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# Numerical modeling of non-isothermal quartz dissolution/precipitation in a coupled fracture–matrix system

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## Abstract

A numerical model is developed to simulate the combined effect of thermal and reactive solute transport in a coupled fracture–matrix system using dual porosity concepts. The model includes solute dispersion in the fracture, lateral diffusion-limited transport of solutes from the fracture into the reservoir matrix, lateral conduction-limited thermal flux from the reservoir into the fracture, as well as thermal conduction and dispersion in the fracture. The model is applied to examine the mass of silica dissolved/precipitated along a fracture and to compute the change in fracture aperture. Results show that the maximum increase in the fracture aperture occurs near its inlet. A parametric study indicates that the reservoir thermal conductivity, reservoir porosity, reservoir effective diffusion coefficient, water velocity in the fracture, and the initial fracture aperture have dominant roles in quartz dissolution/precipitation mechanisms.

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*Keywords:* Dual porosity; Fracture aperture; Quartz dissolution/precipitation; Reactive solute transport; Silica; Thermal transport

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### Nomenclature

$b$	half aperture of the fracture [L]
$c_f$	volume concentration of solute in the fracture [ $\text{ML}^{-3}$ ]
$c_m$	volume concentration of solute in the matrix [ $\text{ML}^{-3}$ ]
$c_o$	solute concentration source at the inlet [ $\text{ML}^{-3}$ ]
$D_f$	thermal conduction of the fluid in the fracture [ $\text{L}^2\text{T}^{-1}$ ]
$D_L$	hydrodynamic dispersion coefficient in the fracture [ $\text{L}^2\text{T}^{-1}$ ]
$D_o$	molecular diffusion coefficient of the solute in free water [ $\text{L}^2\text{T}^{-1}$ ]
$D_m$	effective molecular diffusion coefficient within the reservoir matrix [ $\text{L}^2\text{T}^{-1}$ ]
$D_T$	longitudinal thermal dispersion coefficient in the fracture [ $\text{L}^2\text{T}^{-1}$ ]
$K_a$	surface sorption coefficient of the fracture [L]
$K_f$	reaction rate constant in the fracture [ $\text{T}^{-1}$ ]
$K_m$	reaction rate constant within the reservoir matrix [ $\text{T}^{-1}$ ]
$K_v$	volume sorption coefficient of the reservoir matrix [ $\text{L}^3\text{M}^{-1}$ ]
$\ell$	fracture length [L]
$L_m$	half fracture spacing [L]
$R_f$	fracture retardation factor
$R_m$	matrix retardation factor
$t$	time variable [T]
$T_f$	temperature of the circulating fluid in the fracture [K]
$T_m$	temperature of the stagnant fluid within the reservoir [K]
$T'$	transmissivity within the fracture [ $\text{L}^2\text{T}^{-1}$ ]
$V_o$	mean water velocity in the fracture [ $\text{LT}^{-1}$ ]
$x$	space coordinate along the flow direction in the fracture [L]
$y$	space coordinate in the direction normal to the fracture [L]

### Greek letters

$\alpha_o$	local fracture dispersivity [L]
$\beta_T$	thermal dispersivity of the reservoir matrix [L]
$\lambda_f$	thermal conductivity of the fluid in the fracture [ $\text{L}^2\text{T}^{-1}$ ]
$\lambda_m$	thermal conductivity of the reservoir matrix [ $\text{L}^2\text{T}^{-1}$ ]
$\theta_m$	rock-matrix porosity
$\rho_f$	density of the fluid in the fracture [ $\text{ML}^{-3}$ ]
$\rho_m$	bulk density of the reservoir matrix [ $\text{ML}^{-3}$ ]

## 1. Introduction

The fluid flow pattern in an Enhanced Geothermal System (EGS) is mainly controlled by the network of induced and pre-existing fractures and is affected by changes in permeability resulting from mechanical, thermal and chemical processes. Access to the thermal energy stored in the reservoir rocks strongly depends on the connection between the drilled

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