Silica Gel Formation as a Barrier to CO_2 Leakage

JAY R. BLACK[1,2], CESAR A. CASTAÑEDA-HERRERA[1,2], ELLA M. LLANOS[1,2], GEOFF W. STEVENS[1,2], RALF R. HAESE [1,2]

[1]Peter Cook Centre for CCS Research, The University of Melbourne, Australia; jay.black@unimelb.edu.au
[2]CO2CRC Ltd., The University of Melbourne, Australia

The viability of geological carbon storage would be enhanced if the risk of CO_2 leakage could be abated through mitigation or remediation strategies. Concentrated sodium silicate solutions have been proposed as a promising reagent for reducing reservoir permeability through the formation of a silica gel barrier upon the reaction of the reagent with acidic CO_2 saturated waters or the supercritical CO_2 plume [1-2]. Here we present the results of experiments using columns of an unconsolidated porous media (quartz sand) to test for the conditions of silica gel formation, it's stability and associated reduction in permeability. The experiments and process of gel formation are then modelled using the reactive transport code TOUGHREACT, and scaled up to reservoir conditions.

The effect of reagent concentration, viscosity, pH and temperature have been tested to optimise conditions for forming a stable barrier in a porous media. Large columns with an internal diameter of 1'' and length of 20 cm were used in flooding experiments where changes in permeability due to barrier formation were monitorred. A significant reduction in permeability was observed upon incubating a column half filled with 0.1M KHPhthlate buffer (pH = 4, as a proxy for a CO_2 saturated fluid) with 7wt% SiO_2 for 24 hours at 20°C. Further incubation tests at 30°C and 45°C showed that stronger barriers may form with increasing temperature. Micro-CT analysis using small columns with an internal diameter of ¼'' and length of c. 2.5 cm were conducted to image the gel formation in-situ. Subsequent micro-CT scans of the column after aging the gel showed a small degree (c. 1-2%) of gel swelling or syneresis taking place leading to excess porosity being filled with gel/fluid.

Future experiments using a multi-phase core flooding instrument with the optimal sodium silicate reagent composition and a stream of CO_2 saturated fluid will be conducted to evaluate barrier formation under CO_2 storage reservoir conditions.

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[2] Ito, T., Xu, T., Tanaka, H., Taniuchi, Y. and A. Okamoto. (2014). *Int. J. Greenh. Gas Con.* **20**, pp. 310-323.