Mineral, fluid and gas interactions under CO_2 storage conditions – the role of SO_2, NO_X, and O_2

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Co-contaminant gases such as SO_2, NO_X, and O_2 are present in gas streams from power stations and oxy fuel power plants. Storage of CO_2 streams containing co-contaminants significantly reduces capture costs however they may have significant physical and chemical impacts on well materials, reservoir and cap rocks when in contact with formation water. Geochemical modelling of SO_2 co-injection indicates formation of sulphuric acid and lowered formation water pH compared to pure CO_2 injection resulting in increased mineral dissolution in the near well bore, and possible precipitation of minerals such as ankerite and dawsonite downstream with a decrease in porosity and injectivity.[1] However modelling is hampered by a lack of experimental data at carbon storage conditions for reactions involving co-contaminants SO_2, O_2 or NO_X.

In this context a new experimental apparatus has been constructed to reproduce in situ carbon storage temperature and pressure conditions for mineral – fluid –$scCO_2$ – co-contaminant gas reactions, with periodic sampling of fluids and gases for analysis.

Experimental results and geochemical modelling of the dissolution of pure mineral phases siderite, labradorite and illite in CO_2 saturated brines of high (150 g/l NaCl) and low salinity at representative reservoir conditions (80 °C, 200 bar) will be presented. Recent work on far from equilibrium siderite dissolution at up to 100°C and ~50 bar CO_2 shows increased dissolved iron at pH below 5 owing to proton promoted dissolution (PPD).[2] Labradorite dissolution is expected to be incongruent with enhanced release of sodium, calcium and aluminium over silica at our temperature conditions.[3] Labradorite dissolution may be expected to decrease under saline conditions by comparison to feldspar dissolution experiments in the absence of CO_2.[4] The effect on siderite at our conditions is less clear cut, however recently Testemale et al. observed an order of magnitude decrease in the rate constant for siderite dissolution at 100°C and 300 bar with the addition of 1 mol kg^{-1} NaCl resulting from competition of Na^+ with H^+ affecting PPD.[4] Further experiments will include the co-contaminants O_2 (5%) and SO_2 (1%). Renard et al. observed increased reactivity of carbonate and clay by up to a factor of 10 on addition of SO_2 and O_2.[6] With SO_2 co-injection the lowered pH conditions are expected to increase mineral dissolution rates.

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Tetraether lipids of Archaea in paleoceanography: Unresolved questions and new directions

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Abstract

Thaumarchaeota [1, 2], formerly known as Marine Group I Crenarchaeota, are believed to be the primary source of the ubiquitous glycerol dialkyl glycerol tetraether lipids (GDGTs) found in the environment. GDGTs, including the unique compound crenarchaeol, are abundant in marine and terrestrial aquatic environments, in sediments and soils, and over at least an 85°C temperature range from the polar ocean to hydrothermal springs. Experiments on pure cultures, enrichment mesocosms, and empirical correlations for marine sediments (TEX_{86}; [3]) all show a positive relationship between environmental temperature and the number of cyclopentyl or cyclohexyl rings contained within the GDGT structure. The TEX_{86} paleotemperature proxy has been applied across a large temporal range of geologic events and to sediments of widely varying depositional and diagenetic history. Evaluating whether such broad applicability is widely robust requires answers to a number of lingering questions about: (*1*) the physiological mechanism governing the number and distribution of these types of rings; (*2*) the degree to which microbial community structure influences the TEX_{86} relationship, including the extent to which environmental Euryarchaeota also produce GDGTs; (*3*) the mechanism that transfers the TEX_{86} signal to marine sediments; (*4*) the extent to which this signal is modified via diagenesis, *in-situ* production, or sediment redistribution; (*5*) the taxonomic, ecophysiological, and evolutionary significance of the cyclohexyl ring-containing compounds, crenarchaeol and its regioisomer; and (*6*) the fidelity of empirical temperature correlations based on core-top sediments. I will review these questions with a focus on the promise and prospects offered by isotopic approaches, which to date have remained underutilized.

References

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