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Source Rocks Characterization in Benakat Gully, Limau, and Jemakur-Tabuan Graben, North-South Palembang Sub-Basin, South Sumatra Basin

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ABSTRACT

There are differences opinion among geochemistry expert about determining oil family in the South Sumatra Basin. The first opinion that only analyzing oil samples, argues that oils in this area are derived from fluvio-deltaic and lacustrine source rock, while the second opinion that analyzing source rocks and oils samples, argues that lacustrine oil is not found in this area. Research area is located at Benakat gully, Limau graben, and Jemakur-Tabuan graben which is considered as syn-rift basins, consist of syn-rift sediments. So, expected that source rock with lacustrine characterization could be found in this area.

This paper emphasizes geochemistry methods. Source rock analysis, consist of 68 samples for carbon isotope and 76 samples for biomarker. Characterization has been based on qualitative and quantitative data. Qualitative data comprise evaluation based on chromatograms and mass-fragmentograms, whereas quantitative data consists of a series of cross-plots.

The result from geochemistry analysis, concluded that Lemat Formation in Benakat Gully and Jemakur-Tabuan Graben is interpreted as source rock with estuarine characterization, while Lemat Formation in Limau graben interpreted as source rock with fluvio-deltaic characterization. Talangakar Formation in Benakat Gully, Limau Graben, and Jemakur-Tabuan Graben is interpreted as source rock with deltaic characterization. Based on geochemistry analysis, source rock in research area consist of estuarine, deltaic, and fluvio-deltaic source rocks. There is no source rock with lacustrine characterization in research area. Oil with lacustrine characterization in reseach area, considered generate by Lemat Formation from the deeper strata of stratigraphy, supported by Morley's Paleontology data but it need further exploration and analysis. There is also new interpretation of Lemat Formation's source rock in Benakat Gully and Jemakur-Tabuan Graben, which is part of it having tendency as marine influence, interpreted as source rock with estuarine characterization.

Key words: biomarker, lacustrine, estuarine, fluvio-deltaic, deltaic.

INTRODUCTION

There are a number of sub-basins in the research area which is potential as the hydrocarbon kitchen but it isn't known with more certainty yet about the character of the source rock. There are two group's results of the source rock and oil research, there are: first group is Robinson (1987) and Suseno et al. (1992), researching source rock and oil samples, which is conclude that oil in the research area was generated from fluvio-deltaic source rock, while the second group is ten Haven and Schiefelbein (1995), Ginger and Fielding (2005), Noble et al. (2009), and Rashid et al. (1998), which only researching oil samples, conclude that the oil in the research area besides generated from fluvio-deltaic sediment, there are also generated from lacustrine sediment (Table 1).

LOCATION OF RESEARCH AREA

Research area located in Benakat Gully and Limau Graben, which are located in South Palembang Sub Basin, also in Jemakur-Tabuan Graben which is part of North Palembang Sub Basin, South Sumatra Basin.

RESEARCH METHODS

This paper emphasizes geochemistry methods. Source rock analysis, consist of 68 samples for carbon isotope and 76 samples for biomarker. Characterization has been based on qualitative and quantitative data. Qualitative data comprise evaluation based on chromatograms and mass-fragmentograms, whereas quantitative data consists of a series of cross-plots, example: cross plot of carbon isotope $\delta^{13}C$ saturates - aromatics, distribution of C_{27}-C_{28}-C_{29} sterane, Pr/nC_{17}-Ph/nC_{18}, Pr/Ph-Pr/nC_{17}, carbon isotope $\delta^{13}C$ saturates-Pr/Ph, Pr/Ph-total hopane/total sterane, and ratio of C_{26}/C_{25} (tricyclic).

The results of this study, expected could find out the character of source rock in hydrocarbon kitchen, including the possibility of lacustrine source rock's existence.

REGIONAL STRUCTURAL GEOLOGY OF SOUTH SUMATRA BASIN

Geological structures that control the regional of South Sumatra (Figure 1) were influenced by three tectonic phases (Pulunggono et al., 1992):

- Compression (Upper Jurassic – Lower Cretaceous)
- Tension (Upper Cretaceous – Lower Tertiary)
- Compression (Middle Miocene – Recent)

The first phase: started in Upper Jurassic – Lower Cretaceous, characterized with the subduction of India-Australia plate as a movement mechanism to yield primary stress to the Sundaland trending N 30^o W. This subduction resulted simple shear (N 300^o E) as strike slip fault that was actively moved laterally. This was assumed as the cause of linearity trending N-S as antithetic fault which was inactive.

The second phase: commenced during Upper Cretaceous-Lower Tertiary, characterized by the change of the subduction trend of the India-Australia plate into N-S. This event resulted in the formation of some geological structures (fractures) caused by tension force as linearity with N-S direction. This phenomenon caused the formation of grabens and depressions, such as Benakat Gulley. Initiation of graben filling with Tertiary sediments was started.

The third phase: commenced in the Middle Miocene-present, shown with, again, the change of the subduction direction into N 6^o E, causing rejuvenation and inversion processes on the paleostructures by Plio-Pleistocene (N 330^o E) and the uplifting of the Barisan Montains and also the formation of some thrust faults with the Lematang fault pattern.

REGIONAL STRATIGRAPHY OF SUMATRA BASIN

Based on the tectonostratigraphy framework, Ryacudu (2008) divides Early Tertiary rock units in the South Sumatra Basin as follows (Figure 2):

Pre-rift sequences

This sequence consists of volcanic rock of Kikim Formation and pre-Tertiary rocks. Kikim Formation are the oldest Tertiary rocks in the South Sumatra Basin, consist of volcanic rocks such as volcanic breccia, agglomerate, andesitic tuffs and igneous rocks (as intrusions and lava flows). Age of Kikim Formation based on dating K-Ar is 54-30 Ma (Paleocene - Lower Oligocene, Ryacudu, 2008). The oldest age and the contact with pre-Tertiary rocks are unknown, while the relation with the formation above is unconformity.

Syn-rift sequences

Syn-rift sequence consists of Lahat Group consisting of Lemat and Benakat Formations with interfingering relations. The main constituent of Lemat Formation are coarse clastic rocks (sandstone) with Tuff Member and conglomerate Member, while Benakat Formations dominated by fine clastic rocks (shale). The group does not contain fossils, dating is determined by palinomorf *Meyeripollis naharkotensis* in shale of Benakat Formations indicating Upper Oligocene – Lower Early Miocene. Sandstones of Lemat Formation deposited in fluvial environment, while conglomerate is interpreted as an alluvial fan sediment. Shale of Benakat

Formations interpreted as lake (lacustrine) sediment.

Post-rift sequences

Tanjungbaru Formation, originally considered a GRM (Gritsand Member) formerly known as a member of the Talangakar Formation. This unit is dominated by conglomeratic sandstone deposition system as a result of braided river. Unconformity contact with Lahat Group below it. Member of the Formation Talangakar commonly referred to as TRM (Transition Member) proposed a Talangakar Formation. This Formation consists of alternating sandstones and shales, with thin coal interbedded, deposited in the transition environment, i.e : the delta system to shallow marine, of Early Miocene. Baturaja Formation, Early Miocene (N5-N6), composed of limestone bioclastic, kalkarenit, bioclastic sandy limestones and reefal bioherm with interbedded of calcareous shale, deposited on the carbonate platform. Gumai Formation, Early Miocene to Middle Miocene, composed by calcareous mudstone that contains fossil planktonic foraminifera *Globigerina* and shales napalan with glaukonitic quartz sandstones. Deposited conformity over Gumai Formation is Palembang Group, consist of Air Benakat, Muara Enim, and Kasai Formation. Furthermore, the marine condition is getting shallower and then the Kasai Formation deposited in fluviatil and terrestrial environment.

SOURCE ROCKS CHARACTERIZATION

Figure 3 shows location map of the study area and summary of the source rock geochemical data in Benakat Gully, Limau Graben, and Jemakur-Tabuan Graben.

Source Rocks Characterization in Benakat Gully

Figure 4 shows sterane distribution curve of C_{27},C_{28}, dan C_{29} , cross plot of Pr/nC_{17}-Ph/nC_{18}, Pr/Ph – Pr/nC_{17}, Pr/Ph–hopane/sterane, carbon isotope δ^{13}C saturates – aromatics and carbon isotope δ^{13}C saturates - Pr/Ph, Lemat and Talangakar Formation in Benakat gully. This phenomenon shows Lemat Formation was deposited in estuarine or shallow lacustrine environment, whereas Talangakar Formation was deposited in estuarine or shallow lacustrine to terrestrial environment. Lemat and Talangakar Formation consists of humic and mixed kerogen, but mostly humic kerogen, and influenced by terrestrial material. Lemat Formation mostly deposited in anoxic-suboxic, and Talangakar Formation deposited in oxic condition.

Figure 5 is a comparison of biomarker characterization qualitatively between Lemat and Talangakar Formation in Benakat Gully. From this picture it appears that Lemat and Talangakar Formation, according to ten Haven and Schiefelbein (1995), and Peters et al. (2005), is not a lacustrine sediments because has C_{26}/C_{25} (tricyclic) is smaller than 1. Based on tricyclic data, according to Price et al. (1987), Lemat Formation shows delta pattern, whereas Talangakar Formations shows delta and terrestrial pattern. Based on data of 29H and 30H (hopane) distribution, it appears that Lemat and Talangakar Formation are marine clastic sediments because it shows a pattern 29H <30H (Zumberge (1984), Connan et al. (1988), Price et al. (1987), all in Waples and Machihara (1991). From data of homohopana distribution which decreased regularly from C_{31} to C_{35}, Lemat and Talangakar Formations interpreted as depositional environment which associated with clastic (Waples and Machihara, 1991) or more oxidizing conditions (Peters and Moldowan, 1993). Based on these data, Lemat Formation in Benakat Gully interpreted as estuarine sediments, while Talangakar Formation interpreted as delta sediments.

Sourec Rocks Characterization in Limau Graben

Sterane distribution curve of C_{27},C_{28},C_{29} , cross plot of Pr/nC_{17}-Ph/nC_{18}, Pr/Ph – Pr/nC_{17}, Pr/Ph–hopane/sterane, carbon isotope δ^{13}C saturates–aromatics and carbon isotope δ^{13}C saturates-Pr/Ph of Lemat and Talangakar Formation in Limau Graben can be seen in Figure 6. This phenomenon shows Lemat Formation was interpreted deposited from estuarine or shallow lacustrine to terrestrial environment, whereas Talangakar Formation was deposited in open marine or deep lacustrine, estuarine or shallow lacustrine to terrestrial environment. Lemat and Talangakar

Formations consists of humic kerogen and influenced by terrestrial material on anoxic-suboxic to oxic condition but mostly found on oxic condition. Lemat and Talangakar Formations consist of terrigeneous material and mixed source.

Figure 7 is a comparison of biomarker characterization qualitatively between Lemat and Talangakar Formations in Limau Graben. From this picture, appears that Lemat and Talangakar Formation in Limau Graben is not a lacustrine sediments. Based on tricyclic data, Lemat Formation shows terrestrial pattern, whereas Talangakar Formations show terrestrial and marine pattern. Based on data ^{29}H and ^{30}H (hopana) distribution, it appears that Lemat Formation is marine clastic sediments, while Talangakar Formation is marine clastic and evaporates-carbonate sediment. From data homohopana distribution, Lemat and Talangakar Formations, interpreted having depositional environment which associated with clastic or more oxidizing conditions. Based on these data, Lemat Formation in Limau Graben interpreted as fluvial sediments, while Talangakar Formation interpreted having more marine characterization as delta sediments.

Sourec Rocks Characterization in Jemakur-Tabuan Graben

Curve of sterane distribution C_{27}, C_{28}, and C_{29}, cross plots Pr/nC_{17}-Ph/nC_{18}, Pr/Ph – Pr/nC_{17}, and Pr/Ph–hopane/sterane, carbon isotope $\delta^{13}C$ saturates–aromatics, and carbon isotope $\delta^{13}C$ saturates-Pr/Ph of Lemat and Talangakar Formations in Jemakur-Tabuan graben can be seen in Figure 8. This figure shows Lemat Formation interpreted deposited from estuarine or shallow lacustrine to terrestrial environments, whereas Talangakar Formations deposited from marine or deep lacustrine, estuarine or shallow lacustrine to terrestrial environment. Lemat Formation consists of humic kerogen while Talangakar Formation consists of humic and mixed kerogen, but most of the humic kerogen. Both of these formations are influenced by terrestrial material, with anoxic-suboxic to oxic conditions, but mostly found on oxic conditions. Lemat Formation consist of mixed source, while Talangakar Formations consist of algae, mixed source, and terrigeneous.

Figure 9 is a comparison of biomarker characterization qualitatively between Lemat and Talangakar Formations in Jemakur-Tabuan Graben. From this picture it appears that Lemat and Talangakar Formation in Limau graben, is not a lacustrine sediments. Based on tricyclic data, Lemat Formation shows delta and marine pattern, whereas Talangakar Formations show terrestrial, delta, and marine pattern. Based on data of ^{29}H and ^{30}H (hopana) distribution, it appears that Lemat and Talangakar Formation is marine clastic and evaporates-carbonate sediment. From data of homohopana distribution, Lemat and Talangakar Formations interpreted having depositional environment which associated with clastic or more oxidizing conditions. Based on these data, lemat Formation in Limau graben is interpreted as estuarine sediments, while Talangakar Formation is interpreted as delta sediments.

CONCLUSION

Lemat and Talangakar Formations in Benakat Gully mostly consist of humic kerogen and influenced by terrestrial material. Lemat Formation mostly found on anoxic-suboxic conditions, whereas Talangakar Formation largely found on oxic condition. Based on tricyclic data, Lemat Formation shows delta pattern, whereas Talangakar Formations show delta and terrestrial pattern. Lemat Formation in Benakat gully is interpreted not a lacustrine, but estuarine sediments, and Talangakar Formation is delta sediment. The existence of lacustrine sediment is interpreted under estuarine sediments.

Lemat and Talangakar Formations in Limau Graben consists of humic kerogen and influenced by terrestrial material in anoxic-suboxik to oxic condition, but mostly oxic condition. Based on tricyclic data, Lemat Formation shows terrestrial pattern, whereas Talangakar Formations show terrestrial and marine pattern. Lemat Formations interpreted not a lacustrine, but fluvio-deltaic sediments, and Talangakar Formation is a delta sediment.

Lemat Formation in Jemakur-Tabuan graben consists of humic kerogen while Talangakar Formation consists of humic and mixed kerogen, but most humic kerogen. Both of these Formations are influenced by terrestrial material, with most oxic conditions. Lemat Formation in Jemakur-Tabuan graben is interpreted not a lacustrine but estuarine sediments, and Talangakar Formation is delta sediment.

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REFFERENCES

Artono, E. and Tamtomo B. (2000): Pre Tertiary reservoir as a hydrocarbon prospecting opportunity in the South Sumatra basin, Western Indonesia in the third millennium, AAPG International Conference & Exhibition, Bali, Indonesia.

Ginger, D. and Fielding, K. (2005): The Petroleum systems and future potential of the South Sumatra basin, Proceedings Indonesian Petroleum Association, thirtieth Annual Convention & Exhibition, Jakarta, Indonesia, p. 67-89.

Morley, R.J. (2009): Sequence biostratigraphy of Medco South Sumatra acreage, not published, 85 pp.

Noble, R., Orange, D., Decker J., Teas P., and Baillie, P. (2009): Oil and gas seeps in deep marine sea floor cores as indicators of active petroleum systems in Indonesia, Proceedings Indonesia Petroleum Association, thirty third IPA Annual Convention & Exhibition, Jakarta, Indonesia.

Peters, K.E., and Moldowan, J.M. (1993): The Biomarker guide "Interpreting molecular fossils in petroleum and ancient sediments", Prentice Hall, Englewood Cliffs, New Jersey, 363 pp.

Peters, K.E., Walters, C.C., and Moldowan J.M. (2005), Volume 1, The Biomarker guide, Cambridge University press, 474 pp.

Peters, K.E., Walters, C.C., and Moldowan J.M. (2005), Volume 2, The Biomarker guide, Cambridge University press, p. 475-1155.

Price, P.L., Sullivan, T.O., and Alexander, R. (1987): The Nature and occurrence of oil in Seram, Indonesia, Proceedings Indonesia Petroleum Association, sixteenth Annual Convention, Jakarta, Indonesia.

Pulunggono, A., Agus, H. S. and Kosuma, C. G. (1992): Pre-Tertiary and Tertiary fault systems as a framework of the South Sumatra basin; A Study of SAR maps. Proceedings Indonesian Petroleum Association, twenty first Annual Convention & Exhibition, Jakarta, Indonesia, p. 339-360.

Rashid, H., Sosrowidjojo, I.B., and Widiarto, F.X. (1998): Musi platform and Palembang high: A New look at the petroleum system, Proceedings, Indonesian Petroleum Association, twenty-Sixth Annual Convention, Jakarta, Indonesia, p. 265-276.

Robinson, K.M. (1987): An Overview of source rocks and oils in Indonesia, Proceedings Indonesian Petroleum Association, sixteenth Annual Convention, Jakarta, Indonesia, p. 97-122.

Ryacudu, R. (2008): Tinjauan stratigrafi Paleogen Cekungan Sumatra Selatan, Sumatra Stratigraphy Workshop, IAGI, p. 99-114.

Sarjono, S. and Sardjito (1989): Hydrocarbon source rock identification in the South Palembang subbasin, Proceedings Indonesian Petroleum Association, eighteenth Annual Convention, Jakarta, Indonesia, p. 424-467.

Suseno, P.H., Zakaria, Mujahidin, N., and Subroto, E.A. (1992): Contribution of Lahat Formation as hydrocarbon source rock in South Palembang area, South Sumatra, Indonesia, Proceedings Indonesian Petroleum Association, twenty first Annual Convention, Jakarta, Indonesia, p. 325-337.

ten Haven and Schiefelbein (1995): The petroleum systems of Indonesia, Proceedings Indonesian Petroleum Association, twenty fourth Annual Convention, Jakarta, Indonesia, p. 443-459.

Waples, D.W. and Curiale J.A., (1999): Oil–oil and oil–source rock correlations, Dalam AAPG Treatise of Petroleum Geology, Hand book of Petroleum Geology, Bab 8, ed. Beaumont E.A., The American Association of Petroleum Geologist, p. 8.3-8.71.

No	Researchers	Research area	Source Rock Analysis						Oil Analysis				Correlation		Oil Family
			TOC	Pyrolisis	Maturity	GC	GC-MS	Carbon Isotope	Bulk Composition	GC	GC-MS	Carbon Isotope	Oil-Oil	Source rock-Oil	
1	Robinson (1987)	South Sumatra Basin	✓	✓	–	✓	–	–	✓	✓	✓	✓	✓	✓	Fluvio-deltaic
2	Suseno et.al. (1992)	South Palembang Subbasin	✓	✓	✓	✓	✓	–	–	✓	✓	–	✓	✓	Fluvio-deltaic and shallow marine
3	ten Haven and Schiefelbein (1995)	South Sumatra Basin	–	–	–	–	–	–	✓	✓	✓	✓	✓	–	Lacustrine, deltaic and resinitic.
4	Ginger and Fielding (2005)	South Sumatra Basin	–	–	–	–	–	–	–	✓	–	✓	✓	–	Lacustrine, fluvio-deltaic, and terrigeneous
5	Noble et al. (2009)	South Sumatra Basin	–	–	–	–	–	–	Using data of oil family from Robinson (1987), ten Haven and Schiefelbein (1995), Schiefelbein et al. (1997), and Peters et al. (1999)				✓	–	Lacustine and deltaic
6	Rashid et al. (1998)	Musi Platform and Palembang High	–	–	–	–	–	–	–	✓	✓	–	✓	–	Lacustrine, marine, terrestrial (deltaic-marine, fluvio-deltaic and resinitic/oleanane
7	Sarjono and Sardjito (1989)	South Palembang Subbasin	✓	✓	✓	–	–	–	–	–	–	–	–	–	–

Table 1. Comparison of oil families and analyzes performed on the source rock and oil from some researchers.

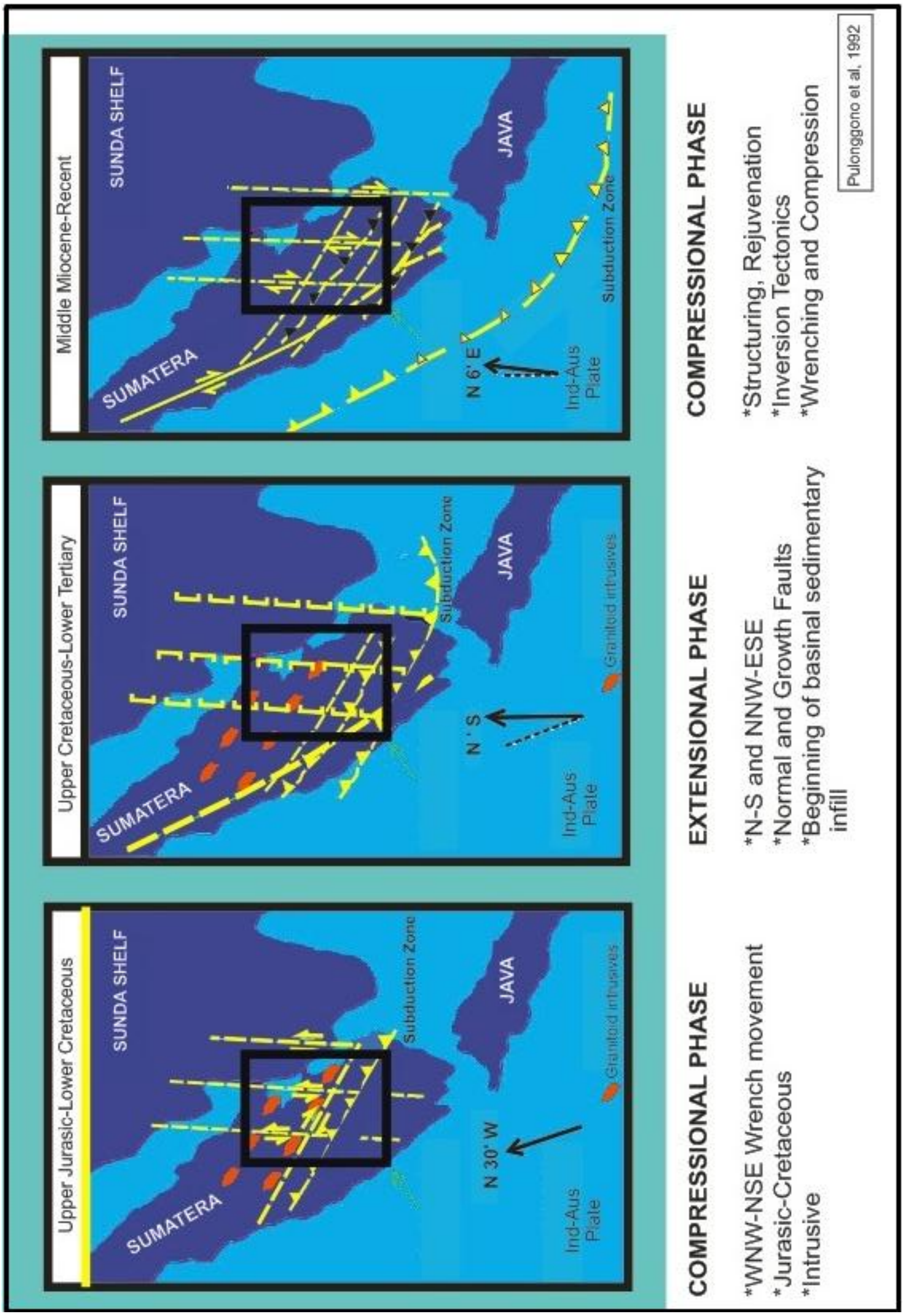

Figure 1. Tectonic evolution of the South Sumatra Basin from Upper Jurassic-now (Pulunggono et al., 1992)

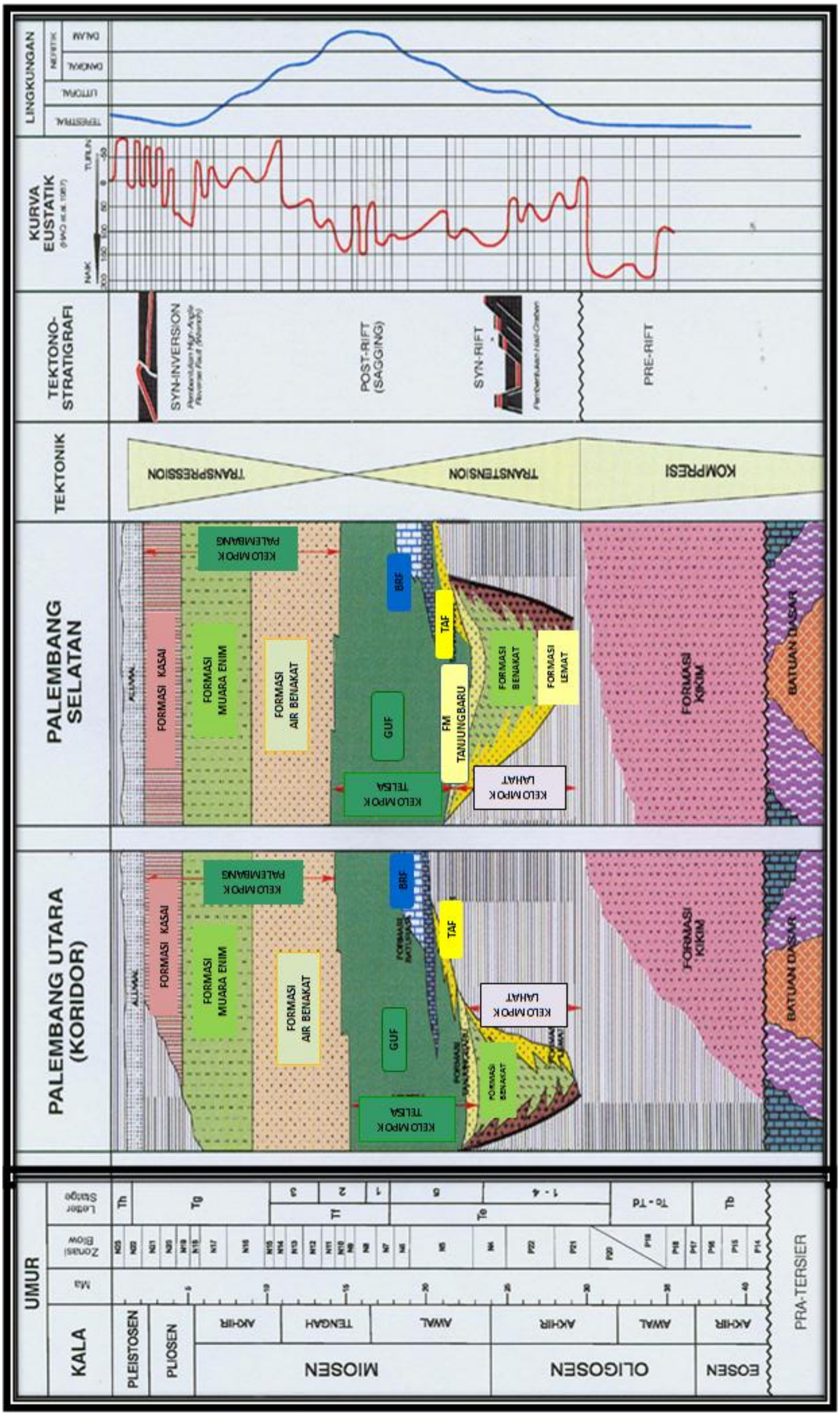

Figure 2. Regional stratigraphy of the South Sumatra Basin (modified Ryacudu, 2008).

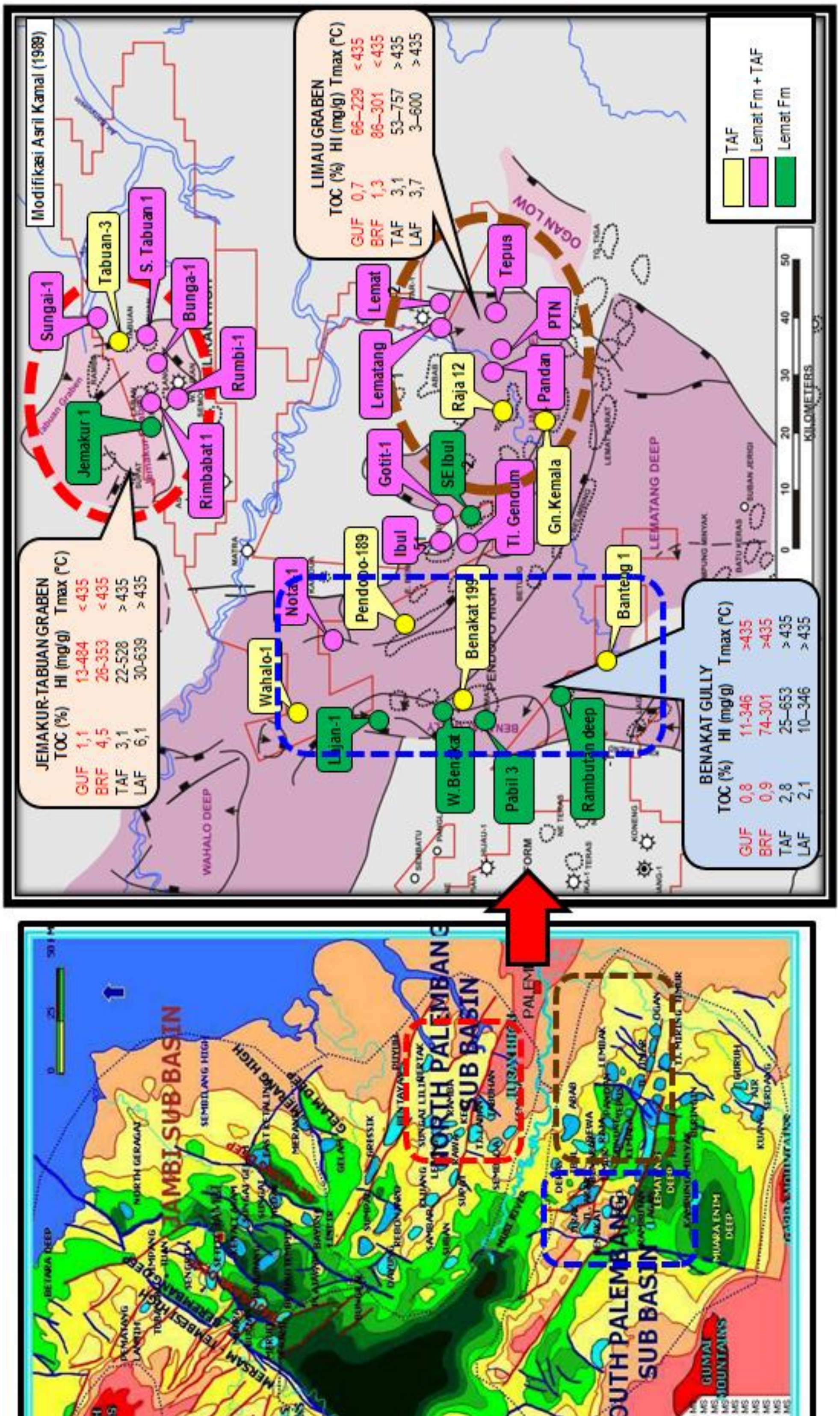

Figure 3. Location map of the study area and a summary of the source rock geochemical data in Benakat gully, Limau graben and Jemakur-

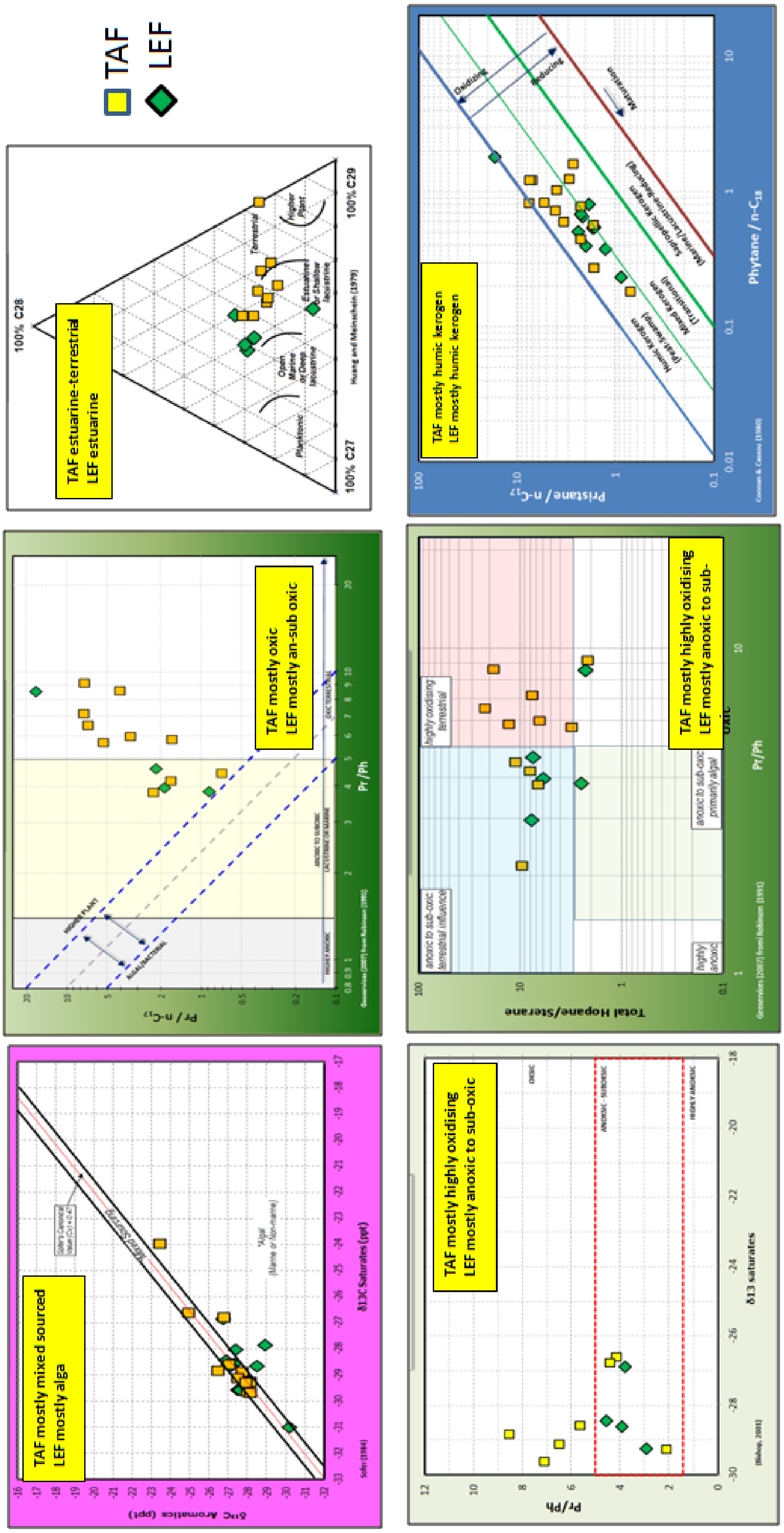

Figure 4. Quantitative method in Benakat gully

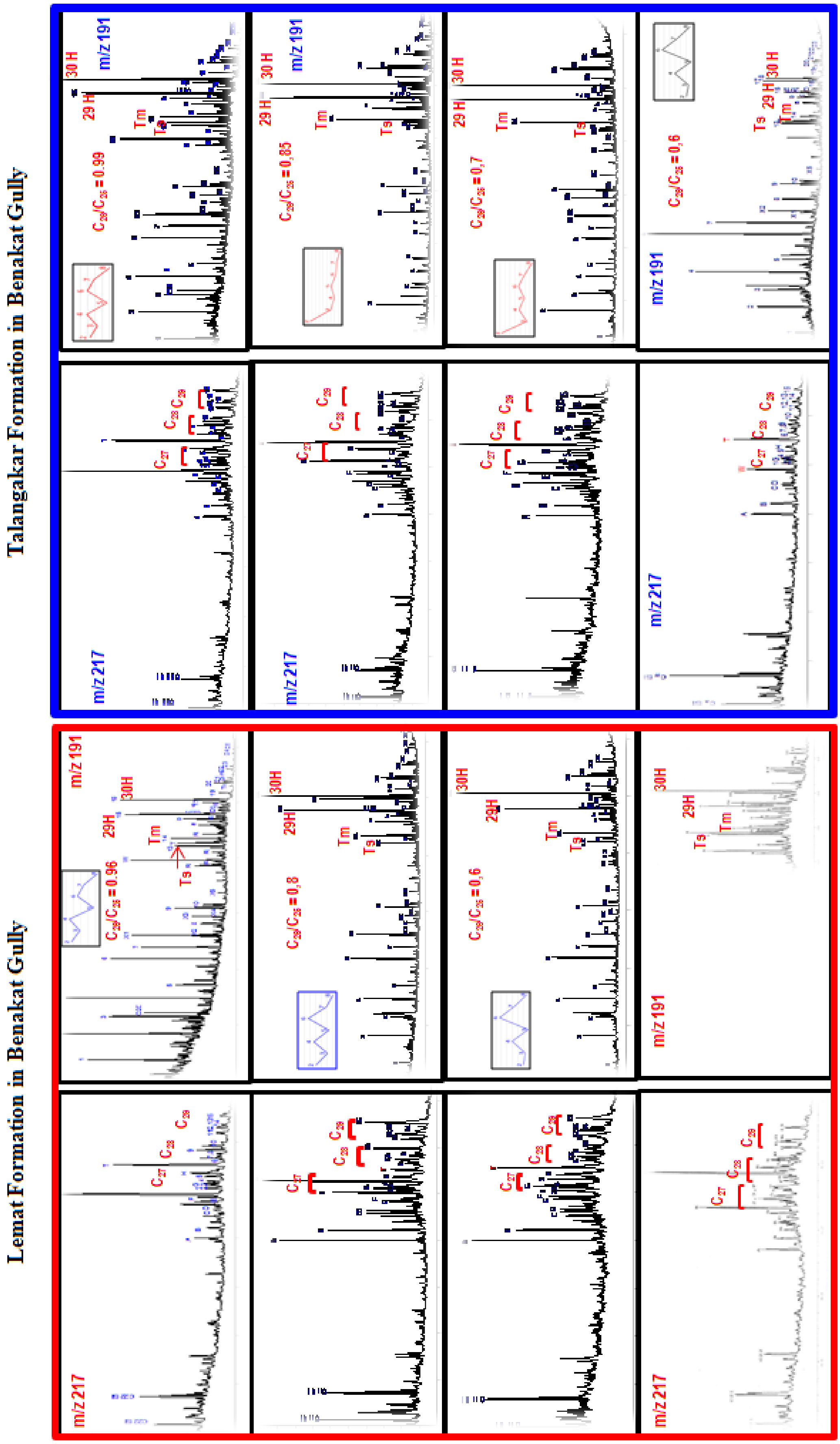

Figure 5. Comparison of biomarker characterization qualitatively between Lemat and Talangakar Formation in Benakat gully.

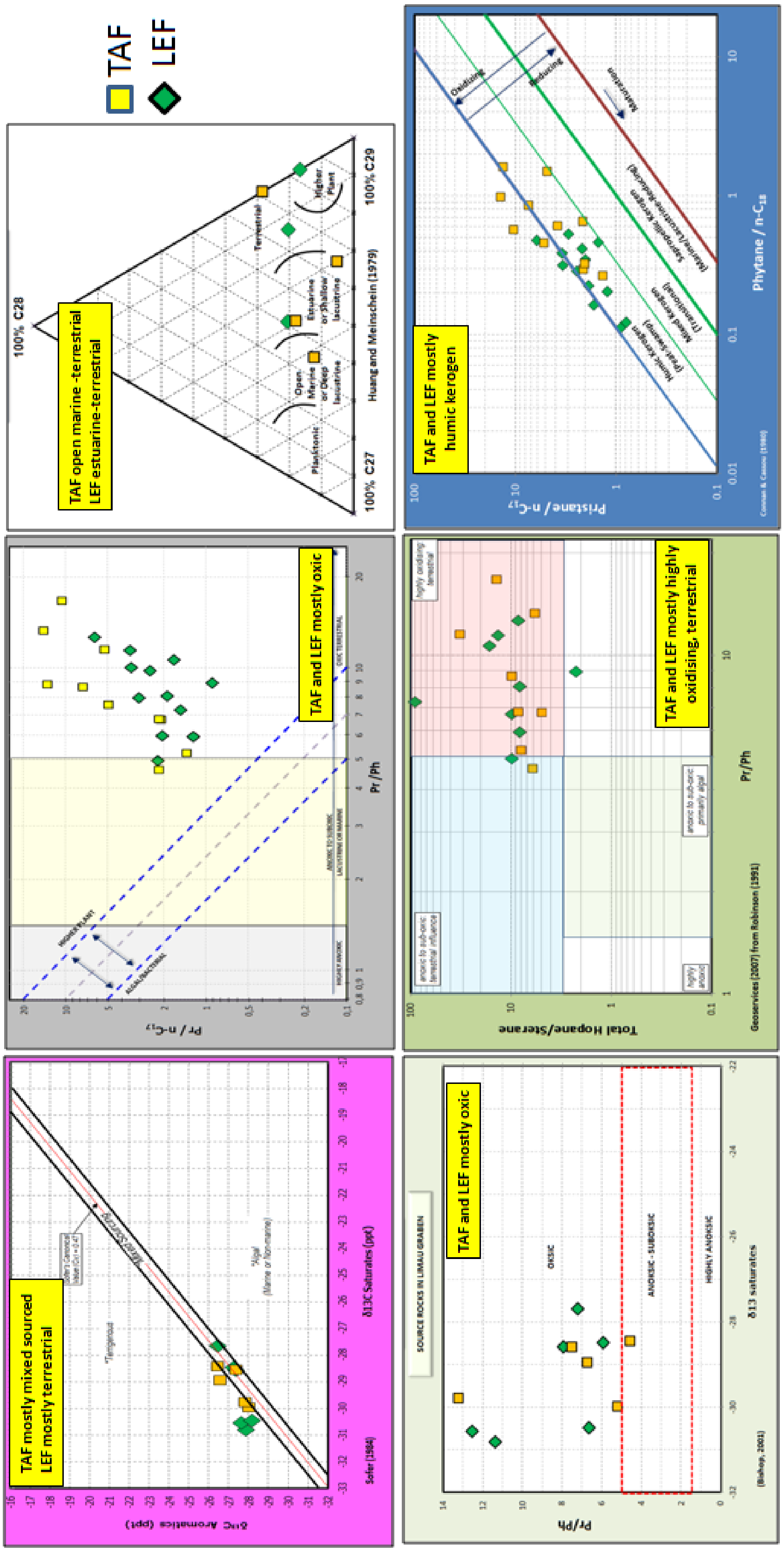

Figure 6. Quantitative method in Limau graben.

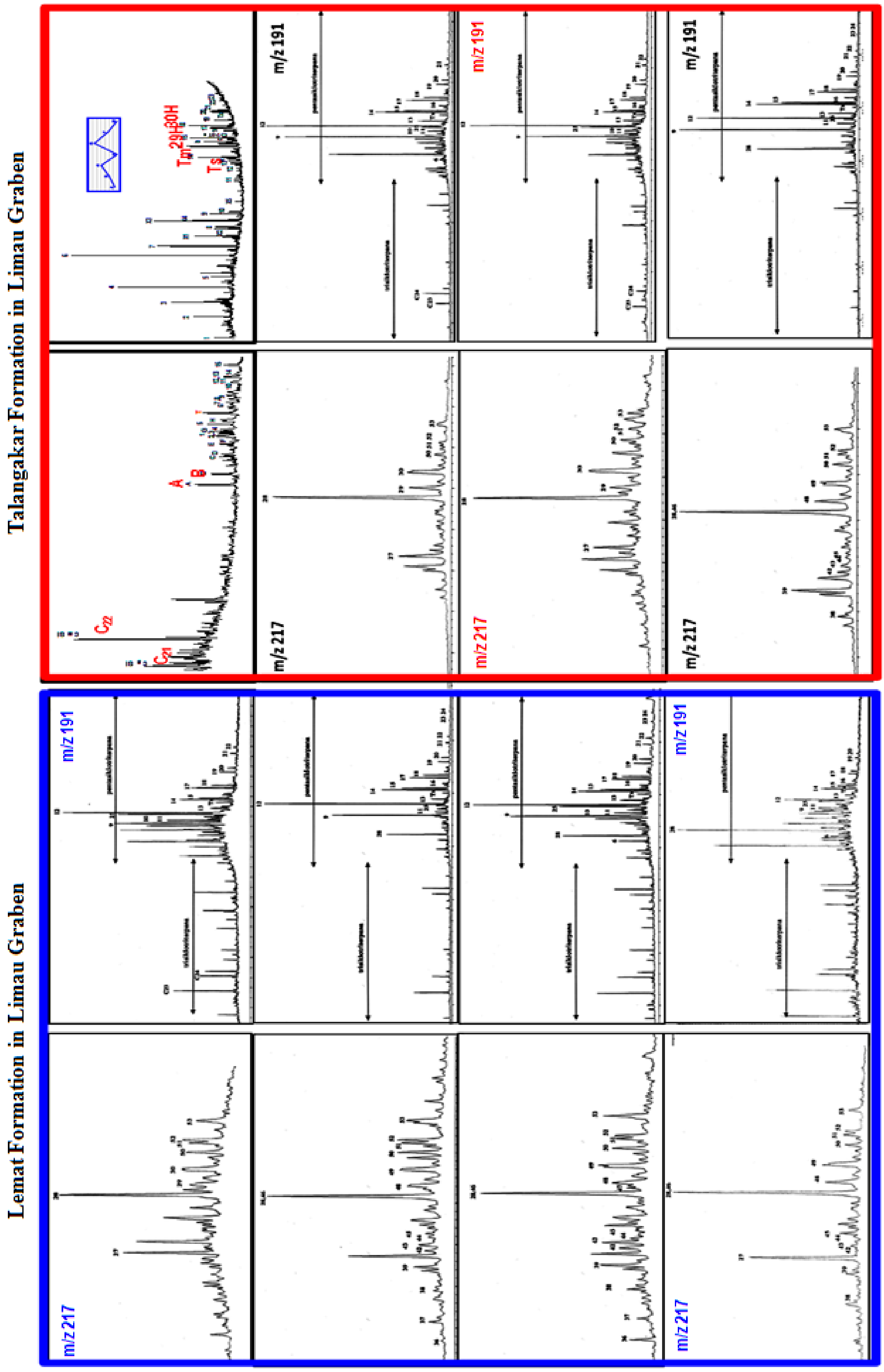

Figure 7. Comparison of biomarker characterization qualitatively between Lemat and Talangakar Formations in Limau Graben.

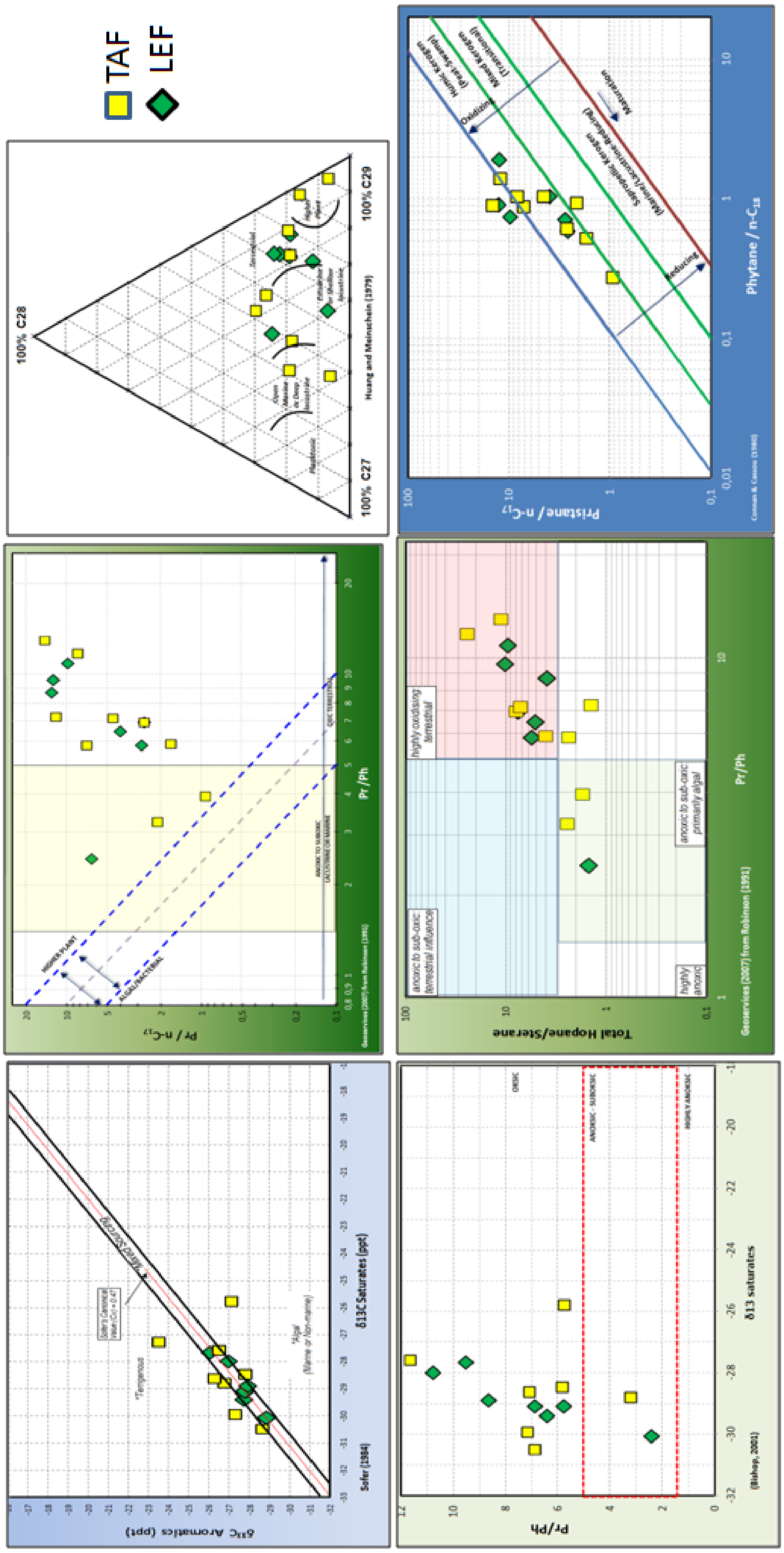

Figure 8. Quantitative method in Jemakur-Tabuan graben.

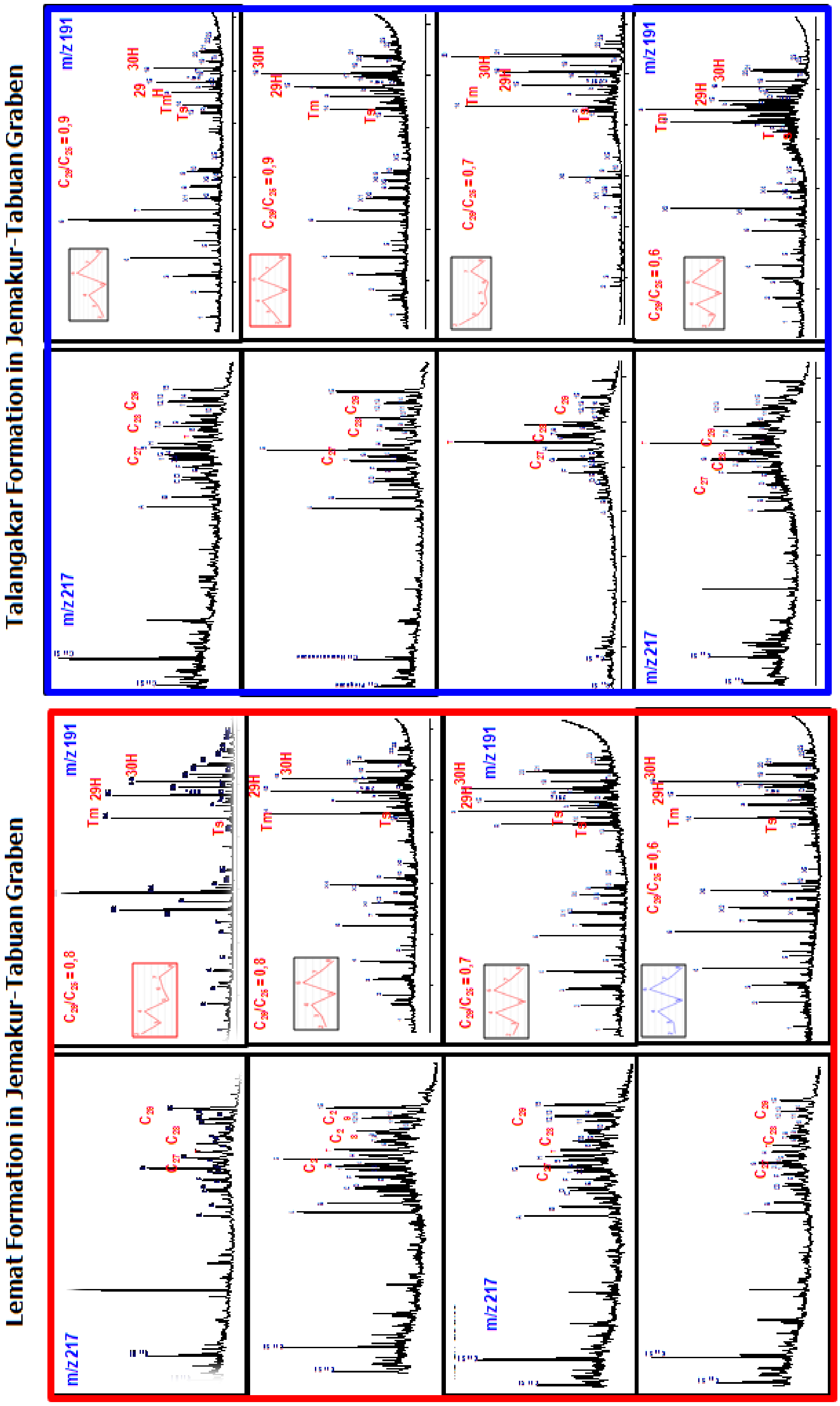

Figure 9. Comparison of biomarker characterization qualitatively between Lemat and Talangakar Formation in Jemakur-Tabuan graben.

Correlation Study of Source Rock and Oil in Limau Graben, South Sumatera Basin: Source Rock and Oil Characterization and Potency of Lemat Formation as Hydrocarbon Source Rocks

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ABSTRACT

Lemat Formation in Limau graben has been considered as syn-rift sediments until now, consist of fluvio-lacustrine sediments, creating source rock with fluvio-lacustrine characterization. While based on existing publications, showing that oil from Limau graben having fluvio-deltaic characterization and generated by source rock from Talangakar Formation with fluvio-deltaic characterization.

This paper emphasizes geochemistry methods. Source rock analysis consist of 26 samples for carbon isotope and 14 samples for biomarker, while oil analysis consist of 15 samples for carbon isotope and 19 samples for biomarker. Characterization has been based on qualitative and quantitative data. Qualitative data comprise evaluation based on chromatograms and mass-fragmentograms, whereas quantitative data consists of a series of cross-plots.

Based on geochemical analysis, source rocks of Lemat Formation in Limau Graben interpreted as source rock with fluvio-deltaic characterization, having terrestrial influence while Talangakar Formation in Limau Graben interpreted as source rock with deltaic characterization, having marine and terrestrial influence. Both, consist of humic kerogen. Whereas, oil samples in Limau Graben interpreted as oil which is generated by source rock with fluvio-deltaic characterization, having terrestrial influence, in anoxic-suboxic-oxic conditions, consisting of humic kerogen. Correlation result between source rocks and oils in Limau Graben, indicating that fluvio-deltaic oil families in Limau Graben are strongly correlate with not only the source rocks of Talangakar Formations but also with source rock of Lemat Formation.

Key words: biomarker, terrestrial, fluvio-deltaic

INTRODUCTION

South Sumatra Basin is a potential and mature basin for hydrocarbon kitchen. There are a number of sub-basins which is potential as the hydrocarbon kitchen in this basin. Limau Graben is one of sub-basin on the South Palembang Sub-basin, formed in Upper Cretaceous to Lower Tertiary, in extensional phase, this is the beginning of sedimentation in this area. Lemat Formation in Limau Graben has been considered as syn-rift sediments until now, consist of terrestrial sediment (fluvio-lacustrine), creating source rock with fluvio-lacustrine characterization. While based on existing publications, showing that oil from Limau Graben having fluvio-deltaic characterization and generated by source rock from Talangakar Formation with fluvio-deltaic characterization. This is interesting to study further, especially about possibility of source rock with fluvio-lacustrine characterization in research area. This study emphasized to source rocks of Lemat and Talangakar Formation in Limau Graben, South Palembang Sub-basin, South Sumatra Basin.

RESEARCH AREA

The research area located in Limau Graben, South Palembang Sub Basin, South Sumatra Basin.

RESEARCH METHODS

This paper emphasizes geochemistry methods. Source rock analysis, consist of 26 samples for carbon isotope and 14 samples for biomarker, while oil analysis, consist of 15 samples for carbon isotope and 19 samples for biomarker. Characterization has been based on qualitative and quantitative data. Qualitative data comprise evaluation based on chromatograms and mass-fragmentograms, whereas quantitative data consists of a series of cross-plots, eg. cross plot of carbon isotope $\delta^{13}C$ saturates - aromatics, distribution of C_{27}-C_{28}-C_{29} sterane, Pr/nC_{17}-Ph/nC_{18}, Pr/Ph-Pr/nC_{17}, carbon isotope $\delta^{13}C$ saturates-Pr/Ph, Pr/Ph-total hopane/total sterane, and ratio of C_{26}/C_{25} (tricyclic).

The results of this study expected could explain the character of source rocks and oil in the Limau Graben, also to find out the possibility of lacustrine source rock existence and determine the correlation between source rocks and oils in this area, so can be known whether Lemat Formation source rocks also have contributed to produce oil in this area or not. In addition, to provide a new opportunity in the exploration of hydrocarbons in the Limau Graben which considered as a mature and potential basin for hydrocarbon.

REGIONAL STRUCTURAL GEOLOGY OF SOUTH SUMATRA BASIN

Geological structures that control the regional of South Sumatra (Figure 1) were influenced by three tectonic phases (Pulunggono et al., 1992):

- Compression (Upper Jurassic – Lower Cretaceous)
- Tension (Upper Cretaceous – Lower Tertiary)
- Compression (Middle Miocene – Recent)

The first phase: started in Upper Jurassic – Lower Cretaceous, characterized with the subduction of India-Australia plate as a movement mechanism to yield primary stress to the Sundaland trending N 30^o W. This subduction resulted simple shear (N 300^o E) as strike slip fault that was actively moved laterally. This was assumed as the cause of linearity trending N-S as antithetic fault which was inactive.

The second phase: commenced during Upper Cretaceous-Lower Tertiary, characterized by the change of the subduction trend of the India-Australia plate into N-S. This event resulted in the formation of some geological structures (fractures) caused by tension force as linearity with N-S direction. This phenomenon caused the formation of grabens and depressions, such as Benakat Gulley. Initiation of graben filling with Tertiary sediments was started. In general faults and grabens formed during this phase show N-S and WNW-ESE directions.

The third phase: commenced in the Middle Miocene-present, shown with, again, the change of the subduction direction into N 6^o E, causing rejuvenation and inversion processes on the paleostructures (N 300^o E/N-S) by Plio-Pleistocene (N 330^o E) and the uplifting of the Barisan Montains and also the formation of some thrust faults with the Lematang fault pattern. During this phase, the Lematang fault pattern that initially acted as depocenter of the Muara Enim Deep has been uplifted being anticlinorium series of Pendopo-Limau (Figure 2.5). Folding and thrust-faulting processes caused by compression force occurred in the back-arc basinal and floured during Plio-Pleistocene.

REGIONAL STRATIGRAPHY OF SUMATRA BASIN

Based on the tectonostratigraphy framework, Ryacudu (2008) divides Early Tertiary rock units in the South Sumatra Basin as follows (Figure 2):

Pre-rift sequences

This sequence consists of volcanic rock of Kikim Formations and pre-Tertiary rocks. Kikim Formations are the oldest Tertiary rocks in the South Sumatra Basin, consist of volcanic rocks such as volcanic breccia, agglomerate, andesitic tuffs and igneous rocks (as intrusions and lava flows). Age of Kikim Formation based on dating K-Ar is 54-30 Ma (Paleocene - Lower Oligocene, Ryacudu, 2008). The oldest age and the contact with pre-

Tertiary rocks are unknown, while the relation with the Formation above is unconformity.

Syn-rift sequences

Syn-rift sequence consists of rock group of Lahat Group consisting of Lemat and Benakat Formation with interfingering relations. The main constituent of Lemat Formation are coarse clastic rocks (sandstone) with Tuff Member and conglomerate Member, while Benakat Formations dominated by fine clastic rocks (shale). The group does not contain fossils, dating is determined by palinomorf *Meyeripollis naharkotensis* in shale of Benakat Formations indicating Upper Oligocene – Lower Early Miocene. The group has non-conformity relationship with rock Formations above and below it. Sandstones of Lemat Formation deposited in fluvial environment, while conglomerate is interpreted as an alluvial fan sediment. Shale of Benakat Formations interpreted as the result of deposition in the lake system (lacustrine).

Post-rift sequences

This sequence consists of a rock from Telisa group consisting Tanjungbaru, Talangakar, Baturaja, and Gumai Formation. Tanjungbaru Formation, originally considered a GRM (Gritsand Member) formerly known as a member of the Talangakar Formation. This unit is dominated by conglomeratic sandstone deposition system as a result of braided river. Unconformity contact with Lahat Group below it. Member of the Formation Talangakar commonly referred to as TRM (Transition Member) proposed a Talangakar Formation. This Formation consists of alternating sandstones and shales, with thin coal interbedded, deposited in the transition environment. Baturaja Formation, Early Miocene (N5-N6), composed of limestone bioclastic, kalkarenit, bioclastic sandy limestones and reefal bioherm with interbedded of calcareous shale, deposited on the carbonate platform. Gumai Formation, Early Miocene to Middle Miocene, composed by calcareous mudstone that contains fossil planktonic foraminifera *Globigerina* and shales napalan with glaukonitic quartz sandstones. The deposition of Gumai Formation marked the peak transgression of the South Sumatra Basin. Air Benakat Formation, Middle Miocene, composed by the dominance of shallow-marine mudstone with sandstone interbedded which is thickening and dominating upward. Sandstone at the top is a quartz sandstone, tufaan and glaukonitic. The presence of the tufa material in the Formation marked the beginning of the influence of the source sediments from the south or uplifting of the Bukit Barisan Mountains. Furthermore, the marine condition is getting shallower so that it becomes transition environment, and then the Formation Muaraenim deposited. Muara Enim Formation, Middle Miocene to Late Miocene. Consists of mudstone, shale, and sandstone and coal interbedded deposited in the delta system or transitional environment. Kasai Formation, Pliocene. Is a volcaniclastic sediment, consisting of mudstone and sandstone's tufa interbedded deposited in fluviatil and terrestrial environments.

CHARACTERIZATION OF SOURCE ROCKS AND OILS IN LIMAU GRABEN

Figure 3 shows location map of research area and data location of oil and source rocks in Limau Graben. Figure 4 shows a cross plot Pr/nC_{17}-Ph/nC_{18} and Pr/Ph – Pr/nC_{17}, source rocks of lemat and Talangakar Formations, and oils in Limau Graben. This image shows both source rocks of Lemat and Talangakar Formation and oils, consists of humic kerogen in suboxic-anoxic until oxic conditions, but mostly in oxic conditions. Cross plot of carbon isotope $\delta^{13}C$ saturates - $\delta^{13}C$ aromatics and carbon isotope $\delta^{13}C$ saturates - Pr/Ph, source rocks of Lemat and Talangakar Formations and oils in Limau Graben shown in Figure 5. This figure shows source rocks of Lemat and Talangakar Formations and oils consists of terrestrial and mixed material, in anoxic-suboxic to oxic conditions, but mostly in oxic conditions.

Figure 6 shows a cross plot of Pr/Ph-hopane/sterane and sterane distribution C_{27}, C_{28}, and C_{29}, source rocks of Lemat and Talangakar Formations and oils in Limau Graben. From this picture it appears that the source rocks of Lemat and Talangakar Formations and oils affected by terrestrial material in anoxic -suboxic until oxic conditions, but mostly in high oxic conditions. Besides, it also looks like Lemat Formations derived from estuarine or shallow lacustrine to terrestrial environments, whereas Talangakar Formation and oils derived from marine or deep lacustrine, estuarine or shallow lacustrine, and terrestrial environments.

Figure 7 is a comparison of biomarker characterization qualitatively between source rocks of Lemat and Talangakar Formation and oils in Limau Graben. From this picture it appears that source rocks of Lemat and Talangakar Formations and oils, according to ten Haven and Schiefelbein (1995), and Peters et al. (2005), is not lacustrine sediments because has C_{26}/C_{25} (tricyclic) smaller than 1. Based on tricyclic data, according to Price et al. (1987), Lemat Formation and oils show terrestrial pattern, whereas Talangakar Formations show marine and terrestrial pattern. These data indicate Lemat Formation interpreted as fluvio-deltaic sediment, whereas Talangakar Formation having more marine characterization than Lemat Formation. Based on data of ^{29}H and ^{30}H (hopane) distribution, it appears that source rocks of Lemat Formation and oils are marine clastic sediments because it shows a pattern $^{29}H < ^{30}H$, while Talangakar Formation not only show $^{29}H < ^{30}H$ but also show $^{29}H > ^{30}H$ is evaporates-carbonate sediment (Zumberge (1984); Connan et al. (1988); Price et al. (1987), all in Waples and Machihara (1991). From data of homohopana distribution which decreased regularly from C_{31} to C_{35}, source rock of Lemat, Talangakar Formations, and oils in Limau Graben interpreted as depositional environment which associated with clastic sediments (Waples and Machihara, 1991) or more oxidizing conditions (Peters and Moldowan, 1993).

Based on these data, oil in the Limau Graben interpreted originated from fluvio-deltaic source rocks and has a correlation with Lemat and Talangakar Formations in Limau Graben.

CONCLUSION

Source rocks of Lemat and Talangakar Formations and oils in Limau Graben consists of humic kerogen and terrestrial and mixed material. Source rocks of Lemat and Talangakar Formations and oils in Limau Graben, is not derived from a lacustrine sediments, affected by terrestrial material in anoxic -suboxic until oxic conditions, but mostly on high oxic conditions. Besides, its also looks like Lemat Formations derived from estuarine or shallow lacustrine to terrestrial environments, whereas Talangakar Formation and oils in Limau Graben derived from marine or deep lacustrine, estuarine or shallow lacustrine, and terrestrial environments. Based on tricyclic data, Lemat Formation and oils in Limau Graben show terestrial pattern, whereas Talangakar Formations show marine and terrestrial pattern. These data indicate Lemat Formation interpreted as fluvio-deltaic sediment, whereas Talangakar Formation having more marine characteriztion than Lemat Formation. Oils in the Limau Graben interpreted originated from fluvio-delta source rocks, has a correlation with Lemat Formation and Talangakar Formation in Limau graben.

ACKNOWLEDGEMENTS

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REFERENCES

Artono, E. and Tamtomo B. (2000): Pre Tertiary reservoir as a hydrocarbon prospecting opportunity in the South Sumatra basin, Western Indonesia in the third millennium, AAPG International Conference & Exhibition, Bali, Indonesia.

Doust, H. and Noble, R.A., (2008): Petroleum system of Indonesia, Marine and Petroleum Geology, **Vol. 25**, p. 103–129.

Ginger, D. and Fielding, K. (2005): The Petroleum systems and future potential of the South Sumatra basin, Proceedings Indonesian Petroleum Association, thirtieth Annual Convention & Exhibition, Jakarta, Indonesia, p. 67-89.

Hall, R. and Morley, C.K. (2004): Sundaland basins, In Continent–ocean interactions within the East Asian marginal seas, ed. Clift, P., Wang, P., Kuhnt, W., dan Hayes, D.E., *Geophysical Monograph*, Vol. 149, p. 55–85.

Law, C.A. (1999): Evaluating source rocks, In AAPG Treatise of Petroleum Geology, Hand book of Petroleum Geology, Bab 6, ed.

Beaumont E.A., The American Association of Petroleum Geologist, p. 6.3-6.41.

Magoon, L.B., and Dow, W.G. (1994): The Petroleum system-From source to trap: American Association of Petroleum Geologists Memoir 60, 655 pp**.**

Mello, M.R. and Maxwell, J.R. (1990): Organic geochemical and biological marker characterization of source rocks and oils derived from Lacustrine environments in the Brazilian continental margin, In Lacustrine basin exploration, Case studies and modern analogs, ed. Katz B.J., *AAPG Memoir 50*, p. 77-97.

Morley, R.J. (2009): Sequence biostratigraphy of Medco South Sumatra acreage, not published, 85 pp.

Noble, R., Orange, D., Decker J., Teas P., and Baillie, P. (2009): Oil and gas seeps in deep marine sea floor cores as indicators of active petroleum systems in Indonesia, Proceedings Indonesia Petroleum Association, thirty third IPA Annual Convention & Exhibition, Jakarta, Indonesia.

Peters, K.E., and Moldowan, J.M. (1993): The Biomarker guide "Interpreting molecular fossils in petroleum and ancient sediments", Prentice Hall, Englewood Cliffs, New Jersey, 363 pp.

Peters, K.E., Walters, C.C., and Moldowan J.M. (2005), Volume 1, The Biomarker guide, Cambridge University press, 474 pp.

Peters, K.E., Walters, C.C., and Moldowan J.M. (2005), Volume 2, The Biomarker guide, Cambridge University press, p. 475-1155.

Peters, K.E. and Cassa M.R. (1994): Applied source rocks geochemistry, Dalam The Petroleum system from source to trap, ed. Magoon L.B. dan Dow W.G., *AAPG Memoir 60*, p. 93-117.

Price, P.L., Sullivan, T.O., and Alexander, R. (1987): The Nature and occurrence of oil in Seram, Indonesia, Proceedings Indonesia Petroleum Association, sixteenth Annual Convention, Jakarta, Indonesia.

Pulunggono, A., Agus, H. S. and Kosuma, C. G. (1992): Pre-Tertiary and Tertiary fault systems as a framework of the South Sumatra basin; A Study of SAR maps. Proceedings Indonesian Petroleum Association, twenty first Annual Convention & Exhibition, Jakarta, Indonesia, p. 339-360.

Rashid, H., Sosrowidjojo, I.B., and Widiarto, F.X. (1998): Musi platform and Palembang high: A New look at the petroleum system, Proceedings, Indonesian Petroleum Association, twenty-Sixth Annual Convention, Jakarta, Indonesia, p. 265-276.

Robinson, K.M. (1987): An Overview of source rocks and oils in Indonesia, Proceedings Indonesian Petroleum Association, sixteenth Annual Convention, Jakarta, Indonesia, p. 97-122.

Ryacudu, R. (2008): Tinjauan stratigrafi Paleogen Cekungan Sumatra Selatan, Sumatra Stratigraphy Workshop, IAGI, p. 99-114.

Sarjono, S. and Sardjito (1989): Hydrocarbon source rock identification in the South Palembang subbasin, Proceedings Indonesian Petroleum Association, eighteenth Annual Convention, Jakarta, Indonesia, p. 424-467.

Suseno, P.H., Zakaria, Mujahidin, N., and Subroto, E.A. (1992): Contribution of Lahat Formation as hydrocarbon source rock in South Palembang area, South Sumatra, Indonesia, Proceedings Indonesian Petroleum Association, twenty first Annual Convention, Jakarta, Indonesia, p. 325-337.

ten Haven and Schiefelbein (1995): The petroleum systems of Indonesia, Proceedings Indonesian Petroleum Association, twenty fourth Annual Convention, Jakarta, Indonesia, p. 443-459.

Waples, D.W. and Curiale J.A., (1999): Oil–oil and oil–source rock correlations, Dalam AAPG Treatise of Petroleum Geology, Hand book of Petroleum Geology, Bab 8, ed. Beaumont E.A., The American Association of Petroleum Geologist, p. 8.3-8.71.

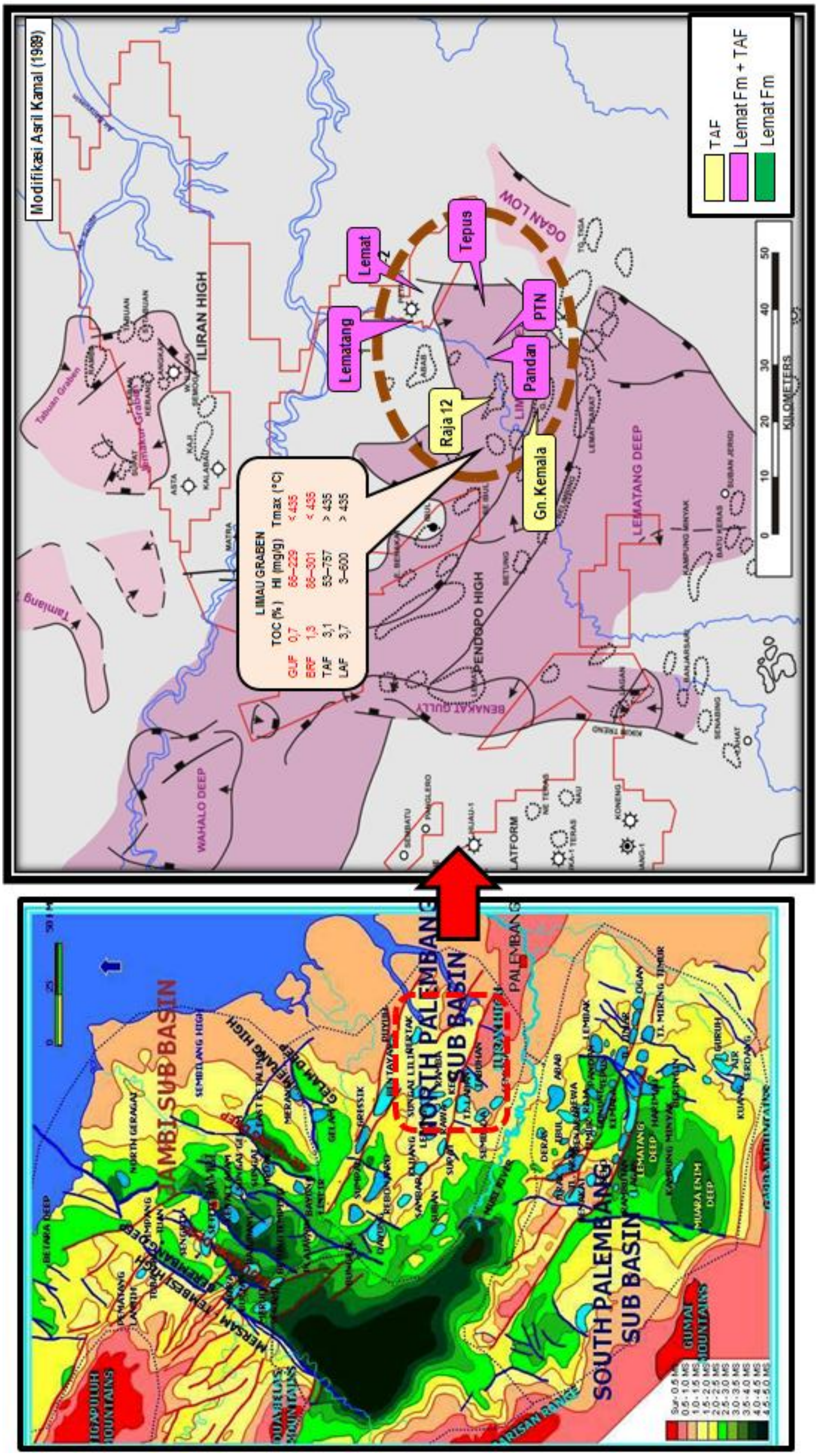

Figure 3. Location map of the study area and a summary of the source rock geochemical data in Limau graben.

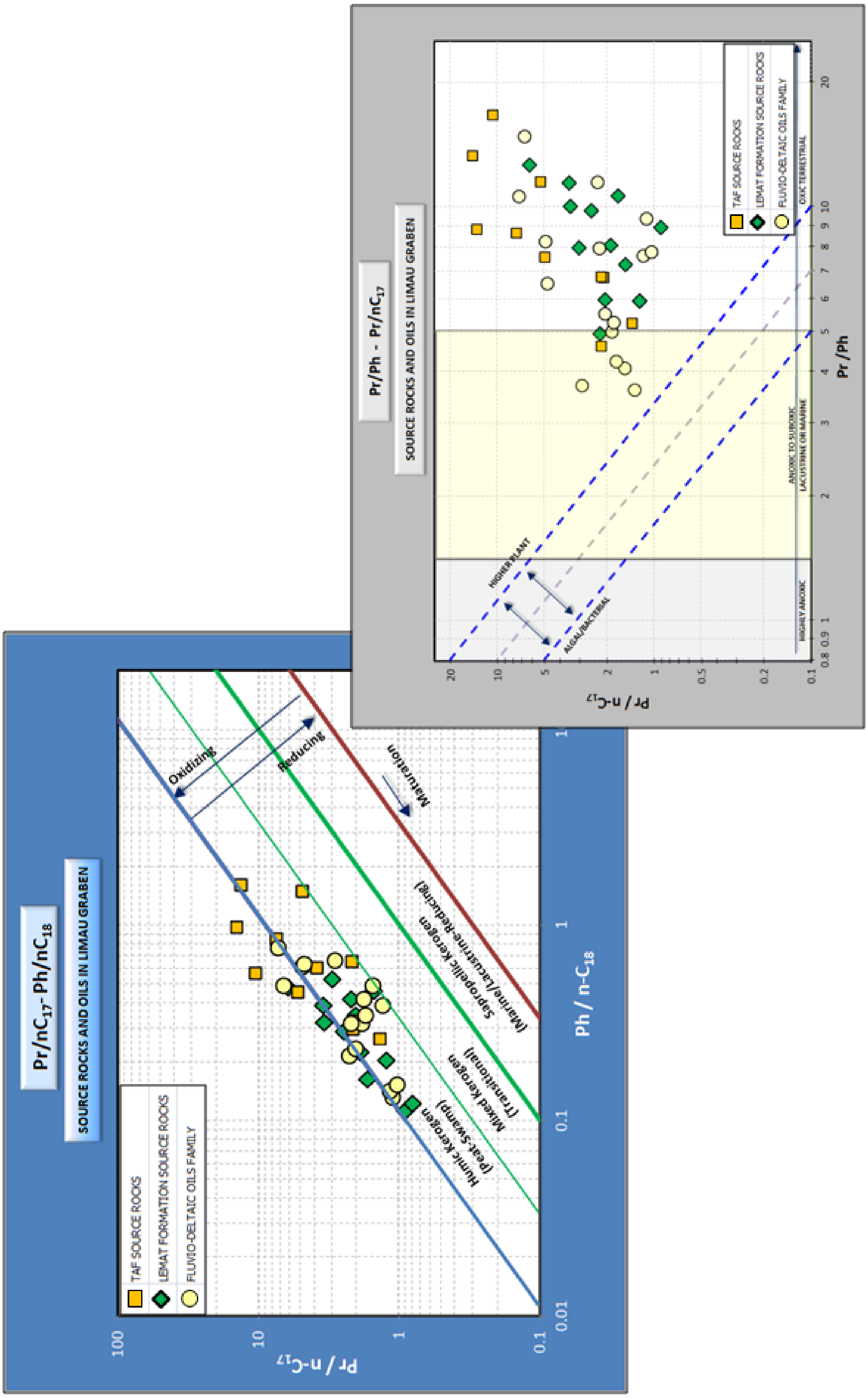

Figure 4. Cross plot of Pr/nC_{17}-Ph/nC_{18} and Pr/Ph – Pr/nC_{17}, source rocks of lemat and Talangakar Formation, and oils in Limau graben.

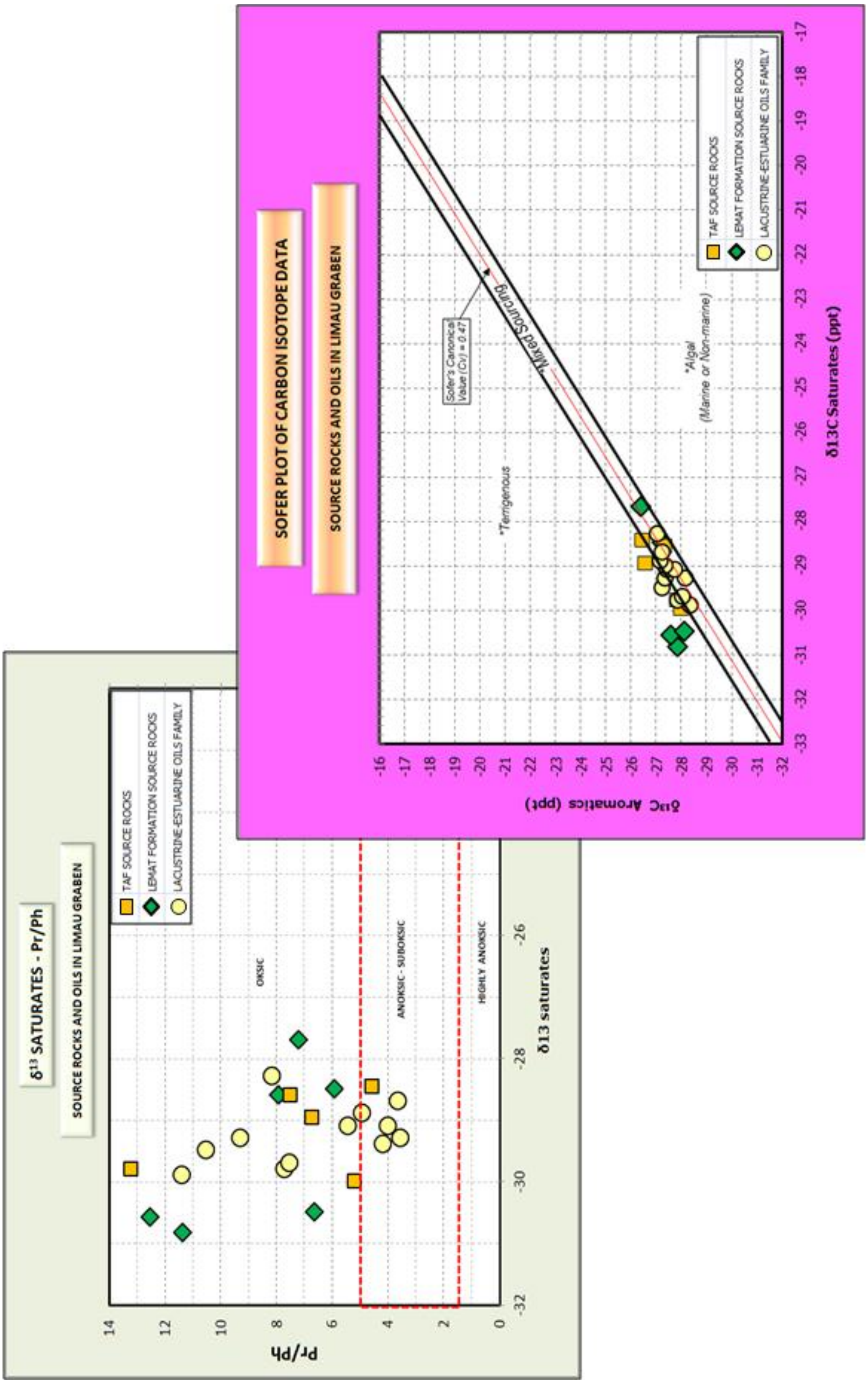

Figure 5. Cross plot of carbon isotope $\delta^{13}C$ saturates - $\delta^{13}C$ aromatics and carbon isotope $\delta^{13}C$ saturates - Pr/Ph, source rocks of lemat and Talangakar Formation, and oils in Limau graben.

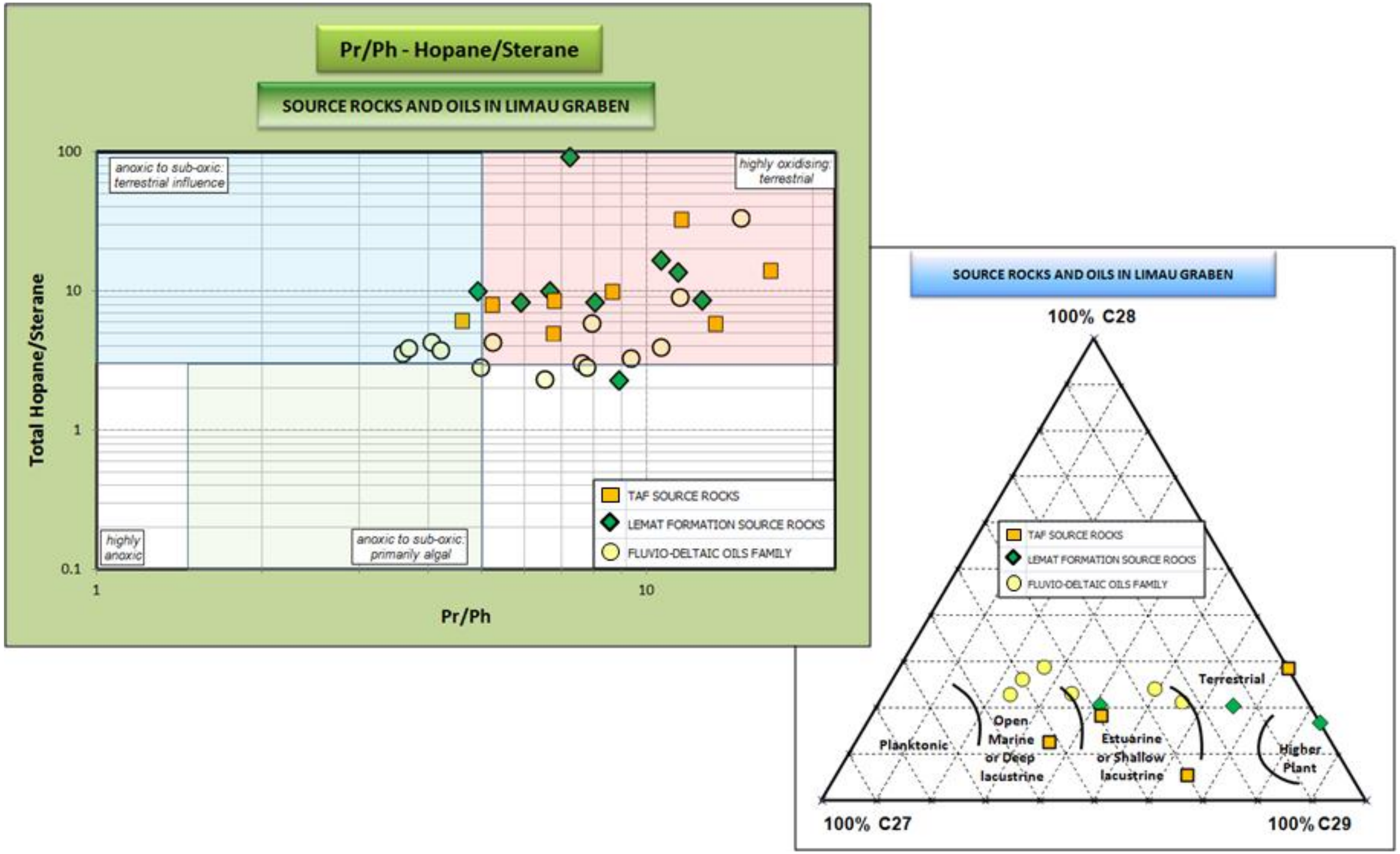

Figure 6. Cross plot of Pr/Ph-hopane/sterane and sterane distribution C_{27}, C_{28}, and C_{29}, source rocks of lemat and Talangakar Formation, and oils in Limau graben.

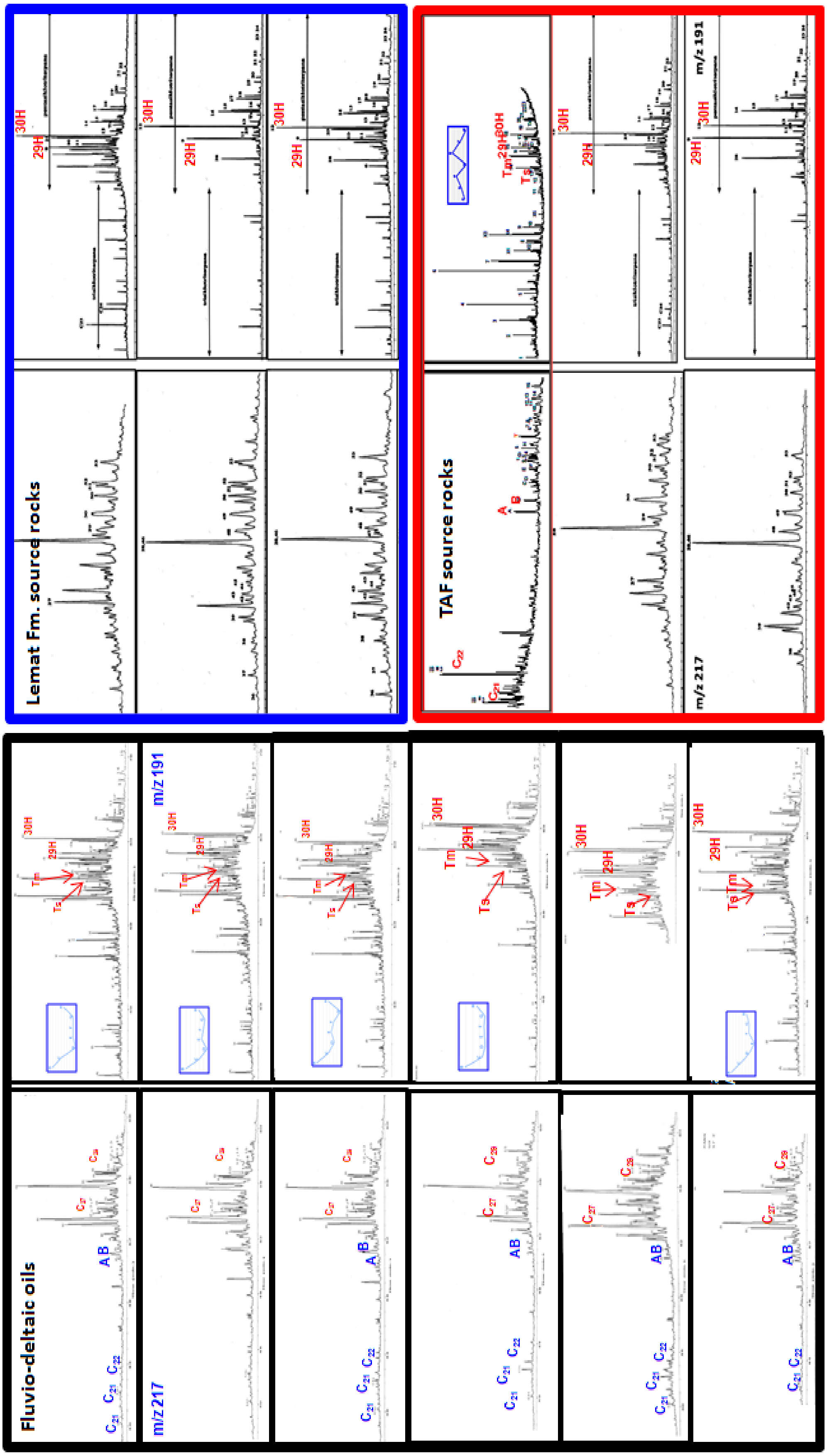

Figure 7. Comparison of biomarker characterization qualitatively between source rocks of lemat and Talangakar Formation, and oils in Limau graben

Determination of Ancient Volcanic Eruption Centre Based on Gravity Methods in Gunungkidul Area Yogyakarta

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ABSTRACT

Ancient eruption centers can be determined by detecting the position of the ancient volcanic material, it is important to understand the elements of ancient volcanic material by studying the area geologically and prove the existence of an ancient volcanic eruption centers using geophysics gravity method. The measuring instrument is Lacoste & Romberg gravimeter type 1115, the number of data are 900 points. The area 60x40 kilometers, the modeling 2D software is reaching depth of 30 km at the south of the island of Java subduction zone. It is suported by geological data in the field that are found as the following:

1. Pyroclastic Fall which is a product of volcanic eruptions, and lapilli tuff with felsic mineral. 2. Pyroclastic flow with Breccia, tuffaceous sandstone and tuff breccia. 3. Hot springs near Parangwedang Parangtritis. 4. Igneous rock with scoria structure in Parang Kusumo, structured amigdaloida which is the result of the eruption of lava/volcanic eruptions, and Pillow lava in the shows the flowing lava into the sea.

Base on gravity anomaly shows that there are strong correlationship between those geological data to the gravity anomaly. The 2D modeling shows the position of ancient of volcanic eruption in this area clearly.

Keywords: Ancient Volcano, Gravity method. 2D program

INTRODUCTION

Theory of Gravity is proposed by Sir Isaac Newton (1642-1727) states that the attraction force of between two particles is proportional to the multiplication of two masses and inversely proportional to the square of the distance between the two centers, so the greater of the distance the second object, the gravitational force is getting smaller, the method is often used for the preliminary survey on monitoring volcano. The research location is in the area of Gunungkidul, Bantul and Klaten, precisely located at geographic coordinates of E 422000-472000, and S 9090000-9145000.[8].

GENERAL GEOLOGY

Southern Mountains zone [14] can be divided into three subzona, namely Subzona Baturagung, Subzona Wonosari and Subzona Gunungsewu [2,6]. Subzona Baturagung mainly located in the northern part, but extends from the western (Mt. Sudimoro altitude, ± 507 m, between Imogiri-Patuk), to the north (Mt. Baturagung, ± 828 m), to the east (Mt. Gajahmungkur, 737 ± m). In the east, the Subzona Baturagung (± 706 m) and Mt. Gajahmungkur (± 737 m). Subzona Baturagung form the most rugged relief with the high are between 100-700 meters and almost entirely composed of volcanic rock [11].

Subzona Wonosari a plateau (± 190 m) located in the central part of the Southern Mountains Zone, namely Wonosari and surrounding area. This plain is bounded by Subzona Baturagung on the west and north side, while the south and east side borders the mountain Subzona Sewu. The main river in this area is K. Oyo that is flowing to the west and merges with K. Opak. The sediment surface in this area is black clay and ancient lake sediments, whereas the rock is essentially limestone.[9].

STRATIGRAPHY

Naming litho units of the Southern Mountains has been widely expressed by some researchers who distinguish stratigraphic western region (Parangtritis – Wonosari). Stratigraphic (fig 1).

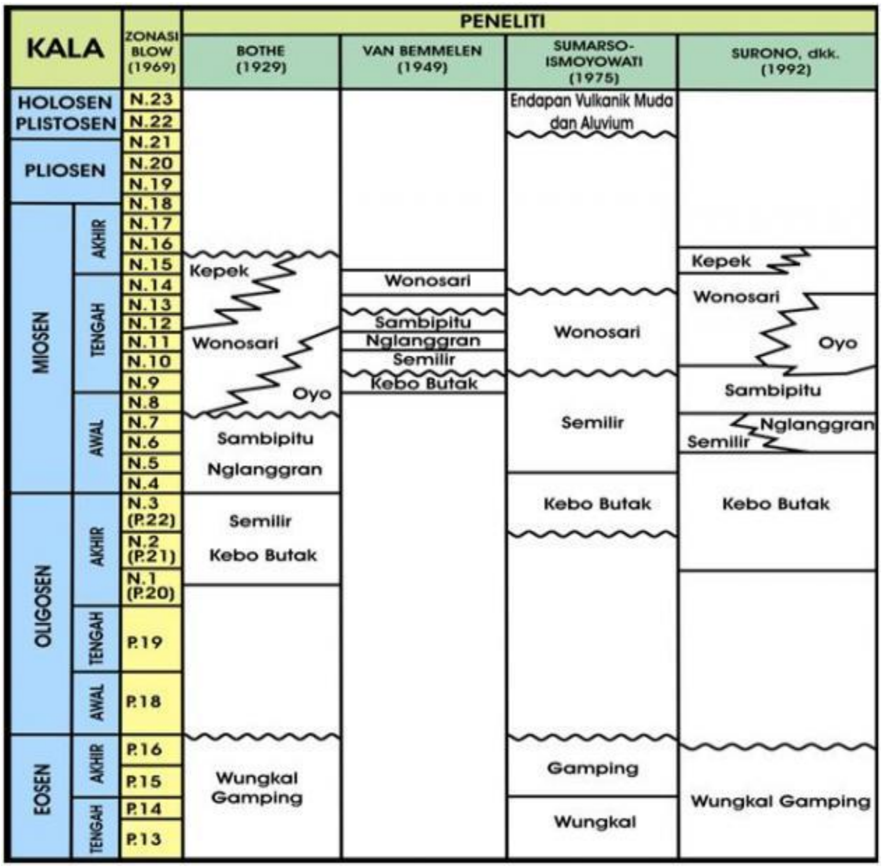


Figure 1. Stratigraphic sequence of Gunungkidul by some authors.

BASIC CONCEPTS OF GRAVITY METHOD

The theory of gravity states that the force of attraction between two particles is proportional to the multiplication of two masses and inversely proportional to the square of the distance between the two centers [1] and[13]. It can be written as;

$$F = G\frac{M.m}{R^2}$$

$$F = m.g$$

$$g = G\frac{M}{R^2}$$

where,
F: forces of attraction between two masses (N)
R : distance between M and m (meters)
M : mass of object 1 (kg)
G: gravitational constant Nm^2/kg^2
m: mass of object 2 (kg)
g: gravity acceleration (m/s^2)

The gravitational constant value *G* can be derived from the experimental results [12], i.e.,

$$G = 6.673 \times 10^{-8} \text{ dyne cm}^2/\text{g}^2 = 6.673 \times 10^{-11} \text{ Nm}^2/\text{kg}^2.$$

The equation (1) shows that the magnitude of gravity is directly proportional to the mass, while the mass is directly proportional to the mass density ρ and the volume of the object, so that the magnitude of gravity measured, reflecting both these quantities, the volume would be related to the geometry of objects [13]. The flowchart or the diagram of processing gravity data is shown in Figure 2.

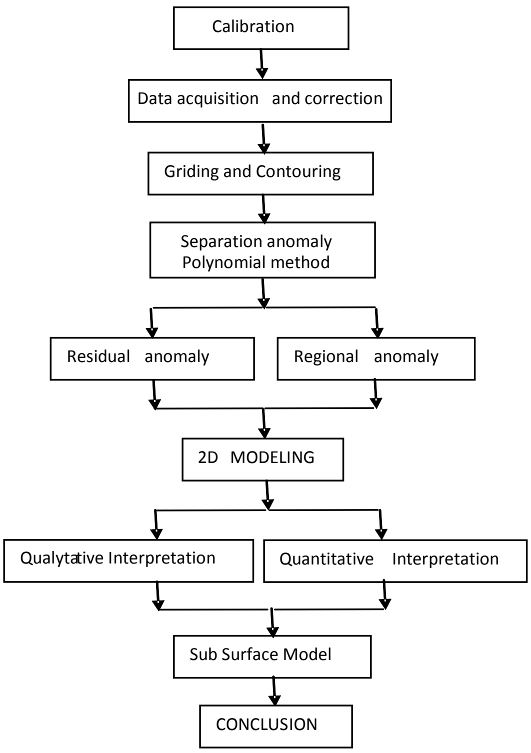


Figure 2. Flowchart of the processing data.

The standard by step correction concepts and data processing see [8,13].

GRAVITY INTERPRETATION

In general, the interpretation of the gravity data is divided into two type, i.e, quantitative (Physical Modeling) and qualitative interpretation (Geological Modeling).

Quantitative Interpretation (Physical Modeling)

Quantitative interpretation is an indirect method, the method of trial and error (trial-error) using 2D modeling [12], The Talwani modeling, basically is performed by varying the form of polygons model in accordance with the consideration of geological geometric of model and sample that are taken from the area of study, and then do a match or fitting of the calculation gravity response of model (anomaly) to the corrected observations. Before calculations the response of the object model, the separation of regional to local effect have to be performed [4]. The regional effect of the anomaly reflects the deep and wide objects, while the local effect of anomaly shows the shallow object [5]..

In general in figure 3, the Bouguer anomaly reflect the effect of rock anomaly areas of study; the general the high anomaly value more than 100 mGal located at the edge of the vicinity study area, i.e., Mt. Nglanggran, Mt. Sudimoro, east of Mt. Nglanggran, until Rongkop Ponjong area and surrounding of cave Cerme near Parangtritis [7]. In figure 4 and figure 5, Mt. Pendul with anomalies of 81-82 mGal shows that the depth of the rock is about 600-2000 meters and the density contrast of 0.2 kg/cm^3. The 2.85 kg/cm^3 density areas in the basement is so low that indicated the presence of anomalies around 60-70 mGal.

The polygon shape display from 2.85 to 2.9 kg/cm^3 can be interpreted as igneous intermediate as a basement [4] that these rocks is the ocean crust rocks. According to this model the mélange and oceanic rocks are as revealed in Karangsambung [2]

Profile A – B, is a profile which extends from Parangtritis Mt Sudimoro, Mt. Nglanggran indicates that the rock has a density of 2.85 kg/cm^3 is Andesite, density of 2.5 kg/cm^3 is breccia and sandstone density is 2.2 kg/cm^3 and 2.4 kg/cm^3 is the density of coral limestone (figure 4).

Profile C – D, figure 5 is a profile from the Rongkop and Ponjong to Mt Nglanggran and Gantiwarno Klaten shows that the gravity anomaly pattern is also similar to the model of Mt. Sudimoro to Mt. Nglanggran, where the density is 2.85 kg/cm^3 at the bottom as an igneous rock, density 2.5 kg/cm^3 is breccia, density is 2.2 kg/cm^3 is and density 2.4 kg/cm^3 is a reef limestone.]

From the quantitative analysis and contour patterns of anomalies and patterns adapted to the configuration of the object model, there are some indications of geological structures such as faults Opak that involve to rock groups with a depth of 700 meters. It generally occupies the western side of the area to the northern side area.

Qualitative Interpretation (Geological Modeling)

Geological modeling is a geological interpretation based on the contour patterns of gravity anomaly that resulting from the distribution of density rock bodies of or the subsurface geological structures. Further, the anomalies gravitational interpreted are produced by local geological information in the form of distribution of objects with different density contrasts or geological structure, which is used as the basis of estimation of the actual geological conditions. To carry out the geological interpretation of the subsurface is through several cross-sectional approaches to gravity data with surface geological data such as geological structure pattern [9] The study area includes the South Java that the value of gravity anomaly is between 60 mGal to 240 mGal.

The variations of the shallow bedrock depths are 500 - 1700 meters, at the perimeter of the high Bouguer anomaly is relatively circular in shape around the area of study. It is interpreted as an ancient volcano. In geologically, this area consists of Tertiary age rocks that are covering Nglanggran Formation volcanic breccia, formation Sambipitu (sandstone, clay, calcareous sand, and tuff). and Wonosari Formation which consists of coral limestone and limestone layered. Those formations were intruded by intrusive andesite into the surface such as Mt. Nglanggran and Mt. Sudimoro.[3].

In briefly, the gravity models in this area suggests that the possibility of the bedrock in the study area is an igneous rock i.e., andesite continental crust. The Formation rocks above it may occur at the end of the Cretaceous era [11]. However, geodynamics processes that occur in Cretaceous is not known for a moment. The gravity section shows a large fault that extends along the river Opak to Northwest – Southeast ward.

Bouguer anomaly map (figure 3), the basin boundary is obtained by riffing deposited on coral limestone formation known as Wonosari that was located above the andesitic breccias.

TECTONIC PROCESSES

According to [4,6]. Geological interpretation based on the contour patterns of anomalous gravity field resulting from the distribution of density anomalies bodies of rock or subsurface geological structures. Further anomalies interpreted gravitational field produced by local geological information in the form of distribution of objects with different density contrasts or geological structure, which is used as the basis of estimation of the actual geological conditions [2].

GEOLOGICAL HISTORY

1. In the early - Middle Miocene [8, 10].: The huge eruption of the volcano in Gunungkidul areas produce materials pyroclastic material spread out to 10-20 km radial.
2. Middle Miocene: because of the Huge eruption of a great many times, and there was wide graben caldera which the middle is the city of Wonosari, this graben. Many fault caused by the edge of the mountain section contained around the caldera
3. In the Upper Miocene - Pliocene: the case of transgression so surface mount caldera sank below sea level, and the life of the coral reef comes the mid section of the caldera
4. Pliocene - Pleistocene: a process of removal (tectonic) that Caldera was lifted up in the earth's surface, the reef becomes Wonosari Formation.
5. Recent : Erosion and denudation resulting in the appearance of the topography and morphology were present.

CONCLUSIONS

1. The existence of an ancient volcano is andesite intrusion of igneous rocks that form the lineament between Mt. Sudimoro

and Mt Nglanggran interconnected to form eruptive fissure with the northwest – southeast direction, it is forming a high pattern of gravity anomaly.

2. The low pattern in the middle area is the basin that located above Wonosari volcanic breccias, and the high pattern anomaly boundaries are forming a circular shape.

3. The high pattern area Ponjong, Rongkop and Wediombo are an ancient volcano that located in the eastern area needs further investigation due to the intrusion not disclosed on the surface.

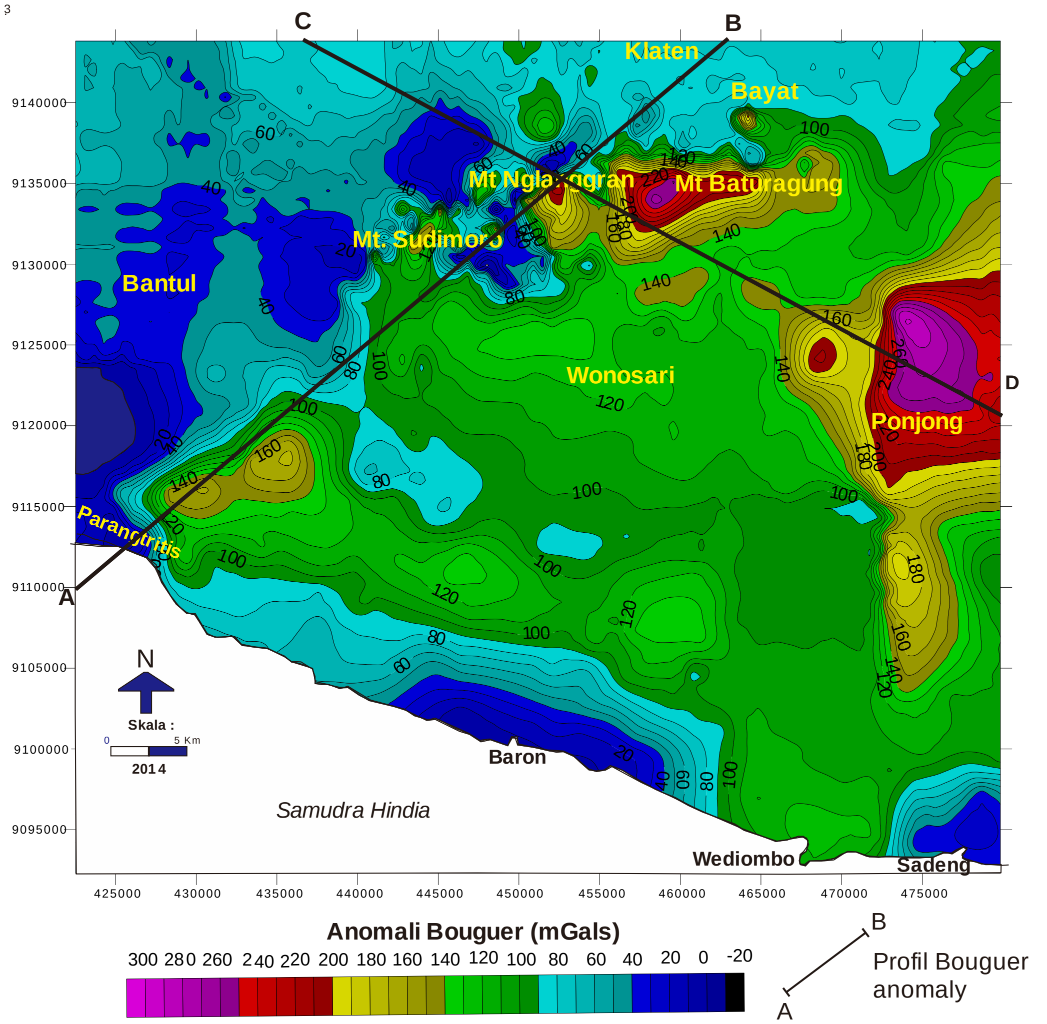
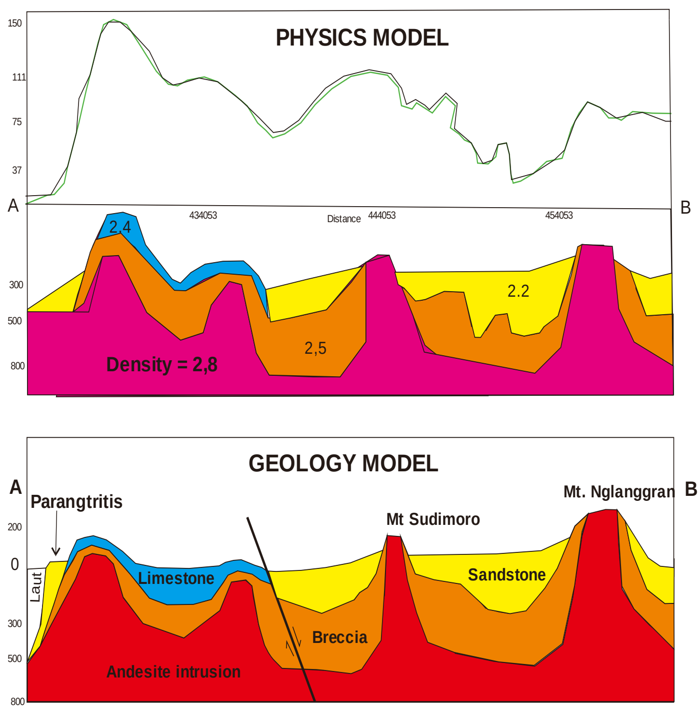


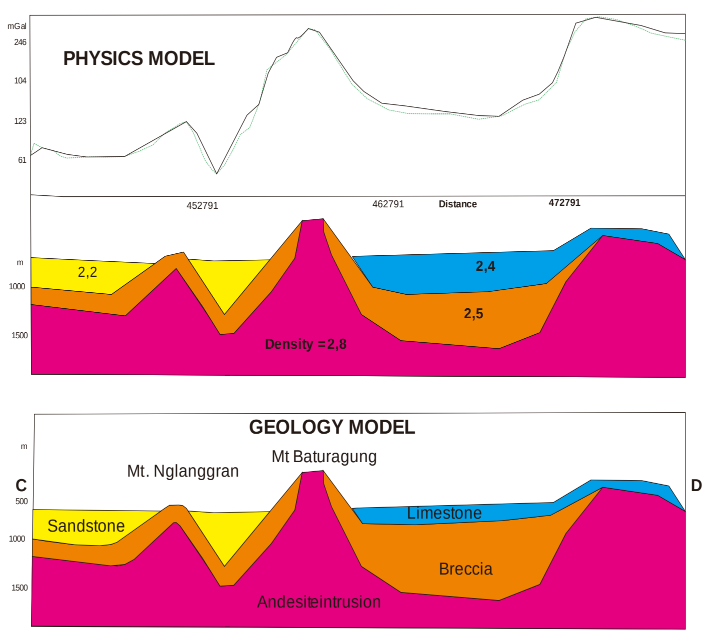
Figure 3 : BOUGUER ANOMALY MAP GUNUNGKIDUL AREA



Legende:

- **Wonosari Formation:** Reef Limestone, Clastic limestone.
- **Sambipitu Formation :** Sandstone, tuff, clay
- **Nglanggran Formation:** Andesitic Breccia, Lava, Sandstone, Pyroclastic Tuff
- **Andesite :** Intrusion.

Figure 4 : PROFILE A - B BOUGUER ANOMALY
Mt. SUDIMORO - Mt. NGLANGGRAN



Legende:

- **Wonosari Formation:** Reef Limestone, Clastic limestone.
- **Sambipitu Formation :** Sandstone, tuff, clay
- **Nglanggran Formation:** Andesitic Breccia, Lava, Sandstone, Pyroclastic Tuff
- **Andesite :** Intrusion.

Figure 5 : PROFILE C - D. BOUGUER ANOMALY
Mt. SUDIMORO - Mt. NGLANGGRAN - Mt Baturagung

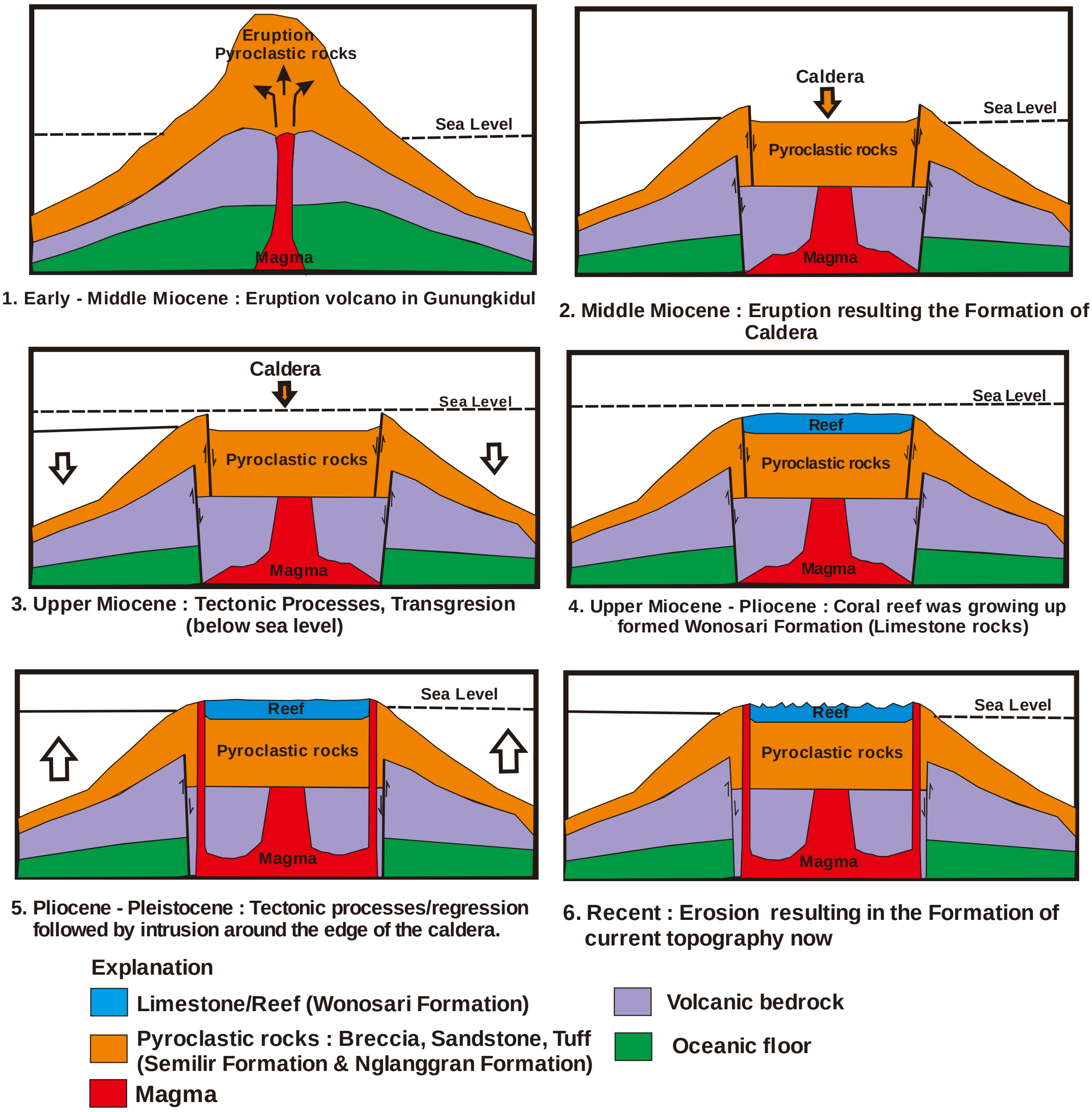


Figure 7. Geological history of the formation the caldera

REFERENCES

[1] Blakely, Richard.J, 1995, *Potential Theory in Gravity and Magnetic Application*, Cambridge Univ. Press.

[2] Bronto, S., Misdiyanta, P., Hartono, G., dan Sayudi, S., 1994. *Penyelidikan Awal Lava Bantal Watuadeg, Bayat dan Karangsambung, Jawa Tengah, Kumpulan Makalah Seminar*: Geologi dan Geotektonik Jawa, Sejak Akhir Mesozoik Hingga Kuarter. *Jur. Tek. Geologi, F. Teknik, UGM*, Yogyakarta, h. 123-130.

[3] Cas, R.A.F., dan Wright, J.V., 1987. *Volcanic Succession*: *Modern and Ancient*, Allen & Unwin, London, 534.

[4] Dobrin, M,B and Savit, CH 1988, "*Introduction to Geophysical Prospecting*", Mc Graw Hill Co, Fourth edition, New York, San Fransisco.

[5] Grant,F,S. & West,G,F, 1965, "*Interpretation Theory in Applied Geophysics*", Mc Graw Hill Co, New York, San Fransisco, Toronto, London, Sydney.

[6] Hartono, G. dan Syafri, I., 2007. Peranan Merapi Untuk Mengidentifikasi Fosil Gunung Api Pada "F. Andesit Tua"

[7] Macdonald, A.G., 1972. *Volcanoes*. Prentice-Hall, Inc. Englewood Cliffs, New Jersey, 510.

[8] Rahardjo, W., Sukandarrumidi dan Rosidi, H. M. D., 1977. *Peta Geologi Lembar Jogjakarta, Jawa, skala 1 : 100.000*. Puslitbang Geologi, Bandung.

[9] Sartono, S., 1990. Extensive Slide Deposits In Sunda Arc Geology, The Southern Mountain of Java, Indonesia. *Buletin Geologi*, Bandung, 20. 3-13.

[10] H.O. Seigel, 1995. A Guide To High Precision Land Gravimeter Surveys. Scintrex Limited 222 Snidercroft Road Concord, Ontario. Canada.

[11] Soeria-Atmadja, R., Maury, R.C., Bellon, H., Pringgoprawiro, H,. Polve, M., dan Priadi, B., 1991. *The Tertiary Magmatic Belts in Java. Proceeidings of Silver Jubilee Symposium On the Dynamics and Its Products*. Research and Development Center for Geotechnology-LIPI; Yogyakarta, September 17-19, h. 98-112.

[12] Talwani, M., J. L. Worzel, and M. Landisman (1959), Rapid Gravity Computations for two-Dimensional Bodies with Application to the Mendocino Submarine Fracture Zone, J. Geophys. Res., 64(1), 49-59,

[13] Telford, W,M, Geldart,L.P, Sheriff,R,E & Keys, D,A, 1976, " *Applied Geophysics"* second edition, Canbridge University Press, New York, London Melbourne.

[14] Van Bemmelen, RW., 1949. *The Geology of Indonesia*, Vol IA. Government Printing Office, The Hague, 732.

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Stability Analysis of Single Slope on Soft Rock Using Saptono's Chart Stability

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ABSTRACT

Stability analysis mining slope is an important activity in the life an open pit coal mine as composed of soft rock. This is because of the safety to mine, machine and personal as well as economic impact on production. In this paper, especially study of existing single slope on soft rock is analyzed using saptono's graphics stability. The soft rock properties are determined in laboratory like cohesion, angle of friction, and density. The stability of single slope is simulated for extreme conditions like saturated conditions. The use of saptono's graphic stability in calculation of safety factor has to overcome the weakness of rock mass. An analysis of stability was applied to a slope, of complex condition, composed of joints condition, spacing, roughness, orientation and water condition. That condition will be calculated with classification rock mass i.e. rock mass rating (RMR). Therefore, RMR is parameter input on stability analysis. It is pertinent to use the slope stability measures or change the slope geometry on soft rock.

Key word: Graphic Stability, Soft Rock, Rock Mass Rating, Cohesion and friction angle, Safety Factor.

INTRODUCTION

This paper discusses the principles of the theoretical work, and demonstration their application in design chart and in the results of computer analyses. During the past half century, a vast body of literature on the subject of circular failure has accumulated, and no attempt will be made to summarize the standard soil mechanics (Hoek & Bray, 1981).

Slope stability criteria that have been widely used are based on the limit equilibrium and numerical methods. While the statistical and graphical methods are rarely used and bearing in mind the nature of the mining operation is very dynamic, the most appropriate method to assess slope stability would then be the graphical method.

Hoek & Bray (1981) was the first one to use a graphical method (curve) for determining the slope stability of loose and homogeneous material. The curve uses cohesion that is derived from Mohr and Coulomb criteria. In its development, Lie et al (2008) also proposed slope stability criteria with graphical method and the rock strength was determined by the Hoek & Brown rock strength criteria (2002).

The Hoek & Bray graphical method does not include rock mass characteristics, whereas Lie et al (2008) incorporate the characteristics of the rock mass in the form of rock constants m, s and Geological Strength Index (GSI, Hoek, 2002). Determination of the rock constants of m and s were done by statistics method based on triaxial test of igneous rocks obtained from an open copper mine in Papua Nuigini.

PROPOSED STABILITY CURVE

Hoek & Bray (1981) charts have been developed by running many thousands of circular analyses from which a number of dimensionless parameter were derived that relate the factor of safety to the material unit weight, friction angle and cohesion, and slope height and face angle. It has been found that chart give a reliable estimate for the factor of safety, provided that the conditions in the slope meet the assumptions used in developing the chart.

As mentioned before that the slope stability curves of Hoek & Bray (1981) and Lie et al (2008) include the cohesion of intact rock that is obtained from direct shear test in laboratory scale. Although the stability curve of Lie et al uses rock mass constants such as m and s for scaling up the cohesion to be representing rock mass condition, it would have been better if the cohesion and internal friction angle are obtained from direct shear tests in the field which take account scale effect (Kramadibrata & Jones, 1993).

Hence, a series of slope stability curves is proposed incorporating all parameters given in that of Hoek & Bray and Lie at al. and by taking account the scale effect and weathering that lead to the strength deterioration. It is expected that the proposed slope stability curve will be well appropriate in the application for assessing slope stability in Indonesian as soft rock.

DERIVATION OFCIRCULAR FAILURE CHARTS IN SOFT ROCK

Dimensional analysis has been extensively used in solving complex engineering problems. Its application is dependent on listing of all the dimensional variables affecting the problems.

It has been of immeasurable value in analyzing complex engineering problems in many field notably fluid mechanics and heat transfer. It has also been used to establish the modeling criteria for the scale model testing of coal-face production system (Roxborough & Eskikaya, 1974), and more recently its use in subsidence modelling was referred to by Whittaker & Reddish (1989) and Kramadibrata (1996).

The authors therefore decided to apply this technique to develop a rock slope stability curve with the intention of deriving a set of dimensionless groups which could thereafter be used to correlate the experimental data and develop appropriate functional relationships.

Application of the dimensional analysis for slope stability analysis is to link 10 physical quantities of which consists of a slope height (h), specific weight of slope material (γ), water content (w), slake durability (sd), uniaxial compressive strength (UCS-σc), cohesion (c), friction angle (ϕ), area of shear plane (A), joint frequency per meter (JF), and Rock Mass Rating (RMR) with water surface condition is saturated (Kramadibrata, 2011). In view of that the rock formation is soft; allowing the UCS varies from 1 MPa to 20 MPa, the relationships between RMR and cohesion of equation can therefore be generated as shown in Figure 1 and 2.

DETERMINATION OF SLOPE STABILITY

Slope Model

Illustration of slope model is shown in Figure 3 with height of h and slope of β, and the parameters used to represent the rock mass properties constituting the slope are uniaxial compressive strength (UCS or σc), RMR and specific weight (γ). The RMR is determined using the data site rock characterization (ISRM, 1981) and the slope is assumed as a single slope, the slope stability calculation is based on the limit equilibrium approach and slope failure occurs at the toe of the slope.

Slope Stability Determination Procedure

The end result of establishing the soft rock slope stability procedure is in form of three curves, namely cohesion determination curve (Figure 1), internal friction angle curve (Figure 2) and safety factor determination curve (Figure 4).

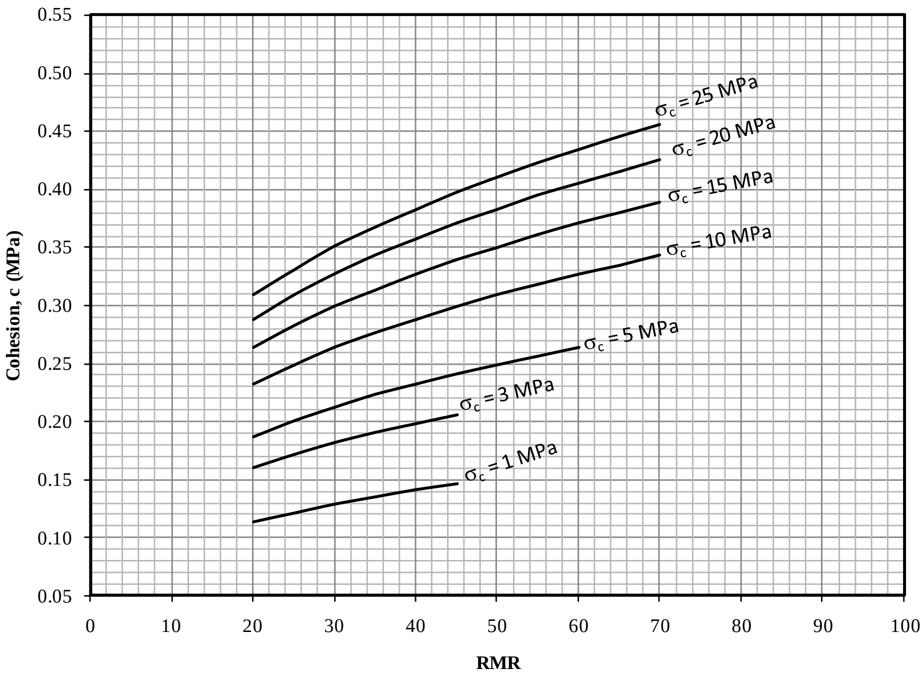


Figure 1. Curve for determination of cohesion with RMR and UCS parameters input (Saptono, 2012)

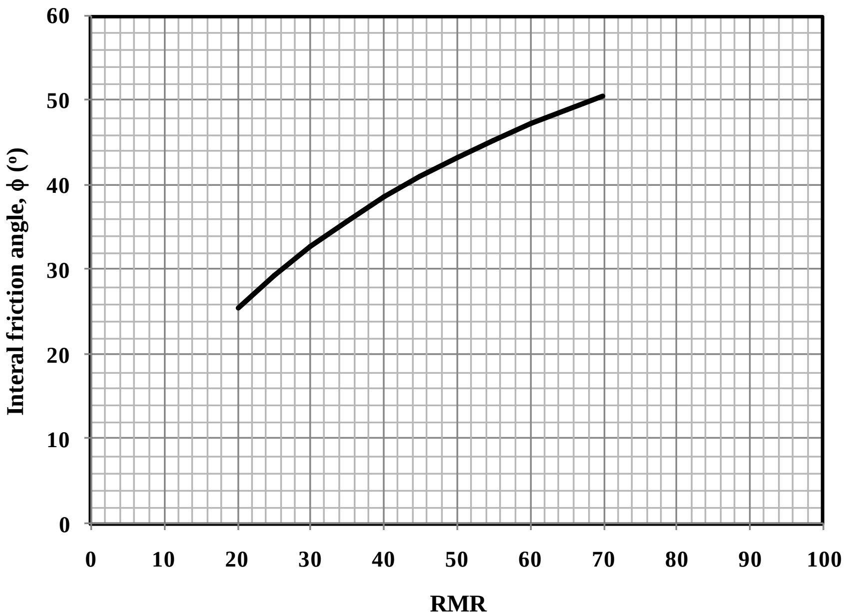


Figure 2. Curve for determination of internal friction angle with RMR parameter input (Saptono, 2012)

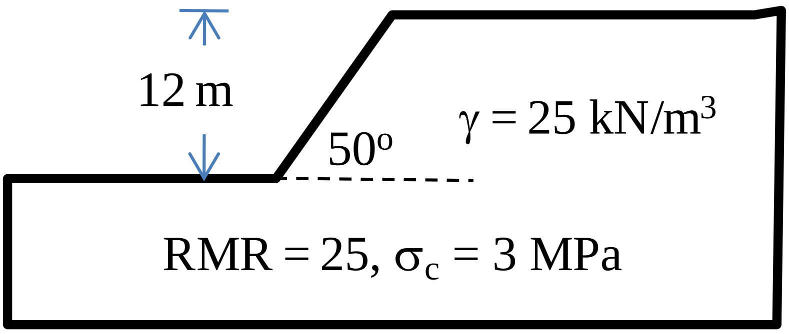


Figure 3. Single Slope Model and rock properties parameters

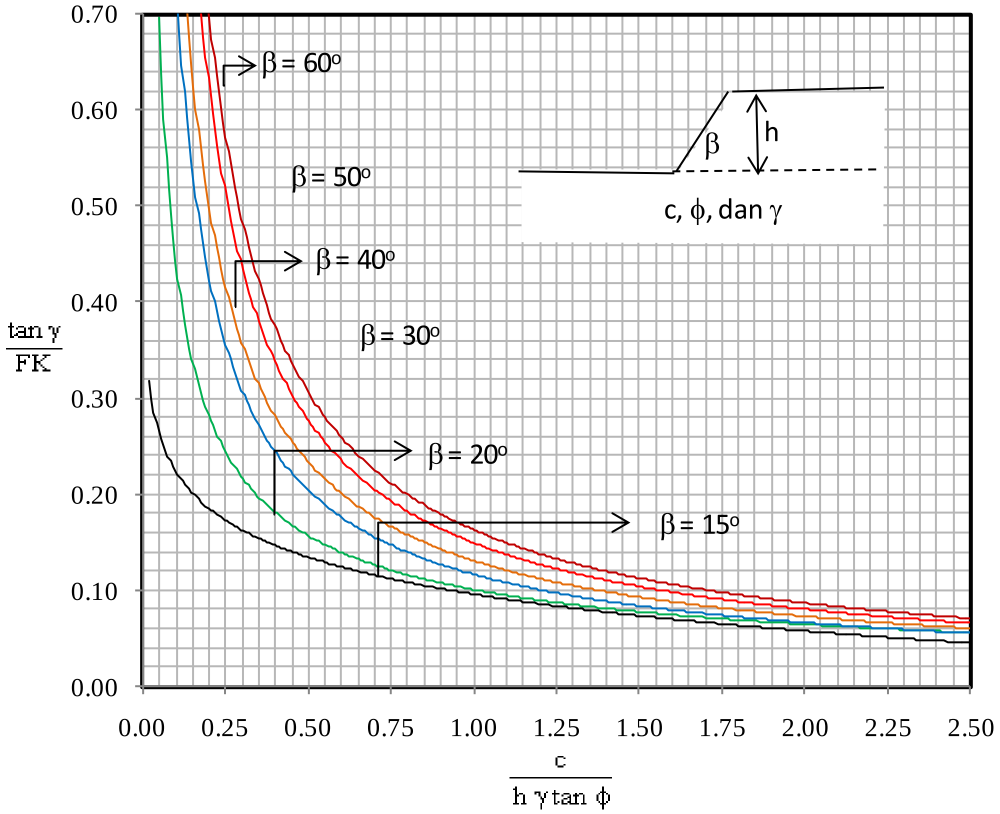


Figure 4. The slope stability chart at different slope angles use of on soft rock (Saptono, 2012)

Use of the Failure Chart

In order to use the charts to determine the factor of safety of a slope, the step outlined here and shown in Figure 5 and 6 should be followed.

Step 1: Decide upon rock characterization by Rock Mass Rating (RMR) based on Bieniawski (1989) and select rock strength parameters appli-cation based on uniaxial compr-essive strength (UCS) and relation RMR and UCS for determination of cohesion (Figure 1).

Step 2 : Determination of friction angle with RMR parameter (Figure 2).

Step 3: Calculate the value of the dimen-sionless ratio c/(γ H tan ϕ) and find this value on the x – coordinate scale of this chart.

Step 4: Follow the vertical line from the value found in step 3 to its intersection with the curve which corresponds to the slope angle.

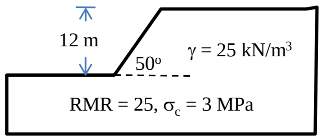
Step 5: Find the corresponding value of tan ϕ/FK, depending upon which is more convenient, and calculate the factor of safety.

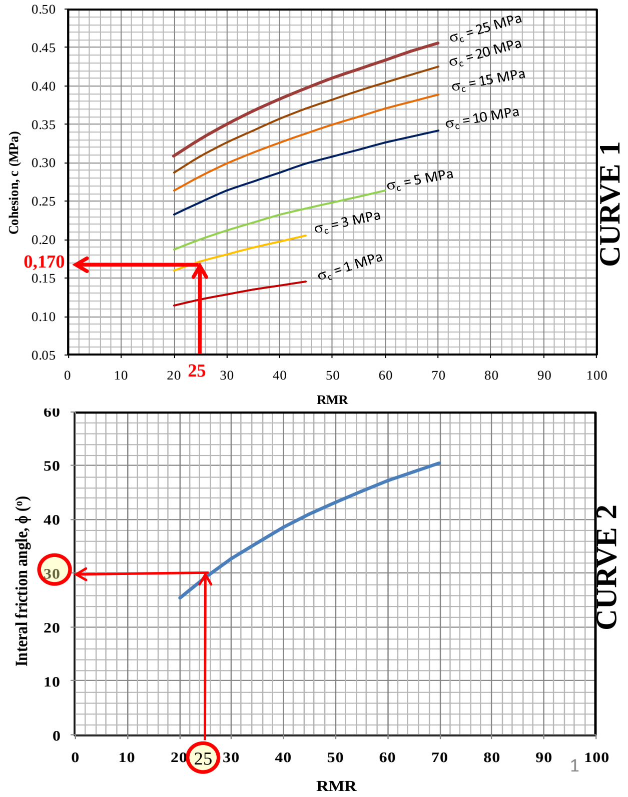
Consider the following example:

A 12 m high cut with a slope face angle of 50° is to be excavated in soft rock with a density γ = 25 kN/m^2, with rock mass characterization RMR = 25 and UCS = 3 MPa. Find the factor of safety of slope.

Example Using Curve 1 & Curve 2

Example:





Stage 1:

Curve 1:
RMR = 25 and σ_c = 3 MPa
c = 0,17 MPa,

Stage 2:

Curve 2:
RMR = 25
ϕ = 30°.

Figure 6. Determination for cohesion and internal friction angle of slope on soft rock

Example Using Curve Soft Rock Stability Analysis

Stage 3:

Curve 3:

- β = 50º
- (c/ γh tan ϕ) = 0,98
- (tan ϕ/FK) = 0,152
- FK = (tan ϕ/0,152) = 3,798

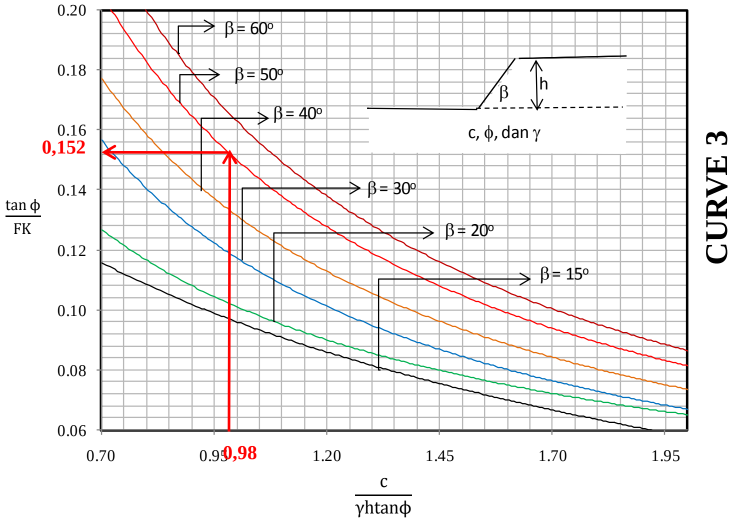


Figure 6. Determination for factor of safety of slope on soft rock

CONCLUDING REMARKS

Determination of criteria and soft rock slope stability analysis is proposed in the form of charts based on: use of RMR and cohesion and internal friction obtained from large-scale direct shear test (scale effect). The all parameters are obtained from coal bearing strata that is located in the tropical region so that rock strength deterioration due to weathering. To develop a rock slope stability curve with the intention of deriving a set of dimensionless groups which could thereafter be used to correlate the experimental data and develop appropriate functional relationships. This research is going to process towards the application step.

ACKNOWLEDGEMENTS

Thanks to the Vice Rector for Research and Innovation ITB which has approved this research to be funded by the DIPA ITB Fiscal Year 2010. Similarly, the authors would also like to thank the Management of PT. Adaro Indonesia, which continues to support the research of rock mass characterization and testing direct shear of large scale and would you like to thank the students, laboratory staff and technicians involved in this research.

REFERENCES

Bieniawski, Z.T., 1989. Engineering Rock Mass Classifications, John-Wiley, New York

Hoek, E. and Bray, J.W., 1981. Rock Slope Engineering, Institution of Mining and Metallurgy, London

Hoek, E., 2002. A Brief history of The Development of The Hoek-Brown failure Criterion, Accessed through the Program RocLab.

Kramadibrata, S. and Jones, I.O., 1993. Size Effect on Strength and Deformability of Brittle Intact Rock, Scale Effects in Rock Masses, Proc. of the Second International Workshop on Scale Effects in Rock Masses, Lisbon, Portugal, (ed. A. Pinto Da Cunha), A.A. Balkema, Rotterdam.

Kramadibrata, S., 1996. The Influence of Rock Mass and Intact Rock Properties on The Design of Surface Mines with Particular Reference to The Excavatability of Rock, Ph. D. Thesis, Curtin University of Technology.

Kramadibrata, S., Saptono, S., Wattimena, RK., Simangunsong, GM., Sulistianto, S., 2011. Developing a Slope Stability Curve of Open Pit Coal Mine by Using Dimensional Analysis Method, 12th ISRM Congress, Beijing, China.

Lie, A.J., Merifield, R.S., Lyamin, A.V., 2008. Stability Charts for Rock Slopes Based on the Hoek-Brown Failure Criterion, International Journal of Rock Mechanics & Mining Science 45, 689 – 700.

Roxborough, F.F., and Eskikaya, S., 1974. Dimensional considerations in the design criteria of a scale model for coal-face production system research. Int. J. Rock Mech. Min Sci & Geomech. Abstr., Vol 11, pp. 129-137.

Saptono, S., 2012. *Pengembangan Metode Analisis Stabilitas Lereng Berdasarkan Karakterisasi Batuan di Tambang Terbuka Batubara*. Disertasi Doktor, Rekayasa Pertambangan, Institut Teknologi Bandung.

Whittaker, B.N., and Reddish, D.J., 1989. Subsidence occurrence prediction and control. Developments in Geotechnical Engineering, 56. Elsevier, pp. 437-473.

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Share Intrinsic Value Valuation Analysis of Company Mining Sector: Study Empirical PT Bumi Resources Tbk (Bumi) in Indonesia

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ABSTRACT

Focusing of this study is Share Intrinsic Value Valuation Analysis Of Company Mining Sector. Share is known to high risk-high return characteristics. Because of that, investing in share needed share valuation analysis to estimate how much intrinsic value is, for a share based on its fundamental data. The purposes of the research were for getting intrinsic value of a share and knowing what the share was in undervalued, overvalued or fairly price condition. The research used company object included in mining sector, it was PT Bumi Resources Tbk (BUMI) in Indonesia. The analysis was done by using top down approach that was begun from economy condition analysis, industry condition, and company condition, then, it was continued by performing share valuation in using Model Discount Dividend Approach and P/E Ratio. The result of the research showed intrinsic value of BUMI's share with Model Discount Dividend Approach was Rp 601 mean while with P/E Ratio approach was Rp 608. If it was compared to market value per October 1st , 2012 was Rp 750 so BUMI's share was assessed overvalued (expensive), theoretically it was recommended to sell if it share had been owned and to postpone the purchasing.

Keywords : Share Valuation, Dividend Discount Model, P/E Ratio (PER)

INTRODUCTION

Mining industry in Indonesia has a very bright prospect and has been a boosting factor for economy and social growth. One sector which has rapidly developed is coal, where Indonesia is the main actor in the world market, as since 2006, Indonesia has placed the second after Australia as a coal exporter.

Coal in Indonesia is largely produced in Kalimantan, Sumatera and some other places. This rapidly growing coal industry is supported by government policies which introduce an aggressive foreign investment, and is also propped up by abundant coal reservoir. It can be concluded that firms which produce coal still have good prospects.

PT Bumi Resources Tbk (BUMI) is one of the firms covering exploration and exploitation of coal content (including coal mining and selling) and oil exploration. This firm went public through IPO (initial Public Offering) in 1990, and is listed at Jakarta Share Exchange (Bursa Efek Jakarta). The firm has several subsidiaries, which include PT Kaltim Prima Coal (KPC) and PT Arutmin Indonesia which are coal producers as well as the biggest income contributors to the firm. Both are the biggest coal producers in Indonesia with a market share of 26.6% (2009) and one of the big three coal exporting countries in the world with groos production in 2006 of 50.7 tons. Below is the ratio of financial performance and share trading activity in the last 5 years:

Table 1.1 Ratio of Financial Performance and Share Trading Activity of BUMI, period 2008 – July 2012

KETERANGAN	**2008**	**2009**	**2010**	**2011**	**Jul-2012**
ofit (in Million) *Growth* (%)	7.066.750 -4,91	1.796.503 -74,58	2.793.770 55,51	1.950.547 -30,18	-3.101.376 -259
EPS (Rp)	364,19	92,58	134,49	93,9	-149,3
Dividen (Rp)	50,60	27,68	41,78	14,13	-
ROE (%)	65,49	35,19	61,76	50,88	-36,83
ROA (%)	19,41	6,99	11,39	8,12	-3,72
DER (%)	2,02	3,95	4,06	5,26	8,91
➢ Volume (million shares) ➢ Nilai (Billion Rp) ➢ Frequency ➢ Days	53.087 254.277 1.205.300 220	105.095 201.041 2.198.359 241	46.722 105.625 1.072.692 245	37.251 101.771 642.882 247	9.708 16.540 266.437 147
Market Price (Rp) *Change* (%)	910	2.425 166,48	3.025 24,74	2.175 -28,09	1.040 -52,18

Source: www.idx.co.id and BUMI Financial Report (processed data)

Table 1.1. above shows that BUMI market price fluctuates widely where in 2009 and 2010 increased with the change of 166.48% and 24.74% respectively. In 2011 it decreased as much as -28.09% and in July 2012 it decreased as much as -52.18%. PT Bumi Resources Tbk consistently pays dividend to share holders annually.

Share trading prices in the share exchange are subject to change anytime, meaning it can increase or decrease unpredictably. Share trading prices movement is basically influenced by the most basic economics theory, i.e. demand and supply law. According to Renal (2009:1) to tackle Share trading prices there are two common approaches, i.e. fundamental and technical analyses. Fundamental analysis values shares based on the fundamental conditions of the respective firm, while technical analysis values shares based on past reflection of prices by reading sentiments, trends, and future projections.

There are several values related to shares, among others are: book value, market value, and intrinsic value. Book value is firm net asset as reported in the balance (Bodie et al, 2006). Market value is share trading prices in the market at a certain time which is determined by market. Intrinsic value is the actual value or value that is supposed to be of a share.

In Investment Valuation (Damodaran, 2002), to decide intrinsic value or fairly priced value of a share of a firm, it is needed a forecasting of firm income and dividend. Fundamental analysis is a method in evaluating security in deciding intrinsic value such as income and dividend by examining a case of economy, finance, and other qualitative and quantitative factors.

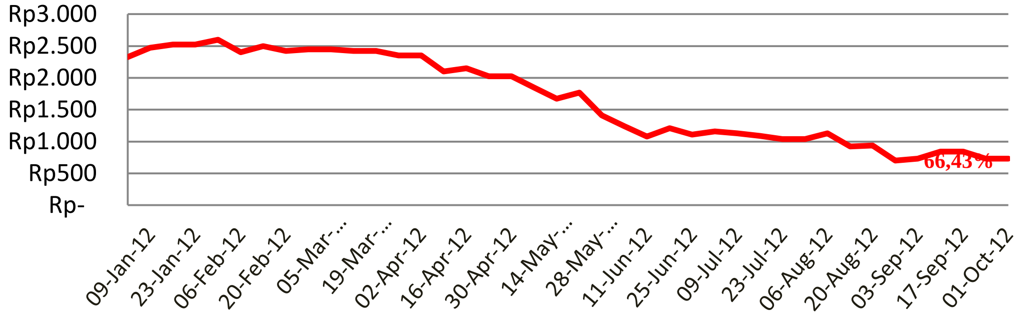
The purpose of fundamental analysis is to yield value that can be compared to the current security price, which later can be valued if the security position is undervalued or overvalued. That intrinsic value gives measurement about base value of a share and is a standard to consider whether the share is undervalued, fairly priced, or overvalued (Brigham and Houston, 2006).

Sehgal and Pandey (2010) also conducted a research to estimate share prices in India share exchange using Price Multiples. This research used data from 1990 – 2007 with 145 samples of firms consisting 13 sub-sector industries. This research discovered that PER was the best compared to PBV, P/S and P/CF. If combination of the methods was used, combination with P/S was very significant. However, the use of PER alone was very good if the comparison was by combining those methods.

Research on share valuation had beforehand been done by Supattarakul and Khanthavit (2011) who conducted a research on firms in Thailand. This research was done in two periods in 1995 – 2004 to estimate share value with Dividend Discount Model (DDM) and Residual Income Model (RIM). The result of this research stated that equity book value gave stronger explanation compared to other variables than DDM and RIM.

The author chose mining sector as the research object to complete the previous research which was about firm share in other industry sectors, so the real condition can be generally better described. Besides that, mining sector tends to be corrected in line with the current global economic crisis. This is a challenge for share holders to judge whether their investment is still worth holding on this mining sector or whether they want to shift to other relatively more stable sectors.

PT Bumi Resources Tbk consistently pays dividend to share holders annually and is the most owned share publicly and the most favorite to investors. The share of BUMI is currently listed on the LQ-45 index period August 2012 – January 2013. This share once yielded high gain when it underwent a fantastic increase in 2007 – 2008, with the highest historical price at Rp. 8,850 in June 2008. But starting from December 2011 – October 2012, this share underwent a decrease tendency, with the lowest historical price at Rp. 650 on 4 September 2012. Below is the movement of BUMI share period 30 December 2011 – 1 October 2012 (weekly):



Graph 1. Market Price Movement of Bumi Share Period 30 December 2011 – 1 October 2012 (Weekly). Source: finance.yahoo.com (data processed)

Based on graph 1.1 above the movement of BUMI share underwent a very extreme decrease and had a very high risk. During that period, this share underwent a decrease of -66.43%. With this steep price decline phenomenon in a very short duration, it was necessary to make a review on the fairness of the price of PT Bumi Resources Tbk share, whether this share was fairly priced or not.

Based on the above explanation, the author meant to re estimate intrinsic value of the firm on different industry sectors using present value approach which discounts value of future cash flow to be the present value that is Dividend Discount Model and an approach using firm earnings, that is Price Earning Ratio (PER). The result of the estimation of the fairness of the share price from each model will then be compared to market prices.

To know the fair price of the share of PT Bumi Resources Tbk, the author was interested to take the title: “**Valuation Analysis of Fair Price of PT Bumi resources Tbk Share (BUMI)”.** With the problem formulation as follows: what is the intrinsic value (fair price) of the share of PPT Bumi Resources Tbk per 1 October 2012? And is the share price of PT Bumi Resources Tbk undervalued or overvalued if compared to its intrinsic value?

The purpose of this research is to find the intrinsic value (fair price) of PT Bumi Resources Tbk share if calculated using Dividend Discount Model and P/E Ratio, also to know if this share is undervalued or overvalued from the intrinsic value if compared to the share trading price.

THEORETICAL BASIS

Share

Bodie, Kane, and Marcus (2009) stated that common shares, also known as equity securities or equities, are the evidence of the possession of some parts of a firm. Furthermore, this means the share holders who invest on the firm also own the firm since they have the possession evidence.

Share Valuation

Every asset, be it financial or real asset possess a value (Damodaran, 2002). Understanding the value of an asset and the factors influencing the asset value is a requirement in prudent business decision making, such as choosing a correct investment in a portfolio, determining the fair price in selling or buying a firm or shares, or in restructuring a firm.

Share analysis is aimed at estimating intrinsic value of a share and then comparing it to the market price of the share. Intrinsic Value (IV) indicates cash flow present value expected of the share. Below is what investors are to do in response to the comparison:

1. If IV > P, the share is considered undervalued and is therefore good to buy or hold if already owned.
2. If IV<P, the share is considered overvalued, and is therefore good to sell.
3. If IV=P, the share is fairly priced and in a balanced condition.

Valuation Process

According to Tambunan (2008), there are three important points that must be analyzed as a part of valuation process before deciding to invest:

1. Economic Condition

Monetary and fiscal policies launched by the government of a country will affect the country’s global economy, which in turn will affect whole industry activity and the firm. Therefore it is advisable, before investing in a country, to analyze deeply its economic condition, such as fiscal policy, monetary policy, inflation rate, and political situation.

2. Industry Condition

This is to identify industries experiencing prosperity or poverty in the economic cycles. Industries react in different ways to certain business cycles. In this process, investors are expected to deeply analyze industries having bright prospect in the future. That way, investors can choose which industry is worth investing in.

3. Firm Condition

The next process is to analyze and compare firm performance using financial ratios and systematic risk. Financial ratio and risk which can be used are liquidity ratio, solvability ratio, and market ratio.

Ordinary Share Valuation

There are two approaches used to calculate ordinary share intrinsic value, which are (Jogiyanto, 2009:130) :

1. Present Value approach

This approach is based on arguments that the value of a firm depends on that firm’s prospect in the future and this prospect is the ability of the firm to produce future cash flow, therefore firm value is determined by discounting future cash flow to be present cash flow.

$$P_0 = \sum_{t=1}^{\infty} \frac{Arus\ Kas_t}{(TI\ 1+k)^t}$$

Notes:

P_o = present value of the firm
t = Period time of t=1 to t=∞
k = interest of discount or the expected rate of return

Earning gained by a firm can be held as retained earning or paid as dividend. Dividend flow can be considered as cash flow that investors received. Since dividend is the only return investors receive, dividend discount model can be used to replace cash flow discount model to calculate share intrinsic value.

Dividend Discount Model is a model to determine estimated share price by discounting all dividend flow which will be received in the future. Systematically, this model can be formulated as follow:

$$P_0 = \sum_{t=1}^{\infty} \frac{D_t}{(1+k)^t}$$

Notes:
P_o = present value of the firm
t = Period time of t=1 to t=∞
k = interest of discount or the expected rate of return
D_t = Dividend paid at the period of t

Share fair price valuation using this dividend approach can be classified into three (Halim, 2005:23), i.e.:

Dividend with zero growth

It is assumed that growth is measured by expected dividend increase rate, and if the future growth is zero, or dividend which will be paid is constant every year until year of t, then share intrinsic value can be formulated as follow:

$$P_0 = \frac{D}{(1+k)} + \frac{D}{(1+k)^2} + \cdots + \frac{D}{(1+k)^{\infty}} = \frac{D}{k}$$

Notes:

P_o = Intrinsic value or theoretical value of the share
D = Dividend which will be received in a constant amount in a period
K = Required rate of return

Dividend with normal growth

This model is used to determine share value, if dividend which is going to be paid undergoes constant growth for the infinite period. This model is also known as Gordon model because Myron J. Gordon is the first to develop and introduce this model. The model equation is as follows:

$$P_0 = \frac{D_0\,(1+g)}{(1+k)} + \frac{D_0\,(1+g)^2}{(1+k)^2} + \cdots + \frac{D_0\,(1+g)^n}{(1+k)^n}$$

$$P_0 = \frac{D_0\,(1+g)^n}{(k-g)} = \frac{D_1}{(k-g)}$$

Notes:

P_o = Intrinsic or theoretical value of the share
D_o = Paid dividend
D_1 = Expected dividend
k = required rate of return gained through CAPM
g = Dividend growth
n = Period of dividend paying

Dividend with two growth period / supernormal

Many firms undergo sales growth, profit, and dividend which are not constant. In the beginning, the growth is above normal, then it gradually becomes normal, and then it will head for constant groth rate. The share price can be calculated by using equation as follows:

$$P_0 = \sum_{t=1}^{n} \frac{D_0\,(1+g_1)^t}{(1+k)^t} + \frac{D_n\,(1+g_2)}{(k-g_2)} \left\{\frac{1}{(1+k)^n}\right\}$$

Notes:

P_o = Fair price or theoretical value of the share
D_o = Dividend of growth above normal
g_1 = Dividend growth above normal
g2 = Normal dividend growth
t = Period time of t=1 to t=∞
n = period of dividend growth above normal
D_n = Dividend with normal growth period

2. *PER Approach (P/E Ratio)*

P/E ratio show ratio of share price to earnings. This ratio shows how big investors value share price to the multiple of earnings. P/E ratio can be calculated using following equation (halim, 2005;27):

$$PER = \frac{P_0}{EPS} \; atau \; PER = \frac{(1-RR)}{(i-g)}$$

Notes:
P_o = Fair price of the share
g = Dividend growth
RR = Retention Rate
i = Required rate of return
EPS = Earning per share = net profit after tax / number of shares

Capital Asset Pricing Model (CAPM)

Capital Asset Pricing Mode (CAPM) was first developed in 1960 by William F. Sharpe, Lintner, and Mossin Brigham (2006) who define CAPM as follows:

"A model based on the proposition that any share's required rate of return is equal to the risk free of return plus a risk premium, where risk reflect diversification".

Which means CAPM is a model which relates expected rate of return of asset with risk to the risk of the asset in the balanced market.

According to the CAPM theory expected rate of return of a security can be calculated using equation (Halim, 2005:74):

$$K_s = R_f + \beta[E(R_m) - R_f]$$

Notes:

K_s= Expected rate of return of a security
β = Beta of asset I
$E(R_m)$ = Expected rate of return from market portfolio
$[E(R_m) – R_f]$ = Risk premium

Beta (β)

Beta can be calculated using regression technique. Regression technique to estimate beta of a security can be assumed using security return volatility as a dependent variables and market return volatility as an independent variable. The more risk an investor is willing to take, the more aggressive the shares one chooses (shares with more than one beta).

Previous Researches

Some researches which studied the fairness of share prices done by previous researchers are among others: a research on share valuation was once carried out by Supattarakul and Khanthavit (2011) who carried out a research on firms in Thailand. This research had a period of research from 1995 -2004 to estimate share value with Dividend Discount Method (DDM) and Residual Income Model (RIM). The result of this research stated that equity book value gives stronger explanation than other variables than DDM and RIM. Therefore it is necessary to do a share valuation before taking decision to invest. According to Halim (2005:20) this makes firm intrinsic value a very crucial measurement for investors to take decisions in buying a firm's shares.

Sehgal and Pandey (2010) also did a research to estimate share trading price at India Share Exchange by using Price Multiples. This research used data from 1990 – 2007 with 145 firm samples comprising of 13 industry sub sector. This research found that PER was the best method compared to PBV, P/S, and P/CF. if a combination should be used, the very significant one would be the combination with P/S, but the use of PER alone was very good compared to the combination of the method.

Andi Wijaya and Viliany (2008) did valuation to the share of PT Indofood Sukses makmur Tbk using Dividend Discount Model (DDM). By using that method the price of the share was overvalued. A similar research was one carried out by Budi Erianda, et al (2011) on the share of PT Teekomunikasi Indonesia Tbk, using Gordon Growth Model approach. It was found out that the share of PT Telekomunikasi Indonesia Tbk was undervalued. In that condition, investors may well buy the share.

Thought Frame

Based on the above-mentioned explanations at the basis of the theory, it can be compiled a thought that describes the fair price valuation of BUMI as Graph. 2.

Hypothesis

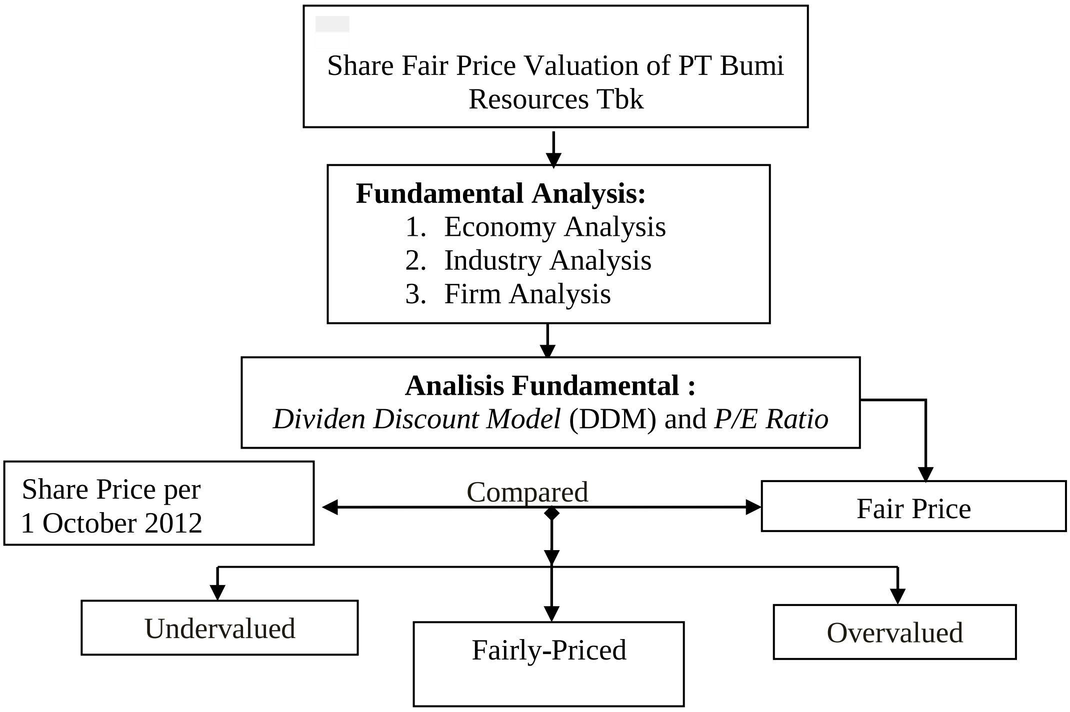
1. H_1 : Share trading price of PT Bumi Resources with Dividend Discount Model and P/E Ratio was considered unfair.
2. H_2 : Fair intrinsic value of PT Bumi Resources Tbk share is smaller compared to share trading price per 1 October 2012, meaning it was overvalued.

RESEARCH METHOD

Research Coverage

The coverage of this research is to calculate the fair price of the share of PT Bumi

Resources Tbk which was preceded by analysis on economic condition, industry condition, and firm condition. The firm condition was calculated by analyzing firm financial ratio. Several financial ratios which generally affect share price are, among others, EPS, BVS, ROA, ROE, NPM, PBV, DPR, and DER. After those three things are found, valuation on the fairness of the share price could be carried out and analyzed using approach of Dividend Discount Model and P/E Ratio. The result of that valuation will then be compared to share trading price per 1 October 2012 in order to make investment decision for investors.



Graph 2. Framework/ Thought Frame

Definition of Operational and Variable Measurement

Definition of Operational and variable measurement used in this research is Variable Valuation. The indicator is when NI < P = Undervalued (price too low); NI > P = Overvalue (price too high); NI = P = fairly priced (price is fair) with nominal measurement. Variable Normal Growth Dividend Discount Model used indicator P_0 with ratio measurement, while variable PER used ratio measurement.

Data Analysis Technique

1. *Normal Growth Dividend Discount Model*

Steps of the analysis:

a) Determine the amount of cash dividend per sheet of share (D_0)

b) Determine required rate of return using CAPM approach:

$$k_s = R_f + \beta[E(R_m) - R_f]$$

Notes:

K_s = Required rate of return of a security
R_f = Risk-free rate of return
B = Beta of asset I
$E(R_m)$ = Expected rate of return from market portfolio
$E(R_m) - R_f$ = Risk Premium

Steps to calculating expected rate of return using CAPM approach is as follows:

1. Calculate individual share return (BUMI) and market return

(JCI=Jakarta Composite Index (IHSG)) using daily data:

$$Return\ Pasar = \frac{IHSG_t - IHSG_{t-1}}{IHSG_{t-1}}$$

$$Return\ Saham = \frac{Harga\ Saham_t - Harga\ Saham_{t-1}}{Harga\ Saham_{t-1}}$$

Notes:

a. t= Index of price/price of share period t
b. t-1= Index of price/price of share period t-1

2. Determine Beta (β)
   Beta (β) is calculated using regression technique with security return volatility (BUMI) as a dependent variable and market return volatility (JCI) as an independent variable.
3. Determine risk-free interest (R_f)
   R_f uses free-risk interest of Central Bank Certificate (*SBI = Setifikat Bank Indonesia)* year 2012.
4. Determine $E(R_M)$ which is the expected return of rate from market portfolio. $E(R_M)$ uses JCI market return period 30 December 2011 – 1 October 2012.

c) Estimate future dividend growth rate:
   g = (1-d) (ROE)
   = RR x ROE

Notes:

1. d= Dividend pay out ratio = dividend per share / earning per share
2. RR= Retention Rate
3. ROE= Return on Equity

d) Value fair price of a share using Normal Growth Dividend Discount Model:

$$P_0 = \frac{D_0\,(1+g)}{(1+k)} + \frac{D_0\,(1+g)^2}{(1+k)^2} + \cdots + \frac{D_0\,(1+g)^n}{(1+k)^n}$$

$$P_0 = \frac{D_0\,(1+g)}{(k-g)} = \frac{D_1}{(k-g)}$$

Notes:

P_o = Intrinsic value or share theoretical value
D_o = Paid dividend
D_1 = Expected dividend
k = Required rate of return of share produced through CAPM
g = Dividend growth
n = Period of dividend paying

2. *P/E Ratio (PER)*

Steps of this analysis are as follows:

1. Calculate average PER of BUMI share for the last five years.
2. Calculate average growth of EPS of BUMI share
3. Calculate next year's EPS projection (E_o)
   E_o = EPS + (1+g)
4. Calculate share's fair price with P/E Ratio:
   P = PER X E_o

ANALYSIS AND EXPLANATION

Fundamental Factor Analysis

Fundamental Factor Analysis in this research was done by analyzing economic condition with other factors which can influence firm's performance and condition to strengthen assumptions used in valuation so it can describe the firm's real condition.

1. *Economic Condition*

Indonesian economic prospect in 2012 is predicted to be still strong, although risk coming from global economy weakening is still high. National economy in 2012 is predicted to grow 6.3% - 6.7% and inflation is predicted to range the target of 4.5% ± 1%.

Below is the inflation growth graph in Indonesia period April 2011 – October 2012:

Graph 3. Indonesia's Inflation Rate Movement. Source: www.tradingeconomics.com and Indonesian Central Bureau of Statistics.

Based on the graph above, we can see that inflation in 2011 was able to be slowed down to 3.79%, much lower than 2010's inflation which was 6.96%. This low inflation realization was reached while the national economy growth condition increased to be 6.5% in 2011 from 6.1% in 2010. Inflation growth in Indonesia was recorded 4.31% in September 2012. Historically, from 1997 to 2012, Indonesia's inflation rate was 12.1%. But this low inflation was not followed by the strengthening of Rupiah towards US Dollar, as since the early 2012 Rupiah had undergone depreciation. Below is the graph of Rupiah movement against US Dollar period January 2011 – October 2012:

Graph 4. The Movement of Rupiah against US Dollar. Source: www.tradingeconomics.com and Indonesian Central Bureau of Statistics.

Based on the graph, the weakening of Rupiah exchange rate which had happened since early 2012 negatively contributed to the whole macro stability. This was the impact of the worsening of the global economy which was started by the Greek's Failure to pay crisis. Meanwhile, banking response to the decrease of Central Bank Rate was still limited, as seen from credit growth and the decrease of interest which was still not as expected. Below is the graph of the decrease of Central Bank rate period January 2011 – October 2012:

Graph 5. Central Bank Rate Movement. Source: www.tradingeconomics.com and Indonesian Central Bureau of Statistics.

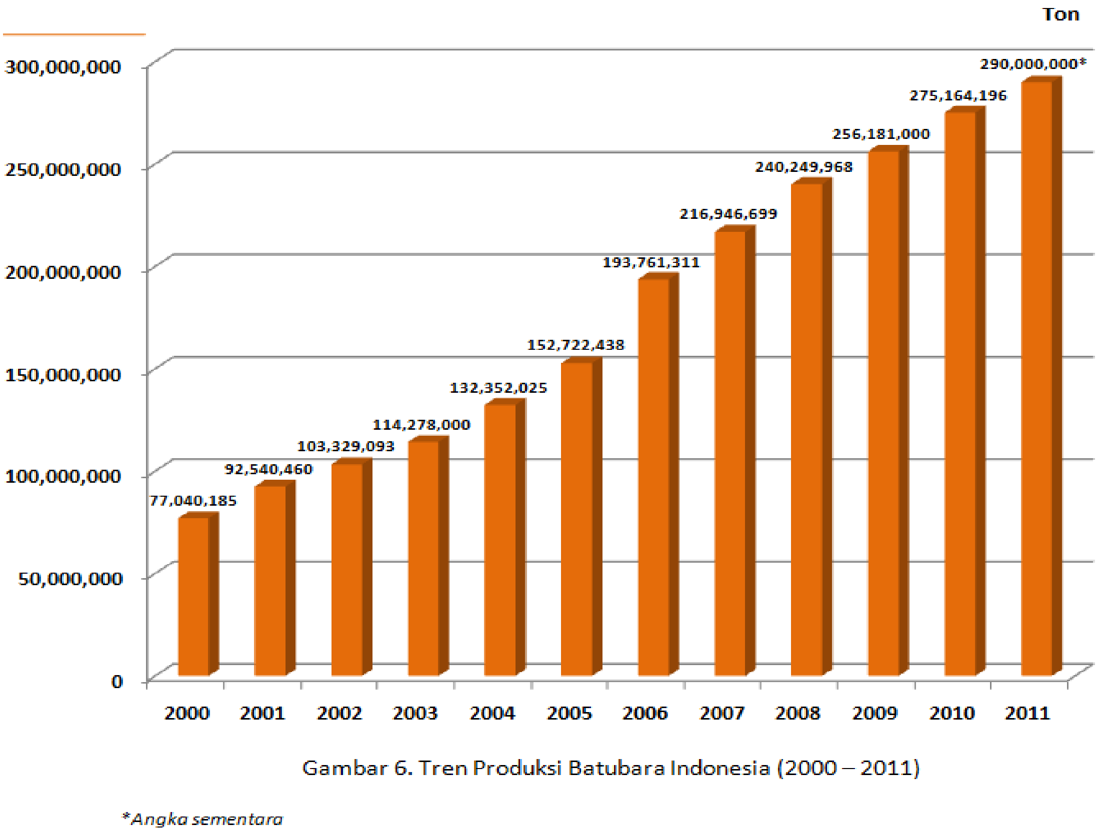
Based on the graph, Central Bank rate was last announced to be 5.75%. As the rate was decreased, it was expected that investors would be more interested to invest on shares than to deposit the fund in the banks. Positive sentiment to world's economy and gradual recovery of liquidity tightening at global monetary market had encourages the flow of fund to Indonesia. This condition had positive impact on the increase of JCI. Below is the movement graph of JCI period January 2011 – October 2012:

Graph 6. Movement of JCI. Source: www.tradingeconomics.com and Indonesian Central Bureau of Statistics.

Based on the graph, it can be seen that JCI had positive performance in the last 2 months, with the highest achievement to be Rp 4311 in October 2012. JCI gained 54 points or 1.28% in the last 30 days. This indicated that trading at Indonesia Share Exchange (IDX) got to normalcy after the impact of global crisis which indirectly also gave negative impact on Indonesia's capital market.

2. *Industrial Condition*

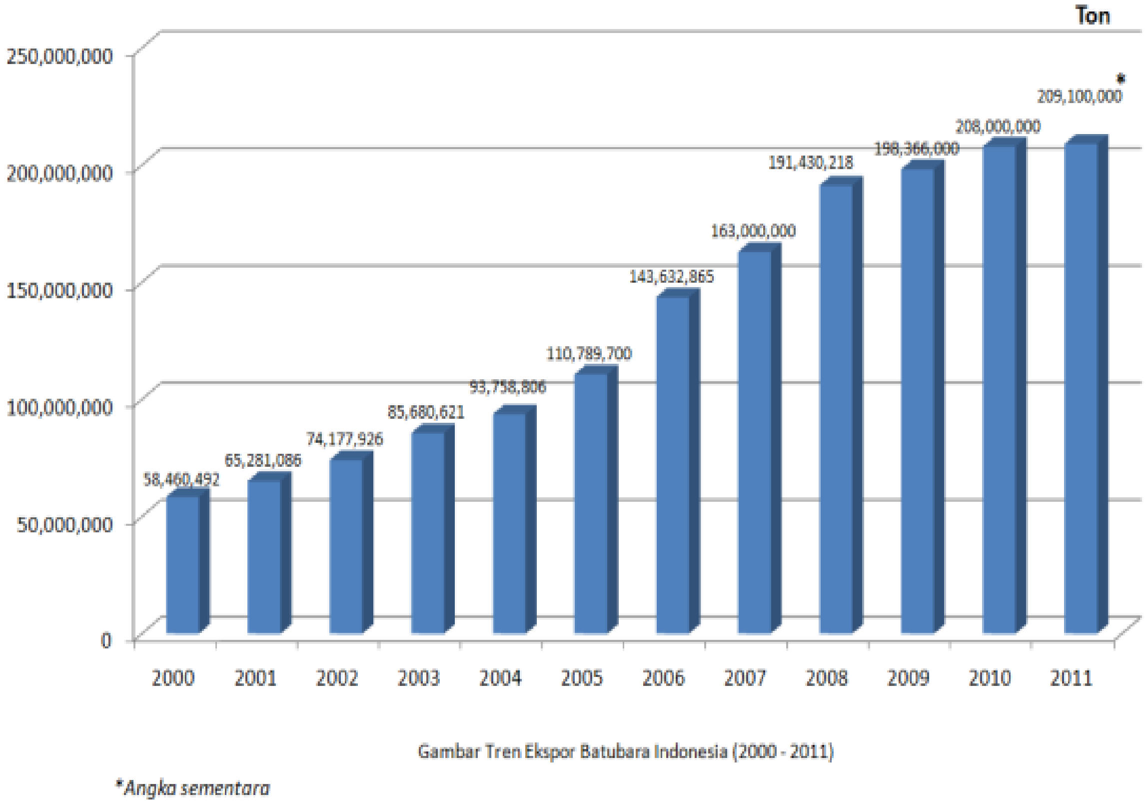
Coal has become a very promising business choice in a coal industry. Up to now, coal has not only gotten domestic market, but also a huge export. Below is the graph of production of coal:



Graph 7. Indonesia's Coal Production Trend. Source: www.indoanalisis.com

Based on the graph, it can be seen that coal production in Indonesia always grows year by year. In 2000, coal production in Indonesia was merely 77 million tons. In 2005, it doubled into 152 million tons. Interestingly, in 2011, the coal production in Indonesia quadrupled compared to that of 2000 into 290 million tons.

Like the ever increasing production trend, sale trend also increased, be it the domestic or export sales. Below is the graph of Indonesia's coal export trend:



Graph 8. Indonesia's Coal Export Trend. Source: www.indoanalis.com

The graph above is Indonesia's coal export trend since 2000 to 2011. This shows increasing demand from export market year by year. This increase can be due to the increase of the world's oil price, making coal an interesting, cheaper, more profitable alternative for foreign countries. But the imperfect recovery of the global economic condition caused the decrease of coal demand in the early 2012, decreasing its price.

3. Firm's Condition

Analyzing a firm's condition can be carried out in a number of ways, among others are by using the firm's financial ratio. This financial ratio can deliver a brief description about firm's condition. Several financial ratios which generally affect share price are EPS, BVS, ROA, ROE, NPM, PBV, DPR, and DER. By using those ratios, a deeper firm's condition can be seen more clearly. To calculate ratios used in firm analysis, the author used data from Company Financial Statement period 2008 – June 2012.

Market Ratio

Table 1. PER Calculation Result

BUMI	**Price Earning Ratio (%)**					**Everage**
	2008	2009	2010	2011	Jue-2012	
result	2,5	26,19	22,49	23,16	-35,79	**7,71**
change	-	948%	-14%	3%	-254%	

Source: data processed in 2012

Base on PER calculation as seen in table 4.1 above, average PER of BUMI was 7.71%. Price Earning Ratio indicates market appreciation toward firm's ability to earn profit. To investors, the lower the PER of a share, the better it is because the share is categorized as cheap.

Table 2. PBV Calculation Result

BUMI	Price To Book Value Ratio (X)					Everage
	2008	2009	2010	2011	June-2012	
Result	1,02	3,39	4,33	4,24	1,56	**2,91**
change		232%	28%	-2%	-63%	

Source: data processed in 2012

Based on PBV Ratio calculation seen in table 4.2, average PBV of BUMI was 2.91 times. PBV indicates how much market appreciates firm's share book value.

Table 3. DPR Calculation Result

BUMI	Dividen Payout Ratio (%)					Everage
	2008	2009	2010	2011	June-2012	
Result	13,89	29,9	31,07	15,24	-	**18,02**
change		115%	4%	-51%	-	

Source: data processed in 2012

DPR is a ration calculating comparison of dividend to firm's profit. Based on the DPR Ratio calculation seen in table 4.3 above, DPR average value of MUNI was 18.02%, which means 18.02% from firm's net profit was divided as cash dividend, while the rest 81.98% was used as additional equity.

Table 4. EPS Calculation Result

BUMI	Earning Per Share (Rp)					Everage
	2008	2009	2010	2011	June-2012	
Result	364,19	92,58	134,49	93,9	-149,3	**107,173**
change	-	-74%	45,3%	-30,18	-259%	

Source: data processed in 2012

Based on EPS calculation result as seen in table 4.4 above, EPS average value of BUMI was Rp 107.17, meaning for each sheet of share there was average profit of Rp 107.13. The higher the EPS, the higher the capital return per sheet of share is.

Table 5. BVS Calculation Result

BUMI	Book Value Per Share (Rp)					Everage
	2008	2009	2010	2011	June-2012	
Resulr	889,87	715,09	699,16	513,52	333,67	**630,26**
change		-20%	-2%	-27%	-35%	

Source: data processed in 2012

Based on BVS calculation result seen in table 4.5 above, BVS average value of BUMI was 630.26. Book Value per Share indicates net asset owned by share holders by owning a sheet of share. The higher the BVS, the higher the net asset owned by share holders owning per sheet of share.

Profitability Ratio

Table 6. NPM Calculation Result

BUMI	Net Profit Margin (%)					Everage
	2008	2009	2010	2011	June-2012	
Result	19,1	5,92	7,12	5,38	-16,81	**4,14**
change		-69%	20%	-24%	-412%	

Source: data processed in 2012

This ratio calculates profit per rupiah sale. Based on NPM calculation as seen in table 4.6 above, NPM average value of BUMI was 4.14%, meaning per one hundred rupiah sale there was net profit of Rp. 4.14. This low profit margin was caused by the high number of debt use.

Tabel 7. Hasil Perhitungan *ROA*

BUMI	Return On Total Asset (%)					Everage
	2008	2009	2010	2011	June-2012	
Result	19,41	6,99	11,39	8,12	-3,72	**8,44**
change		-64%	63%	-29%	-146%	

Source: data processed in 2012

This ratio indicates firm's ability to produce profit from each rupiah used, and shows management effectiveness in using asset to gain income. Based on ROA calculation seen in table 4.7 above, ROA average of BUMI was 8.44%, meaning for each hundred rupiah owned by the firm, it gained profit of Rp 8.44.

Table 8. ROE Calculation Result

BUMI	Return On Equity (%)					Everage
	2008	2009	2010	2011	June-2012	
Result	65,49	35,19	61,76	50,88	-36,83	**35,3**
change		-46%	76%	-18%	-172%	

Source: data processed in 2012

ased on ROE calculation result in table 4.8 above, ROE value of BUMI was 35.3%, meaning for every one hundred rupiah of firm's capital, it gained profit of Rp 35.3. ROE is used to measure firm's ability to produce profit on its capital. The higher the ROE, the better the firm's performance in utilizing its capital to produce profit.

Solvability Ratio

Table 9. DER Calculation Ratio

BUMI	**Debt To Equity Ratio (X)**					**Everage**
	2008	2009	2010	2011	Juni-2012	
Result	2,02	3,95	4,06	5,25	8,91	**4,84**
change		96%	3%	29%	70%	

Source: data processed in 2012

DER Ratio is a ratio measuring how big a debt can be paid by its own capital. The higher the DER, the lower the funding by share holders. Based on table 4.9, DER of BUMI was 4.84 times, meaning that BUMI's debt was 4.84 times its capital.

Analisis Valuasi Saham PT Bumi Resources Tbk

1. *Fair Price Valuation Analysis with Normal Growth DDM*

Below are steps in calculating BUMI's fair share price using normal growth Dividend Discount Model:

a) Determine cash Dividend per sheet of share (D_o)\ Cash Dividend in 2011 which was just paid was Rp. 14.31 and was considered base year (D_o). This dividend distribution was decided in General Meeting of Shareholders (GMS) in 2011.
b) Determine required rate of return. Valuation of share fair price of PT Bumi Resources Tbk can be done if required rate of return is previously calculated using Capital Asset Pricing Model (CAPM), which is:

$$k_s = R_f + \beta[E(R_m) - R_f]$$

Beta (β) can be calculated using regression technique using security return volatility (BUMI) as a dependent variable and market return volatility (JCI) as an independent variable. Beta value for BUMI share period 30 December 2011 – 27 September 2012 was 2.38. The beta of BUMI share which was bigger than 1 ($\beta > 1$) meant that BUMI had high risk, higher than average market risk or security return higher than market return and that share was categorized as aggressive share.

With Beta value (β) figured out, required rate of return can be calculated. The result of required rate of return calculation of the share can be seen from table 4.10 below:

Table 10. Required Rate of Return (K_s) BUMI share in 2012

Year	**R_f**	**Beta (β)**	**$E(R_M)$**	**$(E(R_M) - R_f)$**	***Required Rate of Return (k_s)***
2012	5,75%	2,38	11%	5,25%	18,25%

Source: Data processed in 2012.

c) Estimate future dividend growth rate.

One of the important parts when we carry out share valuation is to estimate growth rate used as the basis to project revenue and earning. Growth estimation is used to keep dividend growth received the same as estimated. Growth estimation is very sensitive, because if it is misestimated, share's fair price will mismatch or far from market price. Growth estimation can be calculated as follows:

g = (1-*d*) (*ROE*)
g = *RR* x *ROE*
$d = \frac{14,31}{93,9}$ x 100% = 15,24%
RR = 1 - 15,24% = 84,76%

g = 0,8476 x 18,28 = 0,1549 or **15,49%**

Expected growth rate gained from the calculation was 15.49%. With the growth as big as 15.49%, meaning PT Bumi Resources Tbk can yield growth rate 15.49% every year.

d) Carry out share's fair price using normal growth Dividend Discount Model.

Fair price of the share of PT Bumi Resources Tbk calculated by using Dividend Discount Model method was Rp. 601/share sheet. That was the estimation for 2012. This fair price had assumption of dividend growth rate of 15.49% and required rate of return of 18.25%.

2. Fair Price of the Share Valuation Analysis Using P/E Ratio

On of the indicators which are very often used in fundamental analysis is Price Earning Ratio (PER). Below are steps to calculating fair price of BUMI share with P/E Ratio method of PER.

Step 1: Calculate average PER of BUMI share period 2008 – June 2012

Table 11. Average PER Calculation of BUMI share

Ratio	**2008**	**2009**	**2010**	**2011**	**June-2012**	***Average***
Price	910	2.425	3.025	2.175	1.040	
EPS	364,19	92,58	134,49	93,90	-149,3	**7,71**
PER	2,5	26,19	22,49	23,16	-35,79	

Source: www.idx.co.id (October 2012, processed)

After average PER was found to be 7.71, next was to count EPS average growth period 2007 – 2011 to gain the projection of the following year's EPS (E_o).

Step 2: Calculate EPS average growth of BUMI share.

Table 12. EPS Average Growth Calculation Period 2007 – 2011

Year	***EPS***	***Change***
2007	382,99	-
2008	364,19	-5%
2009	92,58	-75%
2010	134,49	45%
2011	93,9	-30%
Average Growth		**-16%**

Source: www.idx.co.id (October 2012, processed)

Based on table 4.12 above, EPS average growth was -16%, then EPS projection for the following year (E_o) can be calculated.

Step 3: Calculate EPS projection for the following year (E_o) (2012)
E_o = *EPS* + (1 + g)

E_o = Rp 93.9 + (1 + (-16%)) = Rp 78.88

Step 4: Calculate share's fair price (P_o)

Based on the data, fair price of BUMI share was as follows:

Po = PER average X Eo

Po = 7.71 X Rp 78.88

Po = Rp 607.55 or **Rp 608/**sheet of share

The fair price of share of PR Bumi Resources Tbk by using P/E Ratio was Rp 608/sheet of share. It was the estimation for 2012. This fair price, which was Rp 608/sheet of share, had an assumption of EPS growth rate of -16% and average PER of 7.71.

Discussion

Assessment of Fairness of BUMI Share Price with Normal Growth DDM

The main goal of fair price analysis is to find firms with undervalued share price (fair price > market price), overvalued (fair price <

market price), and fairly priced (fair price = market price).

Table 13. Comparison of Fair Price of BUMI Share to Market Price Using Normal Growth DDM Approach

Share Fair Price	**Share Market Price 1 October 2012**	**Comparison Result**
Rp 601	Rp 750	*Overvalued*

Source: Processed data of 2012

From the table above**,** it can be seen that share fair price < share market price, meaning that the share was overvalued. This was matched with the hypothesis, meaning the share value was lower than its market price, so this share was considered expensive and it was advisable not to buy this kind of share.

The best strategy for this kind of share was selling, because the share price for that year was very fluctuating and tended to decrease than increase.

BUMI Share Price Fairness Assessment with P/E Ratio

P/E Ratio is a quite simple model and it can be used to do quick estimation.

Table 14. Comparison of Fair Price of BUMI Share to Share Market Price with P/E Rati Approach

Share Fair Price	**Share Market Price 1 October 2012**	**Comparison Result**
Rp 608	Rp 750	*Overvalued*

Source: Data in 2012, processed

From the calculation result above, it can be seen that share fair price < share market price, so it can be concluded that the price of BUMI share was overvalued to its fair price. The good strategy for BUMI share was selling, like the one stated by (Tambunan, 2007) by selling overvalued share.

Comparison of Normal Growth Dividend Discount Model with P/E Ratio

The purpose of valuation with normal growth Dividend Discount Model is to give assessment whether the share is fairly priced (undervalued) or not fairly priced (overvalued) so investors are expected o be able to make correct decisions in applying the selling and buying strategies. While the purpose of comparison of these two models is just to find out the result of the two models, not to determine which is better. Below is the valuation result comparison with normal growth Dividend Discount model and P/E Ratio:

Table 15. Comparison of BUMI Share Fair Price to Share Market Price for Normal Growth DDM Model and P/E Ratio Model

Assessment Model	**Share Fair Price**	**Share Market Price 1 October 2012**	**Comparison Result**
Normal Growth DDM	Rp 601	Rp 750	*Overvalued*
P/E Ratio	Rp 608		*Overvalued*

Source: Data in 2012, processed

There was similarity between these two models, i.e. BUMI share price as overvalued. Based BUMI share market price in the early 2012 which was Rp 2,175/sheet, and if compared to share fair price obtained from those two models above, which were Rp 601/sheet and 608/sheet, there was a huge loss and it can be said that investors buying the share then were irrational.

CONCLUSION

Based on the research and explanation above, it can be concluded as such:

1. Intrinsic value (fair price) of BUMI share per 1 October 2012, calculate by using Dividend Discount Model method was Rp 601. While if counted using P/E Ratio was Rp 608.

2. If compared to BUMI share market price per 1 October which was Rp 750, BUMI

share was overvalued, meaning that BUMI share market price was too expensive for the share fair price. Therefore, BUMI share was supposed to be sold by investors owning the share.

3. BUMI share intrinsic value based on Dividend Discount Model method which was Rp 601/sheet was influenced by several factors namely:
    a. Cash dividend in 2011 which was just distributed on the 6th July 2012 which was Rp 14.31.
    b. Future firm growth rate which was 15.49%.
    c. Required rate of return which was gained using Capital Asset Pricing Model (CAPM) approach which was 18.25%.

4. BUMI share intrinsic value based on P/E Ratio (PER) which was Rp 608/share sheet was influence by several factors namely:
    a. EPS average growth rate for the last five years which was -16%.
    b. Firm average PER period 2008 – June 2012 which was 7.71 times.

5. Taking into account economic condition, industrial condition, and firm condition, there are several conside-rations that should be looked upon, among others are:
    a. World's economic growth slowing down, especially in coal-consuming countries like China and India which caused the decrease of the demand of coal in those countries, which resulted in the decrease in the coal price.
    b. Actually coal industry prospect in the future is quite promising, especially domestically because, in the list of coal consumption, Indonesia only ranks the 14th, which is still low, giving advantage to coal industry sector as prominent commodity in Indonesia.
    c. Seen from the performance through ratio analysis against firm financial statement period 2008 – June 2012, profitability rate, that is return on equity (ROE) of BUMI in June 2012 was 36.83%, meaning BUMI would have to work really hard to gain profit for its expansion. While the solvability ratio rate, that is debt equity ratio (DER) of BUMI in June 2012 reached 8.91, meaning that its debt was already 8.91 times its capital.
6. Intrinsic value (fair) of PT Bumi Resources Tbk share obtained using Dividend Discount Model method was Rp 601 and P/E Ratio (PER) was Rp 608, indicating that share valuation before buying it was very important. After finding the fair price of BUMI share using those two methods, it was almost certain that investors would not buy it since it was overvalued, so they could avoid investment loss.

SUGGESTION AND IMPLICATION OF THE RESEARCH RESULT

The author wishes to convey suggestions as follows:

a. This research only used Dividend Discount Model method and P/E Ratio (PER) together with fundamental factor analysis. It is suggested that in the next research other methods should be used, such as Free Cash Flow To Equity (FCFE) which indicates whole net cash flow to all share holders and not only dividend with the purpose to complete the previous research, so they can all describe the real condition. Baurens (2010) stated that it was not possible to say one method was the best or the worst (incorrect).

b. It is highly advisable that the firm should not have any more debt because, seen from comparison between debt and BUMI equity in June 2012 which was 8.91 times, the firm's debt was already so high and this huge debt will put more interest burden which will in turn decrease the firm's profit and the dividend, from the profit, distributed to the share holders will decrease.

REFERENCES

Baurens, Svetlana. 2010. *Valuation of Metals and Mining Companies*. Working Paper

Swiss Banking Institute, University of Zurich.

Bodie, Zvi, Alex Kane, and Allan J. Marcus. 2006. "*Invesment*". 6th Edition, Jakarta: Salemba Empat.

Brigham & Houston. 2006. *Dasar-Dasar Manajemen Keuangan*. Edisi Kesepuluh. Jakarta: Salemba Empat.

Damodaran, Aswath. 2002. *Investment Valuation. 2nd Edition, New York:* John Wiley & Sons Inc.

Drake, P. (2010). Financial ratio analysis.

Farrell, Jr. L, James. 1985. "*The Dividend Discount Model : A Primer*". Financial Analysts Journal, Vol. 41, No 6 (Nov-Dec 1985) pp 16-19+22-25.

Frase, L., & Ormiston, A. (2004). Understanding Financial Statements. New Jersey: Pearson Prentice Hall.

Khairi, Sherly Emita. 2010. *Valuasi Harga Wajar Saham Sektor Perbankan yang Go Public di BEI.* Skripsi, USU, Medan.

Laporan *dividend announcement* tahun 2008 – 2011". http://www.idx.co.id, diakses 23 September 2012.

Laporan keuangan PT Bumi Resources Tbk tahun 2008 - Jun 2012". http://www.bumiresources.com, diakses 2 November 2012.

Laporan tingkat suku bunga Bank Indonesia (*BI rate*) tahun 2012". http://www.bi.go.id, diakses 14 November 2012.

Manurung, Andrian Lorand. 2008. *Valuasi Harga Wajar Saham PT Telekomunikasi Indonesia, Tbk*. Skripsi, USU, Medan.

Olweny, Tobias. 2011. "*The Reliability of Dividend Discount Model in Valuation of Common Stock at the Nairobi Stock Exchange*". International Journal of Business and Social Science, April 2011 pp 127-141.

Sehgal, Sanjay and Asheesh Pandey. 2010. *Equity Valuation Using Price Multiples: Evidence From India.* Asian Academy of Management Journal of Accounting and Finance. Vol. 6, No. 1 pp. 89 108.

Supattarakul, Somchai and Anya Khanthavit. 2011. *Empirical Evidence on Equity Valuation of Thai Firms*. World Academy of Science, Engineering and Technology, Vol. 77; pp. 597 – 606.

Tambunan, Andy Porman. 2007. *Menilai Harga Wajar Saham*. Jakarta: PT Elex Media Komputindo.

Wijaya, Andi & Viliany. 2008. *Estimasi Nilai Intrinsik Saham PT Indofood Sukses Makmur Tbk Dengan Menggunakan Dividend Discount Model*. Jurnal Manajemen, No.1 pp 1-12.

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Gondang Dam Inspection

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ABSTRACT

Gondang dam is the one of dams in Bengawan Solo River Region. The dam site in Gondang Lor village, Sugio district, Lamongan regency, East Java Province. The Gondang dam is water reservoir to supply water at adjacent dam area.The dam must be keep in save condition. One of inspection works to know the dam condition is geotechnical research. The aim of geotechnical research si to get data about physical and mechanical of dam material. The data of dam material is used to evaluate the dam savety.The conclusion of geotehnical reserach result is the dam material is proper to earth dam material.

Key words: dam, save, material, proper.

INTRODUCTION

Bengawan Solo river area, is an area with potential water resources. Water resources management (WRM) aims to supply a variety of needs in the community, in addition to anticipate impending water scarcity in the dry season for the long term, it is one of the strategies that will be done by storing runoff and rainwater through building dams or other water reservoir that serves to recharges groundwater in an effort to conserve the water resources. Gondang Dam is one of the dams in the region of the Solo River in Gondang Lor village, Sugio sub-district, Lamongan regency, East Java. Need some inspection to determine the condition of the dam. One inspection on Gondang Dam is a geotechnical investigation. Geotechnical investigation was to obtain data of the physical and mechanical properties of soil or rock dam material. The goal is to get the parameters that are used for dam safety evaluation in accordance with the geological conditions and physical properties of soil or rock.

METHODOLOGY

This investigation using methods such as drilling in the core zone or impermeable dam body and laboratory testing of soil samples, with the following details:

a. Drilling
   - 3-point core drilling: BG-1 with a depth of 25 meters, BG-2 with a depth of 30 meters and BG-3 with a depth of 20 meters.
   - Standard penetration test
   - Field permeability test
   - Undisturb sample

b. Laboratory tests that includes :
   - Index Test for embankment material :
     - *Natural Water content*
     - *Unit Weight*
     - *Specific Grvity*
     - *Grain Size Analysis*
     - *Atteberg Limit*
   - Mechanical Properties for embank-ment material :
     - *Triaxial CU Test*
     - *Consolidation Test*
     - *Permeability Test*

LOCATION

Gondang Dam is located in Gondang Lor village, Sugio sub-district, Lamongan regency, East Java Province. Access to this dam can be reached from the junction of UNISDA Sukodadi then turn to the south about 8 kilometers until the end of the T-junction. From the T-junction then turn to the west approximately 10 kilometers. Along this path, there is a boundary between Sukodadi sub-district and Sugio sub-district. There are signs that direct way to Gondang Dam (turn to the south). From signs about 3 kilometers to the end of the T-junction and then turn to the west about 1 kilometer.

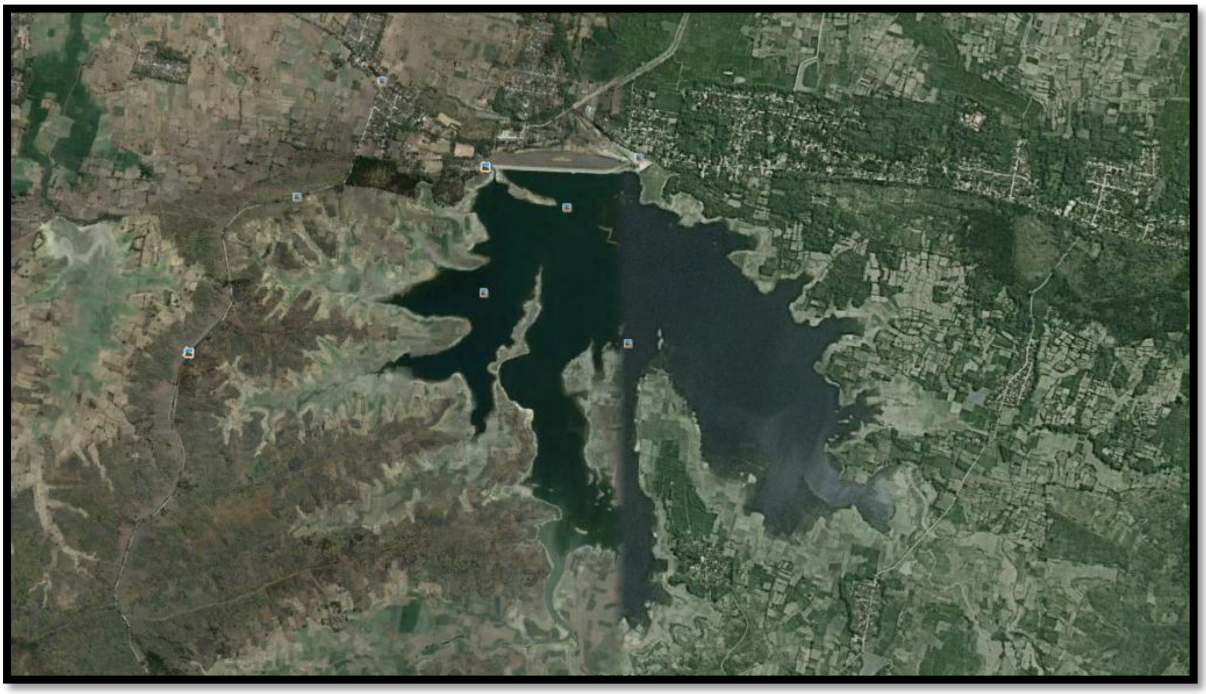

Figure 1. The upper appearance of Gondang Dam from Google Earth.

INVESTIGATION

Geology of Gondang Dam

Gondang Dam was built on the Gondang River, tributary of Bengawan Solo in 1987 in Lamongan Regency. Flow region of Gondang Dam is Gondang village, Daliwangun, Buluplapak, Wudi, Wonokromo and Sekidang. Wide of Gondang Dam is 6.60 hectares with a depth of about 29 meters. In physiographic, Lamongan northern and southern parts classified to the Rembang Zone (van Bemmelen, 1949) which is composed by exposure of sediment is rich in carbonate elements.

While the central part of the region is classified into Randublatung Zone where surface appearance is low, but in fact it is a depression (basins) are covered by sediments which result from the weathering and erosion of older rocks in Kendeng Zone and Rembang Zone.

The geological history of Lamongan began about 37 million years ago (Oligocene period). At that time the area, Lamongan Regency, was still a sea (part of East Java Basin). Furthermore sedimentation process occurs sequentially to upward which rich in carbonat elements. This process occurs until approximately 19 million years (until the Paleocene period). At approximately 1.8 million years ago there was a tectonic activity (Plio-Pleistocene orogenesis) which led to the lifting of Lamongan Regency come to the surface.

Based on the Geological Map Sheet Mojokerto by Y Noya et al (1992) above, the location of study have stratigraphic arrangements that composed by :

a. Lidah Formation (QTL), consist of claystone that have an insert of calcareous sandstones and limestones.
b. Pucangan Formation (QTp), which consist of breccia, tuffaceous sandstones that have insert of claystone and conglomerates.
c. Kabuh Formation (Qpk), consisting of sandstone, tuffaceous have an insert claystone, conglomerates and tuff.
d. Alluvium (Qal), consists of cob-blestone, gravel, sand, silt, and mud.

Topographic conditions of Lamongan Regency can be viewed from a height region above sea level and slope steepness. Lamongan Regency consists of lowland and swampy with a height of 0-25 meters with an area of 50.17% of the total area, with a height of 25-100 meters land area of 45.68% and the remaining, 4.15%, is land with a height of over 100 meters from the surface sea water. Gondang Dam itself, including to area with low topography.

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Result of Drilling

Drilling conducted at 3 points, there are BG-1 with a depth of 25 meters, BG-2 with a depth of 30 meters, and BG-3 with a depth of 20 meters. The location of each drilling point in Gondang Dam depicted in Figure 3.

Based on the drilling results in 3 points of Gondang Dam (BG-1, BG-2, and BG-3), it can be seen the type of soil or rock as follows:

- **BG – 1**

00.00 – 01.40 mSand, loose, gray.
01.40 – 10.00 mSandy clay (silt), stiff to very stiff, greyish-brown, the value of N (SPT) = 12-17.
10.00 – 16.00 m Clay, stiff to very stiff, gray-brown there is little sand, the value of N (SPT) = 16 - 18.
16.00 – 25.00 mClaystone, dense, gray-brown, the value of N (SPT) = 24 – 35

- **BG – 2**

00.00 – 01.60 m Sand, loose, gray.
01.60 – 03.00 m Sandy clay (silt), stiff gray-brown, the value of N (SPT) = 15.
03.00 – 03.40 mCobbly sand, stiff, brownish gray.
03.40 –06.45 m Sandy clay (silt), stiff, brownish gray, the value of N (SPT) = 15 - 20.
06.45 – 27.00 mClay, stiff-very stiff, gray-brown depths of 18-19, soft-stiff, the value of N (SPT) = 15 - 19.
27.00 – 30.00 mClaystone, dense, gray-brown, the value of N (SPT) = 31 - 34.

- **BG – 3**

00.00 – 01.60 m Sand, solid half-off, greyish at a depth of 0 to 0.3 m are soil filler, and asphalt residua.
01.60 – 12.00 mClay, gray-brown, stiff-very stiff, there is a little sand, the value of N (SPT) = 14-19.
12.00 – 20.00 mClaystone, dense, gray-brown, the value of N (SPT) = 20-34.

The correlation between BG-1, BG-2, and BG 3, can be seen on **Figure 5**.

Test Laboratory

Soil mechanics laboratory tests of Gondang dam performed on 3 point drill, drill point BG-1 with a depth of 25 meters, BG-2 with a depth of 30 meters and BG-3 with a depth of 20 meters.

On laboratory analysis, the index test properties consisting of water content, unit weight, the specific gravity, grain size and atterberg, also mechanical properties consisting of Triaxial CU, Consolidation and permeability tests. Laboratory test results can be seen in **Figure 6**.

CONCLUSION

From the foregoing description can be summarized as follows:

1. Gondang Dam is a earthdam, Zonal Dam type, Dam Core Vertical. At the core (impermeable zone) consists of silt and clay, including fine-grained soil. On the outside (pass zone) consists of a pile of limestone fragments.
2. Results of field investigation in the form of drilling, SPT, and permeability testing, soil / rock in Gondang Dam consists of :

   ▪ **The core of dam body**

   A fill of soil material, from top to the bottom, on BG-1 to a depth of 24 meters, the BG-2 to a depth of 27 meters, and the BG-3 to a depth of 12 meters, composed of:

   - Depth, on the BG-1: 0 - 1.4m; BG-2: 0 - 1.6 m; BG-3: 0 - 1.6 m: in the form of sand, gray, are off.
   - Depth, on BG-1 : 1,4 – 10 m; BG-2 : 1,6 -6,4 m : in the form of silt, brownish-gray colored, stiff to very stiff, the value of N (SPT) = 12-17.
   - Depth, on BG-1 10 – 16 m; BG-2 6,4 – 27 m; BG-3 1,6 – 12 m : in the form of clay, brownish-gray colored, stiff to very stiff, there is a little sand, the value of N (SPT) = 16-18.
   - Bedrock palm of dams (BG-1 at a depth of 16-25 m ; BG-2 at a depth of 27-30 m ; BG-3 at a depth of 12-20 m) in the form: Claystone, gray brown, hard, the value of N (SPT) = 24-35.
   - Core permeability coefficient dam body (soil embankment) ranged 2,34E-05 cm / sec - 5,49E-05 cm / sec, palms dam bedrock ranges 4,69E-05 cm / sec - 6,51E-05 cm / sec.

3. Based on the grain size, permeability values and the results of laboratory analysis of soil samples filler, it can be seen that the soil filler in dam core is still appropriate when applied as a soil filler material for impermeable zone on earth dam type.

REFERENCES:

Ir. Shirley LH, 1987, Penuntun Praktis Geoteknik dan Mekanika Tanah (Penyelidikan Lapangan dan Laboratorium), NOVA – Bandung.

Ir. Suyono Sosrodarsono dan Kazuto Nakazawa, 1988, Mekanika Tanah & Teknik Pondasi, Cetakan 4, Pradnya Paramita, , Jakarta.

Ir. I.W. Nortier & Ir. F. Vink, 1980, Ilmu Konstruksi Untuk Ahli Bangunan dan Ahli Bangunan Air, Jilid 2, Bhratara Karya Aksara, Jakarta.

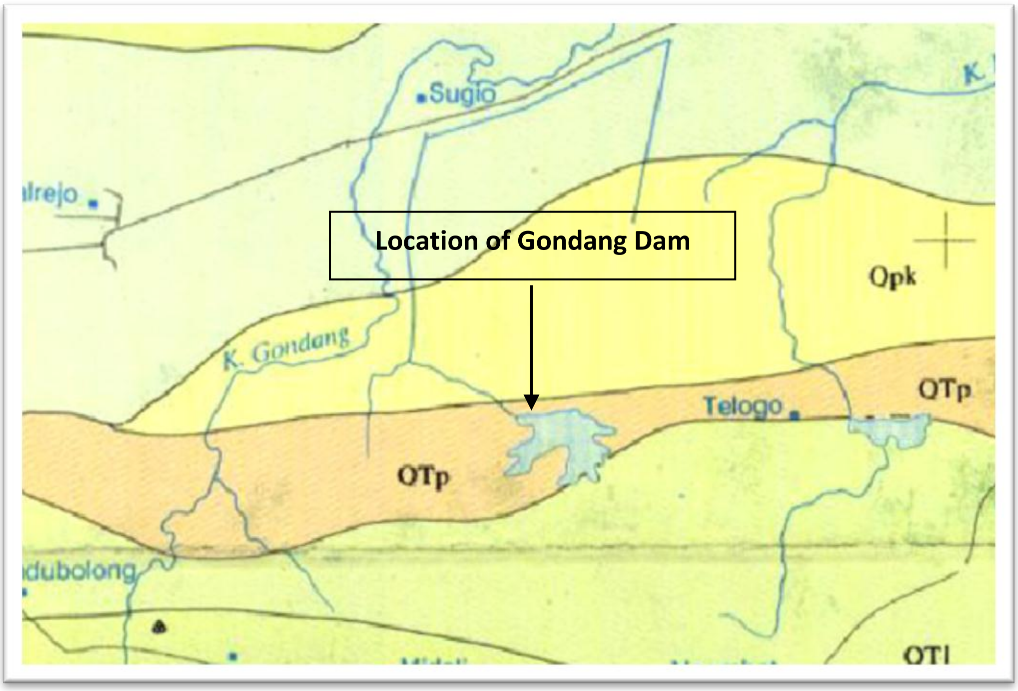

Figure 2. Geological Maps of Gondang Dam, Lamongan
(*Source* : the Geological Map Sheet Mojokerto by Y Noya et al (1992)

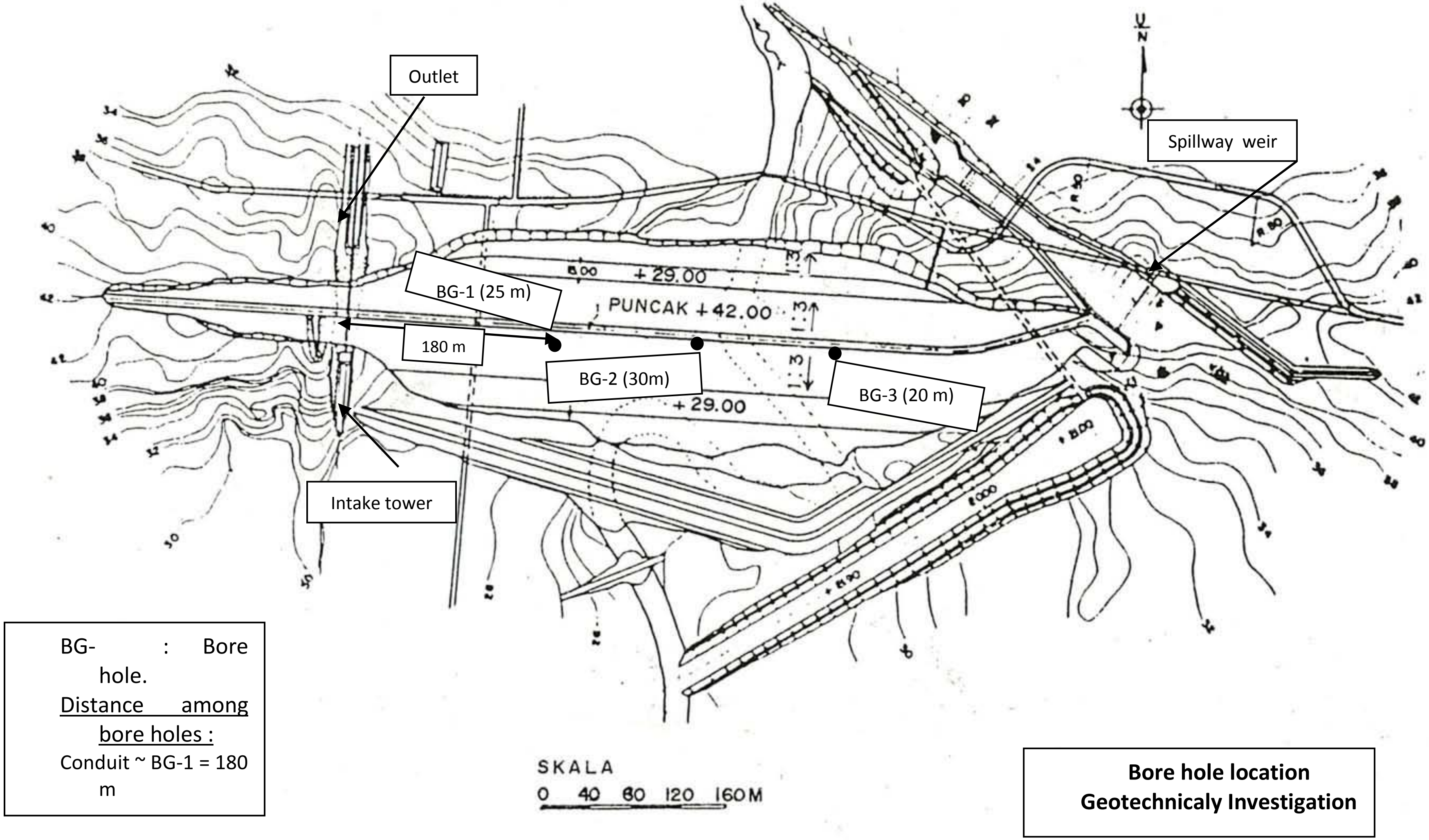

Figure 3. Layout Drilling Point of Gondang Dam

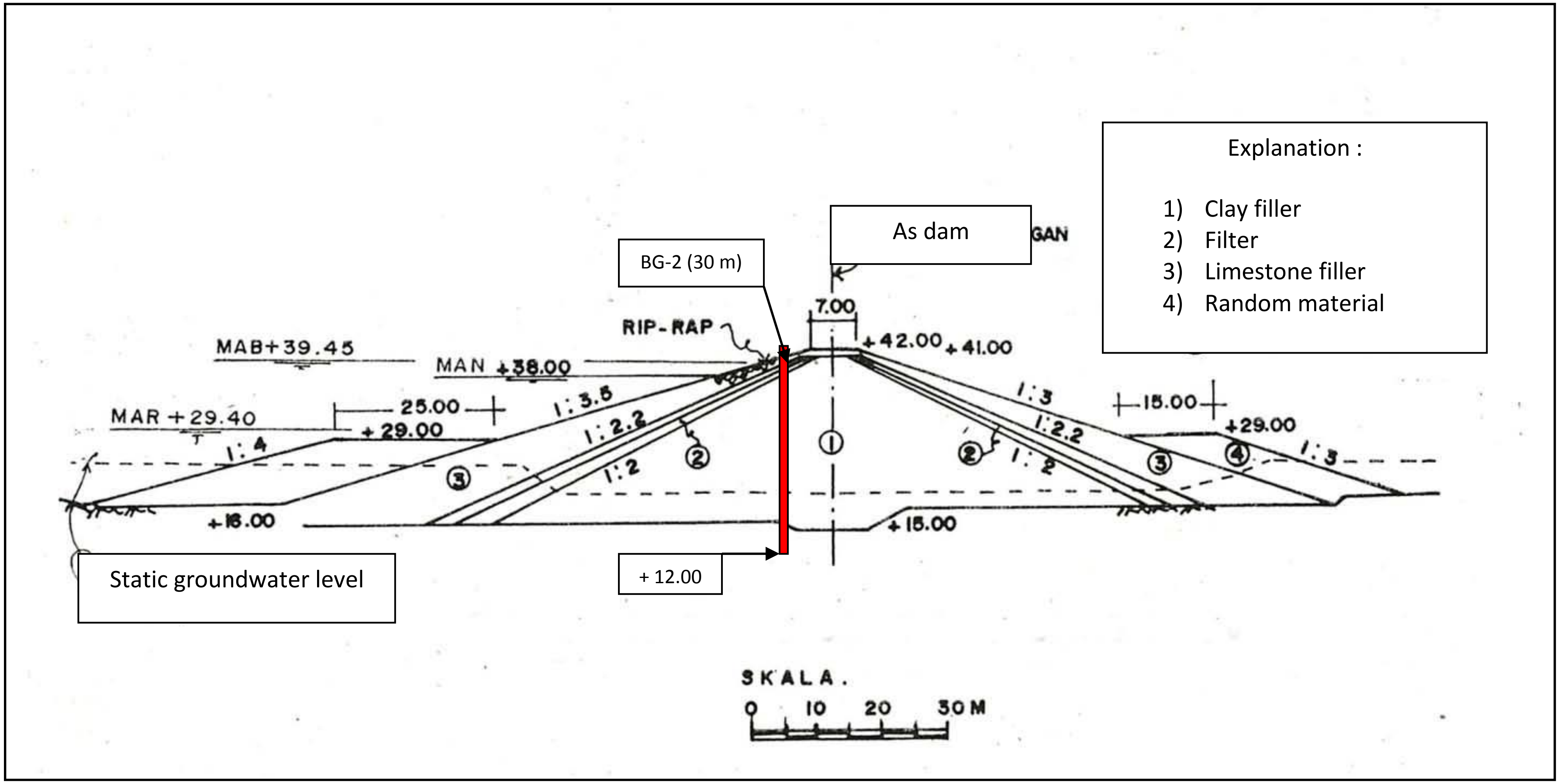

Figure 4. Transverse pieces of Gondang Dam

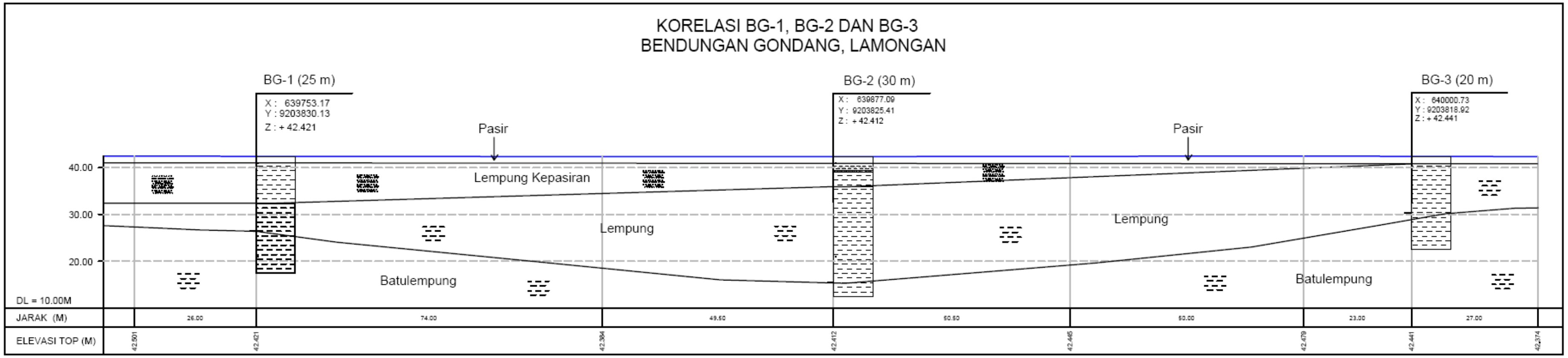

Figure 5. The correlation between BG-1, BG-2, and BG-3

SUMMARY TEST LABORATORIUM
WADUK GONDANG - LAMONGAN

NO.	Hole No.	Depth (m)	Description	SPT	Water Content	Unit Weight			Specific Gravity	Void Ratio	Porosity	Degree of Saturation	Grain Size Analysis				Atterberg			Triaxial CU				Consolidation	
						γ Wet	γ Dry	γ Sat		e	n	S	Gravel	Sand	Silt	Clay	LL	PL	IP	c	c	q	q	Cc	Cv
					(%)	gr/cm³	gr/cm³	gr/cm³	Gs		%	%	%	%	%	%	%	%	%	Kg/cm²	Kg/cm³	°	°		cm²/min
BORE HOLE																									
1.	BG-1	04.50 - 05.00	Lempung Kepasiran, abu - abu kecoklatan, kaku	17	31.420	1.860	1.420	1.880	2.64	0.86	46.28	96.20	0.20	2.14	52.65	45.01	58.77	32.21	26.56	-	-	-	-	-	-
		09.50 - 10.00	Lempung Kepasiran, abu - abu kecoklatan, kaku	18	15.240	1.900	1.650	2.040	2.69	0.64	38.86	64.60	-	-	-	-	66.72	36.85	29.87	0.23	0.317	18,148	22,392	-	-
		14.50 - 15.00	Lempung, abu - abu kecoklatan, kaku, terdapat sedikit pasir	21	35.440	1.600	1.180	1.740	2.69	1.29	56.24	74.29	0.67	3.21	40.21	55.91	64.20	29.39	34.81	0.26	0.338	18,169	22,415	0.24	0.0731
		19.50 - 20.00	Lempung, abu - abu kecoklatan, kaku, terdapat sedikit pasir	27	32.290	1.820	1.380	1.870	2.73	0.98	49.55	89.69	-	-	-	-	59.89	24.62	35.27	-	-	-	-	-	-
		24.50 - 25.00	Lempung, abu - abu kecoklatan, kaku, terdapat sedikit pasir	34	29.850	1.840	1.420	1.900	2.73	0.92	48.02	88.15	-	-	-	-	62.76	32.23	30.53	-	-	-	-	0.1967	0.0061
2.	BG-2	04.50 - 05.00	Lempung Kepasiran, abu - abu kecoklatan, teguh	20	28.900	1.900	1.470	1.930	2.73	0.85	45.96	92.67	0.00	5.03	29.51	65.46	62.07	33.60	28.47	-	-	-	-	-	-
		09.50 - 10.00	Lempung, abu - abu kecoklatan, kaku - sangat kaku, terdapat sedikit pasir	22	30.210	1.930	1.480	1.940	2.74	0.85	45.82	97.70	-	-	-	-	56.52	27.54	28.98	-	-	-	-	0.2296	0.0076
		14.50 - 15.00	Lempung, abu - abu kecoklatan, kaku - sangat kaku, terdapat sedikit pasir	17	31.230	1.880	1.440	1.900	2.70	0.88	46.93	95.52	-	-	-	-	68.95	40.17	28.78	-	-	-	-	-	-
		19.50 - 20.00	Lempung, abu - abu kecoklatan, kaku - sangat kaku, terdapat sedikit pasir	23	34.360	1.800	1.340	1.850	2.73	1.03	50.79	90.76	0.06	1.50	68.56	29.88	63.28	34.99	28.29	0.31	0.29	20,861	24,655	-	-
		24.50 - 25.00	Lempung, abu - abu kecoklatan, kaku - sangat kaku, terdapat sedikit pasir	25	26.400	1.960	1.550	1.980	2.73	0.76	43.26	94.66	-	-	-	-	66.08	38.30	27.78	-	-	-	-	-	-
		29,50 - 30.00	Lempung, abu - abu kecoklatan, kaku - sangat kaku, terdapat sedikit pasir	34	25.990	1.940	1.540	1.980	2.74	0.78	43.74	91.52	-	-	-	-	64.35	29.78	34.57	0.48	0.541	17,907	22,120	0.1808	0.005841
3.	BG-3	04.50 - 05.00	Lempung, abu - abu kecoklatan, kaku - sangat kaku, terdapat sedikit pasir	17	26.140	1.860	1.470	1.930	2.70	0.83	45.39	84.82	-	-	-	-	59.49	25.00	34.49	0.23	0.319	15,954	21,769	0.2133	0.0063
		09.50 - 10.00	Lempung, abu - abu kecoklatan, kaku - sangat kaku, terdapat sedikit pasir	22	35.980	1.850	1.360	1.860	2.73	1.01	50.14	97.70	-	-	-	-	65.33	36.47	28.86	-	-	-	-	-	-
		14.50 - 15.00	Lempung, abu - abu kecoklatan, kaku - sangat kaku, terdapat sedikit pasir	20	29.890	1.930	1.490	1.940	2.74	0.84	45.78	96.98	0.89	3.56	31.57	63.98	70.61	34.57	36.04	0.27	0.35	17,611	22,014	-	-
		19.50 - 20.00	Lempung, abu - abu kecoklatan, kaku - sangat kaku, terdapat sedikit pasir	34	35.050	1.850	1.370	1.860	2.69	0.96	49.02	98.19	0.00	1.96	54.40	43.63	64.32	35.25	29.07	-	-	-	-	0.2037	0.006476

Figure 6. Laboratory test result

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Petrophysical Analysis and Modeling, and Dynamic Simulation in Development of “Victory” Low Resistivity Play in “Papa” Field, Kutai Basin, East Kalimantan

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ABSTRACT

Low resistivity reservoir is an unique reservoir where generally low resistive formation whichis identified as water bearing zone, but water free hydrocarbon are produced. It is of crucialimportance to identify, evaluate, and develop of low resistivity reservoir where nowadays oil and gas industry is facing decline of production, a certain case that will be happened. Thus, development of low resistivity reservoir could be an alternative solution to answer this challenge.

This paper focuses on identifying, evaluating, and developing a low resistivity reservoir of The “Victory” Play in “Papa” Field, Kutai Basin, East Kalimantan. Low resistivity reservoir in “Papa” Field is a sandstone formation, where previous petrophysical interpretations yield high estimates of water saturation. A new workflow in petrophysical analysis is conducted to get petrophysical properties accurately, i.e. shale volume, porosity, and water saturation. Therefore, petrophysical model could be built to generate reservoir models and dynamic simulation is conducted by making development scenario.

According to 5 development scenario conducted in “Victory” Low Resistivity Play, Scenario IV (Base Case + 1 Horizontal Drilling) is the best scenario which is resulting cumulative oil production of 3,420,109 STB (RF = 21.61%) at end of prediction.

Keywords: Low resistivity reservoir, petrophysical analysis, dynamic simulation.

INTRODUCTION

Geographically, “Papa” Field is an offshore field which is located on East Kalimantan, and geologically is located on Kutai Basin. This field was discovered by 1973 and started produced by April 1975. “Papa” Field stratigraphy is consisted by 6 sequences are Maruat Formation, Yakin Formation, Deltaic Sequence, Upper Carbonate Sequence, Low Resistive Sequence, and Shallow Sequence (Figure 1).

Generally, mainly reservoirs in “Papa” Field are sandstone at interval of Middle Deltaic, Lower Deltaic, and Upper Yakin Formation. The reservoir characteristic has deep reservoir with oil characteristic is light oil. “Papa” Field has total wells of 38 wells with oil rate per April 2014 up to 7.65 MBOPD and 15.18 BCFD gas. “Papa” Field reached peak of production by February 1991 with 26,335 BOPD and 53,567 MCFD from 15 wells of natural flow and 15 gas lift wells. After that, trend of production was decline and there is no further development until now.

According to this condition, it is needed a further development in “Papa” Field to increase production where one of alternative solution by developing low resistive sequence.

Statistically, resistivity values in this sequence about 2 – 5 ohm-m and Gamma Ray respons were warm (40-90 API) as shown in Well EP-4 at zone-10 to zone-13 (Figure 2). From previous petrophysical interpretations yield high water saturation estimation and from chart log generally indicated there is no hydrocarbon, but it was proven there is hydrocarbon in some of zones based on test data. Thus, a comprehensive study is needed in log interpretation, a suitable method for water saturation calculation, and to get petrophysical properties accurately, i.e. shale volume, porosity, and water saturation. Therefore, petrophysical model
could be built to generate reservoir models and dynamic simulation is conducted by making development scenario.

METHODOLOGY

Methods implemented for the petrophysical interpretation of well logs as wells as in conducting static and dynamic models consisted of the following sequential steps:

Petrophysical analysis

The petrophysical analysis was built to explicitly determine reservoir quality which can be used to build petrophysical model. A new workflow in petrophysical analysis was conducted as shown in Figure 3. As in all petrophysical analysis, the three basic attributes determined are:

- Shale volume: Volumetric shale fraction was calculated using GR log where previously shale distribution model determined using Thomas Stieber crossplot analysis.
- Effective porosity: Neutron-density logs were used to calculate non-shale porosity whenever they were available
- Water saturation: Determining accu-rate water saturation values was challenging and important for identifying hydrocarbon distribution in "Papa" Field.

Petrophysical modeling

Sequential Gaussian Simulation method was used to buid petrophysical model where previously well log scale-up and variogram analysis were conducted.

Inplace calculation

Initial oil inplace was calculated using volumetric method where properties that were used from petrophysical model results and fluid contacts were determined based on gradient test.

Dynamic simulation

Sequential steps in planning and applying a dynamic simulation as following below:

- Defined the objectives
- Prepared, analyzed, and processed data (geology, geophysics, petrophysics, reservoir, production, and so on)
- Made a geology – reservoir model and its characteristic
- Matched hydrocarbon inplace (initialization) and matched reservoir model performance with historical production (history matching)
- Conducted a reservoir forecasting with development scenarios

RESULTS AND DISCUSSIONS

Petrophysical Analysis

Shale distribution model in sandstone formation was analyzed by using Thomas Stieber crossplot analysis, where it will be known distribution model whether structural, laminated, or dispersed clay. Analysis was conducted at 4 wells in "Papa" Field, i.e. EP-4, DWP-2RD2, NEL-3, and NEL-5RD. Based on the results, shale distribution model in sandstone of "Papa"
Field was laminated-dispersed shale (Figure 4).

Due to shale distribution model in sandstone of "Papa" Field was laminated-dispersed shale, thus Vshale is not equivalent with gamma ray index (Ish) or we cannot used linier equation. In this study, we used Larinov (for tertiary rock) method to calculate shale volume where GRmax and GRmin were determine for each markers.

Neutron-density logs were used to calculate non-shale porosity whenever they were available. Then, porosity values from log interpretation were validated with available core data. Table 1 shows tabulation of porosity log validation with porosity log and Figure 5 shows the crossplot where a good match was obtained.

Water saturation was tried to calculate by using Dual Water, Indonesia, and Simandoux methods. A suitable method was choosen to calculate water saturation after compared to core data and make a crossplot from difference methods. According to Sw calculation at 4 wells with available core interval data, Dual Water method resulted smaller error (Table 2). Then, it was also done crossplot between water saturation calculation using Dual Water and water saturation calculation using Indonesia and Simandoux method (Figure 6 and 7). The results show that Simandoux and Indonesia methods resulted over estimation in water saturation calculation compared to Dual Water Method. Thus, Dual Water is a suitable method to calculate water saturation in low resistive sequence of "Papa" Field. Table 3 shows tabulation of Sw log validation with available core data and Figure 8 shows relationship between Sw from log interpretation and Sw from available core data for each wells.

Identifying proper petrophysical cut-off parameter was required to determine producible hydrocarbon volume and establish an economical reserve estimate. Cut-off values were determined according to test data for each markers. Porosity and shale volume cut-off were determined by doing crossplot both of them and picked the higher Vshale value and the lower porosity as cut-off values, also higher water saturation as the Sw cut-off.

Petrophysical Modeling and Volumetric Calculation

Petrophysical modeling was started by interpretating well log data as data preparation, where 9 wells were interpreted to get petrophysical properties. Figure 9 shows wells location in "Papa" Field. After petrophysical properties were obtained, it is done well log scale-up and variogram analysis as inputing data for petrophysical modeling as well as used stochastic method namely sequential gaussian simulation. Figure 10 shows an example of petrophysical modeling steps for Vshale modeling in "Victory" Low Resistivity Play.

Based on the models were built, it was obtained petrophysical properties distribution in "Victory" Low Resistivity. From the results, "Victory" Low Resistivity Play has average Sw distribution of 72%, average Vshale distribution of 40%, average porosity distribution of 13.07%. And for permeability modeling, it was conducted using property calculator by making an empirical equation from porosity-permeability relationship. Figure 11 shows permeability modeling using empirical equation in "Victory" Low Resistivity Play. From permeability modeling, "Victory" Low Resistivity Play has average permeability distribution of 87.7 mD.

Initial oil inplace calculation by using volumetric method was bounded using polygon, so that inplace calculation was focussed based on area which has well data and inplace calculation was not being over estimation. Figure 12 shows initial oil inplace distribution map in "Victory" Low Resistivity Play with total inplace of 35.47 MMSTB.

Dynamic Simulation

To conduct development scenarios with dynamic simulation, it is needed a reservoir model which is representating the actual reservoir condition. The reservoir model was generated from "Victory" Low Resistivity Play in EP area due to this area has biggest initial oil inplace and good petrophysical properties distribution. Required data in building the reservoir model were geological model, rock and fluid properties data, and production and pressure data. Figure 13 shows process in building "Victory" low resistivity reservoir model.

After all of geological and reservoir data were generated in simulator, it was needed to conduct some of validation procedures, an initial model validation was initialization, a process to match initial oil inplace from reservoir model towards to initial oil inplace from volumetric calculation and to match initial reservoir pressure. Initialization process is shown in Figure 14. Initial oil inplace that was obtained from volumetric calculation if compared to initial oil inplace of the model was not significantly difference. The differences of both of them were 3.09% and the differences between initial reservoir pressure model and data of 0.027%.

After initial oil inplace and initial reservoir pressure have matched, the next step is history matching process of production data. In this step, the previous model that was obtained from initialization step was validated with production data, by seeing production performance resulted from the model and comparing to field historical production data. History matching process is shown in Figure 15, where reservoir pressure and production data from start of production till end of history have matched. Thus, reservoir model that conducted by dynamic simulation is valid.

Development of "Victory" low resistivity play was conducted by making some of development scenarios, consists of five scenarios are Scenario I of base case (existing), Scenario II of base case and two workover wells, Scenario III of base case and one infill drilling (vertical well), Scenario IV of base case and one lateral drilling (horizontal well), and Scenario V of base case and two workover wells as well as one infill drilling (vertical well). Prediction or forecasting step is set till October 2018. Figure 16 shows prediction results and comparison of development scenarios. According to five development scenarios conducted in EP Area of "Victory" Low Resistivity Play, Scenario IV (Base Case + 1 Horizontal Drilling) is the best scenario which is resulting cumulative oil production of 3,420,109 STB (RF = 21.61%) at end of prediction.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

1. Dual Water Method is a suitable method for estimating water saturation in "Papa" Low Resistive Pay Zones
2. Initial oil inplace in "Victory" Low Resistivity Play is estimated about 35.47 MMSTB and it has petrophysical properties distribution with average Vshale distribution of 40%, average porosity distribution of 13.07%, average permeability distribution of 87.7 mD, and average water saturation distribution of 72%.
3. According to 5 development scenario conducted in EP Area of "Victory" Low Resistivity Play, Scenario IV (Base Case + 1 Horizontal Drilling) is the best scenario which is resulting cumulative oil production of 3,420,109 STB (RF = 21.61%) at end of prediction.

Recommendations

1. It is fully recommended to develop low resistivity reservoir in "Papa" Field due to these reservoirs have a good potential to be developed based on volumetric calculation and petrophysical properties distribution.
2. An economic analysis is needed for further study to determine a suitable development scenario in EP Area of "Victory" Low Resistivity Play.

REFERENCES

A. Krygowski, Daniel. 2003. "Guide to Petrophysical Interpretation". Austin, Texas, USA

Amyx, J. W., Jr , Bass, M.D., "Petroleum Reservoir Engineering" , Mc Graw Hill Book Company , New York , London , 1960.

Bowen, D.G. 2003. "Formation Evaluation and Petrophysics". Core Laboratories, Jakarta, Indonesia

Claverie, Michel, et. al., "A New Look at Low-Resistivity and Low-Contrast (LRLC) Pay in Clastic Reservoirs", SPE Annual Technical Conference and Exhibition, 19-22 September 2010.

Ekwere, J.Peters, "Petrophysics", Department of Petroleum & Geosystems Engineering The University of Texas at Austin.

Gandhi, Ankur, et.al., "Low Resistivity Petrophysical Mapping Expands The Terry (Sussex) Play In Wattenberg Field, Colorado", SPWLA 52nd Annual Logging Symposium, May 14-18, 2011.

Hamada, G.M. and Al-Awad, M.N.J, "Petrophysical Evaluation of Low Resistivity Sandstone Reservoirs", Journal of Canadian Petroleum Technology, July 2000, Volume 39, No. 7.

Schlumberger. 2008. "Petrel Introduction Course: Seismic to Simulation Software".

Tudge, Joanne."Low Resistivity Pay; The Role of Chlorite in Controlling Resistivity Responses". Thesis. University of Leicester.

APPENDIX

Table 1. Tabulation of porosity log validated with available core data

Wel Name	Core Interval ft MD	Φ avg		Φ Log vs Φ Core R^2
		Core Data	Log Interpretation	
EP-4	5679 - 5809	17.02	17.38	0.875
DWP-2RD2	5678.1 - 5809.1	17.06	17.15	0.823
NEL-3	4633 - 5081	14.83	15.63	0.6145
NEL-5RD	5702.5 - 5746.7	23.34	23.58	0.6623

Table 2. Determination of Sw calculation method compared to available core data

Well	Core Interval (ft MD)	Sw (%)				Error (%)		
		Core	DW	Indo	Siman	DW	Indo	Siman
EP-4	5679 - 5809	73.21	74.75	79.55	81.09	2.10	8.66	10.76
DWP-2RD2	5678.1 - 5809.1	71.59	66.36	69.19	70.11	-7.31	-3.35	-2.09
NEL-3	4633 - 5081	64.92	65.34	77.47	77.48	0.66	19.34	19.35
NEL-5RD	5702.5 - 5746.7	79.02	79.85	76.54	76.68	1.05	-3.15	-2.97

Table 3. Tabulation of Sw log validated with available core data

Well Name	Core Interval ft MD	Sw avg		Sw Log vs Sw Core R^2
		Core Data	Log Interpretation	
EP-4	5679 - 5809	73.21	74.75	0.6422
DWP-2RD2	5678.1 - 5809.1	71.59	66.36	0.6943
NEL-3	4633 - 5081	64.92	65.34	0.4857
NEL-5RD	5702.5 - 5746.7	79.02	79.85	0.5367

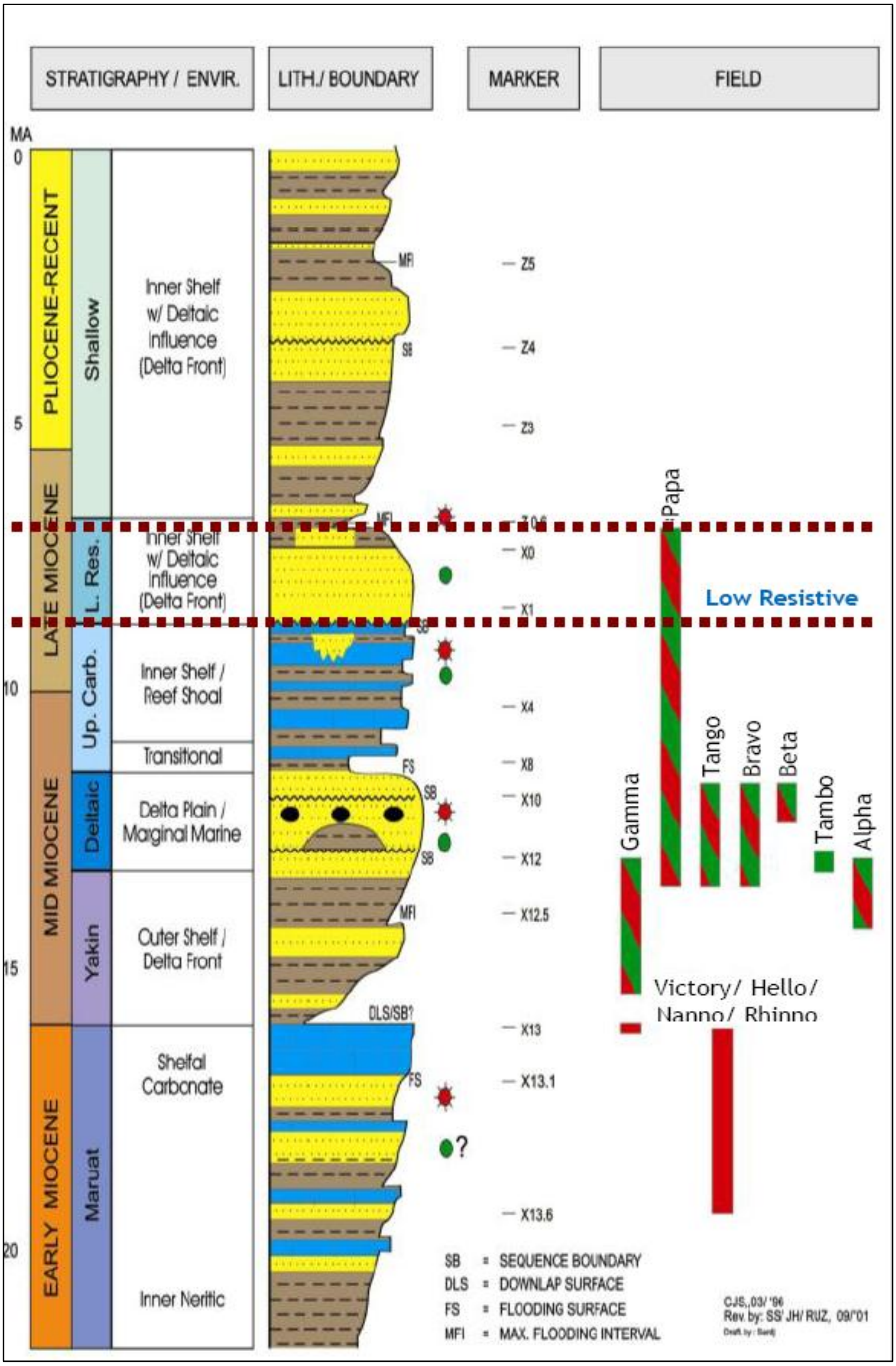


Figure 1. Stratigraphy of “Papa” Field

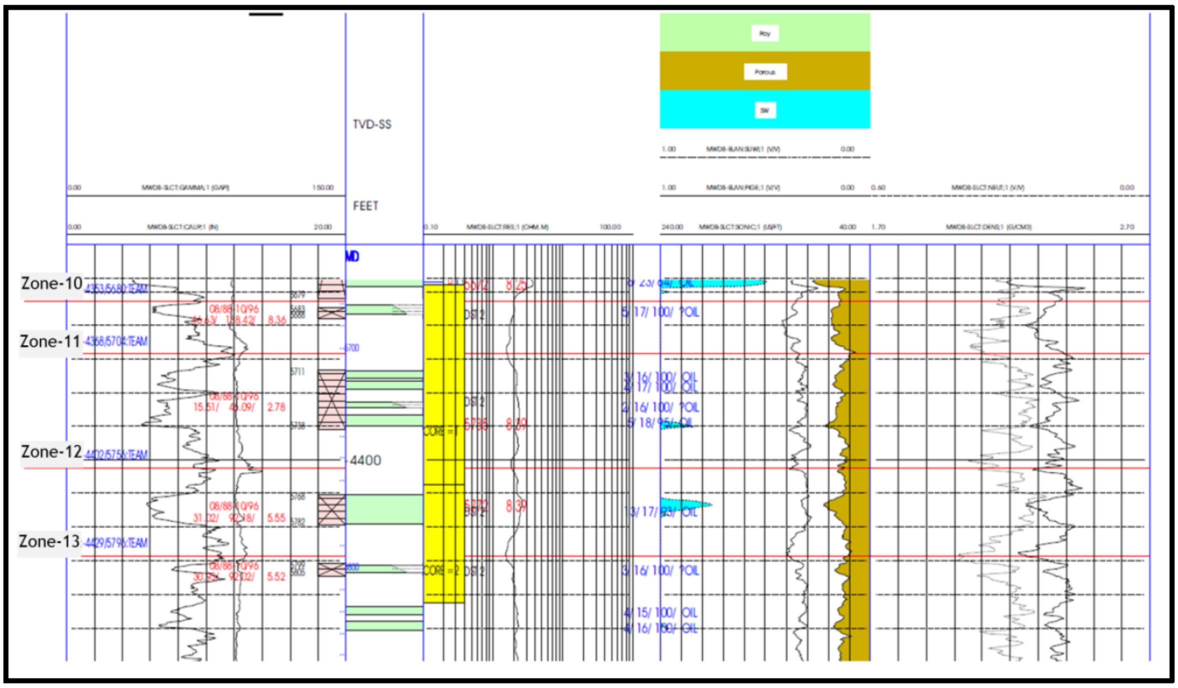


Figure 2. Chart log in Well EP-4 (zone-10 to zone-13)

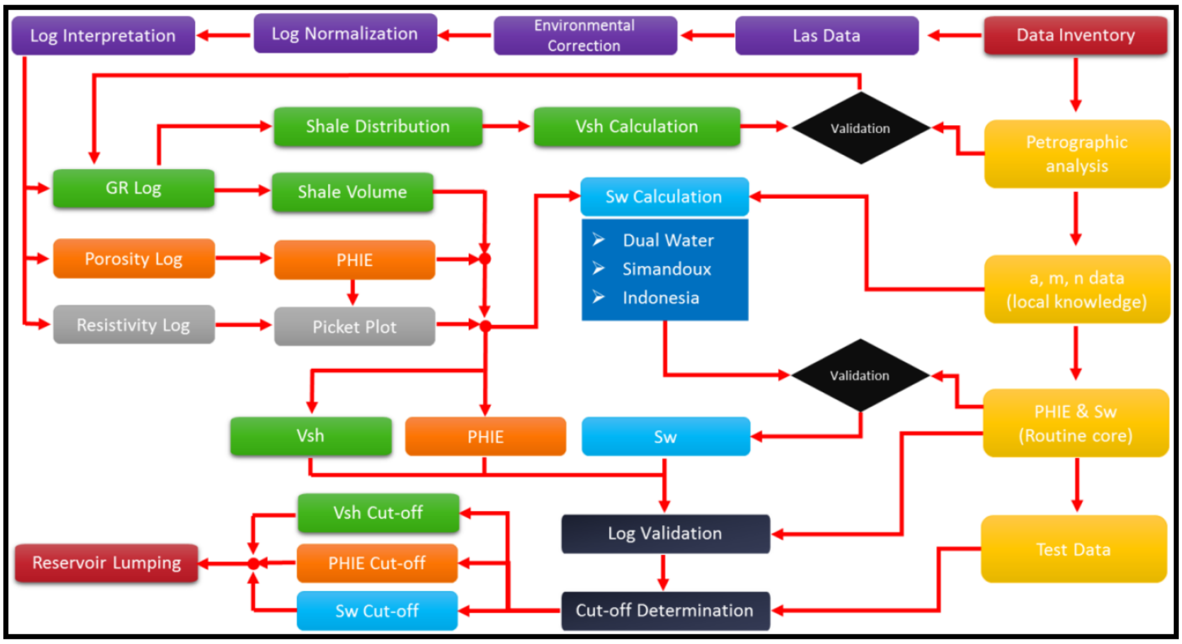


Figure 3. Petrophysical analysis workflow

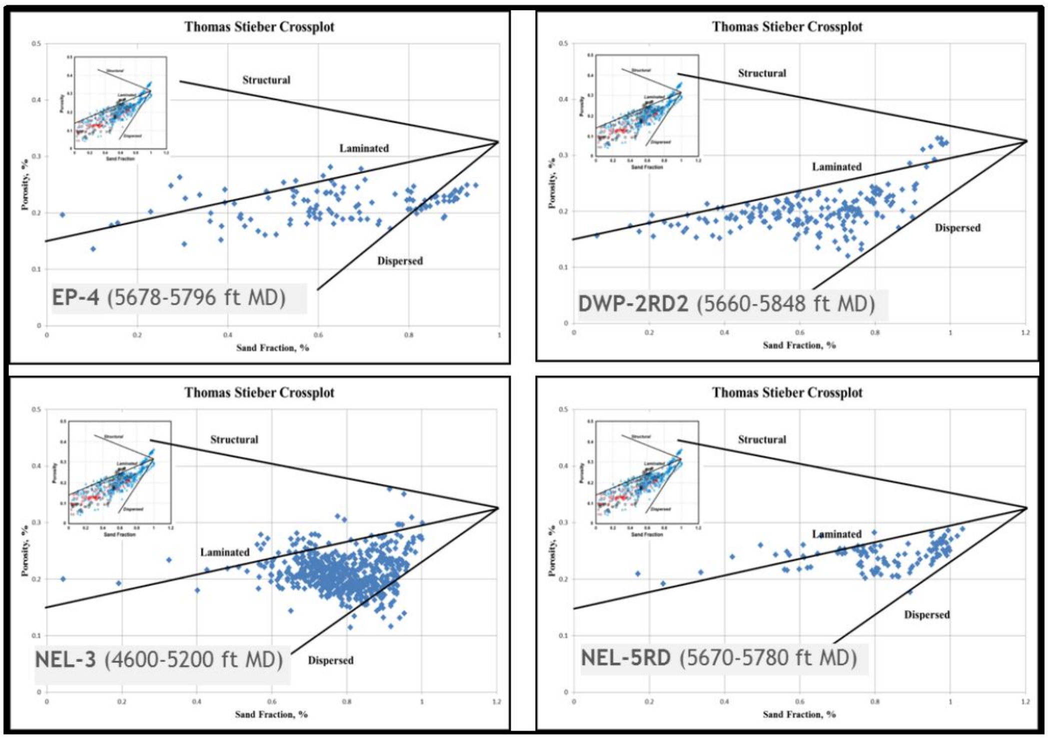


Figure 4. Thomas Stieber crossplot analysis

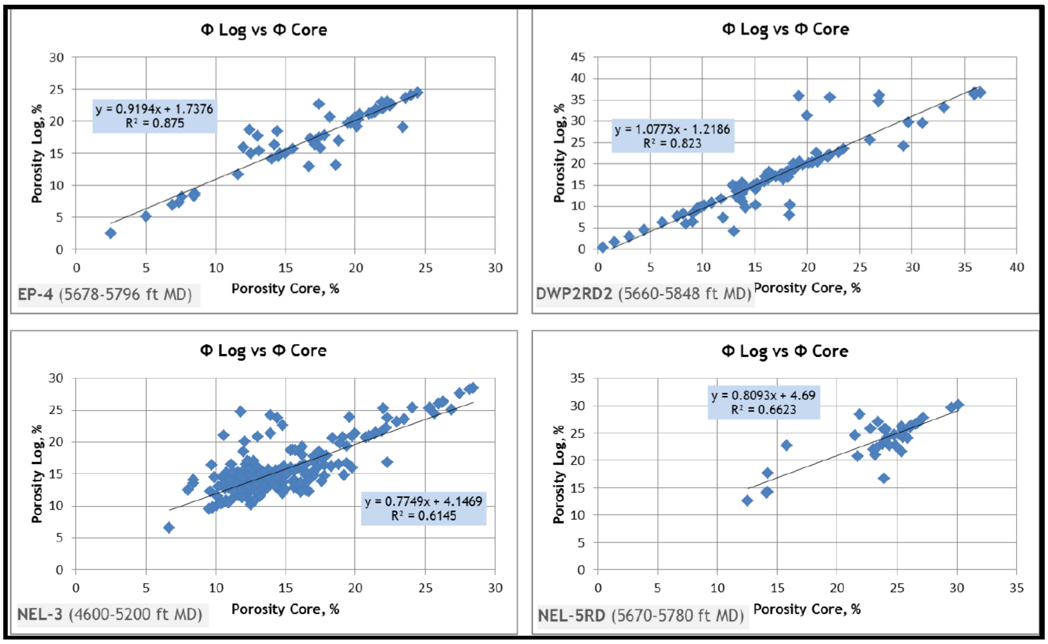


Figure 5. Porosity log validation with available core data

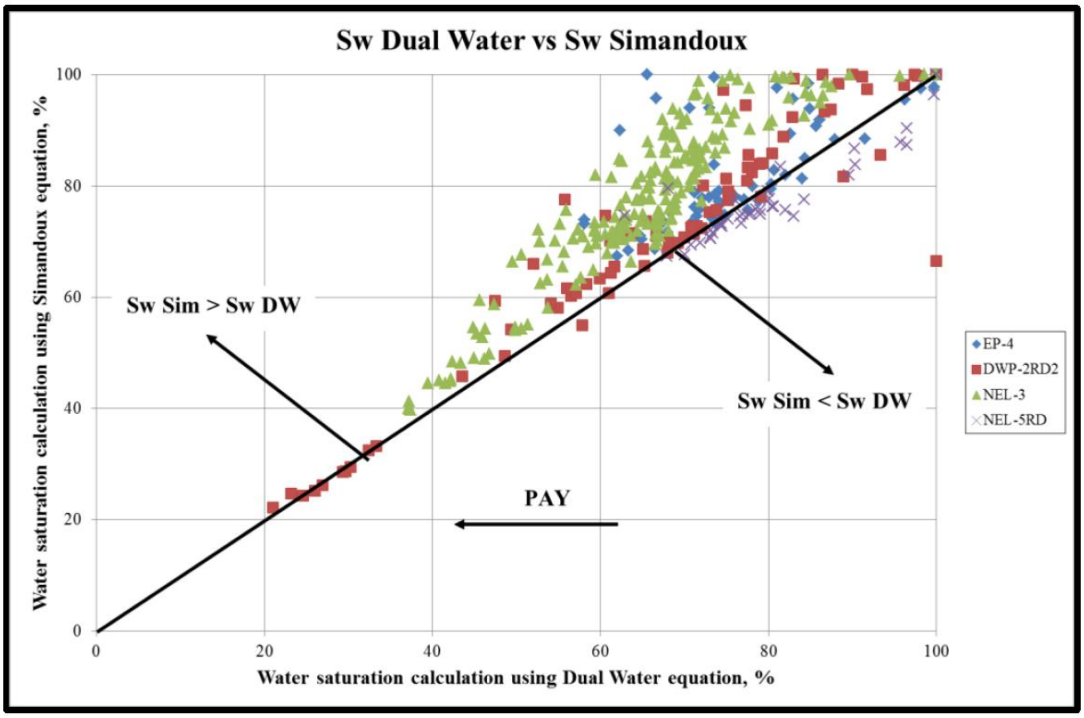


Figure 6. A comparison of water saturation calculation using Dual Water equation and Simandoux equation

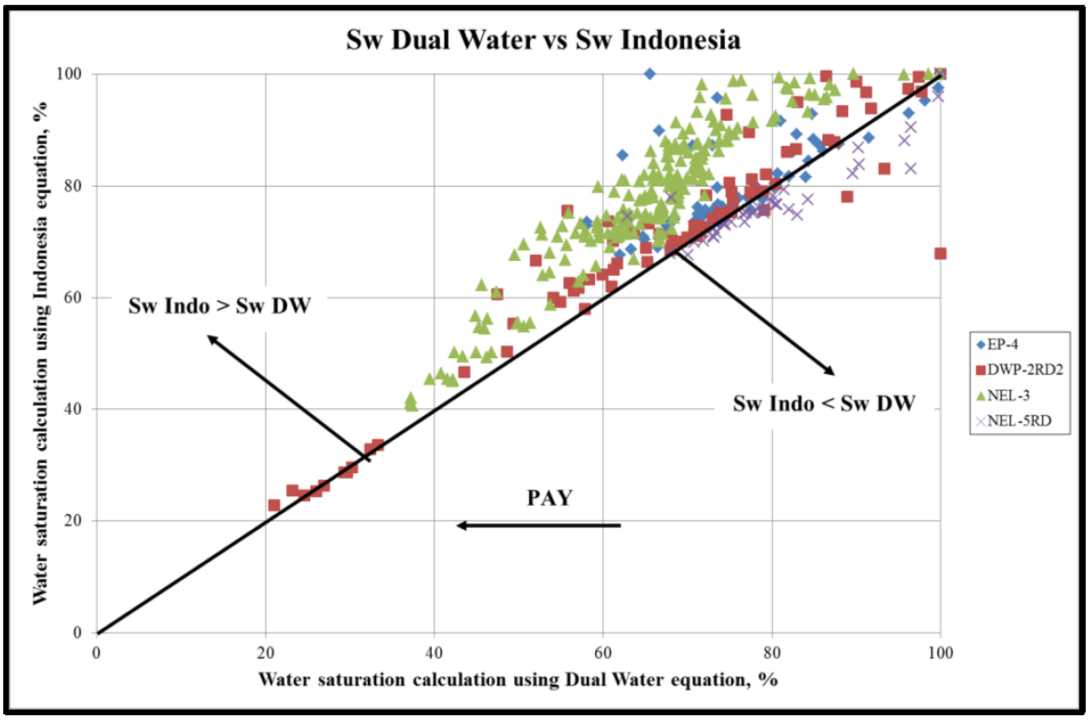


Figure 7. A comparison of water saturation calculation using Dual Water equation and Indonesia equation

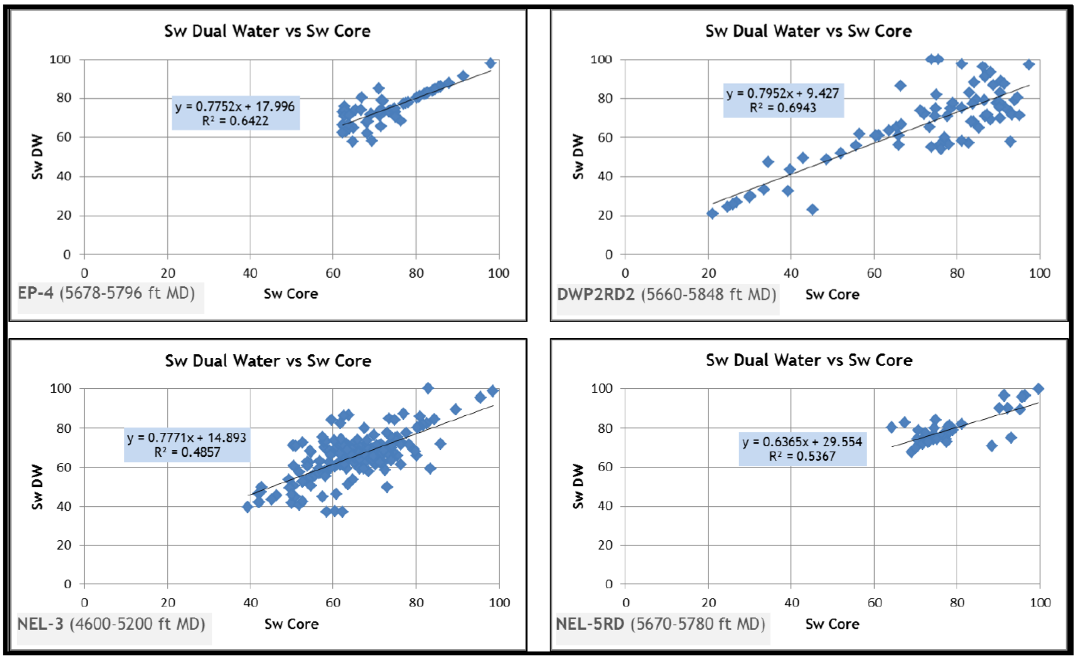


Figure 8. Sw log validation with available core data

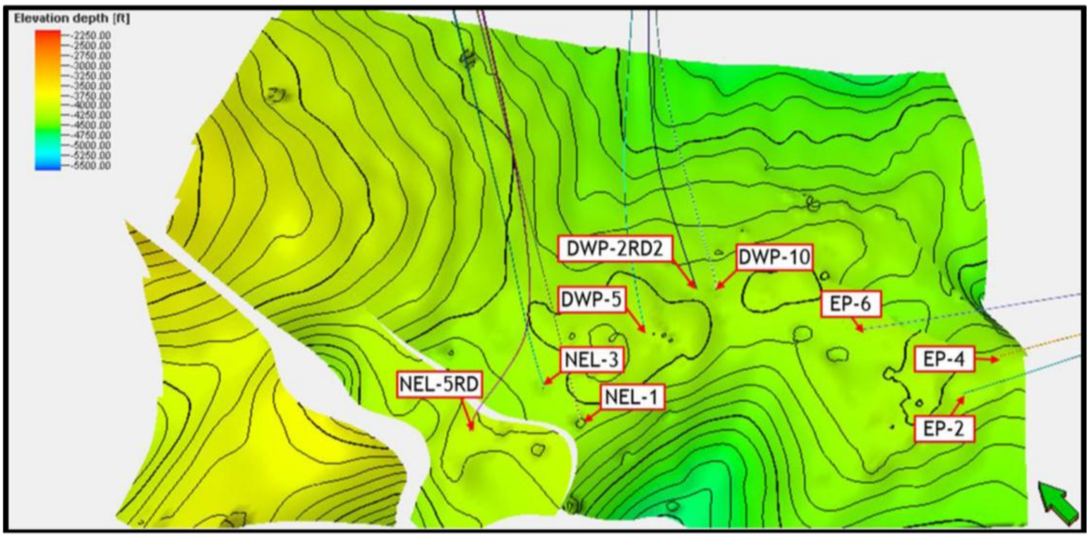


Figure 9. Wells location in “Victory” Low Resistivity of “Papa” Field

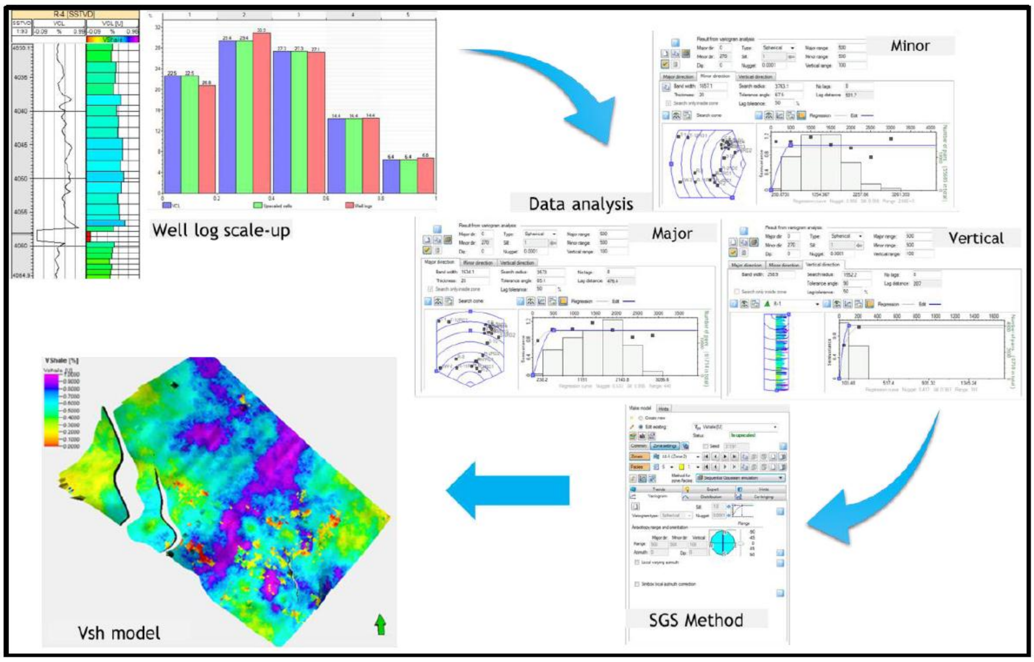


Figure 10. Vshale modeling in “Victory” Low Resistivity Play

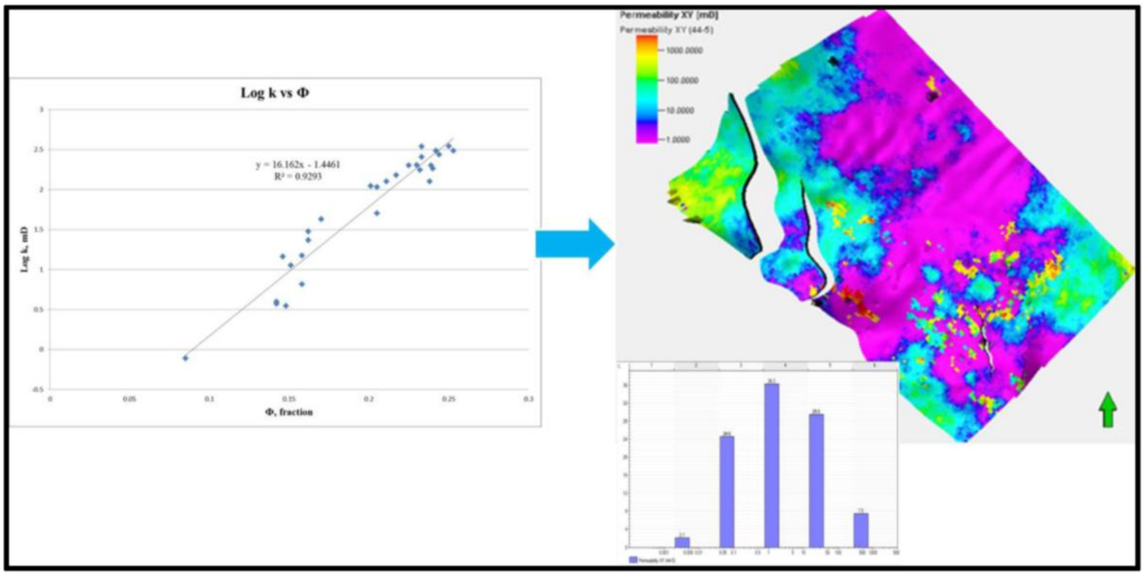


Figure 11. Permeability modeling in “Victory” Low Resistivity Play

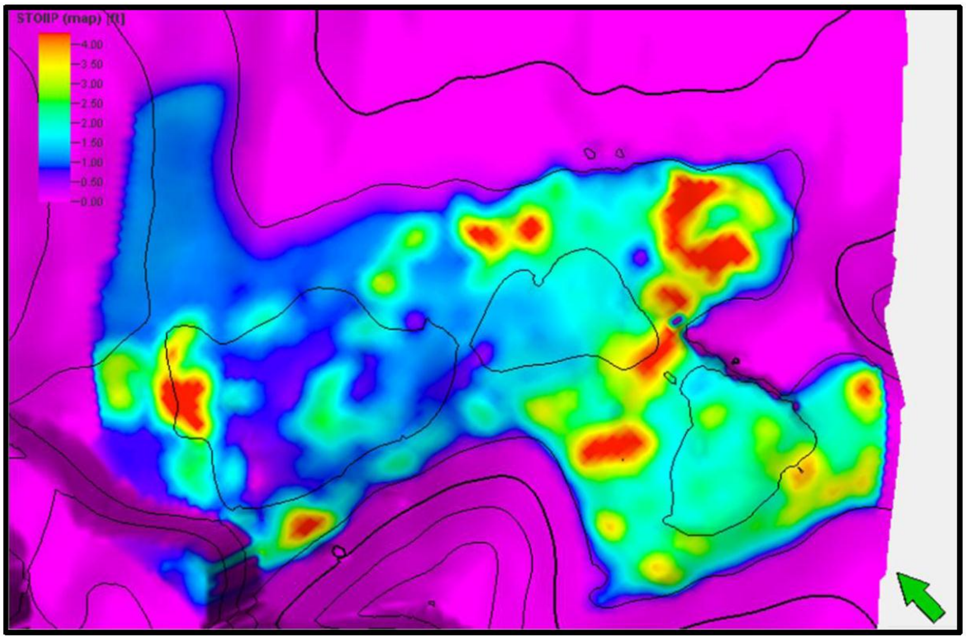


Figure 12. Initial oil inplace distribution of “Victory” Low Resistivity Play in “Papa” Field

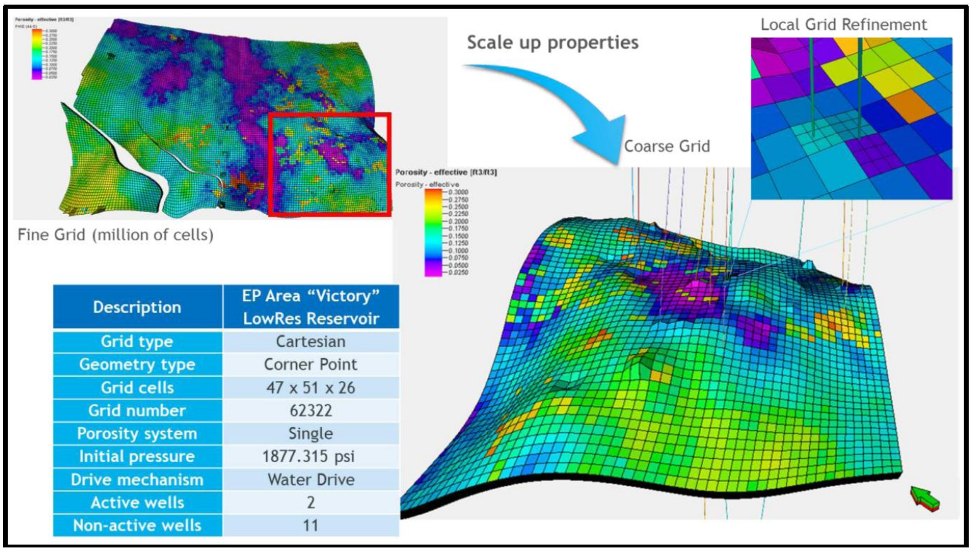


Figure 13. “Victory” Low Resistivity Reservoir model in EP Area

Marker	OOIP, STB			Initial Pressure, psi		
	Volumetric	Simulation	Diff	Data	Simulation	Diff
44-5 Rajah	15,351,123	15,826,889	3.09%	1877.315	1877.82	0.027%

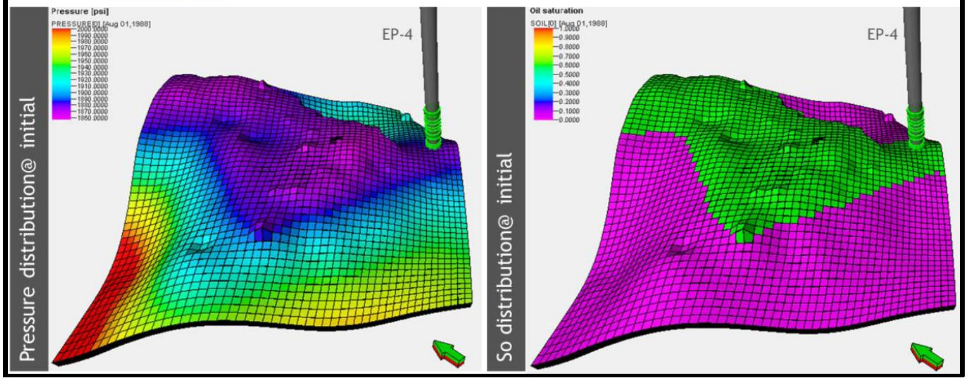


Figure 14. Initialization process (OOIP and initial reservoir pressure)

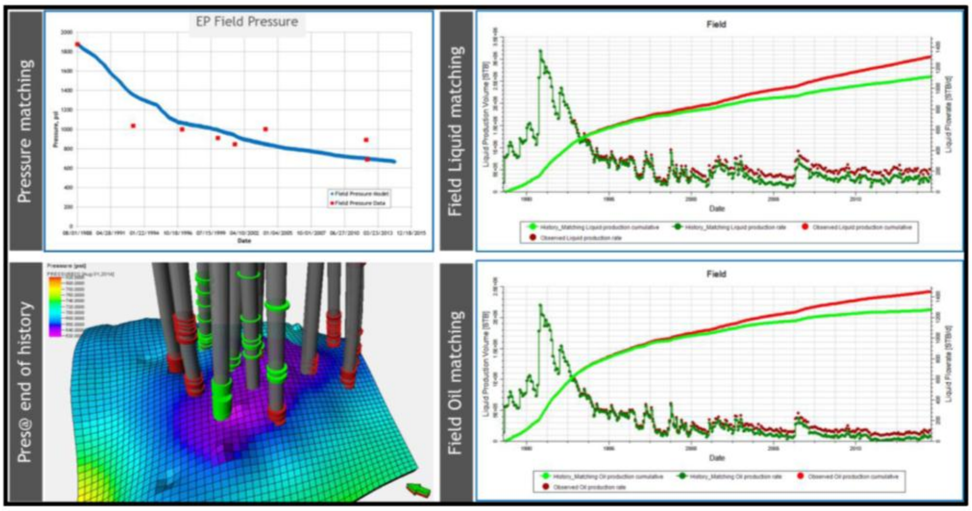
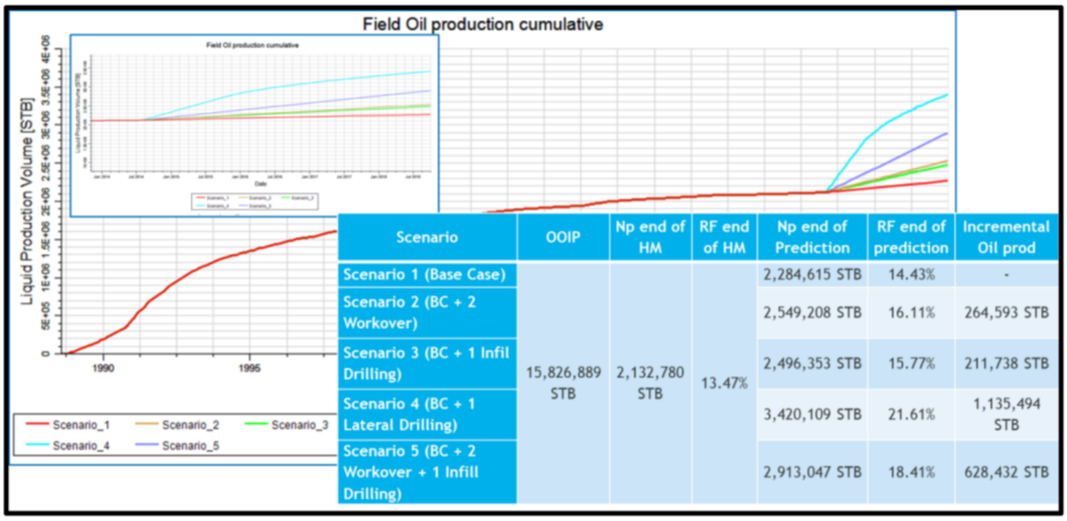


Figure 15. History matching process (pressure and production)



Scenario	OOIP	Np end of HM	RF end of HM	Np end of Prediction	RF end of prediction	Incremental Oil prod
Scenario 1 (Base Case)	15,826,889 STB	2,132,780 STB	13.47%	2,284,615 STB	14.43%	-
Scenario 2 (BC + 2 Workover)				2,549,208 STB	16.11%	264,593 STB
Scenario 3 (BC + 1 Infil Drilling)				2,496,353 STB	15.77%	211,738 STB
Scenario 4 (BC + 1 Lateral Drilling)				3,420,109 STB	21.61%	1,135,494 STB
Scenario 5 (BC + 2 Workover + 1 Infill Drilling)				2,913,047 STB	18.41%	628,432 STB

Figure 16. A comparison of prediction results for each development scenarios in EP Area of "Victory" Low Resistivity Play

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Biozoning on Planktonic Foraminifera of Ngrayong, Bulu, Wonocolo, Ledok, and Mundu Formation, Kecamatan Tambakboyo and the Sorrounding Area, Kabupaten Tuban, Provinsi Jawa Timur

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ABSTRACT

The research area is located in Tambakboyo district and Jatirogo district, Tuban Regency, East Java Province. The research Area is included in the Mandala Rembang Zone, North East Java Basin. The preparation of bio-datum and manufacture of bio-zonation (bio-stratigraphic zone) based on the presence and distribution of taxon identifier of Planktonic Foraminifera fossil in rock sample on surface measure stratigraphic section's line across Ngrayong Formation, Bulu Formation, Wonocolo Formation, Ledok Formation and Mundu Formation in research area.

The biozonation that has been obtained from the biostratigraphy analysis, from older to younger sedimentary rock layers (Ngrayong Formation- Mundu Formation) are 2 Partial Zone and 5 Interval Zone, ie: *Globorotalia menardii* (N12) Partial Zone, *Globorotalia menardii-Globorotalia pseudomiocenica* (N13) Interval Zone, *Globorotalia pseudomiocenica- Globigerina bulloides* (N14-N15) Interval Zone, *Globigerina bulloides-Globorotalia plesiotumida* (N16) Interval Zone, *Globorotalia plesiotumida-Globorotalia tumida* (N17) Interval Zone,*Globorotalia tumida-Globorotalia plesiotumida*(N18) Interval Zone, *Globorotalia plesiotumida* (N19)Partial Zone.

From Bio-stratigraphic analysis in this research area, the conclusion is the sedimentation in research area is younger than the Regional Geology Mandala Rembang Zone.

Key Words : Biozonation, Foraminifera Plankton, Miocen-Pliocen, Geology of Rembang Zone.

PREFACE

The law of Superposition (Steno,1669) is a fundamental law of geology, it is explaining about the sedimentary rock in the lower layer is older than the upper one. However, at the present time (Recent) the sedimentary layers have been folded or faulted due to the tectonic deformation of the earth. At the deposition stage of sedimentary rocks, there is possibility of sea level changes which causes the changes of lithology of sediment layers that which indicate a change in depositional environment. It takes a variety of methods to solve these problems, especially in the determination of the age of deposition of sedimentary rocks, one of them through a biological approach to the sediment layer with Biostratigraphic methods. Biostratigraphy is the branch of stratigraphy, the studies about the distribution of fossils in the stratigraphic record, and classify the rock layers into units based on the fossil content therein. This science utilizes the Chronostratigraphy range of various species of fossils to correlate stratigraphic cross-section, especially the distribution of planktonic foraminifera fossils are used for determining the age of sedimentary rocks as datum planes or in this case is bio-datum.

According to the research results of previous researchers, North East Java Basin Mandala Rembang Zone is a dynamic in term of tectonic and a basin that has a good composition of carbonate sedimentary rock. So, it is very possible to do research in the field of biostratigraphy. For the scientific terms or in terms of industry.

The research area is administratively located in the District Tambakboyo, and District Jatirogo, Tuban, East Java Province (**Figure 1**). Located on 49S zone, UTM coordinates 580000 mE - 586 000 mN mE and 9242000 - 9237500 mN.

The main objective of this study was to determines and arrange the biodatum and biostratigraphic zones based on taxon identifier of planktonic foraminifera that found on research area, and determine the age of rocks or rock units of measurement stratigraphic cross-section.

The research methods used was the analysis of microfossils Foraminifera Plankton in each sample taken at the track of measurement stratigraphic cross-section from the geological surface observation on research area. Then distributing fossil analysis results in a stratigraphic cross-section, and classify the the rock layers into units based on fossil content therein.

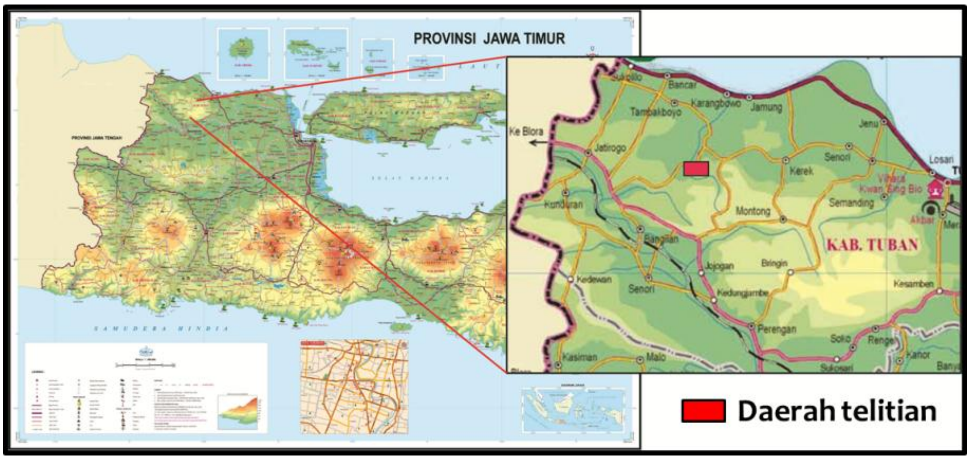

Figure 1. Map of Location Research Areas in East Java Province (Source: Bakorsurtanal / BPN Prov. East Java).

REGIONAL GEOLOGY

Based on Java physiographic zones created by Van Bemmelen (1949) **(Figure 2.)**, the study area includes in the Antiklinorium Rembang-Madura Zone. This zone extends from the northern boundary of Java and the western is separated by Lusi Depression of Randublatung Zone. This zone is characterized by the presence of Antiklinorium Rembang that is the lines of anticline that overlap each other (superimposed). The Sediments at Rembang zone are showing the rocks with a high sand content in addition to the presence of carbonate rocks and the absence of pyroclastic sediments. The sediments are interpreted that deposited on the sea not far from the beach, the sea bottom are diverse in terms of depth due to the giant faults (block faulting). The Rembang zone commonly consists of a sequence of Eocene-Pliocene sediments which include shallow marine clastic and carbonate sediments are widespread. The Rembang zone basement rock is dominated by various types of Cretaceous metamorphic rocks such as slate stone, filit, and Diorite igneous rock diorit (Prasetyadi, 2007). Even though no firm but the boundary is interpreted by unconformity with Ngimbang Formation were deposited on top of it. The sediment sequence above Pre-Ngimbang Formation and Ngimbang Formation are dominated by carbonate sediment of Kujung Formation and Prupuh Formation which is an Oligocene sediment. And the sequence stratigraphy above Kujung Formation according to Pringgoprawiro(1983) (**Figure 3.**) are Tuban Formation, Tawun Formation, Ngrayong Formation, Bulu Formation, Wonocolo Formation, Ledok Formation, and Mundu Formation which are sedimentary rocks deposited in conformity state at Miocene to Pleistocene in the shallow marine area with the composition of carbonate as the dominant.

Based on field data and laboratory analysis and confirmed and be compared to the results of previous research, the stratigraphy of the study area (**Figure 4.**) sequentially from the older to the younger, ie:

Ngrayong sandstones Unit.

Consists of quartz sandstone with claystone and Orbitoid limestone inserts. The age Ngrayong sandstone unit ranges from N12-N15 zones or the Middle Miocene -Late Miocene, depositional environment on neritik bank - central neritik influenced by tidal sea water on transgression phase.

Bulu limestones Unit.

Bulu limestone unit has a lithology characteristic form of orbitoid limestone, with inserts calcareous sandstones in several parts. The age is N15-N16 (Late Miocene), from thin section appears genus *Lepidocyclina* and *Cycloclypeus* which also can be used as a determination of the age that is the middle Miocene - late Miocene (Tf). It deposited on edge of neritic until the transition environment (tidal) on transgression phase.

Wonocolo sandy marl Unit.

This rock unit is composed by sandy marl, and calcarenit (sandy limestone) inserts. The thickness of this unit is 75.25 meters. The age ranged between N16-N17 zones or Late Miocene. Based on the presence of foraminifera bentonik present is *Anomalina colligera, Uvigerina scwageri, Hyperam-mina cylindris, Turbinella funalis* deposited at the central neritik zone until upper bathial according to Barker's classification (1960).

Ledok limestones Unit

This unit has lithological characteristics are sandy marl and calcarenite (sandy limestones) are repeated, with slight inserts calcareous sandstones. The thickness of this unit is 112 meters. The age ranged between N17-N19 (Late Miocene-early Pliocene). It deposited at the central neritik – upper bathial on sea level drop phase, it supported by the presence of sedimentary structures mega-crossbeding and ichnofossil cruziana.

Mundu marl unit.

This unit has massive marl as its lithological characteristics. From the result of calcimetri analysis, it obtained CaCO3 content of Mundu marl unit is 28-29% and named as marl-clay (Petijohn, 1957). The Age range are N19-N21 (early Pliocene), it identified by the presence of *Globorotalia tumida* (without *Globorotalia merotumida* and *Globorotalia plesiotumida*). It deposited on outer neritic- lower bathial in sea level rise phase.

LITHO-STRATIGRAPHIC ON THE RESEARCH AREA

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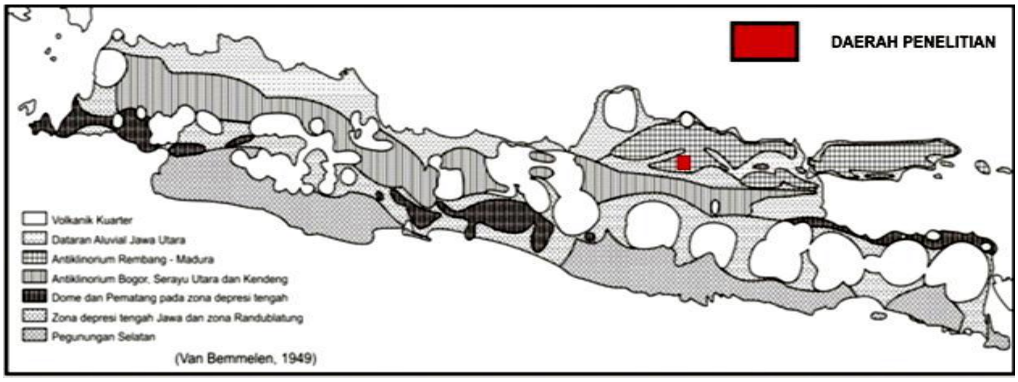

Figure 2. Physiographic of Java (Van Bemmelen, 1949). Research areas included in the Antiklinorium Rembang-Madura.

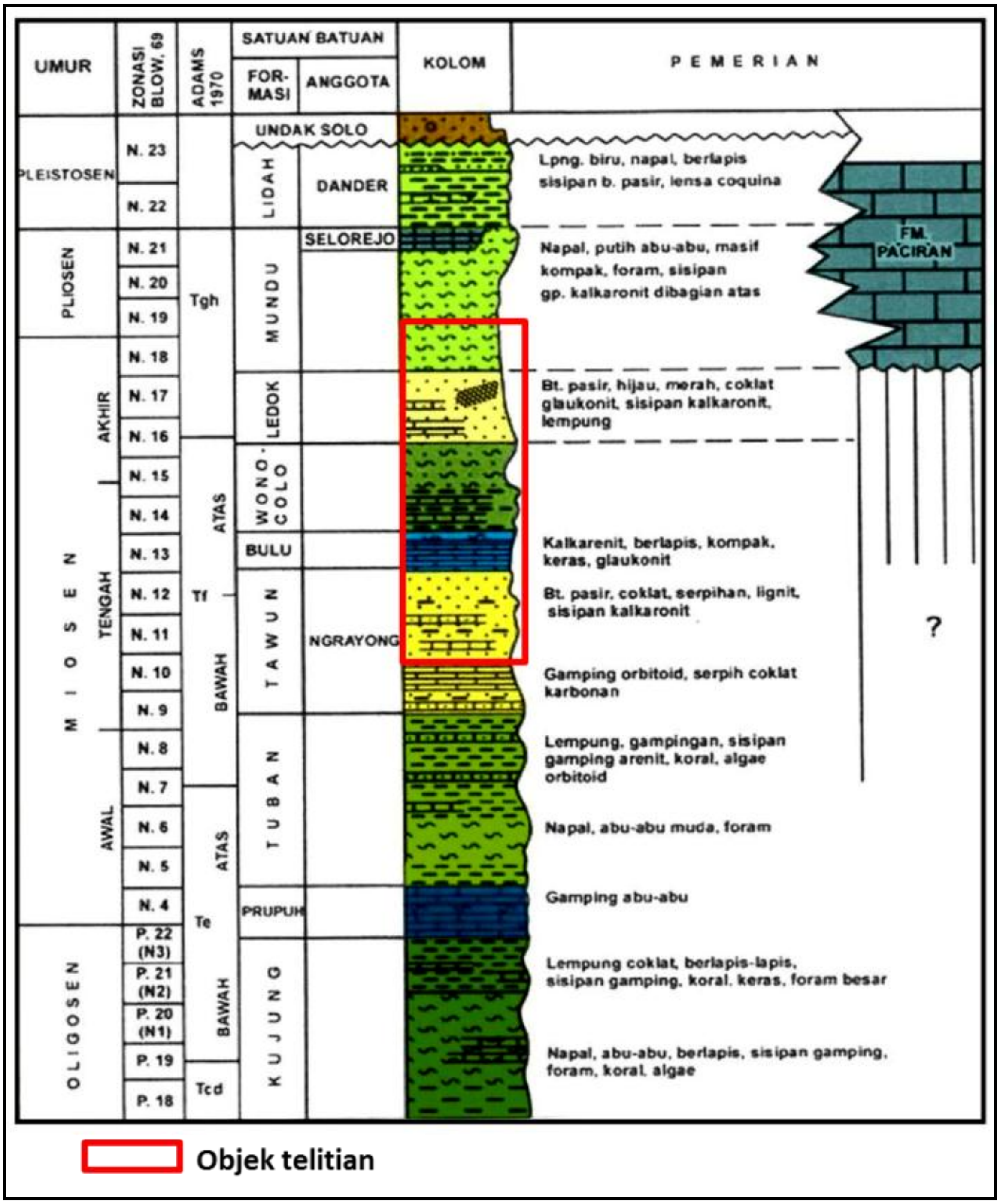

Figure 3. Stratigraphy of Rembang Zone (Pringgoprawiro, 1983).

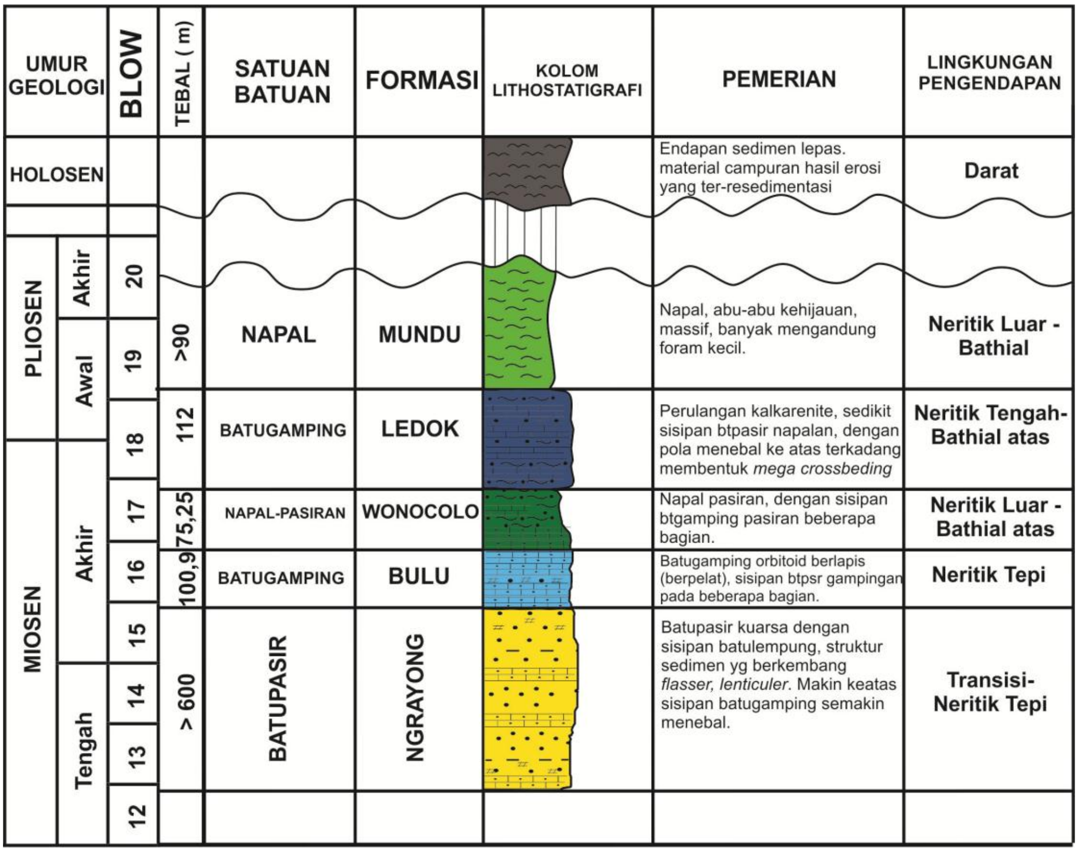

Figure 4. Stratigraphic of Reasearch area (Maulanasyah, 2014).

BIOSTRTIGRAPHIC REASEARCH AREA

Biodatum of Foraminifera Plankton

Biodatum that found by Biostratigraphy analysis of sedimentary rock samples in stratigraphic measured sections in the study area sequentially from the older to younger, include:

1. *Globorotalia menardii* biodatum (First Appearance)

Globorotalia menardii's range age is N13-N23 (Mid. Miocene- Pliocene). This fossil is used for an identifier fossil for bottom of Ngrayong Sandstone Unit in study area. Therefor the writer picked the first appearance of *Globorotalia menardii* as a bio-horizon line of the last N12 and first N13. The biozonation's boundary is in point bios 2.

2. *Globorotalia pseudomiocenica* bioda-tum (First Appearance)

Globorotalia pseudomiocenica's range age is N14-N23 (Mid. Miocene- Pliocene). This fossil is used for an identifier fossil in body of Ngrayong Sandstone Unit in study area. Therefor the writer picked the first appearance of *Globorotalia menardii* as a bio-horizon line of the last N13 and first N14. The biozonation's boundary is in point bios 9.

3. *Globigerina bulloides* biodatum (First Appearance)

This fossil's range age is N16-N23 (Last Miocene- Pleistocene). The first appearance of *Globigerina bulloides* is used for an identifier fossil as a bio-horizon line of last N15 and first N16 in body of Bulu limestone Unit. The biozonation's boundary is in point bios 15.

4. *Globorotalia plesiotumida* biodatum (First Appearance)

This fossil's range age is N17-N18 (Last Miocene- Lower Pliocene). The first appearance of *Globorotalia plesiotumida* is used for an identifier fossil as a bio-horizon line of last N16 and first N17 in body of Wonocolo sandy-marl Unit. The biozonation's boundary is in point bios 18.

5. *Globorotalia tumida* biodatum (First Appearance)

Globorotalia tumida's range age is N18-N23 (Last Miocene- Lower Pliocene). The first appearance of *Globorotalia tumida* is used for an identifier fossil as a bio-horizon line of last N17 and first N18 in body of Ledok limestone Unit. The biozonation's boundary is in point bios 24.

6. *Globorotalia plesiotumida* biodatum (Last Appearance)

This fossil's range age is N17-N18 (Last Miocene- Lower Pliocene). The last appearance of *Globorotalia plesiotumida* is used for an identifier fossil as a bio-horizon line of last N18 and first N19 in top of Ledok limestone Unit. The biozonation's boundary is in point bios 27.

Biozonation of Foraminifera Plankton

Base on Biostratigraphic analysis from stratigraphic measured section in research area, it can be divided into two zones that is Interval Zone and Partial Zone (**Table 1.**). The Interval zones and Partial zones were made by bio-horizons that have been arranged before. The foraminifera planktonic's biozonations sequentially from the older to the younger are:

1. *Globorotalia menardii* Partial zone as indicator of N12 (Mid. Miocene) in Ngrayong sandstone Unit.

2. *Globorotalia menardii - Globorotalia pseudomiocenica* Interval zone as indicator of N13 (Mid. Miocene)in Ngrayong sandstone Unit.

3. *Globorotalia pseudomiocenica – Globigerina bulloides* Interval zone as indicator of N14-N15 (Mid. Miocene- last Miocene) in Ngrayong sandstone Unit to Bulu limestone Unit.

4. *Globigerina bulloides - Globorotalia plesiotumida* Interval zone as indicator of N16 (Last Miocene) in Bulu limestone Unit to Wonocolo sandy-marl Unit.

5. *Globorotalia plesiotumida - Globorotalia tumida* Interval zone as indicator of N17 (Last Miocene) in Wonocolo sandy-marl Unit to Ledok limestone Unit.

6. *Globorotalia tumida - Globorotalia plesiotumida* Interval zone as indicator of N18 (Last Miocene- Early Miocene)in Ledok limestone Unit.

7. *Globorotalia plesiotumida* Partial zone as indicator of N19 (Last Miocene- Early Miocene)in Ledok limestone Unit to Mundu marl Unit.

CONCLUSSIONS

Age's plane : *Globorotalia menardii* (N13), Age's plane *Globorotalia pseudomiocenica* (N14), Age's plane *Globigerina bulloides* (N16), Age's plane *Globorotalia plesiotumida* (N17), Age's plane *Globorotalia tumida* (N18).

The biozonation that has been found are 2 Partial zone (P.Z.), dan 5 Interval zone (I.Z.), yaitu *Globorotalia menardii* P.Z. (N12), *Globorotalia menardii - Globorotalia pseudomiocenica* I.Z. (N13), *Globorotalia pseudomiocenica - Globigerina bulloides* I.Z. (N14-N15), *Globigerina bulloides - Globorotalia plesiotumida* I.Z. (N16), *Globorotalia plesiotumida - Globorotalia tumida* (N17), *Globorotalia tumida - Globorotalia plesiotumida* I.Z. (N18), *Globorotalia plesiotumida* P.Z.(N19).

Base on biostratigraphic analysis's result on research area, Sedimentary rocks in research area deposited at younger age than the regional geology reference of Mandala Rembang Zone (1983).

REFERENCE

Allan, W. H. Bé, 1977. *An Ecological, "Oceanic Micropaleontology", Volume 1,* *Zoogeographic and Taxonomic Review of Recent Planktonic Foraminifera*, pp. 1-100.

Bandy, O. L., 1960. *The geologic significance of coiling rations in the foraminifer Globigerina pachyderma* (Ehrenberg). J. Paleont.

Banner, F.T., and Blow, W.H., 1965. *Two new taxa of the Globorotaliinae (Globigerinacea, Foraminfera) assisting determination of the late Miocene / middle Miocene boundary*. Nature Vol. 207.

Barker R. W., 1960, *Taxonomic Note. Society of economic paleontologist and mineralogist. The Collegiaten Press George Santa Company,* INC, Mekasha, Wisconsin, U.S.A.

Blow, W.H., 1969. *Late Middle Eocene to Recent Planktonik Foraminifera Biostratigrafi Cont, Planktonic Microfosil*, Geneva, 1967, Pro. Leiden, E.j.*Bull*, v.1.

Bolli, H., 1950. *The direction of coiling in the evolution of some Globorotaliidae*. Reprint from contributions from the Cush. Found. Foram. Res., vol. 1, parts 3 and 4.

Dunham, R. J., 1962. *Classification of Carbonate Rock According to Depositional Texture,* In Han, W. E. (ed) 1962, Classification of Carbonate Rock, *AAPG, Bull*. Men 1, h. 108 – 121.

IAGI., 1996. *Sandi Stratigrafi Indonesia (Revisi SSI 1973)*. Komisi Sandi Stratigrafi Indonesia, Ikatan Ahli Geologi Indonesia. Jakarta.

Maha, M., 1995. *Biozonasi Paleobathimetri Dan Pemerian Sistematis Foraminifera Kecil Sumur TO-04, Sumur TO-08 dan Sumur-95 Daerah Cepu dan Sekitarnya Cekungan Jawa Timur Utara*. *Thesis S2* Teknik Geologi,ITB, Bandung, h.10. Tidak dipublikasikan.

Phleger, F.B., 1951. *Ecology of foraminifera*. Elsevier Publishing company, Amsterdam, p.420.

Postuma J.A., 1971, *Manual Planktonic Foraminifera*. Elsevier Publishing Company, Amsterdam, P. 420.

Prasetyadi, C., 2007. *Evolusi tektonik Paleogen Jawa bagian timur*, Disertasi ITB, tidak dipublikasikan

Pringgoprawiro, H., 1983, *Biostratigrafi dan Paleografi Cekungan Jawa Timur suatu pendekatan baru, Thesis Doktor*, ITB, Bandung, Tidak dipublikasikan.

Smyth, H., Hall, R., Hamilton, J., dan Kinny, P., 2005. East Java: Cenozoic basins, volcanoes, and ancient basement, *Proceedings 30th Indonesian Petroleum Association Annual Convention and Exhibition, Jakarta*

Tipsword, H.I., Setzer, F.M. Smith, Jr, F.L., 1956. *Introduction of Depositional Environment in Gulf Coast Petroleum Exploration From Paleontology and Related Stratigraphy*, Houston.

Van Bemmelen, R.W. 1949. *The Geology of Indonesia, Vol. 1A, General Geology*. Martinus Nijhoff, The Hague. The Netherlands.

Verstappen, H. Th., 1985. *Applied Geomorphological Survey and Natural Hazard Zoning*. Enschede: ITC.

Wenworth, C.K., 1922. A Scale of grade class term for clastic sediments. *Journ. Geology*, 30:337–392.

Williams, H., Turner, F.J. and Gilbert, C.M., 1954. *Petrography; An Introduction to the Study of Rock in Thin Sections*. W.H. Freeman and Co., San Francisco.

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Formation Evaluation B Sandstone of Bekasap Formation at Tri Field to Propose Infill Drilling

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ABSTRACT

B Sandstone of Bekasap Formation is located on Central Sumatra Basin. All well on this field already have decline rate. Therefore, efforts should be made to raise take production rate. One of them is infill drilling.

Formation Evaluation is used to know the properties of B Sandstone. The result can be used to determine infill drilling location. The properties of B Sandstone are 9-29% for Vsh , 22-27% for porosity, and 19-60% for water saturation with two proposed well.

Key words: Tri Field, Formation Evaluation, Infill Drilling

INTRODUCTION

To increase oil production that already have decline rate, we need improve or maintain the rate of oil production. One attempt to do that is infill drilling. Infill drilling is a method by adding new well between existing wells to minimize the space, so the reservoir production will be more optimize than before.

BACKGROUND

B Sandstone of Bekasap Formation is located on Central Sumatra Basin and has Early Miocene age. Tri field was first produced in 1989 and has continued until today. Based on production data, wells in this field already have decline rate. Therefore, infill drilling is needed to increase the production rate.

AIMS AND OBJECTIVES

Formation Evaluation in the Field Tri is to determine the value of reservoir properties such as Vsh, porosity, water saturation, and permeability. These data will be used to propose infill drilling on this field.

Commonly, latest study determine the infill drilling based on the extent of reserve remaining, formation productivity, radius of investigation (ri), total wells, location, and pattern of well production. The latest study is not really detail to explain about physical character of reservoir. So this study will be more focus on formation evaluation to analyze the physical character of reservoir as basic to propose infill drilling.

METHOD

Collecting Data

The first step in formation evaluation is collecting data. The data are log data (lithology, resistivity, and porosity), core data (SCAL), and production data.

Processing Data

1. *Interpretation of Lithology*

   The data used is a combination between data logs (Gamma Ray, NPHI and RHOB cross plot, and also resistivity) and core data. Interpretation of lithology was used to determine the type of lithology on each well.

2. *Identification of Permeable Zone*

   Identification of permeable zone use Gamma Ray log. Permeable zones indicate with low Gamma Ray response, otherwise impermeable zones indicated by high Gamma Ray response.

$$V\,shale = \frac{GR_{log} - GR_{min}}{GR_{max} - GR_{min}}$$

3. *Identification of Hydrocarbon Zone*

Next step is identification hydrocarbon zones using resistivity and porosity log (NPHI and RHOB). Hydrocarbon zones indicate with high resistivity and positive separation between Neutron and Density log. Otherwise, water zones indicated by low resistivity and negative separation between Neutron and Density log.

4. *Calculation of Porosity*

Porosity calculation using Bateman-Konen Neutron Density method and the result will be validating with porosity from SCAL data. One of the parameters required in this method is porosity from density and neutron log from shale.

$$\Phi_e = \frac{\Phi_D * \Phi_{Nsh} - \Phi_N * \Phi_{Dsh}}{\Phi_{Nsh} - \Phi_{Dsh}}$$

Φ_e : Effective Porosity
Φ_D : Density Porosity
Φ_{Nsh} : Neutron shale porosity
Φ_N : Neutron Porosity
Φ_{DSH} : Density shale porosity

5. *Determine Water Resistivity (Rw)*

In this study, water resistivity obtained from laboratory test.

6. *Calculation of Water Saturation (Sw)*

The method that used to calculation saturation of water is Simandoux method with
a, m, and n is 1, 1.603, and 1.763. Saturation water obtained by equation:

$$FF = a / (\Phi_e * m)$$

$$1/RT=((Sw * n) / (FF * Rw)) + (Vsh * Sw / RT\_Sh)$$

FF : Formation Factor
a : Turtuosity Factor
m : Cementation Factor
RT : True Resistivity
Sw : Water Saturation
n : Saturation Exponent
Rw : Water Resistivity
Vsh : Volume Shale
RT_sh : *Shale Resistivity*

7. *Permeability Calculation*

Permeability calculation use transform permeability method which determined by the relationship between core data and log data.

RESULT AND DISCUSSION

Formation evaluation of B sandstone has analyzed on 10 wells are T1, T2, T3, T4, T5, T6, T7, T8, T9, and T10.These wells were selected based on available logs (lithology, resistivity, and porosity), SCAL and well test data.

Permeable zone was identified by the normalized Gamma Ray log. Normalization is needed to equalize the range of measurement values GR log data that have different data distributions of 10 existing wells. After normalization, we get value 50 GAPI for GR min, 210 GAPI for GR max, and 61% for Vsh cut-off.

Hydrocarbon zones were identified using resistivity and porosity log. When filled with hydrocarbons, resistivity logs will show a high value and when filled with water will be low resistivity values, this is because the water is conductive and oil is resistive. The resistivity log from 10 wells on this field shows hydrocarbon zone ranges from 9-40 ohm.

Porosity was calculated by Neutron-Density method, the value of matrix Neutron and Density for dry and wet clay was determined by Bateman-Konen cross plot method. The accuracy to determine that value be affected by effective porosity from porous zone. Then, the result of porosity calculation from log will be validated with porosity from core data (picture 1). Based on the result from porosity calculation that validate with production data, the cut-off of porosity is 10%.

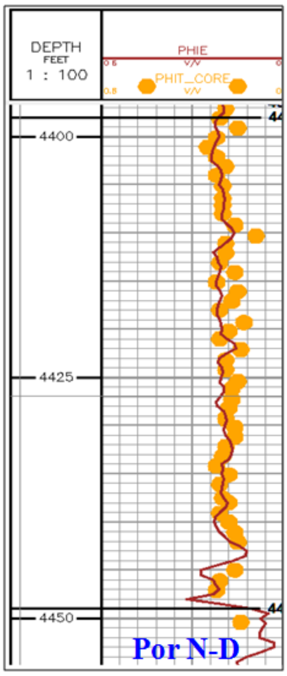

Figure 1. Validation between Porosity Log and Porosity Core

Water saturation was calculated by Simandoux method in equations (2) and (3) with a = 1, m = 1.603 and n = 1.763. This method is very effective to use on shally sand model such as B Sandstone to give the best result. The cut-off of water saturation is 60%.

Permeability value at Tri Field obtained using transform permeability method. It is determined based on equation from relationship between core data and log data. That equation can used to other wells which don't have core data and also to make permeability model. The permeability of B sandstone from lowest to highest is 240 – 6799 mD. This indicates that B sandstone has a good permeability.

Each property at 10 wells has been cut-off and give very good result (Table 1). From this table, we get 9-29% for Vsh, 22-27% for porosity and 19-60% for water saturation.

Table 1. Property of Reservoir at 10 Wells

No	**Well**	***Vsh* (%)**	**Porosity (%)**	***Sw* (%)**
1	T1	19	26	32
2	T2	11	25	19
3	T3	12	27	35
4	T4	14	27	23
5	T5	9	24	38
6	T6	9	27	22
7	T7	17	25	50
8	T8	27	23	52
9	T9	19	23	42
10	T10	29	22	60

Based on the evaluation result of Vsh, porosity, water saturation and support by production data, well location, and the distance of wells, there are two infill drillings that will be proposed. Well-I is located between T2 well and T4 well with coordinate x: 861600 and y: 106300. Top Structure Map of B sandstone shows that the distance between T2 well and T4 well is 350 m, and T4 well have a higher surface than T2 well (Figure 2). Well-II is located between T5 well and T6 well with coordinate x: 861240 and y: 106820. The distance between T5 well and T6 well is 350 m, and T6 well have a higher surface than T5 well (Figure 2).

Geology Cross section on Figure 3.a shows lateral continuity of B sandstone between T2-T4 wells and has relative same values of Vsh and porosity with low water saturation (Figure 3.b and 3.c).

Geology cross section on Figure 4.a shows lateral continuity of B sandstone between T5-T6 wells and has relative same values of Vsh and porosity with low water saturation (Figure 4.b and 4.c).

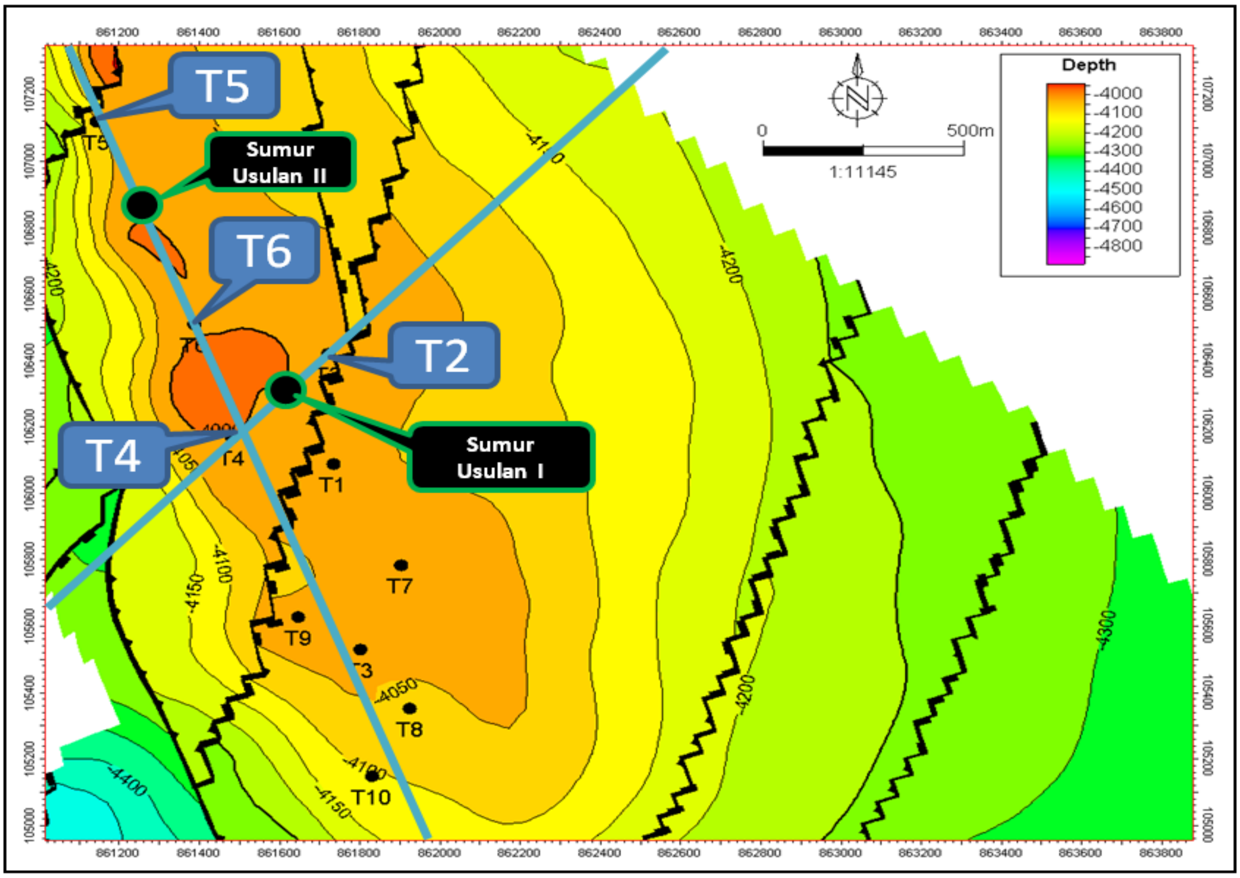

Figure 2. Top Structure Map of B Sandstone and Infill Drilling Proposed Location

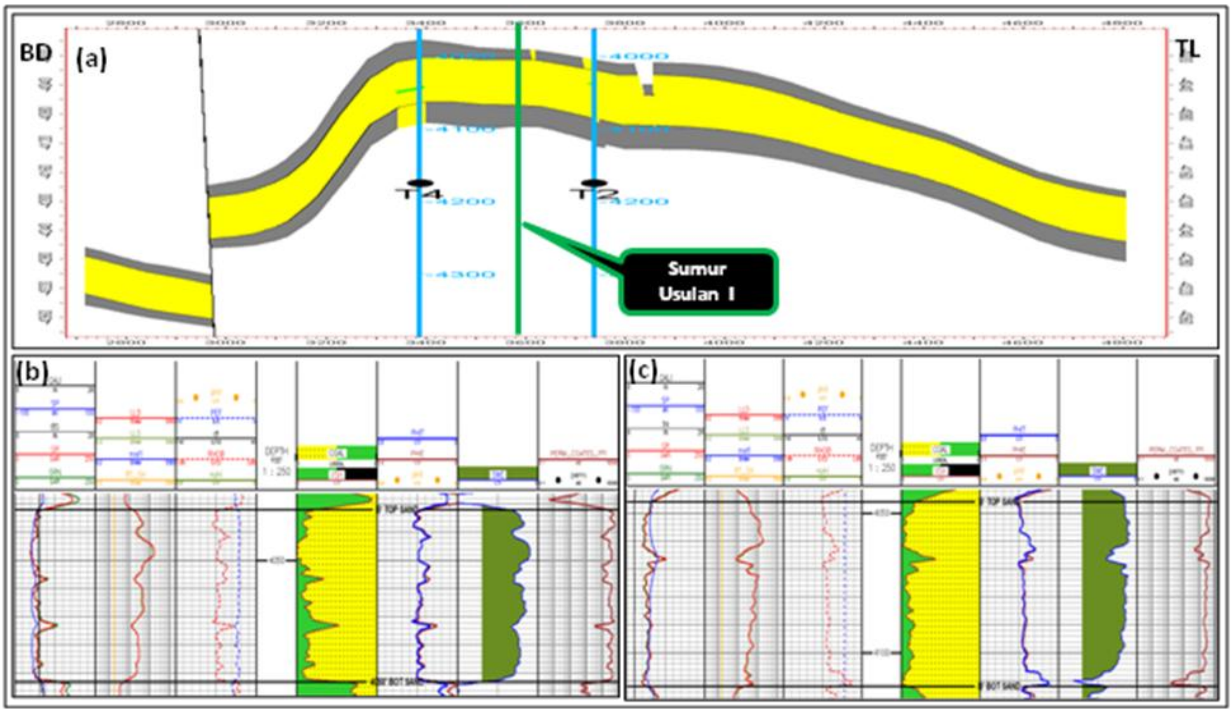

Figure 3. (a) Geology cross section between T4 and T2 wells, (b) Petrophysical Result of T4 well, (c) Petrophysical Result of T2 well

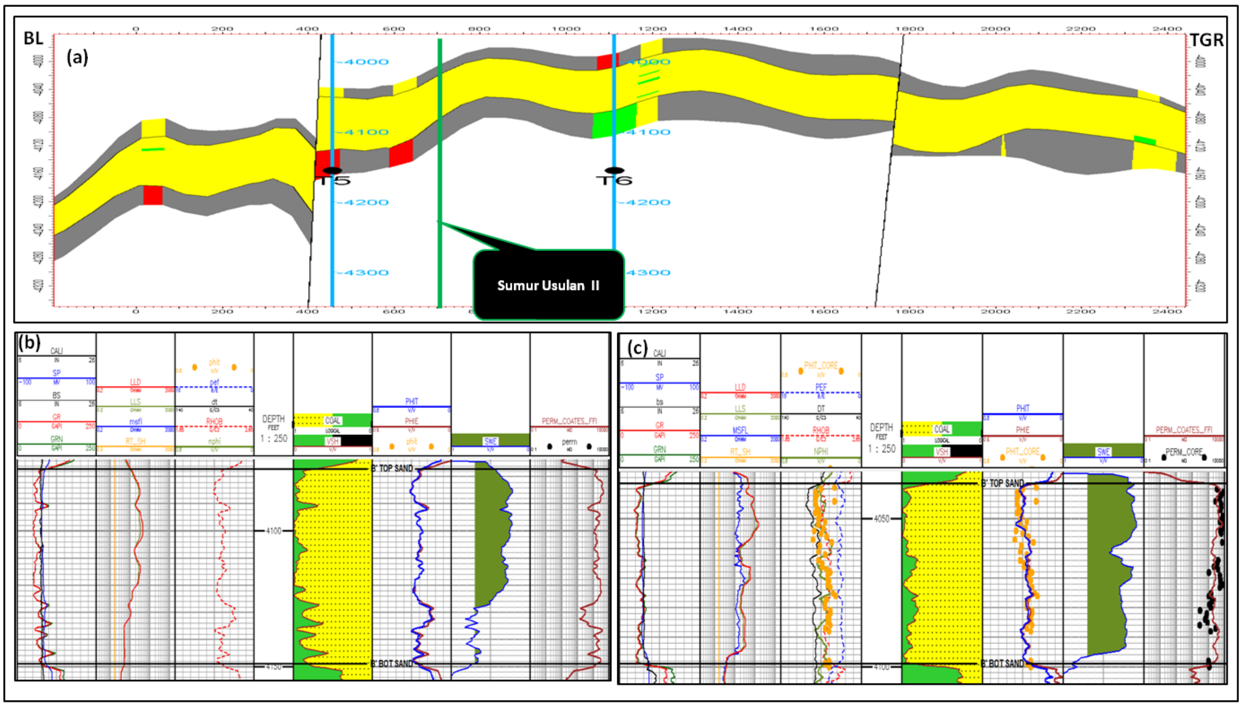

Figure 4. (a) Geology Cross section between T5 and T6 wells, (b) Petrophysical Result of T5 well, (c) Petrophysical Result of T6 well

CONCLUSION

1. B Sandstone layer at Tri Field has properties for Vsh is 9-29%, Porosity is 22-27%, Water saturation is 19-60%, and for permeability is 6799 mD.
2. Based on evaluation result of Vsh, porosity, water saturation, and support by production data, well location, and the distance of wells, there are two propose infill drilling.
3. Well-I is located between T2 well and T4 well with coordinate x: 861600 and y: 106300. Well-II is located between T5 well and T6 well with coordinate x: 861240 and y: 106820

REFERENCES

Bayu Cipto Aji, 2013, *Optimasi Pengurasan Cadangan Reservoir Dengan Metode Sumur Infill Berdasarkan Data Penilaian Formasi*, 08 November 2014, http://bayuciptoaji.wordpress.com/2013/5/25/optimasi-pengurasan-cadangan-reservoir-dengan-metode-*infill*-drilling-berdasarkan-data-penilaian-formasi/

Harsono, Adi, 1997, *Evaluasi Formasi dan Aplikasi Log*, Jilid 6 dan 15, Schlumberger Oilfield Services, Schlumberger oilfield services

Pratama, Yoga, 2010, *Metode Penentuan Lokasi Sumur Pengembangan untuk Optimasi Pengembangan Lapangan X dengan Menggunakan Parameter Porositas, Permeabilitas, dan Saturasi Minyak secara Semi-Analitik, unpublished*

Rider, Malcolm, 2002, *The Geological Interpretation of Well Log*, Chapter 8-10, Edition 2, Rider-French Consulting Ltd, Skotlandia

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Assessment of Aquifer Type on Hydrogeologic System on the Ngoro, Mojokerto District and Gempol, Pasuruan District

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ABSTRACT

Ngoro and Gempol District located on the northern of Penanggungan Mount, in East Java. This area there are a lot of stonesandy minings to support infrastructure development in East Java. Mining Industry is closely related to the hydrogeological system. In order for the mining activities do not interfere with the ground water, then the District of Ngoro and Gempol necessary hydrogeological assessment system

Research area found two types of aquifer that is unconfined aquifer are estimated in area of Wotanmasjedong Village, KunjorowesiVillage, ManduromanggunggajahVillage and Lolawang Village. The confined aquifer found in Jeruk PurutVillage area to western of Bulusari to Gedangsari Village. Caprock is claysandystone and andesitestone.The condition of the aquifers which in turn will be used as the pit bottom level of the mine.

Keywods: aquifers type, pit bottom level

INTRODUCTION

Ngoro and Gempol district located on the northern of Penanggungan Mount, and the border area between Pasuruan and Mojokerto regency. This area there are deposits of stonesandy potential to mine, which until now has been used for the embankment of Lapindo Mud Project and construction of toll roads, increasingly dangerous to the carriying capacity environment.

The decision of the Governor of East Java number : 123, year of 1997 on the closure Industry Minerals Mining Area in District Gempol, Pasuruan regency and district in District Ngoro, District Mojokerto regency, The rule decision has been revoked. While to date the legislation governing the permitted mining area boundary and not allowed to be mined in accordance with the rules of good mining and correct and environmentally sound, has not been published. This is what sparked the miners without permission or licensed to mine in the area tend to be the origin of mining without considering the hydrogeological system. The second concern, the impact caused by mining is subsidence of land surface water (wells), which is based from 2003 until 2009, decreased water level reaches 9 meters (Nusanto Gunawan, 2009). The thing that is important is the sustainability of the management of post-mining.

The aim is formulated based mining limits the carrying capacity of the environment which includes the parameters of lithology, hydrogeology and geotechnical. The result of this formula further disseminated so that people open their knowledge and understanding of disasters that may occur and how mitigation.

Review of the literature shows the study area has the potential area contained water that can be used at any time, but also a difficult area of water in the dry season. Libraries are:

1. Bemmelen R.W. Van, (1949), stating that the local stratigraphy Ngoro, Gempol and Trawas consists of three rock units are units that irreducibly volcanic rocks (pyroclastic deposits), the unit of andesite-basalt lava rocks and alluvial deposits. The composition of bedrock and overburden from the young to the elderly can be sorted

along with the following physical properties:

a. The units of andesite-basalt lava rock

Physical properties owned on this unit is color - gray-black, fine grained - medium, hard, jointly, decaying low - medium and medium graduation - high and dug hard and hold on steep slopes.

b. Pyroclastic deposits

Generally lithologies blackish gray, somewhat compact, low decay, high graduation, rather easy-difficult excavated and somewhat resistant to the steep slope. Soil cover is generally in the form of yellowish brown silty sand, soft, fine-coarse grained, gravel, low plasticity and passing water-moderate medium-high and thin soil between 0.50 to 1.00 meters.

2. Nusanto Gunawan, 2009, in the study area on the slopes of the mountain is quite steep with slope> 15 degrees until the top of the mountain is the catchment rainy areas. For District Ngoro is located at the southern part of Mount jacks, Genting Mountain, Mount Gajahmungkur, Mount Kemuncup and at Mount Penanggungan as a parent. As for the District of Gempol there is in the southern part of Mount Penganggungan, Mount Kemuncup, Mount Wangi, Mount Welirang, Mount Prahu and Mount Arjuna.

3. Gunawan Nusanto 2009, another area that is very possible to be a source of water for the dry season in the surrounding area is Mount Prau. Mount Prau is elongated hill which has an area of approximately 900 hectares, located on the edge of the highway Gempol - Mojosari. With the repeal the decision of the Governor of East Java, concerning in allowing no new mining licenses in the region and Gempol Ngoro, then Mount Prau is an area of great potential and is a target for miners.

4. Down C (2001), Djauhari Noor (2005), stating the change of landscape from mining will affect the decline in the face of the ground water. The observation Gunawan Nusanto 2009, showed that the water level of the wells in the study area of 9 meters (data PODES, 2009), then in 2009, the decline in ground water level reaches 18 meters, so the decrease in depth of 9 meters.

METHODS

The research methodology will be implemented in the study of mining by basing arrangement and management of post-mining hydrogeology include a series of good work in the field, the laboratory and in the studio which includes: preparation of the study, review the survey, mapping, geophysics, aquifer distribution pattern, analysis and formulation of results research, and conclusions.

Hydrogeological studies

Hydrogeological study intended to determine the model of the aquifer that are in the area, which is then used as a reference in determining the limits or boundaries vertical feasibility depth of pi bottom level. Besides, this study aimed to determine the function of the area in relation to the carrying capacity of the environment as a function of recharge area. Geological observations made to determine the condition of the local geology, structure bedding, bedrock and deployment model of sand, stone and gravel based on existing data. Geological mapping carried out by making the lines in accordance with the conditions of observation lithology, structure and geological processes that develop in these areas, and based on the research that has been done before.

Mapping and geoelectric resistivity

Investigations of geoelectric resistivity method will provide an overview of rock properties and rock containing water is based on resistivity value of the electric current is delivered to the underground. To know the difference and spread each layer resistivity subsurface rocks both vertically and horizontally as outlined in the geological cross-sectional shape of the detainees kind. In this investigation have been according to the rules of the Schlumberger electrode arrangement with a distance AB / 2 and MN/2, Voltage difference, current electricity. The parameters are calculated apparent resistivity and geometry factors . Due to the state of geometric factors that are always changing the magnitude of apparent resistivity (Pa) can be calculated by formula is:

$$\rho a = \frac{\Delta V (AB^2 - MN^2)}{I (MN)}$$

where:

ρa = apparent resistivity (Ohm m)
Δ V = voltage difference (volts)
AB = distance between the two current electrodes (m)
MN = distance between the electrode potential (m)
I = current electricity (amperes)

The interpretation of the data field resistivity method is done by connecting the physical properties of rock conditions.

RESULTS AND DISCUSSION

Characteristics of aquifers.

Layers and aquifers in the District Ngoro Gempol largely a porous aquifers composed of sandstone that are local. Groundwater level is the fluid pressure in the pores of a porous medium is equal to the atmospheric pressure is defined as the groundwater level in the unconfined aquifer (Kodoatie, 2012). High groundwater level is equal to the water level in the well. Based on the height of groundwater level, the aquifers in the District Ngoro and Gempol classified as not depressed or unconfined aquifer. But in some areas there is a confined aquifer.

a. The village area Lolawang

Description of the results of the geoelectric data interpretation above attributed to regional geology order to obtain the results of further analysis that found in the village of Lolawang possibility of groundwater, the shallow aquifer with low potential. Shallow depths and dimensions are not great with low potential. The depth of the aquifer is 8.36 to 23 m with the type of silty sand lithology, aquifer thickness of 14.6 m.

b. The village area Wotanmasjedong

This area there is a point of local aquifers with shallow depth and dimension that is not great with low potential. Aquifer is relatively shallow depth of 5.18 to 6.08 m with a silty sand lithology type, thickness is relatively thin aquifer that is 0.9 m. So low groundwater potential and is not a deep aquifer.

c. *The village area Manduromanggunggajah*

Aquifer is relatively shallow depth of 4.46 m with 2,7- lithology types silty sand, is relatively thin aquifer thickness is 1.76 m. On top of a layer of silty sand, in this area there are andesite, so here is confined aquifer. The aquifer is evidenced by the presence in the village artesian Manduromanggunggajah ini. So, groundwater potential in this area is relatively large.

d. The village area Wonosonyo

The depth of the first relatively shallow aquifer is 2.19 to 5.21 m with a silty sand lithology types, relatively thin aquifer thickness is 3.02 m. Then the second aquifer is relatively deep, ie at a depth of 11.7 to 23 m with a thickness of the aquifer is relatively thick and 11.3 m. Potential groundwater in the second aquifer is relatively large but the condition inside.

e. The Village area Sumber Tetek

Aquifer has sufficient depth and dimension in the large, but the potential is small. Relatively shallow depth of the aquifer is 9.15 to 16.9 m with a silty sand lithology type, thickness is relatively thin aquifer that is 7,75 m. With the potential for groundwater in this area is relatively small.

The condition can be interpreted visual field area affixes, loose or discharge area, the area with the type of unconfined aquifer, and confined aquifer. Areas affixes expected in the area over the hillside with a slope of> 25% is in Mount Bekel, Mount Genting, Mount Gajahmungkur, Mount Kemuncup and at Mount Penanggungan as its parent. As for the District of Gempol there is in the southern part of Mount Penganggungan, Mount Kemuncup, Mount Wangi, Mount Welirang, Mount Prahu and Mount Arjuna. Aquifer is estimated in the confined eastern Gempol. This is indicated by the expanse of andesite in the northern part of which is the cap rock. While in the west or east area Ngoro an unconfined aquifer.

Analysis of Water Quality

The potential level of Quality Criteria in District Ngoro by comparing the spread of element content of Fe, Mn and acidity level (pH). The dissemination of the content of other elements or compounds such as: Cl, NO_3, NO_2, SO_4, and TDS concentrations are not increased or is still below a predetermined threshold.

Groundwater quality conditions are taken at UTM coordinates 49 MN 9.16119 million; E 0685075 (Ngoro) and N 9.16049 million; E 0684226 (Gempol), indicating that the physical, chemical and biological remains below the threshold of PP 82001 for drinking water quality class II.

CONCLUSION

From the results of the study while it can be concluded that:

1. The study area, there are two types of aquifers, namely:
   a. Confined aquifer layer, ie at a depth of 8-10 m, from the surface of the surrounding land is located in the District of Gempol east, precisely Bulusari village, the village of Jeruk Purut, District Gempol. Aquifer thickness ranges from 5-10 m.

   b. Unconfined aquifer layer is at a depth of 2.9 m with a thickness of 11.7 m. Aquifer layers are generally composed of a layer of Sandstone and Sand Clay.
2. Areas affixes expected in the area on the hillside with a slope of> 25% is in Mount Bekel, Mount Genting, Mount Gajahmungkur, Mount Kemuncup and at Mount Penanggungan as a parent. As for the District of Gempol there is in the southern part of Mount Penganggungan, Mount Kemuncup, Mount Wangi, Mount Welirang, Mount Prahu and Mount Arjuna.

3. From the analysis of water samples, water quality in the study area including the second quality and deemed to be used as drinking water.

REFERENCES

Bemmelen R.W. Van, (1949) The Geology of Indonesia, Vol IA, Martinus Nijhoff, The Hague.

Down C,. Stocks, 2001, Environtmental Impact of Mining, Applied Science Publishers, London.

Djauhari Noor., 2005, Environmental Geology, Graha Science, Yogyakarta

Gunawan Nusanto, 2009, Technical and Environmental Evaluation of Stonesandy Mining, PT Karya Mitra Sejati, Ngoro, Mojokerto.

Gunawan Nusanto, 2009, Evaluation of Technical and Environmental Stonesandy Mining, PT Imasco, Gempol, Pasuruan.

ACKNOWLEDGEMENTS

1. DP2M-Higher Education that has funded research grants in this competition.
2. Fendy and Ferry which helps a lot of work in the field.

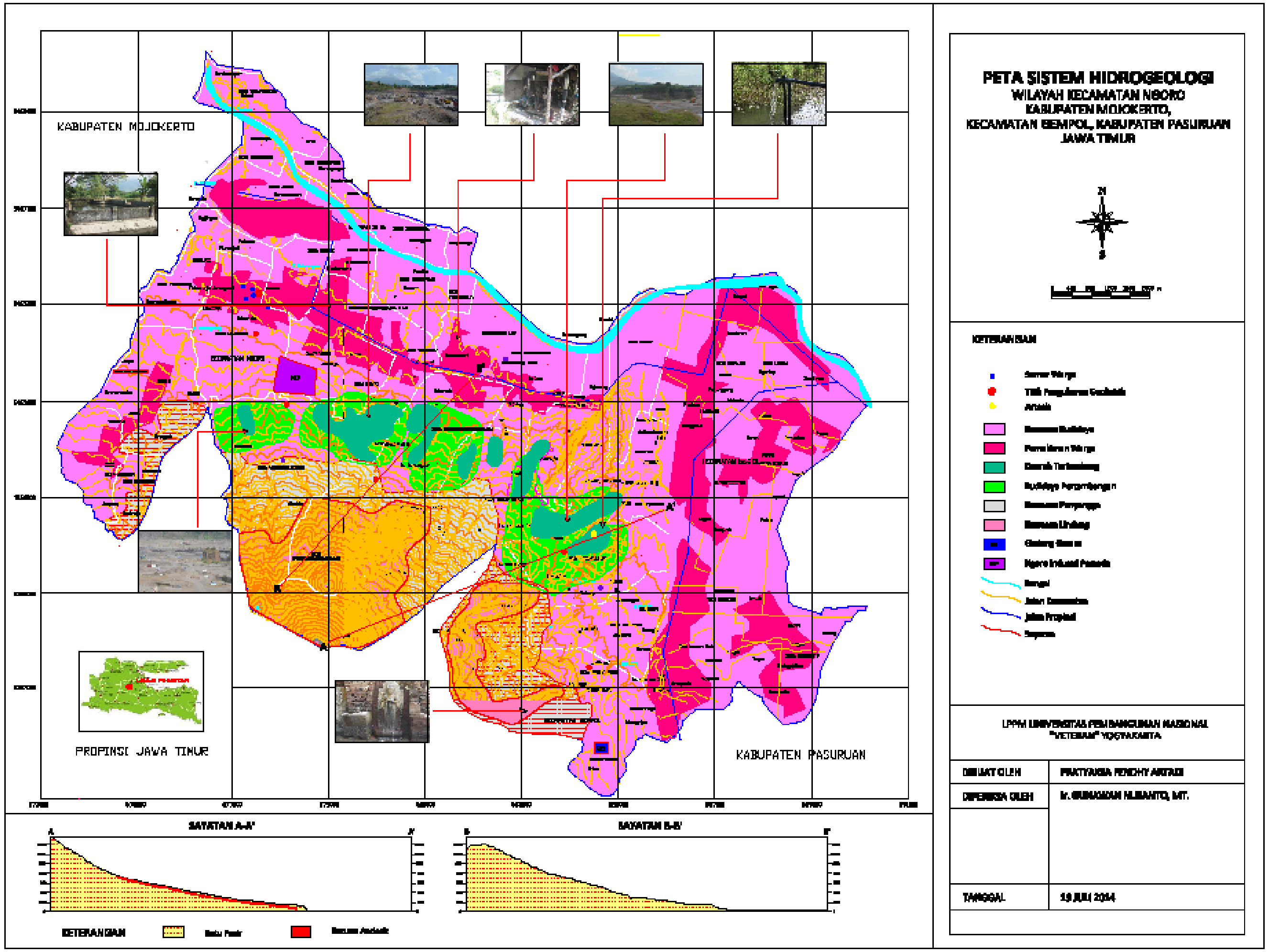

Figure 1. Hydrogeology System Map

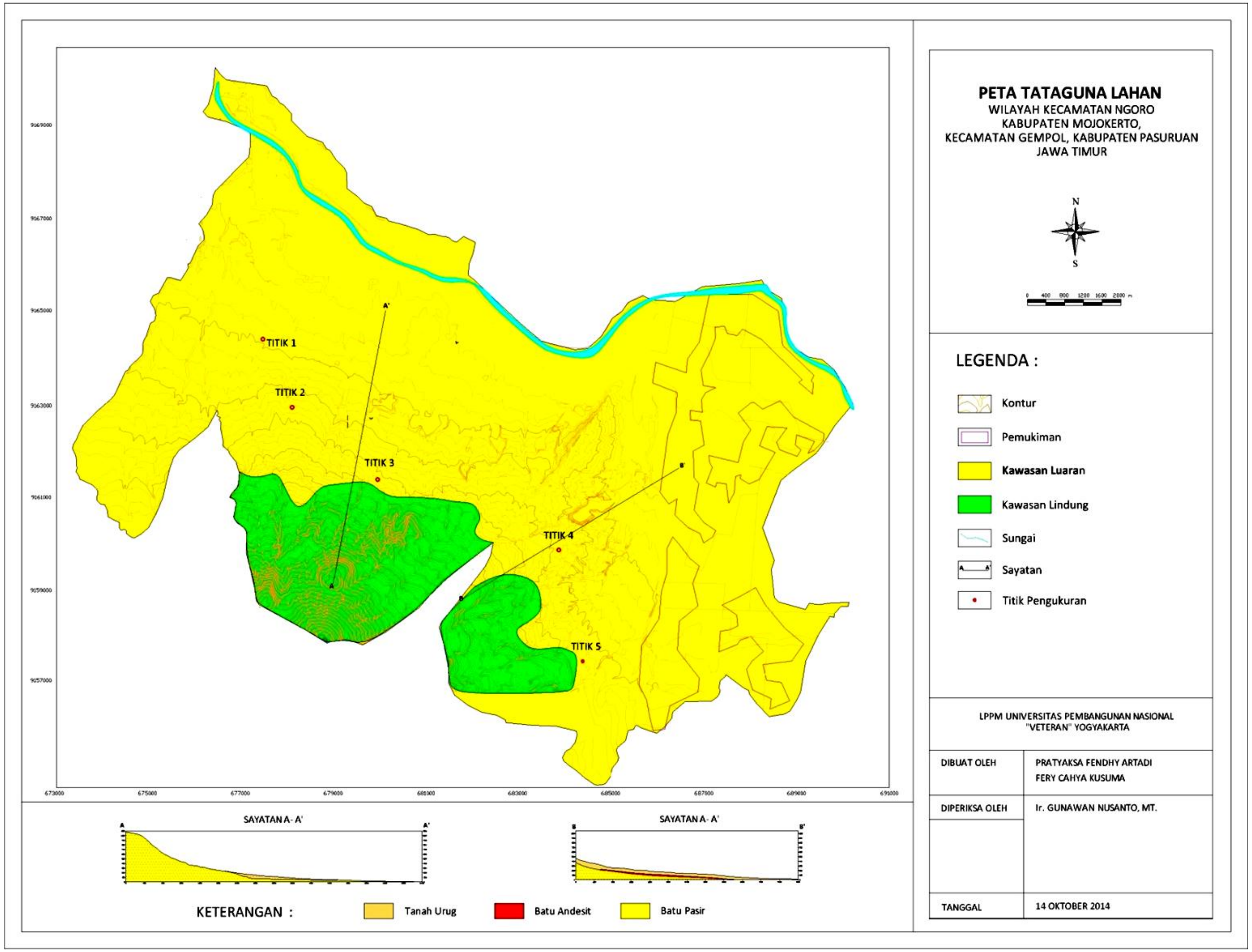

Figure 2. Landuse Map

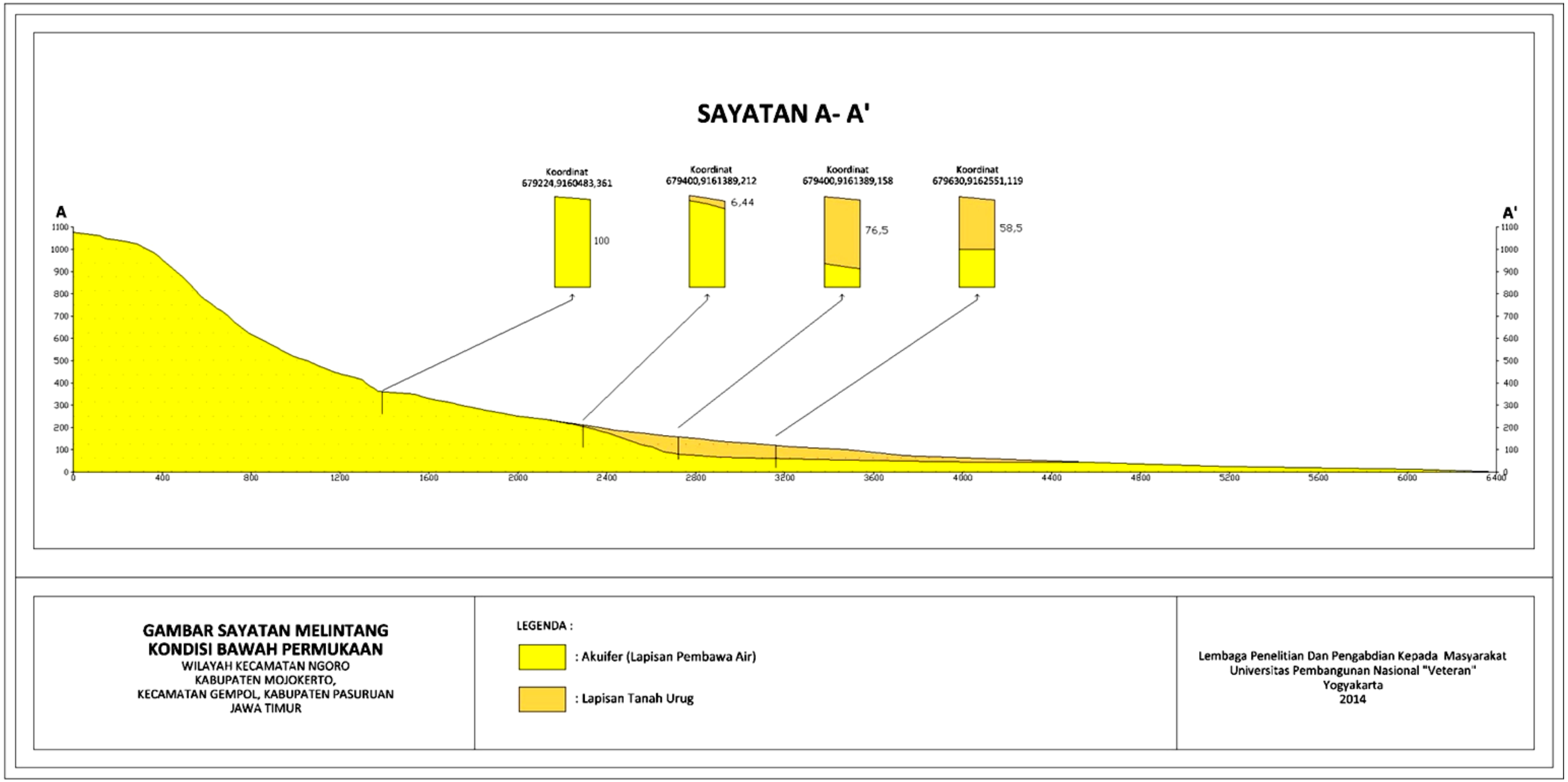

Figure 3. A-A' Profile

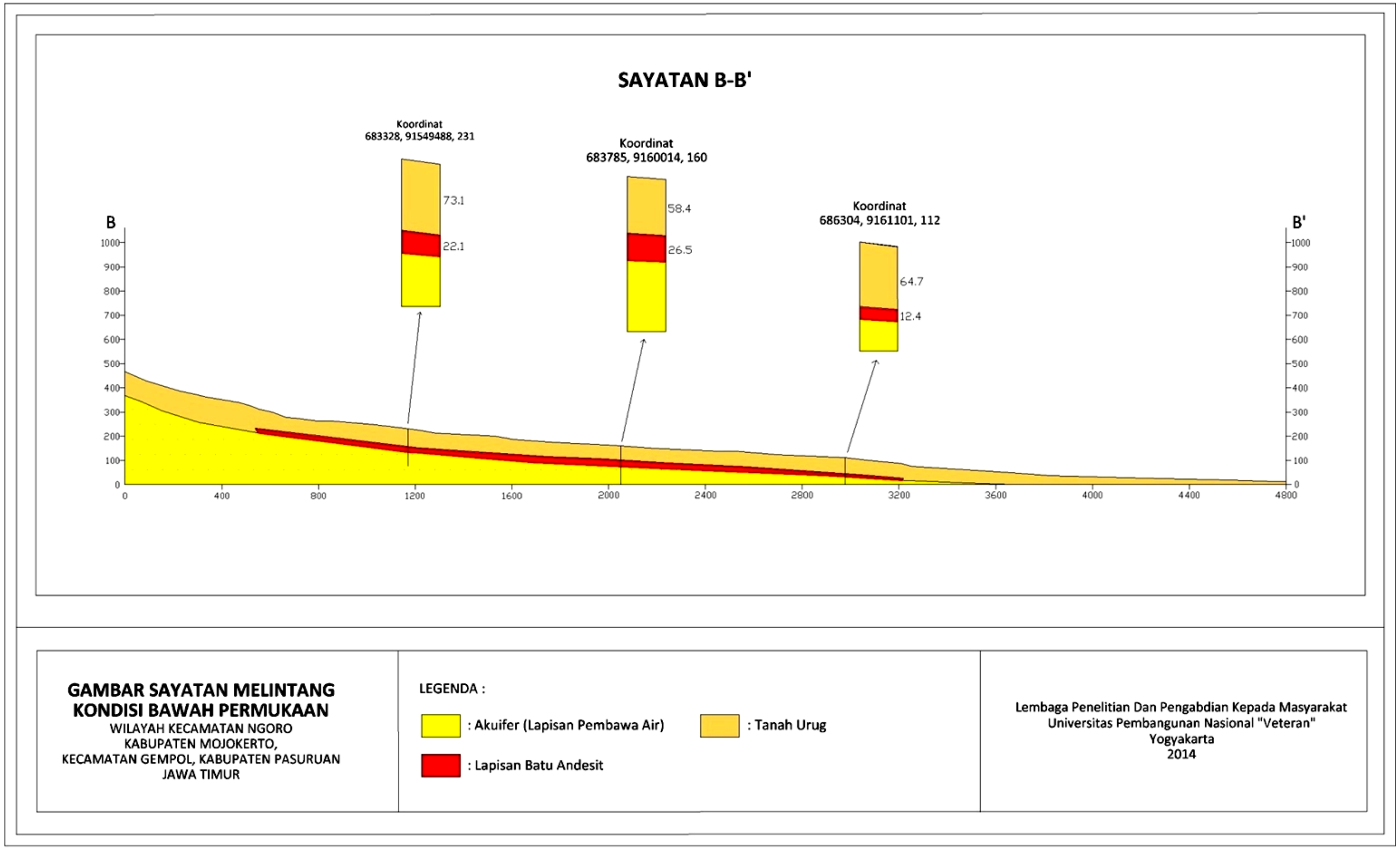

Figure 4. B-B' Profile

Application of Geomagnetic Method to Identify the Distribution of Dacite Igneous Rock in Mount Siwareng, Sleman Regency, Special Region of Yogyakarta

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ABSTRACT

The geological map of Godean area in Yogyakarta region consists of volcanic rocks of Oligocene-Miocene age. A number of igneous rock outcrops are found in this area, specifically in Mount Siwareng, Dusun Margodadi, Desa Sayegan area, where an intrusion of dacite igneous rock can be found. This kind of rock tends to have higher value of magnetic property compared to its surrounding rocks, hence to identify the distribution of dacite igneous rock, the geomagnetic method is applied. The geomagnetic method is a passive geophysical method typically used to understand the condition of underground rock according to the susceptibility value of the rock. Susceptibility is a measure of the extent to which a medium may be magnetized in relation to the lithology and mineral composition. Data sampling was conducted in the area with the coordinates of X=420330-420530 and Y= 9144166-9144489. Data processing was done using the software Excel and Geosoft Oasis Montaj, and 3-D modeling was done using the software Magblox, Bloxer and Rockwork. According to Total Magnetic Field Intensity map, it appears that dacite igneous rock has relatively higher value than its surrounding rocks, which ranges from 140 to 240 nanoTesla, and is located on the northwest side of the research site in radial pattern. According to Reduce to Pole map interpretation, the center of intrusion is located approximately on the west side of the research site. Based on the 3-D modelling, dacite rock has susceptibility value of about 0.5 (SI), and the surrounding rocks (sedimentary rocks) susceptibility value of about 0.0005 (SI). The dacite rock is located on the west side of the research site, spreading to the north. The dacite distribution is roughly 160 meters wide in diameter and about 90 meters deep below ground level.

Keywords: geomagnetic, susceptibility, 3-D modelling, dacite

INTRODUCTION

Outcrops of dacite igneous rock intrusion of approximately Oligocene-Miocene age can be found in Mount Siwareng, Dusun Margodadi, Desa Sayegan, Kecamatan Godean, Kabupaten Sleman, Yogyakarta. To identify this rock intrusion, a geophysical survey is done using geomagnetic method. The geomagnetic method is a geophysical method typically used for early survey in exploration of oil and other valuable minerals. Data collected on field produce graphs and magnetic field anomaly map. Magnetic field anomaly is caused by the result of a magnetic force oscillating with Earth's magnetic field. Magnetic induction anomaly is the result of external magnetic induction in an iron sulfide by Earth's magnetic field. The shape, dimensions and amplitude of an induction anomaly is a function of orientation, geometry, size, depth and magnetic susceptibility of a material as well as the intensity and inclination of the Earth's magnetic field on the surveyed area. In other words, this method is applied in accordance to the susceptibility of the rock.

GEOLOGICAL BACKGROUND

The local geology of the research site is generally dominated by young volcanic sediments (Wartano Raharjo, 1995). An isolated mountain (Figure I) can be found in this area, which consists of volcanic rocks of Oligoene-Miocene age. Volcanic rocks are dacite rocks (Figure II) presumably intruding from Nanggulan Formation, which is mostly composed of sedimentary rocks.

Figure I. Research site

Figure II. Dacite outcrop

LITERATURE REVIEW

Magnetic Force

In magnetics, there are two types of charges, positive charge and negative charge. These charges fulfill Coulomb Law. Opposite charges attract each other, and like charges repel each other with force F. Magnetic method is based on Coulomb Force (Figure III) between two magnetic poles q1 and q2 having distance r in the form of

$$F = \frac{q_1 q_2}{\mu r^2} \hat{r}$$

where μ is the magnetic permeability, which values 4 π x 10^{-7} w / A.m in vacuum. F is Coulomb Force (N), q_1 and q_2 are magnetic pole magnitudes (A/m), and r is the distance between the two poles (m).

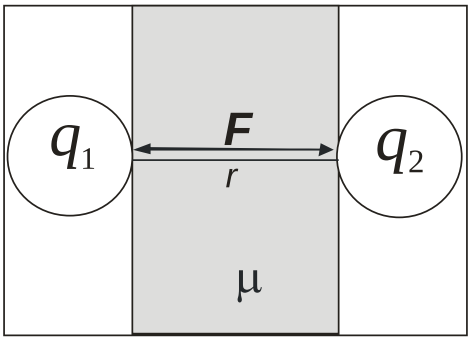

Figure III. Magnetic force between two particles of mass q_1 and q_2

Magnetic susceptibility

The parameter used in this method is susceptibility. Susceptibility is a measure of the extent to which a medium may be magnetized. This value increases as more magnetic minerals are found in the rock. Factors affecting the value of susceptibility include

- Rock lithology
- Mineral composition of the rock

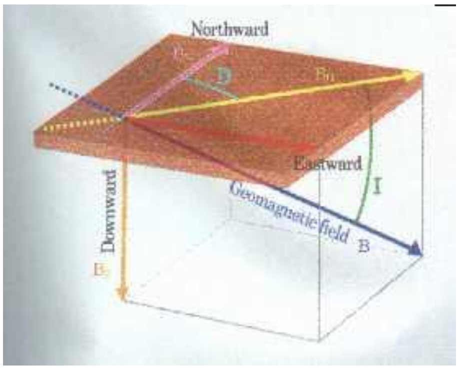

Figure IV. Elements of Earth's magnetic field

Earth's magnetic field is characterized by physical parameters, named magnetic field elements (Figure IV) having quantitative properties such as the direction and magnetic intensity. Those parameters include:

- *Declination (D)* - the angle between magnetic north and horizontal component measured from north to east.
- *Inclination (I)* - the angle between total magnetic field and horizontal plane measured from horizontal plane to vertical plane downwards.
- *Horizontal Intensity (H)* - the total magnitude of horizontal magnetic field.
- *Total Magnetic Field (F)* - the total magnitude of magnetic field vector.

Data Correction

To obtain the survey target, i.e magnetic field anomaly, the previously sampled magnetic field data must be corrected from the effects of other magnetic fields. General methods of correction used in magnetic survey include:

- Daily correction (*H var*)
  the correction to remove the influence of external magnetic field (of the sun and moon) from measured magnetic data (*H*).
- IGRF correction (*Ho*)
  the correction to remove the influence of Earth's main magnetic field from measured magnetic field data.

The value of magnetic anomaly (ΔH) in a rock's magnetic field intensity can therefore be expressed as:

$$\Delta H = H - Ho - Hvar$$

Data Processing Filter

- *Reduce To Pole* (RTP)
  The total magnetic field data are then reduced to pole so that the maximum magnetic field anomaly is located exactly above the body of the source of anomaly (anomaly is monopole).

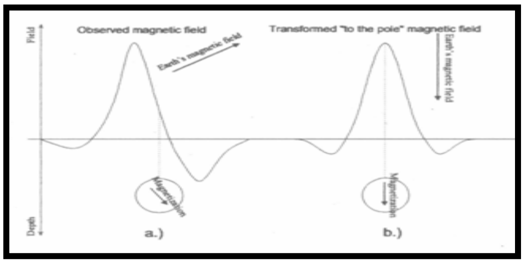

Figure V. *Reduce to Pole*

- *Upward Continuation*
  A process of converting the measured potential field data to higher surface level than the location of measurement. This process is done for easier interpretation by reducing the effect of noise.

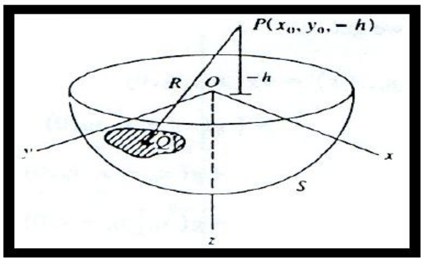

Figure IV. Upward Continuation Filter

METHODOLOGY

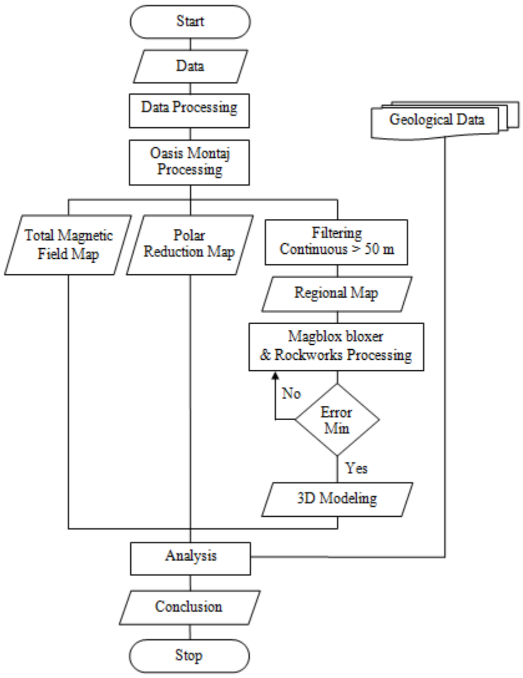

Figure VII. Data Processing Flowchart

The research was conducted on May 24-25, 2014 at 07.00-15.00 WIB in Mount Siwareng area, Dusun Margodadi, Desa Sayegan, Kecamatan Godean, Kabupaten Sleman, DIY. The tool used is PPM G-856. The first step of magnetic data collecting is data acquisition. Data acquisition began with getting geology information in the form of survey design to determine the point and length to measure. The software Excel was used in data processing to calculate the value of Ha. The obtained value of X, Y and Ha are then processed using the software Geosoft Oasis Montaj to produce total magnetic field map, reduction to pole, and regional continuity map 50 meter upwards. Three-dimensional model was processed using Magblox and displayed using Rockwork15. The result is re-modeled in case the result produced does not match. The produced maps and model are then analyzed with the help of geology data of research site to draw the conclusion.

RESULT AND DISCUSSION

Total Magnetic Intensity Map

Figure VIII shows the distribution of magnetic intensity in Mount Siwareng area. Igneous rock intrusion is predicted to have medium to high magnetic anomaly value, as its mineral composition has higher magnetic property than the surrounding rocks. These surrounding rocks are presumed to be sedimentary rocks which have lower intensity since the mineral composition has lower magnetic property. A high range closure of 140-240 nanoTesla can be seen on southwest side (marked in circle) on the map indicating distribution of igneous rock intrusion. Nevertheless, this map is still affected by dipole characteristic of Earth's magnetic field; its central location still cannot be interpreted.

Reduce to Pole Map

After filtering the data by changing dipole effect into monopole, so that the position of anomaly is exactly above its maximum anomaly magnetic field. According to the map (Figure IX), the central location of intrusion is indicated to be on the west side of research site (marked in circle) and spreading relatively to the north.

Regional Upward Continuation 50 m Map

The above map (Figure X) shows that by rising regional map by 50 meters, the effects of local anomaly and noise are relatively removed. In this map, the value of magnetic intensity having depth profile in research site can be seen. Two closures of high value can be found on the west side of research site (marked in circle) and one closure of low value can be found on the southeast. This justifies that the center of igneous rock intrusion is located on the west side of research site as its magnetic property is higher than its surrounding rocks'.

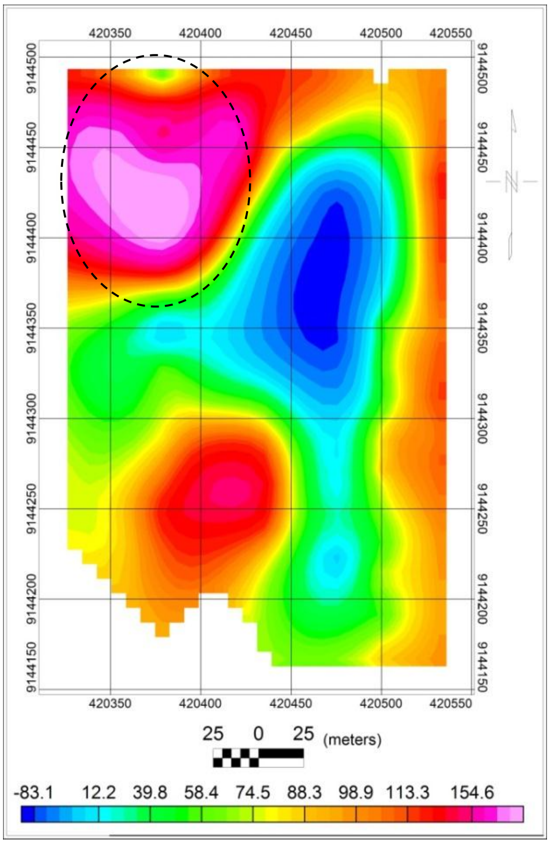

Figure VIII. Total Magnetic Intensity Map

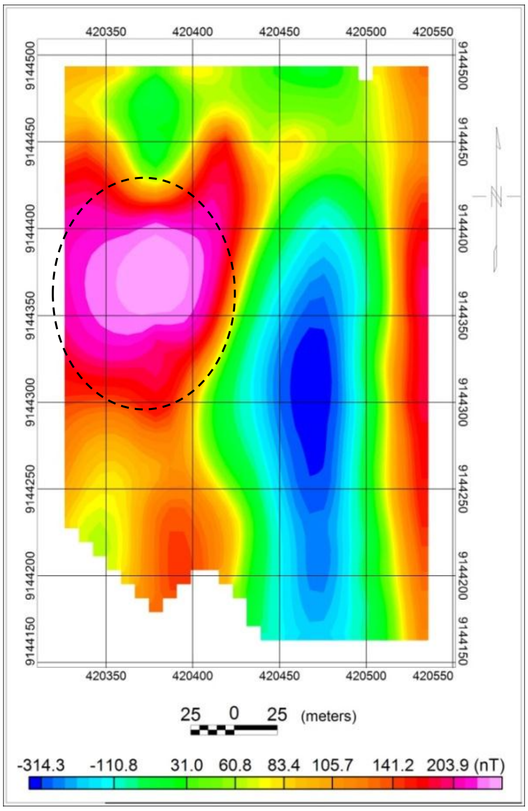

Figure IX. *Reduce to Pole Map*

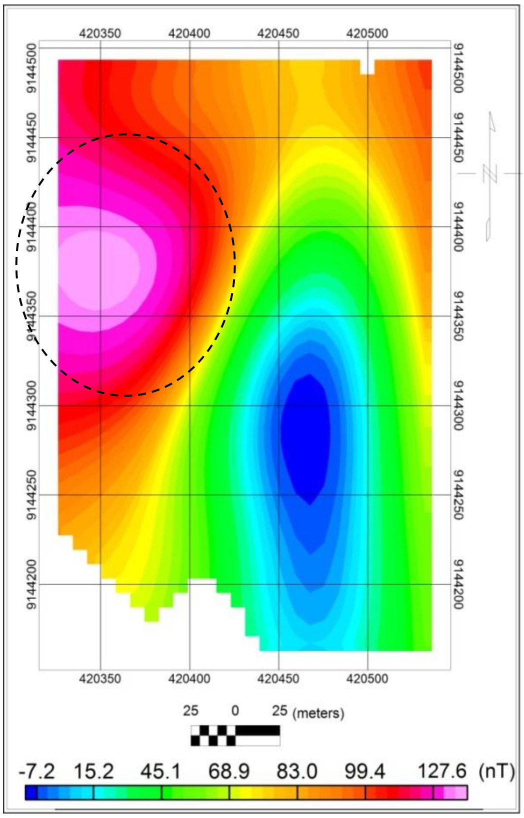

Figure X. Regional *Upward Continuation* 50 m Map

The above map (Figure X) shows that by rising regional map by 50 meters, the effects of local anomaly and noise are relatively removed. In this map, the value of magnetic intensity having depth profile in research site can be seen. Two closures of high value can be found on the west side of research site (marked in circle) and one closure of low value can be found on the southeast. This justifies that the center of igneous rock intrusion is located on the west side of research site as its magnetic property is higher than its surrounding rocks'.

3-D Modeling

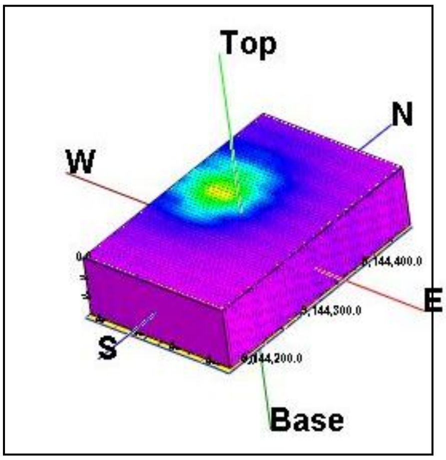

Figure XI. Three-dimensional modeling of dacite igneous rock and sedimentary rock

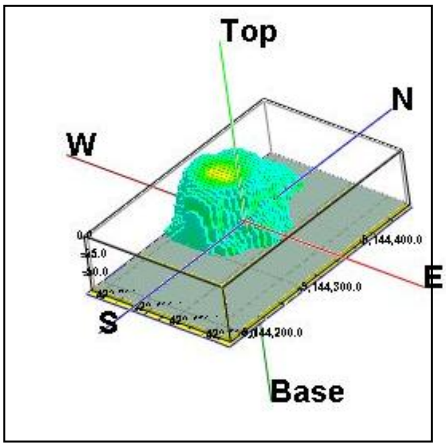

Figure XII. Three-dimensional modeling of dacite igneous rock

The model above is formed based on the susceptibility parameter of the rock (figure XI and XII). Dacite igneous rock has susceptibility value of about 0.5 (SI), and the surrounding rocks (sedimentary rocks) susceptibility value of about 0.0005 (SI). These values are classified by the Telford table (1979). The dacite rock is located on the west side of the research site, spreading to the north. The dacite distribution is approximated to be about 160 meters wide in diameter and about 90 meters deep below ground level.

CONCLUSION

Based on the research conducted in Mount Siwareng area, Godean, DIY, it can be concluded that the intrusion has radial shape, spreading on the southwest side of research site. The intrusion has magnetic anomaly value ranging from 140 to 240 nT and susceptibility value of approximately 0.5 (SI). The center of intrusion is on the west side of research site, roughly 160 meters wide in diameter and spreading up to 90 meters deep below ground level.

REFERENCES

[1] Billim, F., and Ates A, *Analytic signal inferred from reduced from pole data: Jornal of Balkan Geophysical Society*, 6 (2), 66-74. 2003.

[2] Telford, W. M., Geldart, L.P., and Sheriff, R.E, 1979, *Applied Geophysics*, Cambridge University Press, Cambridge.

[3] Wartono Raharjo, Peta Geologi Lembar Yogyakarta Jawa, Pusat Penelitian dan Pengembangan Geologi, 1995.

[4] Yopanz, 2007, *Metode-Metode Geofisika*,http://yopanz.blogspot.com[online access April,5 2013]

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Application of Geology in Studying Groundwater System Beneath Gunung Kendil and Umbul Ponjong in Ponjong District, Gunungkidul

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ABSTRACT

Gunung Kendil is one of the karst hills located in the district of Ponjong, Gunung Kidul regency (8°00'56.64"S, 110°44'18.32"E). This hill is situated approximately 400 meters north of Ponjong District and about 20 km east of Yogyakarta.

Gunung Kendil is composed of bedded-limestone in the bottom part, chalky limestone, massive limestone with conduits, and reef limestone at the top. These rocks are included in Wonosari Formation, which is formed in Middle Miocene age (10-16 million years).

Groundwater system beneath Gunung Kendil is controlled by fractures, faults and bedding. The normal faults below Gunung Kendil are northeast-southwest trending almost facing each other forming a large subsidence. Cross cutting of the two normal faults and the bedding that is gently sloping to the north beneath Gunung Kendil form an underground river flowing toward the southwest and out as springs at the front of the Village Ponjong, called Umbul Ponjong (Sumbergiri) (7°58'34.39"S, 110°44'06.89"E).

The spring is very beneficial to people's lives in the village of Ponjong. At this time Umbul Ponjong already managed by the Regional Government of Gunung Kidul as a unique and interesting tourist area and geological heritage.

Key words: Gunung Kendil, groundwater system, fault, Umbul Ponjong.

RESEARCH BACKGROUND

Gunung Kendil is one of the karst hills located in the district of Ponjong, Gunung Kidul regency (8°00'56.64"S, 110°44'18.32"E). This hill is situated approximately 400 meters north of Ponjong District and about 20 km east of Yogyakarta (Figure 1).

Gunung Kendil is composed of bedded-limestone in the bottom part, chalky limestone, massive limestone with conduits, and reef limestone at the top. These rocks are part of Wonosari Formation, formed in Middle Miocene age (10-16 million years).

Ground water in Gunungkidul, specifically in Gunung Kedil is generally hard to find, especially in long dry season. Therefore, it is necessary to discover groundwater channels to help the people of Gunung Kendil, Desa Ponjong, Kecamatan Ponjong, Kabupaten Gunung Kidul. This is needed for drilling so that the water can be utilized by its people.

Groundwater system beneath Gunung Kendil is controlled by fractures, faults and bedding. The normal faults below Gunung Kendil that are northeast-southwest trending almost facing each other forming a large subsidence. Cross cutting of the two normal faults and the bedding that is gently sloping to the north beneath Gunung Kendil form an underground river flowing toward the southwest and out as springs at the front of the Village Ponjong, called Umbul Ponjong (Sumbergiri) (7°58'34.39"S, 110°44-'06.89"E).

The spring is very beneficial to people's lives in the village of Ponjong. At this time Umbul Ponjong already managed by the Regional Government of Gunung Kidul as a unique and interesting tourist area and geological heritage.

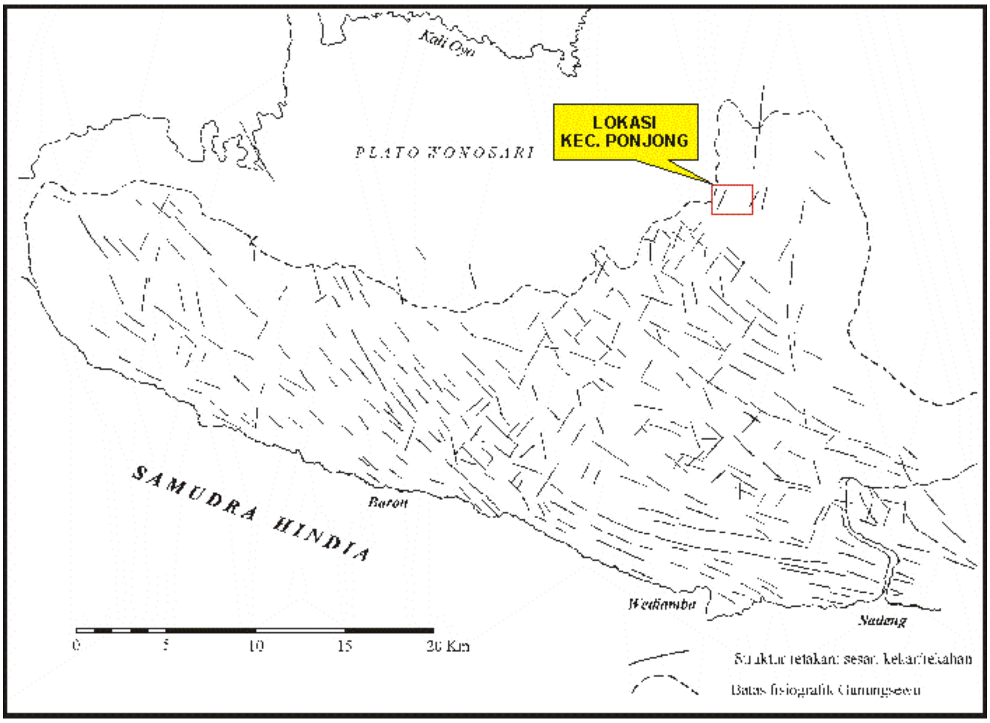

Figure 1. Location of Ponjong District, Gunungkidul

OBJECTIVES

The goal of this research is as follows:

1. To study the groundwater system beneath Gunung Kendil
2. To determine drilling location of well
3. To help developing Gunung Kendil area as a Tourism Village

LITERATURE REVIEW

Gunungsewu

Gunungsewu is the largest tropical karst landscape in Northeast Asia. This area is part of East Java Southern Mountains, in Gunungkidul Regency (DIY), Wonogiri and Pacitan Regency (Central Java). Geographically, Gunungsewu is situated between 6^o 10’ to 6^o 30’ LS and 99^o 35’ to 100^o BT, approximately 25 km southeast of Yogyakarta, 109 km north-northwest of Pacitan, and 20 km southwest of Wonogiri. Gunungsewu has a total area of approximately 800 km^2. This area can be easily accessed from Yogyakarta-Wonosari, Wonogiri and Pacitan, and also established as one of tourism destinations, by Regional Government of DIY as well as Central Java (Figure 2).

Gunungsewu area has an interesting geological phenomenon, a beautiful karst geomorphology, a unique hydrogeology, a breathtaking view, and also a number of geology heritage sites supporting a geopark area. This is what encourages this paper to be written, based on the research supported by LPPM UPN “Veteran” Yogyakarta, to understand the groundwater system specifically in Gunung Kendil, and generally in Southern Mountains.

GEOLOGY OF GUNUNGSEWU

According to van bemmelen's physio-graphical map (1949), gunung sewu is part of east java southern mountains, which is divided into baturagung, panggung, and plopoh in the north, wonosari in the middle, and gunungsewu in the south (figure 3).

Geology of gunungsewu is generally composed of volcanic rocks at the lower part and carbonate rocks at the upper part, formed in tertiary period. Geological map of gunungsewu is shown in figure 4.

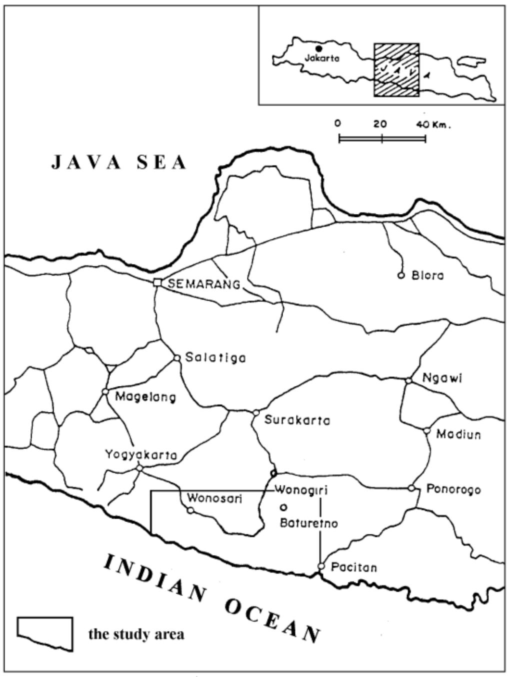

Figure 2. Gunungsewu Location Map

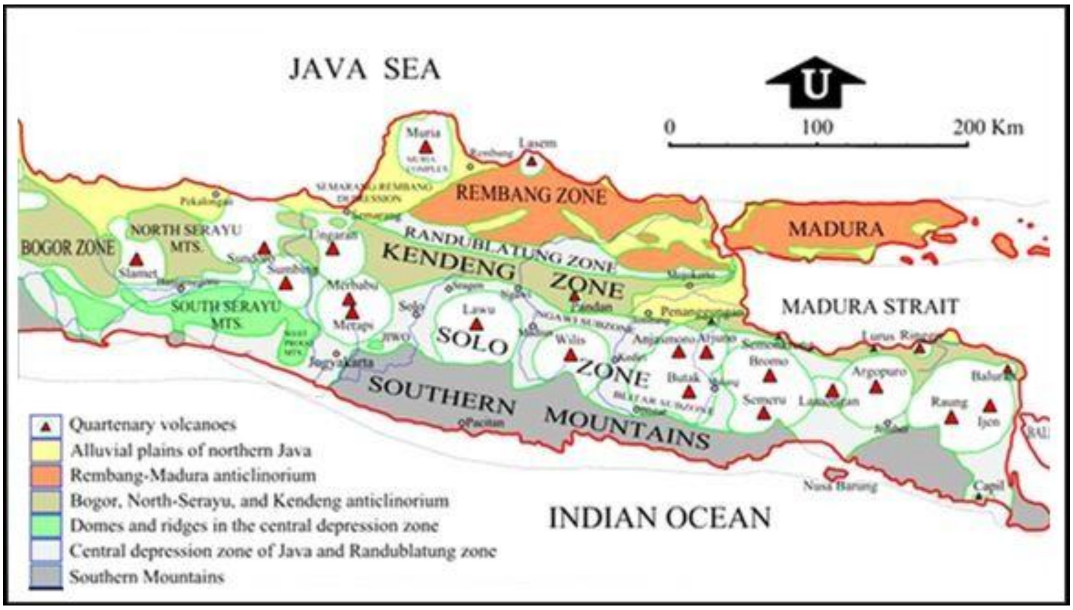

Figure 3. East Java Physiography Map (Van Bemmelen, 1949)

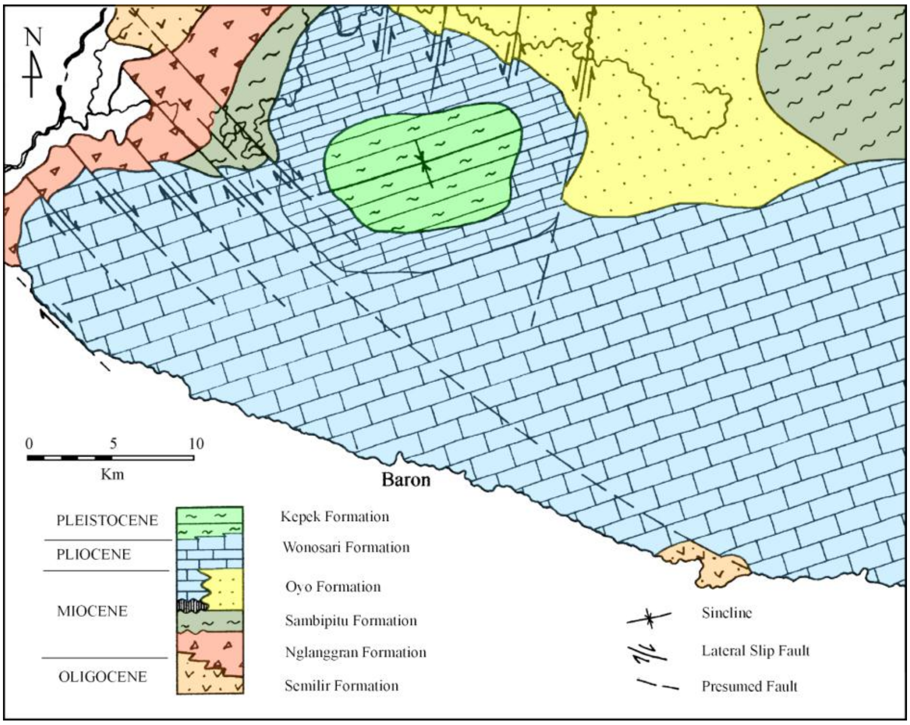

Figure 4. Geological Map of Gunungsewu (Kusumayudha, 2000, 2005)

Stratigraphy

Stratigraphy of Southern Mountains in DIY according to Toha et al (1994) and Suyoto (1994), from the oldest to the youngest is as follows:

Semilir Formation: Semilir Formation is composed of dasitic tuff, sandstone, tufaceous sandstone, glass volcanic, aglomerate, claystone, siltstone, shale, and breccia Semilir Formation is formed in Oligocene to Early Miocene period.

Nglanggran Formation: Nglanggran Formation has conformity at the top, or interfingering with the upper part of Semilir Formation, composed of volcanic andesitic breccia, lava, aglomerate, polimic breccia, ang tufaceous sandstone. This Formation is deposited in Oligomiocene to Middle Miocene Period.

Sambipitu Formation: Sambipitu Formation is composed by intercalation of marl, claystne, carbonate sandstone, tufaceous sandstone above Nglanggran Formation. Except in some places, where interfingering with Nglanggran Formation can be found. This Formation is formed in Middle Miocene.

Oyo Formation: Oyo Formation is composed of sandy carbonate, calcarenite, carbonate sandstone, and tufaceous sandstone. According to Suyoto (1994), its contact to Sambipitu Formation is unconformity. Oyo Formation, with its type location in Oyo River, is formed in Middle Miocene to Mio-Pliocene.

Wonosari Formation: Wonosari Formation is composed of carbonate, massive carconate, and reefThis Formation sometimes shows conformity and different facies with Oyo Formation. An unconformity can even be found in Semin area, formed in Middle Miocene to Pliocene.

Kepek Formation: Kepek Formation is mainly composed interbedded of claystone, marl, and carconate, which is deposited in isolated shallow-sea environment, in Late Pliocene to Pleistocene period.

Terarosa Sediment and Merapi Sediment: Terarosa sediment, alluvial and Merapi sediment is the youngest lithology of Gunungsewu. Alluvial sediment is composed of dark clay, siltstone, sand, gravel and part of plant, whereas Merapi sediment is composed of sand and volcanic ash. Terrarosa is formed of molded limestone, combined with volcanic ash.

Geological Structure

The Southern Mountains area is regionally a high zone. A sincline trending in N75°E - N255-E (northeast - southwest) direction can be found in Wonosari Plato, with the slope angle of its wings is less than 10°. In Baturagung and Gunungsewu, the bedding structure generally forms a slanted homoclinal to the south. In Gunungsewu, the slope of bedding ranges from 5° to 15°. Fault structure of Gunungsewu is trending in northwest-southeast direction. Gunungsewu area is divided into several blocks, separated by faults. These faults also control the hydrogeologic system in Gunungsewu.

Gunung Kendil

Gunung Kendil is located in Ponjong District, approximately 500m from Regional Govenrment office. Gunung Kendil site began to be managed by its owner (Mbah Moyo) for tourism object, bathing area, fishing area, and health therapy as well as geology/hydrogeology nature laboratory.

At the peak of Gunung Kendil, wells have been drilled in two places, producing water with relatively high pressure. The source of the water is an underground river beneath Gunung Kendil. This water fulfills drinking water quality, and has been used in drinking water production, as well as bathing area and health therapy. The groundwater system beneath Gunung Kendil is presumably controlled by fractures, faults, and bedding. Normal faults under Gunung Kendil trending northeast-southwest face each other, forming a large subsidence.

RESEARCH METHOD

Location and Time of Research

This research will be conducted in Gunung Kendil, Ponjong Village, Ponjong District, Gunungkidul Regency. The hill is located approximately 400 m north of Ponjong District, about 20 km east of Yogyakarta City. The research is planned to start from June until October 2014.

RESEARCH METHOD

This research will use Field Detail Mapping Method and Laboratory Analysis Method.

Field Mapping Method

Field detail mapping in Gunung Kendil is done using tools as follows:

- Geological compass
- Geologist hammer
- GPS
- Base Map
- Clipboard
- Protractor
- Geological field book
- Measuring tape

The data recorded in detail mapping include:

- Lithology/rock types
- Developing geology structure type
- Measurements of layers position and geological structures (fractures, faults, bedding)
- Hillside slope
- Surface situation data and settlement
- Rock samples for laboratory analysis
- Water samples

Laboratory Method

This method is done to analyze rock samples, structure type and water sample.

TIME OF RESEARCH

One day of each week from June to October is allocated for detail research, as seen in Table 1.

Table 1. Field Research Activity Time

No	Activity	JUNE				JULY				AUG				SEPT				OCT			
1.	Proposal	■																			
2.	Proposal Presentation		■																		
3.	Field 1			■	■																
4.	Field 2					■	■	■	■												
5.	Field 3									■	■	■	■								
6.	Field 4													■	■	■	■				
7.	Analysis					■	■	■	■	■	■	■	■	■	■	■	■				
8.	Report Writing			■	■	■	■	■	■	■	■	■	■	■	■	■	■				
9.	Final Presentation																	■	■		
10.	Final Report Submission																			■	■

FIELD DATA

Field data obtained include rock type data, fracture data, fault data, morphology data, rock samples, and water samples. Those data is organized as shown below.

Gunung Kendil and Umbul Ponjong Morphology

Gunung Kendil is one of the hills in Gunung Sewu scattered in Southern Mountains of Yogyakarta Special Region, located 400 m north of Ponjong District Government office and 30 km east of Yogyakarta City. It lies in coordinates 8°00’56.64”S, 110°44’18.32”E (Figure 5). A large spring can be found at the southwest side of Regional Government office, its water is collected in two large ponds named Umbul Ponjong (Figure 6).

Figure 5. A photograph of Gunung Kendil taken from west direction.

Figure 6. Tuk Umbul Ponjong taken from northwest direction

Geology of Gunung Kendil

Gunung Kendil is composed of bedded-limestone in the bottom part, chalky limestone in the middle (Figure 8), massive limestone with conduits, and reef limestone at the top (Figure 9). These rocks are part of Wonosari Formation, formed in Middle Miocene age (10-16 million years).

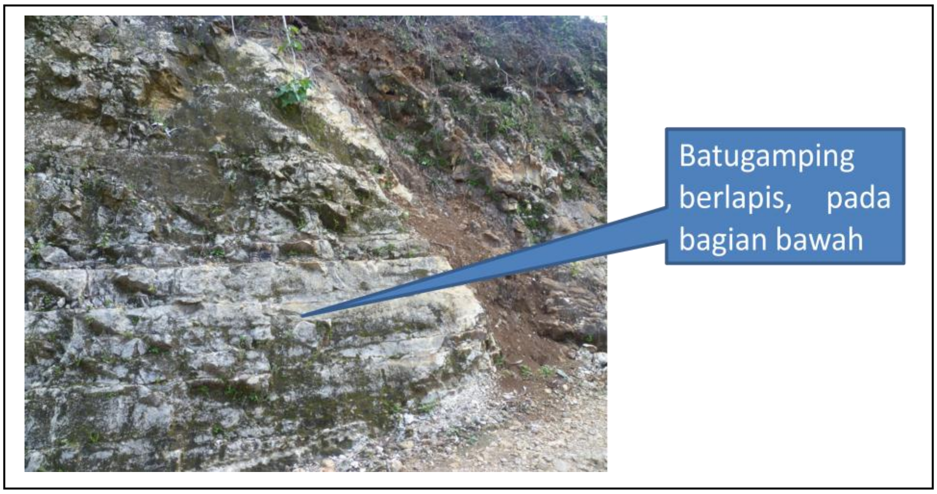

Figure 7. Bedded-limestone in the bottom part of Wonosari Formation

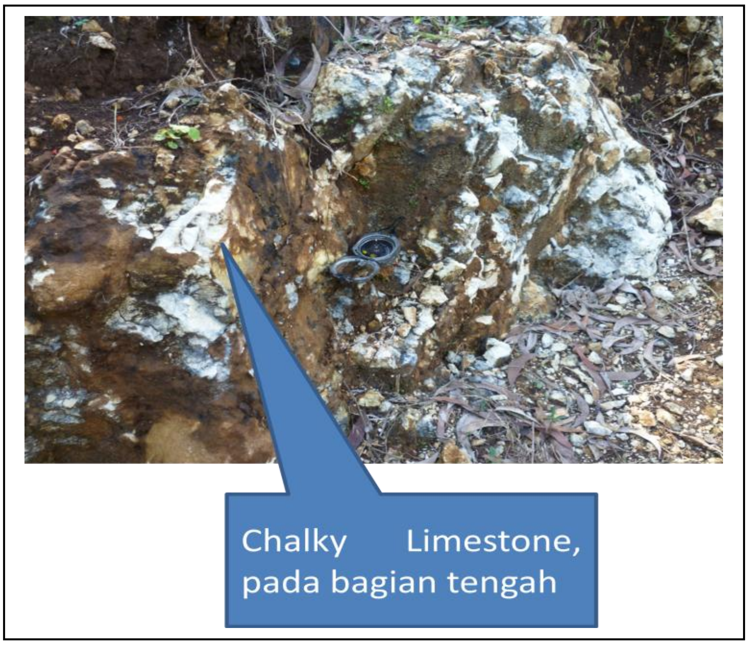

Figure 8. Chalky limestone in the middle

Figure 9. Massive limestone with conduits and reef limestone at the top part of Wonosari Formation

Geological Structure

Measurements of fractures and faults done in Gunung Kendil to understand ground water flow pattern resulted in flow pattern following structure pattern as seen in Figure 10.

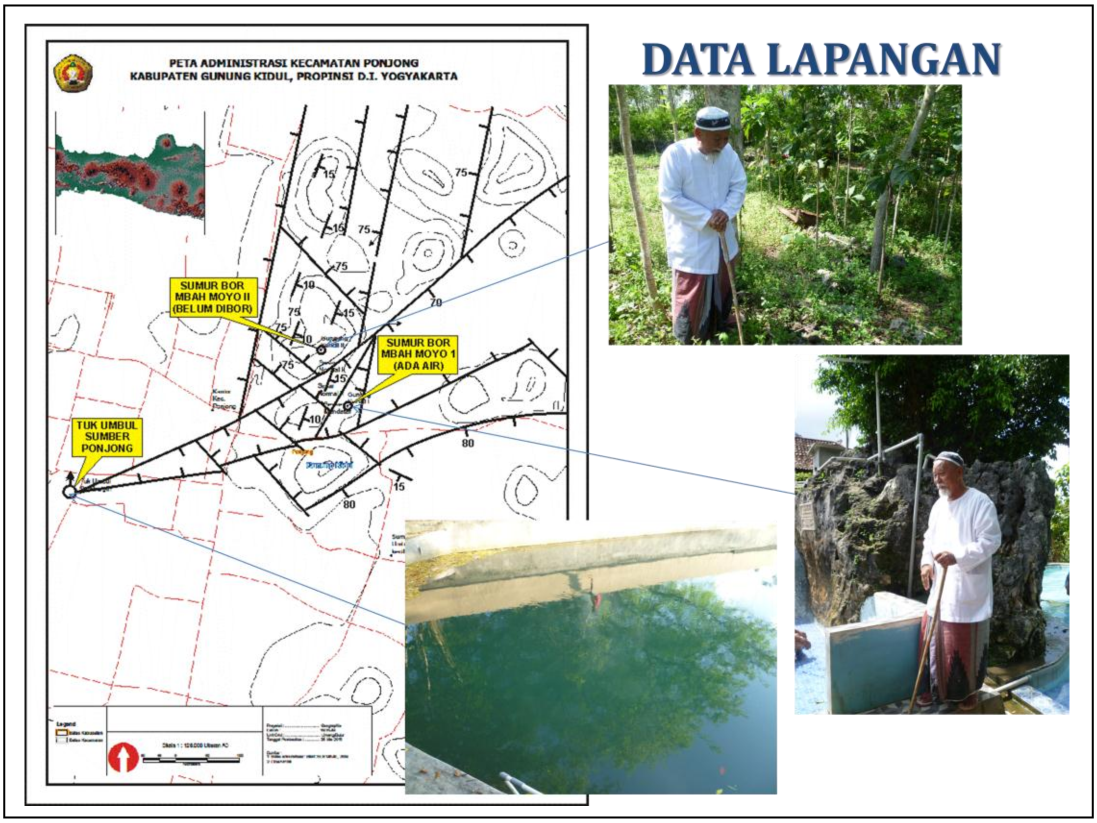

Figure 10. Structure pattern controlling water flow beneath Gunung Kendil up to Umbul Ponjong

Ground Water beneath Gunung Kendil and Sumber Ponjong Spring

At the peak of Gunung Kendil, wells have been drilled in two places for approximately 60 m deep. It connected to an underground river, forming artesian water as seen in Figure 10 and 11.

DISCUSSION

Underground river system beneath Gunung Kendil is controlled by normal faults trending nearly north northwest-south southwest slanted in west-northwest direction with an angle of 75-80 degrees meets with limestone bedding of n20e/15 and fracture of n31e/75. This activated dissolution caused by infiltration of groundwater passing the meeting point of fault, fracture, and fault, forming an underground river trending nearly north-south. The drilled Mbah Moyo 2 Well penetrates this system in 66 meters deep.

This system meets the underground river flowing southwest, controlled by two normal faults trending northeast-southwest which form a grabben. This underground river flows out, forming a spring named tuk umbul smber panjong.

The drilled well mbah moyo 1, 66 meters deep, with coordinates 110 43’141,467e and 7 58’490,798s exactly cut through the underground river flowing to tuk umbul sumber ponjong.

Figure 10. First drilling location for Mbah Moyo Well 1

Ground Water Usage beneath Gunung Kendil

The water from drilling in Gunung Kendil is used for:

1. Fulfilling water needs in Gunung Kendil
2. Water therapy (health)
3. Water tourism area (swimming and recreation)
4. Healthy drinking water

The ground water is used for drinking, washing, and field irrigation.

REFERENCES

Kusumayudha S. B. (2011), Eploring the Prospective of Gunungsewu Area, Indonesia For a World Geopark, Malaysia – Indonesia 4th Geoheritage Joint Converence, 1 – 3 Oktober 2011, Terengganu, Malaysia

Kusumayudha S.B. (2005), Karst Hydrogeology and Fraktal Geometry of Gunungsewu Area, Penerbit Adicita, 171 p.

Kusumayudha S.B. (2004) Introduction to Karst Hydrogeology, Pusat Studi Karst UPN "Veteran" Yogyakarta, 137 p

Kusumayudha S.B. (2000), Quantification of the Gunungsewu Hydrogeologic System by fractal Geometry Analysis, Doctoral Desertation, ITB (unpublished)

Kusumayudha, S.B., A.Santoso (1998), Underground River of Gunungsewu Based on Gravity Anomaly and the Geologic Structure Patterns, *Pros. PIT HAGI XXIII*, 66-72.

Kusumayudha, S.B., M.T. Zen, S. Notosiswoyo, R.S. Gautama (1999), The Hydrogeologic System of Gunungsewu, *Proc. IAGI The 28th Annual Convention*, Vol IV, p 73-84

Setiawan, J. & Kusumayudha, S.B. (2011) Sistem Airtanah di Gunung Kendil dan Umbul Ponjong Sebagai Warisan Geologi yang Unik, Malaysia – Indonesia Join Geoheritage Convention, 1 – 2 Oktober 2011, Terengganu, Malaysia

Simanjuntak S., Handini R., Prasetyo B. (2002), *Pre Historic of Gunungsewu*, Ikatan Ahli Arkeologi Indonesia, 304 p

Suyoto (1994), Stratigraphic Sequence of the Gunungsewu Carbonates, *Proc. PIT IAGI XXIII*, Vol 1, p 19-32.

Van Bemmelen, R.W. (1949), *The Geology of Indonesia*, Vol IA, Martinus Nijhoff, The Hague, 792 p.

White, W.B. (1988), *Geomorphology and Hydrology of Karst Terrains*, Oxford University Press, New York, 464 p.

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Geology and Reservoir 4160 3D Modeling of "X" Layer, "Y" Field in Bekasap Formation, Central Sumatra Basin

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ABSTRACT

Object of the research is Geology and 3D Modeling Reservoir Layers "X" Field "Y". Field "Y" is located in the Central Sumatra Basin. Based on well data analysis, Layer "X" is included in Bekasap Formation, sandstones were prepared on lithology, mudstone, and coal, Bekasap Formation was deposited in fluvio deltaic environment to transitional deltaic, layer thickness "X" has an average of 20 ft. In the Field "Y" there is a growing fault, where the fault consists of the first period and the second period fault. Faulting the first period in the form of the right horizontal fault ride-SSE trending NNW, and second period down and reverse fault is a fault backthrusting of the first period trending NE-SW.

Crease structures that develop in the Field "Y" in the form of folds that form the saddle, this anticline trending folds in the form of a general northwest-south southeast North (NNW-SSE), this was folds reverse fault on the east and westward-shaped asymmetry. These folds formed during the compression that occurs sharpness Piosen until now.

3D modeling consists prepared on the framework, property distribution, and calculation of OOIP layer "X". Property facies, vshale, PHIE and Sw using geostatistical variogram analysis as well as population data distribution method using the SIS for facies and SGS for vshale, PHIE and Sw, while the distribution of K using the equation results Perm vs Core crossplot of log. Based on calculation of volumetric OOIP basis Layers "X" obtained Bulk Volume: 21.017 acre.ft, Net Volume: 20.798 acre.ft, Pore Volume: 4.363 acre.ft, HCPV Oil: 2,542 acre.ft, OOIP: 17.93 MMSTB.

Keywords: Modeling, Geostatistic, Variogram

INTRODUCTION

"Y" field is located in Central Sumatra Basin, one of hydrocarbon-producing basins (Figure 1). Geologically, this basin is also called Neogene Convergent Back Arc Basin and is classified as hydrocarbon-producing sedimentary basin. The Central Sumatra Basin has an area of about 103,500 km^2, mainly consists of land.

"X" layer is part of Bekasap Formation, one of hydrocarbon-producing formations. Bekasap formation is composed of sandstone lithology, shale, and some coal parting, deposited in fluvio deltaic to transitional deltaic environment.

Reservoir 3D modeling on "X" layer is a research study to learn the condition of a reservoir, by integrating seismic and well data to understand the developing structure pattern as well as detailed reservoir property distribution vertically and laterally.

The goal of this research is to make a geological concept and 3D reservoir modeling, in addition to distribute reservoir property in 3D and calculate OOIP volumetrically.

GEOLOGY AND REGIONAL STRATIGRAPHY

The "Y" field is part of Central Sumatra Basin. This basin is historically called as Neogene Convergent Back Arc Basin and is classified as hydrocarbon-producing sedimentary basin, having an area of about 103,500 km^2 of mainly land. Geographically, this basin lies between longitudes 90^oE-103^oE and latitudes 1^oS-4^oS. Central Sumatra Basin is separated from North Sumatra Basin by *Tinggian Asahan* on the north, and separated from South Sumatra Basin by *Tigapuluh* mountain area.

Central Sumatra Basin is one of the three hydrocarbon-producing basins in Eastern Sumatra, developing as a sedimentary basin behind a volcanic arc. Its border is marked by basement rock outcrop, weight anomaly pattern, isopach with cut-off 1,000m and *Tinggian*.

Central Sumatra Basin is mostly formed of two structure patterns, oriented in North-South direction and Northwest-Southeast direction (Heidrick & Aulia, 1993). The North-South structure is relatively older, being formed in Paleogen (Martono & Nayoan, 1974; De Coster, 1975 in Heidrick & Aulia, 1993). According to Eubank and Makki (1987), those two structures were active in Tertiary period. Heidrick & Aulia (1993) categorize the Tectonic Development of Central Sumatra Basin into four episodes based on poly-phase tectonic terminology of Mc-Clay (1996), i.e. F0, F1, F2, and F3 (Figure 2).

Eubank and Makki (1981), Yarmanto and Aulia (1988), as well as Heidrick and Aulia (1993) divide the regional stratigraphy of Central Sumatra Basin from Paleogene to Pliocene and Quaternary period into five groups/formations, namely Pematang Formation, Sihapas Group, Telisa Formation, Petani Formation and Minas (Alluvial) Formation. Whereas Heidrick and Aulia (1996) divide the regional stratigraphy of Central Sumatra Basin into Pre-Tertiary Basement Rock, Paleogene Sedimentary Rock, Neogene Sedimentary Rock, and Pleistocene Sedimentary Rock (Figure 3).

Pre-Tertiary Basement Rocks

This rock is composed of three different micro plate (Eubank and Makki, 1981), namely *quartzite terrain* (Eubank and Makki, 1981), also called *Malacca Microplate* (Pulunggono & Cameron, 1984), and also called *Mutus Assemblage* and *Greywacke Terrain* (Eubank and Makki, 1981), or *Megui Microplate* (Pulunggono & Cameron, 1984). According to Pulunggono and Cameron (1984), *Mergui Microplate* is formed of quartzite, granite, and limestone of Paleozoic age. *Mergui Microplate* is formed of Permo-Carbon rocks consisting of greywacke, quartzite, argillite, and granite intrusion. Mutus Assemblage is formed of argilite, red shale, tuff, and basalt, also chlorite schist of Triassic-Jurassic age.

Pematang Eosen-Oligosen Group

Deposition of tertiary rock is initially formed of non-marine sediment of Pematang Group in the north-south basin, caused by Eocene-Oligocene Rifting (Yarmanto & Aulia, 1993), or in F1 Deformation period (Heidrick & Aulia, 1993). This Pematang Group is unconformities above Pre-Tertiary Basement Rocks.

Early Miocene Sihapas Group

This Sihapas Group is unconformity above Pematang Group in Early Miocene Period. This group is composed of Menggala Formation at the base, followed by Bango Formation, Bekasap Formation, Duri Formation and Telisa Formation at the topmost.

Middle Miocene-Late Miocene Petani Formation

This formation in conformity above Sihapas Group in Middle Miocene-Late Miocene Period. Petani Formation is formed of grey silt, shale, aluvial deposite coally silt, and sandstone.

Plestocene Minas Formation

Minas Formation is unconformty above Pleistocene-aged Petani Formation, in the form of Alluvial rocks which consists of non-consolidated rocks, i.e. gravel, sand, and clay.

Petroleum System of Central Sumatra Basin
Source Rock

One possible source rock is the lacustrin sediment of *Brown Shale* facies of Pematang Formation. In this formation, there are two *Brown Shale* organis facies, namely *algal-amarphous facies* (type-I and I-II) and *carbonaceous facies* (type-III and II-III). *Algal-amarphous* facies belongs to oil prone facies, appearing at the upper part of Brown Shale in Tinggian Aman, Ranggau, balam and Bengkalis. Other possible source rocks are the shale in Bangko Formation, Telisa Formation, Duri Formation or Petani Formation.

Reservoir Rocks

The reservoir rock in Central Sumatra Basin is a *Post-Rift* sedimentary rock. Sihapas Group is the main group of reservoir rocks in Central Sumatra Basin. This group is formed of five rock formations, namely menggala Formation, Bango Formation, Bekasap Formation, Duri Formation and Telisa Formation.

Trap and Seal Rock

The series of structure episodes in Central Sumatra Basin is categorized into genetic groups of F1, F2, and F3. These genetic groups are classified toward the developing structure regime, regionally controlled by a number of faults extending north-south in the form of wrench fault.
Migration and Maturity
The source rocks, i.e. brown shale in Pematang Formation, shale in Bangko Formation, shale in Telisa Formation, shale in Duri Formation and shale in Petani Formation mature in Late Miocene Period and migrated to be trapping in Plio-Pleistocene period until now.

METHODOLOGY

To reach the goal of this research, a number of research methods were used, including:

Geology and Geophysical Analysis: the analysis of geologic structure based on seismic data supported by geologic concepts, and correlation of well data that will be used as the input in *picking horizone*.

3D Geomodeling Analysis: the making of 3D model using parameters resulted from the geology and geophysical evaluation, as well as distributing reservoir property and calculating OOIP.

DISCUSSION

Geology and Geophysical Analysis

The expanding fault in "Y" Field is formed of first period fault and second period fault. The first period fault is a right reverse slip fault trending in NNW-SSE direction, whereas the second period fault is formed of Normal fault and thrust fault in the form of backthrusting of the first period fault trending in NE-SW direction.

First Period Fault in "Y" Field

The first period fault expanding in Field "Y" is formerly a normal fault in the basement rock, extending NNW-SSE, of Oligo-Miocene age. This fault is the one controlling Butun Field. In Late Miocene to Plio-Pleistocene period, stress changed into a strong compression, trending in N-S direction up to NNE-SSW direction, changing the former normal fault into right reverse slip fault moving upwards to WSW-ENE involving Sihapas Group (menggala Formation, Bangko Formation, Bekasap Formation, Telisa Formation and Duri Formation).

Second Period Fault in "Y" Field

The second period fault expanding in "Y" Field can be divided into two blocks, namely anticline block (in the east side of thrust fault, and sincline block in the west side. The anticline block developing in the east, there expand second period faults in the form of backthrusting, extending NE-SW. Whereas faults expanding in the west side are normal faults trending in NE-SW direction. This is caused by a large compression in Plio-Pleistocene period after the first period fault happened and the large compression persists, making the front part of the fault moved upwards, extending in WNW-SSE direction -- parallel to the main fault, which resulted in normal faults (Figure 4 and Figure 5).

Fold Structure of "Y" Field

The expanding Fold structure in "Y" Field is a fold forming a saddle, resulting in a closure. This anticline fold is generally trending in NNW-SSE direction. The fold is located on the east side of the thrust fault, asymmetrically shaped which extends to the west. This fold was formed when compression from Pliocene period until now. The structure of the fold is the main trap in "Y" Field (Figure 4 and Figure 5).

Stratigraphy

Based on drilling in "Y" Field, the deepest well only reached up to Pematang Formation, specifically well A-01. The local stratigraphy, from oldest to youngest, is as follows (Figure 6):
Pematang Group
Sihapas Group (Bekasap Formation, Upper Sihapas Formation, and Telisa Group)
The researched layer is located in Bekasap Formation, composed of sandstone lithology, shale, and some coal parting, deposited in *fluvio deltaic* to *transitional deltaic* environment.

Geomodeling (Static Model)

Structural Modeling

Mapping

Mapping marker was done to marker Top of "X" layer, using output map of 3D seismic interpretation which has been corrected by marker resulted from well correlation.

Fault Modeling

The "Y" Field is a NW-SE trending anticline, with a large fault on the west side of Butun Field. The fault structure pattern of Butun Field is obtained from 3D seismic interpretation, where the main fault is relatively trending in North-South direction.

Pillar Gridding& Segmentasi

The size of the grid used is 50m x 50m, based on the closest distance between wells and size of research area. The "Y" Field is divided into six Compartments: A, B, C, D, E, and F from north to south consecutively.

Make Horizons

Horizon done in "X" Layer modeling, where the map used has been corrected concerning the well data.

Layering

Layering is done to make thinner and detailed layers in each reservoir zone, where "X" layer is proportionally divided into 22 zones.

Determining Fluid Contacts

The fluid contact used is *Lowest Known Oil* (LKO), which is decided based on well data that actually produce oil. The LKO value of "X" Layer is -4190 ft-TVDSS (ref. A-19) dan -4171 ft-TVDSS (ref. A-03).
Figure 7 shows *Structural modeling.*

Property Modeling

Scale Up Well Logs

This process is done to input data properties of wells into 3D Grid, which will then be distributed to all grids using *Property Modeling* process. Scale up is done for *LogVShale*, PHIE and *Facies*. The result of scale up well logs is then validated by considering differences between original log data histogram and the scale up result (Figure 8).

Data Analysis
The method used in analyzing tendency in direction of spatially distributing data is geostatistic variogram analysis, laterally and vertically. The main direction of the variogram axis conforms to sediment direction. Parameters resulted from the variogram analysis include *major range, minor range, vertical range, nugget effect* and *major range direction*. The analysed properties include Facies, *VShale*, and PHIE (Figure 9).

Facies dan Property Modeling

Facies analysis makes use of lithology differences between sandstone and shale, supported by cut off resulted from petrophysic. Facies modeling is done using SIS (*Sequential Indicator Simulation*) method by making probability map beforehand, according to well data resulted from well log scale-up. VShale and PHIE properties modeling is done using SGS (*sequential Gaussian simulation*) geostatictic method guided by for each sand according to parameters resulted from data analysis. To validate the result of property distribution from 3D Grid, histogram of scale up well logs result data is compared to the histogram of properties resulted from modeling (Figure 10).

Permeability Calculation

Permeability distribution makes use of equation resulted from permeability-porosity crossplot from core data, which will then be distributed according to PHIE model (Figure 11).

Water Saturation (Sw) Calculation

Sw calculation used the distribution of logs drilled at earlier time and have complete data, namely well A-01, A-03, A-04, A-05, A-06, A-07, A-08, and A-09. The distribution used the same method as VShale and PHIE, except that its distribution will be controlled by *VShale* distribution. (Figure 12).

OOIP (Original Oil In Place) Calculation

OOIP Calculation is done using Volumetric method. Data needed for OOIP calculation include porosity (*PHIE*) 3D model, *NTG, Sw*, with *cutoff* done according to petrophysical analysis, as well as fluid contacts and value of *Boi*. The value of *Boi* is obtained from *PVT* analysis, having value of 1.1 RB/STB. Results of volumetric calculations are as follows:
Bulk Volume : 21,017 acre.ft
Net Volume : 20,798 acre.ft
Pore Volume : 4,363 acre.ft
HCPV Oil : 2,542 acre.ft
OOIP : 17.93 MMSTB

CONCLUSIONS

1. The expanding fault in "Y" Field is formed of first period fault and second period fault. The first period fault is a right reverse slip fault trending in NNW-SSE direction, whereas the second period fault is formed of normal fault and thrust fault in the form of backthrusting of the first period fault trending in NE-SW direction.
2. The Fold structure developing in "Y" Field is a fold forming a saddle, resulting in a closure. This anticline fold is generally trending in NNW-SSE direction. The fold is located on the east side of the thrust fault, asymmetrically shaped which extends to the west. This fold was formed when compression from Pliocene period until now.
3. The researched layer is located in "Y" Field, "X" Layer, part of Central Sumatra Basin, Bekasap Formation, which is composed of sandstone lithology, shale, and some coal parting, deposited in *fluvio deltaic* to *transitional deltaic* environment.
4. Trapping expanding in Field "Y" is classified as structural type.
5. The 3D modeling of "X" layer was done by distributing properties including facies, *vshale*, PHIE, K, Sw, where geostatistic variogram analysis was used for facies, *vshale*, PHIE and Sw as data population using SIS & SGS as distribution method, whereas Perm vs log Core *crossplot* result equation was used for K distribution.
6. The OOIP calculations using volumetric method resulted in: Bulk Volume : 21,017 acre.ft, Net Volume : 20,798 acre.ft, Pore Volume : 4,363 acre.ft, HCPV Oil : 2,542 acre.ft, OOIP : 17.93 MMSTB

REFERENCES

Edward H. Isaaks, R. Mohan Srivastava, 1989, *An Introduction to Applied Geostatistics*.

Eubank, R.T. and Makki, A.C., 1981. *Structural Geology of the Central Sumatera Basin*. Proceeding IPA, 10th Annual Convention, p. 285-317

Heidrick, T.L., and Aulia, K.A., 1993, *Structural and Tectonic Model of the Costal Plains Block, Central Sumatera Basin Indonesia*. Proceeding IPA 22nd Annual Convention, P. 285-317.

Kelkar, Mohan and Godofreo Perez, *Applied Geostatistics for Reservoir Characterization*.

Satyana, *et al.*,2005, *Petroleum Geology of Indonesia: Current Concep*

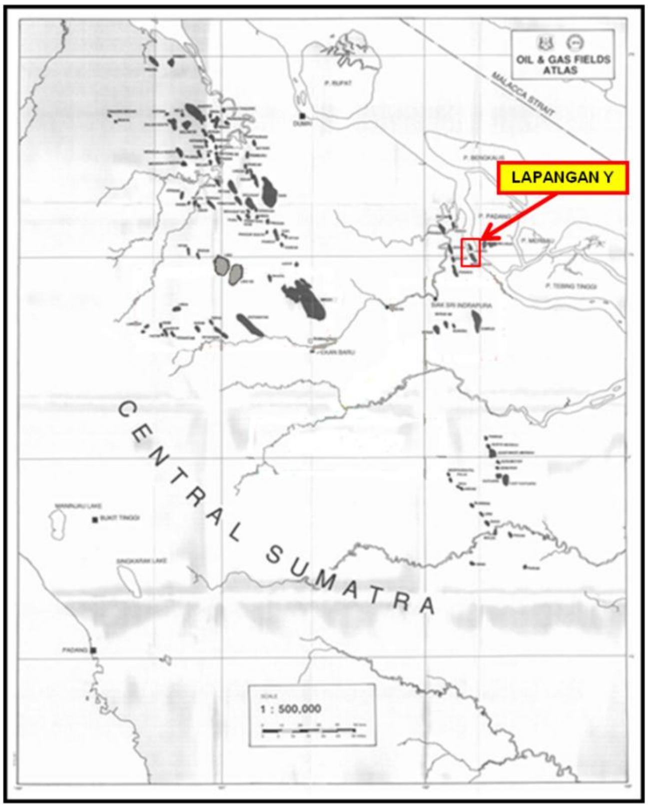


Figure 1. Location of "Y" Field

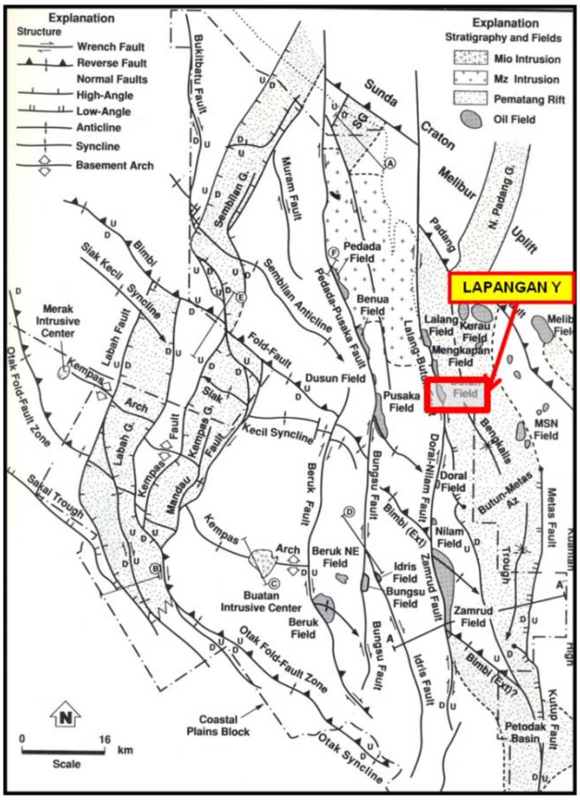


Figure 2. Structure pattern of "Y" Field

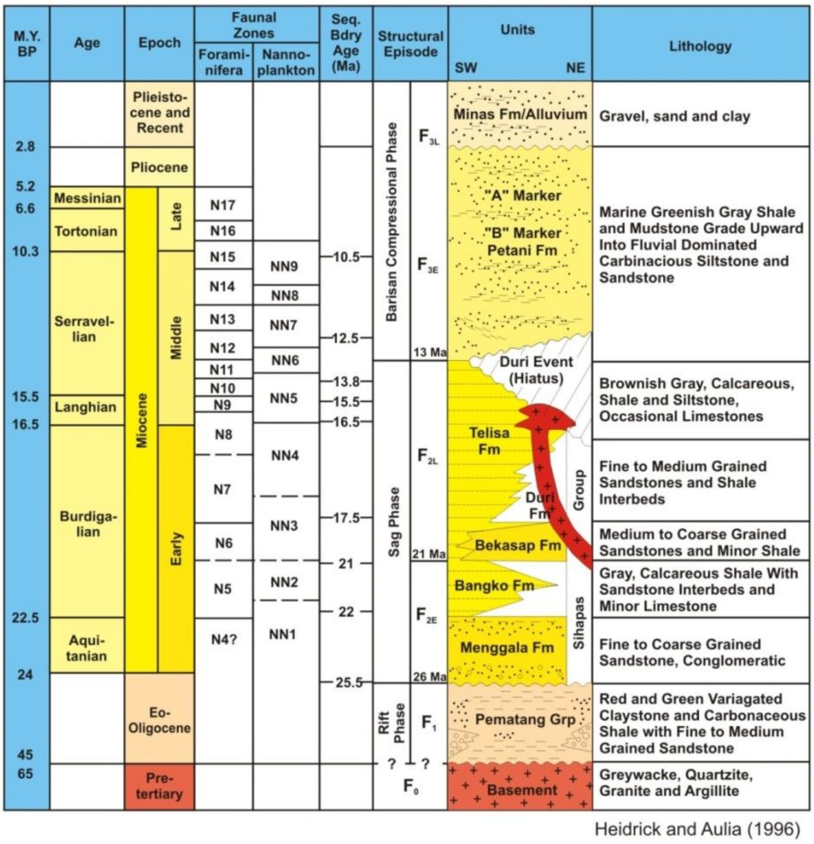


Figure 3. Regional Stratigraphy of Central Sumatra Basin

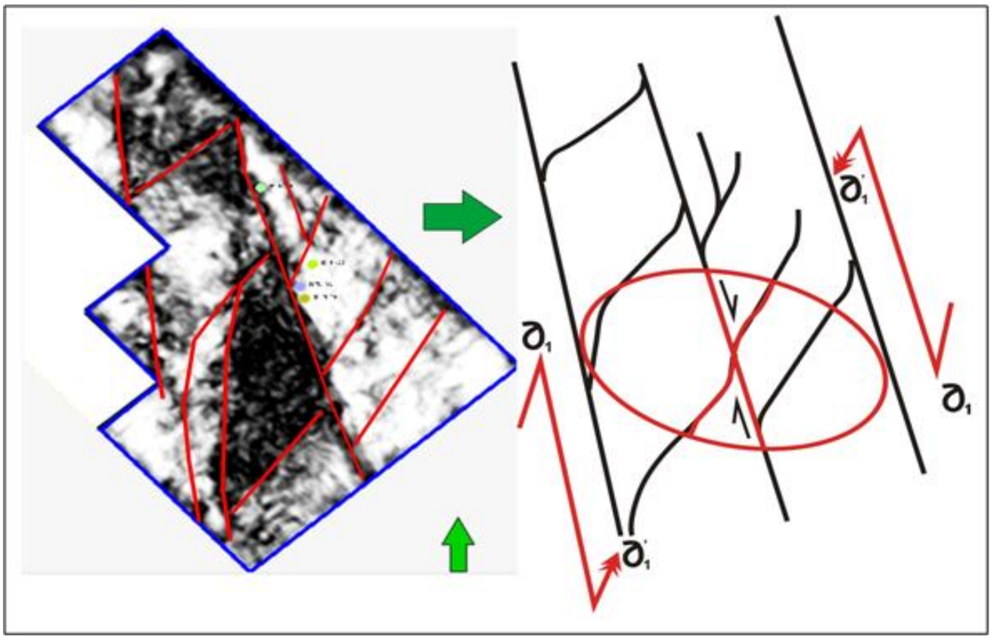


Figure 4. Structure Forming of "Y" Field

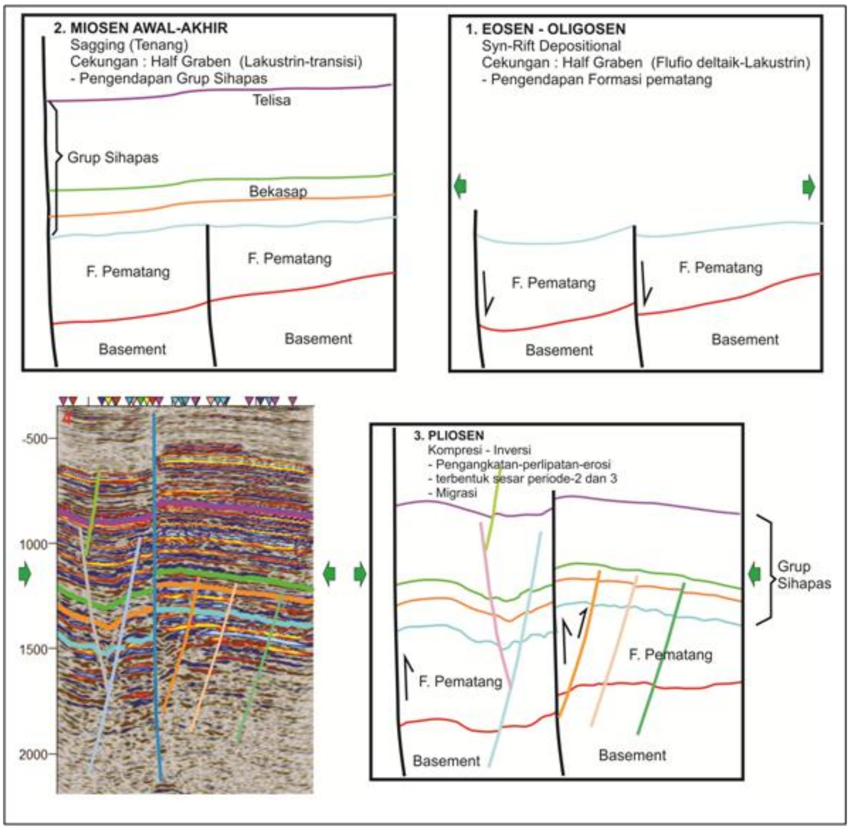


Figure 5. Structure Forming and Deposition in "Y" Field

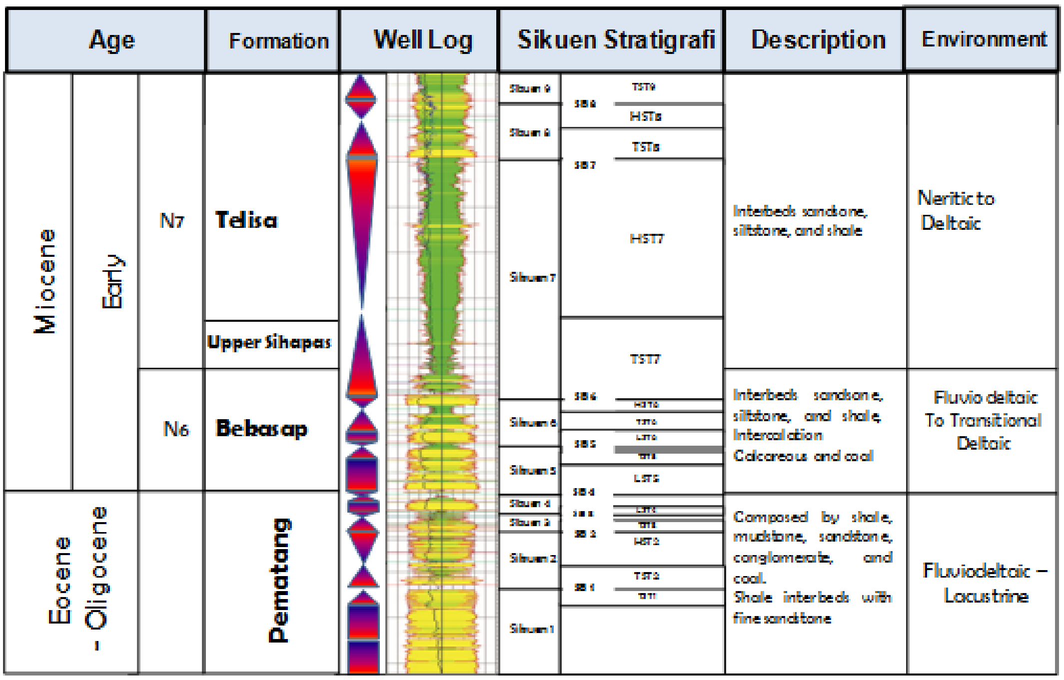


Figure 6. Local Stratigraphy of "Y" Field According to Well Data

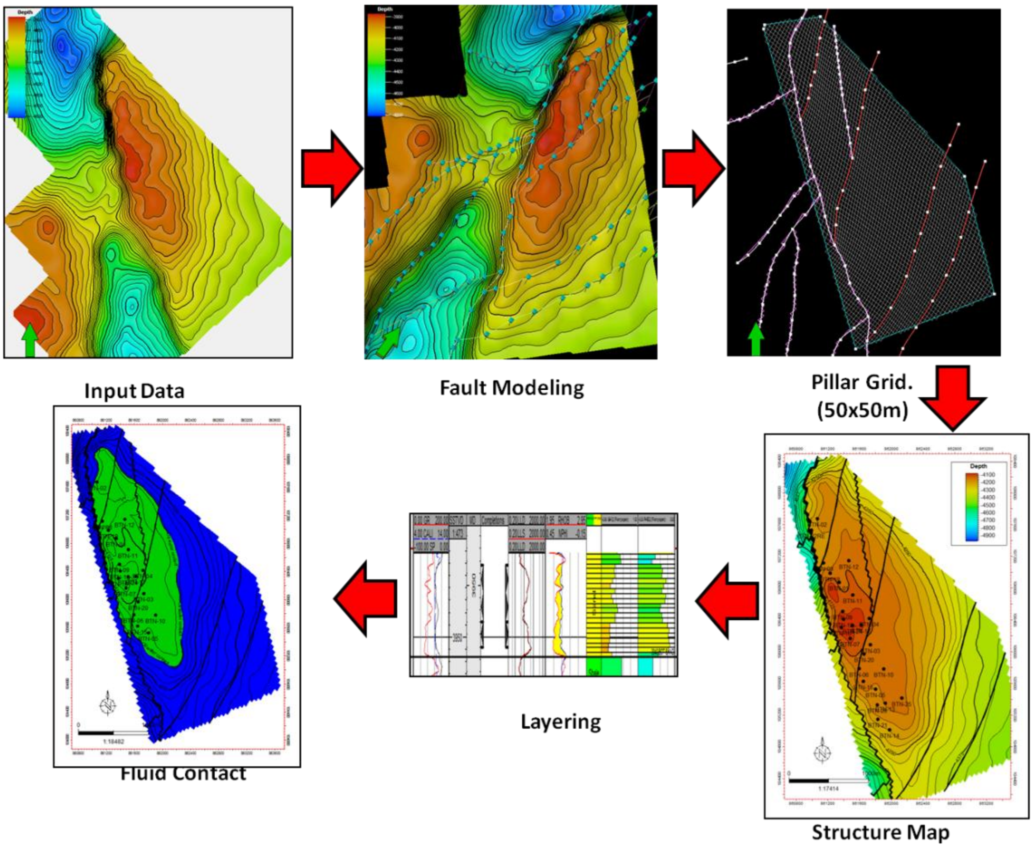
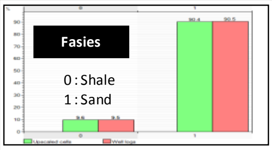
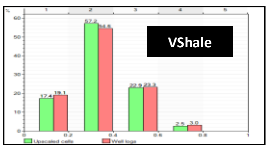


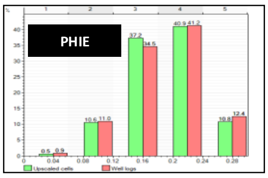
Figure 7. Structural Modeling



Name	Type	Min	Max	Delta	N	Mean	Std	Var	Sum
Upscaled	Disc.	0	1	1	416	1	0	0	377
Well logs	Disc.	0	1	1	1889	1	0	0	1709



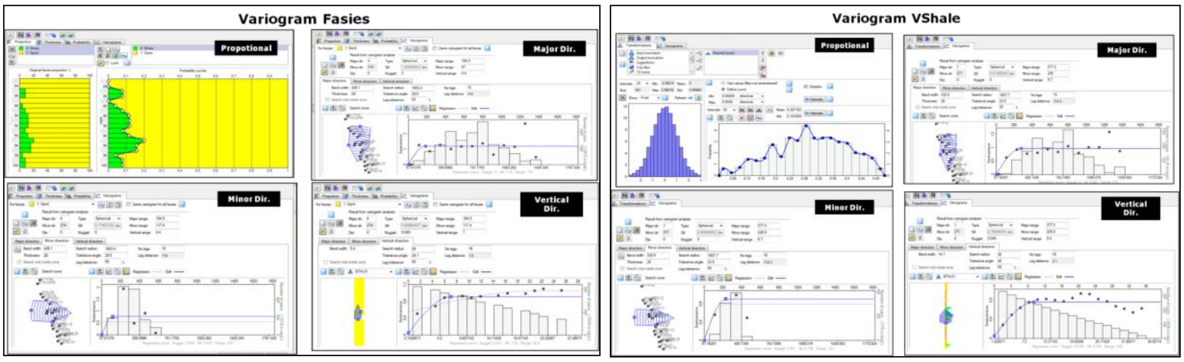
Name	Type	Min	Max	Delta	N	Mean	Std	Var	Sum
Upscaled	Cont.	0.04	0.68	0.64	398	0.32	0.13	0.02	128.61
Well logs	Cont.	0.01	0.73	0.72	2040	0.32	0.13	0.02	651.72

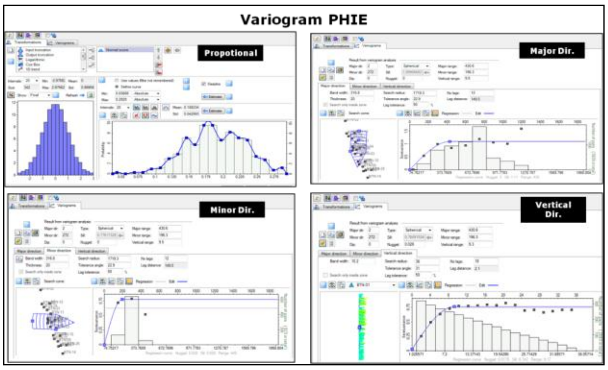


Name	Type	Min	Max	Delta	N	Mean	Std	Var	Sum
Upscaled	Cont.	0.04	0.29	0.26	380	0.18	0.05	0	69.08
Well logs	Cont.	0	0.3	0.3	1969	0.18	0.05	0	359.25

Upscaled Cells
Well Logs

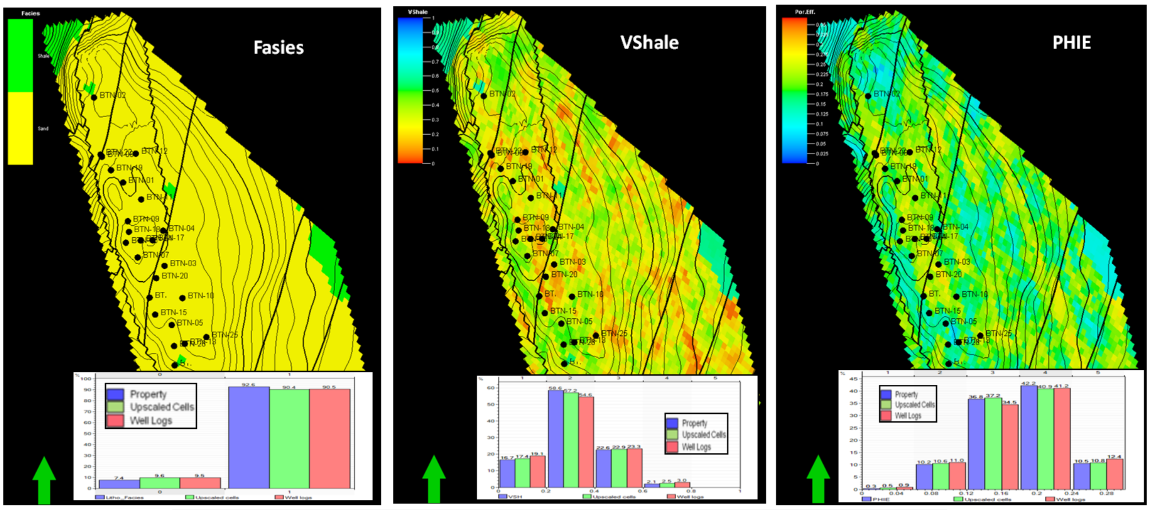
Figure 8. Scale Up Well Logs





Property	Fasies	Model Type	Major Dir.	Minor Dir.	Orientasi	Sill	Nugget	Major Range	Minor Range	Vertikal Range
Fasies	Sand	Spherical	4	274	NE-SW	1	0.02	185	117	7
Vshale	Sand	Spherical	1	271	NE-SW	1	0.02	267	205	8.7
PHIE	Sand	Spherical	2	272	NE-SW	1	0.02	430	196	9

Figure 9. Variogram Geostatistical Analysis



Fasies									
Name	Type	Min	Max	Delta	N	Mean	Std	Var	Sum
Property	Disc.	0	1	1	85392	1	0	0	74467
Upscaled	Disc.	0	1	1	416	1	0	0	377
Well logs	Disc.	0	1	1	1889	1	0	0	1709

Vshale									
Name	Type	Min	Max	Delta	N	Mean	Std	Var	Sum
Property	Cont.	0.04	0.68	0.64	85392	0.33	0.13	0.02	28154.47
Upscaled	Cont.	0.04	0.68	0.64	398	0.32	0.13	0.02	128.61
Well logs	Cont.	0.01	0.73	0.72	2040	0.32	0.13	0.02	651.72

PHIE									
Name	Type	Min	Max	Delta	N	Mean	Std	Var	Sum
Property	Cont.	0.04	0.29	0.26	85392	0.18	0.05	0	15375.58
Upscaled	Cont.	0.04	0.29	0.26	380	0.18	0.05	0	69.08
Well logs	Cont.	0	0.3	0.3	1969	0.18	0.05	0	359.25

Figure 10. Fasies, VShale, PHIE

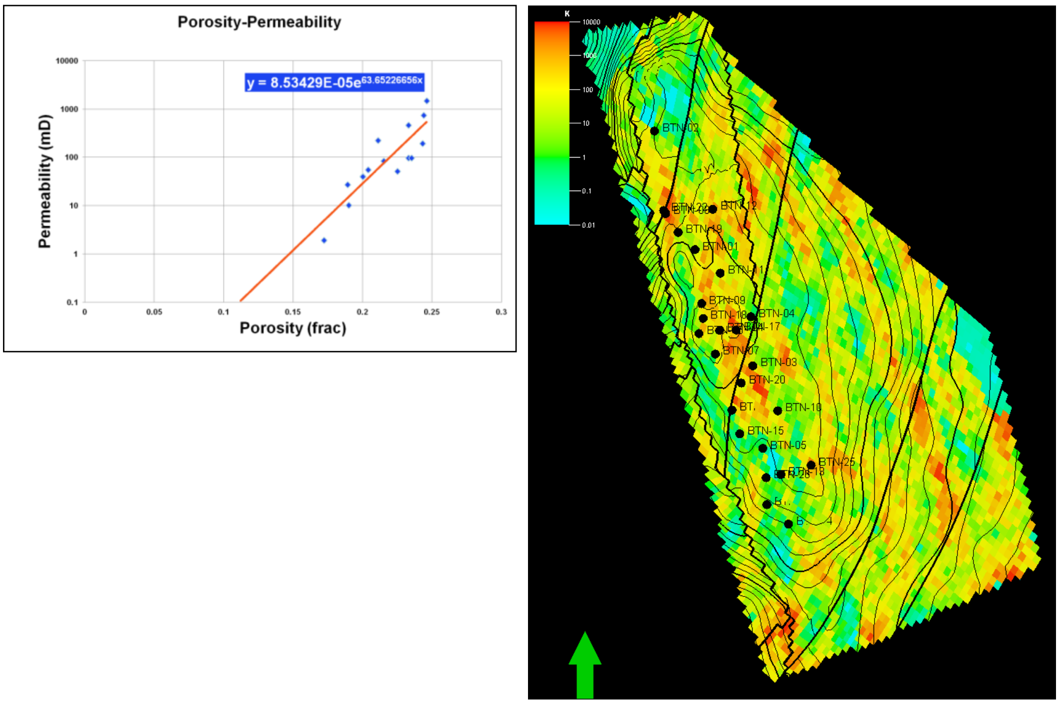


Figure 11. Permeability

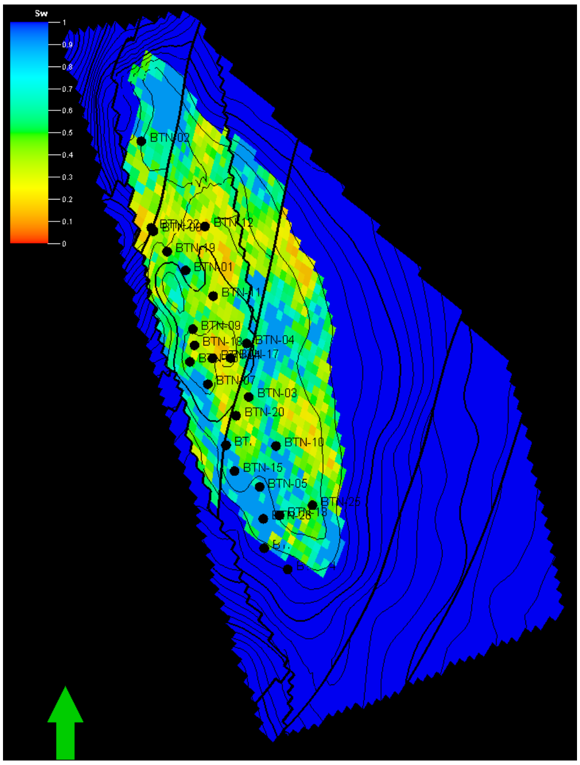


Figure 12. Water Saturation