. Their sole purpose was to bring together a closer association of clubs devoted to the earth sciences, and the practice of lapidary arts and crafts with a vision for the future. Soon rock and gem clubs were spouting up all over.

Grammar schools and middle schools were inviting their local rock and gem club to come in to teach their students programs in the earth sciences. This was one of the gifts the clubs gave to their communities very early on. Naturally this tradition became a charm magnet to inspire children of all ages to learn about the fascinating science hands on.

For generations, adult club members with their gracious personalities invited members to their personal work spaces to teach whoever wanted to learn about lapidary and the basics of jewelry making. Club field trips to collect rock material opened up a world of adventure and art, while at the same time everyone learned to hone their skills the more they learned.

The social relationships of belonging in a club were outstanding, and are what has always set a rock club apart from many other types of clubs. What people found when they discovered a rock club was a feeling of "home," and a good place to have fun while learning. What most people do not know is that CFMS suspended its activities during WWII, but resumed again in June 1946.

I think what people forget is that all the rock and gem clubs are the heartbeat of CFMS and visa versa. Every year the Federation with its family of clubs adds a new growth ring to their historical family tree based on the foundation of those who came before them. To all of them we owe a great sense of gratitude that will always be a part of who we are. What I like to tell people is when we lose those "golden ones" who touched our hearts and inspired us in the hobby, one of the best things you can do is to become in your own way a person who passes on the skills with the gifts of inspiration you were given.

Stay tuned next month for **The Heartbeat of CFMS Part II,** which will describe what the Federation does for the clubs.

To all of us who enjoy the earth sciences, and the practice of lapidary arts and crafts, "*go out and play, put your hearts and your souls into the hobby and make some wonderful memories. It's what we do best and it is our gift to give."* Let's make it great year!

Los Angeles Would Experience Stronger-Than-Expected Ground Motion in Major Earthquake, Virtual Earthquake Generator Shows

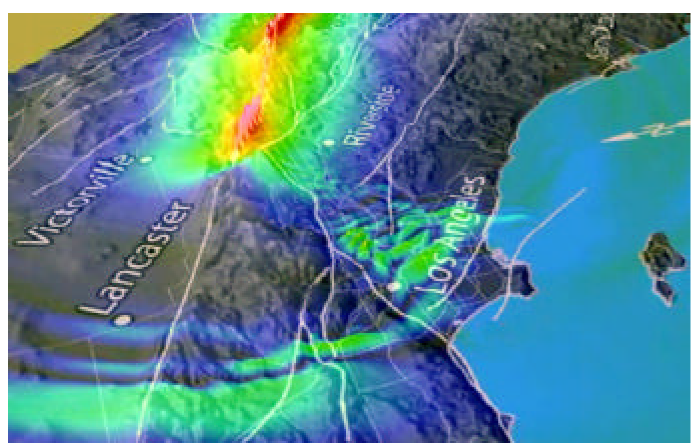
Stanford scientists are using weak vibrations generated by Earth's oceans to produce "virtual earthquakes" that can be used to predict the ground movement and shaking hazard to buildings from real quakes.

The new technique, detailed in the Jan. 24 issue of the journal *Science*, was used to confirm a prediction that Los Angeles will experience stronger-than-expected ground movement if a major quake occurs south of the city.

"We used our virtual earthquake approach to reconstruct large earthquakes on the southern San Andreas Fault and studied the responses of the urban environment of Los Angeles to such earthquakes," said lead author Marine Denolle, who recently received her PhD in geophysics from Stanford and is now at the Scripps Institution of Oceanography in San Diego.

The new technique capitalizes on the fact that earthquakes aren't the only sources of seismic waves. "If you put a seismometer in the ground and there's no earthquake, what do you record? It turns out that you record something," said study leader Greg Beroza, a geophysics professor at Stanford.

What the instruments will pick up is a weak, continuous signal known as the ambient seismic field. This omnipresent field is generated by ocean waves interacting with the solid Earth. When the waves collide with each other, they generate a pressure pulse that travels through the ocean to the sea floor and into Earth's crust. "These waves are billions of times weaker than the seismic waves generated by earthquakes," Beroza said.



This screenshot from a supercomputer simulation shows the waveguide-to-basin effect in Southern California. First predicted in 2006, this effect has remained untested because a large earthquake has not occurred in the region in more than 150 years. Stanford scientists recently confirmed the effect *using the virtual earthquake approach. (Credit: Courtesy of Southern California Earthquake Center)*

Scientists have known about the ambient seismic field for about 100 years, but it was largely considered a nuisance because it interferes with their ability to study earthquakes. The tenuous seismic waves that make up this field propagate every which way through the crust. But in the past decade, seismologists developed signal-processing techniques that allow them to isolate certain waves; in particular, those traveling through one seismometer and then another one downstream.

Denolle built upon these techniques and devised a way to make these ambient seismic waves function as proxies for seismic waves generated by real earthquakes. By studying how the ambient waves moved underground, the researchers were able to predict the actions of much stronger waves from powerful earthquakes.

She began by installing several seismometers along the San Andreas Fault to specifically measure ambient seismic waves.

Employing data from the seismometers, the group then used mathematical techniques they developed to make the waves appear as if they originated deep within Earth. This was done to correct for the fact that the seismometers Denolle installed were located at Earth's surface, whereas real earthquakes occur at depth.

In the study, the team used their virtual earthquake approach to confirm the accuracy of a prediction, made in 2006 by supercomputer simulations, that if the southern San Andreas Fault section of California were to rupture and spawn an earthquake, some of the seismic waves traveling northward would be funneled toward Los Angeles along a 60-mile-long (100-kilometer-long) natural conduit that connects the city with the San Bernardino Valley. This passageway is composed mostly of sediments, and acts to amplify and direct waves toward the Los Angeles region.

Until now, there was no way to test whether this funneling action, known as the waveguide-to-basin effect, actually takes place because a major quake has not occurred along that particular section of the San Andreas Fault in more than 150 years.

The virtual earthquake approach also predicts that seismic waves will become further amplified when they reach Los Angeles because the city sits atop a large sedimentary basin. To understand why this occurs, study coauthor Eric Dunham, an assistant professor of geophysics at Stanford, said to imagine taking a block of plastic foam, cutting out a bowl-shaped hole in the middle, and filling the cavity with gelatin. In this analogy, the plastic foam is a stand-in for rocks, while the gelatin is like sediments, or dirt. "The gelatin is floppier and a lot more compliant. If you shake the whole thing, you're going to get some motion in the Styrofoam, but most of what you're going to see is the basin oscillating," Dunham said.

As a result, the scientists say, Los Angeles could be at risk for stronger, and more variable, ground motion if a large earthquake -- magnitude 7.0 or greater -- were to occur along the southern San Andreas Fault, near the Salton Sea.

"The seismic waves are essentially guided into the sedimentary basin that underlies Los Angeles," Beroza said. "Once there, the waves reverberate and are amplified, causing stronger shaking than would otherwise occur."

Beroza's group is planning to test the virtual earthquake approach in other cities around the world that are built atop sedimentary basins, such as Tokyo, Mexico City, Seattle and parts of the San Francisco Bay area. "All of these cities are earthquake threatened, and all of them have an extra threat because of the basin amplification effect," Beroza said.

Because the technique is relatively inexpensive, it could also be useful for forecasting ground motion in developing countries. "You don't need large supercomputers to run the simulations," Denolle said.

In addition to studying earthquakes that have yet to occur, the technique could also be used as a kind of "seismological time machine" to recreate the seismic signatures of temblors that shook Earth long ago, according to Beroza.

"For an earthquake that occurred 200 years ago, if you know where the fault was, you could deploy instruments, go through this procedure, and generate seismograms for earthquakes that occurred before seismographs were invented," he said.

German Prieto, an assistant professor of geophysics at the Massachusetts Institute of Technology and a Stanford alumnus, also contributed to the research.

Video:
https://www.youtube.com/watch?v=WTg3GzGCRfA

Story Source: The above story is based on materials provided by Stanford University. The original article was written by Ker Than and January 23, 2014 ScienceDaily article.

Journal Reference: M. A. Denolle, E. M. Dunham, G. A. Prieto, G. C. Beroza. **Strong Ground Motion Prediction Using Virtual Earthquakes**. *Science*, 2014; 343 (6169): 399 DOI: 10.1126/science.1245678

Large, deep magma chamber discovered below Kilauea volcano: Largely unknown internal plumbing of volcanoes

A new study led by scientists at the University of Miami (UM) Rosenstiel School of Marine and Atmospheric Science uncovered a previously unknown magma chamber deep below the most active volcano in the world -- Kilauea. This is the first geophysical observation that large magma chambers exist in the deeper parts of the volcano system.

A new study led by scientists at the University of Miami (UM) Rosenstiel School of Marine and Atmospheric Science uncovered a previously unknown magma chamber deep below the most active volcano in the world – Kilauea; Credit: Image courtesy of University of Miami Rosenstiel School of Marine & Atmospheric Science

Scientists analyzed the seismic waves that travel through the volcano to understand the internal structure of the volcanic system. Using the seismic data, the researchers developed a three-dimensional velocity model of a magma anomaly to determine the size, depth and composition of the lava chamber, which is several kilometers in diameter and located at a depth of 8-11 km (5 -- 6.8 miles).

"It was known before that Kilauea had small, shallow magma chambers," said Guoqing Lin, UM Rosenstiel School assistant professor of geology and geophysics and lead author of the study. "This study is the first geophysical observation that large magma chambers exist in the deep oceanic crust below."

The study also showed that the deep chamber is composed of "magma mush," a mixture of 10-percent magma and 90-percent rock. The crustal magma reservoir below Kilauea is similar to those widely observed beneath volcanoes located at mid-ocean ridges.

"Understanding these magma bodies are a high priority because of the hazard posed by the volcano," said Falk Amelung, co-author and professor of geology and geophysics at the UM Rosenstiel School. "Kilauea volcano produces many small earthquakes and paying particular attention to new seismic activity near this body will help us to better understand where future lava eruptions will come from."

Scientists are still unraveling the mysteries of the deep internal network of magma chambers and lava tubes of Kilauea, which has been in continuous eruption for more than 30 years and is currently the most active volcano in the world.

Story Source: The above story is based on materials provided by University of Miami Rosenstiel School of Marine & Atmospheric Science and ScienceDaily article dated January 29, 2014.

Journal Reference: G. Lin, F. Amelung, Y. Lavallee, P. G. Okubo. **Seismic evidence for a crustal magma reservoir beneath the upper east rift zone of Kilauea volcano, Hawaii**. *Geology*, 2014; DOI: 10.1130/G35001.1

Europe's oldest footprints uncovered on English coast

The earliest human footprints outside of Africa have been uncovered, on the English coast, by a team of scientists led by Queen Mary University of London, the British Museum and the Natural History Museum.

Area A at Happisburgh: View of footprint surface looking south, also showing underlying horizontally bedded laminated silts. Credit: Photo by Simon Parfitt / From: Ashton N, Lewis SG, De Groote I, Duffy SM, Bates M, et al. (2014) Hominin Footprints from Early Pleistocene Deposits at Happisburgh, UK. PLoS ONE 9(2): e88329. doi:10.1371/journal.pone.0088329

Up to five people left the series of footprints in mud on the bank of an ancient river estuary over 800,000 years ago at Happisburgh in northeast Norfolk.

Dr Simon Lewis from Queen Mary's School of Geography has been helping to piece together the geological puzzle surrounding the discovery -- made in May 2013 -- which is evidence of the first known humans in northern Europe.

Dr Lewis's research into the geology of the site has provided vital information on the sediments in which the prints were found. "My role is to work out the sequence of deposits at the site and how they were laid down. This means I can provide a geological context for the archaeological evidence of human occupation at the site."

The importance of the Happisburgh footprints is highlighted by the rarity of footprints surviving elsewhere. Only those at Laetoli in Tanzania at about 3.5 million years and at Ileret and Koobi Fora in Kenya at about 1.5 million years are older.

A lecturer in physical geography, and co-director of the Happisburgh project (http://www.ahobproject.org/), Dr Lewis added that the chance of encountering footprints such as this was extremely rare; they survived environmental change and the passage of time.

Timing was also crucial as "their location was revealed just at a moment when researchers were there to see it" during a geophysical survey. "Just two weeks later the tide would have eroded the footprints away."

"At first we weren't sure what we were seeing," explains Dr Nick Ashton of the British Museum "but as we removed any remaining beach sand and sponged off the seawater, it was clear that the hollows resembled prints, and that we needed to record the surface as quickly as possible."

Over the next two weeks researchers used photogrammetry, a technique that can stitch together digital photographs to create a permanent record and 3D images of the surface. It was the analysis of these images that confirmed that the elongated hollows were indeed ancient human footprints.

In some cases the heel, arch and even toes could be identified, equating to modern shoes of up to UK size 8. While it is not possible to tell what the makers of these footprints were doing at the time, analysis has suggested that the prints were made from a mix of adults and children.

Their discovery offers researchers an insight into the migration of pre-historic people hundreds of thousands of years ago when Britain was linked by land to continental Europe.

At this time, deer, bison, mammoth, hippo and rhino grazed the river valley at Happisburgh. The land provided a rich array of resources for the early humans with edible plant tubers, seaweed and shellfish nearby, while the grazing herds would have provided meat through hunting or scavenging.

During the past 10 years the sediments at Happisburgh have revealed a series of sites with stone tools and fossil bones; this discovery is from the same deposits.

The work at Happisburgh forms part of a new major exhibition at the Natural History Museum Britain: One Million Years of the Human Story opening on February 13.

Story Source: The above story is based on materials provided by Queen Mary University of London. And ScienceDaily article of February 7, 2014.

Journal Reference: Nick Ashton, Simon G. Lewis, Isabelle De Groote, Sarah M. Duffy, Martin Bates, Richard Bates, Peter Hoare, Mark Lewis, Simon A. Parfitt, Sylvia Peglar, Craig Williams, Chris Stringer. **Hominin Footprints from Early Pleistocene Deposits at Happisburgh, UK**. *PLoS ONE*, 2014; 9 (2): e88329 DOI: 10.1371/journal.pone.0088329

Giant mass extinction quicker than previously thought: End-Permian extinction happened in 60,000 years

The largest mass extinction in the history of animal life occurred some 252 million years ago, wiping out more than 96 percent of marine species and 70 percent of life on land -- including the largest insects known to have inhabited Earth. Multiple theories have aimed to explain the cause of what's now known as the end-Permian extinction, including an asteroid impact, massive volcanic eruptions, or a cataclysmic cascade of environmental events. But pinpointing the cause of the extinction requires better measurements of how long the extinction period lasted.

Artist's rendering of the landscape during end-Permian extinction. Credit: José-Luis Olivares/MIT

Now researchers at MIT have determined that the end-Permian extinction occurred over 60,000 years, give or take 48,000 years -- practically instantaneous, from a geologic perspective. The new timescale is based on more precise dating techniques, and indicates that the most severe extinction in history may have happened more than 10 times faster than scientists had previously thought.

"We've got the extinction nailed in absolute time and duration," says Sam Bowring, the Robert R. Shrock Professor of Earth and Planetary Sciences at MIT. "How do you kill 96 percent of everything that lived in the oceans in tens of thousands of years? It could be that an exceptional extinction requires an exceptional explanation."

In addition to establishing the extinction's duration, Bowring, graduate student Seth Burgess, and a colleague from the Nanjing Institute of Geology and Paleontology also found that, 10,000 years before the die-off, the oceans experienced a pulse of light carbon, which likely reflects a massive addition of carbon dioxide to the atmosphere. This dramatic change may have led to widespread ocean acidification and increased sea temperatures by 10 degrees Celsius or more, killing the majority of sea life.

But what originally triggered the spike in carbon dioxide? The leading theory among geologists and paleontologists has to do with widespread, long-lasting volcanic eruptions from the Siberian Traps, a region of Russia whose steplike hills are a result of repeated eruptions of magma. To determine whether eruptions from the Siberian Traps triggered a massive increase in oceanic carbon dioxide, Burgess and Bowring are using similar dating techniques to establish a timescale for the Permian period's volcanic eruptions that are estimated to have covered over five million cubic kilometers.

"It is clear that whatever triggered extinction must have acted very quickly," says Burgess, the lead author of a paper that reports the results in this week's *Proceedings of the National Academy of Sciences*, "fast enough to destabilize the biosphere before the majority of plant and animal life had time to adapt in an effort to survive."

Pinning dates on an extinction

In 2006, Bowring and his students made a trip to Meishan, China, a region whose rock formations bear evidence of the end-Permian extinction; geochronologists and paleontologists have flocked to the area to look for clues in its layers of sedimentary rock. In particular, scientists have focused on a section of rock that is thought to delineate the end of the Permian, and the beginning of the Triassic, based on evidence such as the number of fossils found in surrounding rock layers.

Bowring sampled rocks from this area, as well as from nearby alternating layers of volcanic ash beds and fossil-bearing rocks. After analyzing the rocks in the lab, his team reported in 2011 that the end-Permian likely lasted less than 200,000 years. However, this timeframe still wasn't precise enough to draw any conclusions about what caused the extinction.

Now, the team has revised its estimates using more accurate dating techniques based on a better understanding of uncertainties in timescale measurements.

With this knowledge, Bowring and his colleagues reanalyzed rock samples collected from five volcanic ash beds at the Permian-Triassic boundary. The researchers pulverized rocks and separated out tiny zircon crystals containing a mix of uranium and lead. They then isolated uranium from lead, and measured the ratios of both isotopes to determine the age of each rock sample.

From their measurements, the researchers determined a much more precise "age model" for the end-Permian extinction, which now appears to have lasted about 60,000 years -- with an uncertainty of 48,000 years -- and was immediately preceded by a sharp increase in carbon dioxide in the oceans.

'Spiraling toward the truth'

The new timeline adds weight to the theory that the extinction was triggered by massive volcanic eruptions from the Siberian Traps that released volatile chemicals, including carbon dioxide, into the atmosphere and oceans. With such a short extinction timeline, Bowring says it is possible that a single, catastrophic pulse of magmatic activity triggered an almost instantaneous collapse of all global ecosystems.

To confirm whether the Siberian Traps are indeed the extinction's smoking gun, Burgess and Bowring plan to determine an equally precise timeline for the Siberian Traps eruptions, and will compare it to the new extinction timeline to see where the two events overlap. The researchers will investigate additional areas in China to see if the duration of the extinction can be even more precisely determined.

"We've refined our approach, and now we have higher accuracy and precision," Bowring says. "You can think of it as slowly spiraling in toward the truth."

Story Source: The above story is based on materials provided by Massachusetts Institute of Technology. The original article was written by Jennifer Chu. Massachusetts Institute of Technology. "Giant mass extinction quicker than previously thought: End-Permian extinction happened in 60,000 years." ScienceDaily, February 10, 2014.

Famous China fossil site was 'animal Pompeii' of the Cretaceous

Nidhi Subbaraman NBC News

Evidence in bones of land dwellers like birds and dinosaurs indicate that they were killed by pyroclastic flows.

A fossil site in China that has given up thousands of stunningly well-preserved specimens to paleontologists since the 1920s was the Pompeii of the early Cretaceous.

Millions of years ago, birds, dinosaurs and small mammals that lived in this north-eastern region of China were caught off guard by eruptions from nearby volcanoes. A scorching flood of hot rocks and ash petrified them and transported the carcasses into low-lying volcanic lakes, where they remained until humans unearthed them eons later, a new study suggests.

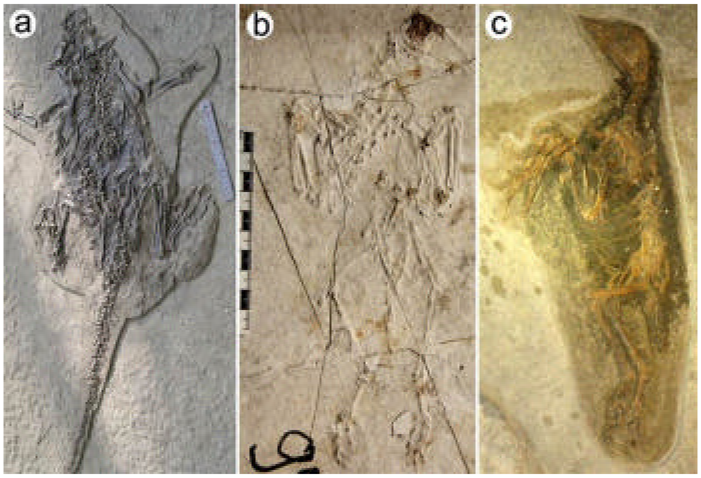


Photo Credit: Baoyu Jiang

Given the abundance of volcanic rocks in the area, scientists have suspected that volcanic activity had a hand in preserving the specimens. But the new work, published in the Tuesday issue of Nature Communications, is the first to make a case for the flows killing and transporting the animals.

"That's quite a radical, new idea," Mike Benton, a paleontologist at the University of Bristol, wrote to NBC News in an email, and "quite a challenge" to the previously theories that indicated that rivers, and not volcanic runoff, carried the animals into the lakes.

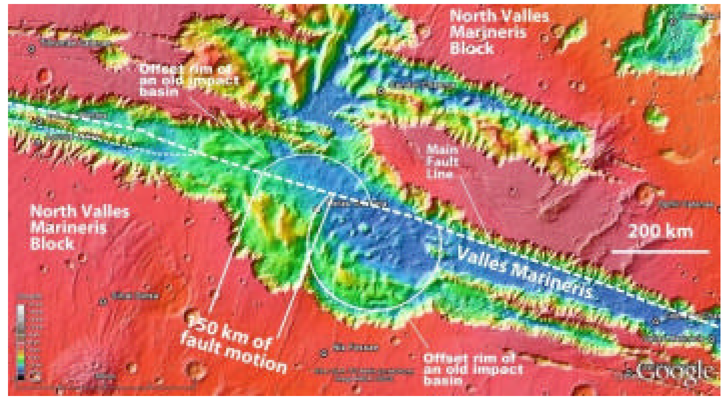
From fossils extracted from five locations from the region, now known as the Jehol biota, researchers identified scorched tissue, and "re-crystallized" sections of bone on fossils. Both were indications that the animals had been exposed to intense heat, Baoyu Jiang, a paleontologist at Nanjing University, and author on the new study told NBC News.

Though famous fish fossils have emerged from the region, only terrestrial fossils — birds, lizards, mammals — showed marks of transport by these volcanic pyroclastic flows, at least so far, he said.

Benton, who was not involved with the new study, said that the "basis of the work is good," but it's "unlikely" that the flows transported the animals. "At Pompeii, people were overwhelmed and killed, but not transported," and it's likely that's what happened to the dinosaurs too.

Scientist Discovers Plate Tectonics On Mars

For years, many scientists had thought that plate tectonics existed nowhere in our solar system but on Earth. Now, a UCLA scientist has discovered that the geological phenomenon, which involves the movement of huge crustal plates beneath a planet's surface, also exists on Mars.



A view of central segment of Mars' Valles Marineris, in which an older circular basin created by an impact is offset for about 93 miles (150 kilometers) by a fault. (Credit: Image from Google Mars created by MOLA Science Team)

"Mars is at a primitive stage of plate tectonics. It gives us a glimpse of how the early Earth may have looked and may help us understand how plate tectonics began on Earth," said An Yin, a UCLA professor of Earth and space sciences and the sole author of the new research.

Yin has conducted geologic research in the Himalayas and Tibet, where two of Earth's seven major plates divide.

Yin made the discovery during his analysis of satellite images from a NASA spacecraft known as THEMIS (Time History of Events and Macroscale Interactions during Substorms) and from the HIRISE (High Resolution Imaging Science Experiment) camera on NASA's Mars Reconnaissance Orbiter. He analyzed about 100 satellite images -- approximately a dozen were revealing of plate tectonics.

"When I studied the satellite images from Mars, many of the features looked very much like fault systems I have seen in the Himalayas and Tibet, and in California as well, including the geomorphology," said Yin, a planetary geologist.

For example, he saw a very smooth, flat side of a canyon wall, which can be generated only by a fault, and a steep cliff, comparable to cliffs in California's Death Valley, which also are generated by a fault. Mars has a linear volcanic zone, which Yin said is a typical product of plate tectonics.

"You don't see these features anywhere else on other planets in our solar system, other than Earth and Mars," said Yin, whose research is featured as the cover story in the August issue of the journal *Lithosphere*.

The surface of Mars contains the longest and deepest system of canyons in our solar system, known as Valles Marineris (Latin for Mariner Valleys and named for the Mariner 9 Mars orbiter of 1971-72, which discovered it). It is nearly 2,500 miles long -- about nine times longer than Earth's Grand Canyon. Scientists have wondered for four decades how it formed. Was it a big crack in Mars' shell that opened up?

"In the beginning, I did not expect plate tectonics, but the more I studied it, the more I realized Mars is so different from what other scientists anticipated," Yin said. "I saw that the idea that it is just a big crack that opened up is incorrect. It is really a plate boundary, with horizontal motion. That is kind of shocking, but the evidence is quite clear.

"The shell is broken and is moving horizontally over a long distance. It is very similar to the Earth's Dead Sea fault system, which has also opened up and is moving horizontally."

The two plates divided by Mars' Valles Marineris have moved approximately 93 miles horizontally relative to each other, Yin said. California's San Andreas Fault, which is over the intersection of two plates, has moved about twice as much -- but Earth is about twice the size of Mars, so Yin said they are comparable.

Yin, whose research is partly funded by the National Science Foundation, calls the two plates on Mars the Valles Marineris North and the Valles Marineris South.

"Earth has a very broken 'egg shell,' so its surface has many plates; Mars' is slightly broken and may be on the way to becoming very broken, except its pace is very slow due to its small size and, thus, less thermal energy to drive it," Yin said. "This may be the reason Mars has fewer plates than on Earth."

Mars has landslides, and Yin said a fault is shifting the landslides, moving them from their source.

Does Yin think there are Mars-quakes?

"I think so," he said. "I think the fault is probably still active, but not every day. It wakes up every once in a while, over a very long duration -- perhaps every million years or more."

Yin is very confident in his findings, but mysteries remain, he said, including how far beneath the surface the plates are located.

"I don't quite understand why the plates are moving with such a large magnitude or what the rate of movement is; maybe Mars has a different form of plate tectonics," Yin said. "The rate is much slower than on Earth."

Earth has a broken shell with seven major plates; pieces of the shell move, and one plate may move over another. Yin is doubtful that Mars has more than two plates.

"We have been able to identify only the two plates," he said. "For the other areas on Mars, I think the chances are very, very small. I don't see any other major crack."

Did the movement of Valles Marineris North and Valles Marineris South create the enormous canyons on Mars? What led to the creation of plate tectonics on Earth?

Yin, who will continue to study plate tectonics on Mars, will answer those questions in a follow-up paper that he also plans to publish in the journal Lithosphere.

Story Source: The above story is based on materials provided by University of California, Los Angeles. The original article was written by Stuart Wolpert; ScienceDaily; August 9, 2012.

Journal Reference: A. Yin. **Structural analysis of the Valles Marineris fault zone: Possible evidence for large-scale strike-slip faulting on Mars**. *Lithosphere*, 2012; 4 (4): 286 DOI: 10.1130/L192.1

Megafloods: What They Leave Behind

South-central Idaho and the surface of Mars have an interesting geological feature in common: amphitheater-headed canyons. These U-shaped canyons with tall vertical headwalls are found near the Snake River in Idaho as well as on the surface of Mars, according to photographs taken by satellites. Various explanations for how these canyons formed have been offered -- some for Mars, some for Idaho, some for both -- but in a paper published the week of December 16 in the online issue of *Proceedings of the National Academy of Sciences*, Caltech professor of geology Michael P. Lamb, Benjamin Mackey, formerly a postdoctoral fellow at Caltech, and W. M. Keck Foundation Professor of Geochemistry Kenneth A. Farley offer a plausible account that all these canyons were created by enormous floods.

Stubby Canyon, Malad Gorge State Park, Idaho. (Credit: Michael Lamb)

Canyons in Malad Gorge State Park, Idaho, are carved into a relatively flat plain composed of a type of volcanic rock known as basalt. The basalt originated from a hotspot, located in what is now Yellowstone Park, which has been active for the last few million years. Two canyons in Malad Gorge, Woody's Cove and Stubby Canyon, are characterized by tall vertical headwalls, roughly 150 feet high, that curve around to form an amphitheater. Other amphitheater-headed canyons can be found nearby, outside the Gorge -- Box Canyon, Blue Lakes Canyon, and Devil's Corral -- and also elsewhere on Earth, such as in Iceland.

To figure out how they formed, Lamb and Mackey conducted field surveys and collected rock samples from Woody's Cove, Stubby Canyon, and a third canyon in Malad Gorge, known as Pointed Canyon. As its name indicates, Pointed Canyon ends not in an amphitheater but in a point, as it progressively narrows in the upstream direction toward the plateau at an average 7 percent grade. Through Pointed Canyon flows the Wood River, a tributary of the larger Snake River, which in turn empties into the Columbia River on its way to the Pacific Ocean.

Geologists have a good understanding of how the rocks in Woody's Cove and Stubby Canyon achieved their characteristic appearance. The lava flows that hardened into basalt were initially laid down in layers, some more than six feet thick. As the lava cooled, it contracted and cracked, just as mud does when it dries. This produced vertical cracks across the entire layer of lava-turned-basalt. As each additional sheet of lava covered the same land, it too cooled and cracked vertically, leaving a wall that, when exposed, looks like stacks of tall blocks, slightly offset from one another with each additional layer. This type of structure is called columnar basalt.

While the formation of columnar basalt is well understood, it is not clear how, at Woody's Cove and Stubby Canyon, the vertical walls became exposed or how they took on their curved shapes. The conventional explanation is that the canyons were formed via a process called "groundwater sapping," in which springs at the bottom of the canyon gradually carve tunnels at the base of the rock wall until this undercutting destabilizes the structure so much that blocks or columns of basalt fall off from above, creating the amphitheater below.

This explanation has not been corroborated by the Caltech team's observations, for two reasons. First, there is no evidence of undercutting, even though there are existing springs at the base of Woody's Cove and Stubby Canyon. Second, undercutting should leave large boulders in place at the foot of the canyon, at least until they are dissolved or carried away by groundwater. "These blocks are too big to move by spring flow, and there's not enough time for the groundwater to have dissolved them away," Lamb explains, "which means that large floods are needed to move them out. To make a canyon, you have to erode the canyon headwall, and you also have to evacuate the material that collapses in."

That leaves waterfall erosion during a large flood event as the only remaining candidate for the canyon formation that occurred in Malad Gorge, the Caltech team concludes.

No water flows over the top of Woody's Cove and Stubby Canyon today. But even a single incident of overland water flow occurring during an unusually large flood event could pluck away and topple boulders from the columnar basalt, taking advantage of the vertical fracturing already present in the volcanic rock. A flood of this magnitude could also carry boulders downstream, leaving behind the amphitheater canyons we see today without massive boulder piles at their bottoms and with no existing watercourses.

Additional evidence that at some point in the past water flowed over the plateaus near Woody's Cove and Stubby Canyon are the presence of scour marks on surface rocks on the plateau above the canyons. These scour marks are evidence of the type of abrasion that occurs when a water discharge containing sediment moves overland.

Taken together, the evidence from Malad Gorge, Lamb says, suggests that "amphitheater shapes might be diagnostic of very large-scale floods, which would imply much larger water discharges and much shorter flow durations than predicted by the previous groundwater theory." Lamb points out that although groundwater sapping "is often assumed to explain the origin of amphitheater-headed canyons, there is no place on Earth where it has been demonstrated to work in columnar basalt."

Closing the case on the canyons at Malad Gorge required one further bit of information: the ages of the rock samples. This was accomplished at Caltech's Noble Gas Lab, run by Kenneth A. Farley, W. M. Keck Foundation Professor of Geochemistry and chair of the Division of Geological and Planetary Sciences.

The key to dating surface rocks on Earth is cosmic rays - very high-energy particles from space that regularly strike Earth. "Cosmic rays interact with the atmosphere and eventually with rocks at the surface, producing alternate versions of noble gas elements, or isotopes, called cosmogenic nuclides," Lamb explains. "If we know the cosmic-ray flux, and we measure the accumulation of nuclides in a certain mineral, then we can calculate the time that rock has been sitting at Earth's surface."

At the Noble Gas Lab, Farley and Mackey determined that rock samples from the heads of Woody's Cove and Stubby Canyon had been exposed for the same length of time, approximately 46,000 years. If Lamb and his colleagues are correct, this is when the flood event occurred that plucked the boulders off the canyon walls, leaving the amphitheaters behind.

Further evidence supporting the team's theory can be found in Pointed Canyon. Rock samples collected along the walls of the first kilometer of the canyon show progressively more exposure in the downstream direction, suggesting that the canyon is still being carved by Wood River. Using the dates of exposure revealed in the rock samples, Lamb reconstructed the probable location of Pointed Canyon at the time of the formation of Woody's Cove and Stubby Canyon. At that location, where the rock has been exposed approximately 46,000 years, the surrounding canyon walls form the characteristic U-shape of an amphitheater-headed canyon and then abruptly narrow into the point that forms the remainder of Pointed Canyon. "The same megaflood event that created Woody's Cove and Stubby Canyon seems to have created Pointed Canyon," Lamb

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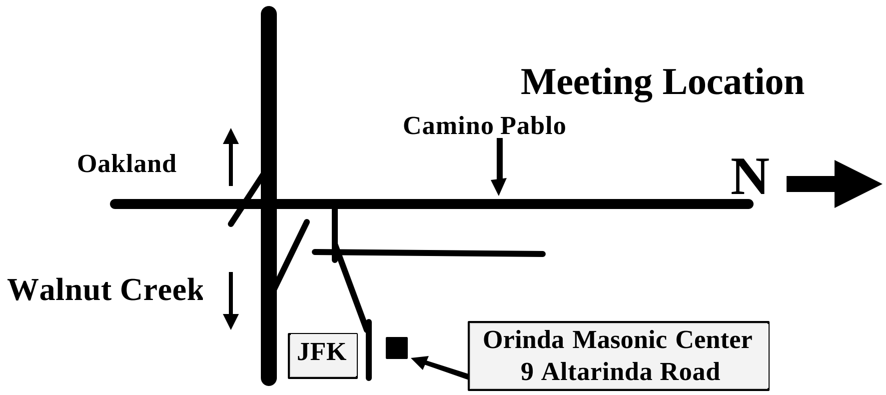

Continued - Megafloods: What They Leave Behind

concludes. "The only difference is that the other canyons had no continuing river action, while Pointed Canyon was cut relatively slowly over the last 46,000 years by the Wood River, which is not powerful enough to topple and pluck basalt blocks from the surrounding plateau,
resulting in a narrow channel rather than tall vertical headwalls."

Solving the puzzle of how amphitheater-headed canyons are created has implications reaching far beyond south-central Idaho because similar features – though some much larger -- are also present on the surface of Mars. "A very popular interpretation for the amphitheater-headed canyons on Mars is that groundwater seeps out of cracks at the base of the canyon headwalls and that no water ever went over the top," Lamb says. Judging from the evidence in Idaho, however, it seems more likely that on Mars, as on Earth, amphitheater-headed canyons were created by enormous flood events, suggesting that Mars was once a very watery planet.

Story Source: The above story is based on materials provided by California Institute of Technology. The original article was written by Cynthia Eller; ScienceDaily January 16, 2014

Journal Reference: M. P. Lamb, B. H. Mackey, K. A. Farley. **Amphitheater-headed canyons formed by megaflooding at Malad Gorge, Idaho**. *Proceedings of the National Academy of Sciences*, 2013; 111 (1): 57 DOI: 10.1073/pnas.1312251111

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