An Effective Method for Optimizing a Complex Compartmentalized Field: Achieving a ~700 BOPD Oil Gain through Reactivation of Idle Wells to Sustain Production – A Pilot Case at Well Falcon#20

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Abstract. The Special Task Force for Upstream Oil and Gas Business Activities (SKK Migas) has established a reactivation program in 2023 to reach 1.086 idle wells in Indonesia to increase oil and natural gas production, especially to achieve the oil production target of 1 million BOPD in 2030. There are 10.398 idle wells in Indonesia. However, not all have the potential to be reactivated for one reason or another, such as the absence of subsurface potential or unfulfilled economics due to high-cost reactivation. This research presents an integrated reservoir management method to define reservoir compartments with the aim of finding potential bypassed oil on idle wells. The methods used consist of facies analysis, well correlation, and reservoir connectivity analysis using reservoir pressure and production data.

Pertamina Hulu Rokan is accelerating the reactivation of 500 idle wells in several fields to boost oil production in 2023, one of which is the Falcon field. Falcon oil field is a small mature field located in Central Sumatra Basin approximately 65 km northwest of Pekanbaru. The oil is produced from Lower Miocene sandstone reservoirs with structures that are anticline with a major north-south trending fault. Geological structure development of the Falcon field is also complicated by secondary tensional faults along the northern part of main fault make several complex compartments of Lower Miocene reservoir sands. This provides for a combination of structural and stratigraphic entrapment around this fault.

The secondary fault acts as seal fault, restricting connectivity of reservoirs in between where it shows different fluid contacts across the fault. This divides the Falcon field into five compartments. Reservoir heterogeneities at the scale of facies differentiation of a tidal bar complex environment has also affected reservoir compartmentalization. Integrated reservoir connectivity analysis using reservoir pressure and production data from active well producer validation determines reservoir compartments and provides new insights to discover potential bypass oil in idle wells near secondary faults even on the flanks of the area.

This method has been applied to Well Falcon#20 and has put well back on production and increased production with peak oil rate of ~700 BOPD from this well. The outcome of the reactivation program was completely successful and exceeded the expectations which will be beneficial for value of information in capturing optimization and development opportunities especially on area near secondary fault. Since the application of these methods, the Falcon field has improved fluid production by up to ~35%. This method has been effectively used in the Falcon field and has the potential to be replicated and applied to other fields with complex compartments.
Keywords: Compartment, idle well, Central Sumatra Basin

1. Introduction

The Special Task Force for Upstream Oil and Gas Business Activities (SKK Migas) has instituted a reactivation initiative in the year 2023 aimed at addressing the 1.086 idle wells across Indonesia to augment the production of oil and natural gas, particularly with the objective of attaining the oil production target of 1 million BOPD by the year 2030. Within Indonesia, there exists a total of 10,398 idle wells (Ditjen Migas ESDM,2022). Nonetheless, it should be noted that not all of these wells possess the viability for reactivation due to various factors, including the lack of subsurface potential or economic infeasibility attributed to the elevated costs associated with reactivation.

PT Pertamina Hulu Rokan – a subsidiary of PT Pertamina Hulu Energi Regional 1 – is accelerating the reactivation of 500 idle wells in several fields to boost oil production in 2023, one of which is the Falcon field. Falcon oil field – a small waterflood field in Rokan Block – is located in Central Sumatra Basin

approximately 65 km northwest of Pekanbaru City in Riau Province (Figure 1.). The oil is produced from Lower Miocene sandstone reservoirs with structures that are anticline with a major north-south trending fault.

Geological structure development of the Falcon field is also complicated by secondary tensional faults along the northern part of main fault make several complex compartments of Lower Miocene reservoir sands. This provides for a combination of structural and stratigraphic entrapment around this fault. Analysis of geological and rock properties on a layer-specific basis may uncover opportunities within mature reservoirs. This research presents an integrated reservoir management method to define reservoir compartments with the aim of finding potential bypassed oil on idle wells.



Figure 1. The Location of Rokan Block in PT Pertamina Hulu Rokan (Riau Province, Sumatera Island, Indonesia).

2. Data and Methodology

In the Falcon field, efforts are being intensified through the reactivation of idle wells. The process for identifying optimal candidates involves several steps, including facies analysis and well correlation for static data. The static data is validated by reservoir connectivity analysis using reservoir pressure and production data to boost confident level of by-passed oil potential. Figure 2 illustrates an integrated and comprehensive analysis to identify unrevealed opportunities in a mature field, enabling the reactivation of idle wells.

2.1. Lookback Previous Job Analysis

As part of the continuous improvement process, taking a lesson learned from a previous job is important. There will be some specific parameter correlations identified during this process. Those parameters include well location in depth structure, production history, wellbore integrity and fish/junk problem, surface facilities readiness, latest oil saturation based on saturation log result.

2.2. Stratigraphy and Well Correlation Analysis

Correlation analysis was conducted to develop and enhance stratigraphic markers in the field, grounded in the principles of sequence stratigraphy. Subsequently, subsurface mapping employing a deterministic methodology was executed to establish a structural framework and elucidate the distribution of facies within the reservoir. The method of determination is accomplished through the creation of a facies map that utilizes the similarities in patterns of petrophysical values and the structural-textural characteristics of sedimentary rocks, utilizing core data as the foundational input.

2.3. Reservoir Connectivity Analysis

The compartmentalization of reservoirs transpires when the flow of fluids and the interconnectivity between them are constrained. An analysis of reservoir connectivity is imperative for the identification of compartmentalization and for obtaining enhanced insights into the geological determinants. The static model, formulated through facies and well analysis, is subsequently supported by reservoir pressure and production data.

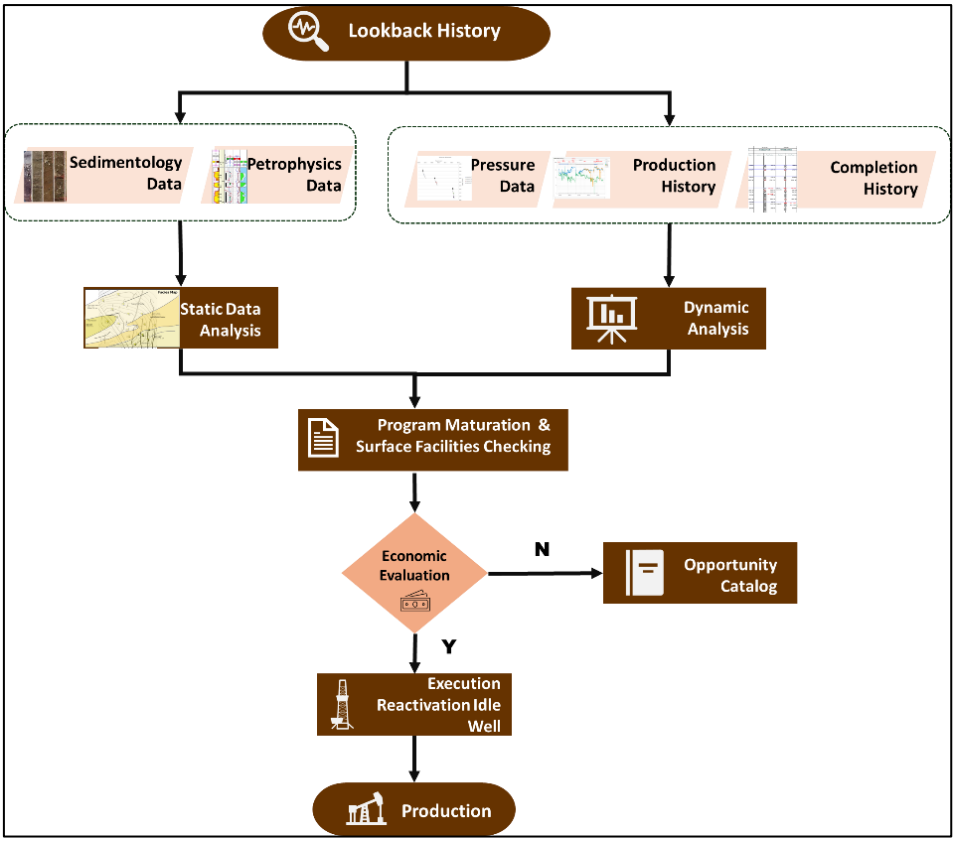


Figure 2. Flowchart of process evaluation to get recommendation for reactivation.

3. Results and Discussion

3.1. Facies Map

The "A" sand formation represents a noteworthy reservoir within the Falcon Field due to its intricate stratigraphy, which has hindered its optimal exploitation. The facies map of the Falcon Field "A" reservoir (Figure 3) illustrates the distribution of depositional environments corresponding to each equivalent sand. Each reservoir exhibits distinct facies characteristics that are contingent upon sedimentological and petrophysical attributes. The depositional environments of these reservoirs originate from tidal bar complex settings. In the context of regional paleogeography, the Falcon Field is situated within the Duku-Sebanga delta-estuary complex as well as the northern lobe of the Minas Delta Complex. The paleo water depth of the "A" sand is interpreted to range from intertidal to inner neritic, with a predominant depositional trend oriented in a NE-SW direction. Within the Falcon Field, the "A" sand is classified as a medium-quality reservoir, characterized by porosities ranging from ~14% to 18% and permeabilities between ~270 to 850 mD. The reservoir sands are classified as fine to very coarse grained, exhibiting an overall tendency towards fining upward.

Reservoirs with better quality are located in proximal mid tidal bar and tidal channel that have an average permeability of more than 500 mD. The distribution of these facies is located in the northern and southern areas of Falcon field. However, by-passed oil potential is located in lower quality reservoirs in proximal margin tidal bar environments with average permeability around 100-300 mD at central area of Falcon field.

3.2. Structural Framework

The tectonism of the Central Sumatra Basin has various combinations, from extensional rifting during the basin formation up to compressional regime during the Mid-Miocene uplifting (Heidrick and Aulia, 1993). Falcon field is in the middle of the Central Sumatra Basin, in an area which is highly deformed and has a complex structural framework (Mertosono, 1975). Falcon field is a small field with domal structural high located on the northeastern side of the main fault (Figure 4.). Falcon fields are broken-up by a complex system of faults into individual blocks. Since the faults are sealing, each block has its

own oil-water contact which tends to complicate development of the fields. The secondary tensional faults along the northern part of main fault make several complex compartments of Lower Miocene reservoir sands.

The secondary fault acts as seal fault, restricting connectivity of reservoirs in between where it shows different fluid contacts and pressure across the fault. This divides the Falcon field into five compartments. The existence of this fault results in the opportunity for bypassed oil to exist in wells located in the flank area. Falcon#20 is a well located in compartment 5 in the Falcon field. This well has been included in the idle well since 2015.

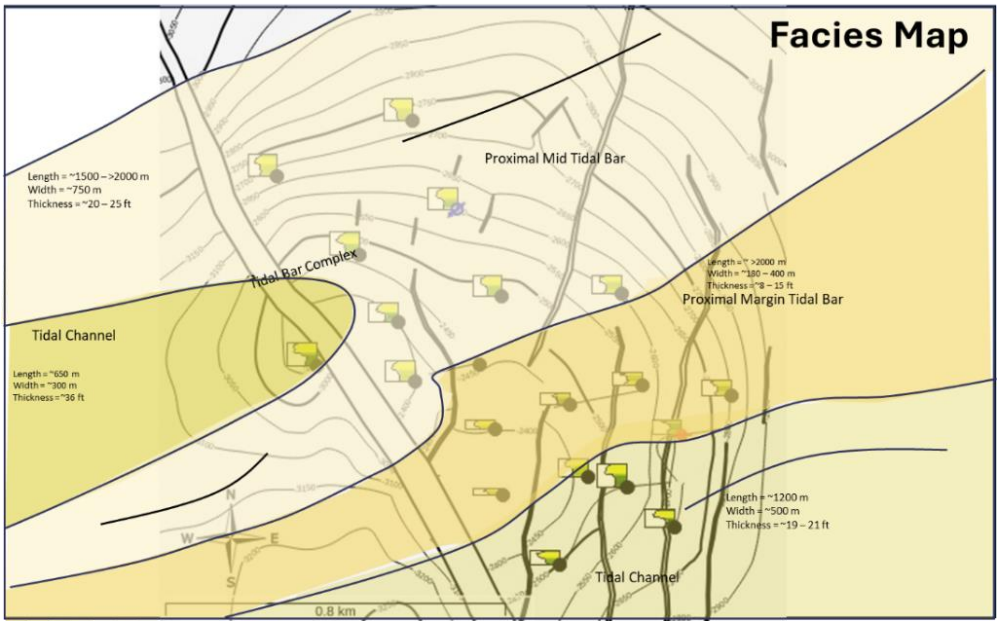


Figure 3. Facies Distribution of "A" sand in Falcon Field.

3.3. Reservoir Connectivity

Reservoir heterogeneities at the scale of facies differentiation of a tidal bar complex environment has also affected reservoir compartmentalization. Integrated reservoir connectivity analysis using reservoir pressure and production data from active well producer validation determines reservoir compartments and provides new insights to discover potential bypass oil in idle wells near secondary faults even on the flanks of the area. Pressure analysis on the 4 newest wells in the Falcon Field shows differences in pressure trends in each compartment (Figure 5.). Compartment 3 has a pressure gradient of 0.16 psi/ft which is different from compartment 4 with a value of 0.22 psi/ft and the highest is in compartment 5 with a pressure gradient value of 0.307 psi/ft.

The difference in oil water contact in each compartment is also used in reservoir connectivity analysis. Falcon#7 in compartment 3 already has oil water contact around 2460 ft TVDSS, but in Falcon#21 in compartment 4 which is more downdip there is still oil and have oil water contact at 2500 ft TVDSS. Likewise, Falcon#22 in compartment 5 which was last drilled at 2700 TVDSS still has oil potential (Figure 6.). Oil opportunities are also impacted by facies. Proximal margin tidal bar in all compartments have bypassed oil opportunity due to reservoir quality. Falcon#20 is a good reactivation candidate because "A" sand in this well has not been producing since 2013 because it moved to more promising sand at that time. The well located in downdip, Falcon#10, had production with Water Cut around 96% in 2006 and Falcon#22 had water cut 80% in 2015 indicating that in Falcon#20 there is still oil that can be optimized.

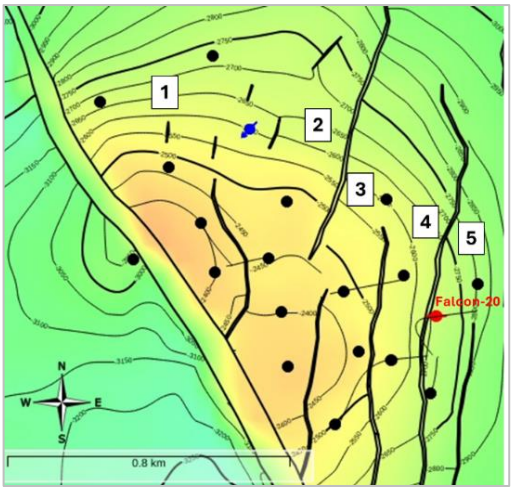


Figure 4. Depth Structure Map of "A" Sand Falcon Field.

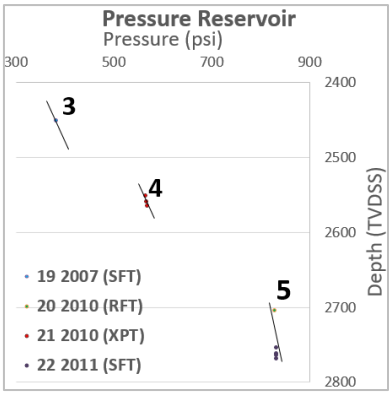


Figure 5. Pressure Analysis from "A" Sand of Falcon Field shows differences in pressure gradient in each compartment.

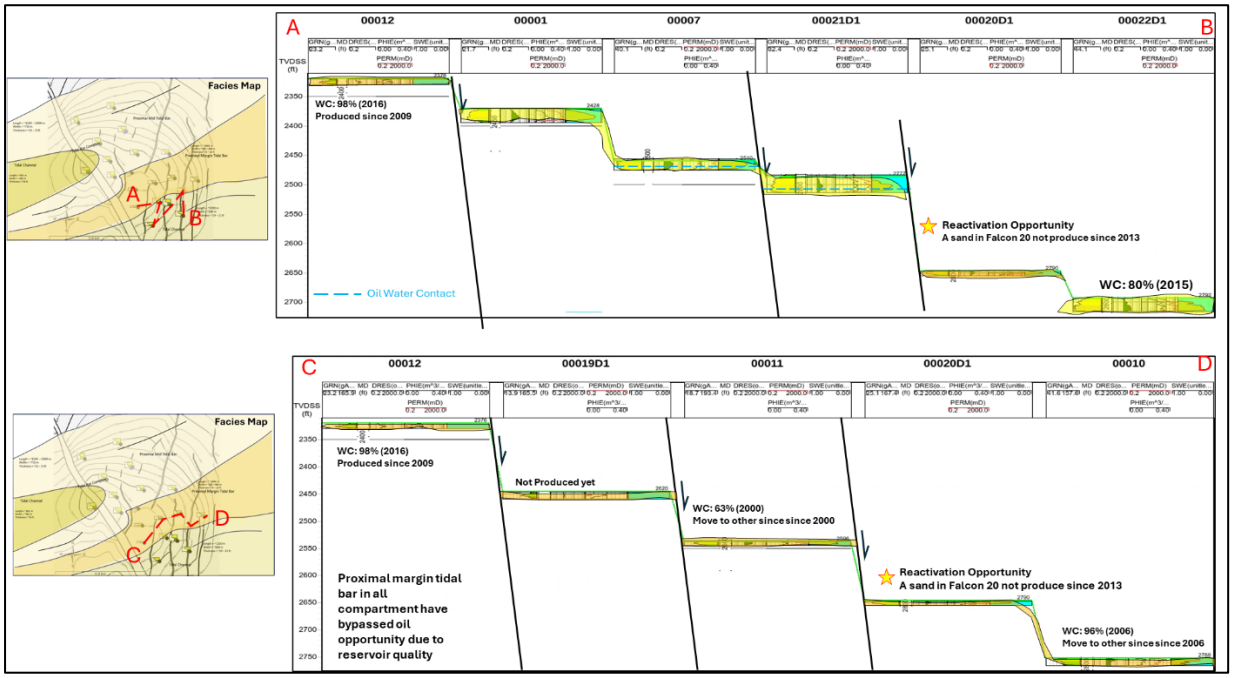


Figure 6. Cross Section A-B shows differences in oil water contact in each compartment. Cross section C-D shows proximal margin tidal bar have bypassed oil opportunity on all compartments.

3.4. Wellbore Integrity and Surface Facilities Readiness

The success of a workover need avoids well bore integrity issue. The most common well integrity issues involve fluid migration through leakage pathways. Various safety barriers are employed in wells to minimize potential leakage and can be confirmed by Cement Bond Log (CBL) data (Raj Kiraj, et al. 2017). This well Falcon#20 already has good CBL (<10 mV) data and unwanted leakage pathway can be avoided. All required surface facilities (such as wellhead, flowline, and electricals) are already installed to support the well reactivation program.

3.5. Well Production (Before and After).

High-resolution stratigraphy approach analysis by layer sand is proven for revealing hidden opportunity in Falcon Field. This approach identifies Falcon#20 and has already been executed with outstanding results with peak oil rate gain ~700 BOPD and total recovery within 1 month ~7 MBO where contribute ~35% of total field production (Figure 7.). This Falcon#20 well is an oil producer well that has long

been shut down with Long Term Closed (LTC) status since 2015 for reasons of being uneconomical. This approach successfully unlocks the opportunity of this idle well.

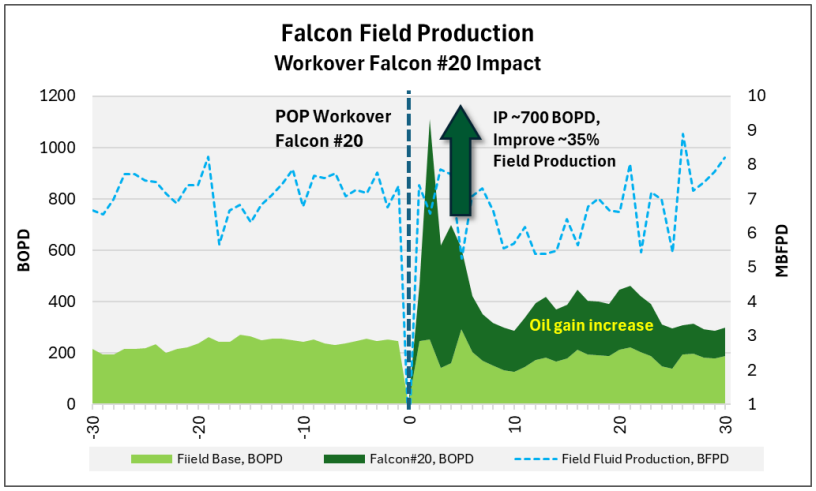


Figure 7. Falcon#20 Impact production to Field Overall Production.

4. Conclusions

The outcome of the reactivation program was completely successful and exceeded the expectations which will be beneficial for value of information in capturing optimization and development opportunities especially on area near secondary fault. Since the application of these methods, the Falcon field has improved field production by up to ~35%. This method has been effectively used in the Falcon field and has the potential to be replicated and applied to other fields with complex compartments.

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