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Gas flow mechanisms in fractured low permeability reservoirs.

OGOUN, E., AISUENI, F., OGUNLUDE, P. and GOBINA, E.

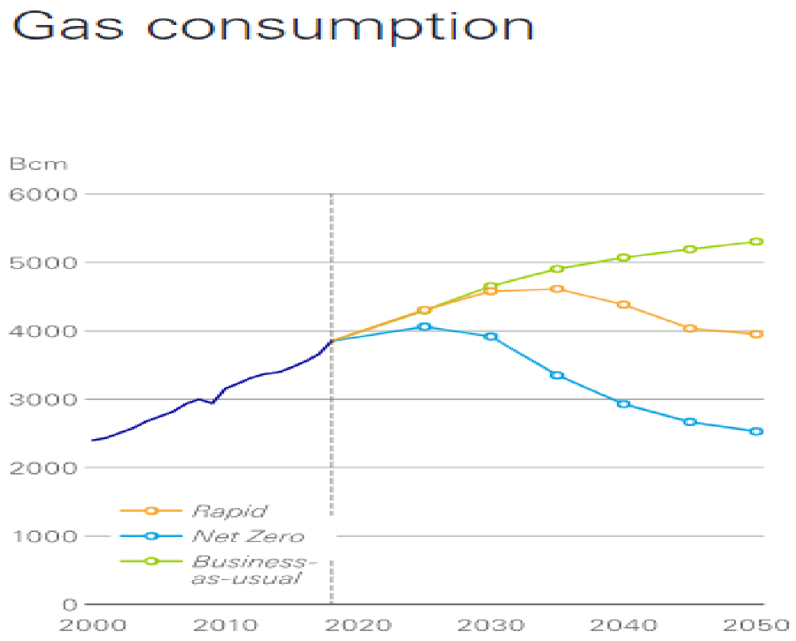
2021

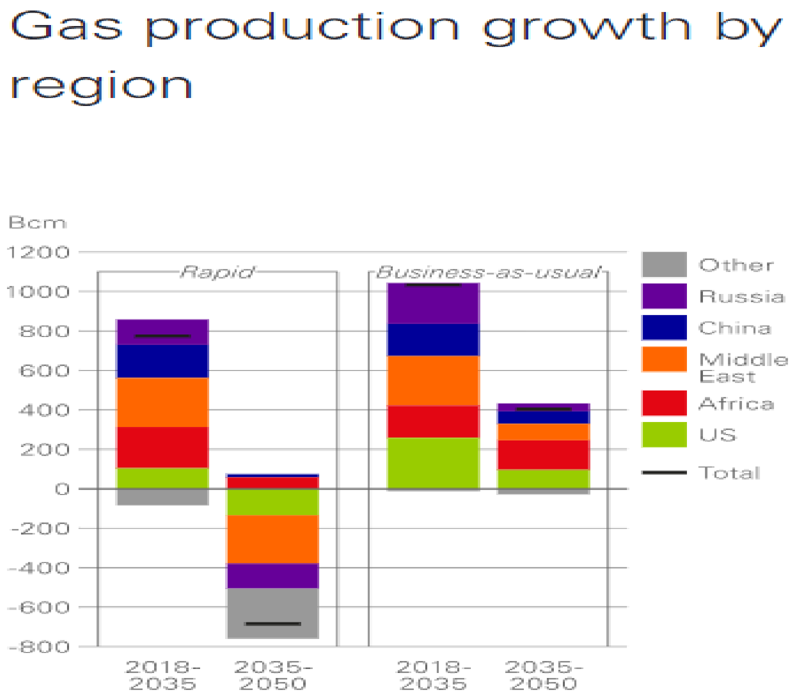
CONTENT OUTLINE

1. Introduction/overview
2. Aim
3. Materials and methods
4. Data summary
5. Results and discussion
6. Conclusion
7. Questions

INTRODUCTION/OVERVIEW

1. Gas demand and production has enhanced the diversification of economic activities from oil, with United State of America, China and Middle East in full swing unconventional gas revolution.





INTRODUCTION/OVERVIEW

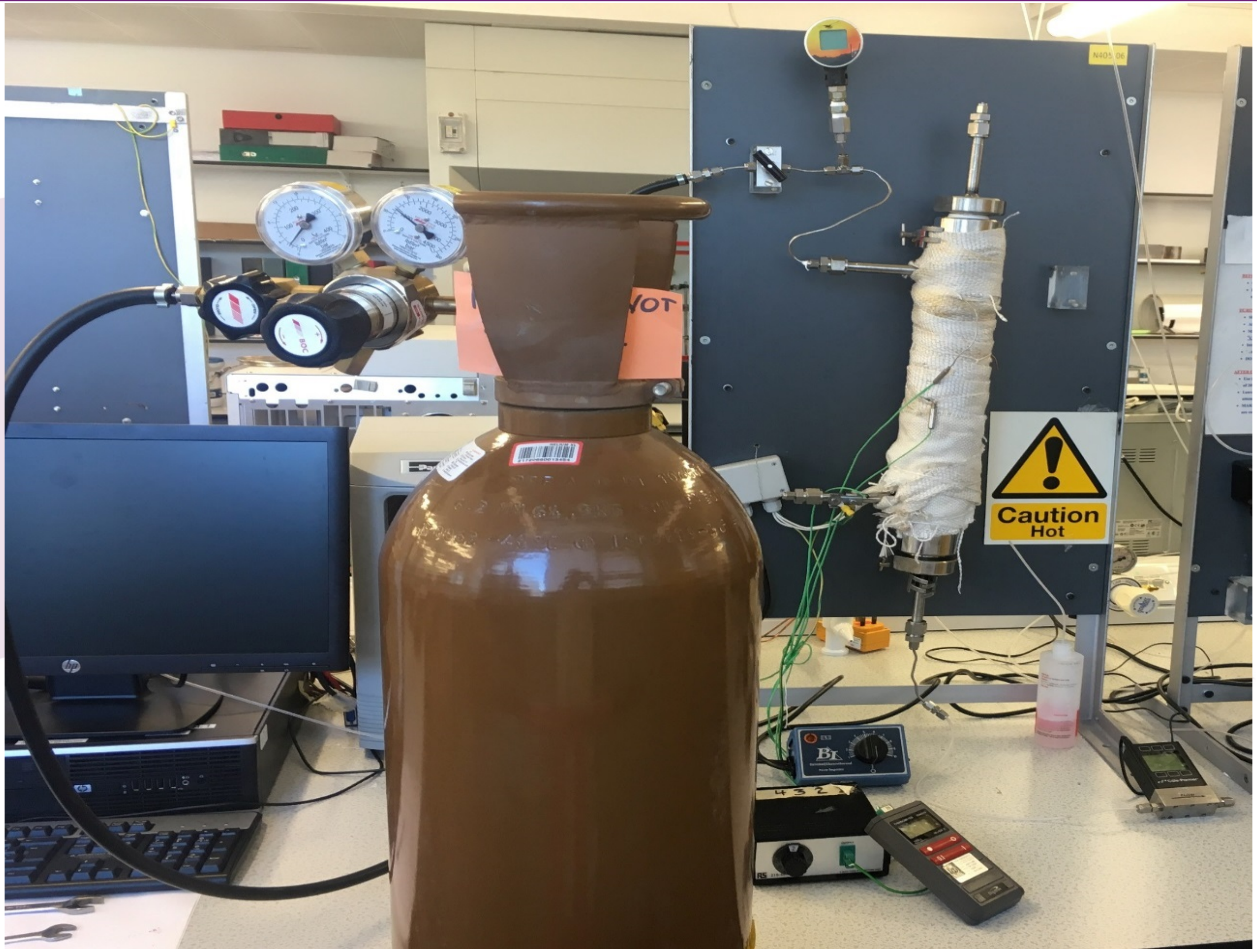
1. Unconventional gas reservoirs usually have very low matrix permeability, less than 0.1mD and a matrix porosity of less than 10%.
2. Unconventional reservoirs in most cases require hydraulic fracturing/fracking to liberate gas at economical quantity to the wellbore.
3. The reservoirs produce at a low flow rate under radial flow conditions without hydraulic fracturing, but after a successful fracture treatment the mechanism of the gas flow in the formation changes from radial flow to linear flow.

RESEARCH AIM

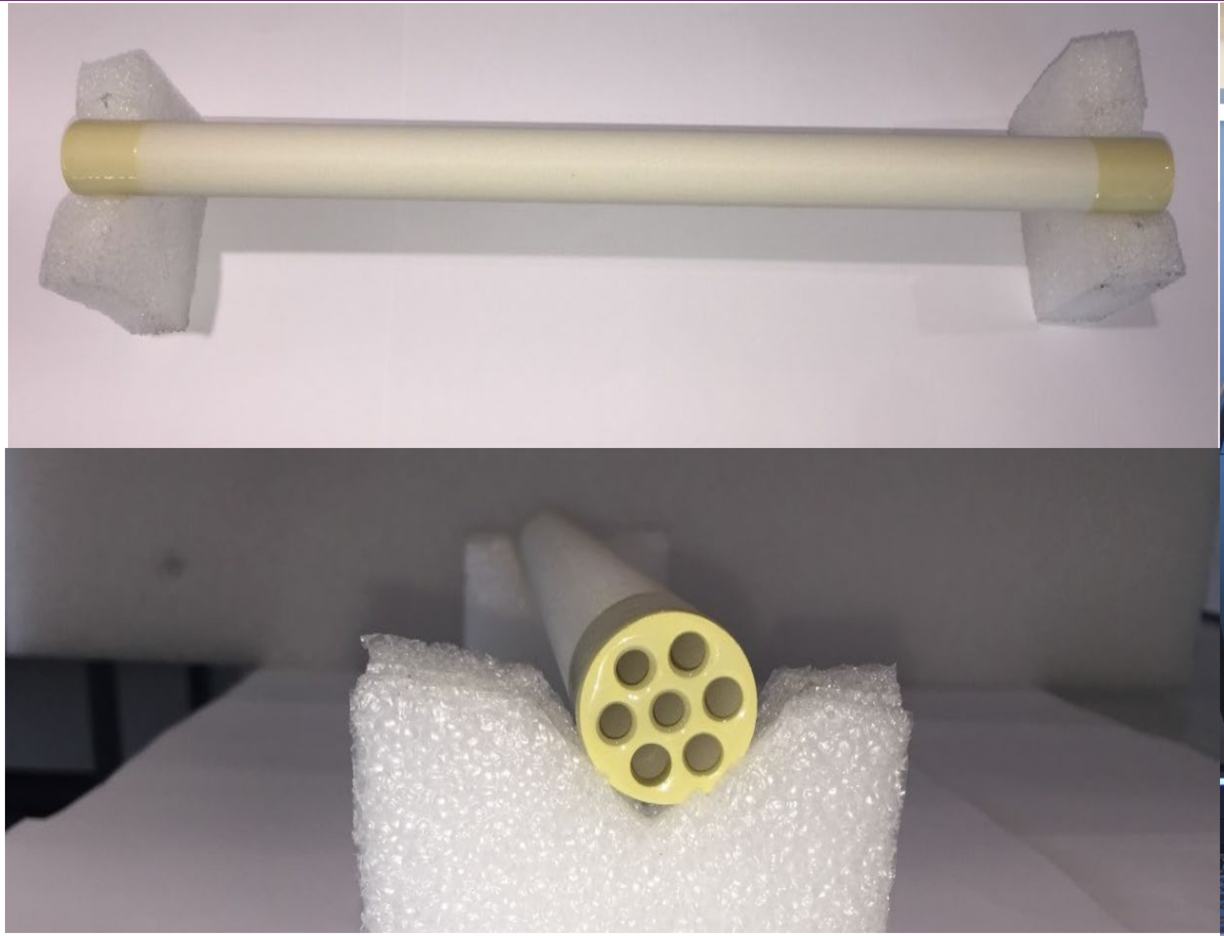
- This research is designed to experimentally study the factors that influence the gas flow mechanism in low permeability reservoir.

MATERIALS AND METHODS

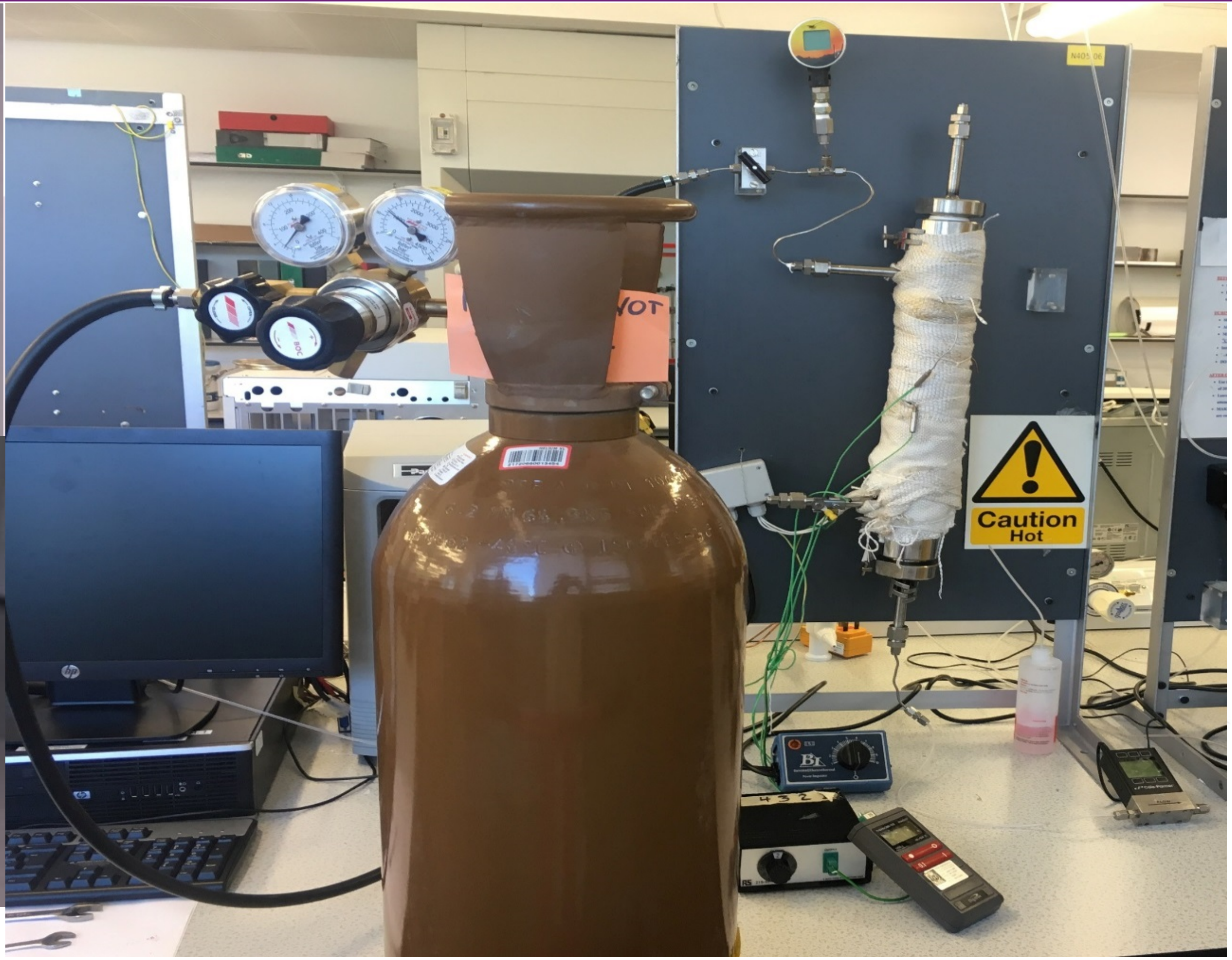
- (1) pressure gauge
- (2) pressure valve
- (3) gas regulator
- (4) gas cylinder
- (5) thermometer
- (6) thermocouple transducer
- (7) flow meter
- (8) heat regulator
- (9) heat jacket and
- (10) core holder.



MATERIALS AND METHODS



Areal and cross-sectional view of membranes used



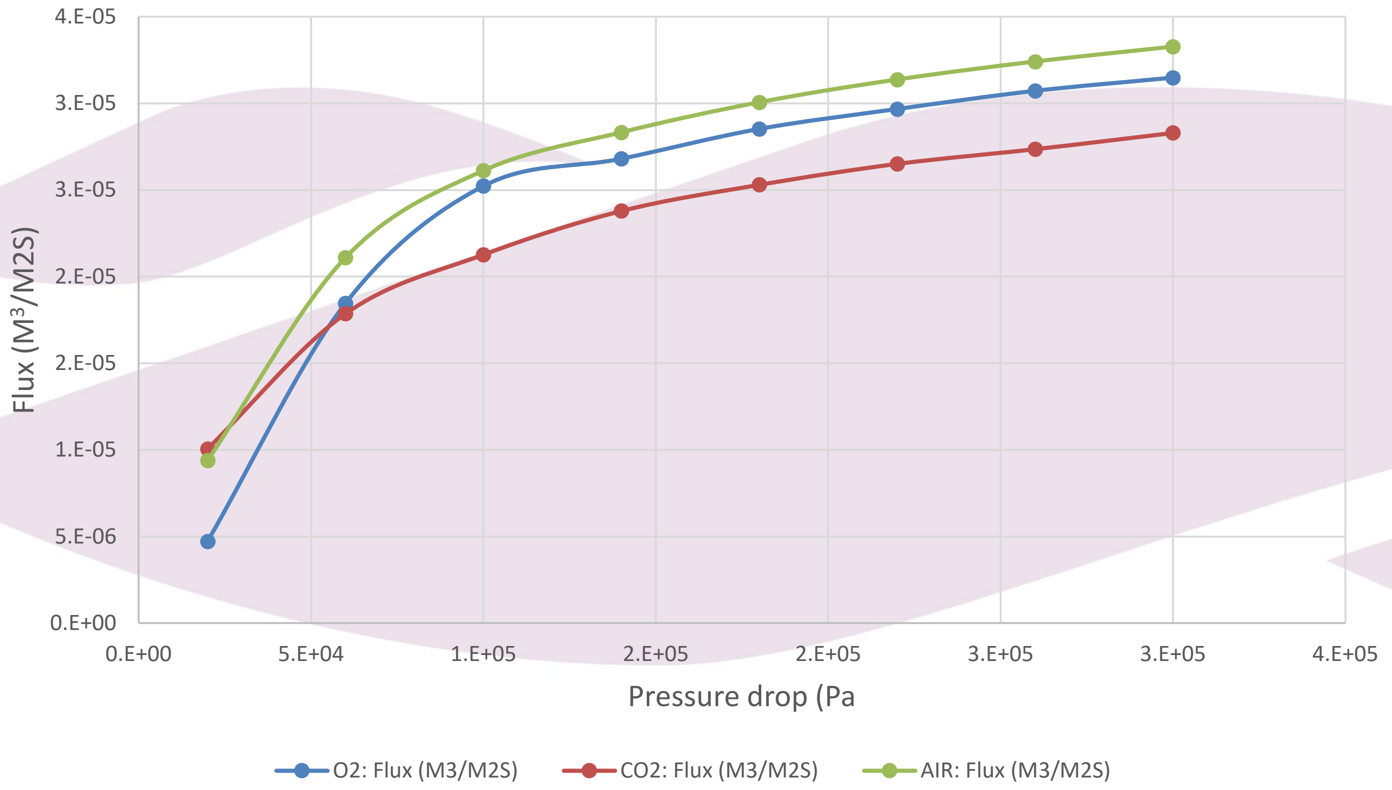
Experimental set-up

DATA SUMMARY

	A	B	C	D	E	F	G	H	I	J	K
1	OXYGEN (O2) GAS : 15NM AT ROOM TEMPERATURE (20 DEGREE CELCIUS)										
2	Inlet pressure (Bar)	Outlet pressure (Bar)	Inlet pressure (Pa)	Outlet pressure (Pa)	Pressure drop (Pa)	Average Pressure (Pa)	Core Surface Area (M^2)	Flowrate (LPM)	Flowrate (M^3/S)	Flux (M^3/M^2S)	Permeance (M^3/M^2SPa)
3	1.2	1	120000	100000	20000	110000	5.339	0.378	2.521E-05	4.722E-06	2.361E-10
4	1.6	1	160000	100000	60000	130000	5.339	1.478	9.854E-05	1.846E-05	3.076E-10
5	2	1	200000	100000	100000	150000	5.339	2.578	0.0001719	3.219E-05	3.219E-10
6	2.4	1	240000	100000	140000	170000	5.339	3.678	0.0002452	4.593E-05	3.28E-10
7	2.8	1	280000	100000	180000	190000	5.339	4.778	0.0003185	5.966E-05	3.315E-10
8	3.2	1	320000	100000	220000	210000	5.339	5.878	0.0003919	7.34E-05	3.336E-10
9	3.6	1	360000	100000	260000	230000	5.339	6.978	0.0004652	8.713E-05	3.351E-10
10	4	1	400000	100000	300000	250000	5.339	8.078	0.0005385	0.0001009	3.362E-10
11											
12	CARBON DIOXIDE (CO2) GAS : 15NM AT ROOM TEMPERATURE (20 DEGREE CELCIUS)										
13	Inlet pressure (Bar)	Outlet pressure (Bar)	Inlet pressure (Pa)	Outlet pressure (Pa)	Pressure drop (Pa)	Average Pressure (Pa)	Core Surface Area (M^2)	Flowrate (LPM)	Flowrate (M^3/S)	Flux (M^3/M^2S)	Permeance (M^3/M^2SPa)
14	1.2	1	120000	100000	20000	110000	5.339	0.805	5.367E-05	1.005E-05	5.026E-10
15	1.6	1	160000	100000	60000	130000	5.339	1.805	0.0001203	2.254E-05	3.756E-10
16	2	1	200000	100000	100000	150000	5.339	2.805	0.000187	3.503E-05	3.503E-10
17	2.4	1	240000	100000	140000	170000	5.339	3.805	0.0002537	4.751E-05	3.394E-10
18	2.8	1	280000	100000	180000	190000	5.339	4.805	0.0003203	6E-05	3.333E-10
19	3.2	1	320000	100000	220000	210000	5.339	5.805	0.000387	7.249E-05	3.295E-10
20	3.6	1	360000	100000	260000	230000	5.339	6.805	0.0004537	8.497E-05	3.268E-10
21	4	1	400000	100000	300000	250000	5.339	7.805	0.0005203	9.746E-05	3.249E-10
22											
23	AIR : 15NM AT ROOM TEMPERATURE (20 DEGREE CELCIUS)										
24	Inlet pressure (Bar)	Outlet pressure (Bar)	Inlet pressure (Pa)	Outlet pressure (Pa)	Pressure drop (Pa)	Average Pressure (Pa)	Core Surface Area (M^2)	Flowrate (LPM)	Flowrate (M^3/S)	Flux (M^3/M^2S)	Permeance (M^3/M^2SPa)
25	1.2	1	120000	100000	20000	110000	5.339	0.752	5.014E-05	9.391E-06	4.696E-10
26	1.6	1	160000	100000	60000	130000	5.339	1.752	0.0001168	2.188E-05	3.646E-10
27	2	1	200000	100000	100000	150000	5.339	2.752	0.0001835	3.437E-05	3.437E-10
28	2.4	1	240000	100000	140000	170000	5.339	3.752	0.0002501	4.685E-05	3.347E-10
29	2.8	1	280000	100000	180000	190000	5.339	4.752	0.0003168	5.934E-05	3.297E-10
30	3.2	1	320000	100000	220000	210000	5.339	5.752	0.0003835	7.183E-05	3.265E-10
31	3.6	1	360000	100000	260000	230000	5.339	6.752	0.0004502	8.431E-05	3.243E-10
32	4	1	400000	100000	300000	250000	5.339	7.752	0.0005168	9.68E-05	3.227E-10

RESULTS/DISCUSSION

- EFFECT OF PRESSURE DROP ON FLUX FOR THE DIFFERENT GASES AT ROOM TEMPERATURE.



Effect of pressure drop on flux for the different gases at room temperature

Effect of pressure drop on flux for the different gases at room temperature

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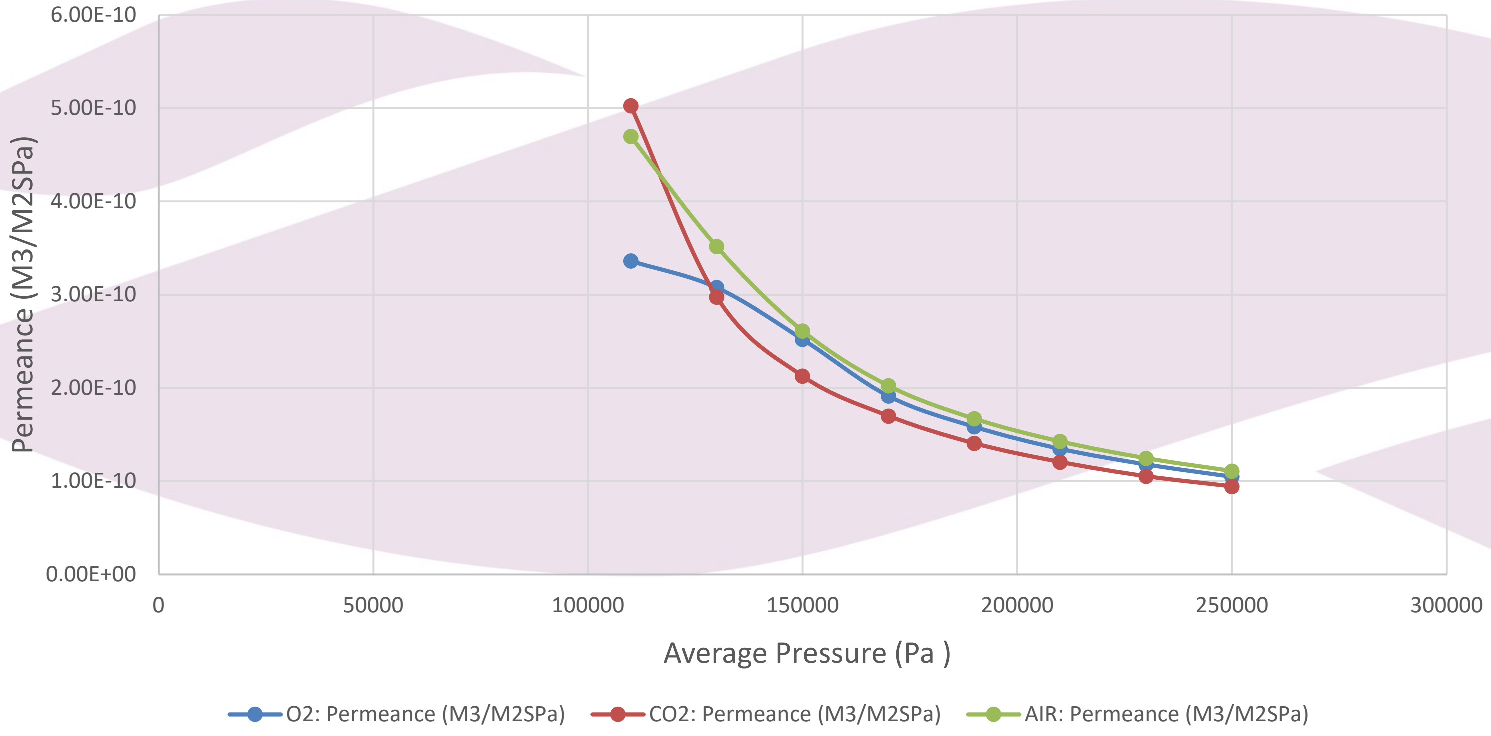
RESULTS/DISCUSSION

- EFFECT OF AVERAGE PRESSURE ON PERMEANCE FOR THE DIFFERENT GASES AT ROOM TEMPERATURE

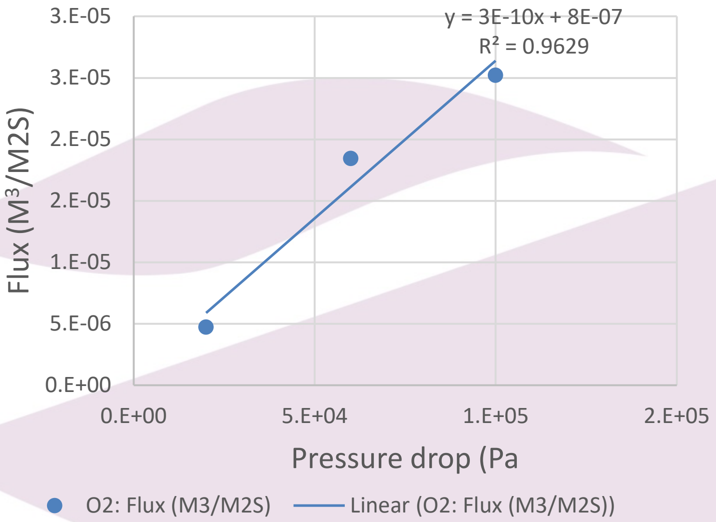


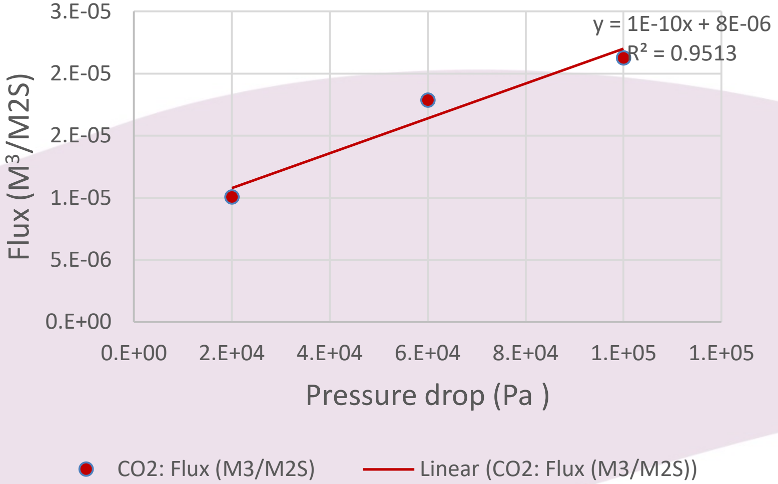
Effect of average pressure on permeance for the different membranes at temperature 200º

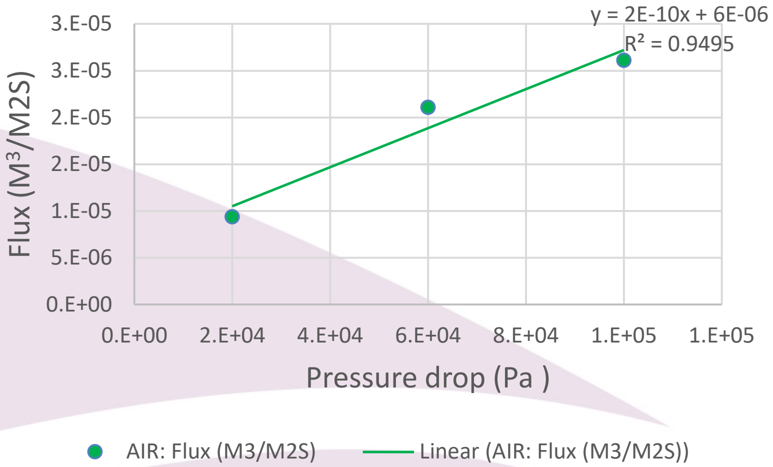
Effect of average pressure on permeance for the different gas at room temperature

RESULTS/DISCUSSION

- EFFECT OF PRESSURE DROP ON FLUX FOR THE DIFFERENT GASES AT ROOM TEMPERATURE AT DARCY'S REGION







In Darcy flow the proportionality constant κ, is called the Darcy permeability, and is used to characterize the porous medium. Thus, the Darcy formula for linear displacement is given by equation

$q/A = Q = -\kappa \Delta P/\mu\delta$

The flux Q was plotted against the pressure drop Δ*P with the slop of the graph equals* −κ/μδ

CONCLUSION

1. The matrix permeability of unconventional gas reservoir is usually very low, less than 0.1 milli Darcy and requires fracture treatment for effective productivity.
2. The long-term productivity of fractured gas reservoirs is directly controlled by the matrix flow and due to the low permeability of these reservoirs the flow velocity within the matrix tends to be very low
3. Gas flow behaviour for O_2, CO_2 and Air was analysed, and the results obeyed the criteria that governs low permeability unconventional reservoirs by dividing the flow stages into Darcy (linear) and Non-Darcy (radial) flow.
4. The Darcy region was investigated to establish the absolute permeability and how fluid viscosity affects the rate of flow. The results indicates that gases with higher viscosity tends to have lower flow rate. Confirming Darcy's equation that permeability of a porous medium is inversely proportional to the viscosity of the fluid.