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Ph.D. DISSERTATION DEFENSE

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Title: CO2 Mineralization for Carbon Removal

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ABSTRACT

The objective of this thesis is to give a detailed analysis of different methods that can be used to sequester carbon dioxide (CO_2) into carbonates through literature review and experimental work. Carbon Capture Utilization and Storage (CCUS), while still in the early stages of its development, is a promising pathway for a sustainable future. The thesis begins by evaluating the economics of carbon capture and the development of different carbon dioxide removal (CDR) technologies. This is followed by an experimental work on the effect of algae and enzymes on the precipitation kinetics of magnesium (Mg)-carbonates in a batch system within a controlled atmosphere. The results show that the addition of the enzyme carbonic anhydrase (CA), either directly or through algae, enhances Mg-carbonate precipitation. The project also determined that it is feasible to reuse carbonates as a potential feed to algae. This opens up the ability to implement a self-sustained CO_2 sequestration system as a CDR.

The project then evaluated the ways brines can be utilized to form both Mg and calcium (Ca) carbonates. Brines are typically rich in Mg and Ca cations and are primed to form carbonates, but the reactions at play have not been studied extensively. Recently, studies have been performed to investigate the inhibition reactions to reduce scaling, but they have not been focused around upgrading the CO_2sequestration of the system. To bridge this knowledge gap the last three chapters of the thesis describe the results of an experimental study on the effect of copper (Cu), nickel (Ni), and zinc (Zn) on the kinetics of Mg- and Ca-carbonate reactions in a batch reactor open to the atmosphere. Cu and Zn were found to hinder the reaction at all quantities, whereas Ni had the potential to hinder or enhance the reaction depending on the concentration. The results allowed for the development of a mathematical model that describes the biochemical process where CO_2 is captured into Mg and Ca-carbonates in the presence of the metal ions. With the kinetics properly modeled future theoretical studies on the effect metals have on brines will be made possible.