NORTHERN CALIFORNIA GEOLOGICAL SOCIETY

MEETING ANNOUNCEMENT

DATE: **February 27, 2013**

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

TIME: **6:30 p.m. social; 7:00 p.m. talk (no dinner) Cost: $5 per regular member; $1 per student or K – 12 teachers**

SPEAKER: **Dr. David Osleger, University of California, Davis**

Paleo-precipitation records from Lake Tahoe sediment cores

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

…Continued on back….

NCGS 2012 – 2013 Calendar

February 27, 2013
Dr. David A. Osleger, UC Davis
Paleo-precipitation records from Lake Tahoe cores

March 4, 2013
Dr. Chris Jackson, Imperial College
AAPG Distinguished Lecturer
3D seismic reflection and borehole expression of tectonically-controlled deep-marine reservoirs; examples from the Northern North Sea hydrocarbon province
11:00 A.M; Chevron San Ramon
If you are interested in attending this presentation, please send an e-mail message with your name and affiliation (NCGS, company or government agency) to Angela Hessler by Thursday, February 28: AngelaHessler@chevron.com

March 27, 2013
Dr. Greg Balco, Berkeley Geochronolgy Center
Applications of cosmogenic-nuclide geochemistry and low-temperaturethermochronometry to Earth surface processes

April 19 to 25 April 2013 **No April NCGS Meeting!**
Pacific Section AAPG Convention
Monterey, CA

May 29, 2013 NCGS Dinner Meeting

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.**

Peninsula Geologic Society

Upcoming meetings

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

Bay Area Science

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

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

Association of Engineering Geologists San Francisco Section

Upcoming Events

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

USGS Evening Public Lecture Series

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

Dr. Christopher A-L. Jackson

AAPG Distinguished Lecturer
Monday March 4, 2013
11:00 A.M. Chevron, San Ramon

If you are interested in attending this presentation, please send an e-mail message with your name and affiliation (NCGS, company or government agency) to Angela Hessler by Thursday, February 28: AngelaHessler@chevron.com

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Unlike many other geologists, as a child I did not have a long-held love of the outdoors or find a particularly spectacular fossil whilst on a family holiday. I did, however, toy with idea of becoming a computer programmer or doing professional sport of some kind; however, I had no talent in either, so I went fossil hunting instead …

I completed a BSc in Geology at Manchester University in 1998, and then stayed on at the same institution to undertake a PhD with Professor Rob Gawthorpe (now at

the University of Bergen). My PhD, which I completed in 2002, focused on the tectono-stratigraphic development of the Suez Rift, and it involved traditional field mapping and logging techniques.

My first real exposure to the power of subsurface data analysis in general, and 3D seismic reflection in particular, came whilst I was working in the Research Centre at Norsk Hydro (now Statoil) in Bergen, Norway, between 2002 and 2004. By integrating these data with, for example, wireline log, core and pressure data, I began to realize that a subsurface approach, if coupled with detailed outcrop-based analysis, was able to provide me with a true, three-dimensional understanding of complex geological structures and stratigraphic bodies.

Upon leaving Norsk Hydro in 2004, to pursue an academic career at Imperial College, I continued and continue to enjoy combining field and subsurface data. My key research interest lies in the tectono-stratigraphic evolution of rift basins, although my exposure to 3D seismic has allowed me to investigate topics as diverse as soft-sediment remobilisation, the development of intrusive and extrusive igneous complexes, and the development of mass transport complexes (MTCs).

Having worked in industry, I am aware of the value of academic research in hydrocarbon exploration and production, thus a significant amount of my research is funded by the hydrocarbon industry and is applied to industrial E&P issues. I hope that my two talks will illustrate some of the novel aspects of my research from a scientific perspective, but also the applicability of integrated approaches to understanding complex hydrocarbon E&P-related issues.

3D seismic reflection and borehole expression of tectonically-controlled deep-marine reservoirs; examples from the Northern North Sea hydrocarbon province

Deep-marine reservoirs form some of the most attractive targets in many mature and frontier basins. Determining the distribution and geometry of these reservoirs, especially within tectonically-active settings, remains a major challenge, however, principally due to the complex interaction of a variety of extra- and intra-basinal controls (i.e. tectonics, climate, sea-level, etc). In this talk I use 3D seismic reflection, well and core data to provide a regional synthesis of the subsurface expression of a series of tectonically-controlled, deep-marine reservoirs that are developed along the western Norwegian margin. I will also outline the key controls on the deposition of these reservoirs and illustrate the key trapping styles.

Turbidite sandstones represent the best reservoirs; in core, individual beds are up to a few metres thick, but amalgamated units up to several tens of metres thick are common. Sandy-mudstone debrites are observed, but they are of poor reservoir quality and may form barriers or baffles to fluid flow. Synthetic seismograms indicate that sandstone-dominated deposits are expressed on seismic data as packages of high-amplitude reflections. Amplitude mapping indicates that 11 slope fans are recognised and that these were fed by sediment routed through upper slope canyons incised into the eastern basin margin. These fans are either ponded behind or overstep intra-basin highs; the key trapping styles are: (i) stratigraphic, and related to up-dip pinch-out of the fans into slope mudstones; or (ii) structural, and related to differential compaction-related drape of fans across underlying fault blocks.

The areal extent of the onshore drainage catchments that supplied sediment to the fans has been estimated based on scaling relationships derived from modern source-to-sink systems. The results of our study suggest that the Turonian fans were sourced by drainage catchments that were up to 2200 km2 and which extended up to 140 km from the shoreline. The estimated inboard extent of the catchments correlates to the innermost structures of a large fault complex, which is thought to have defined the position of the regional drainage divide in this region since the Devonian. I suggest that increased sediment supply to the Turonian fan systems reflect tectonic rejuvenation of the landscape, rather than eustatic sea-level or climate fluctuations. The duration of fan deposition is thus interpreted to reflect the “relaxation time” of the landscape following tectonic perturbation, and fan system retrogradation and final abandonment is interpreted to reflect the eventual depletion of the onshore sediment source. Future exploration success in tectonically-controlled deep-marine reservoirs relies on a robust understanding of the seismic expression, sedimentology, stratigraphic architecture and trapping styles associated with turbidite systems deposited on bathymetrically-complex slopes. Furthermore, important insights into reservoir size and location can be gained by considering the complete “sediment routing system”.

Yosemite's Lyell Glacier may be receding

David Perlman, February 4, 2013

Yosemite's famed Lyell Glacier has stopped moving downhill and may actually be shrinking - another

probable sign that the world's climate is warming, scientists report.

"It appears to have stagnated, and we strongly suspect that it has thinned to less than half the size that would keep it moving," said Greg Stock, Yosemite National Park's geologist who has been measuring the Lyell and nearby Maclure Glacier for the past four years with Robert Anderson of the University of Colorado.

Sources: Esri, Tele Atlas, USGS Todd Trumbull / The Chronicle

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The Lyell is small by world standards - only about a quarter of a mile wide and less than that long - but it stands atop the headwaters of the Tuolumne River, which feeds San Francisco's Hetch Hetchy reservoir.

The glacier is the largest of 14 in the High Sierra that have shrunk by more than half during the past century, according to a recent survey by geologists at Portland State University in Oregon.

"The most logical reason for the shrinking is because of more loss from melting snow as the climate warms," Stock said.

At Yosemite, Stock has monitored the 12,000-foot-elevation Lyell glacier with stakes driven into the ice at its margin and made the most recent measurements during four climbing trips there last summer. It has shrunk by about 60 percent since 1900 and has thinned by about 120 vertical feet, which is probably the reason it has stopped moving, he said.

The two scientists also measured the Maclure Glacier, at 11,400 feet, and found that although it has lost a similar amount of ice as the Lyell, it is still moving downhill at about an inch a day. Although it has thinned considerably, the scientists said, it is still thick enough to move and flow because of increased amounts of meltwater.

The Lyell Glacier's continued shrinking mirrors the fate of hundreds of glaciers worldwide that are also losing ice. Bruce Molina, a glaciologist with the U.S. Geological Survey, recently reported he has photographed 2,000 of the world's glaciers during the past 35 years and has found that at least 1,975 are clearly receding.

Although the Lyell glacier is at the top of the 150-mile Tuolumne River, any loss of ice would have no effect on the supply of water to Hetch Hetchy, Stock said. Far more water flows into the river from all the streams that make up the river's huge watershed, which covers almost 2,000 square miles, he noted.

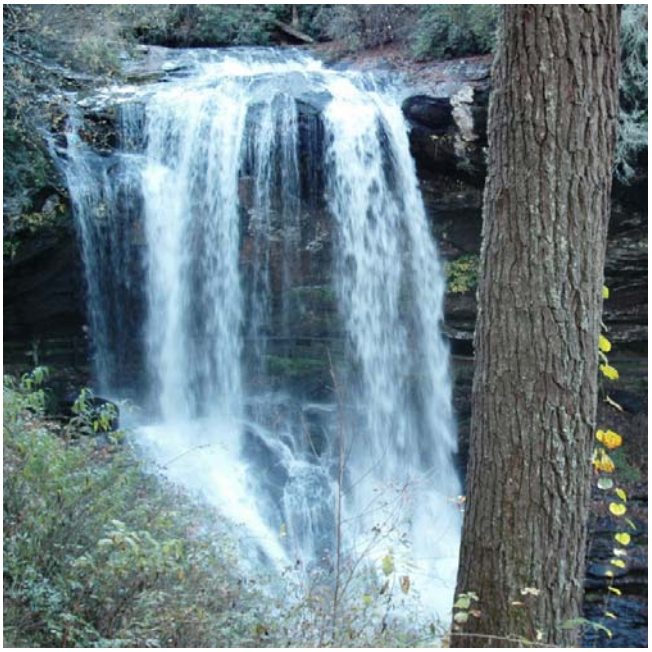
David Perlman is The San Francisco Chronicle's science editor.

Evidence of Geological 'Facelift' in the Appalachians

How does a mountain range maintain its youthful, rugged appearance after 200 million years without tectonic activity? Try a geological facelift -- courtesy of Earth's mantle.

Researchers from North Carolina State University noticed that a portion of the Appalachian Mountains in western North Carolina near the Cullasaja River basin was topographically quite different from its surroundings. They found two distinct landscapes in the basin: an upper portion with gentle, rounded hills, where the average distance from valley to mountain top was about 500 feet; and a lower portion where the valley bottom to ridgeline elevation difference was 2,500 feet,

hills were steep, and there was an abundance of waterfalls. The researchers believed they could use this unique topography to decipher the more recent geologic history of the region.



Waterfall in the rejuvenated Cullasaja River basin. (Credit: Image courtesy of North Carolina State University)

The Appalachian mountain range was formed between 325 to 260 million years ago by tectonic activity -- when tectonic plates underneath Earth's surface collided and pushed the mountains up. Around 230 million years ago, the Atlantic Ocean basin began to open, and this also affected the regional topography. But geologists knew that there hadn't been any significant tectonic activity in the region since then.

"Conventional wisdom holds that in the absence of tectonic activity, mountainous terrain gets eroded and beveled down, so the terrain isn't as dramatic," says Sean Gallen, NC State graduate student in marine, earth and atmospheric sciences. "When we noticed that this area looked more like younger mountain ranges instead of the older, rounded, rolling topography around it, we wanted to figure out what was going on."

Gallen and Karl Wegmann, an assistant professor of marine, earth and atmospheric sciences at NC State, decided to look at the waterfalls in the area, because they would have formed as the topography changed. By measuring the rate of erosion for the falls they could extrapolate their age, and therefore calculate how long ago this particular region was "rejuvenated" or lifted up. They found that these particular waterfalls were about 8 million years old, which indicated that the landscape must have been raised up around the same time.

But without tectonic activity, how did the uplift occur? Gallen and Wegmann point to Earth's mantle as the most likely culprit. "The Earth's outer shell is the crust, but the next layer down -- the mantle -- is essentially a very viscous fluid," Wegmann says. "When it's warm it can well up, pushing the crust up like a big blister. If a heavy portion of the crust underneath the Appalachians 'broke off,' so to speak, this area floated upward on top of the blister. In this case, our best hypothesis is that mantle dynamics rejuvenated the landscape."

The researchers' findings appear in *Geological Society of America Today*. Del Bohnenstiehl, NC State associate professor of marine, earth and atmospheric sciences, contributed to the work.

Story Source: The above story is reprinted from materials provided by **North Carolina State University**.

Journal Reference: Sean F. Gallen, Karl W. Wegmann, DelWayne R. Bohnenstiehl. **Miocene rejuvenation of topographic relief in the southern Appalachians**. *GSA Today*, 2013; 23 (2): 4

Survival of the Prettiest: Sexual Selection Can Be Inferred from the Fossil Record

Jan. 29, 2013 — Detecting sexual selection in the fossil record is not impossible, according to scientists writing in *Trends in Ecology and Evolution* this month, co-authored by Dr Darren Naish of the University of Southampton.

Sexual dimorphism in the pterosaur Darwinopterus. (Credit: Image by Mark Witton)

The term "sexual selection" refers to the evolutionary pressures that relate to a species' ability to repel rivals, meet mates and pass on genes. We can observe these processes happening in living animals but how do palaeontologists know that sexual selection operated in fossil ones?

Historically, palaeontologists have thought it challenging, even impossible, to recognise sexual selection in extinct animals. Many fossil animals have elaborate crests, horns, frills and other structures that look like they were used in sexual display but it can be difficult to distinguish these structures from those that might play a role in feeding behaviour, escaping predators, controlling body temperature and so on.

However in their review, the scientists argue that clues in the fossil record can indeed be used to infer sexual selection.

"We see much evidence from the fossil record suggesting that sexual selection played a major role in the evolution of many extinct groups," says Dr Naish, of the University's Vertebrate Palaeontology Research Group.

"Using observations of modern animal behaviour we can draw analogies with extinct animals and infer how certain features improve success during courtship and breeding."

Modern examples of sexual selection, where species have evolved certain behaviours or ornamentation that repel rivals and attract members of the opposite sex, include the male peacock's display of feathers, and the male moose's antlers for use in clashes during mating season.

Dr Naish and co-authors state that the fossil record holds many clues that point to the existence of sexual selection in extinct species, for example weaponry for fighting, bone fractures from duels, and ornamentation for display, such as fan-shaped crests on dinosaurs. Distinct differences between males and females of a species, called 'sexual dimorphism', can also suggest the presence of sexual selection, and features observed in sexually mature adults, where absent from the young, indicate that their purpose might be linked to reproduction.

We can also make inferences from features that are 'costly' in terms of how much energy they take to maintain, if we assume that the reproductive advantages outweighed the costs.

Whilst these features might have had multiple uses, the authors conclude that sexual selection should not be ruled out.

"Some scientists argue that many of the elaborate features on dinosaurs were not sexually selected at all," adds Dr Naish, who is based at the National Oceanography Centre, Southampton.

"But as observations show that sexual selection is the most common process shaping evolutionary traits in modern animals, there is every reason to assume that things were exactly the same in the distant geological past."

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

Journal Reference: Robert J. Knell, Darren Naish, Joseph L. Tomkins, David W.E. Hone. **Sexual selection in prehistoric animals: detection and implications**. *Trends in Ecology & Evolution*, 2013; 28 (1): 38 DOI: 10.1016/j.tree.2012.07.015

New Evidence On Dinosaurs' Role in Evolution of Bird Flight

A new study looking at the structure of feathers in bird-like dinosaurs has shed light on one of nature's most remarkable inventions -- how flight might have evolved.

An artist's impression of what the Archaeopteryx lithographica would have looked like in flight. (Credit: Image by artist Carl Buel)

Academics at the Universities of Bristol, Yale and Calgary have shown that prehistoric birds had a much more primitive version of the wings we see today, with rigid layers of feathers acting as simple airfoils for gliding.

Close examination of the earliest theropod dinosaurs suggests that feathers were initially developed for insulation, arranged in multiple layers to preserve heat, before their shape evolved for display and camouflage.

As evolution changed the configuration of the feathers, their important role in the aerodynamics and mechanics of flight became more apparent. Natural selection over millions of years ultimately modified dinosaurs' forelimbs into highly-efficient, feathered wings that

could rapidly change its span, shape and area -- a key innovation that allowed dinosaurs to rule the skies.

This basic wing configuration has remained more or less the same for the past 130 million years, with bird wings having a layer of long, asymmetrical flight feathers with short covert feathers on top. They are able to separate and rotate these flight feathers to gain height, change direction and even hover.

This formation allows birds to move in such a way as to produce both lift and thrust simultaneously -- a capability that man, with the help of technology, is still trying to successfully imitate.

The research, published November 21 in *Current Biology*, looked at the dinosaur *Anchiornis huxleyi* and the Jurassic bird *Archaeopteryx lithographica*. The latter is 155 million years old and widely considered to be the earliest known bird, presenting a combination of dinosaur and bird characteristics.

Their wings differed from modern day birds in being composed of multiple layers of long feathers, appearing to represent early experiments in the evolution of the wing. Although individual feathers were relatively weak due to slender feather shafts, the layering of these wing feathers is likely to have produced a strong airfoil.

The inability to separate feathers suggests that taking off and flying at low speeds may have been limited, meaning that wings were primarily used in high-speed gliding or flapping flight.

Dr Jakob Vinther, from the University of Bristol's Schools of Biological and Earth Sciences, said: "We are starting to get an intricate picture of how feathers and birds evolved from within the dinosaurs. We now seem to see that feathers evolved initially for insulation. Later in evolution, more complex vaned or pinnate feathers evolved for display.

"These display feathers turned out to be excellent membranes that could have been utilised for aerial locomotion, which only very late in bird evolution became what we consider flapping flight. This new research is shedding light not just on how birds came to fly, but more specifically on how feathers came to be the way they are today -- one of the most amazing and highly specialised structures in nature."

Dr Nicholas Longrich of Yale University added: "By studying fossils carefully, we are now able to start piecing together how the wing evolved. Before, it seemed that we had more or less modern wings from the Jurassic onwards. Now it's clear that early birds were more primitive and represented transitional forms linking birds to dinosaurs. We can see the wing slowly becoming more advanced as we move from *Anchiornis*, to *Archaeopteryx*, to later birds."

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

Journal Reference: Nicholas R. Longrich, Jakob Vinther, Qingjin Meng, Quangguo Li, Anthony P. Russell. **Primitive Wing Feather Arrangement in Archaeopteryx lithographica and Anchiornis huxleyi**. *Current Biology*, 21 November 2012 DOI: 10.1016/j.cub.2012.09.052

Grand Canyon as Old as the Dinosaurs: Dates for Carving of Western Grand Canyon Pushed Back 60 Million Years

An analysis of mineral grains from the bottom of the western Grand Canyon indicates it was largely carved out by about 70 million years ago -- a time when dinosaurs were around and may have even peeked over the rim, says a study led by the University of Colorado Boulder.

The new research pushes back the conventionally accepted date for the formation of the Grand Canyon in Arizona by more than 60 million years, said CU-Boulder Assistant Professor Rebecca Flowers. The team used a dating method that exploits the radioactive decay of uranium and thorium atoms to helium atoms in a phosphate mineral known as apatite, said Flowers, a faculty member in CU-Boulder's geological sciences department.

A new study led by CU-Boulder indicates the Grand Canyon was largely carved by about 70 million years ago. (Credit: Photo courtesy PDPhoto.org)

The helium atoms were locked in the mineral grains as they cooled and moved closer to the surface during the carving of the Grand Canyon, she said. Temperature variations at shallow levels beneath Earth's surface are

influenced by topography, and the thermal history recorded by the apatite grains allowed the team to infer how much time had passed since there was significant natural excavation of the Grand Canyon, Flowers said.

"Our research implies that the Grand Canyon was directly carved to within a few hundred meters of its modern depth by about 70 million years ago," said Flowers. A paper on the subject by Flowers and Professor Kenneth Farley of the California Institute of Technology was published online Nov. 29 in Science magazine.

Flowers said there is significant controversy among scientists over the age and evolution of the Grand Canyon. A variety of data suggest that the Grand Canyon had a complicated history, and the entire modern canyon may not have been carved all at the same time. Different canyon segments may have evolved separately before coalescing into what visitors see today.

In a 2008 study, Flowers and colleagues showed that parts of the eastern section of the Grand Canyon likely developed some 55 million years ago, although the bottom of that ancient canyon was above the height of the current canyon rim at that time before it subsequently eroded to its current depth.

Over a mile deep in places, Arizona's steeply sided Grand Canyon is about 280 miles long and up to 18 miles wide in places. Visited by more than 5 million people annually, the iconic canyon was likely carved in large part by an ancestral waterway of the Colorado River that was flowing in the opposite direction millions of years ago, said Flowers.

"An ancient Grand Canyon has important implications for understanding the evolution of landscapes, topography, hydrology and tectonics in the western U.S. and in mountain belts more generally," said Flowers. The study was funded in part by the National Science Foundation.

Whether helium is retained or lost from the individual apatite crystals is a function of temperatures in the rocks of Earth's crust, she said. When temperatures of the apatite grains are greater than 158 degrees Fahrenheit, no helium is retained in the apatite, while at temperatures below 86 degrees F, all of the helium is retained.

"The main thing this technique allows us to do is detect variations in the thermal structure at shallow levels of the Earth's crust," she said. "Since these variations are in part induced by the topography of the region, we obtained dates that allowed us to constrain the timeframe when the Grand Canyon was incised."

Flowers and Farley took their uranium/thorium/helium dating technique to a more sophisticated level by analyzing the spatial distribution of helium atoms near the margin of individual apatite crystals. "Knowing not just how much helium is present in the grains but also how it is distributed gives us additional information about whether the rocks had a rapid cooling or slow cooling history," said Flowers.

There have been a number of studies in recent years reporting various ages for the Grand Canyon, said Flowers. The most popular theory places the age of the Grand Canyon at 5 million to 6 million years based on the age of gravel washed downstream by the ancestral Colorado River. In contrast, a 2008 study published in Science estimated the age of the Grand Canyon to be some 17 million years old after researchers dated mineral deposits inside of caves carved in the canyon walls.

Paleontologists believe dinosaurs were wiped out when a giant asteroid collided with Earth 65 million years ago, resulting in huge clouds of dust that blocked the sun's rays from reaching Earth's surface, cooling the planet and killing most plants and animals.

Because of the wide numbers of theories, dates and debates regarding the age of the Grand Canyon, geologists have redoubled their efforts, said Flowers. "There has been a resurgence of work on this problem over the past few years because we now have some new techniques that allow us to date rocks that we couldn't date before," she said.

While the dating research for the new study was done at Caltech, Flowers recently set up her own lab at CU-Boulder with the ability to conduct uranium/thorium/helium dating.

"If it were simple, I think we would have solved the problem a long time ago," said Flowers. "But the variety of conflicting information has caused scientists to argue about the age of the Grand Canyon for more than 150 years. I expect that our interpretation that the Grand Canyon formed some 70 million years ago is going to generate a fair amount of controversy, and I hope it will motivate more research to help solve this problem."

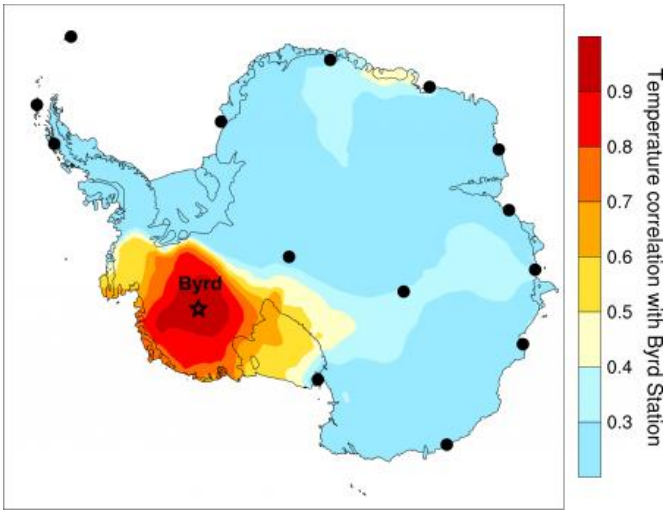
Story Source: The above story is reprinted from materials provided by University of Colorado at Boulder.

Journal Reference: R. M. Flowers and K. A. Farley. **Apatite 4He/3He and (U-Th)/He Evidence for an Ancient Grand Canyon**. *Science*, 29 November 2012 DOI: 10.1126/science.1229390

Study Shows Rapid Warming On the West Antarctic Ice Sheet

In a discovery that raises further concerns about the future contribution of Antarctica to sea level rise, a new study finds that the western part of the ice sheet is

experiencing nearly twice as much warming as previously thought.



Researchers have determined that the central region of the West Antarctic Ice Sheet (WAIS) is experiencing twice as much warming as previously thought. Their analysis focuses on the temperature record from Byrd Station (indicated by a star), which provides the only long-term temperature observations in the region. Other permanent research stations with long-term temperature records (indicated by black circles) are scattered around the continent. On this map, the color intensity indicates the extent of warming around Antarctica. (Credit: Image by Julien Nicolas, courtesy of Ohio State University)

The temperature record from Byrd Station, a scientific outpost in the center of the West Antarctic Ice Sheet (WAIS), demonstrates a marked increase of 4.3 degrees Fahrenheit (2.4 degrees Celsius) in average annual temperature since 1958 -- that is, three times faster than the average temperature rise around the globe.

This temperature increase is nearly double what previous research has suggested, and reveals -- for the first time -- warming trends during the summer months of the Southern Hemisphere (December through February), said David Bromwich, professor of geography at Ohio State University and senior research scientist at the Byrd Polar Research Center.

The findings were published online this week in the journal *Nature Geoscience*.

"Our record suggests that continued summer warming in West Antarctica could upset the surface mass balance of the ice sheet, so that the region could make an even bigger contribution to sea level rise than it already does," said Bromwich.

"Even without generating significant mass loss directly, surface melting on the WAIS could contribute to sea level indirectly, by weakening the West Antarctic ice shelves that restrain the region's natural ice flow into the ocean."

Andrew Monaghan, study co-author and scientist at the National Center for Atmospheric Research (NCAR), said that these findings place West Antarctica among the fastest-warming regions on Earth.

"We've already seen enhanced surface melting contribute to the breakup of the Antarctic's Larsen B Ice Shelf, where glaciers at the edge discharged massive sections of ice into the ocean that contributed to sea level rise," Monaghan said. "The stakes would be much higher if a similar event occurred to an ice shelf restraining one of the enormous WAIS glaciers."

Researchers consider the WAIS especially sensitive to climate change, explained Ohio State University doctoral student Julien Nicolas. Since the base of the ice sheet rests below sea level, it is vulnerable to direct contact with warm ocean water. Its melting currently contributes 0.3 mm to sea level rise each year -- second to Greenland, whose contribution to sea level rise has been estimated as high as 0.7 mm per year.

Due to its location some 700 miles from the South Pole and near the center of the WAIS, Byrd Station is an important indicator of climate change throughout the region.

In the past, researchers haven't been able to make much use of the Byrd Station measurements because the data was incomplete; nearly one third of the temperature observations were missing for the time period of the study. Since its establishment in 1957, the station hasn't always been occupied. A year-round automated station was installed in 1980, but it has experienced frequent power outages, especially during the long polar night, when its solar panels can't recharge.

Bromwich and two of his graduate students, along with colleagues from NCAR and the University of Wisconsin-Madison, corrected the past Byrd temperature measurements and used corrected data from a computer atmospheric model and a numerical analysis method to fill in the missing observations.

Aside from offering a more complete picture of warming in West Antarctica, the study suggests that if this warming trend continues, melting will become more extensive in the region in the future, Bromwich said.

While the researchers work to fully understand the cause of the summer warming at Byrd Station, the next step is clear, he added.

"West Antarctica is one of the most rapidly changing regions on Earth, but it is also one of the least known," he said. "Our study underscores the need for a reliable network of meteorological observations throughout West Antarctica, so that we can know what is happening -- and why -- with more certainty."

This research was funded by the National Science Foundation.

Story Source: The above story is reprinted from materials provided by **Ohio State University**, via Newswise.

Journal Reference: David H. Bromwich, Julien P. Nicolas, Andrew J. Monaghan, Matthew A. Lazzara, Linda M. Keller, George A. Weidner, Aaron B. Wilson. **Central West Antarctica among the most rapidly warming regions on Earth**. *Nature Geoscience*, 2012; DOI: 10.1038/ngeo1671

Thawing of Permafrost Expected to Cause Significant Additional Global Warming, Not Yet Accounted for in Climate Predictions

Permafrost covering almost a quarter of the northern hemisphere contains 1,700 gigatonnes of carbon, twice that currently in the atmosphere, and could significantly amplify global warming should thawing accelerate as expected, according to a new report released November 27 by the UN Environment Programme (UNEP).

A scientist standing in front of an ice-rich permafrost exposure on the coast of Herschel Island, Yukon Territory. (Credit: Michael Fritz)

Warming permafrost can also radically change ecosystems and cause costly infrastructural damage due to increasingly unstable ground, the report says.

Policy Implications of Warming Permafrost seeks to highlight the potential hazards of carbon dioxide and methane emissions from warming permafrost, which have not thus far been included in climate-prediction modelling. The science on the potential impacts of warming permafrost has only begun to enter the mainstream in the last few years, and as a truly "emerging issue" could not have been included in climate change modelling to date.

The report recommends a special IPCC assessment on permafrost and the creation of national monitoring networks and adaptation plans as key steps to deal with potential impacts of this significant source of emissions, which may become a major factor in global warming.

"Permafrost is one of the keys to the planet's future because it contains large stores of frozen organic matter that, if thawed and released into the atmosphere, would amplify current global warming and propel us to a warmer world," said UN Under-Secretary General and UNEP Executive Director Achim Steiner.

"Its potential impact on the climate, ecosystems and infrastructure has been neglected for too long," he added. "This report seeks to communicate to climate-treaty negotiators, policy makers and the general public the implications of continuing to ignore the challenges of warming permafrost."

Most of the current permafrost formed during or since the last ice age and extends to depths of more than 700 meters in parts of northern Siberia and Canada. Permafrost consists of an active layer of up to two metres in thickness, which thaws each summer and refreezes each winter, and the permanently frozen soil beneath.

Should the active layer increase in thickness due to warming, huge quantities of organic matter stored in the frozen soil would begin to thaw and decay, releasing large amounts of CO_2 and methane into the atmosphere.

Once this process begins, it will operate in a feedback loop known as the permafrost carbon feedback, which has the effect of increasing surface temperatures and thus accelerating the further warming of permafrost -- a process that would be irreversible on human timescales.

Arctic and alpine air temperatures are expected to increase at roughly twice the global rate, and climate projections indicate substantial loss of permafrost by 2100. A global temperature increase of 3°C means a 6°C increase in the Arctic, resulting in an irreversible loss of anywhere between 30 to 85 per cent of near-surface permafrost.

Warming permafrost could emit 43 to 135 gigatonnes of carbon dioxide equivalent by 2100 and 246 to 415 gigatonnes by 2200. Emissions could start within the next few decades and continue for several centuries.

Permafrost emissions could ultimately account for up to 39 per cent of total emissions, and the report's lead author warned that this must be factored in to the treaty to address global climate change expected to replace the Kyoto Protocol.

"The release of carbon dioxide and methane from warming permafrost is irreversible: once the organic matter thaws and decays away, there is no way to put it back into the permafrost," said lead author Kevin Schaefer, from the University of Colorado's National Snow and Ice Data Center.

"Anthropogenic emissions' targets in the climate change treaty need to account for these emissions or we risk

overshooting the 2°C maximum warming target," he added.

Most of the recent climate projections are biased on the low side relative to global temperature because the models do not at this time include the permafrost carbon feedback, the report says. Consequently, targets for anthropogenic greenhouse gas emissions based on these climate projections would be biased high.

Ecosystems and Infrastructure under Threat

Warming permafrost also brings negative consequences in terms of ecosystem and infrastructure damage.

The dominant ecosystems in permafrost regions are boreal forests to the south and tundra to the north. Permafrost is impermeable to water, so rain and melt water pool on the surface -- forming innumerable lakes and wetlands which are used by migratory birds as summer breeding grounds.

Ecosystem disturbances due to permafrost degradation will change species composition, and with it animal habitat and migration, according to the report.

Longer growing seasons due to higher temperatures favour the growth of shrubs and woody vegetation resulting in a northward migration of the tree line. Permafrost degradation and the resultant drying of the land can also result in disturbances such as fires. Fire in boreal forests has recently increased in intensity and frequency, and could become more common in tundra regions.

However, thawing permafrost is structurally weak, resulting in foundational settling that can damage or even destroy buildings, roads, pipelines, railways and power lines. Infrastructure failure can have dramatic environmental consequences, as seen in the 1994 breakdown of the pipeline to the Vozei oilfield in Northern Russia, which resulted in a spill of 160,000 tonnes of oil, the world's largest terrestrial oil spill.

Roads, buildings and other infrastructure in discontinuous permafrost, which tends to be warmer, and along the Arctic coast, where salt content means small temperature changes can turn ice to ground water, are most vulnerable to damage.

Climate change already could add up to US$6.1 billion to future costs for public infrastructure in the US state of Alaska between now and 2030, for example, and while there are only a handful of studies and reports evaluating the economic impacts of permafrost degradation, these indicate infrastructure maintenance and repair costs will increase.

"Thawing permafrost represents a dramatic physical change with huge impacts to ecosystems and human infrastructure," said Mr. Schaefer. "Individual nations need to develop plans to evaluate the risks, costs, and mitigation strategies to protect human infrastructure in permafrost regions most vulnerable to thaw."

Recommendations

The report issues the following specific policy recommendations to address the potential economic, social and environmental impacts of permafrost degradation in a warming climate:

- *Commission a Special Report on Permafrost Emissions*: The IPCC may consider preparing a special assessment report on how carbon dioxide and methane emissions from warming permafrost would influence global climate to support climate change policy discussions and treaty negotiations.
- *Create National Permafrost Monitoring Networks*: To adequately monitor permafrost, individual countries may consider taking over operation of monitoring sites within their borders, increasing funding, standardizing the measurements and expanding coverage. This applies particularly to countries with the most permafrost: Russia, Canada, China and the United States. The International Permafrost Association should continue to coordinate development and the national networks should remain part of the Global Terrestrial Network for Permafrost.
- *Plan for Adaptation*: Nations with substantial permafrost, such as those mentioned above, may consider evaluating the potential risks, damage and costs of permafrost degradation to critical infrastructure. Most nations currently do not have such plans, which will help policy makers, national planners and scientists quantify costs and risks associated with permafrost degradation.

UNEP report: http://www.unep.org/pdf/permafrost.pdf

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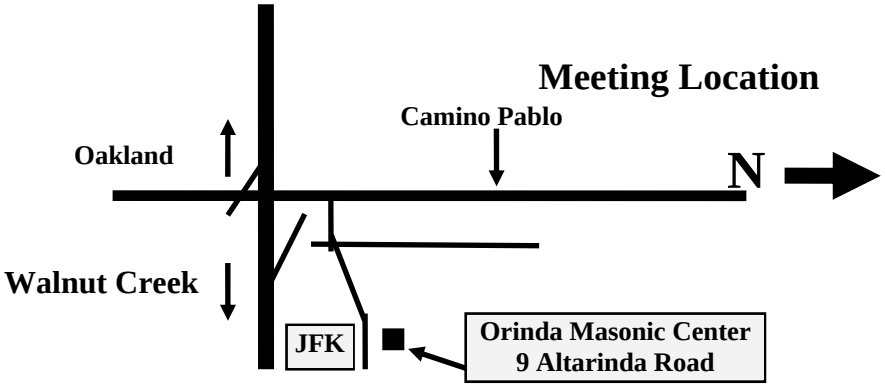

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