Solar Thermochemical Energy Storage

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Abstract: Thermochemical energy storage is the next step in creating a self-sustaining society because it allows for energy supply to meet the electricity demand. Chemical bonds provide much higher storage capacities than the conventional energy storage methods; renewable storage schemes with greater energy storage density will potentially have a faster path to economic viability.

A potential thermochemical storage cycle lies in the carbonation/decomposition of $SrO/SrCO_3$. It offers the prospect of capturing thermal energy and releasing it at temperatures above 1200°C. One of the fundamental aspects of the project depends on the amount of surface area of the physical structure. To obtain an optimal amount of surface area, the current project involves creating a matrix through the mixing of heat treated SrO and decomposition of sacrificial carbon. The temperatures at which the SrO is being heat treated varied along with the size of the particles being used; also the ratio and size of the carbon particles are being varied to find the optimal structure with the most surface area.

Objective: To find the variable/s that most affects the energy density. It is hypothesized that an optimized amount of surface area will maximize the energy density.

Procedure:

1. A matrix was created

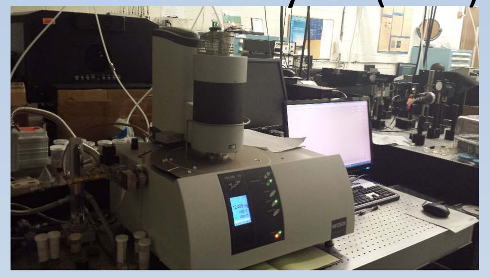
	Parameter	Level	Selected Values
A	Heat treatment temperature (T_H)	-	1235 °C
		+	1400 °C
B	SrO particle size (S)	-	25 µm -38 µm
		+	106 µm -125 µm
C	Graphite particle size (S_g)	-	25 µm -38 µm
		+	106 µm – 125 µm
D	Mass ratio of graphite to SrO (r)	-	0.2
		+	0.7
E	Structure formation temperature (T_s)	-	1100°C
		+	1300°C

2. Heat treat the SrO

3. Crush and sieve the materials to the appropriate sizes

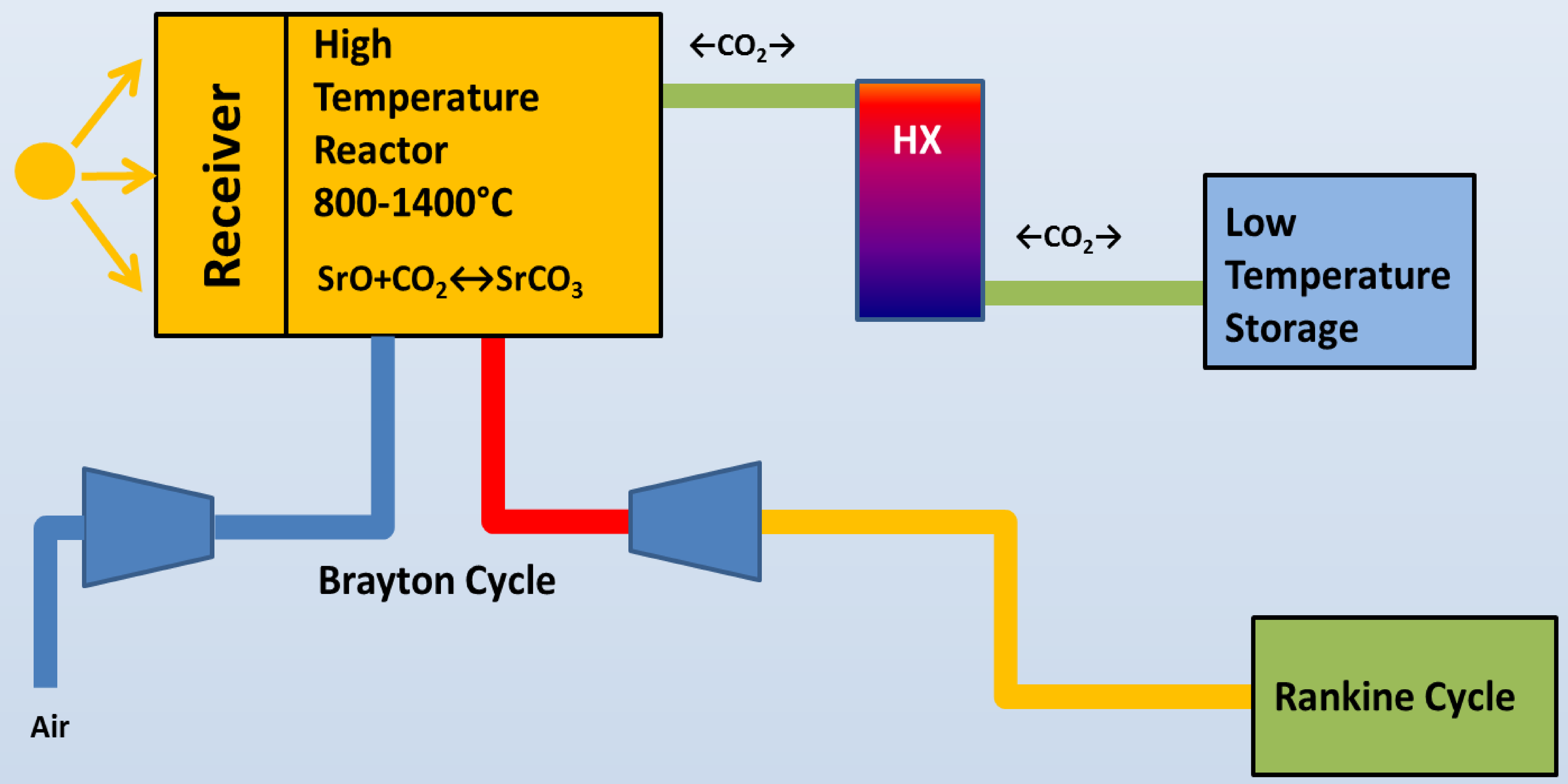
4. Mix the SrO and graphite to the appropriate ratios

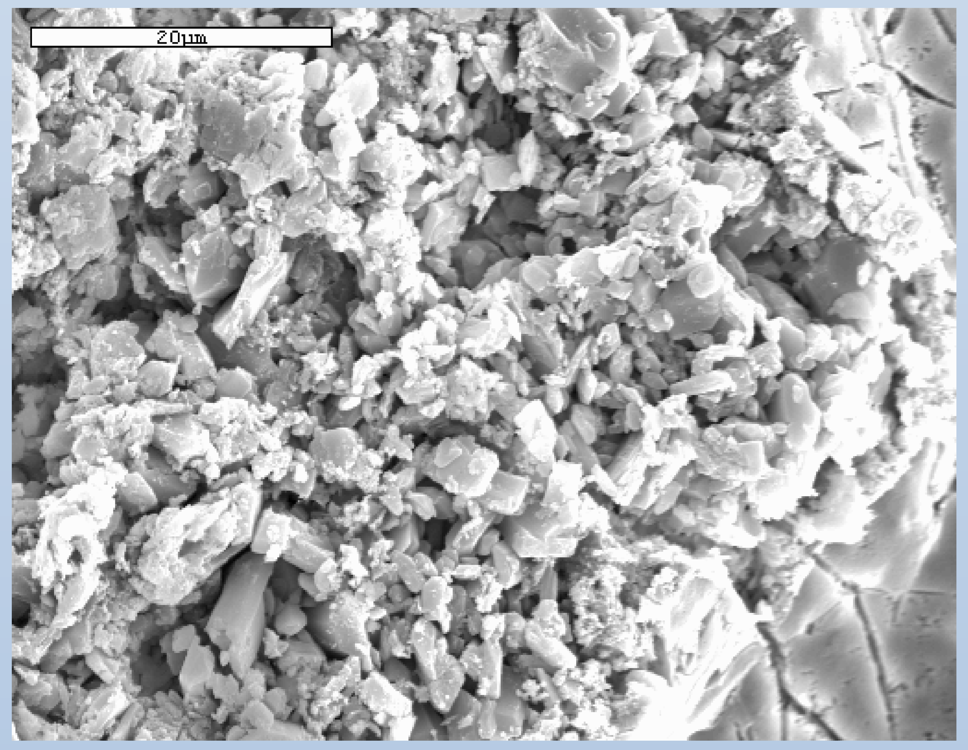
5. Evaluate the reactivity of the samples using a thermo gravimetric analyzer (TGA)



$$SrCO_3 \leftrightarrow SrO + CO_{2(g)}$$

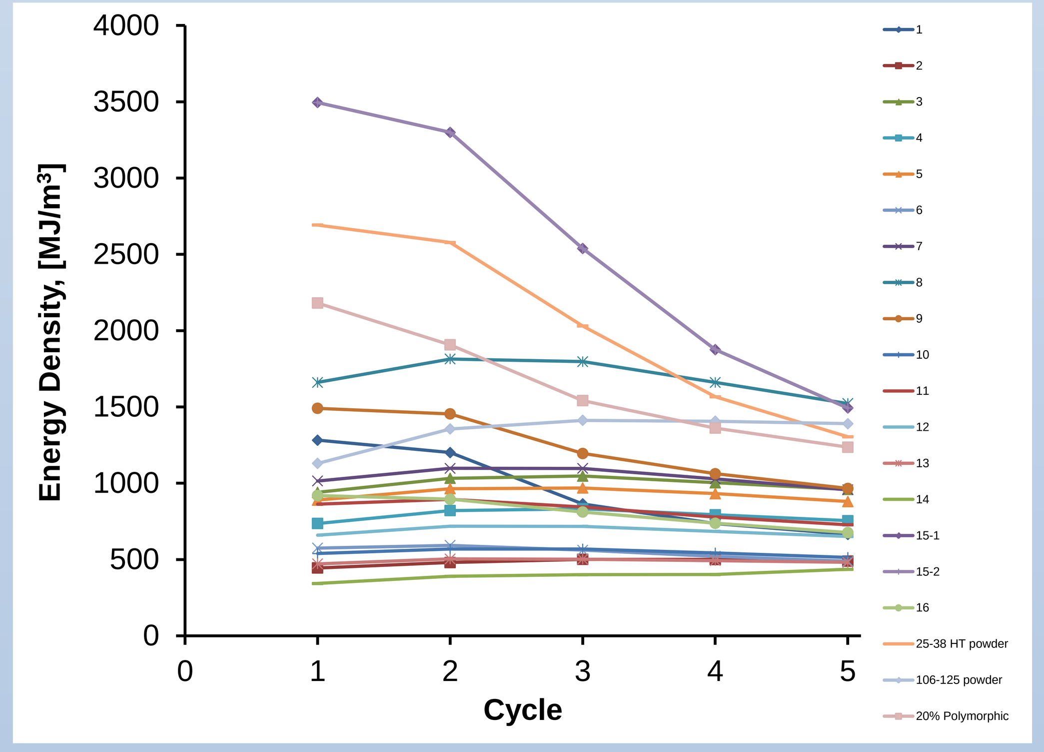
Reversible | **No catalysis** | **High temperature (~1200°C)** | **Safe**



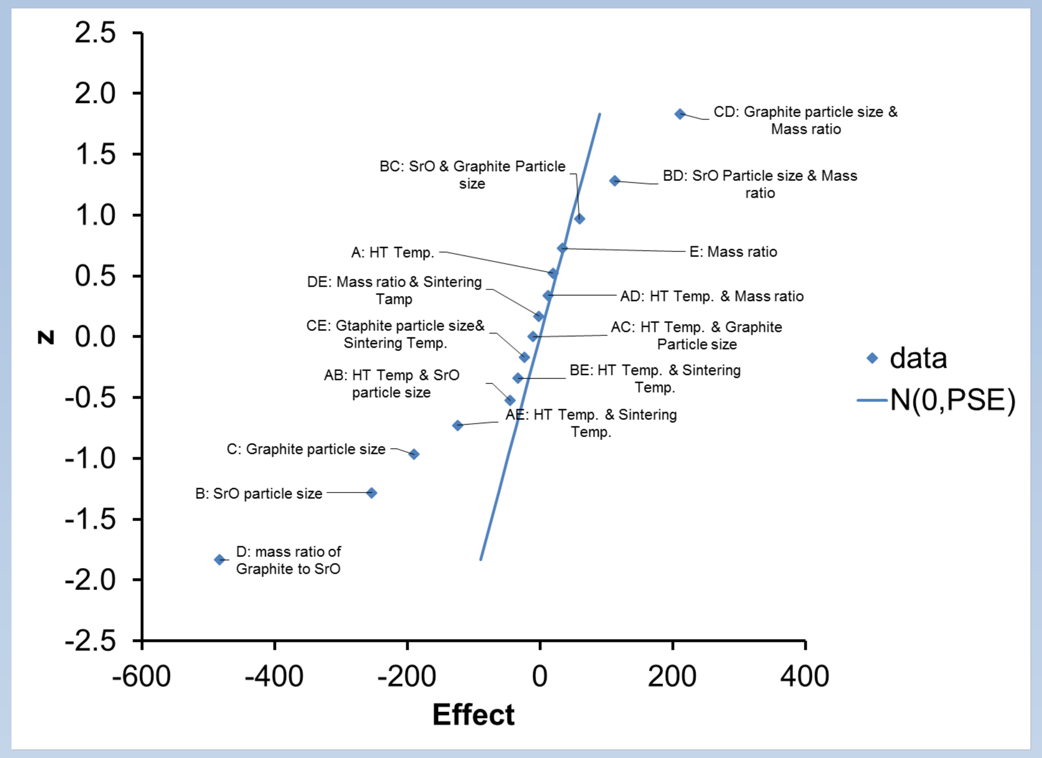


*SEM image of porous SrO/SrCO3 sample 8.

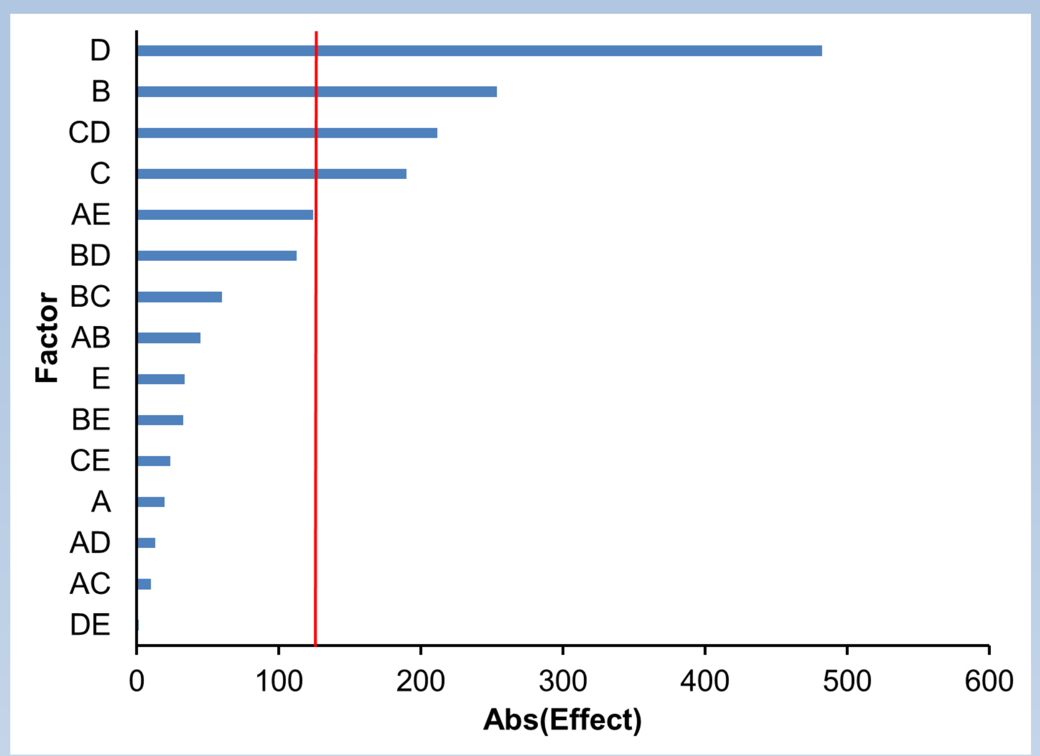
Energy Density of Samples



Z-value of the Parameters



Correlation of results: Lenth's Method



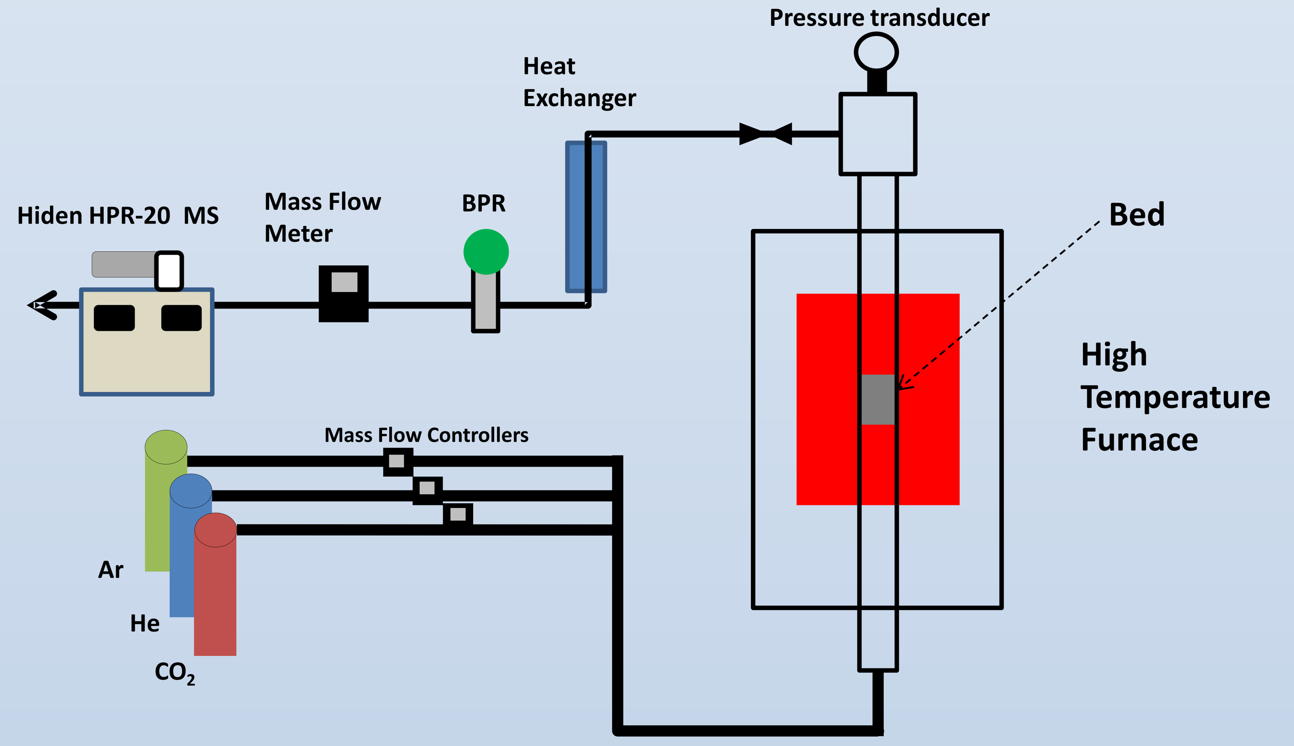
*A baseline of 95 percent.

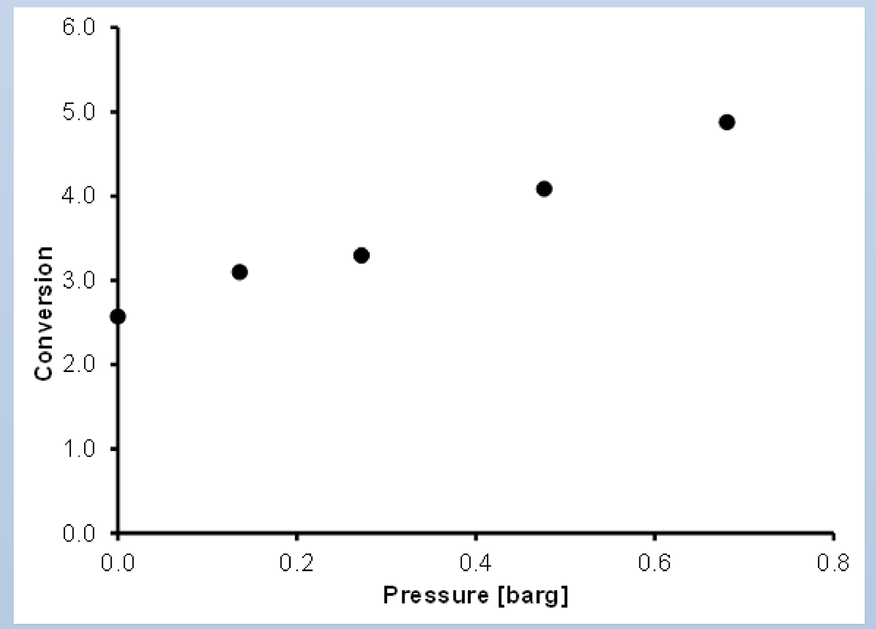
Conclusion:

With 5 cycles done with the TGA, the assumption is that the energy density will be stable with continued cycles for each sample. The sample that showed the most promise was sample 15 in terms of energy density. The energy density of 15 started off around 3500 MJ/m^3 in the first cycle and tapered off to just above 1500 MJ/m^3, about 7% higher than the base powder. When comparing the effects of the parameters alone and together, the data shows that both the size of the SrO particles and the graphite particles create a large effect on the energy density. Surface area appears to have an affect on energy density. The next question should be what stabilizes the energy density ?

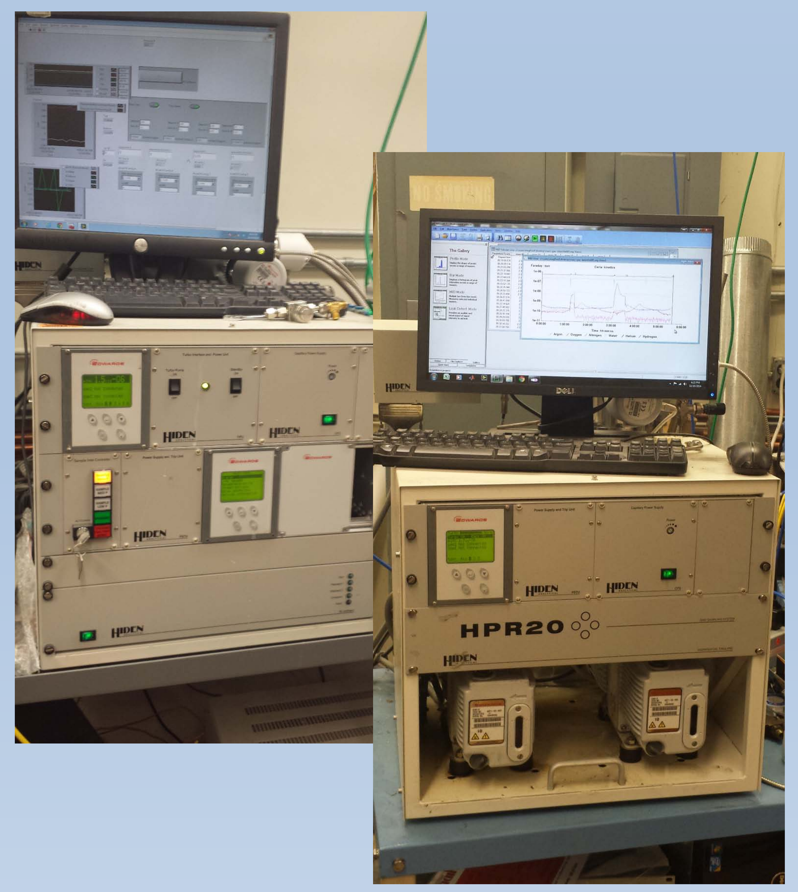
Future Work

Investigation into carbonation at elevated pressure





Preliminary data showing dynamic cycling between 1100 and 1300°C at 10°C/min. pCO_2 = 0.33 bar



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