

Experimental CO₂-Water-Rock Interactions and Potential Impacts of CO₂ Sequestration Below the Hutton and Gubberamunda Sandstones, Surat Basin, Great Artesian Basin

M. Matsui^{a#}, J. K. Pearce^{ab}, G. Dawson^b, K. Baublys^c

^a Gas and Energy Transition Research Centre, University of Queensland, Australia. ^b School of the Environment, University of Queensland, Australia. ^c The School of Environment Geochemistry Laboratory, University of Queensland. #uqmmats4@uq.edu.au

INTRODUCTION

Carbon Dioxide Capture and Storage (CCS) is considered one of the most direct methods for removing CO₂ from the atmosphere. CCS involves injecting supercritical CO₂ (ScCO₂) into deep geological formation, at depths below 800m, such as deep saline aquifers that contain an anticline geological feature. ScCO₂ is buoyant, which raises potential and perceived risks of CO₂ leakage into overlying aquifers or to the surface. A potential solution to this risk is mineral trapping of CO₂, which provides long lasting, thermodynamically stable, and environmentally safe sequestration as carbonate minerals.

Geological Settings:

- The Precipice Sandstone, a formation in Queensland's Surat Basin, is being studied for CO₂ storage potential, with the Evergreen formation acting as a seal.
- The Hutton and the Gubberamunda Sandstones (marked by the green boxes in Figure 1), which are aquifers above this CO₂ storage reservoir, provide groundwater.
- Investigations are ongoing into the effects of CO₂ leakage into these aquifers, focusing on potential acid formation and reactions.

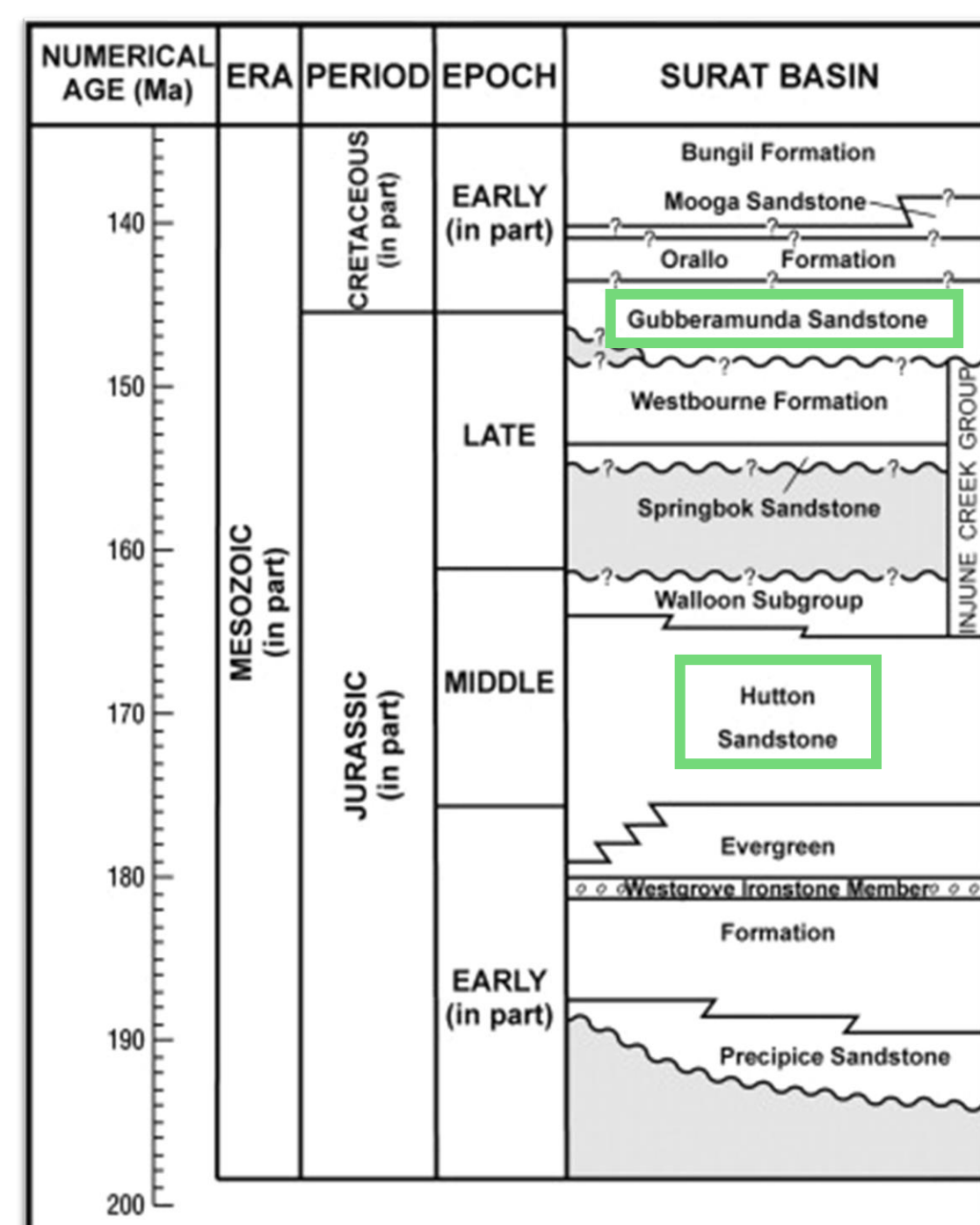


Figure 1: Geological Interpretation of Surat Basin (Hamilton et al., 2012)

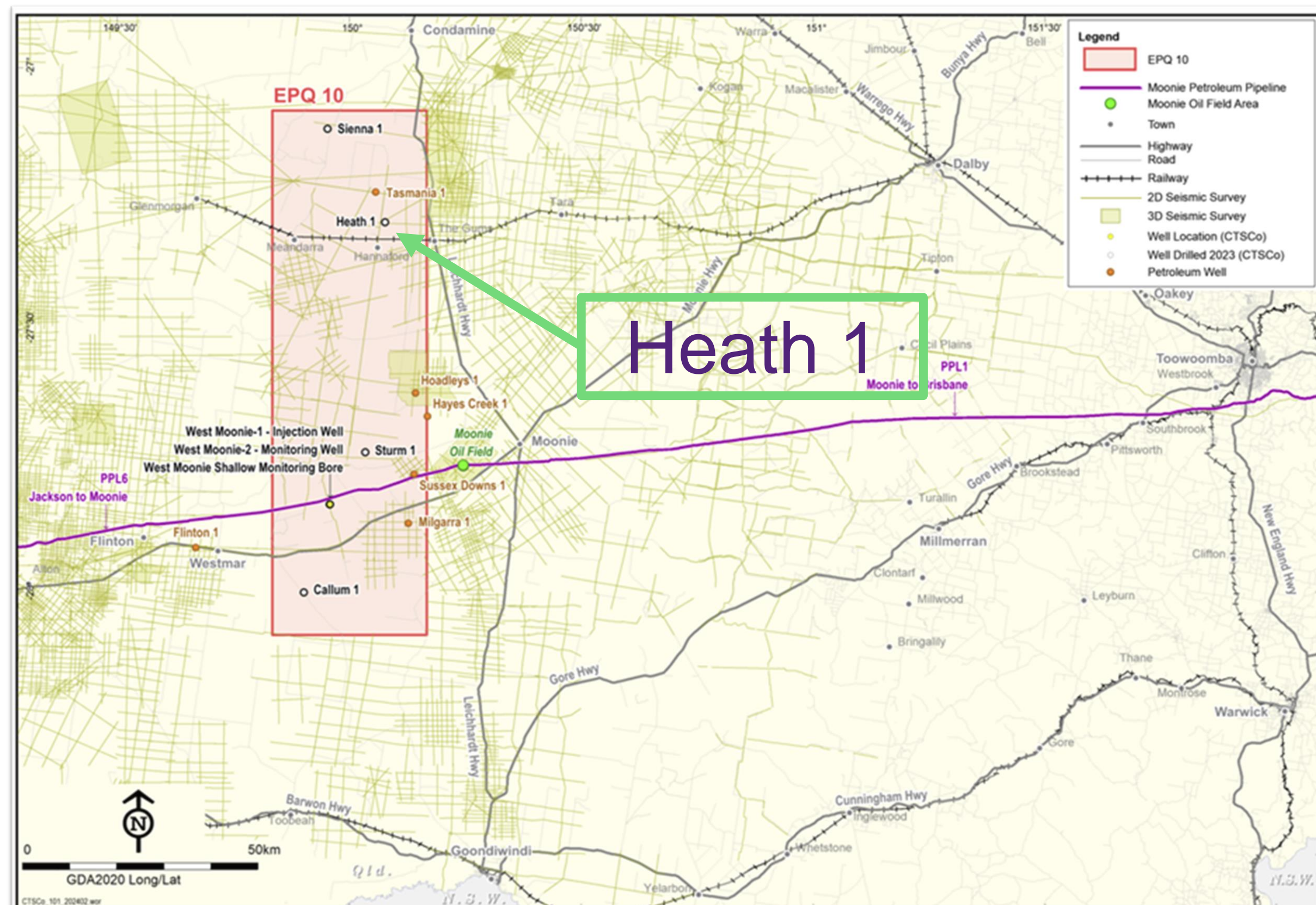
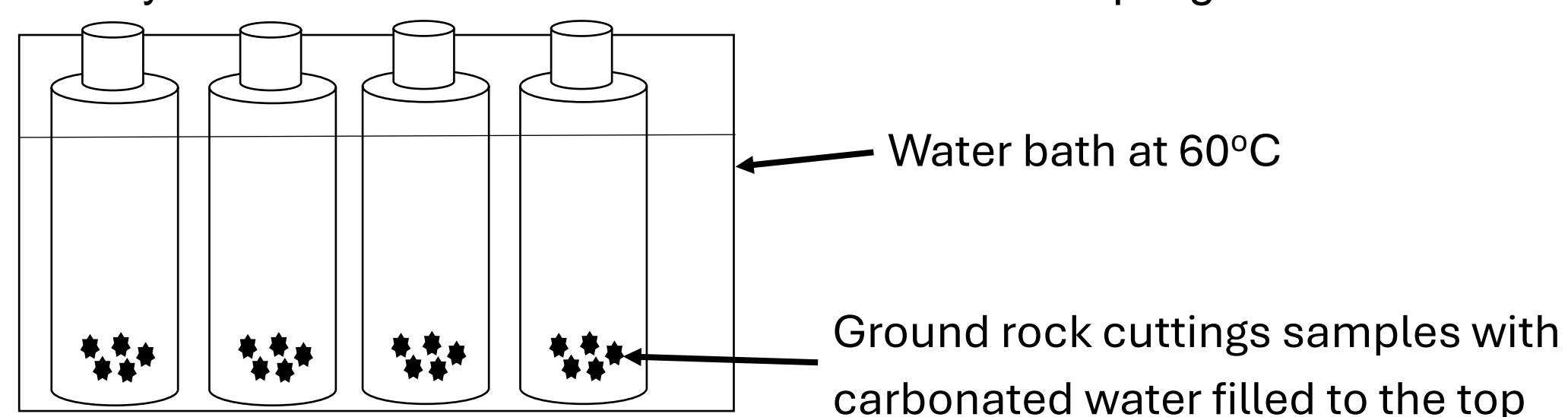


Figure 2: Location map of the Heath 1 well, northeast of Moonie in EPQ10, where rock cuttings were sampled from. Map courtesy of CTSCo Pty Ltd.

- Five representative samples from each sandstone formation were collected at different depths from the Heath 1 well (indicated in Figure 2).
- XRD showed that both sandstones formations contain feldspars and basic aluminosilicates, such as illite, anorthite, smectite and chlorite, which provide metal cations that could potentially react with CO₂ for mineral trapping. E.g. Anorthite $\text{CaAl}_2\text{Si}_2\text{O}_8 + \text{H}_2\text{O} + 2\text{H}^+ = \text{Si}_2\text{Al}_2\text{O}_5(\text{OH})_4$ kaolinite + Ca^{2+}
 $\text{Ca}^{2+} + \text{CO}_3^{2-} = \text{CaCO}_3$ calcite
- There is a lack of detailed information on the changes of these formations in the context of potential geochemical reactivity.

METHODS

CO₂-water-rock experimental reactions were conducted for two weeks. Water samples were collected daily and rock samples before and after reaction were collected for analysis. Carbonated water was refilled after sampling.



RESULTS

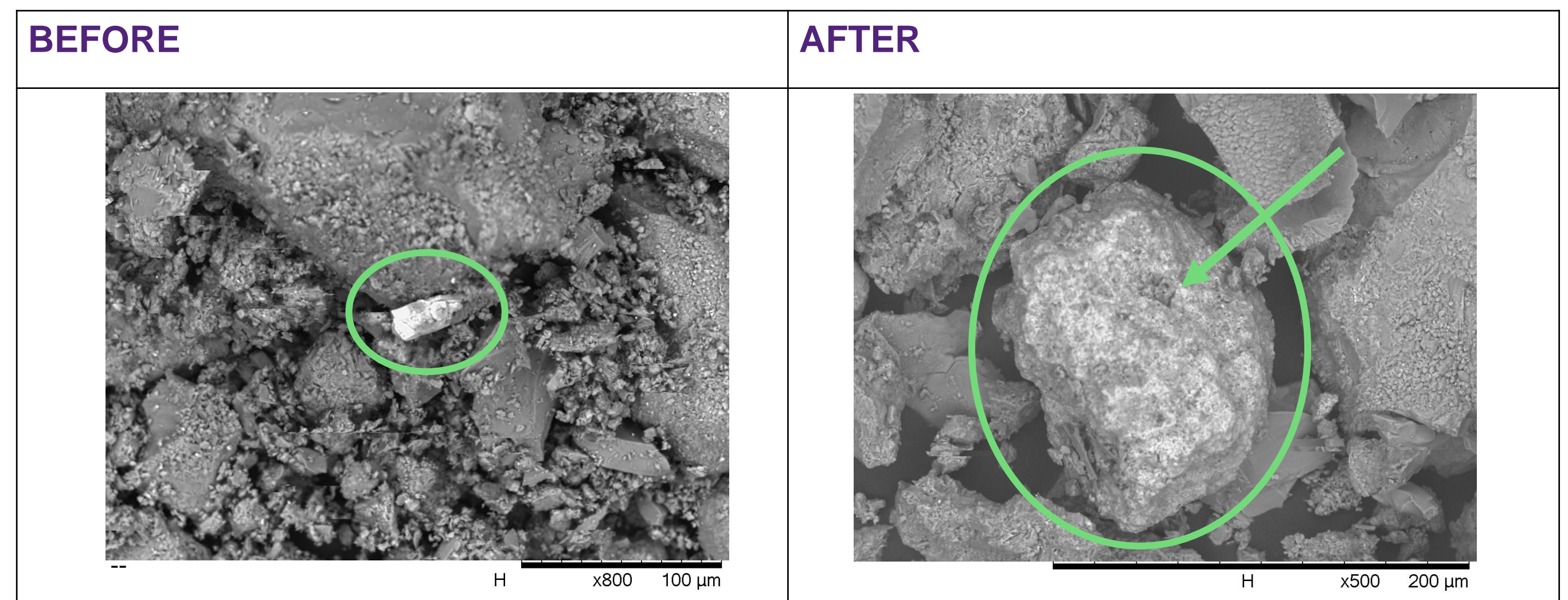


Figure 3: Examples of Characterisation of Changes to Minerals (Siderite), observed through SEM-EDS.

- Corrosion of siderite after reaction, where corrosion is indicated by an arrow in Figure 3.

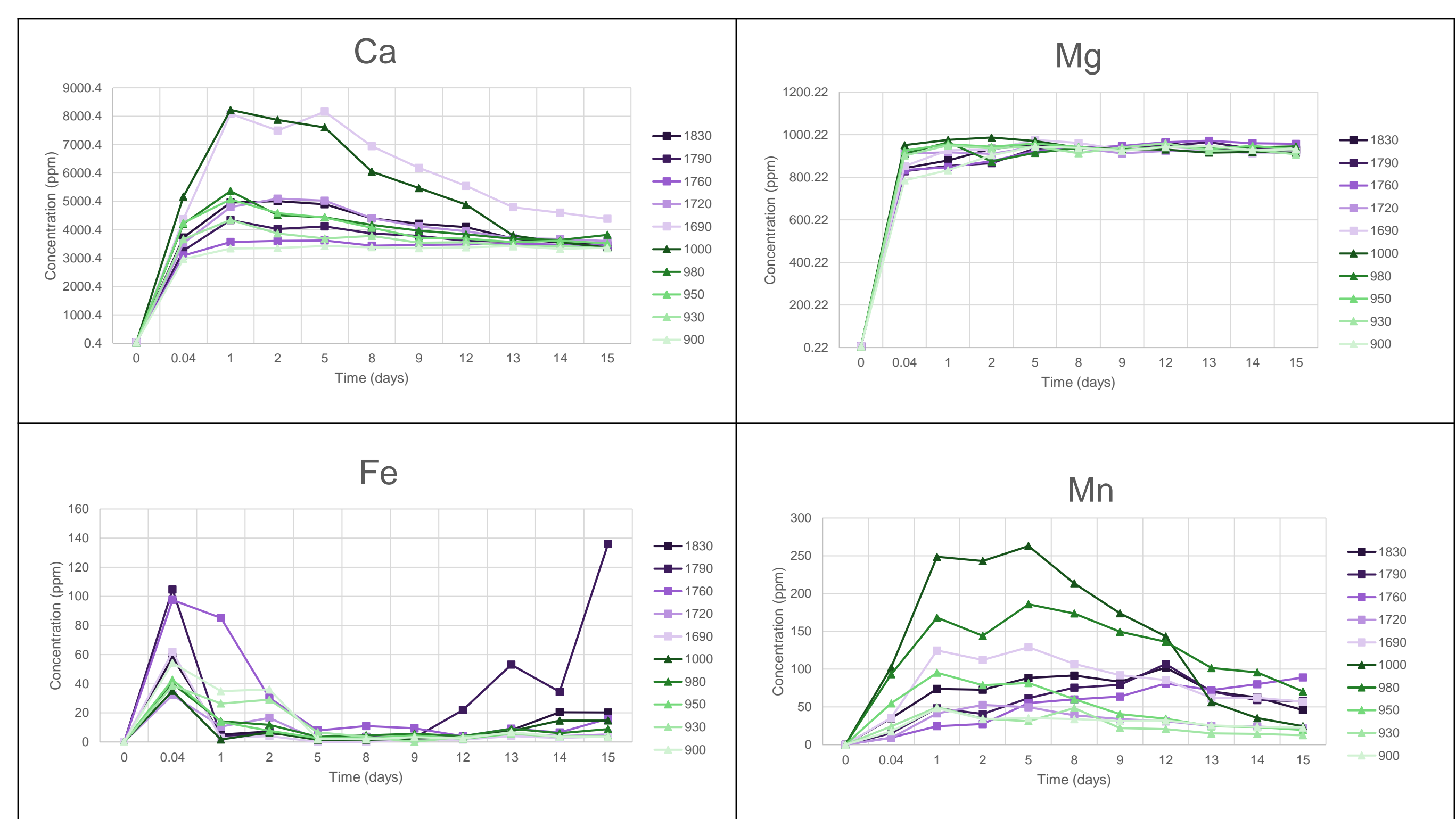


Figure 4: Changes in Dissolved Ion Concentrations during CO₂ - Water - Rock Experimental Reactions. (Different lines show different rock sample depths. Gubberamunda Sandstone = green and triangle, Hutton Sandstone = Purple and square.)

- Various ions were released to water from mineral reactions (a selection are shown). Ca, Fe, Mn concentrations subsequently decreased (Figure 4).

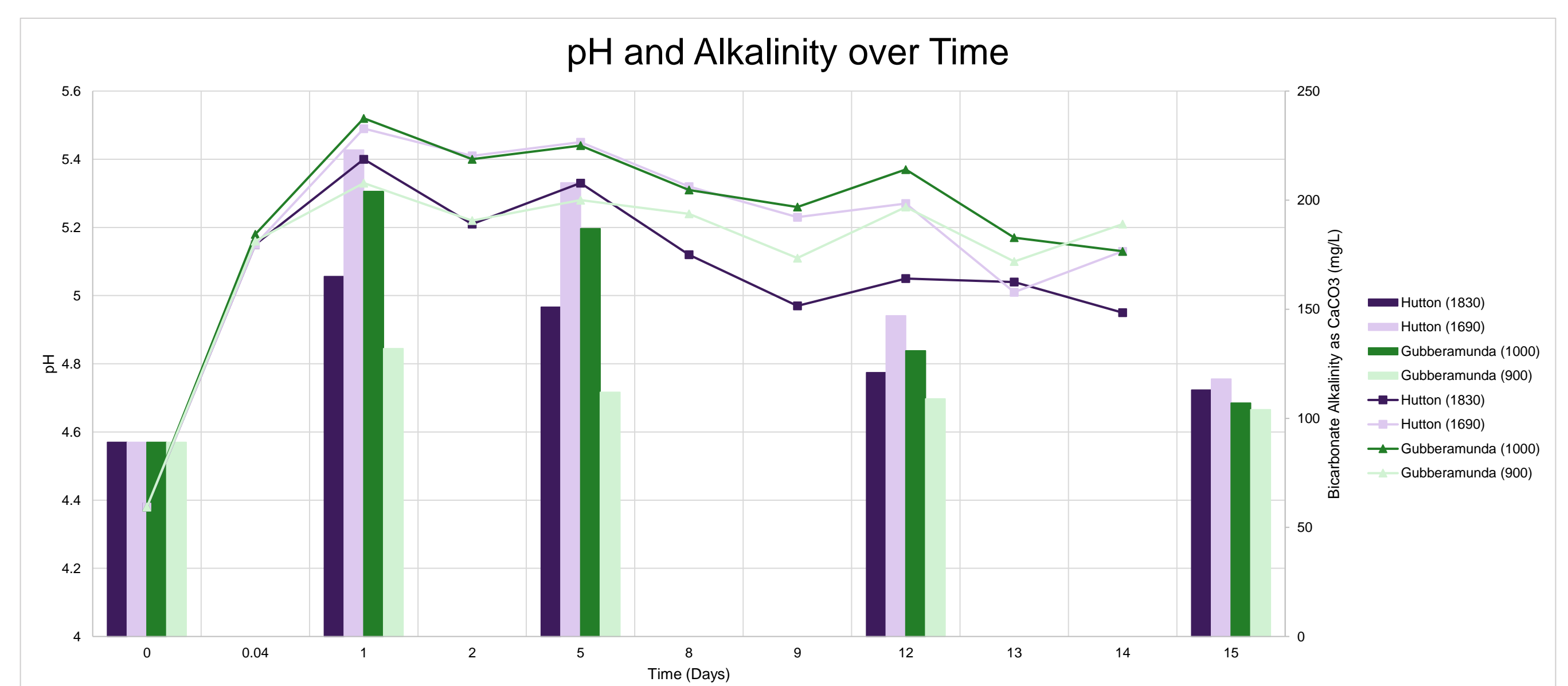


Figure 5: Water pH and Alkalinity Changes over Time. (Only shows the shallowest and deepest samples from the Hutton and the Gubberamunda Sandstone. Time = 0 is the carbonated water only. The pH is shown by lines and alkalinity is shown by bars.)

- Mineral reactions increased/buffered pH and alkalinity initially, later decreased (Figure 5).

CONCLUSIONS

- Mineral dissolution released Ca, Mg, Fe, Mn, Sr, etc available for mineral trapping, potentially producing calcite, dolomite, ankerite and siderite.
- Altered water chemistry, with pH ranging between 4.38 and 5.30 and decreasing alkalinity, offering limited buffering capacity, making the pH more susceptible to fluctuations.
- Toxic inorganic metal concentrations in experiments, such as Sb, As, Ba, Cd, Pb, Se and Ni, mostly exceeded NHMRC Health Guideline Values for drinking water.
- Further geochemical modelling would be needed to upscale impacts to the aquifer where dilution may negate or reduce water quality impacts.
- Work on other wells and other Great Artesian Basin aquifers is ongoing.

Acknowledgements

- The UQ SENV CGMS Environmental Geochemistry laboratory and Dr Ai Nguyen are thanked for analyses.
- The University of Queensland Centre for Microscopy and Microanalysis.