NORTHERN CALIFORNIA GEOLOGICAL SOCIETY

MEETING ANNOUNCEMENT

DATE: **May 29, 2013** **ANNUAL DINNER MEETING!!**

LOCATION: Orinda Masonic Center, 9 Altarinda Rd., Orinda

TIME: **6:00 p.m social; 7:00 p.m. Dinner; 8:00 p.m. Talk.**
Please Watch the Early Start Time
Reservations are required by May 24, 2013
Please Note: Walk-ins Cannot Be Accommodated!
Cost: See Attached Reservation Form

SPEAKER: **Dr. David F. Blake, Principal Investigator, Mars Science Laboratory Rover Curiosity, NASA Ames Research Center**

Geological Investigations of the surface of the Mars

One of the principal goals of the Mars Science Laboratory rover Curiosity is to identify and characterize the early habitable environments of Mars, as recorded in the stratified rocks and soil of Gale crater. The suite of instruments aboard Curiosity will make measurements useful for determining the presence and lateral/vertical distribution of hydrated phases, the mineralogy and "preservation potential" of sediments and rocks, and the identity and isotopic composition of volatiles, organics, and other carbon-containing molecules, should they be present.

Curiosity's mast and arm instruments allow it to perform essentially the same functions as a field geologist would on Earth. Once a location is characterized, Curiosity's sample acquisition system can deliver samples of rock or soil to the "laboratory" instruments CheMin and SAM. CheMin, a powder X-ray Diffraction /X-ray Fluorescence (pXRD/XRF) instrument, determines the quantitative mineralogy of scooped soils and powders obtained from drilled rocks. Hydrated minerals can be identified, along with whole-rock mineralogy for characterizing the environment of formation and preservation potential for organic molecules. SAM consists of a gas chromatograph – mass spectrometer (GC-MS), and a tunable laser spectrometer (TLS). SAM will accept the same powdered rock and soil samples as CheMin, and will identify and measure trace organic carbon, as well as the elemental and isotopic composition of volatiles released during heating.

The overall progress of the mission, as well as mineralogical results from an analysis of the soil of an aeolian bedform ("Rocknest soil") and from a drilled bedrock sample ("Yellowknife Bay") will be described.

….Continued on the Back….

NCGS 2012 – 2013 Calendar

May 29, 2013 **NCGS Dinner Meeting**
Geological Investigations of the surface of the Mars
Dr. David F. Blake, Principal Investigator, Mars Science Laboratory Rover Curiosity, NASA Ames Research Center

June 26, 2013
Dr. Lester McKee and Sarah Pearce, San Francisco Estuary Institute
TBA

Upcoming NCGS Events

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

Summer 2013	***Geology of the Golden Gate Headlands;*** **Dr. William Elder, Golden Gate National Recreation Area**
August 16, 17, 18, 2013 Friday – Sunday	***Lassen Volcanic National Park – a wonderland of volcanoes and thermal features*** **Dr. Patrick Muffler, U.S. Geological Survey, Geologist Emeritus**

Peninsula Geologic Society

Upcoming meetings

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

Bay Area Science

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

Association of Engineering Geologists San Francisco Section

Upcoming Events

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

USGS Evening Public Lecture Series

Evening Public Lecture Series Canceled

The U.S. Geological Survey is temporarily cancelling Evening Public Lecture Series due to travel restrictions the agency has implemented because of the federal budget sequestration.

In addition to the travel restrictions due to the sequestration, the USGS has implemented a hiring freeze; eliminated or significantly reduced participation in all scientific conferences; cancelled all non-mandatory, non-mission critical training; directed a review of contracts and grants to determine which should be delayed, re-scoped, or terminated; and may have to furlough employees for an undetermined amount of time.

Established in 1990, the USGS Evening Public Lecture Series in Menlo Park is usually held on the last Thursday of every month, and provides an opportunity for the public to meet scientists and learn first hand about USGS research and how it affects our daily lives. The lecture series provides the public with relevant, accurate, but non-technical scientific information to create a better understanding of the importance and value of "Science for a Changing World."

The last time a lecture in the Menlo Park USGS series was cancelled was September 2001, immediately after the terrorist attacks. Prior to that, the USGS canceled a lecture in November 1995 when the federal government shut down and employees were furloughed.

The USGS will re-evaluate the future of its public lecture series in Menlo Park as the budget picture becomes clearer. Please continue to check the USGS Evening Public Lecture website for updated information about the status of future lectures at http://online.wr.usgs.gov/calendar/

NORTHERN CALIFORNIA GEOLOGICAL SOCIETY

"GEOLOGY OF THE GOLDEN GATE HEADLANDS"

NCGS FIELD TRIP - Saturday June 22, 2013

Field Trip Leader:
Dr. William Elder
Golden Gate National Recreation Area, San Francisco, CA

Field Trip Director:
Tridib Guha

“Geology of the Golden Gate Headlands”

Abstract: From ancient mid-ocean ridges and hotspots, to seamounts and subduction zones and finally to roaring glacial rivers and drifting sands, learn how geology has shaped the Golden Gate headlands and provided habitat for the diverse biota of Golden Gate National Recreation Area. This field trip focuses on the rocks of the headlands just north and south of the Golden Gate. Exposed in dramatic sea cliffs, these rocks not only form a spectacular backdrop for the Golden Gate Bridge, but also provide a detailed record of Pacific basin and active margin tectonics spanning nearly 200 million years. The significance of these rocks also goes beyond the geologic story that they tell, for these and other rocks of the Franciscan Complex associated with them were central to the development of our current understanding of subduction zones processes and the mechanics of accretionary prisms. Join geologist and park ranger Will Elder for the day as we view exquisitely folded chert, ore-grade manganese beds, textbook pillow basalts, tortured serpentinite cliffs and more, while we explore and reveal stories from the past, present and future of the Golden Gate Headlands.

Biography: Dr. Will Elder has been an interpretive park ranger at Golden Gate National Recreation Area for 15 years, and before that he was a geologist and paleontologist with the U.S. Geological Survey. Will first became acquainted with the local geology as an Earth Sciences student at College of Marin and U.C. Santa Cruz. Following a stint with the geophysics group at USGS in Menlo Park, Will went to University of Colorado, where his dissertation project focused on a major marine extinction that occurred 100 million years ago, during the warmest time in the Earth’s history. Will returned to the USGS at Menlo Park as the Mesozoic invertebrate paleontologist, where he studied many of the fossils known from the Franciscan Complex and published on a wide variety of paleontologic and sedimentologic topics. Today, Will is back thinking about a warm Earth and focusing much of his time on communicating climate change issues to the public.

THIS FIELD TRIP WILL BE LIMITED TO 40 PEOPLE
(Due to very limited parking carpool/vanpool is a must; will circulate the attendees list)

********** **Field Trip Logistics** **********

Time & Departure: June 22, 2013, 9:00 am, meeting place and attendees list will be circulated

Cost: $25/person (guidebook, lunch, refreshments, soft drinks)

**********REGISTRATION FORM (Golden Gate Headlands)**********

Name:_____ E-mail:_____

City Residence:_____ Phone: _____ Phone (alternate):_____

Lunch: Regular:_____ Vegetarian: _____ (Please check one) Check Amount: _____

Please mail a check made out to”**NCGS”** to: **Tridib Guha**
5016 Gloucester Lane,
Martinez, CA 94553

Questions: e-mail: tridibguha@yahoo.com Phone: (925) 370-0685 (evening) (925) 451-1999 (day)

NORTHERN CALIFORNIA GEOLOGICAL SOCIETY

NCGS DINNER MEETING

"RESULTS FROM THE MARS SCIENCE LABORATORY ROVER CURIOSITY's GEOLOGICAL INVESTIGATIONS OF THE SURFACE OF MARS"

Speaker

Dr. David F. Blake, Principal Investigator

Mars Science Laboratory Rover Curiosity

NASA Ames Research Center

Wednesday May 29, 2013

6:00 PM at Orinda Masonic Center

(Reservations are required by May 24, 2013, Limit 100 persons)

We are sorry but we will not be able to accommodate "walk-ins"

Stepping out of our normal routine, the **Northern California Geological Society** is pleased to announce this *special dinner and evening* with **Dr. David Blake**. For this unique event, planned for our normal monthly meeting date, but starting one-half hour early, we are planning in typical NCGS style, a **Back Forty Texas BBQ dinner consisting of Pork Ribs and BBQ Chicken, Tossed Green Salad, BBQ Beans, Fresh Corn Cobettes. For vegetarian dinners a deluxe veggie burger will be served in place of BBQ. Desert will include assorted cookies and brownies. We may be again serving wines from California specials (90 pts +).** Please also note that a vegetarian option is available if notified ahead (please see the registration form below).

Abstract: Geological Investigations of the surface of the Mars

One of the principal goals of the Mars Science Laboratory rover Curiosity is to identify and characterize the early habitable environments of Mars, as recorded in the stratified rocks and soil of Gale crater. The suite of instruments aboard Curiosity will make measurements useful for determining the presence and lateral/vertical distribution of hydrated phases, the mineralogy and "preservation potential" of sediments and rocks, and the identity and isotopic composition of volatiles, organics, and other carbon-containing molecules, should they be present.

Curiosity's mast and arm instruments allow it to perform essentially the same functions as a field geologist would on Earth. Once a location is characterized, Curiosity's sample acquisition system can deliver samples of rock or soil to the "laboratory" instruments CheMin and SAM. CheMin, a powder X-ray Diffraction /X-ray Fluorescence (pXRD/XRF) instrument, determines the quantitative mineralogy of scooped soils and powders obtained from drilled rocks. Hydrated minerals can be identified, along with whole-rock mineralogy for characterizing the environment of formation and preservation potential for organic molecules. SAM consists of a gas chromatograph – mass spectrometer (GC-MS), and a tunable laser spectrometer (TLS). SAM will accept the same powdered rock and soil samples as CheMin, and will identify and measure trace organic carbon, as well as the elemental and isotopic composition of volatiles released during heating.

The overall progress of the mission, as well as mineralogical results from an analysis of the soil of an aeolian bedform ("Rocknest soil") and from a drilled bedrock sample ("Yellowknife Bay") will be described.

Speaker Biography:

Dr. David Blake is the Principal Investigator of the CheMin XRD/XRF instrument on the Mars Science Laboratory rover Curiosity, and is a member of the Principal Science Group that directs the activities of Curiosity during its 2-year mission.

He came to Ames Research Center as a NRC postdoctoral fellow, and became a research scientist in the Exobiology Branch at Ames in 1989. He was the Exobiology Branch Chief from 2000-2004. In nearly 25 years of research at Ames, he has studied astrophysical ices, interplanetary dust, Mars meteorites, lunar soils and stratopheric roots. He received a B.S.in Biological Sciences from Stanford University in 1973. After a stint in the US Navy, he attended graduate school at the University of Michigan, where he received a PhD in Geology & Mineralogy in 1983.

********** **Dinner Logistics** **********

Meeting Details: Social Hour: 6:00 – 7:00 pm; Dinner: 7:00 – 8:00 pm **Presentation**: 8:00 – open

Time: May 29, 2013, 6:00 pm, Orinda Masonic Center 9 Altarinda Road, Orinda, CA. **Cost**: **$25/person**

**********REGISTRATION FORM (Dr. David Blake's Dinner) **********

Name:_____ E-mail:_____

Phone (day):_____ Phone (cell) _____

Dinner: Regular:_____ Vegetarian: _____ (Please check one) Check Amount:

Please mail a check made out to **NCGS** to: **Tridib Guha**
5016 Gloucester Lane
Martinez, CA 94553

Questions: e-mail: tridibguha@yahoo.com Phone: (925) 451-1999

A Comet, Not an Asteroid, May Have Killed the Dinosaurs, Experts Propose

In a geological moment about 66 million years ago, something killed off almost all the dinosaurs and some 70 percent of all other species living on Earth. Only those dinosaurs related to birds appear to have survived. Most scientists agree that the culprit in this extinction was extraterrestrial, and the prevailing opinion has been that the party crasher was an asteroid.

Not so, say two Dartmouth researchers. Professors Jason Moore and Mukul Sharma of the Department of Earth Sciences favor another explanation, asserting that a high-velocity comet led to the demise of the dinosaurs.

Recently, asteroids have been in the headlines. On February 15, 2013, an asteroid exploded in the skies over Siberia. Later that day, another swept past Earth in what some regard as a close call -- just 17,000 miles away.

The asteroid impact theory of extinction began with discoveries by the late physicist and Nobel Laureate Luis Alvarez and his son, the geologist Walter Alvarez, a professor at the University of California, Berkeley. In 1980 they identified extremely high concentrations of the element iridium in a layer of rock known as the K-Pg (formerly called K-T) boundary. The layer marks the end of the Cretaceous period (abbreviated "K"), the epoch of the dinosaurs, and the beginning of the Paleogene period, with its notable absence of the large lizards.

While iridium is rare in Earth's crust, it is a common trace element in rocky space debris such as asteroids. Based on the elevated levels of iridium found worldwide in the boundary layer, the Alvarezes suggested that this signaled a major asteroid strike around the time of the K-Pg boundary -- about 66 million years ago. Debate surrounded their theory until 2010, when a panel of 41 scientists published a report in support of the Alvarezes' theory. The panel confirmed that a major asteroid impact had occurred at the K-Pg boundary and was responsible for mass extinctions.

The scientific community today looks to the deeply buried and partially submerged, 110-mile wide Chicxulub crater in Mexico's Yucatán as the place where the death-dealing asteroid landed. The 66-million-year age of Chicxulub, discovered in 1990, coincides with the KT boundary, leading to the conclusion that what caused the crater also wiped out the dinosaurs.

Moore and Sharma do agree with fellow scientists that Chicxulub was the impact zone, but dispute the characterization of the object from space as an asteroid. In a paper presented to the 44th Lunar and Planetary Conference on March 22, 2013, they described their somewhat controversial findings.

Moore notes that in the past geochemists toiled away, isolated from their geophysicist colleagues, each focused on his or her particular area of expertise. "There hadn't been a concerted synthesis of all the data from these two camps," says Moore. "That's what we've tried to do."

The Dartmouth duo compiled all the published data on iridium from the K-Pg boundary. They also included the K-Pg data on osmium -- another element common in space rock. In sifting through all this they found a wide range of variability, so consequently kept only the figures they demonstrated to be most reliable. "Because we are bringing a fresh set of eyes into this field, we feel our decisions are objective and unbiased," says Sharma.

For example, they deleted data drawn from deep ocean cores where there were very high amounts of iridium. "We discovered that even then there was a huge variation. It was much worse in the oceans than on the continents," Sharma said. "We figured out that the oceanic variations are likely caused by preferential concentration of iridium bearing minerals in marine sediments."

In the final analysis, the overall trace element levels were much lower than those that scientists had been using for decades and being this low weakened the argument for an asteroid impact explanation. However, a comet explanation reconciles the conflicting evidence of a huge impact crater with the revised, lower iridium/osmium levels at the K-Pg boundary.

"We are proposing a comet because that conclusion hits a 'sweet spot.' Comets have a lower percentage of iridium and osmium than asteroids, relative to their mass, yet a high-velocity comet would have sufficient energy to create a 110-mile-wide crater," says Moore. "Comets travel much faster than asteroids, so they have more energy on impact, which in combination with their being partially ice means they are not contributing as much iridium or osmium."

Moore attributes much of the early resistance to a comet impact theory to a lack of knowledge about comets in general. "We weren't certain whether they were dirty snowballs or icy dirt balls," he says. "Today, we are inclined toward the icy dirt ball description."

Comet composition and physical structure were unknown, but with the advent of NASA missions to comets like "Deep Impact" in 2010, a much larger database has been developed. "We now have a much better understanding of what a comet may be like and it is still consistent with the K-Pg boundary data we are seeing," Moore adds.

Sharma says that, "In synthesizing the data generated by two very disparate fields of research -- geochemistry and geophysics -- we are now 99.9 percent sure that what we are dealing with is a 66-million-year-old comet impact -- not an asteroid."

Story Source: The above story is reprinted from materials provided by Dartmouth College, via EurekAlert!, a service of AAAS.

New Evidence Ancient Asteroid Caused Global Firestorm On Earth

A new look at conditions after a Manhattan-sized asteroid slammed into a region of Mexico in the dinosaur days indicates the event could have triggered a global firestorm that would have burned every twig, bush and tree on Earth and led to the extinction of 80 percent of all Earth's species, says a new University of Colorado Boulder study.

Led by Douglas Robertson of the Cooperative Institute for Research in Environmental Sciences, or CIRES, the team used models that show the collision would have vaporized huge amounts of rock that were then blown high above Earth's atmosphere. The re-entering ejected material would have heated the upper atmosphere enough to glow red for several hours at roughly 2,700 degrees Fahrenheit -- about the temperature of an oven broiler element -- killing every living thing not sheltered underground or underwater.

The CU-led team developed an alternate explanation for the fact that there is little charcoal found at the Cretaceous-Paleogene, or K-Pg, boundary some 66 million years ago when the asteroid struck Earth and the cataclysmic fires are believed to have occurred. The CU researchers found that similar studies had corrected their data for changing sedimentation rates. When the charcoal data were corrected for the same changing sedimentation rates they show an excess of charcoal, not a deficiency, Robertson said.

"Our data show the conditions back then are consistent with widespread fires across the planet," said Robertson, a research scientist at CIRES, which is a joint institute of CU-Boulder and the National Oceanic and Atmospheric Administration. "Those conditions resulted in 100 percent extinction rates for about 80 percent of all life on Earth."

A paper on the subject was published online this week in the *Journal of Geophysical Research-Biogeosciences*, a publication of the American Geophysical Union. Co-authors on the study include CIRES Interim Director William Lewis, CU Professor Brian Toon of the atmospheric and oceanic sciences department and the Laboratory for Atmospheric and Space Physics and Peter Sheehan of the Milwaukee Public Museum in Wisconsin.

Geological evidence indicates the asteroid collided with Earth about 66 million years ago and carved the Chicxulub crater in Mexico's Yucatan Peninsula that is more than 110 miles in diameter. In 2010, experts from 33 institutions worldwide issued a report that concluded the impact at Chicxulub triggered mass extinctions, including dinosaurs, at the K-Pg boundary.

The conditions leading to the global firestorm were set up by the vaporization of rock following the impact, which condensed into sand-grain-sized spheres as they rose above the atmosphere. As the ejected material re-entered Earth's atmosphere, it dumped enough heat in the upper atmosphere to trigger an infrared "heat pulse" so hot it caused the sky to glow red for several hours, even though part of the radiation was blocked from Earth by the falling material, he said.

But there was enough infrared radiation from the upper atmosphere that reached Earth's surface to create searing conditions that likely ignited tinder, including dead leaves and pine needles. If a person was on Earth back then, it would have been like sitting in a broiler oven for two or three hours, said Robertson.

The amount of energy created by the infrared radiation the day of the asteroid-Earth collision is mind-boggling, said Robertson. "It's likely that the total amount of infrared heat was equal to a 1 megaton bomb exploding every four miles over the entire Earth."

A 1-megaton hydrogen bomb has about the same explosive power as 80 Hiroshima-type nuclear bombs, he said. The asteroid-Earth collision is thought to have generated about 100 million megatons of energy, said Robertson.

Some researchers have suggested that a layer of soot found at the K-Pg boundary layer roughly 66 million years ago was created by the impact itself. But Robertson and his colleagues calculated that the amount of soot was too high to have been created during the massive impact event and was consistent with the amount that would be expected from global fires.

Story Source: The above story is reprinted from materials provided by University of Colorado at Boulder.

Journal Reference: Douglas S. Robertson, William M. Lewis, Peter M. Sheehan, Owen B. Toon. **K-Pg extinction: Reevaluation of the heat-fire hypothesis**. *Journal of Geophysical Research: Biogeosciences*, 2013; DOI: 10.1002/jgrg.20018

Dinosaur Die out Might Have Been Second of Two Closely Timed Extinctions

The most-studied mass extinction in Earth history happened 65 million years ago and is widely thought to have wiped out the dinosaurs. New University of Washington research indicates that a separate extinction came shortly before that, triggered by volcanic eruptions that warmed the planet and killed life on the ocean floor.

The well-known second event is believed to have been triggered by an asteroid at least 6 miles in diameter slamming into Mexico's Yucatán Peninsula. But new evidence shows that by the time of the asteroid impact, life on the seafloor -- mostly species of clams and snails -- was already perishing because of the effects of huge volcanic eruptions on the Deccan Plateau in what is now India.

Thomas Tobin clears sand from around the fossil of a giant ammonite he found in 2009 on James Ross Island in Antarctica. (Credit: Image courtesy of University of Washington)

"The eruptions started 300,000 to 200,000 years before the impact, and they may have lasted 100,000 years," said Thomas Tobin, a UW doctoral student in Earth and space sciences.

The eruptions would have filled the atmosphere with fine particles, called aerosols, that initially cooled the planet but, more importantly, they also would have spewed carbon dioxide and other greenhouse gases to produce long-term warming that led to the first of the two mass extinctions.

"The aerosols are active on a year to 10-year time scale, while the carbon dioxide has effects on a scale of hundreds to tens of thousands of years," Tobin said.

During the earlier extinction it was primarily life on the ocean floor that died, in contrast to the later extinction triggered by the asteroid impact, which appeared to kill many more free-swimming species.

"The species in the first event are extinct but the groups are all recognizable things you could find around on a beach today," he said.

Tobin is the lead author of a paper in the journal *Palaeogeography, Palaeoclimatology, Palaeoecology* that documents results of research conducted in a fossil-rich area on Seymour Island, off the Antarctic Peninsula.

That particular area has very thick sediment deposits and, for a given interval of time, might contain 10 times more sediment as the well-known Hell Creek Formation in Montana. That means scientists have much greater detail as they try to determine what was happening at the time, Tobin said.

The researchers took small surface core samples from rocks and fossils in the Antarctic sediment and used a method called magnetostratigraphy, employing known changes over time in Earth's magnetic field to determine when the fossils were deposited. The thicker sediment allowed dating to be done more precisely.

"I think the evidence we have from this location is indicative of two separate events, and also indicates that warming took place," Tobin said.

There is no direct evidence yet that the first extinction event had any effect on the second, but Tobin believes it is possible that surviving species from the first event were compromised enough that they were unable to survive the long-term environmental effects of the asteroid impact.

"It seems improbable to me that they are completely independent events," he said.

The paper's coauthors are Peter Ward, Tobin's doctoral adviser, and Eric Steig, both UW professors of Earth and space sciences; Eduardo Olivero of the Southern Center for Scientific Research in Argentina; Isaac Hilburn, Matthew Diamond and Joseph Kirschvink of the California Institute of Technology; Ross Mitchell of Yale University; and Timothy Raub of the University of St. Andrews in Scotland.

The work was funded by the National Science Foundation Office of Polar Programs and the National Scientific and Technological Promotion Agency in Argentina.

Story Source: The above story is reprinted from materials provided by University of Washington. The original article was written by Vince Stricherz.

Journal Reference: Thomas S. Tobin, Peter D. Ward, Eric J. Steig, Eduardo B. Olivero, Isaac A. Hilburn, Ross N. Mitchell, Matthew R. Diamond, Timothy D. Raub, Joseph L. Kirschvink. **Extinction patterns, δ^{18} O trends, and magnetostratigraphy from a southern high-latitude Cretaceous–Paleogene section: Links with Deccan volcanism**. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 2012; 350-352: 180 DOI: 10.1016/j.palaeo.2012.06.029

New Evidence Suggests Comet or Asteroid Impact Was Last Straw for Dinosaurs

The demise of the dinosaurs is the world's ultimate whodunit. Was it a comet or asteroid impact? Volcanic eruptions? Climate change?

In an attempt to resolve the issue, scientists at the Berkeley Geochronology Center (BGC), the University of California, Berkeley, and universities in the Netherlands and the United Kingdom have now determined the most precise dates yet for the dinosaur extinction 66 million years ago and for the well-known impact that occurred around the same time.

The dates are so close, the researchers say, that they now believe the comet or asteroid, if not wholly responsible for the global extinction, at least dealt the dinosaurs their death blow.

"The impact was clearly the final straw that pushed Earth past the tipping point," said Paul Renne, BGC director and UC Berkeley professor in residence of earth and planetary science. "We have shown that these events are synchronous to within a gnat's eyebrow, and therefore the impact clearly played a major role in extinctions, but it probably wasn't just the impact."

The revised dates clear up lingering confusion over whether the impact actually occurred before or after the extinction, which was characterized by the almost overnight disappearance from the fossil record of land-based dinosaurs and many ocean creatures. The new date for the impact -- 66,038,000 years ago -- is the same within error limits as the date of the extinction, said Renne, making the events simultaneous.

He and his colleagues will report their findings in the Feb. 8 issue of the journal *Science*.

The crater of doom

The extinction of the dinosaurs was first linked to a comet or asteroid impact in 1980 by the late UC Berkeley Nobel Laureate Luis Alvarez and his son, Walter, who is a UC Berkeley professor emeritus of earth and planetary science. A 110-mile-wide crater in the Caribbean off the Yucatan coast of Mexico is thought to be the result of that impact. Called Chicxulub (cheek'-she-loob), the crater is thought to have been excavated by an object six miles across that threw into the atmosphere debris still be found around the globe as glassy spheres or tektites, shocked quartz and a layer of iridium-enriched dust.

Renne's quest for a more accurate dating of the extinction began three years ago when he noticed that the existing date conflicted with other estimates of the timing of the extinction and that the existing dates for the impact and the extinction did not line up within error margins.

Renne and his BGC colleagues first went to work recalibrating and improving the existing dating method, known as the argon-argon technique. They then collected volcanic ash from the Hell Creek area in Montana and analyzed them with the recalibrated argon-argon technique to determine the date of the extinction. The formation below the extinction horizon is the source of many dinosaur fossils and one of the best sites to study the change in fossils from before and after the extinction.

They also gathered previously dated tektites from Haiti and analyzed them using the same technique to determine how long ago the impact had occurred. The new extinction and impact dates are precise to within 11,000 years, the researchers said.

"When I got started in the field, the error bars on these events were plus or minus a million years," said paleontologist William Clemens, a UC Berkeley professor emeritus of integrative biology who has led research in the Hell Creek area for more than 30 years, but was not directly involved in the study. "It's an exciting time right now, a lot of which we can attribute to the work that Paul and his colleagues are doing in refining the precision of the time scale with which we work. This allows us to integrate what we see from the fossil record with data on climate change and changes in flora and fauna that we see around us today."

Dinosaurs at the tipping point

Despite the synchronous impact and extinction, Renne cautions that this doesn't mean that the impact was the sole cause. Dramatic climate variation over the previous million years, including long cold snaps amidst a general Cretaceous hothouse environment, probably brought many creatures to the brink of extinction, and the impact kicked them over the edge.

"These precursory phenomena made the global ecosystem much more sensitive to even relatively small triggers, so that what otherwise might have been a fairly minor effect shifted the ecosystem into a new state," he said. "The impact was the coup de grace."

One cause of the climate variability could have been a sustained series of volcanic eruptions in India that

produced the extensive Deccan Traps. Renne plans to re-date those volcanic rocks to get a more precise measure of their duration and onset relative to the dinosaur extinction.

"This study shows the power of high precision geochronology," said coauthor Darren F. Mark of the Scottish Universities Environmental Research Center, who conducted independent argon-argon analyses on samples provided by Renne. "Many people think precision is just about adding another decimal place to a number. But it's far more exciting than that. It's more like getting a sharper lens on a camera. It allows us to dissect the geological record at greater resolution and piece together the sequence of Earth history."

Renne's colleagues, in addition to Mark, are UC Berkeley graduate student William S. Mitchell III; BGC scientists Alan L. Deino and Roland Mundil; Leah E. Morgan of the Scottish Universities Environmental Research Center in Kilbride, Scotland; Frederik J Hilgen of Utrecht University; and Klaudia F. Kuiper and Jan Smit of Vrije University in Amsterdam.

The work was supported by the Ann and Gordon Getty Foundation, UC Berkeley's Esper S. Larsen Jr. Fund and the National Science Foundation.

Story Source: The above story is reprinted from materials provided by University of California - Berkeley. The original article was written by Robert Sanders.

Journal References: P. R. Renne, A. L. Deino, F. J. Hilgen, K. F. Kuiper, D. F. Mark, W. S. Mitchell, L. E. Morgan, R. Mundil, J. Smit. **Time Scales of Critical Events Around the Cretaceous-Paleogene Boundary**. *Science*, 2013; 339 (6120): 684 DOI: 10.1126/science.1230492, and H. Palike. **Impact and Extinction**. *Science*, 2013; 339 (6120): 655 DOI: 10.1126/science.1233948

Congestion in Earth's Mantle: Mineralogists Explain Why Plate Tectonics Stagnates in Some Places

Earth is dynamic. What we perceive as solid ground beneath our feet, is in reality constantly changing. In the space of a year Africa and America are drifting apart at the back of the Middle Atlantic for some centimeters while the floor of the Pacific Ocean is subducted underneath the South American Continent. "In 100 million years' time Africa will be pulled apart and North Australia will be at the equator," says Prof. Dr. Falko Langenhorst from the Friedrich Schiller University Jena (Germany). Plate tectonics is leading to a permanent renewal of the ocean floors, the mineralogist explains. The gaps between the drifting slabs are being filled up by rising melt, solidifying to new oceanic crust. In other regions the slabs dive into the deep interior of Earth and mix with the surrounding Earth's mantle.

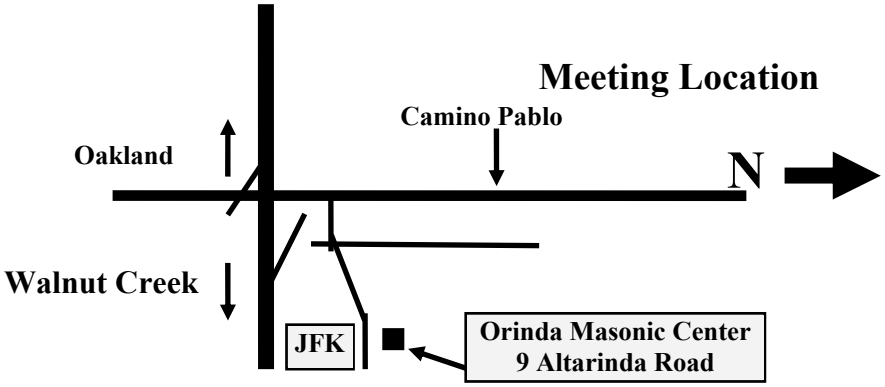
Earth is the only planet in our solar system, conducting such a 'facelift' on a regular basis. But the continuous up and down on Earth's crust doesn't run smoothly everywhere. "Seismic measurements show that in some mantle regions, where one slab is subducted underneath another one, the movement stagnates, as soon as the rocks have reached a certain depth," says Prof. Langenhorst. The causes of the 'congestion' of the subducted plate are still unknown. In the current issue of *Nature Geoscience*, Prof. Langenhorst and earth scientists of Bayreuth University now explain the phenomenon for the first time.

According to this, the rocks of the submerging ocean plate pond at a depth of 440 to 650 kilometers -- in the transition zone between the upper and the lower Earth mantle. "The reason for that can be found in the slow diffusion and transformation of mineral components," mineralogist Langenhorst explains. On the basis of high pressure experiments the scientists were able to clarify things: under the given pressure and temperature in this depth, the exchange of elements between the main minerals of the subducted ocean plate -- pyroxene and garnet -- is slowed down to an extreme extent. "The diffusion of a pyroxene-component in garnet is so slow, that the submerging rocks don't become denser and heavier, and therefore stagnate," the Jena scientist says.

Interestingly there is congestion in Earth's mantle exactly where the ocean floor submerges particularly fast into the interior of Earth. "In the Tonga rift off Japan for example, the speed of subduction is very high," Prof. Langenhorst states. Thereby the submerging rocks of the oceanic plate stay relatively cold up to great depth, which makes the exchange of elements between the mineral components exceptionally difficult. "It takes about 100 Million years for pyroxene crystals which are only 1 mm in size to diffuse into the garnet. For this amount of time the submerging plate stagnates," Langenhorst describes the rock congestion. It can probably only diffuse at the boundary of the lower Earth mantle. Because then pyroxene changes into the mineral akimotoite due to the higher pressure in the depth of 650 kilometers. "This could lead to an immediate rise in the rock density and would enable the submerging into greater depths."

Story Source: The above story is reprinted from materials provided by Friedrich-Schiller-Universitaet Jena.

Journal Reference: W. L. van Mierlo, F. Langenhorst, D. J. Frost, D. C. Rubie. **Stagnation of subducting slabs in the transition zone due to slow diffusion in majoritic garnet**. *Nature Geoscience*, 2013; DOI: 10.1038/NGEO1772



Biography: **Dr. David Blake** is the Principal Investigator of the CheMin XRD/XRF instrument on the Mars Science Laboratory rover Curiosity, and is a member of the Principal Science Group that directs the activities of Curiosity during its 2-year mission.

He came to Ames Research Center as a NRC postdoctoral fellow, and became a research scientist in the Exobiology Branch at Ames in 1989. He was the Exobiology Branch Chief from 2000-2004. In nearly 25 years of research at Ames, he has studied astrophysical ices, interplanetary dust, Mars meteorites, lunar soils and stratopheric roots. He received a B.S.in Biological Sciences from Stanford University in 1973. After a stint in the US Navy, he attended graduate school at the University of Michigan, where he received a PhD in Geology & Mineralogy in 1983.

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