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31 OCT 1983

NPSEN-FM

SUBJECT: Basalt Waste Isolation Program (BWIP), Hanford, Washington, Review of RHO-BW-ST-19P

THRU: Commander, North Pacific Division
ATTN: NPDEN-GS

TO: Nuclear Regulatory Commission
ATTN: Division of Waste Management
Washington, D.C. 20555

1. Reference Interagency Agreement No. NRC-02-81-036 and Task Order No. 10 dated 31 March 1983. As requested by Letter No. 26, dated 1 September 1983, we have reviewed the subject document entitled "Preliminary Interpretation of the Tectonic Stability of the Reference Repository Location, Cold Creek Syncline, Hanford Site." A change of completion date to 31 October 1983 was coordinated between Mr. Paul Prestholt (Nuclear Regulatory Commission) and Mr. Richard Galster (Corps of Engineers). General comments are included in subsequent paragraphs. Specific comments generated by our geology staff are attached.

2. We appreciate the emphasis placed on "preliminary" assessment and the great amount of effort involved to bring the studies to this point. The purpose of this report is to predict whether or not there will be tectonic stability in the area of the Reference Repository Location, and as such, a complete, correct, and well identified compilation of regional structure needs to be presented. The maps included in the report are not inclusive of the present status of structural mapping and many of the structural elements mentioned in the text remain unidentified on the maps. An all-inclusive structure map to include general lithologies and the relationship between structures in the basalt and structures marginal to the basalt plateau is needed.

3. The geophysical data presented provides a significant contribution toward understanding the configuration of deeper crustal layers beneath the Pasco Basin. However, the area covered by the present geophysical data is restricted and coverage over a broader area may be necessary to provide an adequate understanding of the region for the assessment required by 10 CFR 60.

4. The tie between the tectonics of the Pasco Basin region and the plate boundary is not adequately established. Too much is included by reference to other workers' concepts without a clear-cut statement of supportive data.

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BWIP should formulate a tectonic model which considers all existing data and clearly establishes the relationship (or lack of it) between the local and regional tectonics and the local and regional seismicity.

5. The rate of past regional deformation and its relationship to contemporary and future deformation appears subject to question. The determination of strain rates appear relatively well founded for Wanapum and Saddle Mountains time, though some argument can be made for episodic deformation, but data are not presented for the evidence of deformation rates from post-basalt sediments. It is essential that data from the Pliocene/Pleistocene sedimentary section be evaluated for evidence of episodic deformation. Averaging the strain rates over the past 10 million years without intermediate points does not provide an appropriate basis for assessment of contemporary or future strain. It is very possible that strain rates which are higher or lower than the average are applicable.

6. In summary, we believe this document is a very good beginning, but sufficient evidence to support the report's conclusion that tectonic stablility can be reasonably expected over the next 100,000 years is lacking and additional work is required.

7. We appreciate the opportunity to review this important status document and trust our comments will be of assistance to the Commission in its evaluation of the proposed repository.

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Dwain F. Hoyan

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RHO-BW-ST-19P
PRELIMINARY INTERPRETATION OF THE TECTONIC
STABILITY OF THE REFERENCE REPOSITORY LOCATION,
COLD CREEK SYNCLINE,
HANFORD SITE

REVIEW COMMENTS

1. Chapter 1 - Rationale and Approach.

a. (P. 1-6). It is important in the strategy for the tectonic studies to establish the tectonic model in which all available data are considered.

2. Chapter 2 - Geologic Summary.

a. (Plates 2-1, 2-2). Neither plate is well labled in terms of named, mapped structures. A number of strucures mentioned in the text are not identified.

b. (Plate 2-1). Plate would benefit by delineation of general lithologic units such as Columbia River basalt, granites, and other older rocks, post-basalt Cascade volcanics and postbasalt sediments. This would permit immediate understanding of structure patterns which characterize the basalt and those typical of the margins.

c. (P. 2-1). Columbia Plateau is not on the western margin of North American plate but rather near it.

d. (P. 2-1). Tense of subduction of Farallon plate is incorrect.

e. (P. 2-11). Referring to the Columbia Plateau as an area of "low" seismicity does not seem consistant with figures 2-8 and 2-9. Needs to be compared to something.

f. (P. 2-17) Plate 2-1 does not show the system of northeast trending faults (included in Hite System) extending southwest to Prineville, Oregon, as indicated in the text. The Hite System appears to be constrained north of the Blue Mountains Anticline.

g. (P. 2-15/16). Discussion of the somewhat anomalous structure of south of the Yakima Fold Belt (Umatilla Basin) is probably warranted in this summary section.

h. (P. 2-21). John Day Fault shown on plate 3-1 as a normal fault. Text indicates that it is a reverse fault formed under north-south compression.

i. (P. 2-23). Geomorphic evidence of recent movement along the CLEW has indeed been observed. Toe of Rattlesnake Mountain and along Wallula Fault Zone are examples.

3. Chapter 3 - Regional Geologic Setting.

a. (Plate 3-1). The Generalized Geological Map illustrates lithologics but is incomplete with respect to general structures. It is unfortunate that all major structures, Blue Mountain anticline, Columbia Hills anticline, OWL-CLEW zone, Hope Fault, etc. are not shown and labeled on the map. It appears that the Columbia Plateau is void of structure in areas where large structures exist. The heavy (boldface) emphasis on the Aldrich Mountain Anticline and John Day fault is not clear. They do not appear to figure so prominently in the text discussion. There appears to be inconsistency in labeling as to importance. All first order structures should be shown and labeled. Map does not identify the entire Purcell Trench nor is the Lewis and Clark Line identified. Some map designations are incorrect, for example, the region east of the Purcell Trench (East of Pend Oreille and Coeur d'Alene) is labeled as pGm, high grade metamorphic rocks, when actually they are all low grade metasediments (Belt). The La Grande graben is not well defined on map.

b. (P. 3-6) Cheney Fault Zone may also be tension fractures over a buried granite hill beneath the lavas. The zone does not particularly line up well with structures east of the plateau.

c. (P. 3-10 to 3-12). Summary should include a reiteration of the Olympic Wallowa Lineament (OWL) which is manifest across the center of the Columbia Plateau. This feature is a major element in the regional structure. It is mentioned in the text of this chapter in connection with the Cascades, but its cleavage across the entire central plateau is ignored.

4. Chapter 4 - Pre-Columbia River Basalt.

a. The geophysical data analysis presented for a substantial part of the Pasco Basin on figures 4-2 through 4-7 appear to be excellent insofar as they have gone. Stratigraphic identification appears reasonable. It would be appropriate, however, to obtain and interpret such data over a broader area in order to establish more significant trends in the deeper geoelectric layers. The restricted area covered may be one reason for the lack of significant trends in the basement layer.

b. (P. 4-1). The logic relating to the relative importance of deep versus surface structures is questioned. If surface structure is an expression of deep structure, one cannot infer stability from analysis of surface structure only. Deep structure must also be considered. For example, from surface structural expression, one can calculate length of fault deriving magnitude estimates; if deep structures are included, seismic moment estimates are possible (using fault plane area) and more realistic magnitudes can be derived from moment.

c. (P. 4-2). Summary presentation of geophysical resuts, albiet "qualitative," makes it impossible to evaluate the certainty of the data presented without supporting preliminary steps. The crux of the analysis is the inversion of magnetotelluric anomalies, but not one of the 44 stations is presented

even in final form. In the manner presented, all that is possible to evaluate are the conclusions drawn from the presented contours - an evaluation of the logic and not of the results.

d. (P. 4-11). The policy of contouring geophysical data without regard to observed surface geology or even geologic interpretation is contrary to steps 1 and 2 of the six step approach (page 4-1). Contour maps should also display discrete values at their location on the map. This allows for evaluation of possible range of contouring patterns. This is important, especially considering the evaluation of contours with surface structures that follows.

e. (P. 4-11). Central Pasco Basin Stratigraphy; "wide acceptance" of one-dimensional inversion as a first approximation should be justified with at least two references.

f. (P. 4-12). Discussion of layer 4, (and figure 4-6) at -20,000 feet is difficult to evaluate without the magnetotelluric inversons. While we are not familiar with the inversion algorithim used, general inverse theory indicated that a distribution function of the depth estimate can be obtained. The spread would also be of benefit in interpretation.

g. (P. 4-13 and 4-17). Because of the relatively limited area covered by geophysical investigation it probably is inappropriate to make any statement about the lack of dominant structural trends in the basement (geoelectric layer 4). It is important to note, however, that the steepest geoelectric gradients are more or less coincidental with the OWL.

h. It would be helpful to show the RRL on figures 4-2 through 4-7.

i. (P. 4-16). The reference to plate 3-1 relating to "little surficial structural deformation" is inappropriate as nearly all of the Columbia Plateau structure is omitted from the plate. Plate 2-1 would be a more appropriate reference.

j. BWIP have apparently extracted as much from the magnetotelluric data as possible in simple analysis. However, inverse theory has more power in it than has been utilized. Data presentation needs refinement for practical review. Considerably better use should be made of the gravity data including application of terrain corrections, modeling of data using 2-D FFT methods, filtering, and generating surface gravity anomaly maps for their model of four layers and comparing with observed gravity. Isostatic anomaly maps may also be useful. With respect to magnetic data, there is no indication that magnetic polar reversals have been taken into account on the intensity map interpretation. Interpretation would also be improved by generation of magnetic anomaly map for comparison.

k. (P. 4-17). The statement that a through going northwest-southeast feature along the CLEW at the base or below the volcanics has not been detected appears premature. A case can be made for major changes in both geoelectric layers three and four in terms of gradients along or on either side

of the CLEW. Additional data are needed over a greater area before definative statements can be made. There is ample evidence elsewhere to indicate the antiquity of the OWL and its CLEW component. The presence of steep gradients and interpreted rapid changes in topography of the several geoelectric layers along the OWL is what one might expect in a major zone of deformation. The region covered by the data is inadequate to make the statement that the CLEW in the Pasco Basin is not a function of major continuous basement structures. Needs to be viewed from a broader perspective.

5. Chapter 5 - Strain Rates.

a. (P. 5-18). The model suggesting that deformation has been continuous since Miocene is not well supported and needs to be spelled out, since it is an important deduction. The decline in rate of basin subsidence and anticlinal growth appears to be somewhat sudden and coincident with the end of Wanapum time rather than late Grande Ronde time as indicated. The rate of growth during Grande Ronde time appears uncertain and is not well documented. The subsidence of the Pasco Basin is shown on figure 5-7 as about 20 m/m.y. rather than 40 m/m.y. as indicated in the summary. It is essential that changes in deformation rates for the last 10 million years be developed. Any type of pulsating strain rates could influence tectonic projection.

b. (Figures 5-5 and 5-7). The extrapolation of uplift and subsidence rates from late Saddle Mountains time to the present overlooks a data hiatus of 10 million years. The straight line implies a low level of tectonic creep which may be misleading. Suggest captions explaining what the data points are and how they were obtained.

6. Chapter 6 - Contemporary Deformation.

a. (P. 6-1). The projection from the 4m.y. period in which the deformation rate apparently changed to the present is not an appropriate projection. If the deformation rate change took place at the close of the Wanapum time as the graphs indicate, the three Saddle Mountain points between 10 and 13.6 m.y.bp are not projected to the present as much as they are simply connected without benefit of intermediate data.

b. (P. 6-7). An analysis should be made of any logical spatial/temporal progression of swarm activity.

c. (P. 6-7, 6-12 and Figure 6-3). Concentrations of shallow, non-swarm seismicity in the Horse Heaven Hills (Prosser-Richland segment), near the intersection of this segment with the CLEW, and along the CLEW south and southwest of the RRL appears to warrent further discussion. Thorough studies are needed relating swarm and nonswarm seismicity to geologic factors such as thinning and distribution of basalt units, unmapped faults, and basement and intermediate paleotopography in the area north and northeast of the Pasco Basin. An answer as to cause of the swarms is required. The distribution of earthquakes outside the swarm activity requires further analysis, somewhat restricted by the brief (13-year) period of record. None the less, a case for some correlation of seismicity with mapped faults can be made in some instances and warrants further discussion.

d. (P. 6-14/15). It is critical to understand kinematics of the east-west compression in the Walla Walla - Milton Freewater area. The intersection of the CLEW/OWL system with the Blue Mountain/Hite Fault system is a major regional structural intersection capable of several divergent types of motion. The composite focal mechanisms along the Pattlesnake alinement (RAW), strike slip and thrusts, is precisely what might be expected from the generally accepted regional model of north-south compression manifest in dextral strike slip and thrusting. The mechanisms therefore appear to support the model.

e. (P. 6-21/22). No information is provided regarding the accuracy of the triangulation data analysed by Tillson (1970). A summary of the evidence for lack of horizontal crustal displacement would be appropriate. The period of record of leveling, traingulation and trilateration surveys is so short (when compared with the repository life and geologic data) that they can have little meaning. While the effort should continue, little real trends will be realized unless the short-term strain rate becomes more significant.

f. (P. 6-29). A critical examination of figure 6-3 suggests that the majority of seismic events are indeed related to mapped structures. The statement that "most of the seismic activity . . . occurs in the vicinity of the Saddle Mountains structure" is misleading due to the short period of good record. These type of statements are too general, requiring qualification.

7. Chapter 7 - Review of Tectonic Models.

a. (P. 7-1 to 7-9). The summary of regional tectonic models as proposed by a number of workers is excellent as a summary. Nothing is mentioned regarding the data which support or oppose such models. A more appropriate approach would be a thorough summary and discussion of data which support or oppose (a) subduction and its cecession or continuance, (b) regional rotation north and south of the OWL, (c) north-south compression, its cececsion or continuance, all tied to the evidence for the future of the plate boundary. Data should include presentation and discussion of fault plane solutions in the Northwest and how they relate to a contemporary tectonic model.

b. (P. 7-7 and Figure 7-1). The figure appears inconsistent, showing the Intermountain Seismic Belt (ISB) without indicating other general zones of seismicity such as along the San Andreas, Juan de Fuca, and Gorda plates, trans-Idaho, etc. Identification of such zones would be helpful in understanding the contemporary regional model. There is evidence to indicate a restriction of the ISB to the area south of the Lewis and Clark Line. There is no evidence to suggest that it extends to the Canadian border as shown.

c. (P. 7-19). The influence of extra-Plateau structures on structures near the margin of the Plateau would be more obvious if some general geology were shown on the tectonic map (plate 2-1). Suggested units would be the Columbia Basalts, prebasalt granites and sediments, Cascade volcanics (generally postbasalt), and postbasalt sedimentary basins.

d. (P. 7-20). There seems to be a considerable body of evidence pointing to a difference in contemporary strain on the Plateau southwest of the OWL versus northeast of the OWL. This should hardly be an area of disagreement when the OWL is there to absorb the difference by dextral shear. It is hard to imagine how existing anticlinal structure (and associated thrust faults) could "lock up" and not provide relief for additional horizontal northward compressive stress.

e. (P. 7-21). While we agree that a second round of folding has not developed first order folds, the "continuity" of Ringold strata is not well documented in Chapter 5 as referenced, nor is it documented in the other reports we have been tasked to review.

f. (P. 7-21). The apparent disagreement in the rate of deformation between models is understandable in light of the paucity and distribution of data. Strain rates between Elephant Mountain time and the present are not documented and need to be by study of basin sedimentation. It is probably too early in the data base to conclusively support strain rates applicable to the last 10 million years.

g. (P. 7-22). The final statement in chapter 7; concluding that tectonic conditions prevailing over the past 15 m.y. are expected to continue over the next 1 m.y. is too general, includes too many variables, and is not supported by evidence presented.

8. Chapter 8 - Preliminary Assessment of Tectonic Stability.

a. (P. 8-1). The distinction of earthquakes and displacement under conditions of faulting versus aseismic creep with minimal displacement under folding conditions may not be valid. The two are really manifestations of the same process and well may be interchangable. Aseismic creep on faults is well documented elsewhere and some level of seismicity accompanying folding should be expected.

b. (P. 8-2). The conclusion that steady long-term low deformation rates are continuing is premature. The error in the methods of measuring contemporary deformation are on the same order of magnitude as the deformation, the period of monitoring seismicity is short and no real analysis of the post-basalt sedimentary record has been presented to confirm or refute episodic deformation during the last 10 million years.

c. (P. 8-3). Comment relating to apparent lack of "success" in the Shell exploratory holes seems out of place and no point is made. How does the "success" or lack of it relate to the sub-basalt structure.

d. (P. 8-4/8-5). The prediction of future tectonic deformation appears to be based more on local (Pasco Basin) deformation rates rather than on the prognosis of activities at the plate margin. While the local data is important, the regional basis must be included.

e. (P. 8-5/8-6). The final assessment must also be based on the prognosis along the plate margin and the relationship of the Pasco Basin to it. The conclusion that strain rates (deformation) since the Miocene are a magnitude less than that occurring in active orogenic areas is probably true. The suggestion of "tectonic stability" on such a basis is open to question without a sound tie to the origin of the contemporary tectonics.

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