

**U.S. DEPARTMENT OF ENERGY  
OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT**

**PRESENTATION TO  
THE NUCLEAR WASTE TECHNICAL REVIEW BOARD**

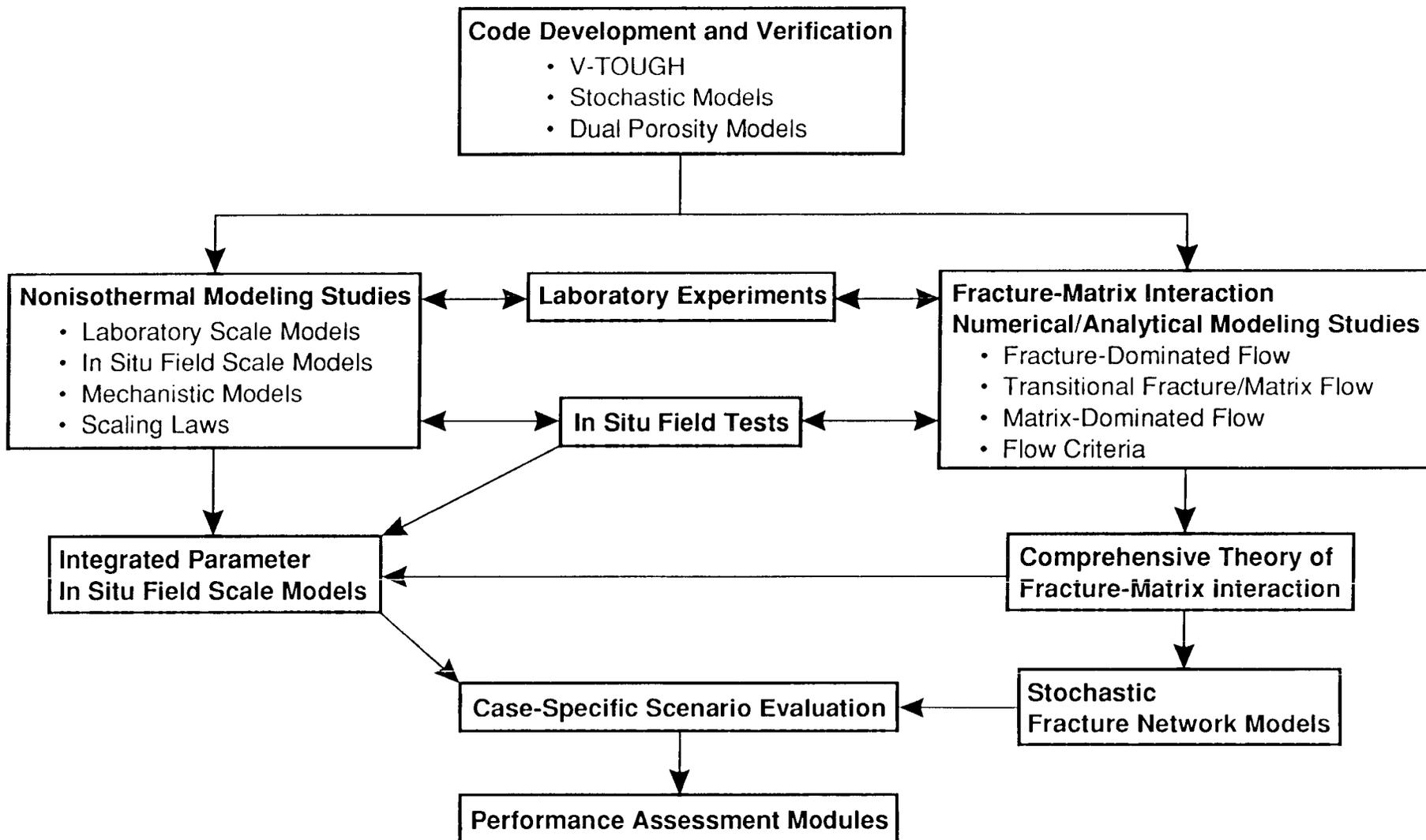
**SUBJECT: THERMO/HYDROLOGICAL  
EFFECTS**

**PRESENTER: DR. THOMAS A. BUSCHECK**

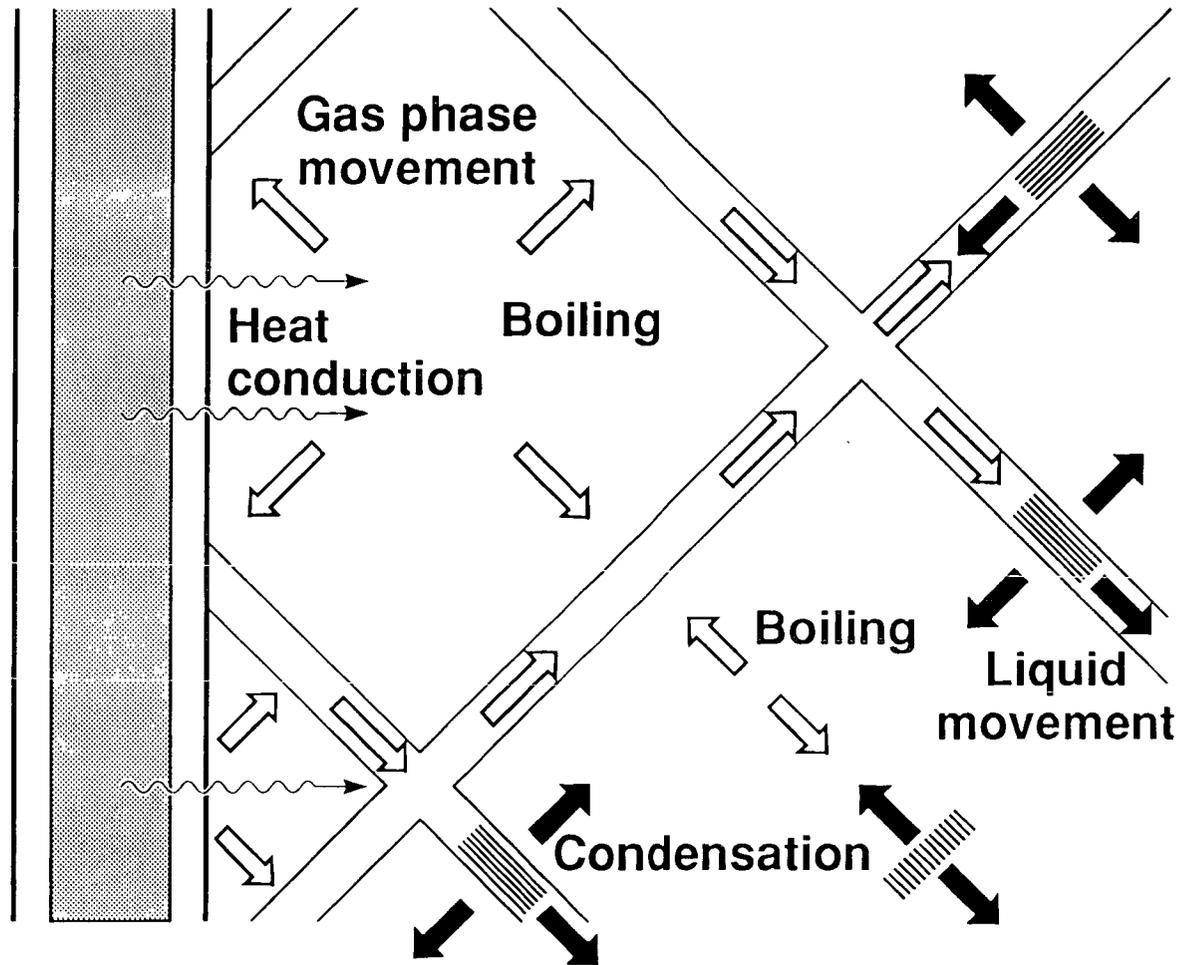
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**PRESENTER'S  
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# Fractures play a key role in drying and wetting behavior



# **Waste package geometry and heating rate strongly affect near-field moisture movement and temperatures**

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- **Drying rate is strongly dependent on heating rate,  $Q_h$  for radial flow, drying rate  $\approx Q_h^{5/2}$**
- **Tests conducted at accelerated  $Q_h$  improperly scale vaporization relative to imbibition and conduction**
  - **Hydrothermal-geochemical coupling is distorted**
  - **Thermo-mechanical coupling is distorted**
- **Model validation will require that the perturbed zone extend over the scale of heterogeneities (e.g., fractures and matrix heterogeneity)**

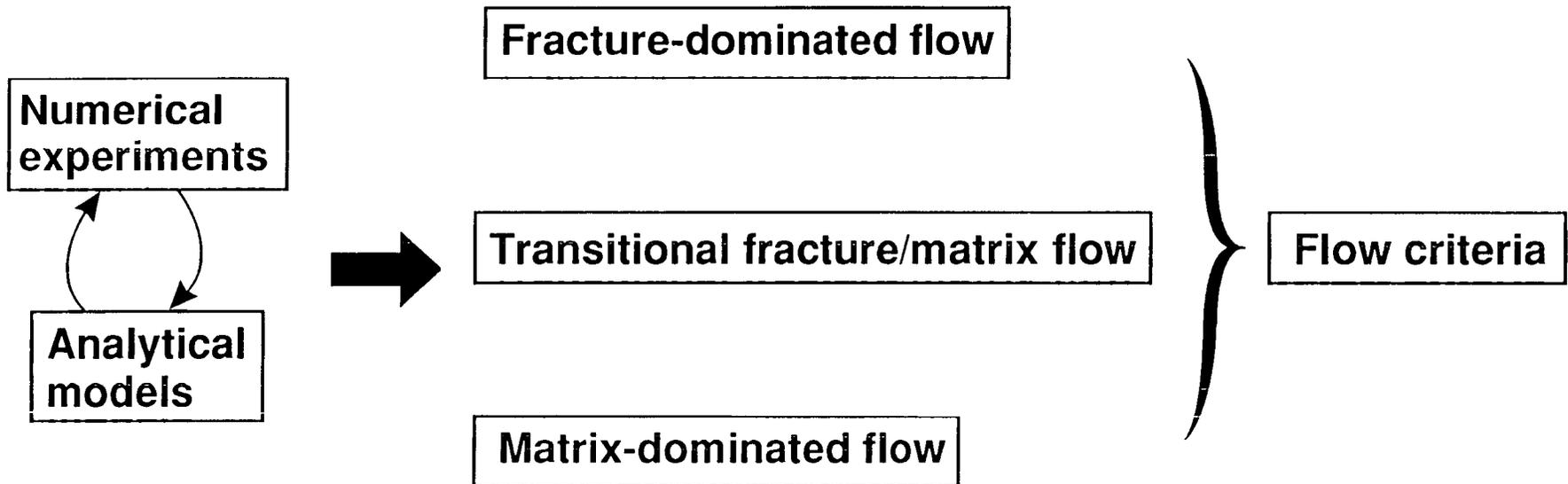
# Fracture/matrix interaction

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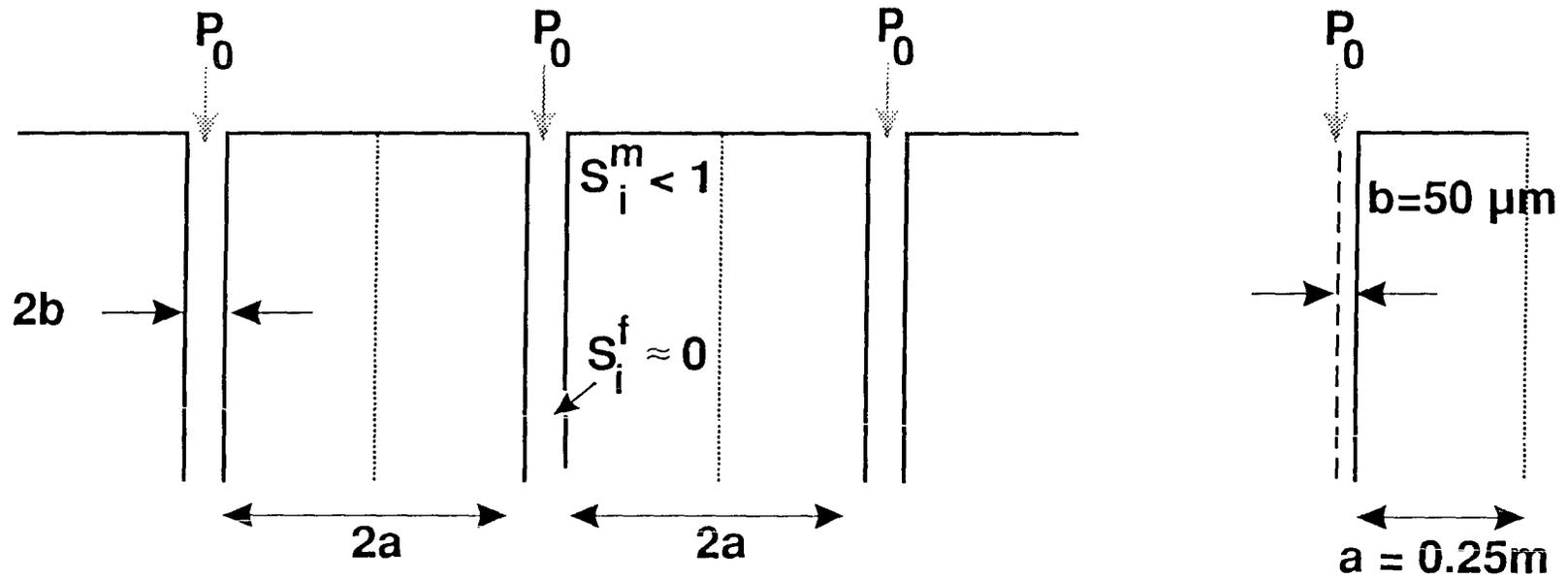
- **What is the QUANTITY and CHEMISTRY of water contacting the waste packages?**
- **Where can it come from?**
  - **perched water**
  - **construction/drilling fluids**
  - **vapor condensation during heating**
  - **rainfall events**
  - **seismic pumping of the water table**
- **How is it getting there?**
  - **fracture-dominated flow**
  - **matrix-dominated flow**

# We have been addressing fracture/matrix interaction with a combination of numerical and analytical models

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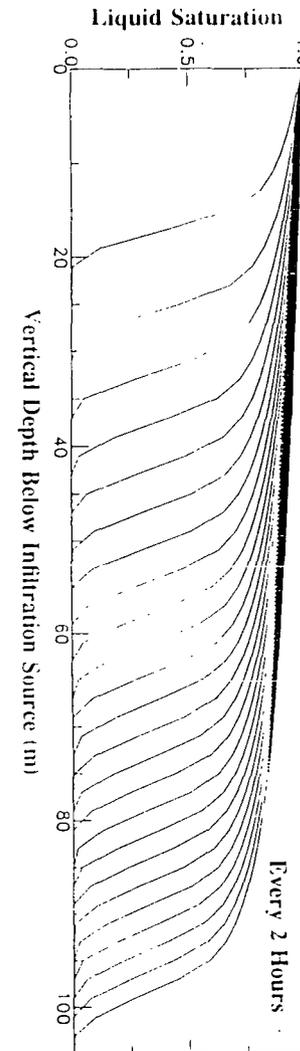
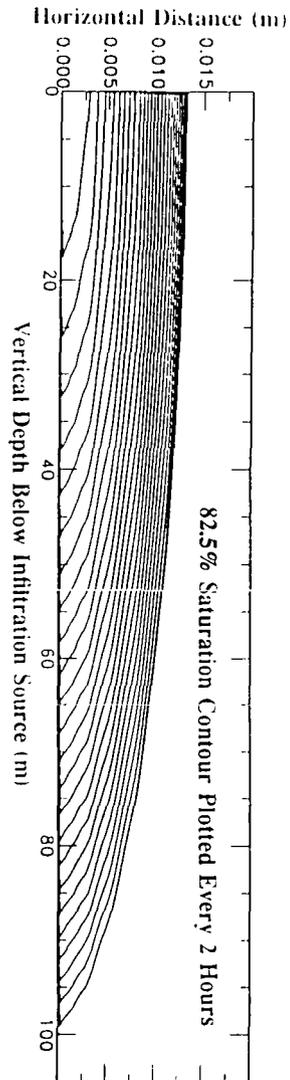


# Parallel Fracture System



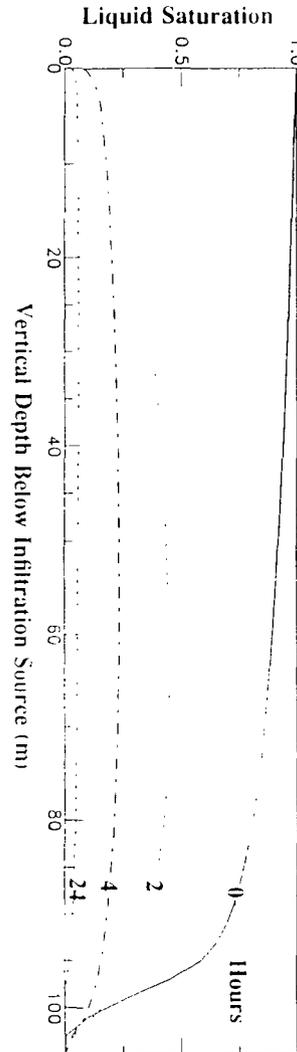
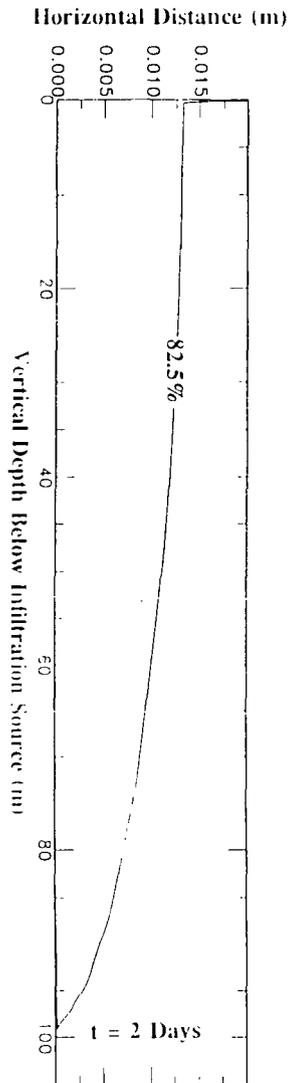
# 48 hour infiltration event with $P_0$ fixed

Fracture-dominated flow with maximal matrix interaction results in the liquid front moving with a  $t^{1/2}$  dependence.



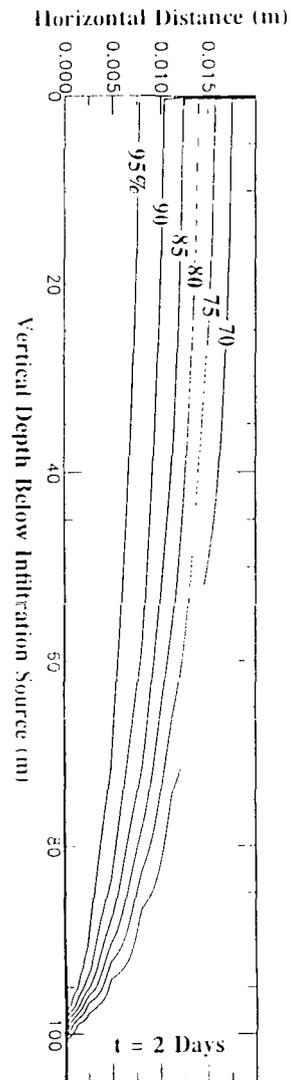
# Saturation profiles following a 48 hour infiltration event

Matrix imbibition results in insignificant fracture flow subsequent to the removal of the infiltration source.

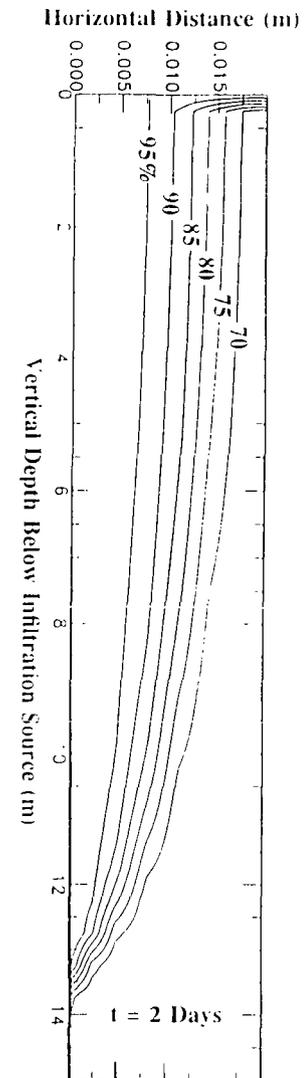


# Fracture penetration is proportional to $b^3$

A twofold increase in fracture aperture results in an eightfold increase in fracture penetration.



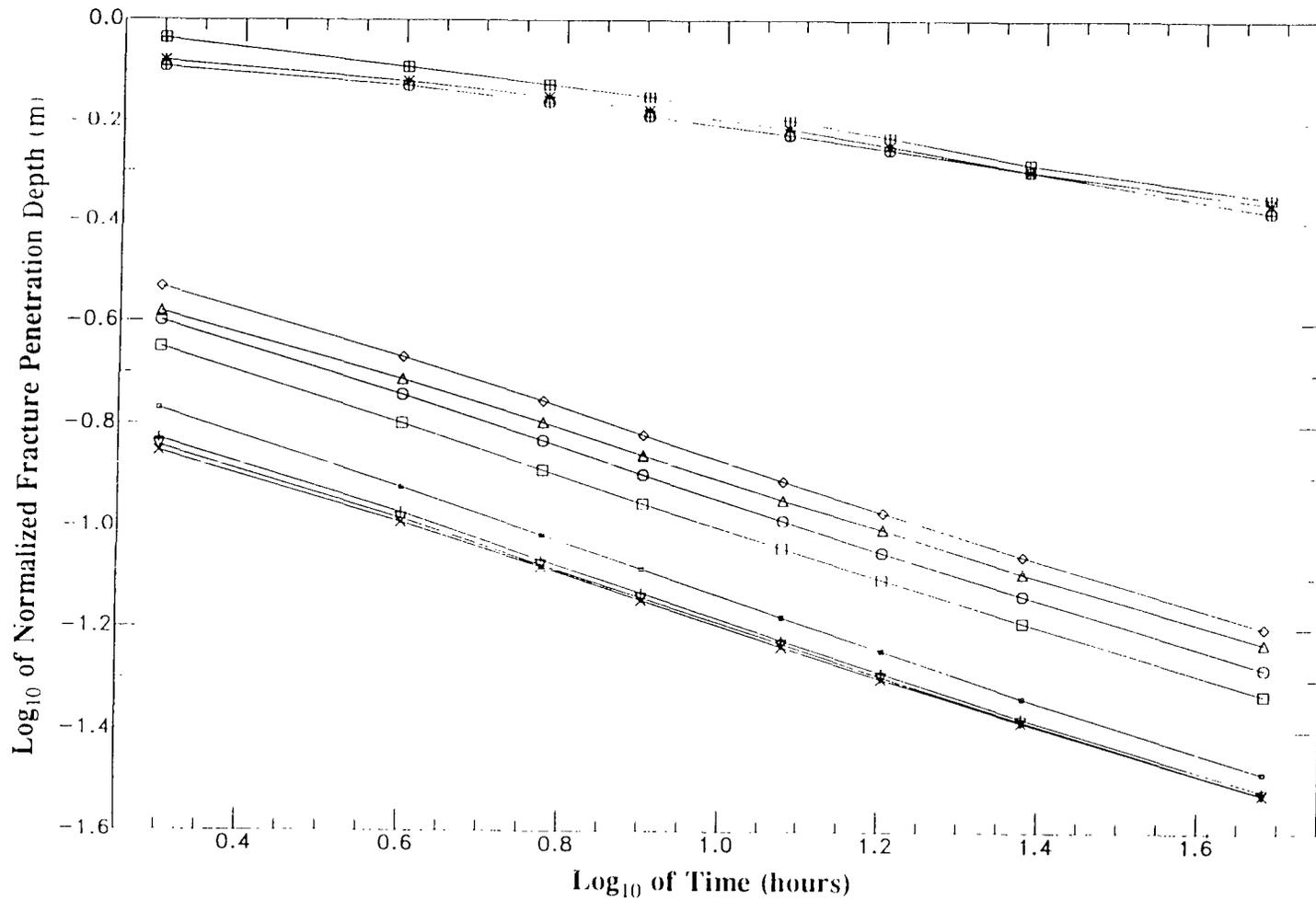
100 μm Fracture Aperture Case



50 μm Fracture Aperture Case

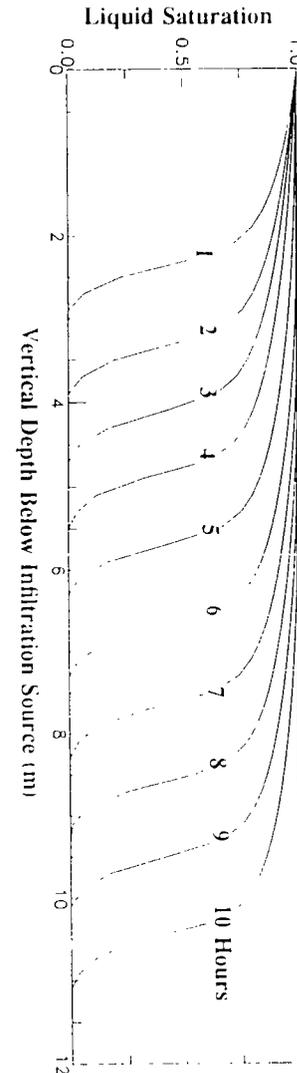
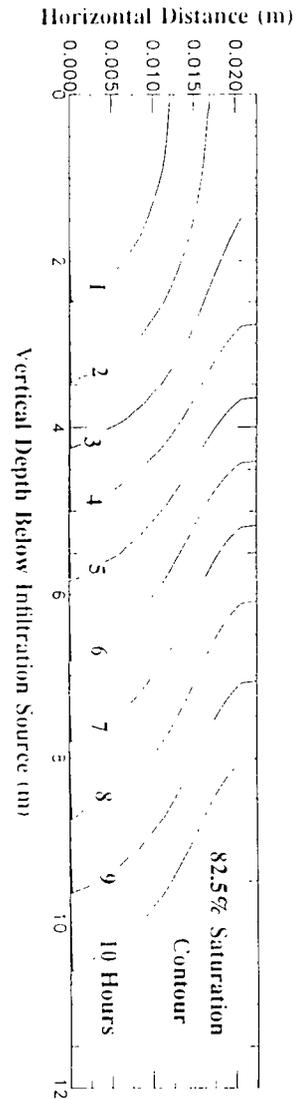
# Parameter sensitivity study of fracture/matrix flow

Cases were considered using repository horizon data. For most cases the liquid front movement has a  $t^{1/2}$  dependence.



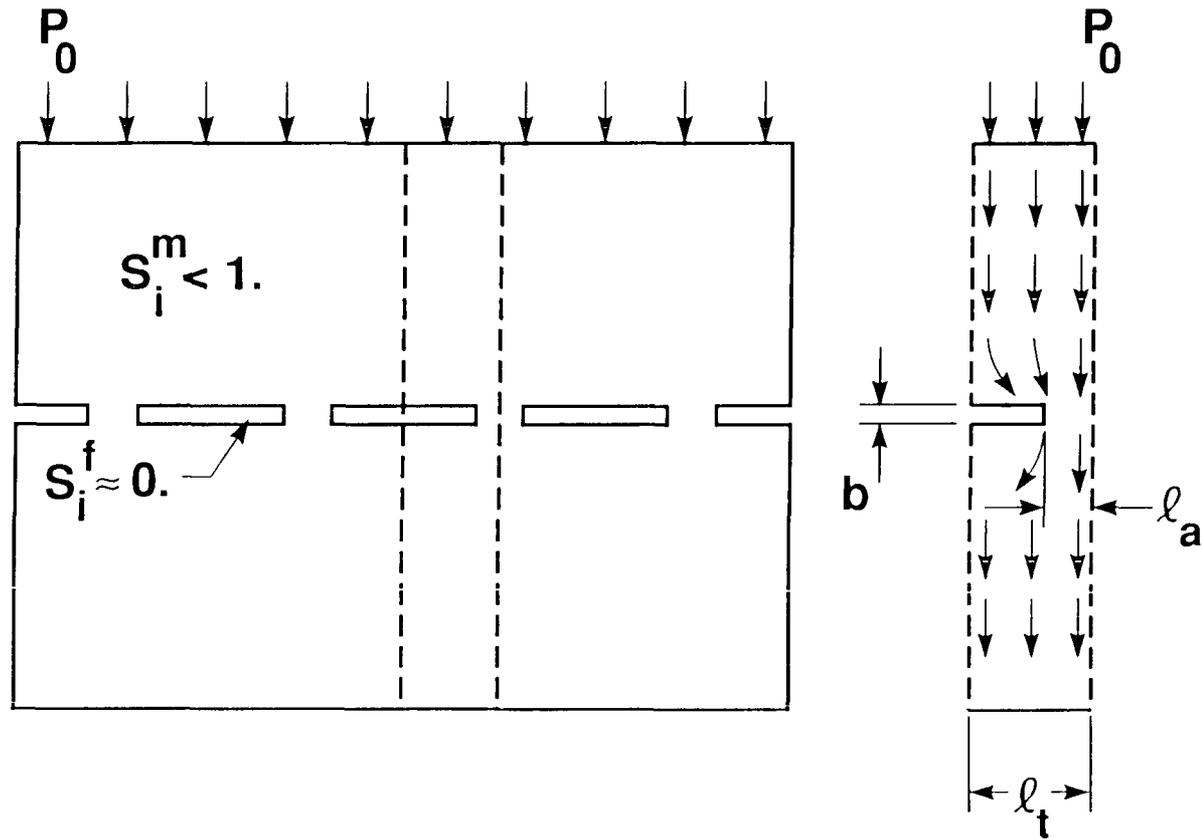
# Ten hour infiltration event with $P_0$ fixed.

Due to closely spaced fractures, the saturation fields interfere within three hours, resulting in the liquid front moving linearly with  $t$ .



# Fractures are not capillary barriers to matrix-dominated flow

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# Matrix-dominated flow across a fracture

Even  $I_a/I_t = 0.01$  has a modest effect on retarding flow across the fracture.

