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# Flow modelling of injection orientation of supercritical CO<sub>2</sub> in porous media for enhanced gas recovery

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<b>Title</b>	Flow modelling of injection orientation of supercritical CO <sub>2</sub> in porous media for enhanced gas recovery
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<b>Publication title</b>	Modelling in Nuclear Science and Engineering Seminar - 2020
<b>Publisher</b>	
<b>Type</b>	Conference or Workshop Item
<b>USIR URL</b>	This version is available at: <a href="http://usir.salford.ac.uk/id/eprint/59487/">http://usir.salford.ac.uk/id/eprint/59487/</a>
<b>Published Date</b>	2020

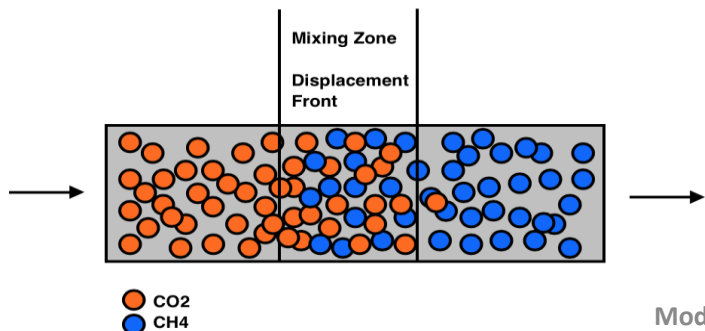
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## 1.0 Introduction

Injection orientation of supercritical CO<sub>2</sub> (SCO<sub>2</sub>) during enhanced gas recovery (EGR) and sequestration is one of the key factors to the overall technique in terms of displacement efficiency and extent of gas mixing. Injection orientation plays a vital role in the behaviour of SCO<sub>2</sub> as it traverses the pore spaces of the porous medium during CH<sub>4</sub> displacement at reservoir conditions under gravity. However, the rate of mixing between the injected CO<sub>2</sub> and the displaced CH<sub>4</sub> appeared more rapid in the horizontal injection orientation compared to that of vertical injection from previous laboratory tests.

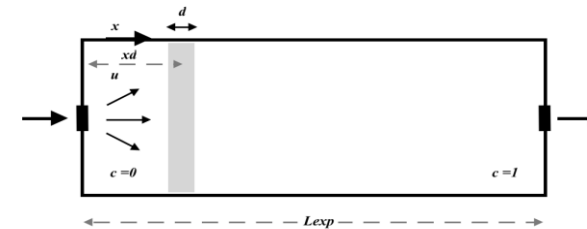
This study aims to investigate the flow behaviour of SCO<sub>2</sub> in a rock core under gravity using a numerical method. The modelling was used to evaluate the gravity effect on the efficiency of CH<sub>4</sub> displacement by mimicking a laboratory experimental approach.



## 2.0 Methodology

### 2.1 Model assumptions and governing equations

1. CO<sub>2</sub> density  $\rho$  and viscosity  $\mu$  are constant
2. Interstitial velocity  $u$ , is constant
3. Porosity  $\phi$  and Permeability  $k$  both of which are assumed constant.
4. Dispersion is also assumed to be isotropic throughout the displacement process.
5. Flow is compressible.
6. Temperature is also assumed to be constant.



#### 2.3.1 Brinkman Equation

$$\rho \frac{\partial u}{\partial t} = \nabla \cdot \left[ -PI + \mu \frac{1}{\varepsilon} (\nabla u + (\nabla u)^T) - \frac{2}{3} \mu \frac{1}{\varepsilon} (\nabla \cdot u) I \right] - \left( \mu k^{-1} + \beta_F |u| + \frac{Q_m}{\varepsilon^2} \right) u + F + \rho g \quad (1)$$

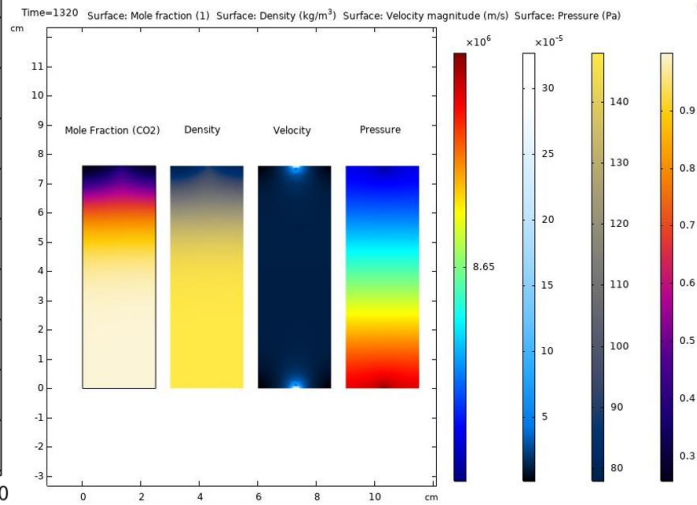
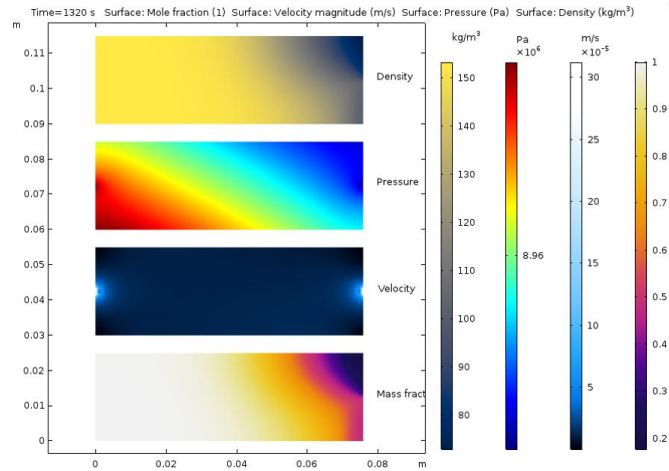
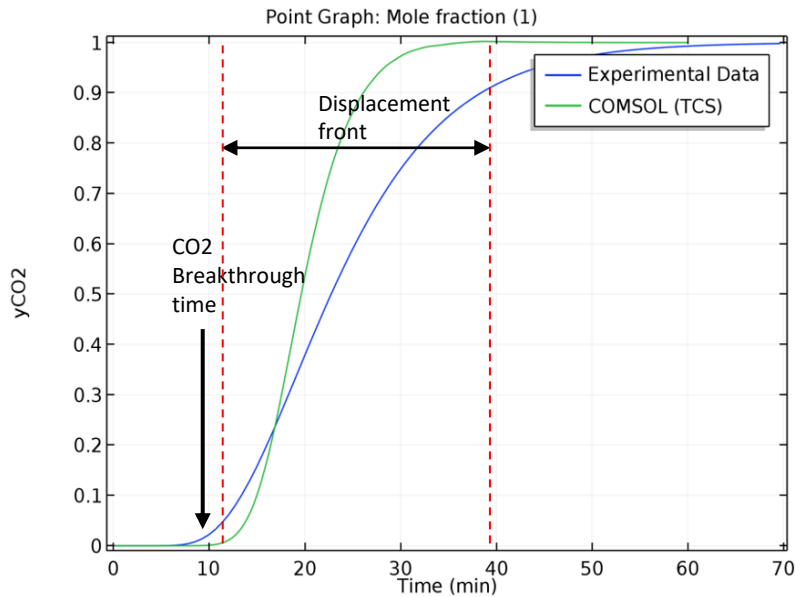
$$Q_m = \frac{\partial \varepsilon \rho}{\partial t} + \nabla \cdot (\rho u) \quad (2)$$

#### 2.3.2 Transport of concentrated species

$$\frac{\partial (\rho \omega_i)}{\partial t} + \nabla \cdot j_i + \rho (u \cdot \nabla) \omega_i = R_i \quad (3)$$

### 3.0 Results

The results show that gravity contributes significantly to the excessive mixing between CO<sub>2</sub> and CH<sub>4</sub> during the displacement process in the horizontal orientation as it sinks to the bottom of the porous media along the longitudinal axis of the porous medium. This is attributed to the density of the SCO<sub>2</sub> in relation to that of CH<sub>4</sub> at those conditions.



### 4.0 Conclusion

The numerical results demonstrated a conceivable representation of the laboratory experimental trend obtained for the concentration profiles of CO<sub>2</sub> as it displaced the CH<sub>4</sub>. This study explains the reason behind the observation of early breakthrough of CO<sub>2</sub> in the horizontal orientation and subsequent higher mixing between CO<sub>2</sub> and CH<sub>4</sub> compared to the vertical orientation injection.

### Acknowledgement

This work was supported by Petroleum Technology Development Fund (PTDF) Nigeria and Spray Research Group of Spray Research Group (SRG).

### References

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