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*Hydrogeology • Mineral Resources Waste Management • Geological Engineering • Mine Hydrology*


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May 22, 1986
Contract No. NRC-02-85-008
Fin No. D-1020
Communication No. 58

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

RE: NTS

Dear Jeff:

I am enclosing a copy of the review of the following document.

1. Rechard, R.P., and Schuler, K.W., 1982, Permeability Change Near Instrumentation Holes in Jointed Rock. Sandia National Laboratory, Albuquerque, NM, SAND81-2584, 19 p.

Please contact me if you have any questions concerning this review.

Sincerely,

James Osinsky/sl

James Osiensky

JO:sl

enclosures

WM-RES
WM Record File
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WM Project 10,11,16
Docket No.
PDR ✓
LPDR B,N,S

Distribution:
Pohle

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# WMGT DOCUMENT REVIEW SHEET

FILE #:

DOCUMENT #: SAND-81-2584

DOCUMENT: Rechard, R.P., and Schuler, K.W., 1982, Permeability Change Near Instrumentation Holes in Jointed Rock. Sandia National Laboratory, Albuquerque, NM, 19 p.

REVIEWER: Williams & Associates, Inc.

DATE REVIEW COMPLETED: May 17, 1986

ABSTRACT OF REVIEW: APPROVED BY: Roy E. Williams

The report under review presents a simplified analysis of the potential effects of a tangential intersection of a joint by a drill hole on the joint permeability in a nuclide migration experiment conducted in the field. The analysis presented in the report suggests that drill holes which intersect joints tangentially minimize changes in the stress normal to the joint which in turn minimizes changes in the joint aperture and joint permeability. The report is of primary interest to the DOE in the design and interpretation of field nuclide migration experiments.

BRIEF SUMMARY OF DOCUMENT:

The purpose of the report under review is to evaluate the effects of various experiment configurations on fracture permeability. The experiments were performed to evaluate the degree to which drill holes alter the normal stress around joints in rock at the point of intersection of the drill hole and a joint. Changes in the normal stress in the vicinity of a joint changes the joint aperture and affects the joint permeability.

According to Kranz and others (1979), fracture permeability (k) is a function of confining pressure ($P_c$), internal fluid pressure ($P_i$), temperature, aperture (e) and surface roughness. The report under review suggests that the aperture is dependent upon

the loading due to present and past mechanical, thermal, and fluid stresses.

The report notes that the permeability of a fracture is controlled by the aperture; however, the dimensions of individual fractures cannot be determined in the field. Because of this fact, the authors of the report suggest that the relationship of aperture or permeability vs. applied stress must be known. The authors note, however, that permeability and aperture do not appear to be unique functions of stress.

The authors of the report evaluated the effects of stress on joint aperture by using the relationship obtained by Walsh (1981):

$$\left(\frac{Ke}{K_o e_o}\right)^{1/3} = \left(1 - \frac{\sqrt{2}\, b}{e_o}\right) \ln\left(\frac{P}{P_o}\right)_e$$

where k is the fracture intrinsic permeability, e is the crack aperture, $k_o e_o$ is permeability-aperture product at reference state, $(P/P_o)_e$ is ratio between unknown and reference effective pressures, b is the r.m.s. of fracture surface protuberances.

This equation has been modified into an expression for the aperture (e) as follows:

$$e = e_o \left[1 - \frac{\sqrt{2}\, b}{e_o} \ln\left(\frac{P}{P_o}\right)_e\right]$$

According to the report, the parameter (b) presumably would account for hysteresis effects as stress was applied and taller asperites crushed. The report notes that permeability vs. stress relationships are not available for tuff from the Nevada Test Site.

According to the report, the effects of changes in both confining pressure ($P_c$) and the fluid pressure in the fracture ($P_f$) usually are combined to give an effective pressure ($P_e$). The authors of the report note that it was not possible to derive an effective pressure in the analysis. Therefore, the authors assumed that $P_c$ could be used in place of $P_e$ as a rough approximation. This substitution implies the fluid pore pressure is atmospheric. The authors of the report suggest that the fact that Jones (1975) was successful in using confining pressure ($P_c$) in fitting data suggests that the substitution is acceptable.

Figure 4 of the report presents postulated changes in the permeability-aperture product (ke) from the drill hole stress perturbance for vertical-horizontal stress ratios (n) of 0.5, 1.0, and 2.0. The authors of the report conclude that a tangential joint intersection minimizes the permeability changes for $n \leq 1$. They conclude also that a tangential intersection increases permeability slightly for $n > 1$.

The authors of the report present the following conclusions and recommendations:

1. Based on the simplified analysis presented in the report, a tangential intersection of the joint by the drill hole should be used to minimize disturbances of joint permeability in the field nuclide migration experiment. This reasoning assumes that the instrumentation hole can be placed accurately along the joint.

2. The nuclide experiment might benefit from a redesign to a perpendicular intersection of the joint by both the injection and collection holes.

3. As a drill hole approaches a joint, the rock mass above the joint would be expected to be free to relax while the lower portion would not be. This situation would cause shear stresses along the joint. The shear stresses could be diminished by drilling beyond the joint.

4. It can be assumed tentatively that shear stress has less influence than normal stress on permeability.

## SIGNIFICANCE TO NRC WASTE MANAGEMENT PROGRAM:

The report under review presents a simplified analysis of the effects that a tangential intersection of a joint by a drill hole would have on joint permeability in the field nuclide migration experiment. The results of the analysis suggest that a tangential intersection of the joint by the drill hole should be used to minimize disturbances of joint permeability. However the report suggests that a perpendicular intersection of the joint would eliminate normal stress concentrations, but that small shear stresses potentially could develop during drilling.

The report is of special interest to the DOE in their design of the field nuclide migration experiment. However, the report may be significant to the NRC in helping to evaluate the results of the field nuclide migration experiment.

PROBLEMS, DEFICIENCIES OR LIMITATIONS OF REPORT:

The report under review presents a simplified analysis of potential changes in joint permeability in the field nuclide migration experiment due to a tangential intersection of a joint by a drill hole. The primary limitations, as noted in the report, are that permeability vs. stress relationships are not known for tuff from the Nevada Test Site. No studies have been completed on the correspondence of lab and field fracture permeability coefficients. Thus, the necessary lab specimen size to obtain representative field values is not known (Witherspoon, 1981). It is not known if the analysis presented in the report is valid with respect to the conditions that may exist within fractured tuff of the Nevada Test Site.

SUGGESTED FOLLOW-UP ACTIVITIES

The report under review is of special interest to the DOE in the design and analysis of a field nuclide migration experiment.

REFERENCES CITED:

Jones, F.O., 1975, A Laboratory Study on the Effects of Confining Pressure on Fracture Flow and Storage Capacity in Carbonate Rocks. J. Petrol. Technol., vol. 21, p. 21-27.

Kranz, R.L., and others, 1979, The Permeability of Hole and Jointed Barre Granite. Int. J. Rock Mech. Min. Sci. and Geomech. Abstr., vol. 16, p. 225-234.

Walsh, J.B., 1981, Effect of Pore Pressure and Confining Pressure on Rock Permeability. Seminar presented January 20, 1981, at Sandia National Laboratories.

Witherspoon, P.A., 1981, Effect of Size on Fluid Movement in Rock Fractures. Geophysical Research Letters, vol. 8, no. 7, p. 659-661.