

## Future Scientific Drilling of Oceanic Crust

Processes that occur within and across the oceanic crust—in particular along mid-ocean ridges and oceanic spreading centers—play a huge role in the dynamics of the Earth. The largest fluxes of heat and material between the Earth's mantle, crust, and seawater occur via magmatic, tectonic, and hydrothermal processes along oceanic spreading centers and their vast flanks. Roughly two thirds of the Earth's surface is accreted through magmatic and tectonic processes along mid-ocean ridges, and subduction of this ocean crust in turn influences mantle compositions. Exchange of elements between ocean crust and seawater strongly influences seawater compositions and leaves a geologic record of fluid-rock reactions in altered ocean crust. Some of these reactions contribute energy to microbial activity of a largely unexplored biosphere. The dynamics of ridge and ocean crustal processes therefore have enormous implications for thermal, chemical, and biological exchanges between the solid Earth and the hydrosphere.

Fully understanding these processes will require scientific drilling. Drilling and retrieving cores allows researchers to get a snapshot of crustal properties through time at specific locations. Examining differences between cores across the ocean could further help researchers form a basic picture of the processes that govern ocean crustal processes. The current stock of retrieved cores and data from borehole logging and experiments offers tantalizing glimpses of several processes, including how crust is generated, or accreted, at mid-ocean ridges, how oceanic crust is a significant sink for important chemical constituents of seawater (including carbon in some instances), how microbial communities are able to live deep within ocean crust, how seawater-crust exchanges may have changed over geologic time with varying climatic conditions, and how pathways of heat and chemicals move between the solid Earth, oceans, and biosphere (see Figure 1). But to further quantify these processes, new drilling and a broader drilling strategy are required that take advantage of the latest drilling and downhole sampling (of both fluids and rocks), experimentation, and logging technology.

Primary themes of future scientific investigation can be divided roughly into three groups: (1) accretion of ocean crust, especially active geologic, geotectonic, and biological processes surrounding the ridge axis (the axial

zone); (2) hydrological-geochemical-microbiological feedbacks as ocean crust matures and migrates from spreading centers; and (3) lithospheric heterogeneity and corresponding biological diversity in slow and ultraslow spreading crust. Interdisciplinary approaches and projects are needed to address these major themes, which will bring exciting new challenges and opportunities during the next phase of ocean drilling.

### *Accretion and Axial Zone Processes*

Oceanic crust is accreted and rapidly evolves during the first few million years of seafloor spreading through vigorous volcanic, hydrothermal, and deformational processes within the axial zone. Thus, understanding axial zone dynamics is very important to our understanding of how crust is sustained and recycled on Earth.

Because little sediment has accumulated and only a thin crustal layer separates the oceans from the mantle, young oceanic crust surrounding the ridge axis also plays direct and critical roles in the thermal, chemical, and biological exchanges between the hydrosphere and solid Earth. Magma distribution; crustal cracking; the depth, vigor, and geometry of hydrothermal circulation; and subseafloor biological activity are inexorably linked to one another. Understanding and quantifying these processes and their linkages will permit quantitative estimates on the biological productivity of the axial subseafloor biosphere, helping to answer questions such as, What is the magnitude of processes in the subsurface compared with biological expression at the seafloor? What are the major metabolic pathways and biogeochemical consequences of these activities in the Earth system?

Progress on many of these issues is restricted by a dearth of information on ocean crustal permeability. Are fluid pathways dominated by faults, fractures, or the permeability of undeformed rocks? How does permeability and fluid flow vary with depth, time, and crustal age, particularly along and across ridge axes? Few constraints are known on the residence time for hydrothermal fluids and how microbiological activity varies within a hydrothermal system. For example, it is debated whether fluid flow is required to transport nutrients to subseafloor microbial communities in ocean crust of all ages. Carbon cycling in ocean crust, and its role in the global carbon cycle, is also unknown. Some scientists suggest that subseafloor pathways allow the dispersal of biota, but this hypothesis remains untested. Moreover, are temperature and availability of chemical energy sources



*Fig. 1. In March–April 1991, divers aboard Alvin observed an astounding bloom of chemosynthetic microbes during an eruption of the East Pacific Rise crest around 9°N. In this photo, fragments of white microbial sulfur floc are being blasted out of the seafloor by hot water venting from the volcanic fissure that fed the eruption. The sulfur floc was precipitated on and under the seafloor by microbial oxidization of hydrogen sulfide. This phenomenon suggests the possible existence of an extensive subsurface biosphere fueled by chemical energy and illustrates the very active exchange processes that take place at mid-ocean ridges [Haymon et al., 1993]. Oceanic drilling in such harsh environments could reveal a wealth of new information about these vital areas.*

and/or other nutrients the limiting factor for the subsurface biosphere? And what are the influences, or feedbacks, of biological processes on the hydrologic properties of the oceanic crust?

The transport of magma from the mantle and its cooling and crystallization within and atop the mid-ocean ridge axial zone are the primary mechanisms that build the ocean crust and drive hydrothermal circulation. Most of this magma crystallizes to form gabbroic rocks in the lower ocean crust, but researchers lack direct constraints on magma distributions and rates of cooling and crystallization. For example, whether there is significant chemical partitioning between the upper and lower crust and whether there is significant off-axis magmatic addition to the lower crust remain unknown. Competing models for ocean crustal accretion can be assessed further only through the study of genetically related mantle, lower crustal, and extrusive sections.

It is no surprise therefore that drilling a complete ocean crustal section into in situ mantle has been, and remains, a long-term priority goal of scientific ocean drilling. Such deep drilling will also ground truth seismic data and finally establish whether the seismic Mohorovičić discontinuity (Moho) is a fundamental petrologic boundary in the Earth's interior.

### *Maturation Processes*

Though there are many unanswered questions about crustal accretion and hydrothermal systems within spreading centers, there are arguably even fewer constraints on the maturation of oceanic lithosphere on ridge flanks. Seawater-crust exchanges during maturation affect ocean crustal composition, permeability, and geophysical properties and are a major influence on seawater chemistry. Secondary minerals from fluid-rock reactions may provide a largely unrecognized record of past seawater compositions and a possible record of global environmental change. Crustal aging likely affects the microbial biogeography of the seafloor and subseafloor biosphere, but how microbial biomes—taxonomically and

functionally—vary spatially and temporally in ocean crust remains unknown. Moreover, as scientists get a better understanding of the in situ physical properties of the ocean crust of different ages, they will be able to improve the use of geophysical data such as velocity and magnetization to gain regional perspectives on crustal aging.

A widely articulated vision by workers in the field is to conduct drilling transects that specifically “track” the aging of the crust along ridge flank segments. Through such an effort, scientists can determine the integrated effects over time of chemical, thermal, and biological processes and exchanges between the oceans and crust. Transects would aim at elucidating the interrelationships among ocean chemistry, ocean sedimentation, crustal evolution over geologic time, and global biogeochemical cycles. Conspicuous gaps in sampling include crust younger than 3 million and 45–80 million years old, the latter interval coinciding with an area of the seafloor where, on average, no anomaly in conductive heat loss is observed. Absence of a heat flow anomaly suggests that older crust is sealed to hydrothermal circulation. However, global data averaging filters out important local effects, and hydrothermal circulation is expected in crust of all ages wherever hydrologic head exists.

### *Lithospheric Heterogeneity*

It is now recognized that exhumed mantle and lower crustal rocks dominate at least 25% of the slow and ultraslow spreading (full spreading rates of approximately <55 and <20 millimeters per year, respectively) ocean ridge systems. The interplay of faulting, hydrothermal alteration, and magmatism in these settings is only now being intensely scrutinized, and new observations are challenging older notions of crustal accretion processes.

For example, workers are still evaluating the differences between crust formed predominantly through faulting and that formed predominantly through magmatism. Where mantle rocks are exhumed during

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## Oceanic Crust

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faulting, serpentinization occurs, changing the composition and mechanics of the crust as water is trapped in hydrous minerals. In places this can cause carbonate veining that can lead to extensive and complex hydrothermal vent sites and may create a significant carbon sink. Serpentinite-hosted hydrothermal systems exhibit distinctive fluid chemistry and fauna, and these systems contrast with basalt-hosted hydrothermal systems. Biological exchanges that thrive via serpentinization reactions may have early Earth and extraterrestrial analogues with implications for origins of life. Yet even the most basic questions about this process remain unanswered: Does serpentinization influence the nature and diversity of some deep-sea ecosystems? What is the extent and distribution of serpentinization at depths greater than the top 100 meters and two deep (>1 kilometer) sections of slow spreading crust currently explored by drilling? What are the time scales of serpentinization? Is exhumed lithospheric heterogeneity reflected in patterns of microbial diversity and function?

### Accessing the Deep Crust

Whether it is drilling axial crust, off-axis crust, or deep holes toward the Moho, the technological challenges of scientific drilling are considerable. Recent work has made several strides toward easing these challenges, and the successful drilling of four deep (>1-kilometer) holes (two in slow spreading crust and two in fast spreading crust) in ocean crust by the Ocean Drilling Program (ODP) and the Integrated Ocean Drilling Program (IODP) brought renewed energy and impetus to scientific drilling of ocean crust.

Technological advances for ultradeep drilling such as those recently explored by ODP and IODP have focused on hole stability, which is greatly improved by using engineering muds instead of seawater for a drilling fluid. Mud operations require either using a riser (currently possible only at water depths less than 2500 meters) to circulate mud back to the ship, or alternatively expelling all mud to the seafloor (expensive for deep drilling as well as environmentally problematic). An exciting development is a joint industry/IODP-funded project to develop a riserless mud recovery system with seafloor-based operation. This will permit using engineering mud at water depths greater than 2500 meters and could be the key to a successful deep hole through oceanic crust.

### Recovering Cores From Young Crust

Axial zone drilling also requires that scientists and engineers overcome challenges surrounding hole stability, recovery, and ship motion (heave compensation) while penetrating the tough but friable basaltic crust. Drilling young, fractured basalt has

been especially challenging, with no existing holes penetrating more than 200 meters into basement in crust younger than 3 million years old. However, recent lessons from on-land drilling of very young basalts in geothermally active areas in Iceland and Hawaii lead to optimism that the long-sought-after goal of drilling into young ocean basalts can soon be realized.

New drilling technology to overcome the challenge of initiating a hole in young, friable basalt includes the hard rock reentry system (HRRS) and the advanced diamond core barrel (ADCB) system. HRRS simultaneously drills a hole using a hydraulic hammer and runs casing, which reduces the risk of hole collapse that has been observed with conventional reentry systems. HRRS was tested near the Mid-Atlantic Ridge in 2004 and in the Manus basin off Papua New Guinea in 2000. Diamond coring has proven extremely successful in on-land drilling in Iceland and was also used to recover intensely fractured dacite in the Manus basin. Yet even when performing well, each technology has limitations. HRRS makes a hole for the casing without coring; it is a critical tool for hole initiation but must be used in conjunction with other equipment for studies that require sampling the very uppermost basalts of unconsolidated ocean crust. In contrast, the primary challenge in using the ADCB system for ocean crust drilling is providing minimal weight-on-bit variation.

Two developments in scientific drilling are promising for drilling young ocean crust. First, the recently refitted passive heave system on the IODP's R/V *JOIDES Resolution* should result in a more stable platform and a higher chance for successful drilling, and the Japanese Agency for Marine-Earth Science and Technology's R/V *Chikyu* provides an even more stable platform. Additionally, a frontier technological area for both scientific and industry drilling is the deployment of remotely operated submersible drill rigs. Several types of submersible drill rigs are rated to ocean depths of 3000–4000 meters and can drill the upper 100–150 meters of the crust with good core recovery.

### Drilling as a Common Baseline for Studies of the Oceanic Crust

Although ocean crust presents challenging conditions, technology development is such that successful drilling of the axial zone and the deeper crust is achievable.

But this is only the start. By combining drilling with borehole experiments and in situ borehole observatories (including existing and new sampling capabilities and sensors), scientists can detect and monitor biological activity and active fluid flow in the crust, and characterize chemical fluxes and the evolution of chemical architecture in young crust. Long-term instrument deployments and active experimental Circulation Obviation Retrofit Kit (CORK) observatories

are revealing first glimpses of the dynamics of shallow mid-ocean ridge processes on short (instantaneous to decadal) time scales. Observatories are often the only way to monitor in situ ocean crustal conditions, collect valuable specimens, determine physical properties, and calibrate remote geophysical observations. An interesting development is the use of observatories to test hypotheses about crustal properties through manipulative experimentation in real time (e.g., hydrological and biological tracer studies).

Drilling also can be combined with geophysical investigations (seismic, magnetic) of the areas surrounding the cores, allowing researchers to ground truth structures only remotely sensed. Further, in combination with numerical models, scientists can mesh together data from cores with other sources of information to gain a broader picture while also arriving at a deeper understanding of ocean crustal processes.

### Acknowledgments

We thank Jay Miller for his valuable contribution on drilling technology and the history of scientific drilling. This article grew out of two workshops, "Melting, Magma, Fluids and Life: Challenges for the Next Generation of Scientific Ocean Drilling Into the Oceanic Lithosphere" (Southampton, UK, 27–29 July 2009; see <http://www.interridge.org/WG/DeepEarthSampling/workshop2009>) and "Scientific Ocean Drilling of Mid-Ocean Ridge and Ridge-Flank Settings" (Austin, Tex., 27–28 August 2009; see <http://www.oceanleadership.org/programs-and-partnerships/usssp/workshops/past-workshops/mor/>).

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absorption of the greenhouse gases mentioned above and which is quantitatively computed as the temperature difference with, versus without, these gases in the atmosphere.

Because clouds strongly affect solar and longwave radiation, the widely used term "greenhouse effect of clouds" is confusing and should be avoided or replaced by standard and clearer phrases such as "longwave radiation effect of clouds." Similarly, because clouds play a crucial role in the radiation balance, 23% of solar energy is absorbed by Earth's atmosphere; while this number cannot be neglected, it is smaller than the atmospheric absorptance of 90% of surface longwave radiation [Trenberth et al., 2009]. Therefore, the greenhouse effect of the atmosphere is not the same as the longwave radiation effect.

To consider the effects of the atmosphere on solar and longwave radiation in the  $T_e$  computation, the planetary albedo (0.3) due to the combined reflection of the atmosphere and surface should be replaced by the surface albedo (0.14) [Trenberth et al., 2009], if the atmosphere were removed. Then  $T_e$  is obtained as  $-5^\circ\text{C}$  from Earth's radiation balance. The  $20^\circ\text{C}$  difference between  $T_s$  ( $15^\circ\text{C}$ ) and  $T_e$  ( $-5^\circ\text{C}$ ), rather than the widely used  $33^\circ\text{C}$  warming, represents the "atmosphere effect" (a term borrowed from *Fleagle*

# FORUM

## What Is the Atmosphere's Effect on Earth's Surface Temperature?

It is frequently stated in textbooks and scholarly articles that the surface temperature of Earth is  $33^\circ\text{C}$  warmer than it would be without the atmosphere and that this difference is due to the greenhouse effect. This Forum shows that the atmosphere effect leads to warming of only  $20^\circ\text{C}$ . This new conclusion requires a revision to all of the relevant literature in K-12, undergraduate, and graduate education material and to science papers and reports.

The greenhouse effect on Earth's surface temperature is well understood qualitatively and is regarded as basic knowledge about Earth's climate and climate change. The  $33^\circ\text{C}$  warming has been used to quantify the greenhouse effect of greenhouse gases, or of greenhouse gases and clouds, in K-12 educational material (e.g., <http://epa.gov/climatechange/kids/greenhouse.html>), undergraduate freshman introductory textbooks on weather and climate [e.g., Ahrens, 2008], and graduate textbooks on climate [e.g., Peixoto and Oort, 1992]. Some textbooks and various other publications have less stringently

attributed the warming to the greenhouse effect [e.g., Wallace and Hobbs, 2006; Le Treut et al., 2007; American Meteorological Society, 2000].

The  $33^\circ\text{C}$  warming is obtained as the difference between the observed globally averaged surface air temperature ( $T_s$ ) of  $15^\circ\text{C}$  and the radiative equilibrium temperature of Earth ( $T_e$ ) of  $-18^\circ\text{C}$ , and it represents the longwave radiation effect of the atmosphere (i.e., without changing the planetary albedo).  $T_e$  is computed from Earth's radiation balance with the observed planetary albedo of 0.3 [Trenberth et al., 2009].

Certain trace gases in the atmosphere—such as water vapor, carbon dioxide, methane, nitrous oxide, and ozone—which absorb a much higher percentage of radiative energy in the infrared than in the solar spectrum, are popularly referred to as greenhouse gases [Fleagle and Businger, 1963]. The warming effect of these trace gases on Earth's surface temperature is referred to as the greenhouse effect, which can be qualitatively understood through the selective

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## MEETING

## Monitoring the Antarctic Circumpolar Current in the Drake Passage

*Oceanography in Drake Passage: Wherefrom, Whereto and What in Between?*  
Liverpool, United Kingdom, 26–27 October 2009

The Antarctic Circumpolar Current (ACC), the world's largest oceanic flow (~135 million cubic meters per second), is an important component of the ocean climate, as it connects the three major oceanic basins. Deep Atlantic water upwells between the ACC and Antarctica and returns to the Atlantic, thus contributing to the closure of the global overturning circulation.

The Drake Passage, between the southern tip of South America and Antarctica, is the region where the ACC is most constricted by landmasses and, owing to its narrowness, is the most convenient place to monitor the ACC. The Drake Passage also has considerable oceanographic interest because it lies along the cold, returning route of the global overturning circulation and is a region of strong deepwater mixing.

One of the longest oceanographic time series in the Drake Passage is the ongoing record of bottom pressures collected by the National Oceanography Centre (NOC) and the British Antarctic Survey (BAS). This time series provides invaluable information about the dynamics and variability of the ACC. To celebrate the 21st anniversary of the first deployment of bottom pressure recorders in the Drake Passage by NOC and BAS, a workshop held at NOC and funded by the United Kingdom's Strategic Ocean Funding Initiative brought together specialists from the United States, France, and the United Kingdom to discuss research in the area. The workshop program, list of participants, and presentation summaries can be found at <http://www.pol.ac.uk/home/news/2009-11DrakePassageWorkshop.html>.

One of the most important results of the past 20 years of ACC observations is that its transport varies remarkably little on interannual time scales. Why, then, should monitoring be continued? Workshop participants agreed that without complete understanding of the mechanisms that stabilize the current, scientists cannot know whether future large ACC changes are possible, so it is important that observations be continued. In addition, it would seem ill advised to halt monitoring at a time when

global changes are pushing the ocean climate away from its preindustrial regime.

Participants acknowledged that ACC transport monitoring requires sustained measurement of sea level and bottom pressure at least at hourly intervals but noted the strong value of repeat hydrographic sections. These measurements are routinely undertaken by NOC and BAS and also less frequently by Spanish, German, and Russian groups. Participants also described projects of shorter duration, such as the American "cDrake" (<http://tryfan.ucsd.edu/cpies/>) and the French "Drake 2006–2009" (<http://drake-ipy.ipsl.jussieu.fr/>), which afford more comprehensive measurements, especially of currents and tracer distributions, but provide less information on interannual variability.

There was a consensus that annual hydrographic and sea level observations should be sustained and augmented with routine measurements of geochemical components, especially carbon dioxide, given ongoing climatic change and global ocean acidification. It is expected that some of these future observations will be carried out using autonomous devices (e.g., Argo floats and gliders) and marine mammals and will be used for model validation, assimilation, and operational forecast.

The workshop highlighted the existence of a strong Drake Passage research community, albeit a loosely organized one. There is, however, an aspiration toward a higher level of coordination, perhaps under the umbrella of an international Drake Passage observatory, starting with the creation of a unified portal for the wealth of data collected in the past few decades. Scientists interested in contributing to such an observatory or in analyzing the resulting data sets are encouraged to contact the authors of this report.

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## Forum

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and Businger [1963]) on Earth's surface temperature.

Note that the term "atmosphere effect" rather than "atmospheric radiation effect" is used, because the observed  $T_s$  is caused by the atmospheric radiation effect (primarily from greenhouse gases and clouds) and surface sensible and latent heat fluxes due to fluid motions in the atmosphere. Without these heat fluxes, the disparity between  $T_s$  and  $T_e$  would be larger. Also note that this revision does not affect the current interpretation of the term "enhanced greenhouse effect" associated with the increase of greenhouse gases in the atmosphere from human activities.

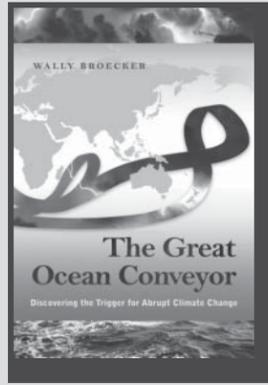
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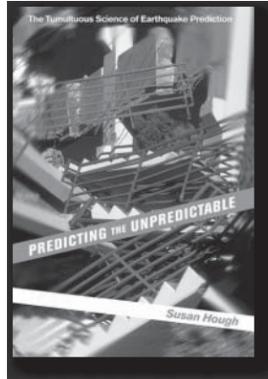
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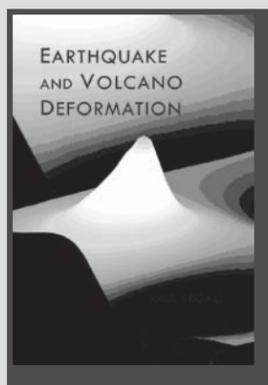
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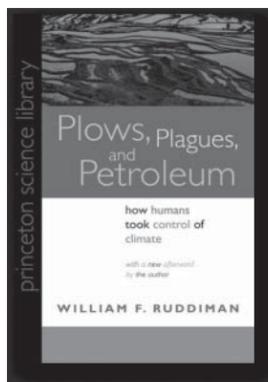
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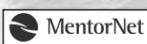
Standard Registration Deadline: 23 August 2010



Photo by Dr. Yildirim Dilek

For information visit: [www.geosociety.org/meetings/2010turkey/](http://www.geosociety.org/meetings/2010turkey/)

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EOS1004

# ABOUT AGU

## Brenguier Receives 2009 Keiiti Aki Young Scientist Award

*Florent Brenguier received the 2009 Keiiti Aki Young Scientist Award at the 2009 AGU Fall Meeting, held 14–18 December in San Francisco, Calif. The award recognizes the scientific accomplishments of a young scientist who makes outstanding contributions to the advancement of seismology.*

### Citation

Florent Brenguier is a bright young geophysicist who has already made very significant contributions to the field of seismology.

His development of monitoring of temporal changes based on correlations of ambient seismic noise is without doubt a major advance that opens new possibilities for studying active objects such as volcanoes and seismic faults.

Using noise cross correlations to detect temporal changes within the media turned out to be a very challenging task, which many have tried without success. The main reason is that detecting temporal variations even within active objects like volcanoes and faults requires measuring extremely weak traveltimes perturbations ( $10^{-4}$  and smaller), and standard traveltimes measurement methods fail at this level of accuracy.

As a consequence, finding ways to extract these tiny temporal variations required a lot of effort in terms of advanced data mining and processing, understanding the role of the noise distribution, and finally, applying theories and methods dealing with scattered wavefields.

Florent was the first one who, thanks to his skill, hard work, and creativity, succeeded



*Florent Brenguier*

in bringing all of these elements together and demonstrating the feasibility of noise-based monitoring of volcanic and tectonic process within the Earth's crust, with two spectacular applications, to the Piton de la Fournaise volcano and to the San Andreas Fault at Parkfield, Calif.

Florent Brenguier is a bright researcher with an extraordinary skill to work with data. He was essential in the development of ambient noise monitoring. His work leads to major advances in seismology, and he is continuing to produce new ideas in this field. For all of these reasons he is a worthy recipient of the Keiiti Aki Young Scientist Award from the Seismology section of AGU.

—NIKOLAI SHAPIRO, Institut de Physique du Globe de Paris, Paris, France

### Response

It is a great honor to receive such a prestigious award. Surprisingly, I am now pursuing my scientific career at the Piton de

la Fournaise Volcanological Observatory where Keiiti Aki spent his last years practicing his extraordinary talent for seismology.

I am very grateful to Michel Campillo (Laboratoire de Géophysique Interne et Tectonophysique, Grenoble, France) and Nikolai Shapiro (Institut de Physique du Globe de Paris (IPGP)) for having initiated and participated in the work for which I receive this award.

I would like to emphasize that Michel and Nikolai lead an exhilarating research group, and my experience participating in that group was extremely positive.

I would also like to acknowledge the Piton de la Fournaise Volcanological Observatory and the Parkfield High-Resolution Seismic

**About AGU** cont. on next page

## Norman L. Bowen Award

### REQUEST FOR NOMINATIONS

The Norman L. Bowen award is given annually for outstanding contributions to volcanology, geochemistry, or petrology. The contribution may be (1) a single outstanding paper published in any journal; (2) a series of papers which, taken together, constitute an outstanding contribution; or (3) any other contribution that the selection committee considers worthy. Special consideration is given to nominees who have not previously received an award.

**Deadline: 1 May 2010**

The nomination file should include:

- a nominating letter from a colleague,
- a curriculum vitae for the candidate,
- a list of publications for the candidate,
- exactly three letters of recommendation from colleagues who are neither from the candidate's current institution nor from the candidate's Ph.D. institution.

The nomination file should be submitted electronically to the chair of the Committee: Frank Spear at [spearf@rpi.edu](mailto:spearf@rpi.edu).

For more information, please visit the Volcanology, Geochemistry, and Petrology section at <http://vgp.agu.org/>.

## Check out the Eos Guide for Authors

[http://www.agu.org/pubs/authors/manuscript\\_tools/eos/](http://www.agu.org/pubs/authors/manuscript_tools/eos/)

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# CALL FOR NOMINATIONS

## The Deadline for 2010 Union Medals and Awards Has Been Extended to 30 April 2010

AGU Union medals and awards are among the most respected in the Earth and space sciences communities worldwide. **Nominate a mentor, colleague, or mentee today** for an AGU Union medal or award specific to his or her achievement or field of study.

### Requirements for Union Medal and Award Nominations

- a letter of nomination outlining the nominee's significant contributions,
- a curriculum vitae,
- a bibliography (with a brief paragraph stating the candidate's total number of publications), and
- a minimum of three and a maximum of six supporting letters (at least two individuals are not to be currently or recently associated with the nominee's institution of graduate education or employment).

**Nominations must be complete and received at AGU headquarters by 30 April 2010.**

For further details or to nominate online:

Web site: [www.agu.org/about/honors/union/nominations/](http://www.agu.org/about/honors/union/nominations/)

E-mail: [leadership@agu.org](mailto:leadership@agu.org), or contact Danica Williams at +1 202.777.7513

### Medal Nominations Being Accepted:

|                          |                          |
|--------------------------|--------------------------|
| William Bowie Medal      | Maurice Ewing Medal      |
| James B. Macelwane Medal | Robert E. Horton Medal   |
| Waldo E. Smith Medal     | Harry H. Hess Medal      |
| Walter H. Bucher Medal   | Charles A. Whitten Medal |
| John Adam Fleming Medal  | Roger Revelle Medal      |

### Award Nominations Being Accepted:

Edward A. Flinn III Award  
Excellence in Geophysical Education Award  
International Award  
Athelstan Spilhaus Award  
Charles S. Falkenberg Award

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Network staff for distributing high-quality continuous data, which I used for the ambient seismic noise studies.

Similarly, I would like to emphasize to my predecessor, David Shelly, that the increasing availability of continuous seismological records strongly transforms the work of seismologists, who now need to elaborate upon novel "data mining" procedures. This is an exciting new domain

for seismology, which is often coupled with geodesy, for example, in nonvolcanic tremor and ambient seismic noise cross-correlation studies.

I am looking forward to continuing to work in that domain and to creating exciting new collaborations for studying the active Earth.

—FLORENT BRENGUIER, Piton de la Fournaise Volcanological Observatory, IPGP, Paris, France

# AGU is now on Facebook

<http://www.facebook.com/AmericanGeophysicalUnion>

## CLASSIFIED

### ADVERTISING INFORMATION

*Eos* is published every Tuesday. For a classified or display advertisement to be published in a future issue of *Eos*, electronic copy must reach us by 7:00 PM., Eastern Time, 9 days prior (Sunday) to publication. No cancellations accepted after deadline.

Ads with "Reply by" deadlines that are less than 14 days from the publication date will not be accepted.

Display and in-column advertising specs, pricing, and submission guidelines can be found online at [www.agu.org/pubs/eos-news/advertising](http://www.agu.org/pubs/eos-news/advertising).

AGU has a nondiscrimination and freedom-of-access policy. All advertisers must attest to nondiscrimination regarding recruiting, hiring, and promoting. AGU acknowledges that citizenship can be recognized as a legitimate requirement for some positions.

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"Positions Available" and "Student Opportunities" are updated every Tuesday and listed on our Web site, accessible to AGU members.

[www.agu.org](http://www.agu.org)

### POSITIONS AVAILABLE

#### Atmospheric Sciences

**Post-Doctoral Research Applicants.** Applicants are sought to join a collaborative research project between the US EPA Office of Research and Development (ORD) and the University of Colorado in Boulder. The post doc will be located at EPA ORD offices in Research Triangle Park in North Carolina and served in the Atmospheric Modeling and Analysis Division (AMAD) of the National Exposure Research Laboratory (NERL). The project is funded through NASA ACPMAP for the purpose of investigating in situ and top-down constraints on NH<sub>3</sub>, focusing on a new bi-directional NH<sub>3</sub> air-surface exchange model developed for the Community Multiscale Air Quality (CMAQ) model.

The participant will use inverse modeling techniques to improve NH<sub>3</sub> emission estimates from agricultural sources and bi-directional air-surface exchange parameters using field-scale and satellite observations. Desired qualifications include experience using chemical transport or air quality models, working knowledge of atmospheric aerosols and chemistry, and strong communication skills.

Experience with atmospheric flux measurement and modeling techniques are a plus. We offer a 20 month post-doctoral position with the possibility of an extension. Applicants should send a cover letter describing research experience and interests, a CV, and contact information for three references to Jesse Bash ([bash.jesse@epa.gov](mailto:bash.jesse@epa.gov)). CU Boulder is an equal opportunity employer.

**Research Positions.** Nanyang Technological University (NTU) in Singapore is offering the following research positions.

*Postdoctoral Fellow, Urban Canyon and Boundary-Layer Modeling.*

We are seeking suitable researcher with an interest in urban canyon and boundary-layer modeling of the Singapore environment.

This work is part of five-year collaboration with the Center for Environmental Sensing and Modeling (CENSAM), established under the auspices of the Singapore-MIT Alliance for Research and Technology (SMART).

*Research Associate/Scientist, Data Assimilation*  
We are seeking suitable candidate for adapting data assimilation codes to a mesoscale NWP model (COAMPS) to assimilate Doppler radar wind and reflectivity data.

### Ocean Dynamics and Prediction Research Naval Research Laboratory



The Naval Research Laboratory has openings for PhD researchers to push forward the frontiers of coastal ocean forecasting. Problems that must be addressed cover a broad spectrum of physical processes including surface waves, sediment transport, nearshore circulation, estuarine and river dynamics, lateral and vertical turbulent mixing, Arctic ice modeling, internal waves, and coupled dynamics (ocean/wave/atmosphere, coastal/shelf-scale currents). This challenging work involves the development of numerical models and data assimilative approaches, the processing and analysis of satellite and in water observation and the construction of model systems for the predicting the ocean environment. This work is long term, and the end goal is to build cutting edge technology for predictive systems that transition to operational forecast centers.

This is an excellent opportunity to work with some of the best modelers and data analysts in the ocean community. The Naval Research Laboratory has access to the major supercomputer sites in addition to excellent local computer resources. The laboratory is collocated with the Naval Oceanographic Office, which is the largest national operational forecast center for oceanography.

To learn more about ongoing research projects and recent publications, visit the web site: <http://www7320.nrlssc.navy.mil/index.php>.

Salary range is \$61,000 to \$101,000 depending on experience. Applicants must be a US citizen or permanent resident at time of application. NRL is an equal opportunity employer. Send resume and references to:

Richard Allard via e-mail: [allard@nrlssc.navy.mil](mailto:allard@nrlssc.navy.mil)  
NRL Code 7322  
Stennis Space Center, MS 39529

## New AGU Journal Editors Appointed

New editors have been appointed for *Geochemistry, Geophysics, Geosystems; Geophysical Research Letters; Journal of Geophysical Research-Oceans; Reviews of Geophysics; and Water Resources Research.*

*Geochemistry, Geophysics, Geosystems* welcomes Joel A. Baker (Victoria University, Wellington, New Zealand), Louis A. Derry (Cornell University, Ithaca, N. Y.), and James A. Tyburczy (Arizona State University, Tempe). They are filling the vacancies of retiring editors Vincent Salters and John Tarduno and are joining continuing editor Thorsten Becker.

*Geophysical Research Letters* has added Paul D. Williams (University of Reading, Reading, UK) and W. K. ("Bill") Peterson (Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder) to its editorial staff.

Thomas H. C. Herbers (Naval Postgraduate School, Monterey, Calif.) has joined *Journal of Geophysical Research-Oceans*.

*Reviews of Geophysics* editor in chief Mark B. Moldwin and editor Peter Riley are joined by Fabio Florindo (Istituto Nazionale di Geofisica e Vulcanologia, Rome, Italy), Gregory Okin (University of California, Los Angeles), and Eelco Rohling (National Oceanography Centre, Southampton, UK). These new editors are replacing retiring editors Henk Dijkstra, Ian Fairchild, Michael Manga, and Daniel Tartakovsky. Alan Robock (Rutgers University, New Brunswick, N. J.) will join the editorial board on 1 July 2010.

*Water Resources Research* welcomes Ronald C. Griffin (Texas A&M University, College Station), who replaces Thomas Torgersen.

The incoming editors thank the retiring editors for their service and for their assistance during these transitions.

—BARBARA MAJOR, Assistant Director, AGU Journals

Job and application details can be found at <http://www1.spms.ntu.edu.sg/~sunshine/WeatherWeb/html/job.html>. Contact: Dr. Teo Chee Kiat, [ckteo@ntu.edu.sg](mailto:ckteo@ntu.edu.sg).

### Biogeosciences

**Tenure Track/Tenured Assistant/Associate/Full Professor Position in the Fields of Geobiology/Geomicrobiology.** Geobiology/Geomicrobiology: The Key Laboratory of Biogeology and Environmental Geology of Ministry of Education, China University of Geosciences-Wuhan, invites applications for tenure track/tenured assistant/associate/full professor position in the fields of Geobiology/Geomicrobiology. Preference will be given to candidates with interests in biogeochemistry, mineral/microbe interactions, microbial life in extreme environments, and environmental remediation of contaminated water resources. The successful candidate will have broad interests in natural surfaces and microbially mediated processes on or near earth surfaces. The position will be available beginning in September 2010 and comes with a competitive salary and startup package. Opportunities exist for collaboration with faculty in Earth Sciences, Paleobiology, Environmental Studies, and other related fields. Responsibilities will include the development of a rigorous research program and teaching and

advising at both the graduate and undergraduate levels. The candidate will teach the undergraduate Geology/Biology curriculum, as well as upper-level undergraduate and graduate courses in his or her field of specialty.

Candidates should electronically submit a letter of application describing their research and teaching interests, curriculum vitae, and the names and contact information for three references to Dr. Ping Li at [plicug@gmail.com](mailto:plicug@gmail.com) or mail a hard copy to Dr. Ping Li, Key Laboratory of Biogeology and Environmental Geology of Ministry of Education, China University of Geosciences, 388 Lumo Road, Wuhan, 430074, China. China University of Geosciences-Wuhan is an Affirmative Action/Equal Opportunity Employer and encourages applications from around the world.

### Geochemistry

**Post Doc-Hydrogeology, (Hydro) Geophysics.** Sandia National Laboratories is one of the country's largest research and engineering laboratories, employing 8,100 people at major facilities in Albuquerque, New Mexico and Livermore, California. We make enduring contributions to secure our society against high consequence terrorist threats and national incidents through effective use of science,

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Leibniz-Institut für Meereswissenschaften an der Universität Kiel



Christian-Albrechts-Universität zu Kiel

The Christian-Albrechts-University will attract more qualified women for professorships.

The Faculty of Mathematics and Natural Sciences at the Christian-Albrechts-University of Kiel, Germany, invites applications for a

### Junior Professorship (W1) in Meteorology

The position is embedded in the Leibniz Institute of Marine Sciences (IFM-GEOMAR) in the research division Ocean Circulation and Climate Dynamics. The W1 Junior Professors will initially be appointed for 3 years („Beamtenverhältnis auf Zeit“); depending on performance the position can be extended by up to 3 additional years.

Possible research foci should concern the interactions of the atmosphere with the oceans. These include the fields of climate variability and predictability and statistical climatology. Research topics can concern large-scale interactions as well as the physical processes upon which they are based. Modelling and observational studies are both welcome as is research in the field of paleo-climate. Model initialization including data assimilation is also relevant, as far as the work relates to the predictability of climate fluctuations. Close collaborations with the other research divisions of the institute as well as with research networks in Kiel, in particular the Excellence Cluster "Future Ocean" and collaborative research centre SFB 754 "Climate – Biogeochemistry Interactions in the Tropical Ocean" are desired.

Applicants are required to have completed a PhD in Meteorology, Physical Oceanography, Physics, Mathematics, or in a related field. The successful candidate will contribute to BSc courses in „Physik des Erdsystems: Meteorologie – Ozeanographie – Geophysik“ and MSc courses in "Climate Physics: Meteorology and Physical Oceanography", which will be taught in English.

The position is opened with respect to Art. § 64 of the Higher Education Act of the State of Schleswig-Holstein.

The Christian-Albrechts-University and the IFM-GEOMAR are seeking to increase the number of women in faculty positions and encourage applications from qualified women. Female applicants will be treated with priority if their qualifications and achievements are equal to those of male applicants. Applications from scientists with disabilities will be treated with priority in case of equal qualifications.

Applications in English including CV, certificates of academic qualifications, list of publications, reprints of three selected publications together with private and academic mailing and e-mail addresses and telephone number should be submitted by **May 7<sup>th</sup>, 2010** to

Dean of the Faculty of Mathematics and Natural Sciences  
Christian-Albrechts-University  
24098 Kiel, Germany

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technology, and systems solutions. Please visit our website at [www.sandia.gov](http://www.sandia.gov). We are searching for Post Docs in the area of Hydrogeology, (hydro) Geophysics for the Waste Isolation Pilot Plant in Carlsbad, New Mexico.

The salary is \$83,100.00 per year. A benefit and relocation package is available.

Conduct field investigations (geophysical and hydrogeological) of the presence and extent of shallow groundwater near the WIPP surface facilities and of recharge and cross-formation leakage in karstic terrain west of the WIPP site, and may also participate in hydraulic well testing and well-test analysis. Tasks will also include development and implementation of appropriate conceptual

models, selection and modification of appropriate numerical simulation codes, conducting simulations, and presentation of results to internal and external customers. The position is in Carlsbad, NM.

Occasional travel to Albuquerque is expected. May also participate in other DOE projects and water-related projects for other clients. Residence in Carlsbad, NM is mandatory.

A Ph.D. or equivalent degree in hydrogeology, (hydro) geophysics, applied mathematics, or engineering with experience in mathematical modeling and numerical simulation of geophysical and/or hydrogeological processes is required. Experience must include development of conceptual

and numerical models, model calibration, pre- and post-processing of data, data analysis, interpretation, and reporting. Demonstrated excellence in the technical field as well as superior oral and written communication skills are mandatory, as is the ability to function effectively within a diverse team.

Ability to develop and maintain collaboration with leaders in the physics community externally is desirable.

Proficiency using Linux, VMS, and Microsoft Windows operating systems; programming in Fortran and C++; expertise with (hydro)geophysical and vadose zone modeling; field experience with hydrogeophysical techniques and with aquifer testing; experience in coupling between hydrological, geophysical, and geomechanical processes; expertise in parameter estimation, geostatistics and uncertainty analysis; experience in conducting technical programs within a regulatory environment; site characterization and/or laboratory experimentation for derivation of model parameters. Experience with stringent QA/QC requirements, such as those associated with the WIPP or Yucca Mountain projects, is highly desirable.

Familiarity with modern methods of well-test analysis (e.g., pressure derivatives) is also desirable.

Please apply online at <http://www.sandia.gov/careers/search-openings.html>, click Search for Openings, and reference Job Requisition Number: 65488.

U.S. Normally Citizenship Required. Equal Opportunity Employer. M/F/D/V.

**Hydrology**

**Postdoctoral Research Associate Position in Ecohydrology.** Princeton University's Civil and Environmental Engineering Department solicits applications for a postdoctoral or more senior researcher to conduct field-based and modeling research into plant water use, soil evaporation, and plant water stress in tropical dryland savannas. The position will be based at the Mpala Research Center (MRC) in central Kenya ([www.mpala.org](http://www.mpala.org)), focused on dynamic characterization of plant water use and plant water stress in dryland ecosystems. The successful applicant will have experience in some combination of flux measurement methods, plant ecophysiology, and stable isotope techniques. Starting salaries will range between \$42,000 and \$45,000.

Initial appointment will be for a 1-year term beginning in the summer/fall of 2010, with possibility of extension up to 3 years depending on performance. Additional information about the position can be found at <http://caylor.princeton.edu>. Interested applicants should submit an application including CV and statement of research interest through <http://jobs.princeton.edu>, position #1000214. Princeton University is an equal opportunity employer and complies with applicable EEO and affirmative action regulations.

**Ocean Sciences**

**Research/Faculty Position in the Area of Physical Oceanography.** The department of Physical Oceanography at CICESE in Ensenada, Baja California, Mexico, announces a research/faculty position in the area of Physical Oceanography. We seek candidates with a Ph.D., capable of conducting independent research in physical oceanography and with a strong record leading or participating in research projects and peer reviewed publications. We are particularly interested in candidates who can strengthen our program in ocean-atmosphere interaction and use models to advance fundamental understanding and predictability of the ocean-atmosphere system. Candidates should have the ability to conduct an active, extramurally funded, research program.

Successful candidates are expected to teach oceanography or meteorology courses at the graduate level and supervise graduate students.

Applicants should submit electronically a CV and statement of research and teaching interests together with names of three references to Alejandro Pares-Sierra ([apares@cicese.mx](mailto:apares@cicese.mx)), chair of the Search Committee. The review process will begin on April 2010.

Successful candidate is expected to begin working at CICESE during fall 2010.

**Solid Earth Geophysics**

**Research Fellows and Post-Doctoral Research Associates.** The Institute of Earth Sciences (IES) seeks applicants for tenure-track research fellows (assistant or associate fellows) and postdoctoral research associates in earth sciences. IES is an institute of Academia Sinica (Taipei), and is the most important earth science research institute in Taiwan. The existing research fields include seismology, tectonophysics, paleomagnetism, neotectonics, high-pressure mineral physics, petrology and petrogenesis, geochemistry, cosmochemistry, paleoclimatology, etc. IES is well equipped with advanced analytical instruments and computing facilities for geochemical and geophysical research.

Several on-going projects are focused on the island of Taiwan, one of the best natural laboratories for active tectonics. However, many faculty members extend their areas of study to other corners of the world. Numerous international cooperative programs are being engaged. The faculty members do not have teaching duties but are allowed to take a small teaching load in universities. They have close collaboration with university professors and undertake direction of thesis work. For the new faculty positions we invite applications from outstanding candidates of all fields, and particularly encourage those who have expertise in seismology and isotope geochemistry.

For the postdoctoral positions the fields are open, but innovative research will be most

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## Atmospheric Sciences and Global Change Pacific Northwest National Laboratory

**PNNL is seeking brilliant minds, from senior scientists to post-docs and support staff.** Join a world-class science program, studying the role of clouds and aerosol processes on climate, and the effect of human decisions on greenhouse gas emissions and climate.

**We're growing rapidly in support of our mission to transform the nation's ability to predict climate change and its impacts.** PNNL scientists are combining modeling with an extensive worldwide field observational system to advance our understanding of the Earth system on regional and global scales.

The result: new insights that help leaders manage risks and cope with climate impacts while meeting society's energy demands.

**Want to Apply?**

View job openings at [www.pnl.gov/atmospheric/jobs.stm](http://www.pnl.gov/atmospheric/jobs.stm).

*Pacific Northwest National Laboratory (PNNL) is an Affirmative Action / Equal Opportunity Employer and supports diversity in the workplace.*

### KlimaCampus Hamburg Centre of Excellence in climate research



## KlimaCampus at the University of Hamburg

The University of Hamburg jointly with the Max Planck Institute for Meteorology and the Institute for Coastal Research at the GKSS Research Centre established a trans-disciplinary research focus on "Integrated Climate System Analysis and Prediction (ClISAP)". The emphasis of ClISAP is to analyze ongoing and past changes of the state of the climate system (natural and human-driven), to determine predictable elements of the climate system over a broad range of space and time scales, and to determine uncertainties intrinsic to predictions of important climate system and environmental indices (see [www.clisap.de](http://www.clisap.de)).

ClISAP invites applicants for up to 4 positions as

**RESEARCH ASSOCIATE**

(wissenschaftliche/-r Mitarbeiter/-in)

with the salary group 13 TV-L and starting as soon as possible.

The positions call for 39 hours per week. The fixed-term contracts will end on October 31<sup>st</sup>, 2012 (see also §2 of the Academic Fixed-Term Contract Law (Wissenschaftszeitvertragsgesetz)).

The university intends to increase the number of women amongst its academic personnel and expressly encourages qualified women to apply. In compliance with the Hamburg Equal Opportunity Law, preference will be given to qualified female applicants.

For more detailed information on area(s) of responsibility, requirements as well as skills requested, please refer to our website at

**[www.KlimaCampus.de](http://www.KlimaCampus.de) – vacancies – scientists** as well as  
**[www.KlimaCampus.de](http://www.KlimaCampus.de) – vacancies – scientists IT**

Please submit application dossiers (application letter stating the corresponding reference number, curriculum vitae, degree certificate(s) etc.) by April 30<sup>th</sup>, 2010 to

**Detlef Stammer, KlimaCampus Hamburg  
Zentrum für Marine und Atmosphärische Wissenschaften ZMAW  
Universität Hamburg, Bundesstraße 53, 20146 Hamburg, Germany**

or to: [office.clisap@zmaw.de](mailto:office.clisap@zmaw.de)

For more information please contact Prof. Dr. Detlef Stammer ([detlef.stammer@zmaw.de](mailto:detlef.stammer@zmaw.de)).

TOR ZUR WELT DER WISSENSCHAFT



**ALFRED WEGENER INSTITUTE FOR  
POLAR AND MARINE RESEARCH (AWI)  
IN THE HELMHOLTZ ASSOCIATION**



The Marine Geology Section at the Alfred Wegener Institute for Polar and Marine Research (AWI) in Bremerhaven, offers

within the framework of the research project MARUM OC3 "Glacial to Holocene atmosphere-ocean interactions between high and low latitudes".

**two PhD positions**

Division: Geosciences

MARUM OC3 is part of the Research Area "Ocean and Climate" of the Center for Marine Environmental Sciences of the University of Bremen and aims to investigate the role of the ocean in linking climate variability between low and high latitudes with a focus on the Pacific Ocean. The project is based on sediment cores that have been recently recovered within the framework of two AWI-lead ship expeditions to the North and South Pacific with the research vessels Sonne (SO202-INOPEX) and Polarstern (ANT-XXVI-2).

**Tasks:** The two PhD students will work on the reconstruction of Late Quaternary ocean and climate variability on millennial to orbital timescales focussing on the high latitudes of the North and South Pacific. We plan to apply a multi-proxy approach involving a large variety of sedimentological, geochemical, and biological proxies. Both students will work closely together. One student will primarily apply opal-based paleoceanographic proxies whereas the second position rather focuses on carbonate-based proxies.

**Requirements:** The successful candidates should hold a MSc in geology, oceanography, geochemistry, or marine environmental sciences. Previous expertise in paleoclimatology and paleoceanography would be a strong advantage. We expect excellent English language skills and the ability to publish in international science journals. Furthermore, team-work skills and the willingness to actively collaborate with a diverse international working group including e.g. biologists, physicists, and climate modellers are expected. The candidates should be willing to participate in up to 2-month long ship cruises as well as possibly in research stays abroad.

The position is limited to three years, salary group 13/2 TVöD (50%, an increase is in preparation).

Wherever applicable, PhD students will be enrolled in the Helmholtz Graduate School "POLMAR" (<http://polmar.awi.de>) or any other postgraduate programme.

For further information: Dr. F. Lamy (E-Mail: [Frank.Lamy@awi.de](mailto:Frank.Lamy@awi.de)), or to Dr. R. Gersonde (E-Mail: [Rainer.Gersonde@awi.de](mailto:Rainer.Gersonde@awi.de)).

Disabled applicants with essentially identical technical and personal suitability will be preferentially selected, **please see our notification on our homepage under job offers / jobs.**

The AWI supports balanced work-life career development via a variety of alternatives. In Bremerhaven, the AWI operates its own nursery.

Applications including CV, degree certificates, a statement of research interests and names and addresses of two referees should be submitted under reference number **20/D-Geo** to: **Alfred-Wegener-Institut für Polar- und Meeresforschung, Personalabteilung (human resources), Postfach 12 01 61, 27515 Bremerhaven / Germany** (<http://www.awi.de>) or by Email (combining all documents in a single pdf-file) to [Frank.Lamy@awi.de](mailto:Frank.Lamy@awi.de). Review of applications will start by **May 1, 2010** and proceed until the position is filled.

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regarded. For inquiry and more detailed information about IES, please visit <http://www.earth.sinica.edu.tw>.

Candidates must have an earned doctorate in earth science or related fields. Successful candidates are expected to have demonstrated research excellence and to develop strong research programs. Applicants should send a detailed vitae/resume including a full list of publications, three or more names of references with addresses (postal, telephone and e-mail) to Director, Institute of Earth Sciences, Academia Sinica, Taipei 11529, Taiwan. (Questions can be directed to Miss Sharon Wang shewen@gate.sinica.edu.tw). Review of applications will begin immediately and continue until the positions are filled.

**Interdisciplinary/Other****Deep Carbon Observatory-Program Associate**

**Position.** The Deep Carbon Observatory (DCO) is an international, multi-disciplinary, decade long effort dedicated to achieving a transformational understanding of carbon's chemical and biological roles in Earth's interior. The research of the DCO is organized around three Science Directorates: Deep Carbon Reservoirs and Fluxes, Deep Life, and Energy, Environment and Climate. The DCO Secretariat, located at the Carnegie Institution of Washington's Geophysical Laboratory, plays a central role in coordinating the efforts of an international community to identify scientific needs and opportunities in deep carbon science. The Secretariat is engaged in fundraising from industrial, governmental and foundation sources; outreach to the scientific community through the sponsorship and organization of Workshops, International Meetings and Conferences; and public education and outreach related to deep carbon science. The Secretariat is supported with a grant from the Alfred P. Sloan Foundation.

The DCO Program Associate, a full-time position, will provide both scientific and administrative assistance with the organization of workshops, calls for proposals, fellowship applications and engagement in fundraising from industrial, governmental and foundation sources. The Program Associate will report to the Program Director who is responsible for the day-to-day operations of the Secretariat. The ideal candidate would have experience as a postdoctoral scientist, although candidates with a Ph.D. or Masters degree in the geosciences, physical sciences, materials sciences or biological sciences with significant experience would also be considered. In addition to interactions with researchers from around the world, duties will include writing and editing materials for the web site, meeting minutes, DCO reports and proposals, and beginning to develop education and outreach components for the DCO. Excellent interpersonal skills, writing and organizational skills are essential. The position will require periodic travel. Salary level is competitive and will be based on the qualifications of the candidate.

Completed applications (including resume and contact information for three references) should be submitted via email to Lauren Cryan at [lcryan@ciw.edu](mailto:lcryan@ciw.edu) indicating "Program Associate for Deep Carbon Observatory" in the subject line. Equal Opportunity Employer.

**Lecturer in Geology.** Washington University in St. Louis invites applications for a 1-year lectureship in geology to begin in Fall 2010. This is a non-tenure track, academic position, eligible for University benefits. The selected applicant will teach 2 courses per semester, likely to include: a graduate level geology course, a geological field methods course, an introductory physical and environmental geology course, and a non-majors general interest course on natural disasters.

Collaborations with faculty and staff are encouraged, as applicant's time and interests allow. For information on department analytical facilities and research foci, see <http://epsc.wustl.edu>. Candidates must have been awarded the Ph.D. at time of appointment, and should send CV, statement of teaching philosophy and research interests, and names and contact information for three recommenders to Dr. Jill Pasteris, Lecturer Search Committee Chair, Department of Earth and Planetary Sciences, Washington University, C/B 1169, 1 Brookings Drive, St. Louis, MO 63130, or via email: [LecSearch@levee.wustl.edu](mailto:LecSearch@levee.wustl.edu). Women and minorities are encouraged to apply. EEO/AA employer.

Employment eligibility verification required upon employment. Applications will be considered until the position is filled, but priority will be given to those received by April 30, 2010.

**Lecturer/Senior Lecturer in Palaeoclimate**

**Modelling.** The Quaternary Research Group in the School of Geography, Politics and Sociology at Newcastle University seeks to appoint a Lecturer/Senior Lecturer in Palaeoclimate Modelling, tenable from September 2010. This appointment is designed to enhance our research standing and reinforce our existing international reputation in the fields of environmental change and Quaternary research. The successful candidate will have a record of research and publication commensurate with the level of appointment. They will also be expected to make a contribution to undergraduate and postgraduate teaching and to undertake supervision of postgraduate students.

Although we are seeking applications from anyone with expertise in palaeoclimate modelling we particularly welcome applications from candidates with a background in atmospheric or earth sciences and with expertise in modelling Quaternary climate change.

For further details and application form please visit our website <http://www.ncl.ac.uk/vacancies/jobs/> and search with reference "B315A (GPS)". Informal enquiries may be made to the Head of Geography, Dr. Stephen Juggins ([Stephen.juggins@ncl.ac.uk](mailto:Stephen.juggins@ncl.ac.uk)), or Prof. Darrel Maddy ([darrel.maddy@ncl.ac.uk](mailto:darrel.maddy@ncl.ac.uk)).

**Modeling Postdoc.** The Sierra Nevada Research Institute (SNRI) at the University of California, Merced seeks a postdoctoral associate with experience in environmental modeling and data

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**Senior Engineering Geologist/ Geotechnical Engineer****Lower Hutt, New Zealand**

The Geotechnical team within the Natural Hazards Group is seeking to appoint a Senior Engineering Geologist or Geotechnical Engineer to provide research leadership to the geotechnical team, which includes scientists in the engineering geology, geomorphology and geotechnical engineering disciplines.

For more information or to apply for this position, please visit our website <https://vacancies.gns.cri.nz>

Closing date:  
Friday, 28 May 2010.

**University of Southern California****Chair, Sonny Astani Department of Civil and Environmental Engineering**

The Viterbi School of Engineering (VSoE) (<http://viterbi.usc.edu>) of the University of Southern California invites nominations and applications for the position of Chair of the Sonny Astani Department of Civil and Environmental Engineering (<http://www.usc.edu/cee>).

The Astani Department has 20 tenured/tenure track faculty (15 in civil engineering and 5 in environmental engineering), 2 senior lecturers, 10 research faculty and about 40 part-time lecturers. The faculty includes two chaired professors, five Young Investigator and Early Career awardees, and a number of fellows of professional organizations. The Department has about 280 undergraduate students enrolled in ABET-accredited undergraduate programs, including a B.S. in Civil Engineering (with specializations in building science, construction engineering, environmental engineering, structural engineering or water resources) and a B.S. in Environmental Engineering. The Department offers strong graduate programs at the masters and Ph.D. levels, with current enrollments of about 140 masters students and about 60 Ph.D. students; concentration areas include coastal/water resources engineering, construction engineering, construction management, earthquake engineering, environmental engineering, geotechnical engineering, structural engineering, structural mechanics and transportation engineering.

In November 2007, the Department was the beneficiary of a \$17 million pledge (<http://viterbi.usc.edu/news/news/2007/cee-announcement-main.htm>) from Mr. Sonny Astani, the largest ever bestowed on a department of civil and environmental engineering, to meet the challenges of megacities and those who live in them (<http://viterbi.usc.edu/assets/053/56844.pdf>). The Astani Department is home to the Center on Megacities (<http://megacities.usc.edu>), studying the complex and interconnected urban systems of megacities through interdisciplinary expertise in science and engineering, and the Foundation for Cross-Connection Control and Hydraulic Research (<http://www.usc.edu/dept/fccchr>), developing and testing countermeasures and devices for preventing contaminants and pollutants from flowing backwards into potable drinking water supplies. The faculty has close working collaborations with other engineering departments in the Viterbi School as well as with the USC Keck School of Medicine, the USC School of Architecture and the USC School of Public Policy, Planning and Development, and participates in USC's CREATE, the Department of Homeland Security's first center of excellence, (<http://www.usc.edu/dept/create>).

The USC Viterbi School of Engineering is among the top tier engineering schools in the world. It counts 168 full-time, tenure-track faculty members, and is home to the Information Sciences Institute (ISI), two National Science Foundation Engineering Research Centers, the Department of Homeland Security CREATE Center, and an Energy Frontiers Research Center (EFRC) supported by the Department of Energy. The School is affiliated with the Alfred E. Mann Institute for Biomedical Engineering, the Institute for Creative Technologies, and the USC Stevens Institute for Innovation. USC Viterbi faculty members conduct research in leading-edge technologies with annual research expenditures typically exceeding \$160 million.

We seek an individual who can provide strong, dynamic and innovative leadership to advance excellence in research, teaching and service to the professional community. In addition to a proven record of scholarly achievement, the candidate must also possess technical leadership, a commitment to civil and environmental engineering education, and effective management and interpersonal skills. The candidate should have an earned doctorate in civil or environmental engineering or in a closely allied field and be eligible for a tenured full professor appointment.

The position is available starting July 1, 2010. Interested candidates should submit contact information, a curriculum vitae, and a cover letter describing their technical qualifications, leadership and future vision. This material should be submitted electronically at <http://www.usc.edu/cee/chairsearch.htm>. Early submission is strongly advised and encouraged. All application material will be held in the strictest confidence. Other inquiries can be directed to:

Chair Recruitment Committee,  
Sonny Astani Department of Civil and Environmental Engineering  
Attention: J. Alvarado  
OHE 200, Mail Code 1450  
University of Southern California  
Los Angeles, CA 90089-1450 USA  
email: [enrinfo@vsoe.usc.edu](mailto:enrinfo@vsoe.usc.edu)

USC values diversity and is committed to equal opportunity in employment.  
Women and men, and members of all racial and ethnic groups are encouraged to apply.

**Neutron Science Senior Scientist**

Neutron Sciences Directorate at Oak Ridge National Laboratory invites applications for Senior Scientists in the areas of Energy Materials, Environmental Geosciences, Nano-Structured Materials, and Biological Systems.

We seek candidates who are internationally recognized authorities in neutron scattering sciences with a distinguished record of research and a demonstrated ability to conceive, lead, and conduct advanced research and development. Although outstanding candidates from all relevant disciplines are invited to apply, areas specifically targeted for development are energy materials (including photovoltaics, catalysis, and solid-state materials), environmental geosciences (including carbon sequestration and chemistry in extreme environments), nanostructured materials (including soft matter, polymers, and self-assembly), and biological systems (bio-energy, bio-membranes and structural biology). Candidates are expected to build programs and partnerships that will deliver outstanding science in these areas and drive the development of innovative scientific methods, tools, and technologies for neutron research.

For more information about the position or to apply visit:  
[http://jobs.ornl.gov/neutron\\_science.shtml](http://jobs.ornl.gov/neutron_science.shtml)

[neutrons.ornl.gov](http://neutrons.ornl.gov)

**BIG DREAMS. BOLD FUTURE.****Director, Florida Institute of Oceanography**

The University of South Florida (USF) invites applications and nominations for the position of Director of the Florida Institute of Oceanography (FIO). The ideal director will provide the vision to lead coastal oceanographic research in Florida to the forefront of the national and international stage. USF is especially interested in candidates who demonstrate strategic leadership that is visionary, innovative and entrepreneurial. The mission of the FIO is to (1) provide a diverse and collaborative statewide forum addressing problems of concern in coastal oceanographic research and education; (2) leverage and integrate existing physical and intellectual resources within the SUS and throughout Florida; (3) anticipate and plan for future infrastructure needs; (4) facilitate, promote and support collaborative ocean-related research and education statewide; and (5) develop and strengthen networks that enable timely identification of oceanographic research opportunities and distribution of research results and other information to the general public, natural resource management agencies and local, state and national policymakers.

In line with the service mission of the FIO, the Director will be expected to work to provide opportunities for the member institutions and their faculties, to maintain close contact with the member institutions through regular visits and to take advantage of opportunities to serve on state and federal commissions, committees and panels relevant to the FIO mission.

**Minimum qualifications:** For consideration, candidates must possess a doctoral degree in a discipline related to oceanography or marine science and at least five years of administrative experience that includes facilities operations, program-building, and fund-raising. In addition, candidates must demonstrate a vision for oceanographic research, unquestionable integrity, and a high level of energy. **Preferred qualifications:** The successful candidate will be a recognized leader, both nationally and internationally; will have demonstrated broad and diverse experience to recognize coming trends in oceanography; will demonstrate success in budget planning, financial management, and supervision of personnel; and will possess effective organizational and communications skills.

This is a 12-month full-time administrative appointment. A faculty appointment may be considered for an appointee with appropriate academic credentials and accomplishments. The anticipated appointment date is August 1, 2010. The salary will be internationally competitive with excellent fringe benefits. USF values campus diversity and encourages members of historically underrepresented groups to apply.

A full position announcement and application instructions may be accessed at: <https://employment.usf.edu>.

USF is an EEO/AA/EA Institution. For disability accommodations contact Ms. Desiree Woroner at [dworoner@usf.edu](mailto:dworoner@usf.edu) at least five working days in advance of need.



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Real Science. Real Life.

## Classified

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assimilation. The position is for high impact research on climate-carbon feedbacks using new atmospheric models and data assimilation methods in a Linux environment. Position includes \$45,000 + benefits and access to the SNRI Yosemite Field Station. For more information and to apply, email a cover letter and resume to Elliott Campbell (ecampbell3@ucmerced.edu). The University of California at Merced is an affirmative action/equal opportunity employer and is supportive of dual career couples.

**Post-Doctoral Position: Neutron Imaging of Water in Porous Media.** Applications are invited for a 12-month post-doctoral position (with the possibility of an extension for an additional 12 months) in the Department of Earth and Planetary Sciences at the University of Tennessee-Knoxville (<http://geoweb.gg.utk.edu/>) to work on neutron imaging of water in porous media. The research will be conducted in conjunction with scientists from the Division of Neutron Sciences at Oak Ridge National Laboratory (<http://neutrons.ornl.gov/>).

Familiarity with soil physics/vadose zone hydrology is expected. Applicants with backgrounds in hydrogeology, civil and environmental engineering or related fields will also be considered. Previous experience with tomographic imaging would be a definite asset. Strong written and oral communication skills, as well as the ability to work effectively in a team environment, are required.

The position is available immediately, and the search will continue until a suitable candidate is identified. To apply, submit a letter of application, CV, and the names and contact information of three references by e-mail to: Dr. Ed Perfect, Department of Earth and Planetary Sciences, University of Tennessee, Knoxville, TN, 37996-1410, USA, e-mail: eperfect@utk.edu, Phone: (865) 974-6017.

**Two Postdoctoral Positions in CO<sub>2</sub> Sequestration Research.** The Department of Geology and Geophysics at the University of Minnesota seeks applicants for two post-doctoral positions involving experimental and theoretical/numerical modeling of rock-fluid interaction of carbon dioxide bearing fluids at elevated temperatures and pressures. Both positions will be involved with all aspects of the research program, including project components that are not within their immediate area of expertise.

The successful candidate for one position will assist with laboratory experiments on the basic geochemical and physicochemical processes of brine and condensed CO<sub>2</sub> (both supercritical and liquid) in geologic media at a wide range of temperatures and pressures and requires a background in geochemistry, physical/surface chemistry, or related fields, and flow/transport processes in fractured and porous media with laboratory research experience with fluid-mineral systems. Experience

using computer modeling approaches of mineral-fluid reactions, spectroscopy, mineral surface analysis, and microscopy is also important.

The second position will entail development and application of computer-based models of the evolution of porosity and permeability in natural and experimental systems and requires a background in numerical modeling of multicomponent-multiphase reactive systems, preferably developing and using lattice-Boltzmann simulations as well as TOUGH2 models. Experience with X-ray tomography imaging, SEM/TEM analyses, microprobe and mineral surface analyses, and microscopy is also highly desired. To investigate the evolution of porosity and permeability due to reactions, a background in topology, percolation theory, or critical path analysis as well as in methods to derive permeability tensors from pore space geometries is desired. A recent Ph.D. in relevant numerical methods, mathematics, computer science, geophysics, chemical/mechanical engineering, or a related field, is essential. Both positions are one-year appointments with a very strong possibility of renewal based upon satisfactory performance. For questions contact the Department of Geology and Geophysics at 612-624-1333. To apply for these positions, candidates must go to <https://employment.umn.edu> (requisition #164591). Please attach a cover letter, resume (CV), statement of research interests, and names of three references. Application review will begin on May 1, 2010 and continues until positions are filled.

The University of Minnesota shall provide equal access to and opportunity in its programs, facilities, and employment without regard to race, color, creed, religion, national origin, gender, age, marital status, disability, public assistance status, veteran status, sexual orientation, gender identity, or gender expression.

## STUDENT OPPORTUNITIES

**Ph.D. Positions in Hydrology.** The Department of Physical Geography and Quaternary Geology at Stockholm University ([www.ink.su.se](http://www.ink.su.se)) seeks candidates for 3 separate positions on (1) nutrient retention and transport under climate change (#463-39-10); (2) hydrological and ecosystem shifts in arctic systems (#463-40-10); and (3) permafrost thawing under climate change (#463-41-10). Visit <http://people.su.se/~stlyo/> for full announcements or contact S. Lyon ([steve.lyon@natgeo.su.se](mailto:steve.lyon@natgeo.su.se)).

**Ph.D. Studentship in Lithospheric Flexure & Seismic Anisotropy.** Applicants are sought for a 3-year Ph.D. studentship at Curtin University in Perth, Western Australia, on the topic of lithospheric flexure and seismic anisotropy. A stipend of \$25,000 + fees is available. Applicants should possess a strong mathematical background and some programming experience, and should hold or expect to receive a first-class degree in geophysics, physics, mathematics, engineering or geodesy. Please send a CV to Dr. Jon Kirby, [j.kirby@curtin.edu.au](mailto:j.kirby@curtin.edu.au), and visit [www.cage.curtin.edu.au/~jfk/PhD.html](http://www.cage.curtin.edu.au/~jfk/PhD.html) for further details.



Faculty of Physical Sciences  
SUERC

### Research Associate/Fellow – Cosmogenic Isotope Analysis

£31,671 - £35,646 (grade7)/£38,951 - £45,155 (grade 8) per annum

This post is available at either grade 7 or grade 8.

At grade 7 you will facilitate project formulation, execution and delivery for users of the NERC Cosmogenic Isotope Analysis Facility (CIAF).

For Level 8 you will contribute to the internationally recognised research of SUERC in the field of environmental change deduced from long-lived isotopes.

The CIAF is one of 5 national facilities operated by SUERC on behalf of the UK Natural Environment Research Council. CIAF provides cosmogenic isotope analyses (10Be, 26Al and 36Cl) for the UK Earth and Environmental Science community. You will join the CIAF team of two scientists and two technicians and will prepare samples for measurement in the SUERC AMS laboratory. Facility scientists are thoroughly involved in collaborative projects from project inception, through data delivery to publication of results.

For an informal discussion about this post and opportunities for career advancement, please contact the CIAF Head of Facility, Prof. Rob Ellam on + 44 (0) 1355 270130 or by e-mail: [r.ellam@suerc.gla.ac.uk](mailto:r.ellam@suerc.gla.ac.uk)

This post has initial funding for 3 years.

Apply online at [www.glasgow.ac.uk/jobs](http://www.glasgow.ac.uk/jobs)

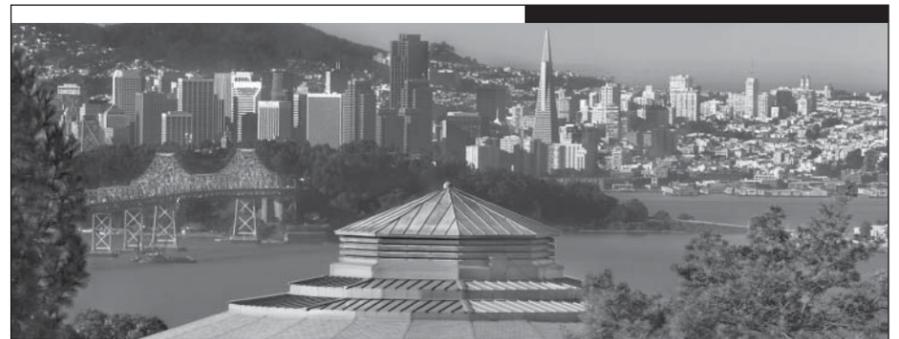
If you are unable to apply online please contact us on + 44 (0) 141 330 3898 for an application pack, quoting Ref 00093-6.

Closing date 30 April 2010.

The University is committed to equality of opportunity in employment.

The University of Glasgow is a registered Scottish charity, number SC004401.

[www.glasgow.ac.uk](http://www.glasgow.ac.uk)



## Senior Geophysicist

The Geophysics Department within the Earth Sciences Division at Lawrence Berkeley National Laboratory has an opening for internationally recognized senior scientist with expertise in seismic modeling, migration and full wave form inversion. An established track record of funding and technical leadership in these areas is essential for this position. The candidate accepting this posting will be expected to maintain and grow a vigorous research program in fundamental subsurface science and contribute solutions to the United States Department of Energy mission critical problems in Energy and Environment. These include carbon sequestration, geothermal resource development, fossil energy, environmental site characterization and remediation. Expertise in large scale computing paradigms in seismology is required, along with skills in high performance computing and a willingness to work with other earth scientists on collaborative and multi-disciplinary projects. Further an ability to work other scientists in fields outside of earth sciences, including biology and medical imaging, is welcomed but not essential for this position.



For details about this position and to apply, please go to: <http://jobs.lbl.gov/LBNLCareers/details.asp?jid=24078&p=1> and follow the online instructions to complete the application process.

LBNL is an Equal Opportunity/Affirmative Action Employer.

# RESEARCH SPOTLIGHT

Highlighting exciting new research from AGU journals

## Gamma ray flashes pinpointed on Earth

Gamma rays have been observed to come from astrophysical processes such as collapsing stars, so in the early 1990s scientists were surprised to observe intense, short (<1 millisecond) bursts of extremely high energy gamma rays from Earth's atmosphere, dubbed "terrestrial gamma ray flashes" (TGFs). These flashes

are believed to result from collisions of electrons that have been accelerated to nearly the speed of light by high electric fields associated with lightning, but it remains largely a mystery exactly how, when, and where this "runaway" acceleration process takes place. Understanding TGF observations requires knowledge of the TGF location, but satellite detection can provide only a broad area over which the TGF may have occurred.

To overcome this, *Cohen et al.* created the first catalog of precise locations of TGF sources. They used data from a network of ground-based radio receivers that detect impulses of lightning known as sferics at very low frequency, even half a world away. With multiple receivers, these observations pinpoint the location and provide a "fingerprint" of lightning discharges that generate TGFs. The authors compared the sferic data with gamma ray data from satellite instruments to associate TGFs with sferics and determine the correct location. The authors found that nearly every TGF had an associated lightning discharge within 1–2 milliseconds. They also noted that some TGFs are associated with a single powerful lightning discharge, while others occur with a train of smaller lightning impulses. (*Geophysical Research Letters*, doi:10.1029/2009GL041753, 2010)

## Laser mapping of fault scarps

Fault scarps, the visible topographic features caused by the motion of faults, can tell researchers about the history of fault motion. Fault scarps that formed more recently tend to be sharper; older ones tend to have softened over time. Mapping fault scarps has been a time-consuming, labor-intensive process requiring ground surveying, often on terrain that is difficult to access.

*Hilley et al.* have found an easier way of mapping fault scarps, using high-resolution

digital topography from airborne laser mapping data. They fit a scarp-like template to the topography data to identify scarps in the data. By modeling the erosion of the scarp as a diffusive mass transport process, they can determine scarp ages.

The researchers applied their method to fault scarp structures at three sites along the San Andreas Fault. The scientists show that their method can automatically identify scarp features within the topographic data and extract the ages of the fault scarps. Knowing the relative ages of fault scarps in a region can help researchers reconstruct a record of fault activity over the past several hundred to several tens of thousands of years. The method also provides a way of automatically analyzing a large volume of laser mapping data and could be useful for other studies of fault zone structure. (*Geophysical Research Letters*, doi:10.1029/2009GL042044, 2010)

—ERNE TRETAKOFF, Staff Writer

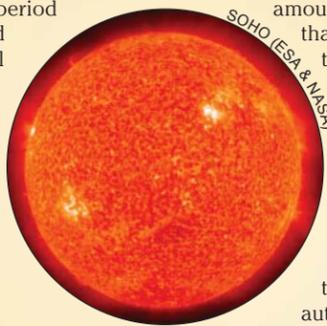


A fault scarp along the San Andreas Fault in the Carrizo Plain, California.

## Prolonged low solar activity will not offset global warming

Solar activity is known to influence Earth's temperature, and it has been suggested that the current period of low solar activity marked by a dearth of sunspots will lead to a more prolonged "grand minimum" similar to the Maunder minimum which lasted from 1645 to 1715, coinciding with the Little Ice Age. Could low solar activity in the future help offset anthropogenic warming?

To determine the potential effects of a prolonged period of low solar activity, *Feulner and Rahmstorf* ran a series of simulations using a coupled climate model that reproduces the cooling during past solar



Few sunspots are visible in this recent ultraviolet image of the Sun.

minima. They found that a new grand minimum would produce only a minimal amount of cooling—no more than 0.3°C in 2100. This potential temperature decrease is much smaller than the increase expected from human-induced warming. Furthermore, any cooling effect would be temporary, since the period of low solar activity would last no more than a few decades. The authors conclude that a new grand minimum cannot offset global warming caused by human greenhouse gas emissions.

(*Geophysical Research Letters*, doi:10.1029/2010GL042710, 2010)