Investigation of The Reactions between Glauconite and Carbon Dioxide, with Implications for Carbon Sequestration

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INTRODUCTION

Rising levels of atmospheric carbon dioxide and its effects have prompted research on methods to capture and store carbon dioxide, known as carbon sequestration. Mineral trapping is considered as a promising technology for CO_2 storage in a high temperature and pressure subsurface environment. Conceptually, upon injection of carbon dioxide as a supercritical fluid into geological formations, the carbon dioxide will react with the host rock to form a secondary carbonate mineral that is stable, thus creating a long-term carbon sink under thermodynamic conditions of the reaction. Previous studies have demonstrated crystallization of magnesite by reactivity of carbon dioxide and olivine-bearing basalt (Robert J. Rosenbauer et al., 2012).

The objective of this study was to develop a protocol to test the reactivity and effectiveness of the Fe/Mg bearing aluminosilicate mineral, glauconite, in carbon storage through crystallization of secondary minerals. For this research, a rock sample in an outcrop from the Cambrian Riley Formation of Central Texas was used because of its richness of glauconite.

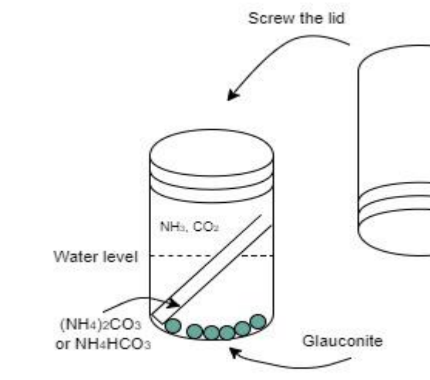
OBJECTIVES, HYPOTHESIS, SIGNIFICANCE

Objective: Testing the reactivity of glauconite in a saturated carbon dioxide environment.

Hypothesis: Glauconite, a type of Mg/Fe silicate mineral that is abundant in many sedimentary formations in Mississippi, can react with CO_2 to form carbonate minerals.

Significance: A protocol was built to test the reactivity of glauconite and carbon dioxide. Glauconite rich reservoirs in Mississippi are potential sites for Enhanced Oil Recovery or temporary carbon storage.

EXPERIMENTAL PROCEDURE

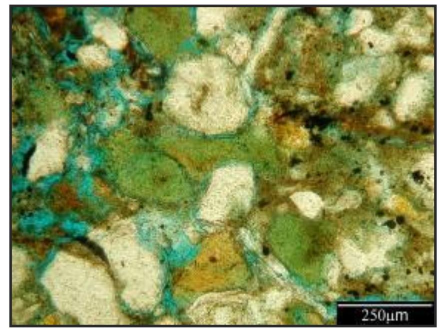


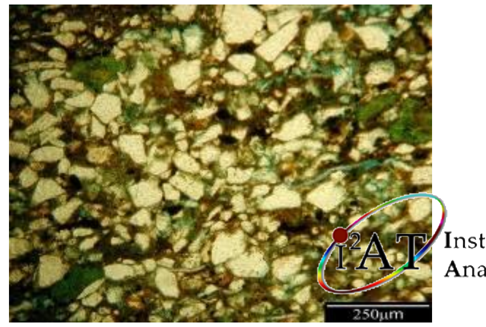
Autoclave set up

Glauconite sample from Riley Formation, Central Texas

1. The 0.002 mole of ammonium carbonate or ammonium bicarbonate was placed in the small quartz tube.
2. The tube was put in the autoclave with powdered glauconite and 5 ml of brine.
3. The lid was screwed on and the autoclave was placed vertically into the 120^oC oven.

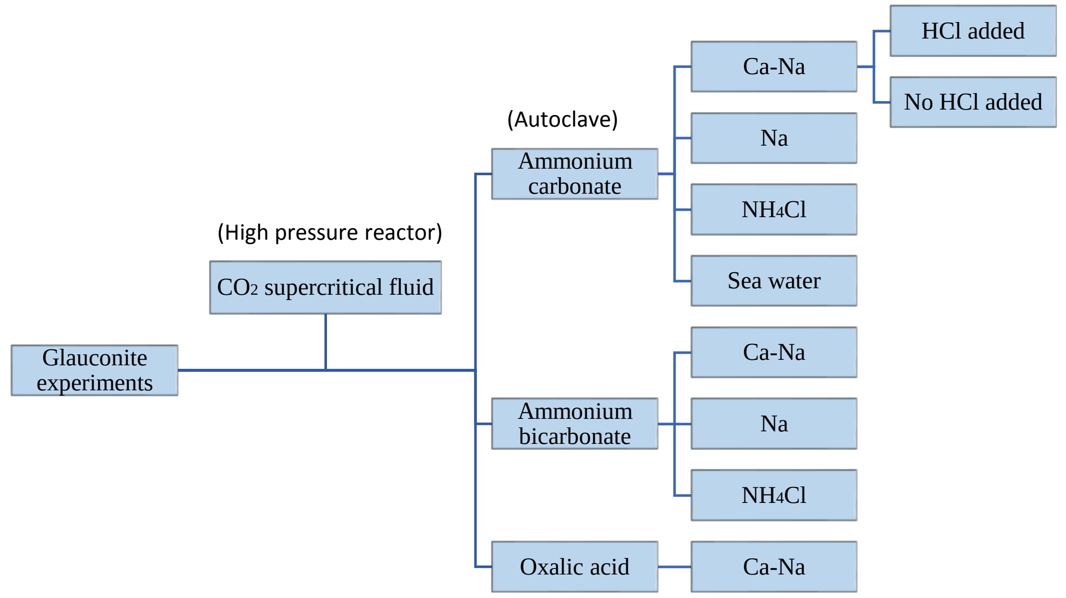
EUTAW FORMATION, HEIDELBERG, MS





Eutaw Formation, Heidelberg, Mississippi. Images courtesy Krystal Collins

EXPERIMENT DEVELOPMENT



EXPERIMENTAL CONDITIONS

Table 4.1: Experiment Condition Summary

Experiments	E1	E2	E3-1	E3-2	E3-3	E3-4	E3-5	E4-1	E4-2	E4-3	E4-4	E4-5	E4-6	E4-7
Temperature (°C)	120	120	120	120	120	120	120	120	120	120	120	120	120	120
Pressure Vapor (bar)	100	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
Sample Weight (g)	1.5	0.7	0.5	0.5	0.5	0.5	0.5	0.25	0.25	0.25	0.25	0.25	0.25	0.5
Sample Size (μm)	100 -5000	70	63	63	63	63	63	63	63	63	63	63	63	63
Brine type	SW	Ca-Na	Ca-Na[1]	Ca-Na[2]	Ca-Na[3]	Ca-Na	Ca-Na	Ca-Na	Ca-Na	Na	Na	NH_4Cl	NH_4Cl	SW
Volume of Brine (ml)	30	4	5	5	5	5	5	5	5	5	5	5	5	10
CO_2 Source	*	**	**	**	**	***	****	**	***	**	***	**	***	***
Mole of Reactants	-	0.0015	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.004
pH	7	7.74	6.45	8.47	-	-	2.93	8.38	6.88	8.82	-	8.69	-	9.13
Duration (days)	10	14	14	14	14	14	14	19	19	19	19	19	19	19

SW: Seawater

Ca-Na[1]: Added 200 μl HCl

Ca-Na[2]: Added 65 μl HCl

Ca-Na[3]: Added 20 μl HCl

*: CO_2 supercritical fluid

**: Ammonium carbonate — $(NH_4)_2CO_3$

***: Ammonium bicarbonate — NH_4HCO_3

****: Oxalic acid — $C_2H_2O_4$

SEM CHARACTERIZATION OF SOLID PRODUCTS

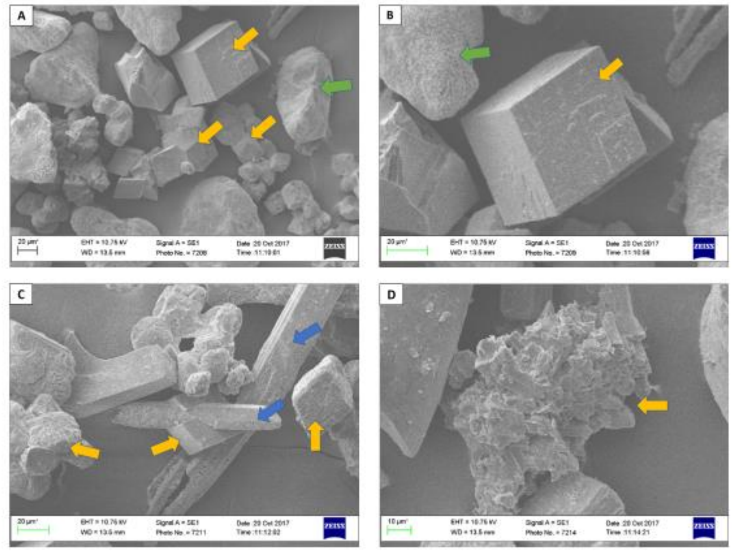
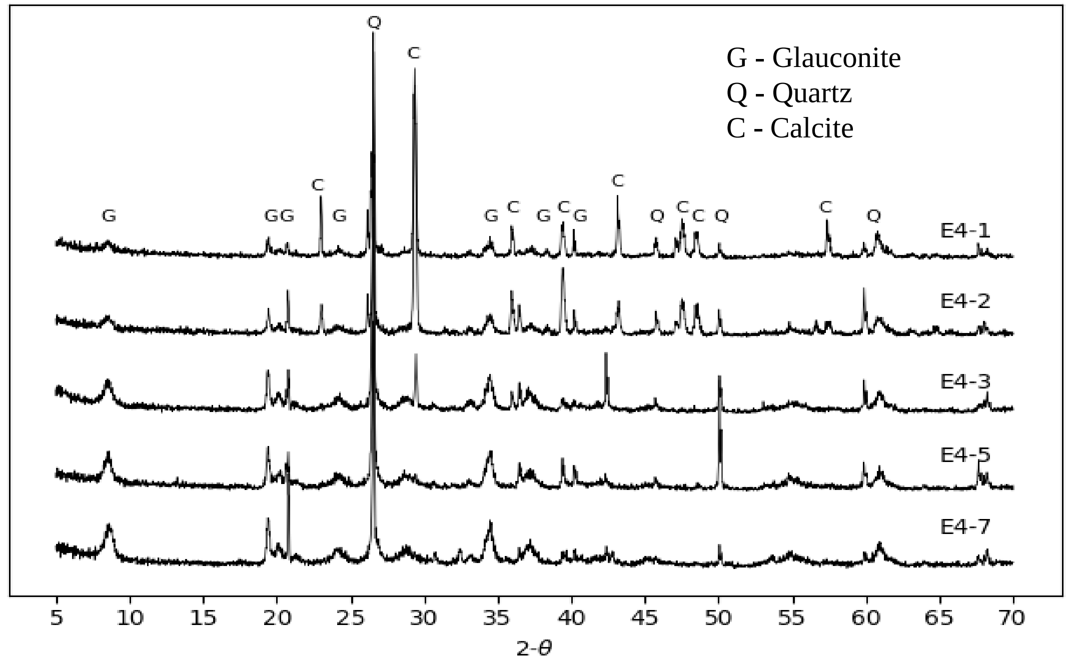


Figure 4.5: Treated samples for experiment E4-2 (calcite-yellow arrow, aragonite-blue arrow, aragonite-blue arrow). The condition of E4-2 is in Table 4.1. (A)(D) A lot of blocky-rhombohedral crystals presented in the sample with size of 20-50 μm.(C) The aragonite rod develops from a calcite crystal. (B) These blocky crystals are separated from glauconite grains

XRD CHARACTERIZATION OF SOLID PRODUCTS



CONCLUSIONS

1. A glauconitic rock sample from the Riley Formation in Central of Texas was selected for this study of reaction between glauconite and CO_2 because of its richness in glauconite.
2. A series of autoclave experiments in different conditions showed that the CO_2 -rock-brine reactions are limited. A longer incubation time, however, might change the results of the experiment.
3. Calcite crystals formed from the brine, not on the glauconite, when pH exceeded 6.88.
4. This shows the potential of carbon sequestration in a saline aquifer with high pH and Ca concentration.

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Rosenbauer, Robert J., et al. "Carbon sequestration via reaction with basaltic rocks: Geochemical modeling and experimental results." *Geochimica et Cosmochimica Acta* 89 (2012): 116-133.