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International Symposium on Earth Science and Technology 2016

Greetings from Cooperative International Network for Earth Science and Technology (CINEST)

We are facing with global environmental problems with problems on resources depletion at behind. In particular, the rapid increases in mineral resources and energy consumptions have cast a shadow over the sustainability of human activities. The CINEST was founded in 2008 to enhance cooperative studies and activities by young researchers and engineers, because their boldly tackles must be keys and absolute foundation to solve problems found on the earth, especially in Asia and Africa. I would like to emphasize to young researchers that performing research "by hand" rather than "by manual" may develop their potential to find new solutions.

This international symposium started from 2008 cooperating with The JSPS International Training Program during 2008 to 2012, and has been supported by Mitsui-Matsushima Co., Ltd. from 2013. The important objective of the symposium is strong networking of young researchers to enhance international collaboration to solve both of global and domestic problems on mineral resource and environment.

Finally, I would like to sincerely thank all of the organizations and participants, and believe the symposium will provide fruitful successes for all.

Welcome to "International Symposium on Earth Science and Engineering 2016."

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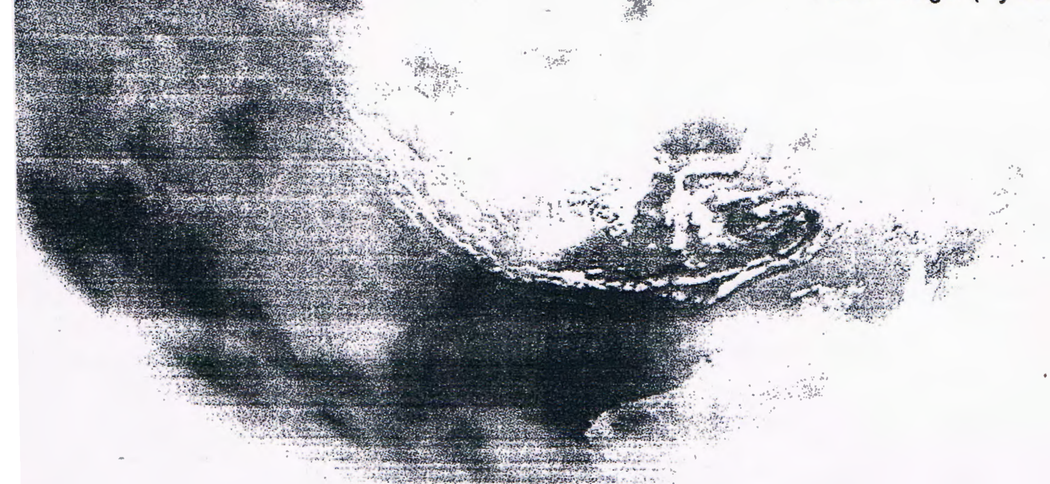

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Saturday, 10th of December, Field Trip "Traditional and Latest Ceramics Technology in Kyushu"

(Registration closed)

8:00 Meet at the meeting place, JR Hakata Station (Chikushi ext.)

8:10 Depart from JR Hakata Station by bus

9:00 Kyushu University, Ito campus (One brief stop on the way)

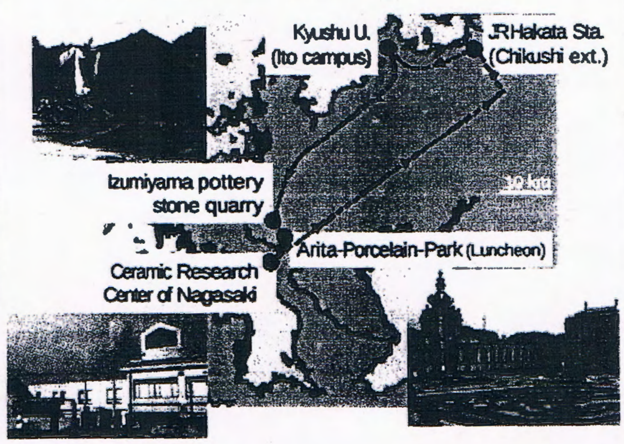
11:00-11:30 **Izumiyama pottery stone quarry** (Arita town, Saga pref.)

11:50-14:00 **Lunch in Arita-Porcelain-Park** (buffet-style, Arita town, Saga pref.)

14:15-15:15 **Ceramic Research Center of Nagasaki** (Hasami town, Nagasaki pref.) (One brief stop on the way back)

17:00 Arrived at JR Hakata station

18:00 Arrived at Kyushu U., Ito campus



Contents

Shale Gas Potential of Talang Akar, South Sumatra Basin Case Study: The "MB" Area, Batanghari Regency, Jambi Province, Indonesia

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ABSTRACT

The purpose of this study is to estimate the potential of shale gas Talang Akar Formation based on the surface and subsurface data analysis.
The MB Area is lies in the Jambi Sub Basin which is part of the South Sumatra Basin. The area is approximately 758 km^2. Administratively, located in Batanghari Regency, Jambi Province.
The Jambi Sub-Basin was underlain by Pre-Tertiary basement rocks. The Tertiary sedimentation commenced with the syn-rift sediments of the Eocene Lahat then Talang Akar formation unconformably overlies the Lahat Formation. That formation was deposited during Oligo-Miocene was succeeded by the pre-dominantly sag phase. Furthermore, Middle-Late Miocene Gumai Formation was deposited overlying Talang Akar Formation. Overlying Gumai Formation was deposited Air Banakat and Muaraenim Formations.
The structural that develops are NE-SW trending normal fault, and NW-SE trending reserve fault & fold fault and folds with NW-SE direction.
Geochemical analysis results indicate that the shale Talang Akar has potential as a source rock that can produce gas when it has reached a level of maturity. Brittleness Index is obtained from X-ray diffraction analysis shows the brittle properties with 46% quartz content (brittle).
The physical reservoir properties used for estimating the shale gas resources at Talang Akar Formation are : porosity (0.04); average water saturation (0.35); bulk volume is 6,38x10^{10}m^3, TOC 1,6%; Vitrinite Reflectance / Ro (1,35%) and physical gas characteristic: free gas content = 78,625 scf/ton and adsorbed gas = 49 scf/ton.

Keyword : Talang Akar, structural, geochemical, source rock, maturity, brittleness index, reservoir, free gas content, adsorbed gas

INTRODUCTION

The Shale of Talang Akar have trusted as a potential source rock in South Sumatera Basin that its one of the biggest hydrocarbon basin in Indonesia. The improvement of conventional gas production gas till look for new field have been done as a solution, but it can't balancing with the increment of needs. Furthermore, the development in unconventional energy, such as shale is needed as the best way to choose .

As a dominant source rock in South Sumatra Basin, the potential of Talang Akar shale can be determine by integrated data availability from surface and sub-surface as well.

DATA AND METHODS

Data has been obtained by observation and systematically sampling toward shale in Talang Akar Formation, then undergone analyzed in laboratory and supported with subsurface data.

Total Organic Carbon (TOC), Rock - Eval Pyrolysis, Maturity of vitrinite Reflectance (Ro), and XRD analysis (Brittleness index) are the surface data for verfication.

Subsurface data that used to determine Boundary of Formation, Geochemical analysis and Petrophysics has been delineated from the only one well. Then, to determine the Geometry of subsurface used Seismic Data.

The integrated data of surface and subsurface used to estimate the potency of shale gas in study area.

GEOLOGICAL FRAMEWORK

South Sumatra Basin separated with Central Sumatra Basin by Tigapuluh Mountain High, separated with Sunda Basin by Palembang / Lampung High, and bounded on the west by the Barisan Mountains. This basin is divided into four sub-basins are: Jambi sub-basin, Palembang Sub-Basin of North, Central Palembang Sub-basin and South Palembang sub-basin. "MB" Area is located in the Jambi Sub-Basin (see **Fig. 1**).

Stratigraphically, Jambi sub-basin underlain by pre-Tertiary rocks there on consists of Lahat Formation (Eocene-Oligocene), then Talang Akar Formation that deposited with unconformity (Oligo-Miocene), and then continued on it deposited Gumai Formation (Middle Miocene), Air Benakat

(Upper Miocene), Muara Enim (Pliocene), and Kasai (Pleistocene), see **Fig. 2**.

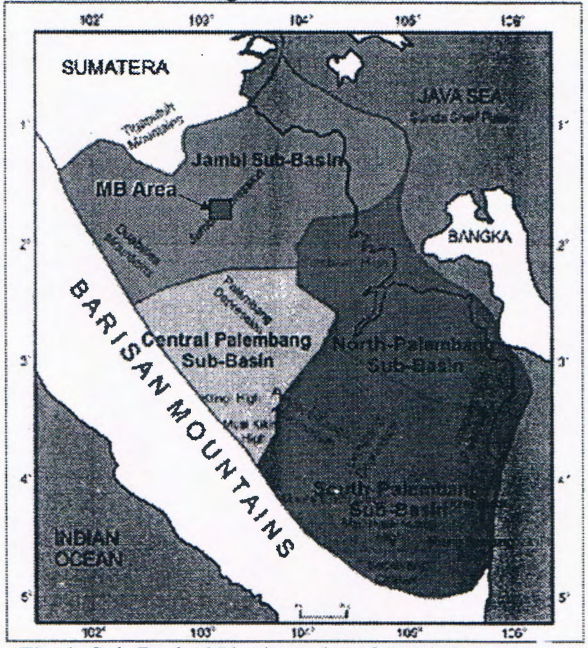

Fig. 1 Sub-Basinal Physiography of South Sumatera Basin (Sarjono and Sardjito, 1989)

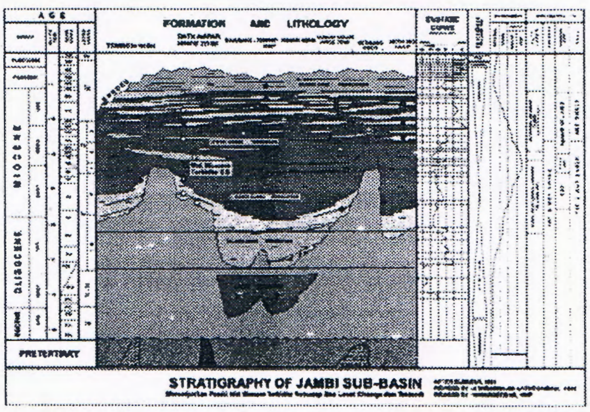

Fig. 2 Stratigraphy of Jambi Sub-Basin (Heriyanto, 2002). Stratigraphy of study area is red marked

In MB Area, Exposed Air Benakat Formation, Muara Enim and Kasai, while the Talang Akar Formation as a reservoir shale gas which has been targeted in this study did not exposed on surface, so that outcrop observations carried out at a distance which is considered the closest location from well **(Fig. 3)**.

Talang Akar Formation outcrops encountered shale with sandstone intercalation. Brown to black shale sized clay-silt, consisting of quartz, silica cement with bedding parallel sedimentary structures; sandstones, gray, coarse grain size, consisting of quartz, silica cement, parallel lamination, lenticular, and bioturbation.

The presence of pollen species are *Monoporites annulatus*, *Dicolpopollis sp*, *Laevigatosporites sp*, *spVerrucatosporites*, *Pteris*, and *Acrostichum aureum*, indicates that shale sample BD-1 Talang Akar Formation in this location is the Lower Miocene. The presence *Zonocostites ramonae* and *Acrostichum aureum* is indicating marine depositional environment adjacent to the mangrove environment.

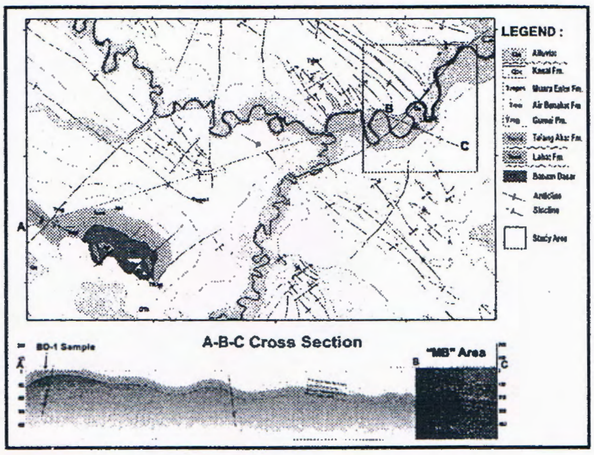

Fig. 3 Geological map of MB area and its adjacent area.

Surface Data

The first step in the exploration stage, the analysis of surface data as the primary data to get an idea of the potential of geochemically and XRD.

Surface Geochemistry sample

The potential of rocks obtained from the analysis of TOC and Rock Eval Pyrolysis can be seen in Table 1 indicates that the sample BD-1 has a value TOC 6.4%, so it has generally been accepted that \the sample containing bigger than 0.5% can be considered has potential sufficient to produce hydrocarbons commercially, therefore, established as the source rock, based on the analysis, the sample has a excellent TOC values (Peters and Cassa, 1994).

Hydrogen index is 572 mgHC/g.TOC and oxygen index of 19 mgHC/g. TOC,and then it plotted on Van Krevelen diagram to indicate that the sample BD-1 has a tendency especially can produce oil **(Fig. 4)**.

The Maturity results from measurement at maximum temperature Tmax (S2) obtained 428°C, while the value of Ro that obtained from vitrinite reflectance of is 0.37. The value of sample BD-1 is considered not reached thermal maturity. In the terminology of the Source Rock (Waples, 1985), including source rock potential (potential source rock), because the sedimentary rocks are immature but has the ability to generated hydrocarbons if it has higher maturity.

Table 1 Analysis result of geochemistry analysis BD-1 sample

No	Sample ID	Lithology	TOC (wt.%)	mg/gm rock			Tmax (°C)	Oil Production Index (OPI)	Potential Yield (S_1+S_2)	Hydrogen index	Oxygen Index
				S_1	S_2	S_3					
1	BD-1	dk gy Sh	6.44	0.15	20.30	0.68	428	0.01	20.45	572	19

S_1 = Free Hydrocarbons; S_2 = Pyrolysable Hydrocarbons; S_3 = Organic CO_2
Oil Production Index = Transformation Ratio = $S_1/(S_1+S_2)$; Tmax = Temperature of Maximum S_2; Oxygen Index = $(S_3/TOC) \times 100$
* Pyrolysis by Rock Eval 6, TOC content by Leco Analyzer; Hydrogen Index = $(S_2/TOC) \times 100$

- ***Brittleness Index***

One parameter of the shale gas potential of is a value brittleness (brittleness index) mainly quartz content of the shale rock. This analysis used to determine the mineral content, percentages and mineral crystallinity of the samples that taken from investigation area. Based on results of XRD analysis, the shale sample BD-1 has the most dominant quartz content of 46% accompanied by a group of clay minerals with a total of 44% consisted of 2% smectite, 16% illite and 26% kaolinite (**Table 2**).

No.	Sample ID/FORMATION	CLAY MINERALS (%)					CARBONATE MINERALS (%)			OTHER MINERALS (%)					TOTAL (%)			BRITTLENESS INDEX
		SMECTITE	ILLITE-SMECTITE	ILLITE	KAOLINITE	CHLORITE	CALCITE	DOLOMITE	SIDERITE	QUARTZ	K-FELDSPAR	PLAGIOCLASE	GOETHITE	PYRITE	CLAY	CARBONATE	OTHER	
1	2636/13 BD-1 (TAF)	2	-	16	26	-	-	-	-	46	5	3	-	2	44	-	56	1

Table 2. Mineral content in X-Ray Diffraction analysis

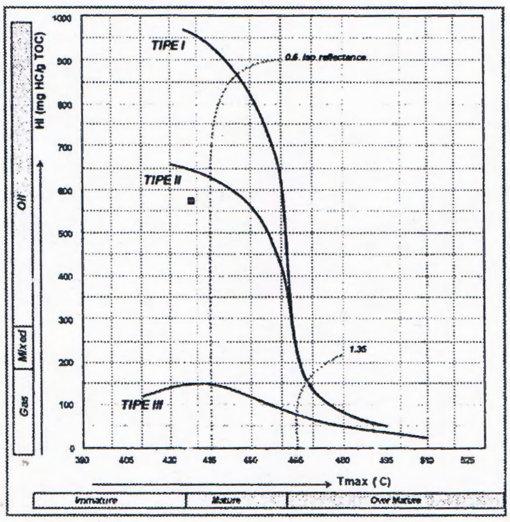

Fig 4. Diagram of Hydrogen Index values versus T_{max} on the sample BD-1 (■).

Subsurface Data

LST-1 is a name of available exploration well data that used in this investigation and it has been integrated with seismic to show the geometry and formation boundary.

Well Data Analysis

Sequence stratigraphy in the well from top to bottom based on data log are: - Muara Enim Formation - Top Formation Air Benakat - Top Formation Gumai - Top Talang Akar Formation - Basement. The results of the analysis are discussed below.

Organic Richness

Geochemical data from LST-1 well data was showing the character of organic carbon content Talang Akar Formation average above 1%, the lowest score obtained by the organic carbon content of 1.34% to 2.32%, the average value of the entire interval was 1.6%.

Kerogen Type

Analysis by well data used plotting the diagram HI versus T_{max} Talang Akar shale as can be seen in **Fig.5**. The results of the analysis obtained type II kerogen and III which shows the Talang Akar Shale in MB Area has a tendency to generated oil and gas.

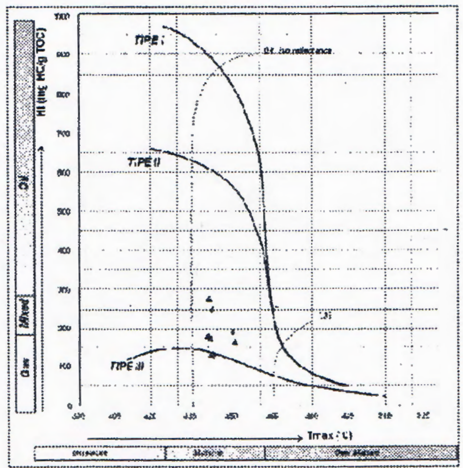

Fig 5. HI versus T_{max} diagram of Lst-1 well (▲)Talang Akar shale

Maturity

Maturity Analysis of organic material carried by reviewing geochemical data on wells LST-1, T_{max} and Ro; T_{max} Parameter is the peak S2 temperature when it reaches maximum, the pyrolysis temperature is used as the peak of maturity, when the maturity of kerogen increases, the temperature showing the maximum rate of pyrolysis also occur improvement, so if T_{max} has higher value, the rock has matured. The plotting data Ro versus depth can be seen in **Fig. 6**.

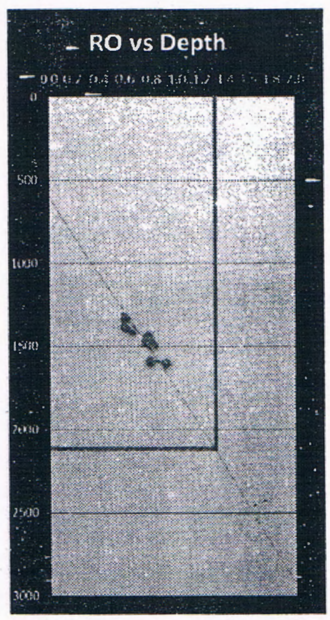

Fig 6. a) plot data Tmax terhadap kedalaman
b) plot Ro terhadap kedalaman

Petrophysical Analysis

Petrophysical analysis performed with worksheet data on wells Lst-1 This analysis was conducted to obtain the value of shale volume, the value of total porosity and water saturation (Sw), see **Fig.7** and **Table 3**.

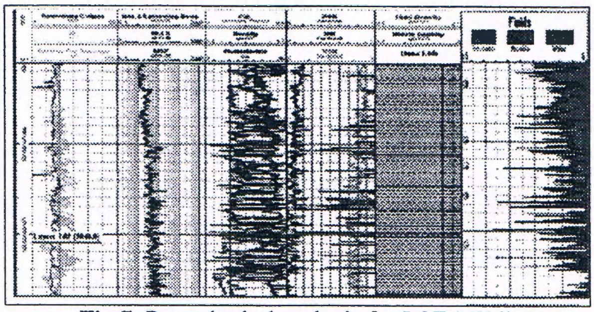

Fig 7. Petrophysical analysis for LST-1 Well

Interval (ft)	Gross (ft)	Net Shale	N/G	Sw	Phit
5367.5 - 4054.2	1313	1125.4	0.14	0.5	0.26

Tabel 3. Petrophysical analysis results

Burial History

Geothermal gradient base on LST-1 well data are + 3,7°C / 100 meters. At this location, the initial maturity of the wet gas starts at a depth of 1500 meters on the value of Ro = 0.8%. Talang Akar formation is at a stage of maturity window gas (% Ro 1:35). With these parameters it is for the location of MB that has a type II/III kerogen can be made at the level trend that Ro = 1.35 is obtained at a depth of 2100 meters. The burial history of the model is known that the early stages of the formation of gas is reached at 6.5 Ma (**Fig. 8**).

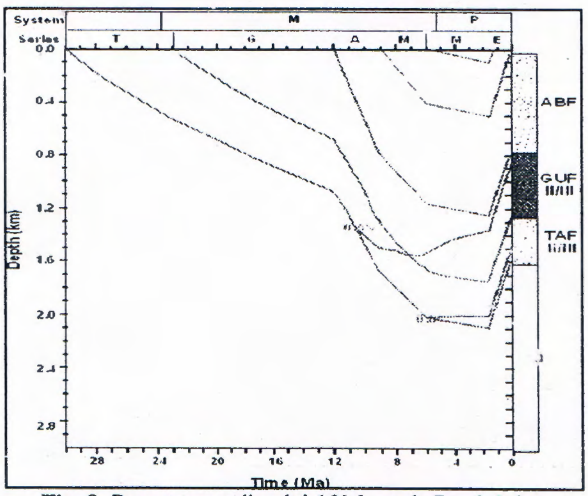

Fig. 8. Pematangan dimulai 10Ma pada Ro=0,5 dan pembentukan gas 6,5Ma pada Ro=0.8

Talang Akar Formation Geometry

On shale gas system, Talang Akar Formation in the study area is regarded as the reservoar of shale gas, while the geometry of the layer is controlled by the upper and lower part which has variation of thickness, to know the volume of it the authors used a software. Talang Akar Formation geometry in MB area shown by the 3-dimensional to provide an understanding to get bulk volume. Talang Akar formation containing gas is calculated from the upper of gas window to the lower formations that underlain as can be seen in **Fig 9.**

With this method, the calculation results of bulk volume of Talang Akar Formation in "MB" Area is 6.39 x 1010 m3 or 5,180,465,025.78 acre ft.

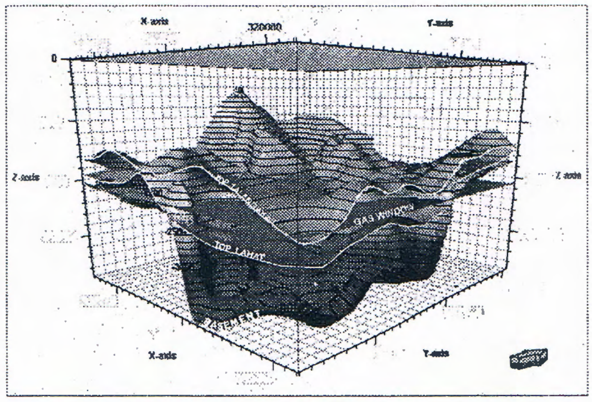

Fig. 9. 3-D view of Talang Akar and its boundary

Free Gas Content

The content of free gas in the study area was calculated using Lewis Formula (2007), this formula basically calculating the gas content per ton of shale, not directly calculate the gas resources in the reservoir, the following formula is used:

$$Gcfm = \frac{1}{B_g} \times [\emptyset_{eff}(1 - Sw)] \times \frac{\varphi}{\rho_b}$$

dengan penjelasan :

Gcfm = volume of free gas (scf/ton)
Bg = gas formation volume factor
Øeff = effective porosity
Sw = water saturation
ρb = bulk density (g/cm^3)
φ = conversion constant (32,1052)

The result of calculation of free gas in the area MB Area is presented in Table 4.

Gf (scf/ton)	Porosity Avg	Sw Avg	ρb (gr/cm^3)	1/Bg	Constant
78.62	0.04	0.6	2.46	300	32.1052

Table 4. Result calculation of free gas

Adsorbed Gas

Initial adsorbed shale gas in place volume in "MB" area calculated using Jarvie charts (2004). Based on this formula, adsorbed gas content determined using the TOC value. Actually, this method used Barnett shale as an analogue (**Fig. 10**), in Indonesia has not model for the calculation. The most important parameter to consider in this calculation is the value of porosity, based on petrophysical analysis the porosity value that shown 0.26 is too large, then, to calculate it use the assumptions below 10% (Slatt, 2012) and the parameters that used in this calculation is 0.04.

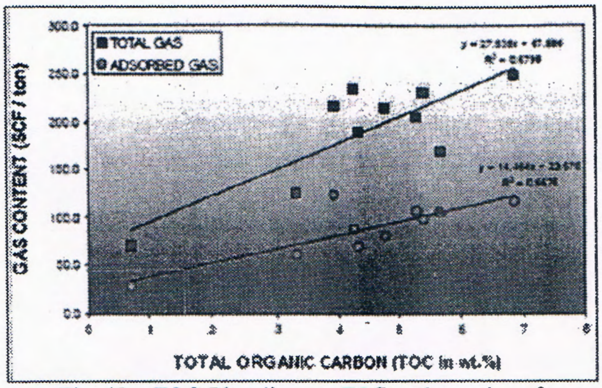

Fig. 10. TOC Plot diagram TOC to determine of adsorbed gas.

Formation	TOC (%) Avg	Gas Content (scf/ton)
TAF	1.6	49

Table 5. Calculation result of adsorbed gas

CONCLUSION

The Shale of Talang Akar in the study area has potential to generate oil and gas when it reaches the level of thermal maturity. Brittleness Index based on surface data of the BD-1 sample contains 46% quartz that easily to produce a crack. MB Area contains free gas 78.62 scf / ton and adsorbed gas 49 scf / ton.

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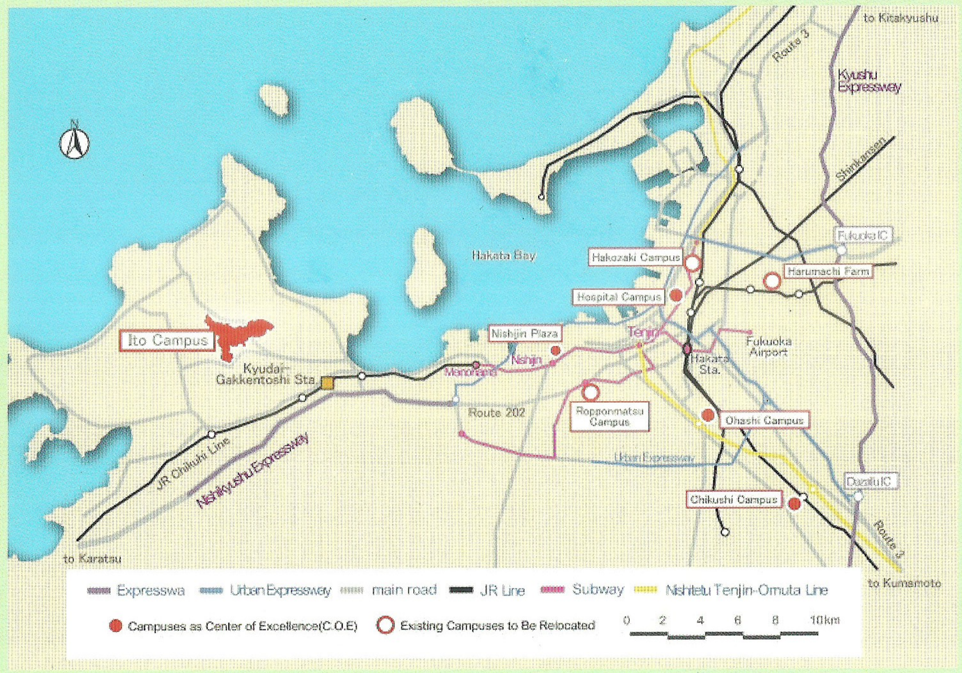

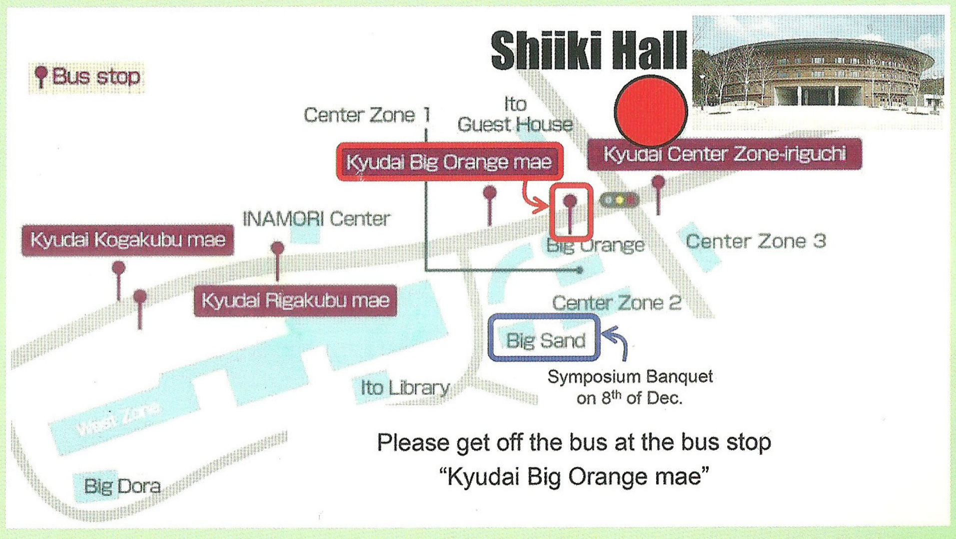

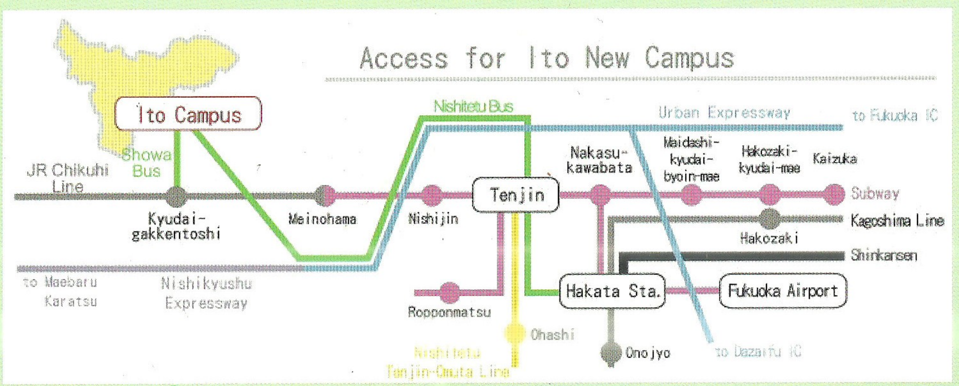

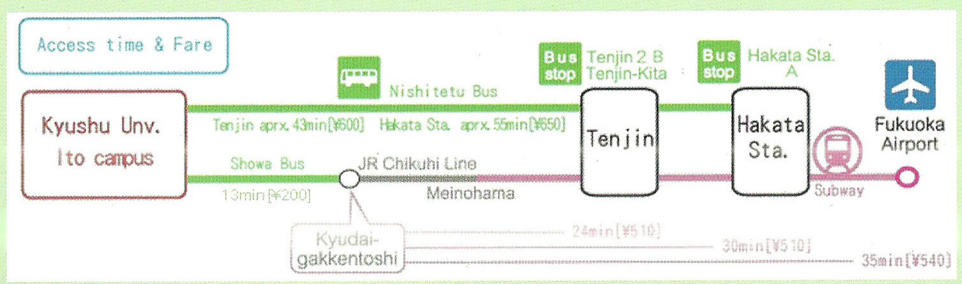

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