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REVIEW COMMENTS
ON
DOE STUDY PLAN 8.3.1.8.1.1
PROBABILITY OF MAGMATIC DISRUPTION OF THE REPOSITORY

Prepared for
The U.S. Nuclear Regulatory Commission
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Reviewed by
Gerry L. Stirewalt and Stephen R. Young
Center for Nuclear Waste Regulatory Analyses

and

Bruce D. Marsh
Consultant

Prepared by
Gerry L. Stirewalt

Center for Nuclear Waste Regulatory Analyses
Arlington, Virginia

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CNWRA REVIEW OF DOE STUDY PLAN 8.3.1.8.1.1 ENTITLED "STUDY PLAN FOR PROBABILITY OF MAGMATIC DISRUPTION OF THE REPOSITORY"

The following comments resulted from an abbreviated technical review of DOE Study Plan 8.3.1.8.1.1 by CNWRA staff and a consultant to CNWRA. Center staff involved in the review were Mr. Stephen R. Young and Dr. Gerry L. Stirewalt. Dr. Bruce D. Marsh of Johns Hopkins University assisted with the review as a consulting specialist to CNWRA in the field of volcanology. This report, prepared by Stirewalt, is a compilation of comments from all three reviewers.

Conduct of the review of this study plan is consistent with activities defined for Task 1 (Prelicensing Activities), Subtask 1.2 (Review of DOE Study Plans) of the Geologic Setting Program Element in Section 3.4 of the CNWRA FY92-92 Operations Plan (Revision 1, Change 2, dated December 1991) for the NRC's Division of High-Level Waste Management. The review is also consistent with technical direction provided to CNWRA by the NRC which was within the cost, scope, and schedule for activities defined in Geologic Setting Program Element Subtask 1.2 of the CNWRA FY92-93 Operations Plan. This technical direction was approved by CNWRA and submitted to the NRC on December 5, 1991.

COMMENT #1

Statement of Concern: Title of Study Plan and Section 1.1, page 5, paragraphs 1 & 2 --- The title of the study plan does not indicate that silicic volcanism will not be considered, although this is inferred from line 6 of paragraph 1 which states that the evaluation will concentrate on future basaltic volcanic activity. Furthermore, in lines 7-11 of paragraph 2, the statement is made that final resolution of the potential for silicic volcanism awaits planned collection of additional data. However, no other details of this planned collection of additional data are included in this study plan, and there is no other study plan referenced to cover this activity.

Basis: It is not clear which study plan will address how additional data will be collected or analyses conducted to evaluate the potential for future silicic volcanism. The title of the study plan under review does not reflect the specific intent of the plan to concentrate on basaltic volcanism.

Recommendation: Consider explaining how evaluation of future silicic volcanism will be brought to final resolution, either by additional discussion or by reference to the appropriate study plan. Also, consider changing the title of the study plan under review to indicate it concentrates on basaltic magmatic disruption of the proposed repository.

COMMENT # 2

Statement of Concern: Section 1.1, page 5, last paragraph, last line --- The statement is made that pre-existing data from volcanic studies will be qualified to QA Level I as needed.

Basis: No statement is made about how this qualification of pre-existing data will be accomplished.

Recommendation: If a procedure exists for QA qualification of pre-existing data, then consider referencing this procedure in the study plan. If no procedure currently exists, then consider providing additional details on how this qualification of pre-existing data will be done.

COMMENT #3

Statement of Concern: Section 2.1.1, page 10, paragraph 2, lines 6-8 --- The statement is made that geochronological data will be accompanied by discussion of the precision, accuracy, advantages, and limitations of the analytical methods.

Basis: From the referenced statement, it is not clear whether uncertainties inherent in each of the different analytical age dating methods will be discussed in connection with the geochronological data base. The data may exhibit uncertainties (showing up, for example, as ranges in the determined ages) which are at least partially dependent upon the age-dating method used.

Recommendation: Consider including in the study plan a discussion of the inherent uncertainties for the different age dating methods. Since procedures exist for evaluating the inherent uncertainties for each method, during conduct of the work outlined in the study plan, consider reviewing age determination results against current standards and interlaboratory calibrations; analyzing uncertainties on a method-by-method basis; and comparing these uncertainties between the various methods so that differences in ages can be better understood.

COMMENT #4

Statement of Concern: Section 2.2, page 13, Table 1, Study 8.3.1.17.4.8 --- Reference is made to effects of the stress field at Yucca Mountain on location of Pliocene and Quaternary basaltic centers.

Basis: The local stress field caused by Basin and Range topography may influence where volcanic eruptions occur in the vicinity of Yucca Mountain. That is, lower valley areas may be favored over higher terrains for basaltic eruptions, if "topographically-induced" stresses steer surface fracture propagation away from the higher areas.

Recommendation: Consider including in the study plan an activity to compile data for determining if the suggested topographic effects may have occurred. If topographic effects do appear to have influenced location of volcanic events, consider setting up a numerical model to represent this "topographically-induced" stress field to allow analysis of fracture propagation through the stress field and assessment of the importance of topography on future volcanism.

COMMENT #5

Statement of Concern: Section 2.2.2, page 14, paragraph 1, lines 1-3 --- The statement is made that the uncertainty of the disruption parameter will be established "through the procedures for calculating the probability of magmatic disruption of the repository and the controlled area".

Section 3.2.2.1, page 20, paragraph 2, lines 4-6 --- The statement is made that values of the disruption parameter will be calculated for the structural models and model subsets.

Section 3.2.2.2, page 24, paragraph 3, lines 8-11 --- The statement is made that "various types of calculations may be used for the disruption parameter, dependent on the type of structural model proposed".

Section 3.2.2.4, page 28, paragraph 1, lines 11-12 --- The statement is made that the effect of various structural models on the disruption parameter will be examined.

Section 3.4.2.1, pages 30 & 31, Equations (2) & (3) --- The equations include disruption parameter E2 (Equation 2) and probability of disruption of the repository d (Equation 3). In the above citations under this comment, examples are cited where it is not clear how the effects of structural control on the disruption parameter will be examined or calculated.

Basis: No details are provided in the study plan to specify how uncertainty in the disruption parameter will be determined; how structural models will be taken into account in calculation of the disruption parameter; or how effects of structural control will be factored into the two referenced equations. The calculated disruption parameter will, in fact, apparently vary with the structural model used.

Recommendation: Consider clearly explaining how uncertainty in the disruption parameter will be determined; how the effect of structural models on the disruption parameter will be examined; and how effects of structural control will be factored into Equations (2) and (3).

COMMENT #6

Statement of Concern: Section 2.4.1, page 17, paragraph 3, lines 6-8 --- A statement is made regarding recommendations of 10 CFR Part 60.111 with respect to tectonic processes which are disposed toward probabilistic assessment.

Basis: While there may be logical reasons for applying a probabilistic approach to analysis of future volcanism, there is no specific mention in 10 CFR Part 60.111 of tectonic processes or probabilistic analyses.

Recommendation: Correctly state the section of 10 CFR Part 60 in which the stated recommendations are made.

COMMENT #7

Statement of Concern: Section 1.1, page 5, paragraph 3, line 16 and Section 2.4.1, page 17, paragraph 3, line 15 --- Reference is made to Crowe, 1990.

Basis: The reference is not included in the list of references in Section 6.0.

Recommendation: Add the missing reference to Section 6.0 as appropriate.

COMMENT #8

Statement of Concern: Section 2.4.1, page 17, paragraph 3, lines 18-19 --- Reference is made to "Pliocene and Quaternary Periods".

Basis: Pliocene refers to an epoch of geologic time, not a period.

Recommendation: Change the wording to refer to the Pliocene Epoch and the Quaternary Period.

COMMENT #9

Statement of Concern: Section 3.2.2.2, page 23, Figure 3 --- Yucca Mountain is located differently in Figure 3A than in Figures 3B and 3C.

Basis: If Yucca Mountain is incorrectly located in Figure 3A, the probability of disruption (Prd) calculation for the Figure 3A example may be rendered inaccurate.

Recommendation: Consider improving the quality of the plots shown in Figure 3, and check to determine if the location of Yucca Mountain in Figure 3A is incorrect. If so, values of Prd presented for this example in the text must be revised.

COMMENT #10

Statement of Concern: Section 3.2.2.2, pages 22-24 --- Three purportedly "deterministic" models are described which relate volcanism with structural control from (1) a northwest-trending regional structure for the Crater Flat Volcanic Zone; (2) a northwest-trending regional structure in combination with a northeast-trending local structural system for the Crater Flat Volcanic Zone; and (3) a northeast-trending structure for the Lathrop Wells Volcanic Center.

Basis: Since the three models appear to represent different interpretations of the same data, it may be more logical to refer to the models as conceptual, rather than deterministic, even if the approach for analyzing them is to be deterministic.

Recommendation: Consider labeling the models as conceptual at this stage of the effort, and explaining that they are based on alternative interpretations of the same data.

COMMENT #11

Statement of Concern: Section 3.2.2.2, page 25, Figure 4 --- The arcuate "splays" off the Bare Mountain Fault link Pliocene and Quaternary volcanic centers, and terminate at a volcanic center or a suspected center.

Basis: There is little description under Model 2 on page 24 to explain these arcuate "splays", and the question arises whether they are purely computational conveniences, or based on field evidence (e.g. - fault trace locations, or lines connecting volcanic centers of similar ages).

Recommendation: Consider providing additional information in the study plan to indicate how the character of the splays illustrated on Figure 4 will be used in assessing the probability of future volcanic activity at Yucca Mountain.

COMMENT #12

Statement of Concern: Section 3.2.2.4, page 29, paragraph 1, lines 2-3 --- The statement is made that the geologic record for the 18 past volcanic events demonstrates that future basaltic eruptions are unlikely at Yucca Mountain.

Basis: The referenced statement seems unwarranted, and possibly prejudgmental, in a study plan written to investigate the probability of volcanic events at Yucca Mountain.

Recommendation: Consider removing the referenced statement from the text of the study plan.

COMMENT #13

Statement of Concern: Section 3.3.1, page 29, paragraph 1, lines 1-3 --- The statement is made that the geophysical approach will be to first review existing geophysical data, with continued efforts dependent upon results of the review.

Basis: There is a concern because it may be difficult to detect a magma body at depth using regional geophysical survey methods. Detailed geophysical studies concentrated around Yucca Mountain in the Crater Flat area are more likely to reveal information than regional surveys.

Recommendation: Consider including as an activity to support this study plan the conduct of appropriate detailed geophysical surveys in the Crater Flat area .

COMMENT #14

Statement of Concern: Section 3.4.2.1, pages 30 & 31, Equations (2) & (3) --- In Equations (2) and (3) for expression of conditional probability, the probability of several events results in a multiplicative variable. It may be difficult to understand the specific geological factors in the physical model being exercised which have the greatest effect on increasing or decreasing the resulting probability.

Basis: Probability scenarios are sometimes hard to comprehend physically and conceptually because it may be difficult to determine all the geological factors which can increase or decrease the resulting probability. It should be considered important to understand the specific geological factors in the physical model being treated which are most sensitive to an increase or a decrease in the probability.

Recommendation: It is suggested that the study plan should clearly specify and treat the geological factors which can affect the probabilities calculated from the equations. Proper treatment may necessitate sensitivity analyses to assess the relative importance of each geological factor. There should be recognition of the fact that the geological factors are inextricably linked to each other.

COMMENT #15

Statement of Concern: Section 3.4.2.2, pages 33 and following, all paragraphs --- There is little discussion in the text concerning relationships between the various geological factors which will need to be used in the probability calculations.

Basis: The interaction of many of the geological variables may need to be considered in the probability calculations.

Recommendation: It may be worthwhile to constrain the geological variables to be used in the probabilistic analyses through consideration of how they may be linked in nature. This concept implies an interconnected network of geological processes. (For example, the intensity of interaction between magma and groundwater depends, among other things, upon effusive rate, style of magma transport, and nature of the wall rock.)

COMMENT #16

Statement of Concern: Section 3.4.2.2, page 35, paragraph 2, line 6 --- Reference is made to Shaw, 1984.

Basis: This reference, as stated, is not include in the list of references in Section 6.0.

Recommendation: Add this reference to the list of references in Section 6.0, or correct the date shown, as appropriate.

COMMENT #17

Statement of Concern: Section 3.4.2.2, page 36, paragraph 1, lines 16-17 --- The statement is made that "for a magmatic event to be significant, it must intrude the controlled area or disrupt the repository".

Basis: The quoted statement may be construed to ignore potential concerns about hydrothermal effects (e.g. - potential effects of additional heat from a magma outside the controlled area) and effects on ground water hydrology (e.g. - magma-induced changes in the water table outside the controlled area which may affect hydrology inside the controlled area).

Recommendation: Consider adding words to the study plan to indicate that potential effects on groundwater and hydrothermal effects resulting from intrusion of magma outside the controlled area will be taken into account.

COMMENT #18

Statement of Concern: Section 3.4.2.5, page 43, paragraph 1, lines 4-6 --- There is brief mention of using a stochastic/probabilistic approach in concert with deterministic methods for assessing risk, but no details are provided for how this may be done for the Yucca Mountain analyses.

Basis: Stochastic/probabilistic analyses are most useful when considering relatively large data sets. For such a data base as exists for volcanism at Yucca Mountain, it should prove useful, when possible, to dovetail these analyses with a deterministic approach as the study plan implies.

Recommendation: Effort should be made to meld probabilistic and deterministic approaches whenever possible. For example, a well-defined physical model of volcanism could be deterministic, and uncertainties and changes in the model could be evaluated probabilistically. Since the probabilistic analyses are to be iterative, the initial physical model could be relatively simple, and its complexity increased as new

data are acquired. In this manner, the physical model being used for probabilistic analyses can be as realistic as possible.

With this recommendation in mind, it may be considered useful and important to test a model by applying it to a similar, better-known, "analog" volcanic system and attempting to predict volcanic events which have occurred in the historical past. (For example, considering all historic cinder cone volcanism in North America, can the model be used to predict Paricutin?) In this manner, computational checks could be presented which could be verified against existing data and understood in terms of human history and experience.

COMMENT #19

Statement of Concern: Section 5.0, page 45, paragraph 3, lines 1-3 --- The "revised methodology" for probability calculations is to be developed.

Basis: Because all of the calculation methods were not presented in this study plan, some uncertainties exist about calculations to be used in the probabilistic assessments proposed in the plan.

Recommendation: Consider providing in the current study plan more information on the calculations to be used in the probabilistic assessments to clear up uncertainties about the calculations.

COMMENT #20

Statement of Concern: Section 6.0, page 50, Crowe & Carr (1980) reference --- The reference seems to be incorrect.

Basis: The correct reference for this open-file report is 80-357, and not 80-375 as shown.

Recommendation: Review the reference and make the appropriate change.