General Geology and Very Low-Grade Metamorphic Rocks Mineral Assemblages Determination in Tugu Peringatan Timur-Barat Highway, Gerik, Perak.

By

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A report on the completion of the prerequisites for a Bachelor of Applied Science (Geosciences) degree with Honors .

Faculty of Earth Sciences

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DECLARATION

I declare that this thesis entitled General Geology and Very Low-Grade Metamorphic Rocks Mineral Assemblages Determination in Tugu Peringatan Timur-Barat Highway, Gerik, Perak. is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently. submitted in candidature of any other degree.

Signature :………………………………….

Name : :…………………………………...

Date :………………………………………

APPROVAL

"I/ We hereby declare that I/ we have read this thesis and in my/our opinion this is sufficient in terms of scope and quality for the award of Bachelor of Applied Science (Geoscience) with Honors"

Signature : ………………………………………..

Name of Supervisor : :………………………….

Date : ……………………………………………

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ZUHAIRA BINTI MUHAMMAD ZAINI THINNAGHARAN

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General Geology and Very Low-Grade Metamorphic Rocks Mineral Assemblages Determination in Tugu Peringatan Timur-Barat Highway, Gerik, Perak.

ABSTRACT

Baling Formation had undergone regional and dynamic metamorphism of the deep marine sedimentary rocks which dated in Early Silurian-Devonian. This study is presents the newest structural data that situated between latitudes of 5^{0} 34' 21" N to 5^{0} 32' 97" N and longitude of 101^{0} 25' 45" E to 101^{0} 24' 01" E. The objective of this study was to produce a geological map of Gerik Highway, Perak on a scale of 1 - 25000 and to determine the sequences of mineral assemblages associated with metamorphism in the study area. Geological mapping and petrography analysis to identify the mineral sequences in the research area were two of the methods used to achieve the objective. Geological study shows the features of the area was dominated with sedimentary rock such as sandstone, mudstone, and shale, with the minor occurrence of metamorphic rocks which was phyllite. From the field study, the left side of the study region was contain of sedimentary rocks based on the sample collection while starting from the west side of the box, a transition of two different rock types occurs in the middle part of the exploration from sandstone to low-grade phyllite, with the lowest intensity of regional metamorphism through the west part of Banding Island. Due to the dense vegetation in the study area, the precise location of the transition process that occurred is still remain unknown. There are no logging or agricultural operations taking place in the remaining portion of the study area, which is covered in dense forest. The foothills of the Gerik Highway are interspersed at the foothills of the range, with two types of hills: elongated hills and isolated hills. The founding in the research shows some majority of structures, according to structural evidence, include joints, faults, quartz veins, overturned folds, anticline and syncline. Direction of major folds and their cleavage indicates the location of the axial planes of the major folds and their overturning directions. In conclusion, the study area had a low percentage of metamorphic rock.

Keywords: Structural Geology, Baling Formation, Banding Gerik, Metamorphic Rock, Sedimentary Rock

Geologi Am dan Penentuan Taburan Mineral Batuan Metamorfik Gred Sangat Rendah di Lebuhraya Tugu Peringatan Timur-Barat, Gerik, Perak.

ABSTRAK

Formasi Baling telah mengalami metamorfisme serantau dan dinamik bagi batuan sedimen laut dalam yang bertarikh di Awal Silurian-Devonian. Kajian ini membentangkan data struktur terbaru antara latitud 5^0 34' 21" N hingga 5^0 32' 97" N dan longitud 101^0 25' 45" E hingga 101^0 24' 01" E.Kajian ini bertujuan untuk menghasilkan peta geologi Lebuhraya Gerik, Perak pada skala 1 - 25000 dan untuk menentukan urutan perhimpunan mineral yang berkaitan dengan metamorfisme di kawasan kajian. Pemetaan geologi dan analisis petrografi bagi mengenalpasti jujukan mineral di kawasan penyelidikan adalah dua kaedah yang digunakan untuk mencapai objektif tersebut. Kajian geologi menunjukkan ciri-ciri kawasan ini di dominasi oleh batuan sedimen seperti batu pasir, batu lumpur, dan syal, dengan kewujudan skala yang kecil batuan metamorfik iaitu filit. Dari kajian lapangan, sebelah kiri kawasan kajian mengandungi batuan sedimen berdasarkan koleksi sampel, manakala bermula dari sebelah barat kotak, peralihan dua jenis batu yang berbeza berlaku di bahagian tengah penerokaan dari batu pasir ke filit gred rendah, dengan intensiti metamorfisme serantau terendah melalui bahagian barat Pulau Banding.Oleh kerana hutan tebat di kawasan kajian, lokasi tepat proses peralihan yang berlaku masih belum diketahui.Tiada pembalakan atau operasi pertanian yang berlaku di bahagian baki kawasan kajian, yang diliputi hutan tebal.Kaki bukit Lebuhraya Gerik diselang-seli di kaki bukit julat, dengan dua jenis bukit: bukit memanjang dan bukit terpencil.Penubuhan dalam penyelidikan menunjukkan beberapa majoriti struktur, mengikut bukti struktur termasuk sesar, kekar, urat kuarza, lipatan, anticline dan syncline. Arah lipatan utama dan belahan mereka menunjukkan lokasi satah paksi lipatan utama dan arah terbalik mereka. Kesimpulannya, kawasan kajian mempunyai peratusan batu metamorfik yang rendah.

Kata kunci: Geologi Struktur, Pembentukan Baling, Banding Gerik, Batu Metamorfik, Batu Sedimen

CHAPTER 1

INTRODUCTION

1.1 Background of Study

The Western Belt of Peninsular Malaysia is rich in Palaeozoic rocks. In the state of Perak, the area of the study was conducted in along the highway of Gerik Highway, Perak, which is on the edge of the west of Jeli, Kelantan. This study is presenting the newest structural data situated between latitudes of 50 34' 21" N to 50 32' 97" N and longitude of 101^0 25' 45" E to 101^0 24' 01" E. The range size of the study research area is 25 Km^2. The main road of the study area is the East-West Highway road.

The study area has a high elevation of contour which is about 580 m and the lowest elevation is about 370m above sea level. The lithologies of the area show that it is dominated by sedimentary rock such as sandstone, mudstone, and shale, with the minor occurrence of metamorphic rocks which is phyllite. Most of the outcrop was easy to be found which is only located along the highway of Gerik Highway.

Meanwhile, most of the outcrop was weathered badly was not easy to take out the sample but the research area has a few geological structures which are easy can be seen.

This project aims to offer a complete overview of the geology of this area, with a focus on the majority of rock types and mineral assemblage occurrences. To obtain data that might improve the geological and petrological understanding of this location, many procedures are applied.

1.2 Study Area

The Western Belt, Central Belt, and Eastern Belt are the three primary belts that run through Peninsular Malaysia. Perak is a state in Malaysia's Western belt(as circled in Figure 1.1 below).

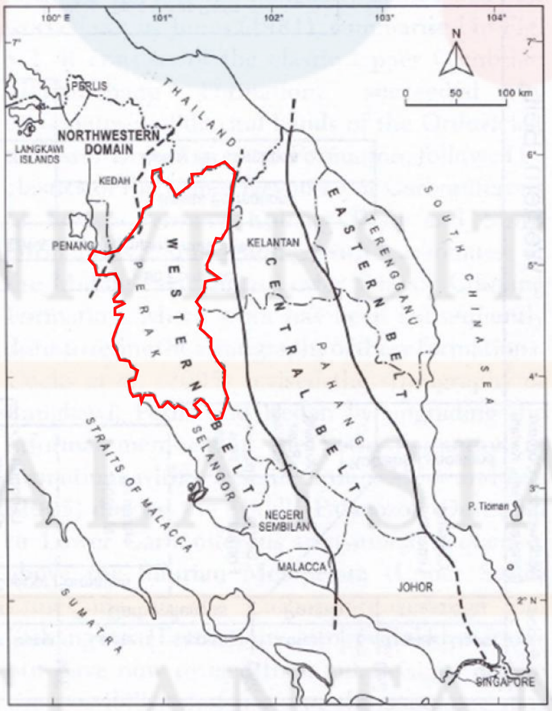
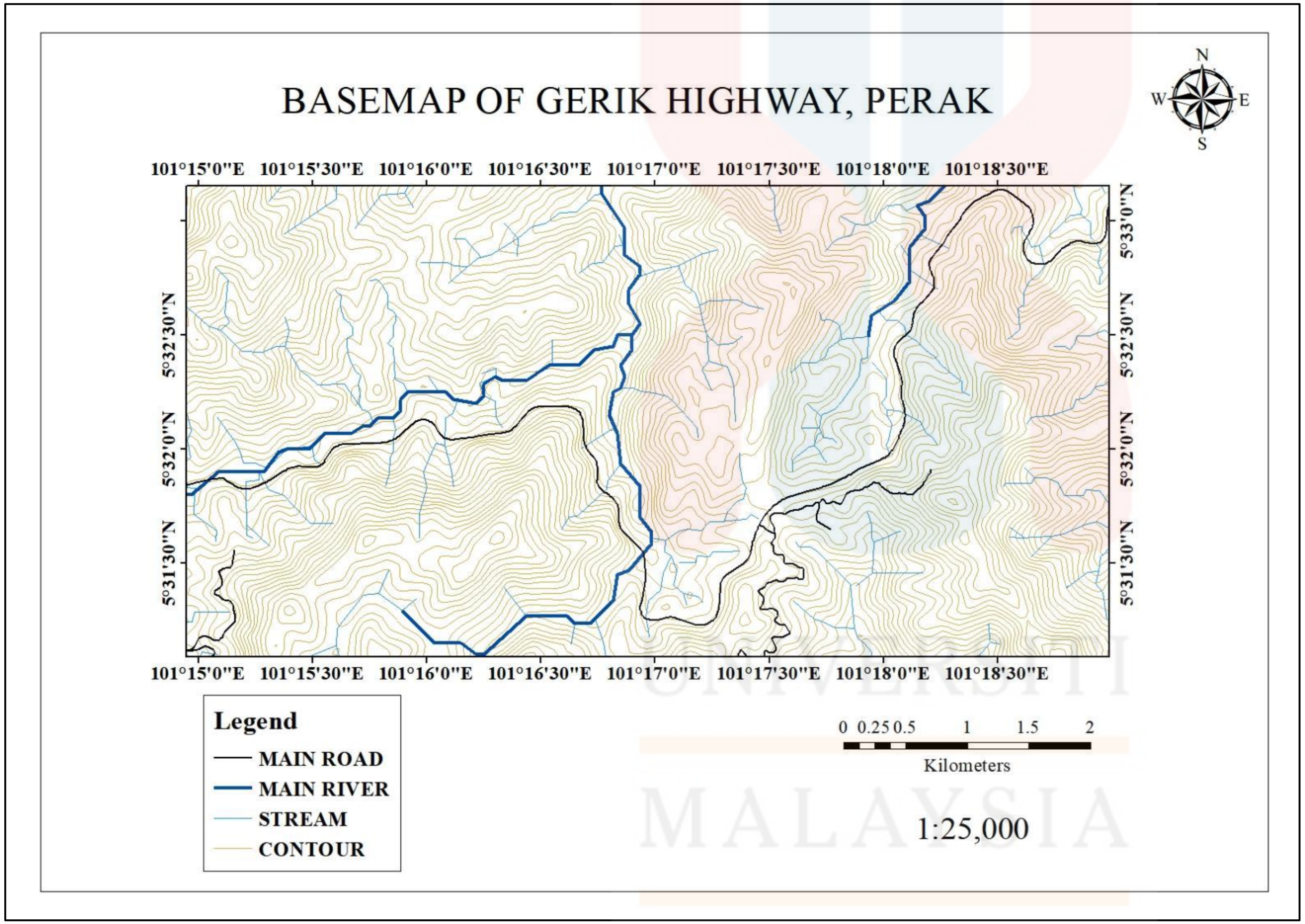


Figure 1.1 The three types of belts in Peninsular Malaysia

(Adapted from C.S.Hutchinson and D.N.K. Tan, 2009)

1.2.1 Location

The geology of the Gerik Highway in the specific research region consisted of a Paleozoic-aged rock known as the Gerik formation (previously known as Gerik Tuff). Tuffs of rhyolitic to rhyolitic composition, limestone, and calcareous shale are examples of frequent lithology. The highest peak was roughly 580 meters above sea level, while the lowest elevation was about 370 meters. This was approve when they are located along Perak's East-West Highway, most of the outcrops are easy to find and approach.



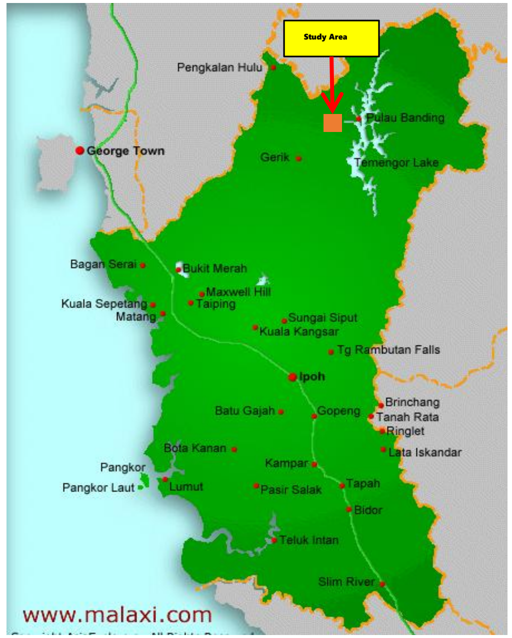


Figure 1.2: Basemap of Gerik Highway, Perak

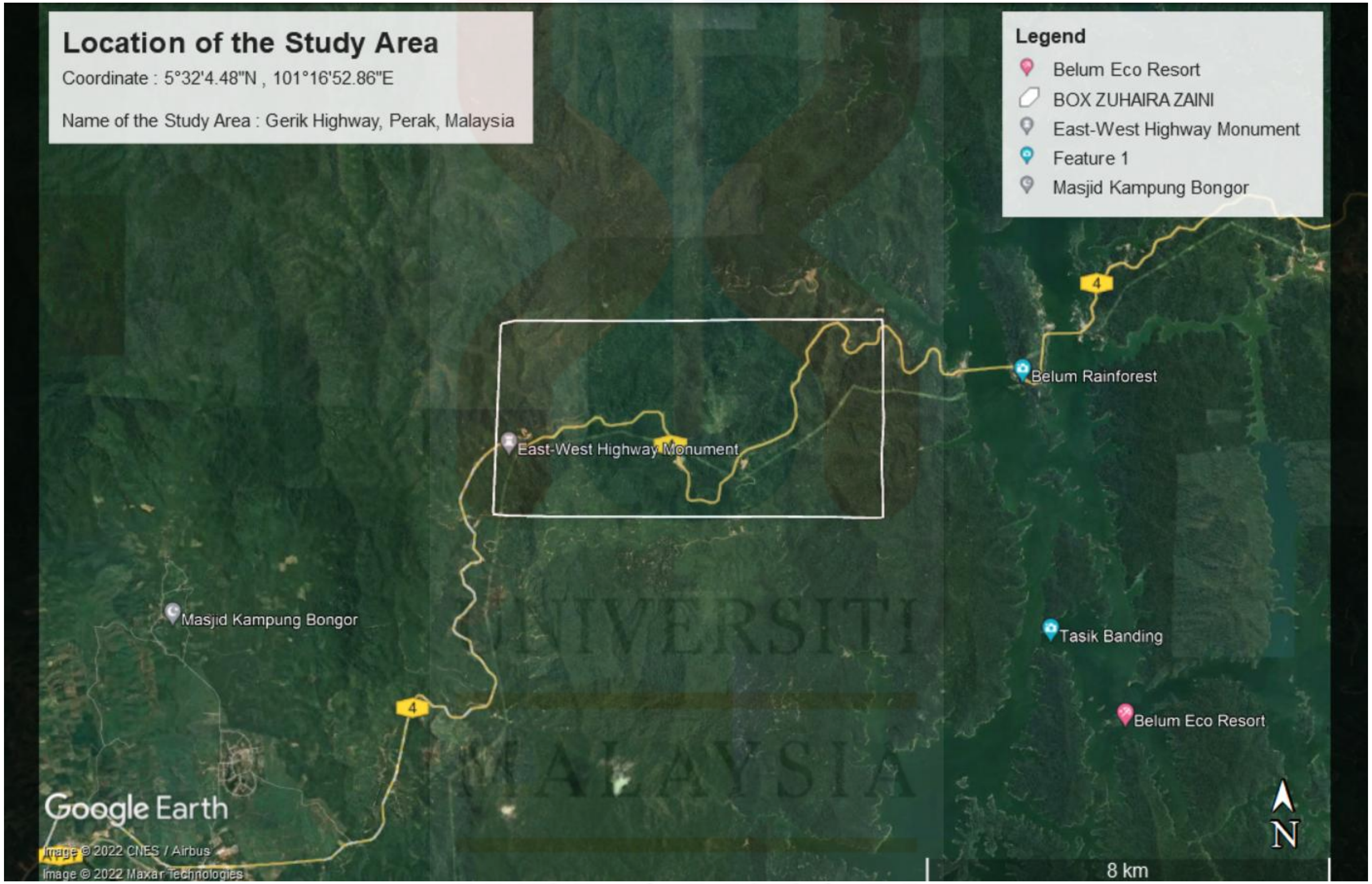


Figure 1.3: The satellite view image of Gerik Highway, Perak

1.2.2 Road Accessibility

According to the research region which is situated in the middle of the Gerik Highway only has a road connection which connect the two of the state , Perak and Kelantan. The total length of the main road, East West Highway, was estimated about 216 KM. Residents and visitors from Gerik or neighbouring states like Penang and Kedah utilise the Main Road East-West Highway, which passes through the study area road, to get to Kelantan. Besides, the only way to cross the study area is by a vehicle as the other areas of the location is covered by dense and thick forest from the forest reserve in Amanjaya. The path runs through two colossal mountain ranges, the Bintang Range and the Titiwangsa Range. The access to East-West Highway from the East is at Kulim, Kedah, at the same time as for Jeli, Kelantan, it is able to access from the West area.

Figure 1.4: Road connection between Perak and Kelantan

1.2.3 Demography

The latest information from the Department of Statistics Malaysia, has shown the data of the population in Hulu Perak which is the main city of Gerik area in Perak. The total population in Hulu Perak is around 56,096 people in year 2010. Malay and other indigenous Bumiputera are about 48,889, Chinese 5,214, Indian 1626, and other ethnicities groups are 367 people. In terms of gender population, males are 29,439 meanwhile females are 26,657 citizens. The population information display that the male population is greater than the female population. Based on the Nationality of Gerik, 28,875 is from Malaysia, approximately 98.2% of the whole population. For different nationality is only 515 people, approximately 1.8% of the Gerik population.

Table 1.1: The population of nationality and genders in Gerik, Perak

NATIONALITY IN GERIK	
Malay & Other Indigenous Bumiputera	48,889,
Chinese	5,214,
Indian	1626
Others	367
Total	56,096

GENDER	**POPULATION**
Male	29,439
Female	26,657

1.2.4 Landuse

The study as was mention is situated in the deep forest of Amanjaya resrve area so the area was covers with thick natural forest. Perak was majorly known to have a total land area of 2097600Ha. Approxiamtely 60% of the land area in Perak is covers with thick forest which is about 1.10 Mha. Other 40 % of the land was cover with plantation and non-forest areas. In Perak, the most landuse for plantation is oil palm plantation, representing about 473kha. The second of most landuse for plantations is rubber mix which is about 219kha. Next is oil palm mix 47.2kha, rubber 44.6kha, fruit mix 11.4kha, and unknown 28.1kha.

Figure 1.5: One of the outcrop that have high vegetation

1.2.5 Social Economic

The social economic factor used in this study area is the East West Highway monument and the Belum Eco Resort which is locate along the Gerik-Jeli highway. The East West Highway Monument commemorates the attack by Communist terrorists on persons engaged in the construction of the East-West Highway and is situated 10.9 kilometres from Gerik and 98.5 kilometres from Jeli. This is known as one kind of rest stop or tourism spot to enjoy the beautiful scenary and a location to picnic and take baths while taking in the surrounding natural beauty and the sounds of birds, bees, and other wildlife.The rest stop is also having toiletries and a rest zone for drivers to take a break at there. Such ecotourism is at Gerik because that place has potential for ecotourism development as it can increase the social economic of Gerik areas.

Figure 1.6: The East West Highway Monument

1.3 Research Problem

The Malaysia-Thailand Border Joint Geological Survey Committee (MT-JGSC) conducted the most recent study on the region in 2012. Previous research has looked at the geology of Gerik Highway on a larger scale, but there had never been a study that focused solely on the geology of one specific area. According to the Sixth Meeting of the Malaysia-Thailand Border Joint Geological Survey Committee held in Kuala Lumpur on June 11, 2009, based on the MT-JGSC research in 2019, both sides have agreed to research the geology of the Belum-Hala Transect suggested by the Malaysian Thai Working Group. Important geological features may be missed in regional investigations. A detailed investigation of the geology and petrographical analysis in determining the mineral assemblages will yield new or additional knowledge on the geology in the area. The research was carried out due to a lack of data on the petrography of the study area's rock, as well as confirmation of the study area's regional history/identification of mineral assemblages. The next problem is that no previous researcher has ever created a lithology map.

1.4 Research Objective

i. To produce a geological map of Gerik Highway, Perak on a scale of 1 - 25000

ii. To determine the sequences of mineral assemblages associated with metamorphism in the study area.

1.5 Scope of Study

The study's focus is on the western section of Malaysia, namely the northwestern part of the Perak state. This research area will only cover a 25-kilometer section of the Gerik Highway in Perak to study geology, petrography, and the transition of rock between sedimentary and metamorphic rock at a specific elevation, which will cover the whole study area. The minerals found in rocks will aid in describing more precise knowledge to determine the mineral assemblages' significance.

1.6 Significance of Study

This study intends to decide the rock sequences that may be determined throughout the exploration to have a look at location and mineral assemblages in addition to offering the maximum updated geological map. This study will give current information and fresh discoveries that past studies have been unable to deliver. Aside from that, a reconstructed geological map may be created by using earlier research as a guide to carry out this new study. The geological mapping will be carried out utilizing the East-West Highway as a traversing medium to shows the distribution lithology of metamorphic rock including including different kinds of rocks and surficial deposits. To assemble the most latest map, all data, consisting of structural data, will be captured. In petrography analysis, thin sectioning, petrographic microscope, X-Ray Diffraction (XRD), and scanning electron microscopy (SEM) might be used. The outcome of the approach we utilize will assist parties such as tourism attractions, higher education institutions, municipal departments, and researchers in the future when it comes to geological knowledge and information for the specific area that was conducted.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The geology of the research area had been examined in terms of regional geology and tectonic setting, structural analysis, and regional stratigraphy in this research. Furthermore, the focus of this study was on petrography investigation in the Gerik Highway area of Perak. As a consequence, many papers, journals, past thesis, reports, and conferences were referenced as references in conjunction with the research.

2.2 Regional Geology and Tectonic Setting

Peninsular Malaysia's Paleozoic rocks are mostly marine, accounting for nearly a quarter of the country's surface area. These results demonstrate that

Paleozoic formations were dispersed in three north-westerly to northerly trending tectonostratigraphic zones that run parallel to the Peninsula's overall elongation trend(Ramli,et al, 2014). The Eastern Zone, Western Zone, and Central Zone were the three zones. Each zone has its own tectonic and stratigraphic features, as well as different sedimentary histories which had been proposed by some authors (e.g., Hutchison & Tan, 2009). The study was placed in the northern section of Perak State, which is part of Peninsular Malaysia's Western Belt Zone. The Sibumasu Terrane, generated from the NW Australian Gondwana border within the late Cambrian-early Permian period, includes the Western Belt. The Sukhothai Arc, which was designed on the Indochinese peninsula Block' boundary (derived from the Gondwana margin in the Early Devonian) in the Late Carboniferous-Early Permian, is described by the Central and eastern bands. The latest research had been focusing on isolated shale outcrops in the Gerik area in Peninsular Malaysia's western region to explore more of the rock type for further research of the Gerik Highway.

In accordance with this, Kelantan was situated at the north of the Central Zone while it runs to Johor in the south, from the eastern foothills of the Main Range to the Lebir fault's eastern boundary to the western boundary of the Dohol formation in the south (Lee et al, 2004).The East Zone runs from eastern Kelantan in the north to eastern Johor in the south, passing through Terengganu and eastern Pahang (Lee et al., 2004). The western zone was the area near the sides of the main range granite batholith heading south from the border between Perak and Thailand towards the Straits of Malacca. The northwestern zone includes Kedah, Perlis and Langkawi.

The Paleozoic, Mesozoic, and Cenozoic rock formations can be used to classify the general geology of Perak. The Paleozoic rock formations of Perak are composed of the Baling Group's Papulut Quartzite and Gerik Siltstone and Lawin Tuff. The Semanggol Formation is the only Mesozoic rock formation found in Perak, and the Enggor Coal Beds, Boulder Beds, Old and Young Alluvium, Simpang Formation,, Lawin Basin Deposits, and Beruas Formation are all Cenozoic. All of this included in the Cenozoic rock formation.

Perak was in the western belt of Peninsular Malaysia. Baling group had been known as one of the group formations on the Western Belt of Peninsular Malaysia. The formation that makes up Baling Group are Bendang Riang formation, Gerik Formation, Lawin Tuff, Papulut Quartzite, and Kroh Formation. The study area's formation is found to be in Gerik Tuff or known as Gerik Formation.

The Baling Group was an extensively notion to consist of all pre-granitic sedimentary rocks, such as pyroclastic layers, withinside the Main Range. The Gerik pyroclastic member is the call given to these pyroclastic facies. The majority of the rocks withinside the Baling group, in line with preceding research, were sediments that constitute a south-easterly extension of the strata in Baling, Kedah. Pyroclastic facies can also be located in this formation; however, due to the fact detrital sediments are regularly polluted via way of means of tuffaceous elements, figuring out the contacts between the sedimentary facies and the volcanic facies was challenging. Both dynamic and thermal metamorphism has affected the entire succession.

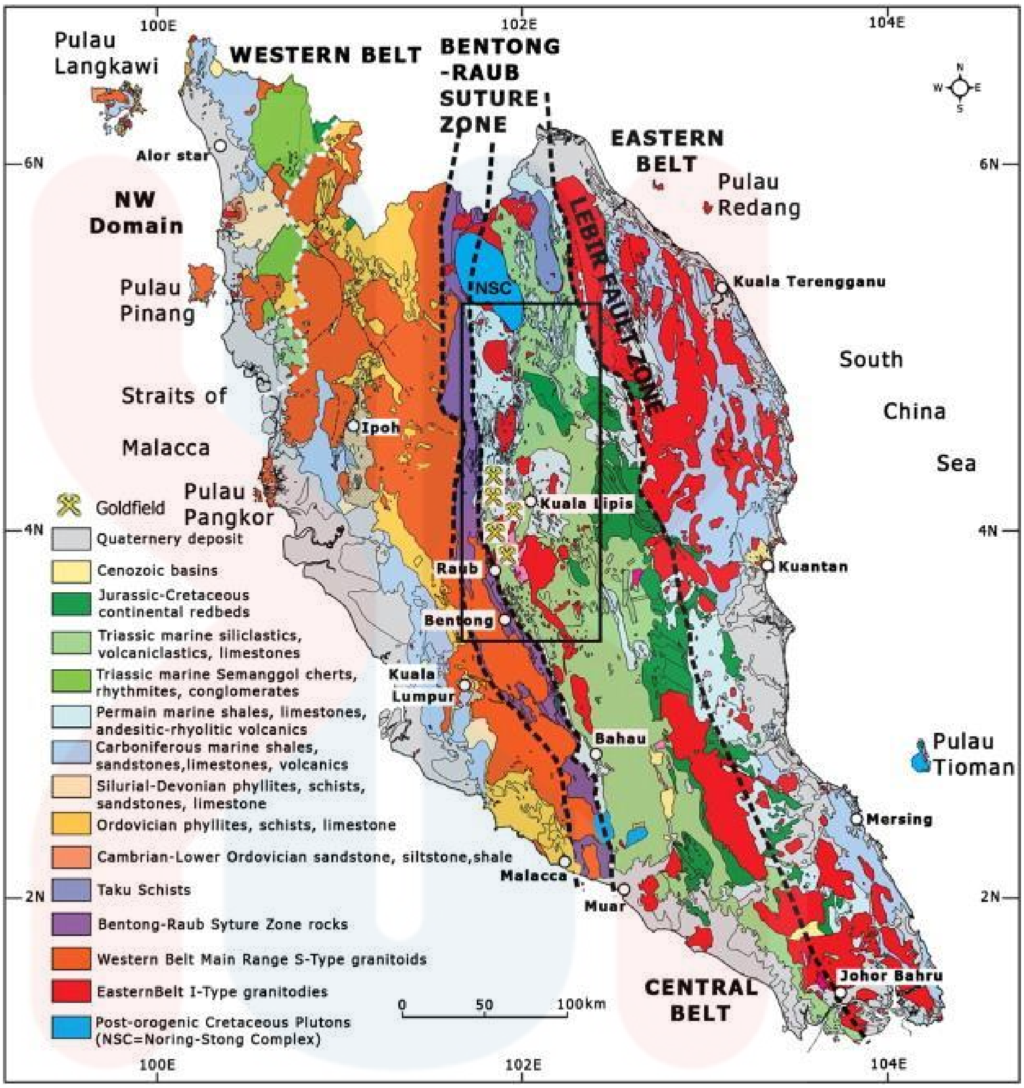


Figure 2.1: The map with divided belt zone.

2.3 Stratigraphy

The study area was in the specific region of Paleozoic aged rock, during the Early Palaeozoic, world geography was in charge by the vast palaeocontinent of Gondwana. Around it was a jumble of considerably smaller but significant peri Gondwanan terranes according to previous research by Cocks and Torsvik, (2002). Peninsular Malaysia was found with the bulk of the Palaeozoic rocks where 25% was considered the land area (Foo, 1983). These Palaeozoic strata are split into four types of north-westerly to northerly trending stratigraphic zones: Western Zone, Eastern Zone, Central Zone, and North-western Zone, all of which are parallel to the Peninsular overall elongation trend. (Lee et al., 2001).

On top of that, the study research area was in the Western Belt which is situated in the northern state of Perak. In other words, the study also stated that most of the oldest rocks were found in the north-western of Peninsular Malaysia while the younger rocks were found in the southern area. Furthermore, the updated Papulut Quartzite is overlain via way of means of thick variably bedded turbidite sequences, that have been dubbed the Grik Formation, observed via way of means of the 'Bendang Riang Formation' of phyllites and metamorphosed limestones, in line with the have a look at the area, that is positioned at the bottom of the collection in northern Perak.

In the state of Perak, particularly in the Ipoh region, limestone hills and caves are widespread geological characteristics. Minerals such as cassiterite are prevalent in this area due to the granitic intrusion. Tin is obtained from cassiterite. Because of the availability of limestone hills, the marble industry grew as well. Granite, argillaceous, metamorphic, and volcanic rocks are among the other types of rocks found in Perak. The geology of the Gerik Highway withinside the precise studies area consisted of a Paleozoic-aged rock referred to as the Gerik formation (formerly referred to as Gerik Tuff). Tuffs of rhyolitic to rhyolitic composition, limestone, and calcareous shale are examples of common lithology.

As was already noted, the geology of the research region is composed of rocks from the Paleozoic-aged Gerik Formation. Actually, the Gerik Formation is a part of the Baling Group. All pre-granite sedimentary rocks in the area of the Main Range, including the pyroclastic layer, belong to the Baling Group. Grik's pyroclastic members are the new name for this pyroclastic flow. The formations of Baling, Kedah extend southeast due to sediments.In the Baling Group, there are rapid lateral and horizontal sedimentary fluctuations. This group usually consists of an upper argillaceous rock layer and a lower arenaceous strata layer. The group's argillaceous component also saw the development of more calcareous phases. There are four major facies that can be distinguished in the Baling region: arenaceous, argillaceous, calc-silicate, and calcareous (Burton, in Jones, 1970).

Table 2.1: Lithological classification of the sediments in the Baling Group at Gerik

Facies	Sub-Facies
Argillaceous	Shale, Phyllite, Mudstone, Siltstone, Hornfels, Schist,
Calcareous	Limestone, Calc-Sillicate Hornfels
Arenaceous	Subgreywacke, Schist and Hornfels, Conglomerate

Burton (1970) proposed the following as the sequence of strata deposition in the Baling area:-

5. Hornfels and limestone

4. Siltstones

3. Hornfels, limestone, and quartzite

2. Limestone and Quartzite

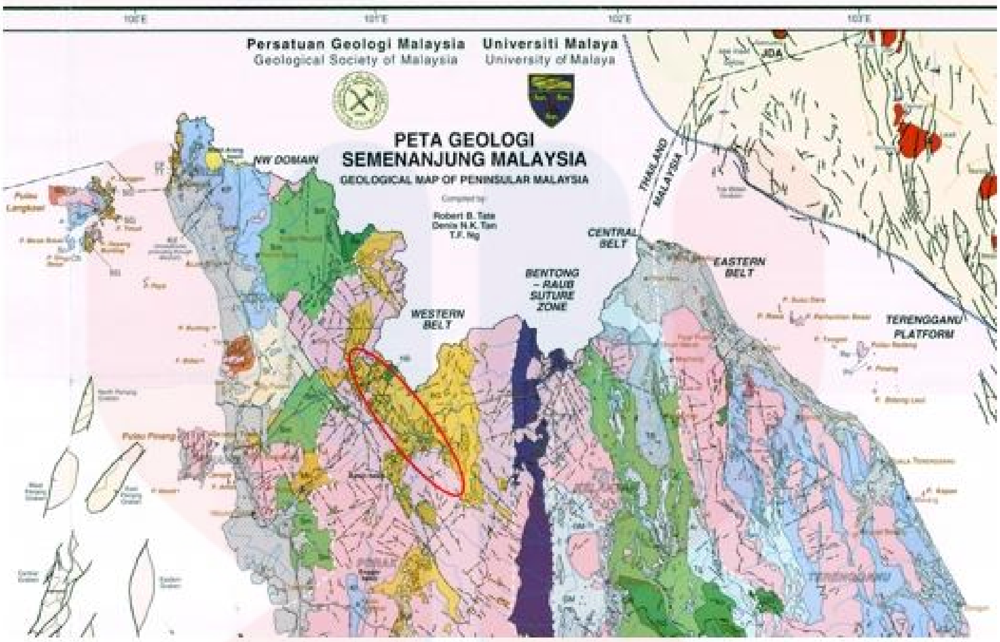
1. Phyllite and Hornfels.

In the Gerik region, the sequence consists primarily of phyllite and shale with the development of shale and limestone quartzite lenses in the lower half and thin lenticular limestone in the upper half. The top of the series also includes quartzite, shale and siltstone.

Table 2.2: Stratigraphic sequence of Sediments in Gerik area

(Modified from Jones, 1970)

<table>
<tr><th>Lower</th><th>Middle</th><th>Upper</th></tr>
<tr><td>Arenaceous</td><td rowspan="4">Gerik Siltstone</td><td>Shale</td></tr>
<tr><td>Papulut Quartize</td><td>Phyllite</td></tr>
<tr><td rowspan="2">Lenses of shale, Limestone and Schitose subgreywacked</td><td>Limestone lenses</td></tr>
<tr><td>Quartize, Schist</td></tr>
</table>



Scale: 1: 1,000,000 (Source: Universiti Malaya and Geological Society of Malaysia, 2009)

Figure 2.2: Geological sketch map of Gerik with study area highlighted in red circle

(Source: Geological Society of Malaysia, University Malaya , 2009)

2.4 Structural Geology

The East-West Highway is known to be included in Baling group. Baling group, formerly known as Baling formation, consists of rock sequences that run east of Semanggol formation and west of Mahang formation. The primary geological characteristics of the Perak state include limestone caverns and hills. The Baling Group, which includes Bending Riang, Papulut Quartzite, Lawin Tuff, Kroh Formation, and Gerik Formation, is one of the Paleozoic era formations. Because the research region is in north Perak, it is thought that the study area was included in the Gerik formation. From the previous studies which have explained the Gerik Formation, the word Gerik formation was proposed unofficially to replace Burton's (1970, 1972, 1986) term Grik tuff for pyroclastic rocks consisting mostly of rhyolitic to rhyolitic tuffs (The Malaysia-Thailand Working Group, 2010). In Gerik, the geological structure that can be interpreted conforms to the regional tectonic patterns of the Malay Peninsular.

Lower Palaeozoic rocks in the Gerik region are noted for folding into a variety of formations with steeply descending limbs. Furthermore, the primary structure was observed with the secondary minor folding. The synclinal axis which is carried out southwards is the most notable feature. It was known to be parallel to the bedding and the major shearing has taken place. Stresses are thought to be oriented north-south. Although no evidence of faulting has been discovered, faulting may have occurred. Granite has the most noticeable joints, which are usually vertical or sharply sloping.

Based on the study of Wong (1974), main range granite invades the rocks of the suture zone. The metamorphic sedimentary rocks of Gerik's West Coast Highway show higher metamorphism to the south. Grade metamorphism extends from the upper greenschist to the lower amphibolite facies. Mohd Raji (1990) also elaborate on areas that explain several different metamorphic facies, such as muscovite-hornblende schist and gneiss-biotite dominated by hornblende schist-hornblende schist. An effective approach for delineation of fracture zones is based on lineament indices extracted from satellite data. Based on the previous research in the study area has shown that the lineament analysis was used to map fractures, locate subsurface structures, and evaluate regional structure. Based on other analysis has shown the joint analysis. Joints are cracks or fracture present in the rocks along which there has been no displacement. Joints occur in all types of rocks. They may be vertical, inclines or even horizontal. Their dip and strike are measured in the same way as that of sedimentary strata.

This part was made a more in -depth study of how the forces that cause structural processes on Earth cause changes in rock structure. The Baling Group has a fairly consistent direction of the strike which is heading northeast, almost parallel to the general trend of the Malay-Thai Peninsula (Burton, 1986). In the Kroh Formation, argillite, calc-silicates, and limestone were the main structures (Burton, 1986). Peninsular Malaysia's regional structural trends are in close agreement with the geological structure of Gerik, Perak (Kee, S., Ismail, M & Kadir, A, 2014). Deformations of Lower Paleozoic rocks have led to complex evolutions of the formation. Lower Paleozoic rocks in the Gerik region are folded into a series of strata with steep limbs. It can also see small creases on the core structure. The south-facing syncline is the most notable structure.

Figure 2.3: Example of Fold structure in the previous research of the study area

Figure 2.4: Example of Fault structure in the previous research of the study area

2.5 Historical Geology

Burton (1970, 1972, 1986) introduce that the term Gerik formation was formally known as the term Grik tuff for the pyroclastic rock which majorly consists of tuffs of rhyolitic to rhyodacitic composition (The Malaysia-Thailand Working Group, 2010). The Gerik formation's Transect region was well-known and well exposed on the western side. The study focuses on Malaysia; however, it is no publicized in Thailand. In the region of Gerik town and the Lawin area, it is pretty well exposed. Furthermore, it was along the East-West Highway route that the rock exposure was observed. especially around the Banding Island area. The Gerik formation may also be found southwest of the Transect region in the Kerunai area. The eastern edge of the Transect region extends northward from the Temengor Dam area, going through the East-West Highway and then Sungai Chachor to the Main Range Granite mass at the river mouth of Sungai Kejar. At the mouth of the Sungai Ta Eng River, there are some nice metasandstone outcrops.

Based on the lithology, lenses of limestone and calcareous shale appear seldom. As for the name of Gerik, it was taken from a town name Gerik which was situated 10 km to the southwest of the Transect"s area boundary. The Malaysia-Thailand Working Group (2010) had investigate the major occurrence of limestone and fossiliferous, sandstone, interbedded tuff, and calcareous shale on a roadcut at Kampung Batu 2, Gerik that has shown the formation was a Permian age The tuffs of the Gerik formation are occasionally metamorphosed.

2.6 Metamorphic Rock

This study specializes in the petrology of the Main Range Granite that extends from the Central Belt of Malaysia, in phrases of figuring out the mineral composition and traits of the granite assemblages withinside the location of interest. The studies additionally emphasize the nomenclature of the recognized rock samples primarily based totally on the International Union of Geological Sciences (IUGS) category that allows you to decide the lithological rock unit of the vicinity. Plus, the textural traits can also be studied that allow you to deduce the geological strategies that arise which contribute to the build-up of the Main Range Granite across the Titiwangsa vicinity. The granitic rocks can also be investigated in phrases of their geochemistry to are expecting the opposite assemblages across the vicinity.

Furthermore, the core method used in the study basically consists of determining the petrographical properties of the minerals contained in the thin section of the resulting rock sample. This method is important because the mineral properties of the thin section themselves determine the properties of the geological process and the properties of the rock in the area of interest. A previous study by the MT-JGSC Committee in 2012 focused only on traverses and stations, but did not completely cover the previously intended study area. As a result, this core method is essential for a more detailed approach, as the area of interest has not been fully investigated geologically.

2.7 Geomorphology

In the aspect of geomorphology, Gerik Highway cane consists of several types of the landscape such as hilly areas, plain areas, and mountainous areas which exist in the northern part of Perak. The previous study in Langkawi(Mohd Shafeea Leman1, 2008), about geomorphology has state that the wealth of geological exposures and landscapes is a remarkable blessing. In the part of the research area on Gerik Highway, there are geological systems is maximum of it's far the natural panorama and some cultural landscapes. Firstly, a natural landscape consisting of mountains, and also plateaus which is made from a chain of landforms, a lake from the man-made lake of Pulau Banding, and natural vegetation. A mountainous area can be seen forming in along the west to the north part of the district. Features like mountain ridges and mountain valleys are visible in this landscape. Hilly areas in Gerik Highway are dispersed at the base of the mountain range and can be found in two types of the hill which are elongated hills and isolated hills. Tectonic activity during the Paleozoic and Mesozoic eras in Peninsular Malaysia primarily affect the continent through folding and faulting creation. Folding and faulting have been reported on both a regional and local scale.

2.8 Petrography

The petrography analysis is conducted more precisely in order to determine the mineral assemblages in th sample for the specific study area. Petrography analysis is widely known with standard method in studying the provenance. For the categorization of a rock, petrographic study determines the origin, whether igneous, sedimentary, or metamorphic, as well as the mineral composition. The petrography of Gerik Formation is mostly expected to be sedimentary rock including sandstone, limestone, mudstone and shale. Even so, a few studies also consider the study area to contain metamorphic rock type which is phyllite. As a result, the thin section tries to present the fundamental petrography acquired by the Gazzi Dickinson Method and to provide a comparison between the petrographics and earlier point count data (Dickinson et al,.19.83).

2.8.1 Metamorphic Rock

Metamorphic rocks are classified according to their nature and composition. This is usually related to rock type determination. Metamorphic rocks can be divided into two types of metamorphic rocks, foliated and non-foliated. Foliated and lineated metamorphic rocks refer to the planar and linear tissue elements of the rock and have no genetic significance. This study focuses on low-grade metamorphic rocks. Knowing that very low-grade metamorphisms are in the lowest temperature range of metamorphisms below 300 ° C will help determine the type of metamorphism. In this area, metamorphism begins during burial and initial nucleation occurs, but replacement of the preserved protolith phases is still visible.

2.8.2 Metamorphism

Metamorphism is the process of changing rocks with changes in mineral composition and ultrastructure. Under conditions between diagenesis and massive melting, metamorphism is usually in the solid-state (Winter, J.2014). Metamorphism occurs when rocks are exposed to the physical and chemical environment. Several metamorphic factors that lead to the metamorphism process are temperature, pressure, fluid type, and stress conditions. IUGS / SCMR recommends that metamorphism can be classified into five types of metamorphosis (Winter, J.2014). Contact metamorphism, regional metamorphism, hydrothermal metamorphism, fault zone metamorphism, and shock metamorphism are different types of metamorphism.

In phrases of thermal metamorphism, the pyroclastic-sedimentary collection has been impacted, ensuing in low-grade metamorphic rocks. From dynamic metamorphism, the improvement of cleavage and foliation permits shale to go through metamorphism to phyllite. Due to the elongation of mineral grains, limestone strata have a platy structure. The Pyroclastic Member of Gerik has been badly destroyed.

2.9 Mineral Assemblages

Metamorphic rocks are characterized by complete changes in mineral composition or changes in the composition of existing mineral phases. The resulting mineral composition reflects the chemistry of the original rock and the new pressure-temperature conditions to which it is exposed. As the temperature and pressure of the rock increase, progressive or prograde metamorphism occurs. Rocks of given chemical composition are expected to undergo a series of continuous chemical reactions with the liquid phase that exists as pressure and temperature rise, resulting in a series of new mineral aggregates that are stable at higher pressures and temperatures.

Scheme for Sedimentary Rock Identification

INORGANIC LAND-DERIVED SEDIMENTARY ROCKS					
TEXTURE	GRAIN SIZE	COMPOSITION	COMMENTS	ROCK NAME	MAP SYMBOL
Clastic (fragmental)	Pebbles, cobbles, and/or boulders embedded in sand, silt, and/or clay	Mostly quartz, feldspar, and clay minerals; may contain fragments of other rocks and minerals	Rounded fragments	Conglomerate	
			Angular fragments	Breccia	
	Sand (0.006 to 0.2 cm)		Fine to coarse	Sandstone	
	Silt (0.0004 to 0.006 cm)		Very fine grain	Siltstone	
	Clay (less than 0.0004 cm)		Compact; may split easily	Shale	

CHEMICALLY AND/OR ORGANICALLY FORMED SEDIMENTARY ROCKS					
TEXTURE	GRAIN SIZE	COMPOSITION	COMMENTS	ROCK NAME	MAP SYMBOL
Crystalline	Fine to coarse crystals	Halite	Crystals from chemical precipitates and evaporites	Rock salt	
		Gypsum		Rock gypsum	
		Dolomite		Dolostone	
Crystalline or bioclastic	Microscopic to very coarse	Calcite	Precipitates of biologic origin or cemented shell fragments	Limestone	
Bioclastic		Carbon	Compacted plant remains	Bituminous coal	

Scheme for Metamorphic Rock Identification

TEXTURE		GRAIN SIZE	COMPOSITION	TYPE OF METAMORPHISM	COMMENTS	ROCK NAME	MAP SYMBOL
FOLIATED	MINERAL ALIGNMENT	Fine	MICA, QUARTZ, FELDSPAR, AMPHIBOLE, GARNET, PYROXENE	Regional (Heat and pressure increases)	Low-grade metamorphism of shale	Slate	
		Fine to medium			Foliation surfaces shiny from microscopic mica crystals	Phyllite	
					Platy mica crystals visible from metamorphism of clay or feldspars	Schist	
	BAND-ING	Medium to coarse			High-grade metamorphism; mineral types segregated into bands	Gneiss	
NONFOLIATED		Fine	Carbon	Regional	Metamorphism of bituminous coal	Anthracite coal	
		Fine	Various minerals	Contact (heat)	Various rocks changed by heat from nearby magma/lava	Hornfels	
		Fine to coarse	Quartz	Regional or contact	Metamorphism of quartz sandstone	Quartzite	
			Calcite and/or dolomite		Metamorphism of limestone or dolostone	Marble	
		Coarse	Various minerals		Pebbles may be distorted or stretched	Metaconglomerate	

Source: The University of the State of New York, 2011. Reference Tables for Physical Setting/EARTH SCIENCE.
URL: http://www.p12.nysed.gov/assessment/reftable/earthscience-rt/esrt2011-engr.pdf

Physical Setting/Earth Science Reference Tables — 2011 Edition 7

Figure 2.5: Scheme of rock identification fro metamorphic and sedimentary rock

CHAPTER 3

.MATERIALS AND METHODS

3.1 Introduction

This chapter describes the different materials and methods used in this study. There is a list of equipment and materials listed with a description of the methods including data collection, data processing, and data interpretation. Moreover, some methods are used to complete geological research and field of study designation. Very few methods initially decided to conduct the survey. In addition, other parties will use the above laws to perform this analysis and allow the audit to collect and audit the information.

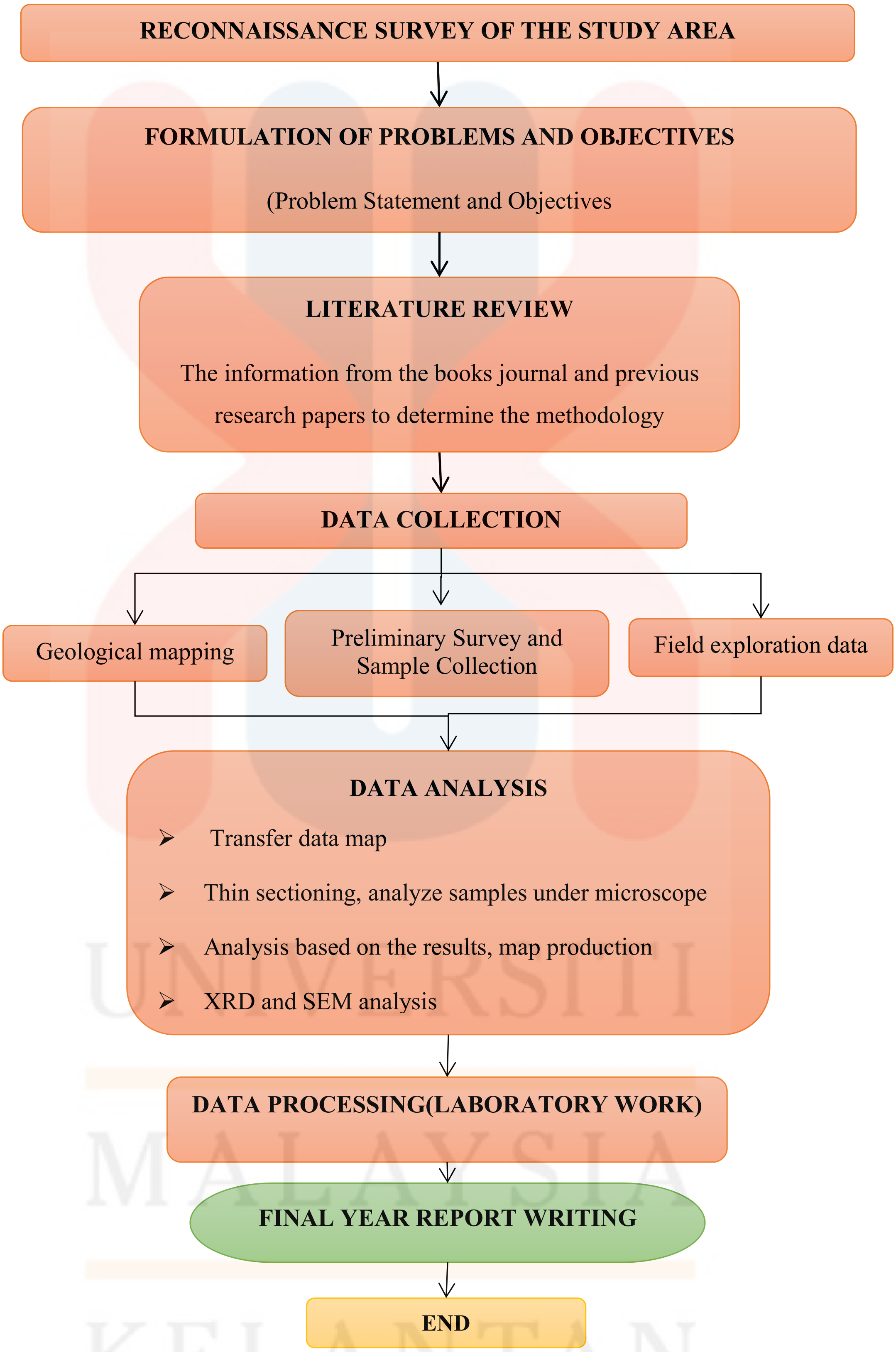


Figure 3.1: Flow chart of Primary Data

3.2 Materials

In this paper there will be some materials will be required equivalent to geologic maps, topographical maps(base map) and GPS associated an earlier geologic studies that were accustomed conduct the analysis. GPS, also known as Global Positioning System, is a satellite- based navigation system. It is used to mark the study area's location as it can provide information such as latitude, longitude, and elevation. Apart from that, the internet resources were the most crucial factor in the development of this project, as the software used to obtain the aerial image was Google Earth, which can provide a rough general image of the study area, including road connections, structural features, topography, and geomorphology. Microscope for the analysis of XPL and PPL for optical properties. Next is, Brunton compass to measure detailed geological mapping, such as measuring strike and dip, determining the magnetic declination, and measuring the bearing of a geological structure.

A camera that records the outcrops or structures found. Apart from that, there are stationery and field books used to write the data collected during the mapping. This notebook is important for keeping the data safe. Geologist's hammer is also one of the important things needed to divide and crush rocks from outcrops for sampling. A magnifying glass is an important instrument for visually identifying minerals in the field and performing the first field analysis prior to petrological analysis.

Few applications or software are used to generate data from this study, such as Google Earth, Microsoft Excel, ArcGIS, Georose, and DiffracEVA. The Google Earth application helps you get an aerial photograph of your study area. Data collection consists of Microsoft Excel. ArcGIS software is used to manage and extract spatial data. Georose software for making rose diagram was obtained by plotting the structural geological data collected in the study area. Finally, Diffrac EVA is software that evaluates X-ray diffraction.

3.3 Methodology

The method of this survey is divided into five parts covering the preliminary survey, field studies, petrological analysis, data processing, and data analysis and interpretation. The primary traversal mode was the road along the highway that was located in the study region. This section provides a comprehensive interpretation and procedure for each methodology in this study. This part also includes the method used to record the primary data.

3.3.1 Preliminary Studies

The study began in March 2022 and the field of study is identified and supported by several references such as journals, books, articles, and previous thesis. These resources reveal the geological aspects of an individual's survey and help complete a basic knowledge of the survey before conducting a field survey.

Previous researchers have generally completed their research area, which may help improve data collection during later traversals. The origin of the lithology can be identified by determining the characteristics of the contour lines and the presence of faults and folds based on the procedure. In addition, literature reviews are essential to obtain known data from previous researchers so that new data for this study can be identified and published. For example, basemaps derived from Google Earth and ArcGIS software were created to explore the geological and petrography characteristics of the study area before crossing the study area.

In addition, the formations that invade the study area can be identified from previous hypotheses by researchers around the study area itself. The sources of the journal and previous treatises were used from the University Malaysia Kelantan (UMK) database and Google Scholar.

3.3.2 Field Studies

One of the methods used to finish this research is geological mapping by traversing. Geological mapping is a method of observing the environment that includes information on the sample's lithology and morphology. The lithology of the area can be precisely identified by observing the outcrops around the study area and determining the characteristics of the Granite Range around the location of interest. Geomorphology is also vital during traversing as it helps to identify the major landforms that occur in the study area. Drawings and sketches can be done in order to have a bigger picture on the characteristics of the major landform. Faults, folds, and major geological characteristics can also be identified by those drawing itself.

For any structural analysis, data gathering will be measured. In general, bedding, foliation, linear characteristics, cleavage, and fold will be used to record and observe structure and structural history. For outcrop analysis, strike and dip will be employed. The direction of a line on an orientation horizontal plane intersecting with an incline rock bed is known as strike. The dip is the angle formed between the horizontal plane and the sloped bed, which is perpendicular to the strike line. Furthermore, data can be acquired by structure investigations, specimen collecting, and mapping images.

3.3.3 Laboratory Work and Thin-section/ Petrography studies

Selected rock samples are extracted from the collected samples and cut into thin sections for petrography examination to establish the kind of rock as well as the mineralogy of the rock. At least 10 samples should be collected to obtain proper data and analysis of metamorphic rocks. The sample is then collected before being processed in the laboratory to make thin section specimen sample.

A. Hand specimen

Rock samples taken in the study area should be fresh from the outcrops. If a weathered sample is collected, it will affect the analysis of the rock. Analysis of hand samples is observed through a magnifying glass to determine mineral composition and rock structure.

B. Thin Section

Thin sections are performed to determine the mineral composition and texture properties of the collected samples. A polarizing microscope is used to inspect thin section. Many methods need to be completed to create a high-quality thin section. The steps required to make thin sections are cutting, impregnation, precision cutting, gluing, cutting, and grinding and polishing.Verify that the glass slide is frosted, flat, and of a consistent thickness.

Thin section procedure is shown as below :

1. Firstly, choose the rock sample with side that was needed to the thin section. Then, a slab of suitable size for mounting on a slide is cut from a piece of rock or drill core with a diamond saw.

2. Next is , the slab's initial lapping follows.The slab is marked on one side and the other side is first flat and smooth wrapped with cast iron wrap with

400 grit carbonundum and then finished with a glass plate with 600 grit carbonundum.

3. Then, next step is glass slide is added. After drying on the hot plate, the glass slide is epoxy glued to the wrapped surface of the plate.

4. Step four, the slab was sectioned. The slab is cut with a thin cutting saw near the slide. The thin section grinder is even thinner.

5. Step 5 is Final Lapping which is when it finish thickness of 30 microns is achieved by manually wrapping the sections on the glass plate using 600 grit carbonundum. Fine grinding of 1000 grit before polishing is optional.

6. The final step is the polishing step. Place the section in a holder and spin it on a grinding machine using a nylon cloth and diamond paste until polishing suitable for microscopic or SEM inspection is achieved.

C) X-Ray Diffraction (XRD) Analysis

The XRD tests are performed on handpicked rock samples from the research region to more precisely characterize their mineral components and analyze the properties like phase composition, structure, and texture (Ermrich, M. & Opper, D., 2013) at the same time figure out what the rock is made of and how much clay is in it. The kind of rock may be determined and identified by recognizing the chemicals in the rock. To validate the rock type, the XRD data are matched to the results of petrographic examinations to get the accurate rock type. In experimental analysis, each sample is ground to a powder. The optimum particle size for powder diffraction samples is 1-5 µm (Ermrich, M. & Opper, D., 2013). Only a small amount of sample powder is required for analysis. This analysis provides results for structural materials such as particle size and crystal orientation.

Figure 3.2: XRD machine

3.3.4 Data Processing

A) Geographic Information System(GIS)

GIS software is used to create lithology maps because it is capable of saving data entry and storing data qualities in attributes. The primary goal, which is to supply information and make a map with a scale of 1: 25000, may be accomplished in either hardcopy or softcopy form from this perspective. To produce a new geological map and additional supportive map of Gerik Highway, Perak, geological data obtained by fieldwork studies, remote sensing, and spatial data were transferred to ArcGIS software. Petrological data were obtained by the petrology analysis which will be transferred to excel before plotting for determining whole rock analysis.

3.3.5 Data Analysis and Interpretation

Use the Arc GIS program to create an up-to-date geological map using the data analysis from this survey. It is a geographic information system (GIS) for making and utilizing maps and geographic data. Once the mineral identification of the thin section is complete, a petrological analysis will be performed. The relative mineral phase composition of the rock type can be estimated using XRD and SEM.

CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

A few geological processes and the evolution of morphology have been demonstrated by the study inquiry. The study area has undergone geological research on geomorphology, lithostratigraphy, structural geology and historical geology Field observation and mapping are also emphasized in this chapter. Research in this area is important since it is where the geological processes and morphological evolution took place.

The examination of the landforms in the research area was covered in this dissertation on geography. It was critical to comprehend the processes involved in earth deformation in order to perform surface morphology. The mechanisms that shape landforms and the scientific study of them are both covered by geomorphology research. The scientific study of landforms, such as drainage systems, valleys, weathering processes, and erosion, with an emphasis on their origin, evolution, form, and distribution over the physical terrain is known as geomorphology.

4.1.2 Accessibility

According to the research, Perak and Kelantan are connected by only one road in the region that is located in the middle of the Gerik Highway. The East West Highway's whole length was calculated to be around 216 KM.The Main Road East-West Highway, which runs through the study area road, is used by locals and guests from Gerik or neighbouring states like Penang and Kedah to travel to Kelantan.

With addition, the only means to get across the research area is by car because the rest of the land is covered in a thick, dense forest that comes from the Amanjaya Forest Reserve. The Titiwangsa Range and the Bintang Range, two enormous mountain ranges, are traversed by the path. Kulim, Kedah is where the East-West Highway can be accessed from the East, and Jeli, Kelantan is where it can be accessed from the West.

Figure 4.1 : The road connection of East-West Gerik Highway, Perak

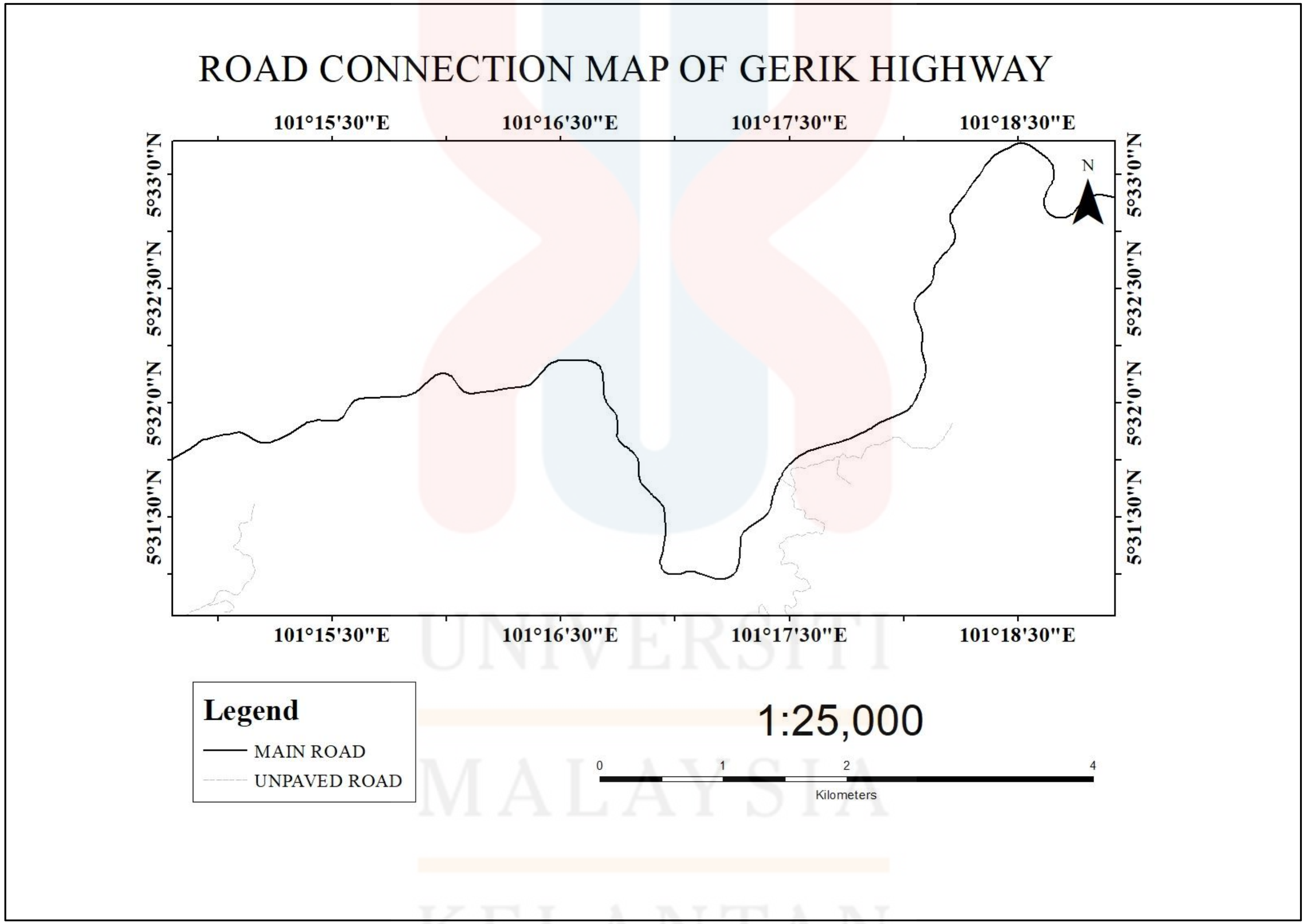


Figure 4.2: The road connection map of the study area

4.1.3 Settlement

A settlement is a place where people live. This could be a village or other smaller-scale community along the streets and highways, rather than a town. Additionally, a colony established by one nation somewhere else can be referred to as a settlement. It might transform from a little, isolated farm into a significant, well-known city home. The settlement may be permanent or temporary, depending on the population over time. The other type of settlement takes place when a dispute is resolved or when something else is settled.

The settlement factor used in this study area is the East West Highway monument and the Belum Eco Resort which is locate along the Gerik-Jeli highway. Additionally, there are restrooms and a rest area at the rest stop for drivers to use. This is regarded as a particular type of rest area or tourist destination where visitors may enjoy the picturesque scenery, have picnics, and take baths while listening to the sounds of birds, bees, and other wildlife.

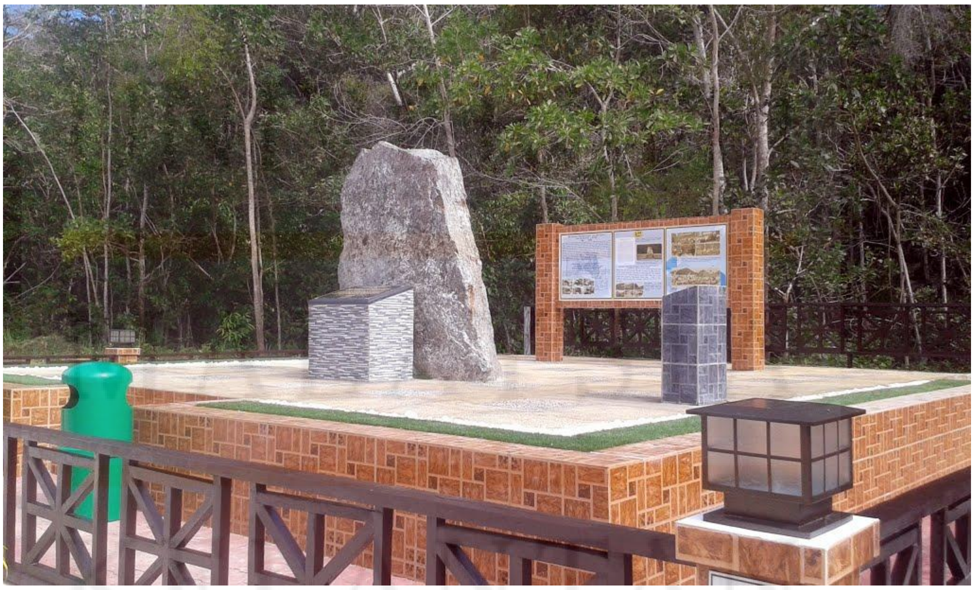


Figure 4.3: shows the East West Highway Monument

4.1.4 Forestry (or vegetation)

Perak was majorly known to have a total land area of 2097600Ha. Approxiamtely 60% of the land area in Perak is covers with thick forest which is about 1.10 Mha. Belum rainforest, which once dominated the region and is believed to have existed for 130 million years, is the oldest rainforest in the world. As previously mentioned, the study was conducted in the dense forest of the Amanjaya Reserve, which was where the belum rainforest was located. As a result, the region was covered in a thick natural forest. The Belum rainforest serves as a habitat for a variety of plant and animal species, ranging from the common to the critically endangered.

4.1.5 Traverses and observation (with traverses and observations map)

Based on the traverse and observation, the study area is mostly covered the paved road. This is because the paved roads is from Jeli to Perak along the Gerik Highway as the main road that connect the whole study area. Other than that, there were also unpaved roads in the study that was used by the lorries for the construction site. In addition, referring to the geomorphology map in Figure 4.5, we can see that the topographic units of the study area are hilly to peak mountainous with mean elevation of 280 - 900 m respectively. Most of the routes in study area are access by walking as geological mapping need a further observation and measurement in order to obtain accurate data. For the observation in the study area, the observation is made based on the geomorphological analysis, outcrops sampling, lithology analysis and structural analysis. The sampling had done in various location according to its lithological unit as the study area composed of four lithological units of interbedded of sandstone, mudstone and shale and the metamorphic rock of phylite.

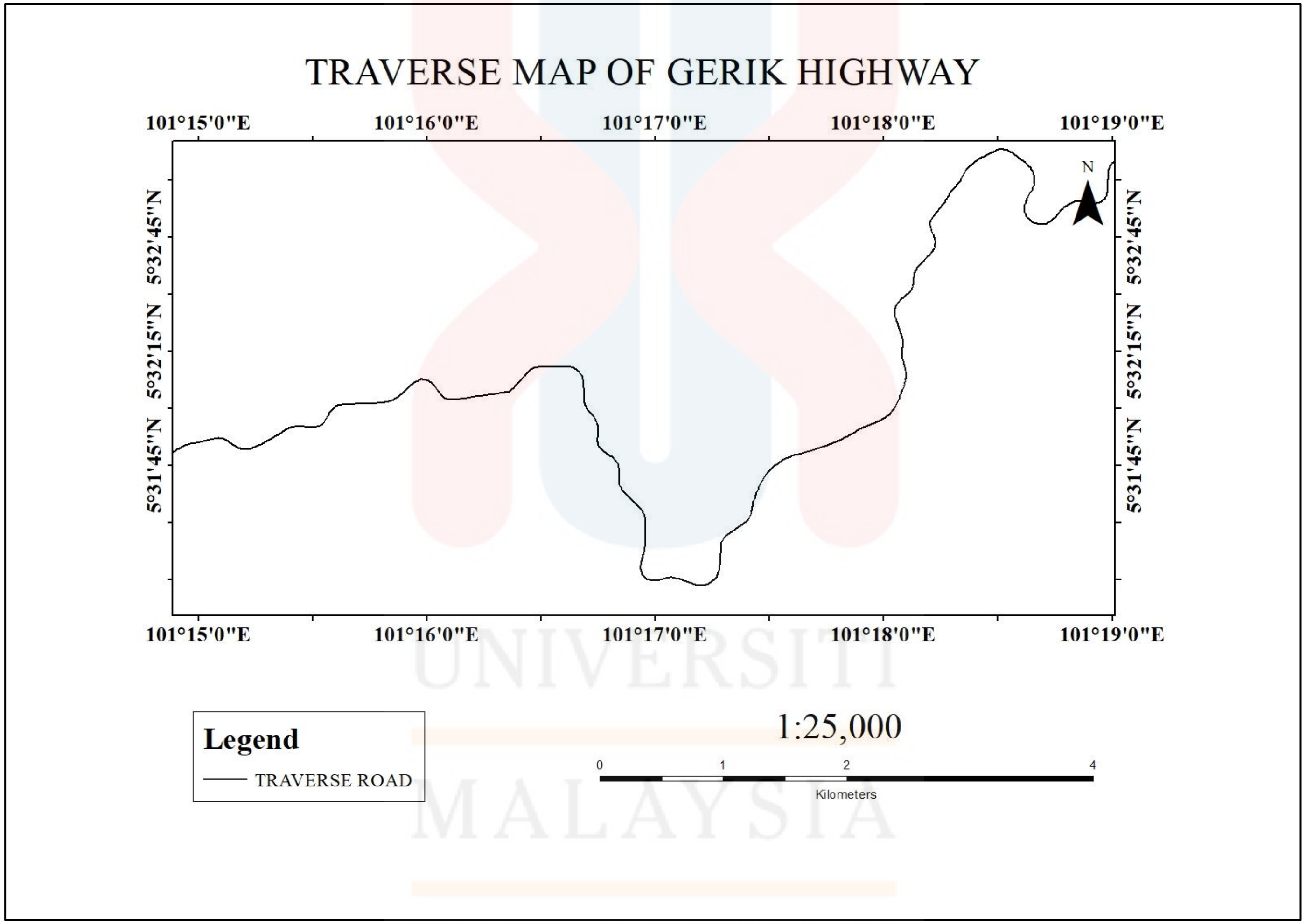


Figure 4.4: The traverse map of the study area

4.2 Geomorphology

4.2.1 Basic Geomorphology Classification

The morphologies are the main criterion for geomorphologic classification in this context. Based on the earlier research of (Irvin et al., 1997), it has been confirmed that a few indicator categories are numerous and diverse. The most important morphologic markers among them, comprising height, slope, aspect, and topographic relief, are surface ground altitude and relief.

Geographers exploited the relief of the landscape to more precisely get geomorphology data. A governing factor that might represent relative terrain characteristics is terrain relief. Research has proven that using topographic contour lines, DEM, and field surveying, relief values may be computed (Bishop et al., 2003). Additionally, it was determined that the general morphologic types can be classified into seven categories based on relief values: plains (30 m), platforms (>30 m), hills (200 m), low relief mountains (200–500 m), middle relief mountains (500–1000 m), high relief mountains (1000–2500 m), and highest relief mountains (>2500 m) (Institute of Geography, 1987a, 1987b).

Table 4.1 provides a rough classification of the primary terrestrial geomorphologic categories. Terrain relief is represented by the longitudinal coordinate and altitude by the horizontal coordinate. The fundamental 25 land terrestrial geomorphologic categories are composed of altitude kinds and relief types.

Table 4.1 : Classification of the basic terrestrial geomorphologic types (Cheng et al., 2011)

Altitude relief	Low altitude (<1000 m)	Middle altitude (1000–3500 m)	High altitude (3500–5000 m)	Highest altitude (>5000 m)
Plain (<30 m)	Low altitude plain	Middle altitude plain	High altitude plain	Highest altitude plain
Platform (>30 m)	Low altitude platform	Middle altitude platform	High altitude platform	Highest altitude platform
Hill (<200 m)	Low altitude hill	Middle altitude hill	High altitude hill	Highest altitude hill
Low relief mountain (200–500 m)	Low relief low altitude mountain	Low relief middle altitude mountain	Low relief high altitude mountain	Low relief highest altitude mountain
Middle relief mountain (500–1000 m)	Middle relief low altitude mountain	Middle relief middle altitude mountain	Middle relief high altitude mountain	Middle relief highest altitude mountain
High relief mountain (1000–2500 m)	—	High relief middle altitude mountain	High relief high altitude mountain	High relief highest altitude mountain
Highest relief mountain (>2500 m)	—	—	Highest relief high altitude mountain	Highest relief highest altitude mountain

Notes: "—" no geomorphologic type represented

A. Geomorphologic classification

In the aspect of geomorphology, Gerik Highway can consists of several types of the landscape such as hilly areas, plain areas, and mountainous areas which exist in the northern part of Perak. The study area was consist of 4 different type of geomorphological unit which is peak, steephills, sloping hills and lowland but contain the same type of drainage pattern which is dendritic pattern due to the high hills area in the map in the geomorphology column. The study area is covered by high elevated hilly area. The highest point of the study area is 860 m above the sea level, while the lowest point is 280 m above the sea level.

Table 4.2: The elevation value of the geomorphological unit

NO	Geomorphological Unit	Symbol	Drainage Pattern	Landform	Elevation(m)
1.	Peak		Dendritic	High Hill	750 - 900
2.	Steep Hills		Dendritic	Hill	600 - 750
3.	Sloping Hills		Dendritic	Low hill	450 - 600
4.	Slightly Sloping Hills		Dendritic	Low land	280 - 450

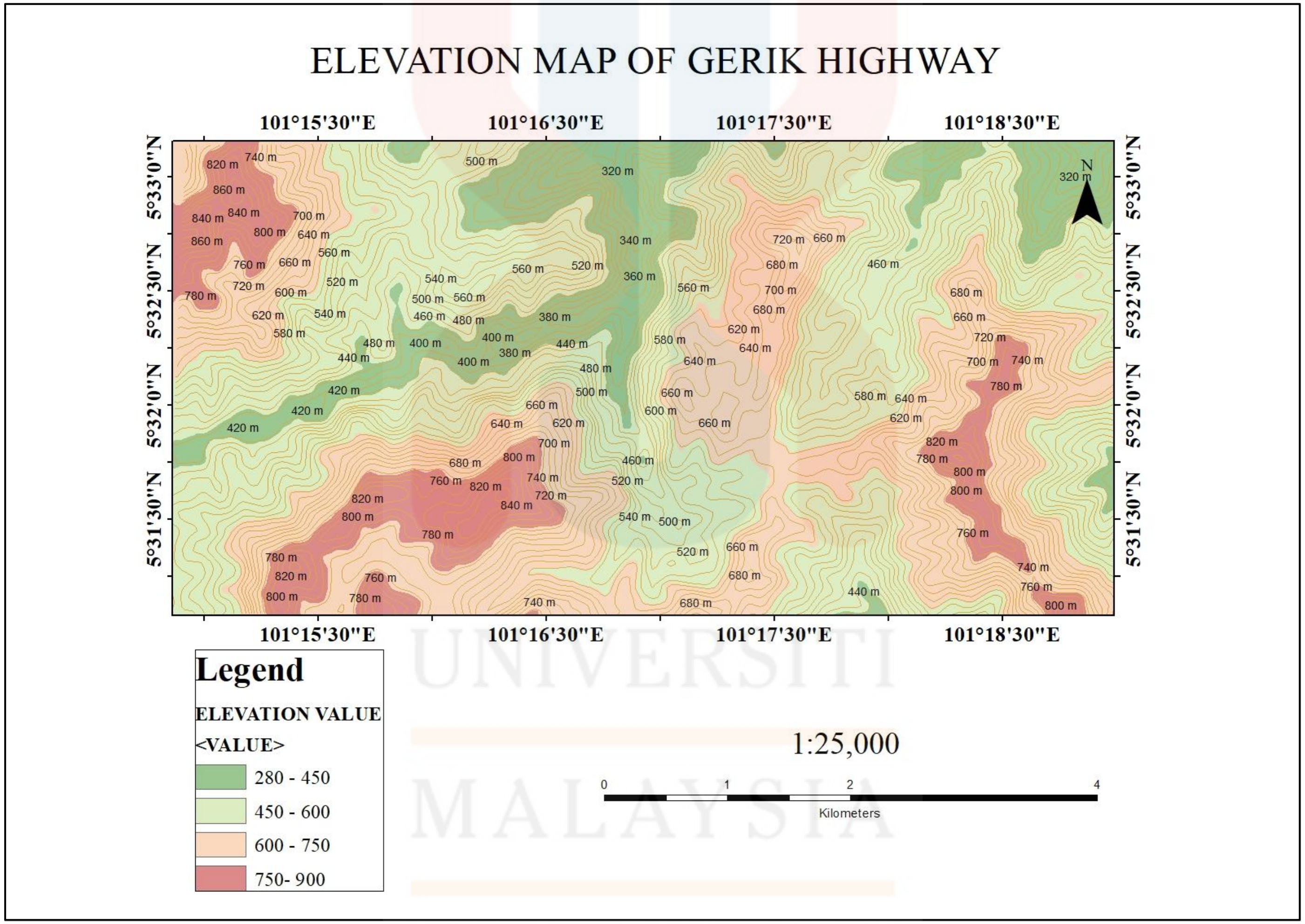


Figure 4.5 : Landform classification map of the study area

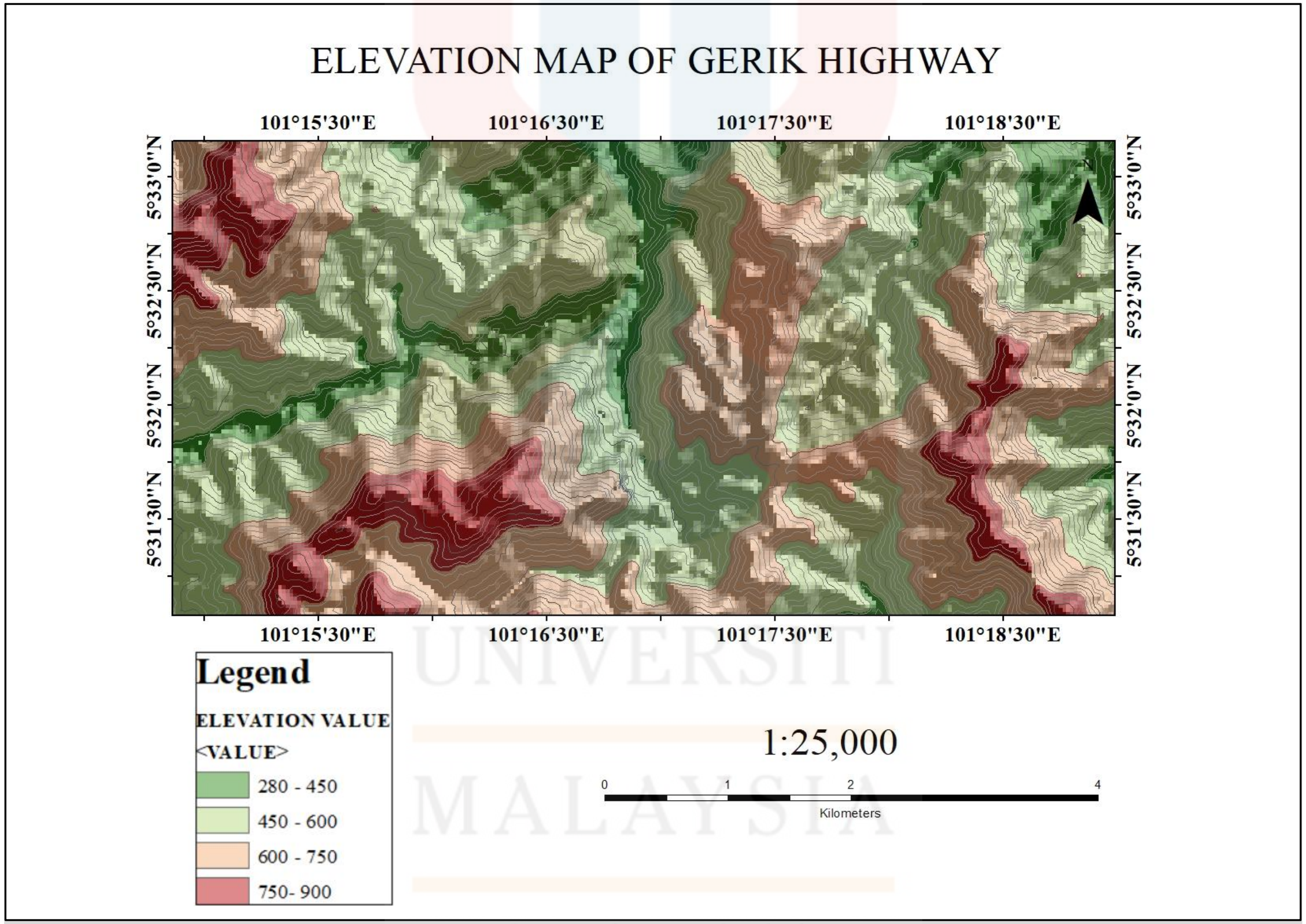


Figure 4.6 : The 3D topography of the study area

4.2.2 Weathering

When bedrock that is present at the area's original location or rock that has been moved, eroded, transported, and deposited thousands of kilometers away from its original location is exposed, weathering has taken place. Rock materials break down in situ at or close to the earth's surface as a result of an interaction collection of physical, chemical, and biological processes required for this process.

There are three categories of weathering, namely:

A. Physical Weathering

B. Chemical Weathering

C. Biological Weathering

Weathering in sedimentary rocks :

a) Physical Weathering

Physical weathering or mechanical weathering is known as the action of breaking big rocks into little ones. The various weather conditions, such as hot days and cool nights, can cause the rocks to split and shatter. The mudstone that is present in the study region contains instances of mechanical weathering. The rocks cracked and disintegrated as a result of the expansion and contraction.

Figure 4.7: The physical weathering of the outcrop

b) Chemical Weathering

The effect of weathering on the molecules and the atom of the rock can be consider as chemical weathering.The chemical reacts as the moisture, and heat present. Oxidation or other reaction such as hydrolysis and carbonation cab occur with the present of water. This type of weathering occurs rapidly by the present of the warm and moisture temperature. Since the observed temperatures are conducive to chemical weathering, the majority of the rocks in Malaysia are subjected to it. Every mineral has a unique resistance to weathering. For instance, quartz has a higher resistance to reactivity than feldspar, which can combine to form clay.

c) Biological Weathering

With the aid of the animals and plants in the landscape, biological weathering may take place. More roots are encroaching on and securing rocks in some of the outcrop's surface.

Figure 4.8: The biological weathering in locality 3 in the study area

4.2.3 Drainage pattern

The planimetric arrangement of streams etched into the land surface by a drainage system is referred to as a drainage pattern, according to Thornbury (1969). Additionally, it has been argued that the topography or rocks beneath the soil determine the drainage patterns. The drainage system also displays the drainage basin's initial slope, original structure, diastrophism, and regional geological and geomorphological history. The drainage system that flow in the entire region of the study area connect to the main lake which is Temenggoh lake. The drainage system of the stream of the study area is consisting of dendritic shape of the river. Dendritic pattern actually resemble as an oak or chestnut tree which was quite similar that shows in the study area.

Nearly at any angle on the study area, the spreading tree-like pattern with uneven branching of tributaries from numerous directions is also referred to as the Tributary River. It grows in areas with uniform subsurface materials. That is, there is no apparent control over the course that the tributaries travel because the subsurface geology has a similar resistance to weathering. Tributaries at an acute angle with larger streams (less than 90 degrees).It generally appears in consistently resistant, bevelled crystalline rocks or horizontal deposits. Subdendritic, pinnate structure, anatomical pattern, and distributary pattern are the four subshapes of the dendritic shape. The southwest region of the study's map shows this dendritic pattern.

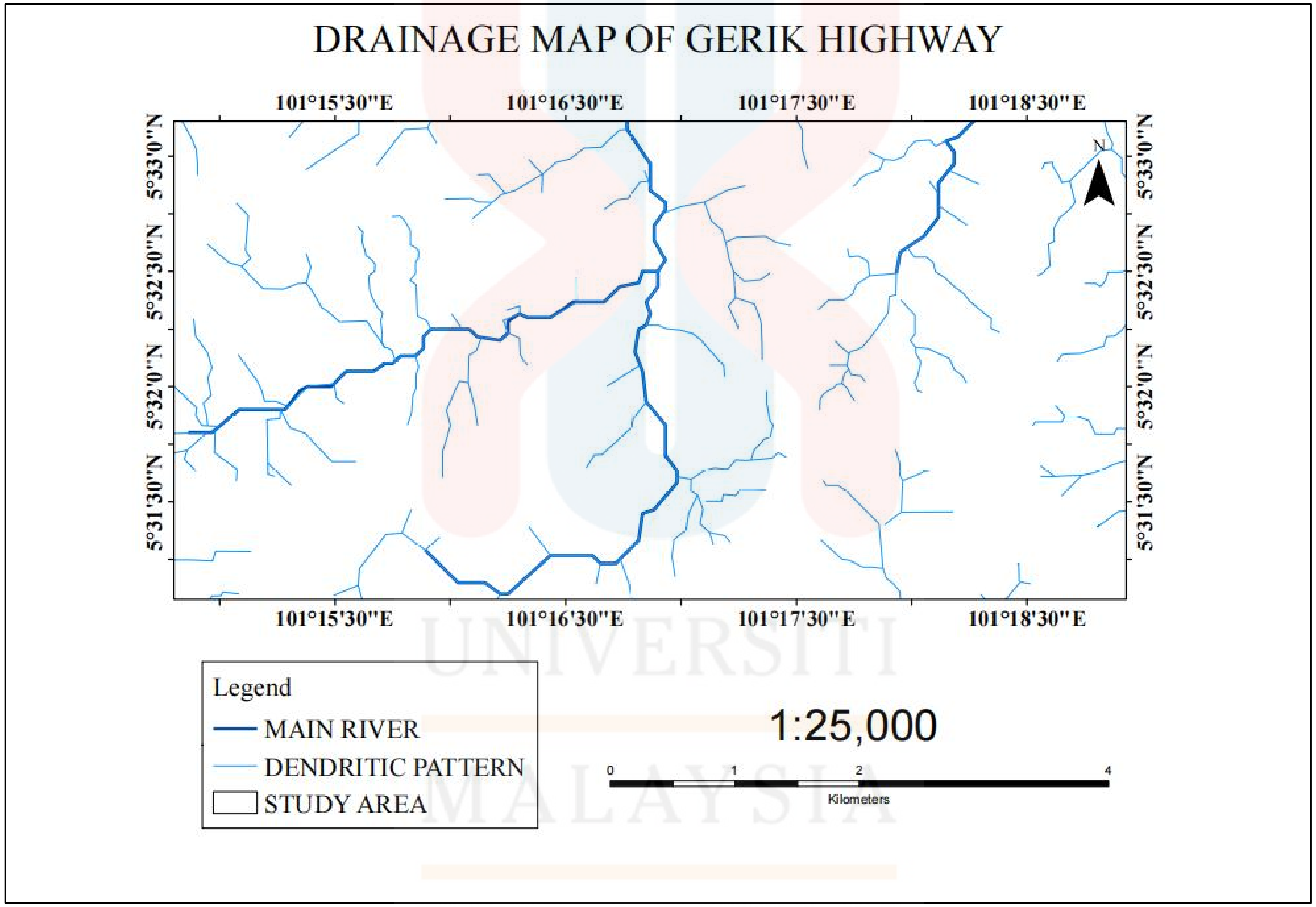


Figure 4.9: The drainage pattern map of the study area

4.3 Lithostratigraphy

Lithostratigraphy focuses on the investigation of rocks in the research region that are correlated with their ages and are used to construct a stratigraphic column. This study area situated on the northern state area of Perak which was in the Western Belt. The oldest rock also stated here in the area of north-western of Peninsular Malaysia. This study focuses on the Gerik Formation where the it was composed of Paleozoic-aged Gerik Formation. All pre-granite sedimentary rocks in the area of the Main Range, including the pyroclastic layer, belong to the Baling Group. Table 4.4 displays the stratigraphy column broken down by the age, lithologies, and rock type.

A) Stratigraphic position (of all units)

Table 4.3: The stratigraphy column from the study research

ERA	PERIOD	UNIT	LITHOLOGY	
Paleozoic	Permian	Shale		
		Mudstone		**Unit 1**
		Sandstone		
		Phyllite		**Unit 2**

B) Unit explanation

Table 4.4: The lithology column from the study research

LITHOLOGY	UNIT	DESCRIPTION
	SHALE	It has mountainous landform. Fine grain shale bedding with more than 3 meters long in diameter to west direction Inferred boundary remarked in this unit. This unit was interpreted as shale and sandstone.
	MUDSTONE	Interbedded with sandstone. Highly relief and highly weathered. Contain geological structure such as anticline and syncline Mainly interbedded of mudstone with sandstone and small amount of shale
	SANDSTONE	Interbedded with mudstone and shale. The rock mass contain good bedding trace, moderate attitude, several joint directions. Interbedded sandstone with mudstone at dense vegetation and forest landforms
	PHYLLITE	Phyllite was highly weathered and contain small amount of quartz vein. Thickness of the quartz vein is about 2-5 cm. The joint structure was visible.

C) Shale Unit (Unit 1)

Shale in the research area was Late Permian in age, according to the Malaysia-Thailand Working Group (2010). It is regarded as the study area's youngest rock. The shale was discovered interbedded with sandstone with extremely fine grain. By looking at the hand specimen or in thin sections, there is no fossil to be found between the two interbedded rocks. The minority of the research area's rocks were shale, with a few having varying thicknesses ranging from fine to medium grain. With the unaided eye, it is easy to perceive the acute contact between the sandstone and shale. Shale and sandstone varied in size with respect to thickness. Both thick sandstone and thin shale are present, as well as the opposite.

Sedimentary rocks of the shale and mudstone variety are the most prevalent. Shale's tiny grain size makes it more difficult to study its provenance than sandstone does. Shale and mudstone cannot be subjected to petrography study because of their too-fine grain sizes. But, as shale contain mostly some silt or sand size particles; larger particles of quartz, feldspar and heavy mineral, shale provenance can be studying by identifying the quartz and feldspar grain.The sandstone and mudstone come in a few different varieties of grain size. The sandstone and mudstone that are interbedded are generally weathered and difficult to distinguish by eye. The shale was discovered to be highly weathered and had a greyish colour. Shale deposits were discovered in the study at low energy paleocurrent sites where there is no mixing in the grain clasts.

D) Sandstone Unit(Unite 1)

Location : N 05^{0} 31’23”, E101^{0}16’57”

Elevation : 540 m

From the locality 3, 4 and 5 where fine-grained sandstone hand specimen sample was found where it is interbedded with mudstone and minor distribution of shale. By looking at the hand specimen or petrographic analysis, there is no fossil to be found between the interbedded rocks. Based on the hand specimen, the sample was obviously predicted as sandstone because of the texture, grain size and the colour of the sample. Sandstone appear in light grey in colour with a very fine grain texture of rock. Some of the rock colour appear darker because of the weathering process that occur. The dominant structure that can be observe from the naked eyes is the bedding and joint structure from the rock mass. The petrographic study of the sample rock reveals that it came from a recycled orogen, according to the results of the analysis (Dickinson and Suczek, 1979). From the microscopic observation, the thin section of sample Z03S1 is poorly sorted. The majority of the contacts between the clasts are made up of floating grain, making long interactions difficult to observe. The silt is made up of many different types of rocks, according to the sample analysis under the microscope. Quartz mineral with subhedral and euhedral structures proved that the silt originated from volcanic rocks.

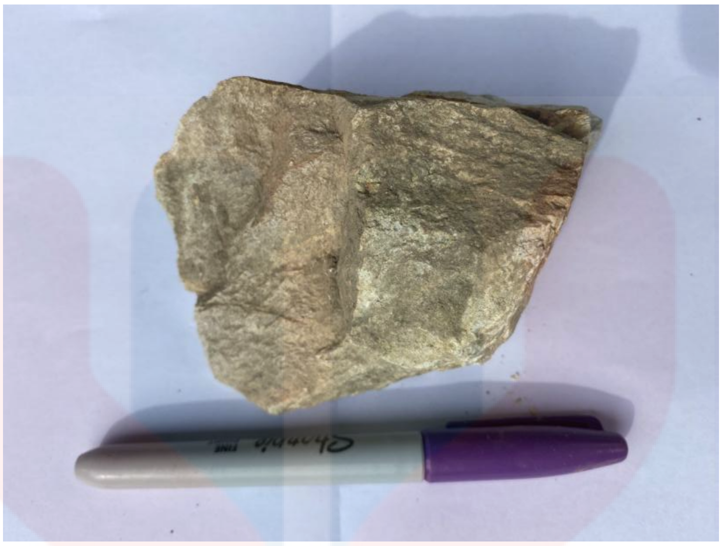
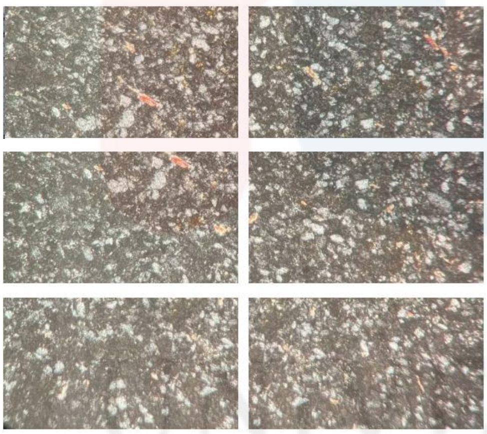
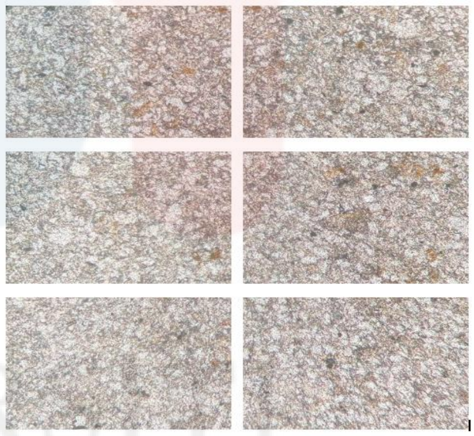


Figure 4.10: Sample of Sandstone (N 05^0 31’23”, E$101^0$16’57”)

Sample code	Z03S1	**Location**	Road in Gerik Highway, Perak
Coordinate	N 05^0 31’23”, E$101^0$16’57”		
Rock Name	Sandstone		
Colour	Light grey		
Texture	Aphanitic		
Structure	Interbedded, Joint		
Domination	Quartz and berlinite		
Thin section Analysis			
Minerals	**Description**		
Quartz	Mainly Quartz, 17^0 degree of extinction, grey to black and white in XPL, appear colourless in PPL, euhedral in shape, the shape remain the same in both lense.		
Calcite	Light colour to light gray, has perfect cleavage		
Feldspar	In PPL, Feldspar mineral is colorless and in XPL the color has a range from white to brown, subhedral. In thin sections, alkali feldspar grains often look like they're sprinkled with dirt (PPL) or tiny confetti (XPL).		

<table>
<tr><td>Description for minerals</td><td colspan="2">In sample of Z03S1,. the rock have a very fine grain texture with quartz minerals and biotite presence filled up in between grains. The quartz mineral still exhibits characteristic of sedimentary rocks. The general mineral shape is known as hypidiomorphic and the crystallinity degree is hypo-crystalline. In cross-polarized light, the mica exhibits 2nd order colour and seems to be second dominating in the thin portion.The quartz mineral still exhibits characteristic of sedimentary rocks.</td></tr>
<tr><td colspan="3">Description
Sandstone is a medium-grained sedimentary rock. It is composed mostly of quartz sand, but it can also contain significant amounts of feldspar, and sometimes silt and clay. Foliation frequently has a wrinkled or waved appearance.</td></tr>
<tr><td colspan="2">XPL
</td><td>PPL
</td></tr>
<tr><td colspan="3">Magnificent : 10x/0.25 P magnificent</td></tr>
</table>

E) Mudstone Unit(Unit 1)

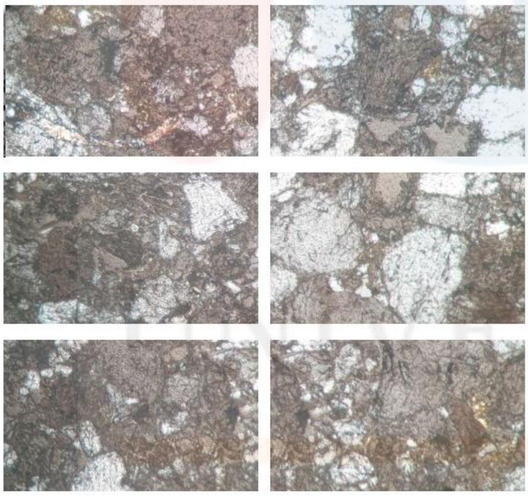
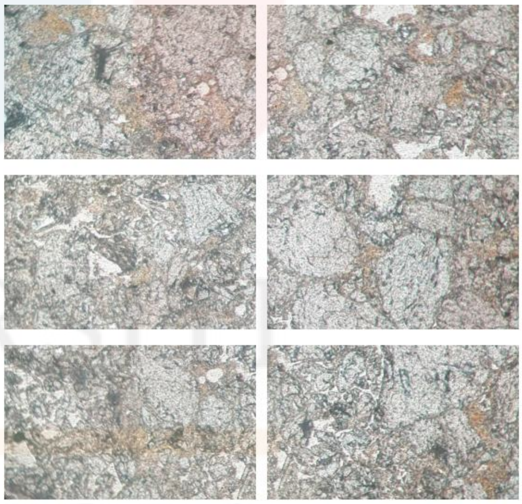
Location : N 05^{0} 31'39", E101^{0}16'51"

Elevation : 530 m

Mudstone specimens from localities 3, 4, and 5 were discovered interbedded with sandstone and a minor distribution of shale. No fossils can be detected between the interbedded rocks, according to petrographic investigation or examination of the hand specimen. Based on the hand specimen, the specimen firstly was predicted as chert but after considering a few factors, the specimen was identify as mudstone because it contains the combination sand and clay. Based on the analysis of petrography and minor assemblages, mudstone consist about a few element of oxide elements. The mudstone at location 3, 4, and 5 consists of 94 - 96% of SiO_2 (table 5.3). The mudstone at localities 3, 4, and 5 also contains oxide elements including CaO, MgO, K_2O, Al_2O, KO, and Na_2O. These oxides are important in determining the origin, degree of weathering, and distance of conveyance of the sediment. Additionally, the maturity and roughness of the rocks will show that they have had extensive transit and weathering. In addition, the technique used to assess the modest presence of shale can be the same technique used to determine the origin of sandstone, which depends on the quartz and feldspar grain. However, as shale contains silt and sand-sized particles as well as bigger quartz, feldspar, and heavy mineral particles, the provenance of the shale can be studied by distinguishing the quartz and feldspar grain.

Figure 4.11: Sample of Mudstone (N 05^0 31'39", E101^{0}16'51")

Sample code	Z05S4	**Location**	Road in Gerik Highway, Perak
Coordinate	N 05^0 31'39", E101^{0}16'51"		
Rock Name	Mudstone		
Colour	Light brown to greyish		
Texture	Aphanitic		
Structure	Bedding, Joint, Anticline		
Thin section Analysis			
Minerals	**Description**		
Quartz	No cleavage, no twinning, Light gray to white to black colour when in plecheorism, euhedral to subhedral in shape		
Biotite	Brown to light grey in colour in XPL, light brown in PPL, contain about 5% in the thin section.		
Plagioclase	Weathered, contain about 1% in the thin section, appears colourless in PPl and have no twinning and no cleavage		
Description for minerals	In sample of Z0541, the rock is a fine grained mudstone that major with the mineral of quartz. The sample has combination		

<table>
<tr><td></td><td>of both sand and clay. The rock have aphanitic texture with quartz minerals and biotite presence filled up in between grains and the veins. Muscovite is classify about 1 % in the thin section which appear in colour changes during the extinction in both lense.The general mineral shape is known as hypidiomorphic and the crystallinity degree is hypo-crystalline.</td></tr>
<tr><td colspan="2">Description
Mudstone is a sedimentary rock with exceptionally nice grain size made up of a mixture of clay and silt-sized particles. Shales and mudstones both fracture into thin chips with about parallel tops and bottoms, while mudstones do so in blocky fashion. Silt and clay particles that are too tiny to see make up mudstones and shales. The main distinction between mudstone and shale is that the latter fractures into thin chips with about parallel tops and bottoms while the former breaks into blocky fragments. The mud used to create both is old.</td></tr>
<tr><td>XPL
</td><td>PPL
</td></tr>
<tr><td colspan="2">Magnificent : 40x/0.25 P magnificent</td></tr>
</table>

F) Phylitte Unit (Unit 2)

Location : N 05° 32’ 56”, E 101° 18’ 17”

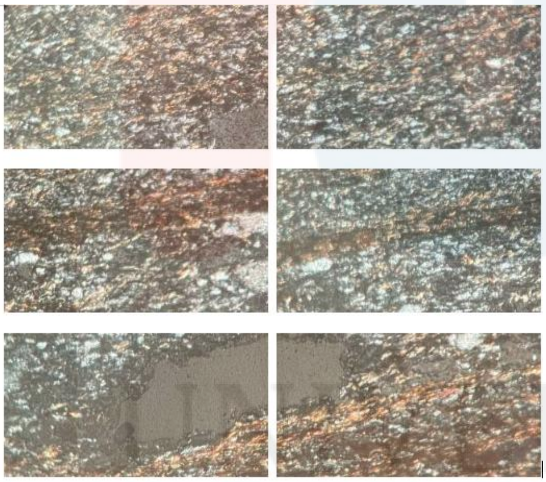
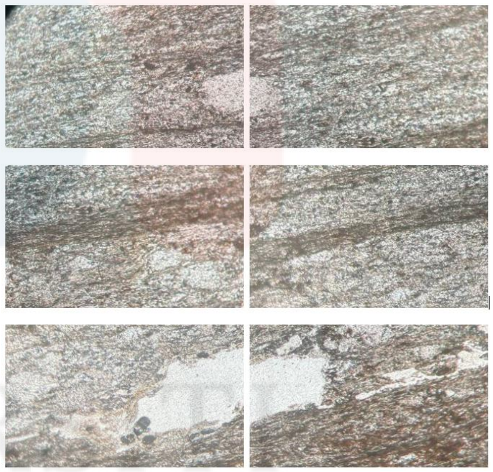
Elevation : 470m

The first location was found to the east of the study region at N 05° 33' 07" and E 101° 18' 27". The outcrop's height can reach 20 meters, while its length can reach 15 meters. The form of the outcrops in the hilly region at 470 meters above sea level reveals that they have undergone extensive biological weathering. The outcrop's morphology at the low-lying plain reveals that biological weathering has caused it to become "highly weathered" with the majority of the outcrop being covered in vegetation. But as shown in Figure 4.21, fresh rock from the outcrop is collected for petrography investigation. The outcrop contain the dominantion of phylite with a few influence of quartz. The sample are foliated where made up of is plate shaped minerals grains and the grains are large enough to be seen under naked eyes.

Figure 4.12: Sample of Phylite(N 05^0 32’56”, E$101^0$18’17”)

Sample code	Z01S1	**Location**	Road in Gerik Highway, Perak
Coordinate	N 05^0 32’56”, E$101^0$18’17”		
Rock Name	Phyllite		
Colour	Greyish to brownish		
Texture	Aphanitic		
Structure	Foliation, Quartz vein, Micro Anticline, Joint		
Domination	Phylite with very minor of quartz vein		
Thin section Analysis			
Minerals	**Description**		
Quartz	Colour in XPL but colourless in PPL, light grey to white to dark black, subhedral to anhedral shape, low relief, no twinning.		
Biotite	Light yellow to brownish, colourless in PPL, has subhedral in XPL but no shape in PPL, low relief, no cleavage appears.		
Mica	Pleochroism, which can be seen in the PPL images, distinguishes biotite from muscovite. Have perfect cleavage		
Feldspar	In PPL, Feldspar mineral is colorless and in XPL the color has a range from white to brown, subhedral.		

<table>
<tr><td>Description for minerals</td><td colspan="2">In sample of Z01S1, the rock is fine grained with clear visible of foliation structure. The rock have aphanitic texture with quartz minerals and biotite presence filled up in between grains. The quartz mineral still exhibits characteristic of sedimentary rocks. The general mineral shape is known as hypidiomorphic and the crystallinity degree is hypo-crystalline. Quartz is more dominant in this thin section.</td></tr>
<tr><td colspan="3">Description

Phyllites typically range in appearance from black to grey to light greenish-gray. Foliation frequently has a wrinkled or waved appearance. Due to the parallel alignment of platy minerals, phyllite exhibits a significant fissility (a propensity to split into sheets or slabs) and may have a sheen on its surfaces from tiny plates of micas.</td></tr>
<tr><td colspan="2">XPL
</td><td>PPL
</td></tr>
<tr><td colspan="3">Magnificent : 10x/0.25 P magnificent</td></tr>
</table>

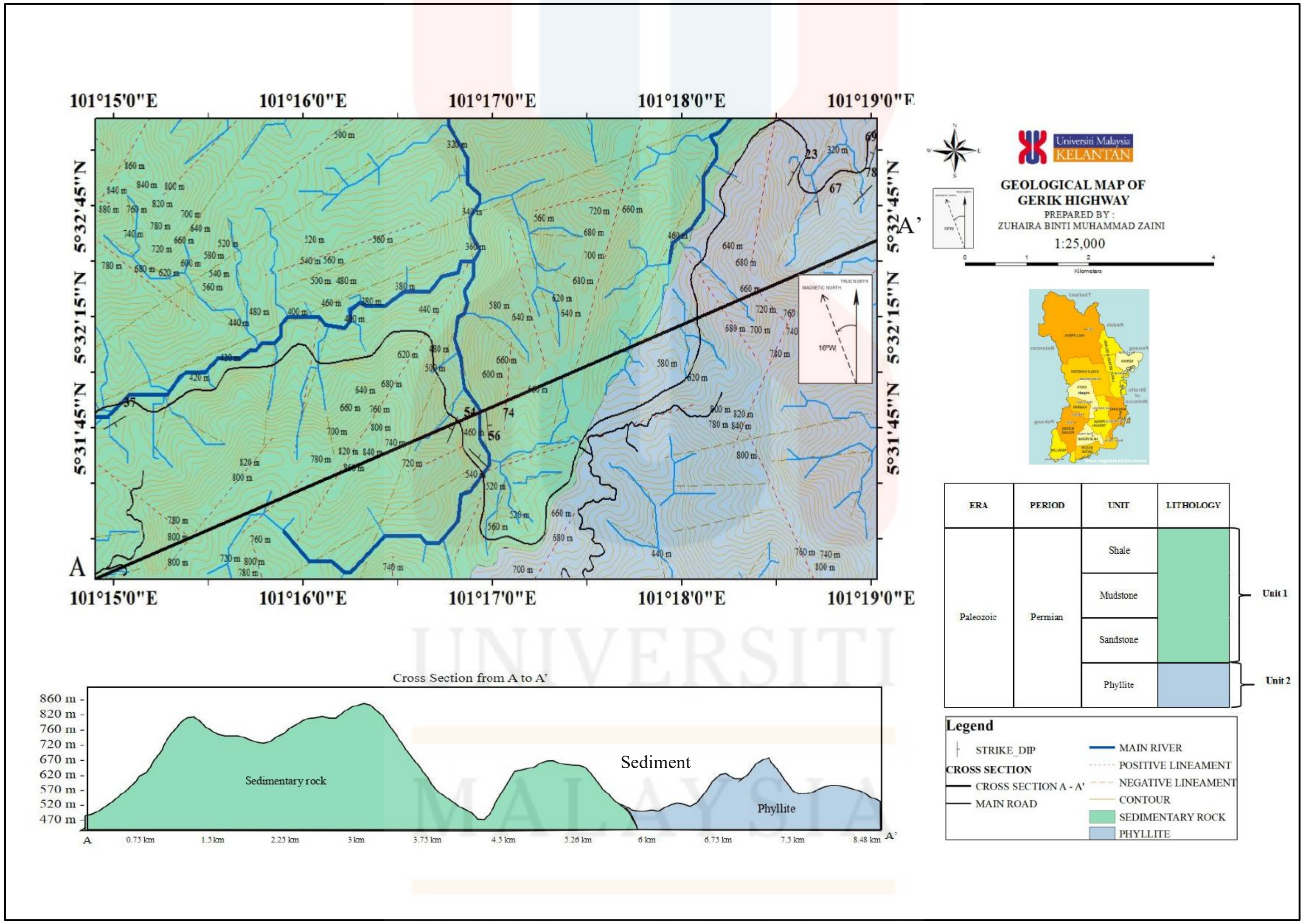


Figure 4.13: The geological map of the study area

4.4 Structural Geology

4.4.1 Bedding Analysis

The definition of a bedding plan is the structure of the upper and lower surface of beds. The easiest physical characteristics of sedimentary rocks to recognise in outcrops are undoubtedly these surfaces. They are typically used to establish the relative timing and order of the accumulation of the sediments comprising the beds and are used to split successions of sedimentary rock into their beds. In addition, the interpretation of these sedimentary rocks is aided by the nature of the bedding planes, including whether they are eroded, cemented, drilled, bioturbated, or depositional surfaces.

Figure 4.14 : The bedding plane in the study area

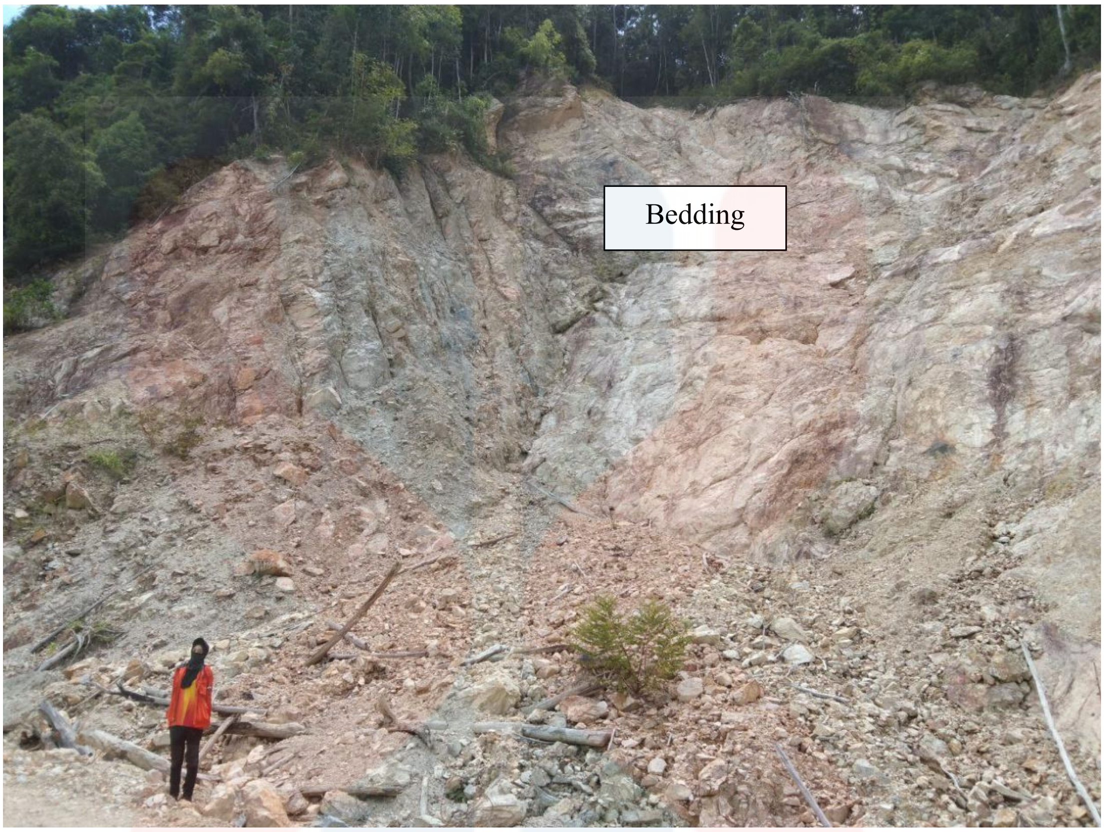


Figure 4.15: The outcrop of bedding plane in the localities 5

4.4.2 Foliation Analysis

Foliation, which gives rocks a striped or layered appearance, is the parallel arrangement of specific mineral grains. These mineral bands align as striped patterns into thin, recognizable layers as the rock is heated and pressed. It was well known that all foliation occurred as a result of extremely high pressure and temperature exerted on metamorphic rocks. All foliation yields the characteristic thin layering. Foliation is known to vary from rocks of different sorts or from one rock to another. On metamorphic rocks, variations in temperature and pressure lead to variations in foliation. Based on localities 1, the reading data of foliation is noted in two different direction which is $120^0/23^0$ on the left side heading towards the SW and the right side is noted as $347^0/33^0$ heading towards the NW of the rock mass.

4.4.3 Lineament Analysis

Positive and negative lineaments are discussed in lineament analysis. The research area's ridges were used to form the positive lineament, and the rivers provided the negative lineament. Both lineaments were identified before being measured using a protractor to determine their bearings. To determine the direction of the applied forces, the rose diagram was drawn using all of the bearings.

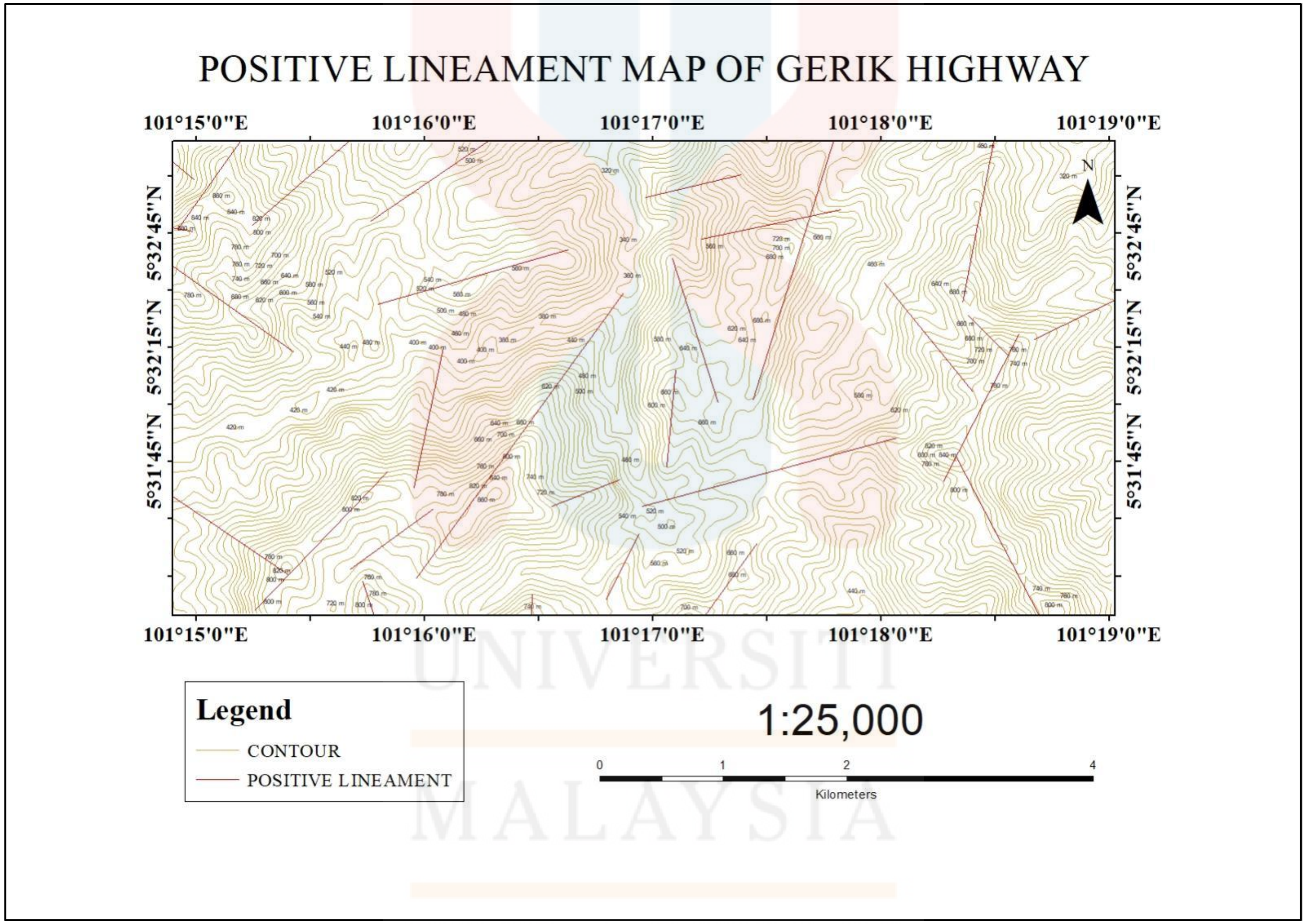


Figure 4.16: The positive lineament map of the study area

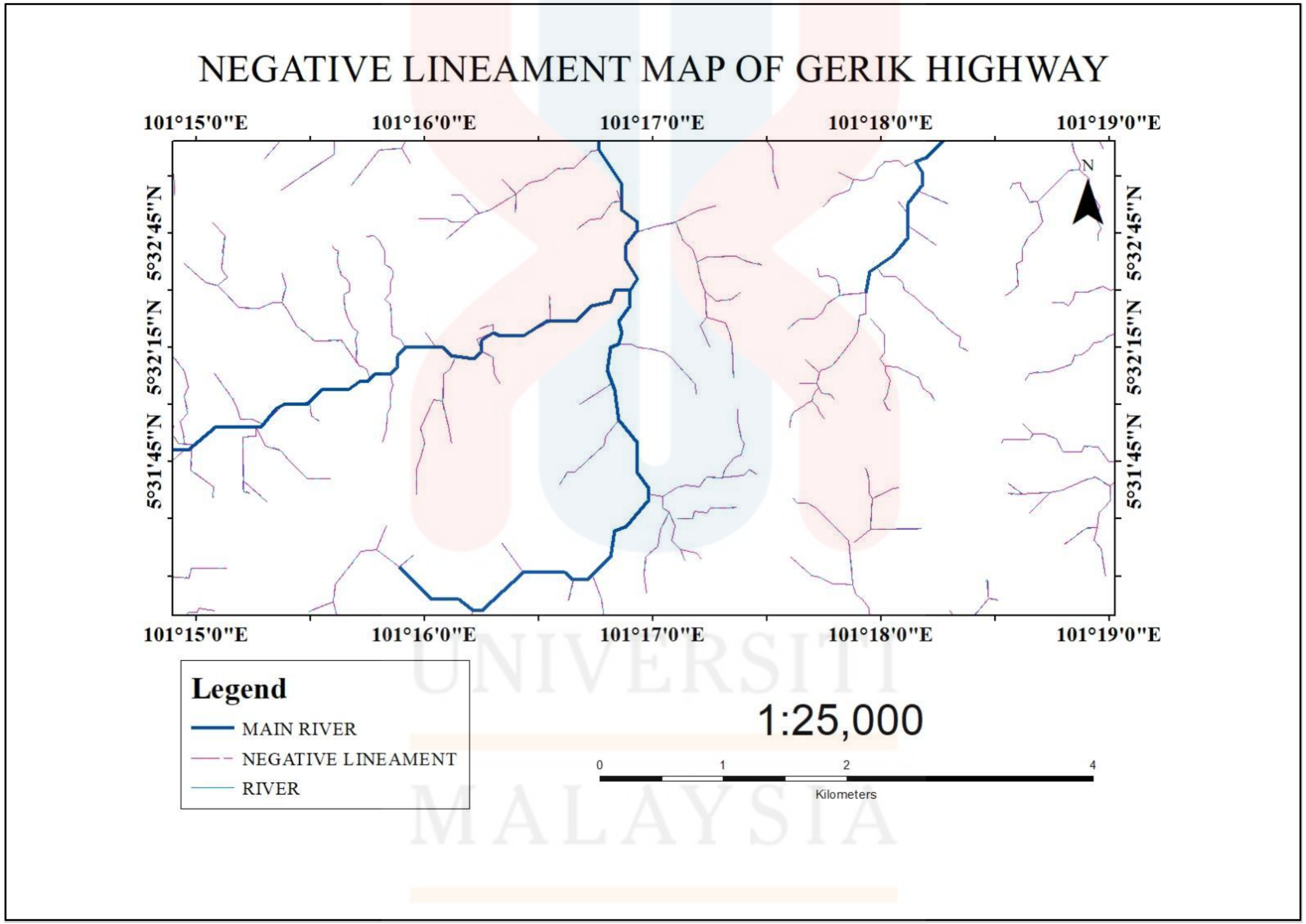


Figure 4.17: The negative lineament map of the study area

I) Positive Lineament

The rose diagram was built using positive lineament data from the study area. The force is moving in a north-east and south-west direction, according to the study of the rose diagram. While the South-East and North-West directions were where the tension was stated.

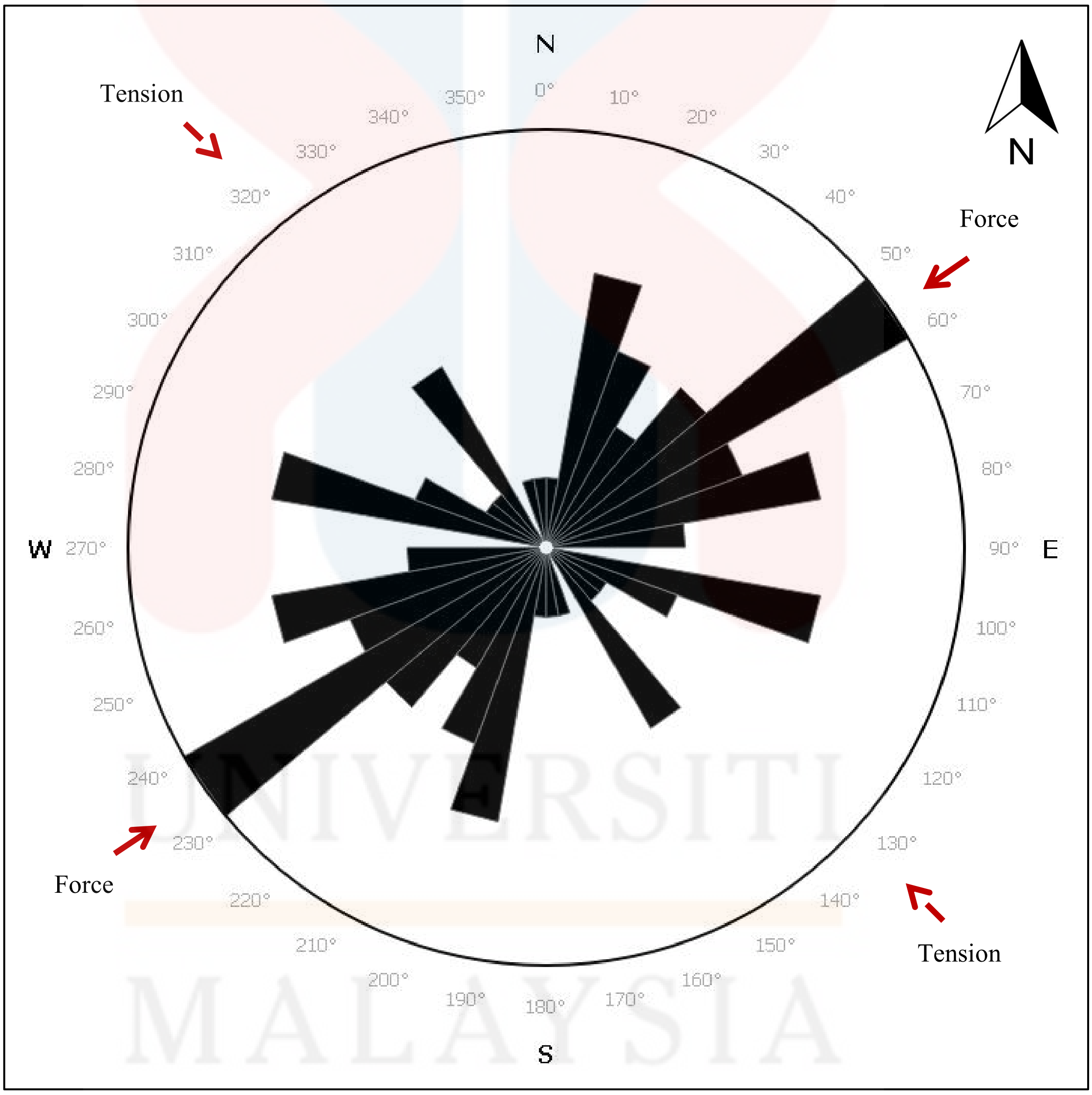


Figure 4.18: The Rose Diagram of Positive Lineament of the study

II) Negative Lineament

The rose diagram contained the plot of the negative lineament analysis. The north-east and south-west directions of the force were indicated. North-west and south-east were used to define the tension's direction.

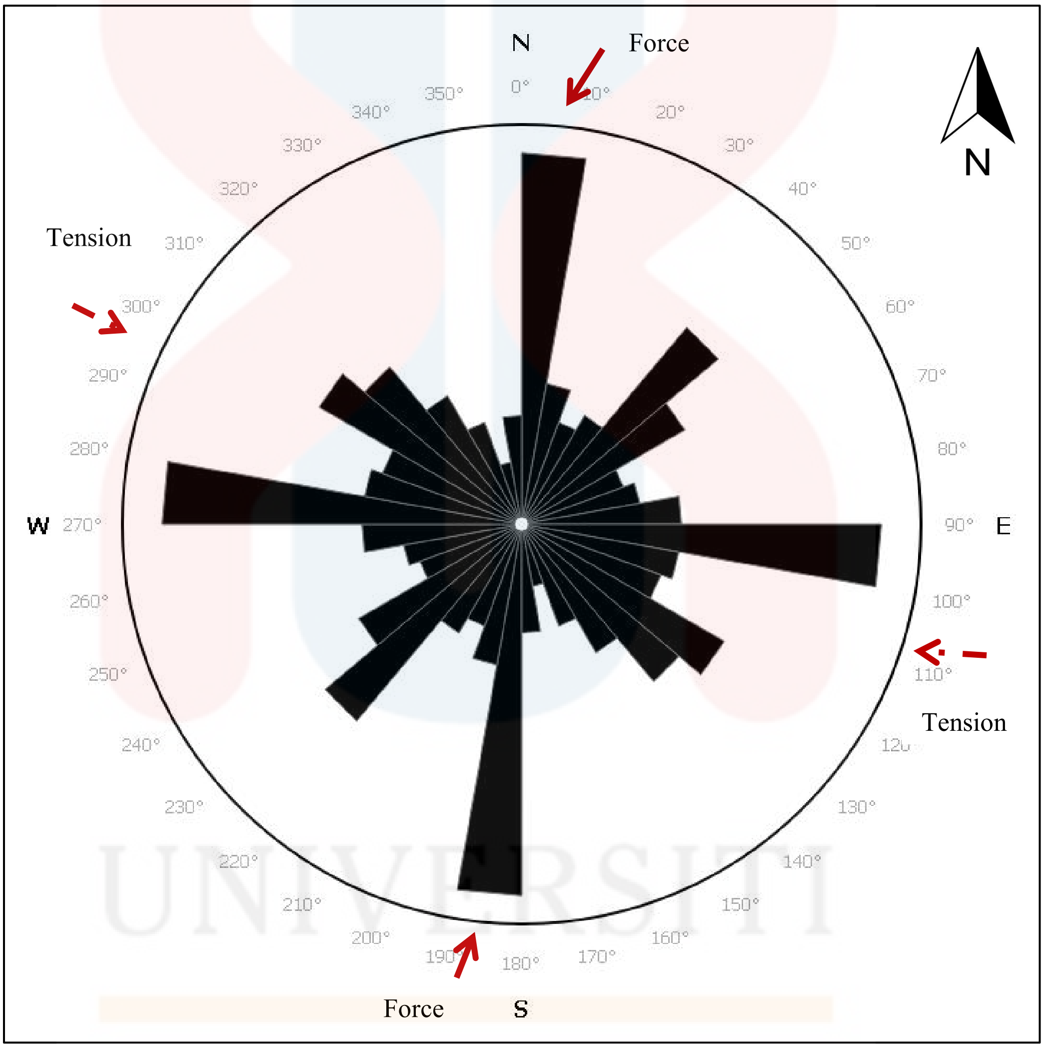


Figure 4.19: The Rose Diagram of Negative Lineament of the study

4.4.4 Joint Analysis

The five locations used for the joint analysis were Z1, Z2, Z3, Z4, and Z5. 200 readings in all were collected at the five previously mentioned locations. For each area where reading was taken, a rose diagram was drawn in the Figure 4.19.

At locality, except for locality Z5, other localities has the major force is from the NE and SW, while Z5 was from NW and SE. All these directions shows the similar to the direction of the positive lineament of the study area while Z5 is similar to the negative lineament. As a conclusion, the direction forces applied at four locations were mostly similar to the negative lineaments of the study area.

The joint from all the localities was formed by the tectonic movement and was exposed by the extensional mineral of weathering and 200 reading of the strike of joint are being interpret and measured.

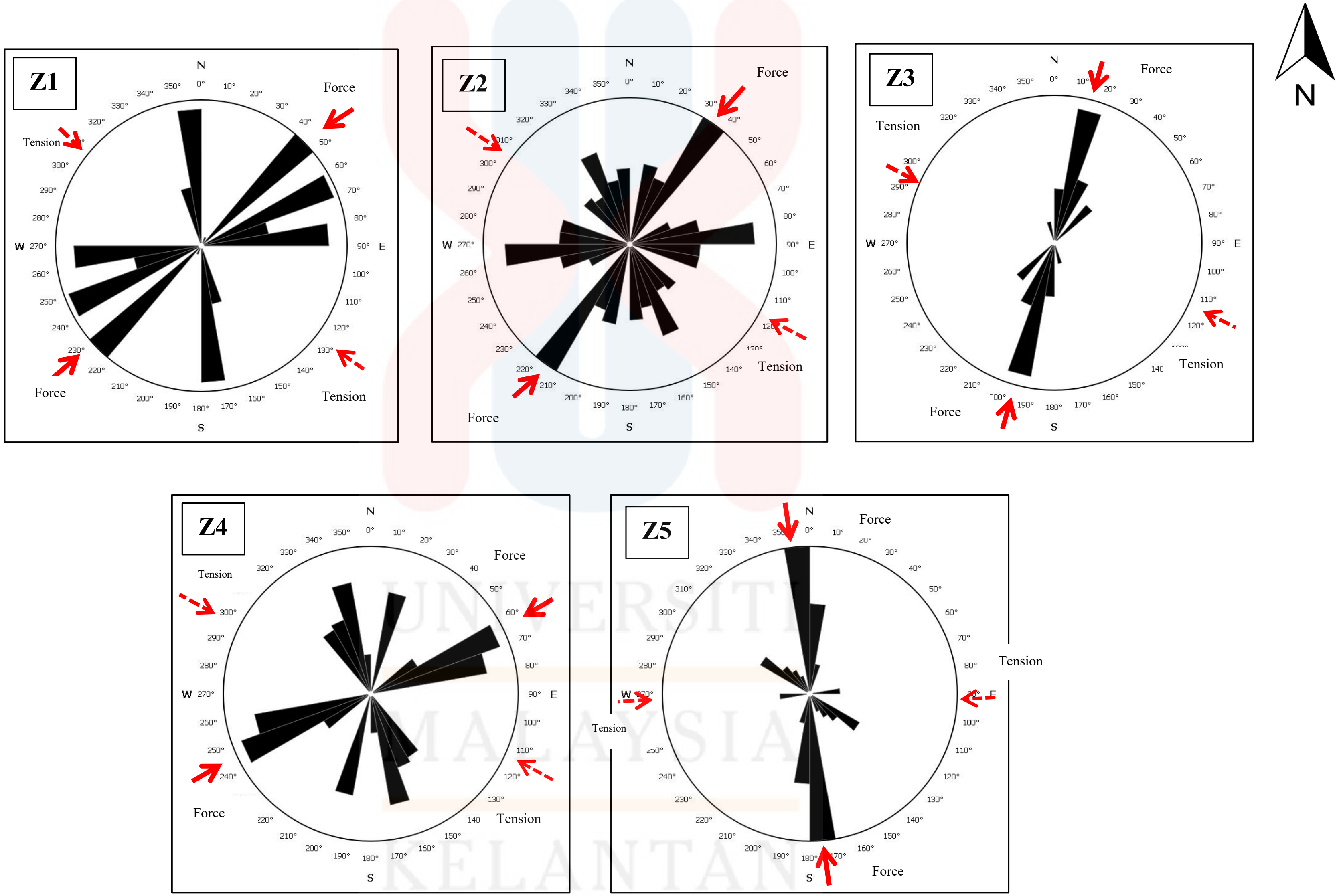


Figure 4.20: The correlation of joint analysis of Z1, Z2, Z3, Z4 and Z5 localities in the georose diagram

4.4.5 Fold Analysis

The outcrop at site Z4 contains mainly minor folds. It is the most prevalent type occurs when one or a stack of flat planar surfaces are bent or curved as a results of deformation that exists. Minor folds, however, frequently hold the secret to the major folds to which they are attached. Folding brought by by exerting tension on the rock. In this research field, incline folding are relatively distinct. They exhibit the same style and shape, and the direction in which the major folds' closures lie and their cleavage reveal the major folds' axial planes' attitude and overturning directions.

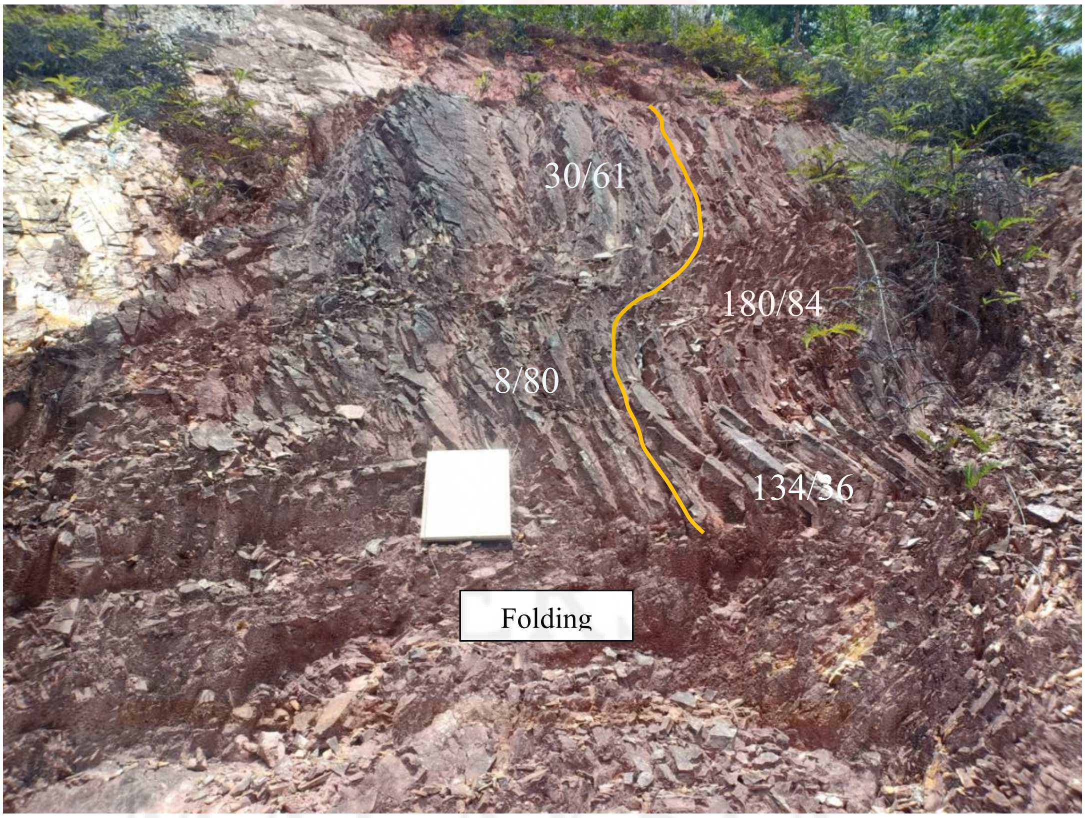


Figure 4.21: Folding structure of the study area near locality 4, the interbedded between mudstone, shale and sandstone.

Figure 4.22: Fold in Locality 4

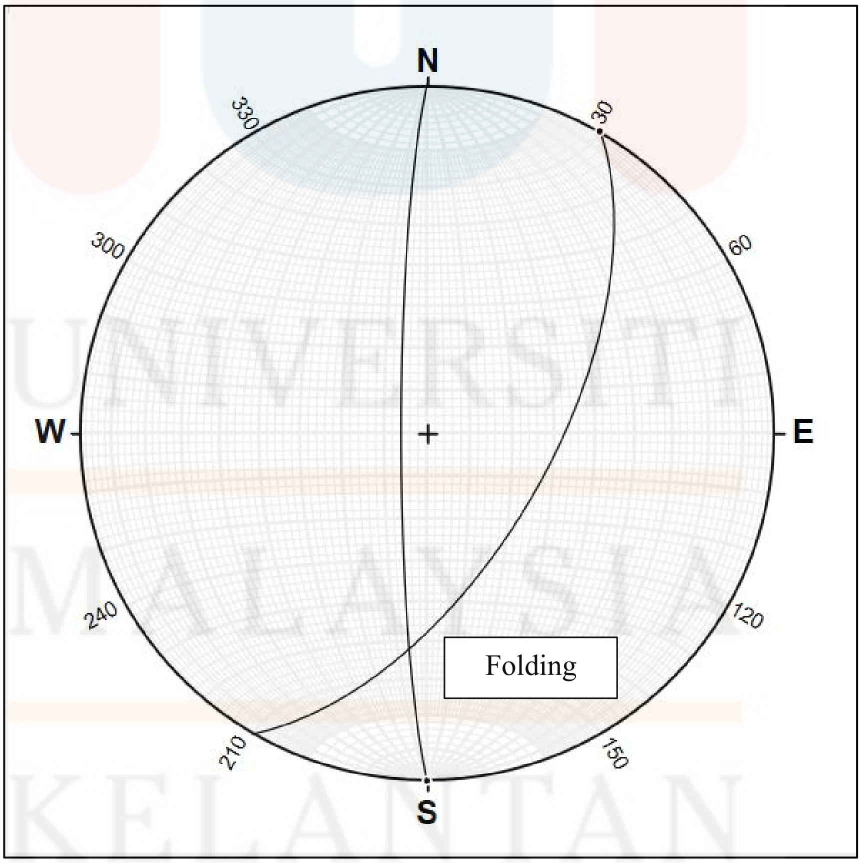


Figure 4.23 : Stereographic projection showed the folding occurred in the study area.

4.5 Historical Geology

In Baling Group, the oldest formation was the Bendang Riang Formation in age from Devonian to Silurian followed by the next formation which was Gerik Siltstone and occurrence of Lawin Tuff formation in age of Upper Ordovician in Permian era. The youngest formation is Papulut Quarzite in the Baling Group age in Cambrian age. The study was placed in the northern section of Perak State, which is part of Peninsular Malaysia's Western Belt Zone. The Sibumasu Terrane, generated from the NW Australian Gondwana border within the late Cambrian-early Permian period, includes the Western Belt. Perak is in the western belt of Peninsular Malaysia. Baling group is one of the group formations on the Western Belt of Peninsular Malaysia.

This group usually consists of an upper argillaceous rock layer and a lower arenaceous strata layer. The group's argillaceous component also saw the development of more calcareous phases. There are four major facies that can be distinguished in the Baling region: arenaceous, argillaceous, calc-silicate, and calcareous (Burton, in Jones, 1970). In other words, the study also stated that most of the oldest rocks were found in the north-western of Peninsular Malaysia and in the Baling Group, there are rapid lateral and horizontal sedimentary fluctuations.

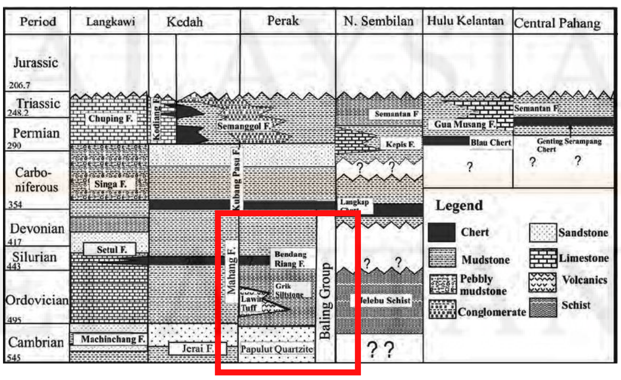


Figure 4.24: The startigraphy of baling group was shown in the red box

CHAPTER 5

PETROGRAPHY ANALYSIS AND SPECIFICATION

5.1 Introduction

This chapter will discuss petrography studies conducted that were carried out in order to analyse the petrography of low grade metamorphism rocks in a particular area near the East-West Highway in Gerik, Perak. This investigation was carried out to determine the rocks' characteristics, nature, and mineral assemblages nature, and mineral assemblages of the rocks.

One of the most reliable sources of information on past orogenic circumstances that might characterise tectonic settings is sedimentary rocks, which are well known for their importance. Fundamental characteristics for understanding the origin of the source rock are the silicate mineral and the rock-fragment composition of siliciclastic sedimentary rocks. The reason why the mineralogy was only present there was a hint as to the make-up of the lost source location. The sedimentary strata' surviving siliciclastic and rock pieces provide crucial proof of the source area's lithology. The clastic sedimentary was differentiate by few several factors which include the weathering, deposition, erosion, source rock, transport, burial and diagenesis.The key characteristics of sedimentary rocks are covered in this chapter in order to interpret their provenance. The sedimentary structure, particle size, roundness, maturity, and form gradient are examples of directional features that are used to evaluate the provenance in this chapter's sedimentary rocks and metamorphic rocks.

In discussion, the chapter has conclude that most of rock in found as sedimentary rock with a total of 4 sample rock while only 2 sample was proven as metamorphic rock. More than 50% of rocks have a high amount of quartz material. Although feldspar, silt, and clay can also be found in substantial numbers in sedimentary rock, quartz sand made up the majority of the material.

5.2 Petrographic Analysis

5.2.1 Phylite Analysis

A) Hand Specimen

Based on the interpretation of the hand specimen, the sample was predicted as Phylite as the first sight after observing the texture of rock that was very fine grain and the colour of the rock material appear to be grayish to brownish. The brownish colour occur because of the weathering process that happen there. The dominant structure that can be observe from the naked eyes is the quartz vein that appears about 10 to 12 cm in size that intrude the rock mass.

Figure 5.1: Hand specimen of sample Z01S1

Hand Specimen			
Sample code	Z01S1	**Location**	Road in Gerik Highway, Perak
Coordinate	N 05^{0} 32’56”, E101^{0}18’17”		
Rock Name	Phylite		
Type of rock	Metamorphic rock		
Colour	Greyish to brownish		
Grain Size	Very fine grained		
Texture	Aphanitic		
Level of weathering	Highly weathered (brownish to blackish)		
Composition	Quartz, Chlorite, Biotite, Feldspar, Mica		
Structure	Foliation, Quartz vein, Micro Anticline, Joint		
Domination	Phylite with very minor of quartz vein		

B) Microscope Analysis

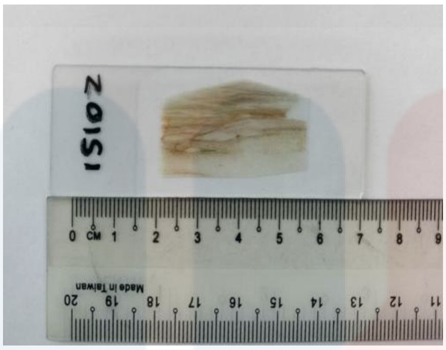
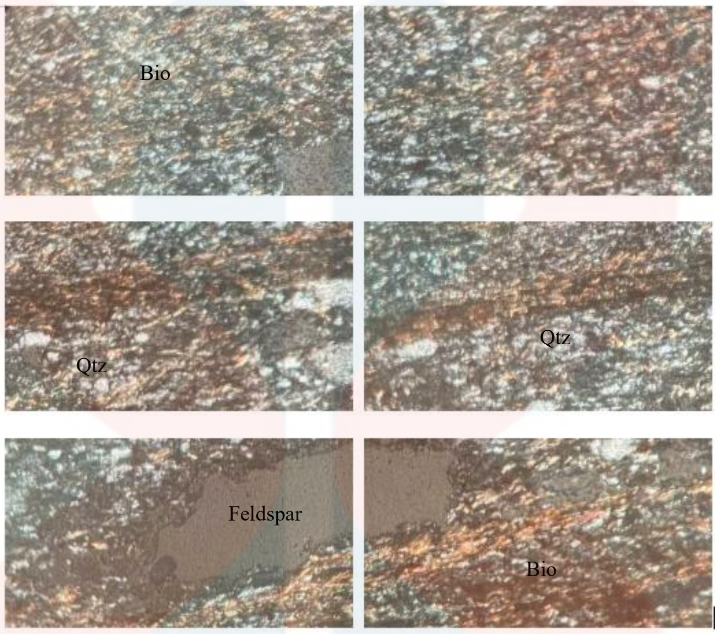


Figure 5.2: Thin section of sample Z01S1

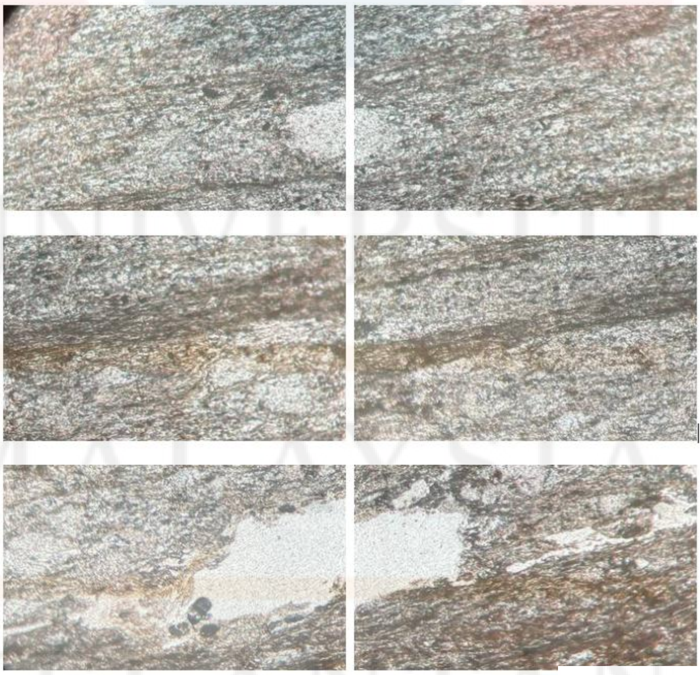
Thin section Analysis	
Minerals	**Description**
Quartz	Colour in XPL but colourless in PPL, light grey to white to dark black, subhedral to anhedral shape, low relief, no twinning.
Biotite	Light yellow to brownish, colourless in PPL, has subhedral in XPL but no shape in PPL, low relief, no cleavage appears.
Feldspar	In PPL, Feldspar mineral is colorless and in XPL the color has a range from white to brown, subhedral. In thin sections, alkali feldspar grains often look like they're sprinkled with dirt (PPL) or tiny confetti (XPL).
Mica	Pleochroism, which can be seen in the PPL images, distinguishes biotite from muscovite. Have perfect cleavage
Opaque	Black in XPL, colourless in PPL, subhedral in shape

Description for minerals

In sample of Z01S1, the rock is fine grained with clear visible of foliation structure. The rock have aphanitic texture with quartz minerals and biotite presence filled up in between grains. The quartz mineral still exhibits characteristic of sedimentary rocks. The general mineral shape is known as hypidiomorphic and the crystallinity degree is hypo-crystalline. Quartz is more dominant in this thin section. Opaque is classify about 1 % in the thin section which appear in black with changes in both lense.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.



Scale : 1mm



Scale : 1mm

Magnificent : 10x/0.25 P magnificent

5.2.2 Quartz Analysis

A) Hand Specimen

Based on the interpretation of the hand specimen, the sample was predicted as Quartz at the first sight after observing the vein structure which very obvious to be seen. The sample was found at the elevation of 470 meter beside the first sample. The texture of rock that was fine grain and the colour of the rock material appear to be milky white. The structure this rock is quartz vein with size about 10 - 12 cm.

Figure 5.3: Hand specimen of sample Z01S2

Hand Specimen			
Sample code	Z01S2	**Location**	Road in Gerik Highway, Perak
Coordinate	N 05^{0} 32'56", E101^{0}18'17"		
Rock Name	Quartz		
Type of rock	Igneous rock		
Colour	Milky white		
Grain Size	Fine grained		
Texture	Aphanitic		
Level of weathering	Highly weathered		
Composition	Quartz and Opaque		
Structure	Micro Anticline, Vein (10-12 cm), Joint		
Domination	Quartz		

B) **Microscope Analysis**

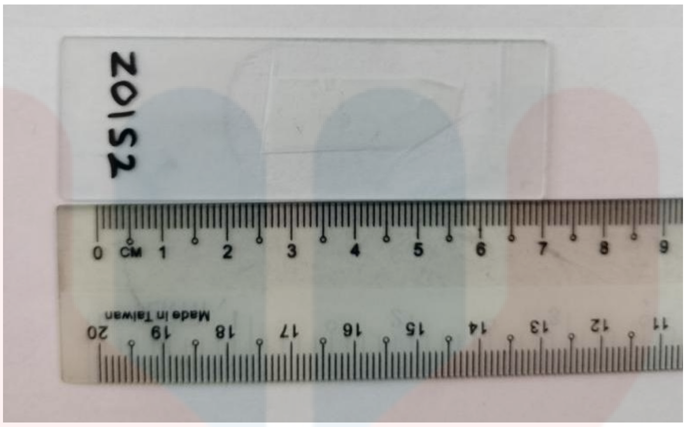
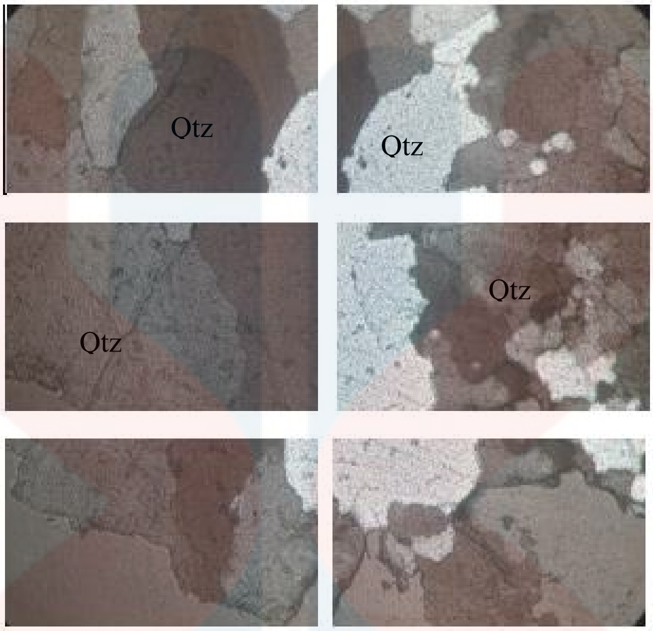


Figure 5.4: Thin section of sample Z01S2

Thin section Analysis	
Minerals	**Description**
Quartz	Colour in XPL but colourless in PPL, light grey to dark gray, black in plecheorism, subhedral to anhedral shape,low relief, no twinning. has extinction. Angle of extinction is $17^0/48^0$, no cleavage
Opaque	Black in XPL, clear white in PPL, no extinction, no plecheorism, no twinning, subhedral in shape

Description for minerals

The hand specimen is highly weathered. In sample of Z01S2, the rock is majorly 90% from the quartz mineral. It is fine grained with an aphanitic texture with quartz minerals and biotite presence filled up in between grains. The quartz mineral still exhibits characteristic of sedimentary rocks. The general mineral shape is known as hypidiomorphic and the crystallinity degree is hypo-crystalline. Opaque present in the thin section which appear in black with changes in both lenses. The quartz also contain fracture because of the deformation in the rock.



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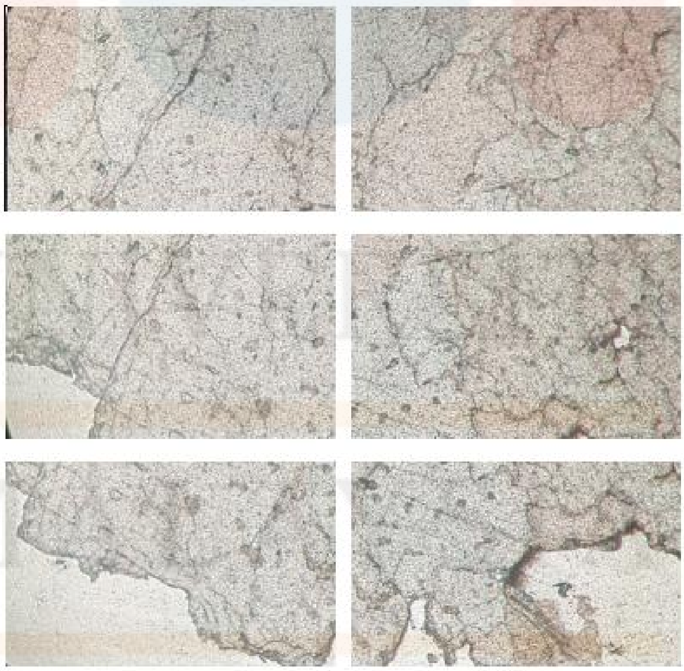


Scale : 1mm

Magnificent : 10x/0.25 P magnificent

5.2.3 Phyllite Analysis

A) Hand Specimen

Based on the interpretation of the hand specimen, the sample was hardly to predict because of heavy weathering. After considering a few factors, the hand specimen was identify as quartzite with the support of petrography analysis. The sample was found at the elevation of 550 meter beside the first sample. In this locality, quartzite is more dominated. The outcrop contain the structure interbedded of quartzite with minor phyllite. The texture of rock that was fine grain and the colour of the rock material appear to be white.

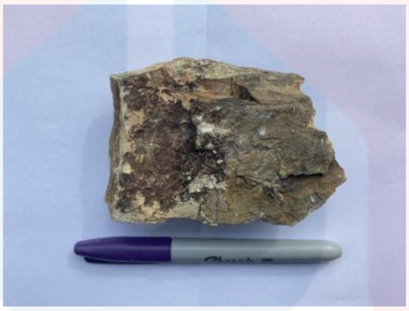


Figure 5.5: Hand specimen of sample Z02S1

Hand Specimen			
Sample code	Z02S1	**Location**	Road in Gerik Highway, Perak
Coordinate	N 05^0 32’5”, E101^{0}18’5”		
Rock Name	Phyllite		
Type of rock	Metamorphic rock		
Colour	White to Greyish		
Grain Size	Fine grained		
Texture	Aphanitic		
Level of weathering	Highly weathered		
Composition	Quartz, Biotite, Feldspar, Muscovite		

Structure	Foliation, Interbedded, Joint
Domination	Quartz

B) Microscope Analysis

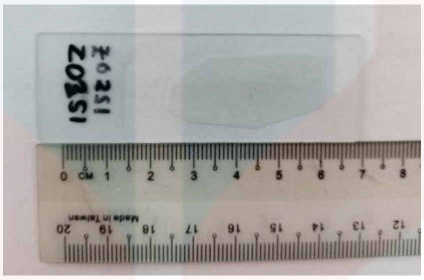
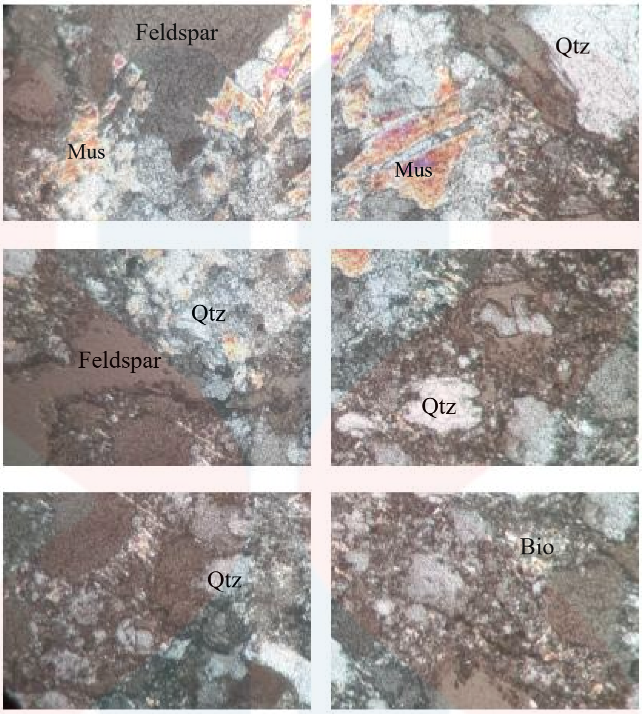


Figure 5.6: Thin section of sample Z02S1

Thin section Analysis	
Minerals	**Description**
Quartz	Mainly composed with Quartz, no twinning, 38^0 angle extinction, colourless in PPL, Anhedral to subhedral in shape, fine grain mineral
Feldpsar	Some feldspar(often altered), no shape , colourless in PPL, has extinction
Biotite	Light brown to light yellow in colour. Size 10-8µm , no twinning, extinction, Brown in PPL
Muscovite	Subhedral in shape, no shape in PPL, Appear colourless in PPL

Description for minerals

In sample of Z02S1, the rock is classified as phyllite because quartz is more dominant in this thin section. It’s a very fine grained rock. The rock have aphanitic texture with biotite presence and a minor presence of muscovite. The quartz extinction is about 38^0 degree exntinction. The general mineral shape is known as hypidiomorphic and the crystallinity degree is hypo-crystalline. The shape of the quartz is hexagonal.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.



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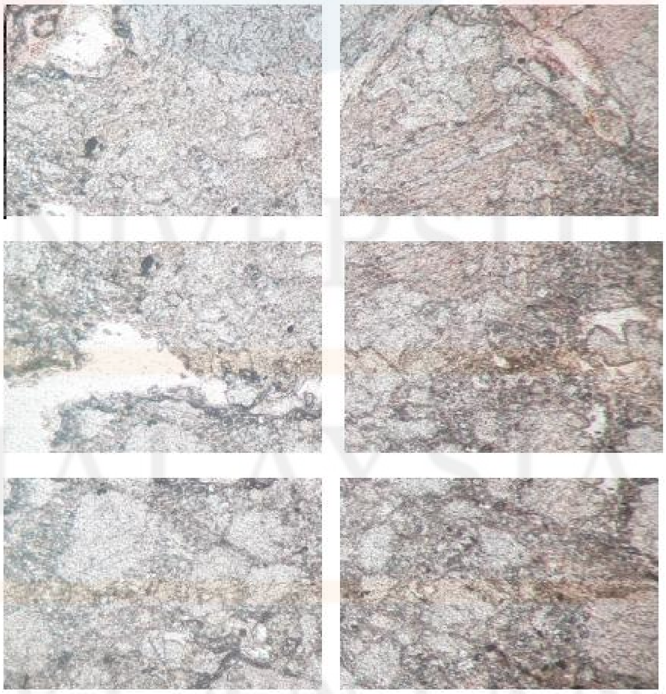


Scale : 1mm

Magnificent : 10x/0.25 P magnificent

5.2.4 Sandstone Analysis

A) Hand Specimen

Fine-grained sandstone hand specimen sample was found where it is interbedded with mudstone and minor distribution of shale. By looking at the hand specimen, there is no fossil to be found between the interbedded rocks. Based on the hand specimen, the sample was obviously predicted as sandstone.Sandstone appear in light grey in colour with a very fine grain texture of rock. Some of the rock colour appear darker because of the weathering process that occur. The dominant structure that can be observe from the naked eyes is the bedding and joint structure from the rock mass.

Figure 5.7: Hand specimen of sample Z03S1

Hand Specimen			
Sample code	Z03S1	**Location**	Road in Gerik Highway, Perak
Coordinate	N 05^{0} 31’23”, E101^{0}16’57”		
Rock Name	Sandstone		
Type of rock	Sedimentary rock		
Colour	Light grey		
Grain Size	Very fine grained		
Texture	Granular		
Level of weathering	Moderately weathered		
Composition	Quartz, Opaque, Feldspar		

Structure	Interbedded, Joint
Domination	Quartz and calcite

B) Microscope Analysis

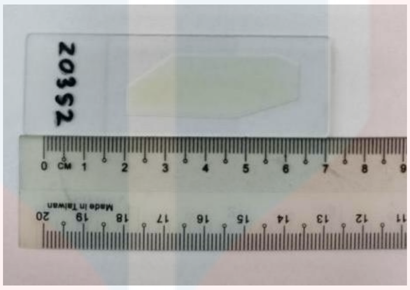
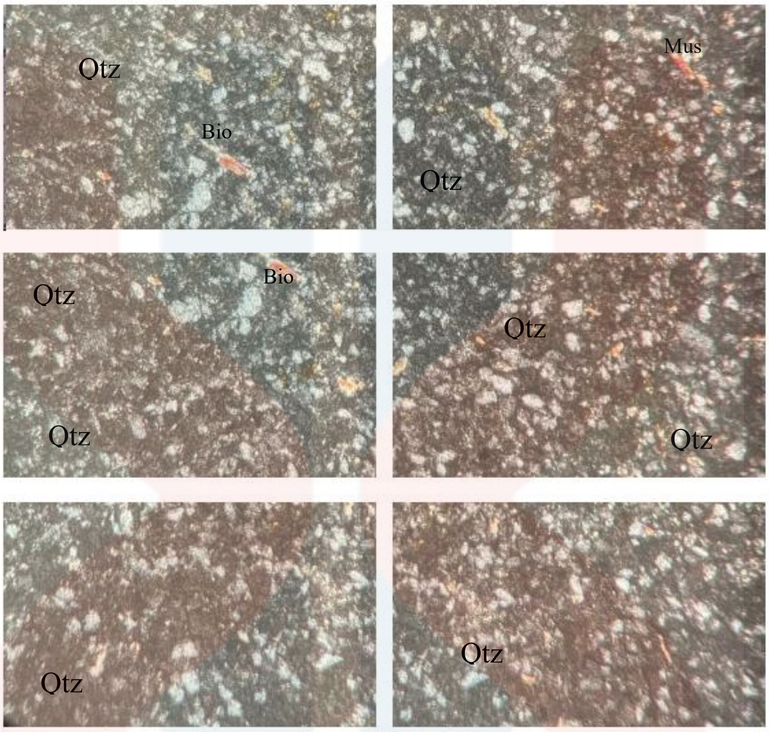


Figure 5.8: Thin section of sample Z03S1

Thin section Analysis	
Minerals	**Description**
Quartz	Mainly Quartz, 17^0 degree of extinction, grey to black and white in XPL, appear colourless in PPL, euhedral in shape, the shape remain the same in both lense.
Opaque	Black in XPL, colourless in PPL, no shape(anhedral), contained only 30% in thin section.
Calcite	Light colour to light gray, has perfect cleavage
Feldspar	In PPL, Feldspar mineral is colorless and in XPL the color has a range from white to brown, subhedral. In thin sections, alkali feldspar grains often look like they're sprinkled with dirt (PPL) or tiny confetti (XPL).

Description for minerals:

Sandstone is a medium-grained sedimentary rock. It is composed mostly of quartz sand, but it can also contain significant amounts of feldspar, and sometimes silt and clay The hand specimen is moderately weathered. The rock is a very fine grained rock. The rock have aphanitic texture with quartz minerals and biotite presence filled up in between grains. The quartz mineral still exhibits characteristic of sedimentary rocks. The general mineral shape is known as hypidiomorphic and the crystallinity degree is hypo-crystalline. In cross-polarized light, the mica exhibits 2nd order colour and seems to be second dominating in the thin portion. Examples of minerals found in the mica group mineral include biotite, chlorite, and muscovite.



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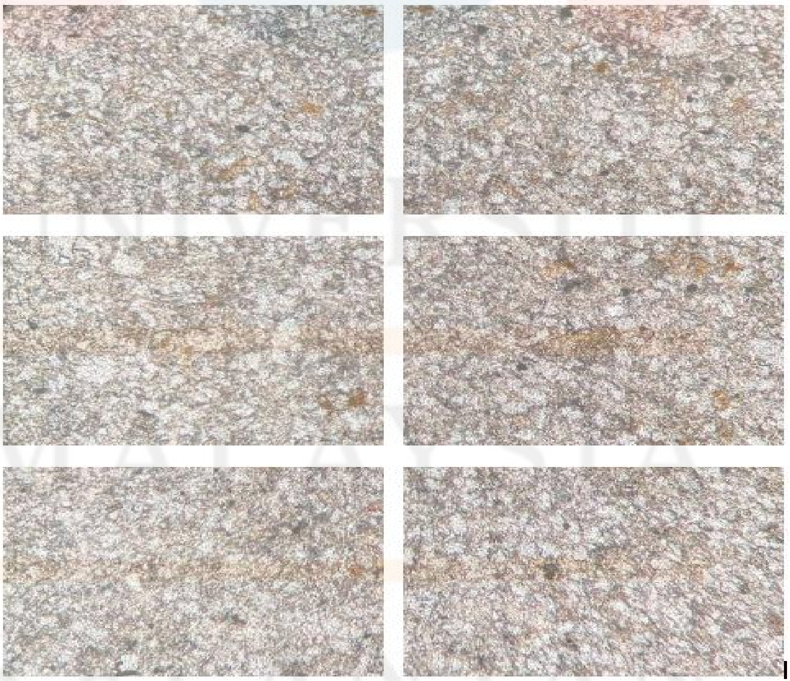


Scale : 1mm

Magnificent : 10x/0.25 P magnificent

5.2.5 Mudstone Analysis

A) Hand Specimen

Mudstone specimens from localities 4 were discovered interbedded with sandstone and a minor distribution of shale. Based on the hand specimen, the specimen firstly was predicted as chert but after considering a few factors, the specimen was identify as mudstone because it contains the combination sand and clay. Based on the analysis of petrography and minor assemblages, mudstone consist about a few element of oxide elements. The colour of the rock appear brownish to greyish with granular texture.

Figure 5.9: Hand specimen of sample Z04S1

Hand Specimen			
Sample code	Z04S1	**Location**	Road in Gerik Highway, Perak
Coordinate	N 05^0 31'37", E101^{0}14'41"		
Rock Name	Mudstone		
Type of rock	Sedimentary rock		
Colour	Brownish to Greyish		
Grain Size	Very fine grained		
Texture	Granular		
Level of weathering	Moderately weathered		
Composition	Quartz, Opaque,Calcite		

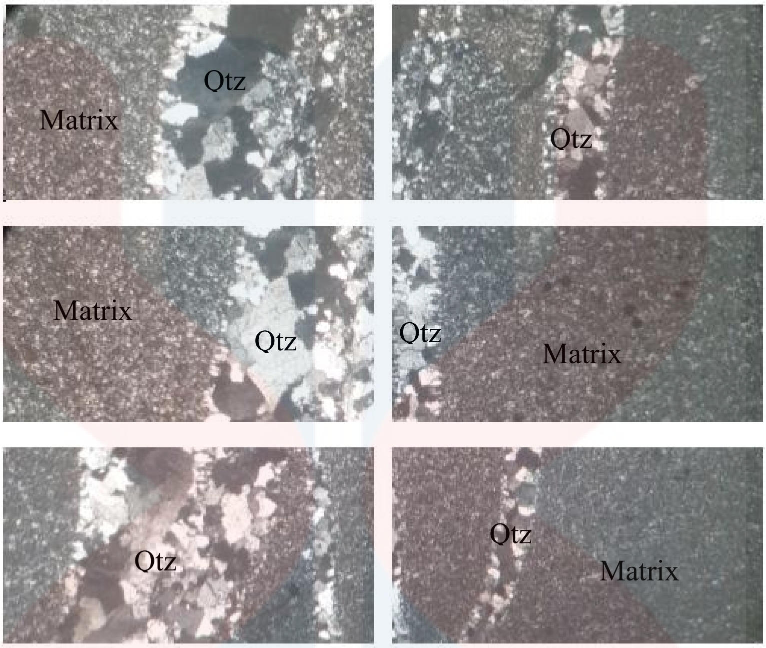
Structure	Bedding, Joint

Figure 5.10: Thin section of sample Z04S1

Thin section Analysis	
Minerals	**Description**
Quartz	Quartz intrusion, grey to black in XPL , appear colourless in PPL
Opaque	Subhedral shape, Black colour in XPL, no extinction and no plecheorism, smalll size around less than 10μm in size
Biotite	Brown to light yellow in XPL, light brown in PPL has very low extinction, anhadrel in shape. The extinction angle is at 17^0 angle

Description for minerals

The hand specimen is moderately weathered. The thin section shows the quartz vein the Mudtsone. Apparently the rock is a very fine grained rock. The rock have aphanitic texture with quartz minerals and biotite presence filled up in between grains and the veins.The vein appears as on the structure the mudtstone. The streak that appear on the is in white colour. The general mineral shape is known as hypidiomorphic and the crystallinity degree is hypo-crystalline. In cross-polarized light, the quartz vein appear to be colourless and have the original shape. Examples of minerals found in the mica group mineral include biotite, chlorite, and muscovite.



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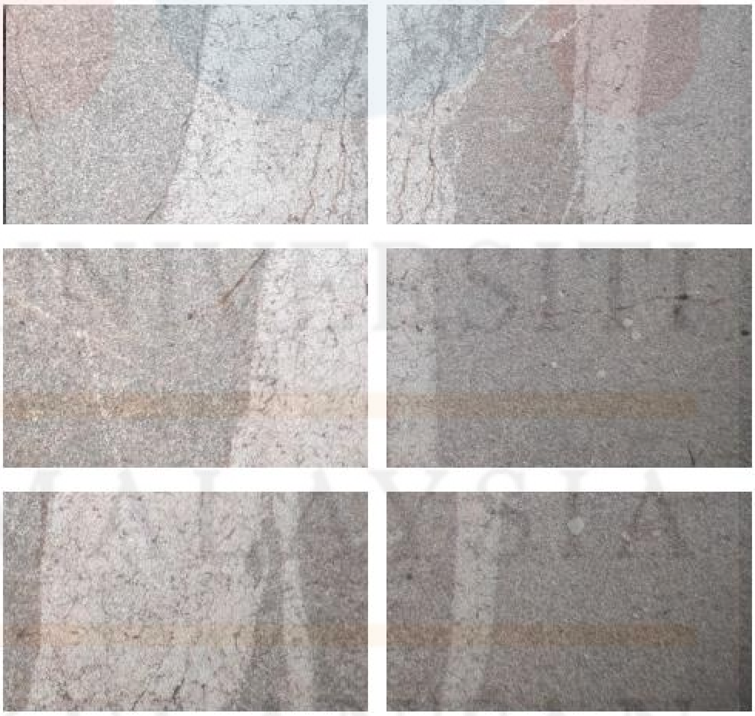


Scale : 1mm

Magnificent : 40x/0.25 P magnificent

5.2.6 Sandstone Analysis

A) Hand Specimen

A hand specimen sample of sandstone was discovered where it is interbedded with mudstone and has a small shale distribution. The hand specimen reveals that there are no fossils hidden within the interbedded rocks. The sample's clear classification as sandstone was expected based on the hand specimen. Sandstone appear in light grey in colour with a very fine grain texture of rock. The dominant structure that can be observe from the naked eyes is the bedding and joint structure from the rock mass.

Figure 5.11: Hand specimen of sample Z05S2

Hand Specimen			
Sample code	Z05S2	**Location**	Road in Gerik Highway, Perak
Coordinate	N 05^{0} 31'39", E101^{0}16'51"		
Rock Name	Sandstone		
Type of rock	Sedimentary rock		
Colour	Light gray to greyish		
Grain Size	Fine grained		
Texture	Granular		
Level of weathering	Slightly weathered		

Composition	Quartz, Biotite, Opaque
Structure	Bedding, Joint

B) Microscope Analysis

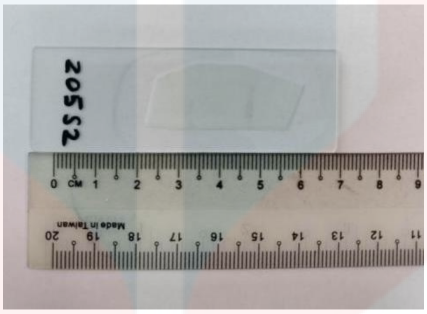
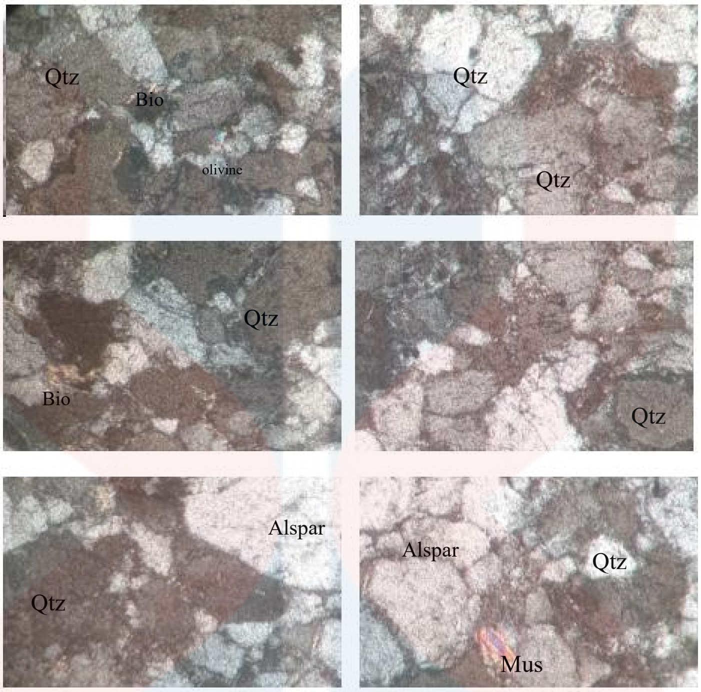


Figure 5.12: Thin section of sample Z05S2

Thin section Analysis	
Minerals	**Description**
Quartz	Mix of monocrystalline and quartz, grey to black(white in extinction), appears colourless in PPL, medium cleavage and no twinning
Plagioclase	Weathered, dark greyish in XPL but colourless in PPL, euhedral in shape
Pyroxene	Only 1-2%, colourless in PPL, euhedral in shape
Opaque	Black in both XPL and PPl, size less then 10µm, 1% in the thin section, no cleavage, no twinning and extinction

Description for minerals

The hand specimen is moderately weathered. Sandstone is a medium-grained sedimentary rock. The rock has a very fine grains. It is composed mostly of quartz sand, but it can also contain significant amounts of feldspar, and sometimes silt and clay.The rock has an granular texture with biotite and quartz filling the spaces between the grains. The sedimentary rock characteristics of quartz are still present. The general mineral shape is known as hypidiomorphic and the crystallinity degree is hypo-crystalline. In cross-polarized light, the mica exhibits 2nd order colour and seems to be second dominating in the thin portion. Examples of minerals found in the mica group mineral include biotite, chlorite, and muscovite. The matrix that binds together the clasts may be the mixture of silt and clay with chemical cement.



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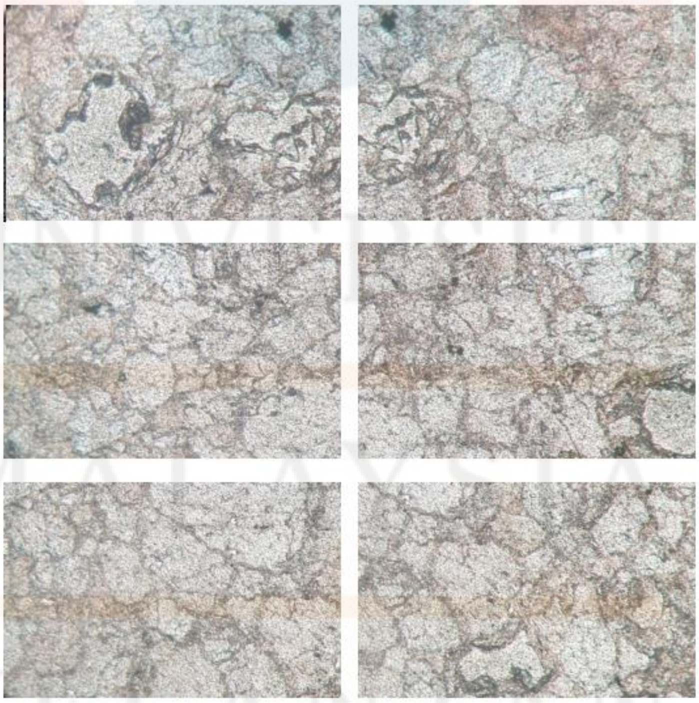


Scale : 1mm

Magnificent : 10x/0.25 P magnificent

5.2.7 Mudstone Analysis

A) Hand Specimen

Based on the interpretation of the hand specimen, the sample was predicted as Mudstone as the first sight after observing the texture of rock that was very fine grain and the colour of the rock material appear to be light brown to greyish. It is identify as mudstone because it contains the combination sand and clay. Mudstone specimens from localities 5 were discovered interbedded with sandstone and a minor distribution of shale. No fossils can be detected between the interbedded rocks, according to petrographic investigation or examination of the hand specimen.

Figure 5.13: Hand specimen of sample Z05S4

Hand Specimen			
Sample code	Z05S4	**Location**	Road in Gerik Highway, Perak
Coordinate	N 05^{0} 31'39", E101^{0}16'51"		
Rock Name	Mudstone		
Type of rock	Sedimentary rock		
Colour	Light brown to greyish		
Grain Size	Fine grained		
Texture	Granular		
Level of	Highly weathered		

weathering	
Composition	Quartz, Biotite, Muscovite
Structure	Bedding, Joint, Anticline

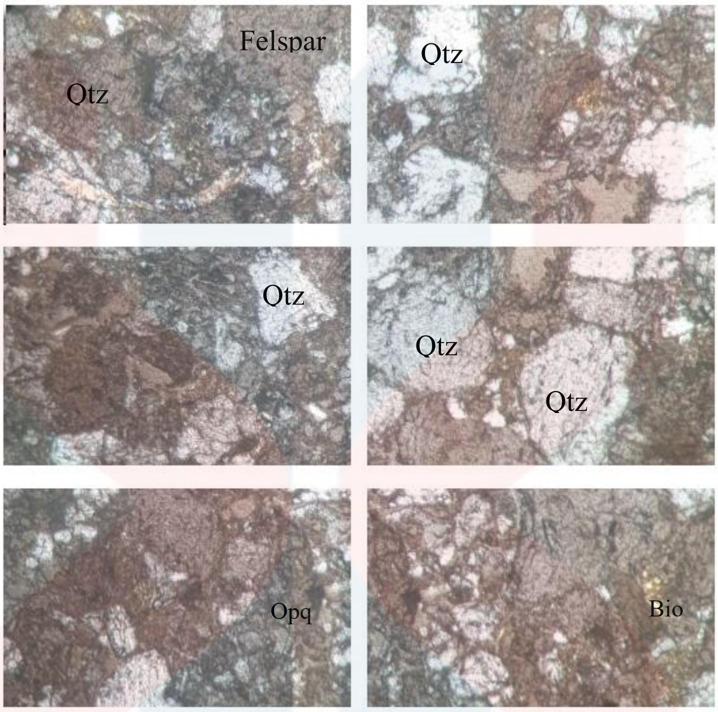
B) Microscope Analysis

Figure 5.14: Thin section of sample Z05S4

Thin section Analysis	
Minerals	**Description**
Quartz	No cleavage, no twinning, Light gray to white to black colour when in plecheorism, euhedral to subhedral in shape
Biotite	Brown to light grey in colour in XPL, light brown in PPL, contain about 5% in the thin section.
Plagioclase	Weathered, contain about 1% in the thin section, appears colourless in PPl and have no twinning and no cleavage

Description for minerals

Mudstone is a fine-grained clastic sedimentary rock that is not laminated or fissile.The hand specimen is highly weathered. Due to highly weathering process occur on the mudstone sample, it tend to break easily. Its similar to shale but not distinctly laminated.Apparently the rock is a very fine grained rock. The rock have aphanitic texture with quartz minerals and biotite presence filled up in between grains and the veins. Muscovite is classify about 1 % in the thin section which appear in colour changes during the extinction in both lense.The general mineral shape is known as hypidiomorphic and the crystallinity degree is hypo-crystalline. Examples of minerals found in the mica group mineral include biotite, chlorite, and muscovite.



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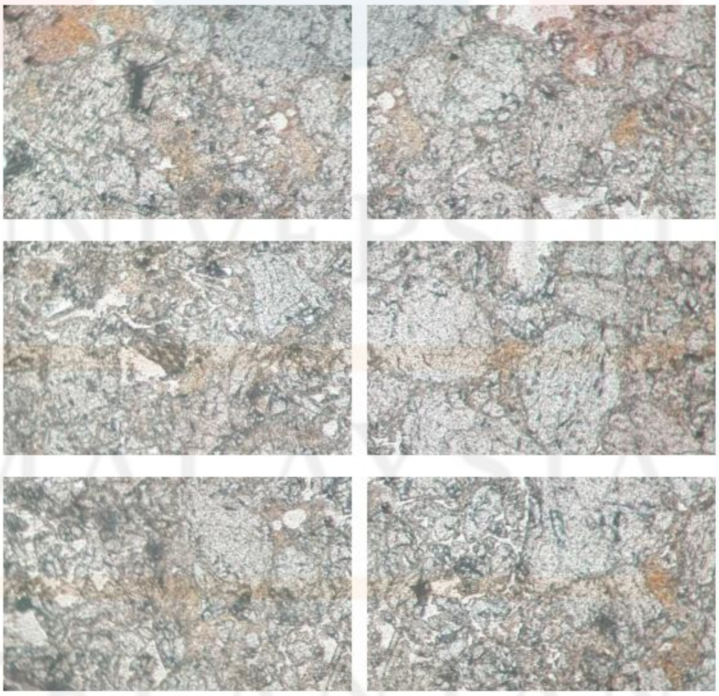

Scale : 1mm

Magnificent : 10x/0.25 P magnificent

5.3 XRD ANALYSIS

XRD methodology was used in this paper in order to create a special procedure for the mineral quantification. In order to decrease the issue when sampling, a consideration amount of material from every sample was ground, sieve and mixed in about 20 gram. For the experiment purpose, only a small amount around 5 gram was needed to for the measurement of the peak intensity. All the test parameters were kept constant for all the XRD determination was run in this analysis. The ratio for the mineral mixing is choose by the observation from the petrographic analysis.

The peaks in the XRD patterns that correspond to each mineral were selected using the pattern database. Each distinct mineral found in the rock sample was represented by the inter-atomic distance (d) value ranges. According to the database that is currently accessible, the information on the mineral reference values of d is provided in Table 5.. The composition and structure does not always have the same stage or phases to represent the value of each mineral phase. Each of the mineral phases shows the range of position where the major peaks of each of the minerals is observed. Examining the sharpest peaks of the various minerals found in XRD test samples of the same type of sample allows one to calculate the value of (d).The most intense peaks in every diffraction pattern have relative intensity values that are significantly higher than those of the other peaks. The second and third peaks of the value, in addition to the highest peaks, are quite challenging to see. The regression calibration curve was used to correct all intensity values, and the mixing ratio was used to calculate the weight percentage of each intensity ratio based on the mineral composition of each sample.

Table 5.1: Test parametes used in all XRD analyse

Parameter	Value
Sample amount	5 gram
Powder Grain size	Maximum 70
2Theta() range	0^0 - 90^0
Slew	5.0001^0/min
Anode	Cu(30kV, 20 mA)
Wavelength	1.5406 Cu
Scanning rate (2)	3.002^0/ 10.002^0

Table 5.2: Range of interatomic distances the most intense peak of the each sample.

Sample	Range of d[Å]
Z01S2	3.34 - 4.25
Z02S2	3.34 - 4.25
Z03S1	3.36 - 4.40
Z04S1	3.31- 4.20
Z05S4	3.32-4.42

Table 5.3: Mineral content (wt %) , crystal system for each type of sample using the XRD methodology

Sample	Mineral	Percentage(%)	Crystal System	Axis System
Z01S2	Quartz	90	Hexagonal	A=4.9134 C=5.4051
	Calcite	19	Hexagonal	A=4.9844 C=17.0376
	Berlinite	4	Hexagonal	A=4.8955 C=10.841
Z02S2	Quartz	98	Hexagonal	A=4.9134 C=5.4051
	Berlinite	86	Hexagonal	A=4.8955 C=10.841
Z03S1	Quartz	96	Hexagonal	A=4.9134 C=5.4051
	Illite	4	Monoclinic	A=5.21 B=9.02 C=10.159
	Biotite	3	Monoclinic	A=5.3204 B-9.21 C=10.104
Z04S1	Quartz	94	Hexagonal	A=4.9134 C=5.4051

	Berlinite	92	Hexagonal	A=4.8955 C=10.841
	Biotite	12	Monoclinic	A=5.357 B=9.245 C=20.234
Z05S4	Quartz	98	Hexagonal	A=4.921 C=5.4163
	Berlinite	51	Heagonal	A=4.8955 C=10.841
	Graphite	90	Orthorhombic	A=2.456 B=4.254 C=6.696
	Muscovite	88	Monoclinic	A=5.18 B=9.02 C=20.04

Result of graph XRD analysis for all sample

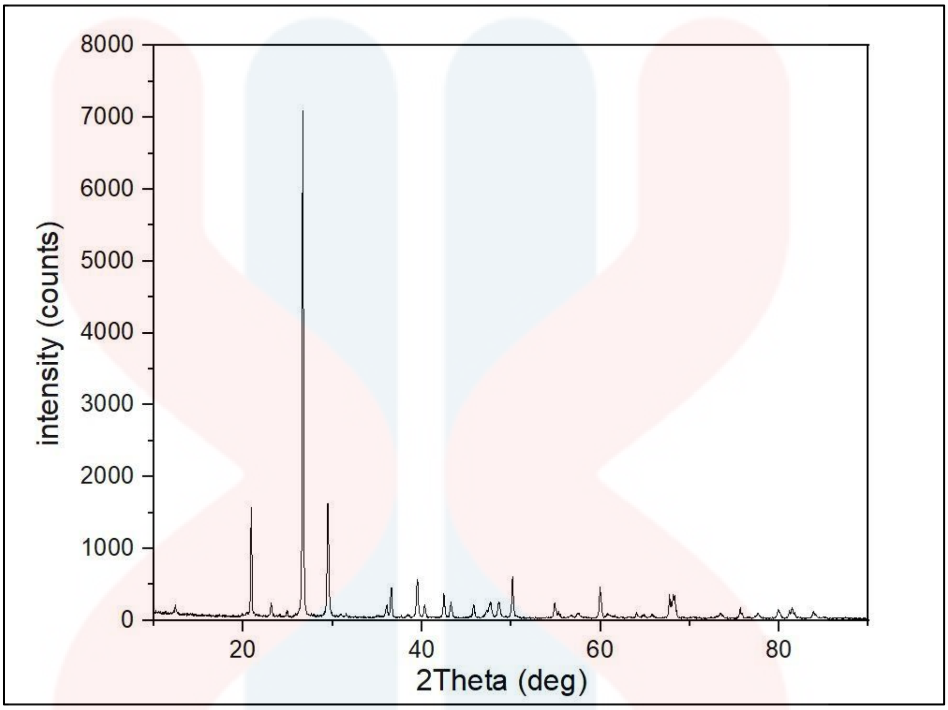

Figure 5.15: A graph for sample Z01S1

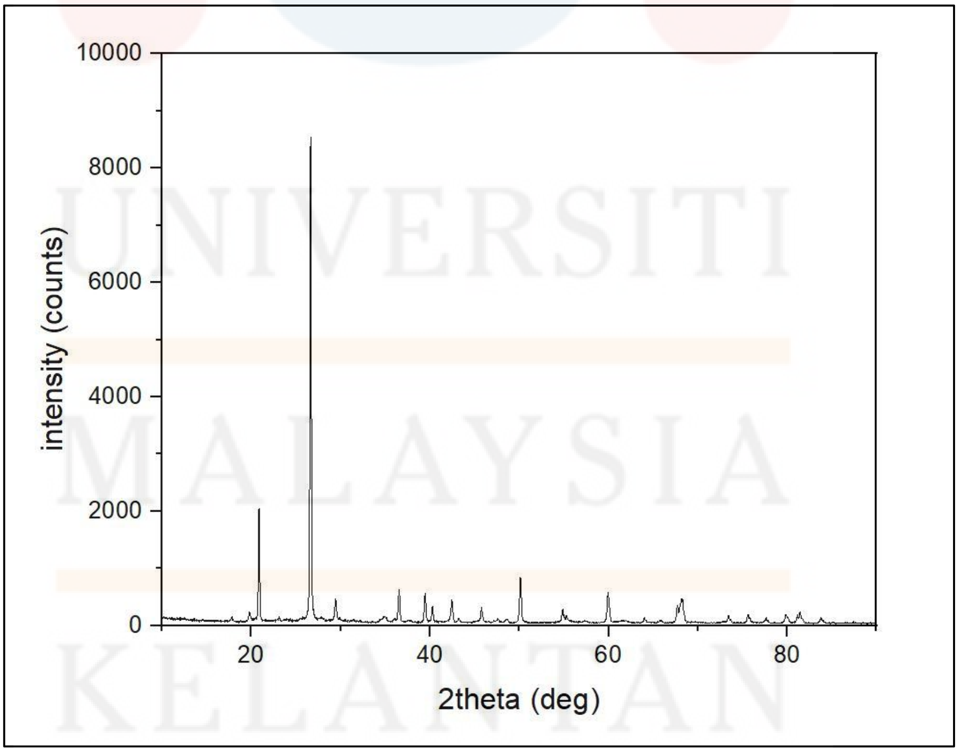

Figure 5.16: A graph for sample Z02S1

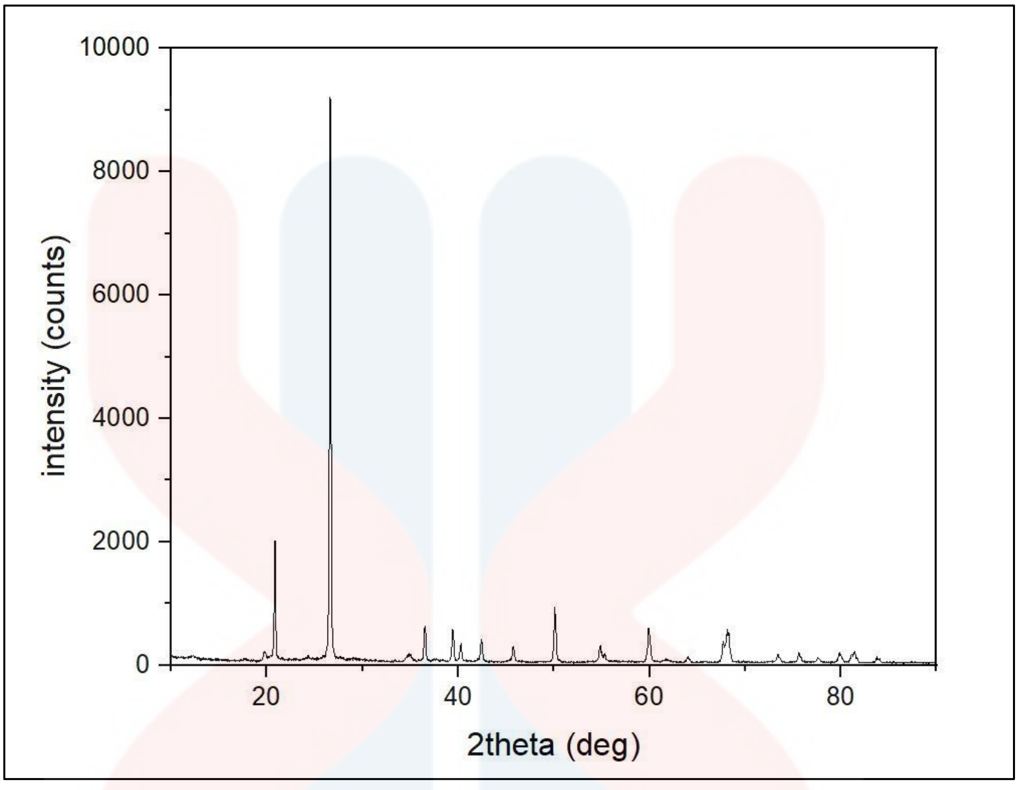

Figure 5.17: A graph for sample Z03S1

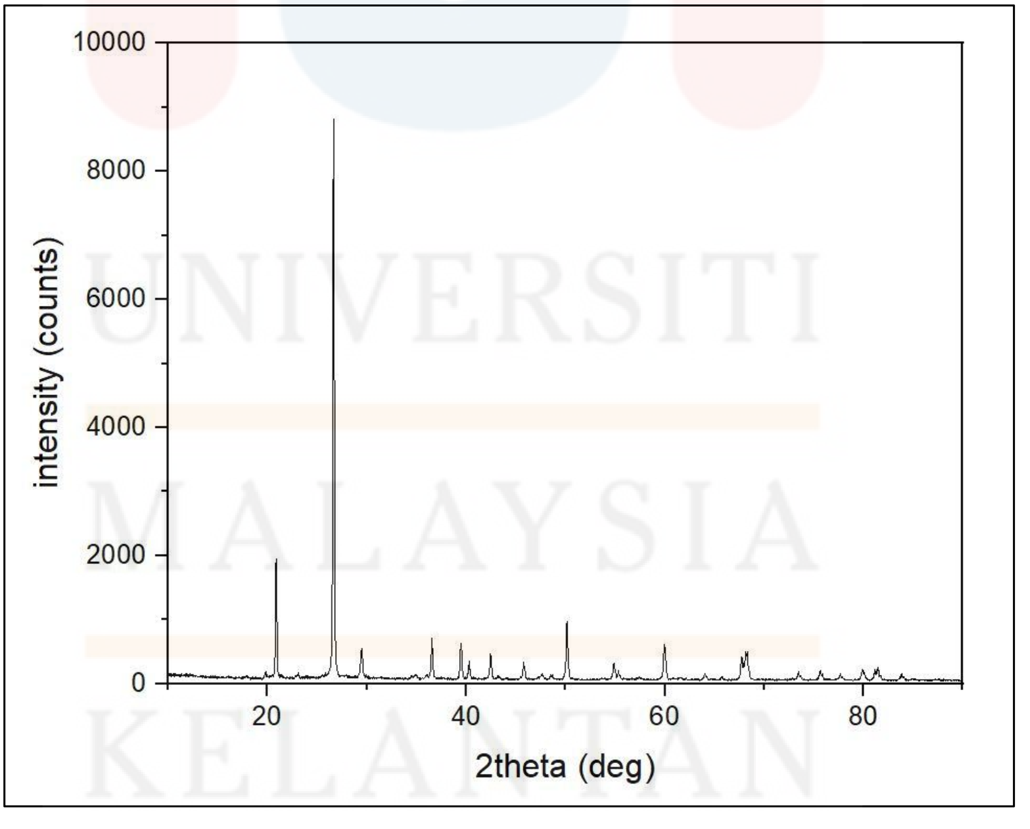

Figure 5.18: A graph for sample Z04S1

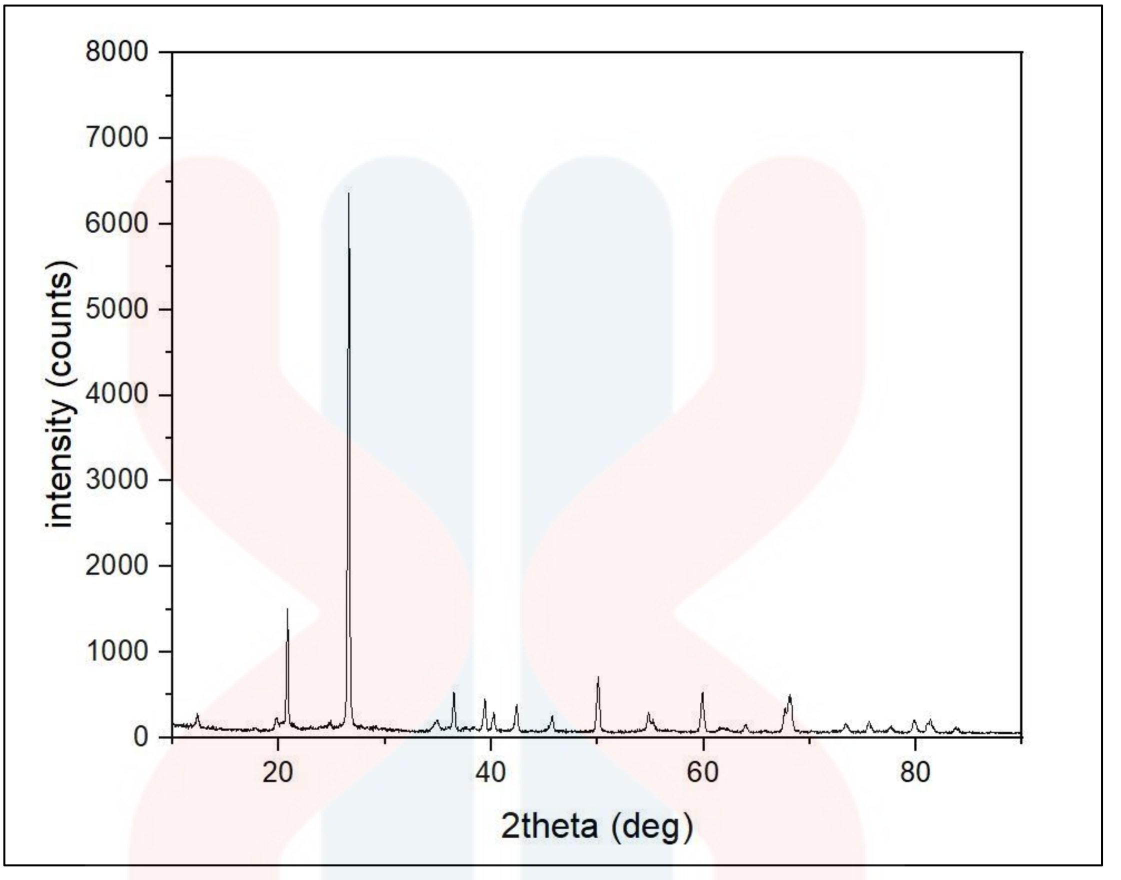

Figure 5.19: A graph for sample Z05S4

Based on the results of the petrographic observation and XRD analysis, these two methodologies produce some differences in the type of mineral that is present, the mineral composition by each sample that has been listed down on the table, and the mineral finding based on the highest peak of the graph XRD analysis. The graph fro sample Z01S1 shows in Figure 5.15, the highest peak of percentage value is Quartz in 90% and followed by calcite about 19%. As for next graph which is graph 2 shows in Figure 5.16 came to hypothesis where the sample proven as Quartz because the highest peak for sample is Quartz with the percentage of 98%. For sample 3 of quartzite shown in Figure 5.17 as the highest peak is also Quartz mineral with the percentage of 96%. Meanwhile, based on the graph analysis for the next sample was sample Z04S1 in Figure 5.18 shows the high peak contain of quartz in

94%, , berlinite in 92% and biotite which about 12%. As for last graph sample analysis in Figure 5.19 shows the higher peak are the quartz mineral in 98% and 54% of berlinite. Mostly of the sample of sedimentary rock contains of Berlinite mixture with the clay mineral.

As a result from petrography analysis and the XRD analysis has proven most of the minerala assemblages in the sample contain highest precenatage of quartz. Quartz also shows a few characteristic such as it is shape are from subhedral to euhedral. Most of it is Hexagonal crustal based on the XRD analysis. Quartz and feldspar are randomly form crystallize in fine matric. Mostly feldspar that consists of the plagioclase shows in sandstone and mudstone composition as shown on XRD analysis. Most of the plagioclase are weathered in the thin section analysis. The mineral still remain the same colour in XPL and PPL lenses with no shape and no twining.

The mudstone at location 3, 4, and 5 consists of 94 - 96% of $SiO2$ (table 5.3). The mudstone at localities 3, 4, and 5 also contains oxide elements including CaO, MgO, $K2O$, $Al2O$, KO, and $Na2O$. These oxides are important in determining the origin, degree of weathering, and distance of conveyance of the sediment. This can be confirmed by subjecting mudstone to the petrographic investigations that were previously mentioned in this chapter's petrographic section. Additionally, the maturity and roughness of the rocks will show that they have had extensive transit and weathering. Even though the sample was taken deep enough, if extensive weathering had taken place, it would have revealed that some of the feldspar had partially converted into clay. This demonstrates how extensively weathering due to transportation or chemical reactions had place in the mudstone at locality 4.

CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

From the study of general geology and stratigraphy, the geological map is updated. Since, the study area is undeveloped area, so that it still covered by heavy forest. In the geological map had made consist to type of lithology which are interbedded of mudstone with sandstone and shale with a minor part about 30 % of Phyllite. It was classified during Permian according to previous study. From the research area are consisting of the 4 type of lithology which are sandstone unit, shale unit, mudstone unit and phyllite unit by the geological mapping and data collection. For specification, the sample are identify by hand specimen based on characteristic of the rock and petrography analysis are been analyses in XRD part. Based on hand specimen the sedimentary rock of the sandstone and mudstone, the texture of both rock shows a very fine grain type. However, based on petrography, the rock was proven to has granular texture rock with hypocrystalline crystal degree.

The research area's provenance, which is in recycled orogen and supported by the grain size, shape, and age, can be identified using petrographic analysis. The severity of weathering in the research region can be determined in large part by the geochemical analysis. As a result, it may be said that petrography is useful in identifying the origin of the source rocks.

6.2 Recommendation

The first recommendation in this paper is by applying more method to prove or get the data more accurately for example like SEM. Scanning electron microscopy (SEM method) is another way to process the data that can be used in this study. SEM analysis provides data on the crystallographic structure and elemental composition SEM samples are obtained by gently crushing rock with a small rock shopper or an X-acto knife. Other than that, due to the difference between the two types of rock which is sedimentary and phyllite, the transition part is still unrecovered and unknown by more detail, so that for next researcher are need to be more explore.

Based on geological structure that is mostly found in the study area is joints. The heavy forestation in the area has given some impacts on doing more research which make the data not enough and should be explore more.In order for future students to study and learn about environmental mapping and enhancement, click here. A portion of the research region is primarily exposed to hazardous human, animal, and social activity, such as mining sites where there are too many men, making it unsuitable for a girl to conduct a survey by herself. There is a need to improve or add more safety conditions as a result.

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