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Department of Energy
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MAY 20 1983

See Pocket 2 for Enclosure

Dr. Robert J. Wright
Senior Technical Advisor
High Level Waste Technical
Development Branch
Division of Waste Management
U. S. Nuclear Regulatory Commission
Washington, DC 20555

Dear Dr. Wright:

INTERPRETATION OF RRL-2 DRILLING RESULTS (SCR-19)

As requested by your memorandum dated April 8, 1983, and discussed with you, P. Prestholt, L. Hartung, M. Pendleton, NRC; J. LaRue, W. H. Price, Rockwell Basalt Project; and A. G. Lassila of my staff, on April 27, 1983, the enclosures which address the four questions in the referenced memorandum are provided for your information. In addition, during the Tectonic Workshop held at Richland the week of April 11, 1983, these questions concerning the interpretation of drilling Borehole RRL-2, were discussed with the NRC and the NRC consultants.

If you have questions covering the enclosed material, please call D. J. Squires of my staff.

Very truly yours,

R.P. Saget for

O. L. Olson, Project Manager
Basalt Waste Isolation Project Office

BWI:DJS

Enclosures

cc, w/encl: M. W. Frei, DOE-HQ

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Enclosure to
5/20/83 from
Olson to Wright

1A. Explain the basis for assuming the 3,773'-3,783' interval of RRL-2 is dense basalt (Reference RHO-BWI-TI-113). What field data and records support this assumption? Is this based solely on hydrological testing and the neutron/neutron log? If so, how much confidence can be placed on this assumption?

The interpretation that the 3,773' to 3,783' interval in borehole RRL-2 is dense basalt is based upon two suites of borehole geophysical logs, a suite of hydrological tests, in situ stress measurements and "Shift Report of Operations".

The borehole geophysical logs performed by Battelle - Pacific Northwest Laboratory (PNL) (attached), across the 3,773' to 3,783' interval, indicate the rock mass to be dense and relatively impermeable. The other suite of borehole geophysical logs conducted by Birdwell indicate identical responses to that of PNL. The neutron log response is typical of a dense interior. The caliper logs do not indicate a washout or out-of-gauge hole. The flowmeter, which was conducted during air lift pumping and fluid temperature logs, do not indicate any fluid passing in or out of the 3,773' to 3,783' interval.

The results of hydrologic testing, "Preliminary Results of Hydrologic Testing the Umtanum Basalt Entablature at Borehole RRL-2 (3,762-3,805 feet)", (RHO-SD-BWI-TI-107, December, 1982), are attached and provide the best documentation of the permeability and rock mass quality. Constant head injection and over-pressure pulse tests provide corroborative data indicating a hydraulic conductivity of 10^{-12} meters/second, which is within the range of values predicted for basalt interiors.[1]

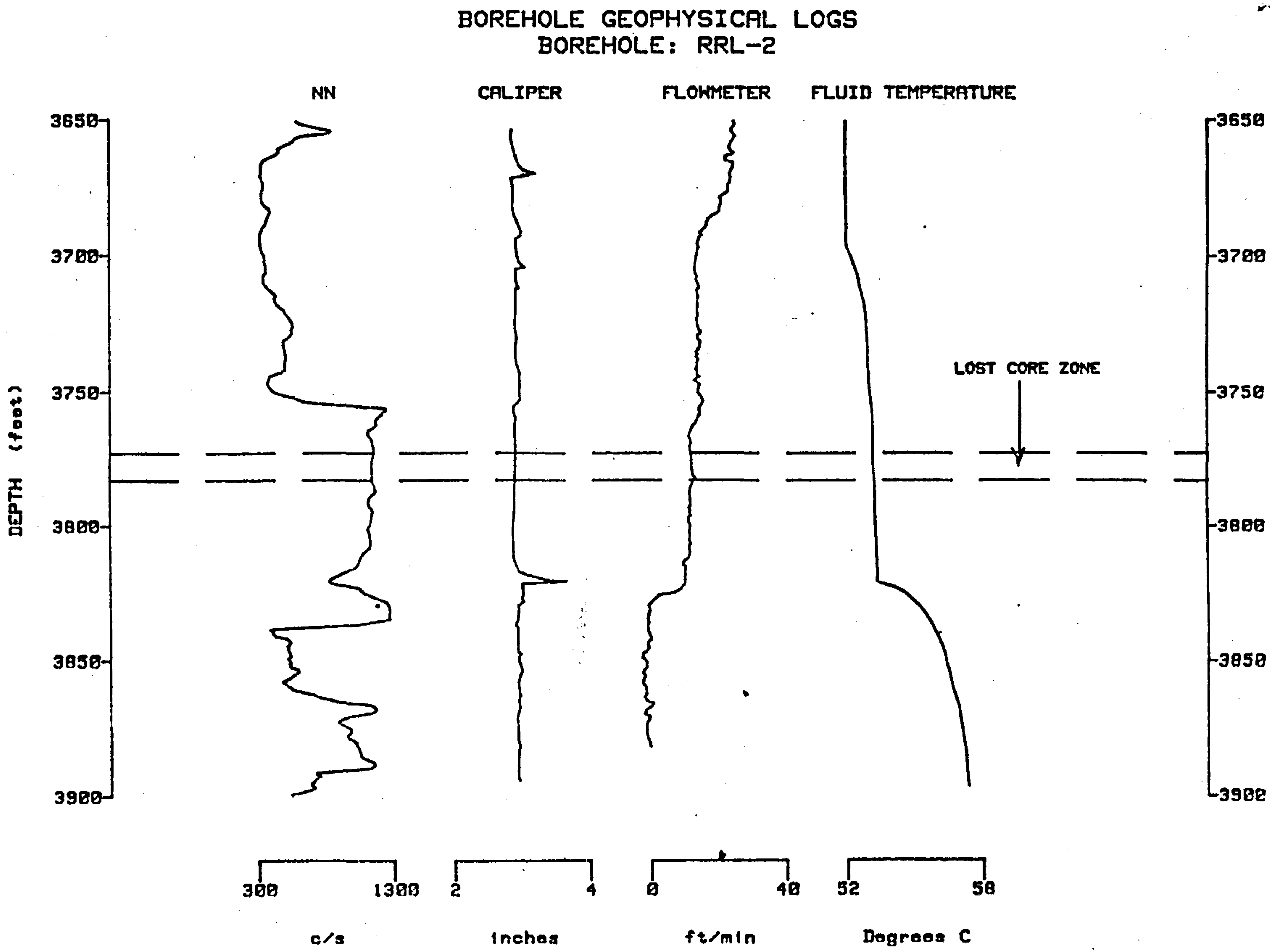
The in situ stress measurements conducted by hydraulic fracturing, "Principal Borehole Report, Borehole RRL-2", (RHO-SD-BWI-TI-113, January, 1983), indicate a dense rock mass. The break down pressure for the test interval which encompassed part of the lost core zone was approximately 5,900 psi. This coupled with the oriented impression packer run after fracture propagation indicates a dense rock mass with no voids or unusual fracturing.*

As all data supports the rock in the zone 3,773'-3,783' being dense basalt interior, we have a high degree of confidence that this is the case.

The "Shift Report of Operations" #119-B, on June 17, 1982, documents that 130 minutes were spent drilling runs #384 and #385. This, plus the condition of the drill bits, provides confidence that the rock mass is dense and no large voids or fractures are present.

*Supporting data will be transmitted to DOE/RL on May 20, 1983.

[1] Strait, S. R., Spane, F. A., Jackson, R. L., and Pidcoe, W. W., 1982, Hydrologic Testing Methodology and Results from Deep Basalt Boreholes, RHO-BW-SA-189, Rockwell Hanford Operations, Richland, Washington.


BOREHOLE GEOPHYSICAL LOGS
BOREHOLE: RRL-2
NN
CALIPER
FLOWMETER
FLUID TEMPERATURE
3650
3700
3750
3800
3850
3900
DEPTH (feet)
LOST CORE ZONE
300
1300
c/s
2
4
inches
0
40
ft/min
52
58
Degrees C

1B. <u>What is the explanation for worn out bits (bits 054 and 044) in 10 feet, and inability to advance, and lost core?</u>

Normally core grinding occurs when core is not accepted into the inner tube due to: (1) the core bit inner diameter being larger than the inner barrel can accept, (2) a faulty core lifter, (3) misalignment of the inner tube, (4) a bent inner barrel, (5) or a break in the core as it is cored and accepted into the inner tube. All of the above were eliminated as causes of the lost core because conditions 1-4 were checked, and condition 5 would have required cutting core and grinding core at the same time. With the rock strength at 30,000 to 35,000 psi (unconfined compression strength)[2] the penetration would have been <u>extremely</u> slow. None of these situations were evident during drilling from 3,773' to 3,783'.

Core bits normally have a set gauge of ± .005". In the case of the NQ 3 size bits being used in RRL-2, the Longyear bit specifications are 1.775" ± .005". The bit utilized in the lost core zone was 1.750" ± .005" or a difference of .025". When the bit was ordered, the specification was taken from an "erroneous" Longyear Triple Tube Bulletin. A bit with a ± .010" or greater difference is considered out of gauge by industry standards. The design parameter of most core barrels in wireline systems cannot handle a tolerance of more than ± .015". The manufacturing standards of ± .005" can magnify these tolerances and under some conditions, or sets of conditions, cause the core barrel not to function.

Inspection of the diamond impregnated core bit that was in the hole from 3,773' to 3,782' showed the inner gauge of the bit to be totally destroyed. It is believed that after runs #384, #385 and #386 the core fell out of the core barrel. In order to pull the core barrel from the hole after a run, the drill string was picked up off the bottom of the hole to a place where a rod joint could be broken. At this time, the core fell to the bottom of the hole. Each subsequent run ground up the dropped core and the irregular pieces of basalt tumbled in the inner gauge of the bit destroying the bit matrix and gauge. At these depths, drillers rarely can go back over the drilled core and recover it because of the problems associated with: (1) position and conditions of the lost core and (2) a lack of ability of the driller to "feel" down hole conditions with 25,000 pounds of drill string (i.e., the driller must rely on torque and pressure gauges). After a second undersize core bit was put on, modifications were made to the core tools and the rods were tripped into the hole. The pump pressure returned to higher than normal readings. After coring one foot with no recovery, the drill string was pulled from the hole and operations were transmitted. After a new bit arrived, coring resumed with no further difficulties.

An independent investigation of the finds has been completed by a Rockwell consultant.[3]

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[2] Schmidt, B., et al., 1980, <u>Thermal and Mechanical Properties of Hanford Basalts: Compilation and Analysis</u>, RHO-BWI-C-90, Rockwell Hanford Operations, Richland, Washington.

[3] Letter, May 5, 1983, J. D.Powers to G. S. Hunt, "Evaluation of Core Loss in Borehole RRL-2"

1C. <u>What is the explanation for continuous mud loss in this zone?</u>

From a depth of 2,913 feet, no zones were cemented and no loss circulation material was used. This was done to allow: (1) hydrologic testing and groundwater sampling after completion of the borehole, (2) monitoring of the effect of the Exploratory Shaft on select intervals, and (3) monitoring of the DC-16 borehole cluster test. From a depth of 3,259 feet (after penetrating the Cohassett flow top and flow bottom) to the bottom of the borehole, all circulation was lost. Zones where circulation were lost are discussed in Section 3. As previously stated, the zone from 3,773' to 3,783' is dense and mud loss did not occur.

2A. What are the zones of mud loss in RRL-2?

Drilling fluid is lost in a borehole when drilling fluid, which is used to lubricate the core bit and carry cuttings to the surface, fails to re-circulate to the recovery tank adjacent to the borehole. This occurs when high permeability zones are penetrated and the zone takes the drilling fluid, not allowing re-circulation. The loss of drilling fluid circulation is one of the techniques used by hydrologists to identify potentially permeable zones.

The zones of drilling fluid loss in borehole RRL-2 are shown in the attachment as the shaded areas of high porosity on the neutron log. These zones were determined by noting, during the drilling operations, where drilling fluid no longer returned to the recovery tank and by inference to the hydrologic testing performed on the zones. When a borehole is open to numerous permeable zones during drilling, as was the case with RRL-2 from 2,913 to 3,973 feet, it is impossible to determine into which zone (or zones) the drilling fluid is being lost. Therefore, hydrologic testing, geophysical logging, and core examination are used to identify zones of fluid loss.

2B. How were the zones of mud loss determined and measured?

There are two reasons why mud loss is considered: (1) mud loss indicates zones of potential permeability and (2) an estimate of the amount of mud loss is used to determine how much fluid must be pumped from the test interval to obtain representative groundwater samples.

Drilling fluid loss is measured by the number of bags of polymer and bentonite mud used to maintain good lubrication around the core bit. When drilling fluid is being lost, additional drilling fluid is prepared in a mixing tank and pumped down the center of the drill rods. To obtain the proper drilling fluid viscosity, approximately 1,000 gallons of water are used in mixing a total of four bags of bentonite mud (#2) and/or polymer (#25). By knowing the number of bags of each used, which is recorded on the "Shift Report of Operations" and shown in the attachment, the amount of drilling fluid pumped down the borehole and lost can be determined. When a borehole is open to several interflow zones, the hydrologist uses judgement (based on hydrologic tests, core inspections, and geophysical logging) in assigning values to each interval.

3. <u>Based on data gathered from RRL-2, what is the amount and rates of mud loss estimated from the exploratory shaft?</u>

It is not possible to equate amounts and rates of mud loss from a small diameter diamond core hole to a large diameter, reverse circulation, drilled shaft. One of the purposes of drilling RRL-2 was to provide core for visual inspection of areas of potential lost circulation and to provide a hole to conduct geophysical logging. The geophysical logs show areas of out of gauge hole and delineate the basalt flow tops, and the most permeable zones. These data provide an indication to the mud engineer on the exploratory shaft drill where to anticipate lost circulation zones. The mud engineers can then prepare the mud with the appropriate additives to minimize fluid loss into the formation.

A diamond drill hole, such as RRL-2, cuts a 2.980-inch diameter hole. The drill rods are 2.875-inch O.D. and the core barrel is 2.875-inch O.D. The stress on the rock formation, caused by the fluid, is much greater than that of a big hole rig because the annulus on the core hole is only .0525-inch around the core barrel and the drill rods. This stress forces the fluid out into the formation, generally into the flow tops. The flow interiors are too impermeable to accept any drilling fluid.

Large diameter, reverse circulation drilled, shafts exert minimal stress or washing action against the hole wall. Any fluid stress is contained within the 13-3/8-inch O.D. drill pipe. The annulus in the exploratory shaft is approximately 48-inches and maintains the hydrostatic pressures in equilibrium.

The mud system in the Exploratory Shaft drilling program can carry any type and amount of lost circulation material needed to prevent loss of circulation. The bentonite mud coupled with loss circulation materials such as fibers and cotton seed hulls can keep loss circulation to a minimum by forming a wall cake that plugs the areas of potential loss. The placing of a cement plug across these zones is routine in a zone where normal loss circulation material fails to seal off the zone.

The lost circulation zones in RRL-2 were not sealed off by cementing or adding lost circulation material for three reasons:

1. Cementing the zones off precludes subsequent hydrologic testing or monitoring of the zones.

2. The small (.0525-inch) annulus between the hole wall and core barrel does not allow the passage of lost circulation material such as fibers and cottonseed hulls. These materials could also affect the hydrologic testing values obtained in the flow tops.

3. The waterway passages in a diamond bit are too small to pump volumes of loss circulation material, (i.e., the bit would become plugged).

In summary, RRL-2 provides an indication to the shaft drilling contractor of where to anticipate lost circulation zones by analysis of drilling records, the core, and geophysical logs. The shaft drilling contractor utilizes a different drilling system and has the ability to counter act lost circulation problems.

4. The summary geologic logs and the shift reports received from BWIP on the RRL holes appear to be typed versions of the original records. We expected to receive, in response to our verbal request, copies of the original records - e.g., form C-2.5 of RHO-BWI-MA-4 for the geologic log.

Copies of the original well site geologists logs were supplied to the Nuclear Regulatory Commission (NRC) at the Tectonics Workshop. The draft summary geologic logs for the boreholes were previously transmitted to the NRC. The summary logs are routinely prepared by the staff geologist after reviewing the core, core photographs and the well site geologist's logs. These logs are prepared to summarize all pertinent field lithologic information necessary for initial stratigraphic correlations. The summary logs and lithologic, chemical and paleomagnetic information are input to prepare the "Deep Borehole Stratigraphic Correlation Charts and Structure Cross Sections" (BWI-DP-035, Data Package 35).

Rockwell Hanford Operations

SUPPORTING DOCUMENT	Number	Rev. Ltr./Chg. No.	Page i of ii
PROGRAM: Basalt Waste Isolation Project	SD-BWI-TI-107	0-0	1 thru 37

Document Title: Preliminary Results of Hydrologic Testing the Umtanum Basalt Entablature at Borehole RRL-2 (3,762 - 3,805 feet)

Baseline Document ☐ Yes ☒ No

WBS No. or Work Package No.: L341A CEI CMO83

Key Words:

Prepared by (Name and Dept. No.): S. R. Strait S.R. Strait; F. A. Spane, Jr. F.A. Spane Jr. — Date: 11/30/82

See Page 2 for Approvals

Abstract

This report presents preliminary results and description of hydrologic test activities for a section of Umtanum basalt entablature at Borehole RRL-2 over the depth interval 3,762 to 3,805 feet. Hydrologic tests conducted include a four step constant head injection test and one over-pressure pulse test. Preliminary results from hydrologic tests performed indicate transmissivity values ranging between 9.0 x 10^{-6} and 2.4 x 10^{-4} ft^2/day, with an assigned best estimate of 1.6 x 10^{-5} ft^2/day. The best estimate of equivalent hydraulic conductivity, based on a thickness for the effective test interval of 43 feet, is 3.7 x 10^{-7} ft/day.

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