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APR 18 1984

Mr. O. L. Olson
Project Manager
Basalt Waste Isolation Project Office
U. S. Department of Energy
P. O. Box 550
Richland, WA 99352

Dear Mr. Olson:

Enclosed for your information are trip reports prepared by our contractors, Lawrence Livermore National Laboratory and Weston Geophysical Corporation, on the status workshop on BWIP geology held in Richland, Washington, on March 13-15, 1984.

If you have any questions, please call me at FTS 427-4674.

Sincerely

"ORIGINAL SIGNED BY"
Robert J. Wright
Repository Projects Branch
Division of Waste Management

Enclosures:
Trip reports as stated

cc: H. Miller
M. Knapp

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TRIP REPORT - HANFORD, WA, March 12-15, 1984

This is the trip report for the DOE/NRC Geology Workshop for the Basalt Waste Isolation Project (BWIP) at Richland, Washington, on March 13-15; 1984. Presentations by RHO first day included: (1) an introductory summary, (2) a tectonic characterization overview, (3) a lithologic characterization overview, (4) an overview of a performance assessment activity, and (5) a concluding summary. On the second day the group divided into two sub-groups. One group discussed geophysical methods, data, and results. The second group discussed concepts regarding the development and applications of tectonic models. Initially, this latter group was to review in more detail seismic and tectonic topics covered during overviews on the first day. Members of the LLNL group participated in this second group.

Discussion of the attributes, use, and purposes of tectonic models was a recurring topic during the three days. Unfortunately, the extensive discussion on this subject in the tectonic group the second day left little time for clarification of questions which arose during the overview presentations of the first day. Thus, some of the points mentioned later in this report might have been resolved had more discussion and clarification taken place.

The presentations were professional and well done. The notes suplied prior to the meeting were very helpful and continuation of this practice is urged. The BWIP people were open and showed a spirit of cooperation.

Review of the trip report from last year's workshop, April 12-15, 1983, reveals that a number of items have been addressed. However, some appear not to have been addressed and LLNL considers these to be open items. Items, or parts of items, which are open are: 1) tectonic rate, 2) resolution of tectonic vs non-tectonic models, 3) causative tectonic processes, 4) seismogenic structures, 5) design earthquakes and attenuation to the site, and 6) stress drop. We believe that, while not specifically addressed during this year's workshop, work is being done on many of these items. Item 7), drill samples, has been satisfactorily addressed. Item 8), direction of research at

RHO, has also been addressed. However, this is an area in which continued effort is required.

1. Tectonic Models

Despite extensive discussions of tectonic models the topic was left unresolved. However, the discussions did provide an opportunity for both RHO/DOE and NRC to exchange views and opinions, and may have provided RHO with some guidance. Given the uncertainties of geology, it is clear that a single all encompassing model probably cannot be developed. Instead, separate models may have to be developed that meet specific goals or objectives. Where more that one mode can be developed to address a specific goal or objective, the appropriate model should be the credible worst case model, and compatible with models developed for other specific goals.

The form the model(s), should or would take was also discussed. The appropriate model(s) may be conceptual, stochastic, or analytical, depending upon the goal. Whether the actual form of the model(s) is one or more of these will depend upon the information available. The more quantitative the available information is the less conceptual the model needs to be. If all aspects of the tectonics of the Pacific Northwest could be mathematically described, then a single analytical model would be appropriate. In general, models evolve from conceptual to stochastic to analytical. Currently, only small sub problems are amenable to analytical analysis. For example, the effects of ground motion on the surface facilities is amenable to calculation, at least approximately, but role of RAW in the regional tectonic can at best be modeled conceptually.

Another factor that needs recognition is the hierarchical nature and dependance of models. A tectonic model for the Yakama Fold Belt must be compatible with a tectonic model of the Columbia Plateau, which must be compatible with a regional model for the Pacific Northwest.

2. Tectonic Characterization/Tectonic Characterization Plan

Tectonic objectives 1 and 2 of the workshop notes imply a concentration of effort on the RRL and controlled area. During discussions the final day, RHO indicates that this was not the case, and that they would work beyond these areas. The amount and priority of such work would depend upon its significance to the RRL and the program objective.

3. Rattlesnake Hills - Wallula Gap Alignment - RAW

The tectonic character of RAW is still open to question. Several specific questions regarding RAW arose during discussions at the workshop. West of the RRL the gravity data shows a north-south gradient where RAW intersects the western edge of the Pasco Basin. An interpretation of this feature could allow 2-3 km post basalt right-oblique slip displacement. Interpretation of this feature will lead to a better understanding of the local tectonic conditions.

Also, the relationship between the Yakima Barricade structure and the RAW needs to be explored. The planned studies for definition of the Yakima Barricade seem reasonable.

Low level seismic activity in the south-southwest part of Rattlesnake Mountain is poorly resolved because of the number and location of existing seismic stations. The southwest dip of a reverse oblique fault, postulated for RAW, could place epicenters of events southwest of existing stations. Maps in ST-19p showed the area between Prosser and Yakima to be the site of a high density of epicenters. Better resolution of earthquake activity and development of focal plane mechanisms may be important in accurately defining the tectonic significance of RAW.

4. Seismic Impact

Study on the impact of seismicity on the stability of an underground repository appears to be making good progress. Some of the assumptions presented in the original SA-269-1 document were improved. Although this study has not yet been completed, the progress to date appears to be promising.

5. Swarm Earthquakes

Swarm earthquakes have occurred east and north of the RRL. Recent relocation of the epicenters suggest the earthquakes occur in a cylindrical zone extending from about 4 to 12 km in depth. It was suggested at the workshop that the swarms originated along the intersection of two vertical faults. The intrusion of magma was suggested as a credible explanation for swarm earthquakes in a paper by Hill, 1977*.

*Hill, D. P., 1977, A Model for Swarm Earthquakes; J.G.R. v. 82, n. 8, pp. 1347-1352.

6. Growth Rate

The growth rate of anticlinal structures, i.e. Saddle Mountain, Untanum Ridge, Yakima Ridge, and Rattlesnake Mountain, are based on thicknesses of basalt and interbeds, across the axis of the folds. Anticlinal growth rates have been measured on the Elephant Mountain basalt and older flows. The data indicate a decreasing growth rate with time for Saddle Mountain, which has received the most effort to data. Analysis of younger growth rates have been made on the Ringold formation on the Taunton Bench. These latter measurments show a zone of scatter, through which the curve between the basalt data and a point representing the present structural relief between Saddle Mountain and the Wahluke syncline passes, if continuous (non-episodic) growth is assumed. The Ringold data could also support a more rapid growth rate during that period, followed by a slower growth rate in the post Ringold to present time period. This could lead to the conclusion that the anticlinal growth is episodic in nature.

Interpretation of the Saddle Mountain structure will be published in the April issue of AGU's Tectonics. Publication in that journal allows a peer review of this work.

7. Pursuit of Hydrocarbon Exploration Well Data

The geological and geophysical data that could be gained from hydrocarbon wells in the Yakimam Fold Belt, such as the Shell Oil Company well in the Saddle Mountains and wells completed earlier, should be integrated with RHO/DOE studies. Securing the data from the holes should be pursued with vigor. Also, the opportunity for the wells to be reoccupied as magnetotelluric base stations should be investigated. This could enhance the information on deep geologic structures and provide a better basis for interpretation of magnetotelluric and other geophysical data.

8. Probabilistic Analysis

In the performance assessment item of the workshop notes, RHO identified: (1) 45 potential disruptive scenarios, (2) five probability of occurence categories, and (3) four families of disruptions. Using a Delphi methodology, and working with a panel of 15 experts RHO has performed an analysis of disruptive scenarios. The results of this analysis were presented. Some of these results need to be examined. Assumptions and uncertainties in the results need to be studied systematically. A formal review of the report

(which is in press) is strongly suggested. This is an important development that needs consideration and discussion at a later time, perhaps at a performance assessment workshop.

9. Geophysical Logs

Good quality borehole geophysical logs can provide information and constraints for both geological and geophysical models. The trace of the neutron-neutron log in DC-16c shows a correlation with the caliper log. To use this log to identify zones of higher porosity borehole enlargement effects must be considered.

10. Paleomagnetic Studies

The use of paleomagnetic techniques to assess past patterns of deformation appears to be a promising method. For an understanding of significance of the paleomagnetic data a comprehensive interpretation is needed. Such an interpretation should point out the significant lineaments that exist on the map, the boundaries between areas of different magnetic character, and other features. This will provide a framework for the analysis of individual anomalies. The results of this study shortly will be published in a peer reviewed journal.

Our recommendations for RNO/NRC include the following:

1. Tectonic Model

The necessary purposes and/or goals of tectonic, geologic and geophysical models need to be resolved or established. Models need to be consistent in a hierarchical sense with other models as well as the data specific to those models. Choice between equally valid models should be made on the basis of a credible worse case model.

2. Tectonic Characterization/Tectonic Characterization Plan

These appear to be under way and should be consistent with the goals and objectives developed for tectonic models. External reviews of the plant will result in a stronger, more intergrated plan.

3. RAW

RAW is believed to be the closest major structural feature to the RRL.

As such, significant effort need to go into characterizing it, understanding its origin and potential effects on the RRL. Areas of investigation should should at least include: (1) the N-S striking gravity gradient at the border of the Pasco Basin and RAW, (2) the seismicity along RAW, with attempts to more accurately locate epicenters and determine local mechanisms, (3) to determine if the Yakima Barricade structure is related to RAW, and, (4) the relationship of RAW to the Yakima fold belt.

4. Seismic Impact

As noted above, progress to data appears to be promising and no additional recommendation, over those made last year, appear necessary at this time.

5. Swarm Earthquakes

We recommend that alternate interpretations of this phenomenon be developed and evaluated. Interpretations other than earthquakes at the intersection of two vertical faults need be considered.

6. Growth Rate

Much of the effort in this area has concentrated on Saddle Mountain. Expansion of this project to a regional scale is recommended. Analysis, evaluation, and credibility of the data in terms of episodic growth is also recommended. Some folds are known to be overthrust. Horizontal deformation resulting in thurst fault displacement is not considered in the vertical fold growth rate analysis used to determine horizontal compression rates and a time-rate history. A definition of the geometry and displacment history of these faults is recommended and tectonic rates should accommodate this data.

7. Pursuit of Hydrocarbon Exploration Well Data

We recommend RHO actively pursue the acquisition of geological and geophysical data from hydrocarbon wells in the area of interest. These are unique opportunities which will help RHO develop better geophysical models which will lead to a better tectonic characterization and model(s).

8. Probabilistic Analysis

In light of some of the concerns which arose in discussion of the Delphi Study we suggest: (1) a formal review of the report and (2) subsequent discussion at a performance assessment work shop.

9. Geophysical Logs

We recommend a review of the procedures and application of geophysical borehole logs at a future workshop. LLNL has agreed to supply papers on geophysical logging with special reference to the γγ density log and the epithermal neutron log.

10. Paleomagnetic Studies

These seem to be proceeding in a professional and satisfactory manner. Paleomagnetic work should be completed to define the size of the individual structural domains which are implied by the present data.