CO2 Capture Project®

PROJECT FACTSHEET

CO_2 STREAM IMPURITIES: IMPACTS ON GEOLOGICAL STORAGE PERFORMANCE AND ASSURANCE *Phase 1 – Reservoir Simulation*

OVERVIEW

The CO_2 streams captured from industrial emissions sources as part of Carbon Capture and Storage (CCS) projects are expected to contain various impurities depending on the process and extent of post-capture gas treatment. The potential for cost savings by delivering less pure CO_2 streams to the storage reservoir are substantial if, transportation notwithstanding, it can be shown that these impurities do not adversely impact injectivity, conformance or containment. Non-compressible gases (e.g. N_2, CH_4, Ar) would be expected to impact flow properties and dynamics of the CO_2 stream whereas reactive gases (e.g. CO, SO_x) may result in dissolution or precipitation of minerals which could impact reservoir or seal permeability and mechanical strength. The behavior of other gases (e.g. H_2, O_2) is likely to be complex in terms of plume dynamics and reactivity. Through reservoir simulation and laboratory experiments the CCP3 CO_2 Impurities Study aims to understand potential impacts and complications to storage containment as a result of variously impure CO_2 streams.

THE PROJECT

The project is divided in three phases:

1) Reservoir Simulation - Develop static reservoir models encompassing a range of heterogeneity. Simulate injection and plume migration of CO_2 streams with single and multiple non-compressible gas impurities with the following maximum concentrations (mol%): N_2 (15), O_2 (5), Ar (5) with CH_4 considered as an impurity 'exsolved' from brine. Plume behavior metrics (rate of vertical ascent, lateral extent and time for CO_2 trapping) were examined for the low dip reservoir models at two depths: 1.5 and 3 km (~5000 and 10,000ft, called 'shallow' and 'deep' respectively).

2) Static Experiments - Conduct batch autoclave experiments using pure CO_2 and CO_2:O_2 (95:5mol%) with reaction modeling of other species SO_x (0.15mol%), CO (2mol%), and H_2 (0.4mol%). Detailed pre- and post-reaction water chemistry and rock petrographic, petrophysical and chemical analyses will be used to document alteration for the CO_2 and O_2 and to 'history match' the experiments using batch geochemical numerical code.

3) Integration – Flow and geochemical results will be integrated into a framework to assess the impact of impurities on plume shape and evolution, CO_2 storage capacity, storage reservoir integrity and well injectivity.

The CO_2 Impurities Study is being conducted by CCP3 in conjunction with the Bureau for Economic Geology.

PHASE 1 RESULTS – RESERVOIR SIMULATION

Flow Dynamics

Because of the lack of accurate data on viscosity and density, a series of experiments was performed at selected pressures and temperatures and for selected multi-component gas mixtures to accurately determine their physical characteristics (PVT data) (*Figure 1*). In addition, a comprehensive literature audit helped in estimating aqueous solubility of the mixture components at various pressure, temperature, and salinity conditions.

Reservoir simulation revealed that impurities impact CO_2 plume shape (rate of vertical ascent and lateral extent) more markedly at shallow depths where the contrast in density and viscosity with pure CO_2 is at its largest (*Figure 2*). For example, a 4% mole fraction impurity in a binary system is sufficient to increase plume length in 'shallow' low-dip sloping layers by 25%, whereas a mole fraction of 9 to 15%, depending on the component, is needed to create the same impact in a 'deep' system.

In all cases, plume extent is greater when impurities are present although residual trapping (retention in pores) occurs more rapidly when this is the case. This is generally the case regardless of reservoir heterogeneity and complexity although heterogeneity tends to moderate the impact of impurities on plume extent. The modeling also shows differential dissolution at the front and edges of the plume. In general, there is a trade-off between larger plume lateral extent due to the presence of impurities and decreased risk owing to faster trapping (pressure management).

Implications for costs and reliability of CCS

From these findings, the implications for the cost of capture and the reliability of long term geological storage could be significant. Long term reliability of CO_2 storage seems unlikely to be compromised by the presence of impurities in the CO_2 stream – indeed trapping timescales may be reduced in many cases, thereby decreasing risk to containment.

However, it seems that the presence of impurities can impact behavior of the CO_2 plume, implying that reservoir modelling for commercial projects needs to factor this in so that the presence of CO_2 in reservoirs can be better understood.

Phases 2 (static experiments) and 3 (integration)

The planned studies are expected to be completed in late 2012.

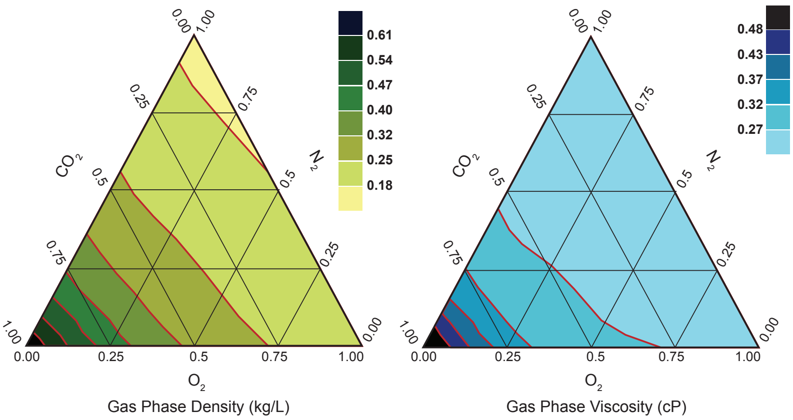
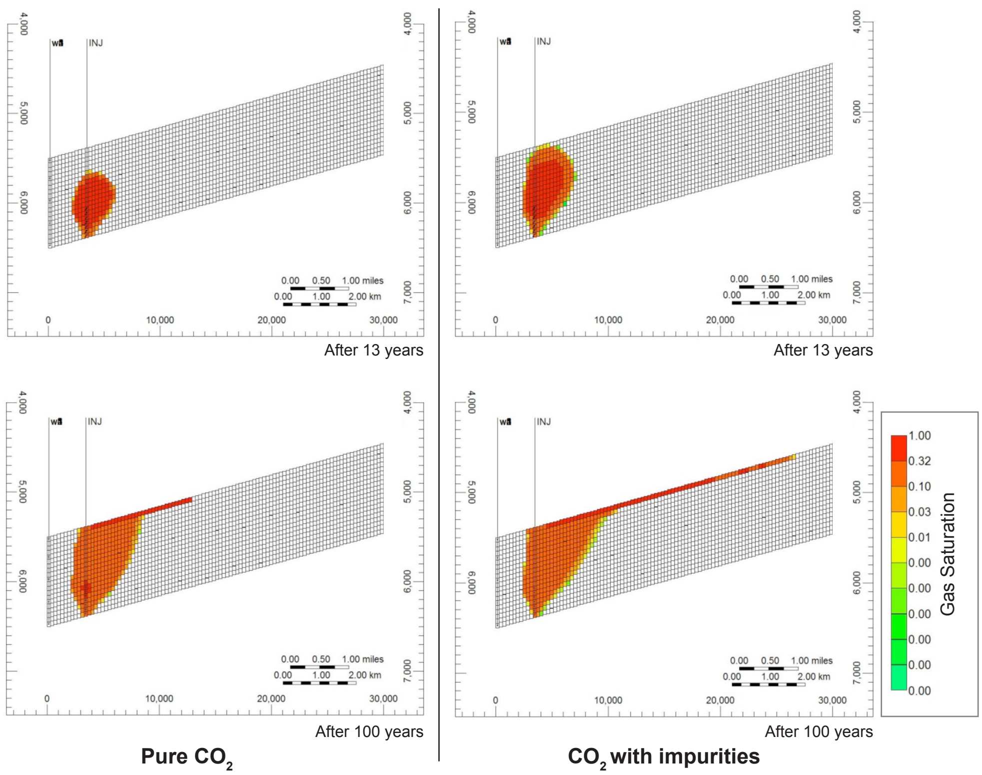


FIG1: CO_2 impurities impact on mixed gas plume density and viscosity

In all cases, viscosity and density of the mixtures are lower than that of pure CO_2 (only SO_2 would have the opposite impact). Figure 1 displays mixture density (left) and viscosity (right) properties expected at ~1.5 km (~5000 ft) deep U.S. Gulf Coast reservoir at 58ºC (135ºF) and 17 MPa (2500 psi)

FIG 2: CO_2-stream impurities impact on lateral extent of CO_2 plume (shallow depth - axes in feet)

Pure CO_2 is injected in the lower part of a sloping aquifer for 30 years at a rate of 0.74 million m³/day (26 MMSCFD) (top left). The CO_2 plume migrates upward, assuming homogeneous permeability in the field, until it reaches the top of the formation. Once the top is reached, the plume progresses up dip until the injected material is exhausted and entirely trapped through residual saturation and dissolution (chart bottom left). For the 81mol% CO_2 (N_2,15%; O_2, 2.1%; Ar, 1.7%) impurity case (top right) migration is faster because mixtures or non compressible gases always have a lower density (and thus greater buoyancy) and viscosity than pure CO_2. After 13 years of injection, the mixed-gas CO_2 has already reach the top of the formation whereas pure CO_2 has not (top right and left, respectively). At 100 years after start of injection, mixed-gas CO_2 (bottom right) has advanced further than pure CO_2 (bottom left) and ultimately mixed-gas CO_2 is trapped faster with no remaining mobile gas than pure CO_2.



ABOUT THE CO_2 CAPTURE PROJECT

The CO_2 Capture Project (CCP) is an award-winning partnership of several major energy companies working to advance the technologies that will underpin the deployment of industrial-scale CO_2 capture and storage.
To find out more visit www.co2captureproject.com