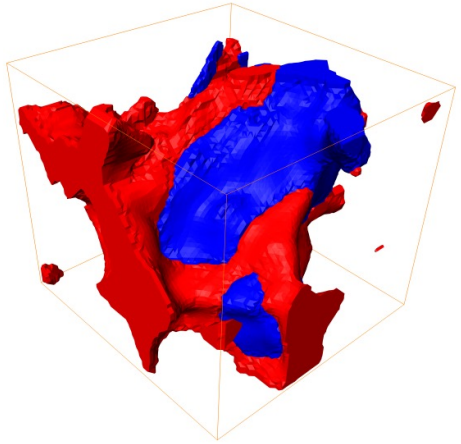
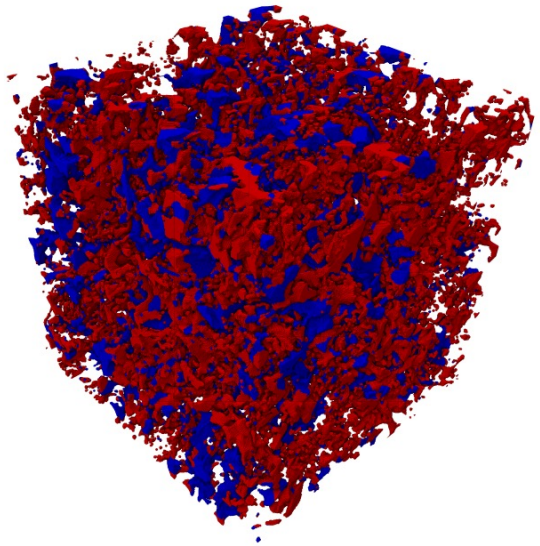
Identification of the leading role of pore structure in recovery during low salinity waterflooding





Edward Andrews, Ann Muggeridge, Alistair Jones, Samuel Krevor

bp

Imperial College London

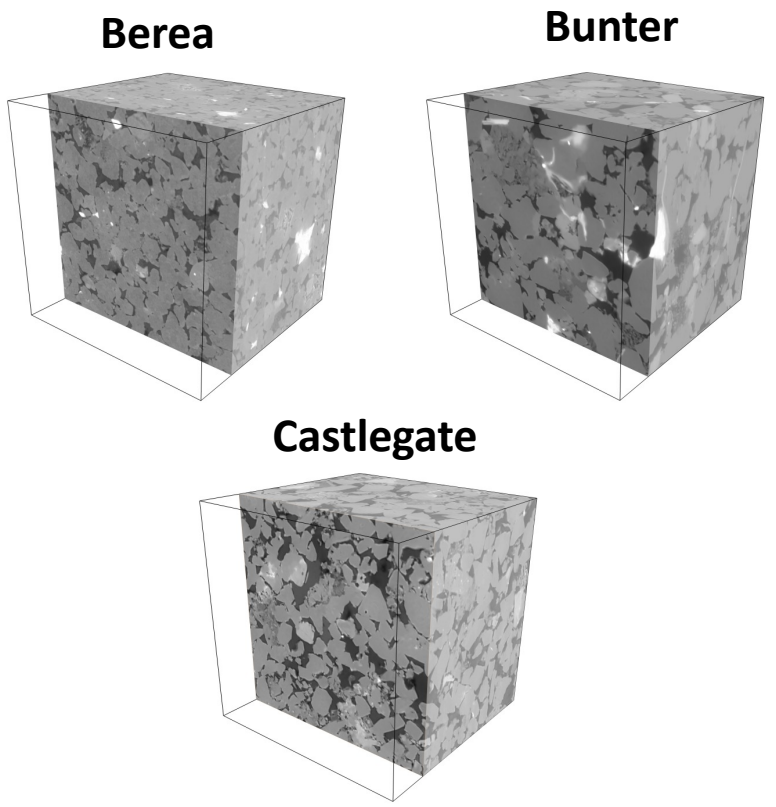
Low Salinity Waterflooding – A Brief Overview

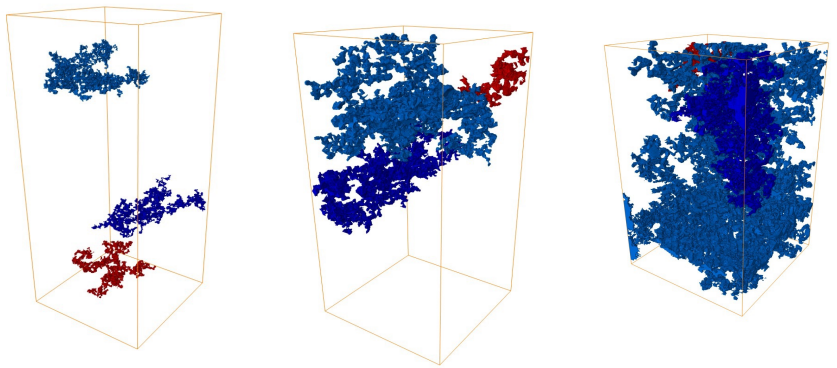
- An Enhanced Oil Recovery (EOR) technique where low salinity water is injected into a target reservoir
- Still no way of identifying which reservoirs will respond well to the technique
- This is partly due a **lack of understanding** around how **pore structure** impacts **oil mobilisation and recovery** during low salinity water flooding

In This Work We….

- Present **pore scale observations** of unsteady state **tertiary low salinity waterflooding** in 3 different oil-wet sandstone samples

- Investigate the role of **pore structure** in facilitating **oil mobilisation** and **production** during low salinity waterflooding





Results - Oil Recovery and Mobilisation

- Additional oil recovery of approximately **3**, **4**, and **1** percentage point(s) in the **Berea**, **Bunter**, and **Castlegate** samples, respectively

Results - Oil Recovery and Mobilisation

- Additional oil recovery of approximately **3**, **4**, and **1** percentage point(s) in the **Berea**, **Bunter**, and **Castlegate** samples, respectively

	Fraction of oil mobilised during Low salinity flooding [-]	**Fraction of mobilised oil produced [-]**
Berea	0.22	0.20
Bunter	0.20	0.32
Castlegate	0.11	0.13

Results - Oil Recovery and Mobilisation

- Additional oil recovery of approximately **3**, **4**, and **1** percentage point(s) in the **Berea**, **Bunter**, and **Castlegate** samples, respectively

	Fraction of oil mobilised during Low salinity flooding [-]	Fraction of mobilised oil produced [-]
Berea	0.22	0.20
Bunter	0.20	0.32
Castlegate	0.11	0.13

Approximately 2x more oil mobilised during low salinity water flooding in the Berea and Bunter sandstones than in the Castlegate sandstone

Results - Oil Recovery and Mobilisation

- Additional oil recovery of approximately **3**, **4**, and **1** percentage point(s) in the **Berea**, **Bunter**, and **Castlegate** samples, respectively

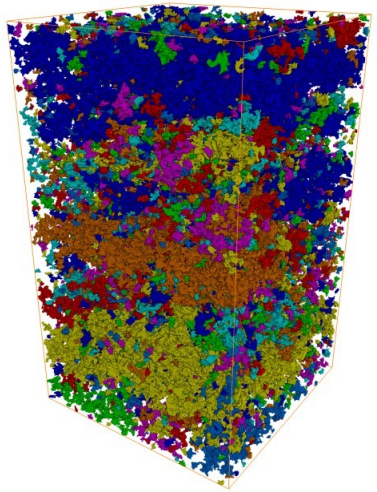
	Fraction of oil mobilised during Low salinity flooding [-]	Fraction of mobilised oil produced [-]
Berea	0.22	0.20
Bunter	0.20	0.32
Castlegate	0.11	0.13

Approximately 2x more oil mobilised during low salinity water flooding in the Berea and Bunter sandstones than in the Castlegate sandstone

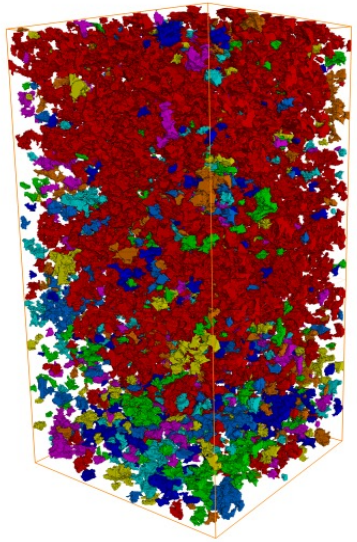
Samples of similar mineralogy, with identical experimental workflows. So why the different responses?

Pore Topology

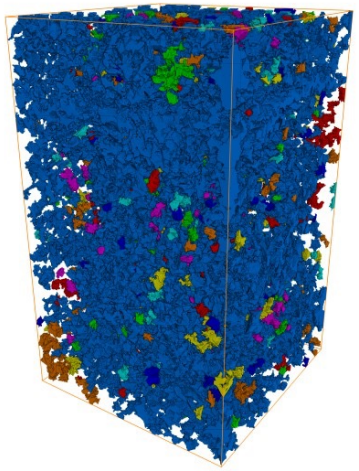
Berea



Bunter



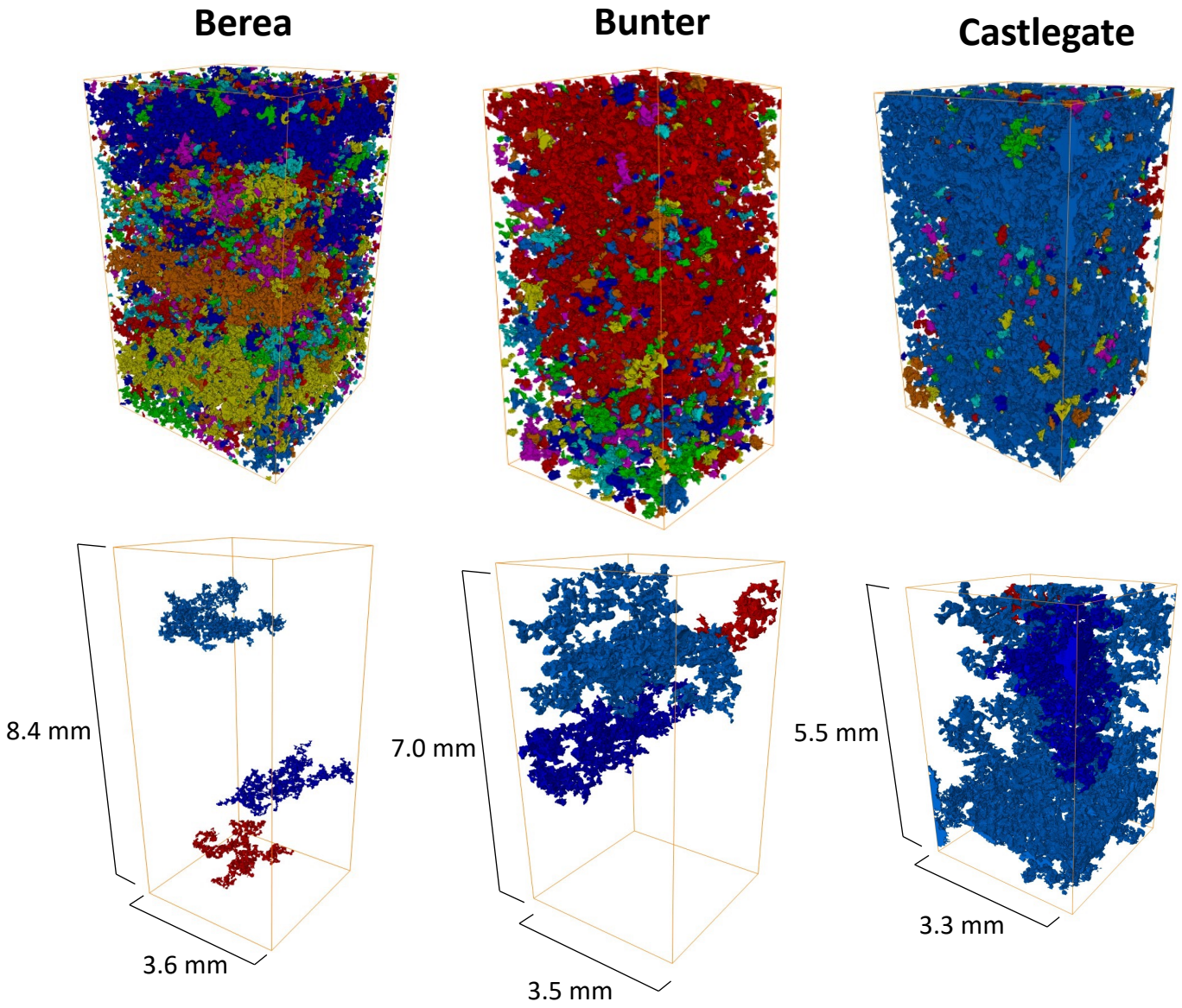
Castlegate



largest pores which make up 60% of total pore volume - different colours represent separate connected pathways

- **Berea** - large pores are poorly connected, with few large groups of connected pores
- **Bunter** - two distinct behaviours:
  - Upper section - Large pores are well connected
  - lower section - Large pores are poorly connected
- **Castlegate** – large pores are very well connected

Pore Topology & Brine distribution

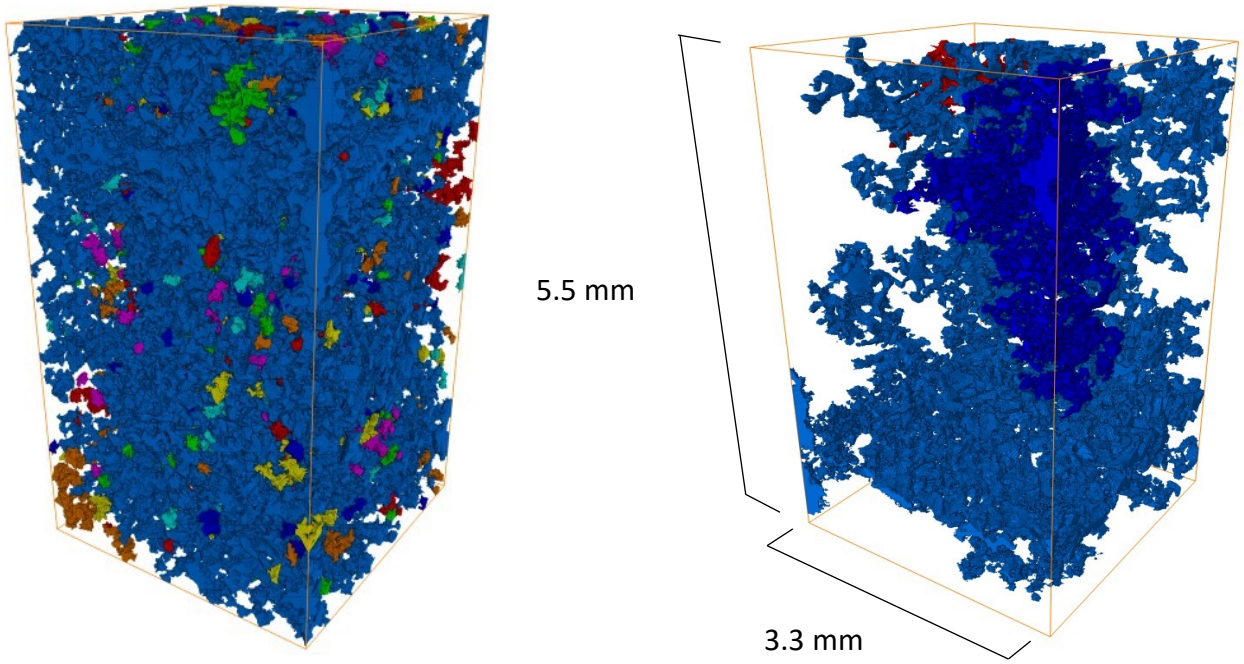


Largest 3 brine blobs after HSWF

- **Castlegate** - Connected brine cluster across region of interest after HSWF
- In the **Castlegate sample, well connected large pores** allow for **brine** to connect in a **stable pathway** during **HSWF** and **subsequent LSWF**

Pore Topology & Brine distribution

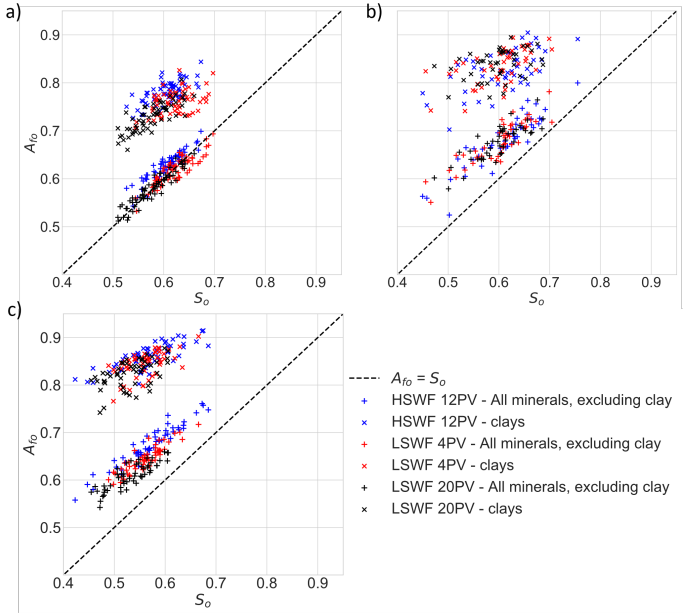
Castlegate

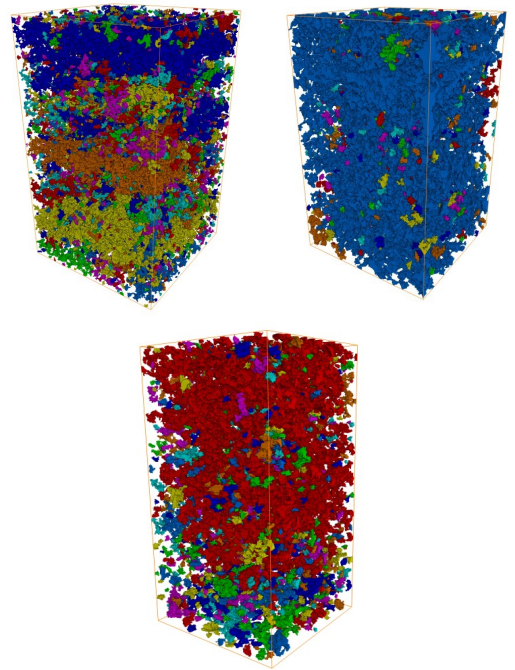


- **Castlegate** - Connected brine cluster across region of interest after HSWF
- In the **Castlegate sample, well connected large pores** allow for **brine** to connect in a **stable pathway** during **HSWF** and **subsequent LSWF**
- In the **Castlegate sample, low salinity brine** can **preferentially flow** along the **existing pathway** of high salinity brine, making **oil mobilisation less favourable**

Conclusions

- Additional recovery observed in all samples after LSWF - highest additional recovery in the **Bunter** and **Berea** samples
- Pore structure, particularly the connectivity of the largest pores, impacts oil mobilisation and recovery
- **Well connected large pores make oil mobilisation less favourable during low salinity water flooding**





Future work

- Further investigate role of pore topology –
  - Pore network modelling?
  - Can pore topology be developed as a screening criteria?

Acknowledgements

Thank you for listening

Any Questions?

Imperial College London