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PRESSURE-INDUCED BRINE MIGRATION INTO AN OPEN BOREHOLE IN A SALT REPOSITORY

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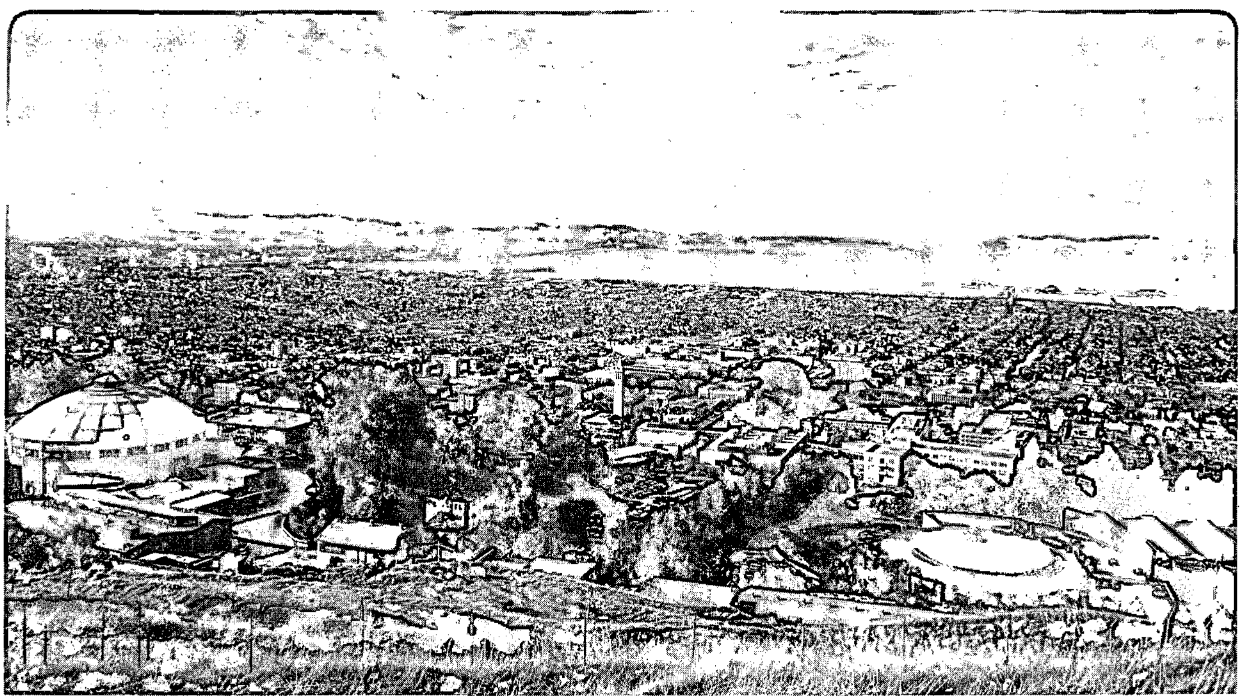

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Pressure-Induced Brine Migration into an Open Borehole in a Salt Repository*

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In the *Environmental Assessment*[1] for a potential nuclear waste repository in salt, estimates of release rates of radionuclides from the engineered barrier system were made by multiplying the brine flow rate into an assumed open borehole at 300 years by the solubilities of radioelements in the waste package. The borehole was conservatively assumed to remain open, at atmospheric pressure, for hundreds and thousands of years. Brine was assumed to migrate into the borehole at a rate given by the Jenks equation[2] for temperature-gradient induced movement of brine inclusions within individual salt crystals. However, it is now recognized that inclusions that reach grain boundaries are likely to move along grain boundaries under the influence of a pressure gradient, along with brine originally present in the grain boundaries. Here we present estimates of the rate of brine accumulation in an assumed open borehole, based on grain-boundary migration theory.

Within a few years after emplacement, brine inclusions inside salt crystals within a few meters of a hot waste package will have migrated to the grain boundaries. Pressure gradients to cause grain-boundary migration result from the difference between the far-field hydrostatic pressure of brine in the undisturbed salt and the assumed atmospheric pressure in the borehole, and from the pressure gradients resulting from thermal expansion of the salt and brine in the time-dependent temperature field. The formulation of brine movement with salt as a thermoelastic porous medium, in the context of the continuum theory of mixtures, was published by McTigue.[3] Chambré obtained the analytic solutions to the governing equations for a spherical-equivalent waste form and to the coupled radionuclide transport problem, driven by thermoelastic effects.[4] In numerical calculations we found that the thermoelastic effects are minute for this case and the McTigue equations reduce to those of standard time-dependent pressure-driven porous media flow.

We present some numerical illustrations of the solution for a spherical-equivalent waste package embedded in an infinite salt medium, using a permeability of 10^{-21} m^2, a value suggested by McTigue[3]. We assume

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a far-field lithostatic pressure of 16.3 MPa and obtain the predicted velocity of brine flow into the open borehole shown in Figure 1. The velocity is small and rapidly approaches steady state, in contrast to the analysis in the *Environmental Assessment* where steady state is reached only after several hundred years. Figure 2 is a comparison of the cumulative brine flow volumes predicted by various models. In Figure 2 the *Environmental Assessment* prediction of cumulative brine inflow, primarily thermally-driven, is shown along with our results for pressure gradient flow. Also shown are cumulative brine flows calculated using McTigue's model equations. For the parameter values adopted herein, grain-boundary migration into an open borehole is driven almost entirely by the large difference between pressures in the far field and in the borehole. On the long time scales of Figure 2, brine is calculated to accumulate linearly with time. It does not level off after about 1,000 years as is predicted in the *Environmental Assessment*.

We have presented selected results from a detailed model for brine movement in the first few years after emplacement. Companion papers deal with brine migration after the borehole has closed, and possible simplification in the analysis.[5,6]

References

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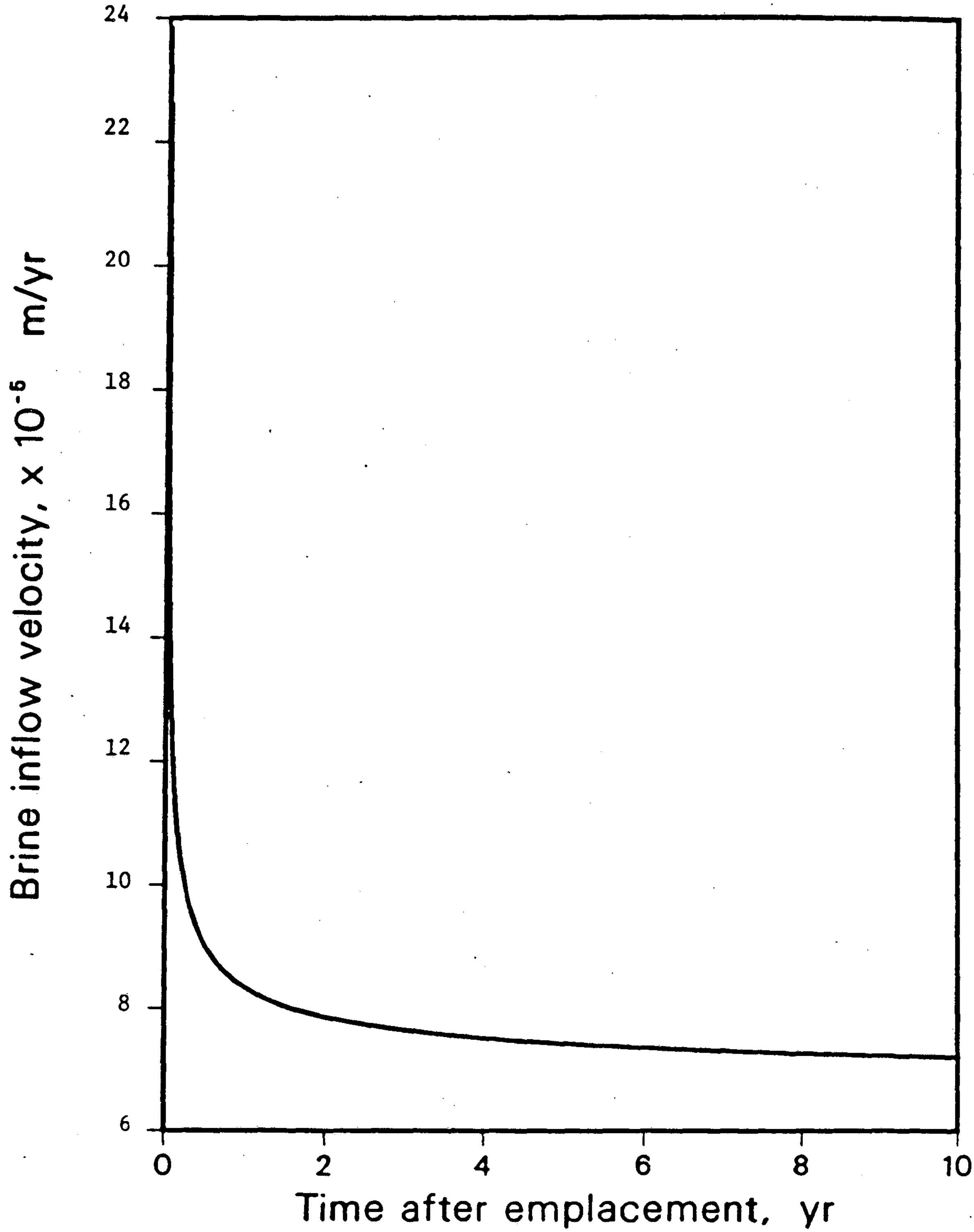

Figure 1. Brine Migration Velocity into an Open Borehole Due to Pressure Difference

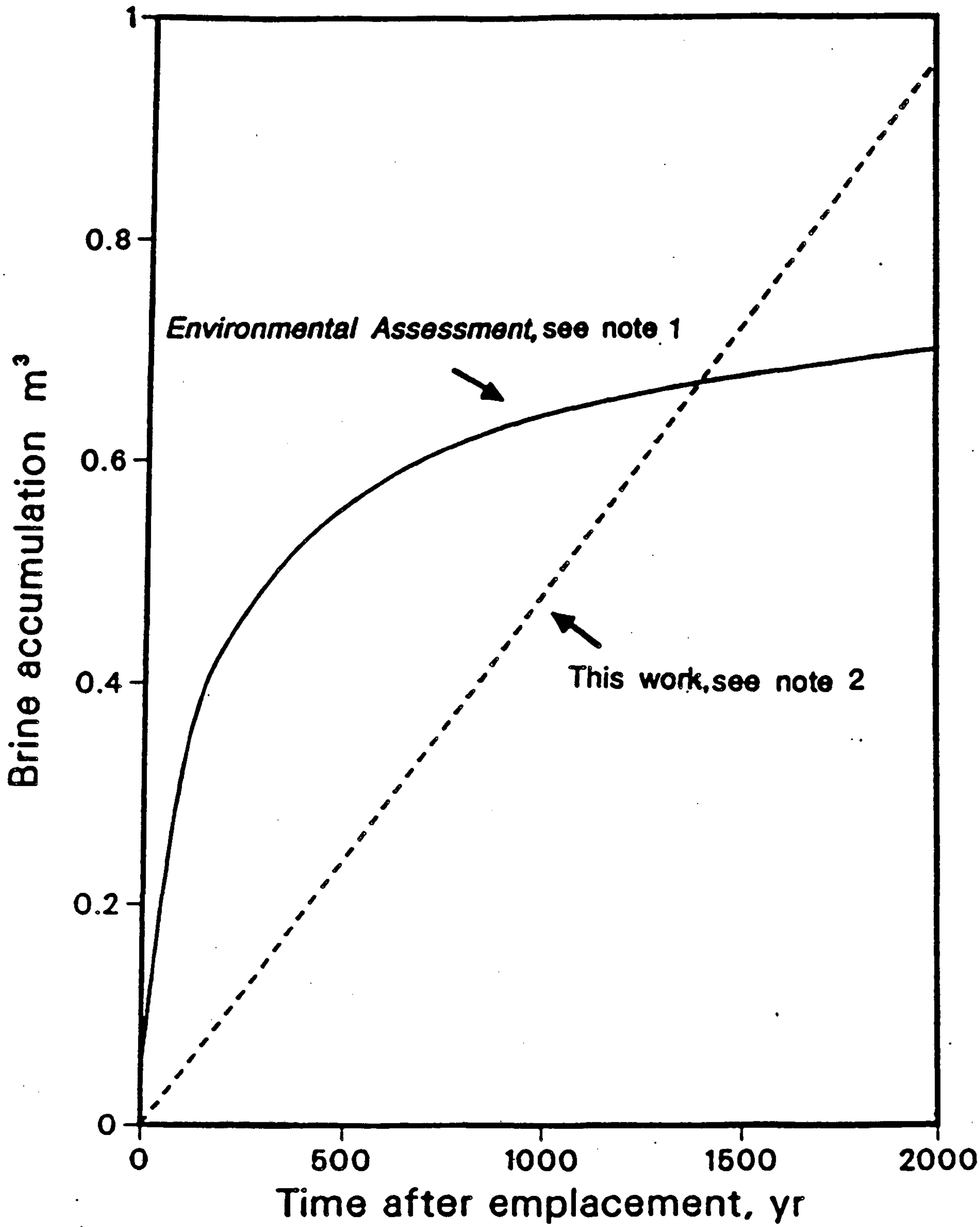

Figure 2. Brine Accumulation in an Open Borehole Calculated by Three Methods

Note 1 Primarily thermally-driven
Note 2 Primarily pressure-difference driven

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