

August 1, 2002

The Honorable Richard A. Meserve  
Chairman  
U.S. Nuclear Regulatory Commission  
Washington, D.C. 20555-0001

SUBJECT: IGNEOUS ACTIVITY ISSUES AT THE PROPOSED YUCCA MOUNTAIN  
REPOSITORY

Dear Chairman Meserve:

For years, the Advisory Committee on Nuclear Waste (ACNW) has been following the efforts of the U. S. Nuclear Regulatory Commission (NRC) and the U.S. Department of Energy (DOE) to evaluate the probability and consequences of igneous activity in the Yucca Mountain region. The ACNW has had numerous presentations from and discussions with the NRC staff and consultants from the Center for Nuclear Waste Regulatory Analyses (CNWRA) about issues surrounding analyses of igneous activity. The level of concern about the possible consequences of igneous activity at Yucca Mountain was elevated again last year by the publication of an NRC-sponsored study by Woods et al. (2002). That study suggested that shock waves generated from magma intersecting a drift might cause very large overpressures.

The implication that might be drawn from this suggestion is that a significant number of waste canisters could be damaged under such conditions. At the March 20, 2002, meeting with the Committee, the Commission expressed its interest in having the ACNW review the issues. The Commission also asked the ACNW about its views concerning the comments made by several consultants to the Nuclear Waste Technical Review Board (NWTRB), as well as its views concerning the adequacy of agreements reached on volcanism between the NRC and DOE staff.

At the Committee's 135<sup>th</sup> meeting on June 18-20, 2002, we heard presentations by the NWTRB consultants, Drs. Derek Elsworth, William G. Melson, and Meghan M. Morrissey.<sup>1</sup> The Committee also had the benefit of comments from two of its own consultants, Drs. William Hinze and Bruce Marsh. The discussions at the meeting focused mainly on the problems of modeling the interaction of magma and open drifts, but also dealt with the issue of evaluation of the probability of a dike intersecting a repository.

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<sup>1</sup> The views expressed were those of the consultants and not the NWTRB.

In this letter, the ACNW summarizes its current views about the probability of a dike intersecting a repository at Yucca Mountain, and the consequences to such a repository should such igneous activity occur.<sup>2</sup>

## **ACNW CONCLUSIONS**

Our main Conclusions are as follows:<sup>3</sup>

- The range of estimated probabilities,  $\sim 10^{-9}$  to  $\sim 10^{-7}$  per year, of an igneous intrusion into the repository used by DOE in its performance assessment is reasonable. New information from recently completed aeromagnetic surveys does need to be evaluated more fully to determine possible changes in the appropriate probability range, but we currently see no reason to expect changes that would fundamentally alter the current conclusions of DOE's performance assessment results.
- The analysis of magma-drift interaction sponsored by the NRC (Woods et al., 2002) is too idealized to be of direct use in interpreting possible impacts on a proposed repository at Yucca Mountain. The main value of the NRC-sponsored study appears to be the elevation of the importance of this modeling activity in technical meetings between the NRC and DOE, so that appropriate agreements for issue resolution, at the staff level, could be made.
- The agreements to resolve the igneous activity key technical issue (KTI) provide a reasonable technical basis for proceeding with the evaluation of a potential license application for the Yucca Mountain repository.

## **DISCUSSION OF PROBABILITY OF IGNEOUS ACTIVITY**

### **Background**

There has been much debate about the probability of igneous activity in the Yucca Mountain region. To develop a basis for a quantitative assessment, DOE sponsored a formal expert elicitation in 1995-1996, the results of which were published in 1996 as the "Probabilistic Volcanic Hazards Analysis" (PVHA—Geomatrix Consultants/TRW Environmental Safety Systems, 1996). In conducting the PVHA, DOE agreed to subscribe to the NRC's guidance on conducting formal expert elicitations found in NUREG-1536 (Kotra et al., 1996).<sup>4</sup> The

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<sup>2</sup> In this letter, the ACNW organizes comments according to the categories of "probability" and "consequence" for convenience, but this organizational strategy should not be taken as an acceptance of a dichotomy by the Committee. In fact, a point of the "consequences" section of this letter is that analyses using unrealistic conditions do not add enlightenment regarding a sensible performance assessment of a potential repository.

<sup>3</sup> There are a number of important issues associated with disruptive igneous activity at or near Yucca Mountain that we do not consider in this letter. In particular, the ACNW has not reviewed the dose calculations and the assumptions made therein and, thus, cannot comment on whether this aspect of the performance assessment is reasonable.

<sup>4</sup> In addition, DOE adopted the recommended guidance found in NUREG-1536 into its internal quality assurance (QA) procedures.

probability range stemming from the PVHA was  $\sim 10^{-9}$  to  $\sim 10^{-7}$  per year, which is used by DOE in its performance assessments.

Since the publication of the PVHA, there have been additional assessments of the probability of igneous activity. Based on extensive geological analyses (e.g., Connor and Hill, 1995), the NRC staff deemed that the upper end of the DOE probability range,  $10^{-7}$  per year, was the "correct" number to use in performance assessment analyses. During the issue-resolution process, DOE agreed to provide a sensitivity study of the risk posed by volcanic activity using the preferred NRC probability value of  $10^{-7}$  per year in addition to the main probabilistic assessment using the PVHA results. Recently, Smith et al. (2002) published a paper that postulated a link between volcanism at Crater Flat (near Yucca Mountain) and volcanism in the Lunar Crater Volcanic Field to the north. With this postulated link, the authors argue that the probability of igneous activity at Yucca Mountain might be higher than estimates based on geological models that do not consider a linkage between Crater Flat and the Lunar Crater Volcanic Field.

In 1999, the U.S. Geological Survey (USGS) undertook new aeromagnetic surveys in the Crater Flats area. The recently published results (Blakely et al., 2002) reveal the presence of several previously unknown anomalies that may be buried centers of past volcanic activity. A report by CNWRA consultants (Hill and Stamatakos, 2002) suggests that the new aeromagnetic information might lead analysts to conclude that estimates of the frequency of volcanic activity should be unchanged, that they should be increased by a factor of two or so, or that they should be increased by almost an order of magnitude depending on hypotheses about the age and temporal clustering of the putative volcanic activity. DOE will have to evaluate new information from the aeromagnetic survey, in the context of the PVHA, to ensure that the total-system performance assessment is consistent with the data and to maintain conformance with NUREG-1536, and its own internal QA procedures.

### **Status**

At the 135<sup>th</sup> meeting of the ACNW, Dr. William Melson reviewed pertinent information dealing with the probability of occurrence of igneous activity at Yucca Mountain. Dr. Melson pointed out that the link postulated by Smith et al. between volcanism in Crater Flat and volcanism in the Lunar Crater Field is controverted by solid geochemical evidence. Also, there is no broadly accepted evidence for the "hot spot" in the upper mantle postulated by Smith et al. Thus, the proposed increase in igneous probability put forth by Smith et al. is not seen as scientifically credible. Dr. Melson also stated his opinion that analyses of the new aeromagnetic anomalies are unlikely to have a significant impact on estimates of the probability of igneous activity at Yucca Mountain.

## **DISCUSSION OF CONSEQUENCES OF IGNEOUS ACTIVITY**

### **Background**

Two decades ago, DOE initiated studies of the volcanic cones and their products in the Yucca Mountain region, which relate to the potential consequences of a disruptive igneous event. These studies were terminated during a budget cut in the mid-1990s when they were still

incomplete because of the estimated low probability of a disruptive igneous event. More recently, the igneous activity KTI came under increased scrutiny because results of DOE's performance assessments indicate that probability-weighted radioactive releases from a potential repository, although quite small from such an event, are the dominant contributor to the peak annual dose during the 10,000-year compliance period.

The NRC staff supported an analysis of possible consequences of a dike intersecting a repository drift. That first-of-a-kind analysis, prepared by Woods et al. (2002), is predicated on a set of simplifying modeling assumptions. It suggests that when magma intersects a drift, a compressional wave will travel along the emplacement drift and will be reflected from the end drift wall, thereby elevating the pressure. A series of reflections by this shock wave lead to rapid amplification of the pressure within the drift to very high values. Such overpressures may be sufficient to breach the waste package canisters, with possible subsequent venting of the magma and waste package contents to the surface. This may be a concern in the analysis of repository performance.

### **Status**

At the 135<sup>th</sup> meeting of the ACNW, Drs. Elsworth, Melson, and Morrissey reviewed pertinent information dealing with the NRC-sponsored work published by Woods et al. and reported their views on the analysis. This group of experts agreed that the idealized analyses of Woods et al. were overly conservative and led to results that were implausible with respect to the proposed repository. A brief summary of the experts' views follows.

The Woods et al analysis assumes that the magma will remain fluid, the drift is perfectly smooth and straight, there is no interaction with waste canisters, and the rock surfaces defined by the drifts are perfect reflectors. At Yucca Mountain, the volumes of magma are very small. The magma is close to its solidus and would immediately form a glass crust on both the drift walls and canisters in the drift, a crust that would thicken until the flow was cut off. The reflections of any shock wave from rough wall surfaces and canisters in the drift (as opposed to a perfectly cylindrical, smooth, unyielding tunnel) would not result in the tremendous overpressures predicted by the Woods et al. analysis. Moreover, if pressures were to develop, they would rapidly be dissipated by hydrofracturing of the drift wall. Dr. Bruce Marsh supported the view that Woods et al. analysis is unrealistic, based on his experience with magma flows throughout the world.

As a general matter and as previously noted by the ACNW, performance assessments based on unrealistic assumptions confound a risk-informed approach [ACNW September 28, 2001 letter]. We consider that a "consequence" analysis of disruptive igneous activity, using assumptions that lack realism, would illustrate this point. Assumptions in an analysis should be

linked to the probability of the consequence, which makes the point the ACNW has made during several meetings – namely, that one cannot really separate probability and consequences.

Sincerely,

**/RA/**

George M. Hornberger  
Chairman

### References

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