Mass transport in fault zones: transition from nonlocal to normal transport

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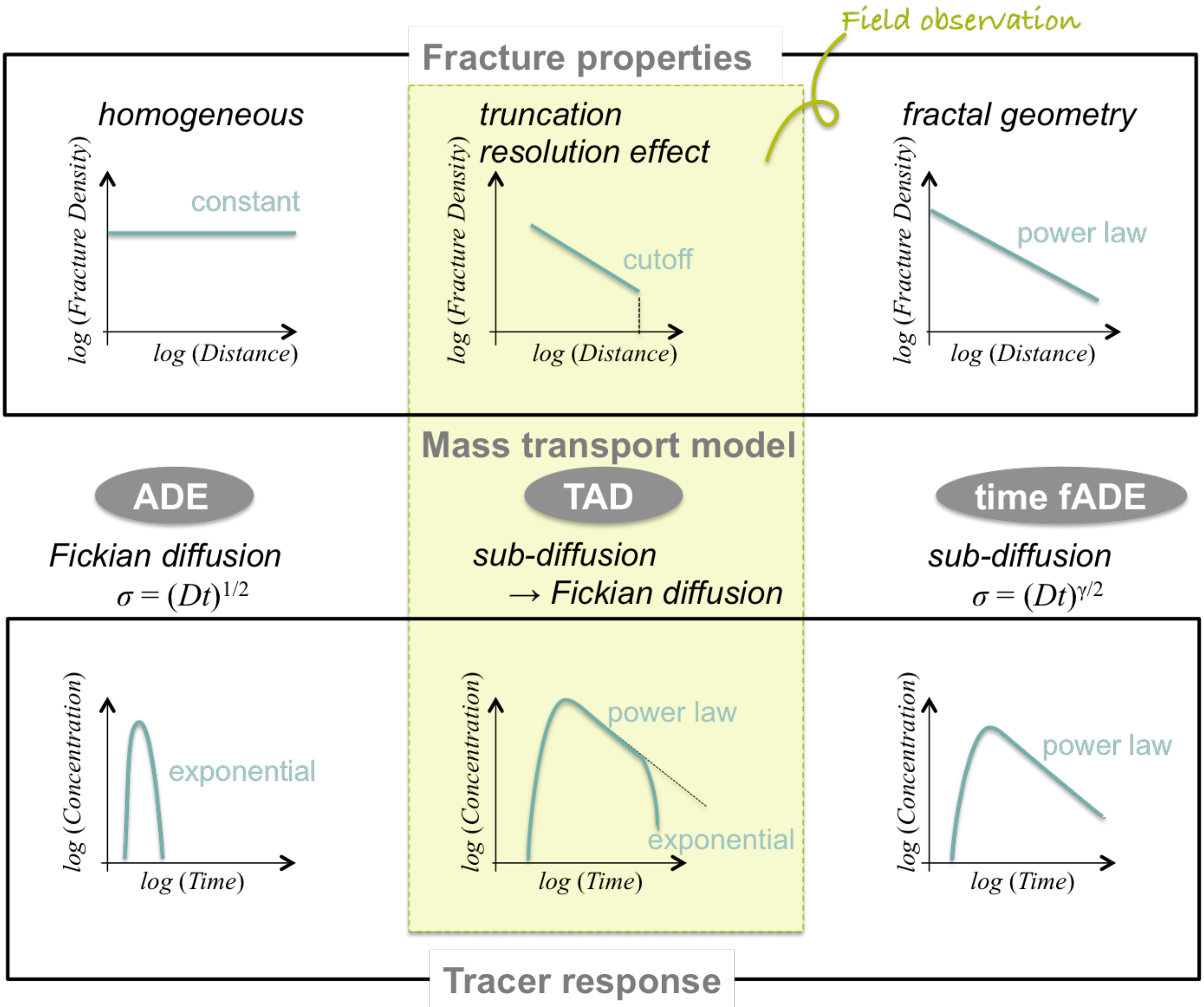
Fault zones clearly affect the flow paths of fluids at the scale of geothermal reservoirs. Fault-related fracture damage decreases to background levels with increasing distance from the fault core according to a power law. This study investigates mass transport in such a fault-related structure using nonlocal models. A column flow experiment has been conducted to create a permeability distribution that varies with distance from a main conduit. The tracer response curve describes a preasymptotic curve implying subdiffusive transport, which is slower than the normal Fickian diffusion. As long as permeability of the surrounding layers varies with distance from a main conduit, the tracer response can be modeled by the time fractional advection dispersion equation (time fADE). In contrast, if the surrounding area is a finite domain, an upper truncated behavior in tracer response (i.e., exponential decline at late time) is observed. The tempered anomalous diffusion (TAD) model captures the transition from sub-diffusive to Fickian transport, which is characterized by a smooth transition from power-law to an exponential decline in the late-time breakthrough curves.

Keywords: time fractional derivative, fractured reservoir, flow experiment, fractal scaling, truncated power-law distribution


Field observation
Fracture properties
homogeneous
constant
log (Fracture Density)
log (Distance)
truncation
resolution effect
cutoff
log (Fracture Density)
log (Distance)
fractal geometry
power law
log (Fracture Density)
log (Distance)
Mass transport model
ADE
Fickian diffusion
σ = (Dt)^1/2
TAD
sub-diffusion
→ Fickian diffusion
time fADE
sub-diffusion
σ = (Dt)^γ/2
log (Concentration)
exponential
log (Time)
log (Concentration)
power law
exponential
log (Time)
log (Concentration)
power law
log (Time)
Tracer response