NORTHERN CALIFORNIA GEOLOGICAL SOCIETY

MEETING ANNOUNCEMENT

DATE: June 24, 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. Will Schweller, NCGS President and Consultant**

Injected Sands – Mother Nature's Giant Frac Jobs?

Injected sands, also known as clastic injections, have been recognized in the geologic literature for well over a century, but have been largely ignored until the past two decades. Discovery of significant oil and gas reserves in injected sands in fields in the North Sea and West Africa, among other areas, sparked a renewed series of studies that has improved our understanding of these unusual features, but many significant questions remain unanswered.

Outcrops of injected sands found in widely separated localities display a wide variety of geometric forms and internal features. Some of the largest and best known examples occur along the California coast near Santa Cruz and inland along the western flank of the San Joaquin valley. The San Joaquin examples demonstrate how injected sand dikes can propagate hundreds of meters upsection, creating significant vertical hydraulic connections and hydrocarbon migration pathways where none previously existed. Other outcrop examples in central France and northern Tunisia show large-scale lateral injection and even downward propagation of injected sand dikes.

While fairly easy to recognize in outcrops, injected sands are much harder to identify in subsurface cores, borehole images, and wireline logs, and are generally too small or thin to see even in high-resolution 3D seismic data. Vertical wells rarely intersect near-vertical dikes, and clastic sills can closely resemble normal deposited sand layers even in cores. Key features in cores and borehole images can be used to improve the confidence in identifying clastic sills and dikes.

Predicting the amount, orientation and possible effects of injected sands in subsurface reservoirs remains a challenge even after they are recognized. In some cases, the improved vertical connectivity from injected sills enables reducing the number of wells to drain a reservoir, while in other cases the injected sand complexes can lead to misleading estimates of total reserves. Comparing limited subsurface data with detailed outcrop studies can help to model the possible geometries and predict the effects of what can be seen as enormous natural frac jobs. Insights from natural outcrops of injected sands can help to predict the character of man-made injected sands in industry frac jobs and wastewater disposal wells.

Continued on back…

NCGS 2014 – 2015 Calendar

September 30, 2015 7:00 pm
Dr. Gregory Beroza, Stanford University, Berkeley Seismological Laboratory - Lawson Lecture
Induced Earthquakes in the 21st Century

October 28, 2015 7:00 pm
Dr. Robert I. Davies, Merced College
Living Above the Fossil Zoo: 23 Million Years of Geologic History Under the Central Valley

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

July 25, 2015
The Geysers - Geothermal Energy
(See attached flyer)
Joe Beall ,Senior Geologist, Calpine Corporation, and **Craig Hartline**, Senior Geophysicist, Calpine Corporation

Fall 2015
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

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.

AGI Resource for Teachers

The following is an email from AGI received by the editor; it may be of use to some of our members.

Greetings,

I wanted to let you know about the American Geoscience Institute's (AGI) Critical Issues Program, a potential informational resource for use in your classroom lessons and/or lesson planning. AGI's Critical Issues Program provides introductory information on issues at the intersection of geoscience and society, including energy, climate, water, natural hazards, and mineral resources.

Our Critical Issues Website is an information hub and an excellent resource for the classroom. Users can start with our geoscience basics and primer pages, which offer quick summaries of topics such as drought, mining, renewable energy, and earthquakes. These introductory pages provide links to more detailed information in a variety of formats, from frequently asked questions, interactive maps, webinars, and case studies, to a database of in-depth research publications.

As you consider whether the information at the Critical Issues website is appropriate for use your students, you might also look at the "informational text" strategies prepared by AGI's Center for Geoscience and Society.

I invite you to explore the Critical Issues website at www.americangeosciences.org/critical-issues. If there are any student groups and organizations that you think would find the Critical Issues Program helpful, please feel free to forward this email on to them. If you have any questions or comments, please contact me (geofellow@agiweb.org) at your convenience.

Regards,
Charlotte Wood
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The American Geosciences Institute is a nonprofit federation of 50 geoscientific and professional associations that represents more than 250,000 geologists, geophysicists and other earth scientists. Founded in 1948, AGI provides information services to geoscientists, serves as a voice of shared interests in the profession, plays a major role in strengthening geoscience education, and strives to increase public awareness of the vital role the geosciences play in society's use of resources, resiliency to natural hazards, and interaction with the environment.

Some sections of the San Andreas Fault system in San Francisco Bay Area are locked, overdue

Four urban sections of the San Andreas Fault system in Northern California have stored enough energy to produce major earthquakes, according to a new study that measures fault creep. Three fault sections -- Hayward, Rodgers Creek and Green Valley -- are nearing or past their average recurrence interval, according to the study published in the *Bulletin of the Seismological Society of America* (*BSSA*).

The earthquake cycle reflects the accumulation of strain on a fault, its release as slip, and its re-accumulation and re-release. Fault creep is the slip and slow release of strain in the uppermost part of the Earth's crust that occurs on some faults between large earthquakes, when much greater stress is released in only seconds. Where no fault creep occurs, a fault is considered locked and stress will build until it is released by an earthquake.

San Andreas Fault.
Credit: © davetroesh123 / Fotolia

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This study estimates how much creep occurs on each section of the San Andreas Fault system in Northern California. Enough creep on a fault can diminish the potential size of its next earthquake rupture.

"The extent of fault creep, and therefore locking, controls the size and timing of large earthquakes on the Northern San Andreas Fault system," said James Lienkaemper, a co-author of the study and research geophysicist at U.S. Geological Survey (USGS). "The extent of creep on some fault sections is not yet well determined, making our first priority to study the urban sections of the San Andreas, which is directly beneath millions of Bay Area residents."

Understanding the amount and extent of fault creep directly impacts seismic hazard assessments for the region. The San Andreas Fault system in Northern California consists of five major branches that combine for a total length of approximately 1250 miles. Sixty percent of the fault system releases energy through fault creep, ranging from 0.1 to 25.1 mm (.004 to 1 inch) per year, and about 28 percent remains locked at depth, according to the authors.

Monitoring of creep on Bay Area faults has expanded in recent years. The alignment array measurements made by the San Francisco State University Creep Project and recently expanded GPS station networks provide the primary data on surface creep, which the authors used to estimate the average depth of creep for each fault segment. Where available, details of past ruptures of individual faults, unearthed in previous paleoseismic studies, allowed the authors to calculate recurrence rates and the probable timing and size of future earthquakes.

According to the study, four faults have accumulated sufficient strain to produce a major earthquake. Three creeping faults have large locked areas (less than 1 mm or .04 inches of creep per year) that have not ruptured in a major earthquake of at least magnitude 6.7 since the reporting of earthquakes by local inhabitants: Rodgers Creek, northern Calaveras and southern Green Valley. The southern Hayward fault, which produced a magnitude 6.8 earthquake in 1868, is now approaching its mean recurrence time based on paleoseismic studies.

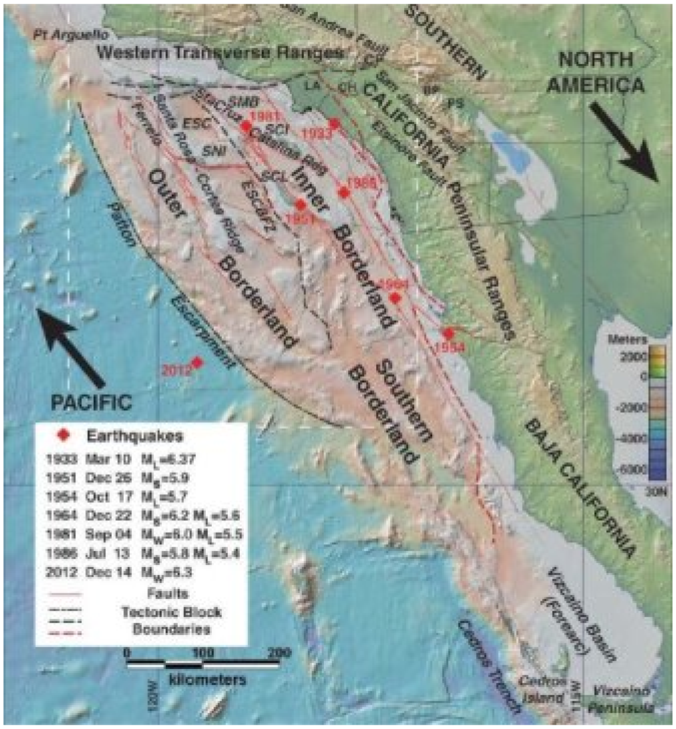
The authors also estimate three faults appear to be nearing or have exceeded their mean recurrence time and have accumulated sufficient strain to produce large earthquakes: the Hayward (M 6.8), Rodgers Creek (M 7.1) and Green Valley (M 7.1).

"The San Andreas Fault and its two other large branches, the Hayward and Northern Calaveras, have been quiet for decades. This study offers a good reminder to prepare today for the next major earthquake," said Lienkaemper.

Story Source: The above story is based on materials provided by Seismological Society of America and ScienceDaily October 13, 2014

Journal Reference: James Lienkaemper, Robert W. Simpson, Forrest S. McFarland and S. John Caskey. **Using Surface Creep Rate to Infer Fraction Locked for Sections of the San Andreas Fault System in Northern California from Alignment Array and GPS Data**. *BSSA*, 2014

Little-known quake, tsunami hazards lurk offshore of Southern California



This map shows the California Borderland and its major tectonic features, as well as the locations of earthquakes greater than Magnitude 5.5. The dashed box shows the area of the new study. Large arrows show relative plate motion for the Pacific-North America fault boundary. The abbreviations stand for the following: BP = Banning Pass, CH = Chino Hills, CP = Cajon Pass, LA = Los Angeles, PS = Palm Springs, V = Ventura; ESC = Santa Cruz Basin; ESCBZ = East Santa Cruz Basin Fault Zone; SCI = Santa Catalina Island; SCL = San Clemente Island; SMB = Santa Monica Basin; SNI = San Nicolas Island. Credit: Mark Legg

While their attention may be inland on the San Andreas Fault, residents of coastal Southern California could be surprised by very large earthquakes -- and even tsunamis -- from several major faults that lie offshore, a new study finds.

The latest research into the little known, fault-riddled, undersea landscape off of Southern California and northern Baja California has revealed more worrisome details about a tectonic train wreck in the Earth's crust with the potential for magnitude 7.9 to 8.0 earthquakes. The new study supports the likelihood that these vertical fault zones have displaced the seafloor in the past, which means they could send out tsunami-generating pulses towards the nearby coastal mega-city of Los Angeles and neighboring San Diego.

"We're dealing with continental collision," said geologist Mark Legg of Legg Geophysical in Huntington Beach, California, regarding the cause of the offshore danger. "That's fundamental. That's why we have this mess of a complicated logjam."

Legg is the lead author of the new analysis accepted for publication in the Journal of Geophysical Research: Earth Surface, a journal of the American Geophysical Union. He is also one of a handful of geologists who have been trying for decades to piece together the complicated picture of what lies beyond Southern California's famous beaches.

The logjam Legg referred to is composed of blocks of the Earth's crust caught in the ongoing tectonic battle between the North American tectonic plate and the Pacific plate. The blocks are wedged together all the way from the San Andreas Fault on the east, to the edge of the continental shelf on the west, from 150 to 200 kilometers (90 to 125 miles) offshore. These chunks of crust get squeezed and rotated as the Pacific plate slides northwest, away from California, relative to the North American plate. The mostly underwater part of this region is called the California Continental Borderland, and includes the Channel Islands.

By combining older seafloor data and digital seismic data from earthquakes along with 4,500 kilometers (2,796 miles) of new seafloor depth measurements, or bathymetry, collected in 2010, Legg and his colleagues were able to take a closer look at the structure of two of the larger seafloor faults in the Borderland: the Santa Cruz-Catalina Ridge Fault and the Ferrelo Fault. What they were searching for are signs, like those seen along the San Andreas, that indicate how much the faults have slipped over time and whether some of that slippage caused some of the seafloor to thrust upwards.

What they found along the Santa Cruz-Catalina Ridge Fault are ridges, valleys and other clear signs that the fragmented, blocky crust has been lifted upward, while also slipping sideways like the plates along the San Andreas Fault do. Further out to sea, the Ferrelo Fault zone showed thrust faulting -- which is an upwards movement of one side of the fault. The vertical movement means that blocks of crust are being compressed as well as sliding horizontally relative to each other-what Legg describes as "transpression."

Compression comes from the blocks of the Borderland being dragged northwest, but then slamming into the roots of the Transverse Ranges -- which are east-west running mountains north and west of Los Angeles. In fact, the logjam has helped build the Transverse Ranges, Legg explained.

"The Transverse Ranges rose quickly, like a mini Himalaya," Legg said.

The real Himalaya arose from a tectonic-plate collision in which the crumpled crust on both sides piled up into fast-growing, steep mountains rather than getting pushed down into Earth's mantle as happens at some plate boundaries.

As Southern California's pile-up continues, the plate movements that build up seismic stress on the San

Andreas are also putting stress on the long Santa Cruz-Catalina Ridge and Ferrelo Faults. And there is no reason to believe that those faults and others in the Borderlands can't rupture in the same manner as the San Andreas, said Legg.

"Such large faults could even have the potential of a magnitude 8 quake," said geologist Christopher Sorlien of the University of California at Santa Barbara, who is not a co-author on the new paper.

"This continental shelf off California is not like other continental shelves -- like in the Eastern U.S.," said Sorlien.

Whereas most continental shelves are about twice as wide and inactive, like that off the U.S. Atlantic coast, the California continental shelf is very narrow and is dominated by active faults and tectonics. In fact, it's unlike most continental shelves in the world, he said. It's also one of the least well mapped and understood. "It's essentially terra incognita."

"This is one of the only parts of the continental shelf of the 48 contiguous states that didn't have complete ... high-resolution bathymetry years ago," Sorlien said.

And that's why getting a better handle on the hazards posed by the Borderland's undersea faults has been long in coming and slow to catch on, even among earth scientists, he said.

NOAA was working on complete high-resolution bathymetry of the U.S. Exclusive Economic Zone -- the waters within 200 miles of shore -- until the budget was cut, said Legg. That left out Southern California and left researchers like himself using whatever bits and pieces of smaller surveys to assemble a picture of what's going on in the Borderland, he explained.

"We've got high resolution maps of the surface of Mars," Legg said, "yet we still don't have decent bathymetry for our own backyard."

Story Source: The above story is based on materials provided by American Geophysical Union and ScienceDaily May 29, 2015.

Journal Reference: Mark Legg, Monica D. Kohler, Natsumi Shintaku, Dayanthie Weeraratne. **High-resolution mapping of two large-scale transpressional fault zones in the California Continental Borderland: Santa Cruz-Catalina Ridge and Ferrelo faults**. Journal of Geophysical Research: Earth Surface, 2015; DOI: 10.1002/2014JF003322

World's oldest stone tools challenge ideas about first toolmakers

Scientists working in the desert badlands of northwestern Kenya have found stone tools dating back 3.3 million years, long before the advent of modern humans, and by far the oldest such artifacts yet discovered. The tools, whose makers may or may not have been some sort of human ancestor, push the known date of such tools back by 700,000 years; they also may challenge the notion that our own most direct ancestors were the first to bang two rocks together to create a new technology.

The discovery is the first evidence that an even earlier group of proto-humans may have had the thinking abilities needed to figure out how to make sharp-edged tools. The stone tools mark "a new beginning to the known archaeological record," say the authors of a new paper about the discovery, published today in the leading scientific journal *Nature*.

Sammy Lokorodi, a resident of Kenya's northwestern desert who works as a fossil and artifact hunter, led the way to a trove of 3.3 million-year-old tools.
Credit: West Turkana Archaeological Project

"The whole site's surprising, it just rewrites the book on a lot of things that we thought were true," said geologist Chris Lepre of the Lamont-Doherty Earth Observatory and Rutgers University, a co-author of the paper who precisely dated the artifacts.

The tools "shed light on an unexpected and previously unknown period of hominin behavior and can tell us a lot about cognitive development in our ancestors that we can't understand from fossils alone," said lead author Sonia Harmand, of the Turkana Basin Institute at Stony Brook University and the Universite Paris Ouest Nanterre.

Hominins are a group of species that includes modern humans, *Homo sapiens*, and our closest evolutionary ancestors. Anthropologists long thought that our relatives in the genus *Homo* -- the line leading directly to *Homo sapiens* -- were the first to craft such stone tools. But researchers have been uncovering tantalizing clues that some other, earlier species of hominin, distant cousins, if you will, might have figured it out.

The researchers do not know who made these oldest of tools. But earlier finds suggest a possible answer: The skull of a 3.3-million-year-old hominin, *Kenyanthropus platytops*, was found in 1999 about a kilometer from the tool site. A *K. platyops* tooth and a bone from a skull were discovered a few hundred meters away, and an as-yet unidentified tooth has been found about 100 meters away.

The precise family tree of modern humans is contentious, and so far, no one knows exactly how *K. platyops* relates to other hominin species. *Kenyanthropus* predates the earliest known *Homo* species by a half a million years. This species could have made the tools; or, the toolmaker could have been some other species from the same era, such as *Australopithecus afarensis*, or an as-yet undiscovered early type of *Homo*.

Lepre said a layer of volcanic ash below the tool site set a "floor" on the site's age: It matched ash elsewhere that had been dated to about 3.3 million years ago, based on the ratio of argon isotopes in the material. To more sharply define the time period of the tools, Lepre and co-author and Lamont-Doherty colleague Dennis Kent examined magnetic minerals beneath, around and above the spots where the tools were found.

The Earth's magnetic field periodically reverses itself, and the chronology of those changes is well documented going back millions of years. "We essentially have a magnetic tape recorder that records the magnetic field ... the music of the outer core," Kent said. By tracing the variations in the polarity of the samples, they dated the site to 3.33 million to 3.11 million years.

Lepre's wife and another co-author, Rhoda Quinn of Rutgers, studied carbon isotopes in the soil, which along with animal fossils at the site allowed researchers to reconstruct the area's vegetation. This led to another surprise: The area was at that time a partially wooded, shrubby environment. Conventional thinking has been that sophisticated tool-making came in response to a change in climate that led to the spread of broad savannah grasslands, and the consequent evolution of large groups of animals that could serve as a source of food for human ancestors.

One line of thinking is that hominins started knapping -- banging one rock against another to make sharp-edged stones -- so they could cut meat off of animal carcasses, said paper co-author Jason Lewis of the Turkana Basin Institute and Rutgers. But the size and markings of the newly discovered tools "suggest they were doing something different as well, especially if they were in a more wooded environment with access to various plant resources," Lewis said. The researchers think the tools could have been used for breaking open nuts or tubers, bashing open dead logs to get at insects inside, or maybe something not yet thought of.

"The capabilities of our ancestors and the environmental forces leading to early stone technology are a great scientific mystery," said Richard Potts, director of the Human Origins Program at the Smithsonian's National Museum of Natural History, who was not involved in the research. The newly dated tools "begin to lift the veil on that mystery, at an earlier time than expected," he said.

Potts said he had examined the stone tools during a visit to Kenya in February.

"Researchers have thought there must be some way of flaking stone that preceded the simplest tools known until now," he said. "Harmand's team shows us just what this even simpler altering of rocks looked like before technology became a fundamental part of early human behavior."

Ancient stone artifacts from East Africa were first uncovered at Olduvai Gorge in Tanzania in the mid-20th century, and those tools were later associated with fossil discoveries in the 1960s of the early human ancestor Homo habilis. That species has been dated to 2.1 million to 1.5 million years ago.

Subsequent finds have pushed back the dates of humans' evolutionary ancestors, and of stone tools, raising questions about who first made that cognitive leap. The discovery of a partial lower jaw in the Afar region of Ethiopia, announced on March 4, pushes the fossil record for the genus Homo to 2.8 million years ago. Evidence from recent papers, the authors note, suggests that there is anatomical evidence that *Homo* had evolved into several distinct lines by 2 million years ago.

There is some evidence of more primitive tool use going back even before the new find. In 2009, researchers at Dikika, Ethiopia, dug up 3.39 million-year-old animal bones marked with slashes and other cut marks, evidence that someone used stones to trim flesh from bone and perhaps crush bones to get at the marrow inside. That is the earliest evidence of meat and marrow consumption by hominins. No tools were found at the site, so it's unclear whether the marks were made with crafted tools or simply sharp-edged stones. The only hominin fossil remains in the area dating to that time are from *Australopithecus afarensis*.

The new find came about almost by accident: Harmand and Lewis said that on the morning of July 9, 2011, they had wandered off on the wrong path, and climbed a hill to scout a fresh route back to their intended track. They wrote that they "could feel that something was special about this particular place." They fanned out and surveyed a nearby patch of craggy outcrops. "By teatime," they wrote, "local Turkana tribesman Sammy Lokorodi had helped [us] spot what [we] had come searching for."

By the end of the 2012 field season, excavations at the site, named Lomekwi 3, had uncovered 149 stone artifacts tied to tool-making, from stone cores and flakes to rocks used for hammering and others possibly used as anvils to strike on.

The researchers tried knapping stones themselves to better understand how the tools they found might have been made. They concluded that the techniques used "could represent a technological stage between a hypothetical pounding-oriented stone tool use by an earlier hominin and the flaking-oriented knapping behavior of [later] toolmakers." Chimpanzees and other primates are known to use a stone to hammer open nuts atop another stone. But using a stone for multiple purposes, and using one to crack apart another into a sharper tool, is more advanced behavior.

The find also has implications for understanding the evolution of the human brain. The toolmaking required a level of hand motor control that suggests that changes in the brain and spinal tract needed for such activity could have occurred before 3.3 million years ago, the authors said.

"This is a momentous and well-researched discovery," said paleoanthropologist Bernard Wood of George Washington University, who was not involved in the study. "I have seen some of these artifacts in the flesh, and I am convinced they were fashioned deliberately." Wood said he found it intriguing to see how different the tools are from so-called Oldowan stone tools, which up to now have been considered the oldest and most primitive.

Lepre, who has been conducting fieldwork in eastern Africa for about 15 years, said he arrived at the dig site about a week after the discovery. The site is several hours' drive on rough roads from the nearest town, located in a hot, dry landscape he said is reminiscent of Arizona and New Mexico. Lepre collected chunks of sediment from a series of depths and brought them back to Lamont-Doherty for analysis. He and Kent used a bandsaw to trim the samples into sugar cube-size blocks and inserted them into a magnetometer, which measured the polarity of tiny grains of the minerals hematite and magnetite contained in the sediment.

"The magnetics pretty much clinches that the age is something like 3.3 million years old," said Kent, who also is a professor at Rutgers.

Earlier dating work by Lepre and Kent helped lead to another landmark paper in 2011: a study that suggested Homo erectus, another precursor to modern humans, was using more advanced tool-making methods 1.8 million years ago, at least 300,000 years earlier than previously thought.

"I realized when you [figure out] these things, you don't solve anything, you just open up new questions," said Lepre. "I get excited, then realize there's a lot more work to do."

Story Source: The above story is based on materials provided by The Earth Institute at Columbia University and ScienceDaily May 20, 2015.

Journal Reference: Sonia Harmand, Jason E. Lewis, Craig S. Feibel, Christopher J. Lepre, Sandrine Prat, Arnaud Lenoble, Xavier Boës, Rhonda L. Quinn, Michel Brenet, Adrian Arroyo, Nicholas Taylor, Sophie Clément, Guillaume Daver, Jean-Philip Brugal, Louise Leakey, Richard A. Mortlock, James D. Wright, Sammy Lokorodi, Christopher Kirwa, Dennis V. Kent, Hélène Roche. **3.3-million-year-old stone tools from Lomekwi 3, West Turkana, Kenya**. *Nature*, 2015; 521 (7552): 310 DOI: 10.1038/nature14464

Common mechanism for shallow and deep earthquakes proposed

Earthquakes are labeled "shallow" if they occur at less than 50 kilometers depth. They are labeled "deep" if they occur at 300-700 kilometers depth. When slippage occurs during these earthquakes, the faults weaken. How this fault weakening takes place is central to understanding earthquake sliding.

A new study published online in *Nature Geoscience* today by a research team led by University of California, Riverside geologists now reports that a universal sliding mechanism operates for earthquakes of all depths -- from the deep ones all the way up to the crustal ones.

"Although shallow earthquakes -- the kind that threaten California -- must initiate differently from the very deep ones, our new work shows that, once started, they both slide by the same physics," said deep-earthquake expert Harry W. Green II, a distinguished professor of the Graduate Division in UC Riverside's Department of Earth Sciences, who led the research project. "Our research paper presents a new, unifying model of how earthquakes work. Our results provide a more accurate understanding of what happens during earthquake sliding that can lead to better computer models and could lead to better predictions of seismic shaking danger."

The physics of the sliding is the self-lubrication of the earthquake fault by flow of a new material consisting of tiny new crystals, the study reports. Both shallow earthquakes and deep ones involve phase transformations of rocks that produce tiny crystals of new phases on which sliding occurs.

"Other researchers have suggested that fluids are present in the fault zones or generated there," Green said. "Our study shows fluids are not necessary for fault weakening. As earthquakes get started, local extreme heating takes place in the fault zone. The result of that heating in shallow earthquakes is to initiate reactions like the ones that take place in deep earthquakes so they both end up lubricated in the same way."

Green explained that at 300-700 kilometers depth, the pressure and temperature are so high that rocks in this deep interior of the planet cannot break by the brittle processes seen on Earth's surface. In the case of shallow earthquakes, stresses on the fault increase slowly in response to slow movement of tectonic plates, with sliding beginning when these stresses exceed static friction. While deep earthquakes also get started in response to increasing stresses, the rocks there flow rather than break, except under special conditions.

"Those special conditions of temperature and pressure induce minerals in the rock to break down to other minerals, and in the process of this phase transformation a fault can form and suddenly move, radiating the shaking -- just like at shallow depths," Green said.

The research explains why large faults like the San Andreas Fault in California do not have a heat-flow anomaly around them. Were shallow earthquakes to slide by the grinding and crunching of rock, as geologists once imagined, the process would generate enough heat so that major faults like the San Andreas would be a little warmer along their length than they would be otherwise.

"But such a predicted warm region along such faults has never been found," Green said. "The logical conclusion is that the fault must move more easily than we thought. Extreme heating in a very thin zone along the fault produces the very weak lubricant. The volume of material that is heated is very small and survives for a very short time -- seconds, perhaps -- followed by very little heat generation during sliding because the lubricant is very weak."

The new research also explains why faults with glass on them (reflecting the fact that during the earthquake the fault zone melted) are rare. As shallow earthquakes start, the temperature rises locally until it is hot enough to start a chemical reaction -- usually the breakdown of clays or carbonates or other hydrous phases in the fault zone. The reactions that break down the clays or carbonates stop the temperature from climbing higher, with heat being used up in the reactions that produce the nanocrystalline lubricant.

If the fault zone does not have hydrous phases or carbonates, the sudden heating that begins when sliding starts raises the local temperature on the fault all the way to the melting temperature of the rock. In such cases, the melt behaves like a lubricant and the sliding surface ends up covered with melt (that would quench to a glass) instead of the nanocrystalline lubricant.

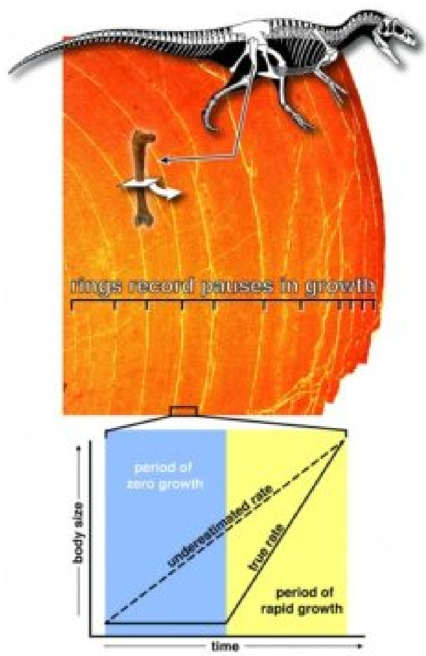
"The reason this does not happen often, that is, the reason we do not see lots of faults with glass on them, is that the Earth's crust is made up to a large degree of hydrous and carbonate phases, and even the rocks that don't have such phases usually have feldspars that get crushed up in the fault zone," Green explained. "The feldspars will 'rot' to clays during the hundred years or so between earthquakes as water moves along the fault zone. In that case, when the next earthquake comes, the fault zone is ready with clays and other phases that can break down, and the process repeats itself."

The research involved the study of laboratory earthquakes -- high-pressure earthquakes as well as high-speed ones -- using electron microscopy in friction and faulting experiments. It was Green's laboratory that first conducted a serendipitous series of experiments, in 1989, on the right kind of mantle rocks that give geologists insight into how deep earthquakes work. In the new work, Green and his team also investigated the Punchbowl Fault, an ancestral branch of the San Andreas Fault that has been exhumed by erosion from several kilometers depth, and found nanometric materials within the fault -- as predicted by their model.

Story Source: The above story is based on materials provided by University of California - Riverside. The original article was written by Iqbal Pittalwala and ScienceDaily May 18, 2015

Journal Reference: H. W. Green Ii, F. Shi, K. Bozhilov, G. Xia & Z. Reches. **Phase transformation and nanometric flow cause extreme weakening during fault slip**. *Nature Geoscience*, 2015 DOI: 10.1038/ngeo2436

Dinosaurs were likely warm-blooded



A microscopic image of the thigh bone (femur) of a dinosaur shows concentric rings. Like tree rings, they formed each year in the dinosaur's bones during the season when resources were scarce. The rings represent unrecorded time, so an annual growth rate (dashed line in graph) is an underestimate relative to the true growth rate during the favorable growing season. Credit: Scott Hartman

Dinosaurs grew as fast as your average living mammal, according to a research paper published by Stony Brook University paleontologist Michael D'Emic, PhD. The paper, to published in *Science* on May 29, is a re-analysis of a widely publicized 2014 *Science* paper on dinosaur metabolism and growth that concluded dinosaurs were neither ectothermic nor endothermic -- terms popularly simplified as 'cold-blooded' and 'warm-blooded' -- but instead occupied an intermediate category.

"The study that I re-analyzed was remarkable for its breadth -- the authors compiled an unprecedented dataset on growth and metabolism from studies of hundreds of living animals," said Dr. D'Emic, a Research Instructor in the Department of Anatomical Sciences as Stony Brook, when referring to "Evidence for mesothermy in dinosaurs."

"Upon re-analysis, it was apparent that dinosaurs weren't just somewhat like living mammals in their physiology -- they fit right within our understanding of what it means to be a 'warm-blooded' mammal," he said.

Dr. D'Emic specializes in bone microanatomy, or the study of the structure of bone on scales that are just a fraction of the width of a human hair. Based on his knowledge of how dinosaurs grew, Dr. D'Emic re-analyzed that study, which led him to the strikingly different conclusion that dinosaurs were more like mammals than reptiles in their growth and metabolism.

Dr. D'Emic re-analyzed the study from two aspects. First, the original study had scaled yearly growth rates to daily ones in order to standardize comparisons.

"This is problematic," Dr. D'Emic explains, "because many animals do not grow continuously throughout the year, generally slowing or pausing growth during colder, drier, or otherwise more stressful seasons.

"Therefore, the previous study underestimated dinosaur growth rates by failing to account for their uneven growth. Like most animals, dinosaurs slowed or paused their growth annually, as shown by rings in their bones analogous to tree rings," he explained.

He added that the growth rates were especially underestimated for larger animals and animals that live in very stressful or seasonal environments -- both of which characterize dinosaurs.

The second aspect of the re-analysis with the original study takes into account that dinosaurs should be statistically analyzed within the same group as living birds, which are also warm-blooded, because birds are descendants of Mesozoic dinosaurs.

"Separating what we commonly think of as 'dinosaurs' from birds in a statistical analysis is generally inappropriate, because birds are dinosaurs -- they're just the dinosaurs that haven't gone extinct."

He explained that re-analyzing the data with birds as dinosaurs lends more support that dinosaurs were 'warm-blooded,' not occupants of a special, intermediate metabolic category.

According to Holly Woodward, Assistant Professor in the Center for Health Sciences at Oklahoma State University, Dr. D'Emic's re-analysis is crucial to building research on the metabolism and development of dinosaurs.

"D'Emic's study reveals how important access to the data behind published results is for hypothesis testing and advancing our understanding of dinosaur growth dynamics," said Woodward.

Dr. D'Emic hopes that his study will also spur new research into when, why, and how pauses or slowdowns in growth are recorded in bones, which may have implications in the development of other species and in the study of bone diseases such as osteoporosis.

Video:
https://www.youtube.com/watch?v=tmG1wyQ1h6g&feature=youtu.be

Story Source: The above story is based on materials provided by Stony Brook University and ScienceDaily May 28, 2015

Journal References:

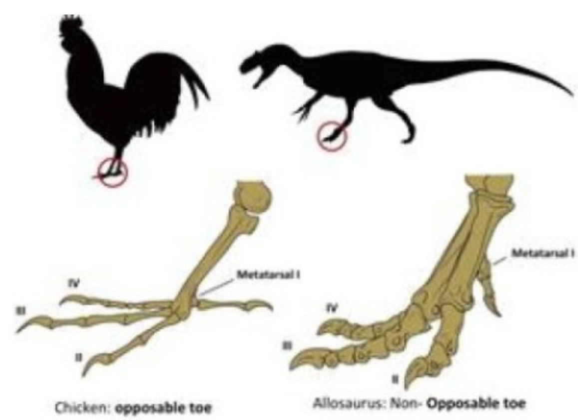
1. M. D. D'Emic. **Comment on "Evidence for mesothermy in dinosaurs"**. *Science*, 2015 DOI: 10.1126/science.1260061
2. J. M. Grady, B. J. Enquist, E. Dettweiler-Robinson, N. A. Wright, F. A. Smith. **Evidence for mesothermy in dinosaurs**. *Science*, 2014; 344 (6189): 1268 DOI: 10.1126/science.1253143

From chicken to dinosaur: Scientists experimentally 'reverse evolution' of perching toe

A unique adaptation in the foot of birds is the presence of a thumb-like opposable toe, which allows them to grasp and perch. However, in their dinosaur ancestors, this toe was small and non- opposable, and did not even touch the ground, resembling the dewclaws of dogs and cats. Remarkably, the embryonic development of birds provides a parallel of this evolutionary history: The toe starts out like their dinosaur ancestors, but then its base (the metatarsal) becomes twisted, making it opposable. Brazilian researcher Joâo Botelho, working at the lab of Alexander Vargas at the University of Chile, decided to study the underlying mechanisms. Botelho observed that the twisting occurred shortly after the embryonic musculature of this toe was in place.

"This is one of the clearest examples of how indirect the morphological consequences of genetic change are mediated," Gunter Wagner, evolutionary geneticist and professor at Yale.

Bird embryos move a lot inside the egg during development, and the onset of movement at this toe coincided with the twisting of its base. Botelho also demonstrated that in this toe, genes of cartilage maturation were expressed at a much later stage than other digits: It retains many rapidly dividing stem cells for a much longer period. Such immature cartilage is highly plastic and easily transformed by muscular activity.



The perching toe from chicken to dinosaur. Credit: Image courtesy of Universidad de Chile

These observations suggested the toe is twisted as a result of mechanical forces imposed on it by the embryonic musculature. Definitive proof, however, would come evolution of the perching toe cannot be understood without the forces of embryonic muscular activity. The study is described as "true developmental mechanics" by Gunter Wagner, an evolutionary geneticist and professor at Yale. "This is one of the clearest examples of how indirect the morphological consequences of genetic change are mediated. The experiments prove that interactions about organ systems channel the directions of organismal evolution."

Story Source: The above story is based on materials provided by Universidad de Chile and ScienceDaily May 22, 2015.

Journal Reference: João Francisco Botelho, Daniel Smith-Paredes, Sergio Soto-Acuña, Jorge Mpodozis, Verónica Palma, Alexander O. Vargas. **Skeletal plasticity in response to embryonic muscular activity underlies the development and evolution of the perching digit of birds**. *Scientific Reports*, 2015; 5: 9840 DOI: 10.1038/srep09840

from experiments. When Botelho applied Decamethonium bromide, a pharmacological agent capable of paralyzing embryonic musculature, the result was a non-opposable toe with a straight, non-twisted base identical to that of their dinosaur ancestors. Only a few experiments are known to recover dinosaur traits in birds (such as a dinosaur-like shank and tooth-like structures). The undoing of the perching digit is thus an important new addition, and the results have now been published in Scientific Reports, an open-access journal of the Nature Publishing Group.

The significance of this experiment, however, goes beyond the fact that a dinosaur-like toe is being retrieved. Evolutionary research often centers on mutations, but the development and

As carbon emissions climb, so too has Earth's capacity to remove CO2 from atmosphere

A new paper, co-authored by Woods Hole Research Center Senior Scientist Richard A. Houghton, entitled, "Audit of the global carbon budget: estimate errors and their impact on uptake uncertainty," was published in the journal *Biogeosciences*. The paper confirms that as carbon emissions continue to climb, so too has Earth's capacity to absorb carbon dioxide from the atmosphere. About half of the emissions of CO_2 each year remain in the atmosphere; the other half is taken up by the ecosystems on land and the oceans.

For Dr. Houghton, "There is no question that land and oceans have, for at least the last five and half decades, been taking up about half of the carbon emitted each year. The outstanding question is, Why? Most of the processes responsible for that uptake would be expected to slow down as Earth warms, but we haven't seen it yet. Since the emissions today are three times higher than they were in the 1960s, this increased uptake by land and ocean is not only surprising; it's good news. Without it, the concentration of CO_2 in the atmosphere would be twice what it is, and climate change would be much farther along. But, there's no guarantee that it will continue."

For at least the last five and half decades, land and oceans have been taking up about half of the carbon emitted each year. The outstanding question is, Why?
Credit: © James Thew / Fotolia

Since 1956, when the monitoring of atmospheric CO_2 concentrations began at Mauna Loa Observatory (MLO), many more stations have been added to measure the amount of carbon in the atmosphere and how it varies seasonally and geographically. The measurements provide the ability to detect changes in the behavior of the global carbon cycle. This paper outlines a new framework for assessing errors and their impact on the uncertainties associated with calculating carbon sinks on land and in oceans.

Dr. Houghton and colleagues conclude that the greater certainty in atmospheric carbon measurements has led to an increased certainty in the calculated rate of carbon uptake by land and oceans. The scientists are confident that the rates have so far increased in proportion to emissions. Monitoring that uptake year by year is critical for understanding the carbon cycle and for knowing how to deal with it.

Story Source: The above story is based on materials provided by Woods Hole Research Center and ScienceDaily May 14, 2015

Journal Reference: A. P. Ballantyne, R. Andres, R. Houghton, B. D. Stocker, R. Wanninkhof, W. Anderegg, L. A. Cooper, M. DeGrandpre, P. P. Tans, J. B. Miller, C. Alden, J. W. C. White. **Audit of the global carbon budget: estimate errors and their impact on uptake uncertainty**. *Biogeosciences*, 2015; 12 (8): 2565 DOI: 10.5194/bg-12-2565-2015

NORTHERN CALIFORNIA GEOLOGICAL SOCIETY

"GEYSERS – GEOTHERMAL ENERGY"

NCGS FIELD TRIP - Saturday July 25, 2015

Field Trip Leaders:
Joe Beall, Sr. Geologist, Calpine Corporation
Craig Hartline, Sr. Geophysicist, Calpine Corporation

Field Trip Director: Dan Day

THIS FIELD TRIP WILL BE LIMITED TO 29 PEOPLE ON A FIRST COME-FIRST SERVED BASIS.

** **Field Trip Logistics in preparation** ********************************

Time & Meeting Place: July 25, 2015, **8:30 AM at the Calpine Visitor Center Parking Lot**

Calpine Geothermal Visitor Center
15500 Central Park Road
Middletown, California 95461

Cost: $20/person, which includes morning coffee, muffins, lunch, and refreshments.

If possible please RSVP by June 26th. The Calpine staff needs time to process people's information, so please fill out all the fields below including your home address

No geologic hammers are allowed!
No more plastic water bottles will be provided on Field Trips! Please bring your personal water bottle.

Please carpool/vanpool and share the ride and cost. We will circulate an attendees spreadsheet for carpooling to the meeting place (Calpine Geysers Visitor Center).

***************************REGISTRATION FORM (Geyser Field Trip)** **********************

Name:________________________________ E-mail:______________________________________

Home address (Street, City, Zip Code)____

____

Carpool origin Residence:__________________________________ Phone: ________________

Phone (alternate):_____________________

Check No./amount ____________________

Please indicate if you will drive a car and the # of people you will take:

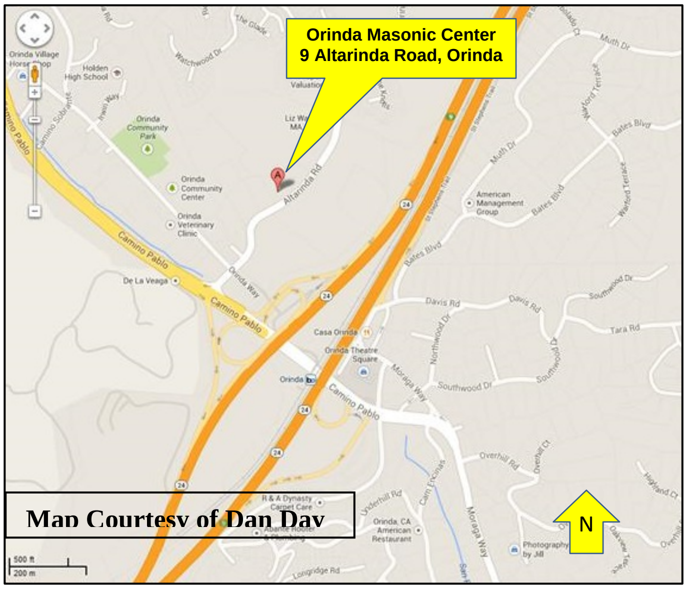
Lunch: Regular:________ Vegetarian: __________ (Please check one)

Please mail registration with a check payable to NCGS to: **Dan Day, 9 Bramblewood Court, Danville, CA 94506**; Any questions e-mail: danday94@pacbell.net or phone: 510-507-0013.

Our Geysers Geothermal Field Trip leaders:

Joe Beall, Sr. Geologist for Calpine, has a PhD in Geology and numerous publications to his credit. From Assistant Professor of Earth Science, he has gone on to conduct exploration programs, from reconnaissance through deep test drilling and evaluation. His most recent efforts have centered on conversion of production wells to injection in order to provide pressure support to The Geysers steam recovery.

Craig Hartline, Sr. Geophysicist for Calpine, holds a Master of Science degree in Geophysics from the University of Akron. After nearly 20 years in seismic research and design, his role at Calpine includes reservoir analysis, seismicity (analysis and outreach), 3D model building, and visualization.
Phone: (925) 451-1999



Biography: Dr. Will Schweller's interest in geology started when he was about 6 years old, collecting rocks and fossils in northwest Pennsylvania. He eventually completed a BS in geology at Penn State University, then switched sides of the country to do a MS in marine geology at Oregon State University working on turbidites in the Peru-Chile trench. He then returned to the East coast to do his PhD at Cornell, studying sediments that overlie the Zambales ophiolite, one of the world's largest ophiolites on the island of Luzon in the Philippines.

Following his long tenure as a graduate student, Will joined Gulf Oil Company's research division in Pittsburgh, Pennsylvania in 1981. Gulf was engulfed by Chevron and Will moved to Chevron's research division in southern California in 1985, and then to the San Ramon location in 1999. During his 28 years with Gulf and Chevron, Will worked on a variety of sedimentary systems but was primarily focused on deep-water sediments and borehole images as well as teaching in classrooms and in the field. He is co-inventor on two patents that define uses of borehole images for building reservoir models.

He retired from Chevron in 2009 and has continued to do consulting and teaching for the oil and gas industry. He was elected president of NCGS in 2014.

Northern California Geological Society
c/o Mark Detterman
3197 Cromwell Place
Hayward, CA 94542-1209

Would you like to receive the NCGS newsletter by e-mail? If you are not already doing so, and would like to, please contact Ton Barry at **tomasbarry@aol.com** to sign up for this free service.