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Carbon sequestration reservoir at Rock Springs Uplift, Wyoming, USA

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The Rock Springs Uplift (RSU) located in southwest Wyoming USA as indicated in Figure 1 is one of several sites across the country to be characterized for suitability for CO_2 sequestration. The RSU was identified for several reasons: proximity to a large CO_2 emissions point source, the overall geometry of the RSU structure, and geologic formations recognized to have properties required for long term storage of CO_2. Original rock cores of the Weber Sandstone formation and the dolomite facies of the Madison Limestone formation from the RSU were prepared into 25-mm diameter rock samples. These samples were vacuum-saturated to 100% saturation with synthetic brine, aged with brine for 800 hours at in-situ temperatures and initial confining pressure of 3.5 MPa, and aged with CO_2-rich brine (400 hours first with brine and another 400 hours with compressed CO_2-saturated brine) at in-situ temperatures and initial confining pressure of 3.5 MPa. During the aging process, the pore and confining pressure were increased in small steps, typically 0.69 to 1.38 MPa at a time using high precision syringe pumps (Teledyne ISCO 260D, Lincoln, NE, USA) until the test conditions were met without fluid flow. Laboratory hydrostatic and triaxial experiments were performed at in-situ reservoir conditions with the temperatures of 90°C for Weber Sandstone and and 93°C for Madison Limestone under three differential pressures of 6.9 MPa, 34.5 MPa and 55.2 MPa.

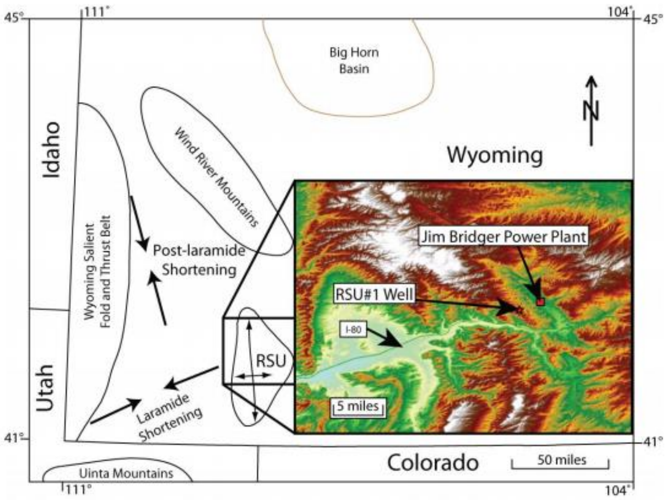

Figure 1: Map showing the Rock Springs Uplift in Wyoming, USA (after [1]).

Geomechanical results of the aged rock samples are presented and discussed. Under the triaxial compression, Weber Sandstone exhibited brittle failure strengths while Madison Limestone exhibited a brittle-ductile transition behavior. For the sandstone samples with similar initial porosity, the Young's moduli increased and Poisson's ratios decreased as the result of CO_2 under the linear elastic regime. No relationship between stress (or strain) data and CO_2 in the nonlinear plastic regime was observed. However, the confining pressure has a greater effect than CO_2 on geomechanical behaviors. For the limestone samples, the change of elastic constants due to CO_2 is more significant than that of sandstone samples. However, no consistent trend was observed on the limestone samples,

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and the effect of CO_2 is not the dominant factor influencing the plastic properties of rocks. DH1c with the lowest initial porosity and differential pressure exhibits the highest peak strength, Young's modulus and Poisson's ratio, indicating the effect of initial porosity. Considering the effect of CO_2 on Mohr failure envelopes, the decreasing trend of cohesion and increasing friction angle was observed in both sandstone and limestone samples. Table 1 summarizes the maximum deviatoric stress, elastic properties, and shear strength parameters of Weber Sandstone and Madison Limestone samples.

Table 1. Summary of maximum deviatorix stress, elastic properties and shear strength parameters of Weber Sandstone and Madison Limestone samples

Geochemical Preparation	Sample ID	Initial Porosity, %	P_d (MPa)	$\Delta\sigma_{pk}$ (MPa)	E (GPa)	ν	c (MPa)	ϕ (^{0})
Saturation with Brine	SV1	8.23	6.9	229.0	37.9	0.36	39.5	47.2
	SV2	9.53	34.5	382.0	43.6	0.20		
	SV3	8.94	55.2	496.4	46.2	0.14		
	DH1	NA	6.9	63.8	23.38	0.47	15.7	27.6
	DH2*	NA	34.5	81.9	30.10	0.27		
	DH3*	NA	55.2	43.3	20.16	0.31		
Aged with Brine	SV1b	7.25	6.9	282.7	42.1	0.24	47.0	47.8
	SV2b	8.98	34.5	440.3	31.4	0.29		
	SV3b*	7.96	55.2	265.6	41.6	0.23		
	DH1b	17.67	6.9	134.7	27.8	0.42	57.7	7.9
	DH2b*	12.93	34.5	65.2	24.6	0.42		
	DH3b	14.80	55.2	150.0	34.2	0.22		
Aged with Brine and CO2	SV1c	10.54	6.9	232.2	40.1	0.29	26.7	55.0
	SV2c	9.16	34.5	482.7	48.5	0.14		
	SV3c	7.85	55.2	575.6	49.2	0.17		
	DH1c	9.50	6.9	216.5	41.0	0.31	30.6	50.4
	DH2c	23.93	34.5	125.6	24.5	0.26		
	DH3c	24.25	55.2	146.2	29.7	0.25		

SV–Weber Sandstone sample; DH–Madison Limestone sample; *–Sample experienced abnormal confining pressure-volumetric strain response; P_d–Differential pressure; $\Delta\sigma_{pk}$–Maximum deviatoric compressive stress; E–Young's modulus; ν–Possion's ratio; c–Cohesion; and ϕ–Friction angle; NA–Not available.

Data Availability Statement

Data will be available upon requested.

Contributor statement

Kam Ng contributed to funding acquisition, projet management and abstract preparation, Hua Yu contributed to laboratory experiments and data analysis.

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