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Contribution ID: **93**

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A numerical study on the role of the slight compressibility on viscous fingering

Wednesday, 2 June 2021 10:00 (1 hour)

Analyzing interfacial phenomena like Viscous Fingering instability happening between two miscible fluids in a porous domain brings advantages in various areas, comprising of chemical and petroleum engineering, environmental engineering, and medicine. Viscous fingering (or Saffman-Taylor) instability (VFI) arises when a low-viscosity fluid is injected to displace a high-viscosity one. From a fluid dynamics point of view, the invading fluid with higher mobility (lower viscosity) penetrates the displaced fluid resulting in appearance of fingers at the interface. In oil recovery, these fingers reduce efficiency of the oil displacement and pose an economic threat for oil and gas industries. So, scrutinizing the physical parameters impacting the instability is crucial. One of the ubiquitous assumptions considered in the numerical studies of VFI is the Boussinesq approximation. This approximation ignores density variations except in the term multiplied by gravity (Buoyancy term). Although this assumption simplifies numerical as well as analytical solutions, it cannot provide precise information, notably when dealing with oil containing dissolved gas. In this study, we try to shed light on the effect of slight compressibility on VFI through the simulation of an iso-thermal miscible displacement flow in a horizontal rectangular homogeneous porous domain. Our simulation study is based on the finite difference method (FDM) with a semi-implicit time stepper. The pivotal goals are to delineate, both qualitatively and quantitatively, whether the fluid's compressibility enhances or attenuates the instability. Thus the influence of fluid's compressibility on breakthrough time, sweep efficiency, mixing zone length, and flow structure are investigated. The results demonstrate that slightly compressible fluids have different fingering patterns compared to incompressible ones. The involved mechanisms retard the growth of the ramifications. This result is also confirmed by the quantitative analyses. In earlier times, the pressure gradient is partially absorbed by compression of the fluids and the mixing zone length (MZL) for slightly-compressible fluids is smaller than the incompressible flow's MZL in the diffusive dominated regime. This effect causes a delay in the starting of fingering dominated period as well which results in the increase of the breakthrough time that brings a rise in sweep efficiency. The outcome of this research is a good explanation for the discrepancy between the experimental and numerical results of previous works.

Time Block Preference

Time Block A (09:00-12:00 CET)

References

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Primary authors: Ms BARARPOUR, Fatemeh; SAJJADI, Mozhdeh (Assistant Professor)

Presenter: Ms BARARPOUR, Fatemeh

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