REPP-CO_2: STATIC AND DYNAMIC LABORATORY EXPERIMENTS WITH scCO$_2$

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Introduction

REPP-CO2 was launched early 2015 as a joint Czech-Norwegian research project focusing primarily on the development of the CO_2 geological storage technology in the Czech Republic. The project represents a major step in the advancement towards validation by means of a pilot project in geological settings similar to possible future CO_2 storage sites.

The core part of the project focuses on the first preparatory phase of the research pilot project on CO_2 geological storage. This consists of obtaining the necessary data (geological, geophysical, well log, etc.), constructing a three-dimensional geological model of the storage complex, developing a dynamic simulation model, which will be subsequently used to model the storage complex behavior during the site's operational (CO_2 injection) phase and post-injection one, executing a risk analysis, and compiling a monitoring plan. In future stages these outcomes could be used as a basis for a future Storage Site Permit Application.

A critical element of the project, supporting the activities mentioned above, is the characterization of reservoir rock and caprock behaviour under dynamic (CO_2 injection) and static (post-injection) conditions.

This is addressed using both static and dynamic experiments with supercritical CO_2 (scCO_2).

Samples

All samples shown in Table 2 were carefully characterized before and after the static experiment using XRD analyses. Measurements were carried out on Bruker-AXS D8 Advance device using LynxEye (radiation CuKλ, voltage 40 kV, current 40 mA). Diffraction database PDF-2, 2011 (International Centre for Diffraction Data, Pennsylvania, USA) was used for quantitative data evaluation.

Table 1: Synthetic brine composition used in all experiments

Synthetic brine Br-45	
TDS (g/l)	9622.3
Ca^{2+} (mg/l)	143
Mg^{2+} (mg/l)	55.2
Na^{+} (mg/l)	3 780
Cl^{-} (mg/l)	4 830
(HCO_3^{-}) (mg/l)	1 410
SO_4^{2-} (mg/l)	786
pH	8.1

Table 2: Samples used for the analyses and sample mineralogy before testing

Well	Interval	Sample description	Dynamic experiment	Static experiment	Quartz	Muscovite	Microcline	Kaolinite	Chlorite	Calcite	Siderite	Dolomite	Albite	Gypsum
Br - 35	900 - 904	Cap rocks	D	S	60.69	8.54	4.92		5.1	7.33		4.83	6.91	1.67
Br - 35	1250 - 1256	-		S	38.03	23.9	5.18		6.43	10.56		5.4	9.09	1.41
Br - 52	1150 - 1155	-		S	60.22	9.83	3.85		6.42	6.97		3.12	7.66	1.92
Br - 54	800 - 806	Cap rocks		S	39.4	20.74	3.88	6.16	5.49	13.13	2.49	1.7	7	
Br - 54	1100 - 1104	Cap rocks		S	31.98	35.78			5.1	12.95	1.7	5.67	6.8	
Br - 60	1150 - 1155	-		S	29.88	35.14			6.63	11.53		8.9	7.92	
Br - 75	1090 - 1095	-		S	36.7	28.1	5.06		4.92	10.03	1.28	3.71	8.6	1.61
Hr – 20	1400 - 1405	-		S	60.6	9.66	0.73		2.25	17.45		3.5	5.81	
Hr – 150	1358 - 1363	Light gray, fine grained sandstone, analogue cap rocks		S	54.92	9.03	5.57	5.56	3.19			13.56	6.76	1.41
Hr – 197	1075 - 1079	Light gray, fine grained sandstone, analogue cap rocks		S	48.57	13.35	2.25	4.61	4.3	4.57		5.32	16.13	
Hr - 158 (1140428)	1750	Light gray, fine grained sandstone, analogue cap rocks		S	47.7	11.08	5.98		4.09	7.25		11.84	11.34	0.72
Hr - 121 (1140429)	1577	Light gray, fine grained sandstone, analogue cap rocks	D	S	42.32	17.33	1.68	6.49	4.45	4.3		12.34	10.06	1.04
Hr - 190 (1140434)	1600	Analogue reservoir rock	D	S	49.57	17.64	1.06	9.07	4.57	8.87		1.66	7.56	

Experimental measurements

Characterization of both formation (reservoir and caprock) and groundwater was carried out. A representative synthetic reservoir brine (Na-Cl type) was prepared from existing analyses of deep groundwater reservoir samples (see Table 1).

For both static and dynamic experiments, rock samples were thoroughly characterized before and after testing. Changes in rock mineralogy, porosity (Hg porosimetry), and BET surface area are going to be determined/quantified.

The static experiments were based on long-term interactions of scCO_2 with different types of rock sample materials at CO_2 storage site conditions namely, 7.5 MPa pressure and 40°C temperature (see Fig. 1).

In addition, the permeability, k_{10}, of rock samples is going to be measured for available samples, using both water and scCO_2 injection in a dynamic (flow-through) apparatus, shown in Fig. 2. The repeated cycles of a sample exposure to scCO_2 and water can be achieved in a new apparatus for a long-term testing period (2 months).

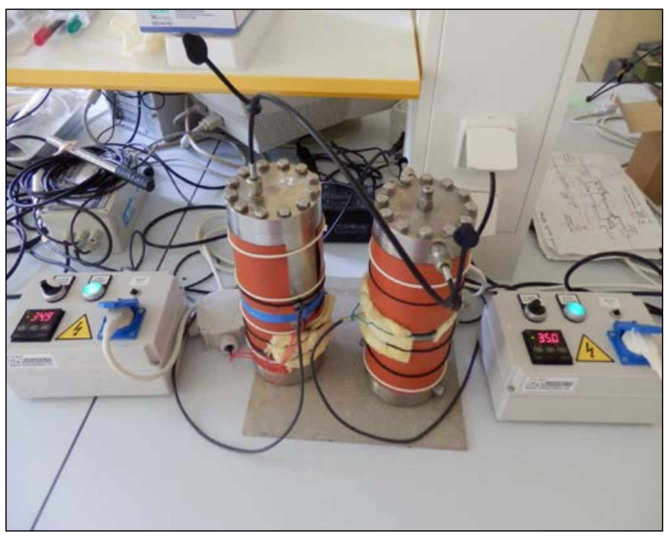

Fig. 1: Photo of double chamber apparatus used for long-term static experiments

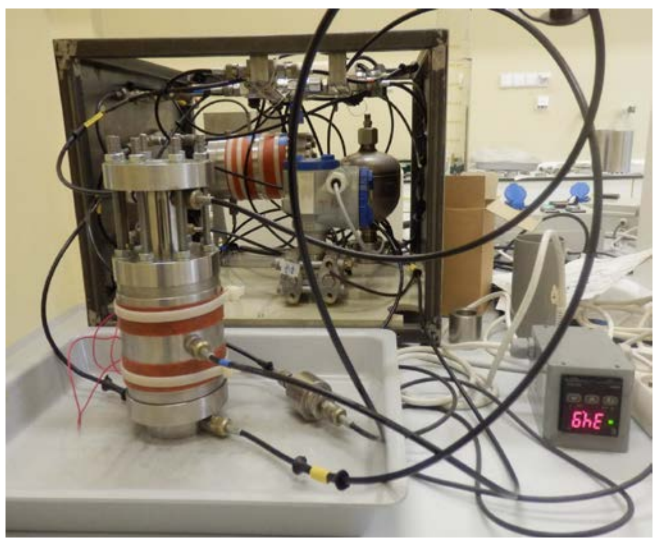

Fig. 2 : Photo of apparatus used for dynamic experiments.

Fig. 3: Photos of sample Hr – 121 before (left) and after (right) long-term dynamic experiments with supercritical CO_2.

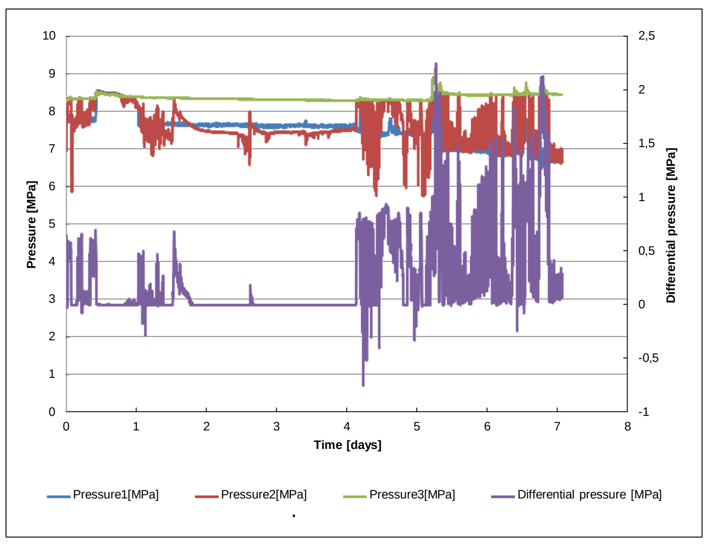

Fig. 4: Dynamic experiment: flow-through with spCO_2. $k_{10,}CO_2$ = 5.23E-07 [m s^{-1}]

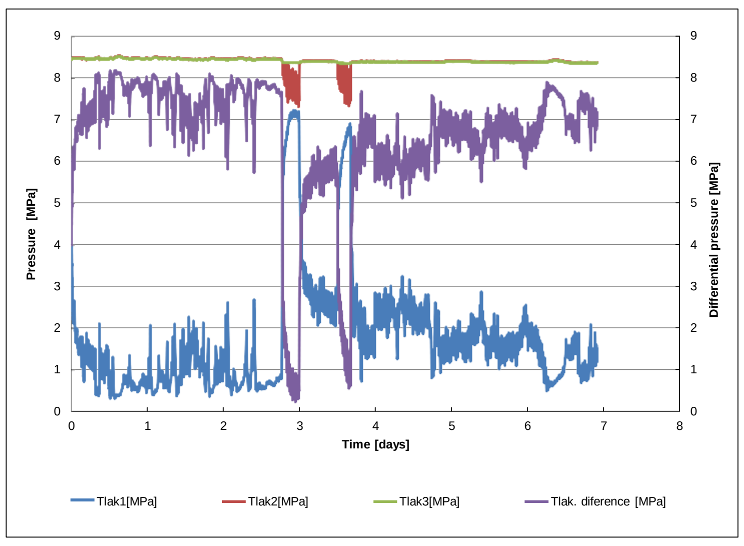

Fig. 5: Dynamic experiment: flow-through with water after experiment with spCO_2. k_{10} water = 5.04E-07 [m s^{-1}] before scCO_2 injection; k_{10} water = 2.67E-08 [m s^{-1}] after scCO_2 injection

Conclusions

The static experiments were conducted for 70 days. Two types of samples, sandstones and claystones, were used. XRD analyses were carried out before the samples exposure to scCO_2; the samples post- scCO_2 exposure XRD analyses are ongoing since the static experiments were completed a few days ago.

The dynamic experiment for the sample HR-121 was carried our for a period of 2 months. The sample deformation after cycles of exposure to water, scCO_2 and water can be seen in Fig. 3. Figs. 4 and 5, show the pressure measurements during exposure to scCO_2, water and then scCO_2.

Fig. 5, shows clearly that the differential pressure increased as the sample became less permeable to water after its exposure to scCO_2. The changes may be caused by formation of new minerals in the sample. This hypothesis will be confirmed when the results of the samples post- scCO_2 exposure XRD analyses will be completed.

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