

## IMPURITY EFFECTS IN O<sub>2</sub>-SO<sub>2</sub>-CO<sub>2</sub>-WATER-ROCK REACTIONS RELEVANT TO CO<sub>2</sub> STORAGE IN THE SURAT BASIN.

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Industrial CO<sub>2</sub> streams from oxyfuel firing and coal combustion will contain impurities including O<sub>2</sub>, SO<sub>x</sub> and NO<sub>x</sub> that may be stored together with CO<sub>2</sub> in geological formations. Carbon dioxide dissolves into formation water subsurface (dissolution trapping) causing acidification and subsequent dissolution of carbonate and silicate minerals. The release of divalent cations into solution stabilises bicarbonate anions (ionic trapping) and may eventually lead to carbonate formation (mineral trapping). However, CO<sub>2</sub>-water-rock interactions have implications for water quality changes, and storage integrity, hence each potential storage site must be assessed.

The majority of experimental and modelling studies of CO<sub>2</sub>-water-rock interactions have focussed on pure (food grade) CO<sub>2</sub> effects. However this level of gas purification during carbon capture and storage is unrealistic. The co-injection of SO<sub>2</sub> has previously been observed to enhance silicate dissolution, or in the presence of significant calcite result in gypsum formation. (1) Impurity gases, especially O<sub>2</sub>, affect the system redox, and mobilisation of redox sensitive elements (such as Fe, As, Cr, U) into formation water may be enhanced or reduced. (2) In the presence of oxygen, subsequent formation of Fe oxides and sulphates may immobilise trace elements, as has been observed in a natural analogue study.

O<sub>2</sub>-SO<sub>2</sub>-CO<sub>2</sub>-water-rock laboratory experiments have been performed on a potential storage site reservoir and cap-rock core at in situ reservoir conditions. Enhanced mobilisation of major elements into solution from dissolution of reactive silicates and carbonates in reservoir and cap-rock was observed. This has been attributed to sulphuric acid generation, with a low fluid pH ~1-2. Elevated concentrations of dissolved di-cations including Fe (up to ~ 1000 mg/kg) and Ca showed enhanced potential for ionic and mineral trapping of CO<sub>2</sub> as calcite, ankerite, and siderite. Secondary iron oxide and sulphate precipitated on cap-rock core in experiments, additionally predicted in preliminary geochemical modelling. Mobilisation of trace elements including U and As were observed at low concentrations, with U within EPA recommended levels. Concentration of As was observed to decrease (to ~3ppb) in the experiment where iron oxide was precipitated suggesting its incorporation into the newly formed phase.

(1) Pearce, J.K., et al., 2013. SO<sub>2</sub> co-injection with potential carbon storage target sandstone from a fresh-water aquifer. *Mineralogical Magazine*, 77(5): 551-635.

(2) Harvey, O.R. et al, 2012. Geochemical Implications of CO<sub>2</sub> Leakage Associated with Geological Storage. PNNL report, PNNL-21550.