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TO BE REFERENCED IN 8.3.1.4.1

AS "MONTAZER, 1985"

United States Department of the Interior

GEOLOGICAL SURVEY
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IN REPLY
REFER TO

December 4, 1985

Paul L. Aamodt
Los Alamos National Laboratories
P.O. Box 1663, MS F-671
Los Alamos, New Mexico 87545

Dear Paul:

Enclosed is an unreviewed draft of the rationale for dry mining of the infiltration and bulk permeability test rooms that Phil Harrold and I prepared. Please distribute this to the committee members for comments. Also, if you think it appropriate, a copy may be sent to WMPO, as this was an action item that was requested by Don Vieth.

P. Montazer

P. Montazer

Enclosure

cc (w/encl.): W. E. Wilson
W. W. Dudley
P. Harrold

RATIONALE FOR DRY MINING IN PORTIONS OF THE LOWER BREAKOUT HORIZON

The Exploratory Shaft Test Plan (ESTP) includes hydrologic tests that require a natural, minimally-disturbed rock mass. This, in turn, requires the use of dry-mining techniques in the construction of the testing chambers and portions of the adjacent access drifts of the lower breakout horizon (Fig. 1). This rationale will summarize these tests and explain the importance of minimizing perturbations of the rock's hydrologic conditions.

When water is introduced to the unsaturated zone, either by natural infiltration from storm runoff or by artificial infiltration from wet-drilling or mining operations, the fluid saturations in the rock mass may change significantly. Whether these changes are measurable or significant depends on the volume of water introduced. Montazer and Wilson (1984) describe how fluid flow through fractures is a very sensitive function of matrix potential and saturation. It can easily be imagined that if water content and saturation were to increase, a critical level of saturation would be reached wherein fractures would suddenly become major conduits for fluid flow. The hydrologic character of the entire rock mass, especially its fluxes and travel times, may change quite rapidly. A very simplified calculation is made in the appendix to demonstrate the significance of wet mining on the hydraulic properties of the rock mass.

The Infiltration and Bulk-Permeability Tests, as currently described in the ESTP, are designed to characterize the hydrologic properties of a natural, unperturbed rock mass. These tests will measure and determine relationships among rock-mass hydraulic and transport properties of the Topopah Spring Welded Unit. Of particular concern will be the hydrologic conditions under which fracture and matrix flow occur. The tests will significantly contribute to an understanding of flow mechanisms by providing a unique opportunity to observe water flow and chemical transport under controlled conditions. The results of the tests will be used to determine flux through the host rock and the effective porosity and hydraulic conductivity at various fluxes.

The natural, unperturbed rock conditions required in the Infiltration and Bulk-Permeability Tests provide the low-moisture conditions necessary for permeability testing of individual fractures, discrete volumes of rock matrix, and the rock mass as a whole. Permeability values are determined from characteristic curves (saturation versus relative permeability) and moisture contents measured over the range of in-situ saturations. These hydrologic parameters are non-linearly related and hysteric (curve shape changes depending on whether the rock mass is undergoing saturation or desaturation). As a result, extrapolation of the saturation and permeability curves may produce misleading or incorrect values. Therefore, the hydrologic parameters must be measured at all levels of saturation, especially those levels at the extreme ends of the saturation range where characteristic-curve shapes are apt to change dramatically.

For this reason, preservation during the construction phase of low moisture-content conditions is essential for effective determination of characteristic curves in and around the testing chambers for the Infiltration and Bulk-Permeability Tests. The introduction of water or drilling and mining fluids may significantly affect the natural state of the formation's moisture content. As a result, it would be impossible to accurately determine portions of the characteristic curves. The tests can only be performed when saturation levels are carefully measured under controlled conditions. This control refers not only to volumes of water, but also rates of water infiltration, and the volumes and location of the affected rock mass. Such control is not feasible during wet-mining operations.

We advocate the use of dry-mining techniques or methods that require minimal amounts of water (that can be carefully monitored and controlled). These procedures should be used in constructing the test chambers for the Infiltration and Bulk-Permeability Tests and adjacent portions of the access drift. A detailed specification of where these methods should be used can be provided when the plans for the lower breakout horizon are finalized.

Reference:

Montazer, P., and W.E. Wilson, 1984, Conceptual hydrologic model of flow in the unsaturated zone, Yucca Mountain, Nevada: U.S. Geol-Survey, Water-Resources Investigations Report 84-4345, 55p.

Appendix

Assume an opening 12 x 12 ft^2 is excavated in a fractured rock mass as shown in figure 1. Each round is about 8 ft deep. The rock mass around the excavation is transected by two sets of orthogonal fractures (a third set is not considered for simplicity). Water that is added to the rock mass during excavation is assumed to be dispersed uniformly throughout the first 3 ft of the rock surrounding the opening. This last assumption generally is not true because water tends to move downward. The following volumetric calculations can be made:

1) Volume of the influenced area:

   $V_s = (18 \times 18 - 12 \times 12) \times 8 = 1440\ ft^3$

2) Fracture porosity:

   (V_p = volume of pore space)

   (assume fracture width (w) of 3×10^{-4} ft)

   $V_p = (4 \times 18 + 16 \times 3) \times 8 \times w = 0.29\ ft^3$

   fracture porosity (Φ_f) = $0.29/1440 = 2. \times 10^{-4}$ or 0.02%

3) It is assumed that the water penetrates approximately 0.1 ft into the walls of the fractures. The volume of this wetted skin (V_{ws}):

   $V_{ws} = (4 \times 18 \times 8 \times 0.2) + (16 \times 3 \times 8 \times 0.2) = 192\ ft^3$

4) Volume of water that is lost to the formation during excavation of each round is assumed to be about 60 gal, or 8 ft^3.

5) The matrix is assumed to have porosity of 15 percent, a saturation of 65 percent, and a water content of 9.75 percent.

6) Therefore, the 8 ft^3 of water will result in and increase in water content of:

   8/192 = 0.04 or

   0.04/0.15 = 0.28 increase in saturation

   Therefore, the final saturation will be increased from 65% to 93%.

7) From figures 2 and 3 it can be seen that this increase in saturation could cause an increase in relative conductivity of an order of magnitude.

8) If the matrix saturation is initially 84% (the upper limit given in Montazer and Wilson, 1984), a 28% increase will result in full saturation and, therefore, will result in flow in the fractures.

It should be noted that if the hysteric wetting curve is used, fracture flow could occur even in the first case. Occurrence of fracture flow will result in a more widespread influence of the rock mass. In addition, increase in saturation of the fracture in the vicinity of the test room will result in early fracture flow during testing. For these reasons, hydrologic testing will be seriously affected by perturbation of flow mechanisms and the ambient moisture content.

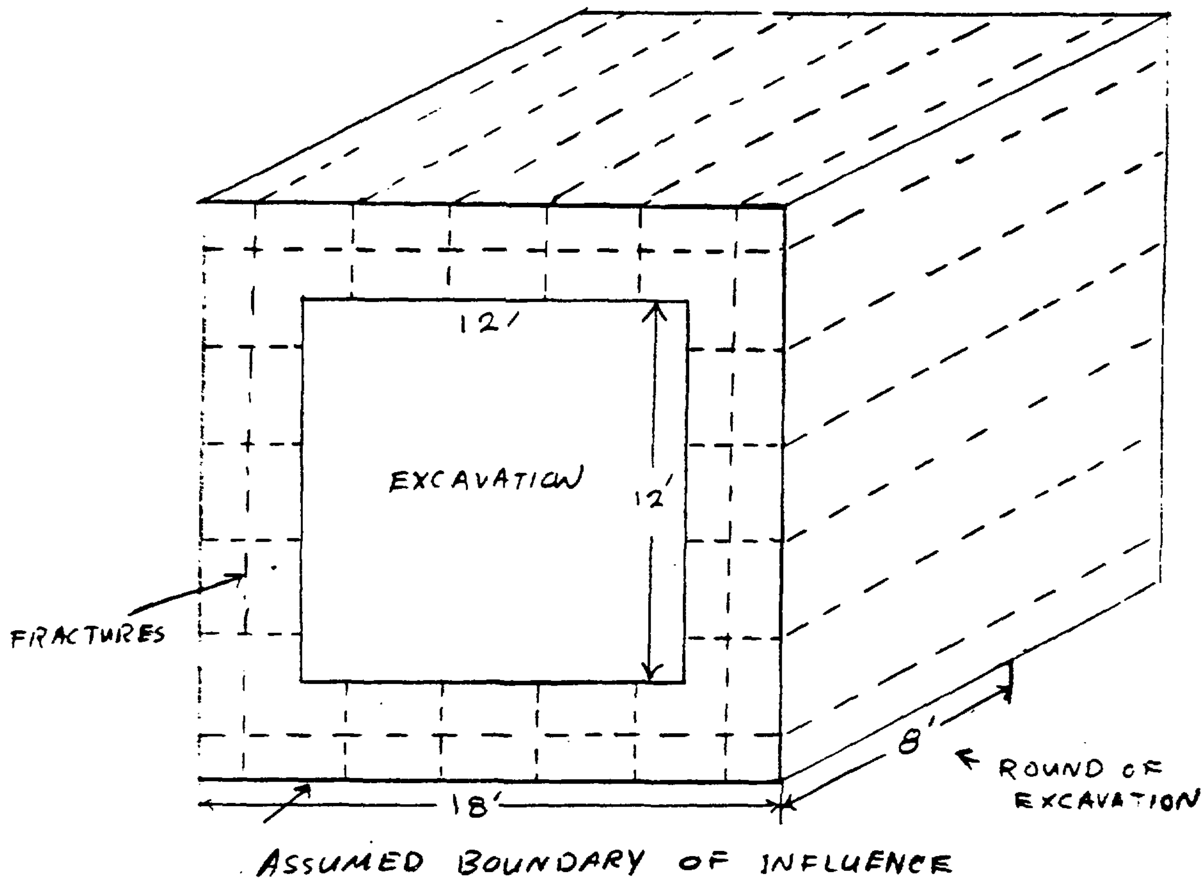

Figure 1.

[Please type "Figure # ." for these illustrations on 2 blank pages so these illustrations can be cut-and-pasted on them]

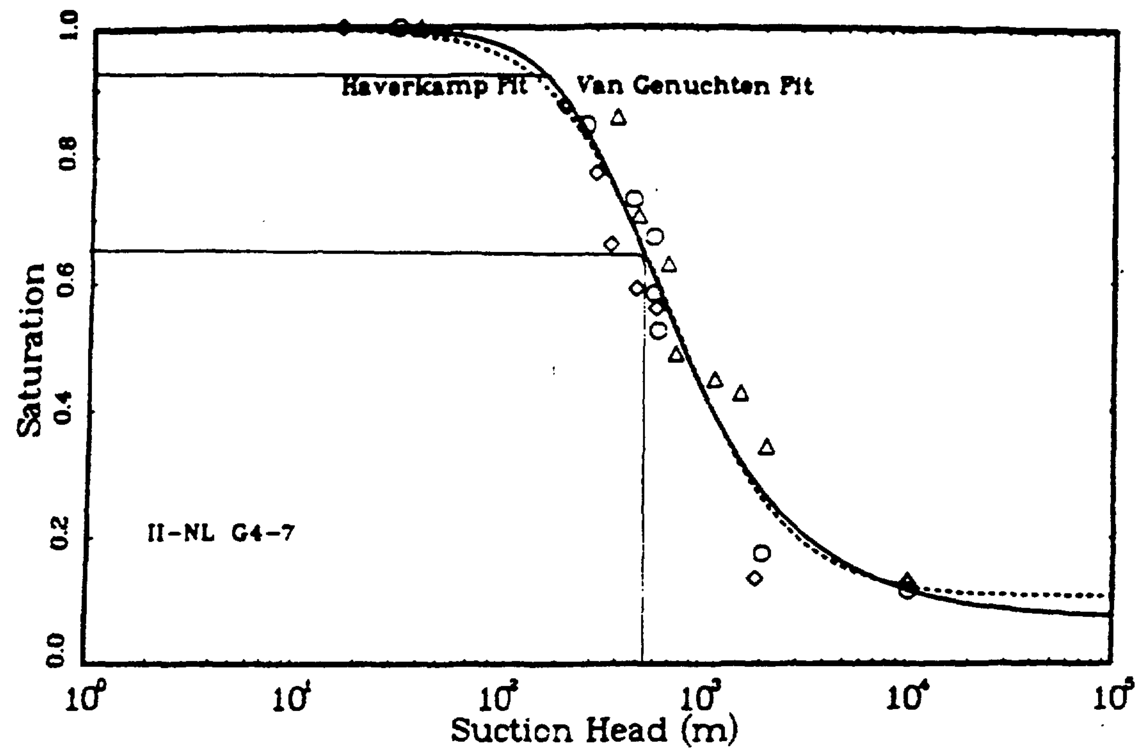

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Figure ~~B.1~~

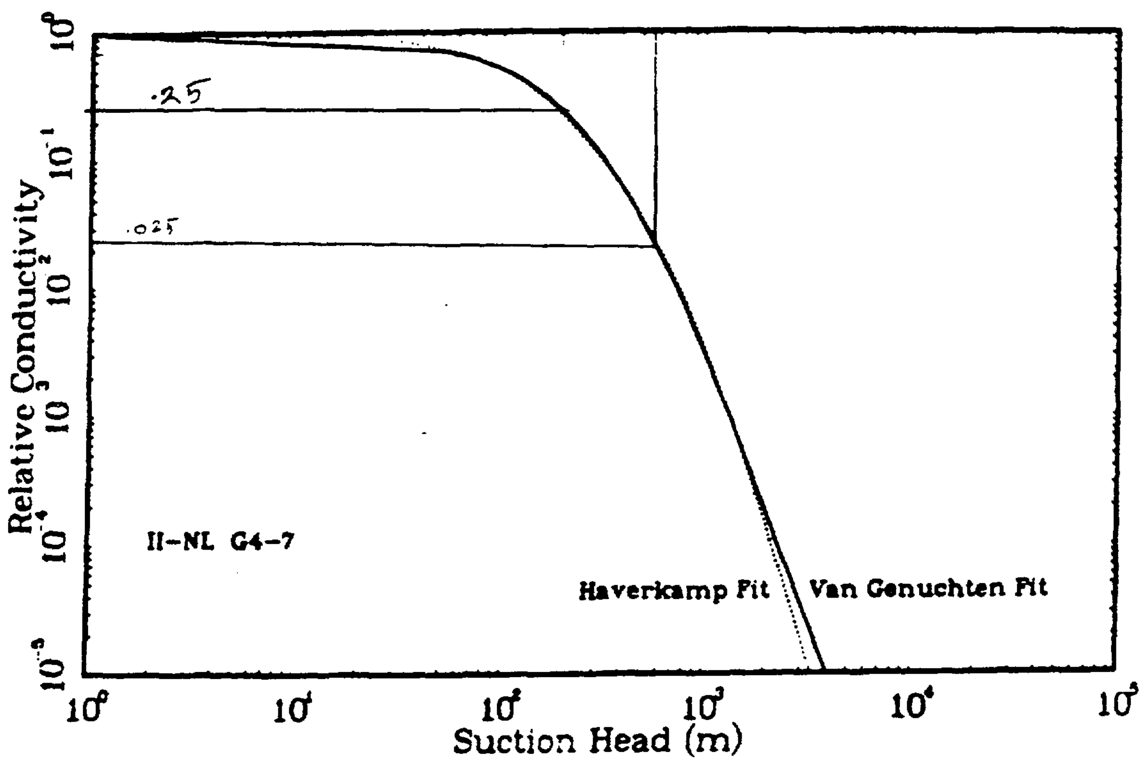

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Figure ~~B.1~~