Understanding carbon dioxide emplacement processes using noble gases and stable isotopes

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Noble gases and stable isotopes have previously been used to quantify the extent of interaction between CO_2 and groundwater in natural subsurface CO_2 reservoirs [1] [2]. However, the timing of reservoir influx is poorly constrained and has been variously estimated between 56Ka [3] and 1.5Ma [4]. In order to understand the extent of slow interactions between carbon dioxide, subsurface fluids and the host rock, as well as to be able to compare older with younger carbon dioxide reservoirs, it is crucial to know the age of reservoir filling.

Here we present a new general model for estimating directly the time of carbon dioxide reservoir infill applied to the Bravo Dome gas field. The model is constructed using the diffusion of groundwater derived noble gases entering the gas column at the gas water contact and yields ages on the order of 15,000yrs. Combining the approximate emplacement time of 15,000yrs with the gas volume that has been subject to dissolution enables estimation of dissolution rates for comparison with other well studied CO_2 systems.

Oxygen isotope data do not show a clear diffusion profile which we interpret as due to re-equilibration of residual water in pore spaces. Isotopic re-equilibration of gases with water, as well as formation temperatures, will also be explored using temperature information derived from clumped CO_2 isotopic analysis.

[1] Gilfillan et al., (2008) *GCA* **72**, 1174-1198; [2] Dubacq et al., (2012) *EPSL* **341–344**, 10-19; [3] Stroud, J. R. (1997) *New Mexico Institute of Mining and Technology*; [4] Sathaye et al., (2014) *PNAS* **111**, 15332-15337.