Experimental CO_2-Water-Rock Interactions and Potential Indicators of CO_2 Leakage into Aquifers Overlying a Storage Site

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INTRODUCTION

Carbon Dioxide Capture and Storage (CCS) involves injecting supercritical CO_2 (ScCO2) into deep geological formations, such as deep saline aquifers, at depths below 800m. As ScCO2 is buoyant, it raises potential and perceived risks of CO_2 leakage into overlying aquifers or to the surface. The ground water in these overlying aquifers is regionally used by various industries, including cattle feedlots, mines and agriculture, as well as private landholders and for town water supply. This study focuses on investigating potential metal mobilisation and changes to isotope tracers that could be used to identify early leaks.

GEOLOGICAL SETTINGS

- The Precipice Sandstone, a formation in Queensland's Surat Basin, is being studied for CO_2 storage potential, with the Evergreen formation acting as a seal.
- The Hutton Sandstone and the Gubberamunda Sandstones formations overly this CO_2 storage reservoir and provide groundwater.
- Five representative samples from the Hutton Sandstone and Gubberamunda Sandstone formation were collected at different depths from the Heath 1 well (indicated in Figure 1).

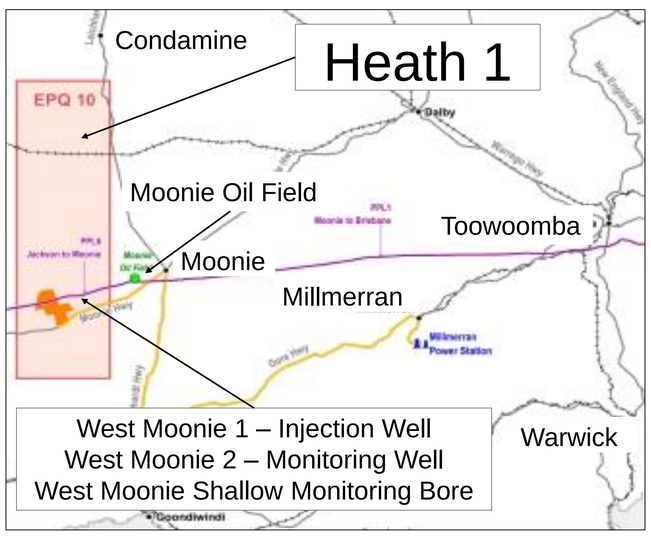
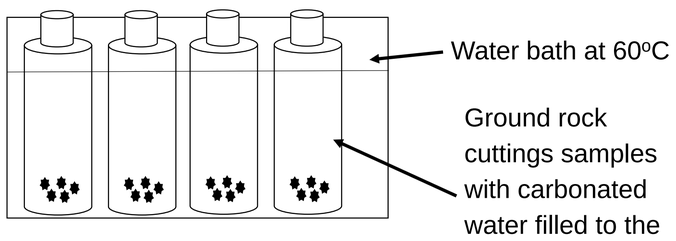


Figure 1: Location map of the Heath 1 well, northeast of Moonie in EPQ10, where rock cuttings were sampled from. Map curtesy of CTSCo Pty Ltd.

METHODOLOGY



Water samples were collected daily and carbonated water was refilled after each sampling. Rock samples before and after reaction were collected for analysis.

RESULTS

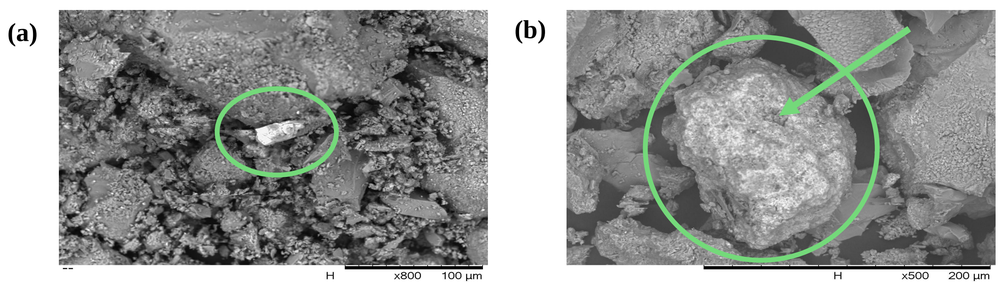


Figure 2: SEM images and EDS of mineralogical components found in rock samples
(a) Siderite before leaching (b) Corroded siderite after leaching (corrosion indicated by green arrow)

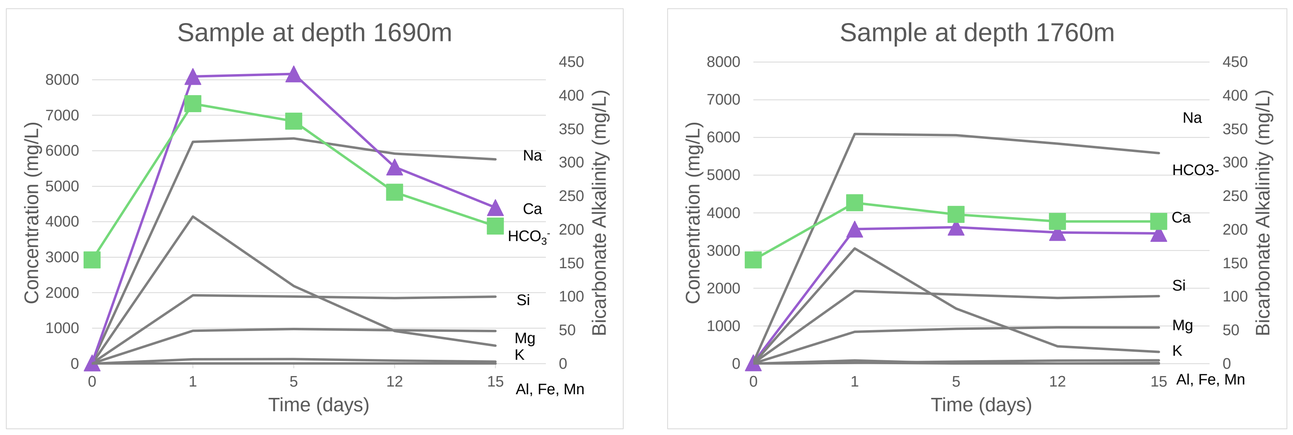


Figure 3: Select experimental results of concentrations of major ions (primary y-axis) and bicarbonate alkalinity (secondary y-axis). CO_2-water-rock interactions were at 60ºC. Calcite content: 2.2wt% at 1690m; 0.1wt% at 1760m.

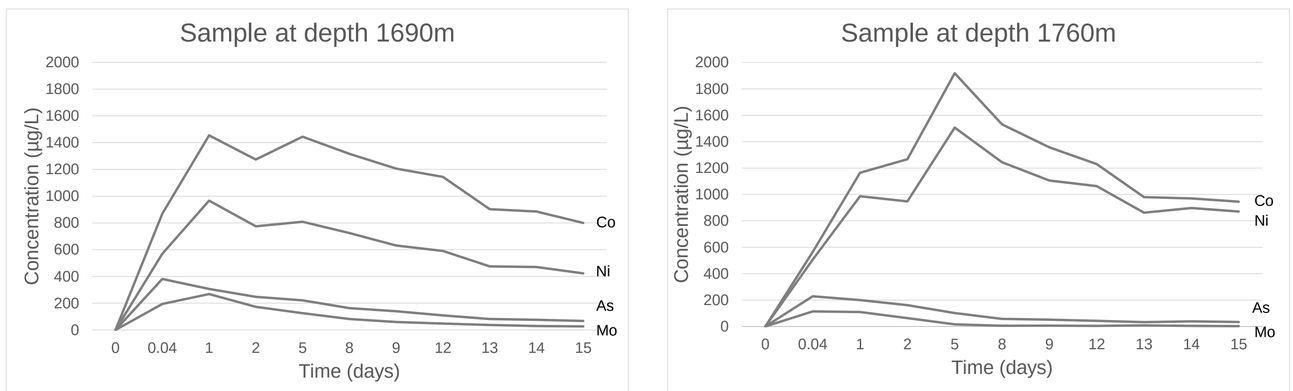


Figure 4: Select experimental results of concentrations of trace elements.

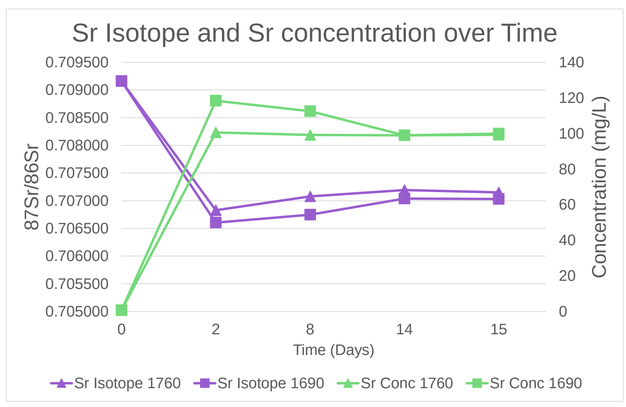


Figure 5: Sr isotope results compared against Sr concentration over time.

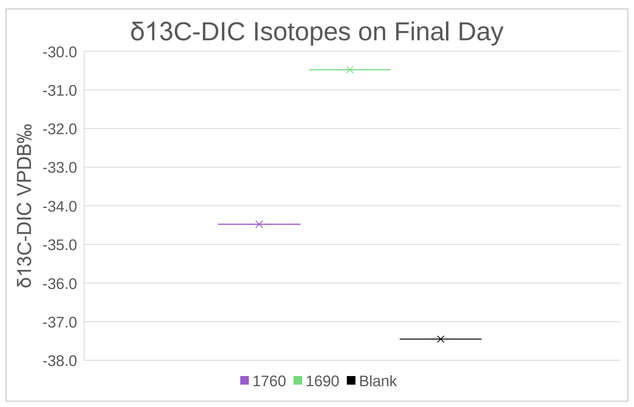


Figure 6: δ^{13}C-DIC changes of water samples on final day.

CONCLUSION

- XRD showed that both sandstones formations contain feldspars, carbonates and basic aluminosilicates, such as illite, anorthite, smectite and chlorite.
- Changes in pH (maximum difference of 0.92) and alkalinity are primarily controlled by calcite dissolution. The initial increase in alkalinity provides buffering capacity, making the pH more resistant to fluctuations.
- Trace elements exhibited distinct release trends, with some exceeded NHMRC Health Guideline Values for drinking water on certain days. This highlights the need for further research to fully understand the long-term geochemical impacts.
- Sr isotopes, δ^{13}C-DIC, bicarbonate alkalinity and certain dissolved elements offer effective tools for early detection and tracking of CO_2 leakage, thereby enhancing the safety and efficacy of geological CO_2 storage.

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