NORTHERN CALIFORNIA GEOLOGICAL SOCIETY

MEETING ANNOUNCEMENT

DATE: **October 30, 2013**

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. David Osleger, University of California, Davis**

Paleo-precipitation records from Lake Tahoe sediment cores

Two sediment cores from the deep floor of Lake Tahoe provide insight into the past 7000 years of precipitation in the Sierra Nevada and surrounding region. Measurements of the grain size of sediment in the cores indicate active deposition through turbidity currents, which may be triggered by earthquakes or by severe storms affecting runoff into the surrounding watershed. Analyses of the magnetic and geochemical properties of the sediment, constrained by radiocarbon dates, suggest that turbidity currents were likely derived from the rapid influx of sediment and organic debris from the watershed, perhaps triggered by high-intensity storms. We correlated broad patterns in the Tahoe cores with climate proxies from 1) elsewhere in the Tahoe basin, 2) closed lakes of the western Great Basin and 3) the San Francisco bay estuary. The reasonable degree of temporal overlap between climatic events in each region reveals apparent trends in severe storm frequency in the Sierra Nevada and a measure of long-term regional paleo-precipitation over the last 7000 years. Paleoclimate studies such as this one from Lake Tahoe provide a baseline of natural variability that can be used for comparative purposes to assess current and future changes in California's climate.

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…Continued on the back…

NCGS 2012 – 2013 Calendar

October 30, 2013
Dr. David A. Osleger, UC Davis
Paleo-precipitation records from Lake Tahoe cores

November 20, 2013 **EARLY DATE!**
James J. Rytuba, Victoria E. Langenheim, and Daniel N. Goldstein, USGS, Menlo Park
Effects of the Paso Robles Geothermal System on water quality and availability in the Paso Robles Groundwater Basin, California

Our Usual December Break

January 29, 2013
TBA

February 26, 2013
TBA

March 26, 2013
TBA

April 30, 2014
TBA

May 28, 2014
TBA

June 25, 2014
TBA

Peninsula Geologic Society

Upcoming meetings

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

Bay Area Science

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

Association of Engineering Geologists San Francisco Section

Upcoming Events

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

Seeking Member Write-Ups

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

NCGS Scholarships Award History

We have recently reviewed the history of NCGS scholarships and discovered that the NCGS began awarding scholarships in 1988, and that we awarded a total of $44,400 in scholarships over that time period. Scholarships were not awarded for a total of five years during that time for various reasons. Since receiving the Richard Chambers Scholarship bequest, NCGS has been able to award scholarships very consistently over the past 10 years.

NCGS 2013-2014 RICHARD CHAMBERS MEMORIAL SCHOLARSHIPS

(Copies of this announcement can be downloaded from the NCGS website.)

The Northern California Geological Society is pleased to announce the availability of their **Richard Chambers Memorial Scholarships** to help support graduate–level student research in geology during the 2013-2014 academic year. More than one scholarship may be awarded at each academic level.

$ 1,000 Scholarships will be awarded to students working towards the Masters Degree

$ 2,000 Scholarships will be awarded to students working towards the Ph.D. Degree

These scholarships will be awarded competitively, based upon our review of submitted summaries of proposed research. Funds are intended to support field and laboratory components of research programs. The research should be scheduled for completion during the 2013-2014 calendar years. Winners' may/will be invited to speak or otherwise present their research at a regular NCGS evening meeting in Orinda, California.

Funding priority for these scholarships will be directed to research focused on topics in general geology, geologic mapping, structural, economic, engineering and/or environmental geology, geophysics, stratigraphy, paleontology and/or paleoecology implemented in northern California and/or states immediately adjacent to northern California.

Application Procedure

Candidates may apply by forwarding a signed cover letter on University Department letterhead requesting the award, accompanied by a brief (no more than 2 pages) summary of their proposed research topic. This letter must include candidates contact information (both departmental and home mailing and email addresses, & telephone numbers).

The bottom of the candidate letter must bear this note (filled out):

Degree Program: _____,

Approved by: _____,
(print): _____,

Title: _____,

Telephone: _____,

e-mail address: _____, and

date: _____.

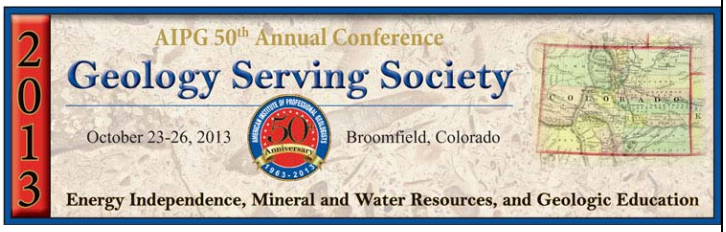
with the signature and printed name, title, telephone & e-mail of the department chair person or thesis advisor. Please indicate which scholarship (Masters or Ph.D.) you are applying for. No other application form is required.

Please submit your letter and proposal by U.S. Mail postmarked **no latter than DECEMBER 14, 2013** to:

Phillip Garbutt, Chair
Voice: (510) 581-9098
NCGS Scholarship Committee
6372 Boone Drive
Castro Valley, CA 94552-5077
e-mail: plgarbutt@comcast.net
NCGS website: http://www.ncgeolsoc.org

Scholarship Awards will be made on or about January 31, 2014

Quick links for the AIPG 50th Annual Conference



Great Presentations! **Amazing Field Trips!**

The Impacts of Impacts: Aspects of Catastrophic Climate and Ecological Changes by Asteroid Impact (Part 2)

by NCGS member ***Bill Motzer***

Reprinted from *The Vortex*, the newsletter of the California Section of the American Chemical Society (CALACS); (see www.calvaryslz.org/calacs/ for PDFs of the original articles and past issues of *The Vortex*)

In my last article, I outlined some climatic and ecological aspects of the K-T impact as found and interpreted in the stratigraphic and fossil record, and what can be expected when another such event occurs (note the "when" not the "if"). This article basically describes events as they may have occurred from the Chicxulub asteroid impact.

Initial and Immediate impact, as shown by modeling and nuclear bomb testing, produced seismic waves ranging from Richter magnitude (M_L) 10 to 13 on the scale with an equivalent energy release (EER) of 1.0 to 100 Tt of TNT. [The largest recorded earthquake (M_L = 9.5) in human history occurred on May 22, 1960 at Valdivia, Chile, with an EER of 178 Gt_{TNT}. By contrast the offshore February 27, 2010 Maule, Chile earthquake (M_L = 8.8) had an EER of 15.8Gt_{TNT}.] At the impact site, atmospheric over pressures of several hundred GPa occurred; resultant shock wave may have reached supersonic velocities, with wind velocities of >2,200 m/s). If such an impact occurred on or near land today, almost all buildings and bridges within a 200 km radius would be destroyed just from seismic shaking and atmospheric overpressures.

Thermal radiation and the resultant fires (conflagrations) were ignited both locally, from the initial fireball created by the impact, and perhaps on a continental wide basis from glowing ejecta (melt droplets) falling back through the atmosphere. Impact site temperatures >10,000 ^oC occurred, most likely produced from the rapidly rising plasma cloud that may also have radiated in the x-ray band. The calculated fireball radius was 236 km for an 18 km diameter asteroid! Thermal ground temperatures at time of impact and for the first 15 minutes in Colorado (~2,500 km from the impact site) have been estimated at >630 ^oC. Wood typically burns between 425 and 980 ^oC with spontaneous ignition at 545 ^oC. Some researchers have suggested ignition of world-wide biomass wild fires from globally dispersed melt droplets and returning ejecta. Evidence for this is fossil charcoal, fullerene spherules, and polycyclic aromatic hydrocarbons (PAHs), which in large quantities are toxic. However, PAHs signatures suggest that they may have been from

pyrolized petroleum rather than burning biomass; petroleum hydrocarbons are indicative of the Chicxulub impact area's rocks. Other researchers are not certain that global conflagration occurred.

Tsunamis >100 m in height resulted from an open ocean impact in a shallow sea because during late Cretaceous time sea levels were 150 to 200 m higher than present. By comparison, the December 26, 2004, Indonesian tsunamis generated 10 m waves. K-T tsunamis debris deposits have been reported in and around the Caribbean area. Not only were these waves immediately devastating to Cretaceous flora and fauna, but the large input of saline ocean water many kilometers inland would have inundated and contaminated thousands of hectares with salt.

Tremendous quantities of dust were also injected into the atmosphere from the enormous volume of pulverized rock caught in the impact cloud. The amount is not precisely known (~100 to 500 GT) because the fine particles have weathered to clay; however, it probably was considerably less than if the impact had been on land. This injected dust resulted in a global "shroud" or thick cloud cover blocking significant amounts of the Sun's radiation from reaching the Earth's surface. The dust, the aerosol effect from enormous quantities of injected SO_2 (see below), and soot from wild fires resulted in a global shroud that caused a "nuclear winter". The global cloud cover may also have been enhanced by huge quantities of vaporized sea water, which injected $OH^{\bullet}$ and $HO_2^{\bullet}$ free radicals and chlorine, contributing to atmospheric ozone destruction. Again, by contrast, the Philippines' Mount Pinatubo injected only 10 Gt of magma as tephra and ash into the atmosphere.

Aerosol effect of SO_2: Atmospheric model estimates suggest that perhaps 75 to 270 Gt of sulfur, from impact in gypsum-rich ($CaSO_4 \cdot nH_2O$) sediments and sedimentary rocks, were instantly injected into upper atmosphere depending on the impactor's actual size. This sulfur was subsequently oxidized to SO_2, SO_3^{2-}, and SO_4^{2-}. By contrast, anthropogenic SO_2 emissions that peaked in the mid 1980s have been estimated at 80 Mt per year and natural SO_2 emissions (e.g., volcanoes) at 25 Mt per year. Mt. Pinatubo's June 1991 eruption injected only 20 Mt of sulfur into the atmosphere.

SO_2- and SO_4^{2-}-bearing aerosols are strong long wave radiation absorbers resulting in initial stratosphere heating with subsequent cooling of the Earth's surface. Studies related to SO_2 aerosol cooling effect from the Mount Pinatubo volcanic eruption (at –0.5 ^{o}C) suggest that such cooling is enough to impact the Earth's surface and shallow seas but not deeper oceans, which have the higher heat capacity capability that ultimately affects Earth's climate. However, global climate cooling would not have lasted for a long period because SO_2 would soon have "rained out" (see acid rain below). Therefore, it is believed that sulfur aerosol effects and associated global cooling lasted for a relatively short period, perhaps only decades to a few hundred years. Sulfur aerosols can also deplete global ozone, resulting in a substantial increase in UV radiation reaching the Earth's surface.

CO_2 atmospheric input was significant because impact occurred in an area with carbonate-enriched sediments and rocks (limestone), particular to Yucatan Peninsula geology. CO_2 levels probably increased by a factor of 2 to 10 and there may have been additional CO_2 dissolution from the ocean's photic zone. Prior to impact, end-Cretaceous estimated CO_2 levels were ~850 ppmv. The additional impact-released CO_2 would have caused an enhanced greenhouse effect perhaps raising surface temperatures from 2 to 10 °C for a period of 10,000 to 100,000 years. How long the increased CO_2 levels (to 8,500 ppmv?) persisted is not precisely known but the fossil record shows that by the early Neogene (60 Ma), CO_2 levels declined to end Cretaceous levels. (See *The Vortex* December 2007: *Where has all the Carbon Dioxide Gone?*)

Heavy acid rain produced from the oxidizing/fusing effect of the impact fireball produced nitrous oxides (NO_2 and NO_3) from atmospheric nitrogen. As previously noted, large quantities of SO_2, SO_3, and SO_4 were also injected into the atmosphere. Both the nitrogen and sulfur oxides then combined with water vapor. The resultant rain out was a solution of nitrous/nitric acid and sulfurous/sulfuric, but the pH of this rain is not known (< pH 3 or 4?) or easily revealed in the fossil record. However, there are indications that rock weathering significantly increased at this time. More recently, some researcher's doubt the importance of acid rain, suggesting that it was neutralized by larnite (β-Ca_2SiO_4) produced in ejecta specific to Chicxulub's area lithology. Therefore, the biosphere acid-rain effect would not have been long, perhaps lasting only a decade or two.

Biota poisoning by metals is unknown but could have occurred if the impactor was a nickel-iron asteroid. However, evidence for heavy metal poisoning in not particularly evident in the fossil record except for the large Ir anomaly at the K-T boundary.

In Part 3, I'll summarize the importance of understanding the environmental/envirochemical effects of asteroid/comet impacts and what we can do to avoid such a calamity.

First Ever Evidence of a Comet Striking Earth

The first ever evidence of a comet entering Earth's atmosphere and exploding, raining down a shock wave of fire which obliterated every life form in its path, has

been discovered by a team of South African scientists and international collaborators.

The discovery has not only provided the first definitive proof of a comet striking Earth, millions of years ago, but it could also help us to unlock, in the future, the secrets of the formation of our solar system.

"Comets always visit our skies -- they're these dirty snowballs of ice mixed with dust -- but never before in history has material from a comet ever been found on Earth," says Professor David Block of Wits University.

The comet entered Earth's atmosphere above Egypt about 28 million years ago. As it entered the atmosphere, it exploded, heating up the sand beneath it to a temperature of about 2,000 degrees Celsius, and resulting in the formation of a huge amount of yellow silica glass which lies scattered over a 6,000 square kilometre area in the Sahara. A magnificent specimen of the glass, polished by ancient jewellers, is found in Tutankhamun's brooch with its striking yellow-brown scarab.

The research, which will be published in *Earth and Planetary Science Letters*, was conducted by a collaboration of geoscientists, physicists and astronomers including Block, lead author Professor Jan Kramers of the University of Johannesburg, Dr Marco Andreoli of the South African Nuclear Energy Corporation, and Chris Harris of the University of Cape Town.

At the centre of the attention of this team was a mysterious black pebble found years earlier by an Egyptian geologist in the area of the silica glass. After conducting highly sophisticated chemical analyses on this pebble, the authors came to the conclusion that it represented the very first known hand specimen of a comet nucleus, rather than simply an unusual type of meteorite.

Kramers describes this as a moment of career defining elation. "It's a typical scientific euphoria when you eliminate all other options and come to the realisation of what it must be," he said.

The impact of the explosion also produced microscopic diamonds. "Diamonds are produced from carbon bearing material. Normally they form deep in the Earth, where the pressure is high, but you can also generate very high pressure with shock. Part of the comet impacted and the shock of the impact produced the diamonds," says Kramers.

The team have named the diamond-bearing pebble "Hypatia" in honour of the first well known female mathematician, astronomer and philosopher, Hypatia of Alexandria.

Comet material is very elusive. Comet fragments have not been found on Earth before except as microscopic sized dust particles in the upper atmosphere and some carbon-rich dust in the Antarctic ice. Space agencies have spent billions to secure the smallest amounts of pristine comet matter.

"NASA and ESA (European Space Agency) spend billions of dollars collecting a few micrograms of comet material and bringing it back to Earth, and now we've got a radical new approach of studying this material, without spending billions of dollars collecting it," says Kramers.

The study of Hypatia has grown into an international collaborative research programme, coordinated by Andreoli, which involves a growing number of scientists drawn from a variety of disciplines. Dr Mario di Martino of Turin's Astrophysical Observatory has led several expeditions to the desert glass area.

"Comets contain the very secrets to unlocking the formation of our solar system and this discovery gives us an unprecedented opportunity to study comet material first hand," says Block.

Story Source: The above story is based on materials provided by Wits University.

Journal Reference: Jan D. Kramers, Marco A.G. Andreoli, Maria Atanasova, Georgy A. Belyanin, David L. Block, Chris Franklyn, Chris Harris, Mpho Lekgoathi, Charles S. Montross, Tshepo Ntsoane, Vittoria Pischedda, Patience Segonyane, K.S. (Fanus) Viljoen, Johan E. Westraadt. **Unique chemistry of a diamond-bearing pebble from the Libyan Desert Glass strewnfield, SW Egypt: Evidence for a shocked comet fragment**. *Earth and Planetary Science Letters*, 2013; 382: 21 DOI: 10.1016/j.epsl.2013.09.003

Icy comet may have caused life on Earth

By Lisa M. Krieger; Bay Area News Group

LIVERMORE -- Life started with a dirty snowball, tossed at Earth from space.

That is the conclusion reached by a group of international scientists, confirming a theory conceived by a Lawrence Livermore Laboratory researcher.

The team fired a speeding projectile into a special ice mixture, creating a hot and high-pressure environment -- akin to the comets that streak through the heavens, piercing our atmosphere.

And presto: Out of the explosion came life's raw materials, called amino acids. This final product -- a pound of "goo," said Livermore Lab climate scientist Nir Goldman -- is a modest ancestor to our now-gloriously lively Earth.

But it is not the only explanation for how our home took its first halting steps to becoming alive. Dozens of other teams are exploring alternate theories.

"But these studies prove that this is one avenue in which amino acids were produced, early on," said Goldman. "It is exciting to ponder the different avenues that could have been the origin of life."

Using computer simulations performed on lab supercomputers, Goldman proposed in 2010 and again in 2013 that an icy comet crashing into Earth billions of years ago could have produced amino acids.

It is known that comets bombarded Earth between 4.5 billion and 3.8 billion years ago.

It is likely that the comet that triggered life hit us at an oblique angle, rather than in a direct smash, he said.

Amid the ice, the comets bore carbon dioxide, methane, ammonia and other trace gases -- precursors of amino acids.

These simple molecules could have supplied the raw materials of life, Goldman believes. And the impact with early Earth would have yielded the energy to drive this prebiotic chemistry.

Goldman's idea was put to the test -- and proven -- by British collaborators, whose findings are published in the latest issue of the journal Nature Geoscience.

Scientists at Imperial College London and the University of Kent sent their comet-like projectile at a speed of 7 kilometers per second into a sizzling environment that was 3,000 degrees Celsius and at a pressure more than 300,000 times Earth's atmospheric pressure.

Several complex organic compounds, including amino acids, were formed in what Goldman calls "a tar-like goo."

"All the raw materials, and resulting pressure and high temperatures, can drive the chemistry," he said. Then those molecules were organized into life's essential structures and devised a means to survive and reproduce themselves.

A different theory proposes that life emerged from the deep sea environment miles below Earth's solid surface, where cells live in the narrowest of cracks and fissures. Yet another asserts that a lightning bolt ignited a chemical reaction of the ocean and a mixture of simple gases in the atmosphere.

"This is one possible avenue," Goldman said. "These results present a significant step forward in our understanding of the origin of the building blocks of life."

Ancient Soils Reveal Clues to Early Life On Earth

Oxygen appeared in the atmosphere up to 700 million years earlier than we previously thought, according to research published today in the journal *Nature*, raising new questions about the evolution of early life.

Some of the rocks that Crowe and his colleagues studied. (Credit: Nic Beukes)

Researchers from the University of Copenhagen and University of British Columbia examined the chemical composition of three-billion-year-old soils from South Africa -- the oldest soils on Earth -- and found evidence for low concentrations of atmospheric oxygen. Previous research indicated that oxygen began accumulating in the atmosphere only about 2.3 billion years ago during a dynamic period in Earth's history referred to as the Great Oxygenation Event.

"We've always known that oxygen production by photosynthesis led to the eventual oxygenation of the atmosphere and the evolution of aerobic life," says Sean Crowe, co-lead author of the study and an assistant professor in the Departments of Microbiology and Immunology, and Earth, Ocean and Atmospheric Sciences at UBC.

"This study now suggests that the process began very early in Earth's history, supporting a much greater antiquity for oxygen producing photosynthesis and aerobic life," says Crowe, who conducted the research while a post-doctoral fellow at Nordic Center for Earth Evolution at the University of Southern Denmark in partnership with the centre's director Donald Canfield.

There was no oxygen in the atmosphere for at least hundreds of millions of years after Earth formed. Today, Earth's atmosphere is 20 per cent oxygen thanks to photosynthetic bacteria that, like trees and other plants, consume carbon dioxide and release oxygen. The bacteria laid the foundation for oxygen breathing organisms to evolve and inhabit the planet.

"These findings imply that it took a very long time for geological and biological processes to conspire and produce the oxygen rich atmosphere we now enjoy," says Lasse Døssing, the other lead scientist on the study, from the University of Copenhagen.

Story Source: The above story is based on materials provided by University of British Columbia.

Journal Reference: Sean A. Crowe, Lasse N. Døssing, Nicolas J. Beukes, Michael Bau, Stephanus J. Kruger, Robert Frei, Donald E. Canfield. **Atmospheric oxygenation three billion years ago**. *Nature*, 2013; 501 (7468): 535 DOI: 10.1038/nature12426

New Fossils Push the Origin of Flowering Plants Back by 100 Million Years to the Early Triassic

Drilling cores from Switzerland have revealed the oldest known fossils of the direct ancestors of flowering plants. These beautifully preserved 240-million-year-old pollen grains are evidence that flowering plants evolved 100 million years earlier than previously thought, according to a new study in the open-access journal *Frontiers in Plant Science*.

Flowering plants evolved from extinct plants related to conifers, ginkgos, cycads, and seed ferns. The oldest known fossils from flowering plants are pollen grains. These are small, robust and numerous and therefore fossilize more easily than leaves and flowers.

An uninterrupted sequence of fossilized pollen from flowers begins in the Early Cretaceous, approximately 140 million years ago, and it is generally assumed that flowering plants first evolved around that time. But the present study documents flowering plant-like pollen that is 100 million years older, implying that flowering plants may have originated in the Early Triassic (between 252 to 247 million years ago) or even earlier.

Many studies have tried to estimate the age of flowering plants from molecular data, but so far no consensus has been reached. Depending on dataset and method, these estimates range from the Triassic to the Cretaceous. Molecular estimates typically need to be "anchored" in fossil evidence, but extremely old fossils were not available for flowering plants. "That is why the present finding of flower-like pollen from the Triassic is significant," says Prof. Peter Hochuli, University of Zurich.

Peter Hochuli and Susanne Feist-Burkhardt from Paleontological Institute and Museum, University of Zürich, studied two drilling cores from Weiach and Leuggern, northern Switzerland, and found pollen grains that resemble fossil pollen from the earliest known flowering plants. With Confocal Laser Scanning Microscopy, they obtained high-resolution images across three dimensions of six different types of pollen.

In a previous study from 2004, Hochuli and Feist-Burkhardt documented different, but clearly related flowering-plant-like pollen from the Middle Triassic in cores from the Barents Sea, south of Spitsbergen. The samples from the present study were found 3000 km south of the previous site. "We believe that even highly cautious scientists will now be convinced that flowering plants evolved long before the Cretaceous," say Hochuli.

What might these primitive flowering plants have looked like? In the Middle Triassic, both the Barents Sea and Switzerland lay in the subtropics, but the area of Switzerland was much drier than the region of the Barents Sea. This implies that these plants occurred a broad ecological range. The pollen's structure suggests that the plants were pollinated by insects: most likely beetles, as bees would not evolve for another 100 million years.

Story Source: The above story is based on materials provided by University of Zurich.

Journal Reference: Peter A. Hochuli and Susanne Feist-Burkhardt. **Angiosperm-like pollen and Afropollis from the Middle Triassic (Anisian) of the Germanic Basin (Northern Switzerland)**. *Frontiers in Plant Science*, 2013 DOI: 10.3389/fpls.2013.00344

Urgent New Time Frame for Climate Change Revealed by Massive Analysis

The seesaw variability of global temperatures often engenders debate over how seriously we should take climate change. But within 35 years, even the lowest monthly dips in temperatures will be hotter than we've experienced in the past 150 years, according to a new and massive analysis of all climate models. The tropics will be the first to exceed the limits of historical extremes and experience an unabated heat wave that threatens biodiversity and heavily populated countries with the fewest resources to adapt.

Ecological and societal disruptions by modern climate change are critically determined by the time frame over which climates shift. Camilo Mora and colleagues in the College of Social Sciences' Department of Geography at the University of Hawaii, Manoa have developed one such time frame. The study, entitled "The projected timing of climate departure from recent variability," will be published in the October 10 issue of *Nature* and provides an index of the year when the mean climate of any given location on Earth will shift continuously outside the most extreme records experienced in the past 150 years.

The new index shows a surprising result. Areas in the tropics are projected to experience unprecedented climates first -- within the next decade. Under a business-as-usual scenario, the index shows the average location on Earth will experience a radically different climate by 2047. Under an alternate scenario with

greenhouse gas emissions stabilization, the global mean climate departure will be 2069.

"The results shocked us. Regardless of the scenario, changes will be coming soon," said lead author Camilo Mora. "Within my generation, whatever climate we were used to will be a thing of the past."

The scientists calculated the index for additional variables including evaporation, precipitation, and ocean surface temperature and pH. When looking at sea surface pH, the index indicates that we surpassed the limits of historical extremes in 2008. This is consistent with other recent studies, and is explained by the fact that ocean pH has a narrow range of historical variability and because the ocean has absorbed a considerable fraction of human-caused CO_2 emissions.

The study found that the overarching global effect of climate change on biodiversity will occur not only as a result of the largest absolute changes at the poles, but also, perhaps more urgently, from small but rapid changes in the tropics.

Tropical species are unaccustomed to climate variability and are therefore more vulnerable to relatively small changes. The tropics hold the world's greatest diversity of marine and terrestrial species and will experience unprecedented climates some 10 years earlier than anywhere else on Earth. Previous studies have already shown that corals and other tropical species are currently living in areas near their physiological limits. The study suggests that conservation planning could be undermined as protected areas will face unprecedented climates just as early and because most centers of high species diversity are located in developing countries

Rapid change will tamper with the functioning of Earth's biological systems, forcing species to either move in an attempt to track suitable climates, stay and try to adapt to the new climate, or go extinct. "This work demonstrates that we are pushing the ecosystems of the world out of the environment in which they evolved into wholly new conditions that they may not be able to cope with. Extinctions are likely to result," said Ken Caldeira of the Carnegie Institution for Science's Department of Global Ecology, and who was not involved in this study. "Some ecosystems may be able to adapt, but for others, such as coral reefs, complete loss of not only individual species but their entire integrity is likely."

These changes will affect our social systems as well. The impacts on the tropics have implications globally as they are home to most of the world's population, contribute significantly to total food supplies, and house much of the world's biodiversity.

In predominately developing countries, over one billion people under an optimistic scenario, and five billion under a business-as-usual-scenario, live in areas that will experience extreme climates before 2050. This raises concerns for changes in the supply of food and water, human health, wider spread of infectious diseases, heat stress, conflicts, and challenges to economies. "Our results suggest that countries first impacted by unprecedented climates are the ones with the least capacity to respond," said coauthor Ryan Longman. "Ironically, these are the countries that are least responsible for climate change in the first place."

"This paper is unusually important. It builds on earlier work but brings the biological and human consequences into sharper focus," said Jane Lubchenco, former Administrator of the National Oceanic and Atmospheric Administration and now of Oregon State University, who was not involved in this study. "It connects the dots between climate models and impacts to biodiversity in a stunningly fresh way, and it has sobering ramifications for species and people."

While the study describes global averages, the authors have visualized their data on an interactive map displaying when climate will exceed historical precedents for locations around the world. "We hope that with this map people can see and understand the progression of climate change in time where they live, hopefully connecting people more closely to the issue and increasing awareness about the urgency to act," said coauthor Abby Frazier.

The index used the minimum and maximum temperatures from 1860-2005 to define the bounds of historical climate variability at any given location. The scientists then took projections for the next 100 years to identify the year in which the future temperature at any given location on Earth will shift completely outside the limits of historical precedents, defining that year as the year of climate departure.

The data came from 39 Earth System Models developed independently by 21 climate centers in 12 different countries. The models have been effective at reproducing current climate conditions and varied in their projected departure times by no more than five years.

The study suggests that any progress to slow ongoing climate change will require a larger commitment from developed countries to reduce emissions, but also more extensive funding of social and conservation programs in developing countries to minimize climate change impacts. The longer we wait, the more difficult remediation will be.

"Scientists have repeatedly warned about climate change and its likely effects on biodiversity and people," said Mora. "Our study shows that such changes are already upon us. These results should not be reason to give up. Rather, they should encourage us to reduce emissions and slow the rate of climate change. This can buy time for species, ecosystems, and ourselves to adapt to the coming changes."

Story Source: The above story is based on materials provided by **University of Hawaii at Manoa**, via EurekAlert!, a service of AAAS.

Journal Reference: Camilo Mora, Abby G. Frazier, Ryan J. Longman, Rachel S. Dacks, Maya M. Walton, Eric J. Tong, Joseph J. Sanchez, Lauren R. Kaiser, Yuko O. Stender, James M. Anderson, Christine M. Ambrosino, Iria Fernandez-Silva, Louise M. Giuseffi, Thomas W. Giambelluca. **The projected timing of climate departure from recent variability**. *Nature*, 2013; 502 (7470): 183 DOI: 10.1038/nature12540

World's Oldest Dinosaur Embryo Bonebed Yields Organic Remains

The great age of the embryos is unusual because almost all known dinosaur embryos are from the Cretaceous Period. The Cretaceous ended some 125 million years after the bones at the Lufeng site were buried and fossilized.

Led by University of Toronto Mississauga paleontologist Robert Reisz, an international team of scientists from Canada, Taiwan, the People's Republic of China, Australia, and Germany excavated and analyzed over 200 bones from individuals at different stages of embryonic development.

"We are opening a new window into the lives of dinosaurs," says Reisz. "This is the first time we've been able to track the growth of embryonic dinosaurs as they developed. Our findings will have a major impact on our understanding of the biology of these animals."

The bones represent about 20 embryonic individuals of the long-necked sauropodomorph *Lufengosaurus*, the most common dinosaur in the region during the Early Jurassic period. An adult *Lufengosaurus* was approximately eight metres long.

The disarticulated bones probably came from several nests containing dinosaurs at various embryonic stages, giving Reisz's team the rare opportunity to study ongoing growth patterns. Dinosaur embryos are more commonly found in single nests or partial nests, which offer only a snapshot of one developmental stage.

To investigate the dinosaurs' development, the team concentrated on the largest embryonic bone, the femur. This bone showed a consistently rapid growth rate, doubling in length from 12 to 24 mm as the dinosaurs grew inside their eggs. Reisz says this very fast growth may indicate that sauropodomorphs like *Lufengosaurus* had a short incubation period.

Reisz's team found the femurs were being reshaped even as they were in the egg. Examination of the bones' anatomy and internal structure showed that as they contracted and pulled on the hard bone tissue, the dinosaurs' muscles played an active role in changing the shape of the developing femur. "This suggests that dinosaurs, like modern birds, moved around inside their eggs," says Reisz. "It represents the first evidence of such movement in a dinosaur."

The Taiwanese members of the team also discovered organic material inside the embryonic bones. Using precisely targeted infrared spectroscopy, they conducted chemical analyses of the dinosaur bone and found evidence of what Reisz says may be collagen fibres. Collagen is a protein characteristically found in bone.

"The bones of ancient animals are transformed to rock during the fossilization process," says Reisz. "To find remnants of proteins in the embryos is really remarkable, particularly since these specimens are over 100 million years older than other fossils containing similar organic material."

Only about one square metre of the bonebed has been excavated to date, but this small area also yielded pieces of eggshell, the oldest known for any terrestrial vertebrate. Reisz says this is the first time that even fragments of such delicate dinosaur eggshells, less than 100 microns thick, have been found in good condition.

"A find such as the Lufeng bonebed is extraordinarily rare in the fossil record, and is valuable for both its great age and the opportunity it offers to study dinosaur embryology," says Reisz. "It greatly enhances our knowledge of how these remarkable animals from the beginning of the Age of Dinosaurs grew."

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

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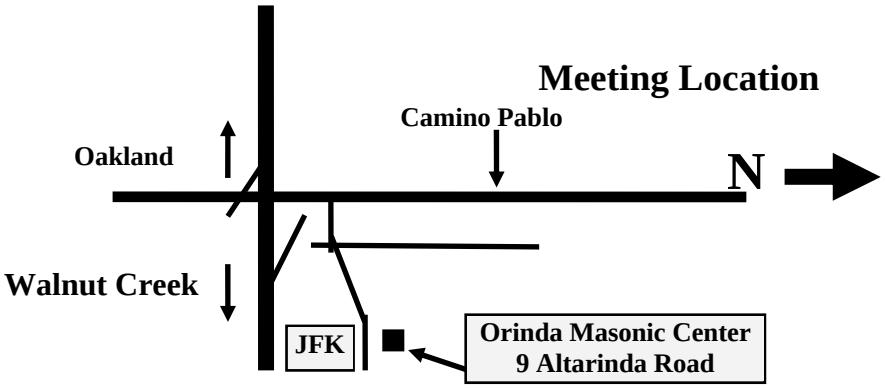

Biography: **Dr. David Osleger** received his PhD from Virginia Tech in 1990 and subsequently enjoyed stays at USC and UC Riverside before joining the faculty in the Geology department at UC Davis in 1998. His research interests include orbital stratigraphy, sea-level history, energy resources, lacustrine sedimentation and paleoclimatology. He teaches courses on the geology of national parks, California geology, natural hazards, environmental geology, the solar system, and 'big history.'

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