DEPARTMENT OF THE ARMY
SEATTLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX C-3755
SEATTLE, WASHINGTON 98124

REPLY TO ATTENTION OF

NPSEN-FM

SUBJECT: Basalt Waste Isolation Project (BWIP), Hanford, Washington; Geology and Geologic Stability Workshop, April 1983

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P. PRESTHOLT
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THRU: Commander, North Pacific Division

TO: Nuclear Regulatory Commission
Washington, D.C. 20555

1. Reference Interagency Agreement (IA) No. NRC-02-81-036 dated 7 June 1981 and Task Order No. 10 dated 31 March 1983. Attached are findings and comments by Mr. Richard Galster, Chief of our Geology Section, resulting from his participation in the subject workshop.

2. This workshop provided the first real examination of detailed field data obtained in the Reference Repository Location (RRL) coupled with a close interchange with the contractor staff regarding the investigation for licensing of a repository. We are impressed with the high caliber of contractor staff investigators.

3. With respect to work being accomplished for site characterization, we offer the following:

a. Some improvement is possible in general exploratory boring procedures and quality control to ensure maximum recovery and utilization of data.

b. The subsurface exploration completed or programmed probably is not adequate to properly characterize the site.

c. Improved coordination between surface and subsurface investigators would be beneficial to both.

d. Further analysis and explanation of core stress effects (disking) is required.

4. With respect to work being accomplished for geologic stability evaluation, we offer the following:

a. Investigations of structure of superbasalt sediments should be accelerated from the standpoint of understanding geologic structure within the Cold Creek Syncline.

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b. A comprehensive regional structure/tectonic map is required as the first step in regional geologic stability.

c. Investigation of geologic structure and tectonics well outside the Pasco Basin is required to understand the near field tectonic setting.

5. A general suggested procedure for analysis of geologic stability is included in the attached comments. We would be pleased to assist the project staff in any way to implement such procedures. We have informally furnished the Rockwell staff with some procedures which may assist them in maximizing the use of borehole data. We continue to be concerned, however, about the apparent separation of the geologic and hydrologic studies and would highly recommend that closer coordination between them is essential to a successful understanding of subsurface structural and groundwater conditions.

6. We appreciate the opportunity of assisting the Commission in this workshop and in the review of this important project.

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Comments on Basalt Waste Isolation Project (BWIP), Geology and Geologic Stability Workshop, Richland, Washington, 11-15 April 1983.

1. General.

a. Under the provisions of Interagency Agreement (IA) NRC-02-81-036 and Tasking Order No. 10 dated March 31, 1983, the undersigned participated in the subject workshop as consultant to the participating staff of the Nuclear Regulatory Commisssion (NRC). Other non-NRC members of the team were Robert D. Munson; U.S. Bureau of Mines, Denver Mining Research Center, Dae H. Chung; Lawrence Livermore National Laboratory (LLNL), and D. B. Slemmons of University of Nevada, Reno, under contract to LLNL.

b. The workshop considered two basic questions: the geologic characteristics of the Reference Repository Location (RRL) and the general regional geologic stability in terms of regional tectonics and seismicity. Several days prior to the workshop, a draft of RHO-BW-ST-19 entitled "Preliminary Interpretation of the Tectonic Stability of the Reference Repository Location, Cold Creek Syncline, Hanford Site" had been furnished for information, but there had been little opportunity for review prior to the workshop. In addition, the geology portion of the NRC's Site Characterization Assessment (SCA) had been furnished. This document presented NRC's analysis of the geology and geologic stability portions of the Site Characterization Report (SCR) which we reviewed and commented upon in November/December 1982.

c. The workshop included time for close interchange between the NRC staff, their consultants, and the Rockwell Hanford Operations (RHO) staff and management. This interchange was appreciated and I was impressed with the technical competence and dedication of the geology, seismology, and geophysics staff. The basic elements for the workshop consisted of review of geologic logs, photos and core of subsurface exploration within the RRL, staff presentations on status of various phases of geologic investigation, plans for additional investigation, an overflight of major regional tectonic features, field examination of exposed basalt flow structures and breccias including discussion of their significance to the RRL. Discussion of the geohydrology was not a part of this workshop.

d. Critical issues identified during this workshop are summarized with comments in succeeding paragraphs.

2. Site Characterization.

a. Data Reviewed.

(1) Findings: RHO provided field logs, shift reports, geomechanical logs and photos of core for three borings, RRLs 2, 6, and 14, for review. Field logs are at a scale of 1 inch equals 10 feet and included lithologic

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descriptions, identification of areas of mud circulation loss, core loss, core recovery and rock quality designation (RQD). Details of rock fractures had been tabulated on computer form sheets separate from field logs. Core photos provided were generally of good quality though photography had evidently been accomplished after the core containers had been transported and the resulting core derangement had not been entirely repaired prior to photography.

(2) Comment:

(a) While the details of data obtained by the drilling program are available, they are not available in a format which would facilitate study and analysis. It would be helpful to have all data on drilling history, rock lithology, geologic structure and geohydrology on a single log form so that relationships between the various features can be easily ascertained. A scale of 1 inch equals 2 feet would be appropriate, at least for boring segments below the top of the Grande Ronde. The next step would involve a synthesis of the data, most logically at a scale of 1 inch equals 10 feet.

(b) It is important to photograph core in its final container before significant transport is done or any samples removed for laboratory analysis. It should be standard practice to mark zones of sample removal in the core container using appropriate blocks.

(c) There is some inconsistency in lithologic description and real meaning of certain terms used on the logs. Further, based on a spot check, there appeared to be some inconsistencies between the core and the geomechanical data sheets. Further efforts in quality control are warranted.

(d) The measuring of the core and recording of recovery is not consistent with normal engineering geology practice. While the core is measured while it lays in the half-round containment inner tube, stubs from previous runs are not determined nor marked. Thus, it becomes difficult to accurately determine the precise location and amount of core loss and there are core recoveries in excess of 100 percent frequently noted on the logs.

(e) Of concern to the NRC staff was 11.5 feet of core loss experienced in RRL-2 at depth of 3,773 to 3,792 feet in rock described as dense basalt. RHO's explanation of this loss involves the use of incompatible drilling bits and the mechanical grinding and washing out of core. While the mechanical loss may indeed be the appropriate explanation, it probably could only have occurred where the core was already subject to closely spaced disking, not in "solid" basalt in an engineering geology sense. Were the incompatibility of the bit and sleeve such as to permit the inner tube to ride on the bit flange, the core barrel would act as a single tube and grinding of poor core might be expected.

(f) Field geological studies relating to intraflow structure have been and continue to be accomplished. As important as these studies are to the understanding of anticipated geologic conditions in the RRL, it is equally important that persons charged with logging core and interpreting core logs

are as knowledgeable in these areas as the field investigators. While both the field investigations and the borehole site characterization work are being carried out by obviously competent professionals, staff training and professional sharing sessions would be helpful in eliminating the few inconsistencies in logging of core and to keep all technical personnel updated on various discoveries in the several interrelated phases of the investigation.

b. Repository Horizons.

(1) Findings: Three distinct basalt flow units within the Grande Ronde Basalt (GR) are presently being considered as host rock for the nuclear repository; the Cohassett flow (GR-4), the McCoy Canyon flow (GR-8) and the Umtanum (GR-9). Though the various flow contacts within the Grande Ronde identified in the observed core are generally welded, several highly diverse types of material occur in each flow including generally welded, but vuggy and vesicular flow breccia in the upper portions of the flow units generally in sharp contact with the denser basalt in the interior and lower portions. Locally, the dense zones are vesicular. One critical item in the flow interiors is what appears to be stress relief features in the form of poker-chip core disking. The reasons for some zones producing disking and some not has not been explained, but does require explanation in order to appreciate their engineering geology significance. The flow top breccias appear to be the principal zones of drilling fluid loss though the initial observed loss is not always at the same strategraphic horizon in adjacent borings. For example, in RRL-2, no fluid return was observed below the brecciated upper part of GR-5 whereas in RRL-6, a 20% loss was noted in the top of GR-8 (McCoy Canyon flow) with 45-90% loss in the Umtanum. In RRL-14 significant fluid losses were experienced in the Cohassett (GR-4) and in GR-5 with total fluid loss within the top of GR-6. Present drilling practice within the Grande Ronde is not to cement off a zone of fluid loss before continuing to drill deeper. While there is some general stratigraphic correlation in these flows between the three borings reviewed, which are up to 1.5 miles apart, there are significant variations in geologic detail of engineering significance.

(2) Comment:

(a) An important question which must be addressed in site characterization is the reasons for disking vs. nondisking of drill core in adjacent zones in brittle basalt at repository depths. While the in-situ stress conditions appear to be the cause of disking, similar ambient stress conditions should be influencing the nondisked core as well.

(b) While one or two additional borings are alluded to in connection with repository characterization, no general plan of exploration for site characterization appears to have been formulated. Data needed for licensing must be sufficient to detail the engineering characteristics of the rock, geohyrodrology and to have reasonable assurance of the location and character of discontinuities throughout the RRL. The inconsistencies of drilling field

loss, core loss, and thickness and correlation lithologic units at depth which have been experienced in the few borings drilled demand that a number of additional boring to and below repository depth will be required to property characterize geologic conditions. It would be appropriate to submit such a plan for NRC and consultant review and comment.

3. Geologic Stability.

a. Near Field.

(1) Findings:

(a) Near-field stability refers to the geologic stability of the RRL itself, but perhaps it should be extended to include the nearby geologic structures which could influence the stability of the repository or influence the ground water flow to and away from it. Staff presentations revealed several investigations relating to near-field geologic stability. These include interrelated studies of existing shallow borehole data in Ringold sediments and seismic refraction anomalies, close-spaced gravity studies, borehole density studies and ground and aerial magnetometer studies. Identification of two "linears"; Nancy and Juniper Springs, trending northeast west of Gable Mountain was discussed together with a geophysically defined feature trending north-south through the Yakima Baracade. This latter feature is believed related to the major hydrologic barrier identified in this area. The north south trending feature has been identified geophysically as a reverse fault dipping steeply west, or a monocline. Structural relief is on the order of 500 feet. RHO has plans for ground geophysical investigations to determine the southward extension of this feature.

(b) RHO presented plans for seismic monitoring in the RRL area to be implemental within a year. These consist of a series of nine borehole seismometers installed in the uppermost basalt flow (Elephant Mountain) and one seismometer to be installed at repository depth. The existing UW/RHO seismic array is only sensitive to magnitude 1.0 or greater events with a location accuracy of 1 to 2 km. The newly programmed system is expected to be sensitive to events of magnitude 0.2 with a location accuracy of 50 to 100 meters. The purpose of the new system is to monitor contemporary microseismic activity to compare with changes which may be experienced after a repository is opened.

(c) A recent (December 1982) in-house report entitled "The Impact of Seismicity on the Stability of an Underground Repository" is serving as a base for seismic design. The paper notes that there appears to be little problem with seismic vibration until seismic velocities reach between 25 and 50 cm/sec. The document appears to be an important element in guiding future design concepts, but has never been published or reviewed.

(2) Comment:

(a) Investigation of the important N-S structural feature and the northeast trending "linears" should be accelerated with the geophysical work

ultimately confirmed by appropriate borings. The investigation on identification of possible structural discontinuities in the Ringold sediments in the near in-field should also be accelerated and a plan developed to confirm by appropriate borings. Such confirmation will ultimately need to be carried deep into the basalt.

(b) Plans for seismic instrumentation in the near field appear well founded and should be adequate for the purpose intended. Such an array may also identify more accurately the position and character of microseismic swarms.

(c) The in-house report referenced in paragraph 3 a (1)(c) should probably be subjected to peer review similar to other status reports published by RHO.

b. Far Field.

(1) Findings:

(a) A volumious amount of material has been written by many investigators on regional structure and tectonics of this region. The present status is summarized by RHO in ST-19 (draft) "Preliminary Interpretation of the Tectonic Stability of the Reference Repository Location, Cold Creek Syncline Hanford Site." The draft furnished did not include a referenced regional tectonic map. The project has maintained heavy emphasis on understanding subbasalt structure in the expanded near field, i.e., Pasco Basin, through sophisticated geophysical techniques. This emphasis is carried through in seismic and strain rate data being developed though data has also been developed in the area south and east of the Pasco Basin. General consideration is being given to the historic and contemporary relationship between the plateau and the plate boundary. A review of a number of proposed historic/contemporary tectonic models is being made.

(b) The RHO staff informally requested guidance on seismotectonic assessment from the NRC and its consultants.

(2) Comments:

(a) A comprehensive structural/tectonic map is necessary prior to meaningful consideration of far-field geologic stability. It is important that such a map consider a large area peripheral to the Columbia Plateau, especially to the south and west. In addition, the details of the regional structure between the plateau, the plate boundary to the west and the Basin-Range Province to the south require examination in terms of establishing the historic contemporary model with which all available data agrees. This will require map, imagery and field examination perhaps far removed from the Pasco Basin in order to understand the contemporary tectonic forces which may be expected to influence the Pasco Basin during the life of the repository. This further requires a sorting out of structures, over a very broad area, recognizing those which were important during the historic, (Tertiary) tectonic process from

those which have contemporary importance. The study of a much larger area than is presently under consideration is required.

(b) Because of the short period of seismic record available for analysis, the geologic stability must rely heavily on tectonic analysis of the Neogene geologic record. The present state-of-the-art for earthquake assessment permits this emphasis on tectonics. We would suggest the following general steps:

- o Compile a detailed regional structural/tectonic map for Washington, Oregon, and adjacent areas of Idaho.
- o Analyze Neogene structural patterns, including necessary imagery and field examination of critical structures with other investigators as appropriate. Emphasize structures of late Neogene displacement both documented and suspected.
- o Incorporate regional geophysical data (magnetic rotation, fault plane solutions, regional stress measurements, etc.) into analysis.
- o Select and test the most appropriate historic/contemporary model given the contemporary stress field and relationships to the stress source.
- o From the geologic record, determine rates of Neogene crustal motion manifest in larger structures. This will then provide guidance in the selection of probable seismogenic structures which should be considered during the life of the repository.
- o Using one or more of several possible methods of analysis determine maximum credible events and anticipated motions for seismogenic structures in the region within and some distance beyond the Pasco Basin.
- o Using appropriate crustal velocity models, attenuate motions to the site for design purposes.

It is very important that the staff charged with the responsibility of tectonic stability are in frequent contact with other investigators. While some of this can be through the technical literature, it is often difficult to keep current from the literature alone. Personal discussion with other investigators at technical meetings and in the field is essential for the staff to accomplish the necessary work and keep current on geological activities of others. Close cooperation between all investigators could result in considerable financial savings to the project.

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