CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

TRIP REPORT

SUBJECT: DOE Peer Review of Igneous Activity Consequences

DATE/PLACE: May 21–22, 2002, Las Vegas, Nevada

AUTHOR: Brittain Hill

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PERSONS PRESENT: John Trapp, Latif Hamdan (NRC); William Hinze (ACNW consultant); Richard Parizek, Derek Elsworth and Leon Reiter (NWTRB), and 30–50 DOE, BSC, and State of Nevada staff and consultants.

BACKGROUND AND PURPOSE OF TRIP:

Bechtel SAIC Company, LLC (BSC) is conducting a peer review of the U.S. Department of Energy (DOE) igneous activity consequences program. The goals of this review are to evaluate the current technical basis used to analyze the consequences of igneous events that may impact a potential high-level waste (HLW) repository at Yucca Mountain, assess the analysis and modeling program, and recommend new tasks that would significantly strengthen the program. The original goal was to focus on the area of magma-repository interactions, thus, six experts in rock mechanics, dike propagation, volcanology, and risk assessment were selected. Panel members were selected and the peer review was being conducted in accordance with existing DOE administrative procedures (i.e., AP-2.12Q). Brief biographies of the panel members are attached at the end of this report, along with initial questions asked of the panel members and literature supplied to the panel. Although the emphasis of the review is on the DOE program, Hill was requested to present the results of ongoing Center for Nuclear Waste Regulatory Analyses (CNWRA) work in the area of magma-repository interactions. Copies of his presentation, and other presentations from the meeting, are available.

SUMMARY OF PERTINENT POINTS:

Jean Younker (BSC) provided an overview of the peer review goals and questions being asked of the panel. The goal is to have a preliminary report completed in August 2002, with a final panel report by January 2003. The plan is to use the initial report to guide development of DOE fiscal year 2003 work plans, if so recommended. BSC plans to have a final evaluation report to DOE in February 2003. Terry Crump (BSC) also provided an overview of relevant regulations, the Igneous Activity Key Technical Issue (KTI), and associated issue resolution agreements. Peter Swift (BSC) gave the standard performance assessment overview for igneous activity, reflecting the Total System Performance Assessment–Site Recommendation (TSPA-SR) and Supplemental Science and Performance Analyses (SSPA). There was little discussion of the technical basis used to support the DOE analyses. Subissue resolution concerns with the TSPA-SR addressed by the SSPA analyses, however, were shown consistent with the information in the SSPA.

Robert Youngs (Geomatrix) presented a generic overview of the DOE probabilistic volcanic hazards assessment (PVHA). This presentation discussed only the DOE PVHA and did not address alternative models or new information of current concern to NRC staff. The probability theme was continued in the presentation by Frank Perry [Los Alamos National Laboratory (LANL)], which emphasized the 1995 DOE view of basaltic volcanism in the Yucca Mountain region.

Greg Valentine (LANL) then gave an overview of Yucca Mountain region volcanology, which summarized the history of DOE studies and a very basic synopsis of information in the Characterize Eruptive Processes Analysis and Model Report (AMR). This concluded the first day's presentations, with no significant discussion on the DOE modeling approach or technical basis for magma-repository interactions. The panel was noticeable frustrated with the lack of relevant information on magma-repository interactions, and by the large uncertainties on some key parameters needed for modeling these interactions.

Hill's presentation on magma-repository interactions evoked considerable discussion on the stated assumptions for the model, primarily on mechanical interactions of dikes and tunnels. Panel members were unfamiliar with many of the uncertainties in the geologic setting of Yucca Mountain, including the distribution and orientation of strain accommodation structures. It took considerable effort to focus discussions on magma-repository interaction topics and not range widely across the igneous activity issue, as was desired by the panel. The panel appeared interested in addressing all igneous activity uncertainties.

George Barr (Sandia) presented his model on dike propagation, which was abstracted from the Dike Propagation near Drifts AMR. He also talked about the need to address specific NRC concerns regarding potential topographic effects, a non-uniform stress field, and strain effects. Ed Gaffney (LANL) concluded with a detailed plan to model potential magma flow effects in drifts using 2D to 3D models. The goal of this modeling would be comparison with CNWRA models for initial flow effects, although some insights on sustained flow phenomena would result from the models.

At the conclusion of the presentations, Bob Budnitz asked numerous questions about the specific goals for the panel. Younker reiterated that the scope of the review encompassed all of igneous activity consequences, and emphasized the need for panel review of the proposed work rather than review of current technical basis. Most panel members appeared interested in developing their own models for discussed processes, rather than acting strictly as reviewers. Eric Smistad (DOE) reminded us that DOE committed only to "evaluate" these processes, and did not necessarily commit to develop models. The peer review panel may thus provide the "evaluation" DOE will use to approach subissue resolution. We should have additional indications of the DOE approach at the next peer review meeting in August, 2002.

CONCLUSIONS:

The DOE peer review originally was focused on models for magma-repository interactions. The scope of this panel, however, appears to have broadened to encompass all igneous activity consequences. The stated goals for the panel are to evaluate the current technical basis used by DOE to analyze consequences of igneous events, assess the DOE analysis and modeling program, and recommend new tasks that would strengthen the DOE program. Based on the presentations at this meeting, there was little review or discussion of the current DOE technical

basis for evaluating the consequences of igneous activity. Most discussions focused on past DOE work in probability and physical volcanology, and on the Center's models for magma-repository interactions. DOE has proposed a very ambitious schedule for the panel to make recommendations and for DOE to act on those recommendations in time to support models for TSPA license application.

PROBLEMS ENCOUNTERED:

None.

PENDING ACTIONS:

None.

RECOMMENDATIONS:

Staff should attend those future meetings of the peer review panel that are open to the public, to monitor DOE plans for resolving igneous activity key technical issue agreements related to consequences.

SIGNATURES:

Brittain E. Hill
Senior Research Scientist

7/9/02
Date

CONCURRENCE:

H. Lawrence McKague, Manager
Geology and Geophysics

7/9/02
Date

Budhi Sagar
Technical Director

7/9/2002
Date

BEH:rae

Attachments (4)

PRELIMINARY DRAFT
VOLCANISM PEER REVIEW PANEL READING LIST

1. Science and Engineering Report, Sections 4.3.2.1, 4.4.3.1 – 4.4.3.3
2. NRC Issue Resolution Status Report: Igneous Activity, Rev. 2, Sections 3.0, 4.2, 5.2
3. Preprints of CNWRA consultant papers (1) Bokhove and Woods, (2) Woods et al.
4. NRC/CNWRA presentation to ACNW: Britt Hill, July 17, 2001
5. KTIs pertaining to Magma/Drift, Magma/Waste Package/Waste Form interactions
6. NWTRB consultant letter reports dealing with Dike/Drift interactions
7. Current TWP on igneous work packages
8. AMR - Characterize Eruptive Processes at Yucca Mountain, Nevada
9. AMR - Dike Propagation near Drifts
10. Schematics showing repository design and layout, drift dimensions, and various EBS design elements.
11. Doubik P, Hill BE, Magmatic and hydromagmatic conduit development during the 1975 Tolbachik Eruption, Kamchatka, with implications for hazards assessment at Yucca Mountain, NV *JOURNAL OF VOLCANOLOGY AND GEOTHERMAL RESEARCH , v. 91(#1) pp. 43-64 JUL 1999*

Peer Review Objectives: Review Project's technical basis for modeling magma-drift interactions and our plans for future work. {Review to include AMRs supporting SR, related literature, challenges to Project's work etc}

Preliminary Draft Potential Questions for Peer Panel:

1. Conceptual Model:
   a. Is the conceptual model adequate for framing the analysis?
   b. Does the conceptual model allow for consideration of the key physical processes that are likely to significantly influence magma/drift interactions?
   c. Have any key processes or parameters been omitted that should be accounted for in the model?

2. What level of analysis (e.g., hand calculations versus code calculations) is "sufficient" to capture the nature of magma/drift interactions, given the uncertainties inherent in the input parameters (e.g., magma properties, repository environment)?

3. Quantitative modeling:

   a. Are the software codes chosen for the analysis adequate to model the anticipated physical processes?
   b. Will the modeling adequately account for all significant fluid dynamic processes expected to occur during a transient or sustained magma/drift interaction?
   c. Will the modeling adequately account for rock-mechanics processes that may affect magma/drift interactions and subsequent magma pathways and eruption characteristics?
   d. Are the physical parameters necessary to model magma/drift interactions likely to be sufficiently constrained to produce results with a "reasonable" level of confidence?
   e. Are the assumptions underlying the models appropriate?

4. What alternatives to the modeling approach are feasible, including experimental alternatives?

5. What is the appropriate role of analog studies for understanding magma/drift interactions? (e.g., literature review of historic volcanoes to understand analogous magmatic processes or examples of magmatic intrusions that have interacted with geologic or human-engineered structures)

6. Will the planned modeling provide results that reasonably and realistically represent magma/drift interaction in terms of drift temperature, pressure, and magma inflow and outflow?

7. Will the uncertainties of the models be readily quantifiable? Will it be possible to easily discriminate uncertainties resulting from uncertainties in input parameters versus uncertainties in understanding of complexities of physical processes? To what extent should the uncertainties be quantified, given the intended use of the model outputs to constrain issues such as waste package damage and the possibility that the presence of the repository will influence magma pathways to the surface?

8. Are the methods proposed for use in validating the modeling models adequate?

Panel Member Biographies

Dr. Robert J. Budnitz, Panel Chairperson, President, Future Resources Associates, Inc.

Dr. Budnitz has been involved with nuclear-reactor safety and radioactive waste safety for many years. From 1978 through 1980, he was a senior officer on the staff of the U.S. Nuclear Regulatory Commission (NRC). From 1978 to 1979, he was the Deputy Director and, from 1979 to 1980, he was the Director of NRC's Office of Nuclear Regulatory Research. As Director, Dr. Budnitz was responsible for formulating and guiding the large NRC research program, which constituted over $200 million annually. Since leaving NRC in 1980, Dr. Budnitz has been a private consultant on reactor safety, radioactive waste, and other related subjects as President of Future Resources Associates, Inc., which he founded in 1981. His clients have included both industrial and governmental organizations.

More than half of his research support in the post-1981 period has been for governmental entities, including NRC, the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), and the National Science Foundation (NSF), as well as foreign governmental organizations (International Atomic Energy Agency, Organization for Economic Cooperation and Development, Nuclear Energy Agency, European Bank for Reconstruction and Development). His work has concentrated on nuclear facility safety and safeguards with an emphasis on systems analysis and technology for high-level radioactivewaste disposal.

Dr. M. Emmanuel Detournay, Professor, Department of Civil Engineering, University of Minnesota.

Dr. Detournay received an Engineering Degree from the University of Liège (Belgium) in 1976 and a Ph.D. in Geo-Engineering from the University of Minnesota in 1983. He joined the University of Minnesota in 1993, after holding the position of Senior Research Scientist at Schlumberger Cambridge Research, Cambridge, England. Prior to his current academic position, he spent 10 years in applied research, mainly in the petroleum industry. His expertise is in Petroleum Geomechanics with an emphasis on mathematical modeling. His research work revolves around three main areas: coupled processes involving interaction between mechanical, hydraulic, thermal, and chemical fields, bit-rock interaction and drilling vibrations, and mathematical modeling of hydraulic fractures. The program on hydraulic fractures is aimed at constructing accurate solutions for fractures of simple geometry (such as radial) propagating in permeable elastic rock and at defining the regimes of propagation of these fractures.

Dr. Larry G. Mastin, Hydrologist, U. S. Geological Survey, Vancouver, Washington.

Dr. Mastin received his B.S. in Geology from the University of California, Davis, in 1980, and he completed his Master's degree in Engineering Geology at Stanford University in 1984, specializing in experimental rock mechanics and tectonic stress. He received his Ph.D. in Geomechanics at Stanford University in 1988, studying the mechanics of intrusion and eruption of a dike that intruded along the west side of Long Valley Caldera about 600 years ago. From 1988 through 1990, Dr. Mastin worked as a postdoctoral researcher at the Geophysics Institute, University of Karlsruhe, Germany,

and studied borehole stability and its relation to the state of tectonic stress at the pilot hole of the German Deep Drilling Program (KTB) in northern Bavaria. Since 1990, Dr. Mastin has worked at the U.S. Geological Survey Cascades Volcano Observatory in Vancouver, Washington. His specialty for the past twelve years has been the dynamics and thermodynamics of explosive volcanic eruptions, especially of those in which magma and water mix. Dr. Mastin has written numerical models of eruption dynamics and has studied the deposits of explosive eruptions at Mount St. Helens, Washington, and Kilauea Volcano, Hawaii.

Dr. J. R. Anthony Pearson, Schlumberger Cambridge Research Centre, Cambridge, United Kingdom.

Dr. Pearson has spent half of his active scientific life in industry (Imperial Chemical Industries, The Metal Box Company, and Schlumberger) and half in academe (University of Cambridge and Imperial College of Science and Technology, London). Most of his technical contributions have been in Fluid Mechanics and Rheology, with a strong emphasis on Mathematical Modeling. His major industrial fields of interest have been in the Mechanics of Polymer Processing (first 25 years) and Oilfield Flows, usually multiphase/multicomponent in both pipes and porous media (last 20 years). He has consulted widely in the chemical and engineering industries in Europe and domestically. He has visited, lectured, and taught at many universities in the United States, Europe, Asia, and Australia.

Dr. Allan M. Rubin, Professor, Department of Geosciences, Princeton University, Princeton, NJ.

Dr. Rubin received his B.A. in Earth Sciences from Dartmouth College in 1982 and his Ph.D. in Geology from Stanford University in 1988. He joined the Princeton University Geosciences Department in 1992 and was promoted to Associate Professor in 1998. Dr. Rubin's background is in rock fracture mechanics and its application to geologic processes. He has written extensively on the mechanics of dike intrusion, with particular emphasis on using combined elastic/fluid mechanical models of dike propagation to investigate the associated off-dike fracturing and faulting of the host rock on a wide range of length scales (centimeters to kilometers). Most recently, he has been applying new techniques for high-precision earthquake relocation to earthquake catalogs in Hawaii and California. These techniques reduce the relative location errors between nearby earthquakes from hundreds of meters to meters, allowing one to image fault-zone structure and earthquake interaction in unprecedented detail.

Dr. Frank J. Spera, Professor of Geological and Planetary Sciences, University of California, Santa Barbara.

Professor Spera conducts research in magma transport phenomena, the experimental rheological properties of magma, and molecular dynamics simulations of geomaterials. He has conducted volcanological studies in Hawaii, the Canary Islands, the Sierra Nevada batholith, and in Italy at Mt. Etna and Mt. Vesuvius. Dr. Spera has authored over 70 scientific papers and is a Fellow of the Mineralogical Society of America.