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Monitoring Reaction-Driven Cracking with nonlinear elasticity

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One method of CO2 sequestration is to react carbonated water with ultramafic rocks to form carbonate minerals. The formation of these minerals causes cracks in the samples, which increase the available surface area for the necessary reactions, making a positive feedback loop for Carbon storage. A key question about this type of sequestration is how to monitor the progression of the carbonation. We use five samples from two different locations (Bay of Islands Ophiolite deposit in western Newfoundland and The Cedars ultramafic suite in California) with different amounts of natural carbonate to investigate various monitoring methods. Some of the rocks were cut to make two samples (A and B in the figure). The amount of carbonate in each sample is determined using x-ray CT and thin section analysis. Because of the sensitivity of nonlinear wave interactions to cracks, one of the monitoring methods that we test is the magnitude of the nonlinear response of the rocks. We test this in two ways, the first uses solely propagating waves to mimic a relatively straightforward field experiment. The second uses Dynamic Acousto-Elasticity Measurements to assess the nonlinearity of each sample. The figure below shows our experimental setup for the propagating wave experiment as well as the results for the peak change in traveltime as a function of carbonate percentage. We interpret the clear trend with increasing carbonate content as an indicator that nonlinearity is a viable method to monitor this type of CO2 sequestration.

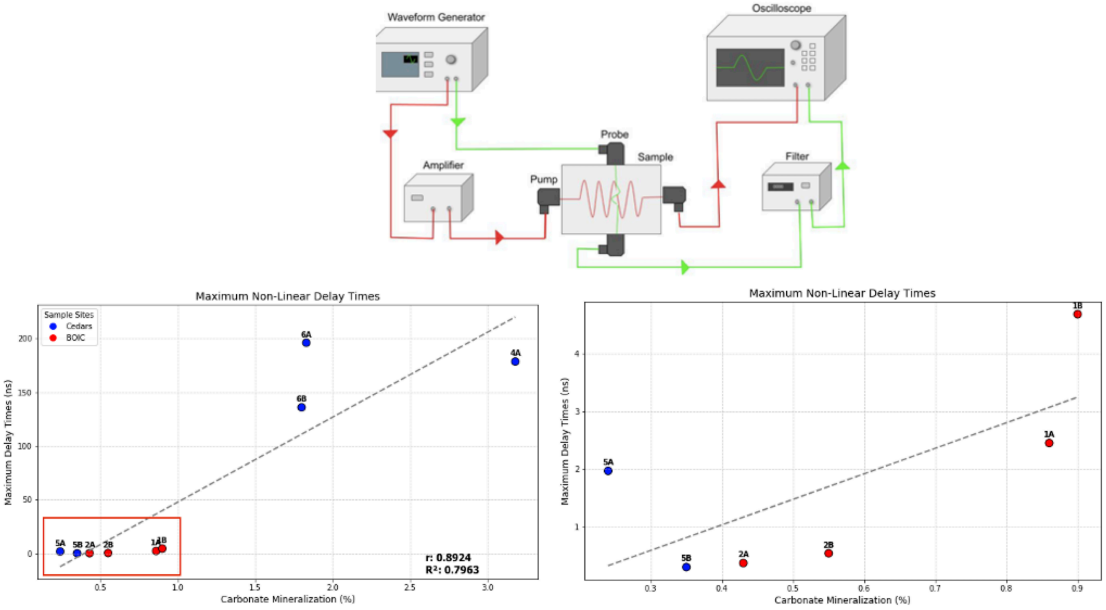

Figure 1: The top panel shows our experimental setup, which uses a straightforward pump/probe setup. Bottom left shows the maximum probe delay time over all phases of the pump for each sample. The area in the red box is shown as a zoom on the right.

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