Analysis the influence of heterogeneity reservoir on RM field

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Abstract. RM field is one of the fields located in Java Island. RM Field has great potential to be developed. In RM field water injection has been done to increase the value of oil production. The purpose of this paper are to find out the effect of heterogeneity on the RM field with dykstra parson and mobility ratio methods. The layers will be analyzed in the RM field were layers 22, 23 and 24. The results of the analysis for the Vdp value at layer 22 is 0.828, the Vdp value at layer 23 is 0.814, and the Vdp value in layer 24 is 0.812. In addition, a mobility ratio analysis was carried out using rock type 1 on the RM field and the M value on rock type 1 was 0.3429. The conclusion is with the dykstra parson analysis, it can be seen that RM field reservoirs tend to be heterogeneous, this is seen from the Vdp value which approaches the number 1, which is equal to 0.812 to 0.828, and with a value of M <1 which means it can produce high sweeping efficiency and produce good oil recovery.

1. Introduction
RM Field is one the fields located in West Java. The main reservoir of this basin is Baturaja Formation. From the characteristics that has been known, RFR Field has a great potential to be developed, and has OOIP value of 203.02 MMSTB.

The purpose of this study is to analyze the effect of reservoir heterogeneity to water injection performance. This study will only discuss about Dykstra-Parson and Mobility Ratio analysis. Reservoir heterogeneity may have good effect than any other factors to water injection performance [1-3]. Application of Mobility Ratio is considered important because it is able to determine sweep efficiency. Sweep efficiency is able to predict water injection performance in specific water injection pattern if mobility ratio has been known [4,5].

2. Methods
Reservoir heterogeneity defined as variation of physical characteristics of rock and fluid from one location to another location. At the low level of stratigraphy, reservoir tend to homogen and more effective for water injection process [6].

The heterogeneity of reservoir is a vital factor when the performance of enhanced recovery project is considered [1]. Detailed heterogeneous models are derived from geological, geophysical and engineering data [2]. There are areal and vertical variations in reservoir properties (porosity, water saturation, critical water saturation etc.), permeability is the most influential factor that affect the water flood performance and main parameter of oil recovery. The heterogeneity is assessed for reservoir permeability based on the well log data available for the area and zone of interest [7-9]. The oil-recovery performance of a reservoir
depends on rock and fluid properties [10]. Ideally, quantification of reservoir heterogeneity should relate to reservoir performance [3].

The vertical sweep efficiency results were correlated as a function of mobility ratio, water-oil ratio and permeability variation [11]. This paper are discussion about mobility ratio dan dykstra parson methods.

2.1. Mobility ratio

Comparison of mobility defined as ratio of fluid effective permeability ratio towards fluid viscosity [12].

Equation for mobility ratio are [13]:

$$M = \frac{\gamma w}{\gamma o} = \frac{krw \mu o}{\mu w (kr o)}$$

Where M is Mobility Ratio, \(\mu_o\) and \(\mu_w\) are the viscosities of the oil and the flood water under reservoir conditions, \(krw\) is the relative permeability to water in the reservoir when only water is flowing, and \(kro\) is the relative permeability to oil when only oil is flowing [4]. If the value of \(M=1\), comparison between oil and water is identical and have same resistance to be able to flow in the reservoir. If \(M<1\), oil flow better than water and it is easier for water to displace oil. This condition generally create higher sweep efficiency, as of will be able to push optimally push oil to surface and eventually produce great value of oil recovery. If the value of \(M >1\), water flow better than oil and it is ineffective to push oil towards surface [5,14].

2.2. Dykstra parson

Dykstra Parson Model is water injection in a reservoir that use multilayer model or 3D model. According to Dykstra Parson Model, factors that affect water injection are: viscosity, mobility ratio, and permeability distribution [14]. Relative permeability is crucial to predicting and modelling oil recovery [15].

Dykstra-Parsons’ V factor is a ratio of vertical to horizontal permeability, or a variation of measured core permeability [8]. Dykstra Parson model describe reservoir heterogeneity vertically in the degree of heterogeneity [12].

The value ranges from zero to unity, zero being completely homogeneous while 1 being a highly heterogeneous system. As a practice, a value of V higher than 0.5 is considered to be heterogeneous [7].

$$Vdp = \frac{K50 - K84.1}{K50}$$

Where Vdp are variation in heterogeneity, fraction K50 are median value of permeability and K84.1 are permeability when the probability is 84.1% [16].

The Dykstra Parson method is still used for water flood performance prediction and analysis, estimating recovery factor, estimate the reservoir’s vertical efficiency and flood pattern selection. [17,18]. One of the common types of heterogeneous systems is the reservoir composed of a number of layers where rock and/or fluid properties vary from layer to layer and the DP method are analyses from layer to layer [18]. Heterogeneity Index can see from Vdp value if Vdp = 0 which means ideal homogenous reservoir and if Vdp value between 0.75 and 1 means extremely heterogeneous reservoir and show reservoir performance is extremely sensitive at large heterogeneity [19,20].

3. Results and discussion

Heterogeneity analysis that will be done in this study is mobility ratio analysis for a rock type and dykstra parson analysis for layer 22-24 [6].

3.1. Mobility ratio

Calculation of mobility ratio (M) is done with 1 rock type. The results of the calculation are as follows:
Rock type 1
Krw @ Sor: 0.107
µo: 0.2939
Kro @ Swc: 0.397
µw: 0.231
Obtained M value on rock type 1 using formula (1) is 0.3429

Form the mobility calculation, obtained the value of M for RM field is less than 1 which means that oil flow better than water and it is easy for water to displace oil. This condition generally create high value of sweep efficiency, so that will be able to optimally pushing oil toward surface and eventually produce good value of oil recovery.

3.2. Dykstra parson
Dykstra parson calculations are performed using formula (2) in each layer with the following results:

Figure 1. Dykstra analysis in layer 22.
Vdp in layer 22 shows that K50 is 35 mD and K84.1 is 6 mD so that the Vdp value is 0.828.

Figure 2. Dykstra analysis in layer 23.
Vdp in layer 23 shows that K50 is 27 mD and K84.1 is 5 mD so that the Vdp value is 0.814.

![Dykstra-Parsons Coefficient](image)

Figure 3. Dykstra analysis in layer 24.

Vdp in layer 24 shows that K50 is 40 mD and K84.1 is 7.5 mD so that the Vdp value is 0.812.

Table 1. Dykstra parson analysis.

| Layer | K50 | K84.1 | Vdp  |
|-------|-----|-------|------|
| 22    | 30  | 6     | 0.828|
| 23    | 22  | 4.5   | 0.814|
| 24    | 40  | 7.5   | 0.812|

Figure 1, 2, 3 and table 1 are summaries of the results of dykstra parson analysis. From the dykstra parson calculation known that Vdp value of field RM is close to one, which means that this reservoir tend to heterogen and it can be seen that the layer which closer to surface is more heterogen and produce smaller value of porosity, so that it is ineffective for water injection. However, another analysis is needed to be conducted to see areal sweep efficiency because dykstra parson calculation is not considering sweep efficiency.

4. Conclusion

From Mobility ratio analysis of RM field on rocktype 1 we obtained the value of M is less than 1. Which means will be produced high sweep efficiency value and great value of oil recovery. RM field reservoir tend to have heterogen characteristics, this is because Vdp value is close to 1 (0.828 until 0.8125). On RM field, the closer the layer to surface the more heterogen it is, it can be seen from the Vdp value.

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References

[1] Jensen J L and Currie I D 2007 A New Method for Estimating the Dykstra-Parsons Coefficient To Characterize Reservoir Heterogeneity SPE Reserv Eng. 5(03) 369–74

[2] Ampomah W, Balch R S and Grigg R B 2015 Analysis of Upscaling Algorithms in Heterogeneous Reservoirs with Different Recovery Processes In Society of Petroleum Engineers (SPE)
[3] Roller C B, Driskill B and Manrique J F 2009 Use of the Allan variance for characterizing reservoir heterogeneity In *SPWLA 50th Annual Logging Symposium*

[4] Johnson C E 2007 Prediction of Oil Recovery by Waterflood - A Simplified Graphical Treatment of the Dykstra-Parsons Method *J Pet Technol.* 8(11) 55–6

[5] Morrison G 2007 *Dykstra-Parsons Water Flood Theory Adapted to Chemical Flood Modelling*

[6] Trisakti S, Fathaddin M T and Sitasremi R 2018 Analisa Pengaruh Heterogenitas Sifat Fisik Batuan Dan Pola Sumur Injeksi Terhadap Efisiensi Pendesakan Minyak Base On Data Simulasi *PETRO*

[7] Kharghoria A, Garcia J G, AlRasheedi K S, Al-Rabah A A K, Sanwoolu A O and Husain H 2018 Assessment of Waterflood Performance in a Heterogeneous Heavy Oil Field in Northern Kuwait In *Society of Petroleum Engineers (SPE)*

[8] Singhal A K and Springer S J 2010 Characterization and Role of Reservoir Heterogeneity in Performance of Infill Wells in Water Flood and Miscible Projects In *Society of Petroleum Engineers (SPE)*

[9] Choi B, Lee K S and Yu K 2015 Permeability-Dependent Retention of Polymer in Heterogeneous Reservoirs In *Society of Petroleum Engineers (SPE)*

[10] Berruin N A and Morse R A 2007 Waterflood Performance of Heterogeneous Systems *J Pet Technol.* 31(07) 829–36

[11] Araque-Martinez A N and Lake L W Sweep Efficiency Estimates for Reservoirs with Nonuniform Layers In *Society of Petroleum Engineers (SPE)*

[12] Craig F F 1971 The Reservoir Engineering Aspects of Waterflooding *In: Climate Change 2013 - The Physical Science Basis*

[13] Khasanov M M, Toropov K V and Lubnin A A 2010 *SPE Russian Oil & Gas Technical Conference and Exhibition*

[14] Smith G E 2007 *Waterflooding Heavy Oils*

[15] Jakobsen S R, Braun T, Ying G and Aga M 2007 Assessing the Relative Permeability of Heterogeneous Reservoir Rock In *Society of Petroleum Engineers (SPE)*

[16] Cartoon M R 2010 The Effects Of Reservoir Heterogeneity On Predicted Waterflood Performance In The Dodsland Field In *Society of Petroleum Engineers (SPE)*

[17] Muradov K M, Prakasa B and Davies D 2008 Extension of Dykstra-Parsons Model of Stratified-Reservoir Waterflood To Include Advanced Well Completions *SPE Reserv Eval Eng.* 21(03) 703–18

[18] Gulick K, Mc Cain and William D 2007 *Waterflooding Heterogeneous Reservoirs: An Overview of Industry Experiences and Practices*

[19] Shehata A M, El-banbi A H and Sayyoub H 2012 Guidelines to Optimize CO2 EOR in Heterogeneous Reservoirs In *Society of Petroleum Engineers (SPE)*

[20] Rashid B, Muggeridge A, Bal A-L and Williams G J J 2012 Quantifying the Impact of Permeability Heterogeneity on Secondary-Recovery Performance *SPE J.* 17(02) 455–68