Application of Hydrodynamic Potential Analysis to Investigate Possibility Reservoir Connectivity between Neighboring Gas Fields

(Penggunaan Analisa Hydrodynamic Potential Untuk Meneliti kemungkinan Konektifitas Reservoir di antara Lapangan Gas yang Berdekatan)

Tri Firmanto1*, Fathaddin M T2, R. S. Trijana Kartoatmodjo2

1Kangean Energy Indonesia Ltd, Jakarta
2Master Program of Petroleum Engineering, Universitas Trisakti, Jakarta

Abstract

*T field is a producing gas field in North Bali PSC, which currently producing 210 mmscfd from paciran sand stone formation. Paciran formation extends more than 20 km across the PSC area, which consists of 3 developed gas fields and one potential development field. The flowing material balance analysis conducted on T field suggests possibility of reservoir connectivity between this field and its neighboring fields. Even though each field is already have a well defined Gas Water Contact, a thorough investigation was done using hydrodynamic potential analysis to see if there is any hydrodynamic potential that allowed connectivity between these fields, and enable tilted contact occurred between these field. Using pressure data taken from each fields exploration wells the analysis can be conducted that conclude that there is an existing hydrodynamic potential between gas fields in paciran formation. A review on the tilted contact analysis concludes that the existing hydrodynamic potential is not enough to tilt the contact as per actually observed contact.

Keywords: Gas Field, Hydrodynamic, Flowing Material Balance, Tilted Contact

Sari

Lapangan T adalah lapangan produksi di North Bali PSC, yang saat ini memproduksi sebesar 240 MMSCFD dari formasi paciran sand stone, Formasi paciran terbentang lebih dari 20 km di areal PSC, dimana di dalamnya terdapat 3 lapangan gas yang sudah dikembangkan dan satu lapangan yang potensial untuk dikembangkan. Flowing material balance yang telah dilakukan di lapangan ini memberikan kesimpulan adanya kemungkinan konektifitas antara reservoir yang teradapat di lapangan T terhadap lapangan lainnya di Paciran formation. Meskipun semua lapangan sudah memiliki Gas water contact yang sudah terdefini dengan baik, analisa hydrodynamic potential dialakukan untuk melihat apakah ada konektifitas antar lapangan yang ada di paciran formation dan mempengaruhi terjadinya tilted water contact di lapangan ini. Berdasarkan analisa yang telah dilakukan dapat disimpulkan bahwa terdapat hydrodynamic potential di antara lapangan – lapangan yang ada di formasi paciran. Review dari tilted contact analysis yang telah dilakukan mendapatkan hasil bahwa hydrodynamic potential yang ada tidak cukup besar untuk dapat menghasilkan tilted contact yang di observasi.

Kata-kata kunci: Lapangan Gas, Hydrodynamic, Flowing Material Balance, Tilted Contact

*Corresponding Author:
E-mail: trifirmanto@gmail.com
Telp : +62-8121003190

I. INTRODUCTION

* T field is a gas producing field in north bali PSC area. The field was discovered in 1982 and currently producing with rate 240 MMSCFD from the paciran sandstone formation with a very good permeability of 1000 md and porosity of 30%. Paciran formation widely extended in the PSC area on which a total of one potential development field three developed gas fields including the currently producing T field.

A detail set of subsurface data was obtained during the exploration phase on wells in each field, including a detailed pressure survey that extends all the way to the aquifer. Review of the current production performance of T field shows that there are possibilities of additional volume that can be recovered by this field.

A static material balance analysis shows a typical water drive reservoir as shown in figure 1. Lack of significant water production from this field suggest that there are other possibilities beside typical aquifer drive. Analysis had been conducted using flowing material balance shows a larger GIIP range of the T reservoir and one of the possibilities is due to connectivity with another gas tank (Firmanto, 2017).
Figure 2 shows the result of the flowing material balance analysis that shows potential of additional GIIP volume in T field.

Analysis of the potential connectivity of T field with another gas tank will require a review of connectivity between this field and its neighboring fields.

II. CONNECTED RESEVOIR REVIEW

2.1 Neighboring fields Connectivity Review

Reviewing the potential field that connected to T reservoir in the paciran formation begins by analyzing the field connectivity across the paciran formation as show in Figure 3. Almost all fields have already had a clear gas water contact and clear structural boundary, except K field. K field, which is located 8 km east of T field, have a gas water contact the below the spill points between K and T field as shown in Figure 4. One of the possibility that will be further investigate in this paper is possibility of tilted contact between T and K field.

2.2 Hydrodynamic Potential Review

Hydrodynamic potential is essentially the hydrostatic pressure within the reservoir aquifer that during the initial condition already in dynamic condition. Wells (1988) had established a simple way to understand about hydrodynamic in reservoir, which essentially the hydrocarbon contact tilt inside the reservoir can occurred if there are different in hydrodynamic potential. The tilt will occur from the higher dynamic potential to the lower hydrodynamic potential. Figure 5 shows the illustration of hydrodynamic potential within a reservoir system.

Dennis et. al. (1998) had listed the relevant simple equation that can be used to investigate T field hydrodynamic potential.

\[
\frac{dz}{dx} = \frac{dp}{dx} = \frac{dp}{dh_{w-h}}
\]

where:

\[
\frac{dz}{dx} = \text{dp per unit length of OWC},
\]

\[
\frac{dp}{dx} = \text{pressure gradient lateral in the aquifer},
\]

\[
\frac{dp}{dh_{w-h}} = \text{difference of water and hydrocarbon pressure gradient}.
\]

III. PACIRAN FORMATION HYDRODYNAMIC POTENTIAL ANALYSIS

Analysis was done using pressure data from all available wells in all fields in paciran formation. A total of 8 wells data were used and the review was done by comparing the pressure gradients of each well in each fields. As mention earlier, hydrodynamic is focusing the attention in the aquifer part, hence a more detailed analysis need to be conducted in the water gradient part of the data. Figure 6 shows direct comparison of all paciran formation pressure gradients. It is shown in the analysis that gas gradient for every fields is the same, which on the pvt analysis data confirmed the gas composition of each fields is the same.

Comparing the water gradient of each fields and rearranging the analysis with the example given by Wells (1988) concludes that there are different in hydrodynamic of each fields in the paciran formation. The analysis shows that there are potential that the contact tilted across the paciran formation getting deeper from the west to the east side, due to hydrodynamic potential in the T field is the highest compare to the other fields.

IV. HYDRODYNAMIC CALCULATION

Calculation was conducted, using formula that had been explained by Denis et al (1998) as explained above. Detailed calculation is shown in Figure 7.
Calculated dynamic potential shows a tilting potential of 8.4 ft/km, which means every km, the gas water contact will be 8.4 ft deeper. Calculating the distance between the T field and the other fields in Paciran formation we can calculate the expected additional contact depth changes in the other field. It is found that the calculated contact changes are much lower than the observed actual contact changes.

IV. CONCLUSIONS

Conclusion that can be drawn from the analysis that had been conducted is as follow:
1. Hydrodynamic potential across Paciran formation is proven, based on consistent different between T water gradient and the other fields across the paciran formation.
2. Presence of hydrodynamic potential only proves that the fields are connected in the aquifer.
3. The calculated contact tilt is much lower than actual contact tilt observed. This result conclude that T reservoir hydrocarbon is not directly connected to K field. Possibility of additional gas tank that support T field production from K field is not proven.

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REFERENCES

Figure 5. T Effect of hydrodynamic behavior on oil and gas accumulations (Wells et all. 2015)

Figure 6. Pressure Gradient Across Paciran Formation
Hydrodynamic Tilt of Water Contact: Dip Per Unit Length of GWC

\[ \frac{d}{dh} = \frac{dp}{dh} \frac{dx}{\Delta h} \]

**Lateral Pressure Gradient Difference in Aquifer (dp/dx)**

<table>
<thead>
<tr>
<th>T (psi)</th>
<th>B(psi)</th>
<th>delta, Psi</th>
<th>dp/dx psi/km</th>
</tr>
</thead>
<tbody>
<tr>
<td>1520</td>
<td>1510</td>
<td>10</td>
<td>1.25</td>
</tr>
<tr>
<td>1662</td>
<td>1532</td>
<td>30</td>
<td>1.5</td>
</tr>
</tbody>
</table>

**Vertical Pressure Gradient Difference (dp/dh)**

\[ \frac{dp}{dh} \] (water) = 0.435 psi/ft
\[ \frac{dp}{dh} \] (gas) = 0.030 psi/ft
\[ w - h \] = 0.405 psi/ft

\[ \frac{dz}{dx} = 3.70 \text{ ft/km} \]

**Additional tilt Multiplier**

\[ \tan \Phi = \frac{\Delta z}{\Delta x} = \frac{\rho_w - \rho_g}{\Delta x} \]

Tilt Mult: 2.272727
Tilt mult x dz/dx: 8.417508 ft/km

**Lateral Distance (dx)**

- T to B: 8 km
- T to S: 20 km
- T to K: 8 km

**Calculated Contact Depth Changes (dz)**

- T to B: 67 ft
- T to S: 74 ft
- T to K: 67 ft

**Actual Observed Contact Depth Changes**

- T to B: 854 ft
- T to S: 1103 ft
- T to K: 316 ft

Figure 7. Hydrodynamic calculation Result