A direct method for determining CO_2 emplacement

CARMEN ZWAHLEN[1]*, GREG HOLLAND[1], NIKO KAMPMAN[12] AND PAUL DENNIS[3]

[1]Lancaster Environment Centre, Lancaster University, Lancaster LA1 4YQ, United Kingdom, (*c.zwahlen@lancaster.ac.uk)

[2]Shell Headquarters, Carel van Bylandtlaan 16, 2596 HR Den Haag, Netherlands

[3]School of Environmental Sciences, University of East Anglia, Norwich Research Park, Norwich NR4 7TJ, United Kingdom

Natural CO_2 reservoirs act as good natural analogues to look at slow phase interactions between carbon dioxide, subsurface fluids and the host rock, which are difficult to observe in injection experiments. However the timing of CO_2 emplacement has to be known to calculate rates and fluxes for the processes of interest. Previous estimates of carbon dioxide reservoir influx times for the Bravo Dome gas field include dating of surface intrusive igneous rocks from the area [1], dating of close-by effusive igneous rocks [1], regional uplift_ENREF_2 [2] and apatite dating [3], leading to ages between 56 ka [4] and 300 Ma [2].

Based on formation water derived noble gases diffusing through the CO_2 gas field, the time of CO_2 emplacement can be assessed directly. The noble gas diffusion profiles yield ages of approximately 15 ka. This is in good agreement with carbon isotope variations across the field, which can also be explained by diffusion. With this approximate emplacement age of 15 ka and the loss of CO_2 predicted from $CO_2/^3He$ ratios, the rate of CO_2 dissolving into the formation water is estimated to be 740,000 m^3/y. A dissolution flux of 90 $g/m^2/y$ has been calculated assuming an average CO_2 density of 75 kg/m^3 and a gas water contact of 780 km^2. This model can be applied to other natural CO_2 fields.

[1] Gilfillan, *et al*. *Geochimica et Cosmochimica Acta* (2008) **72**, 1174-1198; [2] Ballentine, *et al*. *Nature* (2001) **409**, 327-331; [3] Sathaye, *et al*. *PNAS (2014)* **111**, 15332-15337; [4] Stroud, *New Mexico Institute of Mining and Technology*, (1997).