NORTHERN CALIFORNIA GEOLOGICAL SOCIETY

MEETING ANNOUNCEMENT

DATE: **October 26, 2011**

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. Richard Allen**
Director, Berekely Seismological Laboratory, UC Berkeley

Delivering earthquake warning to California

A few seconds before the next big earthquake you could get a warning. Enough time to duck under a sturdy table or move to a safe zone. Enough time to prevent serious injuries from falling book shelves, broken windows, ceiling tiles and lights. This is how Prof. Richard Allen envisions the future of real-time earthquake information. His plan is to use the networks of seismometers distributed across the state to rapidly detect the beginnings of the earthquake, predict the ground shaking, and issue a warning to those in harms way. Warning systems exist in Japan and Mexico, but California's cities lie much closer to the hazardous faults than in those countries. For that reason California's system will need to make use of the first pulses of energy to reach the surface, the P-waves. These do not carry much energy, but they do carry information which can be translated into a prediction of the much larger S-waves that follow and do most of the damage. A prototype system is currently being tested across the state, and it has successfully delivered warnings in several earthquakes. Prof. Allen will talk about this system, how it is possible to predict the shaking, and some of the challenges that we face before a public system can be made available.

…Continued on back page…

NCGS 2010 – 2011 Calendar

October 26, 2011
Dr. Richard Allen, University of California Berkeley, Seismic Hazard Mitigation and Earthquake Early Warning System (Topic)
7:00 pm at Orinda Masonic Lodge

November 16, 2011
Michelle Newcomer, SFSU, Internship projects at NASA Ames (Topic)
7:00 pm at Orinda Masonic Lodge

December 2011 – Our Usual Holiday Break

January 25, 2012
TBA
7:00 pm at Orinda Masonic Lodge

February 29, 2012
TBA
7:00 pm at Orinda Masonic Lodge

March 28, 2012
TBA
7:00 pm at Orinda Masonic Lodge

April 25, 2012
TBA
7:00 pm at Orinda Masonic Lodge

Upcoming NCGS Events

Do you have a place you've wanted to visit for the geology? Let us know. We're definitely interested in ideas. For those suggestions, or for questions regarding, field trips, please contact Tridib Guha at: **Tridibguha@sbcglobal.net**

Peninsula Geologic Society

Upcoming meetings

For an updated list of meetings, abstracts, and field trips go to http://www.diggles.com/pgs/. The PGS has also posted guidebooks for downloading, as well as photographs from recent field trips at this web address. Please check the website for current details.

Bay Area Science

(http://www.bayareascience.org/)

This website provides a free weekly emailed newsletter consisting of an extensive listing of local science based activities (evening lectures, classes, field trips, hikes, and etc).

Association of Engineering Geologists

San Francisco Section

Upcoming Events

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

USGS Evening Public Lecture Series

The USGS Evening Public Lecture Series events are free and are intended for a general public audience that may not be familiar with the science being discussed. Monthly lectures are usually scheduled for the last Thursday evening of each month during most of the year but are occasionally presented on the preceding Thursday evening to accommodate the speakers. For more information on the lectures, including a map of the lecture location (Building 3, 2nd floor; Conference Room A) go to: http://online.wr.usgs.gov/calendar/

- October 27, 2011; *Around the World in 80 Days -- more or less; Studying Migratory Connectivity in a Changing Climate;* Susan Haig, Wildlife Ecologist

Undergraduate Scholarship Grant Suspension

At the NCGS Board meeting of May 14, 2011, NCGS elected to temporarily suspend the undergraduate scholarships for the coming year, principally due to the limited number of proposals that have been received over the recent past.

GeoZeum

Blogging member **Andrew Alden** (*About Geology* and KQED's *Quest* Program) informed attendees at the September NCGS meeting of **Phil Stoffer's** (USGS, Retired) latest endeavor down in **San Juan Bautista**, catch it at

http://science.kqed.org/quest/2011/09/29/geozeum-a-personal-museum-of-geology/ or visit the GeoZeum's website at http://geozeum.com/.

Richard Chambers Memorial Scholarships

(Graduate Scholarships;

$1,000 Masters Level and

$2,000 PhD Level)

K-12 Earth Science Teacher of the Year Award (AAPG Affiliated;

$750 and more!)

& Geoscience Teaching Award (Local Heroes - $500)

Announcements

These announcements appeared in the **September Newsletter.** Please send them to folks you know who might have an interest in these NCGS programs, or if you need new copies go or send interested parties to the NCGS website at www.ncgeolsoc.org. The application process is not difficult.

Undersea quake evidence found off West Coast

David Perlman, Chronicle Science Editor
Saturday, October 8, 2011

The ocean floor off the coast of Northern California and southern Oregon reveals a record of massive earthquakes that have hit the region over the past 10,000 years - and there's a 1-in-3 chance that another could strike again within the next 50 years, scientists say.

Submarine landslides triggered by major quakes on land have sent layers of sediments onto the seabed, and by dating those sediments researchers led by Chris Goldfinger, a marine geologist at Oregon State University, have calculated that the temblors rupture the ground roughly every 240 years on what is called the Cascadia Subduction Zone.

That 600-mile zone runs approximately from the northern end of Vancouver Island in Canada along the coast of Oregon, and into California for 100 miles past Crescent City and Eureka to Cape Mendocino.

Goldfinger and his colleagues have found evidence in those sediment layers that 19 monster quakes with magnitudes of 9 or more have struck along the northern Cascadia zone within the past 10,000 years. Quakes that size would have been as violent as the undersea temblor off Japan that triggered the devastating tsunami there in March, and the great Sumatra quake and tsunami of 2004.

Goldfinger's sediment records show that 22 quakes have struck along the southern segment of the Cascadia zone during the same period. Their magnitudes were lower, Goldfinger found - between 8 and 8.3 - but even those were larger than San Francisco's 1906 Big One with its magnitude of 7.9.

The thin sediment layers, known as turbidites, show up in some 170 core samples that Goldfinger and his colleagues have collected by drilling into the ocean floor of the Cascadia zone.

Turbidites also mark the seafloor off the San Andreas fault, and core samples drilled by Goldfinger's team at more than 30 sites as far south as Monterey Bay revealed evidence of ancient onshore quakes there.

Their findings add information for the earthquake hazard teams that produce probability estimates of future quakes on the San Andreas and the Bay Area's many other faults, according to David Schwartz of the U.S. Geological Survey in Menlo Park.

Goldfinger heads the Active Tectonics and Sea Floor Mapping Laboratory at Oregon State, and most of his lab's studies have focused on the Cascadia Subduction Zone. That region beneath the Pacific Ocean is where a giant slab of Earth's crust called the Juan de Fuca Plate dives down beneath the North American plate, pushing up the Cascade mountains and causing dangerous upward-thrusting earthquakes.

The northern end of the 800-mile-long San Andreas fault runs into the sea near Cape Mendocino and turns west to become the Mendocino Transform Fault that marks the southern edge of the Cascadia zone.

Goldfinger's studies of turbidites and past earthquakes have been published in many recent scientific reports, and are more completely detailed now in a full-length report to the U.S. Geologic Survey.

Gary B. Griggs, an oceanographer and Director of the Institute of Marine Sciences at UC Santa Cruz, has studied turbidite layers in the ocean off Oregon as evidence of Crater Lake's formation in Oregon some 7,700 years ago when a cluster of huge volcanoes now called Mt. Mazama erupted again and again.

Griggs, who has followed Goldfinger's work, said "his work is solid, and it has created a big picture of the seismic past along the Cascadia Subduction Zone."

Journal Reference: Goldfinger, C., 2009, *Subaqueous Paleoseismology*, *in* Mcalpin, J., ed., *Paleoseismology*, 2nd edition, Elsevier, p. 119-169; http://www.activetectonics.coas.oregonstate.edu/paper_files/Goldfinger%20et%20al.,%202008.pdf

Big Dinosaurs Were Warm Beasts

Sara Reardon June 2011

When paleontologist Richard Owen dug up a dinosaur in 1842, he thought it looked like a reptile—a "terrible lizard" with scales, slow-moving legs, and cold blood. But many dinosaurs are now known to have been fast, powerful, and energetic. And since the 1960s, scientists have argued over whether the cold-blooded physiology of a lumbering reptile could have powered something nimble and speedy like a *Velociraptor*. Now, scientists using a technique once reserved for climatologists have found that big four-legged dinos had body temperatures similar to those of mammals—evidence that they either were warm-blooded or were better at conserving body heat than modern reptiles are.

Evolutionary biologist Robert Eagle of the California Institute of Technology in Pasadena heard about a technique from Caltech colleagues, who were using it to reconstruct ancient climates. By analyzing minerals in old rocks, geochemists can determine the relative amounts of different chemical isotopes: atoms of the same chemical element that vary slightly in mass. Different isotopes tend to form depending on whether a chemical reaction took place at high or low temperatures.

Hot-blooded. *Chemical analysis of teeth from Camarasaurus (pictured) and Brachiosaurus suggests that these big creatures had body temperatures similar to a mammal's. Credit: Dmitry Bogdanov; (inset) Thomas Tütken/Bonn University*

The method, called "clumped-isotope thermometry," focuses on a reaction involving the bond between carbon and oxygen. The lower the temperature at which a mineral forms, the more the rare isotopes carbon-13 and oxygen-18 tend to bond, or "clump," together. By studying CO_2 trapped in minerals, geochemist John Eiler of Caltech and other researchers were trying to determine how warm Earth had been when they formed.

Trained as a paleontologist, Eagle realized that he could apply the technique to bioapatite, the mineral that makes up the enamel of teeth. "It's like a thermometer," he says. The results might help add data to resolve the debate over whether dinosaurs were cold-blooded (ectothermic) or warm-blooded (endothermic), which he calls "the most long-standing debate in paleobiology." To try to resolve it, his group analyzed 11 fossilized teeth from the long-necked, 30-ton *Brachiosaurus* and the 50-ton *Camarasaurus*, which had been dug up in Oklahoma, Wyoming, and Tanzania. The 150-million-year-old enamel, they found, formed between 36° and 38°C, the same temperature as the mammalian body. Dinosaurs, it seems, were warm after all.

But this doesn't settle the debate. To be truly endothermic, dinosaurs would have to have constantly maintained the same high body temperature. Big endothermic animals, however, have a problem with heat: their huge bodies retain too much of it. This phenomenon, called gigantothermy, causes them to overheat. Modern behemoths such as elephants are always "right on the edge" of overheating, says Frank Paladino, a physiologist at Indiana University-Purdue University Fort Wayne in Indiana, who studies giant animals such as pandas and leatherback turtles and was not involved in the research. Previous modeling studies, he says, have found that if the biggest dinosaurs were endothermic in the same way mammals are, their body temperature would have reached 40° to 45°C—far too hot for most life.

So if dinosaurs were endothermic, they must have had some sort of refrigerant system. In their paper published online today in *Science*, the authors speculate that the dinosaurs might have released excess heat through their long necks and tails or through air sacs under their skin, or used some unknown mechanism to cool off.

Another possibility is that the body temperatures of giant dinosaurs fluctuated with their surroundings, as those of modern reptiles do. In that case, Paladino points out, they would have been ectothermic without being cold-blooded. "Obviously, dinosaurs were 'warm-blooded'; they lived in a warm climate," he says. The more important question, he says, is whether their cells produced energy at a high or a low rate, and that can't be determined by looking at isotopes in tooth enamel. In the hot climate of the Jurassic, he notes, there would be no environmental pressure for dinosaurs to evolve cellular mechanisms for producing a lot of heat. But as small bipedal dinosaurs began to evolve into birds, they would have needed more energy to be able to flap their wings; endothermy may have evolved at this point.

Eagle agrees. All the discovery shows is that dinosaurs weren't cold like modern reptiles are, he says. He plans to address the endothermy question by looking at teeth from pygmy relatives of the giant dinosaurs and from juveniles of the same species. If their enamel also formed at high temperatures, he guesses, it might be more evidence that the species was endothermic and not just retaining heat because of its size. "But I'm open-minded about which it is," he says. He also plans to use the technique to look at other species and reconstruct evolutionary trees to determine when endothermy evolved. "It's mind-boggling the amount we could do," he says.

This item has been corrected. Frank Paladino's institution was originally incorrect; it is Indiana University-Purdue University Fort Wayne.

Species Moving Due to Global Warming

WASHINGTON (AP) — Animals across the world are fleeing global warming by heading north much faster than they were less than a decade ago, a new study says.

About 2,000 species examined are moving away from the equator at an average rate of more than 15 feet per day, about a mile per year, according to new research published Thursday in the journal Science which analyzed previous studies. Species are also moving up mountains to escape the heat, but more slowly, averaging about 4 feet a year.

The species — mostly from the Northern Hemisphere and including plants — moved in fits and starts, but over several decades it averages to about 8 inches an hour away from the equator.

"The speed is an important issue," said study main author Chris Thomas of the University of York. "It is faster than we thought."

Included in the analysis was a 2003 study that found species moving north at a rate of just more than a third of a mile per year and up at a rate of 2 feet a year. Camille Parmesan of the University of Texas, who conducted that study, said the new research makes sense because her data ended around the late 1990s and the 2000s were far hotter.

Federal weather data show the last decade was the hottest on record, and 2010 tied with 2005 for the hottest year on record. Gases from the burning of fossil fuel, especially carbon dioxide, are trapping heat in the atmosphere, warming the Earth and changing the climate in several ways, according to the overwhelming majority of scientists and the world's top scientific organizations.

As the temperatures soared in the 2000s, the species studied moved faster to cooler places, Parmesan said. She pointed specifically to the city copper butterfly in Europe and the purple emperor butterfly in Sweden. The comma butterfly in Great Britain has moved more than 135 miles in 21 years, Thomas said.

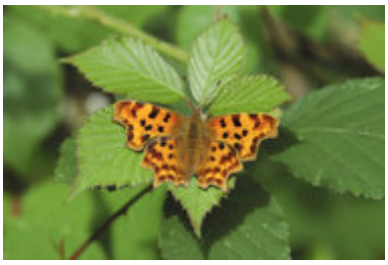


Photo provided by the Butterfly Conservation shows a Comma butterfly.

It's "independent confirmation that the climate is changing," Parmesan said.

One of the faster moving species is the British spider silometopus, Thomas said. In 25 years, the small spider has moved its home range more than 200 miles north, averaging 8 miles a year, he said.

Photo provided by Stanford University biologist Scott Loarie, shows an American Pika.

Stanford University biologist Terry Root, who wasn't part of this study but praised it as clever and

conservative, points to another species, the American pika, a rabbitlike creature that has been studied in Yellowstone National Park for more than a century. The pika didn't go higher than 7,800 feet in 1900, but in 2004 they were seen at 9,500 feet, she said.

For Thomas, this is something he notices every time he returns to his childhood home in southern England. The 51-year-old biologist didn't see the egret, a rather warm climate bird, in the Cuckmere Valley while growing up. But now, he said, "All the ditches have little egrets. It was just a bizarre sight."

Thomas plotted the movement of the species and compared it to how much they would move based on temperature changes. It was a near perfect match, showing that temperature changes explain what's happening to the critters and plants, Thomas said. The match wasn't quite as exact with the movement up mountains and Thomas thinks that's because species went north instead or they were blocked from going up.

Thomas found that the further north the species live, the faster they moved their home base. That makes sense because in general northern regions are warming more than those closer to the equator..

Conservation biologist Mike Dombeck, a former U.S. Forest Service chief, said changes in where species live — especially movements up mountains — is a problem for many threatened species.

Thomas said what he's studied isn't about some far off problem.

"It's already affected the entire planet's wildlife," Thomas said in a phone interview. "It's not a matter that might happen in the lifetime of our children and our grandchildren. If you look in your garden you can see the effects of climate change already."

Did Greenhouse Gases Unleash the Dinosaurs?

by Richard A. Kerr

The Cretaceous period ended 65 million years ago with a bang—an asteroid impact—that did in the dinosaurs. But what about the other mass extinctions? Now researchers teasing apart the record of mass extinction at the dawn of the dinosaur age have come up with a possible volcanic killer: a burst of methane gas triggered by volcanic greenhouse gases.

Linking eruptions to evolution has taken some detective work. The mass extinction 201 million years ago at the end of the Triassic period (known as the end-Triassic extinction) wiped out half the known species on land and in the sea, paleontologists found, which triggered the rise of the dinosaurs. When the extinction nearly wiped out the early relatives of the crocodiles, it removed the biggest competitors of early dinosaurs and let them rise to dominance.

A winner. *The early dinosaurs thrived after the mass extinction at the end of the Triassic period that was triggered by massive volcanic eruptions. Credit: Scott Hartman and Nobu Tamura*

More recently, researchers dating both that extinction and massive volcanic eruptions around then have found that the two major evolutionary and geologic events occurred at the same time. The massive outpourings of lava now strewn along the edges of the North Atlantic Ocean were laid down at the very start of the mass extinction, geochronologists have found. The coincidence is so close—a geologic moment of a few tens of thousands of years or so—that the eruptions and the mass extinction appear to have been connected.

To find out how eruptions—however massive—could cause global extinctions, paleoecologist Micha Ruhl of Utrecht University in the Netherlands and his colleagues went to the fossil record—the very small-scale fossil record. As they report online today in *Science*, they extracted distinctive organic molecules from marine sediments in Austria. The molecular chains, each 23 to 35 carbon atoms long, had been part of plant waxes washed off the land. The proportion of two isotopes of the carbon in the former plant waxes changed dramatically right at the end of the Triassic. That ratio shift depended on the amount of carbon dioxide used by the plants from different sources: carbon dioxide from the eruptions or methane (later converted to carbon dioxide) locked in ice in the sea floor. The group found that at least 12 trillion tons of carbon in the form of carbon dioxide or methane—two greenhouse gases—had gushed into the atmosphere during just 10,000 to 20,000 years.

That is almost twice the amount of carbon dioxide or methane previously suggested, released over a shorter interval. And the new isotopic result suggests that much of the released gas was methane, a far stronger greenhouse gas than carbon dioxide. Ruhl and his colleagues think methane may have been released from methane-laced ice in the sea floor when greenhouse warming melted the ice. The warming in turn could have been brought on by carbon dioxide spewed by the eruptions.

The new isotopic record clearly reveals "a big signal," says paleoceanographer James Zachos of the University

of California, Santa Cruz. "There's compelling evidence for a connection between a major mass extinction" and the release of carbon gases. But exactly how the gas burst did in so many species remains unclear, notes paleontologist Paul Olsen of Lamont-Doherty Earth Observatory in Palisades, New York. "I believe [the volcanism] actually did cause the extinction, one way or another," he says.

The greenhouse gases are now the most obvious candidate for linking eruptions and the extinction. On land, the rapidly strengthening greenhouse might have pushed life to the edge by rapidly warming the world. In the ocean, the link could have been warming, or carbon dioxide could have turned the water acidic, as is happening in today's ocean. Sorting out just how the killing happened, Olsen says, may take a lot more detective work on how the various victims succumbed.

Is Evolution Predictable?

by Elizabeth Pennisi, August 2011

If one could rewind the history of life, would the same species appear with the same sets of traits? Many biologists have argued that evolution depends on too many chance events to be repeatable. But a new study investigating evolution in three groups of microscopic worms, including the strain that survived the 2003 Columbia space shuttle crash, indicates otherwise. When raised in a lab under crowded conditions, all three underwent the same shift in their development by losing basically the same gene. The work suggests that, to some degree, evolution is predictable.

More than 50 years ago, researchers studying basic cell biology began raising a tiny soil worm, the nematode *Caenorhabditis elegans*. A young worm takes one of two life paths: Either it matures in 3 days, reproduces, and dies within 2 weeks, or it goes into a state of suspended animation, remaining what's called a dauer larva. Dauer larvae don't eat, and they can survive stressful environmental conditions for months before turning into adults. Typically, too little food, the wrong temperature, or crowded conditions prompt young worms to become dauer larvae.

Tough choices. *Developing nematodes must choose to mature quickly into reproductive adults or spend extra time as a nonfeeding larva (smaller worm, top). Credit: Image courtesy of Manuel Zimmer*

The animals know their numbers are too high because they can sense odor chemicals called pheromones emitted by their peers. When there's too much pheromone, they choose the dauer route.

Two years ago, researchers noticed that one 50-year-old lab strain of *C. elegans* no longer followed that pattern. Larvae matured quickly despite crowding, rarely if ever entering the dauer state. In the wild, crowded conditions generally mean food is short, so it makes sense for larvae to hunker down and wait for better times. In the lab, however, where there's always plenty of food to go around, the most successful worms are those that evolve to ignore the "too crowded" signal and quickly reproduce.

Geneticist Cornelia Bargmann of Rockefeller University in New York City and her postdoc Patrick McGrath tracked a key change to a mutation that got rid of two genes for a particular type of pheromone receptor. The loss of these genes delayed reproduction, and restoring either gene back to worms hurried them into adulthood. They found that the presence or absence of the genes determined how quickly the worms matured and reproduced.

Satisfied that they had fingered the genetic cause of this evolutionary change, Bargmann's group wanted to see if the same deletion was involved in other cases of dauer loss under crowded lab conditions. The Columbia space shuttle strain fit the bill: In preparation for the space shuttle experiments, biologists had grown these worms in high densities. Within 4 years, the space shuttle worms had ceased to form dauer larvae. As Bargmann and her colleagues report today in *Nature*, this strain is missing the same pheromone receptor genes.

Digging through the scientific literature, the researchers found a different lab-tamed nematode species that had also bypassed the dauer stage. This species, *C. briggsae*, split off from *C. elegans* 20 million years ago, long enough ago for genes to diverge so much that the worms didn't have the exact same pheromone receptor genes. Nonetheless, the group reported, the gene that was the closest equivalent to the missing genes in the two nematode strains was also deleted in these *C. briggsae*.

"What's surprising to me is that the strategies that they evolved are so similar, while the organisms themselves have been separated for a long time," says Jon Clardy, a chemist at Harvard Medical School in Boston, who was not involved in the work.

"It's an amazing study," adds Patrick Phillips, an evolutionary geneticist at the University of Oregon, Eugene, who also was not involved in the work. "One would have predicted there are many ways to break a system," he explains. But only a few can do it without affecting other parts of the organism.

Fifty to 100 genes affect whether a worm enters the dauer state. In theory, deletions on any of them could keep worms from becoming dauer larvae. But many of these genes affect several aspects of the animal's development and physiology, whereas the pheromone receptors simply sense the environment and thus can be lost harmlessly, Bargmann suggests. The study may point to "a general rule," adds Phillips: that evolution tends to delete genes whose loss will not have widespread effects, an idea that is very slowly gaining ground.

Other researchers have uncovered instances in fruit flies, cavefish, and stickleback fish wherein evolution has taken the same path more than once. This work is "another excellent example," says Princeton University evolutionary biologist David Stern. These cases, Bargmann says, are "opening our eyes to a new way of thinking about how evolution happens."

Billion-Year-Old Piece of North America Traced Back to Antarctica

An international team of researchers has found the strongest evidence yet that parts of North America and Antarctica were connected 1.1 billion years ago, long before the supercontinent Pangaea formed.

"I can go to the Franklin Mountains in West Texas and stand next to what was once part of Coats Land in Antarctica," said Staci Loewy, a geochemist at California State University, Bakersfield, who led the study. "That's so amazing."

Loewy and her colleagues discovered that rocks collected from both locations have the exact same composition of lead isotopes. Earlier analyses showed the rocks to be the exact same age and have the same chemical and geologic properties. The work, published online (ahead of print) in the September issue of the journal *Geology*, strengthens support for the so-called SWEAT hypothesis, which posits that ancestral North America and East Antarctica were joined in an earlier supercontinent called Rodinia.

Loewy et al. use new lead (Pb) isotopic data from the 1.1-billion-year-old rocks from Coats Land, to constrain the positions of Laurentia (ancestral North America) and Kalahari (ancestral southern Africa) in the 1-billion-year-old supercontinent, Rodinia. The Coats Land rocks are identical in age to both the Keweenawan large igneous province of the North American mid-continent rift and the contemporaneous Umkondo large igneous province of southern Africa. Comparison of the isotopic compositions, however, unequivocally links the Coats Land rocks with the Keweenawan province. Together with paleomagnetic data this suggests that the Coats Land block was a piece of Laurentia near west Texas 1.1 billion years ago. Furthermore, the Coats Land block collided with the Kalahari Precambrian craton of Africa during a 1-billion-year-old collision. Based on this reconstruction, Laurentia collided with Kalahari along Antarctica's Maud mountain belt, which would represent a continuation of the 1-billion-year-old Grenville mountain belt of eastern and southern North America.

Coats Land with its only rock outcrops, Littlewood (L) and Bertrab (B) nunataks. (Credit: Photo courtesy of Ian Dalziel)

Thus the tiny Coats Land block of Antarctica is a 'tectonic tracer' providing critical clues to the geographic relationships between three of the major continents of the planet in the time interval 1.1 -- 1.0 billion years ago, just prior to the opening of the Pacific Ocean basin, the hypothesized 'Snowball Earth' glaciations, and the rise of multi-cellular life.

Story Source: The above story is reprinted (with editorial adaptations by Science*Daily* staff) from materials provided by Geological Society of America.

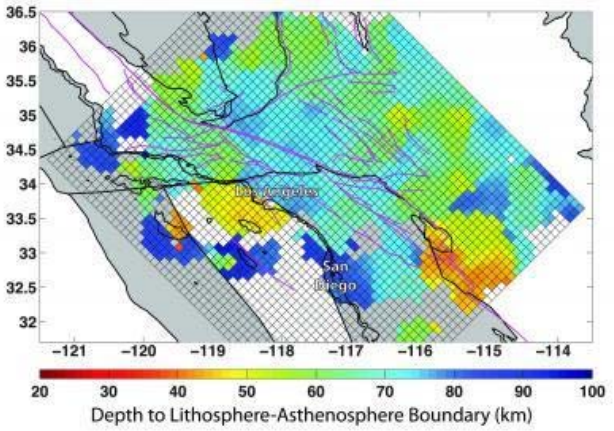
Journal Reference: S. L. Loewy, I. W. D. Dalziel, S. Pisarevsky, J. N. Connelly, J. Tait, R. E. Hanson, D. Bullen. **Coats Land crustal block, East Antarctica: A tectonic tracer for Laurentia?** *Geology*, 2011

Southern California's Tectonic Plates Revealed in Detail

Rifting is one of the fundamental geological forces that have shaped our planet. Were it not for the stretching of continents and the oceans that filled those newly created basins, Earth would be a far different place. Yet because rifting involves areas deep below Earth's surface, scientists have been unable to understand fully how it occurs.

What is known is that with rifting, the center of the action lies in the lithosphere, which makes up the

tectonic plates and includes the crust and part of the upper mantle. In a paper in *Science*, researchers at Brown University produce the highest-resolution picture of the bottom of the lithosphere in southern California, one of the most complex, captivating geologic regions in the world. The team found the lithosphere's thickness differs markedly throughout the region, yielding new insights into how rifting shaped the southern California terrain.



The geologic forces that shape the Earth's surface do their work in the lithosphere, often out of sight and far below the surface. Researchers have now measured the lithosphere's thickness in southern California. It varies widely, from less than 25 miles to nearly 60 miles. (Credit: Fischer Lab, Brown University)

"What we're getting at is how (continental) plates break apart," said Vedran Lekic, a postdoctoral researcher at Brown University and first author on the paper. "What happens below the surface is just not known."

The team measured the boundary separating the lithosphere from the more ductile layer just below it known as the asthenosphere in a 400-by-300-mile grid, an area that includes Santa Barbara, Los Angeles, San Diego and the Salton Trough. The lithosphere's thickness varies surprisingly from less than 25 miles to nearly 60 miles, the researchers write.

"We see these really dramatic changes in lithosphere thickness, and these occur over very small horizontal distances," said Karen Fischer, professor of geological sciences at Brown and a paper author. "That means that the deep part of the lithosphere, the mantle part, has to be strong enough to maintain relatively steep sides."

"This approach provides a new way to put observational constraints on how strong the rocks are at these depths," she added.

Specifically, the researchers found two areas of particular interest. One is the Western Transverse Range Block. The plate lies below Santa Barbara, yet some 18 million years ago, it was located some 125 miles to the south and hugged the coastline. At some point, this plate swung clockwise, rotating more than 90 degrees and journeyed northward, like a mobile, swinging door. Interestingly, the lithosphere remained intact, while the area left behind the swinging plate, called the Inner Continental Borderland and which lies off the coast of Los Angeles, was stretched, the Brown geophysicists believe. Indeed, the lithosphere is nearly 30 percent thinner in the area left behind than the range block.

"The fact that the Western Tranverse Range Block retained its lithosphere along its journey tells us the mantle-lithosphere (of the block) must be very strong," Lekic said.

Another interesting feature noted by the researchers is the Salton Trough, which encompasses the Salton Sea and the city of Palm Springs, and "is a classic example of rifting," according to Fischer. Some 6 million years ago, the continental plate at this location was stretched, but the question remains whether it simply thinned or whether it actually broke apart, creating new lithosphere in between. In the paper, the researchers confirm that the lithosphere is thin, but "we can't tell which of these scenarios happened," Fischer said. However, the thickness of the mantle part of the lithosphere and the fact that deformation at the surface runs all the way to the base of the lithosphere in roughly the same geographical location are new constraints against which modelers can test their predictions, she added.

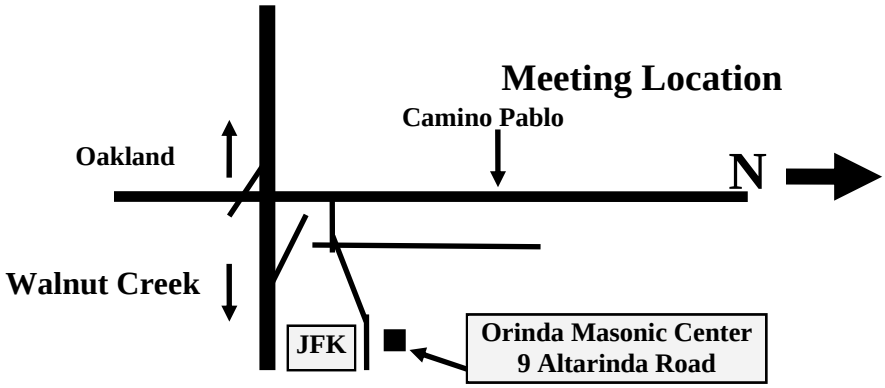
The team made use of permanent seismic recording stations set up by the Southern California Seismic Network and other networks, as well as seismometers from the EarthScope USarray Transportable Array, a grid of National Science Foundation-funded stations that is gathering earthquake information as it moves west to east across the nation. To measure the lithosphere's depth, the authors looked at how waves generated by earthquakes -- called S waves and P waves -- convert from type S to type P across the boundary between the lithosphere and the asthenosphere.

The team will compare its results with those of another famous rift system in East Africa, from a study at the University of Bristol led by Kate Rychert, who earned her doctorate at Brown in 2007.

Scott French, who earned his baccalaureate at Brown and is now a doctoral student at Berkeley Seismological Laboratory in California, is an author on the paper. The National Science Foundation funded the study, through its Earthscope program and an Earth Sciences postdoctoral fellowship to Lekic.

Story Source: The above story is reprinted with editorial adaptations from materials provided by Brown University.

Journal Reference: Vedran Lekic, Scott W. French, and Karen M. Fischer. **Lithospheric Thinning Beneath Rifted Regions of Southern California**. *Science*, 6 October 2011



Biography: **Dr. Richard Allen** is the Director of the Berkeley Seismological Laboratory and an Associate Professor in the Dept. of Earth and Planetary Science at UC Berkeley. He received a BA in Earth Science from Cambridge University in 1994, his PhD in seismology from Princeton University in 2001, and was a Postdoctoral Fellow at Caltech, before taking up his first faculty position at the University of Wisconsin in 2002. He moved to UC Berkeley in 2005 where his research group focuses on 3D imaging of the Earth's internal structure to understand upwelling and downwelling of plumes and plates, and surface deformation responsible for earthquakes. His group has also developed a methodology to deliver warnings prior to earthquake shaking and is currently testing the system in California.

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