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Open Up a New Insight to Explore Bypassed Oil in Stratigraphic Flank Area Reservoir

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Abstract. Recognizing and further improving such stratigraphic or combination trapping configurations are important not only for future exploration portfolio but also in mature fields development, where most of the structural traps have been drilled massively in the past years. Most explorer and subsurface practitioners think that stratigraphic or combination trap has higher risk than other traps, in fact that stratigraphic traps had a commercial success rate (CSR) of 32% globally in line with other trap types (Westwood Energy, 2020).

One of the field candidates which being executed in 2021 was SLD field that discovered in 1975 with a length of 3 kms north-south direction and 2 kms wide east-west direction. SLD field has various productive reservoir and interestingly developed with stratigraphic trap system in Sihapas Group, this anomaly observed from current oil attribute map and proven last workover result in the flank area. The reservoir target for 2021 drilling campaign was 394sd which located in flank area of SLD field. An integrated strategy has been successfully adopted in SLD field, producing with almost ~1000 BOPD gain during 2021 drilling campaign which notably come from 394sd by stratigraphically. From structural position, 394sd is located relatively down-dip in flank area while the reservoir quality change into poor quality in the up-dip position and behave as barrier or stratigraphic trap. Heterogeneity of facies changes in SLD field impacts to the occurrence of stratigraphic trap that proved by the production attribute map from current active and last production of SLD field which positioned in flank area. One of the engineering approaches to effectively producing current oil in SLD field is narrowing well spacing and resulting a good oil production, compared back in 2010 with ~400 meters of spacing. This paper will tell in how we develop well candidacy with stratigraphic uncertainty and gained ~1000 BOPD to arrest production decline of this field.

Keyword(s): stratigraphic/combination trap, flank area, reduce spacing

INTRODUCTION

During the transition period of WK Rokan between PT. Pertamina Hulu Rokan and previous operator, several well candidates were prepared to ensure a smooth transition in restraining the production decline in WK Rokan. It was a challenge to find a high-graded candidates during this period, after we suspend the drilling program for years. Since 1975 to 2020 only 25 wells were drilled with 400 meters of well spacing and current recovery factor (RF) is relatively high for a primary depletion field (RF ~41%). Stratigraphic factor in SLD Field is highlighted for further development play of stratigraphic trap, it occurs because the lateral thickness heterogeneity due to complexity of estuarine successions architecture in its reservoir.

In this paper we present a general approach how to review bypass oil opportunity from stratigraphic area based on historical production and integrated subsurface assessment.

GEOLOGICAL OVERVIEW

UB - SLD are a small-sized fields located in the Central Sumatera Basin (note the size compared to the giant Duri Field or Minas Field), located in the heart of northern Aman Trough. Both fields are producing oil and gas with field dimension of SLD field is nearly 3 kms length and 2 kms wide. Towards the North, UB Field is nearly 5 kms length and 2 kms wide. SLD field was discovered in January 1975 by drilling vertical well of SLD-01, meanwhile discovery of UB field on December 1976 by vertical drilling of UB 01 on top of structure.

UB and SLD oil fields are localized left-stepping en-echelon set of N5-10W bearing strike slip faults. The fault zone is regional in character, extends with 25 kilometers distance. This fault is well expressed seismically on 3D seismic UB – SLD data. The 3D seismic interpretation shows a north-northwest to south southeast fault delimiting SLD Field and UB Field on their western flank. SLD Field is clearly shown as having anticlinal closure at the southern part of field. A similar structure is shown at the northern part of UB field.

Stratigraphically, all sand reservoirs of UB and SLD fields are deposited in a deltaic build-up succession with facies dominantly from incised valley fill to estuarine successions. Reservoir facies in the UB and SLD Fields have been identified from core and the stratigraphic architecture has been defined by detailed wireline log correlation. Vertical and lateral facies distribution, and the evaluation of the stratigraphic architecture, have been rationalized using a sequence stratigraphic approach. Revisions to sand body correlations have been made within the sequence stratigraphic framework. The formations in these fields are member of Sihapas Group that deposited above Pematang Group bounded by sequence boundary of SB 25.5 at base and SB 16 at the top.

METHODOLOGY

Static and production data from the existing wells were processed to map the bypass opportunity, therefore an optimize development scenario and long-term reservoir management can be achieved in this field. Three major processes were integrated and performed to identify development opportunities and support future capital investment decisions for SLD Field.

1. Review well production performance historically
2. Generate production attribute data and evaluate its “anomaly” from static data 3. Generate current static maps of the prolific reservoirs and utilizing seismic data to refine the reservoir boundary

1. Field Development Journey

1st Production Peak (Field Production Peak); 1975 – 1980 Period - In December 1974 SLD-01 was drilled as exploration well in the attic area, then following by 2 (two) delineation wells to confirm the fluid contact and field boundary. These two delineations wells drilled in February 1976, SLD-02 located in the east flank area and SLD-03 in northwest flank area. SLD-01 was put on production (POP) in October 1975 that producing mainly from 420sd interval, SLD-02 was POP in May 1976 that producing from different intervals (mainly coming from 386sd and 394sd), and SLD-03 never been produced due to mechanical issue (already P&A) (Figure 1).

Four follow-up development wells were drilled in February 1977, two wells located in crestal area (SLD 04 and SLD-05) mainly produce commingle from 316sd, 337sd, and 420sd intervals. Other two wells drilled in eastern flank area, where SLD-06 producing single from 420'sd and SLD-07 producing single from 394sd (Figure 1). In May 1978, a tremendous workover job from SLD-06 by opening a new zone (394sd) respectively gain ~ 4,300 BOPD. Then following by drilling of 2 (two) development wells (SLD 08 and SLD-09), where SLD-08 producing mainly from 316sd in June 1978 with initial production gain up to ~ 1,400 BOPD (Figure 1).

Field peak production ~ 10,200 BOPD (*we will call it later as 1s production peak*) achieved in February 1980 through additional four development wells (SLD-10, SLD-11, SLD-12, and SLD-13) as incremental production gain up to ~ 6,300 BOPD (2,900 BOPD from 420sd interval and 3,400 BOPD from Bangko intervals) with base production support ~ 3,900 BOPD from previous eight wells (Figure 1).

Flank Area Development: 1981 – 1988 Period - Follow-up successful drilling result from previous project package (SLD-10, SLD-11, SLD-12, and SLD-13), seven development wells were drilled in 1981 - 1985 (SLD-14 – SLD-20). These wells mostly located on flank area similar location with previous benchmark wells, ~ 3,650 BOPD in total were gained from those wells mostly coming from Bangko and Menggala intervals. But these 7 (seven) wells only able to arrest the field decline rate due to steep production decline from previous 12 drilled wells (Figure 1).

Well Intervention Job (2nd Production Peak); 1988 – 1995 Period - This 2nd production peak is achieved through workover job from two existing wells (SLD-06 and SLD-17) with total gain ~ 3,000 BOPD. Open new zone from 386sd interval for SLD-06 and water shut-off (WSO) job by opening single interval of 394sd in SLD-17. No significant gain from 1 (one) drilled well (SLD-21) that located in northern area and production single from 392sd. WSO Menggala interval and open new zone Bekasap and Bangko intervals in SLD-01 with oil gain ~ 500 BOPD. WSO Bangko interval and open new zone 420sd interval in SLD-10 with oil gain ~ 900 BOPD (Figure 1).

Well Intervention Job (3rd Production Peak); 1996 – 1998 period - Mainly this 3rd production peak is coming from open new zone (NZBP) job of 386sd interval then following by revised packer and upsize job from 420sd interval (Figure 1).

Well Intervention Job (Flatten Production); 1998 – 2019 period - During this period, field production trend is relatively maintained flat. The well intervention job is generally WSO or revised packer, upsizing pump campaign, and re-activation program. Well reactivation is successful in this field. Some wells reactivated in the last 3 years are SLD-09, SLD-10, and SLD-22. This is related to the water coning effect in this field. Both SLD-09 and SLD-10 were idle due to high water cut, then we try to reactivate the well and swab test shows WC has been decreased than previous. Follow up those campaign, in 2019 a re activation program is conduct in SLD-06 and achieving ~ 560 BOPD of oil gain (Figure 1).

2. Production Attribute Map

During the development of 2021 SLD Infill campaign project, production attribute mapping techniques was applied with focus area on trend mapping to review performance of infill programs, generating new infill ideas (assist R2R2P efforts), and identify the good performance area. Production attribute maps are

combinations of individual production data grids (fluid, oil, water cut, injection volumes, pressure, etc.) but can treated as independent maps. Production oil attribute map is designed to provides accentuated dynamic range of key components of a reservoir's "oil deliverability", oil cut, and oil volume combined into one grid. This map is suitable to illustrate and highlights regions of best oil deliverability with lowest water production (Figure 2). From this map, an anomaly was identified surrounding area of SLD-06, SLD-10, and SLD-16 that located on slant structural position of SLD structure (Figure 3).

3. Hydrocarbon Pore Thickness (HPT) Map and Seismic Extraction

Follow up the anomaly area from production attribute map, a static map or we call it later as Hydrocarbon Pore Thickness (HPT) Map was generated in each producing intervals to map the contributor interval of those production anomaly. The gross isopach maps were created by taking the structure maps and calculating the gross thickness between the different surfaces. There are six gross isopach maps were generated for the SLD Field area based on current producing zone from surrounding wells. Net sand isopach were created using the gross isopach and applying reservoir cutoffs which calculated the amount of reservoir quality sandstone in each layer. The cutoffs used were 50% volume clay, 10% porosity, and 10 mD permeability. Net oil pay maps were created by taking the net sandstone maps and calculating the volume of net sandstone within the oil column. Current fluid contact was generated based on highest known water (HKW) and lowest known oil (LKO) from current producing intervals by using water cut (WC) treshold less than 99%. Isoporosity maps were obtained from well logs. The resulting average porosities were then contoured on a two-dimensional map. Then combination of these properties maps was used to generate the current HPT for each target intervals (Figure 4).

To clearly define the reservoir boundary, a seismic extraction method "stratal slicing" was applied to perform horizontal seismic facies analysis (Figure 5). Stratal slicing may be a valid choice, if the goal is to predict a reservoir in a stratigraphically complex but structurally relatively simple formation using a 3D seismic data set with a good signal-to-noise ratio. However, stratal slicing does have limits and unique challenges. Selecting, picking, and verifying a chronostratigraphic framework for stratal slicing remain the biggest challenges. Identification and handling of residual effects of slicing caused by nonlinear, irregular sedimentation require future study.

Bangko Combination Trap Play (386sd, 388sd, 392sd, and 394sd)

Was defined as the "suspect" for production anomaly in SLD flank area. The uppermost unit developed in this sequence is the 386sd. Interval isopach map shows a mottled/irregular distribution in NW-SE trend, reflects its estuarine channel and sand bar/sand flats facies unit. Below that, a prograding shelfal siltstone sitting on top of 392sd. The prograding shelfal siltstone ceased by a locally tidal bar complex of 388sd. The tidal bar complex is only distributed in the northern part of UB field such as UB-22. In SLD field, it is only two pulses of poorly developed prograding sands. The vertical thickness of 388sd is limited to about 20 feet. In SLD field, where interval 392sd – 394sd is thickest (c. 95 feet thick), an upper estuarine unit can be distinguished, based on core from SLD-21. Similar lithotypes are probably present in adjacent wells such as SLD-17, - 12, -15 and -18. To the southern part of the SLD field, the estuarine unit is less developed (c. 16 to 17 feet thick). This part of the conventional 394sd is cut out by erosion in SLD field, in wells such as SLD-21. To the SE, a distinction between two sandstones is problematic, but in the SW flank of the field, in wells such as SLD-21, -17 and -12 a sharp-based sandstone is again present. In the analog of neighboring field, paleocurrent directions in SSW, WSW and SE orientations may reflect changing orientations of the tidal currents that built up the ridges (Figure 4 and Figure 5).

Duri Combination Trap Play (316sd)

Another future stratigraphic or combination trap play is coming from interval 316sd, as seen on seismic attribute map of negative amplitude that has relatively good correlation/trend with sand thickness of 316sd (Figure 7) where this sand only develops in northern part of SLD Field and supported by historical

production plot (Figure 1) of SLD-04, SLD-08, and SLD-23. Interval 316sd is the uppermost estuarine sandstone deposit in Sihapas Group reservoirs. The isopach show a pronounced NE-SW orientation as seen in the southern part or in the SLD Field, orthogonal to the paleo-shoreline (Figure 7). This orientation reflects the original depositional fabric, probably with re-activation by wave action or shifting the orientation of the source. The thickest area is in UB Field as seen in UB-19, UB-16 and UB-18, and locally thick in SLD-23. In general, the sandstone distribution is thinning to the south or to the SLD Field, and the western part of the UB Field.

RESULTS and CONCLUSIONS

Encouraged by good historical performance during early production period and last re-activation program in SLD-06, it decided to drill an infill campaign in the flank area of SLD Field. Four development wells were drilled in 2021 with a good initial oil production ~1000 BOPD (Figure 6). The production was contributed from stratigraphic or combination trap in 386sd, 388sd, 392sd, and 394sd intervals.

In general, there are two types of hydrocarbon trapping mechanism in SLD Field; (1) Structural Trap; the hydrocarbon occurrence will follow accordingly into the structural trend and depth, producing intervals is 370sd and 420sd, (2) Stratigraphic/Combination Trap, the hydrocarbon occurrence will follow mainly on reservoir quality/distribution then controlled by structure, producing intervals is 316sd, 386sd, 388sd, 392sd, and 394sd.

Refer to this drilling result, a follow-up infill campaign will be held in upcoming year to unlock the opportunity from 316sd that has been overlooked.

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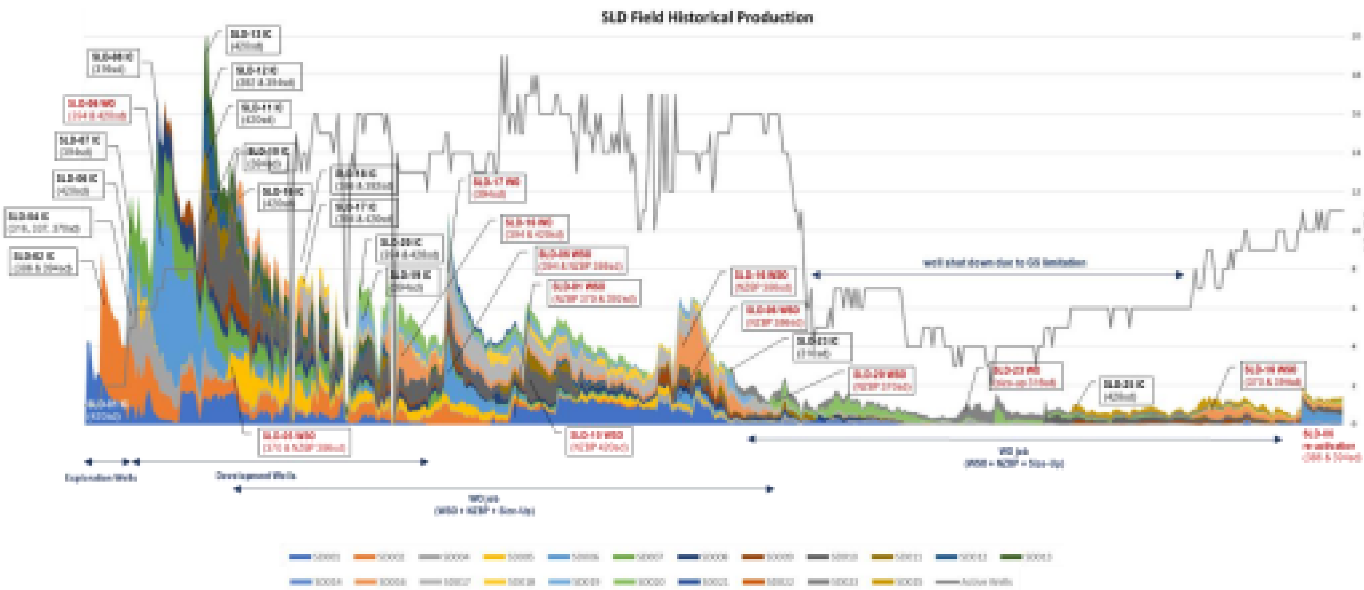

Figure 1. SLD Field historical production plot shows the development journey of this field and the prolific producing reservoirs from 316, 370, 386, 392, 394, 420sd

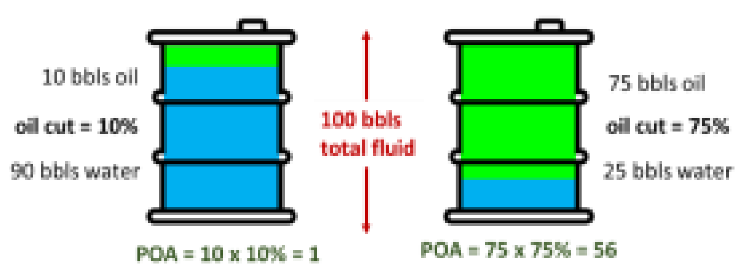

Figure 2. Produced Oil Attribute (POA) cartoon explanation, this POA highlights regions of best oil deliverability with lowest water production, resulting an accentuated dynamic range POA ratio 56x difference

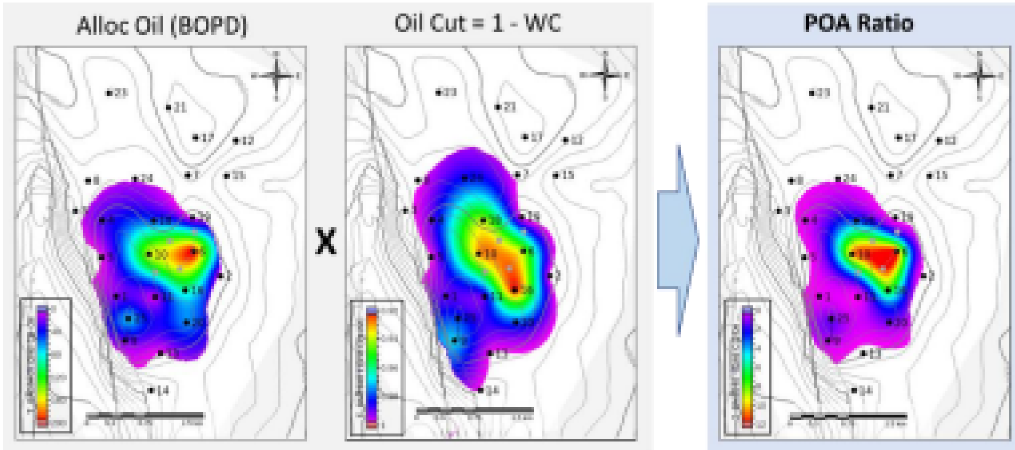

Figure 3. Produced Oil Attribute (POA) application in SLD Field, shows the production anomaly is located in the flank area that follow the sand distribution trend of 388sd, 392sd, and 394sd

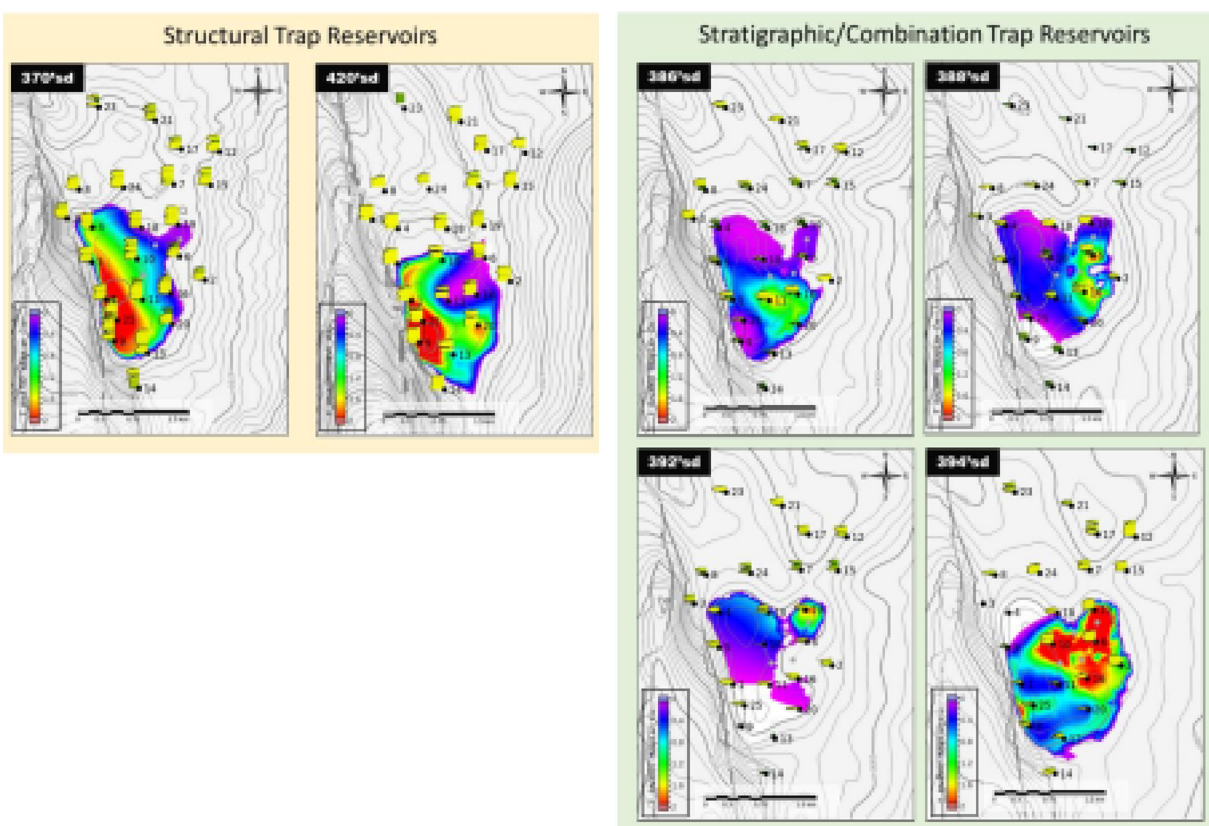

Figure 4. Current HPT maps for producing intervals, generally there are 2 (two) typical hydrocarbon trap in SLD Field; (1) Structural Trap, producing intervals 370sd & 420sd, (2) Stratigraphic/Combination Trap, producing intervals 316sd*, 386sd, 388sd, 392sd, and 394sd

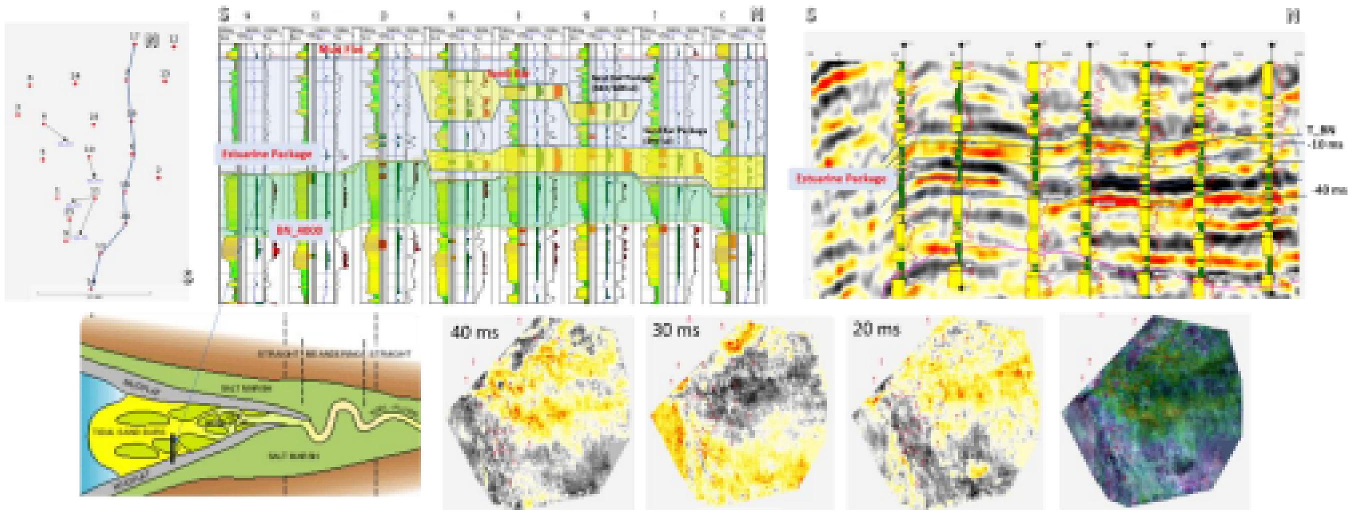

Figure 5. Seismic stratal slice (blended) that shows reservoir boundary by dividing the high vs low/medium confident area for sand bar package exist (394'sd) (Wiyono, A., 2019)

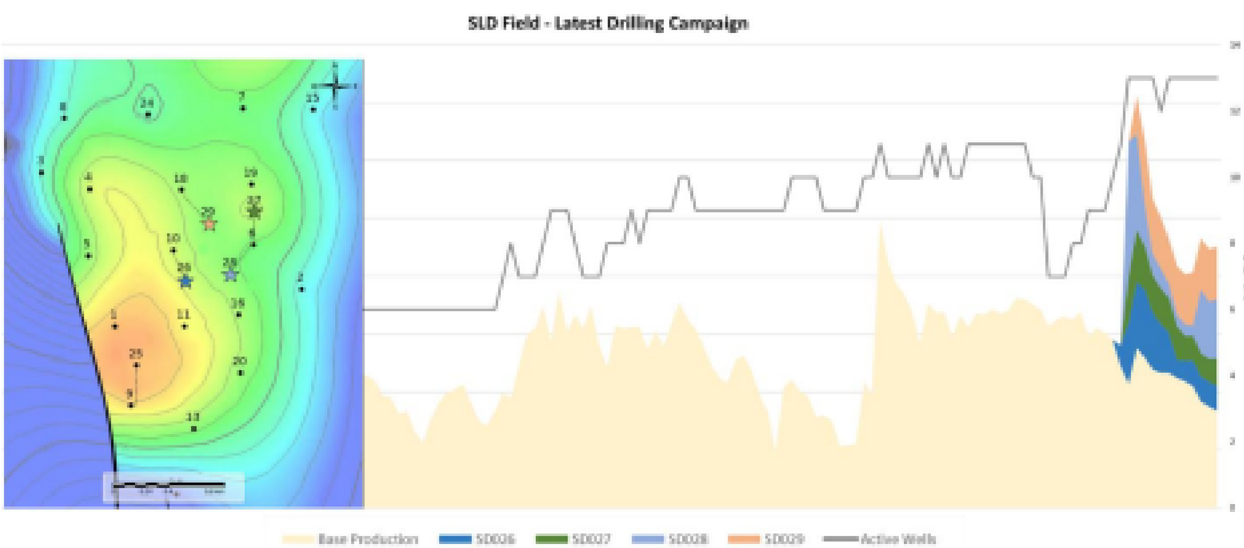

Figure 6. Latest drilling campaign of SLD Field shows that stratigraphic/combination trap is proven shows by significant gain from those latest drilled wells that located in flank area

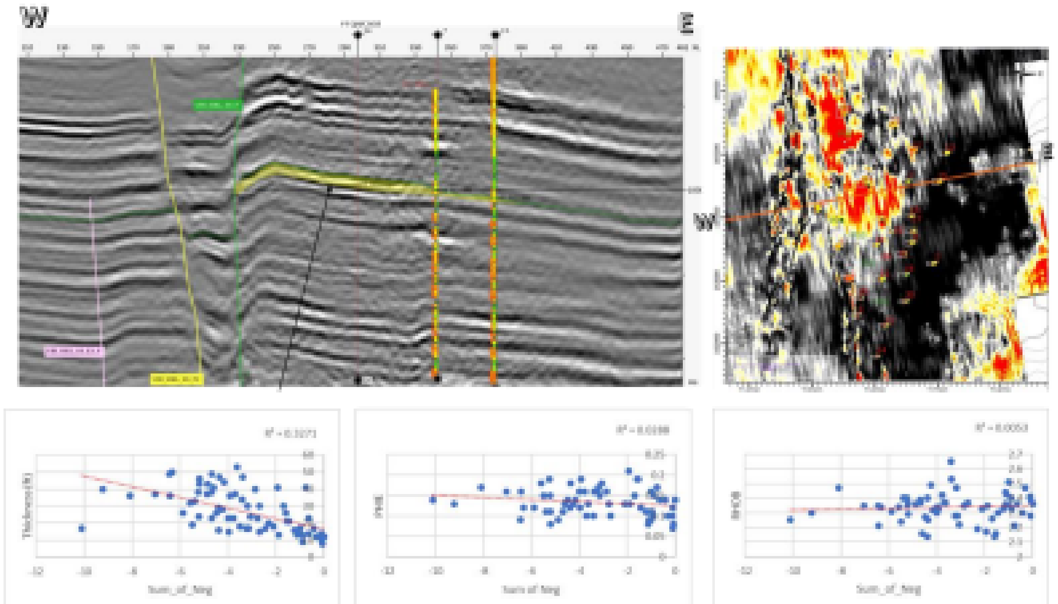

Figure 7. Future stratigraphic/combination trap opportunity is coming from 316sd. Sand distribution of 316sd is shows by seismic attribute map of negative amplitude, that has relatively good correlation/trend with sand thickness of 316sd. Red = thick sand area, Black = thin sand/shale area (Jatmiko, A.M, 2022)