NORTHERN CALIFORNIA GEOLOGICAL SOCIETY

MEETING ANNOUNCEMENT

DATE: **June 25, 2014**

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: **Jason Utas, PhD Candidate, UCLA**

Meteorites

Topics that will be covered include: A brief history of early meteoritics, chondrule/chondrite formation (latest theories), weathering in space, asteroidal heat sources, differentiation, achondrites/iron meteorites, evolving solar system structure, atmospheric passage, and hunting for meteorites.

Meteorites are the material record of the formation of the solar system. The current body of known meteorites includes rocks ranging from 4.568 billion-year-old nebular condensates to ~200 Ma Martian basalts, and fragments from the crusts, mantles, and cores of at least 50 to 100 differentiated planetesimals, most of which have since been destroyed or ejected from the solar system.

The field of meteoritics is a young one. Despite heliocentrism being proposed as early as the third century BCE, it was largely ignored until Copernicus adopted the idea in the 16th century. But an immaculate view of the solar system persisted for some time after the first asteroids were discovered in the early 19th century. In short, no one had any reason to guess that meteorites might originate beyond the Earth until 1801, with the discovery of the first asteroid. Since then, a series of technological advancements – the discovery of new elements, radioactivity, isotopes, and of novel techniques such as different methods of radiogenic dating –have rapidly accelerated our understanding in the field. Prior to 1956, we had almost no way to determine the context of any rock not found in stratigraphic relation with another.

Chondrites are a complex group of quasi-igneous rocks that formed (we're not sure exactly how) in the solar nebula, between approximately 4.568 and 4.566 billion years ago. Their shared defining feature are chondrules: small spherical 'droplets' of rocky material that formed at ~1000 – 1500 K. They are usually composed of olivine and pyroxene, with lesser amounts of feldspar and feldspathic glasses. Different chondrite classes are characterized by their bulk chemistry; we'll discuss and have a look at some examples of different types, as well as how they might have formed. Leading theories include planetary-scale impacts, nebular lightning, and magneto-gravitational interactions between planetesimals and a dense dusty nebular disk. The planets (except perhaps Mars) exhibit bulk elemental abundances that differ appreciably from every known group of meteorites. Possible reasons and evidence ….. *Continued on Page 2…*

NCGS 2012 – 2013 Calendar

June 25, 2014; 7:00 pm
Jason Utas, PhD Candidate at UCLA
Meteorites

September 24, 2014; 7:00 pm
Dr. Thomas Holzer, USGS
Catastrophic Earthquakes In a Crowded World

October 29, 2014; 7:00 pm
B. Lynn Ingram, UC Berkeley
The West without Water

November 19, 2014; 7:00 pm
Christopher Lewis
Tales of the Oil and Gas Fields and Thereabouts

May 3, 2014; NCGS Pt Lobos Field Trip Group Shot

Thanks to Ray Sullivan for Forwarding this Photo!

Peninsula Geologic Society

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

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/.

USGS Evening Public Lectures

Thursday, June 26, 2014, 7:00 p.m. PDT; USGS, Conference Room A, Bldg. 3, Menlo Park, California OR - Watch Live Online
Into the Abyss: Living without Light
Nancy Prouty, Research Oceanographer
More info: http://online.wr.usgs.gov/calendar/
For a copy of the June flyer go to:
http://online.wr.usgs.gov/calendar/2014/June14flyer.pdf
Go to the USGS Evening Public Lecture Series website (http://online.wr.usgs.gov/calendar) and click on the "Video Archives" tab to view last months lecture "Endangered Desert Fish to Human Hepatitis E".

Meteorites

(Abstract Continued)

for this will be briefly discussed; see Dauphas & Pourmand, 2011 and Dodson-Robinson et al., 2009.

Few meteorites have avoided large impacts at least a few times in their history. These violent, hot events are well suited to dating using most methods we have today. They help to tell us about major impacts in the asteroid belt, and to show relationships between meteorite groups. Early heating sources would have also included the radioactive decay of short-lived radionuclides; it might not have taken an impact to melt even asteroids ~50 km in diameter. Aqueous alteration has driven much of the low-temperature metamorphism we see in meteorites, and is important for the formation of organic molecules. Cosmic rays constantly bombard the upper few meters of every body, at a ~constant rate, driving a low level of nuclear reactions.

Radiogenic heating and shock melting have altered many asteroids. Many are recrystallized and differentiated to different extents; some formed metallic cores, cumulate mantles, and felsic crusts, and others appear to have cooled prematurely, preserving a frozen record of planetary formation. Isotopic heterogeneities between bodies and the partitioning of chemically similar elements are especially important when studying texturally similar rocks from (potentially) different parent bodies. Some of these rocks have been shown to come from the Moon and Mars; we don't yet know enough about other parent bodies to tell where other meteorites such as these originated. The field of dynamical modeling has become an increasingly important aspect of cosmochemistry. Models have been devised to help explain the current distribution of asteroids, and of the planets as we now see them. A currently popular model is the Nice model, which hypothesizes that the giant planets have interacted, resulting in orbital changes that have disrupted most smaller bodies in the inner solar system -- and Kuiper

Belt Objects; the late heavy bombardment will be addressed; see Chapman, Cohen, and Grinspoon, 2007.

Most objects that enter the atmosphere are microscopic, and are slowly decelerated by the upper atmosphere before drifting down to Earth's surface. The abundance of particles in the solar system rapidly declines with particle size roughly as an exponential probability density function. 'Shooting stars' are usually sand-grain sized bits of material, with meteorites resulting from much larger bolides. Ablation is rapid, occurring mostly above an altitude of 20 km (60,000 ft). Between ~40 and ~25 km, the incoming meteoroid usually fragments. Ablation is rapid, resulting in the vaporization of surface material, but material is removed so rapidly that it cannot penetrate more than ~1 cm, in extreme cases. Differences in surface area – mass ratios result in a rough size gradation; wind resistance slows smaller fragments more rapidly, while larger fragments travel farther. The resulting distribution of meteorites is usually ~elliptical, although prevailing winds can bend or invert fields if strong enough.

When hunting for meteorites, it is important to keep a few important facts in mind:

1) meteorites fall uniformly across the surface of the Earth
2) older surfaces, esp. deflation surfaces, are places where a rock might sit on the surface for an extended period of time or be exposed if buried
3) ~90+% of meteorites contain ~5 to 25% iron
4) deserts will preserve meteorites for longer than wet areas
5) meteorites lack sedimentary layering, and often possess a fusion crust from coming through the atmosphere – this weathers over time, often leaving a distinctive surface texture

NCGS Over the Last Seventy Years

Contributed by Don Lewis

This year marks the 70th anniversary of the founding of the Northern California Geologic Society. In the February Newsletter there were a couple notes about our early history which, with our members being mainly petroleum geologists, was a bit different from what we are today, particularly in the locations and type of talks at our meetings. As gas exploration waned in the Sacramento valley in the late forties and discoveries were made in the Salinas valley, many members left the Sacramento valley and our meetings migrated to San Francisco. For many years the bulk of members were Chevron geologists, particularly after that company moved many geologists to a downtown Market Street office in about 1971. When Chevron moved to Concord and San Ramon in the mid-eighties, our meeting site followed. As Chevron began moving staff to Houston in 1990, our membership declined gradually but became much more diversified and has remained so.

Chevron for decades contributed financially to NCGS, mainly in the form of support for bringing in American Association of Petroleum Geologists Distinguished Lecturers. With this year's final decampment to Houston of the few remaining Chevron geologists, this support has dried up as has interest in the type of topics usually covered by the lecturers.

Over the years, the NCGS has had some 63 presidents, 26 of whom were from Chevron. Since 1990, only 6 presidents were from Chevron, mainly retired folks sticking it out in the East Bay. To our knowledge, our oldest living president is Tom Wright who had the honor in 1974. Tom was awarded Honorary Membership in 2010 and is still active and attending NCGS meetings. Other Honorary Members still with us are Larry Funkhouser, Eldredge Moores, and Mel Erskine.

In the early decades of NCGS, only one or two field trips per year were run but in the mid-eighties this increased to several per year. In fact, we have more field trips per year than any other local geologic society we've heard about. Our records are incomplete but we know of 120 field trips that NCGS has run; although we likely don't have all of them we know of at least 105 guidebooks for these trips. We are in the process of digitizing many of these. Much of the success of our trips for the last twenty years has been due to Tridib Guha who has either organized everything or helped out on almost all of the 86 trips during that period.

ANNOUNCING

- A WORKSHOP FOR TEACHERS –

(Let your teacher friends and contacts know!)

NCGS FIELD TRIP FOR THE NATIONAL EARTH SCIENCE WEEK

Saturday October 25, 2014

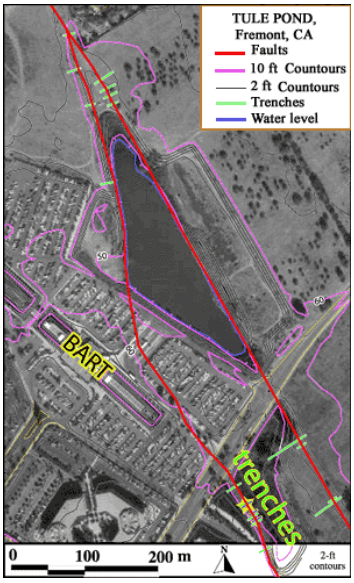
The Hayward Fault – Identifying Urban and Natural Features in the East Bay

Leader: Dr. Joyce R. Blueford, Math Science Nucleus

with Dr. Ray Sullivan, emeritus San Francisco State University

Over the last million years, the natural beauty of Fremont has been shaped by the Hayward Fault. This teacher workshop will start at Tule Ponds at Tyson Lagoon Wetland Center and end up at the Fremont Earthquake Exhibit in Central Park. Discover the "fault creep" and off sets as we walk along the Hayward fault and explore the dramatic faulting effects in both a natural and urban environment. Learn how we use the measurable movements to incorporate into lesson plans.

Both these facilities are part Fremont Learning Corridor that trace the Hayward Fault from Fremont to Union City. The Math Science Nucleus offers a host of field trips in this area. Lesson plans on the geology and natural history along the Hayward Fault (and correlated to the Next Generation Science Standard) will be illustrated.



To learn more about both areas please consult the Math Science Nucleus website (http://msnucleus.org).

NCGS will be hosting a BBQ lunch at Tule Ponds. For registration and/or additional information please email blueford@msnucleus.org. Co-sponsored by Math Science Nucleus

Volcanic Violence

(Part 2)

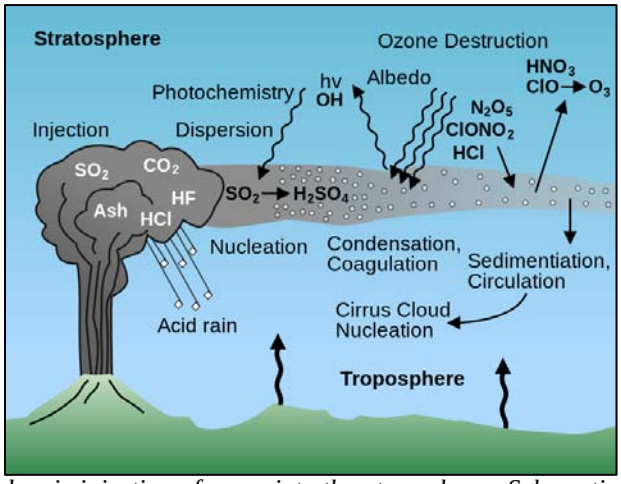
*By NCGS Member **Dr. Bill Motzer***

This article originally appeared in The Vortex from the California Section of the American Chemical Society (CALACS). Go to www.calvaryslz.org/calacs/ where you can download pdfs of the original articles and/or peruse past issues of The Vortex.

May 18th marks the 34th anniversary of the eruption of Mount Saint Helens – the only volcanic eruptive episode that I experienced on a scientific and personal level (see May 2013 Vortex *Volcanic Violence, Part 1* in which I described what happened during that fateful event). At any given time, approximately 1,500 of the world's volcanoes may have been active during the past 10,000 years with 600 having known eruptions during recorded history. About 50 to 70 volcanoes are currently active or erupting each year with 75% occurring in the Pacific Rim of Fire. An estimated 500 to 600 million people live near these volcanoes.

Volcanic eruptions can be devastating, particularly from their explosive power – which makes them significant "physical engines." They are also "heat engines" and depending on their type and location, they transfer heat in the form of magma from the lower crust and mantle to the earth's surface. All magmas contain dissolved gases released before, during, and between eruptive episodes, making volcanoes significant environmental "chemical engines," particularly with respect to emitted gases (see figure below). The most common gases associated with active volcanoes (in general decreasing abundance) are water vapor or steam (H_2O) – constituting approximately 70% to 95% of all eruption gases, carbon dioxide (CO_2), sulfur dioxide (SO_2), hydrogen sulfide (H_2S), hydrogen (H_2), helium (He), carbon monoxide (CO), and hydrochloric (HCl) and nitric (HNO_3) acid. Lesser amounts of argon (Ar), fluorine (F), hydrofluoric acid (HF), nitrogen (N), carbonyl sulfide (COS), carbon disulfide (CS_2), hydrogen bromide (HBr), ammonia (NH_3) and native elements (e.g., sulfur, boron, and gold, and volatile metals: mercury and selenium) may be emitted. Generally, H and CO rapidly oxidize to H_2O and CO_2, respectively and H_2S oxidizes to sulfurous (H_2SO_3) and/or sulfuric (H_2SO_4) acids, but volatile sulfur may also result in direct condensates, sublimates, or encrustations as native sulfur deposits. Chlorine monoxide (ClO) may also form when HCl is oxidized and HF can condense in rain or on ash particles.

Gaseous compositions for different volcanoes are quite variable: e.g., Kilauea in Hawaii is a hot spot basaltic shield volcano with a magmatic temperature of ~1,170 ^oC. Kilauea's H_2O, CO_2, and SO_2 gaseous emissions are 37.1%, 48.9%, and 11.8%, respectively. Momotombo in Nicaragua is an explosive strata volcano with a magmatic temperature of ~820 ^oC; located at a convergent plate boundary, its H_2O, CO_2, and SO_2 concentrations are 97.1%, 1.44%, and 0.50%, respectively.



Volcanic injection of gases into the atmosphere. Schematic by S. E. Wilson, U.S. Geological Survey (2009).

Generally, because of rapid atmospheric oxidation and solubilization in water vapor, most volcanic gases rarely reach or impact populated areas in lethal concentrations. One study showed that lethal effects are quite low ~10 km downwind from a volcano. Usually, such hazards are restricted to surrounding volcanic vents, fumaroles, and to low spots on the volcanoes' flanks. In such areas, volcanic gases (e.g., CO_2, HF, and SO_2) may cause harm to humans, animals, plants and crops, and property (e.g., utility lines, farm equipment, vehicles, and metal objects, which corrode when exposed to gases or acid rain). Exposure to acid gases (e.g., H_2SO_4, HCl, and HF) can damage eyes, mucous membranes, respiratory systems, and, under extreme conditions, may cause death. The different volcanic gases affect the earth,

people and animals in different ways and health hazards can range from minor to life-threatening, particularly for people with chronic respiratory and/or heart disease.

CO_2 is denser than ambient air (~1.8 g/L at 25 ^oC and 1.0 atm), accumulating and concentrating in depressions in lethal concentrations causing suffocation. The OSHA maximum safe level is 30,000 ppm (3%); 40,000 ppm is considered as immediately dangerous to life and health, a 30-minute exposure to 50,000 ppm produces intoxication, concentrations greater (>) 70,000 to 100,000 ppm produce unconsciousness, and lethal concentrations (causing death in 30 minutes) are >100,000 ppm. In the past two decades, hundreds of people have died from CO_2 asphyxiation from nearby volcanoes, most of them in Cameroon, Africa, and Indonesia. Measured concentrations ranging to 100% CO_2 from Mount Vesuvius, in Italy, have claimed the lives of many people from pooling CO_2 in depressions. Locally, high CO_2 atmospheric concentrations, produced by disturbance of deep lake water saturated with volcanic-derived CO_2, may have caused 37 fatalities at Lake Monoun, Cameroon in 1984 and 1,700 casualties at Lake Nyos, Cameroon in 1986.

Fluorine gas and HF can condense in rain or on ash particles coating grass, polluting streams and lakes with excess dissolved fluoride (F^-). Animals eating fluorine-tainted ash, deposited on grass,may be poisoned. Although small amounts of F^- can be beneficial, excess F^- causes fluorosis by destroying teeth and bones. This also impacts humans when F^- is leached into domestic water supplies.

SO_2 emissions may result in climate cooling when H_2SO_4 aerosols form in the upper atmosphere. This occurs when SO_2 as gases and in tephra from large eruptions impact the stratosphere ~10 to 50 km in altitude. Possible reactions are:

$$\mathbf{SO_{2(v)} + H_2O_{(v,\,L)} \rightarrow HSO_3^- + H^+ \rightarrow H_2SO_{3(L)}}$$

$$\mathbf{2H_2SO_{3(L)} + O_2 \rightarrow 2H_2SO_{4(L)}}$$

Liquid (L) H_2SO_4 aerosols (droplets) block sunlight, which may result in global cooling; but ordinarily such cooling is not long. For example, El Chichon in Mexico erupted in 1982 producing an ash plume reaching an altitude of ~26 km. The eruption produced 1.0 to 2.0 $x10^{10}$ kg of H_2SO_4 aerosols that caused northern hemisphere surface temperature decreases of 0.4 to 0.6 ^oC for about one to two years.

But these eruptions are “tame” when past (prehistoric) eruptions are considered. Although the May 18, 1980 Mount St. Helens eruption is considered as a large eruption (~ 1.0 km^3 of erupted material) it is miniscule when compared to the Yellowstone Supervolcanic eruption of 600,000 years ago at ~1,000 km^3. And I’ll discuss that in a future article.

Earthquake cluster likely to strike Bay Area, scientists say

Becky Bach; SJ Mercury News

The Bay Area's Big One will still be plenty big, but it might not be just one, according to a study released Monday by U.S. Geological Survey scientists.

A flurry of mid-sized quakes is more likely to strike the Bay Area rather than a giant 1906-esque rupture, said David Schwartz, a paleoseismologist at the USGS's Menlo Park office and the lead author of the study, which appeared in June's Bulletin of the Seismological Society of America. The study marks the first comprehensive history of the Bay Area's seismicity dating to 1600.

A quake cluster isn't necessarily good news, as it could keep communities constantly cleaning up the earthquake damage, several experts said.

Pictured is an exposure of the San Andreas fault at the U.S. Geological Survey's Vedanta marsh study site near Olema, California. Geologist Tina Niemi, a professor at the University of Missouri, Kansas City places orange nails into the wall of the exposure to show the actual location of the fault., which is a very narrow zone. According to Dr. David P. Schwrtz of the USGS, researchers found strong evidence at this site for the past five earthquakes, including 1906 as well as indications of older earthquakes. (Courtesy David P. Schwartz/USGS)

"It presents a very different problem in how you respond and recover from earthquakes," Schwartz said.

After the 7.8-magnitude 1906 earthquake, the 20th century was abnormally stable, he said. Therefore, an earthquake cluster is overdue, the scientists said.

"Basically, what goes in, must go out," Schwartz said. The region's seismicity stems from the clash of two massive plates in the earth's crust. The Pacific Plate is sliding northwest, while the North American Plate is moving southeast.

Since 1906, the plates have moved about 13 feet in the Bay Area. Like a compressed spring, they're ready to burst.

In the Bay Area, the plate boundary fractures into a handful of fissures, all generally trending northwest-to-

southeast. The well-known San Andreas Fault, which Schwartz calls the "master fault," is accompanied by the San Gregorio Fault, the Hayward Fault, the Calaveras Fault and the Rodgers Creek Fault in the North Bay, among others.

Future quakes are expected to spread out along these faults.

"These faults are being stressed by the plate movements... and they all have to catch up," Schwartz said.

The various faults "talk" to each other, said Roland Burgmann, an earth scientist at UC Berkeley "The communicating family of faults sometimes tend to rupture together as a group or shut each other off."

The 1906 earthquake was likely a fluke, the perfect alignment of conditions that allowed 300 miles of the San Andreas Fault -- from northern Mendocino County to San Juan Bautista -- to release its pent-up pressure. This massive shaking kept the area unusually calm for a century, Schwartz said.

"Eventually, there should be more clusters," Burgmann said.

The scientists based their prediction on the historical record, which shows a cluster of quakes shook the Bay Area from 1690 to 1776. At least six earthquakes, ranging from 6.3 to 7.7 magnitude, rattled the region's major faults during that period, Schwartz said.

The cumulative release of energy from the quakes roughly equals that of the 1906 earthquake, Schwartz said.

"This is a summary of a tremendous amount of work," said Greg Beroza, a Stanford seismologist who was not involved with the study.

Previously, other scientists had scoured the records kept by the Franciscan missionaries at San Francisco's Mission Dolores starting in 1776, Schwartz said. He called the Spanish missionaries "the first seismographers." They described the rumblings in their records, allowing scientists to assess the earthquake's strength by extrapolating from the amount of damage the Franciscans described.

Scientists dated the earlier quakes by digging trenches and calculating the age of charcoal or other organic materials found several feet below the surface, Schwartz said.

This technique misses small or deep earthquakes, which don't break the surface.

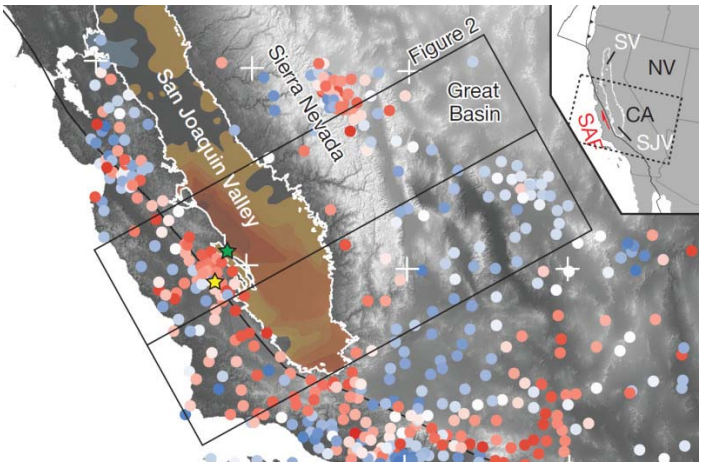
Although the scientists predict a group of tremors, rather than just a single, large earthquake, they admit the future could surprise them. The Bay Area has a 63 percent chance of one of more large earthquakes before 2036, according to estimates released in 2008 by the Working Group on California Earthquake Probabilities, a coalition of state, federal and academic geologists.

The USGS study provides a useful framework to plan for the future, said Thorne Lay, an earth scientist at UC Santa Cruz, who was not involved in the study.

Schwartz said he hopes to look back even farther than 1600 to more fully understand the Bay Area's seismic history--and its future.

"The key question is when are we going to come out of the shadow, when are we going to go back to normal?" Burgmann asked.

California Mountains Rise as Groundwater Depleted in State's Central Valley: May Trigger Small Earthquakes



GPS measurements show that the Sierra Nevada and Coast Ranges rise several millimeters per year (red dots) as a result of groundwater pumping in the Central Valley (brown). Blue dots are sites where the ground has subsided. Credit: Image courtesy of UC Berkeley

Winter rains and summer groundwater pumping in California's Central Valley make the Sierra Nevada and Coast Ranges sink and rise by a few millimeters each year, creating stress on the state's earthquake faults that could increase the risk of a quake.

Gradual depletion of the Central Valley aquifer because of groundwater pumping also raises these mountain ranges by a similar amount each year -- about the thickness of a dime -- with a cumulative rise over the past 150 years of up to 15 centimeters (6 inches), according to calculations by a team of geophysicists.

While the seasonal changes in the Central Valley aquifer have not yet been firmly associated with any earthquakes, studies have shown that similar levels of periodic stress, such as that caused by the motions of the moon and sun, increase the number of microquakes on the San Andreas Fault, which runs parallel to the mountain ranges. If these subtle seasonal load changes

are capable of influencing the occurrence of microquakes, it is possible that they can sometimes also trigger a larger event, said Roland Bürgmann, UC Berkeley professor of earth and planetary science at UC Berkeley.

"The stress is very small, much less than you need to build up stress on a fault toward an earthquake, but in some circumstances such small stress changes can be the straw that broke the camel's back; it could just give that extra push to get a fault to fail," Bürgmann said.

Bürgmann is a coauthor of a report published online this week by the journal *Nature*. The study, based on detailed global positioning satellite (GPS) measurements from California and Nevada between 2007 and 2010, was led by former UC Berkeley postdoctoral fellows Colin Amos, now at Western Washington University, and Pascal Audet, now of the University of Ottawa. The detailed GPS analysis was performed by William C. Hammond and Geoffrey Blewitt of the University of Nevada, Reno.

Draining of Central Valley

Water has been pumped from California's Central Valley for more than 150 years, reducing what used to be a marsh and extensive lake, Tulare Lake, into fertile agricultural fields that feed the world. In that time, approximately 160 cubic kilometers (40 cubic miles) of water was removed -- the capacity of Lake Tahoe -- dropping the water table in some areas more than 120 meters (400 feet) and the ground surface 5 meters (16 feet) or more.

The weight of water removed allowed the underlying crust or lithosphere to rise by so-called isostatic rebound, which has raised the Sierra probably as much as half a foot since about 1860, Bürgmann said.

The same rebound happens as a result of the state's seasonal rains. Torrential winter storms drop water and snow across the state, which eventually flow into Central Valley streams, reservoirs and underground aquifer, pushing down the crust and lowering the Sierra 1-3 millimeters. In the summer, water flow through the delta into the Pacific Ocean, evaporation and ground water pumping for irrigation, which has accelerated in the past few years because of a drought, allows the crust and surrounding mountains to rise again.

Bürgmann said that the flexing of Earth's crust downward in winter would clamp the San Andreas Fault tighter, lowering the risk of quakes, while in summer the upward flexure would relieve this clamping and perhaps increase the risk.

"The hazard is ever so slightly higher in the summer than in the wintertime," he said. "This suggests that climate and tectonics interact; that water changes ultimately affect the deeper Earth too."

High-resolution mapping with continuous GPS

Millimeter-precision measurements of elevation have been possible only in the last few years, with improved continuous GPS networks -- part of the National Science Foundation-funded Plate Boundary Observatory, which operates 1,100 stations around the western U.S. -- and satellite-based interferometric synthetic aperture radar (InSAR). Synthetic aperture radar is a form of radar in which phase information is used to map elevation.

These measurements revealed a steady yearly rise of the Sierra of 1-2 millimeters per year, which was initially ascribed to tectonic activity deep underground, even though the rate was unusually high, Bürgmann said. The new study provides an alternative and more reasonable explanation for the rise of the Sierra in historic times.

"The Coast Range is doing the same thing as the Sierra Nevada, which is part of the evidence that this can't be explained by tectonics," he said. "Both ranges have uplifted over the last few years and they both exhibit the same seasonal up and down movement in phase. This tells us that something has to be driving the system at a seasonal and long-term sense, and that has to be groundwater recharging and depletion."

In response to the current drought, about 30 cubic kilometers (7.5 cubic miles) of water were removed from Central Valley aquifers between 2003 and 2010, causing a rise of about 10 millimeters (2/5 inch) in the Sierra over that time.

After the new results were shared with colleagues, Bürgmann said, some geologists suggested that the state could get a better or at least comparable inventory of available water each year by using GPS to measure ground deformation instead of measuring snowpack and reservoir levels.

Other coauthors are Colin B. Amos of Western Washington University in Bellingham, Ingrid A. Johanson of UC Berkeley. Funding for the research came from NSF EarthScope and UC Berkeley's Miller Institute.

Story Source: The above story is based on materials provided by University of California - Berkeley. The original article was written by Robert Sanders and ScienceDaily May 14, 2014

Journal Reference: Colin B. Amos, Pascal Audet, William C. Hammond, Roland Bürgmann, Ingrid A. Johanson, Geoffrey Blewitt. **Uplift and seismicity driven by groundwater depletion in central California**. *Nature*, 2014; DOI: 10.1038/nature13275

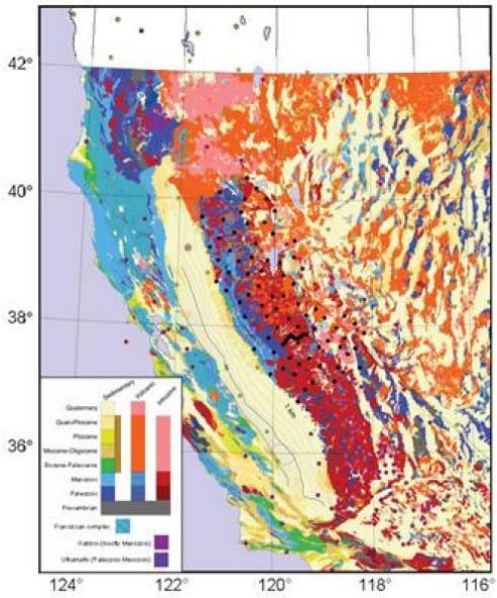
The thin-crusted U.S. Sierra Nevada Mountains: Where did the Earth go?

In an addition to Geosphere's ongoing themed issue series, "Geodynamics and Consequences of Lithospheric

Removal in the Sierra Nevada, California," Craig H. Jones of the University of Colorado Boulder and colleagues examine the seismological study of the entire extent of the U.S. Sierra Nevada range using seismograms collected in the Sierra Nevada EarthScope field experiment from 2005 to 2007.

The southern Sierra Nevada is known to have unusually thin crust for mountains with such high elevations (peaks higher than 4 km/14,000 ft, and average elevations near 3 km/10,000 ft). Jones and his team use measurements of the arrival times of seismic waves (called P-waves) from earthquakes around the globe to image Earth under the Sierra Nevada and neighboring locations.

Their results reveal that the entire eastern Sierra overlies low-velocity upper mantle and lacks the dense, quartz-poor lower crust that they say must have existed 80 million years ago when the granites of the range were created.



Geologic map showing seismic stations used in the study by C.H. Jones and colleagues, "P-wave tomography of potential convective down-wellings and their source regions, Sierra Nevada, California." Credit: Image courtesy of Geological Society of America

Jones and colleagues write that this missing dense material probably was removed within the past 10 million years. "Previous workers," they note, "have suggested it might be within a high-velocity mantle anomaly under the southeastern San Joaquin Valley," which is "the right size to be the old, dense rock previously under the eastern Sierra."

They argue, however, that the geometry and extent of earth within the anomaly does not appear to be consistent with it being a piece of old subducted ocean floor. This would mean that a long strip of dense rock under the Sierra somehow deformed into a steeply plunging ellipsoid at the southwestern edge of the range. This conclusion suggests that the range rose within the past 10 million years as this dense material fell away to the west and south. Finally, Jones and colleagues note that something similar might be underway at the northern edge of the range.

Story Source: The above story is based on materials provided by Geological Society of America and ScienceDaily April 28, 2014

Journal Reference: C. H. Jones, H. Reeg, G. Zandt, H. Gilbert, T. J. Owens, J. Stachnik. **P-wave tomography of potential convective downwellings and their source regions, Sierra Nevada, California**. *Geosphere*, 2014; DOI: 10.1130/GES00961.1

Biggest dinosaur ever' discovered

By James Morgan Science reporter, BBC News

Thanks to Ray Sullivan for forwarding this article!

The "largest creature ever to walk the Earth" has been discovered in Argentina, palaeontologists say.

Weighing in at 77 tonnes, it was as heavy as 14 African elephants, and seven tonnes heavier than the previous record holder, *Argentinosaurus*.

Scientists believe it is a new species of titanosaur, enormous herbivores that lived during the Late Cretaceous, the last days of the dinosaurs.

A local farm worker first stumbled on the remains in the desert near La Flecha, about 250km west of Trelew, Patagonia.

This gigantic dinosaur stood 40m long and 20m tall, based on the length of its enormous thigh bones.

Dr Diego Pol explains how the weight of the dinosaur was calculated. The fossils were then excavated by a team of palaeontologists from the Museum of Palaeontology Egidio Feruglio, led by Dr Jose Luis Carballido and Dr Diego Pol. They unearthed the partial skeletons of seven individuals - about 150 bones in total - all in "remarkable condition".

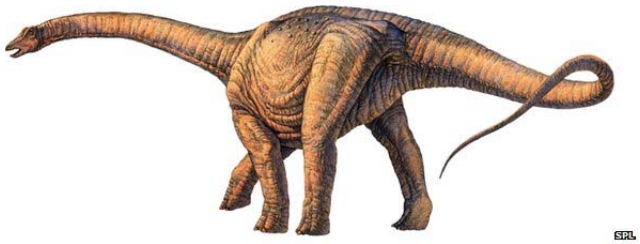
A film crew from the BBC Natural History Unit was there to capture the moment the scientists realized exactly how big their discovery was.

By measuring the length and circumference of the largest femur (thigh bone), they calculated the animal weighed 77 tonnes.

"Given the size of these bones, which surpass any of the previously known giant animals, the new dinosaur is the largest animal known that walked on Earth," the researchers told BBC News.

"Its length, from its head to the tip of its tail, was 40m. "Standing with its neck up, it was about 20m high - equal to a seven-storey building."

The new dinosaur is a type of sauropod similar to Argentinosaurus, illustrated below. This giant herbivore lived in the forests of Patagonia between 95 and 100 million years ago, based on the age of the rocks in which its bones were found. But despite its magnitude, it does not yet have a name. "It will be named describing its magnificence and in honour to both the region and the farm owners who alerted us about the discovery," the researchers said.



There have been many previous contenders for the title "world's biggest dinosaur". The most recent pretender to the throne was *Argentinosaurus*, a similar type of sauropod, also discovered in Patagonia. Originally thought to weigh in at 100 tonnes, it was later revised down to about 70 tonnes - just under the 77 tonnes that this new sauropod is thought to have weighed.

The picture is muddied by the various complicated methods for estimating size and weight, based on skeletons that are usually incomplete. *Argentinosaurus* was estimated from only a few bones. But the researchers here had dozens to work with, making them more confident that they really have found "the big one".

Dr Paul Barrett, a dinosaur expert from London's Natural History Museum, agreed the new species is "a genuinely big critter. But there are a number of similarly sized big sauropod thigh bones out there," he cautioned. "Without knowing more about this current find it's difficult to be sure. One problem with assessing the weight of both *Argentinosaurus* and this new discovery is that they're both based on very fragmentary specimens - no complete skeleton is known, which means the animal's proportions and overall shape are conjectural.

"Moreover, several different methods exist for calculating dinosaur weight (some based on overall volume, some on various limb bone measurements) and these don't always agree with each other, with large measures of uncertainty.

"So it's interesting to hear another really huge sauropod has been discovered, but ideally we'd need much more material of these supersized animals to determine just how big they really got."

Surprising global species shake-up discovered

The diversity of the world's life forms -- from corals to carnivores -- is under assault. Decades of scientific studies document the fraying of ecosystems and a grim tally of species extinctions due to destroyed habitat, pollution, climate change, invasives and overharvesting. Which makes a recent report in the journal *Science* rather surprising.

Nick Gotelli, a professor at the University of Vermont, with colleagues from Saint Andrews University, Scotland, and the University of Maine, re-examined data from one hundred long-term monitoring studies done around the world -- polar regions to the tropics, in the oceans and on land. They discovered that the number of species in many of these places has not changed much -- or has actually increased.

Now wait a minute. A global extinction crisis should show up in declining levels of local biodiversity, right?

That's not what the scientists found. Instead they discovered that, on average, the number of species recorded remained the same over time. Fifty-nine of the one hundred biological communities showed an increase in species richness and 41 a decrease. In all the studies, the rate of change was modest.

But the researchers did discover something changing rapidly: which species were living in the places being studied. Almost 80 percent of the communities the team examined showed substantial changes in species composition, averaging about 10 percent change per decade -- significantly higher than the rate of change predicted by models.

In other words, this new report shows that a huge turnover of species in habitats around the globe is under way, resulting in the creation of novel biological communities. "Right under our noses, in the same place that a team might have looked a decade earlier, or even just a year earlier, a new assemblage of plants and animals may be taking hold," Gotelli says.

Jellyfish world

The causes of this shift are not yet fully clear, but the implications for conservation and policy could be significant. Historically, conservation science and planning has focused on protecting endangered species more than on shifts in which plants and animals are assembled together. "A main policy application of this work is that we're going to need to focus as much on the identity of species as on the number of species," Gotelli says. "The number of species in a place may not be our best scorecard for environmental change."

For example, the scientists write that disturbed coral reefs can be replaced by a group of species dominated by algae. This replacement might keep the species count the same, but not necessarily provide the fisheries, tourism ("algae diving" doesn't have quite the same appeal as "reef diving") or coastal protections that the original coral reef did.

"In the oceans we no longer have many anchovies, but we seem to have an awful lot of jellyfish," says Gotelli. "Those kinds of changes are not going to be seen by just counting the number of species that are present."

Almost unrecognizable

The new research, led by Maria Dornelas at Saint Andrews University in Scotland, carefully looked for previous studies that had tracked and tallied species over many years. The team selected 100 that contained six million observations of more than 35,000 different species -- including datasets that go back to 1874 and many over the last 40 years. Given widespread observation of habitat change and individual species declines -- and knowing that extinction rates are many times higher than normal -- the scientists predicted a drop, over time, in the number of species observed in most of these studies.

Why they didn't find this drop could be driven by many forces. One is related to what science writer David Quammen semi-famously termed our "planet of weeds." In other words, invasive species or successful colonists or weedy generalists -- think kudzu and rats -- may be spreading into new places, keeping the local species tally up, even as the planet's overall biodiversity is degraded.

"We move species around," Gotelli says. "There is a huge ant diversity in Florida, and about 30 percent of the ant species are non-natives. They have been accidentally introduced, mostly from the Old World tropics, and they are now a part of the local assemblage. So you can have increased diversity in local communities because of global homogenization."

And sampling issues may conceal important realities: some species may have become so rare -- think white rhinos -- that they're highly unlikely to be found in a general species survey and so don't show in the initial results nor disappear in later ones.

Range shifts associated with climate change could be at work, too, quickly pushing species into new terrain. On May 6, the White House released its National Climate Assessment noting that, as a result of human-caused warming, "species, including many iconic species, may disappear from regions where they have been prevalent or become extinct, altering some regions so much that their mix of plant and animal life will become almost unrecognizable."

This study in *Science*, published on April 18, underlines this emerging reality, giving it a new and worrisome precision and leading Nick Gotelli and his co-authors to conclude that there "is need to expand the focus of research and planning from biodiversity loss to biodiversity change."

Story Source: The above story is based on materials provided by University of Vermont and ScienceDaily May 13, 2014

Journal Reference: M. Dornelas, N. J. Gotelli, B. McGill, H. Shimadzu, F. Moyes, C. Sievers, A. E. Magurran. **Assemblage Time Series Reveal Biodiversity Change but Not Systematic Loss**. *Science*, 2014; 344 (6181): 296 DOI: 10.1126/science.1248484

Fossil avatars are transforming palaeontology

New techniques for visualizing fossils are transforming our understanding of evolutionary history according to a paper published by leading palaeontologists at the University of Bristol.

Palaeontology has traditionally proceeded slowly, with individual scientists labouring for years or even decades over the interpretation of single fossils which they have gradually recovered from entombing rock, sand grain by sand grain, using all manner of dental drills and needles.

The introduction of X-ray tomography has revolutionized the way that fossils are studied, allowing them to be virtually extracted from the rock in a fraction of the time necessary to prepare specimens by hand and without the risk of damaging the fossil.

Digital reconstructions of the skull of the dinosaur Erlikosaurus made from a CT scan. Credit: Dr Stephan Lautenschlager

The resulting fossil avatars not only reveal internal and external anatomical features in unprecedented and previously unrealized detail, but can also be studied in parallel by collaborating or competing teams of scientists, speeding up the pace at which evolutionary history is revealed.

These techniques have enabled palaeontologists to move beyond 'just so stories', explanations for why sauropod dinosaurs had such long necks, for example, by subjecting digital models of the fossils to biomechanical analysis, including using the same computer techniques that engineers use to design test bridges and aircraft.

However, the scientists from Bristol's School of Earth Sciences highlight that the potential benefits of fossil avatars are not being realized.

Lead author Dr John Cunningham said: "At a practical level, we simply don't have the infrastructure for storing and sharing the vast datasets that describe fossils, and the policies of world-leading museums which protect the copyright of fossils are preventing data sharing at a legal level."

Co-author Dr Stephan Lautenschlager added: "The increasing availability of fossil avatars will allow us to bring long-extinct animals back to life, virtually, by using computer models to work out how they moved and fed. However, in many cases we are hampered by our limited understanding of the biology of the modern species to which we would ideally like to compare the fossils."

Dr Imran Rahman, also an author of the agenda-setting study, said: "Palaeontologists are making their fossil avatars freely available as files for 3-D printing and so, soon, anyone who wants one, can have a scientifically accurate model of their favourite fossil, for research, teaching, or just for fun!"

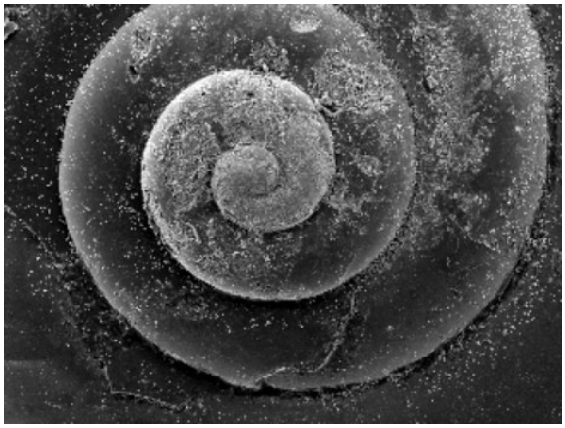
Story Source: The above story is based on materials provided by University of Bristol and ScienceDaily, May 22, 2014.

Journal Reference: John A. Cunningham, Imran A. Rahman, Stephan Lautenschlager, Emily J. Rayfield, Philip C.J. Donoghue. **A virtual world of paleontology**. *Trends in Ecology & Evolution*, 2014; 29 (6): 347 DOI: 10.1016/j.tree.2014.04.004

Modern ocean acidification is outpacing ancient upheaval: Rate may be ten times faster

Some 56 million years ago, a massive pulse of carbon dioxide into the atmosphere sent global temperatures soaring. In the oceans, carbonate sediments dissolved, some organisms went extinct and others evolved.

Scientists have long suspected that ocean acidification caused the crisis -- similar to today, as humanmade CO_2 combines with seawater to change its chemistry. Now, for the first time, scientists have quantified the extent of surface acidification from those ancient days, and the news is not good: the oceans are on track to acidify at least as much as they did then, only at a much faster rate.



Ocean acidification in the modern ocean may already be affecting some marine life, as shown by the partly dissolved shell of this planktic snail, or pteropod, caught off the Pacific Northwest. Credit: Nina Bednaršedk/NOAA

In a study published in the latest issue of Paleoceanography, the scientists estimate that ocean acidity increased by about 100 percent in a few thousand years or more, and stayed that way for the next 70,000 years. In this radically changed environment, some creatures died out while others adapted and evolved. The study is the first to use the chemical composition of fossils to reconstruct surface ocean acidity at the Paleocene-Eocene Thermal Maximum (PETM), a period of intense warming on land and throughout the oceans due to high CO_2.

"This could be the closest geological analog to modern ocean acidification," said study coauthor Bärbel Hönisch, a paleoceanographer at Columbia University's Lamont-Doherty Earth Observatory. "As massive as it

was, it still happened about 10 times more slowly than what we are doing today."

The oceans have absorbed about a third of the carbon humans have pumped into the air since industrialization, helping to keep earth's thermostat lower than it would be otherwise. But that uptake of carbon has come at a price. Chemical reactions caused by that excess CO_2 have made seawater grow more acidic, depleting it of the carbonate ions that corals, mollusks and calcifying plankton need to build their shells and skeletons.

In the last 150 years or so, the pH of the oceans has dropped substantially, from 8.2 to 8.1--equivalent to a 25 percent increase in acidity. By the end of the century, ocean pH is projected to fall another 0.3 pH units, to 7.8. While the researchers found a comparable pH drop during the PETM--0.3 units--the shift happened over a few thousand years.

"We are dumping carbon in the atmosphere and ocean at a much higher rate today -- within centuries," said study coauthor Richard Zeebe, a paleoceanographer at the University of Hawaii. "If we continue on the emissions path we are on right now, acidification of the surface ocean will be way more dramatic than during the PETM."

The study confirms that the acidified conditions lasted for 70,000 years or more, consistent with previous model-based estimates. "It didn't bounce back right away," said Timothy Bralower, a researcher at Penn State who was not involved in the study. "It took tens of thousands of years to recover."

From seafloor sediments drilled off Japan, the researchers analyzed the shells of plankton that lived at the surface of the ocean during the PETM. Two different methods for measuring ocean chemistry at the time -- the ratio of boron isotopes in their shells, and the amount of boron --arrived at similar estimates of acidification. "It's really showing us clear evidence of a change in pH for the first time," said Bralower.

What caused the burst of carbon at the PETM is still unclear. One popular explanation is that an overall warming trend may have sent a pulse of methane from the seafloor into the air, setting off events that released more earth-warming gases into the air and oceans. Up to half of the tiny animals that live in mud on the seafloor -- benthic foraminifera -- died out during the PETM, possibly along with life further up the food chain.

Other species thrived in this changed environment and new ones evolved. In the oceans, dinoflagellates extended their range from the tropics to the Arctic, while on land, hoofed animals and primates appeared for the first time. Eventually, the oceans and atmosphere recovered as elements from eroded rocks washed into the sea and neutralized the acid.

Today, signs are already emerging that some marine life may be in trouble. In a recent study led by Nina Bednaršedk at the U.S. National Oceanic and Atmospheric Administration, more than half of the tiny planktic snails, or pteropods, that she and her team studied off the coast of Washington, Oregon and California showed badly dissolved shells. Ocean acidification has been linked to the widespread death of baby oysters off Washington and Oregon since 2005, and may also pose a threat to coral reefs, which are under additional pressure from pollution and warming ocean temperatures.

"Seawater carbonate chemistry is complex but the mechanism underlying ocean acidification is very simple," said study lead author Donald Penman, a graduate student at University of California at Santa Cruz. "We can make accurate predictions about how carbonate chemistry will respond to increasing carbon dioxide levels. The real unknown is how individual organisms will respond and how that cascades through ecosystems."

Other authors of the study, which was funded by the U.S. National Science Foundation: Ellen Thomas, Yale University; and James Zachos, UC Santa Cruz.

Story Source: The above story is based on materials provided by The Earth Institute at Columbia University and ScienceDaily, June 2, 2014.

Journal Reference: Donald E. Penman, Bärbel Hönisch, Richard E. Zeebe, Ellen Thomas, James C. Zachos. **Rapid and sustained surface ocean acidification during the Paleocene-Eocene Thermal Maximum**. *Paleoceanography*, 2014; DOI: 10.1002/2014PA002621

Humans, not climate, to blame for Ice Age-era disappearance of large mammals, study concludes

Was it humankind or climate change that caused the extinction of a considerable number of large mammals about the time of the last Ice Age? Researchers at Aarhus University have carried out the first global analysis of the extinction of the large animals, and the conclusion is clear -- humans are to blame. A new study unequivocally points to humans as the cause of the mass extinction of large animals all over the world during the course of the last 100,000 years.

"Our results strongly underline the fact that human expansion throughout the world has meant an enormous loss of large animals," says Postdoctoral Fellow Søren Faurby, Aarhus University.

Was it due to climate change?

For almost 50 years, scientists have been discussing what led to the mass extinction of large animals (also known as megafauna) during and immediately after the last Ice Age.

Skeleton of a giant ground sloth at the Los Angeles County Museum of Natural History, circa 1920. Credit: Public Domain, via Wikimedia Commons

One of two leading theories states that the large animals became extinct as a result of climate change. There were significant climate changes, especially towards the end of the last Ice Age -- just as there had been during previous Ice Ages -- and this meant that many species no longer had the potential to find suitable habitats and they died out as a result. However, because the last Ice Age was just one in a long series of Ice Ages, it is puzzling that a corresponding extinction of large animals did not take place during the earlier ones.

Theory of overkill

The other theory concerning the extinction of the animals is 'overkill'. Modern man spread from Africa to all parts of the world during the course of a little more than the last 100,000 years. In simple terms, the overkill hypothesis states that modern man exterminated many of the large animal species on arrival in the new continents. This was either because their populations could not withstand human hunting, or for indirect reasons such as the loss of their prey, which were also hunted by humans.

First global mapping

In their study, the researchers produced the first global analysis and relatively fine-grained mapping of all the large mammals (with a body weight of at least 10 kg) that existed during the period 132,000-1,000 years ago -- the period during which the extinction in question took place. They were thus able to study the geographical variation in the percentage of large species that became extinct on a much finer scale than previously achieved.

The researchers found that a total of 177 species of large mammals disappeared during this period -- a massive loss. Africa 'only' lost 18 species and Europe 19, while Asia lost 38 species, Australia and the surrounding area 26, North America 43 and South America a total of 62 species of large mammals.

The extinction of the large animals took place in virtually all climate zones and affected cold-adapted species such as woolly mammoths, temperate species such as forest elephants and giant deer, and tropical species such as giant cape buffalo and some giant sloths. It was observed on virtually every continent, although a particularly large number of animals became extinct in North and South America, where species including sabre-toothed cats, mastodons, giant sloths and giant armadillos disappeared, and in Australia, which lost animals such as giant kangaroos, giant wombats and marsupial lions. There were also fairly large losses in Europe and Asia, including a number of elephants, rhinoceroses and giant deer.

Weak climate effect

The results show that the correlation between climate change -- i.e. the variation in temperature and precipitation between glacials and interglacials -- and the loss of megafauna is weak, and can only be seen in one sub-region, namely Eurasia (Europe and Asia). "The significant loss of megafauna all over the world can therefore not be explained by climate change, even though it has definitely played a role as a driving force in changing the distribution of some species of animals. Reindeer and polar foxes were found in Central Europe during the Ice Age, for example, but they withdrew northwards as the climate became warmer," says Postdoctoral Fellow Christopher Sandom, Aarhus University.

Extinction linked to humans

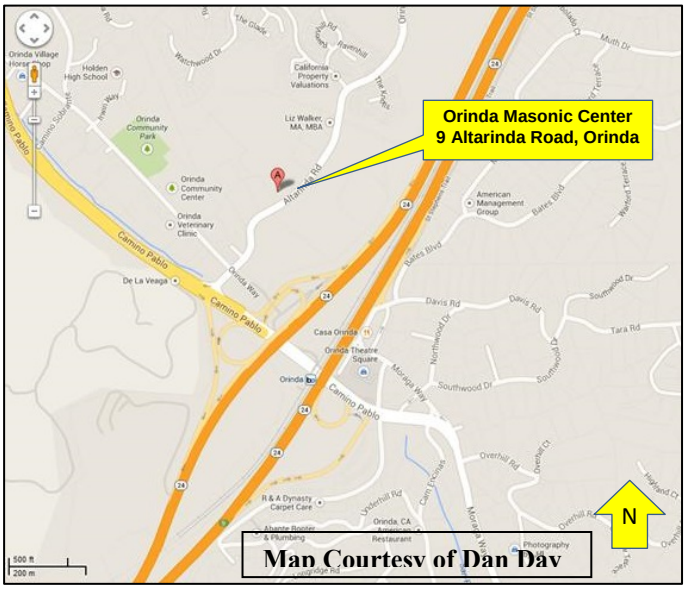
On the other hand, the results show a very strong correlation between the extinction and the history of human expansion. "We consistently find very large rates of extinction in areas where there had been no contact between wildlife and primitive human races, and which were suddenly confronted by fully developed modern humans (*Homo sapiens*). In general, at least 30% of the large species of animals disappeared from all such areas," says Professor Jens-Christian Svenning, Aarhus University.

The researchers' geographical analysis thereby points very strongly at humans as the cause of the loss of most of the large animals.

The results also draw a straight line from the prehistoric extinction of large animals via the historical regional or global extermination due to hunting (American bison, European bison, quagga, Eurasian wild horse or tarpan, and many others) to the current critical situation for a considerable number of large animals as a result of poaching and hunting (e.g. the rhino poaching epidemic).

Story Source: The above story is based on materials provided by Aarhus University. The original article was written by Anne-Mette Siem and ScienceDaily, June 4, 2014.

Journal Reference: C. Sandom, S. Faurby, B. Sandel, J.-C. Svenning. **Global late Quaternary megafauna extinctions linked to humans, not climate change**. *Proceedings of the Royal Society B: Biological Sciences*, 2014; 281 (1787): 20133254 DOI: 10.1098/rspb.2013.3254



Biography: Jason started collecting meteorites with his father in 1998, and they have been enthusiasts since then. Jason has recovered ~400 meteorites, most from California. He received his bachelors in geology and psychology from UC Berkeley in 2013, and is now starting his second year as a cosmochemistry PhD student at UCLA. Research topics include the formation of primitive achondrites, early solar system chronology, and meteor size-luminosity variations with material properties.

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

Would you like to receive the NCGS newsletter by e-mail? If you are not already doing so, and would like to, please contact **Rob Nelson** at **rlngeology@sbcglobal.net** to sign up for this free service.