CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

TRIP REPORT

SUBJECT: Volcanic Flows and Falls: A Conference to Honor Professor Michael F. Sheridan
AI 06002.01.312.603

DATE AND PLACE: May 11–12, 2006
Amherst, New York

AUTHOR: D. Hooper, CNWRA

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SENSITIVITY: Non-Sensitive

PERSONS PRESENT:

Donald Hooper of the Center for Nuclear Waste Regulatory Analyses (CNWRA) participated in the meeting. The technical sessions were attended by approximately 30 volcanologists or scientists conducting research in volcanic hazards. Numerous graduate students from the State University of New York at Buffalo also attended. Most speakers were from universities, but several staff members from Los Alamos National Laboratory were present.

BACKGROUND AND PURPOSE:

This conference celebrates the retirement of Professor Michael F. Sheridan (State University of New York at Buffalo), who is retiring at the end of this academic year. To honor his four decades of scientific insight and enthusiasm, the Department of Geology at the State University of New York at Buffalo hosted this technical conference. Professor Sheridan has made significant contributions to the fields of physical volcanology, igneous petrology, and volcanic hazards. He is also a member of the DOE Probabilistic Volcanic Hazard Analysis panel.

The purpose of this trip was to present to an audience of volcanologists the recent modeling results of tephra dispersal and redistribution at Yucca Mountain, Nevada and to gain valuable insights derived from current volcanological research. Discussion of these models and data will provide an opportunity for peer review and possible improvements to the realism in these calculations. Insights gained from this meeting will help staff develop a technical basis to review DOE information that addresses volcanological issues. Active participation in these technical sessions ensures that NRC licensing decisions can be based on realistic volcanological models and data.

SUMMARY OF ACTIVITIES AND PERTINENT POINTS:

There were fourteen presentations in a single-session format. Donald Burt (Arizona State University) was the first speaker and his presentation was entitled History of Surge Deposit Misidentification at Spor Mountain, Utah and Elsewhere: A Cautionary Message for Mars. For about 15 years the mineralized rocks of Spor Mountain (Utah), and similarly appearing unmineralized rocks in the nearby Thomas Range (Topaz Mountain) and adjacent ranges, were incorrectly labeled as "water-laid tuff" in various U.S. Geological Survey publications. Such mistakes, he noted, were relatively common at the time because the differences between volcanic surge deposits and normal eolian or fluvial sedimentary deposits can be subtle, and the unique bedding characteristics of volcanic surge deposits (such as impact sags) were not described until about 1970 and were not widely publicized until after the 1980 Mount St. Helen's eruption. This misidentification stemming from U.S. Geological Survey publications most likely included some tuff deposits in the Yucca Mountain region that have now been correctly identified as either surge deposits or stratified tuff. Don Burt noted that Michael Sheridan was instrumental in correcting earlier misinterpretations at several locations, including Topaz Mountain (Utah) and Lipari and Vulcano in Italy.

Kenneth Wohletz (Los Alamos Natinal Laboratory) discussed fractures in welded tuff. His talk focused on the Bandelier Tuff of New Mexico. An interesting result of his studies is that a fractured welded tuff can conceal faults because it accommodates strain incrementally in each fracture over a wide area. Calculations based on the fracture data indicate that the Bandelier Tuff conceals fault displacement of up to several meters of displacement.

Greg Valentine (Los Alamos National Laboratory) presented Eruption and Erosion of Small Basaltic Volcanoes in Southern Nevada. His co-authors included Frank Perry, Don Krier, Gordon Keating, Richard Kelley, and Allen Cogbill (all of Los Alamos National Laboratory). They focused on the six Pleistocene basaltic scoria cones in or near Crater Flat, southern Nevada. These cones were built upon gently southward-sloping surfaces and were prone to failure on their down-slope (southern) flanks. Contrary to previous interpretations, they argue that the Pleistocene Crater Flat volcanoes are monogenetic, each having formed in a single eruptive episode lasting months to a few years, and with all eruptive products having emanated from the area of the volcanoes' main cones rather than from scattered vents.

Research by Carmelo Ferlito and colleagues was featured in a talk entitled Magma Mixing Versus Eruptive Behavior: Investigating New Sources of Volcanic Hazard in Basaltic Volcanoes. These authors note that volcanic hazards are extensively studied and assessed for andesitic volcanoes or for volcanoes with a generally acknowledged explosive behavior. Less attention is paid to basaltic systems (such as Crater Flat), which are characterized by less-endangering effusive behavior. They observed how mixing dynamics can affect the eruptive behavior derived from the eruption of 2001 at Mount Etna volcano (Italy), when on its southern flank three different magmas have been emitted from two distinctly oriented vent systems. As a result of magma mixing, the last phase of the eruption was more explosive due to the increased volatile content of the magma. The authors claim that volatile components rapidly exsolved because of their decreased solubility related to wide fractures opening and temperature increase, related to mixing with the more basic, hotter, and undegassed magma. The rapid and efficient degassing led to a strongly increased viscosity of the mixed magma with dramatic effects on its rheology. The simultaneous activation of two independent tectonic systems modified this section of the conduit, which was widened, and made it possible for a larger amount of unusually viscous magma to erupt. This brought about a higher emission rate, thus producing a thick, autoclastic lava flow, which mechanically eroded the substratum for a length of 220 m [722 ft] and set fire to the cable-car station without physically touching the building.

Abani Patra (State University of New York at Buffalo) presented Modeling Geophysical Mass Flows with TITAN: Propagating Parameter Uncertainty. The TITAN toolkit, featuring the TITAN2D code, is a simulation tool for geophysical mass flows incorporating the latest computational and numerical methodology. TITAN2D was developed as an interdisciplinary research project funded by the National Science Foundation. Highlights of TITAN2D can be summarized as follows: (1) it uses large-scale computations to produce realistic simulations of destructive mass flows, (2) it can be integrated with Geographic Information Systems to obtain terrain/cultural features, (3) it can be integrated with multi-scale visualization tools, (4) it uses adaptive meshing and parallel computing for efficiency, (5) it runs on a range of computers from laptops to large clusters, and (6) it employs a simple user interface for application users—open architecture for scientific developers. Abani Patra and colleagues used a number of methods to examine the effect of parameter uncertainty in the context of the non-linear hyperbolic systems solved by the TITAN2D code. In particular, they examined the effect of uncertainty in the starting volumes, friction angles, and location on specific outputs computed using the TITAN toolkit. The primary method used is to sample the assumed input probability distributions at points guided by the need to exactly integrate polynomial approximations using these distributions. They claim this is more efficient than classical Monte Carlo approaches and suitable for non-linear systems. Application of these methods to several volcanic hazard sites has led to a prediction of the uncertainty in desired output parameters—characterized by estimated means and variances. Assuming that friction angles and initial volumes of flowing mass used in the model are constrained to known uniform distributions, they computed probability distributions for mass averaged velocity and maximum pile height. These results appear to be reasonable for observed geophysical mass flows.

The first speaker on the second day was Chris Renschler (State University of New York at Buffalo), who presented Integrating Process Understanding and GI-Science: An Impact Assessment Tool for Volcanic Geohazards. Practical decision-making for civil protection based on predicting the impact of natural hazards often involves using assessment techniques and environmental process models linked with Geographic Information Systems and current remotely sensed imagery. To avoid wasting time and resources on inappropriate data collection, improper model use, and resulting poor decision-making, there is a need for a scientific and functional framework within which to examine implementation and use of geospatial assessment tools. Chris Renschler concluded that integrated research on geohazard modeling and GI-Science (Geographic Information Science) demonstrates the importance of scales, transformation of data, and decision-making.

Bruce Pitman (State University of New York at Buffalo) presented a talk entitled Modeling Granular Avalanche and Debris Flows. This presentation also featured TITAN2D, which is a robust mathematical model for depth-averaged, thin-layer granular flows. Weaknesses of present volcanological models include unrealistic rheology, simulation initiation (i.e., pile dimensions and starting point or points of model runs), and the digital elevation model being used to simulate topography.

The presentation by Andrei Kurbatov (University of Maine) was entitled Tephra Study in the Siple Dome A Ice Core, Antarctica. The Siple Dome A ice core is presently the longest ice core in Antarctica with a Holocene time scale that is based on annual layer counting. He noted that tephra fingerprinting, which mostly relies on geochemical analyses, provides an opportunity to establish correlation with the other environmental records. Although few global, non-Antarctic tephra layers have been found in this ice core, the presence of tephra layers derived from

Antarctic volcanoes provide robust time-lines and cross-correlations with existing Antarctic ice cores.

The next presentation was by Donald Hooper (Center for Nuclear Waste Regulatory Analyses) and entitled Potential Tephra Dispersal and Redistribution at Yucca Mountain, Nevada. The goal of this talk was to present recent modeling results to an audience with volcanological training. Following a possible, although unlikely, volcanic eruption in the potential repository at Yucca Mountain, tephra and high-level waste may be ejected and dispersed according to such factors as the height of the eruption column, particle-size distribution, and structure of the winds aloft. The computer code TEPHRA allows the user to calculate expected tephra (ash) and uranium (fuel) accumulation as areal mass density (variable thickness over a two-dimensional grid) by sedimentation out of the eruption plume. Subsequent surface processes could remobilize contaminated tephra-fall deposits. The post-eruption sediment yield affects the time period that fluvial redistribution could contribute contaminated airborne particulates for inhalation dose calculations. The presentation was well-received and the methodology was viewed favorably.

Eliza Calder (State University of New York at Buffalo discussed New Perspectives in Pyroclastic Flow Deposit Mapping. She presented results from a ground penetrating radar survey of the 1993 pyroclastic flow deposits at Lascar Volcano, Chile, carried out in 2005. These data were augmented with high-resolution digital elevation models and across-lobe profiles of clast density variation. This work is using field evidence from Lascar volcano to present a case for considering the role surface wave instabilities may have played during deposition at other sites.

Marcus Bursik (State University of New York at Buffalo) presented New Perspectives on Tephra Fall Deposits. This presentation focused on the flowfield into which pyroclasts are dispersed and their trajectories are calculated. Numerical experiments with pyroclasts over about 1 cm [0.4 in] in diameter injected into a quasi-steady, two-dimensional subplinian plume flowfield are beginning to provide insight into the nature of pyroclast flight. Type I ballistics are on the order of 5–10 cm [2–4 in] in diameter, and are affected by the flowfield, whereas Type II ballistics are larger and show little effect. The motion of pyroclasts smaller than about 5 cm [2 in] is not well-modeled by a quasi-steady flowfield, as these pyroclasts are essentially suspended, and their flight is apparently the product of the upward propagation of turbulent eddies. Because the eddies do not rise in the quasi-steady model, the motion of suspended pyroclasts cannot be tracked.

The final presentation was the keynote address by Michael Sheridan titled Using Models of Geophysical Mass Flows for Hazard Map Construction and Risk Assessment. He presented his perspectives on volcanic hazards and on the application of mass-flow models in volcanology. New simulation tools are being developed to estimate hazards in order to formulate public safety policy. In one example, he used the 1963 Little Tahoma Peak avalanches at Mount Rainier, Washington, to test the performance of TITAN2D. Tungurahua volcano in Ecuador was used as a case for comparison. In another example, recently discovered volcanological evidence indicates that a catastrophic eruption at Mt. Vesuvius during the Bronze Age brought greater destruction to the surrounding area than the famous Pompeii eruption of AD 79. Michael Sheridan and his colleagues suggest that this event should be a reference for current hazard planning for metropolitan Naples, Italy, home to 3 million people. His conclusions included (i) realistic visualization of computer models can be useful in describing mass flows and portraying them to potential end users, and (ii) current models can achieve about

50 percent confidence in predictive values based on accurate calibration of parameters and boundary conditions.

OTHER ACTIVITIES:

We discussed the organization of a special volume of the Journal of Volcanology and Geothermal Research as a venue for publishing work presented at this conference. The editors are interested in assembling an international team of guest editors for this special volume.

CONCLUSIONS:

The single-session format with lengthy presentations and group discussions was beneficial. The conference attendees agreed that this small, focused meeting (which resembled a workshop) was beneficial and productive. There was also discussion of having another meeting such as this one, although the actual objective or theme is presently undetermined. Conferences like this meeting in Buffalo are consistently insightful and stimulating, often providing ideas for alternative modeling or approaches that will aid staff in the review of a potential Yucca Mountain license application.

A new generation of process-based models is being developed for volcanological and geologic hazard applications. Concurrently, there is a new generation of georeferenced data with high spatial and temporal resolution and demanding storage requirements. These new data require new methods for processing and analysis, but should be able to be coupled with Geographic Information Systems.

PROBLEMS ENCOUNTERED:

None.

PENDING ACTIONS:

None.

RECOMMENDATIONS:

None.

SIGNATURES:

for DH

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6/9/06
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