NORTHERN CALIFORNIA GEOLOGICAL SOCIETY

MEETING ANNOUNCEMENT

DATE: **November 20, 2013** **ONE WEEK EARLY!!**

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. 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

After the 2003 M6.5 San Simeon earthquake, several new hot springs developed along the Rinconada fault that bounds the west side of the Paso Robles Groundwater Basin (PRGB). Aeromagnetic anomalies delineate the boundaries of the basin and thickness of basin fill. The largest hot spring developed in a parking lot in the city center of Paso Robles. Other hot springs developed in front of the Paso Robles McDonalds and along Highway 101. The large pit that was constructed to attempt to manage the hot spring in the city center created a hazard—on days with no wind, CH_4, N_2, CO_2, and H_2S gases accumulated to potentially lethal levels, while sulfuric acid derived from oxidation of H_2S was corroding iron and copper trim on nearby historic buildings. A cover was designed and constructed that collected the hot spring gases and water. The water was piped 1 km to a leach field on the Salinas River floodplain, and the restored parking lot allowed cars to park on top of the hot spring. The low temperature (<40^{o}C) geothermal reservoir is present in the base of the Paso Robles Formation and the upper part of the Miocene Monterey Formation. Precipitates of sulfur, barite and FeS occur in the hot spring pools.

Demands from both population growth and agriculture have made water quality and availability a continuing concern. To address depletion of groundwater, a 25 km pipe was recently constructed to bring water from Lake Nacimiento to supplement municipal water supplies. The main aquifer in the PRGB is in the Pliocene Paso Robles Formation and a shallow alluvial aquifer that is recharged by the Salinas River and with water pumped from Lake Nacimiento.

Geochemical and isotopic data from hot spring waters and Paso Robles city water wells indicate that two water sources affect water quality and availability: meteoric water stored in Recent to Pliocene formations, and geothermal waters present in the deeper Monterey Formation. Geothermal waters and groundwater mix in the PRGB, resulting in distinct changes in chemistry and quality of water derived from wells that extend into the lower part of the Paso Robles Formation. Waters … *Continued on the back…*

NCGS 2012 – 2013 Calendar

November 20, 2013 **EARLY DATE!**
Dr. 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
Dr. Barbara Romanowicz
UC Berkeley Seismological Laboratory
Imag(in)ing the Earth's Interior

February 26, 2013
TBA

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

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 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

Dr. William Terry Herbert Wright III, 70, died on September 6, 2013. Born February 13, 1943 in Newton, MA, he was the son of the late Bill & Ruth Wright, long time residents of Wellesley, MA. After graduating from Wellesley High School in 1961, he earned his BS in Geology from Middlebury College 65. His PhD. in Geology from Univ. of Illinois led to a professorship at Sonoma State College. His passions for the outdoors and for music are legendary among the many that knew and loved him. His writings are at: terrysworld007.blogspot.com Donations can be made to: Friends of the River, www.friendsoftheriver.org in memory of Terry Wright. See more at:

http://www.legacy.com/obituaries/wickedlocal-wellesley/obituary.aspx?n=william-h-wright&pid=167133685#sthash.RwWlfme6.dpuf

Editors Note – An interesting bit of history in light of the recent memorial for Dr. Garniss Curtis.

THE BERKELEY DAILY PLANET

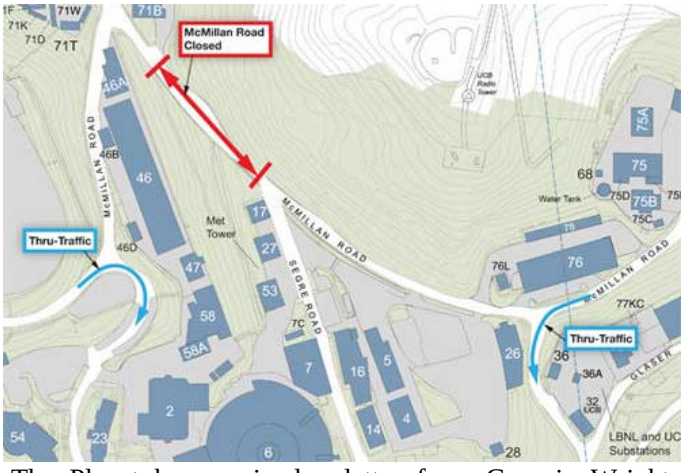
Professor Warned of Berkeley Lab Slide Risk

By Becky O'Malley
Wednesday January 16, 2013 - 03:14:00 PM

The Berkeley Lab (formerly known as Lawrence Berkeley National Laboratory) reported on its website that "consistent rain over the last few months has destabilized the hillside above McMillan Road between Buildings 17 and 71. The hillside continues to inch toward the road, which has been closed as a precaution. A potential landslide warrants the road closure and relocation of Building 46 occupants."

The site is in Strawberry Canyon, in the hills above the University of California at Berkeley campus, where new Berkeley Lab expansion building projects are now in progress.

Unstable Hillside Affects Traffic, Shuttles, Building 46



The Planet has received a letter from Georgia Wright pointing out that the late Geology Professor Garniss Curtis had warned that building the original laboratory in this area

was risky, and that future construction would also be problematical. Wright is the producer of a pair of short videos which focus on Curtis' analysis.

In her letter, she says that "the recent landslide is evidently on the site of the slide in 1974, a topic in the video *'The Fault: Quakes, Slides, and the Lawrence Berkeley Lab.'*

"Prof. Garniss Curtis, who died on December 19, 2011, was interviewed about the geology of the Lab site. He had written the Regents in 2008, warning them not to build on the hill."

Her videos can be found online:

1. The 5-minute version: http://www.youtube.com/watch?v=8FOmckAHpes

2. The 10-minute version: http://www.youtube.com/watch?v=0_e8C5FGsfM

Professor Curtis' Letter

May 11, 2008

To: Regents University of California C/o Anne Shaw, Associate Secretary Regents of the University of California

From: Professor Emeritus Garniss H. Curtis Department Earth and Planetary Science University of California, Berkeley

Re: Certification of Final Environmental Impact Reports for Proposed Computational Research and Theory Facility and Helios Energy Resources Facility and Project Approvals

Dear Ladies and Sirs:

As the request for my geologic opinion on the advisability of constructing large buildings in the lower part of Strawberry Canyon and in the next canyon to the north known as Blackberry Canyon came to me on May 4th, I have to be brief and rely on my memory. I shall first say as strongly as I can absolutely do not construct any buildings in those two canyons, then I shall go into the reason based on the work I did as consultant to Mr. Ben Lennart 25 to 35 years ago who was contracted by the University to investigate a number of sites for possible constructions or for stopping land slides that were threatening buildings.

First, the geologic setting of the two areas: The active Hayward Fault goes across the mouths of both canyons. Further east, the Wildcat Canyon fault parallels the Hayward Fault behind the Botanical Gardens and northward joins the Hayward near the town of San Pablo. Southward the Wildcat Canyon fault can be easily traced to Sibley Park and beyond. A few small epicenters lie along this fault near its junction with the Hayward, but it does not seem to be active elsewhere to the south. However, in the past the area between the two streams and the two faults which includes the whole of the Lawrence Laboratory complex lay four miles to the south next to Sibley Park. The volcanic rocks in both areas have potassium-argon dates of approximately 10 million years, and the rhyolite found in both of them is the same rhyolite. The volcanic rocks underlying most of the Lawrence Lab complex fill an old crater, a collapse caldera. The old volcano that once rose above these rocks collapsed after the expulsion of a very large amount of rhyolite ash, now largely removed by erosion. The volcanic rocks broke up as the collapse occurred and many show crushing and deformation and are mixed with large amounts of ash and volcanic fragmental debris. This material should never have been built on, as it is so clay-rich and unconsolidated. The western rim of this caldera is easily traced from its arcuate shape that is cut off by the Wildcat Canyon not far from the Merry-go-Round in Tilden Park. The boundary rocks to the west are sandstones and shales thought to be of Cretaceous age, that is, they are older than 65 million years.

Exposures of these sandstones and shales are good below Building 50 down to Bowles Hall, and they dip westward at angles of 20 to 25 degrees, about which more later. The Hayward Fault passes very close to the rear of Bowles Hall after going through the Stadium where it has caused major deformation of the support pillars and offset of the two sides of the Stadium since its construction in 1927.

Behind Hearst Mining Building and a few feet to the east, is the Lawson Adit that is a tunnel going eastward. Begun in the 1920s or earlier, it was completed in 1938 when it reached the Hayward Fault. Professor George Louderback told me (personal communication) that it was not an ordinary fault gouge that he found in the Hayward Fault zone but a peculiar mixture of serpentine and metamorphic rocks that also appear on the surface and underlie Stern Hall and part of Foothill Student Housing. Founders Rock near the corner of Hearst and Gayley Road is in this melange. Also in the tunnel are several exposures of the offset of Strawberry Creek as determined from the contained rounded cobbles of Strawberry Canyon origin. Thus this indicates a displacement of more than 600 feet north along the Hayward Fault.

Still further north along the Hayward all the way to San Pablo huge amounts of the melange similar to that in the Lawson Adit have been squeezed out of the Hayward Fault and are gradually sliding down the slope below the fault. Much of this melange has reached the bottom of the hill back of El Cerrito. Along the Arlington many houses built on this melange are sliding and have caused a great number of legal problems. Within the fault itself no movement can the detected in these deposits, some of which are more than 100 feet thick. Thus we believe that movement and expulsion of this melange takes place during major earthquakes on the Hayward Fault.

A great deal of research has been done recently on the Hayward Fault by the USGS at Menlo Park, which was reported in a talk on the last Thursday of this past April. They have established a return time of major quakes of 6.5-7 magnitudes on the Hayward Fault of 130 years. The last major quake along the northern part of the Hayward Fault was 140 years ago, so we are over-due. They estimate that there is approximately a 65 percent chance a major quake will occur in the next 30 years.

Lennart was able to get survey notes from East Bay Municipal Utility District for the San Pablo Dam water tunnel to El Cerrito which crosses the Hayward Fault and shows that the right lateral horizontal movement of approximately one centimeter per year is matched by uplift of the east side of the fault of approximately one centimeter per year also. So, with the evidence of the horizontal displacement of the old Strawberry Creek of 600 feet horizontally along Galey Road, the Cretaceous sedimentary rocks east of the Hayward Fault there have also risen 600 feet. Building 50(?) sits on these Cretaceous strata, which, as mentioned dip westward 20-25 degrees. If an earthquake occurs when these beds are soaked with winter rains the chance of a major landslide are great along the slippage planes of shale dipping westward. Minor slides have already occurred in these beds behind Bowles Hall. Indeed, the Foothill Student Housing was planned to be built there until I called attention to the landslide. A major landslide would probably destroy all the buildings on both sides of Galey Road from the Stadium to the buildings on both sides of Hearst Avenue and would probably reach Dow Library, destroying everything in its path to that point and possibly beyond. Buildings in the lower parts of both Strawberry and Blackberry Canyons would be buried if not destroyed.

Major landslides of the type I have described here are not rare along the Hayward Fault as was shown to us during our study of the Hayward Fault at the base of the hill behind the Clark Kerr Campus. We discovered that most of the campus was underlain by a large landslide that had originated in Claremont Canyon, and was gradually moved northward along the Hayward Fault. Trenches and drill holes showed this landslide to be up to 30 feet thick. It extends westward to and possibly beyond Piedmont Avenue. Further south is a huge landslide that underlies most of the campus of Mills College and extends westward another quarter mile. Still further south are more large slides that have originated in canyons and steep slopes east of the Hayward Fault. As the hills rise and become unstable, earthquakes cause them to break loose and slide. Very few large slides have occurred on the eastern slopes of the Berkeley Hills; hence the relationship to earthquakes of major land slides close to the Hayward Fault along the western slopes of the Berkeley Hills. Normal erosion rounds off unstable areas on the eastern slope of the Berkeley Hills before they break loose and slide.

Most of the buildings of the Lawrence Laboratory are on the unstable ground filling the old caldera particularly the Bevatron and associated buildings. As the Cretaceous beds immediately west of these buildings have been eroded away there is nothing to keep these soft caldera-filled beds from sliding. The buildings on them will certainly move a few feet in a major earthquake if not hundreds of feet. Keep in mind the Loma Prieta quake of 1989 of magnitude 6.9 which from a distance of over 60 miles destroyed a section of the Bay Bridge, as section of the overhead freeway in Oakland killing 63 people, and many houses on filled ground in the Marina of northern San Francisco some 70 miles from the quake!

Major buildings of any kind should not be constructed in either of these canyons bordering this huge block of unstable rock.

Professor Emeritus Garniss H. Curtis Dept. Earth and Planetary Science University of California, Berkeley For: Regents University of California, May 11, 2008.

The Impacts of Impacts: Aspects of Catastrophic Climate and Ecological Changes by Asteroid Impact (Part 3)

*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 Part 1, I discussed current dinosaur extinction theory from the Cretaceous-Tertiary (K-T) boundary layer based on findings by Drs. Louis and Walter Alvarez and their colleagues. In Part 2, I reviewed some of the evidence and probable effects of the Chicxulub asteroid impact. What is the importance of understanding the environmental/envirochemical effects of asteroid/comet impacts? There are several:

(1) **Understanding Global Extinction Events**: Global extinction events by impact are rare, perhaps now occurring on the order of 50 to 100 million year intervals. However, smaller impacts occur on a millennium basis (e.g., Barringer or Meteor Crater in Arizona, a 1,200 m wide crater produced by a 50 m wide iron-nickel meteorite) and on a century basis (e.g., on March 3, 2009, a 20 to 50 m wide meteor – 209 DD45) passed at an altitude of 72,000 km over the south Pacific. Impact by an object of this size is believed to have flattened about 2,000 km^2 of Siberian forest in 1908 (the Tunguska Event) with an explosive force of 10 to15 Mt_{TNT} (about the size of a thermonuclear bomb).

(2) **Environmental effects of smaller impacts** that are perhaps 50% of the size of the K-T event (i.e., 5 km diameter asteroids and assuming that they are singular and not multiple impacts) – may have immediate disastrous effects on civilization, including devastation from tsunamis (if the impact is oceanic), regional fires with associated soot and polycyclic aromatic hydrocarbon (PAH) contamination, immediate and drastic global climate change, perhaps resulting in a "nuclear" winter from the input of dust and SO_2 aerosols, subsequent global warming from large CO_2 inputs, and ozone destruction. These effects would drastically affect agriculture: first from a nuclear winter by abrupt cooling and then from accelerated global warming from CO_2 when SO_2 aerosols settle out of the atmosphere. If the impact(s) occurred near a coastal urban area such as New York or Los Angeles, the immediate devastation from impact-derived tsunamis would be

enormous and would also have extensive global consequences. Most likely modern human civilization would cease.

(3) **Long term environmental effects** on Earth's ecology would occur perhaps lasting decades to centuries on the short end of the time scale to tens of millennia on the long end. If the impactor is similar in size to the K-T asteroid, such ecological devastation could last up to 1,000 centuries.

How do we prepare for such an event and is there anything that we can we do to prevent such a disaster from occurring? According to Astronaut Russell L. Schweikart, Chairman of the B612 Foundation (www.b612foundation.org) we now have the capability to anticipate and prevent an asteroid impact. First we must detect and catalog more than 500,000 near earth objects (NEOs) over the next 15 years; then the space-faring nations must conduct mission planning for manned/unmanned spacecraft to intersect and divert potential impactors.

To paraphrase Sun Tsu (*The Art of War*): "…know thine enemy." In this case the enemy consists of various types of rock and metal asteroids hurtling toward the earth. We currently do not have a great amount of knowledge of the composition of the asteroid belt (which mostly lies between the orbits of Mars and Jupiter). Only a few dedicated robotic missions have occurred (i.e., Mathilde and Eros) to investigate the asteroid belt; therefore, we have to rely on other sources to determine asteroid compositions.

Meteorites may reflect some asteroid compositions because asteroid collision fragments have been inserted into Earth's orbit; however, meteorite sources also include those of other origins such as ejecta from asteroid impacts on other planets and satellites (e.g., Mars and the Moon) where the ejecta had escaped back into space, comets from the Oort Cloud and Kuiper Belt, and interstellar debris. Meteorite compositions and classifications are quite complicated; most are silica rich (rocky materials with some metals) consisting of chondrites (those that have been heated), achondrites (those that have been melted and differentiated), stony irons composed of metals (i.e., iron with nickel ranging from 5 to 20%) and accessory phases such as sulfide minerals, and metallic iron.

More important are meteorite densities: measured chondrite bulk densities range from 1.58 to 3.75 g/cm^3. Stony irons have higher densities (4.16 to 4.22 g/cm^3), pallasites have even higher bulk densities (4.82 to 4.97 g/cm^3) because they contain significant amounts of metallic iron, and iron meteorites tend to have the highest bulk densities (6.99 to 7.59 g/cm^3). Densities are important because the chondrites and achondrites can be easily crushed (with laboratory crushing strengths of 1 to 10 bars), whereas the metallic meteorites are extremely strong (with strength of about 3.5 kbars) and are ductile. The latter compositions may be difficult to destroy with even nuclear explosives.

Asteroid compositions are even more difficult to determine with most categorized by instrument-based spectroscopy (with visual spectra ranging from ~0.4 to ~0.9 – 1.1 μm) and reflectivity (visual albedo, when available and radar returns). There are about 20 asteroid classes, grouped into C-Type (carbonaceous), S-type (siliceous or stony and stony-iron), and M-type (metallic). However, M-type asteroids have virtually no reflectance and are difficult to detect; and these are the ones that we are most concerned with because of their high densities.

Once NEOs have been cataloged and their compositions and densities have been determined, then mission plans to intersect these bodies can be implemented. These may range from (1) destruction strategies including the use of conventional or atomic explosives or (2) deflection strategies such as gravitational tugs and changing the NEO's albedo, planting of solar sails, or installing rocket motors to change the NEOs orbit. If the NEO is detected and approaches from Earth's night side, we may have sufficient preparation time; if it is detected and approaches from the Sun, we may not.

Lest you think that all of this is science fiction or conjecture, Apophis is a NEO, approximately 240 m in diameter with a mass of 1.7 x 10^{10} kg. Discovered in 2004, it will first approach Earth in 2029 at a distance of ~29,400 km (18,300 mi). There is a small probability of impact (~2.7%) in 2029. However, it may miss Earth by passing through a gravitational keyhole ~600 m across. If that occurs then a future impact could then occur on April 13, 2036. As of October 7, 2009, the impact probability was 1:250,000). NASA has calculated an impact release of 510 Mt_{TNT} (about 50 times the Barringer and Tunguska events).

It would be ironic if the "cosmic cannonballs" that caused the extinction of so many species, also enabled the rise of sentient specie that could anticipate and prevent its own destruction. Perhaps the dinosaurs did not die in vain.

(Note: an excellent review of the Chicxulub asteroid impact was just recently published by Schulte, et al., in the March 5, 2010 issue of *Science*, v. 327, pp. 1214-1218.)

Bees Underwent Massive Extinctions When Dinosaurs Did

Oct. 24, 2013 — For the first time ever, scientists have documented a widespread extinction of bees that occurred 65 million years ago, concurrent with the massive event that wiped out land dinosaurs and many flowering plants. Their findings, published this week in the journal *PLOS ONE*, could shed light on the current decline in bee species.

Lead author Sandra Rehan, an assistant professor of biological sciences at UNH, worked with colleagues Michael Schwarz at Australia's Flinders University and Remko Leys at the South Australia Museum to model a mass extinction in bee group Xylocopinae, or carpenter bees, at the end of the Cretaceous and beginning of the Paleogene eras, known as the K-T boundary.

Previous studies have suggested a widespread extinction among flowering plants at the K-T boundary, and it's long been assumed that the bees who depended upon those plants would have met the same fate. Yet unlike the

dinosaurs, "there is a relatively poor fossil record of bees," says Rehan, making the confirmation of such an extinction difficult.

Rehan and colleagues overcame the lack of fossil evidence for bees with a technique called molecular phylogenetics. Analyzing DNA sequences of four "tribes" of 230 species of carpenter bees from every continent except Antarctica for insight into evolutionary relationships, the researchers began to see patterns consistent with a mass extinction. Combining fossil records with the DNA analysis, the researchers could introduce time into the equation, learning not only how the bees are related but also how old they are.

"The data told us something major was happening in four different groups of bees at the same time," says Rehan, of UNH's College of Life Sciences and Agriculture. "And it happened to be the same time as the dinosaurs went extinct."

While much of Rehan's work involves behavioral observation of bees native to the northeast of North America, this research taps the computer-heavy bioinformatics side of her research, assembling genomic data to elucidate similarities and differences among the various species over time. Marrying observations from the field with genomic data, she says, paints a fuller picture of these bees' behaviors over time.

"If you could tell their whole story, maybe people would care more about protecting them," she says. Indeed, the findings of this study have important implications for today's concern about the loss in diversity of bees, a pivotal species for agriculture and biodiversity.

"Understanding extinctions and the effects of declines in the past can help us understand the pollinator decline and the global crisis in pollinators today," Rehan says.

The article, "First evidence for a massive extinction event affecting bees close to the K-T boundary," was published in the Oct. 23, 2013 edition of PLOS ONE. Funding for the research was provided by Endeavour Research Fellowships (Rehan) and Australian Research Council Discovery Grants (Schwarz).

The University of New Hampshire, founded in 1866, is a world-class public research university with the feel of a New England liberal arts college. A land, sea, and space-grant university, UNH is the state's flagship public institution, enrolling 12,300 undergraduate and 2,200 graduate students.

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

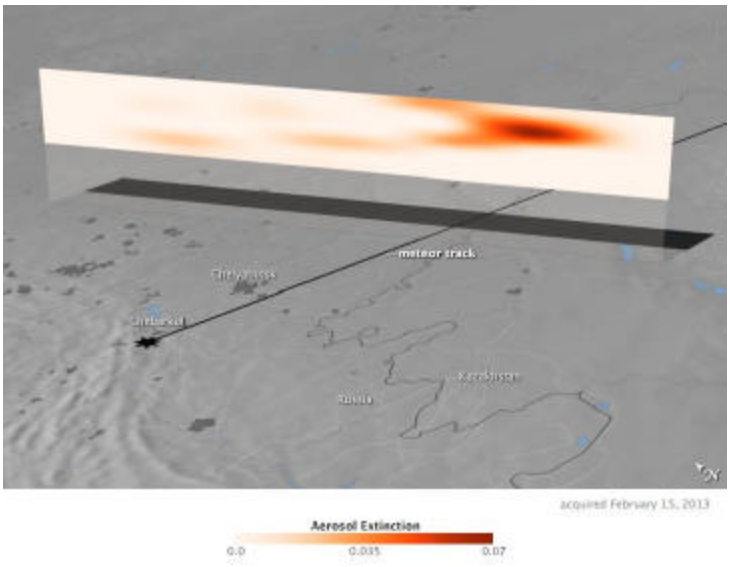
Journal Reference: Sandra M. Rehan, Remko Leys, Michael P. Schwarz. **First Evidence for a Massive Extinction Event Affecting Bees Close to the K-T Boundary**. *PLoS ONE*, 2013; 8 (10): e76683 DOI: 10.1371/journal.pone.0076683

Russian Fireball Yields Scientific Treasure Trove: Researchers Obtain Crucial Data from Meteoroid Impact

Nov. 6, 2013 — A team of NASA and international scientists for the first time have gathered a detailed understanding of the effects on Earth from a small asteroid impact.

The unprecedented data obtained as the result of the airburst of a meteoroid over the Russian city of Chelyabinsk on Feb. 15, 2013, has revolutionized scientists' understanding of this natural phenomenon.

The Chelyabinsk incident was well observed by citizen cameras and other assets. This provided a unique opportunity for researchers to calibrate the event, with implications for the study of near-Earth objects (NEOs) and developing hazard mitigation strategies for planetary defense. Scientists from nine countries have now established a new benchmark for future asteroid impact modeling.



Shortly after dawn on February 15, 2013, a 18-meter-wide (59 foot) meteor screamed into Earth's atmosphere at 18.6 kilometers per second (41,600 miles per hour). Burning from friction with the air, the 11,000-metric-ton space rock exploded 23.3 kilometers (14.5 miles) above Chelyabinsk, Russia. The explosion released 30 times more energy than the atomic bomb that destroyed Hiroshima. (Credit: NASA Earth Observatory image by Jesse Allen, using OMPS data from the Suomi National Polar-orbiting Partnership)

"Our goal was to understand all circumstances that resulted in the shock wave," said meteor expert Peter Jenniskens, co-lead author of a report published in the journal *Science.* Jenniskens, a meteor astronomer at NASA's Ames Research Center and the SETI Institute, participated in a field study led by Olga Popova of the Institute for Dynamics of Geospheres of the Russian Academy of Sciences in Moscow in the weeks following the event.

"It was important that we followed up with the many citizens who had firsthand accounts of the event and recorded incredible video while the experience was still fresh in their minds," said Polpova.

By calibrating the video images using the position of the stars in the night sky, Jenniskens and Popova calculated the impact speed of the meteor at 42,500 mph (19 kilometers per second). As the meteor penetrated through the atmosphere, it efficiently fragmented into pieces, peaking at 19 miles (30 kilometers) above the surface. At that point the light of the meteor appeared brighter than the sun, even for people 62 miles (100 kilometers) away.

Due to the extreme heat, many of the pieces of the debris vaporized before falling out of the orange glowing debris cloud. Scientists believe that between 9,000 to 13,000 pound (4,000 to 6,000 kilograms) of meteorites fell to the ground. This included one fragment approximately 1,400 pound (650 kilogram) recovered from Lake Chebarkul on October 16, 2013, by professional divers guided by Ural Federal University researchers.

NASA researchers participating in the 59 member consortium study suspect that the abundance of shock fractures in the rock contributed its break up in the upper atmosphere. Meteorites made available by Chelyabinsk State University researchers were analyzed to learn about the origin of the shock veins and their physical properties.

"One of these meteorites broke along one of these shock veins when we pressed on it during our analysis," said Derek Sears, a meteoriticist at Ames.

Mike Zolensky, a cosmochemist at NASA's Johnson Space Center in Houston, may have found why these shock veins (or shock fractures), were so frail. They contained layers of small iron grains just inside the vein, which had precipitated out of the glassy material when it cooled.

"There are cases where impact melt increases a meteorite's mechanical strength, but Chelyabinsk was weakened by it," said Zolensky.

The impact that created the shock veins may have occurred as long ago as 4.4 billion years. This would have been 115 million years after the formation of the solar system, according to the research team, who found that the meteorites had experienced a significant impact event at that time.

"Events that long ago affected how the Chelyabinsk meteoroid broke up in the atmosphere, influencing the damaging shockwave," said Jenniskens.

Research is being conducted to better understand the origin and nature of NEOs. These essential studies are needed to inform our approach to preparing for the potential discovery and deflection of an object on a collision course with the Earth.

NASA's recently announced asteroid initiative will be the first mission to capture and relocate an asteroid. It represents an unprecedented technological feat that will lead to new scientific discoveries and technological capabilities that will help protect our home planet.

Aside from representing a potential threat, the study of asteroids and comets represent a valuable opportunity to learn more about the origins of our solar system, the source of water on the Earth, and even the origin of organic molecules that lead to the development of life.

For more information about the Chelyabinsk field study visit: http://cams.seti.org/index-chelyabinsk.html

For more information on asteroids and comets, visit: http://www.nasa.gov/mission_pages/asteroids/main/

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

Scientists Solve Mystery of Odd Patterns of Oxygen in Solar System's Earliest Rocks

Oct. 24, 2013 — Cosmochemists have solved a long standing mystery in the formation of the solar system: Oxygen, the most abundant element in Earth's crust, follows a strange, anomalous pattern in the oldest, most pristine rocks, one that must result from a different chemical process than the well-understood reactions that form minerals containing oxygen on Earth.

"Whatever the source of the anomaly must be a major process in the formation of the solar system, but it has remained a matter of contention," said Mark Thiemens, dean of the University of California, San Diego's division of physical sciences and professor of chemistry. "Our experiments essentially recreate the early solar system in that they take gas phase molecules and make a solid, a silicate that is essentially the building block of planets."

By re-creating conditions in the solar nebula, the swirl of gas that coalesced to form our star, the planets and the remnant rocky debris that circles the Sun as asteroids, the researchers demonstrated that a simple chemical reaction, governed by known physical principles, can generate silicate dust with oxygen anomalies that match those found in the oldest rocks in the solar system, they report in the early online edition of *Science* October 24.

Scientists first noted the discrepancy forty years ago in a stony meteorite that exploded over Pueblito de Allende, Mexico, and it has been confirmed in other meteorites as well. These stony meteorites, asteroids that fell to Earth, are some of the oldest objects in the solar system, believed to have formed nearly 4.6 billion years ago with the solar nebula's first million years. The mix between oxygen-16, the most abundant form with one neutron for each proton, and variants with an extra neutron or two, is strikingly different from that seen in terrestrial rocks from Earth, its moon and Mars.

"Oxygen isotopes in meteorites are hugely different from those of the terrestrial planets," said Subrata Chakraborty, a project scientist in chemistry at UC San Diego and the lead author of the report. "With oxygen being the third most abundant element in the universe and one of the major rock forming elements, this variation among different solar

system bodies is a puzzle that must be solved to understand how the solar system formed and evolved."

Oxygen isotopes usually sort out according to mass: oxygen-17, with just one extra neutron, is incorporated into molecules half as often as oxygen-18, with two extra neutrons. In these stony meteorites though, the two heavier oxygen isotopes show up in equal proportions. The rates at which they are incorporated into minerals forming these earliest rocks was independent of their masses. Thiemens and John Heidenreich demonstrated such mass-independent fractionation of oxygen isotopes in the formation of ozone thirty years ago, but the mechanism for a similar process in forming the solid building blocks of rocks has not be demonstrated experimentally before now.

Indeed, several competing ideas have been put forth as potential explanations for the anomaly. Some have suggested that the mix of oxygen isotopes was different back when the earliest solid matter in the solar system formed, perhaps enriched by matter blasted in from a nearby supernova. Others had proposed a photochemical effect called self-shielding, which this team has previously ruled out. The last-standing idea was that a physical chemical principle called symmetry could account for the observed patterns of oxygen isotopes.

To test that idea, Chakraborty filled a hockey puck sized chamber with pure oxygen, varying amounts of pure hydrogen and a little black nugget of solid silicon monoxide. He used a laser to vaporize a plume of silicon monoxide gas into the mix. These are ingredients seen by radiotelescopes in instellar clouds, the starting point for our solar system.

The silicon monoxide gas reacted with the oxygen and hydrogen to form silicon dioxide, a solid that settled as dust in the chamber and is the basis of silicate minerals like quartz that are so prevalent in the crust of Earth. These reactions of gases formed the earliest solid materials in the solar system.

When Chakraborty and Petia Yanchulova, a physics student and co-author of the paper, collected and analyzed the dust, they saw a mix of oxygen isotopes that matched the anomalous pattern found in stony meteorites. The degree of the anomaly scaled with the percentage of the atmosphere that was hydrogen, an observation that points to a reaction governed by symmetry.

"No mattter what else happened early on in the nebula, this is the last step in making the first rocks from scratch," Thiemens said. "We've shown that you don't need a magic recipe to generate this oxygen anomaly. It's just a simple feature of physical chemistry."

Story Source: The above story is based on materials provided by University of California - San Diego. The original article was written by Susan Brown.

Journal Reference: Subrata Chakraborty, Petia Yanchulova, and Mark H. Thiemens. **Mass-Independent Oxygen Isotopic Partitioning During Gas-Phase SiO2 Formation**. *Science*, 25 October 2013: 463-466 DOI: 10.1126/science.1242237

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

Tell-Tale Toes Point to Oldest-Known Fossil Bird Tracks from Australia

Oct. 28, 2013 — Two fossilized footprints found at Dinosaur Cove in Victoria, Australia, were likely made by birds during the Early Cretaceous, making them the oldest known bird tracks in Australia.

The Cretaceous bird tracks were found on a slab of sandstone. (Credit: Photo by Alan Tait)

The journal *Palaeontology* is publishing an analysis of the footprints led by Anthony Martin, a paleontologist at Emory University in Atlanta who specializes in trace fossils, which include tracks, burrows and nests. The study was co-authored by Patricia Vickers-Rich and Michael Hall of Monash University in Victoria and Thomas Rich of the Museum Victoria in Melbourne.

Much of the rocky coastal strata of Dinosaur Cove in southern Victoria were formed in river valleys in a polar climate during the Early Cretaceous. A great rift valley formed as the ancient supercontinent Gondwana broke up and Australia separated from Antarctica.

"These tracks are evidence that we had sizeable, flying birds living alongside other kinds of dinosaurs on these polar, river floodplains, about 105 million years ago," Martin says.

The thin-toed tracks in fluvial sandstone were likely made by two individual birds that were about the size of a great egret or a small heron, Martin says. Rear-pointing toes helped distinguish the tracks as avian, as opposed to a third nearby fossil track that was discovered at the same time, made by a non-avian theropod.

A long drag mark on one of the two bird tracks particularly interested Martin.

"I immediately knew what it was -- a flight landing track -- because I've seen many similar tracks made by egrets and herons on the sandy beaches of Georgia," Martin says.

Martin often leads student field trips to Georgia's coast and barrier islands, where he studies modern-day tracks and other life traces, to help him better identify fossil traces.

The ancient landing track from Australia "has a beautiful skid mark from the back toe dragging in the sand, likely caused as the bird was flapping its wings and coming in for a soft landing," Martin says. Fossils of landing tracks are rare, he adds, and could add to our understanding of the evolution of flight.

Today's birds are actually modern-day dinosaurs, and share many characteristics with non-avian dinosaurs that went extinct, such as nesting and burrowing. (Martin previously discovered the trace fossils of non-avian dinosaur burrows, including at a site along the coast of Victoria.)

The theropod carnivore *Tyrannosaurus rex* had a vestigial rear toe, evidence that *T. rex* shared a common ancestor with birds. "In some dinosaur lineages, that rear toe got longer instead of shorter and made a great adaptation for perching up in trees," Martin says. "Tracks and other trace fossils offer clues to how non-avian dinosaurs and birds evolved and started occupying different ecological niches."

Dinosaur Cove has yielded a rich trove of non-avian dinosaur bones from dozens of species, but only one skeletal piece of a bird -- a fossilized wishbone -- has been found in the Cretaceous rocks of Victoria.

Martin spotted the first known dinosaur trackway of Victoria in 2010 and a few other tracks have been discovered since then. Volunteers working in Dinosaur Cove found these latest tracks on a slab of rock, and Martin later analyzed them.

The tracks were made on the moist sand of a river bank, perhaps following a polar winter, after spring and summer flood waters had subsided, Martin says. "The biggest question for me," he adds, "is whether the birds that made these tracks lived at the site during the polar winter, or migrated there during the spring and summer."

One of the best records of the dinosaur-bird connection has come from discoveries in Liaoning province of Northeastern China, including fossils of non-avian dinosaurs with feathers. Samples of amber have also been found in Liaoning, containing preserved feathers from both birds and non-avian dinosaurs going back to the Cretaceous.

"In contrast, the picture of early bird evolution in the Southern Hemisphere is mostly incomplete," Martin says, "but with these tracks, it just got a little better."

Story Source: The above story is based on materials provided by Emory Health Sciences, via EurekAlert!, a service of AAAS.

Journal Reference: Anthony J. Martin, Patricia Vickers-Rich, Thomas H. Rich, Michael Hall. **Oldest known avian footprints from Australia: Eumeralla Formation (Albian), Dinosaur Cove, Victoria**. *Palaeontology*, 2013; DOI: 10.1111/pala.12082

Editors Note – Another local seismologist makes good!

Peggy Hellweg monitors world's earthquakes!

Sam Whiting
Friday, November 1, 2013
Special to The San Francisco Chronicle Magazine

On duty: We collect and provide data, report on earthquakes in Northern California, and train new seismologists and do research with the data that we collect. Our funding comes jointly from the federal government and the state, with some from the university.

On education: I grew up in Lafayette. I studied physics at UC San Diego. I needed a part-time job and got a job with a group of seismologists who needed a programmer. I was learning the science behind the programs I was writing, and that was seismology.

Peggy Hellweg is the operations manager of the Berkeley Seismological Laboratory, which is based on the UC Berkeley campus. Photo: Sam Wolson, Special To The Chronicle

On semantics: The difference between geophysics, of which seismology is a part, and regular physics, is that we seismologists don't have a lab to do experiments in. We get what the Earth gives us.

On equipment: That thing across the hall (seismograph) is only for show now. For the earthquakes we are interested in measuring, we'd need a roll of paper that is 3 miles across. Three-mile-across paper is not very convenient. We use computers now. I can display it on my screen.

On data: What you see on the paper and on the screen is data that comes from a station that was built in the 1960s in a tunnel in the Berkeley hills. It goes down to a data center then comes back up analog to the paper and digital to a program on the screen. With the equipment that we have, we can measure earthquakes on the Hayward Fault. But we can also measure a magnitude 4.5 earthquake in Japan or Tonga or India.

In a conference room on the second floor of McCone Hall at UC Berkeley sits an old-style seismograph with a mechanical pencil, ticking away as it marks tremors on a roll of white paper. Across the hall sits Peggy Hellweg, operations manager of the Berkeley Seismological Laboratory.

On location: At Memorial Stadium, we had a steel bore hole 400 feet down with wires that came up and went into a data logger box. Our recording equipment was in the north tunnel. It's basically inside the Hayward Fault. When they retrofit the stadium, they lost the bore hole. Our stuff was unrecoverable. So now they've drilled us a new bore hole at the stadium, just up the stairs from the main entrance. It's probably 500 feet down and there is a steel lid on it.

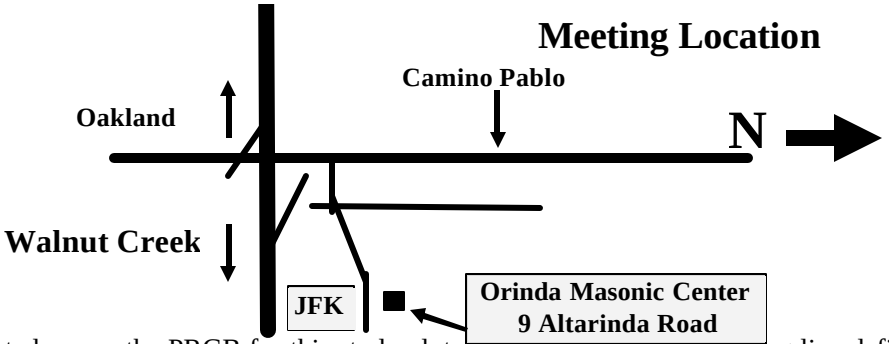
On registration: Nobody wears a pager anymore, but I do. Today, at 3:37 in the afternoon my pager went off with a magnitude 3.8. I was in a staff meeting when it went off. I said, "It's offshore of Eureka. It's not too exciting."

On excitement: Two years ago, in October, there were a couple of earthquakes that happened right here under campus, magnitude 3.9 and 3.8. One happened at about 8 in the evening during the Paul Simon concert up at the Greek Theatre. I was there sitting on the grass and got hit in my butt. A lot of people felt it. I wasn't worried. 3.8 is big enough to feel, just a little shake.

On study: There were more big earthquakes in the last 12 years than in the 12 years before. We are in an era with lots of big earthquakes. Is that significant? It's an interesting historical problem.

I'm interested in the details. Why are some earthquakes big and why are some earthquakes small?

On safety: This building (McCone Hall) is rated "life safe" only. That means I'm supposed to be able to get out with my life, in case of an earthquake, but I may be damaged by ceiling tiles that fall on my head.



collected across the PRGB for this study plot on a two-end member mixing line defined by light stable isotopes (? ^{2}H, ? ^{18}O, and ^{13}C) and conservative elements (B, Cl, Na, Li). Most hot spring waters and well waters are a mixture of the two end members, indicating that well waters include a component of geothermal water. ^{13}C ratios in the geothermal water end-members indicate that these older waters have a component of magmatic or mantle-sourced carbon.

In water wells that contain less than 15% geothermal water, water quality is acceptable. Water wells that contain from 15% to 50% geothermal water can have high Fe, Mn, and NH4 and require treatment. Water wells that have >50% geothermal water have high H_2S and are unpotable. On the east side of the basin, water wells west of the San Juan and Red Hills faults have high levels of Cl, B, and Na, similar in chemistry to the Paso Robles geothermal system but these waters are not thermal. Waters from the geothermal reservoir could be used to substantially increase municipal water availability, as long as water production was managed to limit the amount of mixing to <50%.

Biographies: **Dr. Jim Rytuba** received his B.A. in Geology in 1968 from Amherst College, and his Ph.D. in Geology in 1975 from Stanford University. After starting a gold mineral exploration program for Chevron Oil Co., he joined the U.S. Geological Survey, Menlo Park, Calif. in 1975 where he continues to work. He is a research geologist and chief of the project on unconventional REE resources in high sulfidation systems. He also conducts research of the environmental impact of historic mercury mining in California. In the past three years his research has included a study of the Paso Robles geothermal system and groundwater in collaboration with Vicki Langenheim and Daniel Goldstein.

Vicki Langenheim is a research geophysicist with the U.S. Geological Survey in Menlo Park, Calif., specializing in the application of gravity and magnetic methods to assessment of seismic hazards and groundwater resources throughout the western U.S. She received a Bachelor of Science degree in geophysics from Stanford University and a master's degree in geology from University of California, Berkeley.

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