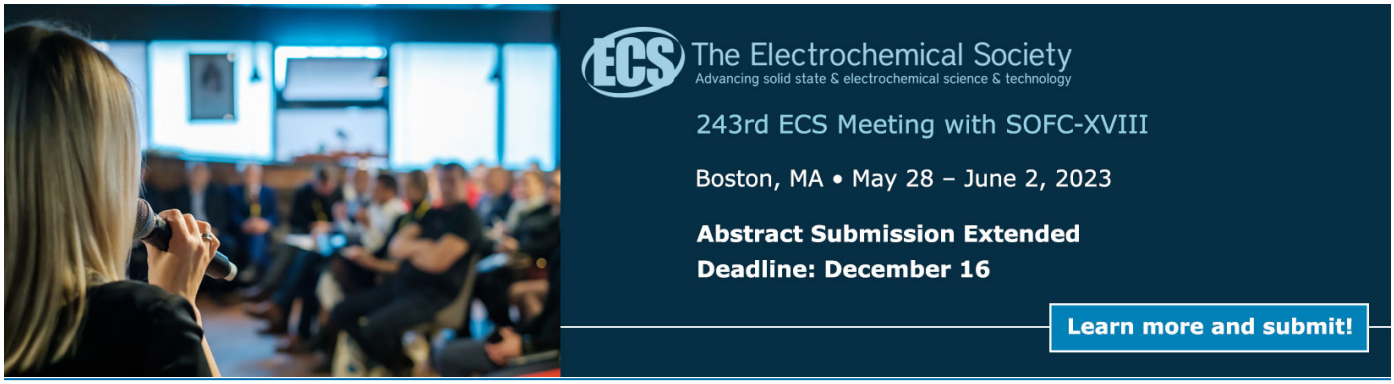
Metamorphic Evolution of the Baling Formation at Banding Island, Perak, Malaysia



Metamorphic Evolution of the Baling Formation at Banding Island, Perak, Malaysia

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Abstract. This paper presented new study on the mineral assemblages and the compositions on the rocks protolith. Banding island and its surrounding area are dominated by low-grade regional metamorphism which located within the East Malaya Block and dated from Ordovician to Permian age. The study area is situated at longitudes of 101° 22' 25"E to 101° 22 35"E and latitudes at 5° 33' 47"N to 5° 32' 95"N. The metamorphic rocks consist of phyllite, mica schist, and metasandstone interbedded with slate. Majority of the phyllite are highly weathered with visible joint. Phyllite in the study area contains quartz veins with thickness varies from 0.5 cm to 6 cm, that follows the direction of rock foliation. Phyllite is dominated with mica group with major muscovite mineral, and the mica is mostly muscovite. While the mica shist is also dominated with mica group with muscovite mineral. The intensity of the regional metamorphism is lowest from the west of the Banding Island to slightly moderate metamorphism toward the east of the study area, which supported by the changes of the metamorphic rock type from phyllite to schist according to the petrographic analysis. Regionally, Perak state especially in Gerik area are dominated by rocks from Paleozoic era as Perak is located in Western Belt of Peninsular Malaysia.

1. Introduction

The metamorphic rocks on Banding Island are based on field observation and petrographic study of rock specimen. The primary focus is on Banding Island, which is located 41 km from Gerik town southwest of Perak and its surrounding along the East-West Highway. Banding island is surrounded by the artificial lake of Temenggor Lake, situated near the Belum rainforest. The study area range is 25 km² that focuses on Banding Island and its surrounding along the East-West Highway. The main objectives of the research are to conduct petrographic analyses of metamorphic rocks and identify the metamorphic evolution of the study area.

Banding island is mostly majorly built up with low-grade regional metamorphic rock, which originated from the East Malaya block during the Ordovician to Permian age. The formation of the study area is believed to be included in Paleozoic formation, which is Baling group as Banding Island is situated in north Perak state. Banding island's highest elevation was recorded at 410 meters, while the lowest would be 270 meters above mean sea level. The lithologies of Banding Island are composed of low-grade phyllite, mica schist and metasandstone interbedded with slate. Most of the outcrops are easily found and reachable as they are situated along the East-West Highway of Perak.

2. Regional geology and tectonic setting

Peninsular Malaysia can be divided into three main belts: Eastern Belt, Central Belt and Western Belt. Perak state is located at the north part of Western Belt. According to Jones [1], the western zone is an area that extends from the border of Perak-Thai heading towards the southwards of Melaka state. The Eastern, Main Range (South Thailand-West Peninsular Malaysia), Northern (Northern Thailand), and Western (Southwest Thailand-East Myanmar) granite provinces are the divisions of the Southeast Asian granite belts [2-4]. The Bentong-Raub suture zone, which denotes the closure of the Paleo-Tethys Ocean divides the Main Range granite province from the Eastern granite province, which is located in the western part of Peninsular Malaysia [5-6]. After the suturing event, the Main Range Granite Province is located on the Sibumasu Terrane, while the Eastern Granite Province plutons were deposited in the Indochina-East Malaya Block [6]. At 230–220 Ma, the Sibumasu and Indochina–East Malaya collision which stitched both plates together, stopped the subduction process [7]. Within the Main Range granite province, the Main Range batholith and the Bintang batholith are two major intrusive stages. The two batholiths were inserted into a band of Lower Paleozoic rocks that also contained meta-volcanic rocks and meta-sedimentary rocks from the felsic to intermediate Ordovician [8, 1].

Perak state is famous for the geological features such as limestone caves and hills. Geological formation identified within Perak state includes Baling Group, Bendang Riang, Papulut Quartzite, Lawin Tuff, Kroh Formation and Gerik formation. The study area, Banding island, was included in Baling group at Gerik, located in the northern part of Perak, which is the island formed in the middle of a man-made lake widely known by locals as Temenggor lake. Baling group was once named as Baling formation are the sequences of rock that spread along the east of Semanggol formation with Mahang formation. The lithology from Baling group can be found in its original place, such as Baling in Kedah and around Gerik in Perak. The two main stratigraphic groups that exist in the western zone are Baling group and Bentong group. Since the area of interest is situated in north Perak, it is included in Baling group stratigraphic unit. It is one of the main stratigraphic groups that formed as an unbroken belt down through the eastern part of the foothills of the Main Range. Baling group which was once named Baling formation is a formation that consists of calcareous, arenitic, and argillite sedimentary rocks that have already undergone metamorphism. Carbonaceous rocks make up the majority of these formations. According to Burton [9], there are 4 facies divided in the formation which are clay facies, limestone facies, calc-silicate facies, and arenite facies. Due to the numerous faults and the fact that these facies alter vertically and horizontally is quite challenging in determining the relation between each facies.

Study areas (Fig. 1) are believed to be included in Gerik's formation since the location of the research area is located in north Perak. This is supported by the types of rock that can be found in the study area. The name of Gerik formation was taken from the nearby town named Gerik located in north Perak, which was previously named Gerik tuff [8, 10]. According to Burton [10], the rock exposures from this formation can be seen well exposed along the East-West Highway that binds Perak to Kelantan state. The Gerik formation is primarily made up of rhyolitic to rhyodacitic composition and tuffs of pyroclastic rocks that form during previous volcanic activities. The Gerik formation's tuffs are occasionally metamorphosed.

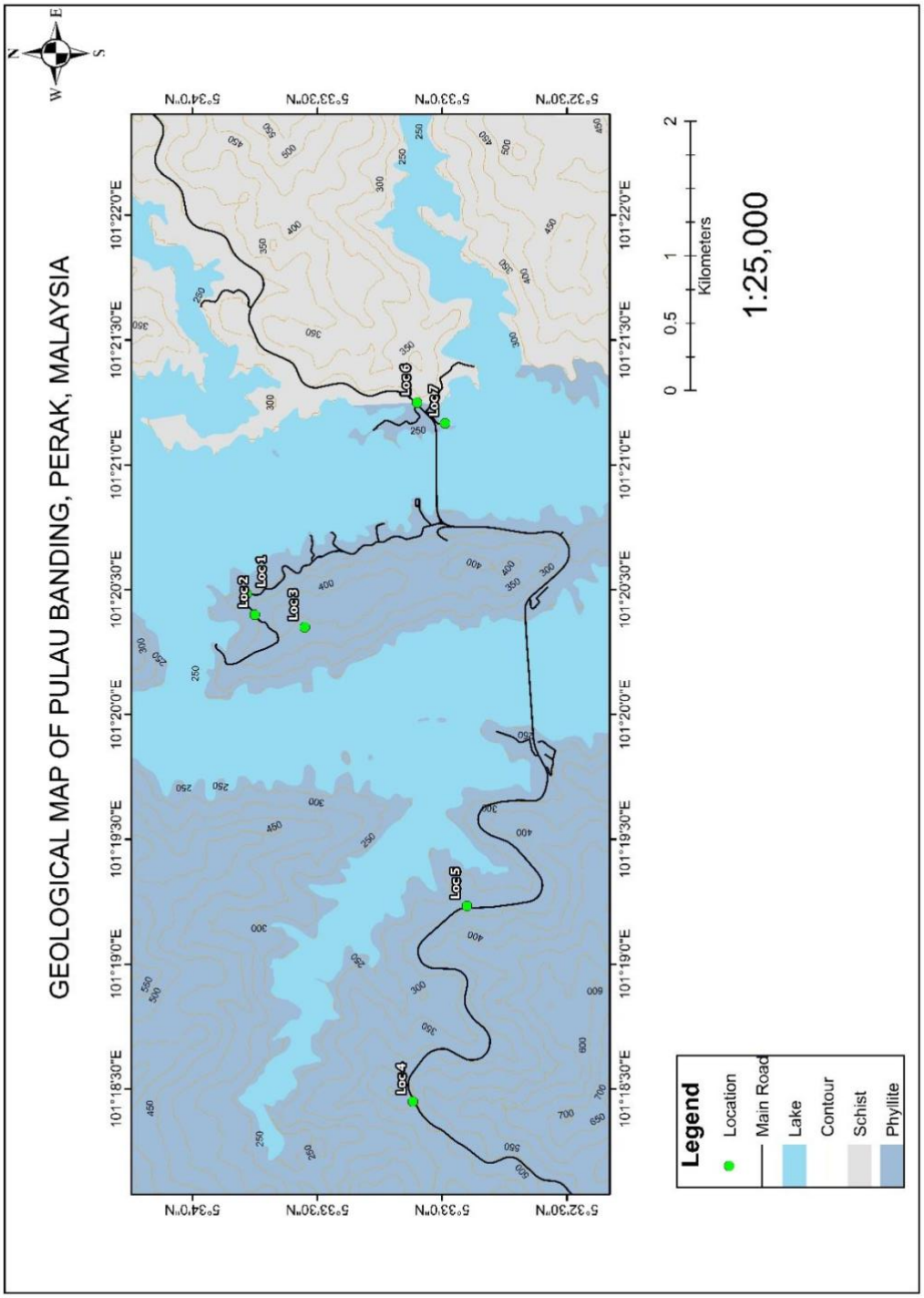

Figure 1. The geological map of the study area.

3. Materials and method

A total of 7 samples of metamorphic rocks around Banding island were deliberately selected for macroscopic and microscopic analysis. Rock samples were divided into two batches and sent for thin sectioning for petrographic study and Scanning Electron Microscope (SEM) analysis. Preparation for the thin section was conducted at the Department of Geology, Faculty of Science, University of Malaya while scanning Electron Microscope (SEM) imaging was conducted in the Faculty of Earth Science in University Malaysia Kelantan. The Scanning Electron Microscope (SEM) instrument was used to form an image by projecting and scanning a concentrated molecule structure of electrons across the samples' surface. For samples preparation, the samples for SEM are crushed or chipped away from original sample into small pieces with measurement of 0.5 cm x 0.5 cm or 2 cm x 2 cm.

4. Result

4.1 Petrography Analysis

Table 1. Shows the samples type of rock.

SAMPLES	ROCK TYPE
E001U	PHYLLITE
E101P	PHYLLITE
E102U	METASANDSTONE
E103Q1	QUARTZITE
E103U2	METASANDSTONE
E201U	METASANDSTONE
E1301MS	MICA SCHIST

Based on the petrography analysis, the sample E001U showing fine grain size with slightly metamorphosed quartz minerals with biotite presence filled up in between grains (Fig. 2a). The quartz mineral still exhibits characteristic of sedimentary rocks; however, the mica minerals are started to develop and fill up the matrix in the rocks. The quartz is greyish to milky white in cross polarized light and wavy extinction. Quartz is more dominant in sample E001U. The mica is showing 2nd order colour in cross polarized light and appear to be second dominant in the thin section. Biotite , chlorite and muscovite is example of mineral presence in the group mineral of mica. In the sample E101P, the rock is fine grained with clear visible of foliation structure (Fig. 2b). The mica minerals such as chlorite and biotite are more dominant compared to quartz. Sample E102U exhibits visible quartz minerals with chlorite and biotite mineral in the matrix (Fig. 2c). Similar to samples E001U and E102U, sample E103Q1 also showing same characteristics and rock textures with the combination minerals of chlorite. However, in the thin section, the mica is more compared to samples E001U and E102U, while the quartz is decreasing in composition. Sample E103U2 exhibits quartz with highly fractured features (Fig. 2e) maybe because of the deformation in the rock. Then sample E201U showing more visible foliation though having the similar rock type with samples E001U E102U, and sample E103Q1. Sample exhibits biotite and muscovite presence with visible foliation (Fig. 2f).

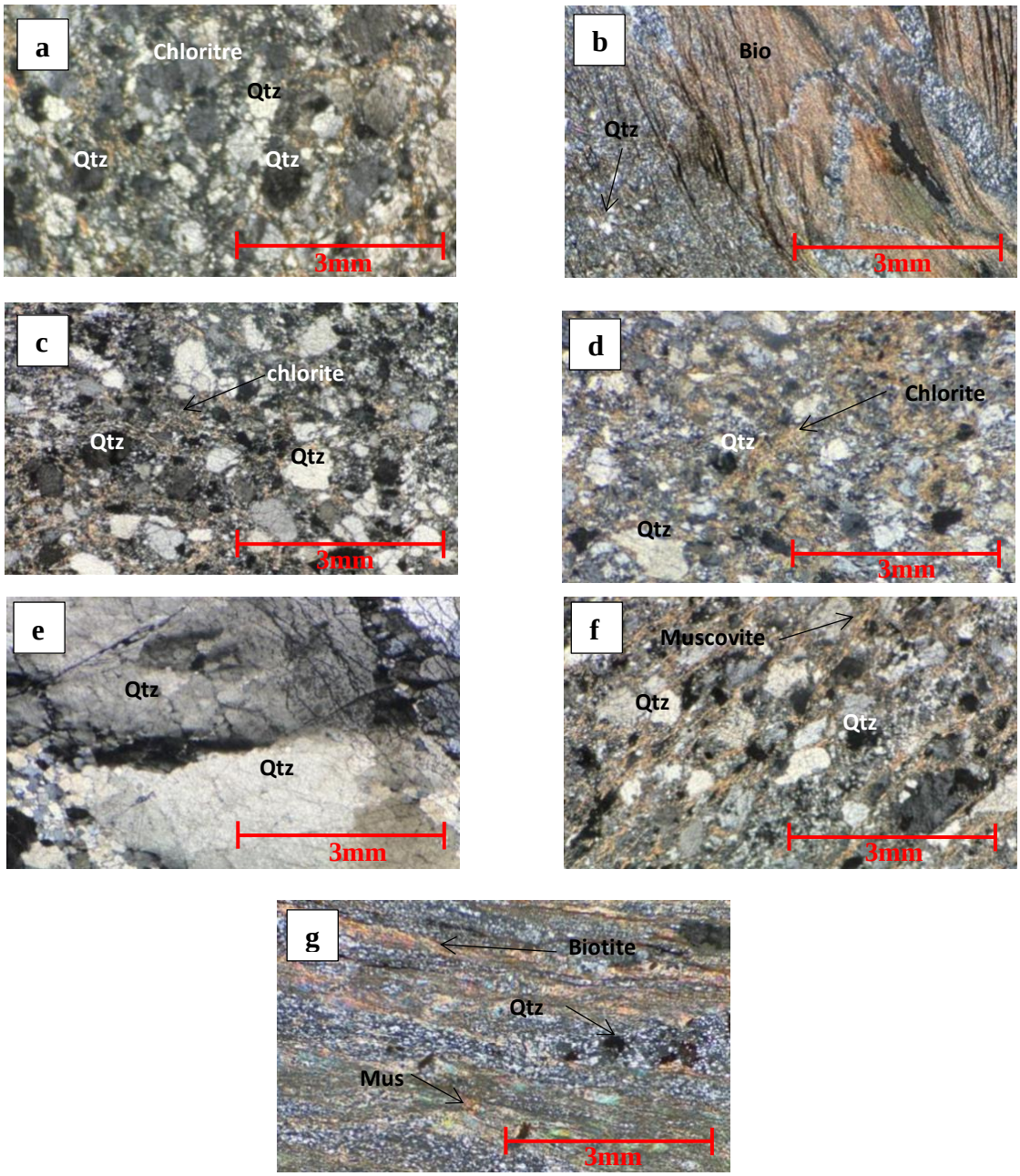

Figure 2. The thin section shows a micrograph of metamorphic rock samples from Banding Island. (**a**) Sample E001U, large minerals of quartz with chlorite presence filled up in between grains. (**b**) Sample E101P, fine grained with clear visible of foliation structure. (**c**) Sample E102U, exhibits visible quartz grain with chlorite presence. (**d**) Sample E103Q1, biotite presence distributed between particles of quartz grain. (**e**) Sample E103U2 exhibits quartz with highly fractured features. (**f**) Sample E201U, biotite distributed between particles of quartz grain and the last sample (**g**), E301MS exhibits biotite and muscovite presence with visible foliation.

4.2 SEM

Based on the Scanning Electron Microscope (SEM) images, in the mica schist showing biotite minerals are visible and showing schistose texture (Fig. 3a). On the other hand, the phyllite are showing the biotite minerals are visible and platy with quartz are more blocky (Fig. 3b). As for the metasandstone showing the quartz minerals are dominant (Fig. 3c).

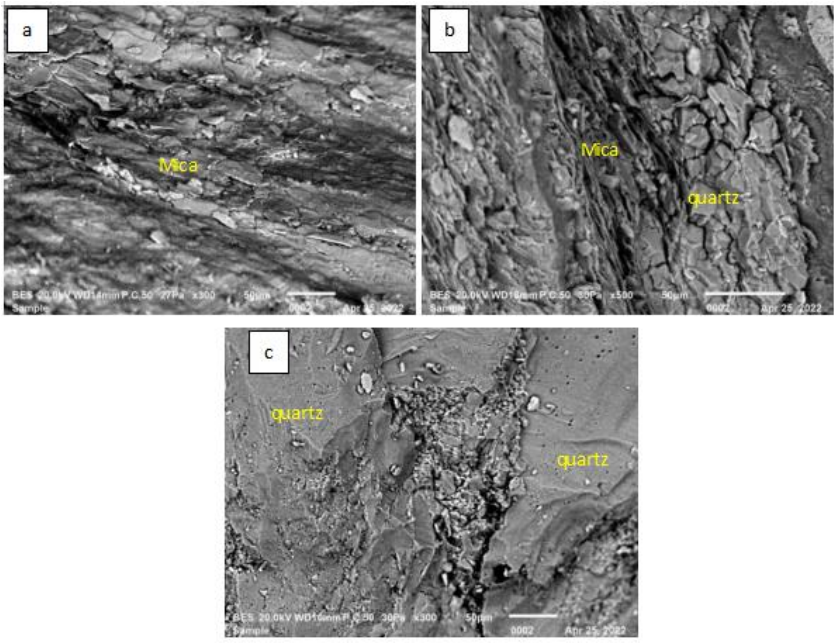

Figure 3. The Scanning electron microscopy image rock samples in the study area. (a). Most mica minerals are visible, (b) mica are visible with quartz are more blocky, (c) quartz minerals are dominant.

5. Discussion

The thin sections of total 7 samples of metamorphic rocks exhibits low grade metamorphism toward medium grade metamorphism. The direction of the regional metamorphism is lowest from the west of the Banding Island to slightly moderate metamorphism toward the east of the study area, which supported by the changes of the metamorphic facies from phyllite to schist according to the petrographic analysis. The mica presence in the samples is filling between spaces of quartz grain and the shape of the grains are subrounded to subangular due to high temperature of previous volcanic activities that caused the border of each grain to melt. Examples of minerals found in the mica group mineral include biotite, chlorite, and muscovite. Some rocks samples exhibit fracture texture as a result from a breakage of its flat surface fixed by its crystal structure. Mica schist shows visible schistose texture as it is the most altered rocks among the other samples and both samples are fine grained. Foliation is most commonly visible in the groundmass as a result of regional metamorphism. The SEM results supported the finding of the petrography analysis that the rocks containing minerals such as quartz and mica.

Mica has heat resistance up to 1000 ° C. It is an excellent heat insulating material due to its low thermal conductivity and high thermal stability and non-flammable as well. The index minerals chlorite, muscovite, and biotite each represent different grades of rock, represent mica group. Muscovite is stable up to about 650-700° C before breaking down into potassium feldspar and quartz alterations. Quartz, on the other hand indicates the maturity of the outcrops. Rock maturity increases with the amount of quartz present. An index mineral is a brand-new mineral that defines a certain zone. The Banding island's series of zones, together with the rocks and typical metamorphic mineral assemblage in each, are as follows:

Chlorite zone : Chlorite, muscovite, and quartz are frequently found in pelitic rocks, which are typically slates or phyllites.

Biotite zone : With biotite, chlorite, muscovite, and quartz, slates give place to phyllites and schists.

The Barrovian zones are the name given to a series of mineral zones that have been identified in different orogenic belts around the world and are now so well-established in the literature.

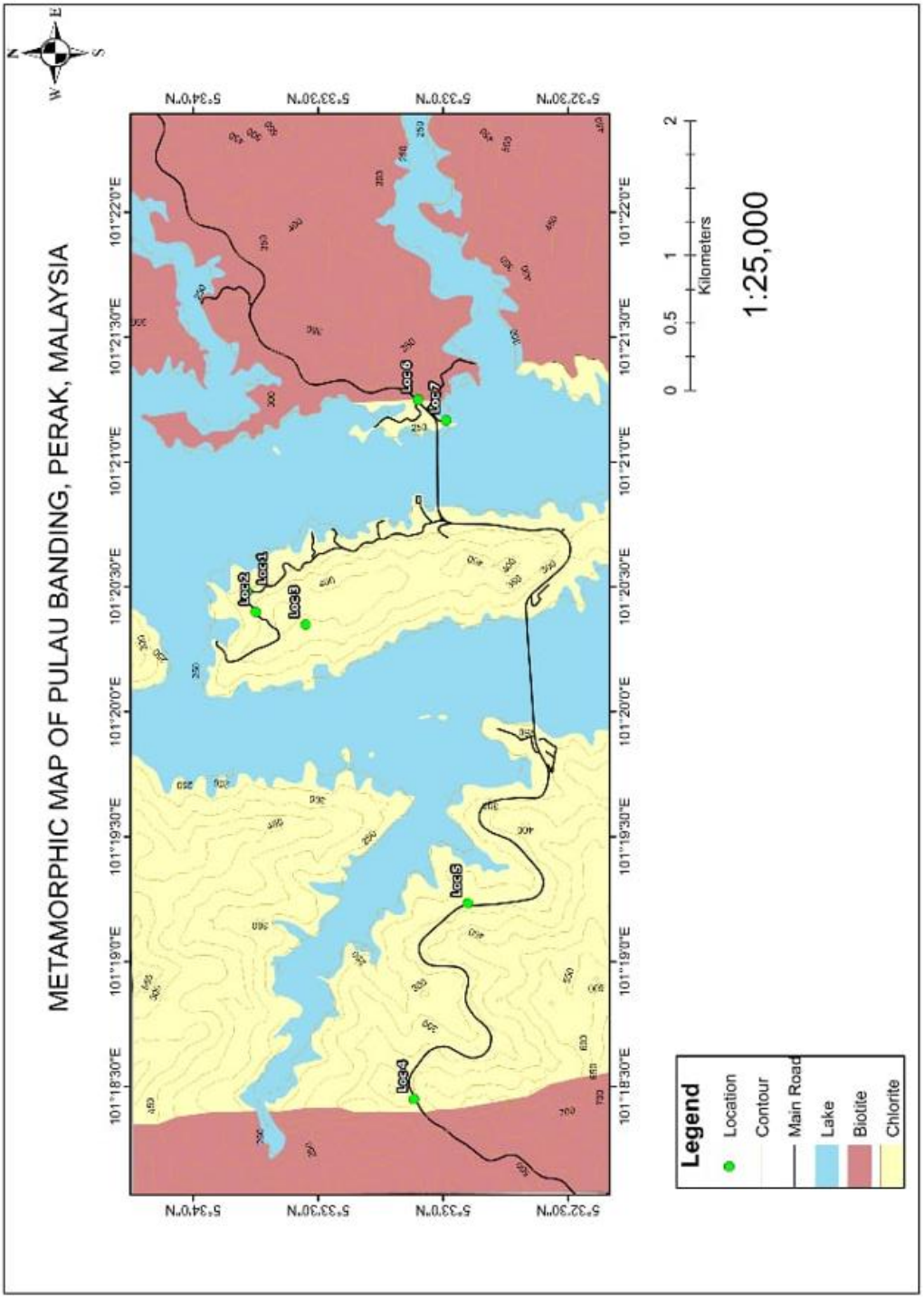

Figure 4 The metamorphic map of the study area

6. Conclusion

As conclusion, this paper shows the new study on the mineral assemblages and the composition of the rocks protolith in the study area is a success. Banding island are dominated with biotite, chlorite and muscovite that belongs to mica group and each mineral developed in different temperature based on conductivity and thermal stability of minerals. The metamorphic rock evolution can be seen through the mineral assemblages of the samples according to the metamorphic zone.

Acknowledgement

Thank you to University Malaysia Kelantan for providing accommodation and facilities at Tropical Rainforest Research Centre (TRACE) during the whole time of conducting this research. Thank you to Faculty of Earth Science for assisting the analysis of SEM.

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