# NORTHERN CALIFORNIA GEOLOGICAL SOCIETY



## MEETING ANNOUNCEMENT

**DATE:** **January 26, 2011**

**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. John Parrish, State Geologist, California Geological Survey;**

## *California Geological Survey – Staying Relevant After 150 Years*

It has been attributed to the historian Will Durant that, "*Civilization exists by geologic consent – Subject to change without notice.*" Unlikely that California's early State Legislature had this in mind in 1851, during the heady Gold Rush Days, when it appointed Dr. John B. Trask (a physician) as the first State Geologist.

Dr. Trask impressed the State's officials with the need for a geological survey, and the Legislature established in 1860 the Geological Survey of California. It appointed Dr. Josiah D. Whitney as the second State Geologist. Dr. Whitney's first work was on the State's paleontology – not its mineralogy. This was especially frustrating to the Legislature, since it wanted information on the State's gold resources. Whitney's rather sharp rebukes to the Legislature and the Governor ultimately resulted in Whitney's departure in 1874.

It is from this example that a renamed survey, the State Mining Bureau, came into existence in 1880, well instructed with the need to be "relevant" in its products.

Since 1860, California has had six different names attached to its Survey. Each name was created to more accurately reflect the relevancy of the work being performed. Perhaps appropriately, the Survey has had 12 different logos over the last 150 years to reflect its work and government agency affiliation.

With few initial lapses, the California Geological Survey (CGS) has evolved to provide relevant products and services to its constituents. Whereas the early Survey was focused on geologic mapping and mineral resources, later surveys have successively expanded into broader areas. The name "Geology" was reincorporated into the Survey's name in 1962, showing that the Survey was more than just Mining. Two State agencies, the Division of Oil, Gas and Geothermal Resources and the Office of Mine Reclamation, were born from CGS.

Today, CGS produces a variety of modern, detailed geologic maps, reports and data about the State's geologic and seismic hazards, mineral resources and other geologically related topics. CGS's products are used by a variety of Federal, State and local government agencies, businesses, consultants, universities and schools. CGS is internationally recognized as a leading influence on public policy related to geologic and seismic hazards. *…continued on the back…*

# *NCGS 2010 – 2011 Calendar*

**Wednesday January 26, 2011**
Dr. John Parrish, State Geologist, California Geological Survey; ***California Geological Survey - Staying Relevant After 150 Years***
7:00 pm at Orinda Masonic Lodge

**Wednesday February 23, 2011**
Andre Brown, P.E.
***Gore Exploration Surveys***
7:00 pm at Orinda Masonic Lodge

**Wednesday March 30, 2011**
Dr. James Moore
***Native American Granite Cisterns in the Sierra Nevada***
7:00 pm at Orinda Masonic Lodge

**Wednesday April 27, 2011**
TBA
7:00 pm at Orinda Masonic Lodge

**Wednesday May 25, 2011**
**DINNER MEETING! EARLY TIME!**
Dr. Eldridge Moores
TBA
6:00 pm at Orinda Masonic Lodge

**Wednesday June 29, 2011**
TBA
7:00 pm at Orinda Masonic Lodge

## Upcoming NCGS Events

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|---|---|
| Early 2011 | Cantua Creek II; Dr. Mel Erskine |
| June 25 & 26, 2011 | Geology of Lake Tahoe Region, Dr. Rich Schweickert, Emeritus, University of Nevada, Reno |

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@sbcglobal.net**

## 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.

- November 9, 2010 – Darcy Ogden, Stanford
- December 7, 2010 - Open
- January 11, 2011 - Jessica Oster, Stanford
- February 8, 2011, Steve Self, The Open University, UK
- March 8, 2011, Mike Sawlan, USGS
- April 12, 2011, open
- May 10, 2011, Jorge Vazquez, USGS
- June 7, 2011, Jon Hagstrum, USGS, Presidential Address

## 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:

- February 8, 2011 Andre Brown W.L. Gore & Associates; *An Innovative Passive Detection Method for Site Screening of VOCs and SVOCs in Soil, Ground Water, and Indoor Air*
- March 9, 2011; Dr. Doris Sloan; CCGO Fundraiser

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/

- January 27, 2011, 7 pm; ***Geologic Sequestration of Carbon Dioxide: Minimizing Environmental Impacts***; Yousif Kharaka
- February 24, 2011; ***ARkStorm scenario modeling of southern California coastal impacts***; Patrick Barnard
- March 31, 2011; ***Geomagnetic field influence on avian homing instincts***; Jon Hagstrom

- April 28, 2011; Earthquake Prediction; Susan Hough
- May 26, 2011; Rare Earth Elements; Keith Long
- June 30, 2011; California Seafloor Mapping Program; Sam Johnson
- July 2011; Climate Variability/Change & SF Bay-Delta; Jim Cloern Ecosystem

## Back Issues to California Geology Available

Don Lewis reports that he is decluttering and has found five 3-ring binders full of old issues of the CA Div Mines & Geology monthly "Mineral Information Service" and its successor, "California Geology". He is not sure how complete a run it is but it runs between 1956-57 and 1960-72, at least. Rather than toss them, he is seeking a NCGS member who might be interested in them; he may ask why to help parse the requests. He should be able to bring them to the Feb meeting. Please contact him at: donlewis@comcast.net.

## The California Earthquake Clearinghouse has a new website

The **California Earthquake Clearinghouse** is a place to coordinate earthquake field investigations and share observations and knowledge among emergency responders and the engineering and scientific communities.

The Clearinghouse will provide a location, real or virtual, after a damaging earthquake, where engineers, geologists, seismologists, sociologists, economists, and other professionals who arrive in the affected area can become part of a larger, temporary organization (the Clearinghouse) to facilitate the gathering of information, maximize its availability, and better use the talents of those present. These experts have a wide range of knowledge and experience, and their observations in the field can add substantially to the information available to officials managing response and recovery operations.

The website provides information on the history and purpose of the Clearinghouse, the member organizations, recommendations for field investigation equipment, safety guidelines, and basic information on how to contribute to the clearinghouse after a California earthquake.

Please visit the new site:
http://www.eqclearinghouse.org/CA/

### Job Opportunity Notice: Hazardous Materials Specialist, Alameda County Environmental Health

Alameda County Environmental Health is seeking groundwater professionals to fill the Hazardous Materials Specialist (HMS) position in its Local Oversight Program (LOP) and Toxics Program. The HMS provides regulatory and technical oversight of subsurface contamination sites. The HMS reviews and analyzes technical data directly related to the investigation and remediation of subsurface soil and groundwater contamination and evaluates the effectiveness of corrective actions at leaking underground storage tank sites and other contaminated sites.

The preferred candidate should possess experience in the following areas: environmental engineering, geology/hydrogeology, groundwater geochemistry, contaminant fate and transport; and conventional and innovative remediation technologies. Experience in applying cutting-edge approaches and technologies for site characterization and remediation a plus. Teamwork and flexibility are essential. Excellent written and verbal communication skills are required.

The county is committed to building one of the most innovative and technically strong regulatory programs in the State and is looking for key individuals with energy, creativity, and technical vision to help us reach this goal. If you are interested, or know someone who may be interested in the position, applications are currently being accepted.

An Alameda County employment application and supplemental questionnaire are required and available online at www.acgov.org or can be obtained at Alameda County Human Resource Services, 1405 Lakeside Dr., Oakland, CA 94612. **Filing Deadline: January 31, 2011, 5 PM.** Contact Donna Drogos at 510.567.6721 for further information.

## Bay Area Science

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

This website came to our attention recently and we wanted to pass the information along to members. The 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.).

On this site, you can:

- Search public science events ranging from interactive discussions to tours.
- Take advantage of incredible local online science content.
- Find a local museums, science cafes, hikes, and tours in your neighborhood.
- Signup for our weekly newsletter with our editor's picks each week.

Whether you want to go to a local museum, watch a science video, or attend a discussion, it's all available on BayAreaScience.org.

If you'd like to submit an event for the calendar, please use our calendar submission page. For more information, please contact us anytime: info@bayareascience.org

## Mudrocks Conference February 7 & 8, 2011 Houston Geological Society

We received word of and a request to advertise this conference on unconventional reservoirs hosted by the Houston Geological Society to be held in early February 2011. The two day technical conference focuses on Mudrock system characterization to improve exploitation of Mudstone "shale gas/oil" reservoirs. The conference will be held at the Waterway Marriott Hotel in The Woodlands, Texas. The cost (including lunches) for HGS members is $550 by Jan 15, 2011 (after $580 US) or for non-members $600 ($630). Registration deadline is February 2, 2011. Please see HGS website for details and registration: http://www.hgs.org.

## Mysterious quake fault tremors to be studied

### Rumblings along stretch of San Andreas Fault could be quake precursors

Seismic detectors will be installed along a stretch of the San Andreas Fault early next year to study mysterious tremors deep underneath, in the hope they will provide information about events that lead up to major quakes.

Seismologists will begin the installation in early 2011 near the town of Cholame, Calif., where the tremors were first detected in 2004. Tremors, which are different from earthquakes, are extremely faint, periodic rumblings some 12 to 25 miles underground — far deeper than earthquakes. Studies suggest tremors may serve as precursors to earthquakes.

"The discovery of tremors deep in the roots of active plate boundary fault zones is arguably the most important discovery in earthquake science in decades," said Roland Bürgmann of the University of California, Berkeley, part of the team that will install the sensors, in a news release about the project. "This is the first project in which a permanent instrument network has been specifically designed with tremor in mind."

There is already a large network of earthquake sensors north of the site of the new project, which is being called TremorScope. The TremorScope instruments will record new data about how the southern San Andreas Fault works, said another team member, Barbara Romanowicz of the Berkeley Seismological Laboratory.

The Cholame tremors occur where the creeping, fairly benign middle section of the San Andreas Fault meets the locked, and thus more potentially dangerous, southern section. Many damaging large quakes have started here and spread southward. The last major quake on the southern San Andreas Fault was the 7.8-magnitude Fort Tejon earthquake in 1857.

While tremor studies may tell geologists what is happening deep under the southern locked portion of the San Andreas Fault, they also may aid earthquake prediction, similar to the way that tremor activity near volcanoes warns of eruptions.

"Since the tremors are really sensitive to small stress changes, changes in tremor activity may be the flag or signal that people have been looking for as a precursor to an earthquake," said team member Robert Nadeau, also of UC Berkeley.

The tremors may originate in small brittle regions that stick and break, while the bulk of the deeper rock creeps more fluidly, Bürgmann said. Whatever the mechanism, study of tremors should turn up new information about how earthquakes are triggered.

"Tremors are markedly different in character from 'normal' earthquakes, and are now allowing scientists to obtain entirely new insights into the dynamics of fault processes at plate boundaries at otherwise inaccessible depths and directly beneath where earthquakes occur," Bürgmann said.

# Raindrops Reveal How a Wave of Mountains Moved South Across the Country

*(An update to Dr. Page Chamberlain's NCGS presentation last year)*

ScienceDaily — Analyzing the isotope ratios of ancient raindrops preserved in soils and lake sediments, Stanford researchers have shown that a wave of mountain building began in British Columbia, Canada, about 49 million years ago and rolled south to Mexico. The finding helps put to rest the idea that there was once a Tibet-like plateau across the western United States that collapsed and eroded into the mountains we see today.

About 50 million years ago, mountains began popping up in southern British Columbia. Over the next 22 million years, a wave of mountain building swept (geologically speaking) down western North America as far south as Mexico and as far east as Nebraska, according to Stanford geochemists. Their findings help put to rest the idea that the mountains mostly developed from a vast, Tibet-like plateau that rose up across most of the western U.S. roughly simultaneously and then subsequently collapsed and eroded into what we see today.

The data providing the insight into the mountains -- so popularly renowned for durability -- came from one of the most ephemeral of sources: raindrops. Or more specifically, the isotopic residue -- fingerprints, effectively -- of ancient precipitation that rained down upon the American west between 65 and 28 million years ago.

Atoms of the same element but with different numbers of neutrons in their nucleus are called isotopes. More neutrons make for a heavier atom and as a cloud rises, the water molecules that contain the heavier isotopes of hydrogen and oxygen tend to fall first. By measuring the ratio of heavy to light isotopes in the long-ago rainwater, researchers can infer the elevation of the land when the raindrops fell.

The water becomes incorporated into clays and carbonate minerals on the surface, or in volcanic glass, which are then preserved for the ages in the sediments.

Hari Mix, a PhD candidate in Environmental Earth System Science at Stanford, worked with the analyses of about 2,800 samples -- several hundred that he and his colleagues collected, the rest from published studies -- and used the isotopic ratios to calculate the composition of the ancient rain. Most of the samples were from carbonate deposits in ancient soils and lake sediments, taken from dozens of basins around the western U.S.

Using the elevation trends revealed in the data, Mix was able to decipher the history of the mountains. "Where we got a huge jump in isotopic ratios, we interpret that as a big uplift," he said.

"We saw a major isotopic shift at around 49 million years ago, in southwest Montana," he said. "And another one at 39 mya, in northern Nevada" as the uplift moved southward. Previous work by Chamberlain's group had found evidence for these shifts in data from two basins, but Mix's work with the larger data set demonstrated that the pattern of uplift held across the entire western U.S.

The uplift is generally agreed to have begun when the Farallon plate, a tectonic plate that was being shoved under the North American plate, slowly began peeling away from the underside of the continent.

"The peeling plate looked sort of like a tongue curling down," said Page Chamberlain, a professor in environmental Earth system science who is Mix's advisor.

As hot material from the underlying mantle flowed into the gap between the peeling plates, the heat and buoyancy of the material caused the overlying land to rise in elevation. The peeling tongue continued to fall off, and hot mantle continued to flow in behind it, sending a slow-motion wave of mountain-building coursing southward.

"We knew that the Farallon plate fell away, but the geometry of how that happened and the topographic response to it is what has been debated," Mix said.

Mix and Chamberlain estimate that the topographic wave would have been at least one to two kilometers higher than the landscape it rolled across and would have produced mountains with elevations up to a little over 4 kilometers (about 14,000 feet), comparable to the elevations existing today.

Mix said their isotopic data corresponds well with other types of evidence that have been documented.

"There was a big north to south sweep of volcanism through the western U.S. at the exact same time," he said.

There was also a simultaneous extension of the Earth's crust, which results when the crust is heated from below, as it would have been by the flow of hot magma under the North American plate.

"The pattern of topographic uplift we found matches what has been documented by other people in terms of the volcanology and extension," Mix said.

"Those three things together, those patterns, all point to something going on with the Farallon plate as being responsible for the construction of the western mountain ranges, the Cordillera."

Chamberlain said that while there was certainly elevated ground, it was not like Tibet.

"It was not an average elevation of 15,000 feet. It was something much more subdued," he said.

"The main implication of this work is that it was not a plateau that collapsed, but rather something that happened in the mantle, that was causing this mountain growth," Chamberlain said.

Mix presented results of the study at the American Geophysical Union annual meeting in San Francisco on Dec. 17.

Andreas Mulch also contributed to the research. He is a researcher at BiK-F, a biodiversity and climate research center in Frankfurt, Germany, and a professor at Goethe-Universität.

*Stanford University (2010, December 21).*

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# Ice Sheet Melt Identified as Trigger of 'Big Freeze'

ScienceDaily — The main cause of a rapid global cooling period, known as the Big Freeze or Younger Dryas -- which occurred nearly 13,000 years ago -- has been identified thanks to the help of an academic at the University of Sheffield.

A new paper, which is published in *Nature* on April 1, 2010, has identified a mega-flood path across North America which channelled melt-water from a giant ice sheet into the oceans and triggering the Younger Dryas cold snap.

The research team, which included Dr Mark Bateman from the University of Sheffield's Department of Geography, discovered that a mega-flood, caused by the melting of the Laurentide ice sheet, which covered much of North America, was routed up into Canada and into the Arctic Ocean.

This resulted in huge amounts of fresh water mixing with the salt water of the Arctic Ocean. As a result, more sea-ice was created which flowed into the North Atlantic, causing the northward continuation of the Gulf Stream to shut down.

*Modern-day Hubbard Glacier in Seward, Alaska. New research has identified a mega-flood path across North America which channeled melt-water from a giant ice sheet into the oceans and triggering the Younger Dryas cold snap. (Credit: iStockphoto)*

Without the heat being brought across the Atlantic by the Gulf Stream, temperatures in Europe plunged from similar to what they are today, back to glacial temperatures with average winter temperatures of -25oC. This cooling event has become known as the Younger Dryas period with cold conditions lasting about 1400 years. The cold of the Younger Dryas affected many places across the continent, including Yorkshire in the Vale of York and North Lincolnshire which became arctic deserts with sand dunes and no vegetation.

Before now, scientists have speculated that the mega-flood was the main cause of the abrupt cooling period, but the path of the flood waters has long been debated and no convincing evidence had been found establishing a route from the ice-sheet to the North Atlantic.

The research team studied a large number of cliff sections along the Mackenzie Delta and examined the sediments within them. They found that many of the cliff sections showed evidence of sediment erosion. This evidence spanned over a large region at many altitudes, which could only be explained by a mega-flood from the over-spilling of Lake Agassiz, which was at times bigger than the UK, at the front of the Laurentide Ice-sheet rather than a normal flood of the river.

Dr Bateman, who has been researching past environmental changes both in the UK and elsewhere in the world for almost 20 years, runs the luminescence dating lab at Sheffield. The lab was able to take the MacKenzie Delta sediment samples from above and below the mega-flood deposits, and find out when the mega-flood occurred, enabling its occurrence to be attributed to the start of the Younger Dryas.

The study will help shed light on the implications of fresh water input into the North Atlantic today.

There are current concerns that changes in the salinity of the ocean today, could cause another shut down of the Gulf Stream. Current climate changes, including global warming, may be altering the planetary system which regulates evaporation and precipitation, and moves fresh water around the globe.

The findings, which show the cause, location, timing and magnitude of the mega-flood, will enable scientists to better understand how sensitive both oceans and climates are to fresh-water inputs and the potential climate changes which may ensue if the North Atlantic continues to alter.

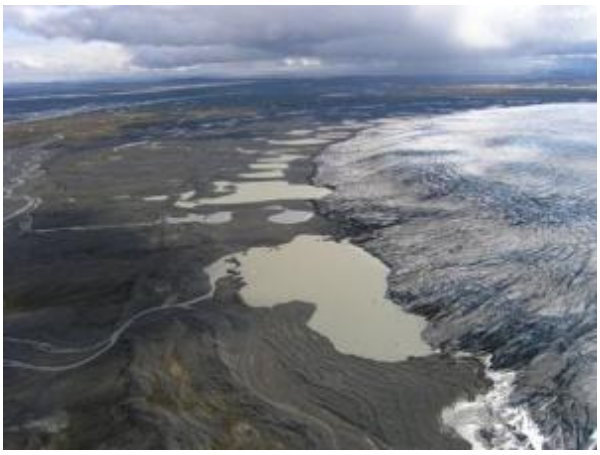
Dr Mark Bateman, from the University of Sheffield's Centre for International Drylands Research at the Department of Geography, said: "The findings of this paper through the combination of luminescence dating, landscape elevation models and sedimentary evidence allows an insight into what must have been one of the most catastrophic geological events in recent earth's history. They also show how events within the Earth-climate system in North America had huge impacts in Europe."

# Newly Discovered Drumlin Field Provides Answers About Glaciation and Climate

ScienceDaily — The landform known as a drumlin, created when the ice advanced during the Ice Age, can also be produced by today's glaciers. This discovery, made by researchers from the University of Gothenburg, Sweden, has just been published in the journal *Geology*.

Drumlins generally consist of an accumulation of glacial debris -- till -- and are found in areas that were covered by ice sheet. As the ice advanced, it moved rocks, gravel and sand and created tear-shaped raised ridges running parallel with the movement of the ice.

"Until now, scientists have been divided on how drumlins were created," says Mark Johnson from the Department of Earth Sciences at the University of Gothenburg. "Because they are formed under the ice, it's not an observable process. Drumlins are common almost everywhere the Ice Age ice sheets existed, but they're almost unknown with modern-day glaciers. Now, though, we've found a new drumlin field by the Múlajökull glacier on Iceland. It's quite unique."



*The edge of the Múlajökull glacier on Iceland. The ridges between the lakes are drumlins. (Credit: Photo by Ívar Örn Benediktsson)*

**The melting of glaciers revieles drumlins**

The melting of glaciers as a result of climate change has helped the researchers to study this geological phenomenon. The drumlin discovery on Iceland has presented unique opportunities to study their structure.

"One of the drumlins we found was sliced through by erosion. This gave us an opportunity to study it layer by layer, and it was clear that it had been built up only recently. In other words, the glacier has not just retreated to reveal old drumlins, but is continuing to create new ones."

There are currently multiple theories about the origins of drumlins. The Gothenburg researchers' discovery shows that they can form within two kilometres of the edge of the ice.

"A surging glacier can move 100 metres a day, as opposed to the more normal 100 metres a year. If we can link drumlins to fast-moving glaciers, this would mean that the ice sheet advanced much more quickly than scientists currently believe."

**Can effect climate research**

The link between drumlins and rapid ice movements is important for climate research. When modelling climate change, we need to know how high and how cold a glacier was in order to understand the last Ice Age. A glacier that moves quickly will not be as thick. This discovery could therefore affect how scientists approach climate modelling.

Solving the riddle of the drumlin is a longstanding dream for Mark Johnson:

"We discovered the drumlin field while flying in towards the edge of the glacier to do a completely different study. It was the most exciting thing I've been involved in during my research. All geologists know about drumlins, and when I began to study

geology in Wisconsin in the 1980s, many people would come there to study the drumlins in the area. Coming up with a theory for how they formed was a big question even then."

The discovery of the new drumlin field was made by Mark Johnson from the Department of Earth Sciences at the University of Gothenburg in collaboration with researchers from Iceland, Norway and the UK.

**Journal Reference**:

M. D. Johnson, A. Schomacker, I. O. Benediktsson, A. J. Geiger, A. Ferguson, O. Ingolfsson. **Active drumlin field revealed at the margin of Mulajokull, Iceland: A surge-type glacier**. *Geology*, 2010; 38 (10): 943 DOI

# Extreme Global Warming in the Ancient Past

ScienceDaily — Variations in atmosphere carbon dioxide around 40 million years ago were tightly coupled to changes in global temperature, according to new findings published in the journal *Science*. The study was led by scientists at Utrecht University, working with colleagues at the NIOZ Royal Netherlands Institute for Sea Research and the University of Southampton.

"Understanding the relationship between the Earth's climate and atmospheric carbon dioxide in the geological past can provide insight into the extent of future global warming expected to result from carbon dioxide emission caused by the activities of humans," said Dr Steven Bohaty of the University of Southampton's School of Ocean and Earth Science (SOES) based at the National Oceanography Centre in Southampton.

It has been known for some time that the long-term warmth of the Eocene (~56 to 34 million years ago) was associated with relatively high atmospheric carbon dioxide levels. However, scientists were previously unable to demonstrate tight-coupling between variations in atmospheric carbon dioxide and shorter-term changes in global climate.

To fill this gap in knowledge, the authors of the new study focused on one of the hottest episodes of Earth's climate history -- the Middle Eocene Climatic Optimum (MECO), which occurred around 40 million years ago.

Algae use photosynthesis to harvest the energy of the sun, converting carbon dioxide and water into the organic molecules required for growth. Different isotopes of carbon are incorporated into these molecules depending on the environmental conditions under which algae grow. Ancient climate can therefore be reconstructed by analysing the carbon isotope ratios of molecules preserved in fossilised algae.

The researchers took this approach to reconstruct variations in carbon dioxide levels across the MECO warming event, using fossilised algae preserved in sediment cores extracted from the seafloor near Tasmania, Australia, by the Ocean Drilling Program. They refined their estimates of carbon dioxide levels using information on the past marine ecosystem derived from studying changes in the abundance of different groups of fossil plankton.

Their analyses indicate that MECO carbon dioxide levels must have at least doubled over a period of around 400,000 years. In conjunction with these findings, analyses using two independent molecular proxies for sea surface temperature show that the climate warmed by between 4 and 6 degrees Celsius over the same period.

"We found a close correspondence between carbon dioxide levels and sea surface temperature over the whole period, suggesting that increased amounts of carbon dioxide in the atmosphere played a major role in global warming during the MECO," said Bohaty.

The researchers consider it likely that elevated atmospheric carbon dioxide levels during the MECO resulted in increased global temperatures, rather than vice versa, arguing that the increase in carbon dioxide played the lead role.

"The change in carbon dioxide 40 million years ago was too large to have been the result of temperature change and associated feedbacks," said co-lead author Peter Bijl of Utrecht University. "Such a large change in carbon dioxide certainly provides a plausible explanation for the changes in Earth's temperature."

The researchers point out that the large increase in atmospheric carbon dioxide indicated by their analysis would have required a natural carbon source capable of injecting vast amounts of carbon into the atmosphere.

The rapid increase in atmospheric carbon dioxide levels around 40 million years ago approximately coincides with the rise of the Himalayas and may be related to the disappearance of an ocean between India and Asia as a result of plate tectonics -- the large scale movements of the Earth's rocky shell (lithosphere). But, as explained by Professor Paul Pearson of Cardiff University in a perspective article accompanying the *Science* paper, the hunt is now on to discover the exact cause.

The researchers are Peter Bijl, Alexander Houben, Appy Sluijs, Henk Brinkhuis, Gert-Jan Reichart (Utrecht University), Jaap Sinninghe Damsté and Stefan Schouten (NIOZ Royal Netherlands Institute of Sea Research) and Steven Bohaty (SOES). The research was funded by the Netherlands Organization for Scientific Research Utrecht University and Statoil, and used samples and data provided by the Ocean Drilling Program (ODP).

**Journal References**:

P. K. Bijl, A. J. P. Houben, S. Schouten, S. M. Bohaty, A. Sluijs, G.-J. Reichart, J. S. Sinninghe Damste, H. Brinkhuis. **Transient Middle Eocene Atmospheric CO2 and Temperature Variations**. *Science*, 2010; 330 (6005): 819 DOI

P. N. Pearson. **Increased Atmospheric CO2 During the Middle Eocene**. *Science*, 2010; 330 (6005): 763 DOI

# Novel Ocean-Crust Mechanism Could Affect World's Carbon Budget and Climate

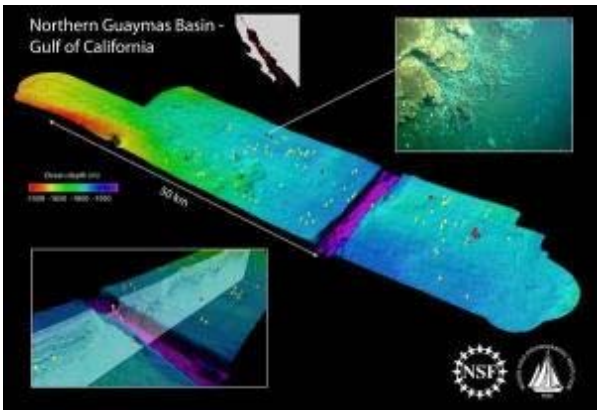
ScienceDaily — Earth is constantly manufacturing new crust, spewing molten magma up along undersea ridges at the boundaries of tectonic plates. The process is critical to the planet's metabolism, including the cycle of underwater life and the delicate balance of carbon in the ocean and atmosphere.

Now, scientists at the Woods Hole Oceanographic Institution (WHOI) have observed ocean crust forming in an entirely unexpected way -- one that may influence those cycles of life and carbon and, in turn, affect the much-discussed future of the world's climate.

Working at the Guaymas basin in the Gulf of California, WHOI scientists confirmed what they suspected from brief glimpses of the area during previous missions: The inner Earth is injecting swaths of magma called sills as far as 50 kilometers away from the plate boundary, on each side of the ridge -- nearly 10 times farther from such an active ocean ridge than had been observed before.

Unlike conventional ocean crust production, where magma bubbles up through volcano-like openings in a narrow (about 5 km-wide) zone at the plate boundary, these recently observed magmatic sills never quite make it to the ocean floor. Rather, they form when magma stops in the thick layers of organic-rich sediment filling the basin and spreads laterally.

Using a sound-wave emitting air gun, side-scan sonar, and ocean-bottom cameras, the scientists determined that the sills are consistently formed at the same shallow depth within the 1-2 km-thick sediment. Normally, when magma erupts at the seafloor, it spreads no farther than 5 km or less from the spreading ridges; any magma found further out than that is usually older material, carried that distance by spreading crust over time and buried deep beneath many years of sedimentation.




*Bathymetry of a rift segment of the North Guaymas spreading center in the central Gulf of California shows a series of subsurface features. They are interpreted to be shallow sills intruded into the sediment-filled basin up to 50 km from the rift axis (lower left). High-resolution imaging by sidescan sonar revealed nearly 100 potential hydrothermal vent sites (yellow points) believed to result from widespread emplacement of magma over an area 10 times wider than expected at mid-ocean ridges. Deep-sea photographic surveys at some of the sites (red points) found elevated temperatures and methane concentrations in near-bottom waters and vibrant chemosynthetic animal communities (upper right, photo, about 5m across) containing tubeworms, clams, crabs, bacterial mats, and microbially precipitated carbonate deposits. The intrusion of magma into the sediments has the potential to release significant amounts of carbon from the sediments, previously thought to act as a long term carbon repository. (Credit: Graphic by S. Adam Soule, Woods Hole Oceanographic Institution)*

The report suggests that rather than escaping through vent openings in the crust confined to the plate boundary, the molten material "intrudes" at numerous points below the sediments up to 50 km from the seafloor ridge, which connects in the north to the San Andreas Fault. This "active, shallow magmatism," releases nutrient-rich fluids from within the sediments that feed new communities of sea creatures much like those observed around vent sites on deep-water, mid-ocean ridges.

It also releases significant amounts of carbon from sediments, the scientists report in the current issue of the journal *Nature Geoscience* on Nov. 14. By raising the temperature of the surrounding sediments, the sills produce up to 10 times more $CO_2$

and methane gas than a similar volume of volcanic rocks that spews through a vent onto the seafloor.

The researchers are not sure just how much of these greenhouse gases remain in the sediment and the water, how much they affect the biological communities, and how much $CO_2$ and methane escapes into the atmosphere. But they do know they have observed a novel mechanism in creating ocean crust.

"There is something different about this ridge," said geologist S. Adam Soule, a member of the WHOI research team led by fellow geologist Daniel Lizarralde. "Somehow it allows the magma to keep spreading."

"What we see is something that is surprising to a lot of people," said Lizarralde. "People are like, 'How can the magma do that?'" But given the geology of this narrow-rift region, he says, the phenomenon "makes a lot of sense." Most undersea volcanic areas are able to "focus" magma intrusion up through an opening that is only about 1 or 2 km wide, he says. "Whatever it is that's different about Guaymas has something to do with controlling these focusing mechanisms."

Even though it is "different" from conventional sites, Soule suspects the Gulf of California is far from the only place on the planet where this phenomenon is occurring. He says there are "lots of places," including the Red Sea, with characteristics similar to those of the narrow sea between the Baja Peninsula and the North American continent. In addition to fairly recent sediment deposits, these areas of continental rifting feature coastal ocean upwelling resulting in "high biological productivity and organic-rich sediment," the researchers report in their study.

Lizarralde, Soule and WHOI colleagues Jeff S. Seewald and Giora Proskurowski detected "thriving animal communities" near the sill areas, Soule said, including tubeworms and bacterial mats. These communities were fostered by the warm water percolating through the sediments to the sea floor, the researchers said.

The findings, Soule added, should be of significant interest to a wide range of scientific disciplines. "For biologists, it is the chemo-synthetic communities at the warm seeps," he said. "Geologists want to know what they can learn about magmatism and how the ocean crust is built. And for climate scientists, it is critical that we have an accurate characterization of tectonic settings that are sources and sinks of carbon."

The WHOI study, funded by the National Science Foundation, represents "a start in assessing the contribution of the seafloor spreading process to the global carbon budget," David Goldberg of the Lamont Doherty Earth Observatory writes in an accompanying News and Views piece in *Nature Geoscience*. "Sills derived from intrusive volcanism in sedimentary basins have been linked to huge natural methane fluxes in the past.

"Further research concerning the biological uptake from seafloor vents is also needed. But what we know now is that sills such as those observed below the Gulf of California, which naturally vent fluids to the ocean, seem to be carbon sources as they cool. "

Lizarralde says the team has written a proposal to go back and further explore the area with other instruments to get a more accurate picture of the carbon flux at the sediment-ocean interface. "The carbon story still remains unclear," he says.

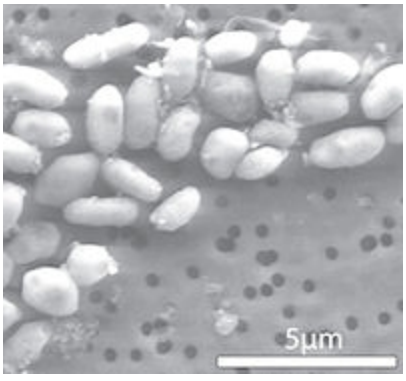
Goldberg concurs that "such exploration of the sea floor is critical to assessing its potential as an anthropogenic carbon reservoir as well as to undertaking the Earth's natural carbon budget."

**Journal Reference**:

Daniel Lizarralde, S. Adam Soule, Jeff S. Seewald, Giora Proskurowski. **Carbon release by off-axis magmatism in a young sedimented spreading centre**. *Nature Geoscience*, 2010; DOI

## Discovery of "Arsenic-bug" Expands Definition of Life

**Dec. 2, 2010:** NASA-supported researchers have discovered the first known microorganism on Earth able to thrive and reproduce using the toxic chemical arsenic. The microorganism, which lives in California's Mono Lake, substitutes arsenic for phosphorus in the backbone of its DNA and other cellular components.




*A microscopic image of GFAJ-1 grown on arsenic.*

"The definition of life has just expanded," said Ed Weiler, NASA's associate administrator for the Science Mission Directorate at the agency's Headquarters in Washington. "As we pursue our

efforts to seek signs of life in the solar system, we have to think more broadly, more diversely and consider life as we do not know it."

This finding of an alternative biochemistry makeup will alter biology textbooks and expand the scope of the search for life beyond Earth. The research is published in this week's edition of Science Express.

Carbon, hydrogen, nitrogen, oxygen, phosphorus and sulfur are the six basic building blocks of all known forms of life on Earth. Phosphorus is part of the chemical backbone of DNA and RNA, the structures that carry genetic instructions for life, and is considered an essential element for all living cells.

Phosphorus is a central component of the energy-carrying molecule in all cells (adenosine triphosphate) and also the phospholipids that form all cell membranes. Arsenic, which is chemically similar to phosphorus, is poisonous for most life on Earth. Arsenic disrupts metabolic pathways because chemically it behaves similarly to phosphate.

"We know that some microbes can breathe arsenic, but what we've found is a microbe doing something new -- building parts of itself out of arsenic," said Felisa Wolfe-Simon, a NASA Astrobiology Research Fellow in residence at the U.S. Geological Survey in Menlo Park, Calif., and the research team's lead scientist. "If something here on Earth can do something so unexpected, what else can life do that we haven't seen yet?"

*The Mono Lake Research area in central California.*

The newly discovered microbe, strain GFAJ-1, is a member of a common group of bacteria, the Gammaproteobacteria. In the laboratory, the researchers successfully grew microbes from the lake on a diet that was very lean on phosphorus, but included generous helpings of arsenic. When researchers removed the phosphorus and replaced it with arsenic the microbes continued to grow. Subsequent analyses indicated that the arsenic was being used to produce the building blocks of new GFAJ-1 cells.

The key issue the researchers investigated was when the microbe was grown on arsenic did the arsenic actually became incorporated into the organisms' vital biochemical machinery, such as DNA, proteins and the cell membranes. A variety of sophisticated laboratory techniques was used to determine where the arsenic was incorporated.

The team chose to explore Mono Lake because of its unusual chemistry, especially its high salinity, high alkalinity, and high levels of arsenic. This chemistry is in part a result of Mono Lake's isolation from its sources of fresh water for 50 years.

*Geomicrobiologist Felisa Wolfe-Simon, collecting lake-bottom sediments in the shallow waters of Mono Lake in California. Credit: ©2010 Henry Bortman*

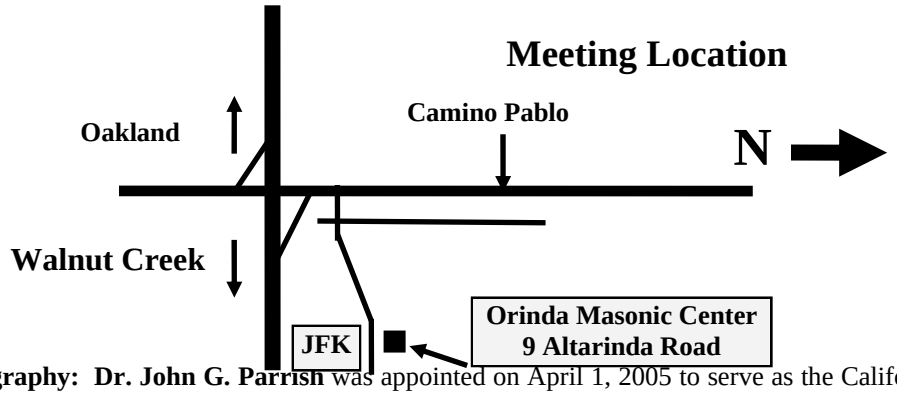
The results of this study will inform ongoing research in many areas, including the study of Earth's evolution, organic chemistry, biogeochemical cycles, disease mitigation and Earth system research. These findings also will open up new frontiers in microbiology and other areas of research.

"The idea of alternative biochemistries for life is common in science fiction," said Carl Pilcher, director of the NASA Astrobiology Institute at the agency's Ames Research Center in Moffett Field, Calif. "Until now a life form using arsenic as a building block was only theoretical, but now we know such life exists in Mono Lake."

The research team included scientists from the U.S. Geological Survey, Arizona State University in Tempe, Ariz., Lawrence Livermore National Laboratory in Livermore, Calif., Duquesne University in Pittsburgh, Penn., and the Stanford Synchroton Radiation Lightsource in Menlo Park, Calif.

NASA's Astrobiology Program in Washington contributed funding for the research through its Exobiology and Evolutionary Biology program and the NASA Astrobiology Institute. NASA's Astrobiology Program supports research into the origin, evolution, distribution, and future of life on Earth.

Credit: Science@NASA




**Biography: Dr. John G. Parrish** was appointed on April 1, 2005 to serve as the California State Geologist and Chief of the California Geological Survey (CGS). The State Geologist is the primary contact and spokesperson for the California Geological Survey with the Director of the Department Conservation, the Resources Agency, the Governor's Office, the State Legislature, and the State Mining and Geology Board. Previously, he was the Executive Officer for the State Mining and Geology Board (SMGB) for eleven years. He served briefly as the Executive Officer for the Board of Registration for Geologists and Geophysicists before his assignment with the SMGB. Before coming to State service, Dr. Parrish spent 21 years in various capacities of geological exploration for a large international petroleum company. He undertook exploration activities throughout the Rocky Mountains, Arkansas, Oklahoma, Texas, the North Sea, North and West Africa, and California. John was the Geological Manager for operations in London, England, and Division Geologist for company operations based in San Antonio, Texas, and Bakersfield, California. A native of California, he was raised in Los Angeles. He received a Bachelor of Science Degree in Geology from the University of Redlands in Southern California; a Master of Science Degree in Geology from the University of Houston, Houston, Texas; a Master of Business Administration from the California State University; and, a Ph. D. in Marine Geology from the University of Wales, Aberystwyth, Wales, U. K. Parrish is a California licensed PG, a CPG by the American Institute of Professional Geologists, a Certified Petroleum Geologist by the American Association of Petroleum Geologists and a Founding Member of the Energy Minerals Division, and a Member of the Society of Mining and Metallurgical Engineers. He is the Chair of the Geologic Hazards & Policy Committee of the Association of American State Geologists; Chair of the California Earthquake Prediction and Evaluation Council (CEPEC) which reports directly to the California Emergency Management Agency on earthquake matters; Chairman of the Western States Seismic Policy Council; Board Member on the Consortium of Organizations for Strong Motion Observation Systems, and Member of the USGS's Scientific Earthquake Studies Advisory Committee. Recently Parrish was awarded the John T. Galey, Sr. Memorial Public Service Award by the American Institute of Professional Geologists. This national award is given to an individual for outstanding public service well beyond the normal professional responsibilities.

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