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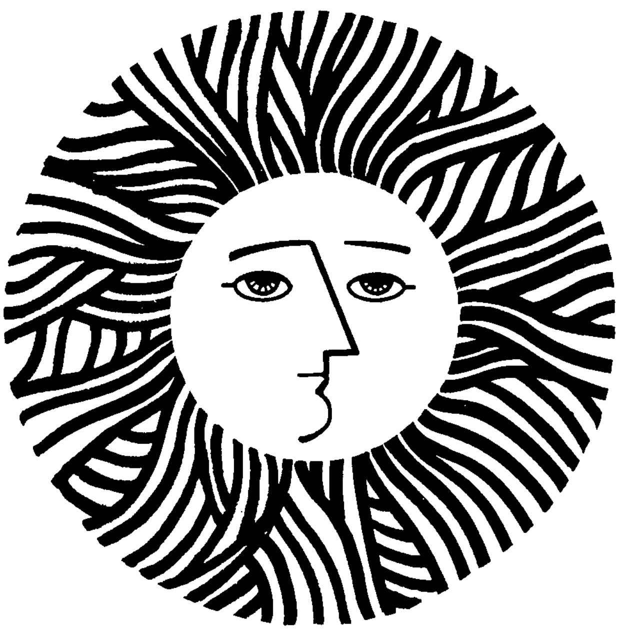

LAWRENCE BERKELEY LABORATORY
Room: 128 Bldg.: 70 Ext.: 6241

May 20, 1980

TO: Charles Grua, Art Hartstein, and Paul Weiber

FROM: Peter Persoff, Joe Ratigan, Mohsen Mehran, and Phyllis Fox

RE: April Monthly Progress Report
Control Technology for In-Situ Oil Shale Retorts
LBID-206

PRESENTATIONS AND PUBLICATIONS

The paper "Hydraulic Cement Production from Lurgi Spent Shale" by P. K. Mehta and P. Persoff was presented at the Thirteenth Oil Shale Symposium, Golden, Colorado, April 17, 1980.

DOE PEER REVIEW

Comments of individual reviewers at the DOE Oil Shale Retort Abandonment Peer Review Session, February 6 - 7, 1980, were received. These review comments generally support the direction of research under this program.

TASK 3. BARRIER OPTIONS

Development of cementitious properties in spent shale.

Work to develop hydraulic cements from spent shale by addition of limestone and calcining is now complete, except for confirming work to be done with additional samples of spent shale when they become available. Meanwhile a new program has been initiated to develop cementing properties in spent shale without addition of any material. In this program spent shale will be heated to low temperatures (up to 950^{o}C) under controlled flowing atmospheres. This treatment may produce MgO by dolomite decomposition in a weakly crystalline form that gains strength upon hydration.

Testing of grouted core samples.

Testing techniques and equipment for measuring permeability and triaxial compressive strength on grouted core samples have been checked out on other samples similar to those to be tested (Q-0 to Q-5). Accurate permeability measurement requires that the sample be thoroughly saturated. The usual technique for saturating rock samples is to place the samples in de-aired water under a vacuum for 24 hours. The same technique will be used for this program except that during saturation the electrical conductivity will be periodically measured. This way one can tell when saturation is complete rather than waiting an arbitrary length of time. An electronic device for measuring conductivity of soil samples is now being fabricated for this part of the work.

Structural modeling of grouted retorts.

The modification to the finite-element program described in last month's report is being debugged. This modification will allow the effect of voids in the grouted retort to be considered in subsidence calculations.

TASK 5. LEACHING OPTIONS

Investigations and batch studies leading to the determination of the rate of diffusion of total organic carbon (TOC) within the pores of the solid shale continued. It is presumed that the rate of movement of TOC from a slab of spent shale into surrounding water can be related to diffusion of TOC within the solid phase. Some difficulty has been encountered with bacterial growth in batch reactor studies in the early stages of leaching. Concentrations of salts and organics in the leaching water are relatively low and apparently provide a favorable environment for biological growth. The presence of the organisms in the leachate interferes with the accurate determination of TOC. A 3 mg/l concentration of silver sulfate maintained in the fluid in the batch reactor appears to control bacterial growth satisfactorily.

A modified method of determining the total amount of organic carbon in spent shale is being investigated. Previously the organic carbon content of the shale needed in the development of the equilibrium isotherm was found by oxidation of organics by hot acids. The revised method is an adaptation of a test suggested by ASTM for use in determining the organic content of soil. A good correlation was obtained of TOC concentrations within the solid phase as measured by the two methods. Investigations into possible chemical interferences in the modified test are continuing.

TASK 6. GEOHYDROLOGIC MODIFICATION

Development of groundwater flow model.

One of the methodologies of dewatering currently under consideration is dewatering by internal drainage as the retorted area expands with time. To simulate drainage under conditions similar to those of trace C-b in the Piceance Creek Basin, the computer program TRUST has been modified to account for an expanding retorted region with time.

Tract C-b hydrology as described in Energy Development Consultants (1980) has been used as a basis for computations of mine drainage. According to this report, development of each panel of retorts is expected to last four years. Each panel consists of 32 clusters with eight retorts in each cluster. Assuming retort dimensions to be 200 ft x 200 ft x 310 ft and pillar size to be 60% of the retort size, the expansion of the radius of an equivalent circular area of retorted region with time is shown in Figures 1 and 2. This computation is based on the assumption that the annual increase in the area of retorted region (including pillar area) is 94 acres.

For modeling purposes and as a first approximation to conditions prevailing on tract C-b, three stratigraphic sections with different hydrogeologic properties are assumed: the Upper Aquifer, the Mahogany Zone, and the Lower Aquifer. To evaluate the critical parameters of the medium with regard to the magnitude of flows and fluxes in a mine drainage operation, a sensitivity analysis was carried out using the values given in Table 1. In cases A, B, and C, three layers with different material properties are considered while in case D, the retorted region is assumed to be surrounded by the low permeability Mahogany Zone which retards flow into the drainage area. In Table 1, $S(\psi)$ and $K(\psi)$ refer to saturation vs pressure head and permeability vs pressure head relationships. These relationships were selected based on other related materials because no experimental data for oil shale are available. Figure 3 shows the variation of saturation with pressure head for two different materials. Residual saturation of $S(\psi)_2$ is three times greater than that of $S(\psi)$. The relationship between permeability and pressure head is given in Figure 4.

Figure 5 shows the flux into the mine for the various cases considered. The difference in flux between cases A and B is contributed to by the difference in the assumed relationship between the degree of saturation and pressure head. It is evident that as desaturation proceeds, the effect of residual saturation becomes more dominant. The reduction in flux in case C is due to the low permeability of the Mahogany Zone. The drastic reduction in flux in case D is caused by the low permeability zone that surrounds the retorted region.

According to Smith et al. (1978), a continuous layer of nearly impermeable oil shale overlies the Mahogany Zone. This suggests that mine expansion in the Mahogany Zone without disturbing the lower and upper aquifers may be a viable control technology (case D). More sensitivity analyses on the effect of permeability and permeability-pressure head relationships are underway which will be discussed in the next report.

REFERENCES

ASTM Special Technical Publication 479 (no date cited), Special Procedures for Testing Soil and Rocks for Engineering Purposes, Suggested Methods of Test for Organic Matter Content of Soil by Redox Titration, ASTM Philadelphia.

Smith, J.W., T. N. Beard, and L. G. Trudell, 1978. Colorado's Primary Oil Shale Resource for Vertical Modified In-Situ Processes, LETC/RI-78/2, Laramie Energy Technology Center.

Energy Development Consultants, Inc., March 1980. Technology Characterization Task Report (draft).

Table 1. Selected properties for sensitivity analysis.

Case	A		B		C		D	
Layer	Unsaturated Properties	Saturated Permeability (m^2)	Unsaturated Properties	Saturated Permeability (m^2)	Unsaturated Properties	Saturated Permeability (m^2)	Unsaturated Properties	Saturated Permeability (m^2)
Upper Aquifer	$S(\psi)_1;K(\psi)_1$	4.80×10^{-14}	$S(\psi)_2;K(\psi)_1$	4.80×10^{-14}	$S(\psi)_1;K(\psi)_1$	4.80×10^{-14}	$S(\psi)_1;K(\psi)_1$	4.80×10^{-14}
Blanket							$S(\psi)_1;K(\psi)_2$	1.30×10^{-15}
Mahagony Zone	$S(\psi)_1;K(\psi)_2$	1.28×10^{-14}	$S(\psi)_1;K(\psi)_2$	1.28×10^{-14}	$S(\psi)_1;K(\psi)_2$	1.30×10^{-15}	$S(\psi)_1;K(\psi)_2$	1.30×10^{-15}
Blanket							$S(\psi)_1;K(\psi)_2$	1.30×10^{-15}
Lower Aquifer	--	1.28×10^{-14}	--	1.28×10^{-14}	--	1.28×10^{-14}	--	1.28×10^{-14}

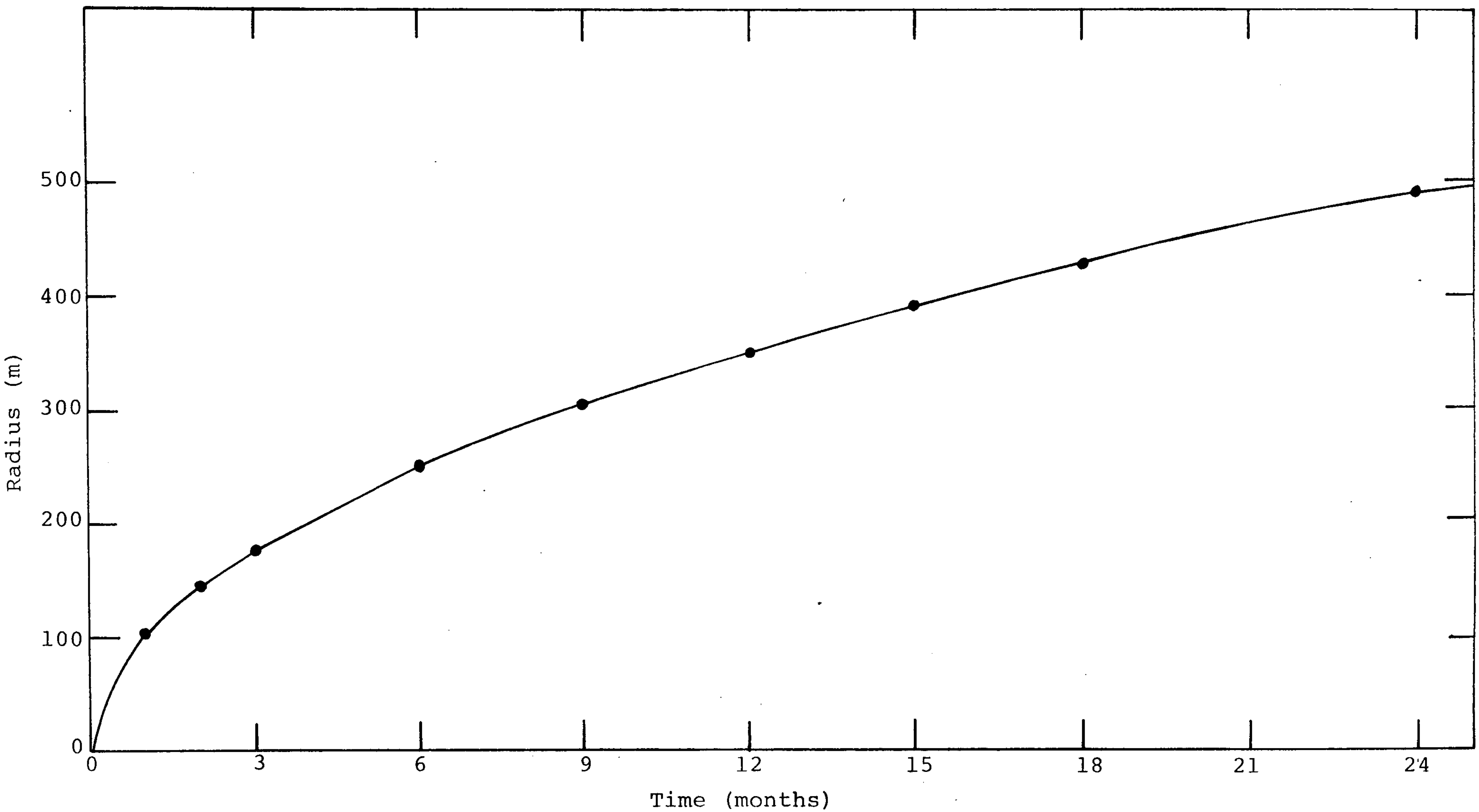

Figure 1. Expansion of retorted area radius with time.

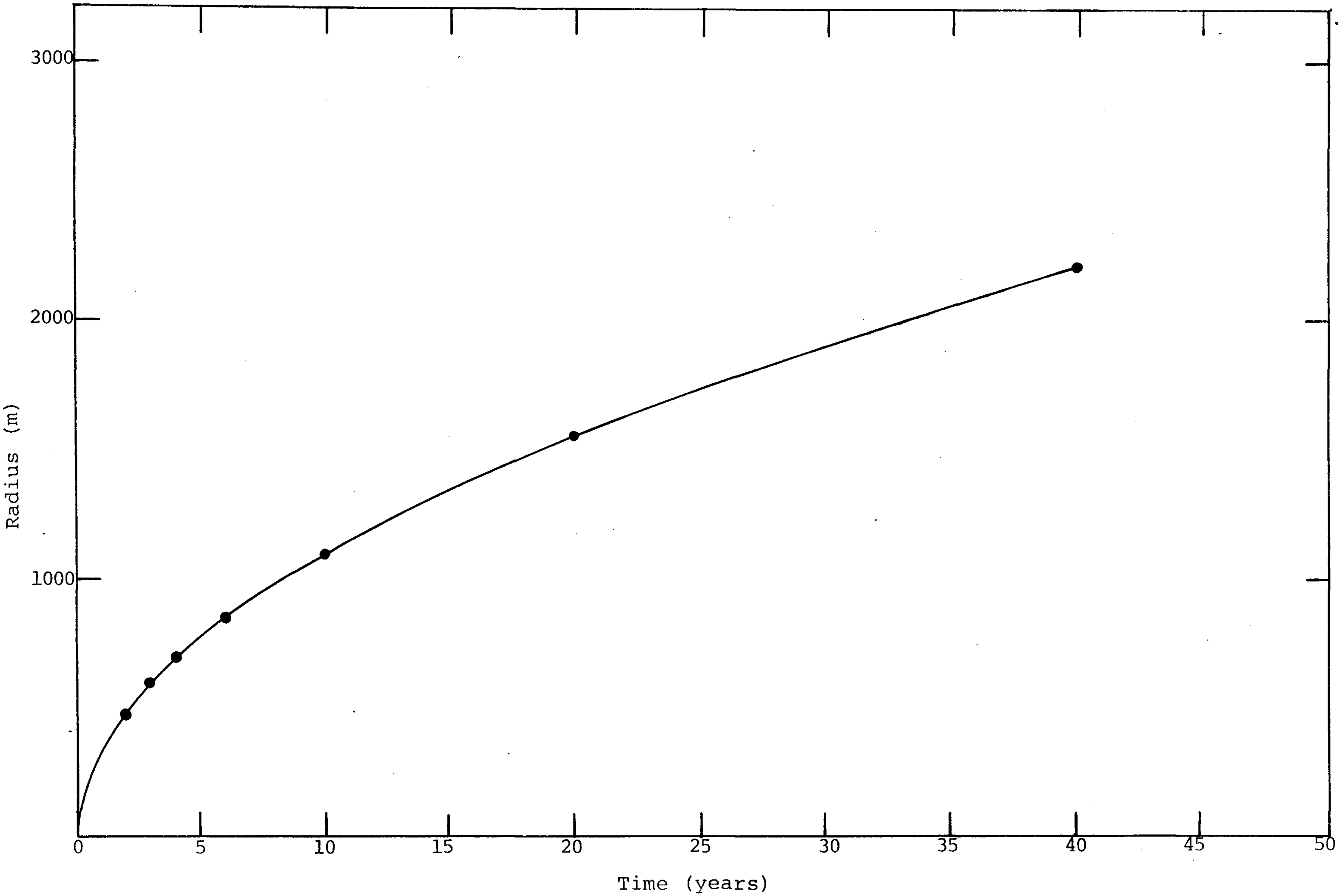

Figure 2. Expansion of the retorted area radius with time.

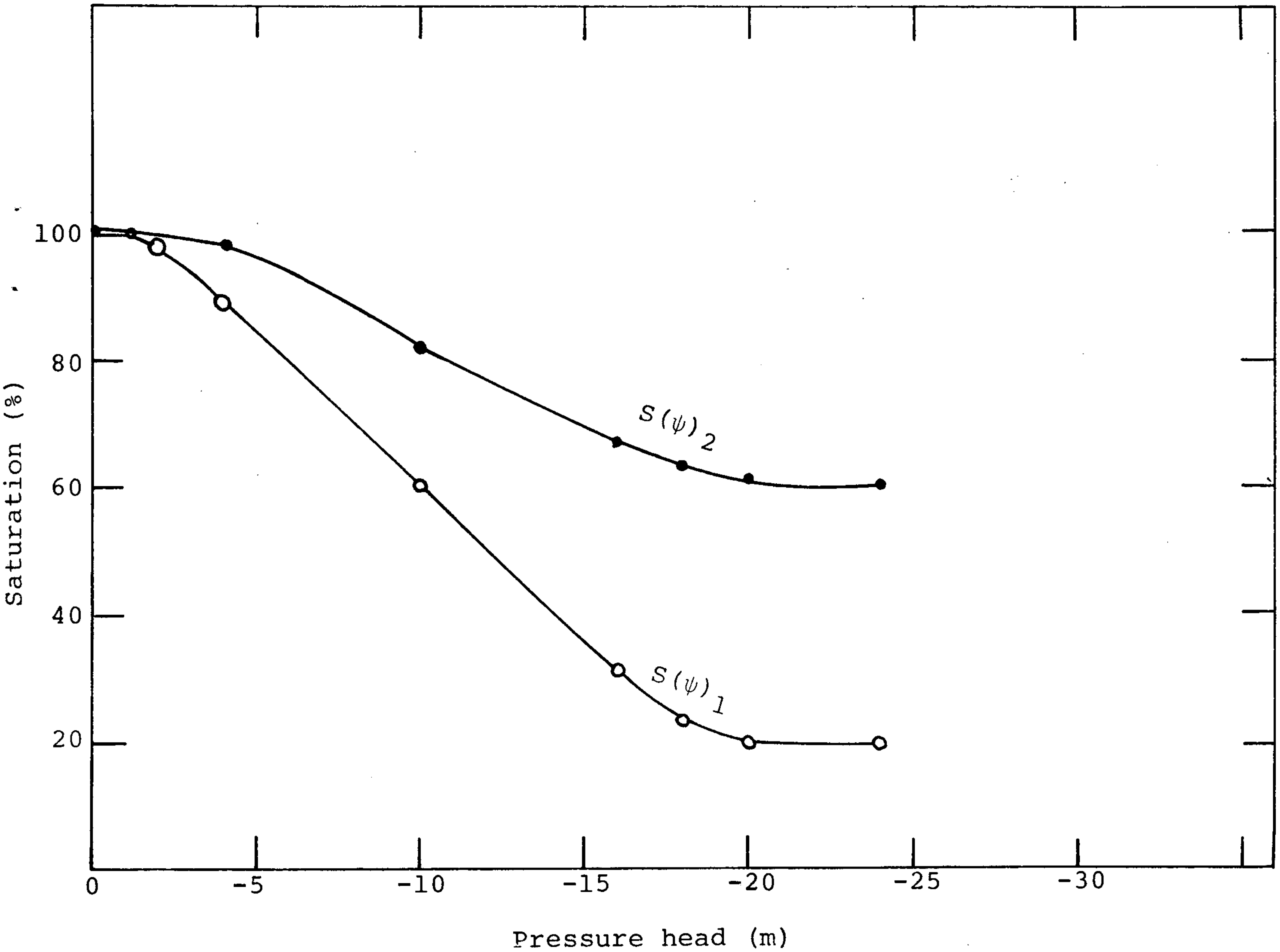

Figure 3. Percent saturation as a function of pressure head.

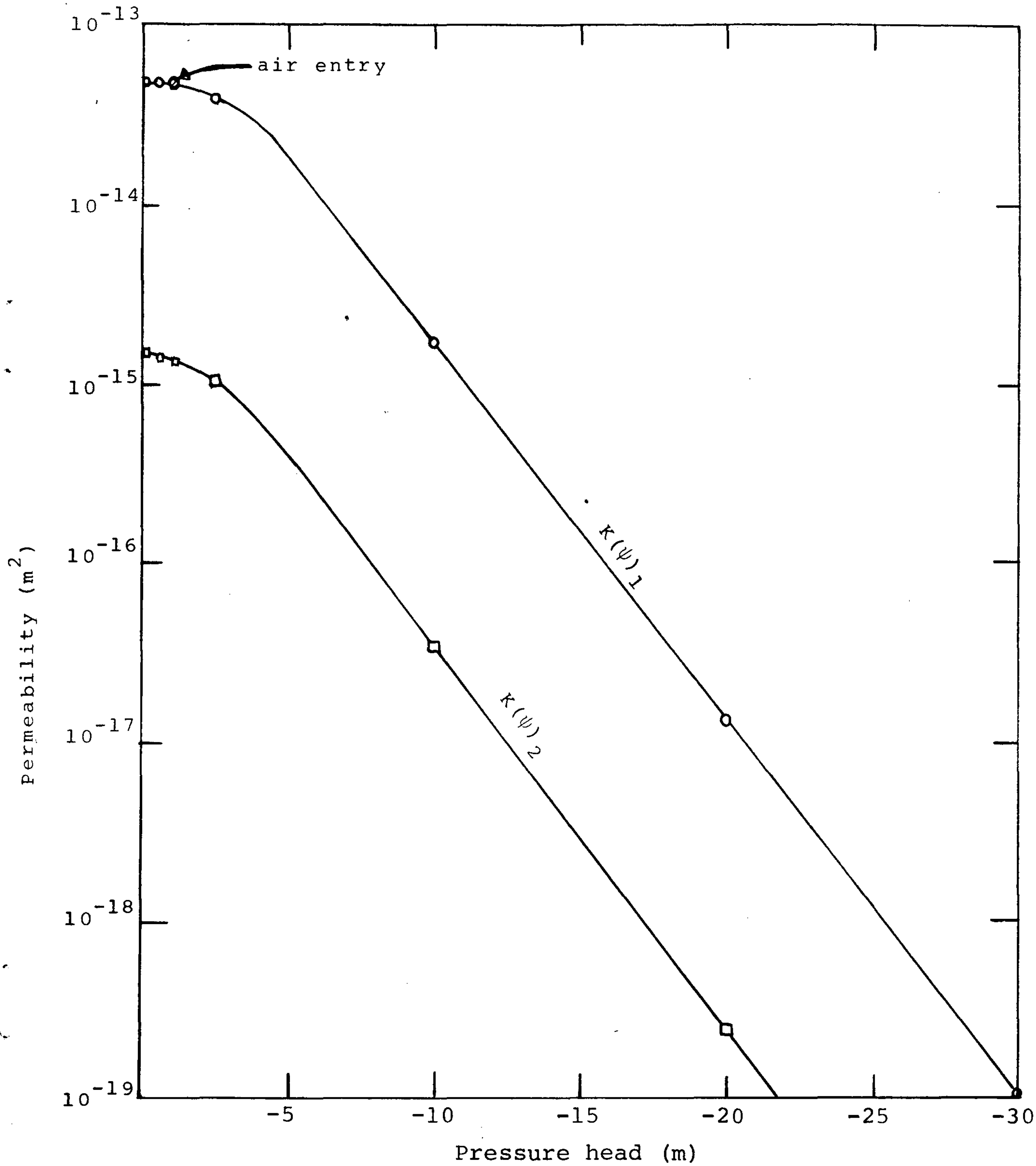

Figure 4. The relationship between permeability and pressure head for the upper aquifer, $K(\psi)_1$, and the mahogany zone, $K(\psi)_2$.

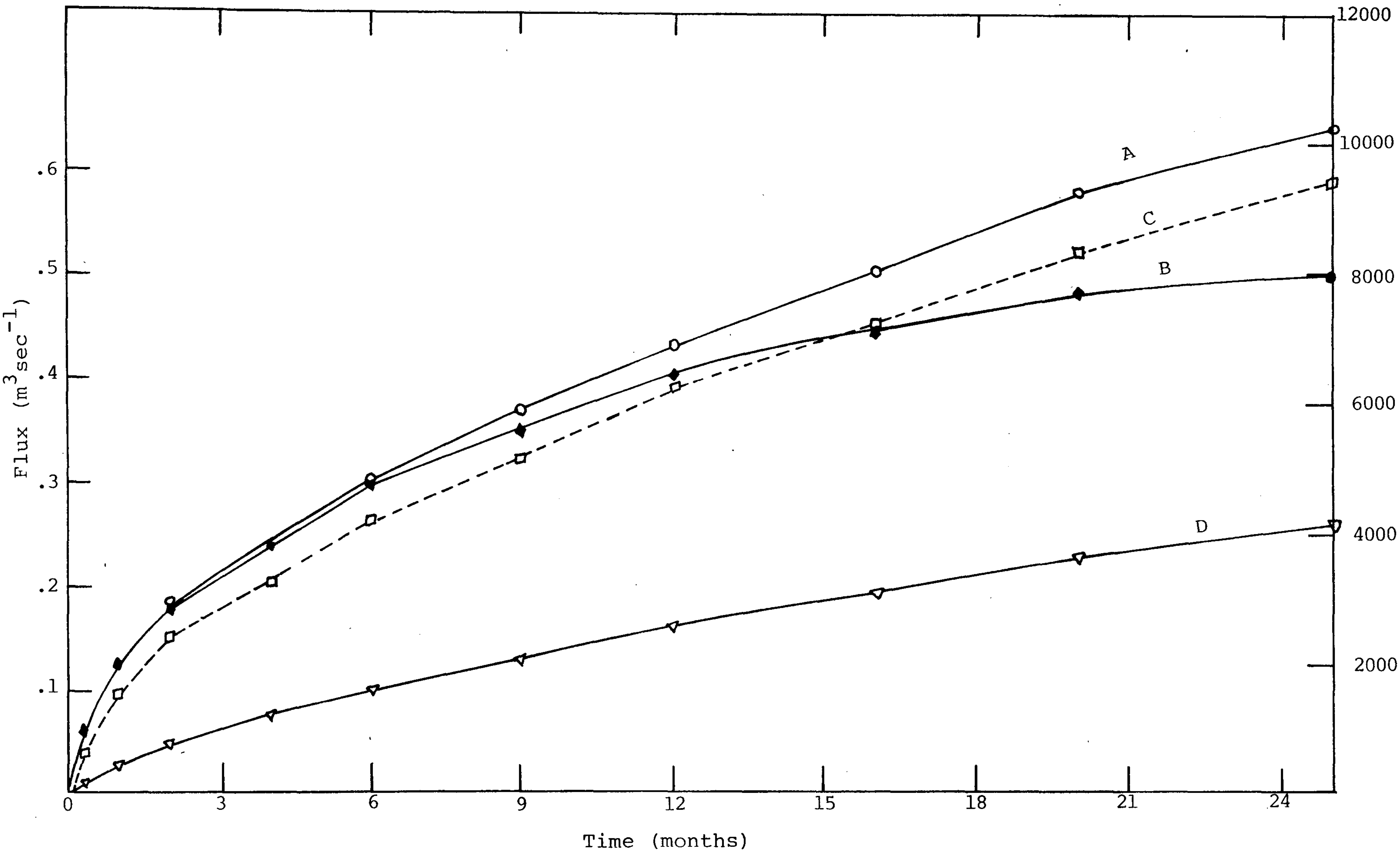

Figure 5. Rate of change in flux in mine drainage of an expanding retort in Tract C-b.

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