raise the likelihood of the U.S. commitment to the IODP proceeding as planned, rather than through a slower or delayed implementation.

"The problem is bringing a facility online. Doing a vessel conversion to make it ready for a science program is difficult to do on a time scale we are talking about without NSF budget increases," Malfait said.

For more information, visit the Web sites: http://www.iodp.org/, and http://www.oceandrilling.org.

Randy Showstack, Staff Writer

Blowin' in the Wind: Research Priorities for Climate Effects of Volcanic Eruptions

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Volcanic eruptions inject gases and ash into the atmosphere, with climatic impacts on time scales up to decades. At the AGU Chapman Conference on Volcanism and the Earth's Atmosphere, held in Greece last summer, 108 scientists gathered to assess our understanding of volcanic emissions and the atmosphere's response to them, and to outline topics for future interdisciplinary collaboration that will lead to better understanding and prediction of the effects of large explosive eruptions.

The meeting was held at a conference center perched on the rim of the caldera of a 17th-century BCE eruption, which has been linked to the legend of Atlantis, the decline of the Minoan civilization in Crete, and the Biblical stories of the parting of the Red Sea and the Egyptian plagues. On the last day of the meeting, the entire group discussed future research priorities. Continued research is needed and will be focused on these issues:

What exactly goes into the atmosphere during an explosive eruption?

The impacts of volcanic eruptions on weather, climate, and atmospheric chemistry depend on what material eruptions put into the atmosphere. Climatically significant inputs include sulfur species (especially SO_2), halogens, H_2O, and fine silicate particles. What are the magmatic controls on how much sulfur is emitted from eruptions? When eruptions take place in wet environments, how much of the water in the plume is primary magmatic water, as compared to entrained water from the atmosphere, lakes, or the ocean? What are the detailed chemical and microphysical transformations that occur in the eruption column and downwind plume, and how do they affect the composition of the stratospheric injection?

How do quiescent emissions change over time? What is their current source strength?

Explosive eruptions are not the only volcanic source to the atmosphere. While quiescent emissions have regional rather than global impacts, they are important in the context of anthropogenic tropospheric aerosols [*Graf et al.*, 1997]. If the source strength changes significantly over time, this can produce large regional climate changes. More monitoring of the chemistry and magnitude of continuing quiescent emissions will be essential if we are to understand issues such as the impact of anthropogenic aerosols.

How can we better quantify the record of climatically significant volcanism?

To measure the natural climatic forcing from volcanic eruptions for the past, so that we may place anthropogenic climate change in context, we need a better record of the frequency and magnitude of past eruptions. Several new ice core analyses were presented by Ellen Mosley-Thompson, Drew Budner, and Andrei Kurbatov, but more are needed, especially from Alaska and other high Arctic sites. Unlike many other attempts to reconstruct past climate and its forcing, the evidence from past volcanic eruptions is preserved in ice cores, waiting for us to analyze it. A major advance to allow better interpretation of the location of eruptions that produce ice core signatures would be better atmospheric models of transport and deposition that could trace sulfate aerosols from the vent to the ice.

More study is also needed of possible volcanic components of distal sediments on land and in lakes and deep oceans. Volcanic geology and stratigraphy remain important areas of study, and continued refinement of petrologic methods will enhance interpretation of in situ deposits. Archeology and biostratigraphy of deposits associated with eruptions are relatively untapped approaches that can help to date and interpret the local environmental impact of past eruptions.

Can we design an improved system for measuring and monitoring the atmospheric gases and aerosols resulting from future eruptions?

In spite of current technology, without better planning and an investment in equipment, there may be significant gaps in observations of the next major volcanic eruption. Near vent observations, unless the eruption is forecast in advance as were Mount St. Helens in 1980 and Mount Pinatubo in 1991, will depend on work with local observers. As many volcanoes are in developing countries, a program to train, work with, and support local observers will significantly enhance our ability to monitor small and medium eruptions. Given the lack of a global satellite monitoring system, to be ready for the next major eruption we should have a fleet of stratospheric balloons, lidar-equipped airplanes, and stratospheric airplanes equipped for in situ observations ready to be deployed within weeks of the eruption.

While there are many lidar observatories in the Northern Hemisphere mid-latitudes, and several in the Southern Hemisphere mid-latitudes, there are no lidars in the tropics designed for measuring stratospheric aerosols. It would be relatively cheap and quick to fill in this gap [*Robock and Antuña*, 2001]. Because of the diversity of observations available for eruptions, a data assimilation system using atmospheric models must be developed; it is the only way to produce a stratospheric aerosol data set that can be used for atmospheric chemistry and climate calculations.

How can we better model the climatic impact of eruptions, including microphysics, chemistry, transport, radiation, and dynamical responses?

A few general circulation models have simulated the general climatic response to the 1991 Pinatubo eruption using a specified distribution of aerosols [*Stenchikov et al.*, 1998]. Remaining problems include adequately accounting for the effects of the Quasi-Biennial Oscillation, microphysical evolution and transport of the aerosols, effects on ozone, the amount and impacts of water vapor injection into the stratosphere, and the regional response.

Data assimilation experiments and model intercomparison programs, like the Pinatubo Model Intercomparison Project (PINMIP) now being carried out under the Global Circulation Model-Reality Intercomparison Project for SPARC (GRIPS) [*Pawson et al.*, 2000], will help to improve the models. The ultimate goal would be to couple conduit models of magma, plume models discussed above, and microphysical and transport models in the stratosphere to climate models to predict the impact of the next large eruption as soon as it occurs. An important ancillary activity is to better characterize the climatic response to past volcanism. Tree ring analysis would be an important source of information.

How do high-latitude eruptions affect climate?

Most research on the impacts of volcanic eruptions on climate has focused on tropical explosive eruptions, such as the recent 1963 Agung, 1982 El Chichón, and 1991 Pinatubo eruptions. But there have been larger high-latitude eruptions in the historic past that have also had profound influences, the most notable recent one being the 1783 Laki fissure eruption in Iceland [*Franklin*, 1784]. Thor

Thordarson, Ellie Highwood, and David Stevenson presented new analyses of emissions from the 8-month-long eruption and climate model simulations of its effects and demonstrated the need for additional work on this topic. The eruption affected air quality and climate for most of the Northern Hemisphere. If it occurred today, it could halt air traffic there for 6 months [*Thordarson and Self*, 2002]. Questions that still need answers include whether high-latitude eruptions can affect the climate in the other hemisphere, and what the effects would be of eruptions from high-latitude Southern Hemisphere volcanoes.

How important are indirect effects of volcanic emissions on clouds?

The indirect effect of tropospheric sulfate emissions on clouds is an area of intensive research. Can volcanic examples be used to improve current models? Do the aerosols from the stratosphere seed cirrus clouds and affect their optical properties and lifetimes?

Where are the important potential sites for future eruptions?

For monitoring, emergency response, warning aircraft, and real-time prediction of climatic response, it would be helpful to know which volcanoes would be most likely to erupt. This will involve production of improved risk maps and catalogs of hazards. It will again require working with and supporting local observers.

Some research aimed at answering the above questions is already under way, nurtured by the interactions of the volcanology and climate communities at this Chapman Conference. An AGU book with papers from the conference will be published next year. Continued support by funding agencies to enable all of the research listed here would produce valuable scientific results.

"The answer, my friend, is blowin' in the wind." [*Dylan*, 1962]

The AGU Chapman Conference on Volcanism and the Earth's Atmosphere was held 17–21 June 2002, in Santorini, Greece.

Acknowledgments

I thank Stephen Self, Greg Zielinski, and Mike Carroll for valuable comments on the manuscript. This conference was convened by the International Association of Volcanism and Chemistry of the Earth's Interior (IAVCEI) and International Association for Meteorology and Atmospheric Sciences (IAMAS) Joint Commission on Volcanism and the Earth's Atmosphere, which will also convene a symposium on volcanism and the Earth's atmosphere at the International Union of Geodesy and Geophysics (IUGG) General Assembly in Sapporo, Japan (June–July 2003). The U.S. National Science Foundation, NASA, and IAVCEI provided travel support for many of the participants. Ann Singer of the AGU Meetings Department, with the assistance of Ed Lipschitz, provided wonderful support for the organization and on-site operation of the conference. Stephen Sparks' idea to have the conference in Santorini led to its large attendance and dramatic success. The program committee—Michael Carroll, Paul D. Cole, Hans-F. Graf, Stephen Self, Stephen Sparks, Georgiy Stenchikov, and Gregory A. Zielinski—assisted in choosing topics and inviting speakers. This work was supported by NASA grants NAG 1-2154 and NAG 5-9792 and NSF grant ATM-9988419.

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Experiment in New Madrid Zone to Employ Active Source

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An active source seismic experiment is scheduled for the end of October in the central United States' New Madrid Seismic Zone (NMSZ). Researchers from the Center for Earthquake Research and Information (CERI) of the University of Memphis and the U.S. Geological Survey are planning 2600-lb and 5000-lb explosions at the southern and northern ends of the NMSZ, respectively. Broadband seismic instruments, other temporary broadband seismic stations, and an array of accelerographs near each source will record the large surface waves generated by the explosions in the unconsolidated sediments of the Mississippi embayment.

Large explosions have been used to probe deep crustal structure in this area before. However, the focus of the Embayment Seismic Excitation Experiment is on the seismic response of the thick, unconsolidated sediments that blanket the NMSZ rather than deeper crustal structure. Seismologists and earthquake engineers generally believe that thick, unconsolidated sediments increase hazards due to strong ground-shaking from large earthquakes.

The potential for large earthquakes within the NMSZ and the occurrence of thick sections of laterally continuous, unconsolidated sediments immediately above the earthquake zone make for a dangerous mix that is unique to the central United States. It seems likely that these sediments would tend to amplify the seismic waves from nearby large earthquakes. However, there is conflicting evidence that the thick sediments could actually damp out strong shaking through anelastic energy absorption.

Surprisingly, there is very little information on the elastic or anelastic characteristics of Mississippi embayment sediments even though there are large population centers in the region that could benefit from improved knowledge of the earthquake hazards. Past studies involving estimates of sediment anelasticity have suggested that embayment sediments should be highly attenuating. The amplitude of high-frequency seismic waves should be significantly reduced as they propagate up through the sediments. However, some recent field observations of surface waves from small controlled sources are inconsistent with these high values of anelastic damping. One observation of probable surface waves from a 1991 test explosion near Memphis, Tennessee, suggests that high-frequency surface waves propagate efficiently to distances of at least 25 km.

The motivating hypothesis of ESEE is that embayment sediments do not damp out seismic waves as much as previously believed. Wave field simulation of ground motions from a large explosion suggests that there would be no observable surface waves seen at distances as little as 10 km, if the seismic damping values are as high as expected. Thus, the test of the hypothesis is unusually simple for a seismic experiment; one needs only to observe surface waves at distances greater than 10 km to show that damping is not as severe as presently thought.

The experiment will take advantage of the geometry of the existing permanent CERI network to record surface waves that propagate in a variety of directions and in sediments of varying thickness. The seismic data will be