Comparison of CO_2-EOR Performance between Offshore and Onshore Environments

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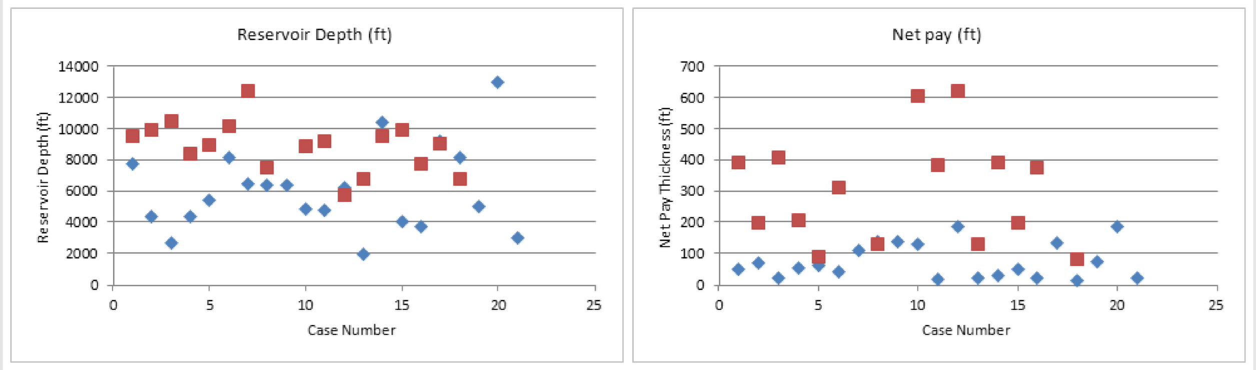
1 BACKGROUND

The majority of CO_2-EOR projects are located in onshore fields in North America and the primary target for CO_2 flooding is EOR. CO_2 injection is being considered for offshore application in provinces such as the North Sea both for EOR and Storage purposes where there are fundamental differences compared to onshore CO_2 flooded reservoirs.

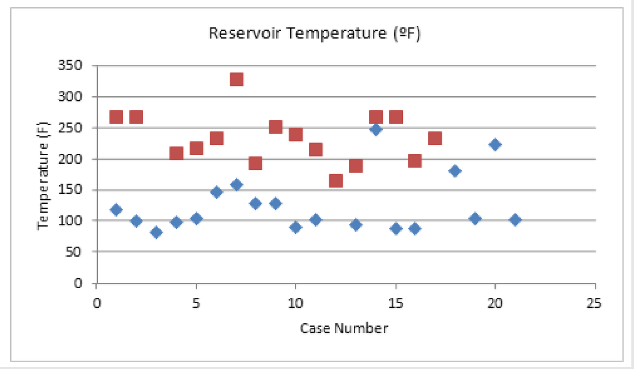
2 Why / PURPOSE

Offshore reservoirs (with specific attention to offshore North Sea) are fundamentally different from onshore US candidates for CO_2 flooding in a number of ways;

- Offshore reservoirs are typically bigger, deeper and thicker compared to onshore.
- Well spacing is larger offshore.
- The reservoir properties (pressure, temperature and formation characteristics) are fundamentally different between the two environments.
- Injection and production rates are higher offshore.
- The motivation for CO_2 flooding offshore is different from onshore.
- The cost structure offshore is fundamentally different compared to onshore.



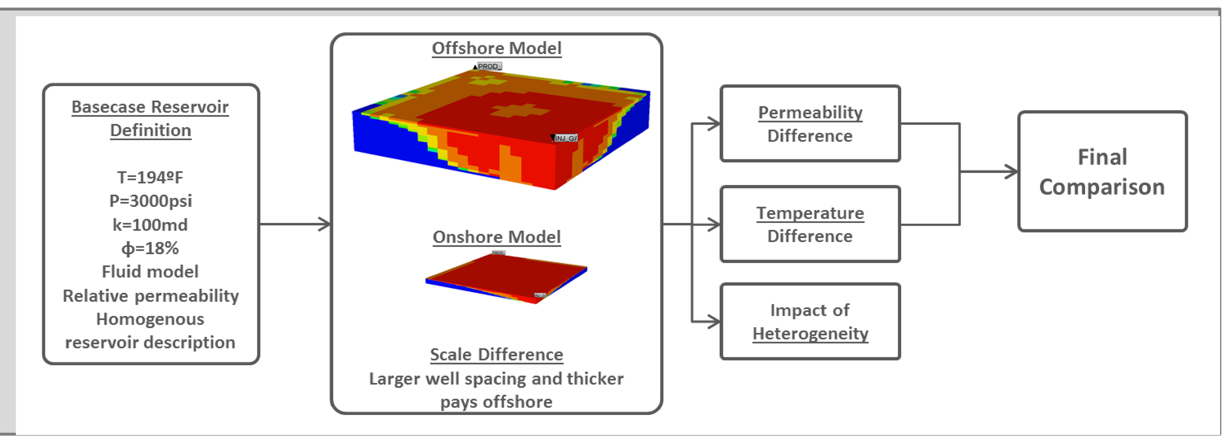
Major differences in terms of reservoir properties between a number of onshore US CO_2 flooded reservoirs (blue diamonds) and offshore North Sea hydrocarbon flooded reservoirs (red squares)



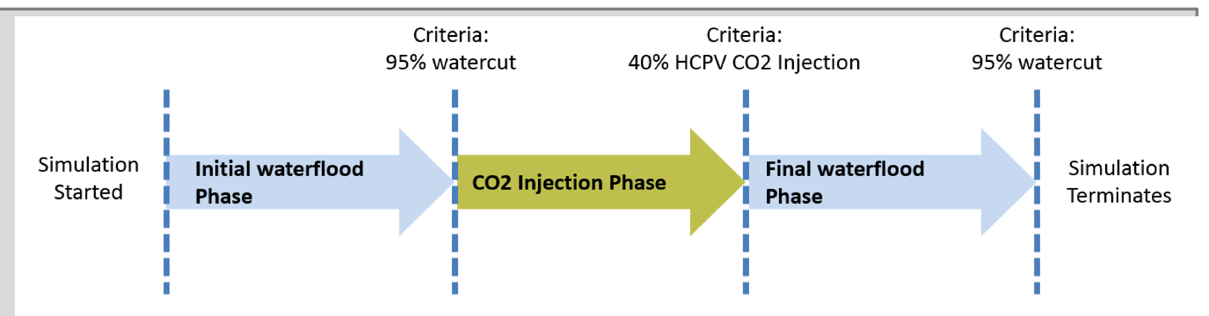
This study aims to investigate the impact of these differences on the performance of CO_2 flooding offshore compared to onshore US.

3 METHODOLOGY

Comparison Strategy: The CO_2 flooding process is simulated in two different sized box models, each representing either onshore or offshore environments and their performances are compared.
The same reservoir properties and fluid descriptions have been used in both models. However in terms of dimensions, offshore, well spacing is 1.6 time larger than onshore and it is also 7.5 times thicker.



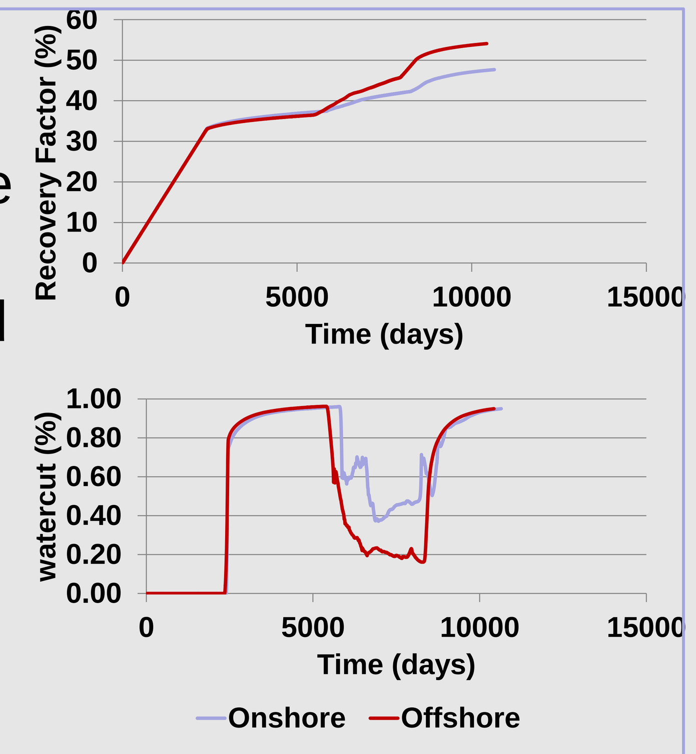
Depletion Strategy: In all comparison scenarios both models undergo the same injection and depletion strategy. The depletion strategy illustrated (right) allows for controlling the average reservoir pressure at around identical values in both models, since pressure has a significant impact on the process efficiency.



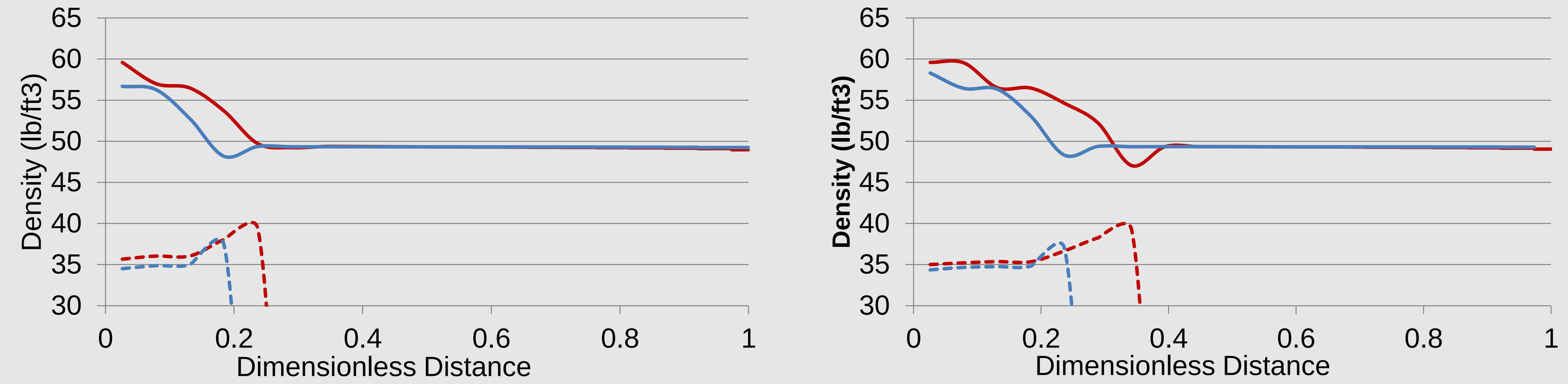
Both models are flooded under "slug" flooding strategy, where a single batch (40%HCPV) of CO_2 is injected right after initial waterflood. Once all the desired CO_2 is injected, the process is followed again by final water injection to recover the remaining oil. The rate of injection and production is controlled at 5%HCPV per year, hence the rates are different in each environments based on the reservoir volumes.

4 RESULTS

1: Impact of scale differences: Changing scales from onshore to offshore, favourably alters the pressure profile of the system, increases the magnitude of viscous forces and retard the gravity segregation of CO_2.
Right figures show that under comparable reservoir conditions, the "slug" CO_2 flooding strategy increases the recovery factor by 6.4% offshore compared to onshore.

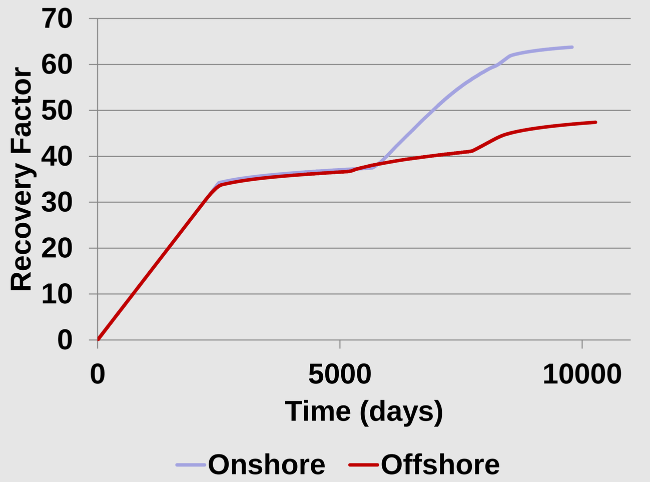


2: Impact of Pressure Profile Modifications: Offshore due to larger well spacing, the process has to operate at higher pressures, hence promoting the compositional interactional (miscibility development) between oil and CO_2, leading to higher recoveries.



Oil and gas densities from injector to producer, red: offshore, blue: onshore, solid lines: oil density, dashed lines: gas densities
Left at 10%HCPV CO_2 injection, Right at 20%HCPV CO_2 injection

3: Comparison under realistic reservoir conditions: Reservoir conditions at onshore US CO_2 projects are usually more favourable for CO_2 flooding than offshore North Sea.
When the comparison is performed under more realistic reservoir conditions, the performance becomes poorer offshore compared to onshore.



Comparison of recovery factors
Offshore at T=194ºF and K=300md
Onshore at T=120ºF and K=50md

4: Final Conclusions: Changing scales improves the CO_2 flood performance offshore. However the adverse impact of reservoir conditions for CO_2 flooding offshore, makes the process ultimately poorer offshore. This poor performance of CO_2 flooding offshore can be compensated by increasing the operating pressure offshore, bringing performance to the same level as onshore, but at higher compression costs, hence making the CO_2-EOR process more expensive offshore.

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