Study of Near-Wellbore Injectivity of CO_2 Sequestration in Saline Aquifers

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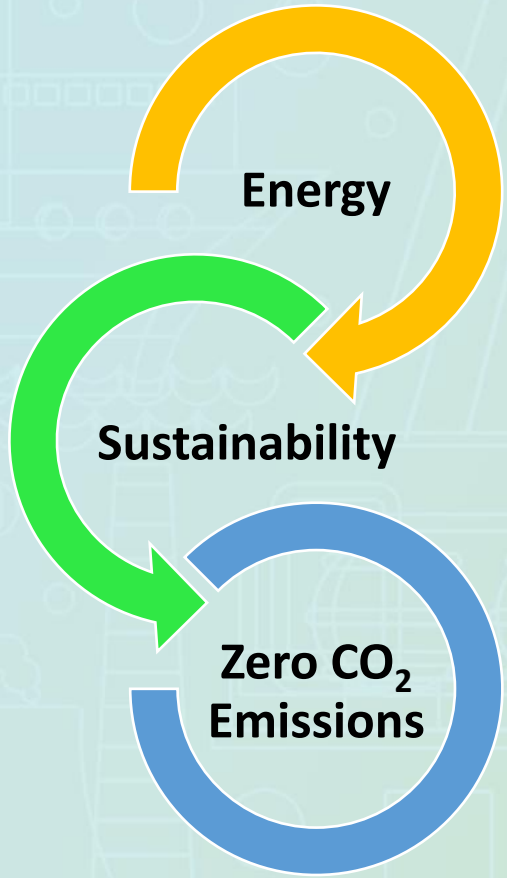
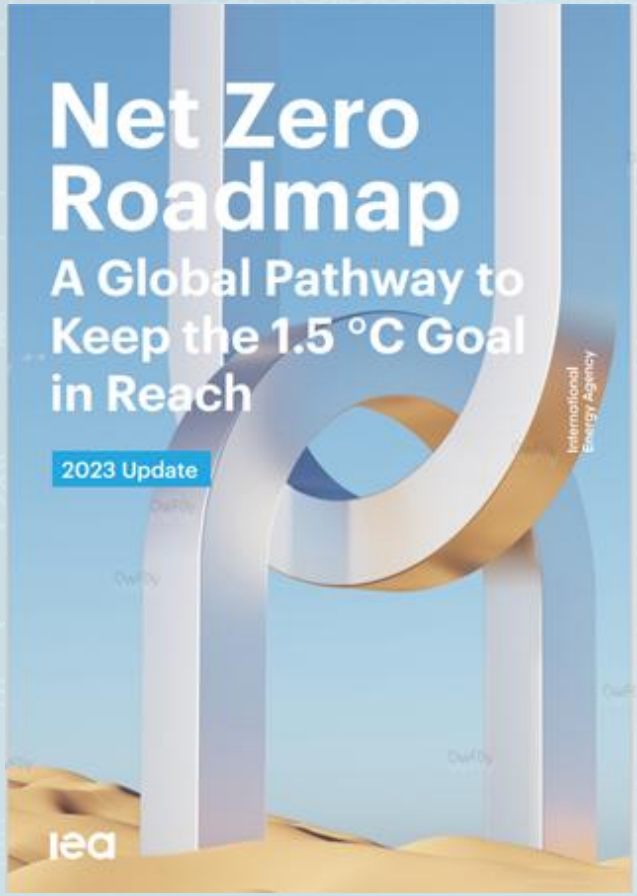
Outline

- Saudi Aramco Initiative Toward Zero CO_2 Emissions
- Carbon Capture and Storage (CCS) in Oil & Gas Industry
- CO_2-brine-rock Interactions Mechanism
- Salt Precipitation Characterization Results



Saudi Aramco Initiative Toward Zero CO_2 Emissions



- Historic Paris agreement to reduce global warming

2015

- Cut emissions by at least 45 % compared to 2010 levels

2030

- Transition to net-zero emissions must be fully complete

2050

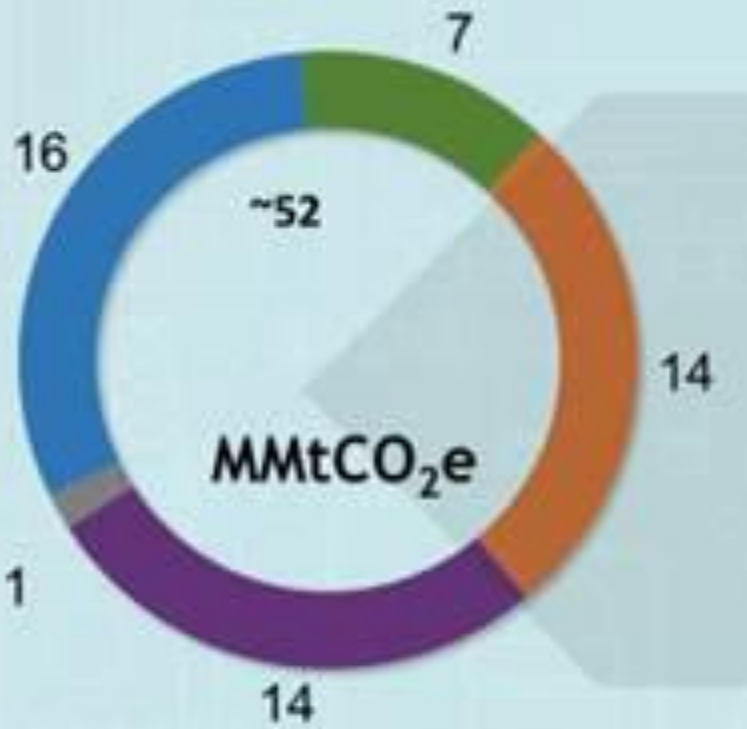
International Energy Agency | Net Zero Roadmap.2023

Corporate Levers To Achieve Reductions In GHG Emissions

Net Zero Ambition

In October 2021, Aramco announced its ambition to achieve net-zero Scope 1 & Scope 2 GHG emissions across its wholly-owned operated assets by 2050

GHG Reductions Targeted by 2035

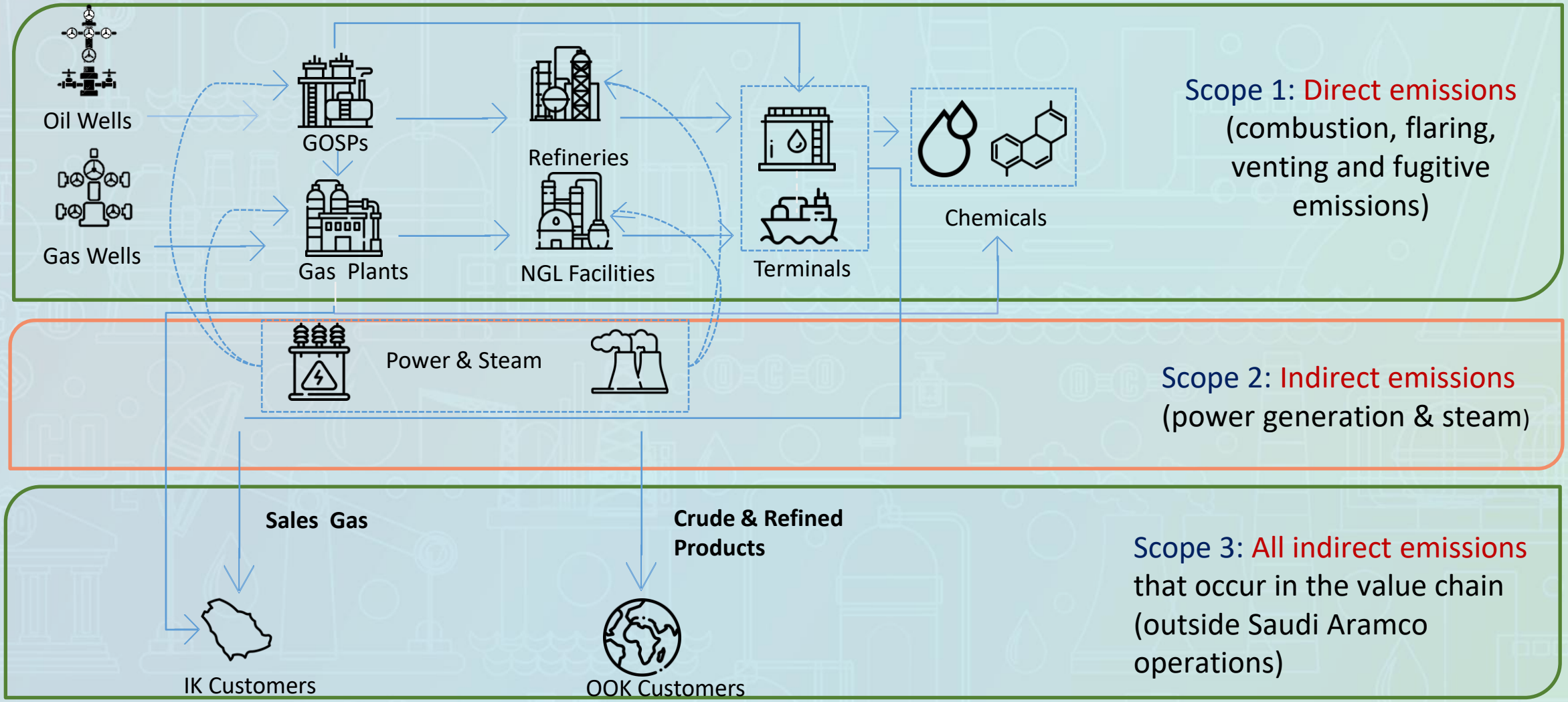


Aramco Sustainability Report, 2023

Corporate Levers

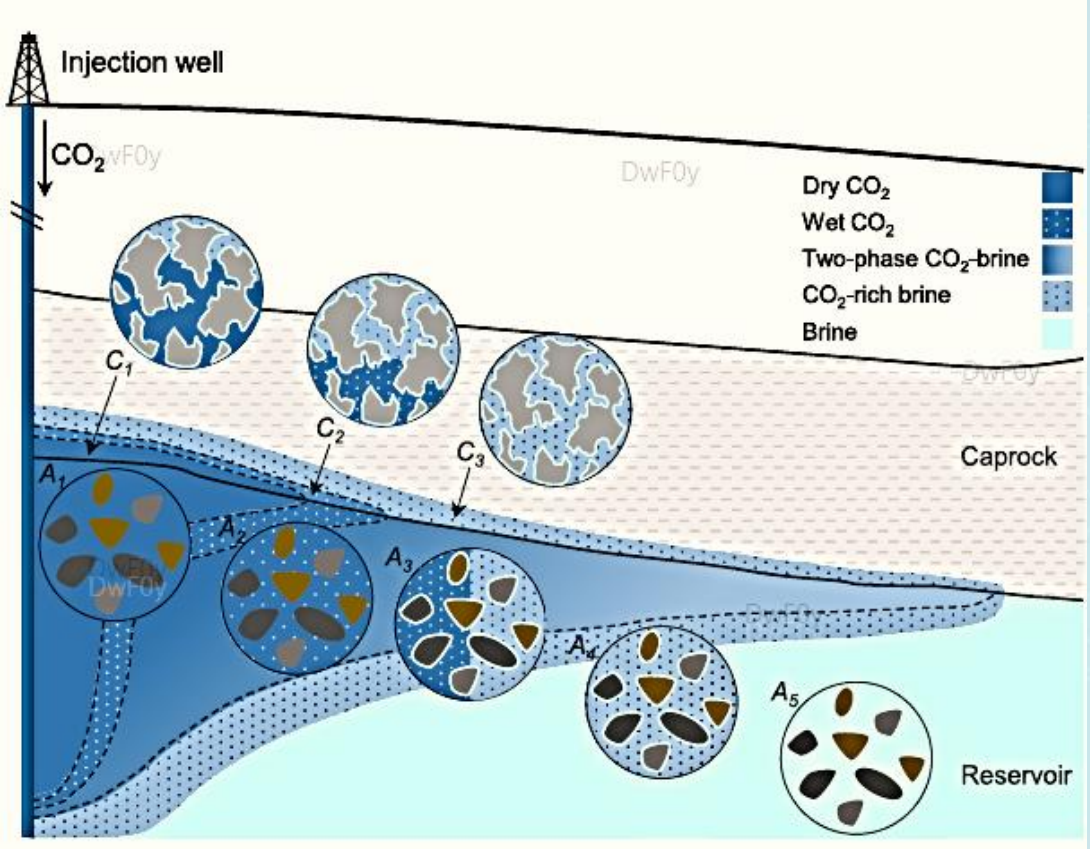
- Offsets
- Energy Efficiency
- CCUS
- Renewables
- Methane & Flaring

Operating Model



Saudi Aramco Sustainability Report. 2023.

CO2 Sequestration in Saline Aquifer



Co_2-brine-rock Interactions

$$CO_2\,(g) + H_2O \leftrightarrow H_2CO_3\,(aq) \quad (1)$$

$$H_2CO_3\,(aq) \leftrightarrow H^+\,(aq) + HCO^-_3\,(aq) \quad (2)$$

$$HCO^-_3\,(aq) \leftrightarrow H^+(aq) + CO^{2-}_3\,(aq) \quad (3)$$

Schematic of a geological CO_2 storage site with zones formed around the injection well

Research Objective

To investigate the salt precipitation impact on CO_2 injectivity during sequestration in the carbonate saline aquifers

Experimental Study

1

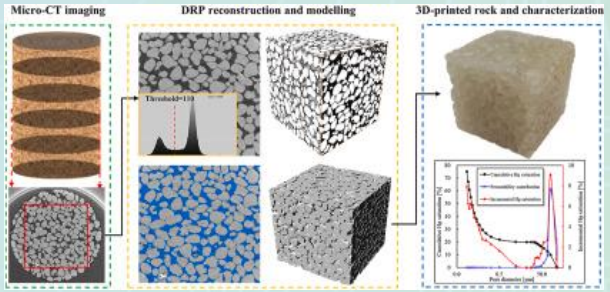
Preparing Brine

3

Saturation cores in brine

5

Post- characterization

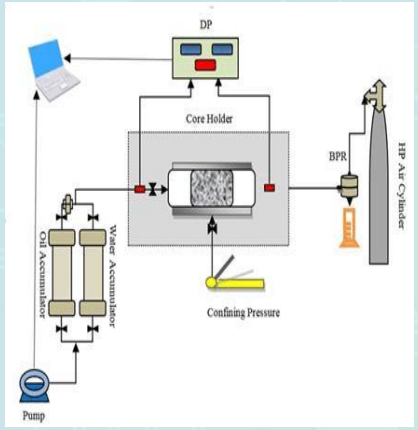


2

Pre-characterization

4

Core flooding



Experimental Procedure

Pre-test

- Measure core properties, such as weight, porosity, permeability, microstructures
- Saturate cores (1.5 x 3.0 inch) with brine of pH 6.5 for 2 months
- Chemical composition of brine can be found in the paper

Test

- Mimic the actual CO2 sequestration process in near-well region in the saline aquifer
- Inject 10 pore volumes (PV) of dry CO2 or N2 at rate of 1 cm3/min
- The back pressure is 1100 psi
- Monitor the injection pressure

Post-test

- Dry cores at 100 C for 24 hours to remove absorbed water
- Measure the remaining salt, porosity, permeability, micro structures

Core Flooding Experiments

Core Flooding Parameter	Value
Temperature	50 ˚C
Confining stress	2500 psi
Back pressure	1100 psi
Injection rate	1 cm^3/min

Core #	Porosity	Permeability	Flooding gas
1	14.4	2.07	N_2
2	15.5	3.31	CO_2
3	18.3	31.7	CO_2
4	17.7	23.6	N_2

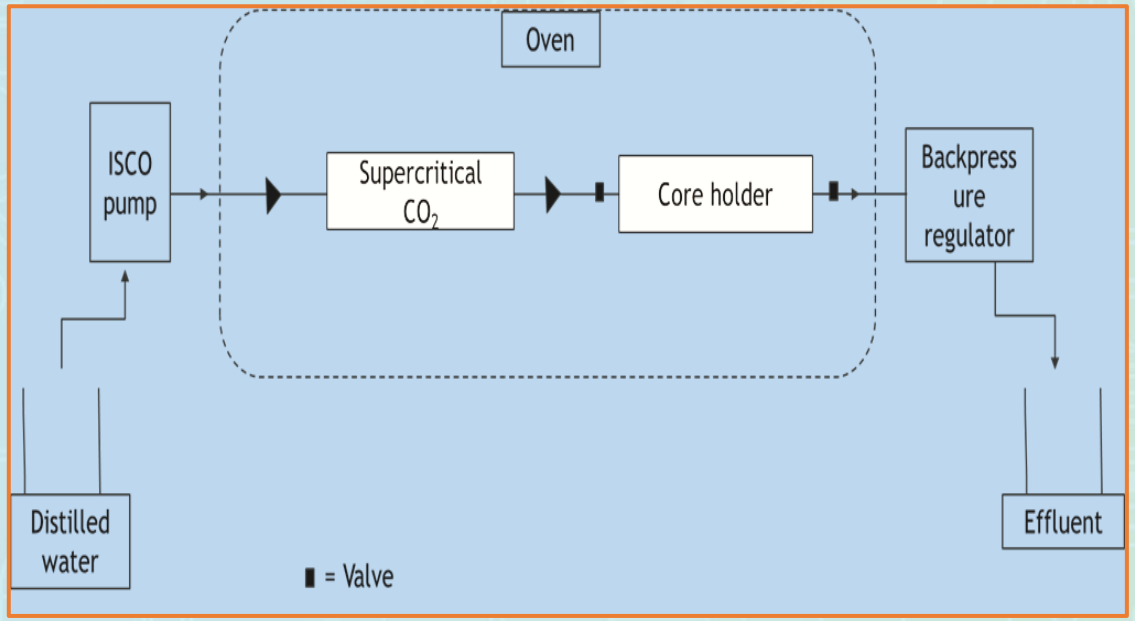
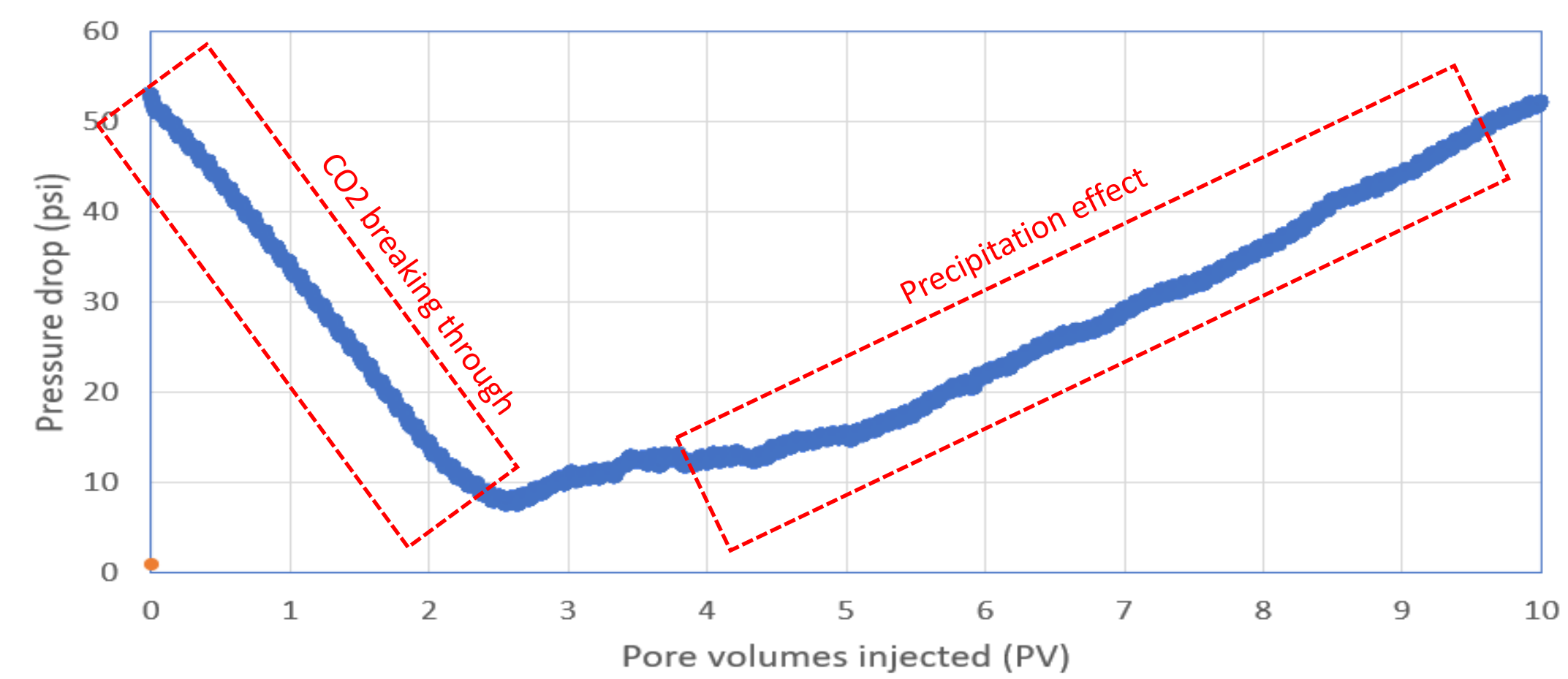


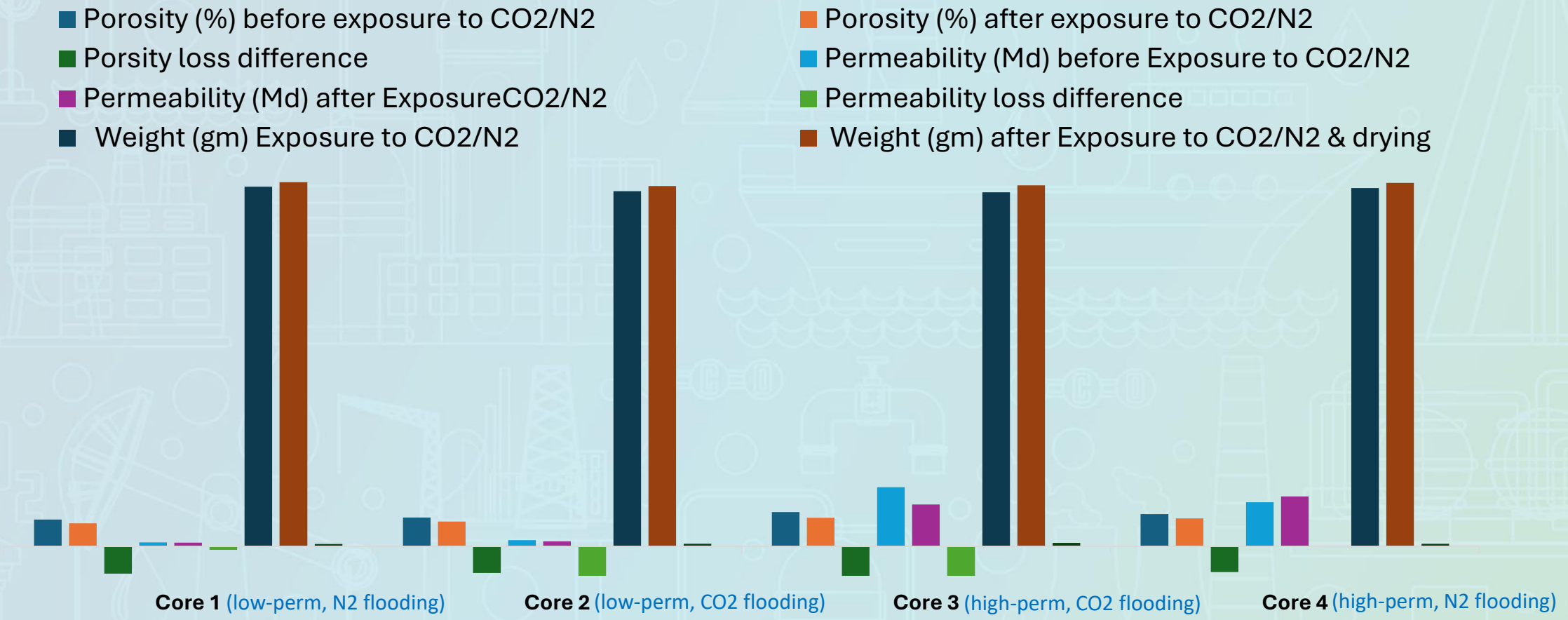
Diagram of core flooding setup

Experimental Results



ΔP vs. PV drop profile for CO_2 injection into brine-saturated core #3

Experimental Results



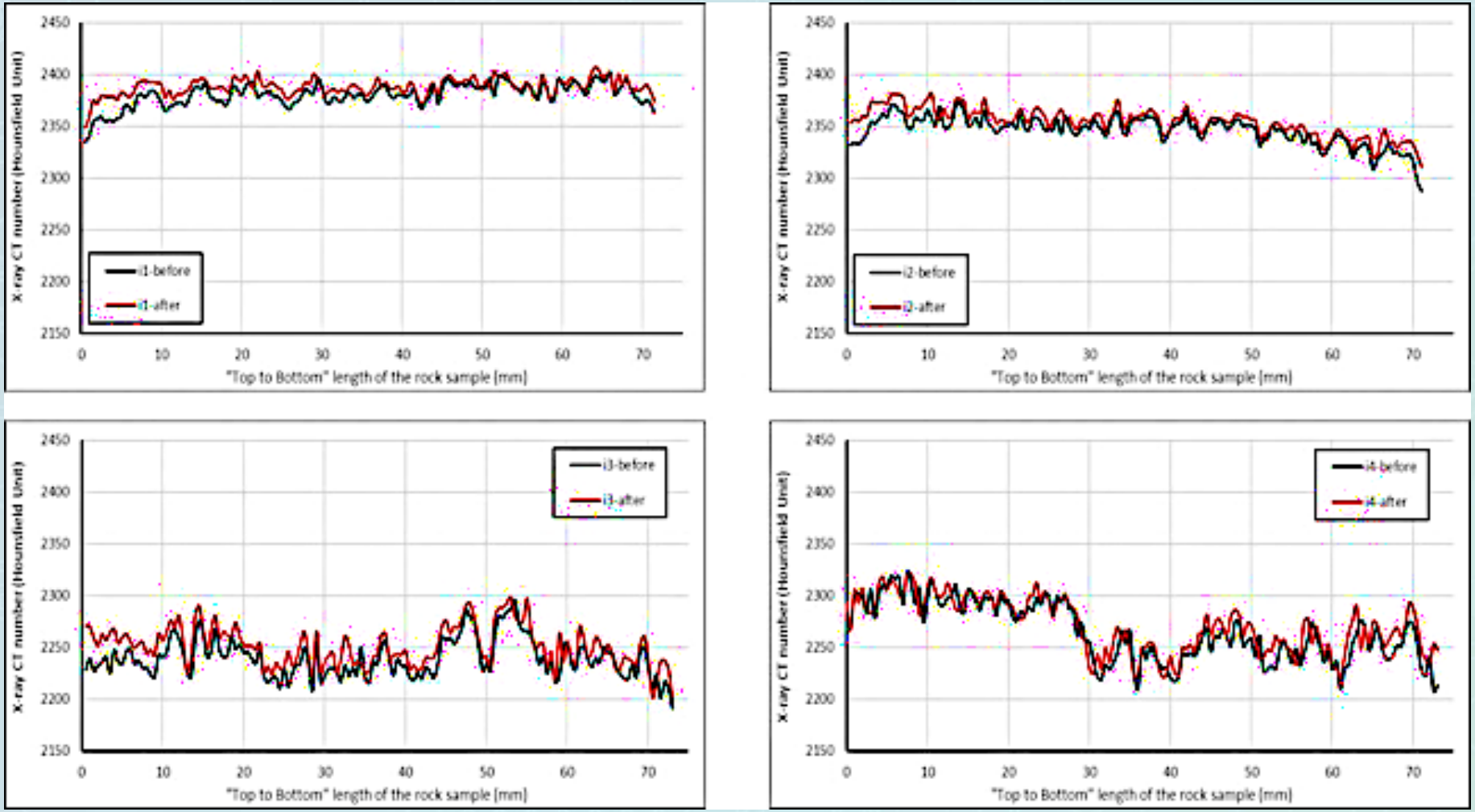
A comparison diagram of weight, microstructured values, and loss/increase difference percentage of all core plugs before and after introducing N_2 and CO_2

Experimental Results

Core #	Flooding gas	Initial Porosity	Post-test Porosity	Initial Permeability (mD)	Post-test Permeability (mD)	Salt precipitated (gm)
1	N_2	14.4	12.3	2.07	**2.03**	**2.38**
2	CO_2	15.5	13.3	3.31	**2.77**	**2.75**
3	CO_2	18.3	**15.3**	31.7	**22.5**	**3.68**
4	N_2	17.7	**15.0**	23.6	**21.7**	**2.79**

Lab observations:
(1) Both CO2 and N2 cause dry-out (salt precipitation)
(2) CO2 seems to be more severe

Results



CT Scan diagrams show the relation between the x-ray CT number (Hounsfield units) and the core plugs 1-4.

Conclusion

- Saudi Aramco has committed to net-zero emission by 20250; CCUS is an important program for achieving this target; this project is part of CCUS program.
- Core flooding test shows that both CO_2 and N_2 will cause dry-out (salt precipitation) in carbonates cores.
- Salt precipitation increases the bulk density of cores and modify the microstructural characteristics of cores.
- In comparison, CO_2 flooding results in a more significant permeability reduction than N_2.
- The rock dissolution and crystals of salt (NaCl) scale on the pores of cores can be observed in the lab test.
- Salt precipitation changes the microstructural characteristics of the cores, introducing formation damage near wellbore, subsequently imposing negative impact on the sequestration process of CO_2 in the saline reservoirs.

Thank you