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Experimental Study of CO_2 Contamination on the Porosity of Dry Kwale Field Reservoir Rock

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ABSTRACT

Experimental study was carried out to investigate the effect of CO_2 injection on the porosity of Kwale Field, Niger-Delta, reservoir rock samples. The drill cuttings used have porosity higher than the average Kwale field porosity and this could have been due to fracturing during drilling but it is still very applicable and authentic in this research. This is because investigation made was on variation in porosity due to reaction with injected CO_2 and was carried out at moderate pressure of about 750°C that cannot worsen any existing fractures, if there is any at all. There was an increase in the porosity of sample 1 from 0.3773 to 0.5139 representing 36.2% increase while sample 2 has its porosity increased from 0.3727 to 0.8484 representing an increase of 29.48%. Since both were dry cores and injected at same CO_2 pressure and temperature, it shows that the texture of the core has been eroded by the injected CO_2. If the porosity variation was purely due to injection pressure, then there would have been same percentage increase in porosity but in this case the content of the samples must have contributed to porosity variation during contamination with CO_2.

Keywords: *porocity variation, CO_2 contamination, CSS, Kwale field, Niger delta.*

1. INTRODUCTION

Seals around reservoir are extremely important in order for the reservoir to retain its fluid. This study research into the possibility of an increase in reservoir porosity and this will be due to the dissolution of part of the rock grain minerals or the rock cementing materials.

Increase in porosity and permeability is a possible indication that the reservoir may not be able to retain its fluid or injected fluid. These increases could be an indication of reduced reservoir rock integrity over time at high injection pressure conditions. CO_2 is injected into reservoir rocks at high pressure but low temperature. This is due to the fact that the CO_2 is compressed at a temperature lower than deep reservoir temperature. At the point of injection, the rock temperature will almost be equal to the CO_2 temperature but away from the point of injection, there is rapid increase in temperature till almost the average reservoir temperature. The reaction of the CO_2 with the reservoir is expected to be at varying temperature and pressure as injection continues for a very long period of time. But for short-time injection period, it is expected that almost all reactions will take place near the point of injection, and at CO_2 pressure and reservoir temperature and, until the CO_2 moves from a limiting reactant to an excess reactant. This is an important consideration as reactions are influence by temperature and pressure. Moreover, the reaction resembles that of a plug reactor and not a batch reactor. This is because the reaction starts at the point of injection and proceed along the path of the CO_2 gas flow.

Temperature variation from point of injection to the production well can be assumed to simulate counter-current flows due to the large volume of the reservoir rock. In this case, the average temperature is assumed to comply with the law of counter current flow regime.

2. METHODOLOGY

- The weight and the initial porosity of the rock samples were measured using the porosimeter.

- CO_2 gas at moderate temperature was injected intermittently every two days into the cuttings and the porosity measured after further two days to allow reaction between cuttings and CO_2.

3. RESULTS

The drill cuttings of average weight of 18.01g were obtained at the depth of about 3234.34m and has initial porosity of 37.73% for sample 1 and a porosity of 37.17% for sample 2. They were dry samples injected with CO_2

Table 1: Porosity Variation For Dry Rock Sample 1

Time (hours)	Bulk Volume cc	Porosimeter constants	Grain volume, cc	Pore volume. cc	Porosity	Change in Porosity
0	4.32	160.61	2.69	1.63	0.377315	0
24	4.32	160.67	2.63	1.69	0.391204	0.013889
48	4.32	160.73	2.57	1.75	0.405093	0.027778
72	4.32	160.78	2.52	1.8	0.416667	0.039352
96	4.32	160.84	2.46	1.86	0.430556	0.053241
120	4.32	160.91	2.39	1.93	0.446759	0.069444
144	4.32	160.95	2.35	1.97	0.456019	0.078704
168	4.32	161.03	2.27	2.05	0.474537	0.097222
192	4.32	161.05	2.25	2.07	0.479167	0.101852
216	4.32	161.06	2.24	2.08	0.481481	0.104167
240	4.32	161.08	2.22	2.1	0.486111	0.108796
264	4.32	161.14	2.16	2.16	0.5	0.122685
288	4.32	161.16	2.14	2.18	0.50463	0.127315
312	4.32	161.2	2.1	2.22	0.513889	0.136574
336	4.32	161.2	2.1	2.22	0.513889	0.136574

Table 2: Porosity Variation For Dry Rock Sample 2

Time (hours)	Bulk Volume cc	Porosimeter constants	Grain volume, cc	Pore volume. cc	Porosity	Change in Porosity
0	4.32	160.59	2.71	1.61	0.372685	0
24	4.32	160.6	2.7	1.62	0.375	0.002315
48	4.32	160.65	2.65	1.67	0.386574	0.013889
72	4.32	160.71	2.59	1.73	0.400463	0.027778
96	4.32	160.74	2.56	1.76	0.407407	0.034722
120	4.32	160.77	2.53	1.79	0.414352	0.041667
144	4.32	160.81	2.49	1.83	0.423611	0.050926
168	4.32	160.85	2.45	1.87	0.43287	0.060185
192	4.32	160.89	2.41	1.91	0.44213	0.069444
216	4.32	160.93	2.37	1.95	0.451389	0.078704
240	4.32	160.97	2.33	1.99	0.460648	0.087963
264	4.32	161.01	2.29	2.03	0.469907	0.097222
288	4.32	161.05	2.25	2.07	0.479167	0.106481
312	4.32	161.09	2.21	2.11	0.488426	0.115741
336	4.32	161.09	2.21	2.11	0.488426	0.115741

Below in Fig. 1, and 2 are the graphical representations of the porosity variation with time of injection of CO_2

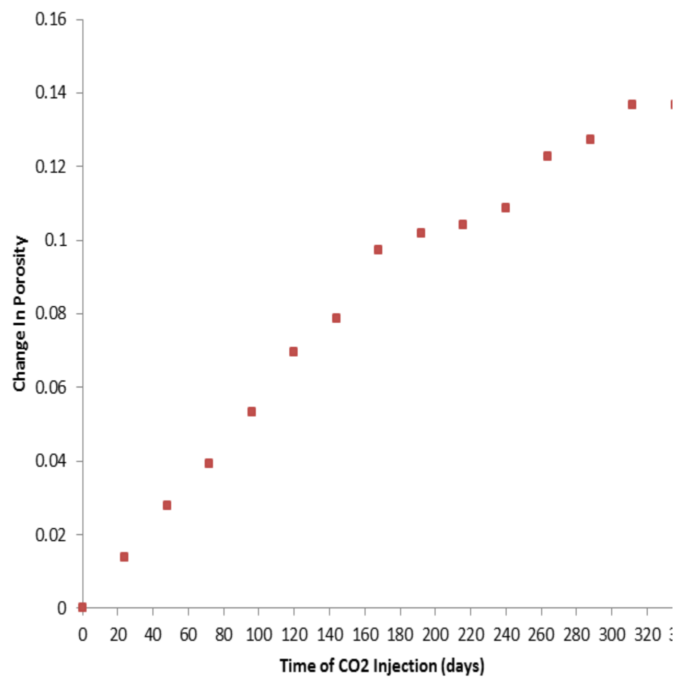

Fig. 1: Porosity Variation For Rock Sample 1 Injected With CO2

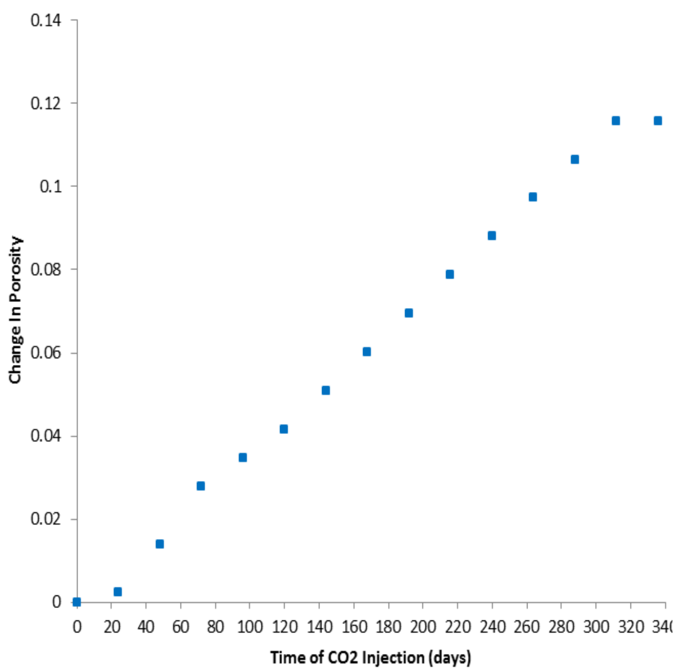

Fig. 2: Porosity Variation For Rock Sample 2 Injected With CO2

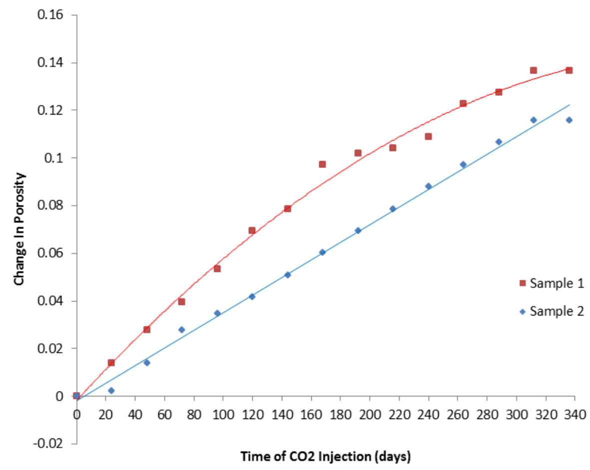

Fig. 3.9: Comparison of Porosity Variations For Dry Core Samples 1 and 2 Injected With CO2

4. CONCLUSION

From fig.1, the porosity of the Sample 1 follows a simple polynomial curve of order 2 while there was a linear variation in the porosity of sample 2 as indicated in Fig.2 above with a slope of 0.004. This shows that CO_2 has higher effect on the porosity of Sample 1 than that of Sample 2 as illustrated by Fig.3 above. The CO_2 eroded sample 1 more than sample 2 and area where sample 1 was cut out is more likely to fail than zone of sample 2 during CO_2 storage in the reservoir.

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