Fault seal controls on security of CO_2 storage in aquifers.

J.D.O Williams[1], G.Johnson[2], J.M. Miocic[2], A. Chadwick[1] & R.S. Haszeldine[2].
[1]British Geological Survey, Environmental Science Centre, Keyworth, Nottingham, NG12 5GG, [2]School of GeoSciences, University of Edinburgh, James Hutton Road Edinburgh, EH9 3FE.

Structural traps for engineered storage of CO_2 usually rely on a component of fault seal. In assessing the performance risk of storage sites, the conditions under which natural CO_2 and CO_2/hydrocarbon mixtures are retained by faults is poorly known. Mechanical failure can occur by flow along the fault plane due to extension, compression or shear. Geometric juxtaposition of aquifers or lack of low permeability fault gouge can enable flow across the fault plane. It is well established that faults which are close to being critically stressed have markedly different properties with respect to both their fluid flow and geomechanical characteristics.

Here we examine three case studies. In the first two, the Rotliegend Sandstone reservoirs of the Oak and Fizzy Fields in the Southern North Sea, both of which are natural fault-bound gas fields with high CO_2 content, we modify standard fault seal approaches to account for the different physical and chemical properties of CO_2 to oil and CH_4. In particular the impact of IFT and contact angle on threshold capillary pressure is investigated. Faults of both the Oak and Fizzy fields are analysed for fracture stability and slip tendency and are found to be stable (relative to present-day stresses) in all modelled scenarios and could withstand CO_2 column heights in excess of trap height. However, under detailed assessment of fault seal potential for CO_2-CH_4 mixtures, both fields appear to be limited in column height by cross-fault leakage through carbonate layers of the overlying Zechstein Group.

The third case study assessed the Captain Sandstone saline aquifer of the Inner Moray Firth. The *in situ* stress field was characterised using data available from hydrocarbon exploration wells. A range of potential stress fields were identified, and regional 3D geometric mapping of the major faults was then used to assess fault stability under the different potential stress regimes. Additionally, stereographic plots of fault dip angle and strike were used to deduce the pore pressure perturbation that could cause the mechanical reactivation of faults of any orientation. This accounted for unmapped faults that might truncate the storage reservoir and its overburden. In the stress scenario with the highest differential stress magnitudes low overpressures in the region of ~1.5 MPa could cause the reactivation of preferentially oriented faults, whereas higher induced pressures may be supported in lower differential stress regimes. Higher overpressure would also be required to cause the reactivation of the non-optimally oriented faults.