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HYDROCARBON SHALE POTENTIAL IN TALANG AKAR AND LAHAT FORMATIONS ON SOUTH AND CENTRAL PALEMBANG SUB BASIN

POTENSI *SHALE HC* PADA FORMASI TALANG AKAR DAN LAHAT DI SUB-CEKUNGAN PALEMBANG SELATAN DAN TENGAH

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ABSTRAK

Sub-cekungan Palembang Selatan dan Tengah mempunyai potensi shale hydrocarbon (shale HC) yang cukup menjanjikan pada Formasi Talang Akar (TAF) dan Formasi Lemat/Lahat (LAF/LAF). Hasil interpretasi seismik memperlihatkan adanya potensi shale HC yang tersebar di beberapa area sekitar sumur Rukam-1, Kemang-1, Singa-1 dan Tepus-1. Secara umum, hasil pemodelan termal menunjukkan awal kematangan minyak pada nilai Ro= 0.6% di kedalaman (h) sekitar 2000 m, pembentukan minyak pada nilai Ro = (0.7-0.9) % di kedalaman antara (2200 ≤ h <3100) m dan pembentukan gas pada nilai Ro antara (0.9-1.2) % di kedalaman antara (3100-3500) m. Formasi Talang Akar dan Lahat/Lemat berturut-turut mempunyai lingkungan pengendapan laut dangkal dengan Tipe Kerogen II/III dan lakustrin dengan Tipe Kerogen III. Berdasarkan pengolahan lanjut data seismik (metode atribut seismik dan spectral decomposition) diperkirakan di area-area tersebut memiliki nilai TOC yang memenuhi syarat sebagai shale HC, yaitu nilai TOC > 2%. Perhitungan (P-50) potensi sumberdaya migas non-konvensional ini diperkirakan cukup besar (mencapai 4200 MMBOE) pada Formasi Talang Akar dan Lahat/Lemat.

Kata Kunci: *shale hydrocarbon*, formasi Talang Akar, formasi lemat/Lahat, TOC, migas non-konvensional

ABSTRACT

South and Central Palembang Sub - basin over Talang Akar (TAF) and the Lemat/Lahat Formations (LEF/LAF) has shale hydrocarbons (HC shale) which are considerably promising. Seismic interpretation results shows potential HC shale scattered in several areas around the Rukam-1, Kemang-1, Lion-1 and Tepus-1 wells. Generally, thermal modeling results indicates early maturity of oil on the value of Ro = 0.6% at about 2000 m depth (h), the formation of oil on the value Ro = (0.7-0.9)% at between (2200 £ h <3100) m depth and formation of gas at Ro values between (0.9-1.2)% at a depth between (3100-3500)m. Talang Akar and Lahat/Lemat Formations have a shallow marine depositional environment with Type II/III kerogen and lacustrine with Type III kerogen. Based on advanced seismic data processing (a method of seismic attributes and spectral decomposition) these areas are expected to have a TOC> 2% value that qualifies as shale HC. The assessment (P-50) of potential non-conventional oil and gas resources at Talang Akar and Lahat/Lemat Formations is estimated to be fairly large (up to 4200 MMBOE).

Keywords: Shale hydrocarbon, Talang Akar Formation, Lemat/Lahat Formation, TOC, Unconventional oil and gas

I. INTRODUCTION

South Sumatra basin consists of 4 sub-basins, specifically South, North, Central Palembang and Jambi Sub-basins (LEMIGAS, 2001). Several previous studies such as Sarjono and Sardjito (1989), Suseno et al. (1992), Argakoesoesmah et al. (2004), Ginger - Fielding (2005) and Yuliandri et al (2013) have noted the existence of shale/shale derived TAF and LEF/LAF as source rock that produces conventional oil and gas. Some authors stated that both these formations are mature in terms of capacity to produce oil and gas. Conversely, however, some also state that both formations (mainly TAF) tend to be immature.

For decades, this basin produced oil and gas in large quantities derived from the conventional sandstone reservoir of Talang Akar Formation or limestone from Baturaja Formation (Bishop, 2001). In fact nowadays, many oil and gas fields in this basin are less productive or even are no longer productive. In the future it is expected that South Sumatra Basin has huge potential for non-conventional oil and gas, which is derived from shale hydrocarbon.

HC Shale is a hydrocarbon which is generated directly from the shale. These kind of shale are known as source rock reservoir (SRR) because it is not only found as host rock (source rock) but also as reservoir (Chopra et al. 2013). Shale in the basin that produces oil and gas are proven to actively produce hydrocarbons (Jarvie, 2008), including South Sumatra Basin. Oil and gas in shale is taken with hydraulic fracking methods (Chopra et al. 2013). HC shale development in South Sumatra Basin is expected to follow the results of development of shale HC in the United States.

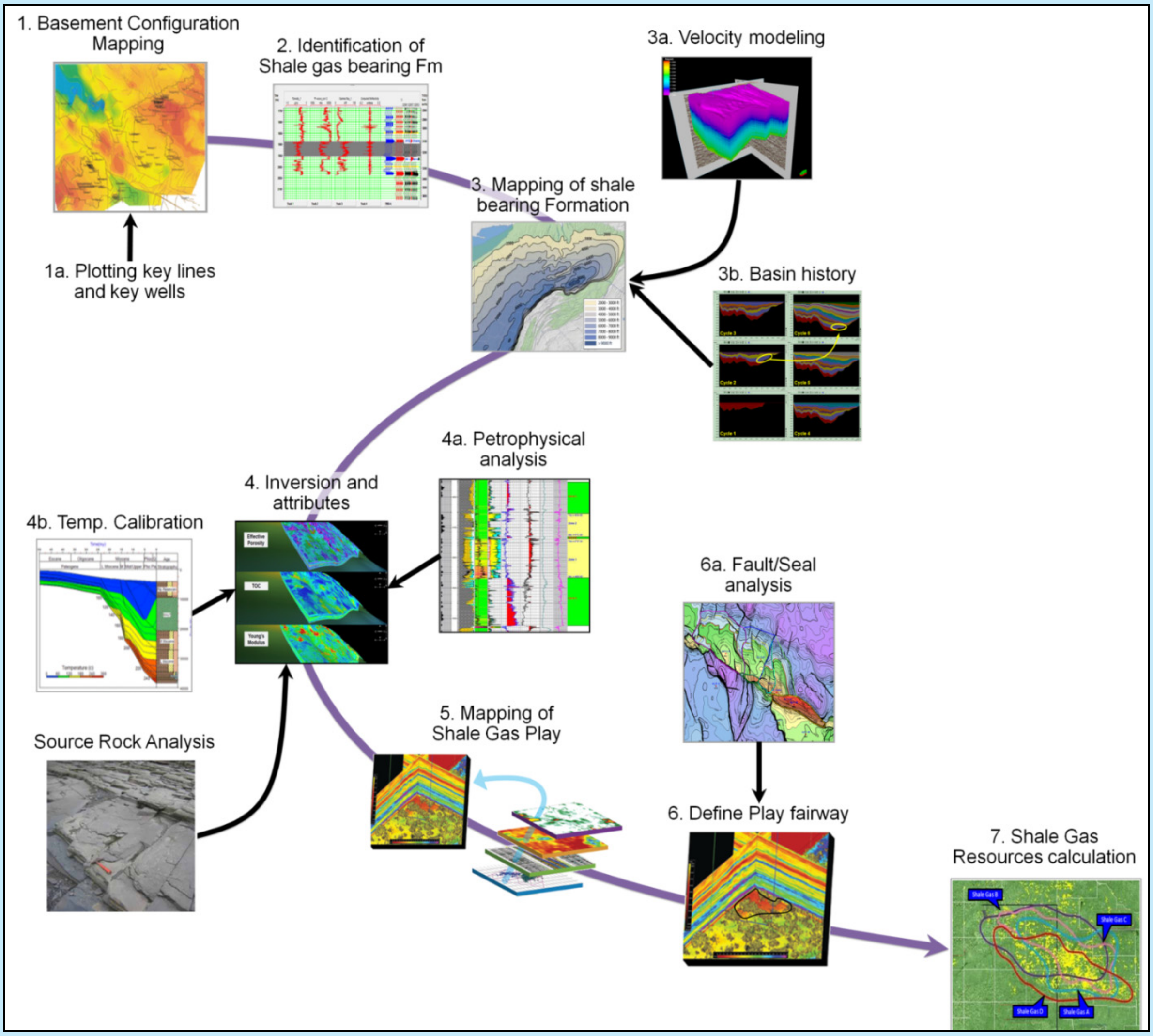


Figure 1
Workflow sweet spot mapping.

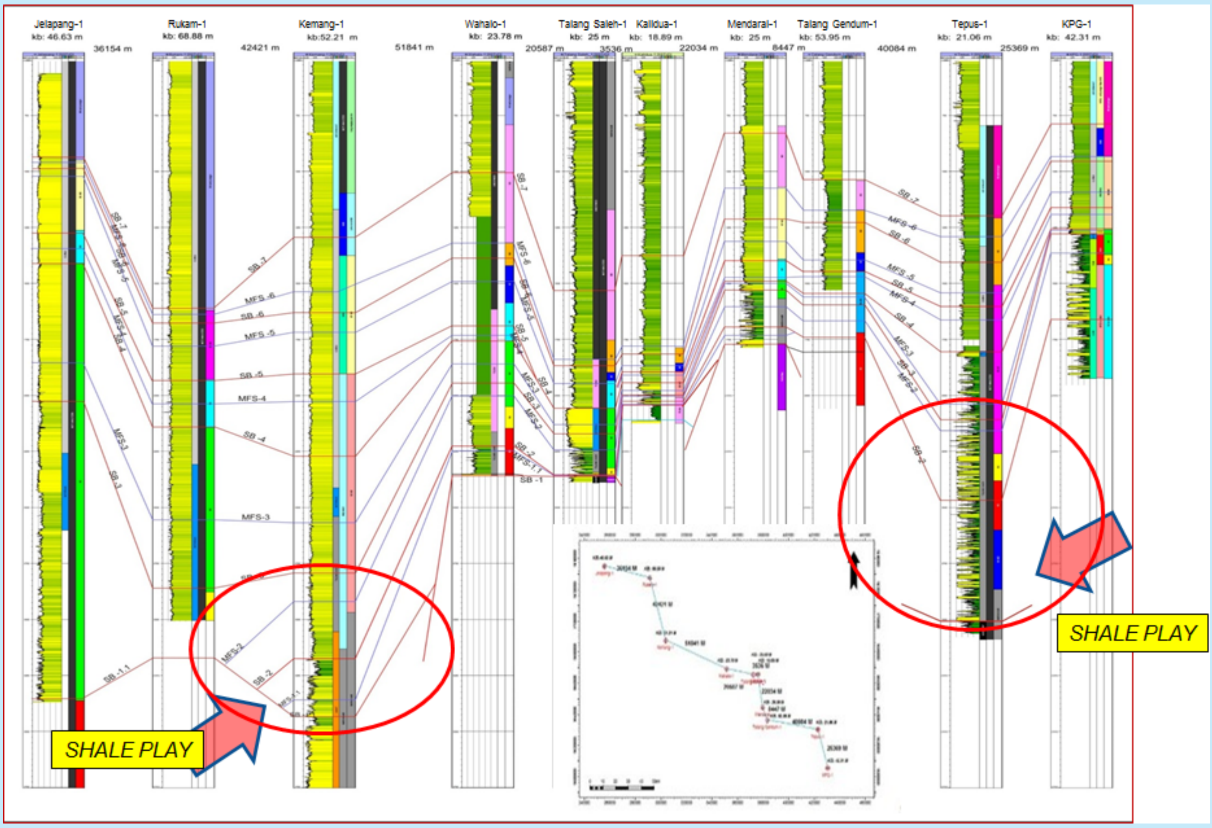


Figure 2
Correlation between wells of study area, showing the presence depth are identified as shale play.

This study examined the potential of shale HC in the two formations based on secondary and primary data utilizing field data and the sub surface data (seismic and wells). Seismic data and wells use 150 tracks and 22 wells approximately. The seismic data is the data post stack migration of 1970-2007, the dominant period being between 1970 and 1980. Most of these vintage seismic data are vector data, with the result that the further processing of geophysical data such inversion could not be applied in this study.

II. METHODOLOGY

The methodology used to determine the sweet spot (high graded area) can be seen in Figure 1. Successful identification of the sweet spot area will determine the amount of potential HC shale in the research area. Theoretically, data processing using inversion, seismic attributes and geochemical modeling can produce several physical parameters and geo chemistry distribution maps like V-shale, porosity, Sw, TOC, index of brittleness and maturity maps. However, due to limitations of the data (data that is not preserved seismic amplitude, no S wave log data and at least geochemical data, especially the data Vr), not all of these maps have been made.

Processing geophysical CWT (Continuous Wavelet Transform) and attributes of sweetness were conducted to determine the potential of HC shale play. Sweet spot area identification was conducted by taking account of geometry (thickness and depth) of the structure of the source rock reservoir (SRR) and the limit of the maturity of oil and gas (oil/gas window). Furthermore, the resource potential of shale HC was undertaken by inserting the values of petro-physical parameters (porosity, Sw and density) with a certain cut off.

III. RESULTS AND DISCUSSION

A. SEQUENCE STRATIGRAPHY ANALYSIS

Sequence boundary (SB) correlation was carried out in several wells starting with the KPG-1 well (the southeast) to Jelapang-1 (Southwestern) which has shown shale play relatively more deeper around the Kemang and Tepus wells (Figure 2). Moreover, there are images of sequence stratigraphic correlation

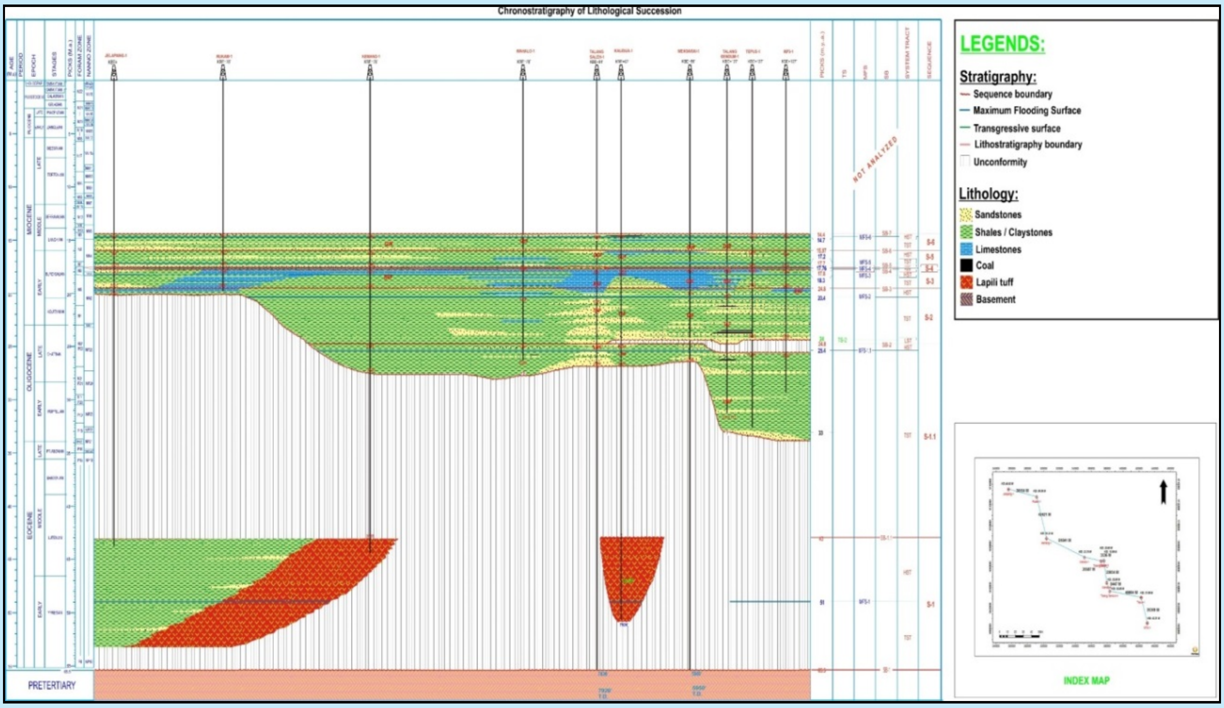


Figure 3
Chronostratigraphy Cross sectional 0f North West-South Eastwards.

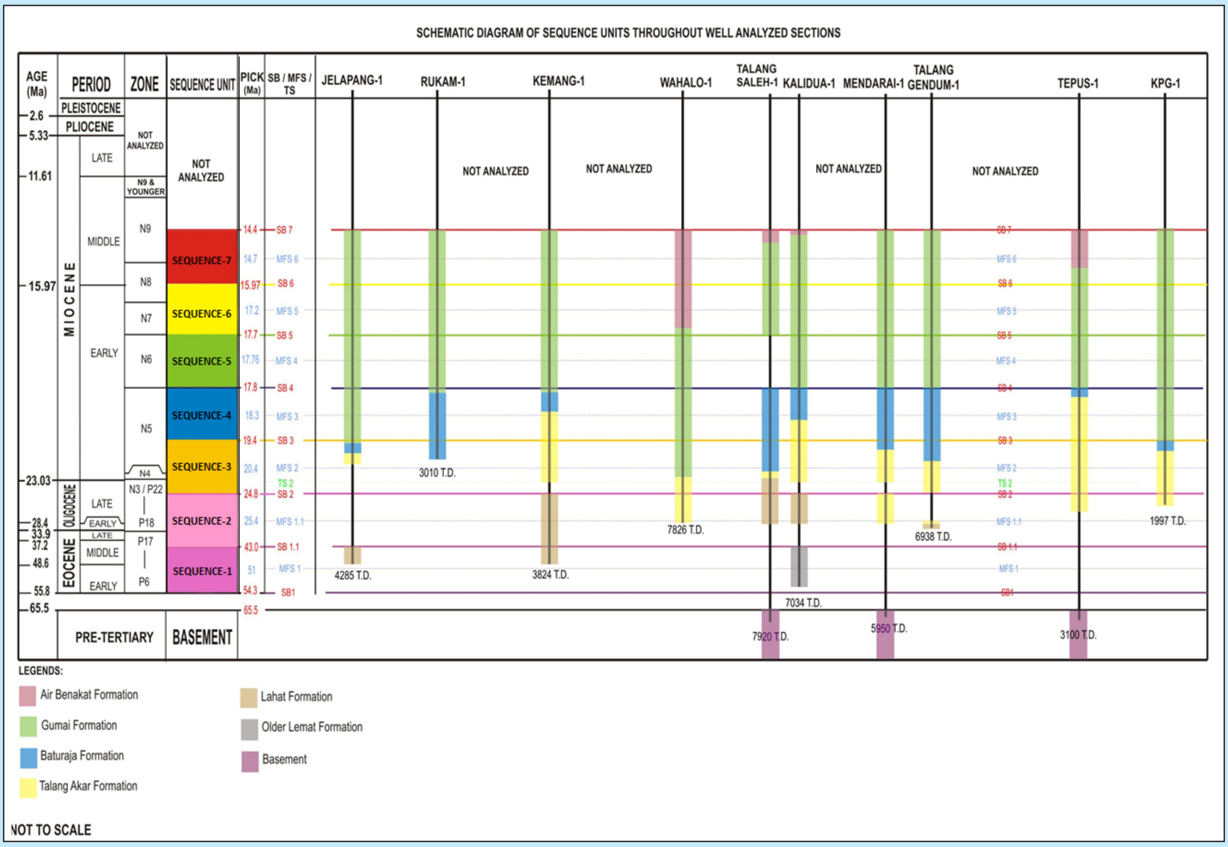


Figure 4
Schematic Chronostratigraphy wells along with the penetrated litostratigraphy unit.

of lithological units penetrated by wells and the relationship between the unit sequence stratigraphy with stratigraphic unit sequentially (Figure 3 and 4).

B. Seismic and Geophysics Advanced Processing Interpretation (Cwt And Sweetness)

Based on a basement structure map (BEICIP, 1985 and Pertamina-BPPKA, 1997) of several depth locations that were known (see Figure 5), there is an indication of the presence of source rock. Some seismic interpretation (Figure 6 and 7) shows the depth in the sequence 1, 2 and 3. Generally, sequence-1 is limited by SB-1 and USB-1.1; while the sequence-2 is limited by SB-1.1 and SB-2, then sequence-3 is limited by SB-2 and SB-3. SB-1 is the top basement and SB-3 equivalents top TAF. Lemat/ Lahat formation are mostly part of Sequence-1 and 2, while the formation Talang Akar tend to be sequence-3.

CWT and sweetness processing was applied to some tracks (see Figures 8 and 9). Sequence 1, 2 and 3 in some wells show a reddish yellow color, which is a good indication of shale play as a source rock reservoir (SRR) -hydrocarbon. KPG-1 wells in these sequences have a fairly large TOC, which is about 2-7%. Unfortunately, in these wells SRR sequence is not yet mature enough, for VR is around 0.6%.

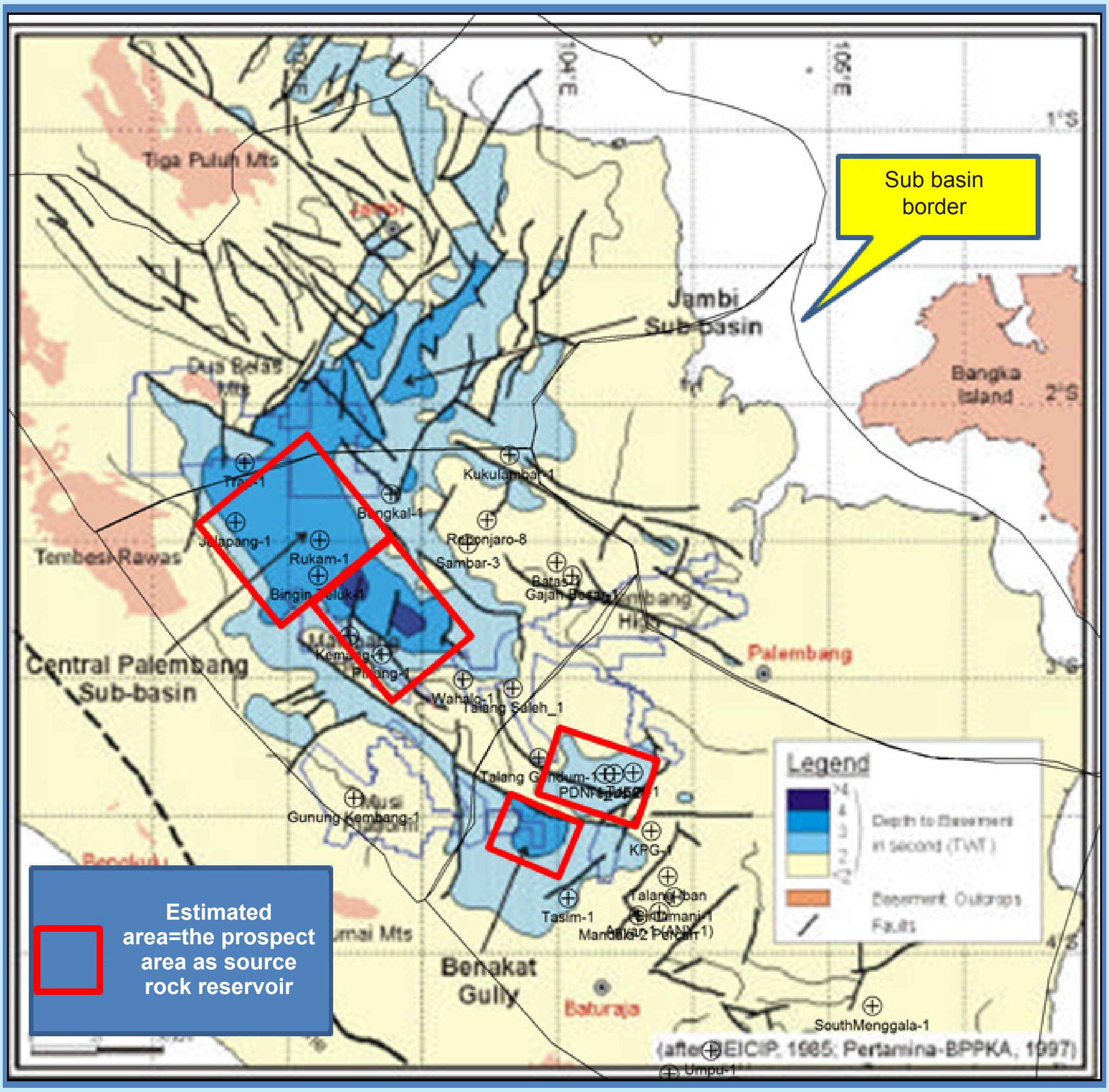


Figure 5
Four Points area (red) estimated potential as a source rock reservoir of South and Central Palembang Sub-basin.

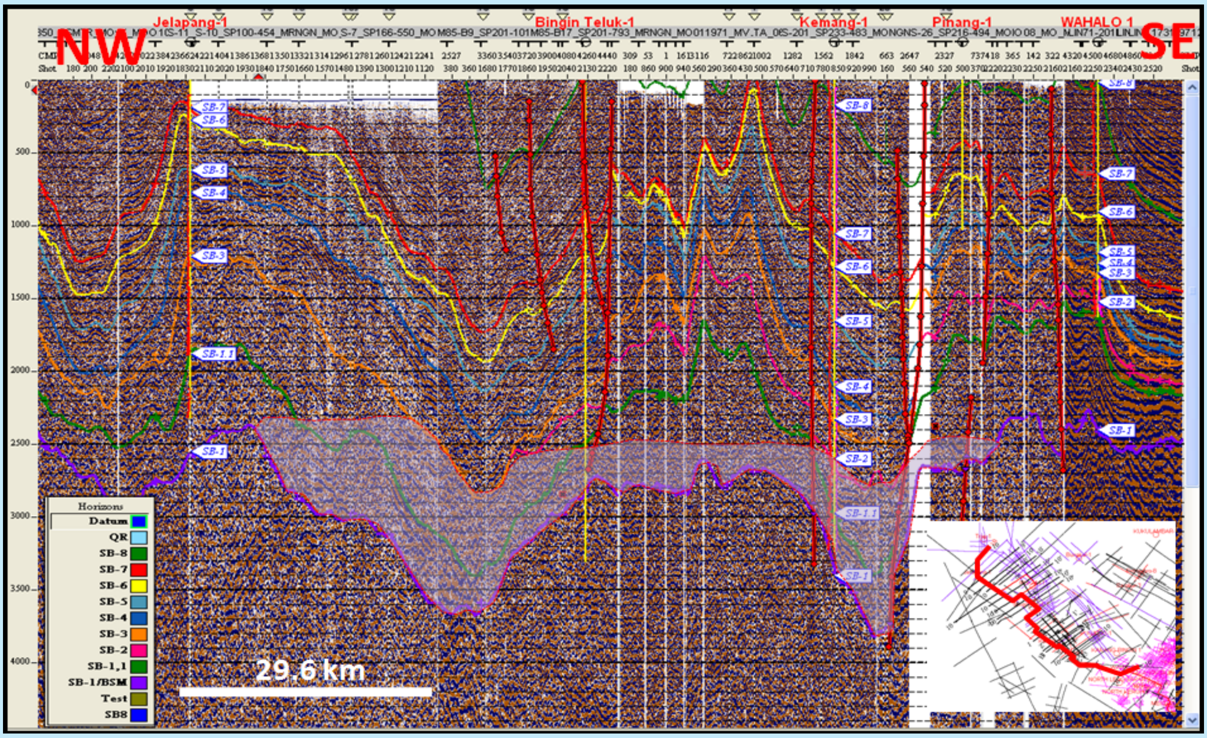


Figure 6
Seismic cross-sectional indicates subsidence filled by Lahat/Lemat and Talangakar Formations around The Kemang –Bingin, Teluk and Kemang wells.

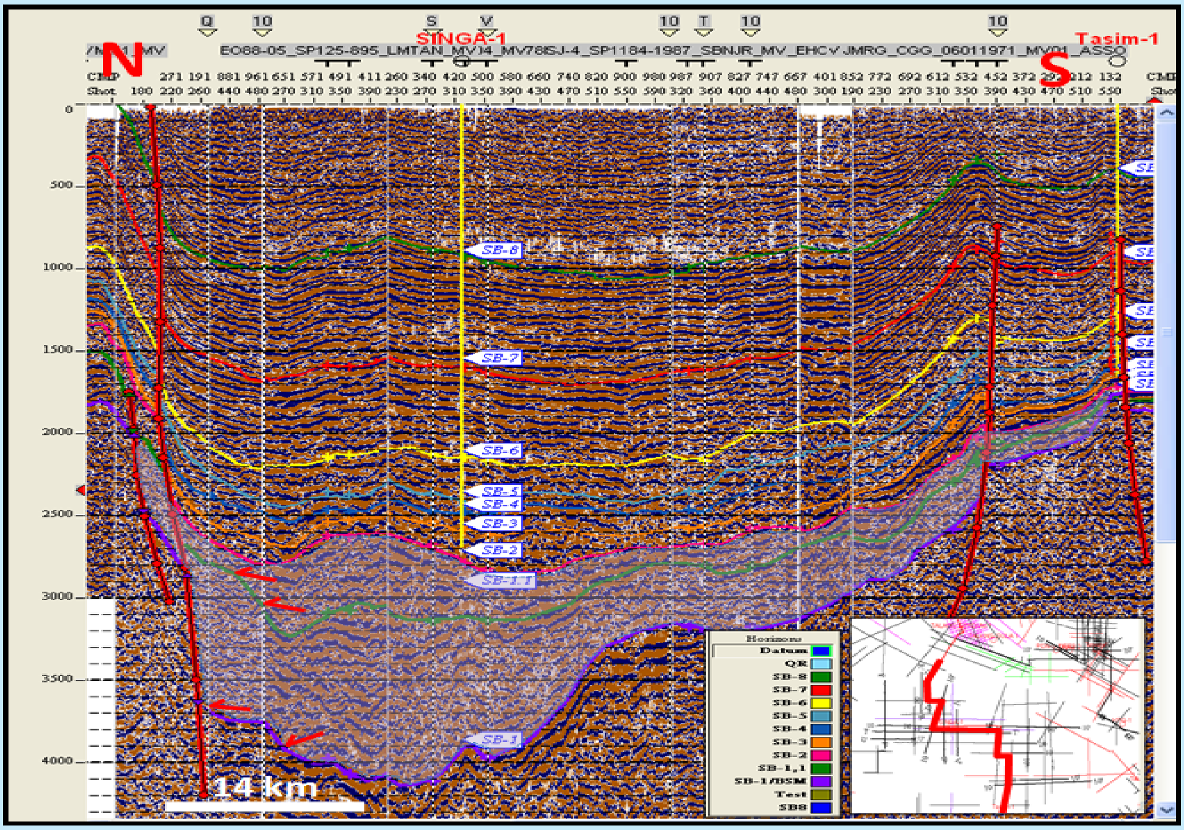


Figure 7
Subsidence around Singa well of highly sedimentation area of Lahat/Lemat Formation.

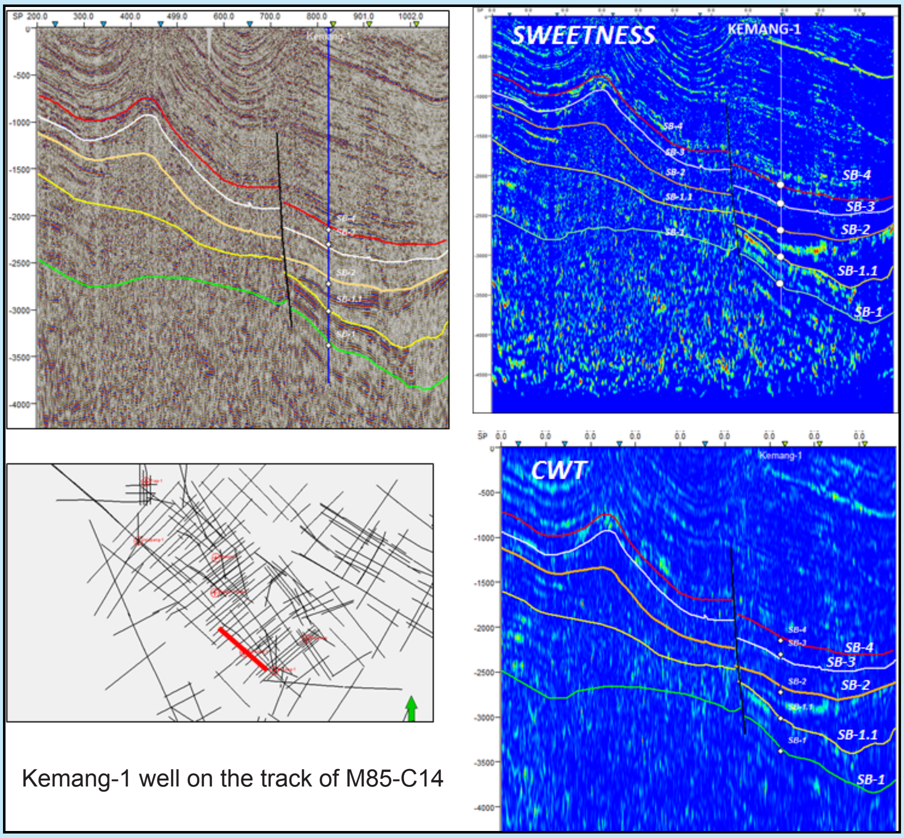


Figure 8
Sweetness and CWT Application on the M85-C14 track near the Kemang-1 well

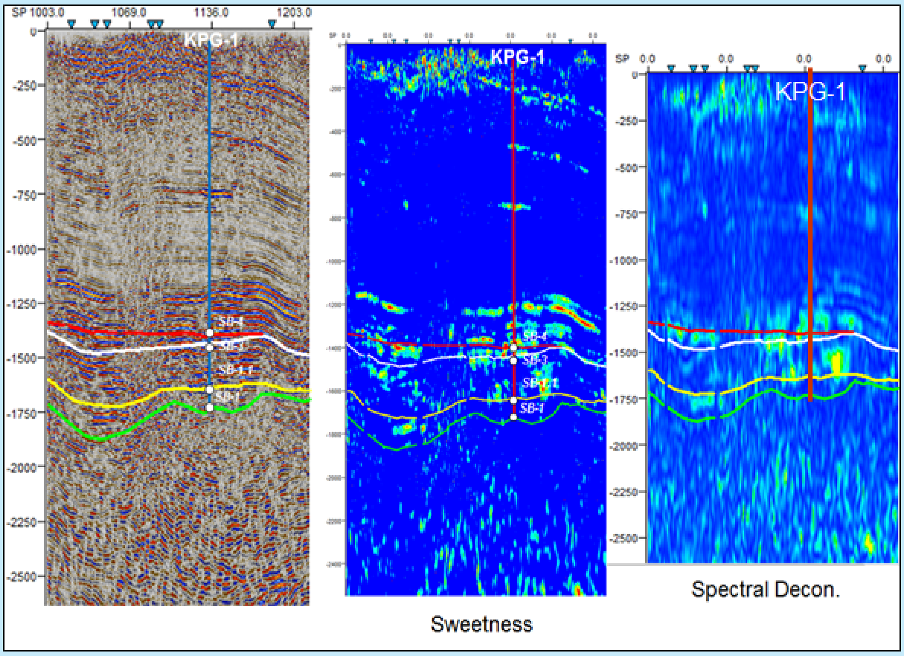


Figure 9
Sweetness and CWT Application on the 93PB-280 track near the KPG-1 well.

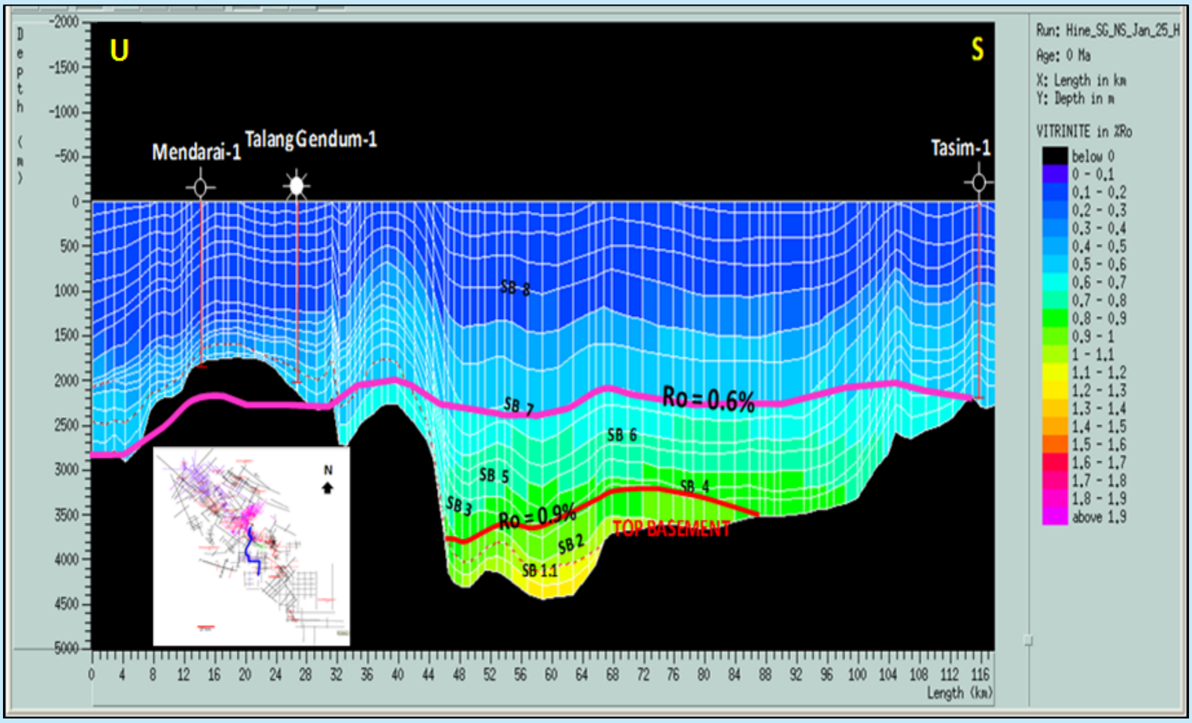


Figure 10
Thermal maturity deployment model in the cross sectional that passes through the Mendarai-1, Talang Gendum-1, and Tasim-1 wells.

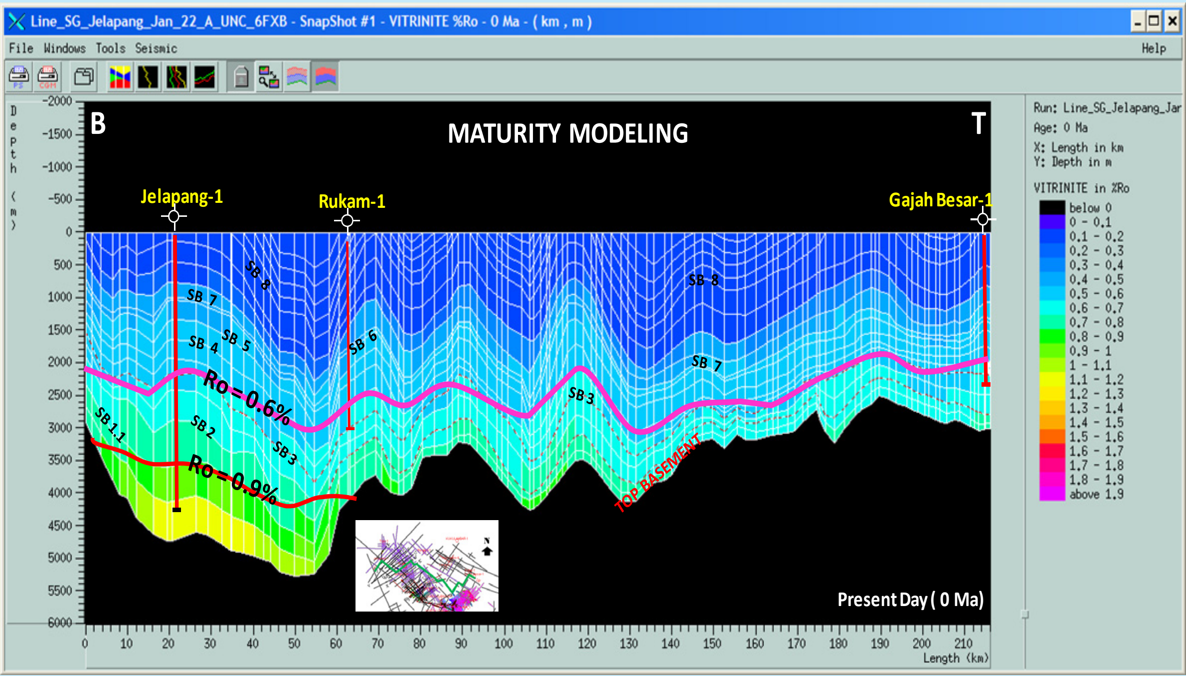


Figure 11
Thermal maturity deployment model in the cross sectional-2 that passes through the Jelapang-1, Rukam-1, and Gajah Besar-1 wells.

C. Geochemical Modelling

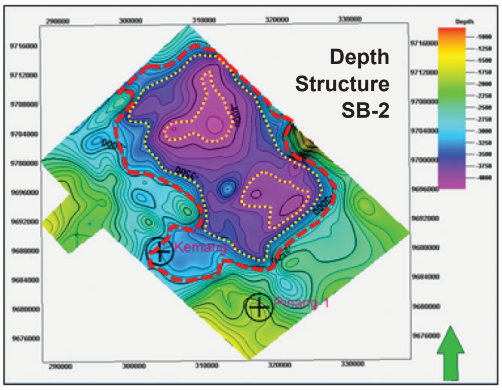
Geochemical data analysis from several wells in South and Central Palembang sub-basin are producing Type II/III kerogen for TAF on the contrary Type III kerogen to LAF/LEF. On the other hand, VR / Ro data is very limited and relatively small (except Tepus, large elephant-1 and banyan-7 wells), but from the data Tmax, TAF and the LAF show a mature stage in all three wells. However, there was no well data found in the surrounding subsidence area.

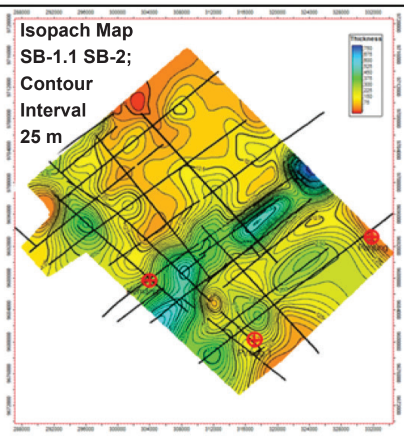
Geochemical modeling was used to determine the maturity level of SRR performed at two of combined seismic tracks (see Figure 10 and 11). Results of geochemical modeling / thermal modeling showed that the average early mature oil at Ro = 0.6% and oil generation (Ro = 0.7-0.9) occurred at a depth of 2200 to less than 3100 m and maturity at the rate of late mature oil (0.9% <Ro <1.2%) was found in the depth range between 3100 s/d 3500 m. Areas that have a maturity level of late mature oil have potential for shale gas formation.

D. Petro-Physical And Sweet Spot Map Analysis

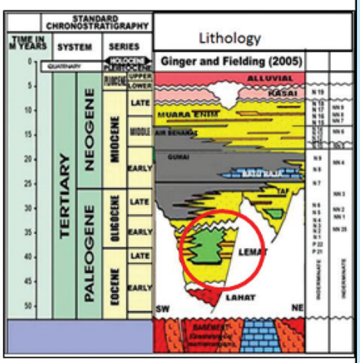
Petro-physical analysis that was performed is not supported by core data as validation, and the results are still considered to be less worthy (less degree of trust). The combined results of the petro-physical analysis of primary data and secondary data is used to predict the values of petro-physical like Vshale, density, porosity, Sw and also the value of the gas content.

This research has produced 9 area sweet spot maps of three sequences that exist in some areas (around Jelapang-Rukam, Kemang-1, Singa-1 and Tepus-1 wells). Areas near the Singa-1 well, are also known as the Benakat Gully area. Figure 12 and 13 respectively are two examples of computation (P-50) of shale gas resource potential (combined absorbed and free gas) and shale oil (using the formula





P-50 assessment of Original Gas In Place (OGIP) based on sweet spot are interpretation Sequence 2 amongst SB-1.1 – SB-2 Kemang area and around it based on criteria:
Tends to be Kerogen Type III
Gas Window (Ro 1.0 approximately on around 3100m depth (red border)
P-50 computation of Original Gas In Place (OGIP), yellow border
Thickness > 30m and ≤ 4000 m



Area	Sekuen	Kedalaman *gas window*	Bulk Volume (acre.f)	Bulk Volume (m3) [pet]	Bulk Volume (cm3)	Net Volume (cm3)
Kemang	SB-1.1 - SB-2	3100	7,99E+07	9,85E+10	9,85E+16	4,92588E+16

Density (gr/cm3)	Mass of Rock Unit (gr)	Mass of Rock Unit (ton)	Gas Content (scf/ton)	Ads. Gas in Place (TCF)
2,6	1,28073E+17	128.072.750.000	40	5,123

N/G shale ~ 50%

Density (gr/cm3)	Mass of Rock Unit (gr)	Mass of Rock Unit (ton)	PHIe	Sw	Bg (rcf/scf)	Free Gas volume (scf/ton)	Free Gas in Place (TCF)
2,6	1,28073E+17	128.072.750.000	0,04	0,6	0,0069	28,633	3,667

Figure 12
Sweet spot area interpretation and shale gas assessment of sequence-2 in Kemang well area and surrounding area.

Downey et al. (2011)). The assessment of free gas is using the formula derived by Lewis et al. (2010). Total computation (P-50) HC resource potential of shale (shale gas and oil) from 9 sweet spot maps are expected to reach 4200 MMBOE.

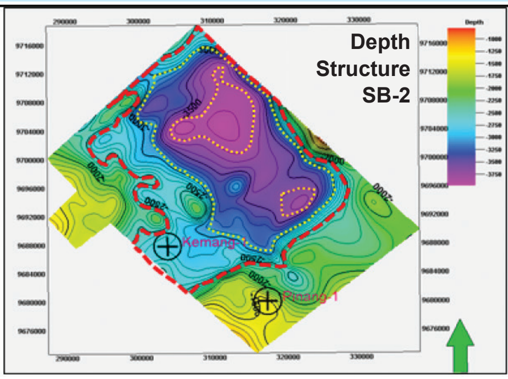
E. Discussion

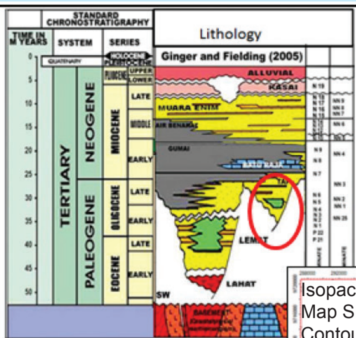
Earlier research did not declare that there was any potential source rock in Lemat/Lahat and Talang Akar formations in South Sumatra Basin. Argakoesoemah et al. (2004) focused his research in Middle Palembang Sub-basin, while Sarjono and Sardjito (1989) and Yuliandri et al. (2013) in South Palembang Sub-basin. The Authors (except Yuliandri et al. 2013) did not describe in detail regarding the sweet spot map and how much hydrocarbon potential is in the area of South Palembang and the Middle Palembang Sub-basins. In general, the reference that has been written concluded source rock maturity in Lahat/Lemat Formation and partly in Talang Akar Formation.

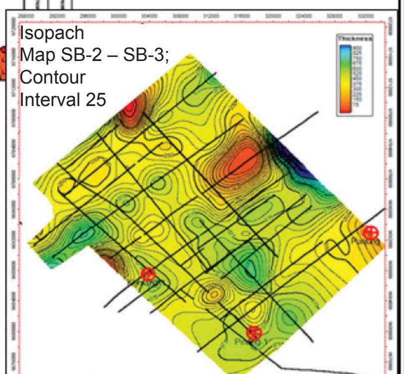
Previous results of studies did not show a significant difference. However, they are very supportive in getting information on the depositional environment in both these formations. This is slightly different from the study results of Sarjono and Sardjito (1989), because Tasim-1 well (TSM-1) Gumai, TAF and the LAF/LEF Formations are considered to be already matured, while according to this study, which is based on modeling of geochemical (thermal modeling) and Ro data, these formations were assessed as less mature source rock.

IV. CONCLUSIONS

South Sumatra basin in the regional South and Central Palembang Sub-basin, has identified non-conventional oil and gas potential of shale hydrocarbons in the Talang Akar (TAF) and lemat/Lahat (LEF/LAF) Formations. In general, Lahat/Lemat Formation was included in sequence-1 (SB-1 - SB-1.1) and sequence-2 (SB-1.1 - SB-2), whereas the sequence-3 is equivalent to the Talang Akar Formation. There are four target areas for mapping hydrocarbon shale (HC shale), which are Jelapang-Rukam, Kemang, Singa and Tepus wells. Seismic attributes processing (sweetness and CWT) on







P-50 computation of Original Gas In Place (OGIP) based on sweet spot area interpretation Sequence III amongst SB-2 – SB-3 Kemang and surrounding area based on criteria:

- Tends to be Kerogen Type II/III
- Oil Window (Ro 0.7 – 0.8 approximately) on around 2500m depth
- (red border)
- The estimation of P-50 bordered in yellow line border
- Thickness > 30m and ≤ 4000 m
- For Oil generation TOC ≥ 1

Area	Sekuen	Kedalaman *gas window*	Bulk Volume (acre.f)	Bulk Volume (m3) [pet]	Bulk Volume (cm3)	Net Volume (cm3)
Kemang	SB-2 - SB-3	**2500**	8,04E+07	9,92E+10	9,92E+16	3,96871E+16

N/G shale ~ 40%

Density (gr/cm3)	Oil Density (gr/cc)	Mass of Rock Unit (mgr)	Mass of HC	Oil Volume (cm3)	S1 (mgHC/gr)	Oil in Place (MMBO)
2,55	0,8	1,012E+14	5,0601E+13	63.251.348	0,5	397,839

Figure 13
Sweet spot area interpretation and shale oil potential assessment of sequence-3 in Kemang well and surrounding area.

existing seismic wells showed the attractive HC shale play in some target sequences, however attribute mapping was not conducted because the seismic data was dominated by seismic vectorization results.

The sweet spot map for HC shale resource assessment was conducted by considering the elements of geometry/dimensions of the structure of the source rock reservoir (SRR), specifically the thickness (> 30m) and (<4000m) depth; limitation of P-50 and the approximate depth of the oil/gas window derived from modeling the thermal maturity. Results of geochemical modeling/thermal modeling carried out on some tracks showed that the average early mature oil at Ro = 0.6% and oil generation (Ro = 0.7-0.90) occurred at a depth of 2200 to less than 3100 m and maturity level at the rate of late mature oil / Early gas window (0.9% <Ro <1.2%) was found in the depth range between 3100 to 3500 m. Areas that have a mature level of late maturity are potential areas for shale gas formation.

Based on the sweet spot map (there are nine sweet spot maps) and petro-physical cut off, computation (P-50) HC shale resource potential in some sequence in each targeted area is estimated to produce a total OGIP of shale gas = 15.600 TCF (about 2650 MMBOE) and OOIP total of shale oil = 1 550 MMBOE. Therefore, the total potential of non-conventional oil and gas resources from HC shale in South and Central Palembang Sub-basin is 4200 MMBOE.

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