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SHALE GAS SWEET SPOT POTENTIAL OF TUNGKAL GRABEN, JAMBI SUB-BASIN SOUTH SUMATERA BASIN

(*Potensi Sweet Spot Gas Serpih Dalaman Tungkal, Subcekungan Jambi, Cekungan Sumatera Selatan*)

Taufik Ramli, M. Heri Hermiyanto Z., and **Andy Setyo Wibowo**
Centre of Geological Survey, Geological Agency
Jl. Diponegoro No. 57, Bandung, Jawa Barat 40122, Indonesia
Telephone: 62-22-7203205, Fax: 62-22-7202669

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ABSTRAK

Dalaman Tungkal berada di Subcekungan Jambi, yang merupakan bagian utara dari Cekungan Sumatera Selatan. Cekungan ini merupakan salah satu cekungan penghasil hidrokarbon terbesar di Indonesia. Terdapat beberapa batuan sumber di Cekungan Sumatera Selatan. Lapisan serpih dan batubara dari Formasi Talangakar (TAF) diketahui sebagai salah satu batuan sumber utama di cekungan ini, dan diharapkan juga sebagai batuan reservoir untuk gas serpih di Dalaman Tungkal. Data yang digunakan adalah data geologi permukaan sebagai analogi singkapan yang diambil di bagian selatan kaki Bukit Tigapuluh dan diintegrasikan dengan data bawah permukaan (data sumur dan data seismik) di Area Dalaman Tungkal. Studi ini menggunakan metoda yang terintegrasi antara analisis lingkungan pengendapan, analisis geokimia organik, analisis petrografi, interpretasi data seismik, deliniasi sweet spot dan perhitungan volumetrik. Formasi Talangakar yang diobservasi di lapangan dan data sumur, disusun oleh serpih dan batulanau dengan sisipan batubara, batupasir dan batugamping. Formasi ini diinterpretasi diendapkan pada lingkungan transisi. Serpih dan batulanau Formasi Talangkar memiliki karakteristik yang berpotensi sebagai pembawa gas serpih, dengan kekayaan material organik yang cukup, tipe kerogen yang sesuai, mencapai kematangan pada jendela gas, dan tingkat kegetasan baik. Berdasarkan parameter yang telah ditentukan, diketahui net to gross 0.158, kematangan memasuki jendala gas pada kedalaman 10250 kaki dan luas area sweet spot mencapai 8.9 x 108 ft^2, dengan total potensi sumberdaya gas serpih dengan metoda Ambrose mencapai 2.12 TCF.

Kata Kunci: *Tungkal Graben, Jambi sub-Basin, TAF, TOC, brittleness index, sweet spot, Gas in Place.*

ABSTRACT

The Tungkal Graben is located in Jambi Sub-basin, the northern part of South Sumatera Basin. This basin is known as one of the largest hydrocarbons producing basin in Indonesia. There are several proven source rocks in the South Sumatera Basin. The paralic shales and coal horizon of Talangakar Formation (TAF) are known as primary source rock in this basin and considered as a reservoir of shale gas-bearing in Tungkal Graben Area as well. This study used surface geological data that was collected from the southern foot of Tiga Puluh Mountain as the outcrop analogy and subsurface data (existing well and seismic data) in Tungkal Graben Area. This study applied integrated methods including environmental deposition analysis, organic geochemistry analysis, petrophysical analysis, seismic interpretation, sweet spot delineation, and volumetric of gas in place (GIP) calculation. TAF observed both on the outcrop and well is transition deposit that consists of the dominance of shale and siltstone with interbedded of coal, sandstone, and limestone. Shale and siltstone of TAF have characteristic which is appropriate as a shale gas bearing, with sufficient organic content richness, suitable kerogen type, its maturity entering the early gas generation and proper brittleness index (BI). The sweet spot area is an area that has met the criteria for potential shale gas and determined by pay zone criteria. Depend on the criteria, Net to gross for shale gas is 0.158, early gas generation estimated at a depth of 10250 feet, and sweet spot area reaches 8.9 x 108 ft^2. Thus, the total potential of shale gas resources from the calculation using the Ambrose method is 2.12 TCF.

Keywords: Tungkal Graben, Jambi sub-Basin, TAF, TOC, brittleness index, sweet spot, Gas in Place.

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I. INTRODUCTION

The Tungkal Graben is located in Jambi Sub-basin. This Subbasin lies within the northern part of South Sumatera Basin (Figure 1). South Sumatera Basin is a mature basin in Sumatera Island. This basin is known as one of the largest hydrocarbons producing basin in Indonesia.

Theoretically, hydrocarbon that expelled into a conventional reservoir is estimated only about 60% (Jarvie, 2008), whereas the rest remain in the source rock body which has very poor porosity and permeability. Therefore, The South Sumatera Basin has the potential of shale gas.

Base on regional studies, there are several proven source rocks in the South Sumatera Basin. The paralic shales and coal horizon of TAF are known as the primary source in this basin (Ginger & Fielding, 2005). Some shale samples from TAF collected from the foot of Tiga Puluh Mountain show good quality as source rock potential, and then used as an analogy for well data. Therefore, shale of TAF below gas window is considered as reservoir of bearing shale gas in Tungkal Graben Area.

The objective of this study is to know the characteristic of shale of TAF as reservoir of shale gas-bearing potential and delineate the sweet spot area (determined by pay zone criteria: volume shale > 0.5, TOC > 1, BI > 0.3 and must be in the early gas generation), by integrating various analysis of surface geological data and existing subsurface data (well and seismic data) in Tungkal Graben and surrounding areas.

A. Regional Geology

The South Sumatra Back Arc Basin | is one of the Tertiary sedimentary basins formed by fault extension movements due to the collision of the Indian Ocean Plate with the southeastern part of the Sunda Shelf since the Paleogene. The basin is divided into several sub-basins, each of which has its characteristic structural pattern due to the influence of the underlying bedrock configuration. The history of the basin can be divided into three tectonic megasequences (Ginger & Fielding, 2005).

- Syn-Rift Megasequence (c. 40 – c. 29 Ma). The South Sumatra Basin experienced large extensional events from the Eocene to the Early Oligocene as the result of subduction along West Sumatera Trench. The beginning extension was oriented east-west, then it has been rotated approximately 15 degrees clockwise since the Miocene according resulting in the current north-northeast south-southwest

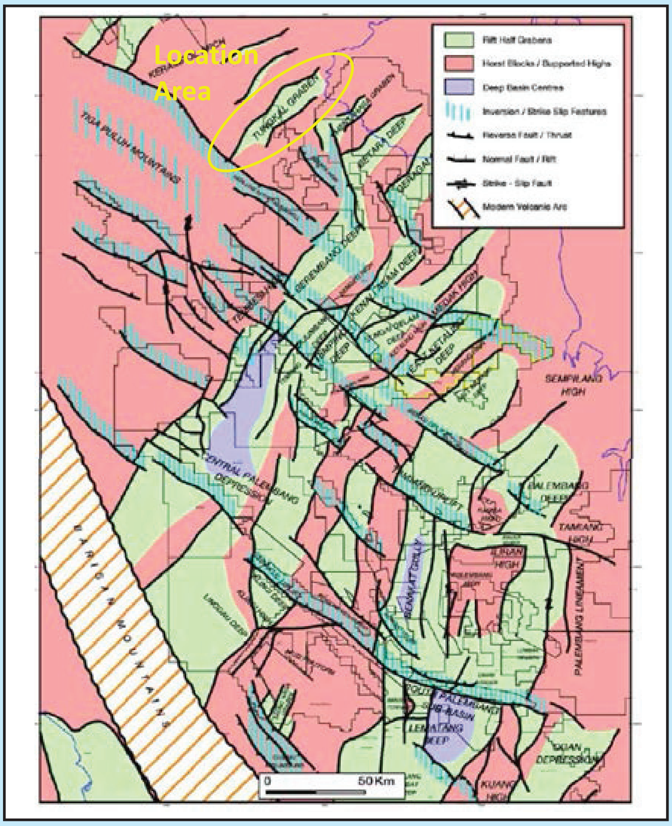

Figure 1
Tungkal Deep is located in Jambi Sub-basin, northern part of South Sumatera Basin (Ginger, 2005).

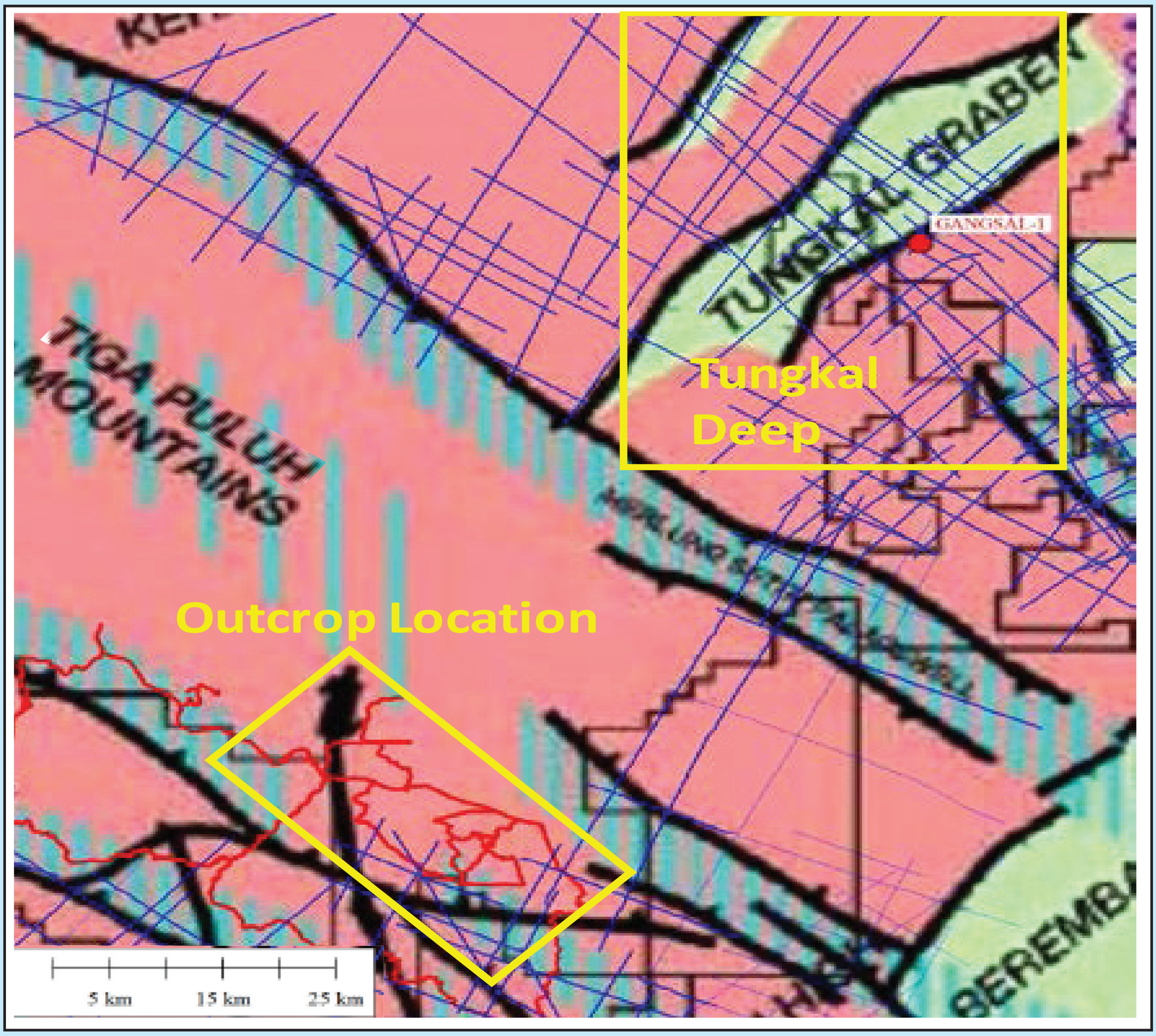

Figure 2
Data availability map in study area,
consist of seismic (blue line), well (red dot) and surface geological transection (red line).

orientation of the graben (Figure 1). During this period the Lahat Formation, Lemat Formation and Talangakar Formation are deposited (Figure 2).

- Post Rift Megasequence (c. 29 – c. 5 Ma). Rifting ended at 29 Ma, but the South Sumatran Basin remains subsidence due to equilibrium was re-established. Subsidence and sea level-rise results in transgression and reach a maximum at 16 Ma and inundate the entire basin. A decrease in subsidence rate and an increase in sediment input from 16 ma to 5 ma results in a regression. In this phase there is evidence of a significant tectonic effect. During this period the Baturaja Formation, Gumai Formation, Airbenakat Formation, and Muara Enim Formation are deposited (Figure 2).
- Syn-Orogenic/Inversion Megasequence (c. 5 Ma – Present). Uplifting due to the Barisan Orogeny throughout Sumatra since 5 Ma. This orogeny results in a northwest-southeast orientated inverted/transpressional folds and cut across much of the underlying syn-rift fabric (Figure 1). During this period the Kasai Formation and Alluvium deposited (Figure 2).

II. METHODOLOGY

The main data used in this in the study are surface geological data that collected from southern foot of Tiga Puluh Mountain, and existing well and seismic data in Tungkal Graben and surrounding areas (Figure 3). The surface geological data consist of stratigraphic measurement, outcrop sample, and the result of laboratory analysis. While subsurface data consist of Gangsal-1 Well and several existing 2D seismic data acquired from 1969 to 2008. The method used in this study is:

- Environmental Deposition analysis both of outcrop sample and well data, from lithology description and SEM analysis.
- Review of geochemical analysis from both of outcrop sample and well data (Hermiyanto et al, 2018), to provide information about kerogen type, richness and maturity of source rock.
- Petrophysical Analysis to generate the property of source rock (volume shale, porosity, gas saturation, and TOC and Brittleness Index estimation from log).
- Seismic Interpretation to provide an overview of structural configuration and delineate the sweet spot area.
- Calculate the volumetric of gas in place in sweetspot area.

III. RESULT AND DISCUSSIONS

Before performing subsurface data analysis, surface geological data analysis is performed as an analogy to TAF. TAF outcrops are very limited. TAF that observed at TR 23 (1°23’15,3348”S, 102°45’39,3912”E) in the foot of Tiga Puluh Mountain consist of siltstone and shale with thin coal and sandstone interbedded (Figure 4). The outcrop description is shale of TAF has a blackish brown color, carbonaceous, not calcareous, with coal and fine grains sandstone as interbedded (Figure 4 c – d). While siltstone with is light grey color, sandy, slightly calcareous, slightly soft and locally carbon streak with thin coal and sandstone interbedded (Figure 4 d). The thickness of TAF shale can reach 12 meters (Figure 4 a). The TPI/GI analysis of TAF coal, which indicates the formation was deposited on marsh peatlands (Hermiyanto et al, 2018). The deposition environment for this type of peatland according to Diessel (1992) is the lower delta plain with tidal influences. This is also reinforced by the

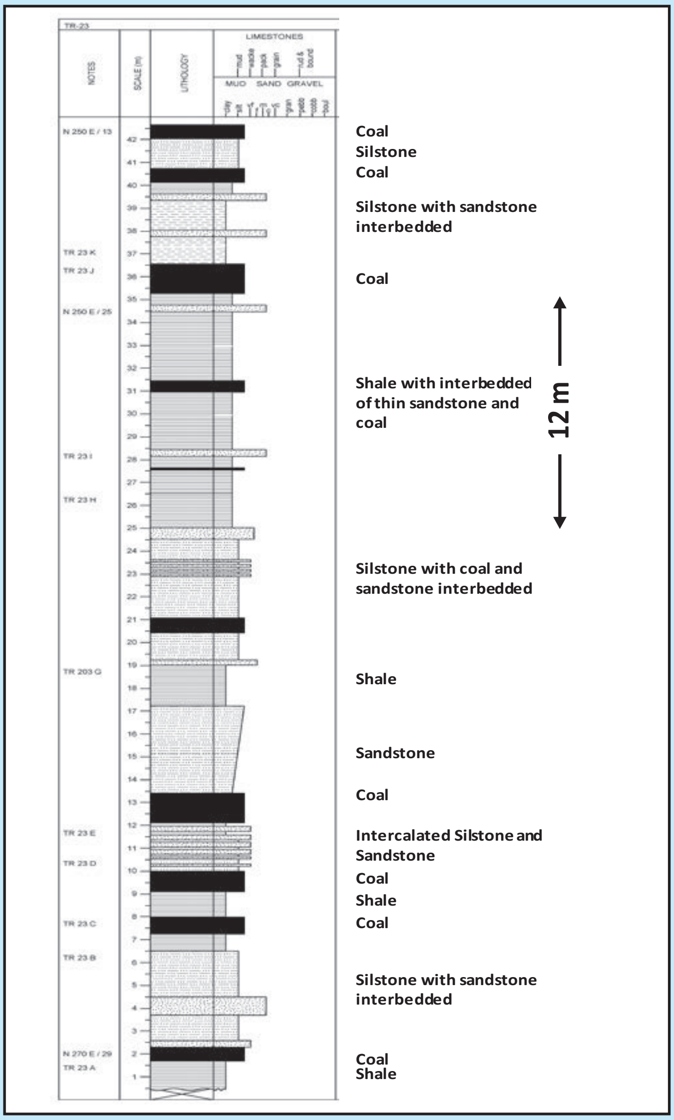

Figure 3
Stratigraphic section of TAF that observe in the foot of Tigapuluh Mountain.

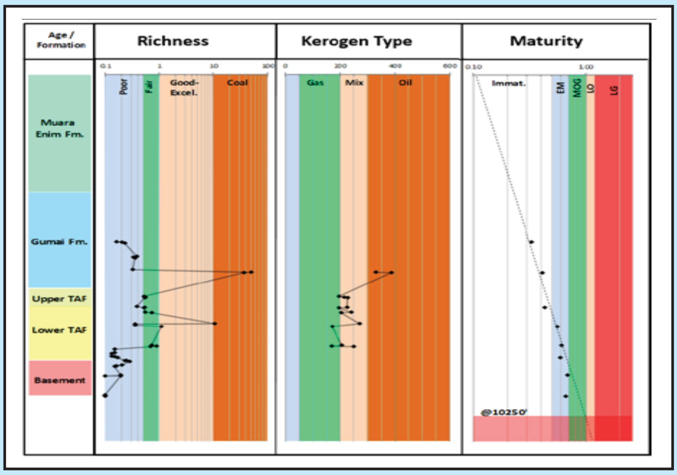

Figure 4
Geochemical review of Gangsal-1 well.

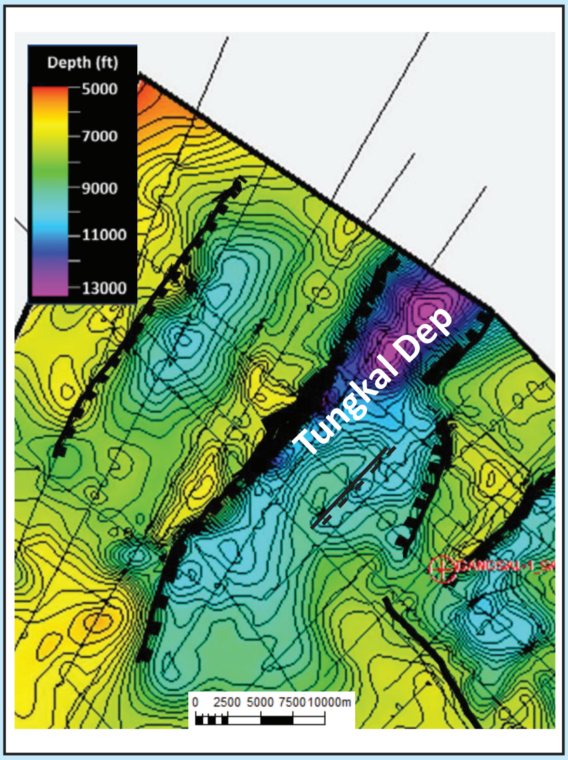

Figure 5
Depth structure map of basement that show southwest-northeast trend of the graben.

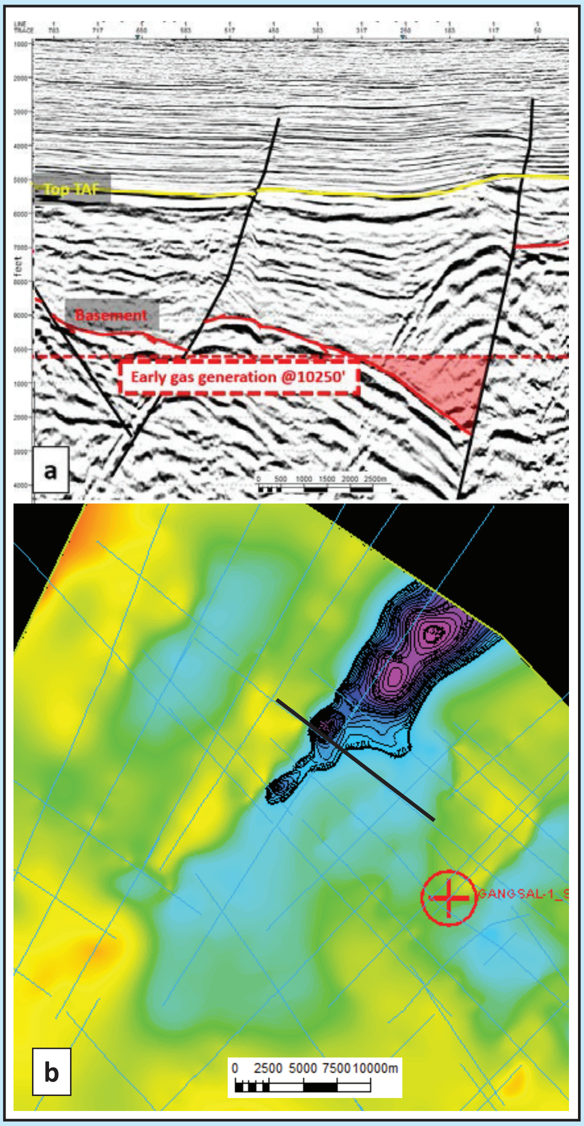

Figure 6
Shale gas sweet spot for TAF at Tungkal deep. a) seismic interpretation of Tungkal deep and show early gas generation estimated at a depth of 10250 feet, b) map of potential sweetspot of Tungkal deep.

SEM analysis of the TAF shale that show the presence of framboidal pyrite mineral as an indicator of the transition deposition environment.

Geochemical Analysis of TAF outcrop sample at TR 23 (Table 1) show the total organic content (TOC) range between 2.18 - 20.42% (very good - excellent) for shale (TR 23 A, B, G, H) and 1.59 % (good) for siltstone (TR 23 D). HI values for the shale range from 73 - 211 mg HC / g TOC and 122 mg HC / g TOC for siltstone. The kerogen types of shale and siltstone are type III based on cross plot diagram of TOC and S2 (Langford and Blanc-Valleron, 1990). Then, TAF has a range of Tmaks of 428 - 439oC with tend to indicate immature – mature category. Besides that, XRD analysis is also done to determine the value of the brittleness index (BI) using Wang dan Gale (2009) formula. The result shows the BI value of shale is 63.25 – 70.78 % which is categorized as brittle and 38.75 % (less brittle) for siltstone (Perez & Marfurt, 2013).

In the Gangsal-1 well, the TAF is composed of shale and sandstone with an interbedded of limestone, thin coal and tuffs. Shale have the characteristics of dark gray color, hard, broken platy-subfissile, wax luster, non-calcareous, and there is carbon streak associated with pyrite. Sandstone has the characteristics of light gray, grain size very fine-medium, locally coarse-sized grain, grain shape sub-angular-subrounded, poorly sorted, non-calcareous. The wackestone limestone interbedded, light gray, hard, microcrystalline, and have angular fragments. Based on the description of the cutting data of the TAF at this well indicates that this formation is a transition deposit.

Furthermore, a review of geochemical data was carried out at the Gangsal-1 well (Figure 5). Review of the data carried out to determine the richness of carbon content, kerogen types of shale rocks and the maturity of the source rock that has the potential to be a shale gas bearing. The richness of carbon content of TAF is poor – good. The kerogen type is type II-III, which tends to produce gas and oil. While its maturity entering the early gas, generation is estimated at a depth of 10250 feet based on the trend of maturity (Figure 5 dan Figure 7 a).

Petrophysical analysis is carried out to generate the property of source rock, which is volume shale, porosity, gas saturation, TOC and Brittleness Index estimation from log. Estimation of the value of TOC is done using the method of Passey et al. (1990), by calibrated using the result of laboratory analysis of well data. Estimation of BI value is undertaken with approach of Modulus Young and Poisson's Ratio. Petrophysical summary of TAF parameters are: Average Vsh= 0.154, Porosity = 7.8 %, Sw = 0.27 %, and kerogen density = 2.465 gr/cm^3, Average TOC = 1.64% and Average BI = 44,085%.

Seismic Interpretation is done to provide an overview of structural configuration and then it can lead to delineate the sweet spot area. From the results of the interpretation of seismic data, the geological structure that developed in the study area was a normal fault (Figure 7 a - b). The trend of normal fault that forms the half-graben is southwest-northeast (Figure 6).

The sweet spot area is an area that has met the criteria for potential shale gas. Sweet spot is determined by pay zone criteria, that is: volume shale > 0.5, TOC > 1, BI > 0.32 (less brittle-brittle) and the shales in these plays must be in the early gas generation. Because there are no wells in the sweet spot area, the parameters used for next gas in place calculations are taken from the nearest well, the Gangsal-1 well. From these criteria, it is known that the net to gross (NTG) shale at TAF interval of Gangsal-1 well is 0.158, with maturity entering the early gas generation estimated at a depth of 10250 feet (Figure 7 a), and sweet spot area reaches 8.9 x 108 ft2 (Figure 7 c).

Gas in place (GIP) calculated using the Ambrose method, with total gas in place is the amount of free gas and absorb gas. However, for calculate the adsorbing gas content using Jarvie TOC vs Gas Content chart, because of there are no Langmuir Isotherm Analysis. The result for adsorb gas from the Jarvie TOC vs Gas Content chart of TAF is approximately 41.98 SCF/TON. Therefore, the total potential of shale gas resources from the calculation using the Ambrose method is 2.12 TCF.

IV. CONCLUSIONS

TAF observed both on the outcrop and well is transition deposit that consists of the dominance of shale and siltstone with interbedded of coal, sandstone, and limestone. Shale and siltstone of TAF have a characteristic which is appropriate as a shale gas bearing, with sufficient organic content richness, suitable kerogen type (kerogen type II dan III), and its maturity entering the early gas generation, but based on Brittleness Index (BI) value of TAF surface data, shale of TAF has better quality as shale gas-bearing than siltstone of TAF. The sweet spot area is an area that has met the criteria for potential shale gas, that is: volume shale > 0.5, TOC > 1, BI > 0.32 (less brittle-brittle) and the shales in these plays must be in the early gas generation. By these criteria is known that the net to gross is 0.158, with maturity entering the early gas generation estimated at a depth of 10250 feet, and the sweet spot area reaches wide 8.9 x 108 ft^2. Thus, the total potential of shale gas resources from the calculation using the Ambrose method is 2.12 TCF.

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REFERENCES

Ambrose, R. J., Hartman, R., Diaz-Campos, M., Akkutlu, I. Y., & Sondergeld, C.H. , 2012. Shale Gas-in-Place Calculations Part I: New Pore-Scale Considerations. *SPE Journal,* March.17(01).

Diessel, C. F. K., 1992. *Coal Bearing Depositional.* 1st ed. Berlin, Germany: Springer-Verlag.

Ginger, D. & **Fielding, K**., 2005. *The petroleum systems and future potential of the South Sumatra basin.* Jakarta, Indonesian Petroleum Association.

Hermiyanto, H., Ramli, . T. & **Syamsir**, 2015. *Rekomendasi Wilayah Kerja Migas Non Konvensional Sub Cekungan Jambi.,* Bandung: Centre of Geological Survey, Geological Agency.

Jarvie, D., 2008. *Unconventional Shale Resource Plays: Shale-Gas and Shale-Oil Opportunities.* Texas: Wordwide Geochemistry.

Perez, R. & **Marfurt, K.**, 2013. *Calibration of Brittleness to Elastic Rock Properties via Mineralogy Logs in Unconventional Reservoirs.* Cartagena, Colombia, AAPG International Conference and Exhibition.

Wang, F. P. & **Gale , J. F. W.**, 2009. Screening criteria for shale-gas systems. *Gulf Coast Association of Geological Societies Transactions,* Volume 59, pp. 779-793.