

Structural Analysis: Folds Classification of metasedimentary rock in the Peninsular Malaysia

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Abstract. Understanding shear zone characteristics of deformation are a crucial part in the oil and gas industry as it might increase the knowledge of the fracture characteristics and lead to the prediction of the location of fracture zones or fracture swarms. This zone might give high influence on reservoir performance. There are four general types of shear zones which are brittle, ductile, semibrittle and brittle-ductile transition zones. The objective of this study is to study and observe the structural geometry of the shear zones and its implication as there is a lack of understanding, especially in the subsurface area because of the limitation of seismic resolution. A field study was conducted on the metasedimentary rocks (shear zone) which are exposed along the coastal part of the Peninsular Malaysia as this type of rock resembles the types of rock in the subsurface. The analysis in this area shows three main types of rock which are non-foliated metaquartzite and foliated rock which can be divided into slate and phyllite. Two different fold classification can be determined in this study. Layer 1 with phyllite as the main type of rock can be classified in class 1C and layer 2 with slate as the main type of rock can be classified in class 1A. This study will benefit in predicting the characteristics of the fracture and fracture zones.

1. Introduction

Metasedimentary rocks are highly correlated with the temperature and also pressure which might be caused by regional metamorphism or contact metamorphism. These two different conditions influence the rock properties. Different types of rocks with different properties will form because of this relation and can be related to the shear zones. According to Haakon F (2010), a shear zone is a tabular zone with strain rate is higher compared to the surrounding rocks. Shear zones can be divided into four zones which are brittle, ductile, semibrittle and brittle-ductile zones (George H D et. al 2012). The characteristics of shear zones allow us to divide them into these types of zone. Figure 1 shows a simple model that might help in understanding the metamorphic facies together with its characteristics might help in the study that might influence the fracture.



Different properties of the rock were highlighted because they might influence rock characteristic especially structures. There is a lack of understanding of the rock characteristic especially in the subsurface as the resolution of the seismic is limited. The limited resolution of the seismic gives limitation in understanding the rock characteristic in the subsurface. Thus, an outcrop study was conducted in order to enhance the understanding of the rock characteristic on the surface and to improve the understanding of the rock characteristic in the subsurface. The similarity of the rock types from the outcrop-surface and in the subsurface were highlighted by Ngoc H N (n.d.) and Suhaileen S (2005). Based on this study, the possibilities to locate the fracture zone, which might be an element that can increase reservoir performance can be better understood.

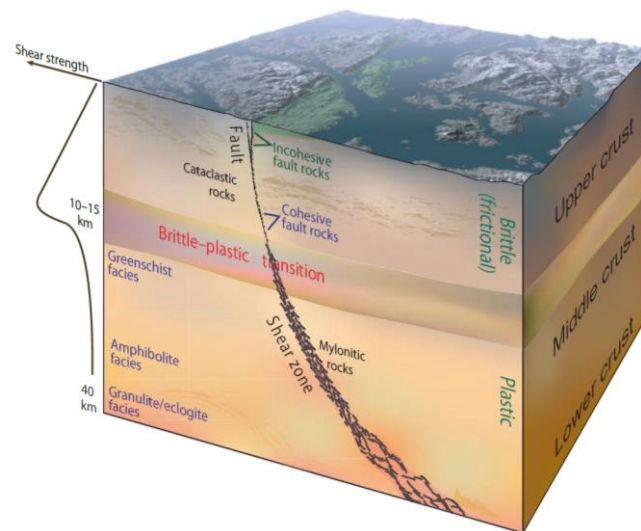


Figure 1: Simple model for shear zones that were illustrated by Haakon F 2010

2. Geological setting of the study area

A field study was conducted on the outcrops that are well exposed along the coastal part of the Peninsular Malaysia. It is located in the eastern belt of the Peninsular Malaysia. The study area might be related to the fault zones which are Lepar Fault zone, Mersing Fault zone and Balau Murau Fault zone. Based on the previous studies, this study area is filled with the distribution of phyllite, slate, shale and sandstone, argillaceous carbonaceous with local limestone as well as felsic to intermediate volcanic. The study was conducted on the metasedimentary rock as this type rock shows high similarity with type of rocks in the subsurface.

3. Methodology

A few structural analysis was conducted in order to understand the characteristic of the structure in the subsurface. Other types of rock which is granite was analysed by Annur S (2013). In this paper, a structural analysis for metasediment was conducted in order to understand the structural characteristic especially on geometry of the rock. The study was conducted based on the structural characteristics (fold, faults and fracture) that were exposed in the study area as the weathering affects the exposure of the rock. Strike and dip orientations of rocks were collected. Fold geometry was studied based on the fold classifications layer thickness variations (Figure 2.0) by Ramsay (1967) and also by using the combination of the dip of the axial plane and the plunge of hinge line (Figure 3.0)

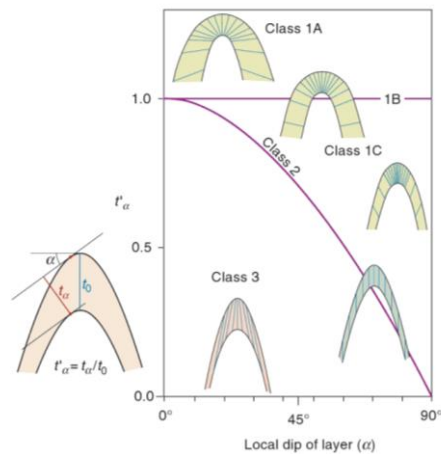


Figure 2: Fold classifications layer thickness variations based on Ramsay, 1967 from (Haakon F 2010)

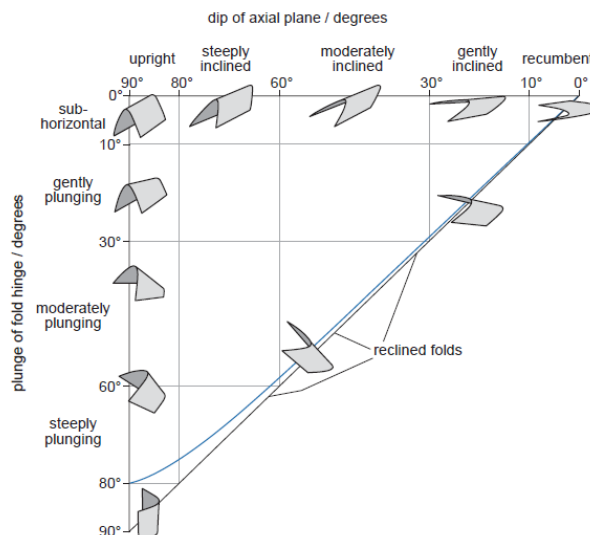


Figure 3: Fold type classifications using the dip and the axial plane and the plunge of hinge line based on Ramsay, 1967 from (Angela L C 2010)

4. Metasedimentary rocks

Three main types of metasediment which are metaquartzite, slate and phyllite were determined in the study area. The characteristics of the rock types can be determined as in the following table (Table 1). Figure 4 and figure 6 show the type of rocks in the study area.

No	Rocks	Characteristics
1	Metaquartzite Colour: white to beige	1) Type of rock: Non foliated metamorphic rock 2) Others: Mineral - Quartz grain (Size: Medium to coarse)
2	Slate Colour: Black	1) Type of rock: Foliated metamorphic rock - Parent rock: shale, mudstone or siltstone 2) Grain size: Very fine grain 3) Others: Slaty cleavage with quartz veins in the joint
3	Phyllite Colour: Dark gray	1) Type of rock: Foliated metamorphic rock - Parent rock: slate 2) Others: Quartz veins in the joint

Table 1: Metasediment rock types (metaquartzite, slate and phyllite) based on colour, type of rock and other characteristic that can be observed in the study area

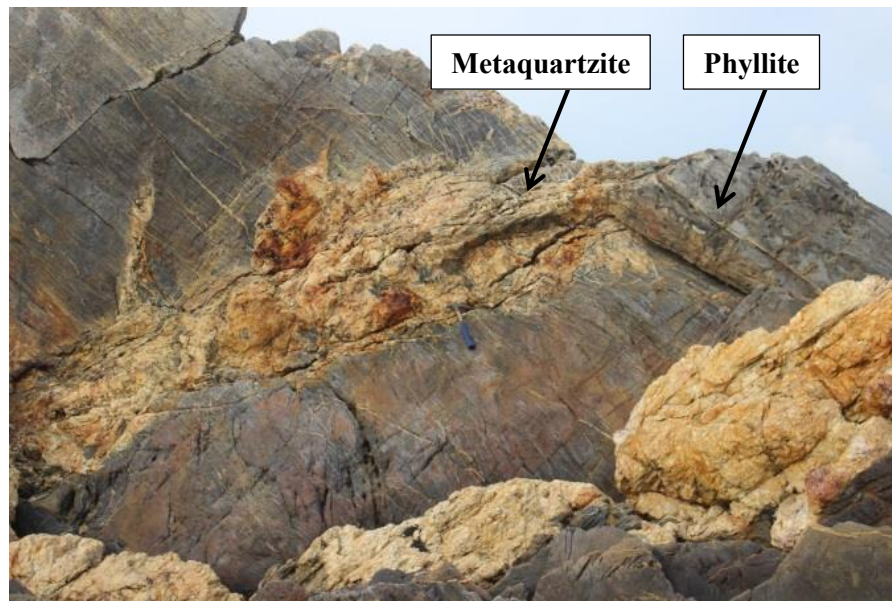


Figure 4: Different types of metasediment rocks with non-foliated, white to beige colour metaquartzite and foliated, gray phyllite can be observed in this location

5. Structural Geometry

Structures that are exposed in this field can be classified into a few types of geometry. The highlighted structure in this field area is fold with structural development that might relate to the formation of the fracture or can be known as fold related fracture. Small scale structures were determined in a fold and the analysis was divided into layer 1 and layer 2 which can be determined in figure 5.0. Based on the analysis, the plunging of the fold hinge about more than 30° oriented from South to North. Based on the classification in figure 3, which was classified by Ramsay 1967, the fold in this location can be classified as moderately plunging.

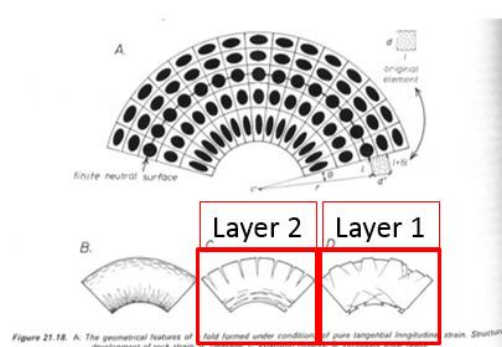
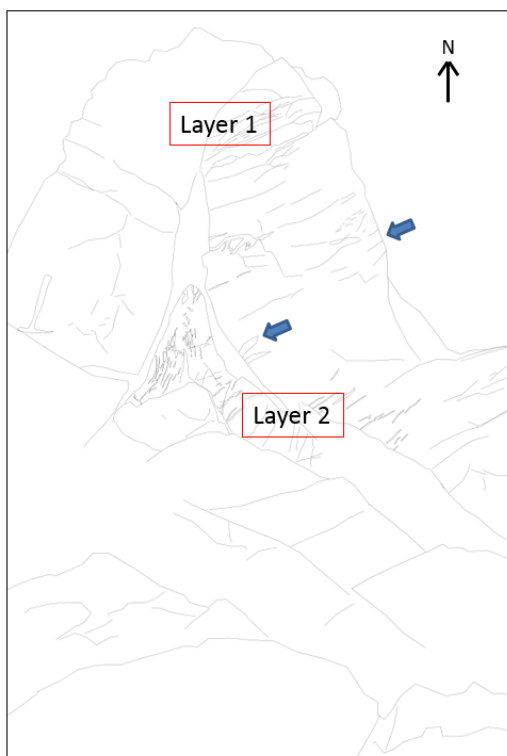


Figure 5: Left figure shows two layers which were divided into layer 1 and layer 2 for this study area. The characteristic of the layer can be compared with the right figure which based on strain and small scale structures in folds based on Ramsay (1967).

Based on the fold classification layer thickness variations by Ramsay (1967) in figure 2, the fold in this area were analysed. Ramsay (1967) classified the fold based on $t'_\alpha = t_\alpha/t_0$ as in figure 6 left side (bottom). In this case, the calculation is $t'_\alpha = t_\alpha/t_0$ with t'_α is similar to t'_α in Ramsay (1967). Table in figure 6 shows detail analysis of the fold. Based on the analysis, the fold in the study area can be classified as Class 1A for Layer 2 and Class 1C for Layer 1 (Figure 6.0: Fold classifications layer thickness variations). Other interesting features in this fold is tension gashes as well as pinch and swell that can be defined in the second layer.

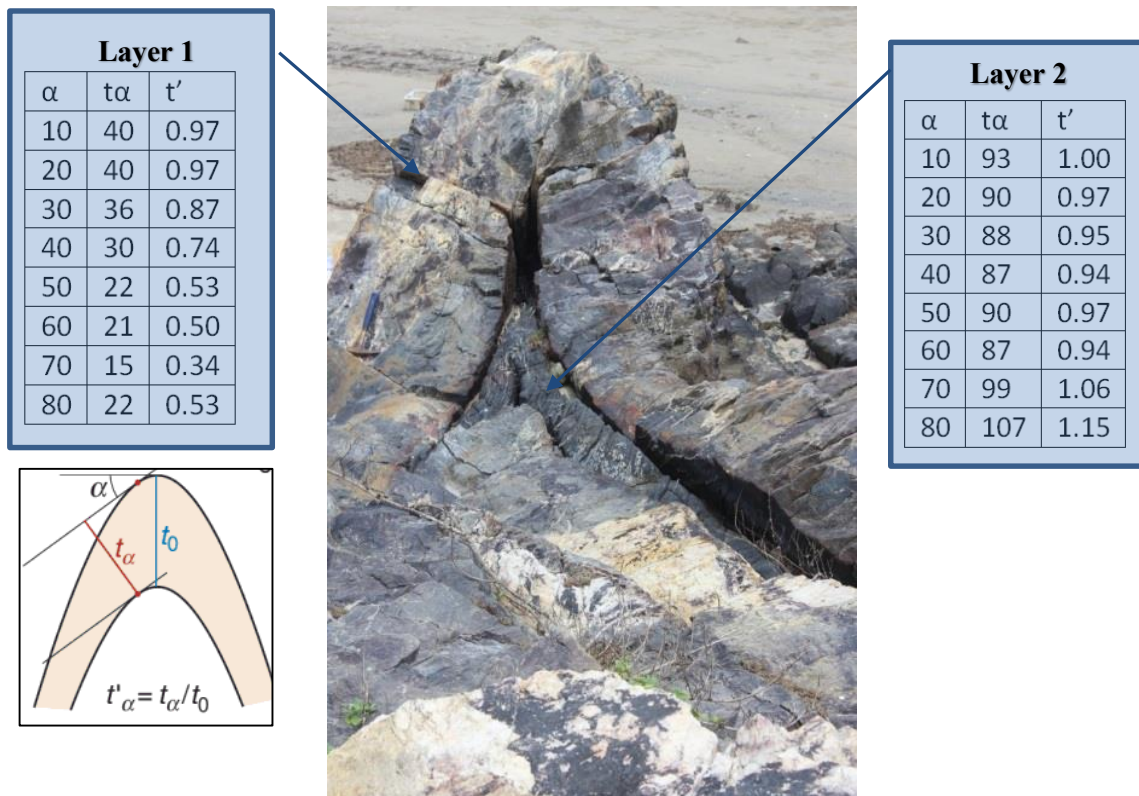


Figure 6: The analysis of fold in the study area (middle figure) was classified by using layer thickness variations based classification from Ramsay (1967). Two layers for fold were classified as in the figure (left-bottom). Layer 1- phyllite can be classified as Class 1C and Layer 2 - slate as Class 1A.

6. Discussion

The main structural that can be observed in this study area is fold which can be classified as Class 1C and Class 1A. This classification is based on the layer as there are two main types of rock which is slate (Layer 2) and phyllite (Layer 1). Based on the analysis, different types of rocks show different classification of fold geometry. The analysis of this study is crucial as it can enhance the understanding of the rock as different types of rocks with different properties will form different. Understanding different types of the rock with different properties is important because the analysis in this study shows different characteristics of the rock can be determined. The formation of the fracture in the layering of the fold can be the evidence of the relation in between fold and fracture. The characteristic of structural analysis especially fold in the outcrop is highlighted as it can enhance the understanding of the relation of fold with the fracture which cannot be determined in the seismic data which is low in resolution.

7. Conclusion

Fractures are the major paths as it gives some effects on increasing or decreasing the reservoir performance. Based on the structural identifications on this research, factors that might be related to the fracture zones can be determined based on the rock characteristic that are highly correlated with the temperature and also pressure. Fractures that were observed can be fracture related faults and also fracture related fold. In this study, based on the classification from Ramsay (1967), the fold classification can be divided into two classes which are layer 1 with phyllite in Class 1C and layer 2 with slate as the main rock in class 1A. The fracture between the layering of the rock can be observed and it shows the relation in between fold and fracture. This study might help in predicting the characteristics of the fracture and fracture zones. Currently, I am still working on predicting the fractures especially in the subsurface which is still in progress.

8. Acknowledgement

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9. References

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