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Successful Application of Imaginary Stratigraphy Boundary from Production Mapping for Infills Project in Mature Fields, Central Sumatra Basin, Indonesia

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Successful Application of Imaginary Stratigraphy Boundary from Production Mapping for Infills Project in Mature Fields, Central Sumatra Basin, Indonesia

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Abstract

Locating successful infill wells in mature field is challenging due to dense well spacing and low production performance. Four infill wells were proposed in 2017 to improve oil recovery from 2 mature fields in Rokan Block of Central Sumatra Basin with producing up to 98% water cut. Direct vertical assessment from stratigraphy analysis does not always relate to actual production performance. COWC does not seem to raise up homogenously across the field based on correlation between field structure and well perforation depth. Delineating sweet spot area based on production attribute mapping can assist more reliable stratigraphic imaginary boundary to define surface location and subsurface target for infills. Production attribute mapping is used to qualitatively interpret fluid distribution and potential of current remaining oil in the field. Focus of reservoir objective analysis can be done thru well correlation by posting surrounding well perforation interval and outline area of interest from the mapping above. The drilling result has confirmed that this method works effectively and can be used to justify new infill well projects to prove the concept of bypass oil possibility in mature oil fields. The new wells are completely drilled and POP by April 2018. Production performance from those four new wells are showing incremental production up to 1800 BOPD with average 70% water cut. Result from this simplified approach can also be useful for identifying fluid movement pattern and helpful in avoiding areas that would yield poor infill drilling results.

Keywords: subsurface mapping, stratigraphic analysis, field development, mature basin

1. Introduction

The Tertiary back arc basin Central Sumatra Basin (CSB) is bound to the southwest by the Barisan Mountains anticlinal uplift and volcanic arc, to the north by the Asahan arch, to the southeast by the Tigapuluh high, and to the east by the Sunda craton (figure. 1). The Lower and Middle Miocene sediments in the Central Sumatra Basin are comprised of several lithological units, including the productive reservoirs, which are related laterally by facies changes (Yarmanto, 2010).

Mertosono and Nayoan (1974) proposed a five-fold subdivision for the Cenozoic rock-stratigraphic units in the Central Sumatra Basin. The five units include (oldest to youngest), the Pematang formation, Sihapas group, and Telisa, Petani, and Minas formations. Figure 2 generalizes the time-rock stratigraphic succession and indicates the temporal limits of the three major episodes of structural development within Central Sumatra Basin

Identifying sweet spots for infill drilling based on potential remaining oil prognosis are important for reducing subsurface uncertainty and improving economics of proposed well recommendation in mature basin such a CSB. In CSB, new infill drilling project is still economically attractive to execute in mature fields if the proposed infill wells meet or even exceed economics hurdle parameters, which are mainly affected by project cost, reserves estimation and production forecasting. Reducing project cost to improve likelihood of well prospecting recommendation is out of scope of this paper.

However, one of the most important matters that make analysis in mature fields relatively challenging is aligning recommendation from static geological-geophysical (G&G) interpretation to dynamic production data.

In general, the well prospecting evaluation is following reservoir management study. G&G evaluation is starting from well correlation, review the existing subsurface maps, and end up with play identification for infills either structural or stratigraphic concept. In addition, production rate as the factual live data is the most frequently and easily accessed data in mature fields. However, this production data is commonly analyzed and presented as individual well analysis instead of map presentation.

Combining production data as an attribute of common static map is proven useful in well prospecting in 2 different mature field in Rokan Block.

2. Methodology

The integrated reservoir characterization is essential to developing a full understanding of current field condition and predicting how it will perform.

G&G static data used consist of corresponding interpretation products such as evaluated logs, cross-sections, depth structure map, and original hydrocarbon pore thickness (HPT) map. Production data input are obtained from production test result including oil- cut (%), fluid rate, and last three years cumulative oil production. After several attempts in gridding all production data, seems grid oil-cut is the best one that has alignment with geological framework interpretation. This oil cut map than used as soft constrain data in building current hydrocarbon pore thickness map. The current HPT map is simply obtained by multiplying original HPT map with oil cut (%) data from the last production test data.

The current HPT map can be used as direct indicator to locate sweet spot area for infill. Lateral variation in current HPT map is considered as imaginary stratigraphy boundary for infills purposes.

Interpreted well correlation with additional information from production data such as perforation interval, lowest perforation depth, and production test data is also used in defining reservoir objectives for well prognosis. This correlation is appropriate to describe reservoir vertical heterogeneity and conformance.

3. Case Study

3.1 AMP Infill 2017

AMP field is an oil field located 25 km south west of Duri Field, Riau Province (figure 3). AMP field is in Central Sumatra Basin and its included in Rokan PSC which operated by PT Chevron Pacific Indonesia with participating interest 100% until contract limit August 2021.

Structurally, AMP field is compartmentalized into 5 blocks: A, B, C, D, and E. NW – SE oriented thrust fault at C, D, E block is bounded this field with another field in the west (figure 4). Stratigraphically, AMP field has all formation in Central Sumatra Basin. It has more than 10 producing sandstone reservoirs, but Bekasap reservoirs are the main producers. Figure 5 is showing north-south reservoir continuity across the field.

AMP field was discovered in June 1981 based on drilling result of exploration well AMP-01 where initial oil production was 1645 BOPD and water cut 8%. The field peak production was 5258 BOPD achieved in 1988. As of January 2017, AMP field has 26 wells. Since 2015 waterflood project has been initiated to maintain the decline rate at the level of 29% until at the end of contract life.

Having good response indication from waterflood activity, Asset Development Team in 2017 conduct subsurface evaluation to identify infill drilling opportunity within 200 meters well spacing. The objective of infill project is to recover estimated remaining oil potential from reservoirs in Sihapas Group, mainly Bekasap Formation. Pematang reservoir is considered having less opportunity since the reservoir only develop in Block D and E.

Project Team initially proposed 4 directional wells, but further technical and economics assessment shows only 2 wells have higher confidence level. Figure 6 is showing proposed well location and rank based on confidence level.

3.2 PTN Infill 2017

PTN Field is one of the biggest fields in Sumatera Light Oil North Asset of Chevron Pacific Indonesia in Central Sumatera Basin, Rokan PSC. PTN Field is located 10 km from Duri field (figure 3).

PTN field is a NW-SE trending anticlinal structure bounded on the southwest by a major reverse fault (figure 7). PTN Field has total 25 reservoirs from Bekasap, Bangko, Menggala, and Pematang Formation. Figure 8 is showing reservoir continuity across the field.

PTN field was discovered in December 1964 and commenced to oil production in December 1968 with IP of PTN-001 is 17,000 BOPD with 0.5% WC. PTN Field has peak production in 1971 from 11 wells around 100,000 BOPD produced from Menggala and Pematang formation. In 2008, pilot waterflood applied in PTN Field in southern area with targeted Bekasap sand. Current field production is 5,541 BOPD and 94% water cut. Oil cumulative has reached 47% RF of total OOIP. As of January 2017, PTN field has 127 wells.

Although currently field is producing with high water cut, at some area bubble production map still showing significantly lower water cut (+/- 70%) suggesting remaining potential in the field (figure 9). Based on that finding, new infill project was initially proposed six new infills in 2017 to develop unrecovered oil within 200-250 meter existing well spacing. However, the actual well drilled is only two wells because based on economic assessment, drilling 2 infills will yield the highest value creation. Directional well type was selected as preferred alternative because the wells will be targeting multiple reservoirs based on assessment to the existing wells that currently produced by commingling two or more reservoirs from Bekasap to Pematang Formation.

4. Result and Discussion

A total of four wells were drilled in AMP and PTN field from January to February 2018 period. Oil production are being on streamed to the pipeline on March 2018. Production attribute maps and updated current HPT map was applied during well prospecting in 2017. Both maps are showing specific pattern in AMP and PTN field. The different contrast color can be used to distinguish reservoir quality and may be related to lateral facies variation. In general, hotter color is interpreted as high remaining oil accumulation in HPT map and good oil production in production attribute map.

There are three cluster area that can be distinguished in PTN field based on the attribute maps, which are North, Central, and South (figure 10). The north cluster is opportunity to develop stratigraphic play in flank area. Central area is the high dense well location and attic area. South area is similar to the north cluster where opportunity to develop stratigraphic play concept for the infill. The last 2 drilled wells in PTN field are in central (PTN-128) and south (PTN-129) cluster.

Good reservoir quality is observed with northeast-southwest direction from HPT and production map in AMP field as shown in figure 11. The last 2 drilled wells in AMP field are in block B (AMP-27) and block C (AMP-28). Structurally, both wells are located in flank area.

Based on post mortem evaluation to all drilled wells as shown in table 1, all the proposed wells are fairly meet or even exceed the technical expectation, as none of the proposed wells are resulting zero oil production.

The negative variance in the table means the actual value is lower than the expected value. Conversely for the positive variance. The negative variance appears in AMP-28 and PTN-128. PTN-128 shows negative variance in initial production (IP) because completion is not fully optimized as currently too many sand open commingled. AMP-28 has negative variance in pay thickness but still in the acceptable range of +/- 10%. However, the well could reach peak production up to 1000 BOPD, the highest peak production among others.

From interpreted well correlation, both fields are showing good reservoir continuity. However, producer performance is showing distinguish variation laterally. This study has shown that by taking advantage from the lateral variation of production performance, uncertainty in infill wells proposal can be minimized. The application of this study may not be limited to field development only, but also possible to be applied for first pass and preliminary assessment in field optimization review. For instance, injectors placement in waterflooded field. Selecting good location for injector from these 2 maps are the opposite of selecting good location for infills. For infills proposal purposes, the brightest color will be the preference of proposed location. Conversely, suitable location for injectors are in the cold color area.

5. Conclusion and Recommendation

Based on the explanation above, some key takeaways from the study are:

1. The applied mapping method is simple and quick since it used the most common accessible geological and production data in mature field
2. Production data display in map can be a good driver for geologist to investigate furthermore detail stratigraphic analysis
3. Variation of production data laterally may reflect to reservoir quality different and may relate to facies changes although the logs correlation is not showing.
4. Utilizing integrated dynamic attribute mapping of HPT and production can yield better visualization of current fluid production condition
5. The application of this method is not only limited for new infill purposes but also may be useful in supporting daily base business activity in asset optimization team.

6. Acknowledgement

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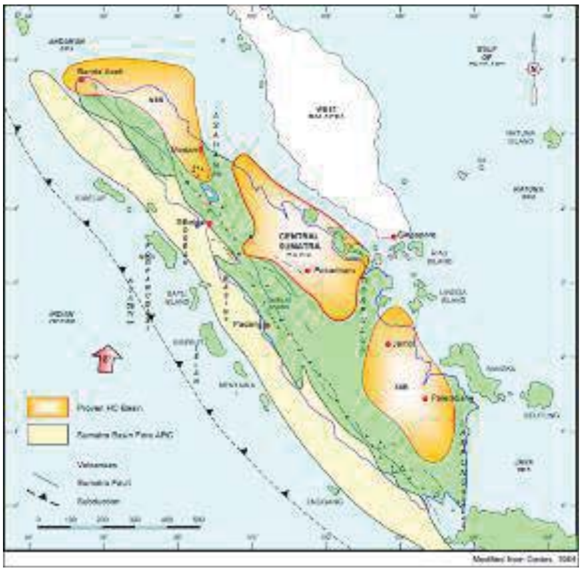

Figure 1. The Central Sumatra Basin, Tertiary back arc basin

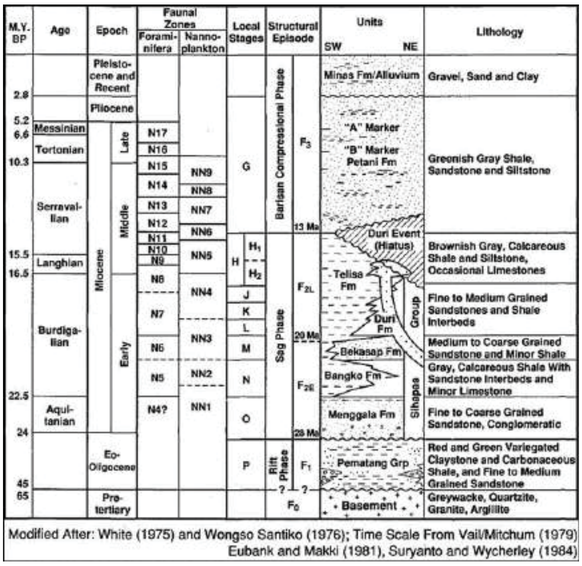

Figure 2. Cenozoic time-stratigraphic chart of the Central Sumatra basin showing major formations, deformational episodes recognized, and brief lithologic description of respective formations (Heidrick, T. L and Aulia, K, 1996)

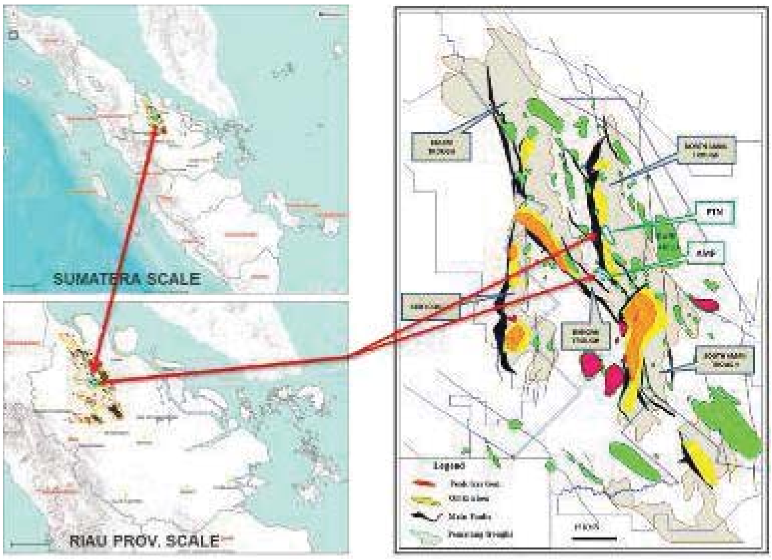

Figure 3. AMP & PTN field location within North Aman Trough, Central Sumatra subbasin

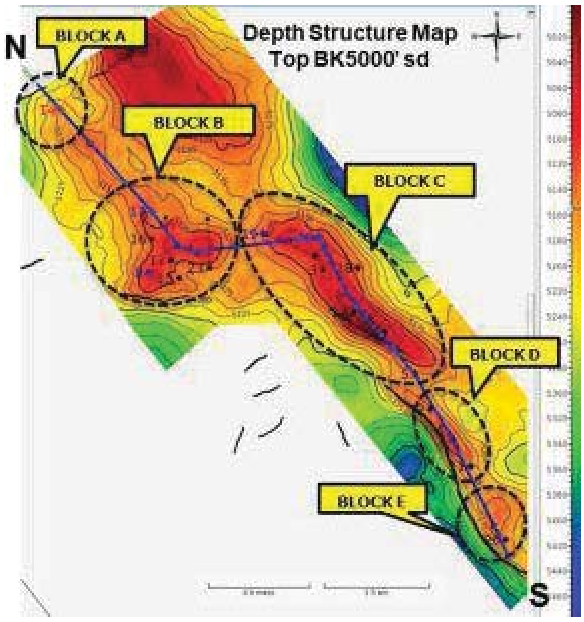

Figure 4. Depth Structure Map Top Bekasap of AMP Field

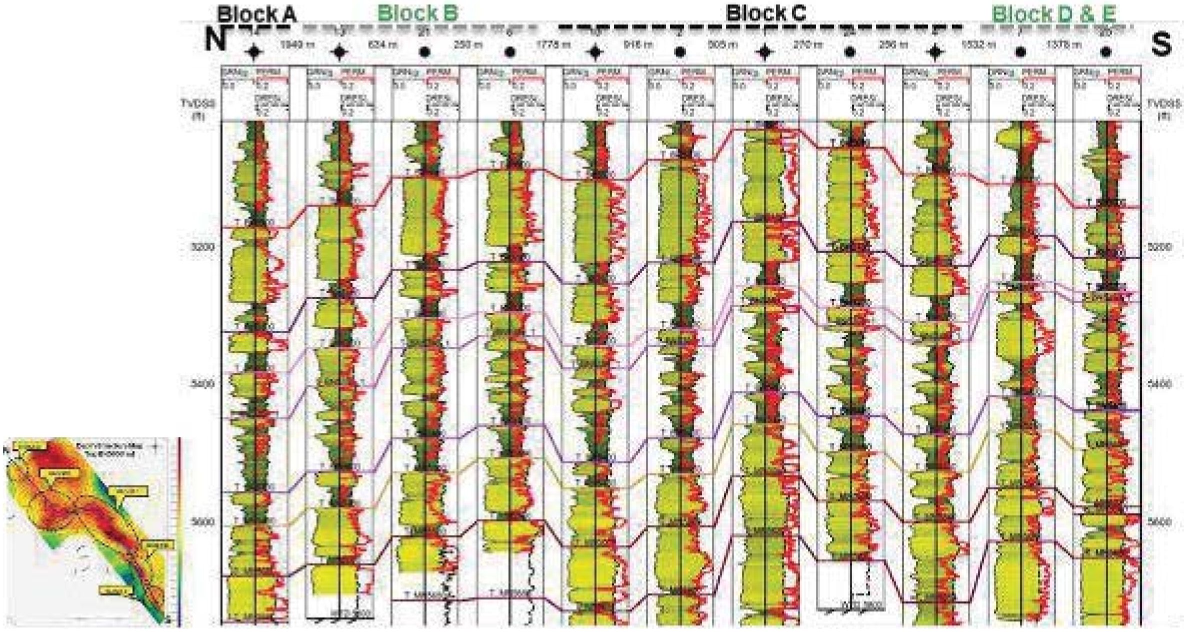

Figure 5. Reservoir continuity in AMP field from North-South well correlation

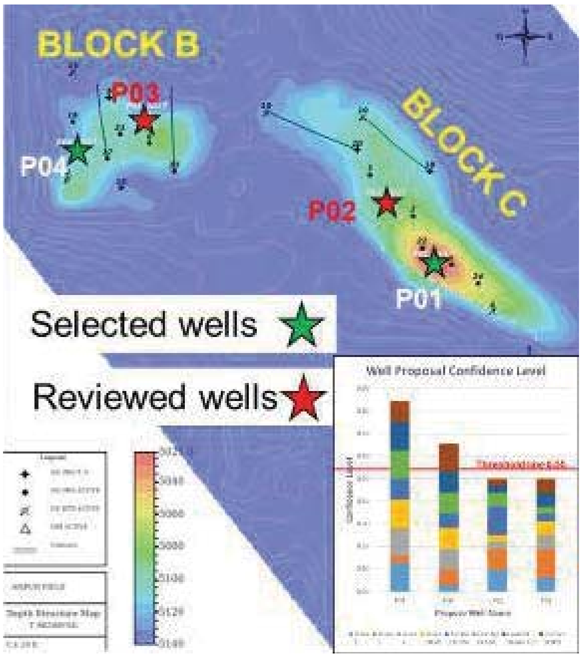

Figure 6. Proposed Well Ranking in AMP field during infill well prospecting

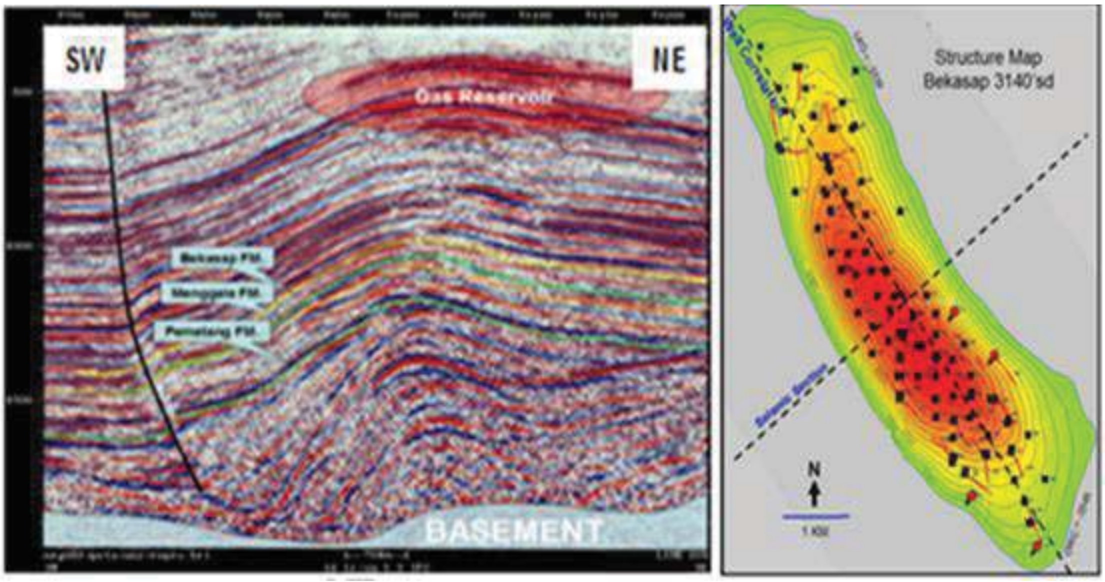

Figure 7. PTN field structure

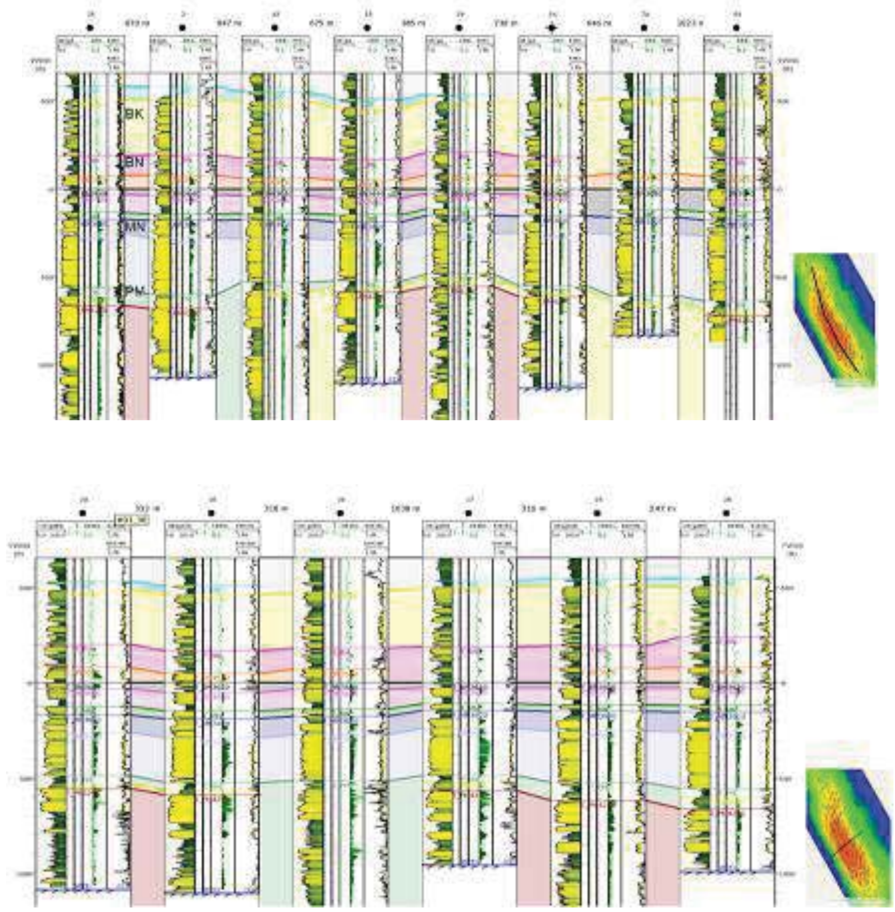

Figure 8. Reservoir continuity in PTN field from north-south (above) and west-east (below) well correlation

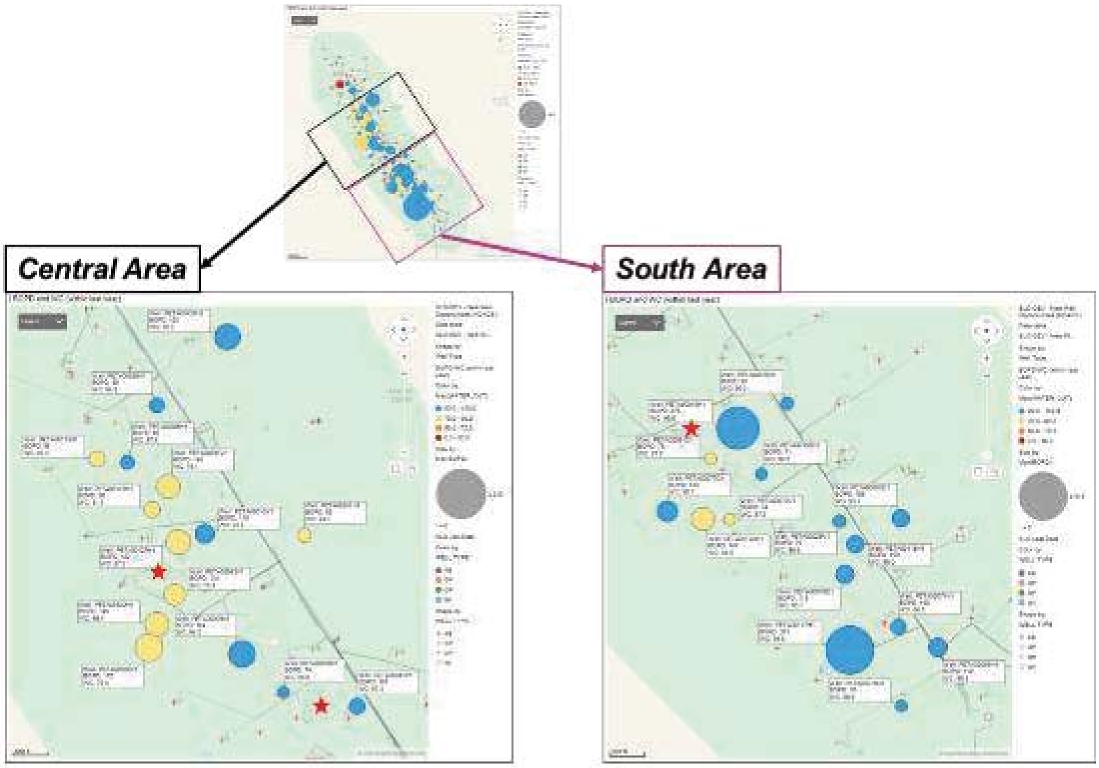

Figure 9. Production Bubble map PTN field suggesting remaining potential in the field

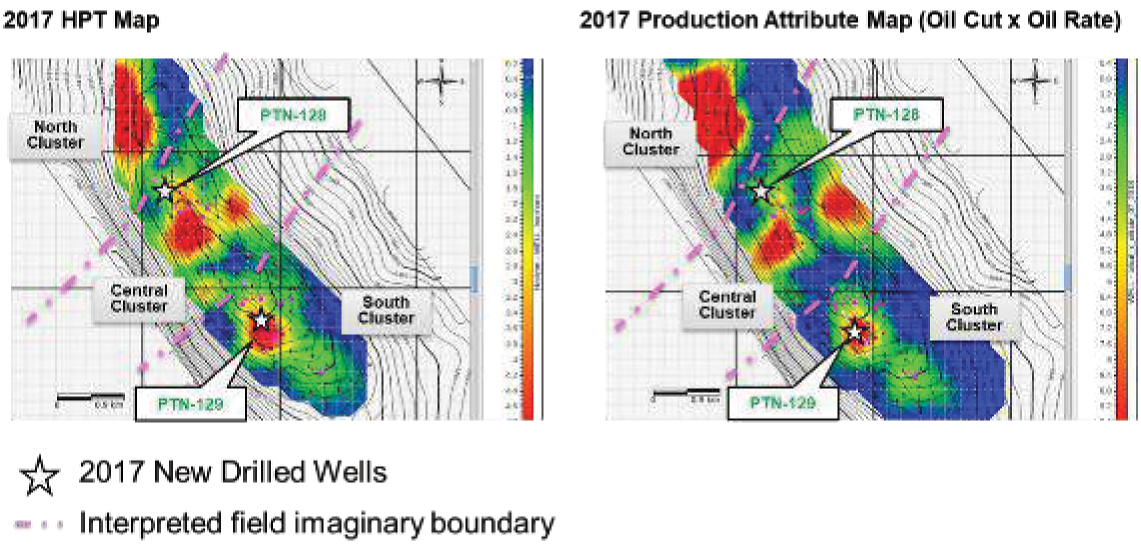

Figure 10. PTN field imaginary boundary based on attribute maps

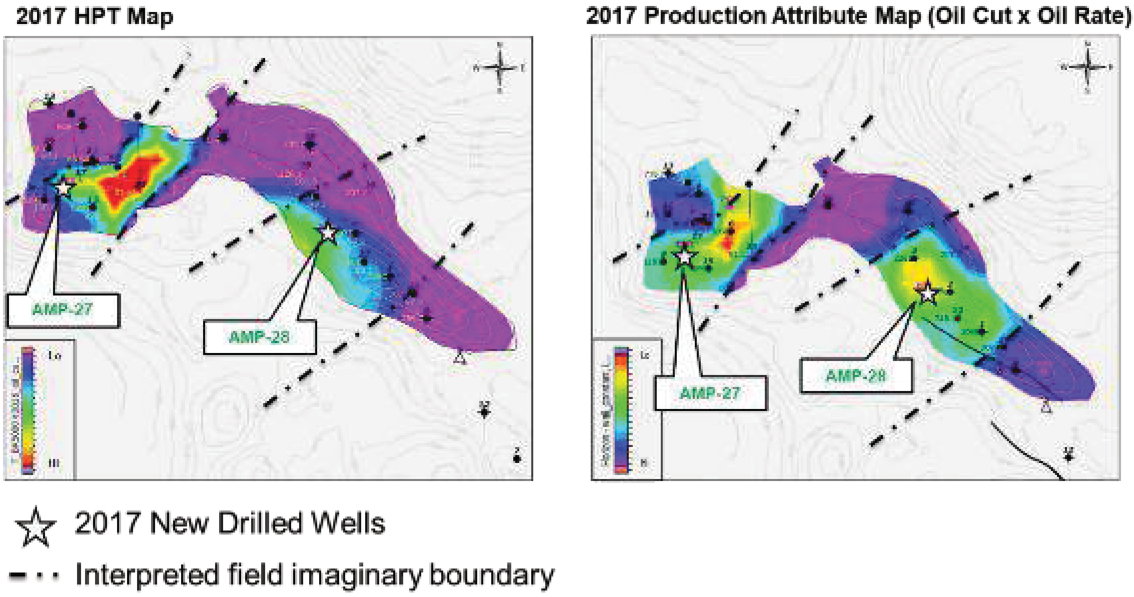

Figure 11. AMP field imaginary boundary based on attribute maps

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Table 1. Summary actual vs prognosis 2017 infills project

Well	Prognosis						Actual					
	POP Date	Depth (ft)	Pay Thick (ft)	HPT	Initial Prod (BOPD)	Peak Prod (BOPD)	POP Date	Depth (ft)	Pay Thick (ft)	HPT	Initial Prod (BOPD)	Peak Prod (BOPD)
PTN-128	31-Mar-18	4,761	61	5	193	193	7-Apr-18	4,758	98	10	89	207
PTN-129	16-Apr-18	4,583	53	4	193	193	16-Apr-18	4,583	97	11	478	768
AMP-27	3-May-18	5,900	53	3	194	184	30-Apr-18	5,900	68	6	227	312
AMP-28	22-May-18	5,800	68	4	227	227	11-May-18	5,820	61	5	624	1,011
Total		21,044	235	16	807	797		21,061	324	32	1,418	2,298

Well	Summary: Actual / Prognosis			
	Pay Thick variance	HPT Variance	Initial Production Variance	Peak Prod Variance
PTN-128	61%	121%	-54%	7%
PTN-129	83%	173%	148%	298%
AMP-27	28%	65%	17%	70%
AMP-28	-10%	46%	175%	345%