Carbon Dioxide Hydrates-Based Carbon Sequestration on the Seabed

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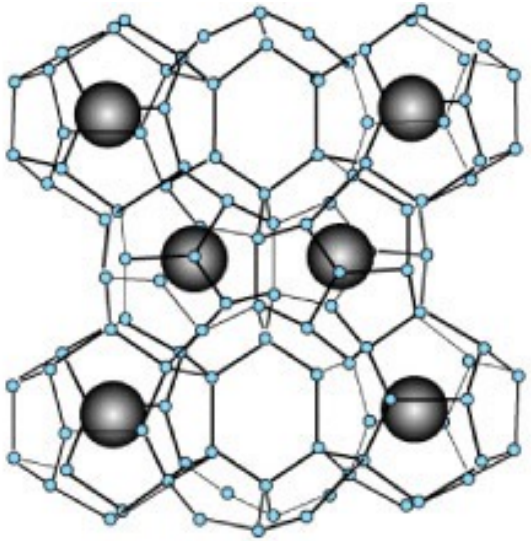
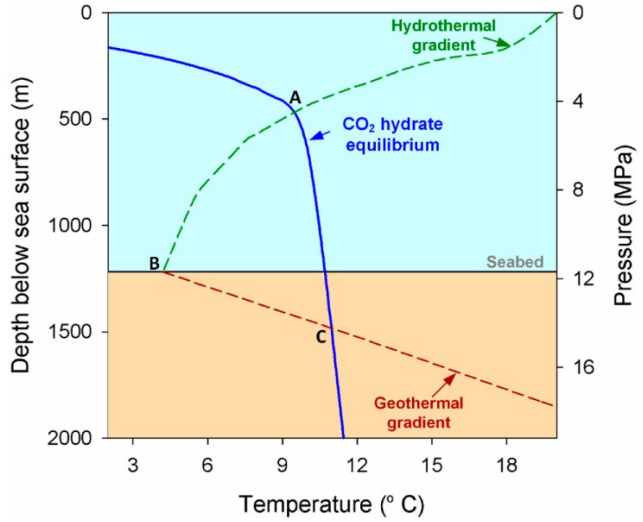


Molecular structure of hydrate

Plug of CO_2 hydrate
Ref: Bahadur group

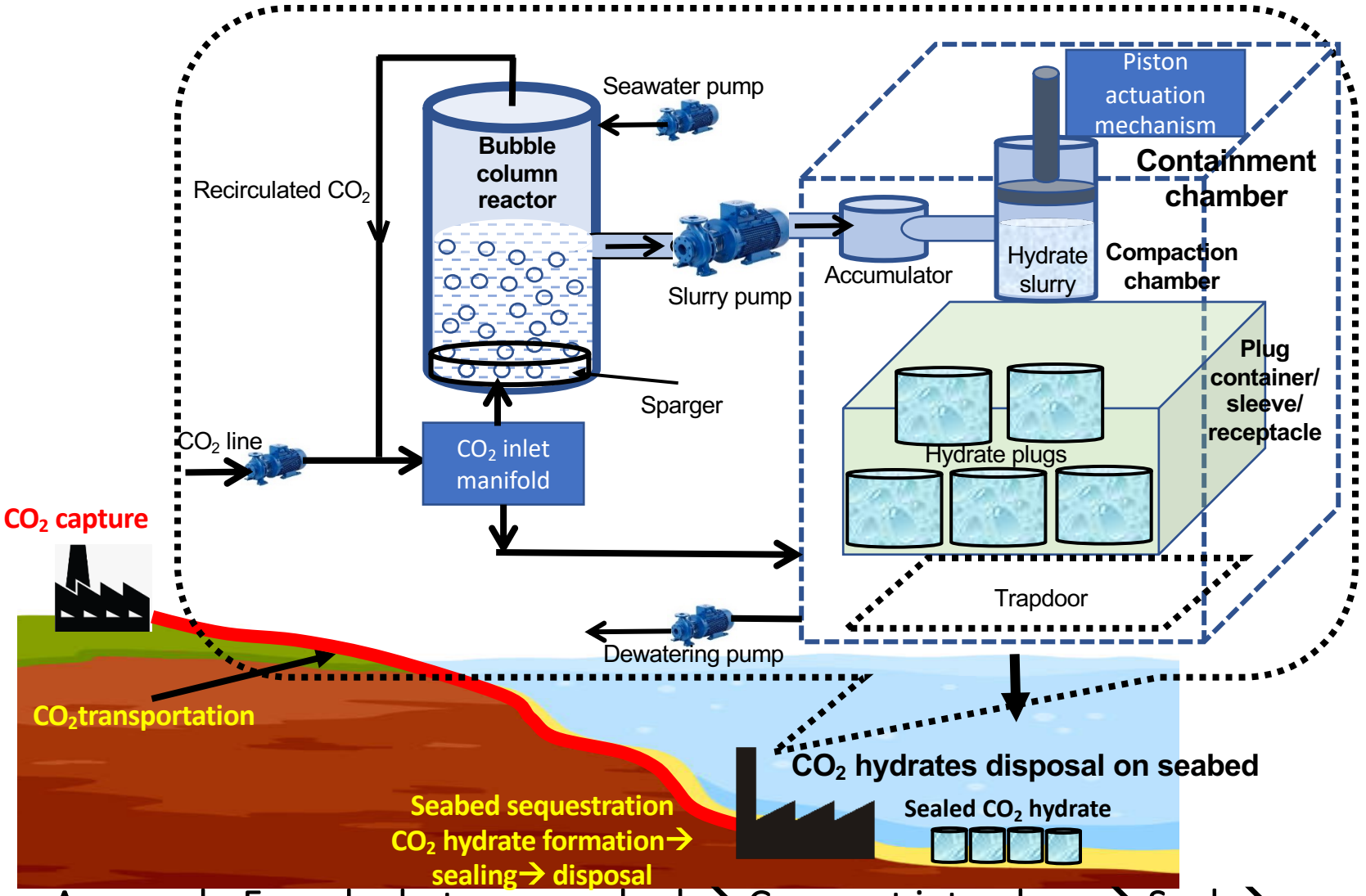


Stability zone for CO_2 hydrates (Ref.: Qureshi et al., CEJ, 2022)

- Ice-like materials with water cages hosting CO_2 molecules
- $CO_{2(g/l)} + nH_2O_{(l)} \rightarrow CO_2.nH_2O_{(s)}$; $n \equiv$ Hydration number: 5.6 - 6.6
- Form at medium-pressure (> 400 psi), low-temp (1-4 ℃)
- Density: 1040-1160 kg/m^3 (heavier than water)
- Hydrates dissociate when in direct contact with seawater- needs sealing

Plan of Action:
- Techno-Economic optimization
- Verify sealing and stability
- Pilot plant

Proposed Process Schematic and Key Challenges



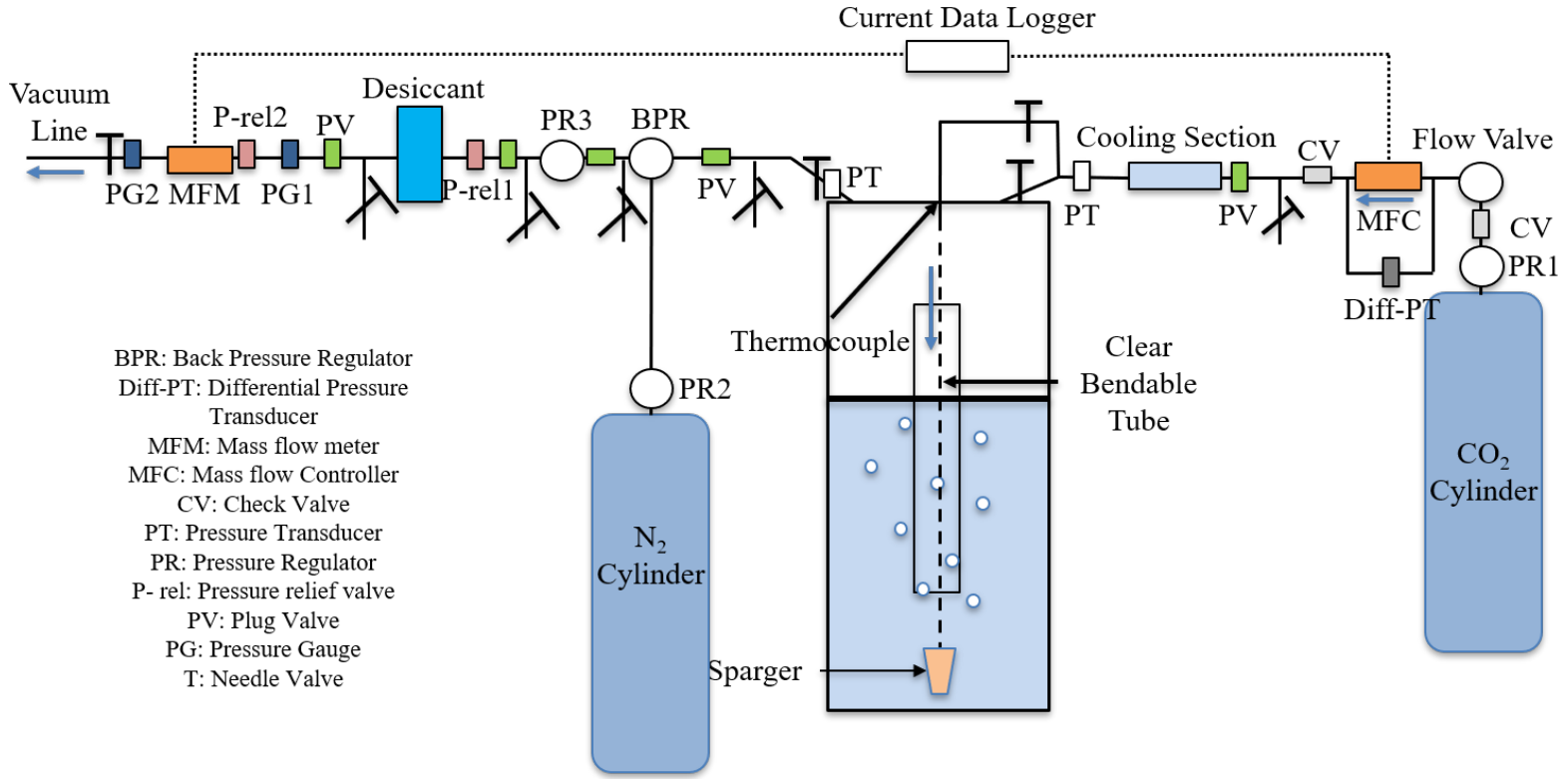
Approach: Form hydrates on seabed → Compact into plugs → Seal → Dispose

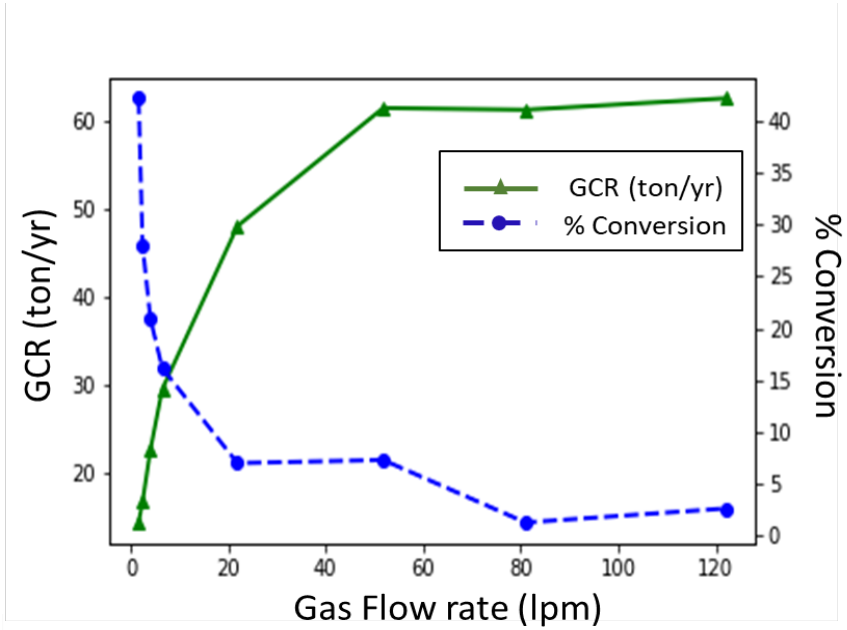
Key benefit: Seabed provides suitable conditions for stable hydrate formation. No refrigeration or overpressurization needed at seabed

Key Challenges

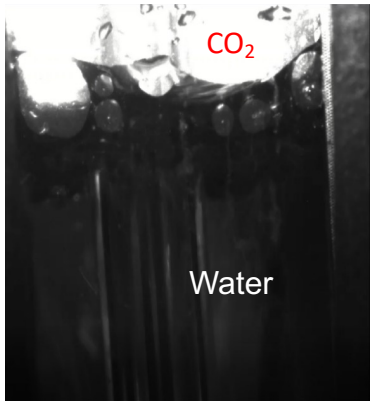
Challenge	Next Steps
Sealing (need CO_2 impermeability, bio-friendly, flexibility, tear resistance, burst resistant, durability)	- EPDM and EPR being tested - Multi-layer sleeves - Coatings on polymers
Maximize hydrate formation rate to get MT/yr and GT/yr levels	Extensive work on hydrate promotion in group
Geological risks at seabed	Analysis of i) subsidence of compressible mudrock, ii) potential seafloor instability.
Regulatory challenge: Standards do not exist	- Reach out to BOEM and EPA
Economic feasibility: Need revenue stream since 45Q is only for reservoir injection	- Interest in O&G sector to bring this technology forward - Carbon offsets market
Cost benefits of technology towards overall CCS costs yet to be understood	- Technoeconomic model for 1MT/yr storage site being developed - Cost benefits of using 50-60% pure CO_2 for CCS being studied

Current Work and Key Results

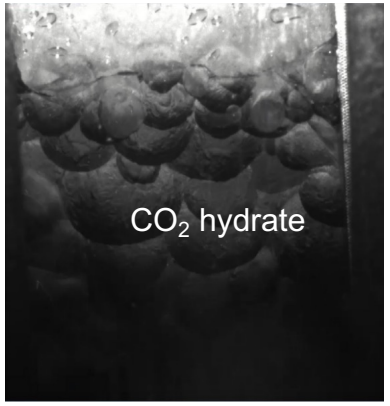




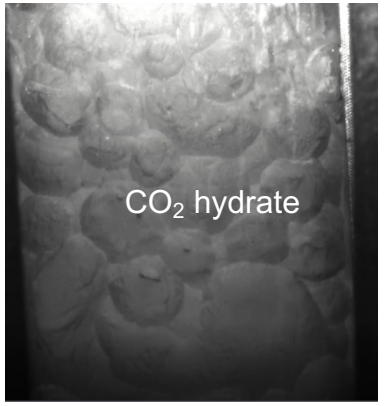
Reactor @ UT



t=0: CO_2 bubbling prior to hydrate formation



t= 2 min: CO_2 hydrate growth from interface towards water



t= 5 min: Completion of CO_2 hydrate growth