

# Constraining Oxygen isotope equilibrium exchange between CO<sub>2</sub> and water during fluid cycling in a closed system

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Carbon Capture and Storage (CCS) is the only currently available suite of technologies that can directly address CO<sub>2</sub> emissions from fossil fuel combustion. CCS is a crucial component of national and international climate change mitigation goals (Martin-Roberts et al., 2021). The scaling of these technologies, regardless of the means of capture, rely on the safe injection and secure storage of CO<sub>2</sub> in the subsurface (Alcalde and Flude et al., 2018).

Residual trapping of CO<sub>2</sub> is a critical element of secure CO<sub>2</sub> storage. The amount of CO<sub>2</sub> stored by this means plays a key role in predicting CO<sub>2</sub> plume migration, immobilisation, storage security and reservoir management. However, it is difficult to assess pore-space saturation of CO<sub>2</sub> within a subsurface reservoir. δ<sup>18</sup>O measurements of both CO<sub>2</sub> and reservoir fluids from field-scale CO<sub>2</sub> injection projects have provided estimates of in-situ CO<sub>2</sub> reservoir saturations (Serno et al., 2017).

Here, we present results from laboratory experiments to represent different volumes of a reservoir water in contact with a free CO<sub>2</sub> phase, in order to determine the O isotope equilibration time at ambient conditions and O isotope behaviour in both CO<sub>2</sub> and water during fluid cycling in a closed system, as an analogue of a single-well push-pull scenario. We find that full oxygen isotope equilibration between CO<sub>2</sub> and water is established after 72 hours at atmospheric conditions and the water δ<sup>18</sup>O value does not change after 48 hours.

Our observed maximum change in the δ<sup>18</sup>O value of water of 1.2% during the back-production phase of our fluid cycling experiment would be negligible when using unenriched water and CO<sub>2</sub> sources during field projects. However, our results show that changes in the δ<sup>18</sup>O values of the CO<sub>2</sub> during a back-production scenario may be larger than 3.5%, indicating that it is inaccurate to solely use the O isotope composition of CO<sub>2</sub> to quantify CO<sub>2</sub> pore-space saturation in a single-well push-pull configuration.

## References

Alcalde and Flude et al., 2018. *Nature Communications*, 9(1), 1-13. DOI:10.1038/s41467-018-04423-1

Martin-Roberts et al., 2021. *One Earth*, 4(11), 1569-1584. DOI:10.1016/j.oneear.2021.10.002

Serno et al., 2017. *International Journal of Greenhouse Gas Control*, 63, 370-385. DOI: 10.1016/j.ijggc.2017.06.009