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NUCLEAR REGULATORY COMMISSION

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MEMORANDUM TO: Michael J. Bell, Branch Chief  
ENGB/DWM/NMSS

FROM: John Trapp, Senior Geologist *John Trapp*  
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ENGB/DWM/NMSS

THROUGH: David J. Brooks, Section Leader *David J. Brooks*  
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SUBJECT: TRIP REPORT: THE DEPARTMENT OF ENERGY EXPERT ELICITATION IN  
VOLCANISM AND APPENDIX 7 VISIT ON GEOPHYSICS

On December 5-6, 1995, Keith McConnell and I attended the fourth workshop sponsored by the Department of Energy (DOE) using expert elicitation to address the subject of volcanic probability. In addition, on December 7 we attended an Appendix 7 visit with DOE on the subject of the status of the DOE geophysical program. A summary of observations from both these interactions is provided below.

#### VOLCANISM EXPERT ELICITATION

The purpose of this workshop was for the experts to present and discuss the assessments that they had made regarding their evaluation of volcanic hazard at Yucca Mountain. Attachment 1 to this memorandum is the summary of the workshop. The detailed handouts are too numerous to attach, however, they can be viewed in John Trapp's office.

Due to budgetary activities which have occurred over the last few months, the Geomatrix staff was not as far along with the expert elicitation process as expected. This meeting was the first opportunity for the experts to ascertain how the information that they had provided the elicitors was transformed into probability numbers, therefore, they had not had time to determine if the results accurately represented their views. Of primary interest to the staff was Robert Young's presentation on the preliminary calculated results for the probabilities and sensitivities. Of particular importance was the observation that the spatial variables were more important than the time variables, and that the consideration of the site being within or outside of the source zone of high igneous activity was the most important variable. In addition, Geomatrix staff noted the mean value of each expert's input and the "relatively" small range in results. Although final judgment should be withheld until the final report is received, there are several conclusions that can be made which may need to be revisited in the future:

1. The source zones selected by the experts in general all appeared very similar and seemed quite close to the Crater Flat Volcanic Zone proposed by Crowe of Las Alamos National Laboratory (LANL).

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2. The experts generally consider Yucca Mountain to be outside the zone of high activity.
3. The experts generally believe there is some geologic separation between Crater Flat and Yucca Mountain.
4. When adjusted, the resultant probabilities were much lower than numbers presented in other reports, including previous DOE/LANL reports and reports prepared by Connor and Hill of the CNWRA.

During the period set aside for observers comments, John Trapp provided the following:

1. The Nuclear Regulatory Commission is in the process of finalizing its position of expert elicitation, and there is nothing in the position which would appear to be an obvious contradiction to what has been done during this elicitation. The staff would emphasize, however, the documentation, transparency, and ability to update all the results, as new information becomes available, is of extreme importance.
2. Although Geomatrix staff appear satisfied with the clustering of the means and the relatively small range in the experts' probability values, the staff is concerned that variation of the mean values is much smaller than has been noted in other elicitations that it is aware of and could be an indication of potential flaws in the elicitation process.

An outgrowth of this meeting is a concern that the results of this elicitation may not reflect the full range of viable geologic models and reflect descriptions of the geologic framework of Yucca Mountain that cannot be confirmed by geologic data. Furthermore, the models resulting from the elicitation differ from the models being used by DOE in the area of structure and tectonics. The final elicitation report should be reviewed in detail by the staff to determine whether these potential flaws persist.

#### APPENDIX 7 VISIT ON GEOPHYSICS

The purpose of the Appendix 7 visit on geophysics was to review the status of data available on geophysics with emphasis on data which directly applies to concerns in volcanology. Primary presenters of information included Tim Hawe/DOE and Ernie Majer/Lawrence Berkeley Laboratory. The list of attendees at this Appendix 7 is provided in Attachment 2.

The first grouping of data reviewed was the preliminary data forwarded to staff by on-site representatives in late November 1995. This is primarily site scale data and is available for review in either Harold Lefevre's office or John Trapp's office. The regional scale data consisted of the "final" interpretation of the deep seismic lines across Crater Flat and the regional gravity data with emphasis on the depth to Paleozoic basement. DOE had hoped to have the preliminary interpretation of the depth to crystalline basement from magnetic data also available for review, but the maps were not available at that time. The following general observations can be made:

1. DOE appears to have made significant progress in the area of geophysics. The information that was presented, in both site and regional scales, is quite pertinent for geologic, hydrologic, and engineering interpretations.
2. From a structural geology standpoint, Yucca Mountain appears to be part of the Crater Flat structural basin. This has implications to models used in assessing volcanic probability.
3. The seismic lines indicate a four-fold subdivision of the tectonic environment: 1) Bare Mountain; 2) the deep Crater Flat basin; 3) an area of "imbricate" faulting which extends under Yucca Mountain to either the Bow Ridge or Paintbrush Canyon fault systems (preferred DOE interpretation is the Bow Ridge); and 4) a generally featureless zone extending to the east end of the lines across Jackass Flat.
4. The depth to Paleozoic basement, as seen in the gravity models, suggests a model where the basin is structurally pinned to the north along the Timber Mountain Caldera boundary with east-west extension becoming more pronounced in a southerly direction.
5. Within the scales of the maps, all Quaternary volcanism is within the Crater Flat structural basin.
6. The subsurface characteristics for the area of the Lathrop Wells cone and the area of the repository site appear identical from the gravity data.
7. Neither the gravity data, nor the seismic data appears to support a differentiation in geologic conditions between Yucca Mountain and Crater Flat as has been suggested in the preferred models by the volcanism expert elicitation panel.

Although all the data should be available in final form in the DOE Geophysical Synthesis Report, we, with the cooperation of the on-site representatives, have obtained preliminary versions of the seismic lines and will obtain the gravity and magnetic maps when they become available. This appears to be key information for the volcanologists and structural geologists.

We believe this Appendix 7 visit was very productive, and substantial progress was made toward issue resolution. Although the number of participants was larger than would normally be expected at such a visit, DOE was well prepared to discuss all aspects of the data. Also, DOE's openness was a positive aspect of the visit and contributed greatly to the NRC understanding of site conditions. In addition, it would appear that if the upcoming synthesis reports contain both the synthesis and the basic data, then it should be possible to close many of the NRC open items in the area of geophysics.

Attachments: As stated

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Attachment 1

**SUMMARY**  
**WORKSHOP TO REVIEW PRELIMINARY ASSESSMENTS**  
**PROBABILISTIC VOLCANIC HAZARD ANALYSIS PROJECT**  
**YUCCA MOUNTAIN REGION, NEVADA**

December 5 and 6, 1995

Holiday Inn-Emerald Springs, Las Vegas, Nevada

The Workshop to Review Preliminary Assessments was the last of four workshops conducted for the Probabilistic Volcanic Hazard Analysis (PVHA) project, which is sponsored by the U.S. Department of Energy (DOE) and managed by Geomatrix Consultants. The purpose of this workshop was to allow the expert panel members to present and discuss their preliminary assessments used to evaluate volcanic hazard at Yucca Mountain. The preliminary hazard calculations also were presented, and the sensitivities in the various hazard models were discussed. The majority of the presentations by the expert panel focused on the spatial and temporal issues most important to the various hazard models. The discussion of hazard model sensitivity to various PVHA issues was an important aspect of this workshop, as it provided the experts with a framework for evaluating and revising their initial assessments.

Copies of some of the overhead transparencies shown during the course of the workshop are included with this summary, along with brief summaries of the speakers' technical presentations. The preliminary calculated annual probabilities of intersection with the proposed repository aggregated across all experts is included for completeness. However, the probability distributions for individual experts are not provided because these results were preliminary and are being revised.

**DAY 1 - TUESDAY, DECEMBER 5**

A welcome and introduction to the workshop was given by the PVHA project manager, Kevin Coppersmith of Geomatrix Consultants. In acknowledgement of new workshop observers, he briefly reviewed the members of the expert panel and the methodology development team (MDT), as well as the presenters from previous workshops. In addition,

he reviewed the workshop goals and ground rules, and discussed what has occurred since the last workshop held in May. The workshop agenda was shown, and a change noted to postpone discussion of preliminary calculated results until the afternoon.

Mel Kuntz (U.S. Geological Survey [USGS]) gave the first of four presentations pertaining to regional PVHA issues. He discussed the tectonic setting of Yucca Mountain, and the factors influencing the spatial occurrence of volcanism in the Yucca Mountain region (YMR) and the southwest Basin and Range in general. George Thompson (Stanford University) gave the next presentation, which focused on the structural controls of volcanism in the YMR. He discussed the crustal stress regime in the southwest Basin and Range, and the spatial characteristics of faulting and volcanism in the YMR. Rick Carlson (Carnegie Institute of Washington) gave the next presentation, which focused on the background source zone he considered as the region of interest in his hazard assessment. He discussed the primary factors controlling melt production in the YMR, and the applicability of the Amargosa Valley isotopic province (AVIP, defined by G. Yogodzinski in PVHA Workshop 3). R.V. Fisher (University of California, Santa Barbara) gave the final presentation on regional PVHA issues. He discussed his background source zones, pointing out that he considers the Quaternary volcanic fields in the YMR to be most relevant for assessing the background rate of volcanism at Yucca Mountain.

Following a short break, Kevin Coppersmith briefly discussed the criteria the experts considered in their definitions of a volcanic "event". Three presenters followed with discussions of their event definitions. Bill Hackett (WRH Associates) gave the first presentation, which drew largely on the analogy of volcanic events within the eastern Snake River Plain. Mike Sheridan (State University of New York, Buffalo) gave the next presentation on event definition. He discussed the various spatial, temporal, and geochemical aspects of an event, and pointed out that a definition should be based on available data for volcanism in the YMR and must be appropriate for the time scales considered for the hazard analysis. George Walker (University of Hawaii) gave the final presentation of the morning session. His presentation drew on numerous analogs, and he argued that observations

suggest volcanic events are short lived (i.e., on the order of 100 years).

The afternoon session began with a presentation by Bruce Crowe (Los Alamos National Laboratory), which focused on event "counts" at selected volcanic centers in the YMR. He noted that the uncertainty in the number of events at various centers is reflected by a large distribution of events. R.V. Fisher gave the next presentation, which was the first of three on spatial issues. He briefly described his spatial models, (field shape, spatial smoothing and zonation), which are based on observations of the basaltic volcanic fields in the YMR and southwest Basin and Range. Mike Sheridan gave the next presentation. He discussed the spatial aspects of his field shape and zonation models, which take into account observations of the basaltic volcanic fields in the YMR and the behavior of fields in analog regions. Mel Kuntz gave the final presentation on spatial models. He briefly reviewed his four alternative models (uniform, zonation, spatial smoothing and field shape), and discussed the geologic features he considered for defining his source zones.

The next three presentations focused on interpreted volcanic source zones. The first speaker was Alexander McBirney (University of Oregon), who presented his source zone map and discussed the types of geologic structures he identified and used to define his zones (e.g., extensional basins, faulted blocks of exposed bedrock, etc.). Wendeil Duffield (USGS) and Bill Hackett followed with brief presentations of their interpreted source zones, which are based principally on observed volcanic centers.

Bob Youngs (Geomatrix Consultants) gave the final presentation of the day. He described the three types of event calculations performed (i.e., a point event, a dike or dike set of random length centered on a point event, and a dike or dike set of random length randomly located on a point event), and discussed the preliminary hazard results based on each of the experts' assessments.

The session ended with short questions and comments from observers. Some of the comments and questions pertained to the spatial aspects of volcanism and faulting, the

significance of volcanic ashes revealed in trench exposures (i.e., the temporal relationship between faulting and volcanism), and the timeframe used for estimating volcanic hazard in the analysis.

## **DAY 2 - WEDNESDAY, DECEMBER 6**

A welcome to the second day of the workshop was given by Kevin Coppersmith, who announced that revisions to the day's agenda were going to be made to facilitate more discussion on the spatial and temporal issues most sensitive to the hazard results. Following this announcement, Bob Youngs presented and discussed the results of the sensitivity analysis. His analysis showed that spatial issues are more important to the volcanic hazard than are temporal issues. The important spatial issues include whether or not the site lies within a zone of high activity, the length of an event vs. distance to more active sources, the use of source zones vs. spatial smoothing, and smoothing distance factors. The temporal issues of importance include the event counts at a particular center, and the use of a homogeneous vs. a nonhomogeneous recurrence rate.

Following a short break, George Walker continued the presentations from the previous day on interpreted volcanic source zones. Based on his experience, he discussed an approach to defining source zones based on the thickness of underlying lithosphere, as well as the geometry and orientation of dikes and recurrent volcanism. Bruce Crowe gave the final presentation on source zones. He briefly reviewed his zones, and described the basis for the boundaries of his local Crater Flat source zone. Because of the proximity of Crater Flat to the proposed repository, his presentation prompted further discussion on the various structural/tectonic models of the Crater Flat basin, and in particular, the location of its eastern boundary. During this discussion, George Thompson reviewed the new USGS seismic reflection line across the basin and Yucca Mountain, and briefly described his interpretations of the Amargosa Valley aeromagnetic anomalies. The session concluded with a discussion on the ways of expressing the uncertainty in the location of the eastern Crater Flat boundary.

The afternoon session began with a continuation of the discussion on ways to express or capture uncertainty, led by Kevin Coppersmith. He presented each experts' weighted distribution of event counts at selected centers, their weighted distribution of spatial and temporal models, their weighted distribution of hidden event factors, their time periods of interest, and their weighted distribution of dike (event) lengths. George Walker then began a series of presentations on event geometries. He noted that data on dikes are relatively scarce, and that measured dike lengths are related to how much of the dike is exposed at the earth's surface. Bruce Crowe gave the next presentation. He discussed his dike length distribution, which is based primarily on dike exposures in southeast Crater Flat. He also discussed dike orientation and randomness in the regional stress field. Several members of the expert panel commented on their selected event lengths and orientations. Kevin Coppersmith urged the panel members to consider both the (aleatory) uncertainty in the length and orientation of the dikes within a volcanic field as well as the (epistemic) uncertainty in the length and orientation of events being defined for the PVHA.

Pete Morris (Applied Decision Analysis and MDT member) gave the next presentation, entitled "Aggregation of Expert Assessments". His presentation focused on a variety of topics, including the objective of aggregation, results of the elicitations, and conditions for equal weights; he also requested expert panel feedback on the elicitation and aggregation processes. Feedback comments from the expert panel highlighted the importance of the project field trips and training in estimating uncertainties. One suggestion for improving the elicitation process would be to perform an initial elicitation early in the project, to help the experts organize and focus their thoughts on the most relevant hazard issues.

Kevin Coppersmith led a final discussion regarding the schedule for the panel members to revise their elicitation judgements, and stressed the importance of thoroughly documenting the assessments. Carl Stepp (Woodward-Clyde Federal Services and MDT member) continued the discussion of documentation, stating that DOE might use the final document in the license application process. He pointed out that the documentation of the uncertainty of knowledge is critical, and that all data, hypotheses and alternatives, considered or not, need

to be documented.

The day ended with comments and questions from some of the observers. One comment was that the final report should be prepared for the scientific community (i.e., suitable for submission to a technical journal) as well as for the license application. The question of "what new data or discoveries could significantly change the experts' assessments" was put to the panel. A wide variety of answers, including the occurrence of an earthquake swarm near Yucca Mountain, and the identification of a Quaternary dike or a rhyolitic dome in the region were mentioned and briefly discussed.

Kevin Coppersmith concluded the workshop by thanking observers for attending, and by thanking the major PVHA project participants, including members of the expert panel, members of the MDT, and the DOE and Yucca Mountain Project M & O participants.

Attachment 2

DEC. 7, 1995

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