MODELING OF TRANSPORT CONTAMINANTS MOVEMENT IN A GEOTHERMAL REINJECTION SYSTEM

by

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A thesis submitted in partial fulfilment of the requirements for the degree of Master of Science in Chemical Engineering

College of Engineering
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April 1995

ABSTRACT

A simulation technique has been developed to assess the impact of shallow reinjection of geothermal wastewater at Palinpinon field to the surrounding groundwater resources. The physical model assumes single fracture connecting the reinjection and the groundwater wells. Using the analytical solutions of the resulting coupled dispersion-advection equation for the fracture flow and the diffusion equation for the flow into the rock matrix, relative concentrations of chloride at various points within the fracture and at observation points 4000 and 2000 meters away are calculated. For porosities of 0.03 to 0.1 which is typical for welded tuffs and clay alteration products which are the dominant rocks in the area, matrix diffusion was found to be an efficient retardation mechanism for the dispersion of the waste fluids.

Boron dispersion was also modeled by taking into account its probable adsorption into clays. Using reasonable estimates for the retardation coefficients for boron, adsorption may delay its breakthrough by up to 100 days.

A general program coded in FORTRAN 77 has also been developed to evaluate the general transient solutions of the mass transport equations in fractured porous media. The method employed in the evaluation is the Gauss-Legendre quadrature. The technique provides insights into the gross behavior of reinjected fluids by putting constraints on breakthrough times, relative concentrations of the contaminant along the fracture and within the matrix and matrix retention of contaminants.

NOTATION

Transport Parameters:

c_f, c	[M/L^3]		Concentration in the fracture.
c_m, c'	[M/L^3]		Concentration in the matrix.
c_o	[M/L^3]		Input concentration.
c/c_o			Relative concentration.
q	[M/L^{2}T]		Diffusive flux perpendicular to the fracture axis.
V	[L/T]	V	The velocity of water in the fracture.
α_L	[L]	AL	The value of the longitudinal dispersion in the direction of the flow.
R		R	Face retardation coefficient.
τ		TAU	Matrix tortuosity.
D^*	[L2/T]	DASTX	Free water molecular diffusion coefficient.
$2b$	[L]	FW	Fracture width.
θ		PORS	Matrix porosity.
R'		RPRIM	Matrix retardation coefficient.
x	[L]	X	Coordinate along the fracture axis.
λ	[1/T]	XLAMDA	Decay constant equivalent to $\ln 2/t_{1/2}$.
t	[T]	T	Time.
y	[L]	YM	Direction adjacent to the fracture.

Other Parameters:

Y' $$Y' = \frac{v^2\beta^2 x^2}{4A\xi^2} + B(y - b)$$

B $$B = (R'/D')^{1/2}$$

T'		$T' = \left(t - \frac{Rx}{V}\right)^{1/2}$
W		$W = \frac{Rx}{VA} + B(y - b)$

SFTM Implementation

Main Program

a and b	F,S	Integration limits.
c/c_o	CONC	Calulated value of the relative concentrations.
	M	Number of points for the Gauss-Legendre formula.

Function FRACT

ξ		XI	Integration variable of the general analytical solution.
D	[L2/T]	HD	Hydrodynamic dispersion $D=\alpha_L+D^*$.
ν		XNU	$\nu=V/2D$.
η		ETA	$\eta = \frac{\lambda R}{4D\xi^2}$.
β^2		BSQRD	$\beta^2 = \frac{4RD}{V^2}$.
D'	[L2/T]	DPRIM	$D' = \tau D^*$
A		A	$A = \frac{bR}{\theta(R'D')^{1/2}}$.
Y		YBAR	$Y = \frac{\nu^2\beta^2x^2}{4A\xi^2}$
T		TBAR	$T = \left(t - \frac{Rx^2}{4D\xi^2}\right)^{1/2}$

Function GAUSS

c	C	$c = (b-a)/2$
d	D	$d = (b+a)/2$
i	I	Subscript for vectors p and k.
j	J	Index on the repeated sum of Eq. (4.7).
	JFIRST	Initial value of j, k_i.
	JLAST	Final value of j, k_{i+1}-1.
	KEY	Vector k.
	NPOINT	Vector p.
	SUM	Repeated sum of Eq. (4.7).
	WEIGHT	Vector of weight factors, w_j.
	Z	Vector of Legendre polynomial roots, z_j.

Function ERFC

Y	Y	Dummy argument of the complementary error function defined as erfc(Y).

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