Effect of Wettability on Relative Permeability

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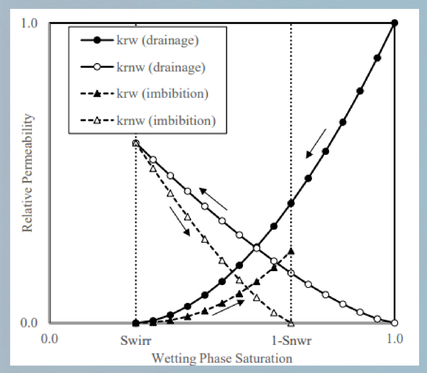
ABSTRACT

Accurate modelling of transport properties especially relative permeability is important for fluid flow in porous media, Hydrogen storage and CO_2 storage simulations present significant challenges. Conventional compositional simulations use averaged transport properties to model multiphase flow in porous media, categorizing the phases as wetting and non-wetting phase. These transport properties are input into empirical models, such as Corey's models. However, the empirical models are static and fail to accurately capture the hysteresis of relative permeability, resulting in computational issues and inaccuracies.

In this study, we model relative permeability as a function of state parameters; phase saturation (S), phase connectivity (X), wettability(Contact angle) and examine the effect of wettability on relative permeability.

INTRODUCTION AND BACKGROUND



Yoga and Johns 2022

$$Kro = Kro^0 \left(\frac{S_o - S_{or}}{1 - S_{or} - S_{wirr}} \right)^{n_o}$$

$$Krw = Krw^0 \left(\frac{S_w - S_{wir}}{1 - S_{or} - S_{wirr}} \right)^{n_w}$$

- Models Kr only as a function saturation
- Turning Parameter n_j does not capture the complex physics of porous media

Equation of State Relative Permeability Model

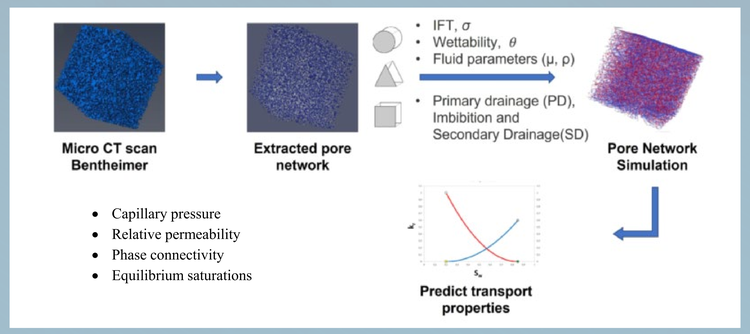
$$dkr_j = \frac{\partial kr_j}{\partial S_j} dS_j + \frac{\partial kr_j}{\partial \hat{X}_j} d\hat{X}_j + \frac{\partial kr_j}{\partial I_j} dI_j + \frac{\partial kr_j}{\partial Nca} dNca + \frac{\partial kr_j}{\partial \lambda} d\lambda$$ Khorsandi et al., 2017

$$dkr_j = \frac{\partial kr_j}{\partial S_j} dS_j + \frac{\partial kr_j}{\partial \hat{X}_j} d\hat{X}_j + \frac{\partial kr_j}{\partial I_j} dI_j$$

OBJECTIVES

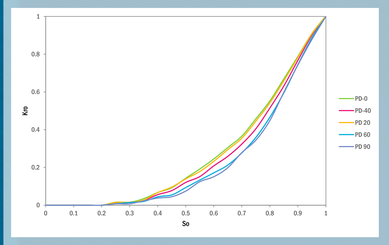
- Demonstrate that relative permeability is a continuous function of saturation, phase connectivity, and wettability (contact angles)
- Investigate the influence of wettability on the phase connectivity path.
- Investigate the behavior of relative permeability in the saturation and phase connectivity (S-X) space under various wettability scenarios

METHODOLOGY

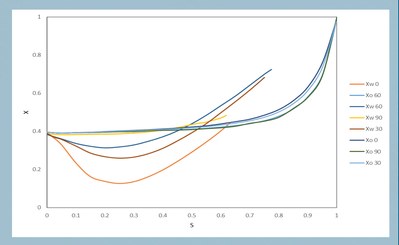


Mukherjee et al., 2021

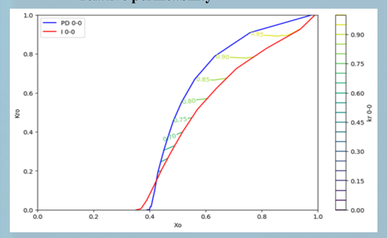
RESULTS

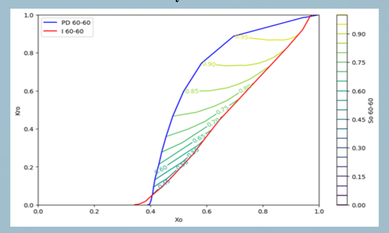


Effect of wettability on non-wetting relative permeability

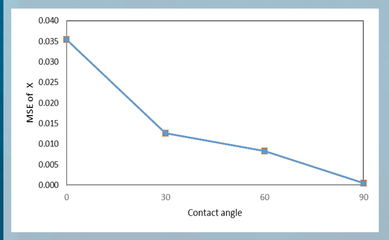


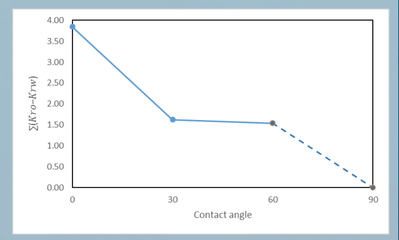
Effect of wettability on Phase connectivity





Trends of phase saturation, phase connectivity, wettability and relative permeability for the nonwetting phase





Convergence of Phase connectivity and relative permeability with wettability

CONCLUSIONS

- The research demonstrates strong evidence that relative permeability is a continuous function of saturation, phase connectivity, and wettability (defined by contact angles)
- Wettability influences phase connectivity; this influence is seen in the decrease of non-wetting phase connectivity from mid to high saturations, the influence on wetting phase connectivity is seen from low saturations
- Non-wetting phase relative permeability is less dependent on phase connectivity at high saturations and more dependent at mid to low saturations for strong water wet case (0 contact angle) and non-wetting phase relative permeability is dependent on phase connectivity at high, mid and low saturations for medium water wet case (60 contact angle).

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