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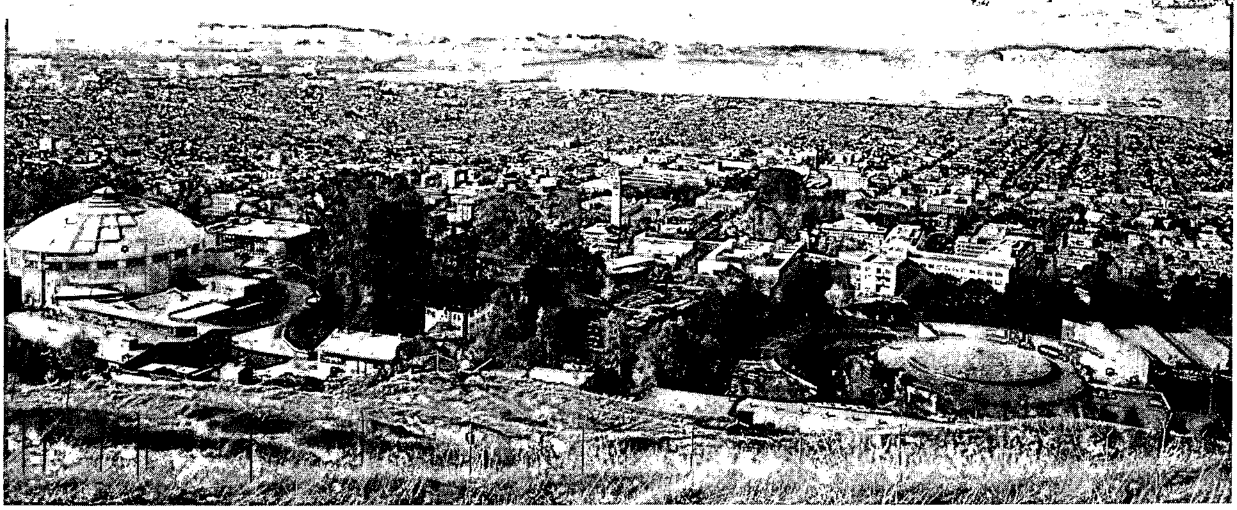

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J. Ahn, P.L. Chambré, T.H. Pigford, and W. W.-L. Lee

Department of Nuclear Engineering
University of California

and

Earth Sciences Division
Lawrence Berkeley Laboratory
University of California
Berkeley, California 94720

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Transport of Radionuclides Released From a Multiple-Patch Source into a Planar Fracture with Transverse Hydrodynamic Dispersion

J. Ahn, P. L. Chambré, T. H. Pigford, and W. W.-L. Lee

Department of Nuclear Engineering and Lawrence Berkeley Laboratory
University of California
Berkeley, CA 94720

Fractures are considered a main path for hydrological transport of radionuclides released in a geologic repository. Although actual fractures form a complex network, single-fracture transport models are useful in predicting travel time and concentrations of released nuclides. Analytical solutions[1] for one-dimensional transport in a single fracture with molecular diffusion in the surrounding rock matrix have been shown for the cases with and without longitudinal hydrodynamic dispersion in the fracture, for a source of infinite width. In reality, however, when multiple waste packages of finite size are exposed to a fracture, the released radionuclides will spread due to hydrodynamic dispersion transverse to the flow direction. To show these effects, we present analytical solutions[2] and numerical illustrations for the space-time-dependent concentrations of radionuclides released from finite patch sources into a planar fracture with transverse dispersion and matrix diffusion.

We consider a waste repository (see Figure 1), wherein waste packages are arranged in a square array with a pitch d. A planar fracture of aperture 2b and of infinite extent intersects the waste packages. Radionuclides are released only into the fracture, and the part of a waste package exposed to the fracture is approximated as a plane source of dimensions 2a, 2b. We consider advection and transverse hydrodynamic dispersion in the fracture, equilibrium sorption at fracture walls, diffusion into the rock matrix, equilibrium sorption within rock matrix, and radioactive decay. The fracture aperture is small enough that concentration in fracture water can be assumed to be uniform across the fracture. Partial differential equations are established for the concentration in the fracture and the concentration in the rock matrix, and analytical solutions are obtained[1,2].

In Figure 2 we show the ratio of radionuclide concentration resulting from the multiple-patch source to the concentration resulting from a single, infinite source of equivalent areal strength, as a function of a distance parameter, $\theta = (z \cdot D/v)^{1/2}$, where z is the downstream distance, D the transverse dispersion coefficient in the fracture and v the ground-water velocity, for the number of patches varying from 10 to 80. In the near-field region, there are plumes around individual patch sources, periodic with a period of the waste package pitch d, producing different ratios with the concentration from an infinite source. In Figure 2 we show the ratios at the peaks and valleys. At greater distances along the longitudinal coordinate transverse dispersion merges the individual plumes, and the concentration ratio becomes unity. In the far field the multiple-patch concentration becomes less than the infinite-source concentration because of transverse dispersion at the outer edges of the finite-width plume. In this region the concentration field can be adequately predicted by replacing the individual sources by a single finite plane source of the equivalent source strength. Figure 2 is valid for any nuclide, rock, and time.

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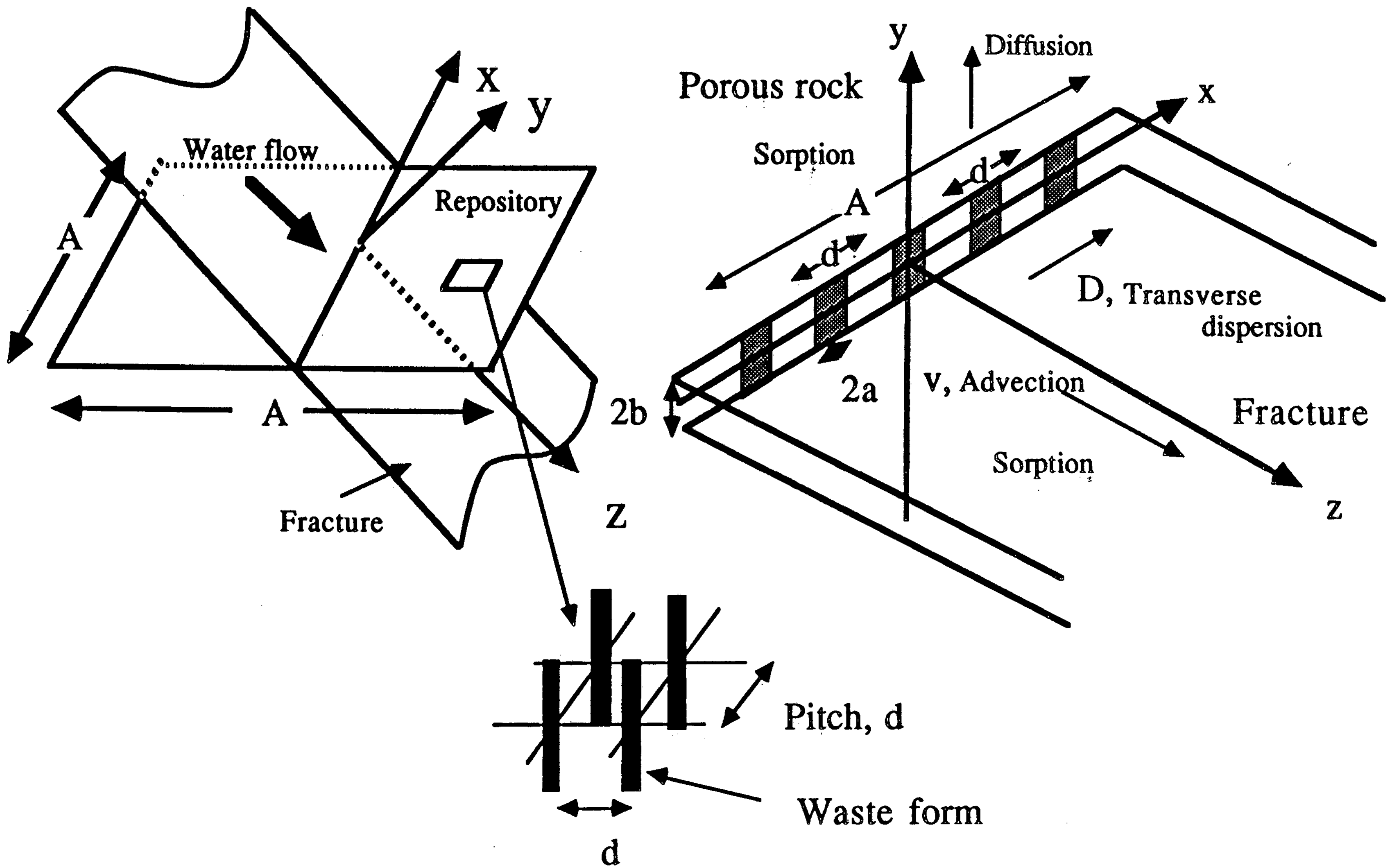

Figure 1. Relation between a planar fracture and a geologic repository, showing the processes considered in the model.

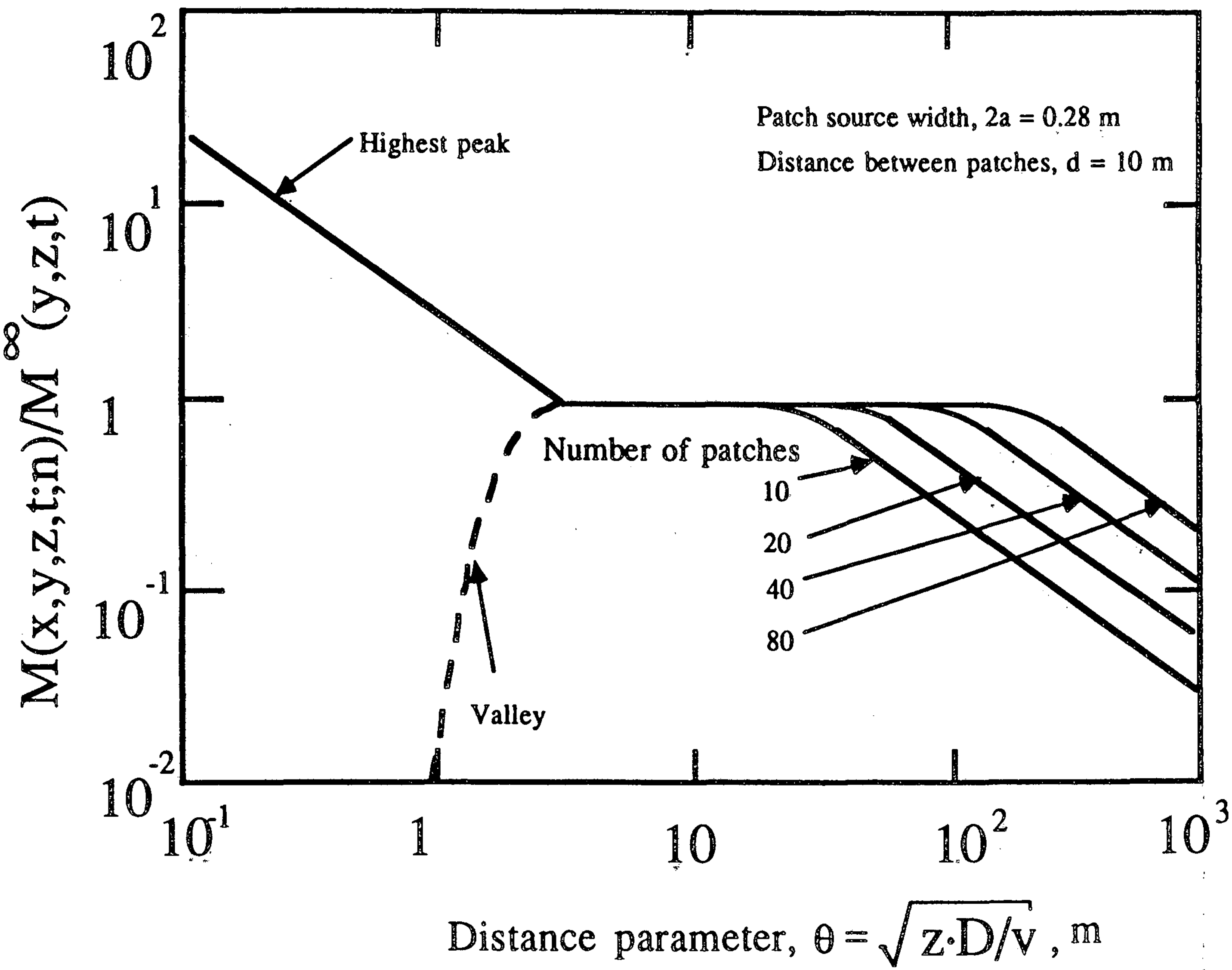

Figure 2. Comparison of the concentration resulting from a multiple-patch model, (n = number of patches) with the concentration resulting from an infinite-source model.