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August 8, 1991

John W. Bartlett, Director
Office of Civilian Radioactive
Waste Management
U.S. Department of Energy
Washington, D.C. 20545

Dear Dr. Bartlett:

The State of Nevada has reviewed the Department of Energy (DOE) Study Plan "Probability of Magmatic Disruption of the Repository" (Study Plan 8.3.1.8.1.1) and its cited references and is providing its comments in this letter and attachment. The State's comments address the adequacy, completeness, and technical accuracy of the Study Plan to meet the purposes of site characterization.

The State's primary concerns regarding the subject Study Plan are summarized as follows:

1) The subject Study Plan addresses an issue of great importance relative to public health and safety - future magmatic disruption of the repository. There is no doubt that the phenomenon (a volcanic event) is stochastic, and the answer (magmatic disruption of the repository) is necessarily probabilistic. However, the Study Plan as conceived contains numerous flaws. The Plan is compartmentalized into activities without a well-defined approach for unifying the data for stochastic events obtained from each activity into the development of an acceptable probability of magmatic disruption of the repository.

2. We have great concern about the sequence of activities in this Study Plan and the relation of those activities to activities in other Study Plans which provide needed input data. If the presence of a magma body is detected as part of Activity 3 (Identification of Magma Bodies in the Vicinity of the Site), the identification may necessitate substantial revision to the

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Plan and the refocus of other Plan activities. Yet according to the Study Plan schedule, most work under the Plan will have been accomplished, including calculation of the probability of repository disruption, prior to the identification of magma bodies (Activity 3).

3. The Study Plan fails to recognize and acknowledge the controversy in the scientific literature regarding structural control of volcanism, age dating of volcanic events, and methods for determining the probability of future volcanic activity in southern Nevada. Even the discussion of the use of expert opinion fails to address treatment of differing points-of-view.

4. In the letter (Loux to Bartlett) dated February 21, 1991, the State transmitted its comments on the DOE Study Plan for "Characterization of Volcanic Features" (Study Plan 8.3.1.8.5.1). A primary concern from the State's review was that the Plan assumes that <u>all</u> of the centers of volcanic activity are known and well defined, yet the Plan did not contain a complete reference base to support this assumption of complete knowledge. As we understand, the "Characterization" Study Plan will provide the input data necessary to accomplish the "Probability" Study Plan. However, the "Probability" Study Plan fails to address the uncertainties which may be in the input data and how that uncertainty will be handled in calculating probabilities.

Should you have questions, this Office is available to meet with the Department and discuss the State's comments at any time.

Sincerely,

Carl Walker /for

Robert R. Loux
Executive Director

RRL:jem

Attachment

cc: Carl Gertz, YMPO
✓ Joe Youngblood, NRC
Dade Moeller, NRC-ACNW
Don Deere, NWTRB
Dwayne Weigel, GAO
Steve Kraft, EEI

ATTACHMENT

STATE OF NEVADA COMMENTS ON THE STUDY PLAN FOR PROBABILITY OF MAGMATIC DISRUPTION OF THE REPOSITORY (STUDY PLAN 8.3.1.8.1.1)

Activity 8.3.1.8.1.1.1 - Location and Timing of Volcanic Events

The Activity proposes to determine the location and timing of known Pliocene and Quaternary volcanoes by the compilation of geologic data gathered from other activities. This activity may only partially achieve its objective because of problems inherent in the age dating techniques required to establish timing of volcanic events. Such problems were discussed in the State's comments on Study Plan 8.3.1.8.5.1 "Characterization of Volcanic Features". Geochronology studies may not resolve age discrepancies for individual volcanic centers which involve different dating tools (e.g., Fleck et al., 1991). For older volcanic centers (greater than about 1 Ma), traditional age dating techniques may provide sufficient precision to establish the timing of volcanic events. For younger centers (less than 1 Ma), the use of traditional whole rock K-Ar dates is suspect.

Since the data for this Activity will come from a variety of sources it is extremely important that the data be appropriate and representative. To obtain information on location and structural control of volcanoes required for Activity 8.3.1.8.1.1.2 - Structural Controls of Basaltic Volcanic Activity, it will be necessary to extend the compilation of data to a larger area than the Yucca Mountain region. A

compilation that includes Pliocene and Quaternary volcanic activity in Death Valley, the Lunar Crater-Reveille field, Buckboard Mesa and the Cima Field is recommended to obtain a better regional appreciation of the distribution of volcanoes with respect to structures and topography.

The text indicates that geologic map compilations will be performed as part of the Activity. Geologic map compilations commonly require field checking and additional geological mapping to resolve boundary problems between geologic maps, check discrepancies on existing maps, and add detail where necessary. Therefore, a discussion of planned geologic field mapping studies should be added into Section 3.0 Descriptions of Tests and Analyses .

Activity 8.3.1.8.1.1.2 - Evaluation of the Structural Controls of Basaltic Volcanic Activity

The objective of this activity is achievable, if care is taken in selecting models for the structural control of volcanism. Structural control of basaltic volcanism should be evaluated at two scales. First, the control of large-scale regional structures (strike-slip faults, detachments) and volcano alignments related to these structures should be evaluated. Second, control of structures on and adjacent to Yucca Mountain and volcano alignments related to these structures

should be evaluated. Models for structural control because of the different scales of geologic structures may be different. For example, northwest striking structures may result in a regional alignment of Pliocene and Quaternary cones in a northwest direction. But, at the scale of Yucca Mountain, northeast striking structures control the alignment of volcanoes (Smith et al., 1990). Although both models may be supported by the data, a judgement must be made as to which model is most appropriate for risk studies at Yucca Mountain.

Studies by Smith et al. (1990) suggested that the volcanoes in Crater Flat are controlled by short northeast striking fault segments. If this observation is correct, then the location of future volcanism on Yucca Mountain (where several of these northeast striking segments are exposed) can be more tightly constrained. It is important to consider the possibility that the sites of future volcanism may be controlled by specific segments of structures and such models should be factored numerically into the disruption parameter of the probability formula.

Some of the models discussed in this Activity are based on faulty assumptions. Deterministic Model 1 (p. 22) lacks validity. The investigators propose a simple linear regression model based on longitude and latitude of volcanic centers to derive confidence bands for the fitted regression

line. The probability of disruption is calculated as $P_{rd} = 1 - C_i$, where C_i is the level of significance of the confidence band that intersects Yucca Mountain. There are several flaws in this approach:

FLAW NO. 1 No randomness remains after a particular confidence band is constructed. Therefore, probability $(1 - C_i)$ in its interpretation as long-term relative frequency makes no sense in this situation.

FLAW NO. 2 There is an assumption that all future volcanic activity will occur only along the fitted regression line (with normal variation). There are two problems with this assumption: No geophysical basis is provided to justify this restriction; and it is assumed that the regression lines shown are the best fit. The similarity of the regression lines (Fig. 3, p. 23) is due to the presence of two influential, extreme cases. If these cases were treated as outliers and removed, the new regression lines would be far different. The new regression lines would probably approach far closer to Yucca Mountain.

Also, the small number of data points make it difficult to test normality of the error. In the absence of normality, the 'best fit' need not be the line found by linear regression. Latitude and longitude are both random variables, and while a linear regression can be done of one random variable on another, there are certain restrictions on their underlying conditional probability distributions for such a regression to be statistically valid.

FLAW NO. 3 The author assumes in calculating the probability of repository disruption as $P_{rd} = 1 - C_i$ that only a bullseye volcanic event at the site could cause repository disruption. Effects of a nearby volcanic event on the hydrologic system at the repository is not addressed.

Model 2 (p. 24) may assume correctly that the strike-slip fault of Crater Flat will control future volcanic activity, but the plan does not mention how the data in Table 2 (p. 26) will be used to determine the probability of disruption at the repository. The same argument can be made for the data in Table 3 from Model 3. Legitimate mathematical models must

first be developed and shown to be reasonable for predicting future volcanic events. A detailed plan must also be developed to incorporate multiple models if more than one reasonable model is found.

On page 17 (paragraph 1), the author of the Study Plan states "These analyses (the determination of relative risk) are best applied at active or dormant volcanoes for decisions involving land use or potential danger to property or human life from impending volcanic eruptions." The determination of relative risk zones in the vicinity of the proposed repository is an important first step in applying a probabilistic approach to risk assessment. Risk zones not only provide an indication of potential danger from a future eruption, but provide a geographic focus for the development of numerical models. The risk zone approach similar to that used by Smith et al. (1990) is quite appropriate for the Yucca Mountain study.

On page 17 (paragraph 3), the author states "The probabilistic approach to volcanic risk assessment is preferred for several reasons...There has been a uniformity in the composition, volume, and style of basaltic volcanism in the Yucca Mountain region during the last 9 Ma." This statement is generally true. However, when detailed stratigraphic studies are combined with comprehensive age dating and geochemical studies, cyclic trends are observed. For example, in the

Reveille Range (Naumann et al., 1990) there are two episodes of basaltic volcanism separated by a time period of about 1 Ma. Each displays a trend from subalkalic to alkalic compositions. Therefore, in the Reveille Range, chemical changes appear to be cyclic, not uniform. Detailed geologic and geochemical studies must be completed before statements regarding the uniformity of geological processes can be made with any certainty.

In Figure 3 of the Study Plan, it is noted that the lines of equal probability trend mainly to the northeast, even though volcanoes used for the data analysis are oriented in a northwesterly direction. What is the significance of this apparent discrepancy to the evaluation of structural controls and how will it be resolved?

The author carefully lays out a rationale for this Activity and proposes to carry out a well-planned scientific study to determine the probability of disruption of the proposed Yucca Mountain repository by a volcanic eruption. However, on page 28 and 29 of the Study Plan, the author states "The geologic record of the past 18 events demonstrates that future basaltic eruptions are unlikely to occur at Yucca Mountain." This statement infers that the author of this Study Plan has already reached a conclusion before work on the study has

begun. A statement such as this is inappropriate for this Study Plan.

Activity 8.3.1.8.1.1.3 - Presence of Magma Bodies in the Vicinity of the Site

The author proposes to rely mainly on interpretations of geophysical data to satisfy the objectives of this Activity. Geophysical data alone may not be sufficient to determine if there is a buried magma body in the vicinity of Yucca Mountain. There is considerable controversy related to the interpretation of deep geophysical anomalies because of the lack of experience in interpreting such data and the lack of knowledge of the physical properties of the crust beneath the Yucca Mountain area. Deep drilling and isotopic studies of deeply circulating water (as suggested in the Study Plan) may be required in addition to geophysical studies to achieve the objective of this Activity. The Activity should discuss alternative plans for identification of magma bodies if geophysical surveys prove less than satisfactory.

Since geophysical surveys are a form of remote sensing, the Activity should provide a detailed plan of confirmation studies should the presence of magma bodies be suggested. Such confirmation is important since the positive

identification of a magma body would have a significant impact on the results of the remainder of the Study Plan.

On page 15, the Study Plan states: "The geophysical data will be reviewed by a recognized consultant in geophysics who is not involved in the preclosure tectonics program." What criteria will be used to evaluate possible candidates and select the consultant? The statement implies that the consultant will be selected from contractors already involved in the Yucca Mountain Project. Credibility of the review would be greatly enhanced if the consultant was independent, with no past or present affiliation with the Yucca Mountain Project.

The SOBART project (Southern Great Basin Transect) (Born, et. al., 1991) has, as one of its objectives, the identification of magma bodies beneath Crater Flat, essentially the same objective as this Activity. How will the results of the SOBART project be integrated with this Activity?

<u>Activity 8.3.1.8.1.1.4 - Probability Calculation and Assessment</u>

This Activity has many flaws that could preclude finding a true answer to the probability of future disruption of the

repository by volcanic activity. The problems seriously endanger the validity of this Activity. These problems are:

1. Equation 2 (p. 30) is not suitable for the stated purpose. The Plan identifies Equation 2 as a conditional probability. It is not a conditional probability because there are no defined events.

2. Equation 3 (p. 31) requires restrictive and hierarchical model assumptions that are treated rather casually by the author. The author seems to be unnecessarily limiting himself in the choice of available statistical models to a simple Poisson model even before the completion of Activity 8.3.1.8.1.1.1 (Location and Timing of Volcanic Events).

3. The author claims that a probabilistic approach requires a random or exponential distribution of the data (p. 42). This is an erroneous claim. Data, even when random, can show an overall structure, temporally and/or spatially. Also, the author states that a uniform rate of activity is required for a stochastic approach (bottom of p. 42). A nonhomogeneous Poisson process is just one counter example where that statement is incorrect.

4. Given that the geologic repository must be safe for at least 10,000 years, the term "annual probability" (p. 32, 33, etc.) in volcanic risk assessment studies is erroneous. The term is correct if the projected life of the geologic repository is one year.

The Activity attempts to incorporate many different models to estimate the probability parameters. This will be a difficult task for which there is no integration plan or method developed for combining all the inputs from the different proposed models. The weighting system, by expert opinion (p. 40), is not well-defined. The proposed spreadsheet matrix (p. 40) is not a plan but an approach to assemble the data.

The proposed methods of estimating the recurrence rate parameter and the disruption parameter will almost certainly produce a wide range of results. If this is so, the proposed method of combining all the models into a spreadsheet which produces a combined probability distribution is questionable.

The reference list is incomplete relative to texts on statistics and probability theory. Appropriate and adequate references could eliminate many of the errors noted above and increase confidence in the validity of the study results.

SEQUENCE OF ACTIVITIES

There is a possibility that the sequence of events discussed in Section 5.0 could be seriously disrupted. The decision document to amend the Study Plan (if the magma body is detected) (p. 46) is prepared after all other activities in the Study Plan are conducted. If magma is found, all other activities are affected by the outcome of Activity 3. It appears that Activity 3 is the priority in this Study Plan. Therefore, a decision document to amend the Study Plan in the event of the presence of magma must be prepared as early as possible in the schedule, but certainly before any probability decisions are made. We would recommend Activities 1 and 3 be combined and a decision document be prepared based on results of Activities 1, 2, and 3.

REFERENCE LIST FOR STATE OF NEVADA COMMENTS

Born, D.J., Sass, J., and Schweickert, R., 1991, Death Valley-Yucca Flat Transect-Outline of Science Plan: Sandia Labs, Draft, 28 pp.

Fleck, R.J., Lanphere, M.A. and Turrin, B., Chronology of late Miocene to Quaternary volcanism and tectonism in the southwest Nevada Volcanic Field: Geological Society of America Abstracts with Programs, v. 23, no. 2, p. 25.

Naumann, T.R., Smith, E.I., and Shafiqullah, M., 1990, Post 6-Ma intermediate volcanism in the Reveille Range, Central Great Basin, Nevada: Geological Society of America, Abstracts with Programs, v. 22, no. 3, p. 72.

Smith, E.I., Feuerbach, D.L., Naumann, T.R. and Faulds, J.E., 1990, The area of most recent volcanism about Yucca Mountain, Nevada: Implications for volcanic risk assessment: in Proceedings of the International Nuclear Waste Symposium, v. 1, American Nuclear Society and American Society of Civil Engineers, p. 90-97.