Fracture Analysis of basement rock: A case example of the Eastern Part of the Peninsular Malaysia

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Abstract. In general, reservoir rocks can be defined into carbonates, tight clastics and basement rocks. Basement rocks came to be highlighted as their characteristics are quite complicated and remained as a significant challenge in exploration and production area. Motivation of this research is to solve the problem in some area in the Malay Basin which consist fractured basement reservoirs. Thus, in order to increase understanding about their characteristic, a study was conducted in the Eastern part of the Peninsular Malaysia. The study includes the main rock types that resemble the offshore rocks and analysis on the factors that give some effect on fracture characteristic that influence fracture systems and fracture networks. This study will allow better fracture prediction which will be beneficial for future hydrocarbon prediction in this region.

1. Introduction

Reservoir rocks such as carbonates, tight clastics and basement rocks are the important elements in the petroleum system. The aid of fractures’ elements can give some effects on increasing or decreasing the reservoir performance. The factors that influence fracture characteristics remain as a challenge in the exploration and production area. Two of the factors that influence fracture characteristic are rocks types and also stress (tectonic). Different rock types will produce different marks such as fracture as responses to the internal and also external factors.

Fractures can be defined as planar or subplanar discontinuity which forms due to the external or internal stress (Haakon F, 2010). Fractures are usually found in brittle structures as their rock body accommodate the stress or deformation in showing the marks when they lost cohesion through fractures characteristics (George HDet. al 2012). Fractures can be defined in three types which are shear fractures and extension fracture joints or fissures as shown in Figure 1.0: Types of fractures.
Fracture analysis of the basement rocks is important as metamorphic and igneous fractured reservoir fields are already been discovered and developed in South East Asia including in the Bach Ho (Vietnam), Suban Gas Field (Indonesia) and Malay Basin (Malaysia). The definition of the basement rock is quite extensive as different researchers define the basement in many ways. According to Landes KK (1960), basement rocks are any metamorphic or igneous rocks which are overlain by sedimentary layer while North FK(1990) defines basement rocks to include any sedimentary origin if they have little to zero matrix porosity. In this paper, the researchers agree with Ngoc (n.d.) definition, as he defines the basement rocks are any metamorphic or igneous rocks which are overlain a study area of petroleum basin.

2. Geological setting of the study area

A study was conducted in the East domain of the Eastern part of the Peninsular Malaysia (Figure 2.0) as the rock types in this location resembles the basement rock in the offshore part and it can be a good analogue study. Based on the study, the main lithology of the research areas is granite and might be I-type granitoids as according to MetCalfe I (2013) I-type granitoids can be found in the Eastern Belts of the Malay Peninsula. Their characteristics are equigranular to weakly porphyritic with alkali feldspar-orthoclase to intermediate microline (Charles S H, 1977). This type of rock was chosen because Ngoc H Y (n.d) and Suhaileen S (2005) mention that there are various types of basement rocks including Mesozoic granitic (intrusive and volcanic rocks) in the Malay basin area.
Figure 2.0 shows the granitoids bodies in the Peninsular Malaysia area. These granitoids bodies with a few fault zones which are including Lebir fault zone, Besut fault zone, Kg Buloh fault zone, Ping Teris fault zone, Lepar fault zone, Mersing fault zone and Balau-Murau fault zone were mapped by Charles S H and Tan D N K (2009) become an interest as their fracture characteristic might resemble the offshore part. Three localities were chosen based on the good exposure of the fracture on the rock.

3. Methodology

Fracture analysis based on the scan-lines method was carried out on the three different localities. There were about eleven scan-lines with different length. The length of the scanlines was depending on the exposure of the rock. Six main data were collected in this location. Main data which based on discontinuity survey data sheet were collected. The data includes fracture types, fracture spacing strike, dip orientation and dip value. Distance and length of the coordinates (Figure 5.0) were collected by using Global Positioning System (GPS).
4. Rock types and Fracture Characteristics (Fracture Patterns)

Based on the study, three main features of the rocks’ types determined are granite (the main type of rock), dolerite dykes and also enclaves. Generally, granites in this location compose main mineral like quartz (~1cm), feldspar (0.50mm-1.5mm) and plagioclase. Dolerite dykes can also be determined with black in colour features (Width: 0.06m-2m; Length: 1m-20m). In certain part of the igneous rock, enclaves with a different mineralogy were determined. They might be fragment from the country rock.

![Outcrop example of weathered granite with black dolerite dykes (left) and enclaves, xenoliths (right) in Teluk Cempedak Beach. Different types of mineral can be observed in this location](image)

Figure 3.0: Outcrop example of weathered granite with black dolerite dykes (left) and enclaves, xenoliths (right) in Teluk Cempedak Beach. Different types of mineral can be observed in this location.

Granite in the study areas show fractures which are known as joints (Mode I). They are in ladder pattern which are in systematic joints and cross joints. Systematic joints are long and continuous and evenly spaced while the cross joints are evenly spaced joints which against the systematic joints (figure 4.0).

![Two different joints which are systematic joints and cross joints in the outcrop in Teluk Cempedak (A) and comparison with George H D et. al 2012 fracture patterns (joints)](image)

Figure 4.0: Two different joints which are systematic joints and cross joints in the outcrop in Teluk Cempedak (A) and comparison with George H D et. al 2012 fracture patterns (joints).

Based on the data analysis, there are two sets of fracture network for each of the locations except for the third location as this location is quite difficult to be assessed. Major fracture conjugates for the
first location are NE-SW and NW-SE, the second location are NE-SW and E-W and third location is NE-SW.

Figure 5.0: Fracture orientation

5. Factors that caused fractures

Based on the results of this research, factors that might influence the fracture system and fracture network are the rock characteristic, external factors (tectonic) and internal factor such as weathering. Rocks characteristic can be determined by using Poisson’s ratio which is the ratio of lateral strain to longitudinal strain. It is also known as extensional ratio (George HDet. al 2012). Understanding the characteristics of the rock especially in the value of Poisson’s ratio (Figure 6.0) is important for characterising fractures.

$$\text{Poisson’s ratio} = \frac{e_{\text{lat}}}{e_{\text{long}}}$$

Granite’s poisson’s ratio is about 0.04 (weathered) to 0.11 (fresh). This value shows that the granite tends to show brittle deformation and accommodate their pronounced loss of cohesion in showing some marks through fracture (joints) which is extension fin nature.
Figure 6.0: Poisson’s ratio of granite compared to the other rocks (left) and their behaviour in the experimental deformation structures under extension and contraction (right) (Haakon F 2010)

6. Conclusion

Understanding rock characteristics and rock patterns like systematic joints and cross joints is crucial because they might be conduit or seal for the reservoir rocks. Other than that, it is important to identify fracture sets for each of the location as they might be influenced by local tectonics like in this area as there are a few set of fracture sets which are NE-SW and NW-SE for the first location, NE-SW and E-W for the second location and NE-SW for the third location is. Further study should be conducted to understand the fracture characteristic in spatial space and which tectonic factors that might influence them. As conclusions, fracture characteristic in the onshore (as an analogue) study might give some good predictions for the study on the offshore data.

7. Acknowledgement

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8. References

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