TRIP REPORT

BASALT WASTE ISOLATION PROJECT

JULY 7 - 18, 1980

Ludwig Hartung

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September 1980

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FIGURES

BACKGROUND

Purpose of Visit

During the period July 7-17, 1980, the NRC undertook a visit to investigate the regional geology and hydrology of the Columbia Plateau and to review field studies undertaken by the U.S. Department of Energy (DOE) and its contractors for the Basalt Waste Isolation Project (BWIP) at the Hanford Reservation near Richland, Washington. The main contractor is Rockwell Hanford Operations (RHO).

This visit represents the first of several planned visits to review DOE exploratory activities related to the investigation of possible sites for a high-level waste repository. The sites are in a variety of geologic media and are located at various points throughout the United States. NRC plans an overview of all DOE siting studies.

The purposes of the BWIP visit were fourfold, namely, to provide an opportunity for the NRC staff to become familiar with BWIP; to establish contacts and consult with specialists concerning the geology and hydrology of the Columbia Plateau; to review the nature and thrust of technical investigations at BWIP; and to develop a basis from which to refine the various NRC regulatory and guidance documents currently under preparation.

Organization of Trip

An itinerary is presented in Appendix A. The first week and part of the second week were devoted to discussions with federal, state, and university

specialists involved in geoscience studies of the Columbia Plateau. July 14-16 were devoted to the siting investigations in the Hanford Reservation.

The NRC staff participating in the visit included Ludwig Hartung (engineering geology), Linda Lehman (groundwater modeling), David Siefken, (hydrogeology) and group leader, Robert Wright (exploratory geology). Participating in the second week of the staff visit was F. Larry Doyle, (hydrogeology). Participating in the three days at BWIP was Ben Kelly, geologist with the Office, Chief of Engineers of the U.S. Army Corps of Engineers.

Organization of Report

This report consists of summary descriptions of the knowledge gained in specific specialities; namely, the geologic setting, tectonic activity, hydrogeology, groundwater modeling, and design. The summary descriptions include an identification of some technical issues arising before or during the trip.

The summary descriptions are followed by major observations made by the group relative to the investigations at BWIP. A separate item cites the comments received from DOE and RHO personnel during an informal discussion of the draft technical criteria for 10 CFR 60. Attached as appendices are the list of meetings other than those at BWIP (Appendix B) and notes of each meeting (Appendix C).

GEOLOGIC SETTING

The DOE investigation of basalt as a possible repository host rock is concentrated on the Columbia Plateau of southeast Washington, with emphasis on the 570 square mile Hanford Reservation. The rocks of chief interest in the Reservation are the layered basalt flows and sedimentary interbeds of the Columbia River basalt group. Above these rocks and concealing them over most parts of the Reservation are unconsolidated and partly consolidated beds of silt, sand, clay, and gravel comprising the Ringold and Hanford formations.

The rocks that lie below the basalt group are imperfectly known. A wildcat oil well, the Rattlesnake Hills Well No. 1, which was drilled in 1957-58 by Standard Oil Company of California in the Rattlesnake Hills just outside the Reservation (Figure 1), bottomed in basalt at 10,665 feet. This deeper basalt is believed to represent an older series of volcanics that predate the Columbia River basalts. At the moment, considerable interest is directed toward a deeper hole now being drilled near Yakima to an estimated depth of 20,000 feet by Shell Oil Company. RHO is making an effort to obtain information on the basalt sequence from this well.

The basalt group is composed of scores of individual lava flows that were extruded from long fissures, mostly within the period of time between 14.5 and 17 million years ago. The fissures, now marked by dikes, have been identified mainly in the eastern part of the Columbia River plateau. This indicates that the flow of lava was from east to west. The youngest flows are about 6 million years old. The westernmost dike exposed in outcrop is approximately one mile

downstream of Ice Harbor Dam (20 miles east of Richland). The presence of dikes within the Pasco Basin is an unanswered question at this time.

Some basalt flows lie directly upon the subjacent flows, indicating a short time period between extrusions. Other flows are separated by stream and lake deposits, some with abundant plant remains, indicating a considerable time period between extrusions.

An important feature of a typical basalt flow is the marked contrast in permeability between the uppermost portion of the unit and the central and lowest portions (Figure 2). The upper portion, the "flow breccia zone," comprises up to 30 percent of total flow thickness and is characterized by vesicles (gas holes), breccia and rubble that formed by cracking and movement of the partly hardened crust as the lava moved. This rock is lower in density than average basalt, and the hydraulic conductivity is much higher (on the order of 10^3 times greater) than the hydraulic conductivity of the high density basalt below.

The middle and lower portions of a flow are more massive, higher in density, and characterized by more-or-less vertical joints. The joints in the center "entablature" zone are irregular and discontinuous, whereas the joints in the lower "colonnade" zone are more evenly spaced and more continuous.

As now planned, a waste repository would be placed in the center (entablature portion) of a 200-foot thick basalt, the Umtanum unit, which, in the proposed siting area within the Cold Creek Syncline, is about 3,700 feet below ground

surface. The Umtanum was selected as being a thick flow at an accessible depth. Except for thickness, it is a typical basalt flow.

From the standpoint of hydrologic parameters important to performance of a repository, the parts of a basalt flow present striking contrasts. Interbeds between basalt flows and the flow breccia zone provide relatively porous pathway for groundwater flow in a dominantly horizontal direction. The entablature and colonnade zones provide a very restricted pathway for groundwater flow in a dominantly vertical direction. To assess the main questions related to movement of groundwater in and around a repository, testing programs should be developed to measure the varied hydraulic properties of the interbeds and the separate parts of the Umtanum and the basalt above and below. It is essential to determine whether the vertical permeability in the entablature and colonade portions of a flow or the horizontal permeability in the interbed and underlying flow breccia zone controls the potential releases from the repository and whether any subsequent transport is upward through overlying basalt flows or is lateral through an interbed/flow breccia zone to the discharge area of the basalt aquifer.

TECTONICS

The basalt flows within the Pasco Basin are folded into a semiparallel series of anticlines and synclines trending east to southeast. The synclines are broad and open, whereas the anticlines are more deformed and generally asymmetric, with the north limb dipping steeply or, in places, overturned. On the anticlines in the Hanford Reservation the basalt is exposed at the surface in the areas shown by stippling on Figure 1. Regional geology suggests that the causative north-south compression must have originated within the last 6 million years, after formation of the Columbia River basalt group. Regional geology also suggests that the portion of the Columbia Plateau to the east of the Pasco Basin may have been tectonically more stable during this period.

The main questions, from the site suitability standpoint, are (1) the present influence of the remnant stresses and their influence upon stability during the next 10,000 years and (2) the effect of folding, faulting, and fracturing on hydrologic properties of the basalt. This problem is being tackled by two methods: structural geology and seismology.

The structural geology work focuses on the faults, particularly those which evidence recent movement. Faults are investigated in detail and dated where possible. To support the dating efforts, the recent sedimentary units are being mapped (on a scale of 1:125,000), correlated and dated (where possible) over broad areas of southern Washington and northern Oregon. One of these units is a bed of 7,000 year old loess (wind-blown silt) which has proved

useful in dating structural offsets. For example, the Finley Quarry fault (which we visited) does not cut the loess, suggesting that there has been no movement within the past 7,000 years. Particular interest is attached to Toppenish Ridge, a feature within the Yakima Indian Reservation, where youthful scarps have been described and variously explained both as faults and as slips in soil due to slope instability. Access to this site is limited and the investigations are incomplete. Shannon and Wilson have contracted to deliver, during September 1980, a summation and analysis of all structural studies to date for both the WUPPS and BWIP siting investigations.

From the seismic standpoint, the Columbia Plateau has historically been relatively stable. Since 1969, a detailed record of recent seismicity has been developed by an earthquake monitoring network established by the U.S. Geological Survey (USGS) and currently maintained by the University of Washington. The network consists of 36 telemetered stations extending from Pendleton, Oregon, north to Winthrop, Washington. During the 10-year period of 1969-79, 2,242 earthquakes were recorded, of which 2,129 were with the area of interest to BWIP. Most of these in the area of interest have a magnitude less than 3.0, are shallow (less than 2 km) and probably originate along minor faults within the basalt sequence. They exhibit a marked clustering effect, and 13 swarm areas have been identified. All but three of the swarm areas coincide generally with Saddle Mountain, an east-trending anticline immediately north of the Hanford Reservation. The 207 seismic events deeper than 6 kilometers are not clustered, but occur with a broad band, trending generally north-south.

HYDROLOGY

With the exception of discussions concerning the proposed Ben Franklin Dam on the Columbia River near Wooded Island north of Richland, the visit concentrated on the hydrogeology of the Columbia River flood basalts and the groundwater/surface water interrelationship between the aquifers present in the basalt sequence and the Columbia River. Little consideration was given during this staff visit to the units overlying the basalts, which comprise an alluvial aquifer, except as this aquifer affects or interacts with aquifers in the basalt group.

The current state of knowledge concerning hydrology is presented in report RHO-BWI-ST-5, Hydrologic Studies within the Columbia Plateau, Washington - An Integration of Current Knowledge, October 1979.

The hydrogeologic regime within that portion of the Hanford Reservation currently under investigation consists of an unconfined (water table) aquifer in the alluvial deposits of the Ringold and Hanford Formations, underlain by a sequence of confining beds and confined aquifers in the basalts. The RHO staff indicates that potentiometric level measurements and differences in hydrochemistry indicate hydraulic separation of the aquifers within the basalt sequence into the following major aquifer units: the Saddle Mountain basalt, the Wanapum basalt, the Grande Ronde basalt above the Umtanum, and the Grande Ronde basalt below the Umtanum. The Umtanum is considered to be a confining unit.

Investigations currently underway are aimed principally at determination of potentiometric levels and hydrochemistries at various depths, within separate basalt flows, and at various locations across the Reservation in order to develop a three-dimensional understanding of the groundwater system. In addition, borehole testing of hydraulic conductivity is being performed, primarily in the more permeable flow breccias and interbeds. Isotopic analyses to identify the approximate age of the groundwater in the separate aquifer units are also in process.

Most of the testing performed serves two purposes, development of testing techniques appropriate for the basalts and identification of physical and chemical properties. Especially needed for the latter purpose, and currently under development at borings DC-2-A1 and DC-2-A2, are inclined borings to intersect the vertical jointing of the entablature and colonnade portions of the basalts. The inclined holes will be used for fracture characterization studies and determination of the physical and chemical properties of the separate portions of the basalt flows. Also needed, and under development, are two-well injection tracer tests in isolated portions of boreholes to determine the effective porosity and dispersivity within specific portions of the basalt flows. Fracture characterization studies may benefit from the use of a continuous sequence of borehole photographs such as performed by the U.S. Army Corps of Engineers, Walla Walla District, geologists.

Additional work is currently in progress, conjunctively with groundwater modeling exercises, to define the locations and modes of recharge and discharge

for the separate aquifer units; to determine the extent and direction of hydraulic communication between the separate aquifer units; and to determine the effects of the series of east-west trending anticlines and synclines on the groundwater flow system. In this manner, the types and locations of boundary conditions for the separate aquifer units may be delineated; mass balances of water inflow and outflow may be established for each aquifer unit; and the effects of groundwater flow on waste isolation can be determined, taking into account the relative significance of horizontal flow through the flow breccias and vertical flow through the entablature and colonnade zones.

The major technical issue is the need for improved hydrologic testing. Two major concerns related to this issue were identified during the staff visit. Simply stated, these concerns are that all borings currently being drilled and tested are vertical borings which were drilled using mud for circulation. At issue is the ability to perform meaningful hydrologic tests and to collect representative groundwater samples within the colonnade and entablature portions of the basalt in vertical boreholes where there have been few intersections with vertical joints and where the fractures may have been partially or completely sealed by drilling mud.

The hydrologic testing currently being performed in vertical boreholes could also be performed in inclined boreholes. Borehole survey techniques could be used such that inclination and bearing corrections can be applied to measured depths so that stratigraphic depth and thickness correlations can be made. There is a definite need to reevaluate whether vertical borings provide the

opportunity to determine the hydrologic data, particularly for the entablature and colonnade portions of the basalt flows, needed for evaluation of the site.

In addition, there is a definite need to reevaluate whether the drilling techniques optimize the ability to perform hydrologic testing. Consideration should be given to drilling without mud, particularly in the Umtanum and adjacent basalt flows. Other methods of stabilization, such as maintenance of a positive head in the borehole, should be investigated. In those portions of the borehole where mud is circulated, alternative methods of borehole development, such as the use of high pressure jetting or block surging, should be investigated.

GROUNDWATER MODELING

A variety of groundwater flow and transport models are currently under study and development. These include both far-field and near-field models, the latter being defined as representing that area affected by the emplaced wastes (particularly thermal effects). The results of groundwater modeling studies performed by RHO should be considered preliminary. These studies are aimed primarily at reproducing the measured potentiometric levels, using the physical characteristics and properties of the separate aquifer units as obtained from a limited number of borehole tests.

The principal groundwater modeling studies by RHO have been performed using the Gupta model, a three-dimensional, finite-element, porous medium model. Additional preliminary regional groundwater modeling studies have been performed by the U.S. Geological Survey (Tacoma, Washington) using the Trescott-Larson model, a three-dimensional, finite-difference, porous medium model. In addition, the Swift code, a three-dimensional, finite-difference, porous medium model with a double porosity option to simulate fracture flow, is currently being modified and evaluated for use at BWIP.

The most significant technical issue arising from the preliminary results of the modeling is the treatment of boundary conditions, particularly the interrelationship of the Columbia River to the confined aquifers in the basalt sequence. The issue centers on whether the Columbia River functions as a line sink (continuous discharge area) for the confined aquifers along its entire length through the Hanford Reservation or whether discharge is principally in

the basalt outcrop areas farther away near Wallula Gap. At present, the preliminary results of the two modeling studies differ, with the USGS modeling reflecting continuous discharge along the length of the river and the RHO modeling showing discharge primarily in the outcrop areas. Potentiometric surface maps in the report RHO-BWI-ST-5 appear to support the former interpretation, based upon the presence of marked reentrants in the potentiometric contours for both the Saddle Mountain and Wanapum aquifers along the Columbia River. Resolution of the issue and implications with respect to the vertical hydraulic conductivity within and between the basalt flows will depend upon the results of future siting investigations.

DESIGN

The Near Surface Test Facility (NSTF) is a multipurpose excavation into the north side of Gable Mountain for in situ testing of basalt. The construction of the NSTF was completed in June 1979 and testing was started in July 1980. The first series of tests are intended to study thermally induced stress from gross thermal loading, and the second series of tests are directed toward local, thermally induced stress and radiation effects resulting from the emplaced wastes. The design of the NSTF employs normal configurations for the tunnels using conventional excavation techniques and support systems. The tests are intended to assess the feasibility of basalt as a repository host rock, to refine methods of testing and data analysis, and to provide a basis of design for key repository elements.

A draft plan for a future deep test facility, the Exploratory Shaft Test Facility (ESTF), was submitted to the BWIP office in May 1980 (RHO-BWI-CO-49, Rev. 1). The ESTF has two objectives, geotechnical and hydrological characterization of the site.

The construction of the ESTF is estimated to take approximately one year. A 6-foot diameter shaft would be bored blind to a depth of 3,700 feet and 460 feet of entries would be provided at the base for testing space. The shaft would be lined by sinking the casing in the drilling fluid and then grouting the annulus between the casing and the shaft walls. Various tests and investigations as outlined in the test plan for the ESTF are scheduled to be conducted in boreholes drilled from the access shaft and in the entrys.

Several observations about the NSTF and the ESTF can be made, based on review of documents and the discussions with RHO. These observations center on three topics:

1. Development of information in the ESTF
2. Interface with siting activities
3. Flexibility of design

The objectives of the ESTF stress geotechnical and hydrologic verification. However, shaft excavation by boring seriously limits the amount of geotechnical data that can be obtained between the ground surface and the 3,700-foot level. The shaft provides a unique opportunity to observe and test the rock units between the Umtanum unit and the surface, but this can be realized only by sinking the shaft using conventional means and making appropriate tests during shaft construction.

A second point has to do with the proposed tests for the ESTF. It is not clear from a review of the test plan and discussion with the design contractor what parameters are to be measured, what criteria were established to determine that the desired parameters were, in fact, being measured, and how the evaluation of the data would be applied to the site characterization program and the development of the repository design. In addition, it is not clear as to the technical relationship between the types and purposes of tests scheduled in the NSTF and the ESTF. Considering the geotechnical and hydrologic tests proposed for the ESTF, it is also not clear that the design of the test facility is appropriate for the planned tests.

The ESTF is a complex effort and it is essential to develop the purposes and design of the tests to be undertaken before the design of the ESTF is finalized. The purposes of the tests are linked to the parameters needed to demonstrate suitability of the site and the compatibility of the repository design to the site. In addition, it is necessary to input the results of construction and testing from the NSTF into the design of the ESTF and the tests to be performed. Finally, it is essential that DOE identify how the construction and testing in the ESTF will result in verification of the conceptual design of the repository.

A preconceptual design report (RHO-BWI-CD-35) was published in February 1980, establishing the basis of design for a repository in basalt. The objectives of the report are to:

1. Develop a feasible reference design based on existing technology,
2. Establish the technical baseline and assemble schedule and cost data for the conceptual design, and
3. Recommend alternatives that should be considered in subsequent design.

This report presents a well-organized and complete design program supported by appropriate studies. The concept of flexibility of design is expressed through the review of alternate sites and the concept of modular design. The concept of interfacing design with siting requirements is presented in Section 1.2.1 of the report.

OBSERVATIONS

Between July 14 and 16, discussions were held in the Hanford offices of RHO; two BWIP borehole locations where drilling was underway were visited; the core library was visited briefly; and the Near Surface Test Facility was visited. These activities, together with information and impressions gained during meetings elsewhere, gave rise to some observations about the technical investigations at BWIP.

The observations deal with the thrust and methodology of investigations; they do not concern the organization and management of the investigations. As might be expected, the observations reflect special interest in the fields of knowledge represented by numbers of the group, notably hydrogeology and underground testing. Observations are not attempted in fields where the group has inadequate familiarity--notably geophysics, seismology and waste form. It should be said, furthermore, that time did not permit a complete and exhaustive review of all aspects of the geotechnical and earth science work.

The main observations are summarized below:

- Major studies related to regional mapping, basalt correlation, and tectonics are currently is progress. These studies appear to be well-conceived and should provide significant results.
- Improvement of hydrologic testing methods should receive continuing attention. Clearly, the most challenging technical problem is the satisfactory characterization of the groundwater regime in a series

of basalt flows, each of which is dominated by horizontal permeability in the upper zone and joint-controlled, vertical permeability in the middle and lower zones. It is essential that the drilling result in a borehole and core that is suitable for not only stratigraphic and petrologic studies but also for meaningful hydrologic testing.

The borehole should be as free from the effects of drilling as possible. Most notably, this includes the absence of materials coating the borehole walls or sealing fractures in the basalt. In order to optimize the ability to perform hydrologic tests in the boreholes, consideration should be given to drilling without mud and development of the boreholes by high pressure jets or block surging before testing. In addition, the use of multiple borehole deflections is recommended in order to drill inclined holes which will intersect a greater number of joints than in vertical borings. Inclined borings should provide a better opportunity to characterize the fracture systems and to obtain more representative hydraulic conductivities and water samples in the entablature and colonnade portions of the basalt flows.

- Improvement of core drilling procedures should receive continuing attention. The core that was observed at the site showed substantial mechanical breakage and was poorly suited for geotechnical study. Complete recovery of the core is needed, and, the core should be of as high a quality as the basalt will permit. This may be accomplished by investigating means to reduce mechanical breakage, such as varying

drilling rpm, bit pressures, types of bits, or lengths of core runs with major changes in basalt units. This requires careful supervision of the drilling contractor by an experienced drilling supervisor representing BWIP. Field experience in "hard rock" is essential for the drilling supervisor.

- The location and mode of groundwater discharge into the Columbia River, as now modeled, is preliminary and needs rigorous field verification. The preliminary conclusions are based on limited borehole information of uneven quality. There appears to be a difference between the conclusions of RHO and the USGS. The difference is significant with respect to both direction of groundwater flow, the distance and travel time to the accessible environment, and the degree of vertical hydraulic communication between basalt aquifers. The difference should be resolved by application of more field data, including establishing agreement between several lines of evidence such as potentiometric levels, hydrochemistry, and groundwater age determinations.
- Consideration should be given to confirming the results of the NSTF heater tests in the ESTF in order to verify those repository design parameters related to thermomechanical and geomechanical properties of the basalt. It is difficult to envision the transfer process by which the results from heating tests in the Pomona basalt in the NSTF, where the rocks are unsaturated, can be applied to the saturated Umtanum basalt at proposed repository depth of 3,700 feet.

- The design of the ESTF and the tests to be performed should begin with identification of the parameters needed to demonstrate suitability of the site and the compatibility of the repository design to the site and to confirm design assumptions used in the conceptual design of the repository. Based upon the parameters needed, the appropriate testing techniques and instrumentation requirements should be identified. These testing techniques and other requirements should then dictate the design of the ESTF.

DISCUSSION OF 10 CFR 60

On July 14, for a short period, and on July 16, for a longer period, NRC, RHO, and DOE personnel participated in open, wide-ranging, informal discussions of the draft technical criteria for 10 CFR 60, excluding the waste form.

The main subjects that were brought up for clarification are listed below, in no particular order.

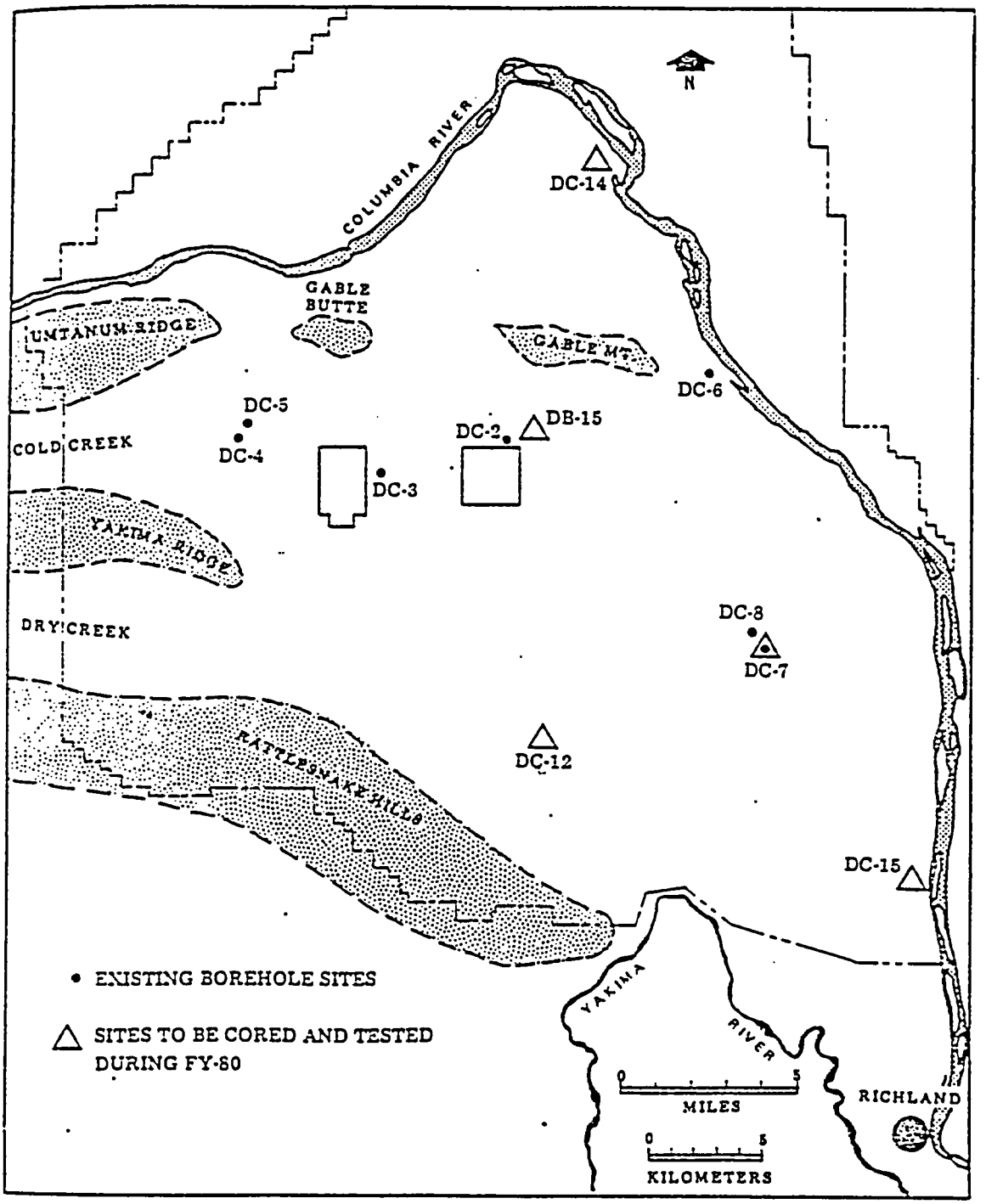
1. How much drilling can be done at a selected site before site characterization?
2. How much investigation is needed 1 km below repository level? Testing the zone 1 km below a respository at Hanford (3,700 feet below the surface) would require work to a depth of about 7,000 feet below surface.
3. What is meaning of "long-term" as used in various contexts?
4. The criteria for hydrology are too loose to be considered "technical criteria."
5. What is meant by "expert opinion" in connection with evaluation of models?
6. How can validation of models be satisfactorily achieved? What is "satisfactory"?
7. What are the most hazardous, but credible, risk scenarios?
8. What are the EPA criteria for release concentrations for evaluation of dispersion rate?
9. What is meant by "civil engineered structure"?
10. What underground structures are safety related?
11. What is required to monitor baseline conditions before and changes during shaft sinking?

12. Does the section on faulting attempt to redefine "capable fault"?

13. The section on resources looks workable and is an improvement over earlier drafts.

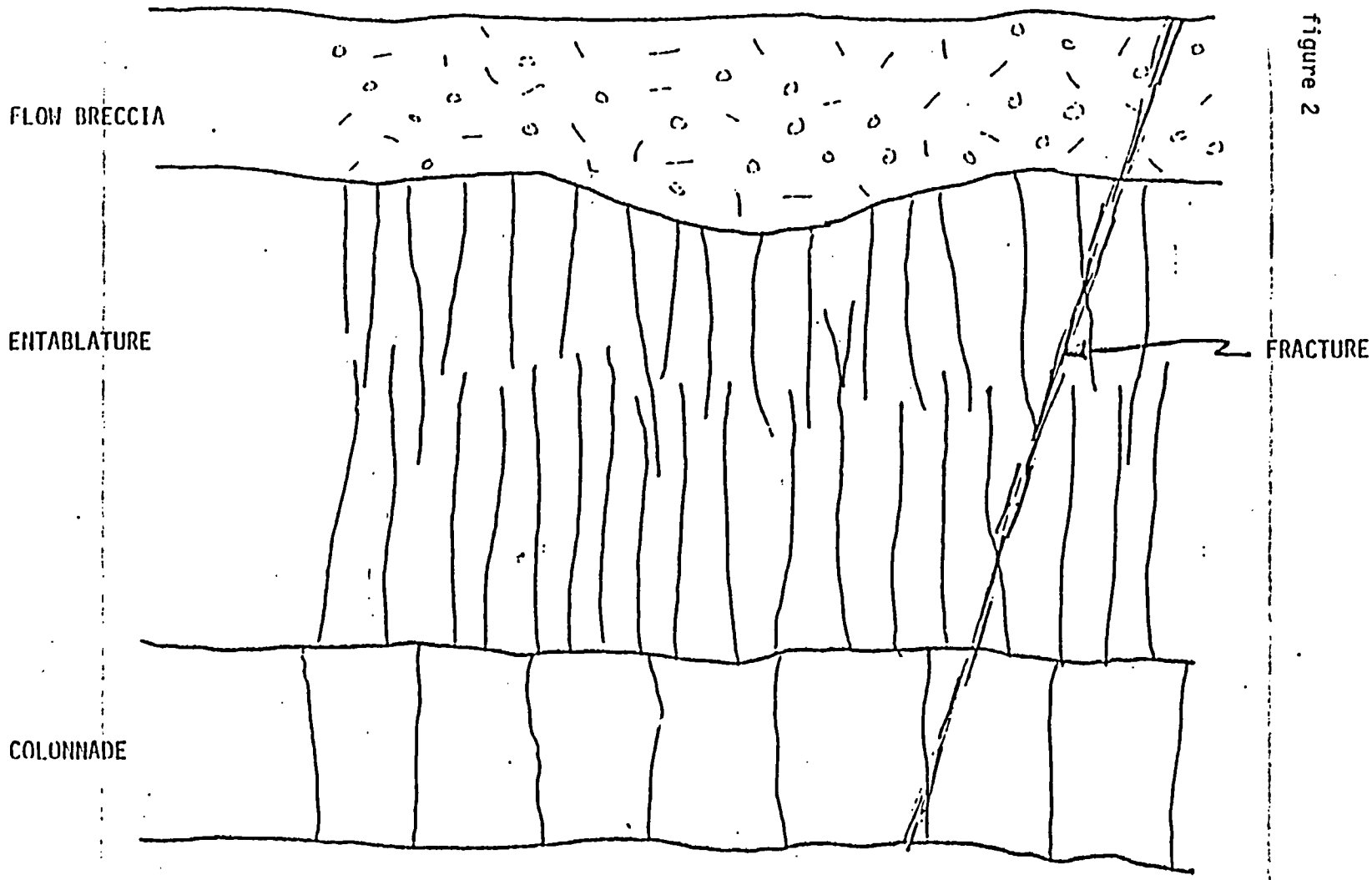
14. What types of comments does NRC expect to make in the analysis of the SCR?

figure 1



(Figure 2 of RHO-BWI-79-100)

figure 2



STRUCTURES IN A BASALT UNIT

APPENDIX A

ITINERARY - FIRST WEEK

	AM	PM
Monday July 7		John Beaulieu, State Department of Geology and Mineral Industries 1069 State Office Building 1400 So. Fifth Avenue Portland, Oregon 97201 (503-229-5580)
Tuesday July 8	Col. Terence Connell District Engineer (Lewis Gustafson, Chief, (Geology Section) Portland District, Corps of Engineers P. O. Box 2946 Portland, Oregon 97208 (503-221-6460)	Donald Swanson, United States Geological Survey Vancouver, Washington
Wednesday July 9	Donald Ford, State Dept. of Natural Resources Division of Geology and Earth Resources Olympia, Washington (206-753-6183)	Wilbur Hallauer, Director State Dept. of Ecology Olympia, Washington (206-753-2800)
Thursday July 10	Stuart Smith Department of Geophysics University of Washington Seattle, Washington (206-543-8020)	Col. Leon Moraski, Dist. Engineer (Dick Golster, Chief Geology Section) Seattle District, Corps of Engineers P. O. Box C-3755 Seattle, Washington 98124 (206-764-3704)
Friday July 11	Col. Henry Thayer, District Engineer (Fred Miklancik, Chief Foundation & Material Br.) Walla Walla District, Corps of Engineers Bldg. 602, City County Airport Walla Walla, Washington 99362 (509-525-5430)	
Saturday July 12	NRC staff field trip in the region surrounding the Hanford reservation.	

ITINERARY - SECOND WEEK

	AM	PM
Monday July 14		
Tuesday July 15	Basalt Waste Isolation Project, Hanford Reservation	
Wednesday July 16		
Thursday July 17	Bill Meyer U.S. Geological Survey 1201 Pacific Ave, Suite 600 Tacoma, Washington 98402 (206) 593-6510	

APPENDIX B

BWIP TRIP - MEETINGS OTHER THAN AT HANFORD

State Organizations

Oregon Department of Geology and Mineral Industries, Portland

Washington Division of Geology and Earth Resources, Olympia

Washington Department of Ecology, Olympia

Federal Organizations

U.S. Geological Survey, Denver

U.S. Geological Survey, Vancouver, Washington

U.S. Geological Survey, Tacoma

Army Corps of Engineers, Portland

Army Corps of Engineers, Seattle

Army Corps of Engineers, Walla Walla

University

Department of Geophysics, University of Washington, Seattle

APPENDIX C

Meeting Notes

There follows, in chronological order, a brief summary of each meeting with groups other than DOE and RHO.

U. S. Geological Survey
Denver - July 7

Attendees Ken Kipp; Lehman (NRC).

Discussion

Kipp has made some modifications to the SWIFT code, and others could be added to provide easier application. The NRC version should be reviewed to determine whether modifications are feasible or needed.

Other models that are available include:

- Phreeque - Geochemical code of USGS just being released.
- Percol - ID transport single species that includes macro-ion chemistry that affects Kd values.
- VTT - Kipp developed this code while at Battelle Northwest
- Kriging - Method developed to maximize ore reserve estimates which can be generally applied to evaluation of distributions of variables.

Sorption studies are under way at New Mexico Tech. by Al Gutjar, Lynn Gelhar, and Leslie Smith. Breakthrough curves are being investigated by statistical means using blocks of varying hydraulic conductivity.

Oregon State Department of Geology and Mineral Industries
Portland--July 7--

Attendees John Beaulieu, Jim Bela; Hartung, Siefken, Wright (NRC).

Discussion

Oregon has one nuclear reactor and the state agencies are generally familiar with the licensing process and waste disposal problems. The Department is pleased to meet with the NRC, because Oregon needs to be aware of nuclear developments before decisions need to be taken by the state.

The state is mapping rocks younger than the Columbia River basalts in Oregon, under contract to RHO. Two-thirds of the work will be done in 1980, and the final areas will be mapped and report published in 1981. The project is mainly concerned with the nature, scope, and dating of faulting.

The Department of Geology does not have much to do with groundwater. This is handled by the State Department of Water Resources, which interchanges information with the Department of Geology and the USGS.

Shell is drilling a ± 20,000 foot deep hole through the basalts north of Yakima to be completed in 1981. There are no "deep" drill holes in Oregon. A hole near Condon, Oregon, penetrates to the basal sediments (Mesozoic) at the southern margin of the basalt flows.

U.S. Army Corps of Engineers
Portland - July 8

Attendees Clayton Amundson, Philip Grubaugh, Lewis Gustafson, Jack Richards, David Sebofield, John Sager; Hartung, Lehman, Siefken, Wright (NRC).

Discussion

COE has instrumentation reports for various projects in the district, for example, the Bonneville Tunnel (in a landslide), Dworshak Dam, and Libby Dam. COE installs a strong-motion accelerograph at each dam site, and the information is fed to the USGS for their studies.

In general, the deep basalt aquifers of northern Oregon dip gently northward to the Columbia River, with recharge in the outcrop area in the Blue Mountains. The aquifer is currently overpumped in some areas, most notably the Hermiston area, where new wells go 1,000-1,500 feet deep to provide adequate yields. Several reports which may provide significant information on the deep basalt aquifers in Oregon are:

1) USGS report on the hydrology of the Umtilla Indian Reservation
2) USGS Report HA-387, Hydrology of Basalt Aquifers in the Hermiston Ordinance Area, Umatilla and Morrow Counties, Oregon.

COE is preparing reports to reevaluate the seismicity and predicted ground motions for their dams. The Applegate Lake report is completed, and another should be available by the end of FY81. Information from strong-motion accelerographs is included within the reevaluation.

U.S. Geological Survey
Vancouver (WA) - July 8

Attendees Donald Swanson; Hartung, Lehman, Siefken, Wright, (NRC).

Discussion

Swanson is currently working half-time under a contract with RHO, on mapping and chemistry of the Columbia River basalts. The rest of his time is spent comparing the Columbia basalts to the Hawaiian basalts. Mapping on a 1:250,000 scale is complete in Washington and the maps of northern Oregon are expected to be complete by the end of this summer.

Swanson is an authority on the Columbia Plateau, and the discussion covered a considerable range of geologic topics. Because of the relevance of much of the material to BWIP, a summary of the information is reported below, by topic.

Basalt Extrusions

Ninety-nine percent of the Columbia River basalts were extruded between 17 and 14-1/2 million years before present (MYBP). However, some large volume flows occurred between 14-1/2 and 6 MYBP, but the flows occurred much less frequently. The time period of 15-17 MYBP corresponds to a pulse of volcanic activity around the Circum-Pacific Belt. The cause of these eruptions is not known at the present time, but dikes have been located in the Columbia Plateau which

are the presumed feeders for the lava flows. The dikes are oriented NNW-SSE and have been identified only in the east and southeast portions of the Columbia Plateau. The westernmost dike found to date is located approximately 1 mile downstream of Ice Harbor Dam on the Snake River. No dikes have been found in the Pasco Basin.

The flows are thought to have moved as sheet flows, with velocities on the order of 15 km/hr under a low gradient. The basalt flowed down existing topography, even crossing the Cascade Range through the Columbia River valley. There is little evidence of cinder cone development with only a half dozen cones being known. No lava tubes have been found within the Columbia Plateau.

Structure

The Columbia Plateau is currently undergoing N-S compression and E-W tension. This is not considered severe nor different than the stress regime of the entire Northwest. The Pasco Basin began to subside approximately 10 MYBP, although several lines of evidence indicate that most subsidence occurred after the basalt flows. The main evidence supporting this view comes from the fact that the basalts appear to be of uniform thickness and that the sedimentary units (interbeds) are not thicker in the basins.

Generally speaking, the basalt region east of the Pasco Basin has been structurally stable for a long time. Part of the evidence for this lies in exposed sections of the ancestral Snake River Canyon, which can be seen near Lower

U.S. Geological Survey (Cont.)

Monumental Dam. The ancestral canyon gradient can be reconstructed and it has been found to be very similar to that of the present Snake River. The ancestral canyon was formed approximately 12 MYBP.

Deeper Units

The units underlying the basalts have not been positively identified. One deep well (RSH-1) at Rattlesnake Hills penetrated to a depth of 10,665 feet. The data from this well is poor but indicated older volcanics, possibly andesites, at that depth. There is much speculation as to what underlies these rocks. Resistivity studies suggest sediments below the volcanics at a depth of about 15,000 feet. Shell Oil Company is drilling a deep hole, which suggests a belief in the presence of deep sediments. RHO has reached an agreement with Shell whereby Shell will give geophysical data through the basalts. If sediments are reached, the information on the sediments will probably remain proprietary.

Basalt Flows

A typical Columbia River basalt flow is of fairly uniform thickness and is comprised of an upper zone (flow breccia), the entablature zone, and a basal colonnade zone. The upper zone may be 5-30 feet thick in a 200-foot thick flow and consists of porous, vesicular, blocky basalt. Where the upper zone is thick, cracks may not be present. The center two-thirds of the flow is comprised of the entablature. It is generally marked by many small cracks which are thought to represent cooling features due to rain or water infiltrating the flow. These fractures are dominantly vertical and may have a wavy or a

U. S. Geological Survey (cont.)

fan-shaped appearance. Compared with the colonnade, the entablature zone contains at least 30 percent more glass, is very fine grained and contains more joints. The underlying colonnade is characterized by hexagonal columns and may comprise 1/4 to 1/3 of the total flow. Columns may be up to 5 feet apart. Generally, a sharp contact exists between the lower colonnade and the entablature.

The basalts exhibit considerably lateral discontinuity, with flow fronts ending abruptly. Some flows pond against the Cascades.

Interbeds

The interbeds are mainly sediments with sources in the rim area of the Columbia Plateau. They generally thicken towards the Cascades. The sediments may contain volcanic clastics, clays (which have been derived from weathering of basalts), true saprolites and very fine-grained sands and silts that were derived from very low energy streams or lakes.

In the Grande Ronde sequence, which contains the proposed repository host rock at BWIP, the interbeds are fine-grained silts and sands. These interbeds are extremely variable in thickness and may range from 5 to 200 feet thick.

Other Observations

Two normal units and two reversed units are identified magnetically within the basalt group.

U.S. Geological Survey (Cont.)

There is evidence to indicate that the ancestral Columbia River may have moved farther west during the deposition of some interbeds.

Washington State Division of Geology and Earth Resources
Olympia - July 9

Attendees Donald Ford; Hartung, Lehman, Siefken, Wright (NRC).

Discussion

The state of Washington's mapping contract with RHO was concluded in October 1979. Now the state is preparing a bibliography for basalt geology and mapping folds in the rocks younger than the basalts. Vaughn Livingston (State Geologist) and Donald Ford (Assistant State Geologist) are on the Geologic Review Committee, which is part of the State Overview Committee for BWIP.

There is little evidence of uplift or subsidence in the Columbia Plateau, except for the Pasco basin. Some faulting is recognized in individual areas, for example, Toppenish Ridge, Umtanum Ridge and Rattlesnake Ridge. Toppenish Ridge, Saddle Mountain, Wallula Gap and an area south of Pomeroy show some possible fault scarps. The techniques available to make absolute dating of tectonic activities are limited.

Clastic dikes are believed to be surface fractures with filling from the surface (see BWI-C-84 reports). In June, the Shell Oil Company started a borehole near Roza Dam and Selah, north of Yakima (Section 34, R19E, T17N). Targeted depth is approximately 20,000 feet. On July 9, the hole was 1,000 feet deep.

Washington Department of Ecology
Olympia - July 9

Attendees Tom Cook, Peter Grimstad, Glen Fielder, Wilbur Hallauer, Tim Krundson, Nancy Kirner (Department of Social and Health Service); Hartung, Lehman, Siefken, Wright (NRC).

Discussion

The Department is completing a Surface Impoundment Assessment for the Columbia River, including the potential for contamination from the present activities at the Hanford Reservation. This study deals mostly with the shallow hydrology, rather than the deep hydrology within the basalts. The proposed Ben Franklin Dam, just up the Columbia River from Richland, Washington, has the potential for significant rises in groundwater levels. These rises may potentially result in increased releases from low-level waste stored on the Hanford Reservation.

The hydrogeology investigations group includes four technical staff members who function primarily as troubleshooters. Work performed by this group for RHO includes preparation of a hydrology bibliography and hydrology map. In addition, Peter Grimstad is a member of the BWIP Hydrology Overview Group.

The Department of Ecology indicated that there will be an initiative on the acceptability of importation of high-level and low-level radioactive wastes on the November ballot. They will provide a copy for NRC information purposes.

Geophysics Department, University of Washington
Seattle - July 10

Attendees Stuart Smith, Steven Malone; Hartung, Lehman, Siefken, Wright (NRC).

Discussion

The Geophysics Department is currently being funded by DOE to study:

1) the effects of cracks on seismic attenuation, and

2) general geologic processes in Eastern Washington.

The Department took over the seismic network around Hanford in 1975 and has extended the area of investigation. Most earthquake activity in Western Washington is concentrated in the Puget Sound trough, which is a NW trending zone of activity running from Mt. St. Helens to Olympia, Washington. Isostatic rebound is also occurring in Puget Sound.

The stress regime in the Columbia River basin, and the Northwest in general, is not unique and is considered low when compared to stresses experienced in California. The earthquake activity in the Pasco Basin occurs mainly in swarms. Most swarm areas are north of Hanford in the Saddle Mountains, with some swarms also near Wooded Island and Eltopia, east of the Reservation. The magnitudes typically range from 1.5-3.0. The majority have shallow foci, on the order of 1-2 kms. (i.e., within the basalt), with less than 10 percent located beneath the basalts. The earthquakes are not representative of the typical shock-after shock sequence, but have been shown to be concentrated over short periods of time.

Geophysics Dept., University of Washington (Cont.)

To assign the Wooded Island and Eltopia swarms to a fold axis or fault does not make sense. Rather, the interpretation is that these events represent slip along a fracture, which may be quite limited, say 1 meter in length, within the basalt. University of Washington's interpretation is that the swarms represent movement along fractures within the flows. They believe the major effect of this seismicity would be increased permeability of the units, rather than ground acceleration.

One common misconception is that small magnitude earthquakes tend to gradually release stress and many small quakes may remove necessity of a larger quake. This is not true and an example where it is not true is the San Andreas fault.

There is a high gravity anomaly over Pasco Basin which is due to thickness of the basalt. If no other forces were present, the Pasco Basin would continue to subside.

The Wallula-Olympic lineament, which is south of the Reservation, is an old and important regional boundary separating older and younger rocks.

U. S. Army Corps of Engineers
Seattle - July 10

Attendees Dick Golster, Leon Moraski; Hartung, Lehman, Siefken, Wright (NRC).

Discussion

The discussion centered on geologic investigations, construction experience, and instrumentation for Corps projects in the Columbia Plateau. The Corps indicated that a contract for field mapping in the Wallula Gap area was in the final stage of completion, with the report to be completed by October 1981. In addition, the Seattle District is in the process of preparing seismic studies for MacNary Dam and four dams on the Snake River (within the Walla Walla District).

The Corps offered to provide a set of east and west-looking sideview low angle radar (SLAR) photographs of the Columbia Plateau to the NRC (since received). Chromoflex topo overlays are available to the same scale from the USGS.

Typical instrumentation experiences include gravity surveys at Libby and Dworsak Dams to look at loading effects of reservoir filling and a variety of monitoring devices inside the dams. These included foundation deformation meters (inverted plumb bobs), joint meters across monoliths, and laser systems for alignment.

U. S. Army Corps of Engineers (Seattle) (Cont.)

Based on instrumentation experience, the following advice with respect to instrumentation was offered:

1. No electronics in boreholes
2. Must have method of manual check and calibration
3. Avoid a major console for telemetered data
4. Build in redundancy with another kind of instrumentation, if possible.

U. S. Army Corps of Engineers
Walla Walla, Washington - July 11

Attendees Ed Joscelyn, Larry McDevitt, Fred Miklacic, W. Sively, W. Stocker, Henry Thayer, R. Weller; Hartung, Lehman, Siefken, Wright (NRC).

Discussion

The COE, Walla Walla District, was consulted because of its experience in dam construction in basalt. They have done extensive stress tests and are also experienced in grouting techniques. For grouting purposes, hydraulic conductivities less than 5×10^4 cm/sec indicates a "tight" basalt. Quite a bit of hydraulic conductivity data is available in the Foundation Report of Lower Monumental Dam, a copy of which was provided.

Over-pumping of the upper aquifers on the east side of the Columbia River near Pasco have led to State regulations which restrict the pumping to 10 feet of drawdown per year or 30 feet of drawdown per 3 years.

Fracture characterization, using a down-hole camera, developed by COE, was demonstrated. This technique allows statistical distributions of fracture orientations to be plotted by viewing the photograhs taken in the borehole. This method is a potentially valuable tool for determining frequency and orientations of fractures. However, it cannot photograph through drilling mud; and in-hole water must be clear.

U. S. Geological Survey
Seattle - July 17

Attendees Chuck Collier, Richard Golster, John Klein, William Meyer; L. Hartung, Linda Lehman, D. Siefken, R. Wright (NRC).

Discussion

Meyer made the presentation for the USGS. The modeling at the BWIP Hanford project is done using the GUPTA model. Use of this model was discontinued by the USGS in March 1980 because the range of leakage factors was not documented and the model did not include a mass balance. The USGS used Trescott-Larson as a parallel effort to the GUPTA model.

The first modeling effort was for the period prior to the start of irrigation (1958-1962) in the Pasco Basin, and all available data, such as pumpage distribution and rates, hydraulic parameters, flow systems, and boundaries were collected. The draft report of the work was sent to Rockwell in April 1980. The work showed that the groundwater flow is to the Snake and Columbia Rivers, with the rivers functioning as line sinks. Washington Department of Ecology studies also showed that irrigation in Oregon (the Umatilla area) and Horseheaven Hills (south of Richland) may affect the hydraulic gradient in the Pasco Basin. USGS feels that the groundwater hydrology in this area is complex and interfaces with many factors, for example, the geologic framework, water levels, stresses, boundaries, and lateral (as well as vertical) permeability.