NORTHERN CALIFORNIA GEOLOGICAL SOCIETY

MEETING ANNOUNCEMENT

DATE: October 28, 2015

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: **Dr. Anne M. Sanquini, recently of Department of Geological Sciences, School of Earth, Energy and Environmental Sciences, Stanford University**

Inspiring Earthquake-Resistant Construction in the Kathmandu Valley, Nepal

A 20-minute documentary film was created to accelerate the rate at which Nepali communities retrofit or rebuild their local public school buildings to be life-safe in the event of a major earthquake. It features local Nepalis as role models who have already strengthened their schools, and is based on the theory of communicating actionable risk, diffusion of innovation theory, and social cognitive theory. Public schools in Kathmandu Valley with buildings in need of seismic work were assessed for eligibility in the study. Of these, 16 were selected and matched into 8 pairs based on seismic condition of the buildings. One school in each pair was randomly assigned to see the intervention film and the other to see an attention placebo control film on an unrelated topic. Pre and post observations were recorded from 761 adult participants, using a questionnaire created for this purpose. Comparisons between the two groups of schools were made with the school as the unit of analysis. When compared to the control schools, the schools whose community members saw the retrofit intervention film statistically significantly increased their: 1) knowledge of specific actions to take in support of earthquake-resistant construction, 2) belief in the feasibility of making buildings earthquake-resistant, 3) willingness to support seismic strengthening of the local school building, and 4) likelihood to recommend to others that they build earthquake-resistant homes. This outcome suggests that employing a film featuring community members who have already taken the desired action increases factors that may accelerate adoption of risk reduction actions by others who are similar to them.

Biography. Dr. Anne M. Sanquini recently received her Ph.D. from the Department of Geological Sciences, School of Earth, Energy and Environmental Sciences, Stanford University, and is in process of establishing a consulting practice in disaster science. She holds an M.S. in

NCGS 2015 – 2016 Calendar

November 18, 2015 (1 Week Early) 7:00 pm
Dr. Andrea Foster, U.S. Geological Survey
The Environmental Legacy of California's Gold Rush: Arsenic and Mercury Contamination from Historic Mining

NCGS Field Trips

October 24, 2015 (Saturday, 9 am – 4 pm)
Anatomy and provenance of a deep-water boulder conglomeratic submarine canyon in the Upper Cretaceous Panoche Formation (Cenomanian), Great Valley Group, San Luis Reservoir, central California-
Dr. Todd J. Greene, Department of Geological and Environmental Science, California State University, Chico

(Space may still be available; see field trip flyer in September newsletter, also emailed by Dan Day on 10/8/15)

Additional Trips in 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.

Early Career Scientists Sought to Speak in K-12 classrooms

The following is an email from The National Center for Science Education received by the Kathleen Burnham; it may be of interest to some of our members.

Dear Kathleen,

The National Center for Science Education is piloting a new program this fall to get early career scientists into K-12 classrooms to talk about climate change and evolution!

We are looking for all types of early career scientists, from graduate students all the way up to folks in their first years of their academic positions. The time commitment for the program is low, just one in-class visit and regular monthly social media interactions throughout the semester, but the impact will be enormous. This is a great opportunity for scientists looking to share their work with a broader audience and inspire a new generation of scientists and science-loving citizens.

Interested? Intrigued? Know of a great fit for such a new and innovative program? Perfect! Sign up yourself, share with colleagues or departments who might be interested, and send some early career scientists our way!

To find out more about the program and sign up, visit our website or contact Minda Berbeco at berbeco@ncse.com.

Sincerely,

Minda Berbeco
Programs and Policy Director
National Center for Science Education
420 40th Street Suite 2
Oakland, CA 94702
p. 510-601-7203 e. berbeco@ncse.com

2015-2016 Richard Chambers Memorial Scholarships

The NCGS will award Richard Chambers Memorial Scholarships to up to three students in early 2016. Up to three $ 1,000 scholarships will be awarded to students pursuing Masters Degrees and one $ 2,000 scholarship to a student pursuing a Doctorate Degree.

The 2015-2016 RCMS application deadline is December 18, 2015. Applicants should go to the NCGS website for the application process. Phil Garbutt will bring copies of the application procedures to the NCGS general meetings between now and December.

Signs of ancient mega-tsunami could portend modern hazard

Geologists think the eastern flank of the Cape Verde islands' Fogo volcano crashed into the sea some 73,000 years ago, leaving this giant scar, and generating a gigantic tsunami.
Credit: Satellite image from NASA

Scientists working off west Africa in the Cape Verde Islands have found evidence that the sudden collapse of a volcano there tens of thousands of years ago generated an ocean tsunami that dwarfed anything ever seen by humans. The researchers say an 800-foot wave engulfed an island more than 30 miles away. The study could revive a simmering controversy over whether sudden giant collapses present a realistic hazard today around volcanic islands, or even along more distant continental coasts. The study appears today in the journal *Science Advances*.

"Our point is that flank collapses can happen extremely fast and catastrophically, and therefore are capable of triggering giant tsunamis," said lead author Ricardo Ramalho, who did the research as a postdoctoral associate at Columbia University's Lamont-Doherty Earth Observatory, where he is now an adjunct scientist. "They probably don't happen very often. But we need to take this into account when we think about the hazard potential of these kinds of volcanic features."

The apparent collapse occurred some 73,000 years ago at the Fogo volcano, one of the world's largest and most active island volcanoes. Nowadays, it towers 2,829 meters (9,300 feet) above sea level, and erupts about every 20 years, most recently last fall. Santiago Island, where the wave apparently hit, is now home to some 250,000 people.

There is no dispute that volcanic flanks present a hazard; at least eight smaller collapses have occurred in Alaska, Japan and elsewhere in the last several hundred years, and some have generated deadly tsunamis. But many scientists doubt whether big volcanoes can collapse with the suddenness that the new study suggests. Rather, they envision landslides coming in gradual stages, generating multiple, smaller tsunamis. A 2011 French study also looked at the Fogo collapse, suggesting that it took place somewhere between 124,000-65,000 years ago; but that study says it involved more than one landslide. The French researchers estimate that the resulting multiple waves would have reached only 45 feet--even at that, enough to do plenty of harm today.

A handful of previous other studies have proposed much larger prehistoric collapses and resulting megatsunamis, in the Hawaiian islands, at Italy's Mt. Etna, and the Indian Ocean's Reunion Island. But critics have said these examples are too few and the evidence too thin. The new study adds a new possible example; it says the estimated 160 cubic kilometers (40 cubic miles) of rock that Fogo lost during the collapse was dropped all at once, resulting in the 800-foot wave. By comparison, the biggest known recent tsunamis, which devastated the Indian Ocean's coasts in 2004 and eastern Japan in 2011, reached only about 100 feet. (Like most other well documented tsunamis, these were generated by movements of undersea earthquake faults--not volcanic collapses.)

Santiago Island lies 55 kilometers (34 miles) from Fogo. Several years ago, Ramalho and colleagues were working on Santiago when they spotted unusual boulders lying as far as 2,000 feet inland and nearly 650 feet above sea level. Some are as big as delivery vans, and they are utterly unlike the young volcanic terrain on which they lie. Rather, they match marine-type rocks that ring the island's shoreline: limestones, conglomerates and submarine basalts. Some weigh up to 770 tons. The only realistic explanation the scientists could come up with: A gigantic wave must have ripped them from the shoreline and lofted them up. They derived the size of the wave by calculating the energy it would have taken to accomplish this feat.

To date the event, in the lab Ramalho and Lamont-Doherty geochemist Gisela Winckler measured isotopes of the element helium embedded near the boulders' surfaces. Such isotopes change depending on how long a rock has been lying in the open, exposed to cosmic rays. The analyses centered around 73,000 years--well within the earlier French estimate of a smaller event. The analysis "provides the link between the collapse and impact, which you can make only if you have both dates," said Winckler.

Tsunami expert Bill McGuire, a professor emeritus at University College London who was not involved in the research, said the study "provides robust evidence of megatsunami formation [and] confirms that when volcanoes collapse, they can do so extremely rapidly." Based on his own work, McGuire s says that such megatsunamis probably come only once every 10,000 years. "Nonetheless," he said, "the scale of such events, as the Fogo study testifies, and their potentially devastating impact, makes them a clear and serious hazard in ocean basins that host active volcanoes."

Ramalho cautions that the study should not be taken as a red flag that another big collapse is imminent here or elsewhere. "It doesn't mean every collapse happens catastrophically," he said. "But it's maybe not as rare as we thought."

In the early 2000s, other researchers started publishing evidence that the Cape Verdes could generate large tsunamis. Others have argued that Spain's Canary Islands have already done so. Simon Day, a senior researcher at University College London has sparked repeated controversy by warning that any future eruption of the Canary Islands' active Cumbre Vieja volcano could set off a flank collapse that might form an initial wave 3,000 feet high. This, he says, could erase more than nearby islands. Such a wave might still be 300 feet high when it reached west Africa an hour or so later he says, and would still be 150 feet high along the coasts of North and South America. So far, such studies have raised mainly tsunamis of publicity, and vigorous objections from other scientists that such events are improbable. A 2013 study of deep-sea sediments by the United

Kingdom's National Oceanography Centre suggests that the Canaries have probably mostly seen gradual collapses.

Part of the controversy hangs not only on the physics of the collapses themselves, but on how efficiently resulting waves could travel. In 1792, part of Japan's Mount Unzen collapsed, hitting a series of nearby bays with waves as high as 300 feet, and killing some 15,000 people. On July 9, 1958, an earthquake shook 90 million tons of rock into Alaska's isolated Lituya Bay; this created an astounding 1,724-foot-high wave, the largest ever recorded. Two fishermen who happened to be in their boat that day were carried clear over a nearby forest; miraculously, they survived.

These events, however, occurred in confined spaces. In the open ocean, waves created by landslides are generally thought to lose energy quickly, and thus to pose mainly a regional hazard. However, this is based largely on modeling, not real-world experience, so no one really knows how fast a killer wave might decay into a harmless ripple. In any case, most scientists are more concerned with tsunamis generated by undersea earthquakes, which are more common. When seabed faults slip, as they did in 2004 and 2011, they shove massive amounts of water upward. In deep water, this shows up as a mere swell at the surface; but when the swell reaches shallower coastal areas, its energy concentrates into in a smaller volume of water, and it rears up dramatically. The 2004 Indian Ocean earthquake and tsunami killed 230,000 people in 14 countries; the 2011 Tohoku event killed nearly 20,000 in Japan, and has caused a long-term nuclear disaster.

James Hunt, a tsunami expert at the United Kingdom's National Oceanography Centre who was not involved in the study, said the research makes it clear that "even modest landslides could produce high-amplitude anomalous tsunami waves on opposing island coastlines." The question, he said, "is whether these translate into hazardous events in the far field, which is debatable."

When Fogo erupted last year, Ramalho and other geologists rushed in to observe. Lava flows (since calmed down) displaced some 1,200 people, and destroyed buildings including a new volcano visitors' center. "Right now, people in Cape Verde have a lot more to worry about, like rebuilding their livelihoods after the last eruption," said Ramalho. "But Fogo may collapse again one day, so we need to be vigilant."

Journal Reference: R. S. Ramalho, G. Winckler, J. Madeira, G. R. Helffrich, A. Hipolito, R. Quartau, K. Adena, J. M. Schaefer. **Hazard potential of volcanic flank collapses raised by new megatsunami evidence**. *Science Advances*, 2015; 1 (9): e1500456 DOI: 10.1126/sciadv.1500456

The fingerprints of sea level rise

Greenland's rising bedrock interacts with its ice loss from global climate change.
Credit: ESA/Sentinel-2, Copernicus Sentinel data

When you fill a sink, the water rises at the same rate to the same height in every corner. That's not the way it works with our rising seas.

According to the 23-year record of satellite data from NASA and its partners, the sea level is rising a few millimeters a year -- a fraction of an inch. If you live on the U.S. East Coast, though, your sea level is rising two or three times faster than average. If you live in Scandinavia, it's falling. Residents of China's Yellow River delta are swamped by sea level rise of more than nine inches (25 centimeters) a year.

These regional differences in sea level change will become even more apparent in the future, as ice sheets melt. For instance, when the Amundsen Sea sector of the West Antarctic Ice Sheet is totally gone, the average global sea level will rise four feet. But the East Coast of the United States will see an additional 14 to 15 inches above that average.

Tides, winds and ocean currents play a role in these regional differences, but an increasingly important mover and shaker is the solid Earth itself. Global warming is not just affecting the surface of our world; it's making the Earth move under our feet.

Unless a volcano or earthquake is in the news, we tend to think of our home planet as solid rock. But 50 miles (80 kilometers) below our feet, there's a layer thousands of miles thick that can flow like a liquid over thousands of years. The tectonic plates of Earth's crust float on this viscous layer, called the mantle, like a vanilla wafer on a very thick pudding.

If you were to put a strawberry on top of that vanilla wafer, the added weight would make the cookie sink into the pudding. In the same way, heavy weights on Earth's crust push it down into the mantle, which flows away and bulges out elsewhere. The miles-thick ice sheets of Greenland and Antarctica have been depressing the crust beneath them for millennia. That weight has a second

effect that you won't see in your dessert: its gravitational pull on the surrounding ocean makes seawater pile up around the coastlines.

These weight-filled dents in the mantle don't make a permanent scar. When the extra weight lifts, the mantle rebounds. This doesn't just happen at the majestic pace of mountain ranges crumbling. It happens every day.

"The solid earth can respond very quickly -- nearly instantaneously," said Mark Tamisiea, a scientist at the National Oceanography Centre, Liverpool, England, who studies the connection between sea levels and Earth processes. Tamisiea cited the example of solid-Earth tides, which pull the crust outward as much as a foot (30 centimeters) toward the moon as it passes overhead. Similarly, Earth has an instant initial response to glaciers and ice sheets melting, called the elastic response.

Since NASA launched the Gravity Recovery and Climate Experiment (GRACE) twin satellites in 2002, scientists have had an extremely precise measurement of the contribution that ice sheets' loss of mass contributes to changes in gravity and what it is adding to sea level rise. "Because of GRACE, we've had a pretty good idea of what's happening since 2002," said Steve Nerem of the University of Colorado, head of NASA's Sea Level Change Team. "We know how much [of sea level rise] is from Greenland, how much is from Antarctica, how much is from glaciers."

Because every ice sheet and glacier has a unique location and size, each one creates a pattern of response in the ocean as individual as a fingerprint. "The physics behind understanding these fingerprints is very well understood," Tamisiea said. "It's like the tides." He and Jerry Mitrovica of Harvard University have calculated the fingerprints of East and West Antarctica and Greenland around the globe. "We do each ice sheet individually so we can use the latest GRACE analysis," Tamisiea explained. "You can sort of add the effects up and see what the result is for any given location."

As any ice sheet melts, sea levels along coastlines as much as 1,500 miles (2,000 kilometers) away will fall as seawater escapes from the reduced gravitational pull and the crust lifts. The escaping seawater flows clear across the equator: the melting of Antarctica affects the U.S. East and West coasts, and Greenland's disappearance impacts the coastline of Brazil. These regional differences are significant -- such as in the case of the East Coast of the United States.

The East Coast is also on the losing end of another important solid-Earth process that affects regional sea levels: post-glacial rebound. After the elastic response to a crustal weight loss, uplift continues more slowly for many millennia. North America is still responding to the massive melt-off at the end of the last ice age 6,000 years ago. The North American tectonic plate wasn't evenly loaded during that ice age: ice sheets were sitting on what is now Canada and Greenland, while most of today's United States remained ice free. This ice load pushed the mantle out from under Canada and buoyed up the United States. Today, the U.S. side of the North American plate is sinking like the downhill end of a seesaw as the northern side continues to lift.

Greenland's uplift from postglacial rebound means the island is gaining mass from below and its bedrock is continuously rising. At the same time, it is losing mass from above as its ice melts. GRACE measures the net result of these opposing processes, not just the result of melting ice alone. A National Science Foundation- and NASA-funded program called the Greenland GPS Network is working to overcome this problem. Led by Michael Bevis of Ohio State University, Columbus, the program is using more than 50 GPS stations in Greenland to measure Greenland's rise and fall. The network is dense enough, and the instruments record elevation precisely enough, to distinguish the steady, long-term rise caused by postglacial rebound from shorter-term changes in elevation caused by the weight of the winter snows and loss of weight in summer. The goal of the project is to provide a "correction factor" for postglacial rebound that can be applied to measurements by GRACE and succeeding missions so the remainder is an accurate measurement of the loss of mass from melting.

Scientists currently believe ice sheet fingerprints will be the major driver of future regional variations in sea levels. They are working on questions of how these solid-Earth processes interact with other global and local drivers of sea level rise. "We have to understand global and larger-scale regional changes to do localized impact studies," Tamisiea explained. "In some places, it may very well be that regional processes will be the most important signal. There has to be a continuum of understanding of the global average, regional changes and more localized processes. We'll need all of those layers to make viable predictions."

Story Source: The above article was written by Carol Rasmussen of the NASA Earth Science News Team (2015-279) and is reprinted from the NASA/Jet Propulsion Laboratory website (http://www.jpl.nasa.gov/news/news.php?feature=4701).

Tiny ancient fossil from Spain shows birds flew over the heads of dinosaurs

A new paper documents the intricate arrangement of the muscles and ligaments that controlled the main feathers of the wing of an ancient bird, supporting the notion that at least some of the most ancient birds performed aerodynamic feats in a fashion similar to those of many living birds.
Credit: Stephanie Abramowicz

Birds have an enormously long evolutionary history: The earliest of them, the famed *Archaeopteryx*, lived 150 million years ago in what is today southern Germany. However, whether these early birds were capable of flying -- and if so, how well -- has remained shrouded in scientific controversy. A new discovery published in the journal *Scientific Reports* documents the intricate arrangement of the muscles and ligaments that controlled the main feathers of the wing of an ancient bird, supporting the notion that at least some of the most ancient birds performed aerodynamic feats in a fashion similar to those of many living birds.

An international team of Spanish paleontologists and NHM's Director of the Dinosaur Institute, Dr. Luis M. Chiappe, studied the exceptionally preserved wing of a 125-million-year-old bird from central Spain. Beyond the bones preserved in the fossil, the tiny wing of this ancient bird reveals details of a complex network of muscles that in modern birds controls the fine adjustments of the wing's main feathers, allowing birds to master the sky.

"The anatomical match between the muscle network preserved in the fossil and those that characterize the wings of living birds strongly indicates that some of the earliest birds were capable of aerodynamic prowess like many present-day birds," said Chiappe, the investigation's senior scientist.

"It is very surprising that despite being skeletally quite different from their modern counterparts, these primitive birds show striking similarities in their soft anatomy," said Guillermo Navalón, a doctorate candidate at the University of Bristol in the United Kingdom and lead author of the report.

Ancient birds may have flown over the heads of dinosaurs but some aspects of the precise flight modes of these early fliers still remain unclear. "The new fossil provides us with a unique glimpse into the anatomy of the wing of the birds that lived amongst some of the largest dinosaurs," said Chiappe. "Fossils such as this are allowing scientists to dissect the most intricate aspects of the early evolution of the flight of birds." Other members of the research team included Dr. Jesús Marugán-Lobón, Dr. José Luis Sanz, and Dr. Ángela D. Buscalioni from Madrid's Universidad Autónoma in Spain.

Story Source: The above post is reprinted from materials provided by Natural History Museum of Los Angeles County.

Journal Reference: Guillermo Navalón, Jesús Marugán-Lobón, Luis M. Chiappe, José Luis Sanz, Ángela D. Buscalioni. **Soft-tissue and dermal arrangement in the wing of an Early Cretaceous bird: Implications for the evolution of avian flight**. *Scientific Reports*, 2015; 5: 14864 DOI: 10.1038/srep14864

Asteroid impact, volcanism were one-two punch for dinosaurs

These are layered lava flows of the Deccan Traps east of Mumbai, India.
Credit: Mark Richards/UC Berkeley

Berkeley geologists have uncovered compelling evidence that an asteroid impact on Earth 66 million years ago accelerated the eruptions of volcanoes in India for hundreds of thousands of years, and that together these planet-wide catastrophes caused the extinction of many land and marine animals, including the dinosaurs.

For 35 years, paleontologists and geologists have debated the role these two global events played in the

last mass extinction, with one side claiming the eruptions were irrelevant, and the other side claiming the impact was a blip in a long-term die-off.

The new evidence includes the most accurate dates yet for the volcanic eruptions before and after the impact. The new dates show that the Deccan Traps lava flows, which at the time were erupting at a slower pace, doubled in output within 50,000 years of the asteroid or comet impact that is thought to have initiated the last mass extinction on Earth.

Both the impact and the volcanism would have blanketed the planet with dust and noxious fumes, drastically changing the climate and sending many species to an early grave.

"Based on our dating of the lavas, we can be pretty certain that the volcanism and the impact occurred within 50,000 years of the extinction, so it becomes somewhat artificial to distinguish between them as killing mechanisms: both phenomena were clearly at work at the same time," said lead researcher Paul Renne, a UC Berkeley professor-in-residence of earth and planetary science and director of the Berkeley Geochronology Center. "It is going to be basically impossible to ascribe actual atmospheric effects to one or the other. They both happened at the same time."

The geologists argue that the impact abruptly changed the volcanoes' plumbing system, which produced major changes in the chemistry and frequency of the eruptions. After this change, long-term volcanic eruptions likely delayed recovery of life for 500,000 years after the KT boundary, the term for the end of the Cretaceous and the beginning of the Tertiary period when large land animals and many small sea creatures disappeared from the fossil record.

"The biodiversity and chemical signature of the ocean took about half a million years to really recover after the KT boundary, which is about how long the accelerated volcanism lasted," Renne said. "We are proposing that the volcanism unleashed and accelerated right at the KT boundary suppressed the recovery until the volcanoes waned."

Co-author Mark Richards, a UC Berkeley professor of earth and planetary science and the one who originally proposed that the comet or asteroid impact reignited the Deccan Traps lava flows, is agnostic about which event was the real death knell for much of life on Earth. But the link between the impact and the flood basalts is becoming harder to deny.

"If our high-precision dates continue to pin these three events -- the impact, the extinction and the major pulse of volcanism -- closer and closer together, people are going to have to accept the likelihood of a connection among them. The scenario we are suggesting -- that the impact triggered the volcanism -- does in fact reconcile what had previously appeared to be an unimaginable coincidence," he said.

Renne, Richards and their colleagues will publish the new dates for the Deccan Traps eruptions in the Oct. 2 issue of the journal *Science*.

Impact or volcanism?

Since 1980, when UC Berkeley geologist Walter Alvarez and his father, the late UC Berkeley physicist Luis Alvarez, discovered evidence of a comet or asteroid impact on Earth 66 million years ago, scientists have argued about whether the impact was the cause of the mass extinction that occurred at the same time, the end of the Cretaceous period, or the KT boundary. Some argued that the huge volcanic eruptions in India known as the Deccan Traps, which occurred around the same time, were the main culprit in the extinctions. Others insisted the death knell had been the impact, which left behind a large crater dubbed Chicxulub off Mexico's Yucatan peninsula, and viewed the Deccan Traps eruptions as a minor sideshow.

Earlier this year, Richards, Renne and eight other geoscientists proposed a new scenario: that the impact ignited volcanoes around the globe, most catastrophically in India, and that the two events combined to cause the KT extinction.

In attempts to test this hypothesis, the team last year collected lava samples from throughout the Deccan Traps east of Mumbai, sampling flows from near the beginning, several hundred thousand years before the extinction and near the end, some half a million years after the extinction. High-precision argon-40/argon-39 isotope dating allowed them to establish the chronology of the flows and the rate of flow over time.

In the *Science* paper, they describe major changes in the Deccan Traps volcanism, which was probably "bubbling along happily, continuously and relatively slowly" before the extinction, Renne said. After the impact, the eruption rate more than doubled and the volcanism became more punctuated, with more voluminous lava flows interspersed with long periods of quiet. This is consistent with a change in the underground plumbing feeding the flows, he said: Smaller magma chambers before the impact became larger, which means they took longer to fill but spewed more lava when they did erupt.

"At the KT boundary, we see major changes in the volcanic system of the Deccan Traps, in terms of the rate at which eruptions were happening, the size of the eruptions, the volume of the eruptions and some aspects of the chemistry of the eruptions, which speaks to the actual processes by which the magmas were generated," Renne said. "All these things changed in a fundamental way, and increasingly it seems they happened right at the KT boundary. Our data don't conclusively prove that the

impact caused these changes, but the connection looks increasingly clear."

Richards said that a large nearby earthquake of a magnitude 8, 9 or 10 -- as large or larger than the quake that struck Japan in 2011 -- could also have reignited the Deccan Trap flows. In fact, large quakes may have rattled underground magma chambers and ignited eruptions throughout Earth's history. But the simultaneous changes in the lava flows and the impact at the KT boundary seem more than mere coincidence.

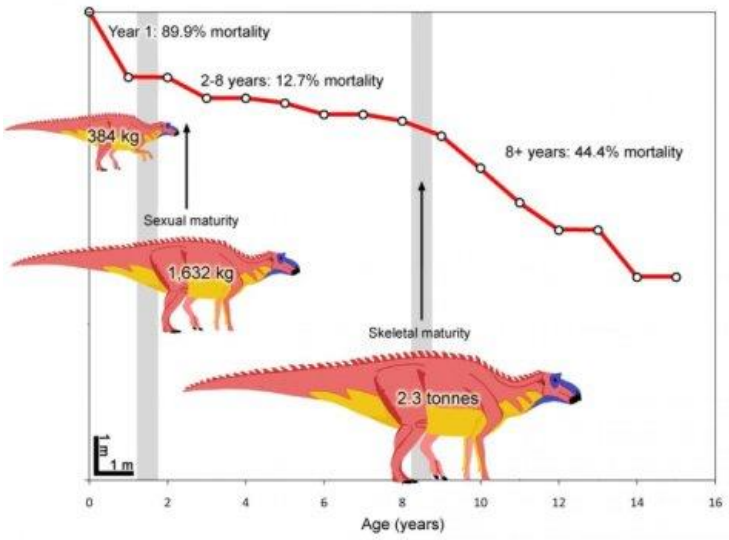
"These changes are consistent with an accelerated rate of magma production and eruption that you could get from a large earthquake such as would be created by the Chicxulub impact," he said.

In 2013, Renne and his team at the Berkeley Geochronology Center and elsewhere also dated the KT boundary extinction and dust from the impact and found they occurred within less than 32,000 years of one another -- the blink of an eye in geologic terms, he said. Renne's team plans to obtain isotope dates for more basalt samples from the Deccan Traps to detail the history of the lava flows that cover much of western India, in order to better understand how they changed with time and correlate to the impact and extinctions. Meanwhile, Richards is working with volcano experts to understand how large ground shaking caused by earthquakes or asteroid impacts affects volcanic eruptions.

Story Source: The above post is reprinted from materials provided by University of California, Berkeley. The original item was written by Robert Sanders.

Journal Reference: P. R. Renne, C. J. Sprain, M. A. Richards, S. Self, L. Vanderkluysen, K. Pande. **State shift in Deccan volcanism at the Cretaceous-Paleogene boundary, possibly induced by impact**. *Science*, 2015; 350 (6256): 76 DOI: 10.1126/science.aac7549

Largest dinosaur population growth study ever shows how Maiasaura lived and died



Research published in the journal Paleobiology is showing more about the life history of Maiasaura peeblesorum than any other known dinosaur.
Credit: Courtesy Holly Woodward

Decades of research on Montana's state fossil -- the "good mother lizard" Maiasaura peeblesorum -- has resulted in the most detailed life history of any dinosaur known and created a model to which all other dinosaurs can be compared, according to new research published recently in the journal *Paleobiology*.

Researchers from Oklahoma State University, Montana State University and Indiana Purdue University used fossils collected from a huge bonebed in western Montana for their study.

"This is one of the most important pieces of paleontology involving MSU in the past 20 years," said Jack Horner, curator of the Museum of the Rockies at MSU. "This is a dramatic step forward from studying fossilized creatures as single individuals to understanding their life cycle. We are moving away from the novelty of a single instance to looking at a population of dinosaurs in the same way we look at populations of animals today."

The study was led by Holly Woodward, who did the research as her doctoral thesis in paleontology at MSU. Woodward is now professor of anatomy at Oklahoma State University Center for Health Sciences.

The *Paleobiology* study examined the fossil bone microstructure, or histology, of 50 *Maiasaura* tibiae (shin bones). Bone histology reveals aspects of growth that cannot be obtained by simply looking at the shape of the bone, including information about growth rate, metabolism, age at death, sexual maturity, skeletal maturity and how long a species took to reach adult size.

"Histology is the key to understanding the growth dynamics of extinct animals," Woodward said. "You can only learn so much from a bone by looking at its shape. But the entire growth history of the animal is recorded within the bone."

A sample of 50 might not sound like much, but for dinosaur paleontologists dealing with an often sparse fossil record, the *Maiasaura* fossils are a treasure trove. "No other histological study of a single dinosaur species approaches our sample size," Woodward said.

With it, the researchers discovered a wealth of new information about how *Maiasaura* grew up: it had bird-level growth rates throughout most of its life, and its bone tissue most closely resembled that of modern day warm-blooded large mammals such as elk. Major life events are recorded in the growth of the bones and the rates at which different-aged animals died.

"By studying the bone histology, and looking at patterns in the death assemblage, we found multiple pieces of evidence all supporting the same timing of sexual and skeletal maturity," said Elizabeth Freedman Fowler, curator of paleontology at the Great Plains Dinosaur Museum in Malta and adjunct professor at MSU, who performed the mathematical analyses for the study.

Sexual maturity occurred within the third year of life, and *Maiasaura* reached an average adult mass of 2.3 tonnes in eight years. Life was especially hard for the very young and the old. The average mortality rate for those less than a year of age was 89.9 percent, and 44.4 percent for individuals 8 years and older. If *Maiasaura* individuals could survive through their second year, they enjoyed a six-year window of peak physical and reproductive fitness, when the average mortality rate was just 12.7 percent.

"By looking within the bones, and by synthesizing what previous studies revealed, we now know more about the life history of *Maiasaura* than any other dinosaur and have the sample size to back up our conclusions," Woodward said. "Our study makes *Maiasaura* a model organism to which other dinosaur population biology studies will be compared."

The 50 tibiae also highlighted the extent of individual size variation within a dinosaur species. Previous dinosaur studies examined a small subset of dinosaur bones and assigned ages to the entire sample based on the lengths of the few histologically aged bones.

"Our results suggest you can't just measure the length of a dinosaur bone and assume it represents an animal of a certain age," Woodward said. "Within our sample, there is a lot of variability in the length of the tibia in each age group. It would be like trying to assign an age to a person based on their height because you know the height and age of someone else. Histology is the only way to quantify age in dinosaurs."

Horner, a coauthor on the research and curator of the Museum of the Rockies at MSU where the *Maiasaura* fossils are reposited, discovered and named *Maiasaura* in 1979. He made headlines by announcing the world's first discovery of fossil dinosaur embryos and eggs. Based on the immature development of the baby dinosaur fossils found in nests, Horner hypothesized that they were helpless upon hatching and had to be cared for by parents, so naming the dinosaur *Maiasaura*, Latin for "good mother lizard."

Studies that followed revealed aspects of *Maiasaura* biology including that they were social and nested in colonies; *Maiasaura* walked on two legs when young and shifted to walking on all four as they got bigger; their preferred foods included rotting wood; and that their environment was warm and semi-arid, with a long dry season prone to drought.

The tibiae included in the *Paleobiology* study came from a single bonebed in western Montana covering at least two square kilometers. More than 30 years of excavation and thousands of fossils later, the bonebed shows no signs of running dry. Woodward plans to lead annual summer excavations of the *Maiasaura* bonebed to collect more data.

"Our study kicks off The *Maiasaura* Life History Project, which seeks to learn as much as possible about *Maiasaura* and its environment 76 million years ago by continuing to collect and histologically examine fossils from the bonebed, adding statistical strength to the sample," she said.

"We plan to examine other skeletal elements to make a histological 'map' of *Maiasaura*, seeing if the different bones in its body grew at different rates, allowing us to study more aspects of its biology and behavior. We also want to better understand the environment in which *Maiasaura* lived, including the life histories of other animals in the ecosystem," she added.

The *Maiasaura* Life History Project will also provide opportunities for college-aged students accompanying Woodward in her excavations to learn about the fields of ecology, biology and geology, thereby encouraging younger generations to pursue careers in science.

James Farlow, professor emeritus of Geology at Purdue University, contributed to the *Paleobiology* paper.

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

Journal Reference: Holly N. Woodward, Elizabeth A. Freedman Fowler, James O. Farlow, John R. Horner. Maiasaura, a model organism for extinct vertebrate population biology: a large sample statistical assessment of growth dynamics and survivorship. *Paleobiology*, 2015; 1 DOI: 10.1017/pab.2015.19

125-million-year-old mammal fossil reveals the early evolution of hair and spines

Cretaceous mammal Spinolestes (life reconstruction) in its natural environment of the Las Hoyas wetland. Credit: Oscar Sanisidro

The discovery of a new 125-million-year-old fossil mammal in Spain has pushed back the earliest record of preserved mammalian hair structures and inner organs by more than 60 million years.

The specimen, named *Spinolestes xenarthrosus*, was fossilized with remarkably intact guard hairs, underfur, tiny hedgehog-like spines and even evidence of a fungal hair infection. The unusually well-preserved fossil also contains an external ear lobe, soft tissues of the liver, lung and diaphragm, and plate-like structures made of keratin known as dermal scutes. The microscopic structures of hair and spines in Spinolestes are the earliest-known examples in mammalian evolutionary history.

The findings are described by scientists from the Autonomous University of Madrid, University of Bonn and the University of Chicago in a study published in *Nature* on Oct. 15.

"Spinolestes is a spectacular find. It is stunning to see almost perfectly preserved skin and hair structures fossilized in microscopic detail in such an old fossil," said study co-author Zhe-Xi Luo, PhD, professor of organismal biology and anatomy at the University of Chicago. "This Cretaceous furball displays the entire structural diversity of modern mammalian skin and hairs."

The Las Hoyas Quarry in east-central Spain was once a lush wetland with a thriving diversity of life around 125 million years ago during the early Cretaceous period. Spanish paleontologists have studied the site since 1985 and found hundreds of fossils, including important birds and dinosaurs. In 2011, the first mammal fossil at the site was discovered by a team led by Angela D. Buscalioni, PhD, professor of paleontology at the Autonomous University of Madrid, who partnered with collaborators including Luo and Thomas Martin, PhD, professor of paleontology at the University of Bonn, to study the rare specimen.

Cretaceous furball

Spinolestes xenarthrosus lived in the Cretaceous period and belonged to an extinct lineage of early mammals known as triconodonts. The specimen measured roughly 24 cm in length and is estimated to have weighed around 50 to 70 grams, about the size of a modern-day juvenile rat. Its teeth and skeletal features indicate it was a ground-dweller that ate insects. Its soft tissues, with discernable microscopic structures, were preserved through a rare process known as phosphatic fossilization. Individual hair follicles and bulbs, as well as the composition of individual hair shafts, could be identified using an electron scanning microscope.

Spinolestes had remarkably modern mammalian hair and skin structures, such as compound follicles in which multiple hairs emerge from the same pore. It had small spines around a tenth of a millimeter in diameter on its back, similar to modern hedgehogs and African spiny mice, which appeared to be formed by the fusion of filaments at follicles during development. The team even found abnormally truncated hairs that are evidence of a fungal skin infection known as dermatophytosis, which is widely seen among living mammals.

"Hairs and hair-related integumentary structures are fundamental to the livelihood of mammals, and this fossil shows that an ancestral, long-extinct lineage had grown these structures in exactly the same way that modern mammals do," Luo said. "Spinolestes gives us a spectacular revelation about this central aspect of mammalian biology."

Spinolestes is also the first example of a Mesozoic mammal in which soft tissues in the thoracic and abdominal cavities are fossilized. The team noted microscopic bronchiole structures of the lung, as well as iron-rich residues associated with the liver. These areas were separated by a curved boundary that is thought to be a muscular diaphragm for respiration. This represents the earliest-known record of mammalian organ systems.

The fossil of Spinolestes contains a large external ear, the earliest-known example in the mammalian fossil record, as well as dermal scutes -- plate-like structures made of skin keratin. A more developed form of scutes can be seen in modern armadillos and pangolins.

Spinolestes had extra articulations between vertebrae, which strengthened its spinal column -- modern-day mammals such as armored shrews and armadillos possess similar articulations. The authors speculate that this might provide a clue as to the lifestyle of Spinolestes. Armored shrews, for example, use their exceptional vertebral strength to push apart logs or dead palm leaves to feed on insects within.

"With the complex structural features and variation identified in this fossil, we now have conclusive evidence that many fundamental mammalian characteristics were already well-established some 125 million years, in the age of dinosaurs," Luo said.

Story Source: The above post is reprinted from materials provided by University of Chicago Medical Center.

Journal Reference: Thomas Martin, Jesús Marugán-Lobón, Romain Vullo, Hugo Martín-Abad, Zhe-Xi Luo & Angela D. Buscalioni, 2015. A Cretaceous eutriconodont and integument evolution in early mammals, Nature 526, 380–384 (15 October 2015). DOI: 10.1038/nature14905.

Mound near lunar South Pole formed by unique volcanic process

A giant mound near the Moon's South Pole appears to be a volcanic structure unlike any other found on the lunar surface

The formation, known as Mafic Mound, stands about 800 meters tall and 75 kilometers across, smack in the middle of a giant impact crater known as the South Pole-Aitken Basin. This new study suggests that the mound is the result of a unique kind of volcanic activity set in motion by the colossal impact that formed the basin.

"If the scenarios that we lay out for its formation are correct, it could represent a totally new volcanic process that's never been seen before," said Daniel Moriarty, a Ph.D. student in Brown's Department of Earth, Environmental and Planetary Sciences and the study's lead author.

Mafic Mound (mafic is a term for rocks rich in minerals such as pyroxene and olivine) was first discovered in the 1990s by Carle Pieters, a planetary geologist at Brown and Moriarty's adviser. What makes it curious, other than its substantial size, is the fact that it has a different mineralogical composition than the surrounding rock. The mound is rich in high-calcium pyroxene, whereas the surrounding rock is low-calcium.

"This unusual structure at the very center of the basin begs the question: What is this thing, and might it be related to the basin formation process?" Moriarty said. To investigate that, Moriarty and Pieters looked at a rich suite of data from multiple lunar exploration missions. They used detailed mineralogical data from the Moon Mineralogy Mapper, which flew aboard India's Chandrayaan-1 spacecraft. NASA's Lunar Orbiter Laser Altimeter provided precise topographic data, and data from the GRAIL mission characterized gravitational anomalies in the region.

Those combined datasets suggested that Mafic Mound was created by one of two unique volcanic processes set in motion by the giant South Pole-Aitken impact. An impact of that size may have created a cauldron of melted rock as much as 50 kilometers deep, some researchers think. As that sheet of impact melt cooled and crystallized, it would have shrunk. As it did, still-molten material in the middle may have been squeezed out the top like toothpaste from a tube. Eventually, that erupted material may have formed the mound.

Such a process could explain the mound's strange mineralogy. Models of how the South Pole-Aitken melt sheet may have crystallized suggest that the erupting material should be rich in high-calcium pyroxene, consistent with the observed mineralogy of the mound.

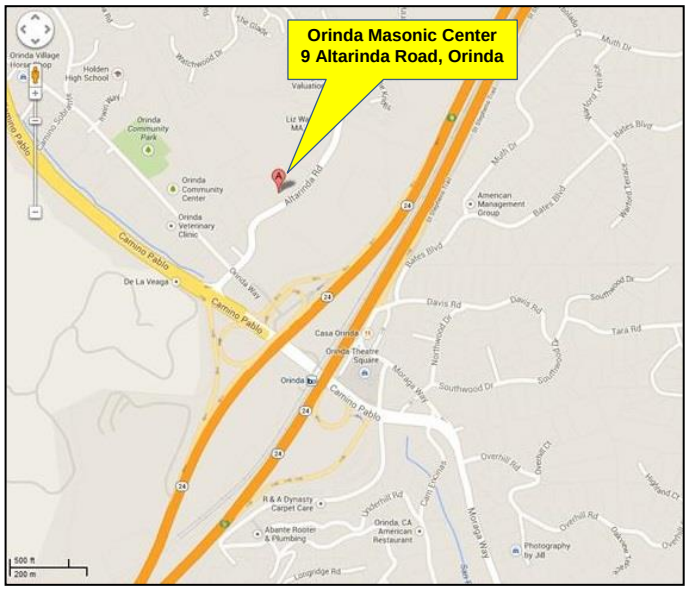
Another scenario that fits the data involves possible melting of the Moon's mantle shortly after the South Pole-Aitken impact. The impact would have blasted tons of rock out of the basin, creating a low-gravity region. The lower gravity condition could have enabled the center of the basin to rebound upward. Such upward movement would have caused partial melting of mantle material, which could have erupted to form the mound.

If either scenario is true, it would represent a unique process on lunar surface. Moriarty said a sample return mission to the South Pole Aitken Basin would be a great way to try to verify the results. "It's the largest confirmed impact structure in the solar system and has shaped many aspects of the evolution of the Moon," Moriarty said. "So a big topic in lunar science is studying this basin and the effects it had on the geology of the Moon through time."

A sample return mission to the basin could bring back bits of lunar mantle, the composition of which is still not fully understood. A returned sample could also put a firm date of the impact, which could be used as a standard to date other lunar features. A sample could also help shed light on a unique lunar volcanic process.

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

Journal Reference: Daniel P. Moriarty, Carle M. Pieters. The nature and origin of Mafic Mound in the South Pole-Aitken Basin. Geophysical Research Letters, 2015; DOI: 10.1002/2015GL065718



Speaker Biography (continued): Geology (2010) from San Jose State University and a B.A. in Mass Communications (1975) from the University of Minnesota. In-between earning these degrees, she worked ~30 years in high tech marketing and general management. Before entering the doctoral program at Stanford, Anne supported paleoseismic studies at the Earthquake Science Center of the U.S. Geological Survey, Menlo Park. She has been in the Kathmandu Valley, Nepal five times over the past three years as part of her doctoral research study, and was there with her team during the magnitude 7.8 earthquake of April 25, 2015.

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