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The Unexpected Awakening of Chaitén Volcano, Chile

On 2 May 2008, a large eruption began unexpectedly at the inconspicuous Chaitén volcano in Chile's southern volcanic zone. Ash columns abruptly jetted from the volcano into the stratosphere, followed by lava dome effusion and continuous low-altitude ash plumes [*Lara,* 2009]. Apocalyptic photographs of eruption plumes suffused with lightning were circulated globally.

Effects of the eruption were extensive. Floods and lahars inundated the town of Chaitén, and its 4625 residents were evacuated. Widespread ashfall and drifting ash clouds closed regional airports and cancelled hundreds of domestic flights in Argentina and Chile and numerous international flights [*Guffanti et al.,* 2008]. Ash heavily affected the aquaculture industry in the nearby Gulf of Corcovado, curtailed ecotourism, and closed regional nature preserves. To better prepare for future eruptions, the Chilean government has boosted support for monitoring and hazard mitigation at Chaitén and at 42 other highly hazardous, active volcanoes in Chile.

The Chaitén eruption discharged rhyolite magma, a high-silica composition associated with extremes of eruptive behavior ranging from gentle lava effusion to violent, gas-driven explosions. As the first major rhyolitic eruption since that of Alaska's Katmai-Novarupta in 1912, it permits observations that are benchmarks for future such events. It also reignites the debate on what processes rekindle long-dormant volcanoes, justifies efforts to mitigate rare but significant hazards through ground-based monitoring, and confirms the value of timely satellite observations.

Background and Chronology of the 2008 Eruption

At 1122 meters high, Chaitén volcano (42.83°S, 72.65°W) stands 10 kilometers northeast of the town of Chaitén on the Gulf of Corcovado. Its last known major eruption occurred 9400 years ago and produced a caldera 3–4 kilometers in diameter, with deposits containing rhyolite pumice capped by mafic scoria [*Naranjo and Stern,* 2004]. On the basis of the caldera collapse volume, the previous eruption merited a volcanic explosivity index (VEI) of 5, ejecting nearly 4 cubic kilometers of material. Prior to May 2008, a large obsidian lava dome more than 5600 years old, with a volume of nearly half a cubic kilometer, occupied the caldera.

Before the 2008 eruption, Chaitén was unmonitored. Retrospective analysis revealed that precursory seismic activity detected by instruments up to 300 kilometers to the north [*Basualto et al.,* 2008], began on 30 April 2008 with volcano-tectonic (VT) earthquakes (magnitudes ranging from 3 to 5) located within 20 kilometers of Chaitén. Large VT events peaked at 15–20 per hour from 1 to 2 May, coincident with an explosive eruption around 0800 coordinated universal time (UT) on 2 May that lasted about 6 hours and lofted ash to an altitude of more than 21 kilometers. Seismicity declined abruptly on 3 May, probably reflecting erosion of a conduit to the surface, but sustained ash emission interspersed with stratospheric plumes continued for several days.

On 4 May, the Chilean Servicio Nacional de Geología y Minería (SERNAGEOMIN) deployed a seismic network around Chaitén. SERNAGEOMIN found that a persistent pattern of VT seismicity (about 70 events per day, average $M > 3.5$) occurred from 4 to 12 May [*Basualto et al.,* 2008]. Ash plumes continued for about a week, punctuated by two additional stratospheric columns (between 20 and 22 kilometers in altitude) on 6 and 8 May. Theoretical models of eruption columns [*Sparks,* 1986] imply discharge of about 1 cubic kilometer of magma in the eruption's first week, placing it among the largest since the August 1991 eruption of Hudson volcano, located about 300 kilometers south of Chaitén. Subsequent work on tephra volume [*Watt et al.,* 2009] suggests that the eruption fell in the middle VEI 4 range.

Eruption of a new lava dome through vents in the preexisting dome began around 10–12 May, extruding between 20 and 100 cubic meters of lava per second through late July. Nonetheless, seismicity declined from mid-May through June, suggesting ease of magma flow in the conduit. During July, ash and steam emissions subsided while lava extrusion continued, accompanied daily by up to 300 hybrid earthquakes, which have characteristics transitional between low- and high-frequency events. Earthquake magnitudes increased from less than 2.5 to 4 by the end of July, raising concerns about renewed explosive eruptions, but seismicity declined in August.

By late September 2008, the new lava dome volume was about half a cubic kilometer. A large dome collapse, a lateral blast, and pyroclastic flows occurred on 19 February 2009, resulting in further ashfall in Argentina. Since then, dome growth, frequent block and ash flows, and low-altitude ash and gas emissions are ongoing as of June 2009. Current seismicity is characterized by about 15 hybrid events daily (average $M < 4.5$). The current volcanic alert code is red, indicating that activity could escalate to dangerous levels at any time and without warning.

By S. A. Carn, J. S. Pallister, L. Lara, J. W. Ewert, S. Watt, A. J. Prata, R. J. Thomas, and G. Villarosa

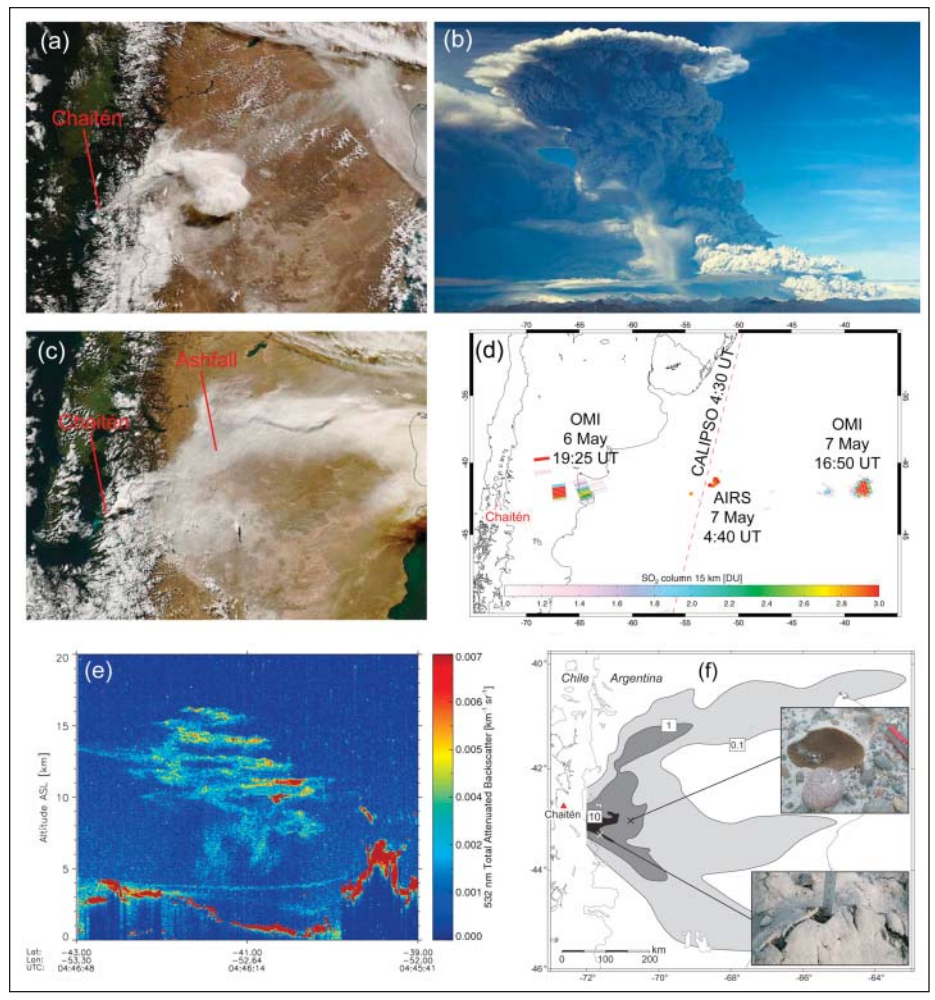

Fig. 1. (a) Terra Moderate Resolution Imaging Spectroradiometer (MODIS) image at 1505 coordinated universal time (UT) on 6 May 2008, showing the ash cloud that began erupting from Chaitén about 3 hours earlier. (b) Photo (from the north) of stratospheric eruption column on 2 May (courtesy of El Mercurio Online; http://www.emol.com). (c) Aqua MODIS image at 1915 UT on 6 May, showing ash deposited by the 6 May eruption cloud over southern Argentina. (d) Ozone Monitoring Instrument (OMI) and Atmospheric Infrared Sounder (AIRS) detection of sulfur dioxide (SO_2) in the drifting 6 May eruption cloud. The Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) satellite track is indicated. (e) Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP) backscatter data (0430 UT on 7 May) showing aerosols from the 6 May eruption between 5 and 16 kilometers in altitude (x-axis shows latitude and longitude). (f) Shaded isopach map (thickness in millimeters) of ashfall over Argentina, modified from Watt et al. *[2009]. Inset photographs show surface ash cover at two locations.*

Satellite Observations

Chaitén's eruption demonstrates the value of satellite observations of unexpected natural hazards. Numerous spaceborne assets imaged the eruption clouds, elucidating their altitude and extent (Figure 1; see also the electronic supplement to this *Eos* issue at http://www.agu.org/eos_elec/). Altitude determines a volcanic cloud's effect on aviation and climate, and is used to assess eruption magnitude.

Key observations came from NASA's A-Train, a fleet of five polar-orbiting spacecraft with overpass times separated by about 8 minutes. A-Train sensors include the Ozone Monitoring Instrument (OMI) and the Atmospheric Infrared Sounder (AIRS), which measure volcanic sulfur dioxide (SO_2); the Moderate Resolution Imaging Spectroradiometer (MODIS), which provides visible images and measurements of ash mass loading; and the Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP) on the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) satellite, which provides vertical profiles of aerosol. This sensor synergy permits direct measurement of volcanic cloud altitude, an improvement over indirect altitude determinations using infrared cloud top temperatures, observed cloud drift, or ground-based clinometry.

Geostationary Operational Environmental Satellite (GOES) images captured the eruption onset at around 0800 UT on 2 May, with the ash cloud top altitude estimated at about 12 kilometers, near the tropopause. On 3–4 May, CALIOP detected aerosol at about 30°S and near 12 kilometers in altitude, collocated with SO_2 detected by OMI. CALIOP data were consistent with the presence of solid particles—possibly fine volcanic ash, ice crystals, or a mixture of both.

The next, and largest, explosive eruption occurred around 1200 UT on 6 May, emitting a cloud that drifted east and deposited ash over a large swath of Argentina (Figure 1). Ground-based observers reported eruption column altitudes of 30 kilometers. Cloud top temperatures and visible plume movement suggested altitudes of 18–20 kilometers; this was corroborated on 8 May when CALIOP detected aerosols at similar heights. These aerosols were interpreted as ash or an ice-ash mix [*Thomason and Pitts,* 2008]. GOES identified a third stratospheric eruption at approximately 0330 UT on 8 May, producing aerosol detected by CALIOP on 9 May at about 13 kilometers in altitude.

CALIOP subsequently detected stratospheric aerosol from Chaitén drifting over southeastern Australia, suggesting long-range transport of fine ash. The rhyolitic ash clouds also produced a distinctive spectral signature in AIRS data, suggesting that ash composition could be determined from satellite measurements.

OMI measured strikingly low SO_2 emissions during the eruption, only about 10 kilotons of SO_2 in the clouds emitted on 2, 6, and 8 May. At the low sulfur abundances typical of rhyolites (~50 parts per million), degassing

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of about 0.1 cubic kilometer of rhyolite would be commensurate with the observed SO_2 yield, also supporting an eruption VEI around 4. No significant climate impact is expected due to these low SO_2 emissions.

Eruption Deposits

Chaitén ash samples contain fine particles (diameter < 100 microns) characteristic of silicic explosive eruptions. Because of extensive ash fallout over land, the eruption offers a rare opportunity to investigate the characteristics, distribution, deposition, and fate of fine ash following explosive eruptions, and permits evaluation of ash dispersion and fallout models [*Folch et al.,* 2008].

Teams from Argentina, the United Kingdom, and the United States sampled the ashfall and measured its thickness; estimates suggest that about 0.2 cubic kilometers (160 megatons) of ash was deposited over 200,000 square kilometers of Argentina [*Watt et al.,* 2009]. A complex ash dispersal pattern, with several discrete but overlapping depositional lobes, arose from changing wind patterns during the initial, and most explosive, eruption period (Figure 1f; see also the electronic supplement to this *Eos* issue at http://www.agu.org/eos_elec/). These data and material collected are being used to improve ash fallout models and investigate environmental impacts of fine ash deposition [e.g., *Martin et al.,* 2009].

Estimates of magma discharge for the first week of the Chaitén eruption vary widely. Some field data suggest total volumes of several cubic kilometers, and volumes based on eruption column models [*Sparks,* 1986] range from about 1 to 6 cubic kilometers, although the larger value neglects column height fluctuations and is clearly an overestimate [*Folch et al.,* 2008]. Determining the total volume discharged is important not just to assign a VEI but also to better understand the conduit, vent, and plume dynamics.

Analysis of deposits [*Castro et al.,* 2008; *Lowenstern et al.,* 2008; *Muñoz et al.,* 2008] shows that the eruption tapped an extremely crystal-poor rhyolite magma similar to the rhyolite erupted 9400 years ago, with evidence for 4–5% dissolved water by weight prior to final ascent. These conditions are similar to those of many other explosively erupted rhyolites. Calcium-rich cores in plagioclase crystals, aluminum-rich amphiboles, and relatively unevolved trace element abundances suggest rhyolite extraction from a more mafic crystal mush at depth. Lack of amphibole decompression rims indicates rapid magma ascent, consistent with the abrupt eruption onset. Unlike the event 9400 years ago, there is no evidence of mafic magma having erupted so far in 2008–2009. Like eruptions such as Pinatubo (Philippines) in 1991 and Usu (Japan) in 1663, basaltic magma at depth may have played a role in mobilizing silicic magma to drive an explosive eruption after centuries to millennia of dormancy.

Eruption Response

Because Chaitén was unmonitored before the eruption, precursory observations were unavailable and affected communities were unprepared. SERNAGEOMIN is now monitoring the volcano, assisted by the U.S. Geological Survey Volcano Disaster Assistance Program (VDAP). In late May 2008, real-time telemetered seismometers were installed around Chaitén by SERNAGEOMIN and VDAP. Because of ongoing volcanic activity, on 29 January 2009 the Chilean government announced that the town of Chaitén will be relocated to a more protected site 9 kilometers to the northwest.

The international nature of this event necessitated cooperation between Chile and Argentina, both of which are at high risk from the 122 active volcanoes close to their shared border. The Buenos Aires Volcanic Ash Advisory Center, the Argentine Space Agency, and the University of Chile's Center for Space Studies were primarily responsible for operational tracking of ash emissions for aviation safety using satellite data. Ash transport and fallout were also simulated using meteorological forecasts and dispersion models running in operational mode [*Folch et al.,* 2008].

Spectacular lightning displays inspired a team from the New Mexico Institute of Mining and Technology to deploy an autonomous electrical monitoring array on Chiloe Island (70–110 kilometers from Chaitén) in late May 2008. This array continuously maps electrical discharge, revealing the spatiotemporal distribution of charged particles (ash and volatiles) in the eruption plume. Data analysis alongside other monitored parameters (e.g., seismicity, infrasound) will permit evaluation of remote electrical activity monitoring as a proxy for eruption intensity.

Most important, the 2008 eruption of Chaitén focused the attention of the Chilean government on its volcano hazards and resulted in a new national volcano-monitoring program (Red Nacional de Vigilancia Volcánica), which over the next 5 years will build real-time monitoring networks at Chile's highest-risk volcanoes. Such efforts, combined with continued international monitoring, the refinement of models, and the elaboration of the eruptive histories of the region's volcanoes, are needed to mitigate the impacts of future eruptions.

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Initiative to Improve Process Representation in Chemistry-Climate Models

Chemically active species in the atmosphere (e.g., aerosols, ozone, methane) play important roles in climate and air quality. Atmospheric concentrations of these species respond relatively rapidly to changes in emissions, providing opportunities for rapid response mitigation options. Because of the large spatial and temporal variability of these species, their global distributions must be calculated with a model, as must their influence on climate. Models are also needed for future projections of these species and their interaction with climate. Understanding what controls the distribution of these species, their role in climate change, how they will change with climate, and the coupling between climate and air quality is therefore critical.

Studies [e.g., *Eyring et al.,* 2006; *Textor et al.,* 2007] have shown large intermodel differences in the distribution of these species and their precursors, and also have provided insights into which models do well at producing certain features. However, studies have not fully clarified why models do well at producing certain features, nor have studies identified whether these models improved accuracy in one feature at the expense of another feature. Differences in emissions, model configurations, and the treatment of component processes, and inconsistencies in the design of projects involving multiple models, have impaired the characterization of the role of a changing chemical composition in climate. Sometimes even simple coding and physical or chemical process representation errors contribute to differences between models; such errors need to be identified and corrected. In addition, observational data sets need to be used to more stringently constrain atmospheric process representation.

Motivated by these deficiencies, a new Atmospheric Chemistry and Climate Initiative (AC&C; Figure 1), established over the course of a series of meetings from 2006 to 2009, aims in its approximately 5-year initial phase to improve process representation in chemistry-climate models while building upon existing activities in this area. The goal of AC&C—jointly led by the International Global Atmospheric Chemistry (IGAC) project of the International Geosphere-Biosphere Programme (IGBP) and the Stratospheric Processes and their Role in Climate (SPARC) project of the World Climate Research Programme (WCRP)—is to achieve synergy across related scientific fields (aerosols, reactive gases, emissions). This brief report serves to inform the community and also to invite interested parties with suitable models and data sets to become involved in this initiative.

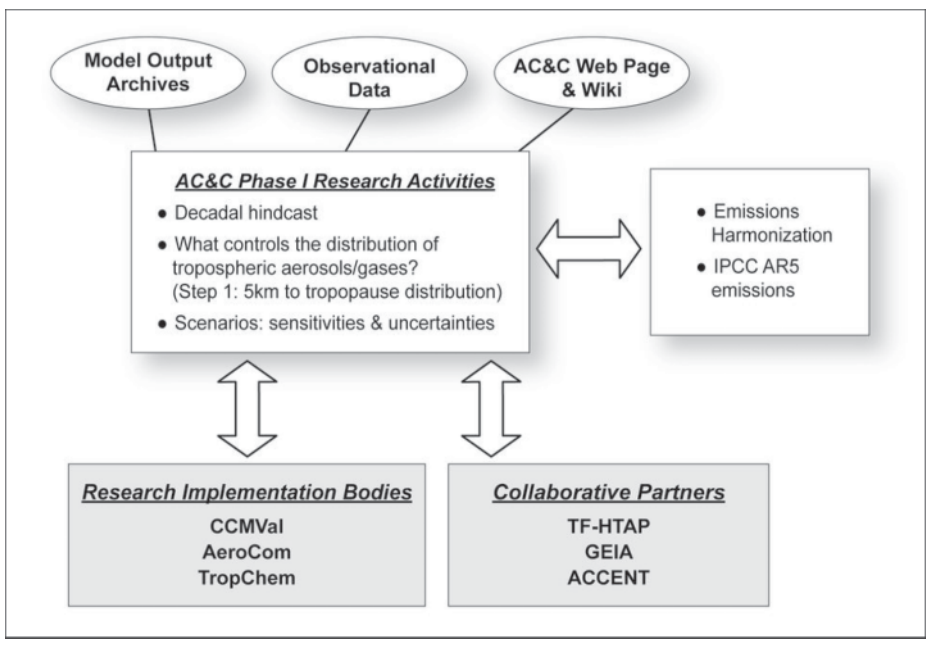

Fig. 1. The Atmospheric Chemistry and Climate Initiative (AC&C) will initially involve three research activities (large box) and supporting efforts (ovals). Model runs are being streamlined through and coordinated with the research implementation bodies and the collaborative partners. The TropChem (tropospheric chemistry) group is acting as the organizing body for tropospheric gas phase runs. In parallel, emissions are being coordinated through the Global Emission Inventory Activity (GEIA) to be consistent across the AC&C model runs and with the Intergovernmental Panel on Climate Change Fifth Assessment Report (AR5) representative concentration pathways. CCMVal is Chemistry Climate Model Validation project; AeroCom is Aerosol Model Intercomparison Project; and TF-HTAP is Task Force on the Hemispheric Transport of Atmospheric Pollutants. ACCENT refers to a European model comparison project.

Decadal (1980–2009) Hindcast Activity

To have confidence in near-term (~30-year) climate and regional air quality forecasts, it is necessary to know that models can accurately represent critical chemistry-climate interactions and to know the magnitude and source of uncertainties. The AC&C initiative will use four hindcasts to test model skill:

• *Inert tracers* (chlorofluorocarbons and nitrous oxide), to quantify the importance of changes in emissions, tropospheric meteorology, and stratosphere-troposphere exchange variability;

• *Aerosols,* to test the accuracy of models in reproducing observed past trends in concentrations, chemical composition, optical properties, and aerosol optical depth; to study the effects of emissions trends; and to

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NEWS

New Study Finds Increasing Gender Equity at U.S. Research Institutions

Women and men faculty in science, engineering, and mathematics for the most part have comparable opportunities within major U.S. research universities, according to a report released 2 June by the U.S. National Research Council (NRC). The report found that gender does not appear to have been a factor in a number of important career transitions and outcomes, including hiring for tenure track and tenure positions and promotions.

"That is probably going to be surprising to many people. It was surprising to our own panel. And it may not have been the case if we had done the study in 1985 instead of 2005," said Claude Canizares, cochair of the NRC committee that prepared the report, entitled *Gender Differences at Critical Transitions in the Careers of Science, Engineering and Mathematics Faculty*.

The congressionally mandated report, sponsored by the National Science Foundation, also found that "although women represent an increasing share of science, mathematics, and engineering faculty, they continue to be underrepresented in many of those disciplines."

The report based its findings on two commissioned national surveys, conducted in 2004 and 2005, of more than 1800 tenured and tenure-track faculty—in biology, chemistry, mathematics, civil and electrical engineering, and physics—at 89 research-intensive universities.

The report, which does not focus on the geosciences, contrasts with a 2006 report, *Beyond Bias and Barriers*, released by the U.S. National Academies' Committee on Science, Engineering, and Public Policy, which concluded that "women who are interested in science and engineering careers are lost at every educational transition." Canizares said the new NRC report, which has a different focus and benefits from the two recent surveys, is a snapshot in time, whereas the earlier report examined accumulated experiences sometimes stretching over a period of decades.

Key findings of the NRC report include:

• Tenure-track women received a greater proportion of first job offers than their proportion in the interview pool;

• Male and female faculty generally have similar access to many kinds of institutional resources;

• Women were less likely to engage in conversation with colleagues on a range of professional topics, including research, salary, and benefits. The report notes, "This distance may prevent women from accessing important information and may make them feel less included and more marginalized in their professional lives."

• There is little evidence that women and men exhibited different outcomes regarding grant funding, honors and awards, and other measures;

• Male full professors earned about 8% more than females, though salary differences disappeared at associate and assistant professor ranks; and

• Women are applying for tenure-track positions at a lower rate (dramatically lower in biology and chemistry) than they are earning Ph.D.s.

Committee cochair Sally Shaywitz, Audrey G. Ratner Professor in Learning Development at the Yale University School of Medicine, New Haven, Conn., told *Eos* that based on data from a certain group of universities, and using a certain methodology, the report found "there was fairly gender equity in hiring, interviews, and promotions."

"Things look better than people might have expected," she added. "But then, on the other hand, when you compare the number of graduates in postdoctoral programs and the proportion of women, we saw less of a proportion entering academic life. There is a great need for longitudinal studies so that we can actually track men and women finishing their education, and then find out the whys behind this."

Canizares, vice president for research at the Massachusetts Institute of Technology, told *Eos* that although universities are paying attention to the gender issue and are trying to deal with the factors under their control, "It is also very clear that we are still a very long way from gender equity in all disciplines."

"Those knobs we can turn seem to be in some sense not the way we are going to change things. Now we have got to look for much more systemic things like climate [within institutions], like the length of time we are forcing people to be in the uncertainty of a not permanent position, and try and see what we can do about those factors," he said, referring to the increasing amount of time often required to enter academia.

"White males constitute less than a third of the population of the United States. Why are we tying two hands behind our backs, so to speak, in trying to attract the best and the brightest talent to these careers?"

National Academy of Sciences president Ralph Cicerone said the report can help to document progress that has already occurred and point out areas that still need attention. "Getting these results out into the university community is one of the things we should be doing. And somehow encouraging people to re-do this survey this year and next year so we can get longitudinal data," he told *Eos*.

Cicerone also expressed disappointment that the geosciences were not covered in the NRC report and said he is not sure whether those findings can be extrapolated to the geosciences. "I wonder if there is some way that geosciences faculty could be inspired, perhaps through AGU or through the Academy, somehow to do a similar study," he said.

For more information about the report, visit http://www.nap.edu/catalog.php?record_id=12062.

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understand the impact on aerosol trends of changes in meteorology (and natural emissions) versus changes in anthropogenic emissions;

• *Tropospheric ozone,* to understand the effect of large changes over the past several decades in lower stratospheric ozone, stratosphere-troposphere exchange, emissions, and climate;

• *Methane,* to test against observed trends and variability and to quantify the importance of changes in emissions and of variations in concentrations of the hydroxyl radical.

Each model run will be defined by multiyear observational data sets, consistent emissions inventories, objective model grading criteria, model comparison, and evaluation.

Vertical Distributions Activity

Model comparisons conducted under the Chemistry-Climate Model Validation project (CCMVal, for ozone [e.g., *Eyring et al.,* 2006; *Braesicke et al.,* 2008]) and the Aerosol Model Intercomparison Project (AeroCom, for aerosols [e.g., *Textor et al.,* 2007]) have identified particularly large uncertainties in modeled distributions of trace species in the upper troposphere, even when the same emissions are used. Species at these altitudes are radiatively important, and aerosols at these altitudes have a longer lifetime and a large integrated impact. Initial model runs will be designed to understand convection and scavenging processes, as these are among the most uncertain and most significant processes in models affecting upper tropospheric distributions. A particular focus will be the distributions of tracers in the tropical tropopause layer.

Scenarios Activity

A set of representative concentration pathways (RCPs) of emissions is being prepared for the next Intergovernmental Panel on Climate Change (IPCC) assessment, planned for 2013 [*Moss et al.*, 2008]. Many climate modeling centers will perform simulations to define the chemical composition of the atmosphere as needed for these simulations. However, some modeling centers may not have the capability to create their own time-evolving distributions of ozone and aerosols (consistent with each RCP), do not need to carry this information iteratively, or would prefer to use a standard climatology. This activity will provide well-evaluated distributions for use in such climate and Earth system models.

In addition, because there has been no systematic effort to date to archive, evaluate, and compare the composition changes used in Coupled Model Intercomparison Project (CMIP) simulations, an atmospheric chemistry and climate model intercomparison project is needed. This activity would include diagnostics from the CMIP5 simulations and from additional runs of composition-climate models, archiving more detailed data on the processes governing the behavior of gas phase and aerosol species. Additional specific time-slice experiments would enable the participation in this activity of chemistry transport models.

While AC&C's first phase is well under way, future plans will be shaped through lessons learned from this phase and from the interest of the science community. For more information, visit http://www.igac.noaa.gov/ACandC.php.

Please see the electronic supplement to this *Eos* issue (http://www.agu.org/eos_elec/) for a list of lead researchers for the AC&C.

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FORUM

Geomagnetic and Archeomagnetic Jerks: Where Do We Stand?

The Earth's magnetic field is generated mainly by a self-sustaining dynamo in the fluid outer core. Known as the core or main field, the dynamo's magnetic field is not constant but changes with time, a phenomenon denoted as secular variation. Unfortunately, no common agreement exists about the definition of secular variation: While some use this term for the temporal changes of the core field in general, others use the term only for its linear part (first time derivative).

Two more terms are linked to core field temporal variations: geomagnetic jerks and archeomagnetic jerks. They are used to describe specific magnetic field signatures in the observations, implying a phenomenological classification. We suggest that a characterization of magnetic field changes based on the physics of the underlying core process may be more useful. Such a classification is proposed here to help avoid further misunderstanding through terminology.

Problems in Terminology

Whether or not something is perceived as a trend depends on the timescale in consideration: A linear change over a timescale of years to decades may be more complicated when looking at the century to millennium timescale. Indeed, the secular variation for the past few centuries—over which direct measurements are available—is far from linear. Phenomena characterized by a sudden change in the trend of the first time derivative of the magnetic field (corresponding to a step in the second time derivative) are called geomagnetic jerks. They originate in the Earth's core and occur over short timescales. But how short is "short"?

Using additional information provided by geomagnetic field models and the latest satellite data [*Mandea and Olsen,* 2006; *Olsen and Mandea,* 2007], authors have found new characteristics of secular variation regarding spatial resolution and the duration of "sudden" changes. Yet a problem arises: Should every fluctuation of the core magnetic field that occurs on timescales of just a few months to a couple of years be called a geomagnetic jerk?

The terminology is further complicated by the term "archeomagnetic jerk" [*Gallet et al.,* 2003], which is meant to denote sharp features at a timescale intermediate between geomagnetic jerks (1–2 years in a centennial time series) and excursions (10^3–10^4 years in a time series 10^5–10^6 years in length). Whereas a geomagnetic jerk is defined based on a sudden change of the second time derivative of the magnetic field, an archeomagnetic jerk has been defined based on a sudden change of the magnetic field itself. Thus, the term archeomagnetic jerk may be misleading.

To better characterize observed values without ambiguity, we suggest a classification of the magnetic field temporal changes based on the physics of the underlying core process.

Geomagnetic Jerks

Geomagnetic jerks have been explained by invoking torsional oscillations in the fluid outer core [*Bloxham,* 2002]. These oscillations consist of time-dependent axisymmetric and equatorial symmetric zonal flows, with typical periods of several decades. Theoretical considerations suggest that such oscillations should be contained in core flows, and because of their timescale they can be observed in historical data. For core dynamics, torsional oscillations are very important because they are the most robust observed dynamic feature inside the core and provide a crucial link between magnetic field observation and dynamo theory. We suggest that changes in the geomagnetic field due to the torsional oscillations should be denoted as geomagnetic jerks.

As an example of geomagnetic jerks observed from historical data, the black curve in the magnified part of Figure 1 shows the temporal changes of the annual means of declination (dD/dt) since the first French observatory was installed in the Paris region. Also shown are predictions of dD/dt for Chambon-la-Forêt observatory in France, as given by the gufm1 model (dashed curve [see *Jackson et al.,* 2000]) and the preliminary CALSK10 model (black curve with dots (M. Korte, personal communication, 2009)).

These curves indicate that there are linear segments of constant slope of dD/dt, lasting from a few decades (e.g., 1925–1970) to nearly a century (e.g., the first part of the nineteenth century), as well as short-term abrupt changes on decadal or even subdecadal timescales. The estimations deduced from the preliminary CALSK10 model indicate periods characterized by important accelerations, as around 7000 B.C.E. with a change of about 0.5° in some 100 years or, starting with the eighteenth century, of more than 0.3° in less than 200 years.

Rapid Secular Variation Fluctuations

Torsional oscillations may give only a snapshot of the dynamo on a decadal timescale. No direct information is available for very short timescales (less than a couple of years) or at the timescale of magnetic field generation (more than thousands of years). Thus, magnetic field changes arising on both of these timescales should be denoted a bit differently.

Can we find flows in the core that are (1) consistent with the very rapid changes of the field (<1 year) recently observed using magnetic satellite data [*Mandea and Olsen,* 2006; *Olsen and Mandea,* 2007] and (2) in agreement with the observed change in the length of day (LOD)? Recently, *Olsen and Mandea* [2008] have shown that changes in the magnetic field occurring over only a few months, as well as the fluid flow at the top of the core generating them, can be resolved. The derived time-dependent core flow, fitting the recent secular variation behavior and being in agreement with the LOD variation, is spatially rather localized and involves rapid variations over timescales of only a few months, with surprisingly large local accelerations. We suggest calling these changes rapid secular variation fluctuations, or, in short, rapid fluctuations.

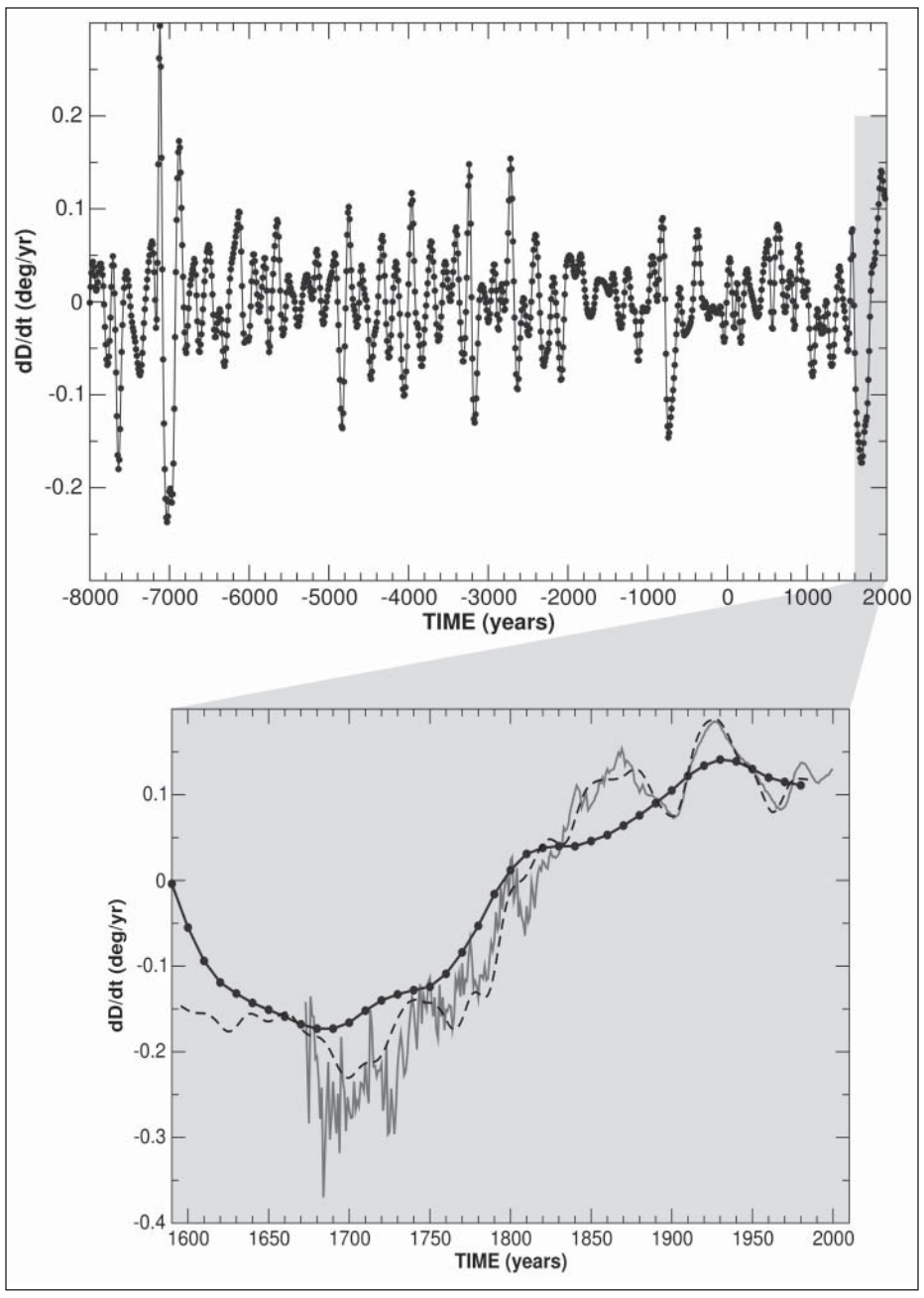

Fig. 1. Temporal evolution of the declination for Chambon-la-Forêt location (France) given by the preliminary CALSK10 model (black curve with dots). The magnified part of the figure indicates the secular variation recorded in the Paris region and adjusted to the Chambon-la-Forêt observatory (gray curve), and the corresponding predictions for the same site given by the gufm1 model (dashed curve) and the preliminary CALSK10 model (black curve with dots). Note the well-known geomagnetic jerks around 1900, 1925, 1970, and 1980, with a rounded shape due to the 11-year smoothing used. During the period preceding the twentieth century, the data are of lower quality; however, a clear jerk appears around 1870. There is no evidence of a jerk with a similar magnitude prior to this date; nonetheless, some events, though drowned out by the high-amplitude noise, can be noted over the general increasing tendency.

Archeomagnetic Jerks

Are there flows that are consistent with changes observed in the secular variation covering a few millennia, and also with the LOD variations on a millennial timescale? *Dumberry and Bloxham* [2006] have shown that the amplitudes and characteristic timescales of the observed LOD changes can be explained by zonal flow variations deduced from secular variation on millennial timescales. Changes in the magnetic field configuration are generated by convective motions, which in turn produce observable secular variation. Recently, *Wardinski and Korte* [2008] found that a toroidal flow explains better the long-term variation in the geomagnetic field secular variations compared with a geostrophic flow. The significant periodicities for the large-scale zonal flows range from some 540 to 1050 years.

We suggest that the term archeomagnetic jerk should be used to denote these long-term changes in the secular variation, rather than current classificiations that use the term to define changes in field direction.

We hope that our suggested changes in terminology of geomagnetic field variations will help to better track the different temporal variations revealed by observations and facilitate future developments concerning the dynamics of the fluid core.

Acknowledgments

We thank Monika Korte for providing the preliminary CALSK10 model and Alexander Jordan for his support in improving Figure 1.

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—Mioara Mandea, Helmholtz-Zentrum Potsdam, Deutsches GeoForschungsZentrum, Potsdam, Germany; E-mail: mioara@gfz-potsdam.de; and Nils Olsen, National Space Institute, Technical University of Denmark, Copenhagen, Denmark

MEETING

Workshop on Marine Research Drilling

Cold-Water Carbonate Reservoir Systems in Deep Environments (COCARDE): A Pilot Industry-Academia Partnership in Marine Research Drilling; Fribourg, Switzerland, 21–24 January 2009

Cold-water carbonate mounds supporting cold-water coral ecosystems, often dominated by *Lophelia pertusa* and *Madrepora oculata*, are widespread along the Atlantic margins from Norway to Mauritania. During the past 10 years, the scientific community has accumulated new insights on their occurrence and development and identified their potential role in reservoir formation, thus establishing a framework for collaboration with the hydrocarbon industry.

A Magellan workshop, sponsored by the European Science Foundation (ESF; http://www.esf.org/), was held in Switzerland in January. The workshop gathered 35 scientists from 10 European and two extra-European countries (Canada and Morocco), representing 20 research teams, including members of two Integrated Ocean Drilling Program (IODP) proposals. Some of the participants were also involved with two ESF European Collaborative Research (EUROCORES) projects [Microbial Diversity and Functionality in Cold-Water Coral Reef Ecosystems (MiCROSYSTEMS) and Mid-Latitude Carbonate Systems: Complete Sequences From Cold-Water Coral Carbonate Mounds in the Northeast Atlantic (CARBONATE)], and the European Union Framework Program 6 integrated project Hotspot Ecosystem Research on the Margins of European Seas (HERMES).

The scientists, representing a wide spectrum of geological and biological disciplines, came together to launch the Cold-Water Carbonate Reservoir Systems in Deep Environments (COCARDE) initiative and to discuss and plan future common research strategies and joint projects for the study of these important geological settings together with industry, ideas that are also being discussed within IODP.

The workshop was organized in five panels, addressing the most important key processes that contribute to the shaping of the mound structures. Panel 1, "Environment," stressed the importance of understanding the entire architecture of cold-water coral carbonate mounds to open new insights into the role of both primary oceanic processes and early diagenesis in determining the internal architecture of a mound reservoir. Panel 2, "The microbial filter," focused on these structures as giant biogeochemical reactors. Panel 3, "Petrophysical characterization," pointed out the need for a better understanding of subrecent diagenetic processes and their impact on the primary fabric and petrophysical characteristics of a cold-water coral mound, which might help scientists to understand and predict the occurrence of later diagenetic processes that play an important role in reservoir formation. Panel 4, "Connectivity issues and compartmentalization in mixed cold-water carbonate/siliciclastic contourite systems," showed that the association of cold-water coral carbonate mounds with contourites offers various opportunities for connectivity at several scales, including the role of fine-grained contourite drift as reservoir seals. Panel 5, "Ancient cold-water carbonate systems and potential recent analogs," discussed the importance of combined research on fossil and modern cold-water carbonate settings to provide the baseline reference standard for a better understanding of these systems and their potential as hydrocarbon reservoirs.

The ideas expressed during the Fribourg workshop will be compiled into a draft proposal promoting the "carbonate factory" theme for future post-IODP planning. COCARDE endeavors to sail under the flag of the Intergovernmental Oceanographic Commission/United Nations Educational, Scientific, and Cultural Organization (IOC-UNESCO) Geosphere-Biosphere Coupling Processes program. In the future, as part of the International Continental Scientific Drilling Program, COCARDE will aim to obtain complete records cored through ancient mounds with continuity and resolution comparable to those achieved in drilling marine mounds. The ESF EuroDiversity program and the ESF MiCROSYSTEMS project will support a workshop with field seminars on carboniferous mounds in Cantabria, Spain, in early September 2009.

The full text of this meeting report can be found in the electronic supplement to this *Eos* issue (http://www.agu.org/eos_elec/).

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MEETING ANNOUNCEMENTS

■ 22–24 June 2009 **NASA Earth System Science at 20: Accomplishments, Plans, and Challenges**, Washington, D. C., USA. Sponsor: NASA. (Web site: http://dels.nas.edu/osb/nasa.shtml)

The symposium will include an open forum to examine the history of the NASA Earth System Science Program and its future, and an open science meeting to discuss scientific findings and advances from the Earth Observing System and other NASA or NASA-partnered Earth science missions.

■ 26 June 2009 **Making a Geology Course More Engaging for Students: Incorporating More Interactive Assignments and Activities to Promote Critical Thinking and Reflection**, Allendale, Michigan, USA. Sponsors: Center for Excellence in Science and Mathematics Education, Grand Valley State University; Pew Faculty Teaching and Learning Center, in cooperation with Frederik Meijer Honors College, Grand Valley State. (Conference Coordinator, Tel.: +1-616-331-3912; Fax: +1-616-331-8658; E-mail: CESME@gvsu.edu; Web site: http://www.gvsu.edu/cesme/index.cfm?id=0C039FB7-CAEB-47AE-9434A83EE1EA87B9)

The workshop will focus on developing engaging ways of presenting material and teaching concepts.

■ 25–30 July 2009 **2009 Annual Meeting of the American Crystallographic Association**, Toronto, Ontario, Canada. Sponsors: American Crystallographic Association (ACA); Canadian Institutes of Health Research; Natural Sciences and Engineering Research Council; others. (D. Rose, Department of Biology, University of Waterloo, 200 University Avenue West, Waterloo, ON, N2L 3G1, Canada; Tel.: +519-888-4567 ext. 35208; Fax: +519-746-0614; E-mail: drrose@scimail.uwaterloo.ca; Web site: http://www.cins.ca/aca2009/index.html)

Session themes include green biochemistry, the structure of nanophase materials, and complementary methods for macromolecular crystallography.

■ 12–14 August 2009 **Cryospheric Changes and Influences: Cryospheric Issues in Regional Sustainable Development**, Lijiang, China. Sponsors: Climate and Cryosphere project (CliC); International Association of Cryospheric Sciences; International Union of Geodesy and Geophysics; others. (S. Kang, Conference Secretariat, Tel.: +0086-10-6284-9681; E-mail: shichang.kang@itpcas.ac.cn; Web site: http://clic.npolar.no/meetings/First_circular_lijang.doc)

Sessions will include cryospheric distribution and changes, cold region hydrology and water resources, frangibility and adaptability of cryosphere, and mitigation and adaptive countermeasures on cryospheric changes.

■ 7–11 September 2009 **First Antarctic Climate Evolution Symposium**, Granada, Spain. Sponsors: U.S. National Science Foundation; Consejo Superior de Investigaciones Científicas (CSIC); Scientific Committee on Antarctic Research; others. (Carlota Escutia Dotti, Instituto Andaluz de Ciencias de la Tierra CSIC, University of Granada, Granada, Spain; E-mail: cescutia@ugr.es; Web site: http://www.acegranada2009.com/)

The symposium will focus on the integration of paleoenvironmental data and numerical models for an improved understanding of processes related to the past, present, and future dynamics and interactions of the Antarctic atmosphere, ocean, cryosphere, and biosphere.

■ 28 September to 1 October 2009 **MARGINS Theoretical and Experimental Institute: Volatiles in the Subduction Factory**, Timberline, Oregon, USA. Sponsor: MARGINS. (MARGINS Office, Lamont-Doherty Earth Observatory of Columbia University, 61 Route 9W, Palisades, NY 10964, USA; Tel.: +1-845-365-8711; Fax: +1-845-365-8150; E-mail: margins@nsf-margins.org; Web site: http://www.nsf-margins.org/SF/2009/index.html)

The meeting will focus on the behavior, mass balance, and influence of volatiles in subduction zones. The meeting will encompass research topics within MARGINS subduction factory, seismogenic zone experiment, and rupturing continental lithosphere initiatives that are directly influenced by subduction-related fluids.

■ 5–9 October 2009 **Second International Symposium on the Geology of the Black Sea Region**, Ankara, Turkey. Sponsors: Mineral Research and Exploration Institute of Turkey (MTA); Chamber of Geological Engineers. (A. I. Okay, Eurasia Institute of Earth Sciences, Istanbul Technical University, Maslak, Istanbul 34469, Turkey; Tel.: +90-212-285-6208; Fax: +90-212-285- 6210; E-mail: okay@itu.edu.tr; Web site: http://www.mta.gov.tr/isgb/)

All aspects of the geology of the Black Sea region onshore and offshore, including tectonics, petroleum geology, marine geology and geophysics, volcanology, mining geology, engineering geology, and Quaternary geology, will be discussed at the symposium. Abstract deadline is 25 June.

ICDP Workshop on the Integration of Deep Biosphere Research into continental drilling campaigns

Microbiological and biogeochemical investigations over the last two decades have demonstrated the occurrence of microbial life widely disseminated within the deep subsurface of the Earth, and it has been estimated that the biomass of the so-called deep biosphere might be equal to or even larger than that of the surface biosphere. Thus, the deep biosphere must play a fundamental role in global biogeochemical cycles over both short and longer time scales. Its huge size, as well as the largely unexplored biogeochemical processes it is driving, makes the investigation of the extent and dynamics of deep microbial ecosystems in the subsurface an intriguing topic in today's biogeoscience research. Our knowledge of the deep biosphere is still fragmentary, especially in terrestrial environments. To overcome this, the aim of this ICDP workshop is to strategically integrate deep biosphere research into continental drilling campaigns.

The workshop will address scientific, technical, administrative and logistical prerequisites for the integration of deep biosphere research into continental scientific drilling. Especially, the development of adequate technical protocols to recover appropriate contamination controlled sample material and the integration of a newly developed mobile microbial laboratory (GFZ BUGLab) will be an issue of paramount importance. Furthermore, identification of upcoming ICDP drilling projects for deep biosphere research and new targets for dedicated continental deep biosphere drilling projects in the future will be in the focus of the meeting. The workshop will be held at the German Research Centre for Geosciences - GFZ in Potsdam, Germany, from September 27 to 29, 2009.

We invite researchers from the international scientific community from disciplines such as microbiology, biogeochemistry, geology and geochemistry as well as engineers with experience and interest in deep biosphere research and drilling to participate at the workshop. ICDP will support travel and expenses for approximately 30 participants, with preference for individuals from ICDP member countries. Interested scientists and engineers are requested to contact the Steering Committee members before **July 31, 2009** (Kai Mangelsdorf, GFZ, Telegrafenberg B423, 14473 Potsdam, Germany, k.mangelsdorf@gfz-potsdam.de; Jens Kallmeyer, University of Potsdam, Dept. of Geosciences, Karl-Liebknecht-Str. 24, 14476 Golm, Germany, jens.kallmeyer@geo.uni-potsdam.de). Selected participants will be informed by the Steering Committee in early August.

ABOUT AGU

Fein Receives Edward A. Flinn III Award

Jay S. Fein received the Edward A. Flinn III Award at the Joint Assembly, held 26 May 2009 in Toronto, Ontario, Canada. The award honors "individuals who personify the Union's motto 'unselfish cooperation in research' through their facilitating, coordinating, and implementing activities."

Citation

I am honored to present Jay S. Fein, recipient of the 2009 AGU Edward A. Flinn III Award. I have known Jay for over 25 years and have often witnessed his deep commitment to leading and serving the atmospheric sciences community. This commitment goes well beyond what his program management job at the National Science Foundation calls for; Jay is visionary and insightful and has on many occasions supported high-risk innovative research that has proven to be watershed science. He has an uncanny ability to balance risk taking, leadership, and partnering with national and international agencies and community members on projects in a way that does not compromise his federal oversight responsibilities, and always in a humble and gracious manner.

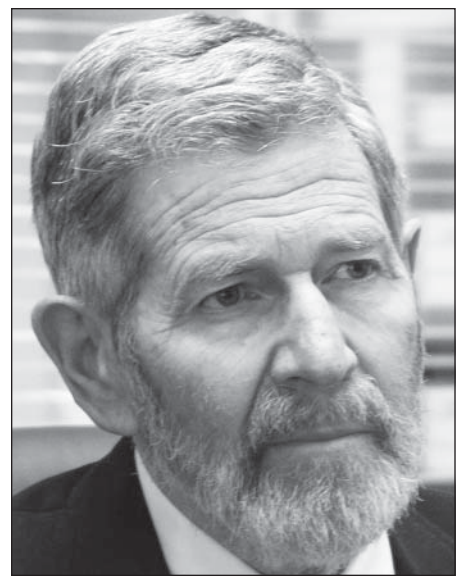
Long ago Jay recognized the importance of pursuing parallel climate and weather paths in complex field campaigns in order to fundamentally understand the climate system. He has provided sage advice, and served as a brilliant mediator when necessary, in such major international field programs as the Monsoon Experiment (MONEX; 1979), Tropical Ocean–Global Atmosphere/Coupled Ocean-Atmosphere Response Experiment (TOGA/COARE; 1992–1993), Indian Ocean Experiment (INDOEX; 1998), The Observing-System Research and Predictability Experiment (THORPEX) Pacific-Asian Regional Campaign (T-PARC; 2008), and many others.

Jay saw the need for comprehensive global models early on. When Francis Bretherton, Dave Schimel, and I were organizing the community Climate System Modeling Project (CSMP) in the late 1980s and early 1990s, Jay encouraged, supported, and helped define the CSMP vision. CSMP evolved into the Community Climate System Model (CCSM) effort, which now includes over 300 scientists from the National Center for Atmospheric Research and many universities and labs working to develop a fully coupled model of Earth's climate system. Jay was instrumental in rallying the community behind CCSM and in obtaining computer resources for the model, which has been critical to the Intergovernmental Panel on Climate Change assessments.

Jay has also played a vital leadership role in pioneering satellite observing technology. He supported the high-risk but highly successful Global Positioning System/Meteorology (GPS/MET) program (1995–1997), which provided the first soundings of Earth's atmosphere using the radio occultation technique. It took courage and foresight for Jay to embrace GPS/MET in the early 1990s, because at that time the radio occultation technique was virtually unknown to most atmospheric scientists. Jay then helped lead the Taiwan-U.S. Constellation Observing System for Meteorology, Ionosphere and Climate (COSMIC) mission. COSMIC extended GPS/MET by launching six microsatellites in 2006 that provide between 1500 and 2000 soundings of the global atmosphere each day in near real time. The benefit of these soundings for numerical weather prediction has been demonstrated by leading weather centers around the world. COSMIC was an extremely complex program to organize, from the political as well as the scientific and technological side, requiring negotiations and coordination among five U.S. agencies and Taiwan. It never would have happened without Jay's profound commitment and support.

In addition to his extraordinary scientific and organizational skills, Jay Fein is a true gentleman. He has had a major impact on science overall and on my career and that of many others. I am proud to call him my friend.

—RICHARD A. ANTHES, University Corporation for Atmospheric Research, Boulder, Colo.



Jay S. Fein

Response

I am deeply honored to be the 2009 recipient of AGU's Edward A. Flinn III Award, and I thank AGU, its Award Nominations Committee, and, in particular, my nominators, Rick Anthes, Jack Fellows, and Roger Wakimoto.

Whatever successes have come my way, however, have less to do with me than with the brilliant and creative research scientists and institutional leaders I have had the pleasure to work with over the past several decades. I have been fortunate to be able to work in a science I love and with the best group of colleagues one could hope for. I have also been fortunate to witness the birth and maturation of "Earth system sciences," the goal of which was enunciated in a presentation on 26 June 1986, by Francis Bretherton:

> To obtain a scientific understanding of the entire Earth system on a global scale by describing how its component parts and their interactions have evolved, how they function, and how they may be expected to continue to evolve on all timescales.

He further pointed out that the impact of human activities poses an additional challenge:

> To develop the capability to predict those changes that will occur in the next decade to century, both naturally and in response to human activities.

The worldwide communities of geoscientists, working with colleagues in many areas of science and applications, have made extraordinary advances in meeting these challenges posed over 2 decades ago. This is a remarkable testimony to the visionary brilliance of Bretherton and his peers, including past recipients of this award as well as my nominators. That I have been fortunate enough to be a part of this extraordinary group and this period of advancement has been delightful to me and also very gratifying.

—JAY S. FEIN, National Science Foundation, Arlington, Va.

AGU JOURNAL HIGHLIGHTS

Silicate spatter from Nicaragua's Mayasa volcano offers insight into volcanic processes Nicaragua's Masaya volcano is considered a "laboratory volcano" because its persistent aerosol emissions can be readily monitored at the summit as well as farther downwind. These aerosol plumes are a complex mixture of gas and particles that evolve over a range of timescales. Studies of plumes offer snapshots of plume chemistry at a given time, providing more general insights into processes occurring at the magma surface and in the vent and crater. *Martin et al.* directly sampled and remotely studied the aerosol plume emanating from Masaya's active vent, specifically focusing on studying the size distribution of silicate particles with diameters less than 10 micrometers. Using an automated scanning electron microscope, the authors found that fine silicate particles in Masaya's plume are most typically spherical, with diameters close to 1 micrometer, and are best represented as droplets of quenched magma produced through spattering. Further analyses showed that these particles become depleted in metals by reactions with acidic droplets in the plume, with the smallest particles being most significantly altered through this process. (*Journal of Geophysical Research-Atmospheres*, doi:10.1029/2008JD011211, 2009)

Rapid increase in the amount of fresh water within the Arctic Ocean Fresh water flowing into or out of the Arctic Ocean plays an important role in ocean circulation and may be a factor in the response of the world ocean to climate change. To study recent change in freshwater content of the Arctic, *McPhee et al.* analyzed data from an extensive aerial hydrographic survey carried out in March and April 2008. Their study showed a dramatic increase in the amount of fresh water in the Arctic Ocean as well as a significant change in the distribution of fresh water, as compared with average winter values. In particular, the authors found that freshwater volume in the Canada and Makarov basins on the Pacific side of the Lomonosov Ridge increased by about 8500 cubic kilometers; the freshwater volume on the Eurasian area decreased by about 1100 cubic kilometers. The freshening of the Arctic occurred in conjunction with the recent dramatic loss of Arctic sea ice, the authors noted. They found that these changes have altered Arctic Ocean circulation, with a large increase in northward transport of fresh water in the Canada Basin. (*Geophysical Research Letters*, doi:10.1029/2009GL037525, 2009)

Including zonal ozone asymmetries is key to accurate climate modeling Ozone levels are not uniform in space but vary with height, latitude, and longitude. However, most coupled atmosphere-ocean climate models and simulations of the middle atmosphere simply use prescribed zonal average ozone levels as input. To assess the influence of three-dimensional (3-D) ozone variations on simulated temperatures, *Gillett et al.* used the Canadian middle atmosphere model with coupled chemistry, which interactively simulates 3-D variations in stratospheric ozone and temperature. They compared temperature in the atmosphere in a simulation with 3-D ozone variations with temperature in a simulation with zonally averaged ozone. Consistent with previous studies, they found a significant temperature response to zonal asymmetries in ozone, comparable in magnitude to the response of temperature to ozone depletion. The authors concluded that zonal variations in ozone levels have important effects on climate and that realistic simulations of future atmospheric temperature trends require climate models to include the zonally asymmetric component of the ozone distribution. (*Geophysical Research Letters*, doi:10.1029/2009GL037246, 2009)

—MOHI KUMAR and ERNIE TRETKOFF, Staff Writers

CLASSIFIED

POSITIONS AVAILABLE

Atmospheric Sciences

Post-Doctoral Position/Harvard University. Applications are invited for a post-doctoral position with the Atmospheric Chemistry Modeling Group at Harvard University. The successful applicant will investigate the effects of a changing climate on extratropical fires, and effects of the fires on tropospheric composition and air quality. They will use a coupled chemistry/climate model and will contribute to the development of a model that projects the effects of climate on fires, http://www.fas.harvard.edu/~logan/. They will join a diverse and vibrant research group working on a range of global and regional tropospheric chemistry and climate problems, http://www.as.harvard.edu/chemistry/trop.

Preference will be given to candidates with experience with global models, or fire modeling, or related topics. Send curriculum vitae, brief statement of research experience and goals, and contact information for three references to Dr. Jennifer Logan, jlogan@seas.harvard.edu, as one pdf file. Harvard University is an Equal Opportunity/Affirmative Action employer.

Postdoctoral Researcher Atmospheric Research & Mass Spectrometry. A postdoctoral non-tenure-track position in the area of gas particle reactions of PAH nitration and oxidation. The experience in atmospheric research using mass spectrometry and chromatography, and in writing papers is highly desired. The successful applicant is expected to assist students. A Ph.D. degree in Analytical Chemistry is required. Please send your application including cover letter, resume, publication list, two letters of recommendation, and an applicant control card http://www.und.edu/dept/aao/apcontrolcard.htm. Contact Dr. Alena Kubatova: email akubatova@chem.und.edu. University of North Dakota is an Affirmative Action/Equal Employment Opportunity Employer and women and minorities are encouraged to apply.

Postdoctoral Research Position. Applications are solicited for a postdoctoral research position at the Center for Clouds, Chemistry and Climate (C4) of the Division of Climate, Atmospheric Science and Physical Oceanography (CASPO) at Scripps Institute of Oceanography (SIO) at the University of California, San Diego (UCSD). Potential candidates should have a Ph.D. or equivalent in atmospheric science or a related discipline.

The Center for Clouds, Chemistry and Climate will soon conduct an assessment of radiative forcing and climate impact by black carbon (BC) aerosols in California. This is an exciting and challenging project involving 4 laboratories in California, and will provide the postdoctoral researcher with a unique experience interacting with leading climate scientists. Specifically, the successful candidate will be expected to compile and evaluate BC regional properties in California, including spatial and time variations, optical properties, vertical profiles, the mixing state, and deposition on snow based on multi-platform (satellite, unmanned aircraft, and surface) observational data and regional chemical transport model assimilation for the last 40 years. He/she will collaborate with other scientists to estimate the radiative forcing of BC and anthropogenic aerosols using the assimilated data, and assess the regional climate response with a regional climate model (WRF), plus be expected to publish works in peer-reviewed journals and support other research programs in aerosol climatic impact.

Applicants should have experience with satellite remote sensing or ground-based aerosol data; good understanding of aerosol properties, transformation, radiative effects, and regional climate modeling; proficiency in programming, data analysis, and familiarity with visualization software.

Position will be open until filled. For early consideration, applications should be received by July 15, 2009. Please send your application to Dr. Yan Feng at, yafeng@ucsd.edu, including a letter of intent addressed to Professor V. Ramanathan, current curriculum vitae with publication record and names of 3 references including the thesis advisor. SIO/UCSD is an equal opportunity employer.

Senior Research Climatologist. The Division of Illinois State Water Survey within the Institute of Natural Resource Sustainability at the University of Illinois is seeking a full-time Senior Research Climatologist. The primary function of the position will develop a research program focused on climatological processes or impacts of climate variations and change, particularly in the US Midwest and the nation. Please refer to http://www.isws.illinois.edu/jobs/joblist.asp. To ensure full consideration, a cover letter, resume and the names, addresses, phone numbers, and e-mail addresses of three professional references must be received by July 15, 2009. All requested information must be submitted for your application to be considered. The University of Illinois is an Equal Opportunity/Affirmative Action Employer. The administration, Faculty and staff embrace diversity and are committed to attracting qualified candidates who also embrace and value diversity and inclusivity.

Visiting Scientist Programs. UCAR Air Force Weather Agency (AFWA), Offutt Air Force Base, Nebraska, General Meteorological Algorithm Development, Associate Scientist I. This is a new, full-time position. Initial consideration will be given to applications received prior to July 1, 2009. Thereafter, applications will be reviewed on an as-needed basis. Relocation benefits will not be provided. Conduct research, collaborate, and apply numerical weather prediction techniques to smooth and accelerate the transition of new technologies in meteorology, specifically analyze data for use in weather forecast algorithm development, software development and visualization based upon algorithms developed and modified, and verification of existing algorithms and software validation.

Bachelor of Science in Meteorology or Atmospheric Sciences is required, and enrollment in a Masters degree program in Meteorology or Atmospheric Sciences would be desirable.

For a more detailed position description you may email vsp@ucar.edu, or visit the VSP Website at http://www.vsp.ucar.edu/opportunities/. UCAR is an EO/AAE who values and encourages diversity in the workplace.

Geochemistry

Ph.D. Student and Postdoctoral Positions. Openings at the Peter A. Rock Thermochemistry Laboratory at UC Davis, Alexandra Navrotsky. Fundamental thermodynamics and high temperature calorimetry of systems relevant to SOFCs, nano and microporous materials, actinides and nuclear waste, minerals, CO_2 sequestration, polymer derived ceramics, sulfides, melts and glasses. See website, http://thermo.ucdavis.edu, and contact anavrotsky@ucdavis.edu for more information.

Hydrology

Ph.D. Candidate. New Mexico State University seeks a highly qualifed M.S. or Ph.D. candidate for a degree in Range Science with a specialization in Watershed Management. The student will participate in a study of river valley hydrology and interactions between surface water and groundwater. Field research will take place in northern New Mexico. Funding is provided by the National Science Foundation NM EPSCoR project Climate Change Impacts on New Mexico's Mountain Sources of Water. As part of the larger EPSCoR project, the successful candidate will interact with researchers from throughout New Mexico and the western U.S. Applicants should have a B.S. or M.S. degree in Watershed Science, Hydrology, Range Science, Environmental Science, Natural Resources, or a related field. Experience in field hydrology measurement and hydrologic modeling are desirable. To apply or for further information contact Dr. Sam Fernald, Box 30003 MSC-3I, New Mexico State University, Las Cruces, NM 88003, 575-646-1041, fernald@nmsu.edu.

Postdoctoral Fellow in Groundwater Modeling. The University of Calgary, Department of Geoscience, www.ucalgary.ca/geoscience/, seeks a postdoctoral research fellow to conduct watershed-scale modeling of groundwater in bedrock aquifers and its interaction with surface water. Duties will include using data from ongoing field studies to parameterize and calibrate models, and code modification when required. The successful candidate will have a Ph.D. degree in geosciences, engineering or a related field with significant experience in numerical groundwater modeling. Research experience in land-surface and soil hydrological processes is an asset. The position is for two years with a possible extension to a third year. Interested candidates should send their CV, academic transcripts, and the names and addresses of three references to Dr. Masaki Hayashi, hayashi@ucalgary.ca.

Solid Earth Geophysics

Research Associate in Geodesy. Newcastle University-Salary: Up to £28,839, rising to £35,469. Based in the School of Civil Engineering & Geosciences, you will join the Newcastle Geodesy team and carry out research related to determining large scale movement of water mass by measuring deformation of the Earth and changes in the Earth's gravity field. The aim of the project is to develop an integrated observation model using gravity measurements from GRACE and SLR, and measurements of the Earth's shape from GPS. In addition, the results will improve the realisation of the Terrestrial Reference Frame used throughout the Earth Sciences and in particular for altimetric and tide gauge estimates of sea level rise. You should hold a PhD (or be expecting the imminent award of one) in geodesy or geophysics and have a proven or emerging track record of self motivated progress in academic research, including publication in peer-reviewed journals. This post is available for 30 months in the first instance.

For further information please e-mail: peter.clarke@ncl.ac.uk or tel: + 44 (0) 191 222 6351.

Please apply online at http://www.ncl.ac.uk/vacancies/. Closing date: 17 July 2009, Job Reference: D478R.

Visiting Assistant Professor at Tulane University. The Department of Earth and Environmental Sciences at Tulane University seeks to fill a one-year, non-tenure-track visiting faculty position to teach introductory Physical Geology and other undergraduate and/or graduate courses commensurate with the applicant's experience. The position is subject to budgetary approval by Tulane University. The deadline for applications is June 30, 2009, but the position will remain open until filled. Applications should be sent (email preferred) to Dr. Stephen A. Nelson, Department of Earth and Environmental Sciences, Tulane University, 6823 St. Charles Avenue, New Orleans, LA 70118-5698, USA (snelson@tulane.edu), and should include a curriculum vitae, a statement of teaching interests and goals, and the names and contact information of at least three refrences. Further information can be obtained at http://www.tulane.edu/~eens/. Tulane University is an affirmative action/equal opportunity employer. Women and minorities are encouraged to apply.

Visiting Professor/Post-doc Position at ERI, the University of Tokyo. The Earthquake Research Institute, the University of Tokyo, invites applications for Visiting Professor/Post-doctoral Fellow positions in the research fields of earthquakes, volcanoes, and physics of the earth's interior. The period of each position will be three through twelve months during the period from April 1, 2010 to March 31, 2011. Candidates are requested to submit the following set of documents:

- CV with birth date and detailed account of academic activity.
- List of academic publications.
- Summary of research that the candidate has conducted (300-500 words).
- Title of research and research proposal at ERI (300-500 words).
- Desired length of stay; from three to twelve months.

Candidates are also requested to nominate a host researcher of ERI. If you need detailed information on host researchers, please visit our website at http://www.eri.u-tokyo.ac.jp/

The appointed candidates are expected to carry out research at ERI as an employee of the University of Tokyo. Monthly salary, ancillary expenses including partial housing costs and commuting allowance will be paid based on the rules of the University and ERI.

The deadline for this application is July 10 (Friday), 2009. If you need further information regarding this position, please feel free to contact Professor Teruyuki Kato.

Teruyuki Kato
Head Office of International Earthquake and Volcano Research Promotion
Earthquake Research Institute, the University of Tokyo
1-1, Yayoi 1, Bunkyo-ku, Tokyo 113-0032 JAPAN
Phone: +81-3-5841-5818
Fax: +81-3-5841-5693
E-mail: teru@eri.u-tokyo.ac.jp

Interdisciplinary/Other

Assistant, Associate, or Senior Research Scientist. The Lunar and Planetary Laboratory at the University of Arizona expects to fill up to 2 non-tenure track faculty positions at the level of Assistant, Associate, or Senior Research Scientist. These ranks are equivalent to the corresponding professorial ranks, but without a commitment for state support or teaching responsibility. Research Scientists report to the director of the Lunar and Planetary Laboratory. Salary and position title will be based on the qualifications of the selected candidate(s), who will be responsible for raising 100% of their salaries and research funds through their own extramural grants and contracts. For full position details and to apply online, please see www.hr.arizona.edu and reference job #42950. The University of Arizona is an AA/EEO/ADA employer-M/W/D/V.

Environmental Surface Chemistry Research Scientist. Project Description: The Savannah River National Laboratory is seeking applicants interested in conducting fundamental and applied research in any one of the following areas: quantifying short-term and long-term mechanisms controlling metal/radionuclide fate and transport, understanding the role of microorganisms in solubilizing metal/radionuclide, identifying and quantifying redox reactions of radionuclides with natural organic matter, natural sediments, and iron oxides.

Qualifications: The incumbent would identify and quantify rate-limiting environmental processes occurring at solid-liquid interfaces through the use of wet-chemistry, spectroscopy, microscopy, and numerical modeling. Possessing skills related to colloid chemistry, geochemistry, nanotechnology, radiochemistry, microscopy, or spectroscopy is desirable. The applicants must work effectively within an interdisciplinary team focused on identifying heterogeneities and integrating results at

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multiscales in reactive transport calculations. PhD in Chemistry or Engineering required. Radiochemistry experience strongly desired. US Citizenship Required.

How to Apply: Qualified applicants are encouraged to submit a cover letter, detailed CV and reference job number SRNS-08-70 to the SRNL Recruiting Office at SRNLResearchRecruiting@srnl.doe.gov. EOE.

Faculty Position. The Department of Earth Sciences, Zhejiang University, China, is seeking faculty members at the level of associate or full professors who have made outstanding contributions in any of following fields including atmospheric science, dynamic meteorology, mineralogy, petrology, geochemistry, structural geology, geotectonics, geophysics, human and physical geography, Geographic Information System (GIS) and remote sensing. Information about the department may be found at http://www.css.zju.edu.cn/english/departments_4.php. Applications, including a detailed resume, statements of research and teaching interests, and names of at least three potential referees, should be sent to: Dr. Zhongyue Shen (gs_zshen@zju.edu.cn) or Ms. Youjun Fang (dilith@zju.edu.cn), Tel: 0086-571-87951336; Fax: 0086-571-87951336.

Planetary Geology Postdoctoral Fellow. The Arizona State University School of Earth and Space Exploration has an opening for a Post-Doctoral Fellow in support of the Lunar Reconnaissance Orbiter Camera. We are seeking an enthusiastic, self-motivated individual to participate in the analysis of existing and future remote sensing data of the Moon. Expertise in fields of instrument calibration, multispectral analysis of planetary materials, derivation and analysis of topographic data, and or geomorphology are desirable.

Applicants with comparable expertise in other aspects of planetary science will be considered. Approximately 50% effort will be devoted to mission support activities. The successful candidate must have the ability to work independently and at a high level of productivity under deadline constraints. We would prefer the successful candidate to start after July 1, 2009.

Arizona State University offers a competitive salary and benefits package, and is located in Tempe, AZ. Interested applicants should send their CV to Carmen Salas at Carmen.Salas@asu.edu. Submission Deadline: June 24th 2009. Arizona State University is an equal opportunity affirmative action employer.

Postdoctoral Position: Atmospheric Boundary Layer and Wind Energy. The St. Anthony Falls Laboratory of the University of Minnesota invites applications for two postdoctoral positions to participate in recently funded research projects on atmospheric boundary layer turbulence and wind energy. The goal is to study the interactions between boundary layer turbulence, wind turbines, topography, plant canopies and urban canopies. One candidate will work on large-eddy simulations (LES) of high-Reynolds-number boundary layer flows. The other candidate will perform wind-tunnel experiments using PIV and hot-wire anemometry. Both positions are initially for one year and renewable for additional years. For further details on the positions, please contact Professor Fernando Porte-Agel, (fporte@umn.edu). The University of Minnesota is an equal opportunity educator and employer.

Professorship in Earth System Modelling. A position as professor in Earth System Modelling is vacant at the Department of Earth Science, University of Bergen, Norway. The applicant must have an established international record of research in geoscience with an emphasis on quantitative solid earth system modelling on local to global scales, and its interaction with tectonics and climate. Candidates with experience in one or preferably several of the following topics will be considered: quantitative geomorphology and stratigraphy; modelling of surface processes, transport and deposition; modelling and implications of paleoclimate; bio-geochemical modelling; and modelling of basin filling and basin development. A strong quantitative, interdisciplinary earth science background is preferred, as well as ability to develop and lead research programs in these fields. Experience in analyzing field and/or subsurface data is an advantage.

A description of the position with details of curriculum and area of responsibility, particular duties and other circumstances which will be stressed at the time of appointment is available at: https://secure.jobbnorge.no/visstilling2.aspx?stillid=57962.

For further information about the position please contact, Professor Olav Eldholm, Head of Department (phone +47 55583281/+47 55583600; email Olav.Eldholm@geo.uib.no), Professor William Helland-Hansen (email: William.Helland-Hansen@geo.uib.no) or Professor Ritske Huismans (email: Ritske.Huismans@geo.uib.no).

Research Geologist, Department of Mineral Sciences, National Museum of Natural History, Smithsonian Institution. The Department of Mineral Sciences invites applications for the position of Research Geologist in volcanology. The successful applicant will direct the operations of the Smithsonian's Global Volcanism Program, which documents and researches activity of the world's volcanoes toward development of space/time understandings of global activity. Applicants should have a PhD or equivalent with subsequent experience in volcanology focusing on one or more of the fields of physical volcanology, igneous petrology, geophysics, gas geochemistry, or remote sensing, evidenced through publications with high impact in the peer-reviewed literature. The person selected will have had experience working on volcanoes, using field and laboratory or data analysis techniques, ideally also with experience in utilizing large data sets placing volcanoes in regional and global context. Analytical instrumentation within the Department includes an electron microprobe, field emission variable pressure analytical SEM, XRD, FTIR, Time of Flight-SIMS, fluid inclusion heating/freezing unit, cathodoluminescence microscope and spectrometer, wet chemistry lab, and experimental laboratories (gas-mixing, hydrothermal, piston-cylinder, diamond-anvil cell). In addition to research, the successful candidate will be expected to participate in museum activities, such as exhibits programs, educational outreach activities, and to be involved with professional associations and other organizations within the scientific community.

Full-time, permanent appointment with full Government benefits. GS-1350-14; US citizenship required. The museum's authorized salary range for this position at this time is $102,721-$116,419 per annum. For complete requirements and application procedures go to www.sihr.si.edu and refer to Announcement #09A-RM-295132-DEU-NMNH or contact Raquel Manso, 202-633-6388, mansor@si.edu. The announcement opens June 9, 2009. Applications must be received by July 21, 2009 and must reference the announcement number. All applicants will be notified by email when their application is received. The Smithsonian Institution is an Equal Opportunity Employer.

Research Leader. Water Management and Conservation Research Unit, Maricopa, AZ. (Supervisory Research, Agricultural Engineer/Soil Scientist/Hydrologist).

Salary Range of $96,863 to $148,123 USD.

Announcement Open: May 20, 2009 to July 15, 2009.

The U.S. Department of Agriculture (USDA), Agricultural Research Service (ARS), Water Management and Conservation Research Unit in Maricopa, Arizona, is seeking a permanent, full-time scientist to conduct and lead research targeted at developing principles and practices for improving irrigation systems, including the reuse of wastewater for irrigation and methods to overcome water scarcity.

For details and application directions, a full text vacancy announcement may be obtained via the Internet at: http://www.afm.ars.usda.gov/divisions/hrd/index.html announcement number ARS-X9W-0202 or call Bert Clemmens, (520)316-6373. U.S. Citizenship is required. A Federal benefits package is available. Applications must be received by July 15, 2009. USDA/ARS is an equal opportunity employer and provider.

Senior Engineer/Scientist Opening Announcement. Respond to http://jobs-schafer.icims.com/jobs/1543/job.

Overview: Schafer Vallecitos Laboratory (SVL) is seeking a Senior Engineer/Scientist to add to our mass spectrometry group. The Senior Engineer/Scientist will perform isotope ratio measurements using secondary ion mass spectrometry (SIMS), will analyze and interpret SIMS data, and will devise or modify techniques and procedures to address new analytical requirements. SVL performs materials characterization and related analytical services on commercial and government contracts. The activities of the group include chemical and elemental analysis of materials on a production basis, maintenance of several mass spectrometers and ancillary equipment, development of new or improved MS analysis techniques, and quality assurance of analytical data.

Responsibilities to include:

- Perform isotope ratio measurements using magnetic-sector secondary ion mass spectrometry (SIMS).
- Analyze and interpret SIMS data, and prepare reports of analysis.
- Devise or modify techniques and procedures to address new analytical requirements.
- Daily team interaction with scientists, engineers, and technicians.
- Participation in equipment maintenance is also required.
- Individual will be a key resource for Schafer and our customers, maintaining our expertise in the field of high sensitivity SIMS.

Primary Qualifications: The successful candidate will have:

- A Ph.D. in a physical science or engineering, or equivalent experience, preferrably in materials science, physics, nuclear chemistry, or geology.
- Extensive hands-on experience using inorganic isotope-ratio mass spectrometry to solve problems in materials science, nuclear energy, or geology. This will include knowledge of the theory, instrumentation, and application of magentic-sector SIMS or thermal ionization mass spectrometry (TIMS).
- Experience in the analysis of scientific data, including statistical methods and data modelling, and the ability to create computational tools to implement analysis methods.

Additional qualifications:

- Recognized within the Mass Spectrometry community as a principal authority in the field of SIMS.
- Demonstrated ability to solve technical problems.
- Expertise in data evaluation and quality control.
- Experience with analytical instrument control computer hardware and software is preferred.
- Competence in vacuum technology and electronics is preferred.
- Proven ability to write clear scientific reports and proposals.
- Must be a US citizen with the ability to obtain government security clearance.

Schafer offers a competitive salary, excellent benefits, and a professional working environment. Schafer Corporation is an Affirmative Action, Equal Opportunity Employer.

STUDENT OPPORTUNITIES

Ph.D. Position in Environmental Sustainability of Biomass for Biofuels & Bioenergy. Topics include biomass inventory & availability, GIS/RS models of biomass, energy crops, carbon/nutrient cycles and native and cultivated forest/agric. systems. Forestry, ecosystem/soil sci. or agrology background required with interest in quantitative methods. GIS/RS experience ideal; proficiency in English necessary. Stipend, tuition & fees included. Start fall semester 2009. Send GRE scores, statement of interest, CV and two references to Dr. Robert Froese at froese@mtu.edu.

Imperial College London

Faculty of Engineering
Department of Earth Science and Engineering

Research Associate position in Isotope Geochemistry (Clumped Isotopes)

Fixed-term appointment for up to 36 months

Salary Range: £30,360 – £38,730 p.a.
All appointments will be made based on level of experience

Major long-term funding by Qatar Petroleum and Shell International through the recently established Qatar Carbonates and Carbon Storage Research Centre (QCCSRC) is enabling Imperial College London to expand significantly its research into Clean Fossil Fuels – aimed in particular at improving the energy efficiency of oil and gas recovery closely coupled with reducing greenhouse gas emissions through advanced carbon capture and storage technologies. The Centre is located in the Faculty of Engineering which was rated the top Engineering Faculty in the UK in the 2009 Research Assessment Exercise.

In the framework of the QCCSRC project, fundamental research into carbonate geology will be conducted. A major part of this effort will be to establish the "Clumped Isotope" paleo-thermometer using a newly acquired isotope ratio mass spectrometer (IRMS) system. One of the primary aims of the Research Associate will be to establish, and if possible improve, the clumped isotope technique with a view to measuring small samples of carbonate. Furthermore, the candidate will be involved in research using the clumped-isotope to measure precipitation temperature of shells and diagenetic cements from Middle Eastern outcrops as an integral part of the QCCSRC project.

You will hold a fixed-term, three-year appointment as Research Associate. The ideal start date would be October 1st 2009, but this is negotiable. Previous experience with isotopologues is not required; however candidates should have a strong background in analytical geochemistry or analytical chemistry. Candidates with IRMS experience and/or a strong background in isotope geochemistry will be desirable. This project will require a significant amount of analytical development, and the candidate should be comfortable operating and maintaining complex analytical instruments.

You will work with a larger team of researchers under the QCCSRC project, and will be expected to publish research in journals, present results at international conferences, and help in preparing project reports. The nature of this project involves close collaboration with the oil and gas industry in Qatar, and potential field work in the region.

All candidates are welcome to apply. Enquiries concerning this position should be directed to Dr Cedric John at cedric.john@imperial.ac.uk.

Candidates should indicate on their application form that they are applying for a **QCCSRC Fellowship in isotope geochemistry.**

Our preferred method of application is online via our website at the following link: http://www3.imperial.ac.uk/employment (select "Job Search"). Please complete and upload an application form as directed and submit any other relevant supporting documents such as your full CV. Please quote reference number: **EN20090095JU**.

Should you have any queries please contact: Mrs Darakshan Khan – d.khan@imperial.ac.uk

Closing date: 1st July 2009
Interviews (in London): mid-July 2009

Committed to equality and valuing diversity. We are also an Athena Silver SWAN Award winner and a Stonewall Diversity Champion.

MARGINS Distinguished Lectureship Program

Application Deadline: July 1, 2009

We invite all colleges and universities in the US to apply to host a speaker from the MARGINS Distinguished Lecture Program. Applications are due by July 1, 2009 for visiting speakers in Fall 2009 – Spring 2010. Invitations from institutions not currently involved with MARGINS research are strongly encouraged, including those granting undergraduate or Masters degrees, as well as those with Ph.D. programs. Institutions may request a technical and/or public lecture.

The MARGINS Office will cover airfares for speakers' travel and will coordinate travel and off-site logistics. Host institutions are responsible for local expenses for the duration of the visit.

For more information on the speakers and to apply please see the MARGINS DLP web page (*www.nsf-margins.org/DLProgram/*). Deadline for applications is on July 1, 2009. Please direct any question to the MARGINS Office: margins @nsf-margins.org.

View 2009-2010 speakers at: ***www.nsf-margins.org/DLProgram/09-10/***
Apply at: ***www.nsf-margins.org/DLProgram/09-10/DLApp09.html***

2009-2010 SPEAKERS:

Becky Dorsey, *Univ. of Oregon*; **Tim Dixon**, *Univ. of Miami*;
Chris Goldfinger, *Oregon State.*; **Katherine Kelley**, *Univ. of Rhode Island*;
Simon Klemperer, *Stanford*; **Donna Shillington**, *LDEO*;
Rudy Slingerland, *Penn. State*;

MARGINS NSF