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LAWRENCE BERKELEY LABORATORY
Room: 128 Bldg.: 70 Ext.: 6241

December 9, 1980

TO: Charles Grua, Brian Harney, and Art Hartstein

FROM: Peter Persoff, Bill Hall, Mohsen Mehran, and Phyllis Fox

RE: Monthly Progress Report for November
Control Technology for In-Situ Oil Shale Retorts
LBID-320

TASK 3. BARRIER OPTIONS

Permeability Measurements on Candidate Grouts

Data analysis has been completed for permeability measurements on two specimens of Q-0 grout (2/3 Lurgi spent shale, 1/3 sand, and water) and one of Q-1 grout (same with 2½% portland cement). The results of these tests are shown in Figure 1. The permeability of these grouts, like that of a soil, depends upon the state of stress (confining pressure). The actual permeability that will exist in a field application depends upon the stress that will be seen by a grouted retort; structural calculations are needed to determine this.

A minor effect also shown in Figure 1 is that permeability is lower when measured at a higher hydraulic gradient. This was not expected. The explanation may be that after each stepwise increase in the hydraulic gradient, more rapid flow through the specimen dislodges some particles and results in a denser, more stable packing which is less permeable. This effect was more pronounced for Q-0, which contains no cement, than for Q-1, which contains 2½% portland cement; this would support this hypothesis.

Rheological Properties of Spent Shale Grouts

Data were analyzed from rheological measurements on grouts R-4 and R-5. These are Lurgi spent shale grouts with lignosulfonate fluidizer and fly ash. The grouts conform to the Casson Model (see Figure 2) with the constants shown in Table 1. Although the flow cone times for both grouts were nearly identical, R-4 had a higher intercept (yield value) and lower slope. The uncertainty shown in Table 1 is the standard deviation

of multiple determinations, and is apparently due to thixotropy, that is, change of properties with shearing history.

Table 1. Casson model flow constants for Lurgi spent shale grouts

	R-4	R-5
yield stress ($dyne/cm^2$)	62.4±6.4	54.4±7.0
slope of line $(g/cm\text{-}sec)^{\frac{1}{2}}$	1.45±0.22	2.33±0.14
flow cone time (sec)	22.2	22.4
water-solids ratio	0.691	0.635

TASK 5. LEACHING OPTIONS

Leaching of Organics from Spent Shale

At the beginning of the month, 28 small column runs had been completed. During November, the data for all runs were reviewed and the construction of a data base for the final analyses was begun. Data from the last fourteen runs are being smoothed statistically for use in the verification of the leaching and transport model. The first 14 runs were conducted with leachate flowing upward in the column. Data from these runs are useful in understanding the mechanisms involved in leaching but are not suitable for model verification because of the adverse effects of density currents in the pores of the bed. In addition, all leachate samples from runs 24 through 28 are being remeasured for TOC to minimize the chance of analytical errors. These five runs were conducted under similar experimental conditions; only the pore velocities and the types of spent shale were varied. These latter runs are expected to be the principal source for the data base.

A simple mathematical model for the movement of TOC within the boundaries of the solid particles was developed and tested with data from runs 26 and 27. The agreement between experimental and predicted results is quite good. A slightly more complex model is now being developed and tested.

TASK 6. GEOHYDROLOGIC MODIFICATION

Dewatering and Reinvasion Calculations

Long-term simulations of dewatering were carried out for tracts C-a and C-b using saturated hydraulic properties reported in the literature (see Table 2). Twenty percent residual saturation was assumed and unsaturated properties were calculated using the Millington-Quirk formula as described last month.

Inflow rates (dewatering flows) for the two tracts are shown in Figures 3 and 4. The gradual increase in the dewatering flow rate is due to expansion of the retorted area with time. In Figure 3, two extreme reported values of permeability for the lower aquifer were used to calculate the inflow rate; this shows the importance of knowing this value accurately.

Drawdowns of the phreatic surface under the Piceance Creek (3500 m from the center of tract C-b) and Yellow Creek (5000 m from the center of tract C-a) are shown in Figures 5 and 6. In the latter case, the initial rise in the water table is due to recharge before the effect of mine dewatering is felt.

Table 2. Properties used for long-term dewatering simulations.

Property	Upper Aquifer	Confining Layer	Lower Aquifer
Saturated Permeability (m^2)	7.64×10^{-14}	2.00×10^{-15}	2.45×10^{-14}
Storage Coefficient	--	--	1×10^{-4}
Porosity	0.15	0.01	0.01
Residual Saturation	0.20	0.20	--

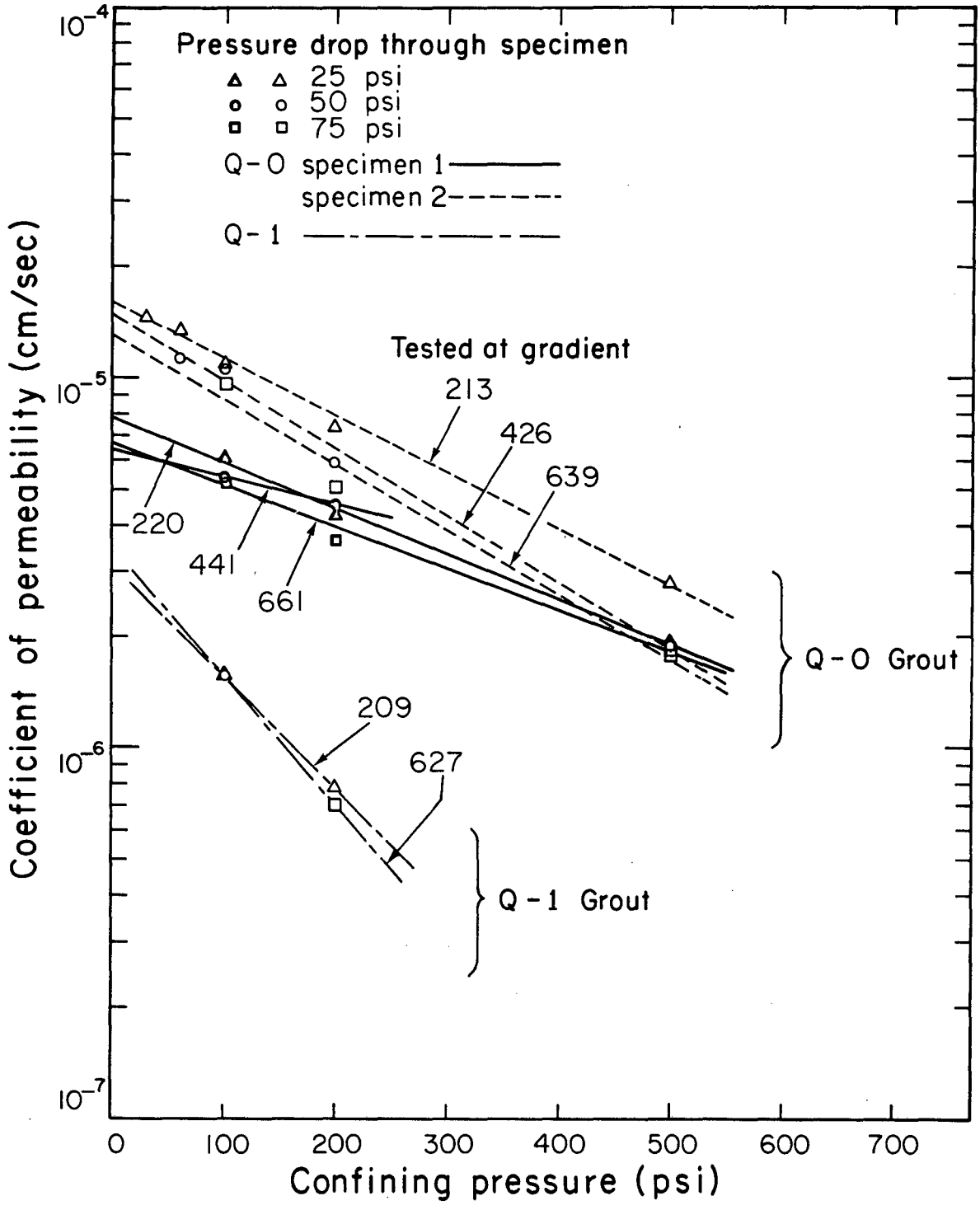

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Figure 1. Variation of permeability with confining pressure and hydraulic gradient during test for grouts Q-0 (no cement) and Q-1 (2½% portland cement).

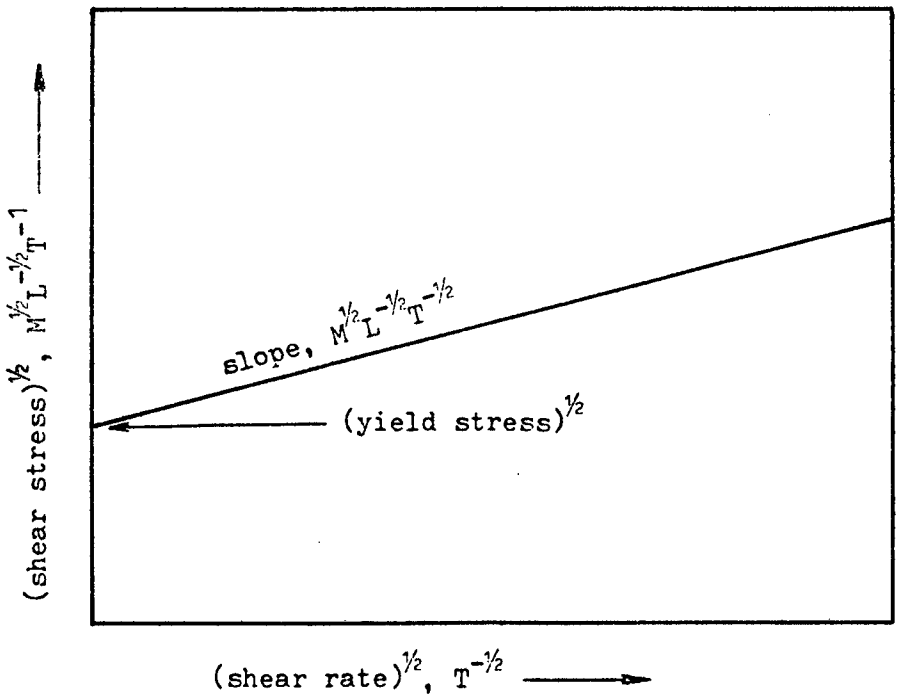

Figure 2. Schematic rheogram for Casson fluids.

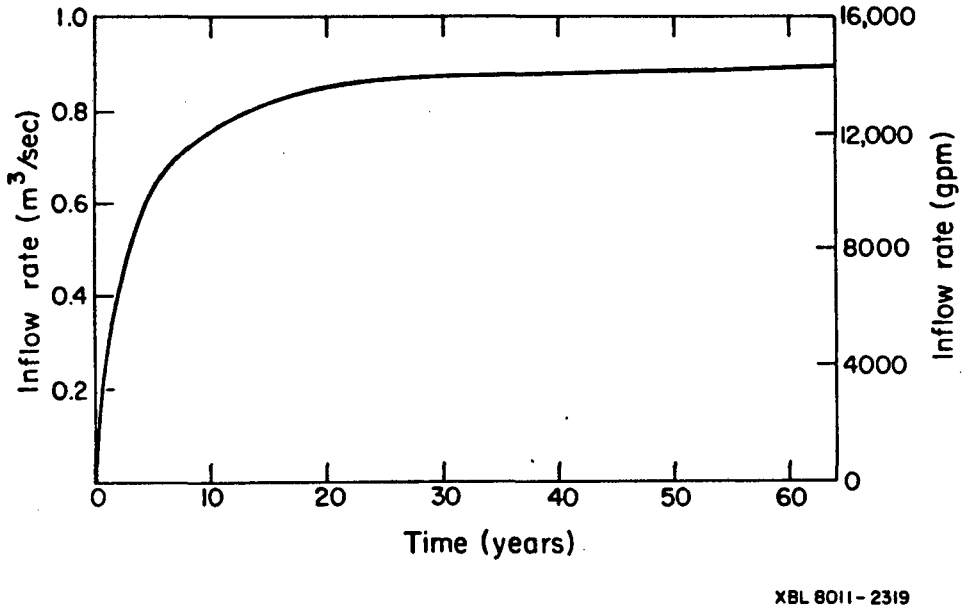

Figure 3. 60-year simulation of dewatering for tract C-b, using hydraulic conductivity data reported in Tipton and Kalmbach (1977). Storage coefficient of the lower aquifer = 10^{-4}.

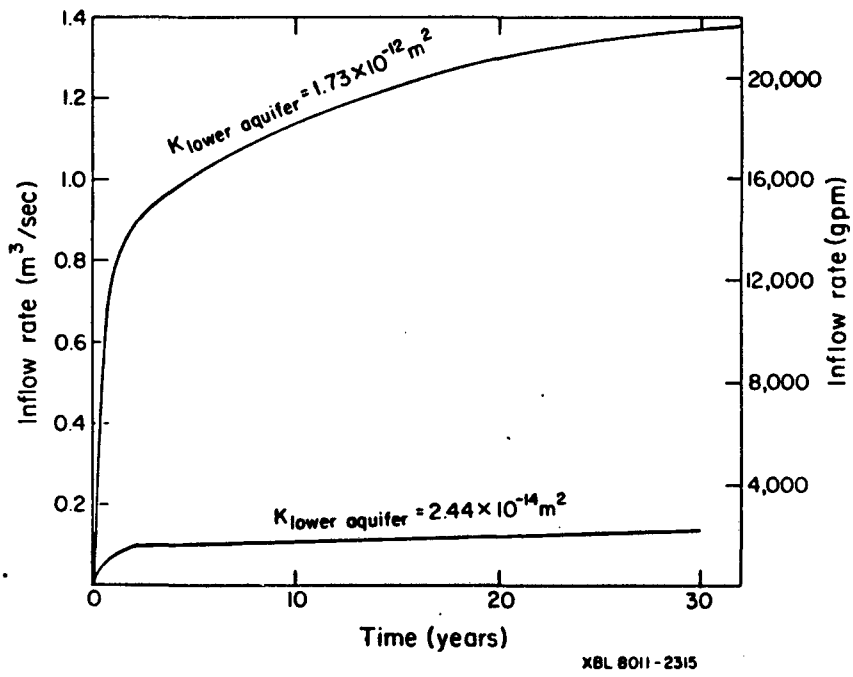

Figure 4. 30-year simulation of dewatering for tract C-a, for two extreme reported values of permeability for the lower aquifer.

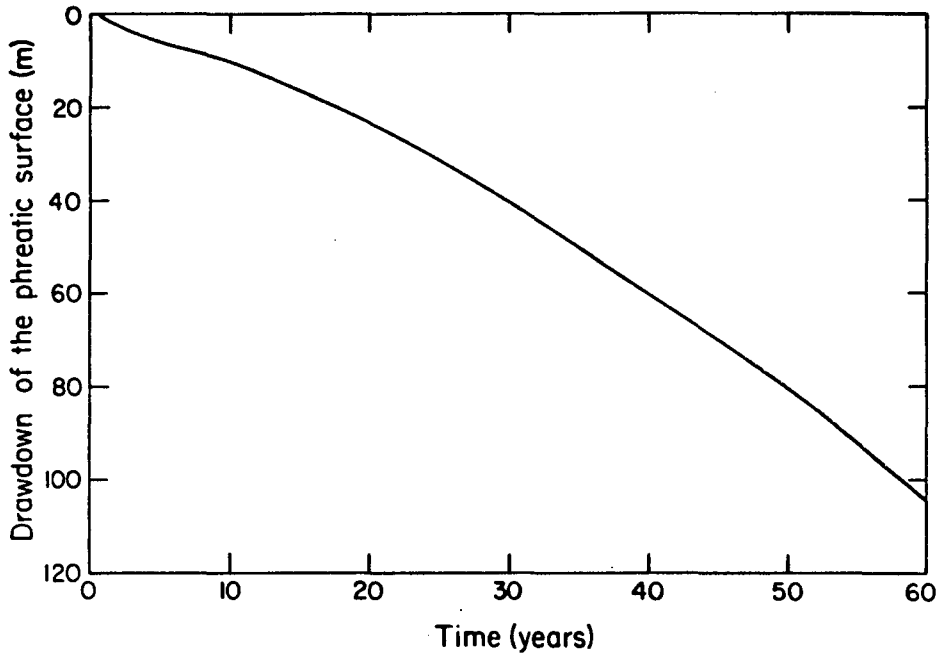

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Figure 5. Drawdown of the phreatic surface 3.5 km from the center of tract C-b.

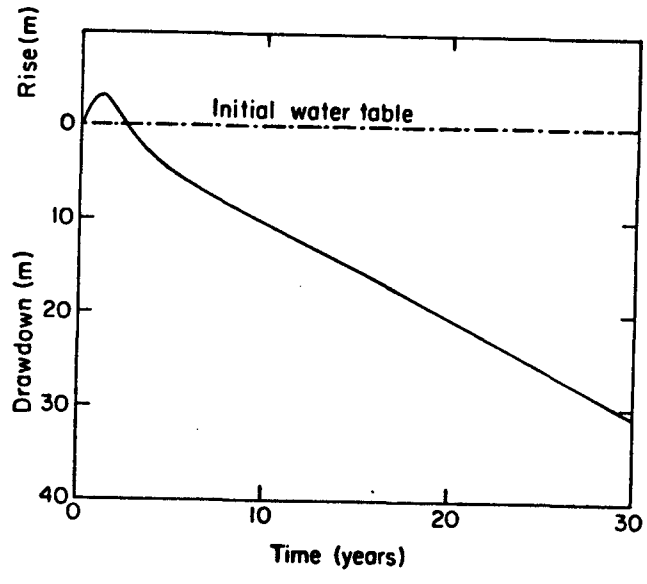

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Figure 6. Drawdown of the phreatic surface 5 km from the center of the tract C-a.

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