Research Summary

Application of Fractals to Modeling and Analysis of Naturally Fractured Unconventional Reservoirs

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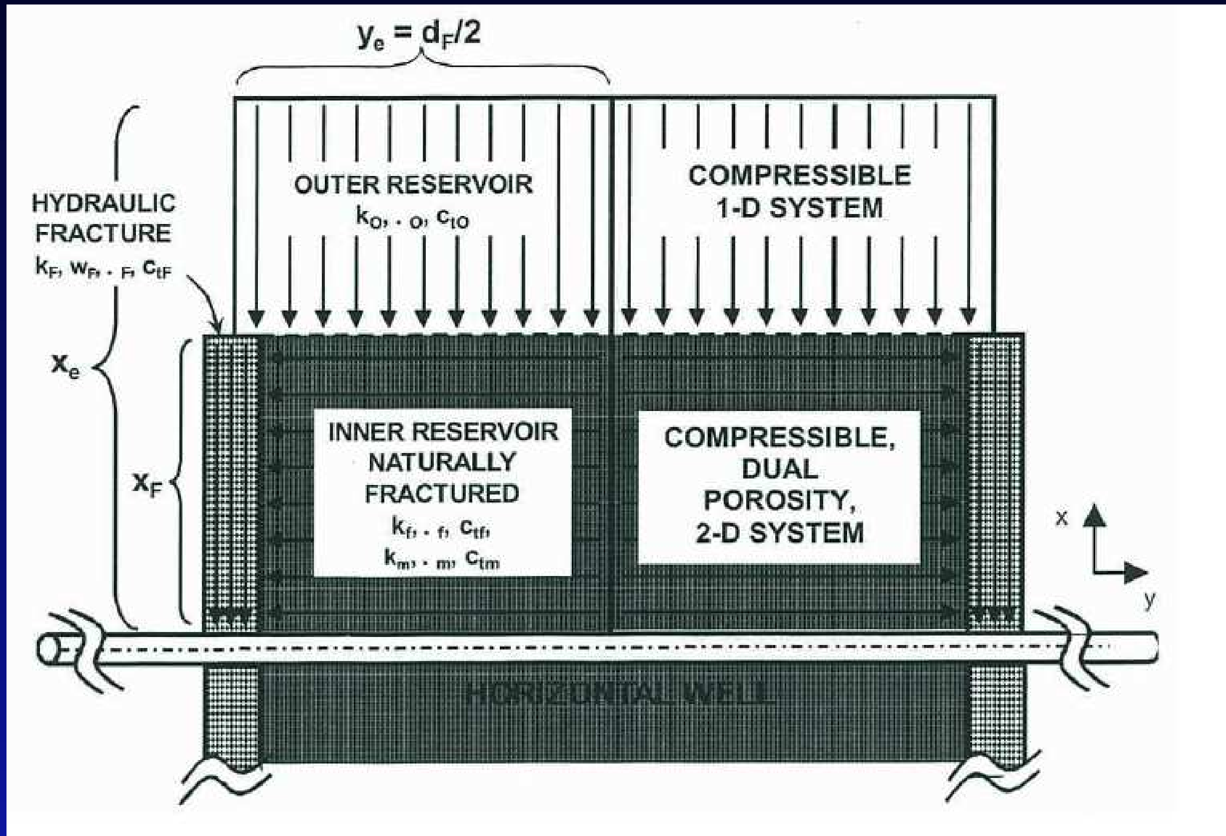
Model Description

Trilinear Flow Model

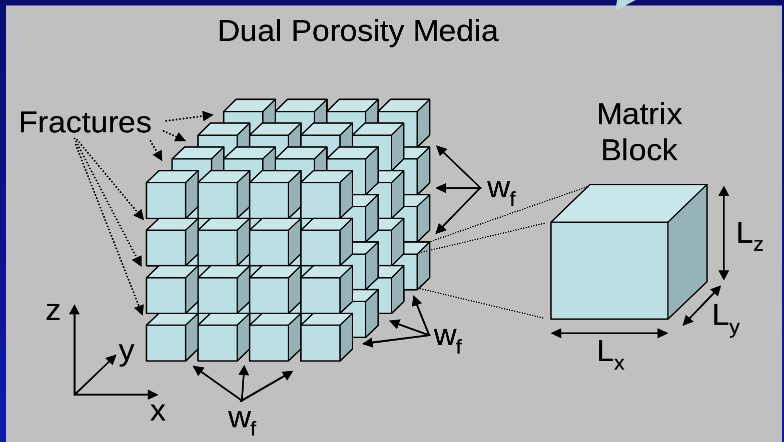


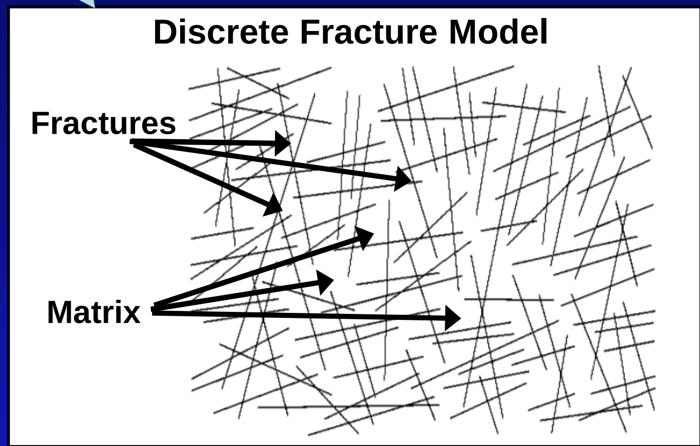
(Brown, M., 2009)

Previous Modeling Approach

Currently producing nano-porous unconventional reservoirs are characterized by a complex network of fractures

Representation of Fractures in Reservoir Models

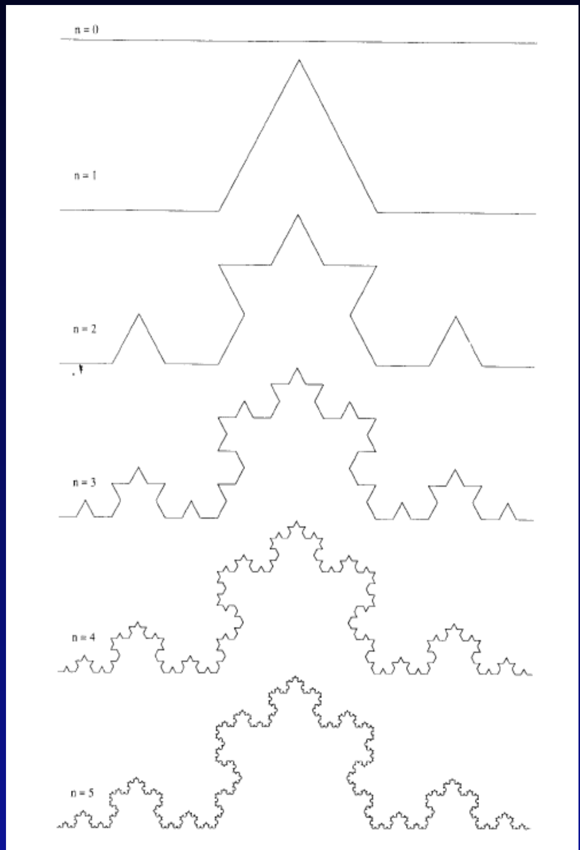




Objective

- To model the inner reservoir region by fractal geometry
- To define fracture properties as fractals for both space and time variables
- To implement them in the diffusion equation

Fractal Geometry



Koch curve

$$\Delta P = \left(\frac{1}{\Delta y}\right)^{d_f}$$

$$4 = \left(\frac{1}{\frac{1}{3}}\right)^{d_f}$$

$$d_f = \frac{\ln 4}{\ln 3} = 1.2619$$

d_f is the fractal dimension

ΔP is the change in the number of segments

Δy is the change in the length of the segments

Previous Studies

Chang and Yortsos (1990)

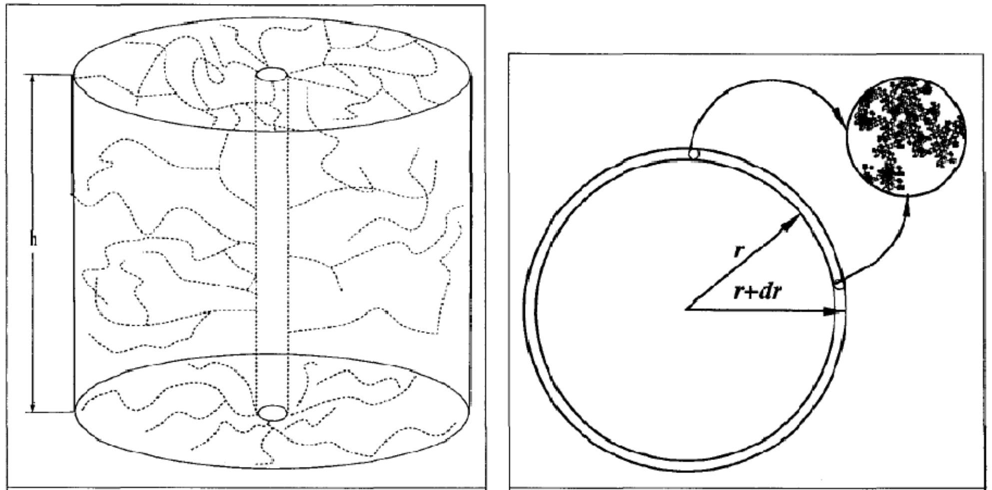


Fig. 1—Schematic of porous media.

Fig. 2—Flow across a differential shell.

$$\phi(r) = \phi_0 \left(\frac{r}{r_0} \right)^{d_{mf} - d}$$

$$k(r) = k_0 \left(\frac{r}{r_0} \right)^{d_{mf} - d - \theta}$$

$$\frac{\partial C}{\partial t} = \frac{\partial}{\partial x} \left(D_f x^{-\theta} \frac{\partial C}{\partial x} \right)$$

Previous Studies

Chang and Yortsos (1990)

- Since the diffusion process of fractal reservoirs is history dependent, this solution can not fully describe the anomalous diffusion properties of fractals

Previous Studies

Flamenco-Lopez and Camacho (2003), Camacho et al. (2008) & Camacho et al. (2011)

A new equation which includes a temporal fractional derivative

$$\frac{\partial^{\gamma} P_{Df}}{\partial t_D^{\gamma}} = \frac{1}{r_D^{d_{mf}-1}} \frac{\partial}{\partial r_D}\left(r_D^{\beta} \frac{\partial P_{Df}}{\partial r_D} \right)$$

where

$$\beta = d_{mf} - \theta - 1$$

$$\gamma = 2 / (2 + \theta)$$

Shortcomings of Previous Studies

(Raghavan & Chen, 2013)

- Based on radial symmetry
- Not appropriate to model flow to a fractured well

Method of Research

- Understanding the existing approaches and utilize them to construct a solution for our problem
- Demonstration of applicability and improvement in results by simulated and field examples