



## **Experimental determination of trace element mobility in UK North Sea sandstones under conditions of geological CO<sub>2</sub> storage**

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Offshore UK geological formations have the capacity to store > 100 years' worth of UK CO<sub>2</sub> output from industry and power generation, if utilised for carbon capture and storage (CCS) schemes. During CO<sub>2</sub> storage or CO<sub>2</sub>-Enhanced Oil Recovery (CO<sub>2</sub>-EOR), formation waters may be produced at the surface to be disposed of into the marine environment.

Laboratory and field scale studies, with an emphasis on the effects on onshore shallow potable groundwaters, have shown that CO<sub>2</sub> dissolution in formation waters during injection and storage acidifies the waters and promotes mobilisation from the reservoir sandstones of major and trace elements into solution. Of relevance to the UK context, eight of these elements are specifically identified as potentially hazardous to the marine environment: As, Cd, Cr, Cu, Hg, Ni, Pb, Zn.

Batch experiments using simple borosilicate flasks sat on heating mantles were used in this study to determine concentrations of these 8 elements which could be leached from selected North Sea sandstones with bubbled CO<sub>2</sub> and saline solutions, at formation temperatures. These concentration data were compared with produced water data from current UK offshore hydrocarbon extraction activities.

The comparison showed that, taking the North Sea as a whole, the experimental results fall within the range of concentrations of current oil and gas activities. However, on a field-by-field basis, concentrations may be enhanced with CO<sub>2</sub> storage, such that they are higher than waters normally produced from a particular field. Lead, nickel and zinc showed the greatest concentration increases in the experiments with the addition of CO<sub>2</sub>, with the other five elements of interest not showing any strong trends with respect to enhanced CO<sub>2</sub>.

The origin of the increased trace element concentrations was investigated using sequential leaching experiments. A six step method of increasingly aggressive leaching was developed, based on modification of methods outlined by Tessier et al. (1979) and Wigley et al. (2013), to suit the North Sea sandstones used previously in the batch experiments. The extraction method targeted water soluble elements, elements leached through desorption from mineral surfaces, and elements released through the dissolution of carbonates, oxides, sulphides and silicates.

From this experimental technique, trace element concentrations were classed as 'mobile' or 'immobile' under weak acid conditions of CO<sub>2</sub> storage. The majority of elements were classified as largely immobile. Using the batch experiment results we determined that dissolution of carbonate and feldspar minerals was responsible for much of the observed mobilised concentrations, although the abundance of these minerals was not a predictor for absolute or relative concentrations.

### References:

Tessier, A., Campbell, P. G. C., & Bisson, M. (1979). Sequential Extraction Procedure for the Speciation of Particulate Trace Metals. *Analytical Chemistry*, 51(7), 844–851.

Wigley, M., Kampman, N., Chapman, H. J., Dubacq, B., & Bickle, M. J. (2013). In situ redeposition of trace metals mobilized by CO<sub>2</sub>-charged brines. *Geochemistry, Geophysics, Geosystems*, 14(5), 1321–1332. doi:10.1002/ggge.20104