

## **Summary Highlights of NRC/DOE Technical Exchange and Management Meeting on Igneous Activity**

September 5, 2001  
Las Vegas, Nevada

### Introduction and Objectives

This Technical Exchange and Management Meeting on Igneous Activity is one in a series of meetings related to the U.S. Nuclear Regulatory Commission (NRC) key technical issue (KTI) and sufficiency review and the U.S. Department of Energy (DOE) site recommendation decision. Consistent with NRC regulations on precicensing consultations and a 1992 agreement with the DOE, staff-level resolution can be achieved during precicensing consultation. The purpose of issue resolution is to assure that sufficient information is available on an issue to enable the NRC to docket a proposed license application. Resolution at the staff level does not preclude an issue being raised and considered during the licensing proceedings, nor does it prejudge what the NRC staff evaluation of that issue will be after its licensing review. Issue resolution at the staff level, during precicensing, is achieved when the staff has no further questions or comments at a point in time regarding how the DOE is addressing an issue. The discussions recorded here reflect NRC's current understanding of aspects of igneous activity most important to repository performance. This understanding is based on all information available to date which includes limited, focused, risk-informed reviews of selected portions of recently provided DOE documents (e.g., Analysis and Model Reports (AMRs) and Process Model Reports (PMRs)). Pertinent additional information (e.g., changes in design parameters) could raise new questions or comments regarding a previously resolved issue.

Issues are "closed" if the DOE approach and available information acceptably address staff questions such that no information beyond what is currently available will likely be required for regulatory decision making at the time of any initial license application. Issues are "closed-pending" if the NRC staff has confidence that the DOE proposed approach, together with the DOE agreement to provide the NRC with additional information (through specified testing, analysis, etc.) acceptably addresses the NRC's questions such that no information beyond that provided, or agreed to, will likely be required at time of initial license application. Issues are "open" if the NRC has identified questions regarding the DOE approach or information, and the DOE has not yet acceptably addressed the questions or agreed to provide the necessary additional information in a potential license application.

The objective of this meeting was to discuss and review the progress on resolving the Igneous Activity KTI, specifically Subissue 2 (see Attachment 1 for the description of the subissues). The quality assurance (QA) aspect of this KTI was determined to be outside the scope of the meeting and is being tracked in NRC's ongoing review of the DOE's QA program.

### Summary of Meeting

At the close of the Technical Exchange and Management Meeting, the NRC stated that the status of Igneous Activity Subissues 1 and 2 are now closed-pending. Consistent with what was discussed during the Total System Performance Assessment and Integration (TSPAI) Technical Exchange and Management Meeting on August 6-10, 2001, with the status of

Igneous Activity Subissue 2 changing to closed-pending, TSPAI Subissue 3 can now be classified as closed-pending.

Specific NRC/DOE agreements made at the meeting are provided as Attachment 1. A modification to an existing NRC/DOE agreement is provided as Attachment 2. The agenda and the attendance list are provided as Attachments 3 and 4, respectively. Copies of the presenters slides are provided as Attachment 5. Highlights from the Technical Exchange and Management Meeting are listed below.

## Highlights

### **1) Opening Comments and Overview**

NRC opened the meeting with an overview of igneous activity (see "Overview of Igneous Activity Meeting" presentation given by James Andersen) and stated that this meeting would address part of DOE's performance assessment related to igneous activity. NRC discussed what performance assessment is and the terms and definitions used. NRC then discussed igneous activity, the terms used, and the general areas within the Igneous Activity KTI which would be discussed during the meeting. NRC further stated that staff would be available to discuss general comments or questions with members of the public during the breaks and after the meeting.

NRC then provided an overview of the Igneous Activity KTI. NRC stated that during the June 21-22, 2001, Technical Exchange and Management Meeting, NRC and DOE reached six agreements related to the biosphere, modified five existing Igneous Activity agreements, and superceded three existing Igneous Activity agreements, but that NRC and DOE were not able to reach agreement in a number of areas for which NRC proposed 13 additional agreements. NRC stated that these 13 proposed agreements should provide a starting point for today's technical exchange.

### **2) Technical Discussions - Igneous Activity Subissue 2**

DOE provided an overview of the Igneous Activity issue (see "DOE Plans to Address NRC Proposed Agreements Associated with the Igneous Activity Consequences Subissue" presentation given by Eric Smistad and Gregory Valentine). DOE stated that it has planned work to evaluate igneous consequences to strengthen the basis supporting any potential license application. DOE stated that its objective for the meeting is to discuss its plans to address NRC proposed agreements from the June 2001 technical exchange. DOE noted that any references to design elements refer to the license application design and that references to completion dates are expected dates (final dates are contingent on planning and budget).

DOE stated that the 13 NRC proposed agreements can be broken down into four areas: (1) ash and soil redistribution; (2) magma-drift interactions; (3) magma-waste package interactions; and (4) magma-waste form interactions. DOE then discussed each specific area and the NRC proposed agreements related to the area.

## Ash and Soil Redistribution

DOE stated that the NRC proposed agreements in this area discussed: (1) the effects of eolian and fluvial remobilization are bounded; and (2) the effects of ash/soil suspension on radionuclide concentrations. DOE discussed its planned work in the ash/soil remobilization area. DOE stated that it will conduct analog studies of remobilized ash deposits, conduct field studies of Yucca Mountain surficial erosion rates, and develop mathematical models based on the first two studies. NRC questioned DOE's planning for eolian remobilization. DOE stated that it parallels what it is doing in the fluvial area. NRC asked if any of the analogs it is considering have tephra-fall deposits on low permeability soils that are analogous to the Yucca Mountain area. DOE stated that Lathrop Wells was one such analog site but that other analog sites had not yet been identified. NRC asked whether DOE is planning to look at flooding data at Yucca Mountain, such as from the 1996-1998 floods. DOE stated that it plans to do that. NRC questioned whether DOE will evaluate potential change in grain sizes due to transport and abrasion. DOE stated that it planned to look into this process.

DOE then addressed ash/soil suspension effects. DOE discussed its planned work and stated that it would assess the waste incorporation mechanism in the ASHPLUME code and complete analysis of waste concentration on ash particles suspended in air versus concentration in soil. DOE also clarified which work would be covered by certain AMRs and noted that the planned work would be captured in the Input Parameter Values for External and Inhalation Radiation Exposure Analysis AMR or other appropriate technical documents.

### Magma-Drift Interactions

The second area DOE discussed was magma-drift interactions. DOE stated that the NRC proposed agreements discussed an evaluation of: (1) stress accumulation from high-level waste thermal-mechanical effects; (2) how presence of engineered repository structures can affect magma flow processes for the duration of an igneous event; (3) how the presence of repository structures may affect magma ascent, conduit localization, and evolution of the conduit and flow system; and (4) mechanical strength of natural or engineered barriers that are proposed to restrict magma flow within intersected drifts.

DOE discussed its planned work to evaluate stress accumulation from high-level waste thermal-mechanical effects and stated that it would evaluate: (1) Yucca Mountain stress field and strain data; (2) analyze topographic effects on dike propagation; and (3) analyze effects of excavated structures and heat. NRC noted that the level of work in this area would depend on the exact assumptions used in the performance assessment. NRC asked whether DOE had models available to address the strain issue. DOE stated that existing models may need modification to evaluate strain response as well as stress accumulation.

DOE discussed its planned work to evaluate the effects of engineered repository structures on magma flow processes. DOE stated that it would perform a dike propagation analysis, exsolution/fragmentation kinetics analysis, and magma and gas flow analysis. NRC asked if the analysis would look at propagation of a dike through an intact block relative to propagation along a fault. DOE stated that the propagation study was directed towards the repository area and also asked if the question included capture of a dike by a fault. NRC stated it did. DOE stated that field studies on conduit geometry will examine the role of pre-existing faults on dike

and conduit formation. NRC asked whether DOE was using experiments in the fragmentation kinetics analysis. DOE described some of the experiments it planned to do in this area.

DOE discussed its planned work to evaluate the effects of subsurface repository structures on the ascent of basaltic magma. To address the issue, DOE stated that its planned analyses included dike propagation, magma and gas flow, and conduit size/geometry. The NRC had no questions in this area.

DOE discussed its planned work to evaluate the mechanical strength of natural or engineered barriers. DOE stated that it planned to perform a magma and gas flow analysis which would investigate erosion and entrainment of debris in drifts, as well as pressure-temperature conditions and durations. The NRC had no questions in this area.

DOE discussed its planned work to evaluate the presence of backfill or rockfall which may affect magma flow processes. DOE stated that this issue is closely related to the issue of mechanical strength of debris accumulations or barriers (discussed above). As discussed above, DOE stated that it planned to perform a magma and gas flow analysis to address this issue. The NRC noted a particular concern with the ability of partial blockage to affect flow processes in the drift. DOE indicated that planned studies would examine this process.

#### Magma-Waste Package Interactions

The third area DOE discussed was magma-waste package interactions. DOE stated that the NRC proposed agreements discussed an evaluation of: (1) canister responses to stress from dynamic magmatic repressurization, gravitational loading, and heating; (2) aging effects on materials strength properties resulting from basaltic magmatic conditions; and (3) the response of Zone 3 waste packages, or waste packages covered by backfill or rockfall, if exposed to magmatic gases. DOE noted that in the Total System Performance Assessment for Site Recommendation, it defined Zone 1 as those waste packages which totally breach due to the magma; Zone 2 as those waste packages which were affected by contact with magma but only partially breached, and Zone 3 as those remaining waste packages that were not directly contacted by magma.

DOE discussed its planned work to evaluate waste package response to stress. DOE stated that it planned to; (1) perform magma and gas flow and hydrothermal analyses which will provide pressure, temperature, chemistry, and dynamic conditions for analyses and waste package modeling; and (2) develop models for the response of the waste package to those conditions. NRC questioned whether the magma and gas flow analyses information would be coming out of the revised dike propagation analysis. DOE stated that it would be. NRC asked if the gas chemistry would consider changes in oxygen fugacity due to atmospheric mixing. DOE stated the studies would consider this. NRC asked if DOE will be providing a range of oxidation conditions to the DOE Waste Package Group for its models. DOE stated that this range would be provided.

DOE discussed its planned work to evaluate aging effects on materials strength properties when exposed to basaltic magma. DOE stated that it planned to perform: (1) waste package analyses which will include effects of aging prior to onset of an igneous event; (2) magma and gas flow analyses which provide pressure, temperature, chemistry, and dynamic conditions for

analyses and modeling of waste package response; and (3) analysis which will include aging effects after onset of an igneous event and will also address seismic vulnerability of aged waste packages. NRC clarified that its primary concern in this area was temperature/pressure effects on the waste package for the duration of the igneous event and what those effects have on subsequent waste package performance. NRC asked whether DOE would evaluate the exposure in Zones 1, 2, and 3. DOE stated that it would.

DOE discussed its planned work to evaluate the waste package response to magmatic gases. DOE stated that it planned to: (1) perform magma and gas flow and hydrothermal analyses which will provide information on the distribution and time histories of magmatic gases in the repository; and (2) develop models for the response of waste packages to those environmental conditions. DOE noted that, in general, all the igneous activity issues get wrapped up into the Igneous Activity Consequences AMR which in turn is an input into the total system performance assessment.

### Magma-Waste Form Interactions

The fourth area DOE discussed was magma-waste form interactions. DOE stated that the NRC proposed agreements discussed: (1) an evaluation of how magma ascent and flow through repository structures may incorporate high-level waste located along potential flow paths; (2) the physical and chemical response of high-level waste and cladding after heating and potential disruption of waste package; and (3) providing an independent technical basis for the method of high-level waste incorporation used in DOE models.

DOE discussed its planned work to evaluate magma incorporation of high-level waste form into magma along flow paths. DOE stated that it planned to perform magma and gas flow analyses which would provide pressure, temperature, chemistry, and dynamic conditions for analyses and modeling by its Waste Form Department. DOE further stated that its Waste Form Department would: (1) analyze waste form response to magmatic environment in drifts both within and outside of waste packages to determine waste form physical and chemical phases; (2) determine waste form physical and chemical phases for waste brought to the surface by magma; (3) determine waste form physical and chemical phases for waste in ash plume; and (4) describe potential changes in waste form caused by surface transport processes. NRC asked if DOE plans to develop a model to determine what percentage of high-level waste could be entrained by lava flows, versus entrained in the tephra eruption. DOE indicated they would continue to consider a range of eruption models.

DOE discussed its planned work to evaluate physical and chemical response of high-level waste and cladding. DOE stated that it planned to perform magma and gas flow and hydrothermal studies to provide pressure, temperature, chemistry, and dynamic conditions for waste form analyses and modeling. DOE stated that its Waste Form Department would then evaluate: (1) commercial spent nuclear fuel/high-level waste glass/defense spent nuclear fuel dissolution kinetics after exposure to magma; and (2) commercial spent nuclear fuel cladding pressurization and creep/hydride failure. NRC clarified that dissolution processes included high-level waste dissolution into magma, and aqueous dissolution after the igneous event. DOE agreed that both dissolution processes would be considered.

DOE discussed its planned work to strengthen its technical basis for the method of high-level waste incorporation in DOE ash dispersion models. DOE stated that it planned to assess the waste incorporation mechanism that is implied in the ASHPLUME code. The NRC had no questions in this area.

### **3) DOE Proposed Igneous Activity Agreements**

DOE then discussed four proposed agreements which it believed addressed the 13 NRC proposed agreements from the June 2001 technical exchange and management meeting. DOE presented each of the four agreements and how the agreements addressed the NRC issues (see "DOE Plans to Address NRC Proposed Agreements Associated with the Igneous Activity" presentation for the wording of the DOE proposed agreements - Attachment 5).

After caucusing on the DOE proposed agreements, the NRC stated that it agreed with Proposed Agreement 1, which would be renumbered to Igneous Activity Agreement 2.17, but noted that the NRC does not require bounding conservative modeling assumptions. The NRC stated that it needed DOE to justify its modeling assumptions. With regard to Proposed Agreement 2, the NRC stated that it agreed with the wording of the agreement. With regard to Proposed Agreements 3 and 4, the NRC agreed with the wording of the agreements with minor editorial changes.

DOE noted that it would like to include a reference to other appropriate technical documents in each agreement. The NRC agreed with the proposal. NRC and DOE also discussed the need to have additional technical exchanges, Appendix 7 meetings, and workshops to discuss DOE's progress and the NRC's work in the igneous activity consequence area. DOE stated that it was open to have additional public interactions as it moved forward in its plans and analyses, as appropriate.

Based on reaching these four agreements, the NRC stated that Igneous Activity Subissue 2 can be classified as closed-pending. Consistent with what was discussed during the TSPA Technical Exchange and Management Meeting on August 6-10, 2001, with the status of Igneous Activity Subissue 2 changing to closed-pending, TSPA Subissue 3 can now be classified as closed-pending.

### **4) Other Igneous Activity Agreements**

NRC and DOE also discussed Igneous Activity Agreement 1.02. NRC stated that it needed a schedule and document reference. DOE stated that the schedule for the aeromagnetic data evaluation was fiscal year 2003 and that it would be documented in the Characterize Framework for Igneous Activity at Yucca Mountain AMR.

### **5) Public Comments**

Elaine Hiruo (PLATT Publishing) asked whether the Igneous Activity consequences subissue was closed. The NRC clarified that with the agreements reached with DOE, the Igneous Activity consequence subissue is classified as closed-pending. The pending portion of this classification is the additional information DOE agreed to provide to the NRC.

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