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The Relationship of Rock Properties and Elastic Properties by Using Integrated Seismic Quantitative Interpretation Methods to Characterize Carbonate Facies Banggai Basin

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The Relationship of Rock Properties and Elastic Properties by Using Integrated Seismic Quantitative Interpretation Methods to Characterize Carbonate Facies Banggai Basin

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Abstract

The exploration activity in Eastern of Indonesia are mostly concern on carbonates play. The unique characteristics of carbonate and its complexity needs to be evaluated by using integrated methods. The location of research area are in Banggai Basin within the Senoro – Toili Block on the eastern arm of Sulawesi. Several rocks are presence at Miocene carbonate section that potentially pointed as reservoir, ranging from bioclastic carbonates platform facies of Tomori and Minahaki Formations to reefal carbonates buildup of Mantawa member. Our approach is to introduce fundamental rock physics relations, which help to quantify the geophysical signatures of rock and fluid properties. Since rock properties are a consequence of geologic processes, we begin to quantify the seismic signatures of various geologic trends. Objective of this research is to integrating both the data and expertise of geophysics and geology for carbonate reservoir characterization.

There are so many parameter and uncertainty to evaluate the carbonates reservoir. Therefore, the integration of rock properties and elastic properties will be comprehensive ways to evaluate the carbonates reservoir. Hence, seismic quantitative interpretation will be used as the main methods, including post-stack amplitude analysis, offset-dependent amplitude analysis (AVO analysis), acoustic and elastic impedance inversion beside carbonates diagenesis analysis, lab analysis (petrography), and petrophysical analysis.

The final product of the research will be the matched sensitive parameter that shows relationship on rock properties and elastic properties, including P-wave and S-wave impedances and also AVO analysis and classification to characterize the carbonate reservoir by its facies in Banggai Basin.

The research highlight quantitative seismic interpretation method to reduce uncertainty in reservoir characterization especially in carbonate reservoir.Keywords: Vertical Well, BHA Tendencies, Real-Time Survey

1. Introduction

The exploration activity in Eastern of Indonesia are mostly concern on carbonates play. The unique characteristics of carbonate and its complexity needs to be evaluated by using integrated methods. Extracting information about reservoir quality from seismic data is a key challenge in exploration, appraisal and production of hydrocarbons. The location of research area are in Banggai Basin within the Senoro – Toili Block on the eastern arm of Sulawesi (Figure 1). Several rocks are presence at Miocene carbonate section that potentially pointed as reservoir, ranging from bioclastic carbonates platform facies of Tomori and Minahaki Formations to reefal carbonates buildup of Mantawa member. Traditionally, seismic interpretation has been essentially qualitative.

Several well data with Well Logs, Final Well Report and DST data has been used for study.

Reservoir which is the main focus of Inversion Study and Senoro Field is a carbonate reservoir that is at the Mentawa formation interval Minahaki. Seismic data used are post-stack seismic data and pre-stack results from the 3D PSTM process. The seismic data has good quality, after seismic re-processing is carried out at by doing denoise and zero phase seismic manufacturing. The seismic data frequency is around 6 - 50 Hz, with a dominant frequency of around 15 Hz. Continuity of the reflector can be followed well and the seismic bandwidth is relatively the same. The total seismic area that is processed is around 128 km2. Post-stack seismic data is used for rock physics analysis, and AI inversion seismic analysis.

1.1 **Geology and Stratigraphy**

The stratigraphy of Eastern Sulawesi is related to two distinct depositional time periods. Firstly representing a continental margin rift / drift sequence of Banggai-Sula deposition prior to the collision, and secondly representing a foreland basin flysch-molasse sequences, deposited in front of an easterly-migrating thrust front after collision had occurred. A generalized stratigraphic column of the Tomori-Banggai Basin is presented in Figure-3. Basement is overlain locally by thin the Late Eocene – Early Oligocene basal clastics and carbonates, and regionally by a thick section of the Miocene carbonates and clastics, namely the Salodik Group. This carbonate group includes the Tomori, Matindok, Minahaki and Stratigraphic Sequences. Tomori Formation, which is essentially of the Lower Miocene age, consists predominantly of shallow-water bioclastic platform limestones, occasionally dolomitic, with minor claystones and coals. The Tomori Formation contain good to excellent potential source rocks, which are believed to be the origin of the hydrocarbons in this area and other structures in the Eastern Sulawesi area. The Matindok Formation is Middle Miocene age consists predominatly of claystone and shale with sandstone, limestone and coal. Shale and coals within this unit indicate fair potential gas prone source rocks. The Minahaki Formation in the research area and adjacent areas consists of clean platform facies limestones and dolomites of Upper Miocene age, which is capped at the top by reefal buildup namely Mentawa Member, and basinal facies limestone, marl and claystone namely Stratigraphic Sequence. The Minahaki bioclastic limestone platform facies and Mantawa reefal buildups provide good productive gas reservoirs.

1.2 Data

The study carried out using 5 wells (SNR-1, SNR-2, SNR-3, SNR-5, and SNR-6) also zero phase 3D seismic post stack. Each wells have velocity survey (checkshot) in Figure-4.

Another main data that used in the study is core data and thin section (petrography) data of each wells. Digital and analog data will be used to justify the relationship of rock properties and elastic properties

2. Methodology

The geometrical expression of seismic reflectors was mapped in space and traveltime, but little emphasis is put on the physical understanding of seismic amplitude variations, however, seismic interpreters have put increasing emphasis on more quantitative techniques for seismic interpretation, as these can validate hydrocarbon anomalies and give additional information during prospect evaluation and reservoir characterization *(P. Avseth, T. Mukerji and G. Mavko 2005 and Cambridge*

University Press, 2010). Traditionally seismic facies interpretation has been predominantly qualitative, based on seismic traveltimes. The traditional methodology consisted of purely visual inspection of geometric patterns in the seismic reflections *(e.g., Mitchum et al., 1977; Weimer and Link,1991).*

Robust and flexible methods for estimation of reservoir properties from seismic data are essential for quantitative interpretation in reservoir characterization and monitoring. Several methods are commonly used to assess reservoir conditions from seismic reflection amplitudes. The conventional way is to perform qualitative seismic interpretation to outline geological structures and reservoir architecture from seismic reflection events, their geometry and character.

There are so many parameter and uncertainty to evaluate the carbonates reservoir. Therefore, the integration of rock properties and elastic properties will be comprehensive ways to evaluate the carbonates reservoir. Hence, seismic quantitative interpretation will be used as the main methods, including post-stack amplitude analysis, acoustic impedance inversion beside carbonates diagenesis analysis, lab analysis (petrography), and petrophysical analysis.

Quantitative interpretation addresses a direct link between parameters describing reservoir properties (e.g. porosity, lithology and fluid saturation) and its effective (or upscaled) rock properties (e.g. compressional and shear impedances and velocities) that may be inferred from seismic observations at a scale characterized by the seismic wavelength. Hence, a stronger integration of rock physics in reservoir characterization is a reasonable approach to achieve a more quantitative interpretation. Forward rock physics modelling of effective rock properties from reservoir properties can be challenging if input model parameters are poorly constrained, but is commonly feasible.

Our approach is to introduce fundamental rock physics relations, which help to quantify the geophysical signatures of rock and fluid properties. Since rock properties are a consequence of geologic processes, we begin to quantify the seismic signatures of various geologic trends. Objective of this research is to integrating both the data and expertise of geophysics and geology for carbonate reservoir characterization Figure-5.

3. Case Study

There are several case study that was hard to identified diffrences between lithology facies and it’s connection between porosity and facies type in carbonate reservoir.

4. Result and Discussion

The well interpretation begin by determine the carbonate presence using triple combo logs Figure-6. Advance interpretation done using core description and petrography analysis which shows two different facies of carbonates Figure-7. The correlation with the orientation NE-SW shows the build up carbonate developed in the northern part of the area, and the platform carbonate located in the southern part. The carbonate later on known as Mentawa carbonate (Reef build up), and Minahaki carbonate (Platform carbonate). Well data as a representative of vertical resolution generates geological phenomenon which is very critical as basic concept. Using those concept seismic data interpretation contributes for horizontal resolution, qualitatively it produces structural map on Figure-8. The well and seismic data shows correlation result, Build up facies located in the Northeast and Platform facies located in the Soutwest.

The quantitative interpretation done using rock properties and elastic properties to give better understanding the relationship of its parameters. Using well SNR-1 as a representative of Build up carbonate and SNR-6 as platform carbonate shows there is a relationship. By using density plot as a guidance to set trendline up, SNR-1 has the equation of (R2 = PHIT -3.5709E-5 * AI+0.5083229 = 0.7600858), while SNR-6 has the equation of (R2 = PHIT -4.141041E-5*AI+0.5372917=0.8042644) on Figure 10. The trendline plotted as trendline model of each carbonate facies characteristics on Figure-11. The relationship of rock properties and elastic properties need to be distributed on the seismic section by determine AI cut off which shows in Figure-12. The cut off determined by set the gap of the AI point, the value is 7771.196.

5. Conclusion

The results show that we can potentially distinguish between different types of lithology facies in the study area.

6. Recommendation

Some recommendations which is included the 3D Seismic Pre-Stack Data to used as primary data and conduct some Reprocessing in available seismic data.

7. Acknowledgement

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8. References

Aki, K.T., and Richards, P.G., 1980, Quantitative Seismology : Theory and Methods: Vol. 1, W.H. Freeman and Co.

Dunham, R. J., 1962, Classification of carbonate rocks according to depositional texture. In: Ham, W. E. (ed.), Classification of carbonate rocks: American Association of Petroleum Geologists Memoir, p. 108-121.

Embry, AF, and Klovan, JE, 1971, A Late Devonian reef tract on Northeastern Banks Island, NWT: Canadian Petroleum Geology Bulletin, v. 19, p. 730-781.

Hall, R., 2002, Cenozoic geological and plate tectonic evolution of SE Asia and the SW Pacific: computer based reconstructions, model and animations, Journal of Asian Earth Sciences, 20 (4), p.353-431.

Mavko, G., Mukerji, T., and Dvorkin, J., 2009, The Rock Physics Handbook : Tools for Seismic Analysis of Porous Media (Seconded.), Cambridge University Press.

Mavko, G., Mukerji, T., and Dvorkin, J., 2009, The Rock Physics Handbook : Tools for Seismic Analysis of Porous Media (Seconded.), Cambridge University Press

Ødegaard, E., and Avseth,P., 2004, Well log and seismic data analysis using rock physics templates: First Break, 22, 37-43, doi : 10.3997/1365-2397.2004017.

P. Avseth, T. Mukerji, G. Mavko, Quantitative Seismic Interpretation: Applying Rock Physics Tools to Reduce Interpretation Risk, Cambridge University Press, 2005

Pertamina – BPPKA, 1996, Petroleum Geology of Indonesia Basins

Wilson, J.L. (1975) Carbonate Facies in Geologic History. Springer Verlag, New York

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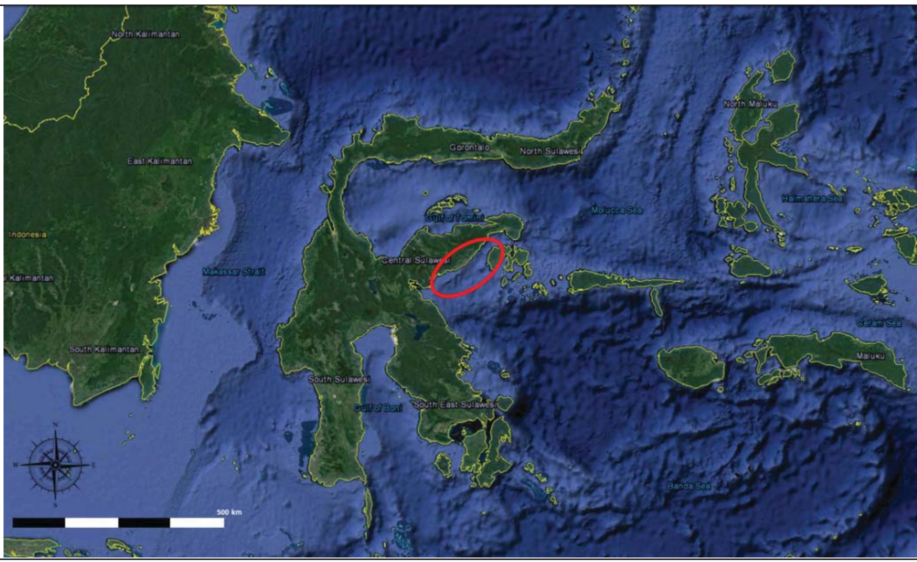


Figure-1. Location of Research area

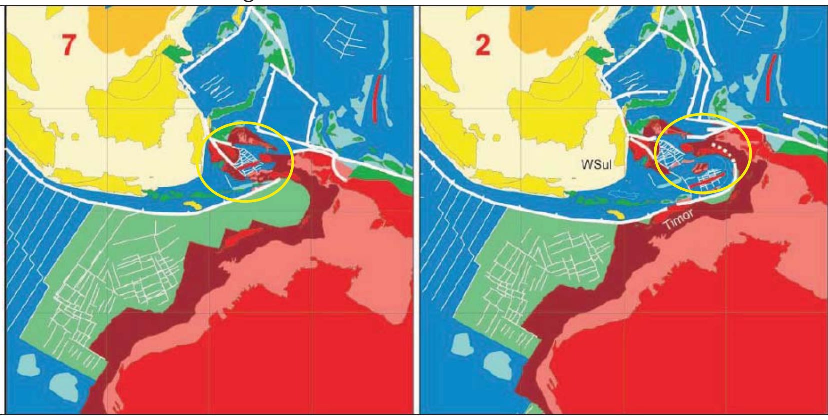


Figure-2. Location of research area related to Australia–SE Asia collision began in the Early Miocene when the Sula Spur collided with the North Sulawesi volcanic arc. Subduction rollback began at about 15 Ma into the Jurassic Banda Embayment causing extension of the Sula Spur (Hall, 2012)

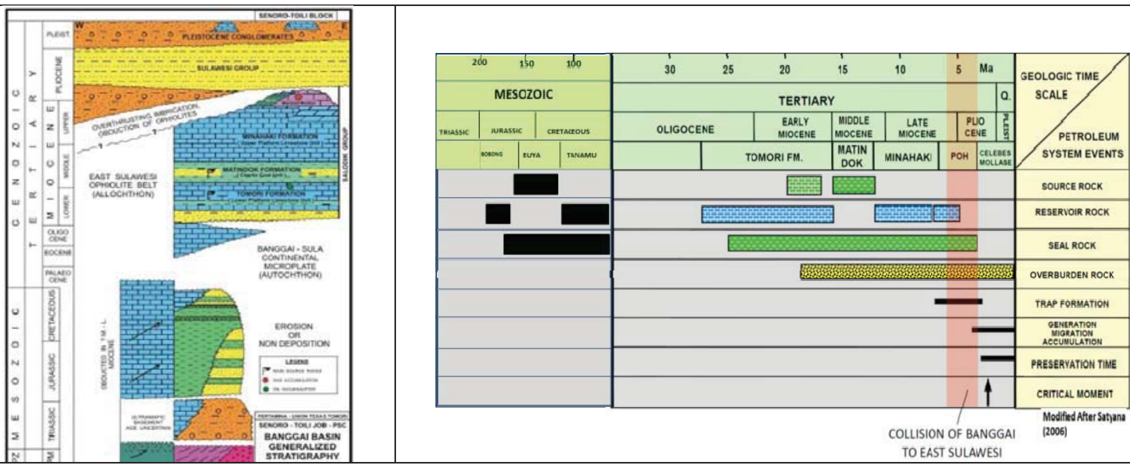


Figure-3. Stratigraphic column (Pertamina – BPPKA,1996) & Petroleum System Chart of Banggai Basin (Satyana, 2006)

Figure-3. Stratigraphic column (Pertamina – BPPKA,1996) & Petroleum System Chart of Banggai Basin (Satyana, 2006)

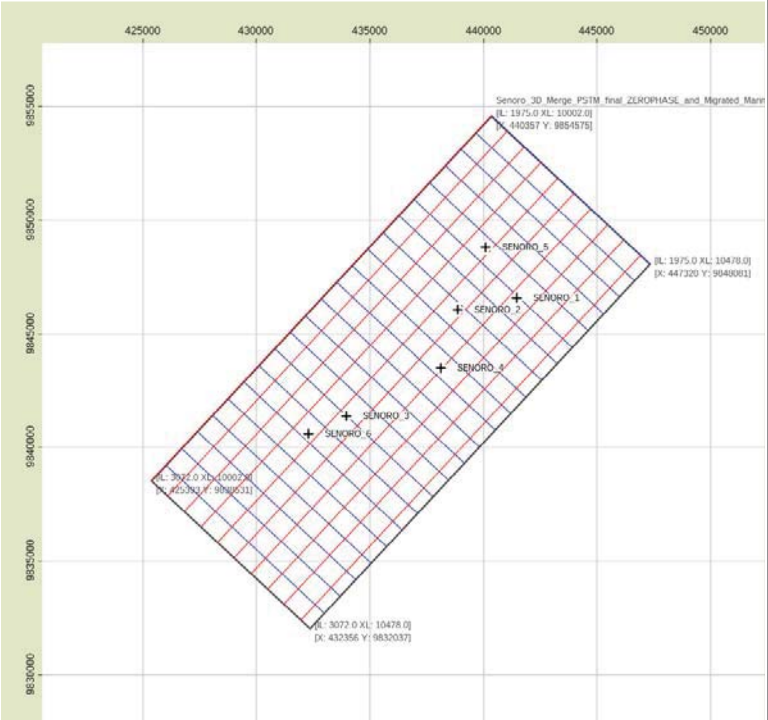


Figure-4. Basemap of study area.

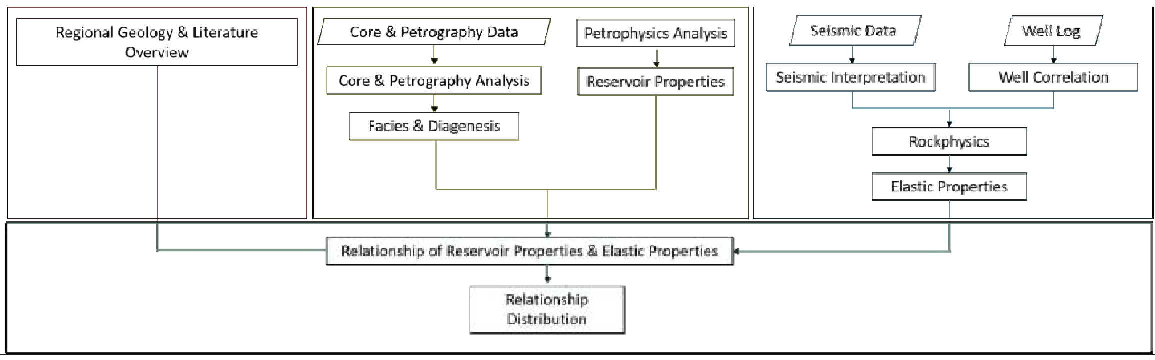


Figure-5. Integrated workflow of the study

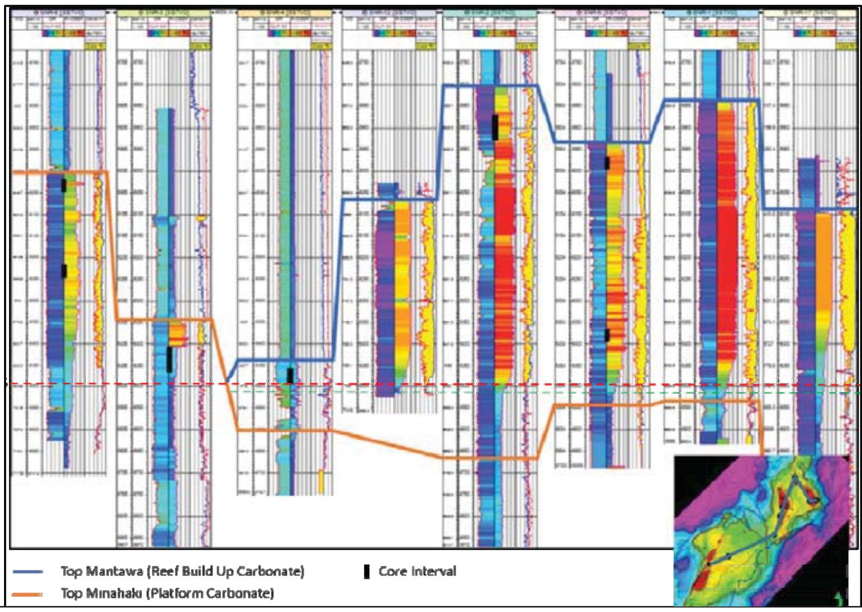
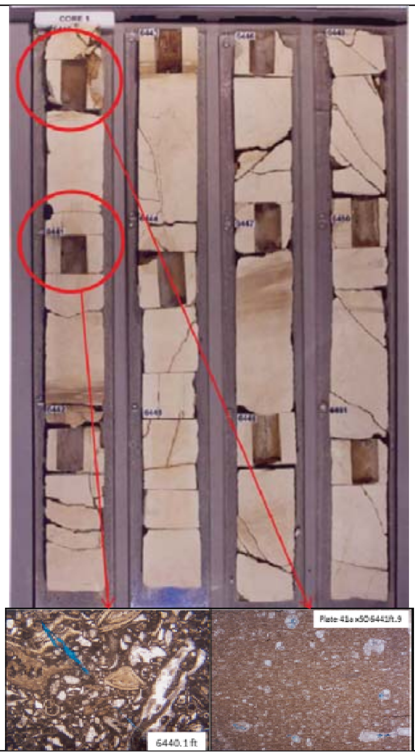
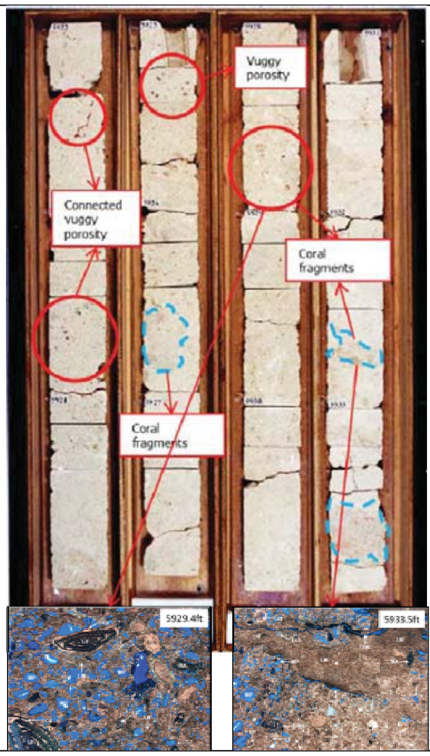


Figure -6. Well correlation from Southwest to Northeast showing two different facies based on core sample characteristics.



Core characteristics of Southwest
(Deep Shelf Margin Facies)



Core characteristics of Northeast
(Organic Buildup Facies)

Figure-7. Core description and petrography analysis show the differences of two carbonate facies.

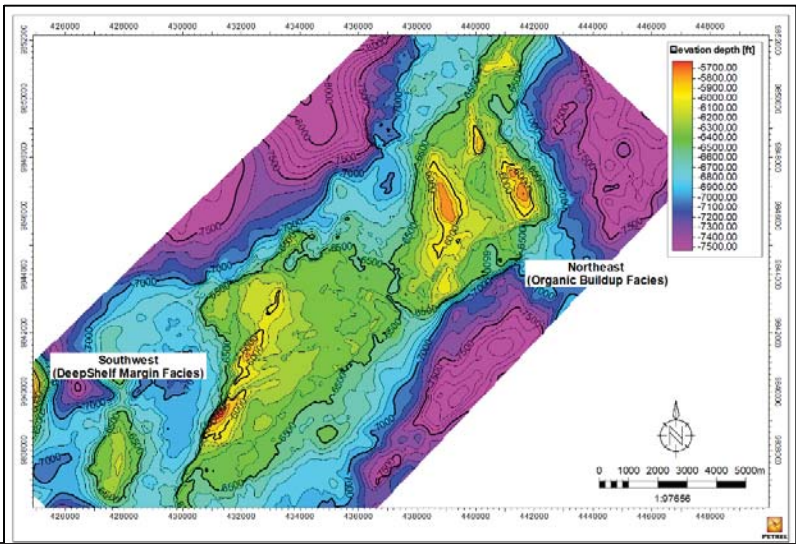


Figure-9. Structural map area was divided into two main carbonate facies

SNR-1 | **SNR-6**

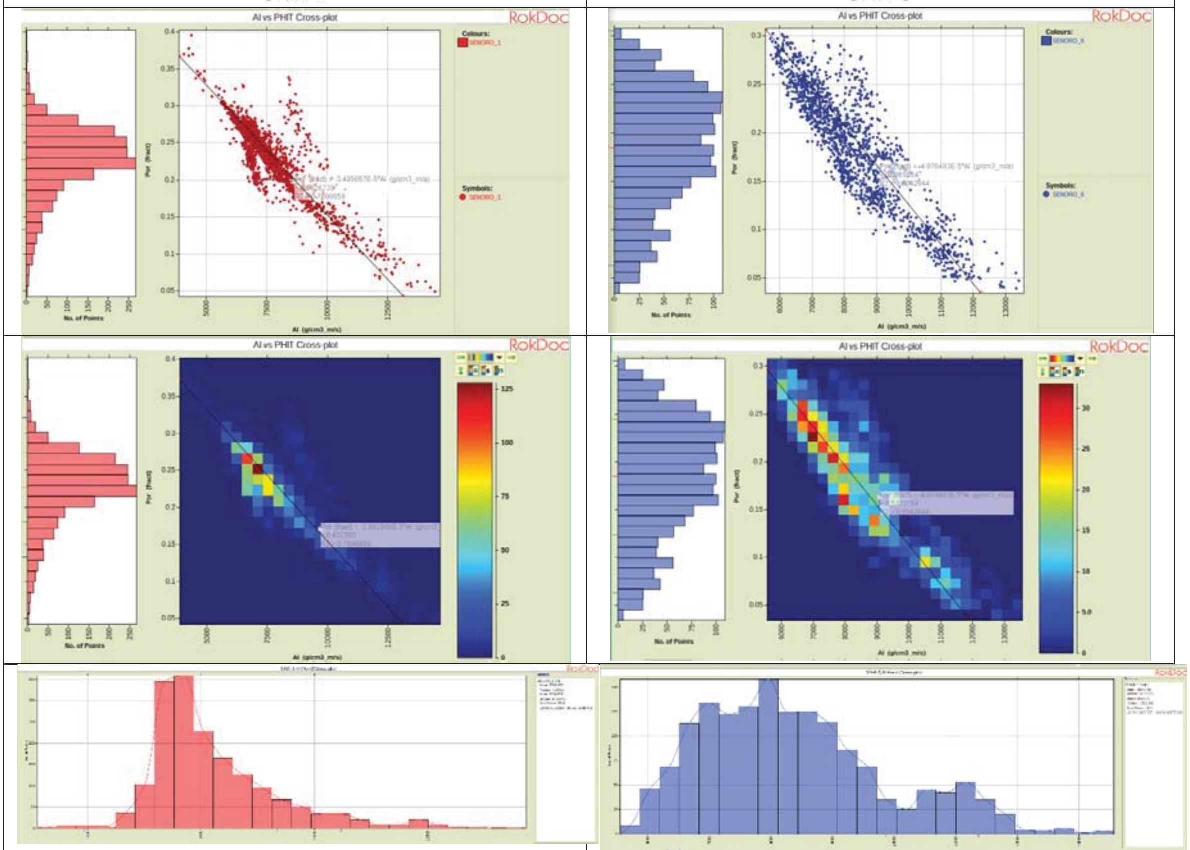


Figure-10. AI vs PHIT Crossplot of SNR-1 and SNR-6 shows relationship

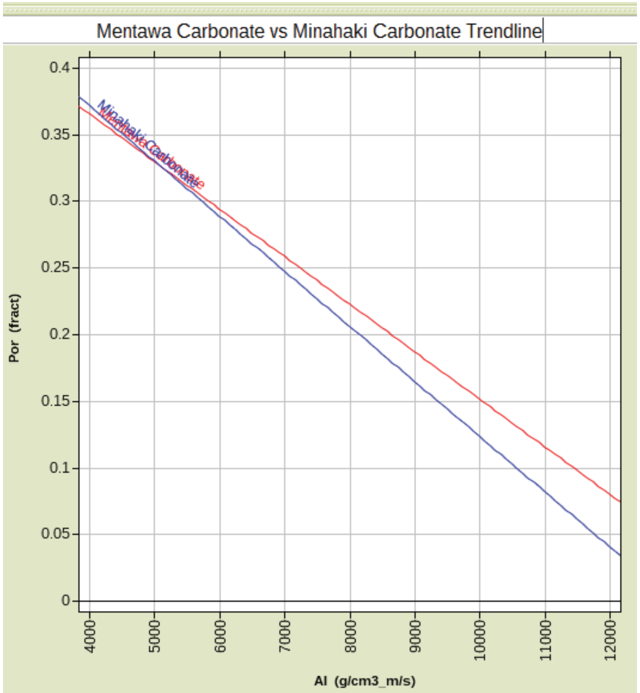


Figure-11. Mentawa Carbonate vs Minahaki Carbonate Trendline Characteristics

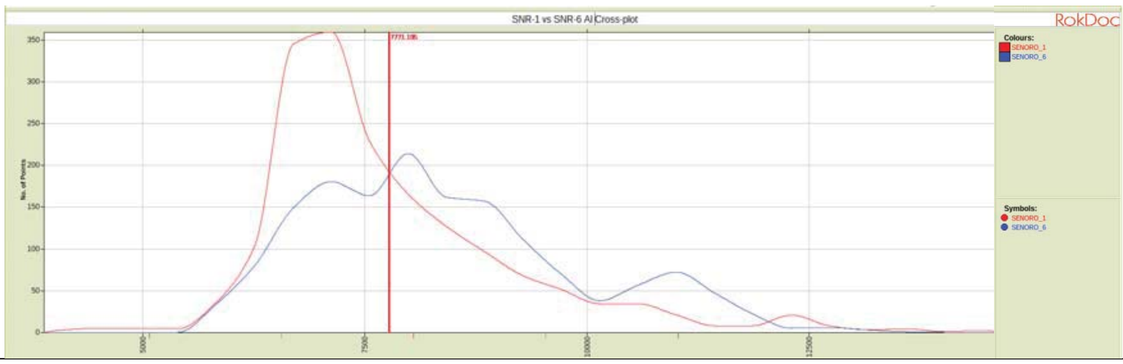


Figure-12. Mentawa Carbonate vs Minahaki Carbonate AI cut off