Analysis of Porosity and Permeability on Channel Deposit Sandstone using Pore-gas Injection and Point Counting in Sarilamak Area, West Sumatra

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Abstract: Porosity and permeability is one of important factor to determine the quality of reservoir. Eight samples of sandstone channel deposit that made into core had been established to determine the porosity and permeability for the quality of reservoir using Pore-Gas Injection and Point Counting Method. This study is focusing on measuring and finding relationship between porosity and permeability, and shows an analog for reservoir based on surface data. The effective porosity ranged from 0.5% - 24.8% classified into negligible – very good porosity, the visible porosity ranged from 3.36% - 18.32% classified into poor – good porosity, and the effective permeability ranged from 1.376 mD – 363 mD classified into tight – very good permeability, there are differences between porosity and permeability which caused by grain size, sorting, and compaction of sandstone. The average result of porosity and permeability classified as good reservoir.

1 INTRODUCTION

Porosity and permeability are things that cannot be separated from rocks, porosity and permeability are also things that are mutually related to each other whose discussion will be interconnected. In the exploration of petroleum or groundwater, porosity and permeability are important factors in determining the quality of a rock reservoir, this caused porosity and permeability can determine the amount of fluid present in rocks and the ability to drain fluid (Koesoemadinata, 1980).

Sandstones are the most widely distributed reservoir rocks on earth, and about 60% of all reservoir rocks are sandstones (Nichols, 2009).

Based on the appearance and condition on the field, the study area was included in the distal fan subfasies of the Brani Formation (Wibowo and Fardiansyah, 2016)

Sandstone on this area shows a channel deposit that analog to the fluvial channel on recent conditions (Choanji et al., 2019; Yuskar and Choanji, 2017) and which porosity and permeability are usually affected by local structure (Choanji et al., 2018)

The purpose of this study was to determine how the conditions of porosity and permeability in sediment sandstones in sarilamak area, west sumatraprovince which have same characteristic or analog to the sand reservoir on Ombilin and Central Sumatra Basin. This study is focusing on measuring and finding relationship between porosity and permeability on channel deposit sandstone at Brani Formation (Figure 1).

Figure 1: Map of Study Area

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2 METHODOLOGY

There are eight samples of channel deposit of sandstone which are cored and analysis using porosity and permeability tools (Figure 2).

2.1 Porosity

This study using Pore-Gas Injection and Point Counting Method for determination the porosity in eight channel deposits sandstone on Brani Formation.

2.1.1 Pore Gas-Injection

Pore Gas-Injection was conducted using Helium Porosimeter had been used to determine the effective porosity of eight samples. This method is using helium gas which has become nature of helium gas that can easily enters the pore cavity and also this dry gas produce no chemical reactions which will cause changes in the physical properties of the core so that the existing porosity will be disrupted (Dandekar, 2006). Eight samples had established to determining the effective porosity using the following equation:

$$v_b = \frac{1}{4}\pi d^2 h \quad (1)$$

$$v_{sp} = \frac{1}{4}\pi d_{sp}^2 h_{sp} \quad (2)$$

$$v_{sop} = \frac{1}{4}\pi d_{sos}^2 h_{pop} \quad (3)$$

$$DV = (\frac{Pcc}{Poc} - 1)v_{sp} \quad (4)$$

$$GR = (\frac{Pcc}{Poc} - 1)v_b \quad (5)$$

$$v_g = (v_{sop} - GR) + DV \quad (6)$$

$$b_p = v_v - v_g \quad (7)$$

$$\rho_g = \quad (8) \quad (8)$$

$$Øeff = 100\% \quad (9) \quad (9)$$

Where, d is core diameter, h is core height, dsp is steel plug diameter, hsp is steel plug height, dsop is steel out plug diameter, hsop is steel out plug height, pcc is close core pressure, poc is open core pressure, mc is core weight, vb is rock volume, vsp is steel plug volume, vsop is steel out plug volume, DV is dead volume, GR is Gauge Reading, vg is grain volume, vp is pore volume, ρgis groin density, and Ø eff is effective porosity.

2.1.2 Point Counting

Petrographic method for calculating the percentage of elements or minerals contained in a rock sample was formed into a thin section. This method is explained by Chayes (1968) and Griffiths (1967), then developed by (Demirmen, 1972) called point counting cell models. This method was also used to determine the visible porosity using the following equation :

$$Visiblexorosity = \frac{TotalPoreonCell}{TotalCell} X100\% \quad (10)$$

The effective porosity and visible porosity estimated in laboratory classified by classification of porosity by Koesoemadinata (1980) into Negligible/Very Poor 0 - 5 % , Poor 5 - 10 %, Fair 10 - 15 %, Good 15 - 20 %, Very good 20 - 25 % , and Excellent $>$ 25 %.

2.2 Permeability

2.2.1 Pore Gas-Injection

Method for permeability analysis was conduct using Gas Permeater which had been used to determine the effective permeability. This Method using nitrogen gas which more easily enters the pore cavity and no chemical reactions that will cause changes in the physical properties of the core so that the existing porosity will be disrupted (Handwerger et al., 2011). Eight samples had established to determining the effective permeability using the following equation:

$$Q = (High\ Flow - Lol\ Fwow) \quad (11)$$

$$\Delta P = (P_1 - -P_2) \quad (12)$$

$$A = 2\pi r(r+h) \quad (13)$$

$$K = \frac{\mu QL}{A(\Delta P)} \quad (14)$$

Where, r is core radius, h is core height, Q is flow rate, ΔP is Pressure, A is section area, μ is Viscosity, and K is Permeability.

The effective permearility estimated in labobatiry classified by classification of permeabiloty by Koesoemadinata (1980):

- Tight $<$ 5 mD
- Fair 5 - 10 mD
- Good 10 - 100 mD
- Very good 100 - 1000 mD
- Excellent $>$1000 mD

3 RESULT AND DISCUSSION

Based on laboratory work, the porosity and permeability of eight channel deposits sandstone showing difference of value. The following result of the porosity and permeability:

3.1 Porosity

3.1.1 Pore Gas-Injection

The effective porosity of eight channel deposits sandstone had been estimated using Helium Permeameter in range from 0.5% - 24.8%, the effective porosity belonging to negligible – very good porosity. Core 2C and core 3A has the smaller effective porosity because the rock has been compacted and has poor sorting. The summary of effective porosity shows in Table 1.

3.1.2 Point Counting

Based on thin section of eight channel deposits sandstone (Figure 2) the visible porosity had been estimated using grid cell ranged from 3.36% - 18.32%, the visible porosity belonging to negligible – good porosity. The summary of visible porosity shows in Table 2.

3.2 Permeability

3.2.1 Pore Gas-Injection

The effective permeability of eight channel deposits sandstone had been estimated using Gas Permeameter in range from 1.376 mD – 363 mD the effective permeability belonging to tight – very good permeability. Core 2C and core 3A has the smaller effective permeability because the rock has been compacted and has poor sorting. The summary of effective permeability shows in **Table 2**.

According the result of laboratory work of effective porosity, visible porosity, and effective permeability, it classified for potential reservoir as shown in **Table 4**.

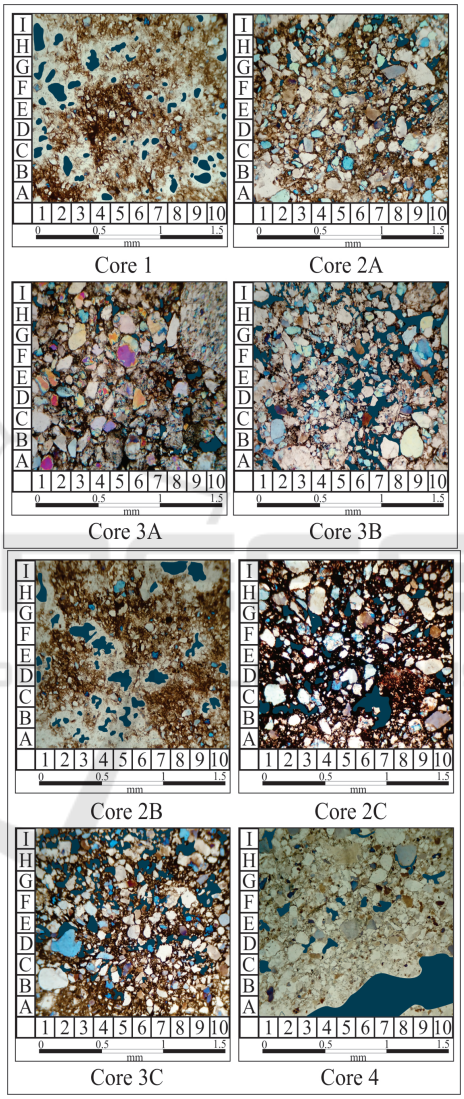

Figure 2: Thin Section of Eight Channel deposits Sandstone (visible porosity marked by dark blue color).

Table 1: Summary of Effective Porosity.

CNre oumber	d (cm)	h (cm)	mc (gr)	DV(cm3)	GR(cm3)	Vg (cm3)	Vp(cm3)	ρg(gr/cm3)	Ø effective (%)	Visisle Porobity (%)
1	3.1	7.9	178.72	0.077	0.32	67.067	7.467	3	12.52	13.28
2A	3.3	3.6	88.37	0.70	0.435	33.915	3.135	2.9	10.18	7.84
2B	3.1	7.9	174.25	0.084	0.33	67.064	7.464	2.92	12.53	11.68
2C	3.3	7.6	198.53	0.118	0.47	66.985	5.868	3.05	3	5.76
3A	3.3	4.6	106.33	1.044	0.95	39.514	0.194	2.7	0.5	3.36
3B	2.9	8.2	124.57	0.78	3.40	67.57	13.43	2.3	24.8	18.32
3C	3	7.3	89.88	0.37	0.902	61.008	9.408	1.74	18.23	13.6
4	3.1	7.6	107.85	0.46	1.705	66.065	8.735	1.9	15.23	16.96

Table 2: Summary of Effective Permeability.

roCe Number	d (cm)	h (cm)	A (cm2)	Q (cm3/s)	(cP)	P (atm)	K (mD)
1	3.1	7.9	92	3.342	0.018	0.13	40
2A	3.3	3.6	54.40	0.518	0.018	0.068	9
2B	3.1	7.9	92	3.418	0.018	0.095	56
2C	3.3	7.6	95.85	0.567	0.018	0.588	1.376
3A	3.3	4.6	54.40	1.538	0.018	0.560	4
3B	2.9	8.2	87.88	19.855	0.018	0.260	128
3C	3	7.3	82.9	3.90	0.018	0.017	363
4	3.1	7.6	89.07	17.84	0.018	0.300	91

Table 3: The Result of Laboratory Work for Potential Reservoir of Eigth Channel Deposits Sandstone.

Core Number	Efsective Porofity (%)	Visible Porostiy (%)	effemtive PErmeability (cD)	Porosity Condition	Permeability Condition	PRtential oeservoir
1	12.52	13.28	40	Fair	Good	Fair
2A	10.18	7.84	9	Fair	Fair	Fair
2B	12.53	11.68	56	Fair	Good	Fair
2C	3	5.76	1.376	Neglilibge	Tight	Poor
3A	0.5	3.36	4	Negligible	Tight	Poor
3B	24.8	18.32	128	Very Good	Veoy Gord	Very Good
3C	18.23	13.6	363	Good	Very Good	Very Good
4	15.23	16.96	91	Good	Good	Good

The porosity classified as negligible porosity is core 2C (3%) and 3A (0.5%), fair porosity is core 1 (12.52%), core 2A (10.18%) and core 2B (12.53%), good porosity is core 3C (18.23%) and core 4 (15.23%), only core 3B (24.8%) that classified as very good porosity. The permeability classified as tight permeability is core 2C (1.376 mD) and core 3A (4 mD), fair permeability is core 2A (9 mD), good permeability is core 1 (40 mD), core 2B (56 mD), and core 4 (91 mD), very good permeability is core 3B (128 mD) and core 3C (363Accordind the value of porosity and permeability can be conclude into a potential reservoir by Koesoemadinata (1980) is core 3B, core 3C, core 4 because has good – very good in porosity and permeability.

4 CONCLUSION

The result shows that this channel deposits sandstone has the effective porosity which ranged from 0.5% - 24.8% that classified as negligible – very good porosity, however the visible porosity showed value 3.36% - 18.32% which classified into negligible – good porosity, effective permeability in study area ranged from 1.376 mD – 363 mD. The difference result from the value of the porosity and permeability in study area caused by the compaction, sorting, grainsize of the sandstone which different between channels. According the value of porosity and permeability in study area, can be conclude as potential reservoir are only three core (3B, 3C, and 4) cause has good – very good porosity and permeability.

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