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Hydrogeology • Mineral Resource Management • Geological Engineering • Mine Hydrology

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Communication No. 91

Mr. Jeff Pohle
Division of Waste Management
Mail Stop 623-SS
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

RE: NTS

Dear Jeff:

A copy of the review of each of the following documents is enclosed.

1. Hodson, J.N., and Hoover, D.L., 1978, Geology and Lithologic Log for Drill Hole UE17a, Nevada Test Site. USGS-1543-1, 14 p.

2. Hodson, J.N., and Hoover, D.L., 1979, Geology of the UE17e Drill Hole, Area 17, Nevada Test Site. USGS-1543-2, 33 p.

3. Trimmer, D., 1982, Laboratory Measurements of Ultralow Permeability of Geologic Materials. American Institute of Physics, REV. SCI. INSTRUM. 53 (b), p. 1246-1254.

Please contact me if you have any questions concerning these reviews.

Sincerely,

Jim Osiensky /sl

Jim Osiensky

JO:sl

WM-RES
~~WM Record File~~
D1020
W&A

WM Project 10, 11, 16
Docket No. ______
XPDR ✓
LPDR ✓ (B, N, S)

Distribution:
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WMGT DOCUMENT REVIEW SHEET

FILE #:

DOCUMENT #: USGS-1543-1

DOCUMENT: Hodson, J.N., and Hoover, D.L., 1978, Geology and Lithologic Log for Drill Hole UE17a, Nevada Test Site. USGS-1543-1, 14 p.

REVIEWER: Williams & Associates, Inc.

DATE REVIEW COMPLETED: October 31, 1986

ABSTRACT OF REVIEW: APPROVED BY: Roy Williams/al

Drill hole UE17a is one of a series of holes drilled to evaluate the suitability of the Unit J of the Eleana Formation as a medium for nuclear waste storage. The hole was drilled to a depth of 370 m. The report presents data on the geology of the Syncline Ridge area. The report is not significant with respect to the local geology and hydrogeology in the vicinity of Yucca Mountain. However, some of the information presented in the report may be useful with respect to interpreting the regional geology and hydrogeology of the Nevada Test Site.

BRIEF SUMMARY OF DOCUMENT:

The report under review presents geologic and lithologic data for drill hole UE17a. Drill hole UE17a is located in area 17 of the Nevada Test Site. The hole was drilled to determine the thickness of alluvium and to evaluate the lithologic and stratigraphic characteristics of the underlying Paleozoic rocks. Drill hole UE17a is located within the Syncline Ridge structural block, northwest of Syncline Ridge. The hole is 370 m deep and is bottomed in a quartzite subunit of the Eleana Formation. According to the report, drill hole UE17a was drilled into the zone of saturation to define the static water level.

According to the report, air foam mist was used as circulating medium during drilling; the report notes that sepiolite air foam inadvertently was added to the hole. Water in the hole caused the sepiolite to settle out of the drilling fluid. Drilling problems were encountered between the depths of 251.5 and 289.6 m due to caving of the hole. According to the report, high-viscosity bentonite mud was placed in the hole to stop caving and to hold the hole open for geophysical logging.

Drill hole UE17a was cased to a depth of 368.8 m with 10.8 cm-diameter steel casing. According to the report, "The drilling mud was circulated out of the hole with water." A gun perforator was used to perforate the casing in the following intervals: 227.1 to 251.5 m, 306.3 to 309.4 m, and 324.6 to 362.7 m. According to the report, drilling tools were used to push debris from the perforating operation downhole to a depth of 367.9 m. The report notes that hydrologic testing was conducted by the USGS. However, the results of this testing are not presented in the report.

Drill hole UE17a penetrates 22.3 m of alluvium of Quaternary age, 144.2 m of Tippipah Limestone of early Pennsylvanian to early Permian (?) age, and 203.6 m of Unit J of Eleana Formation of Mississippian age. Table 1 of the report presents a lithologic log of drill hole UE17a.

According to the report, an east-trending, pre-Tertiary, strike-slip fault is present between drill holes UE17a and UE16c. Lateral displacement along the fault is estimated to be at least 1 km. Vertical displacement along the fault is estimated to be at least 144.2 m because that thickness of Tippipah Limestone is missing from drill hole UE16c. Table 2 of the report lists probable faults penetrated by drill hole UE17a.

The report notes that groundwater was first detected during drilling at a depth of 176.8 m. Groundwater inflow into the hole became significant at a depth of 324.6 m; inflow remained relatively constant during the remainder of drilling.According to the report, water appeared to be coming from open fractures.

A core index was calculated for each core sample obtained from drill hole UE17a to evaluate the rock competency. According to the report, a fracture analysis was performed on the first two cored intervals to evaluate fracture frequency. Core index information for the three cored intervals is presented on page 11 of the report.

Fracture analysis data for drill core from the Tippipah Limestone is presented in table 3 of the report. These data are presented graphically in figure 3 of the report. According to the report, 63% of the fractures penetrated in drill hole UE17a were closed and 37% were open.

SIGNIFICANCE TO NRC WASTE MANAGEMENT PROGRAM:

The report under review is one of a series of basic data reports on drill holes in the Syncline Ridge area. The report is significant with respect to the geology of the Syncline Ridge area; however, drill hole UE17a is located approximately 35 km northeast of the proposed repository in Yucca Mountain. Drill hole UE17a was drilled in 1976 to provide data for a preliminary investigation of the Eleana Formation as a possible repository for nuclear wastes. The report is not significant with respect to the local geology and hydrogeology in the vicinity of Yucca Mountain. However, data presented in the report may be valuable with respect to understanding the regional geology and hydrogeology of the Nevada Test Site.

PROBLEMS, DEFICIENCIES OR LIMITATIONS OF REPORT:

The report under review contains no significant problems, deficiencies, or limitations. The report is a basic data report.

SUGGESTED FOLLOW-UP ACTIVITIES:

No follow-up activities are suggested.

WMGT DOCUMENT REVIEW SHEET

FILE #:

DOCUMENT #: USGS-1543-2

DOCUMENT: Hodson, J.N., and Hoover, D.L., 1979, Geology of the UE17e Drill Hole, Area 17, Nevada Test Site. USGS-1543-2, Denver, 33 p.

REVIEWER: Williams & Associates, Inc.

DATE REVIEW COMPLETED: October 31, 1986

ABSTRACT OF REVIEW: APPROVED BY: Roy Williams/al

The report under review describes the geology of drill hole UE17e at the northwest corner of Syncline Ridge. Drill hole UE17e is one of a series of test holes drilled in the vicinity of Syncline Ridge to evaluate the Eleana Formation as a potential horizon for a nuclear waste repository. Data presented in the report are specific to the Syncline Ridge area and are not significant with respect to the local geology and hydrogeology of the Yucca Mountain area. However, data presented in the report may be of value with respect to understanding the regional geology and hydrogeology of the Nevada Test Site.

BRIEF SUMMARY OF DOCUMENT:

The report under review describes the geology of drill hole UE17e, located at the northwest corner of Syncline Ridge on the Nevada Test Site. The drill hole was drilled to obtain lithologic data for the quartzite and argillite subunit of Unit J of the Eleana Formation and to obtain samples for mineralogical, chemical and physical-property analyses. Drill hole UE17e is one of a series of test holes drilled to evaluate the potential suitability of the Eleana Formation as a geologic repository for nuclear wastes.

Drill hole UE17e is located in area 17 of the Nevada Test Site approximately 35 km northwest of the potential geologic repository in Yucca Mountain. The drill hole was drilled to a total depth of 914.4 m within Unit J of the Eleana Formation. Drill hole UE17e was cored from the depths of 3.05 to 914.4 m. According to the report bentonite mud was used as the circulating medium during drilling. In addition, heavy (barite) mud was used to control the zones that were squeezing during geophysical logging of the hole. According to the report, geophysical logs recorded for the drill hole include caliper, resistivity, inductives, gamma-ray neutron, 3-dimensional velocity, and temperature.

According to the report, the Eleana Formation of Devonian and Mississippian age contains 10 units from Unit A at the base to Unit J at the top. Figure 2 of the report presents the pre-Tertiary stratigraphic units of the Syncline Ridge area. Table 1 of the report presents the lithologic log for drill hole UE17e. The lithologic log shows that drill hole UE17e is bottomed in the argillite subunit of Unit J at a total depth of 914.4 m.

Drill hole UE17e is located within the Syncline Ridge structural block. Evidence of regional compressional deformation is present in the drill hole as highly variable bedding plane dips, fractures, shear plans, faults, and folded and sheared quartz-filled fractures. According to the report, the majority of fractures and shear planes penetrated by drill hole UE17e are parallel to bedding planes. Table 2 of the report lists the depths at which faults were penetrated by the drill hole. According to the report, faults were identified by visual observation of the core and with the aid of the geophysical logs.

Core index was calculated for each cored interval to evaluate the rock competency; in addition, a fracture analysis was performed on the core from 3.05 to 914.4 m. Figures 3 and 4 of the report present histograms of core indices within Unit J of the Eleana Formation.

Table 3 of the report lists the number of fractures penetrated by drill hole UE17e for specific depth intervals. According to the report, the fracture frequency is 8.4 fractures per meter above a depth of 152.7 m; the fracture frequency is 3.5 fractures per meter below a depth of 152.7 m. Information on the condition (open or closed and clean and polished) is presented in tables 4 and 5 of the report. Rosette diagrams of the fractures are presented in figures 5 through 17 of the report. Table 6 of the report lists the quartz-filled, calcite-filled, and calcite and quartz-filled fractures penetrated by the drill hole. Table 7 of the report lists the clay-filled, iron-stained, and iron and clay-filled fractures penetrated by the drill hole.

Thermal conductivities of the core at 25°C were measured by the USGS at Menlo Park, California. Table 8 of the report lists these conductivity measurements. In addition to thermal conductivities, natural state densities and porosities were measured for 30 different core samples of argillite from drill hole UE17e. These data are presented in table 9 of the report. Table 10 of the report lists the results of geomechanical measurements conducted on 15 core samples from the drill hole.

SIGNIFICANCE TO NRC WASTE MANAGEMENT PROGRAM:

The report under review presents data on the geology of drill hole UE17e located at the northwest corner of Syncline Ridge. Drill hole UE17e was drilled to evaluate the quartzite and argillite subunits of Unit J of the Eleana Formation as a horizon for a potential geologic repository for nuclear wastes. The report under review is not significant with respect to the local geology and hydrogeology in the vicinity of Yucca Mountain. However, some of the information presented in the report may be of value in understanding the regional geology and hydrogeology of the Nevada Test Site.

PROBLEMS, DEFICIENCIES OR LIMITATIONS OF REPORT:

The report under review contains no significant problems, deficiencies or limitations. The report is one of a series of basic data reports describing the geology in the vicinity of Syncline Ridge. Geophysical logs for drill hole UE17e are not presented in the report.

SUGGESTED FOLLOW-UP ACTIVITIES

No follow-up activity is suggested.

WMGT DOCUMENT REVIEW SHEET

FILE #:

DOCUMENT #:

DOCUMENT: Trimmer, D., 1982, Laboratory Measurements of Ultralow Permeability of Geologic Materials. American Institute of Physics, REV. SCI. INSTRUM. 53 (b), p. 1246-1254.

REVIEWER: Williams & Associates, Inc.

DATE REVIEW COMPLETED: Draft, October 9, 1986

ABSTRACT OF REVIEW: APPROVED BY: Roy Williams/al

The report under review describes an apparatus for measuring permeability of geologic materials as a function of confining pressure, pore pressure, and deviatoric stress. Permeabilities (intrinsic permeability) on the order of 10^{-11} to 10^{-24} m^2 may be measured along with electrical conductivity, acoustic velocity and amplitude. The testing method described in the report should be of interest to people involved directly with the measurement of permeability of core samples.

BRIEF SUMMARY OF DOCUMENT:

The report under review presents a description of a new apparatus for measuring permeability of geologic materials as a function of confining pressure [to 200 megapascals (MPa)], pore pressure (to 25 MPa) and deviatoric stress (500 to 800 MPa). The apparatus described in the report is capable of measuring permeabilities two to three orders of magnitude lower than those that have been reported in the literature.

Permeability measurements are made on large samples (0.15 meters in diameter by 0.28 meters in length). The permeability of the sample is measured by inducing a pore water pressure gradient between the ends of the sample while water transport through the sample is monitored. According to the report, permeabilities as low as 10^{-17} m^2 (hydraulic conductivity equal to 9.8×10^{-9} cm/sec) are measured with a conventional steady-state flow technique. A transient pulse technique is used for rock samples having permeabilities between 10^{-17} and 10^{-24} m^2. The transient pulse technique is necessary because the water flow rates through samples with permeabilities less than 10^{-17} m^2 are too small for convenient direct measurement. According to the report, a modified transient pulse technique is used for samples with permeabilities in the range of 10^{-22} to 10^{-24} m^2. For these very low permeabilities, the time constant of the system is very long. Under these conditions, establishment of equilibrium requires two weeks to six months. Therefore, in order to simplify the testing procedure, the author makes the assumption that the system reaches equilibrium when the pressure in the upstream reservoir has changed less than 0.1 MPa in 10^6 seconds (approximately one week). According to the report, measurement is terminated when either the pressure in the upstream reservoir has decayed by 1.0 MPa (50% of the pressure step) or the time has exceeded 10^6 seconds.

Equation 2 of the report describes the pressure-time history for water flow through a compressible sample-reservoir system. This equation is as follows:

$$\frac{\partial^2 P}{\partial x^2} = \frac{\mu \beta \phi_e}{k} \frac{\partial P}{\partial t},$$

$$\phi_e = \phi_c + \frac{\beta_r - (1+\phi_c)\ \beta_s}{\beta},$$

for $t>0$, $0<x<L$, and with boundary conditions

$$\frac{\partial P}{\partial x} = \frac{\mu V_1 \beta}{Ak} \frac{\partial P}{\partial t} \quad x = 0, t>0,$$

$$\frac{\partial P}{\partial x} = \frac{\mu V_2 \beta}{Ak} \frac{\partial P}{\partial t} \quad x = L, t>0,$$

and initial conditions

$$P(x,0) = P_0 \quad 0<x\leq L,$$

$$P(0,0) = P_0 + \Delta P,$$

where:

P = pressure,
X = distance from the upstream end of the sample,
ϕ_e = the effective sample porosity,
ϕ_c = the interconnected porosity of the sample,

β = the compressibility of water,
β_r and β_m = the compressibilities of the sample (bulk and mineral matrix, respectively,
V_1 and V_2 = the volumes of the upstream and downstream reservoirs, respectively),
ΔP = the step increase in pressure, and
t = the time since ΔP was applied.

Because of the large size of the samples, the pore volumes of the samples are large relative to the reservoir volume. Because the water storage in the rock is significant, Equation 2 cannot be simplified. Therefore, the author of the report modeled the experiment using a finite element computer code.

According to the report, a parameter study indicated that for a given sample geometry, pore fluid, and reservoir volume, the pressure-time history is a function of permeability and effective porosity. The report suggests that the permeability of a sample can be inferred by visually comparing experimental pressure-time histories with numerically generated histories if the effective porosity is known.

According to the report, Equation 4 can be used to determine effective porosity for samples with time constants that are small enough to allow sample equilibrium. Equation 4 is as follows:

$$(P_o+\Delta P)\,V_1 + P_o\,(V_2+AL\phi_e) = P_f\,(V_1+V_2+AL\phi_e)$$

or

$$\phi_e = \frac{(P_o+\Delta P-P_f)\,V_1 + (P_o-P_f)\,V_2}{(P_f-P_o)\,AL}$$

The report notes that for samples that display time constants too long to allow effective porosity to be determined from Equation 4, effective porosity must be determined by comparing the experimental data with numerically generated curves.

According to the report, the next step is to generate a family of curves with the appropriate effective porosity and various permeabilities. The permeability of the sample then is inferred by visually matching the experimental data to numerically generated pressure-time histories. Figures 3A and 3B of the report present examples of numerically generated pressure vs log time histories. According to the report (p. 1248), the shaded portions of the curves are given the most weight in determining permeabilities for the following reasons:

1. The thermal transient induced by the initial pressure pulse has disappeared by this time.

2. The slope is greatest allowing maximum (curve matching) resolution.

3. This portion of the curve is relatively insensitive to the water-storage term.

Test samples are prepared from diamond drill core that is approximately 0.17 meters in diameter. The samples are ground and cut to form right circular cylinders that are 0.15 meters in diameter and 0.28 meters long. Pages 1249 through 1252 describe the sample preparation and the testing apparatus.

Figure 13 of the report presents permeability data as well as normalized conductance, acoustic velocity, and amplitude data for the Westerly granite. Figure 14 of the report presents the same type of data for fractured Westerly granite. The report notes that as in the case of intact rock, the acoustic and conductance data show a good correspondence with the permeability data.

SIGNIFICANCE TO NRC WASTE MANAGEMENT PROGRAM:

The report under review presents a description of a testing method for measuring permeability in geologic materials as a function of confining pressure (to 200 MPa), pore pressure (to 25 MPa), and deviatoric stress (500 to 800 MPa). The testing procedure described in the report under review is not significant with respect to the NRC Waste Management Program at the present time. The report should be of primary interest to people involved directly with laboratory measurements of very low permeability geologic materials.

PROBLEMS, DEFICIENCIES OR LIMITATIONS OF REPORT:

The report under review presents a description of testing techniques and data analysis, sample preparation, a description of the apparatus used in the experiments, and a discussion of typical results. The primary limitation of the testing method is that the effective porosity and permeability of the core sample is determined by comparing experimental data to numerically generated curves. The portions of the curves that are given the most weight in determining permeabilities are very similar. Because of this similarity it is difficult to decide which curves yield the best match with the experimental data. The curve matching procedure is very subjective.

SUGGESTED FOLLOW-UP ACTIVITIES:

No follow-up activities are necessary.