GEOLOGY AND GEOCHEMISTRY OF GRANITE ROCK OF KAMPUNG LAWAR, BATU MELINTANG, JELI, KELANTAN

by

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A report submitted in fulfilment of the requirements for the degree of Bachelor of Applied Science (Geoscience) with Honours

FACULTY OF EARTH SCIENCE
UNIVERSITI MALAYSIA KELANTAN

2023

DECLARATION

I declare that this thesis entitled Geology and Granitic Rocks of Batu Melintang A 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 hereby declare that I have read this thesis entitled and in my opinion this thesis is sufficient in terms of scope and quality for the award of the degree of Bachelor of Applied Science (Geoscience) with Honours.

Signature :

Name of Supervisor :

Date :

ACKNOWLEDGEMENT

I am really grateful because I managed to complete my final year project and thesis report writing. Special thanks for those who help me throughout this journey directly and indirectly. Firstly, I want to thank the Almighty as I was able to complete the final year project without much difficulty with his graces and blessing.

Aside, I would like to express my utmost grateful to my final year project supervisor, Dr. Nor Shahida binti Shafiee @ Ismail for all the guidance and time in helping me to conduct my project. I am deeply grateful for her kindness in explaining the details of the project including the help that was given when I was facing some difficulties while was on this project.

Next, I would like to thank my parent and family who always giving me moral supports till the day I manage to complete this project. In additional, I would like to express my special thanks of gratitude to my mapping partners, Fairuz Farhana, Shawn Iversen, and Siyad Abdirahman who always there with me throughout this mapping process. Thank you for always sticking together even though we have to face many difficulties on finishing our final year project.

Not forgetting special thanks to the laboratory staff of Gold Rare Earth and Material Technopreneurship Centre (GREAT), Universiti Malaysia Kelantan, for providing the equipment to analyses for collecting the data.

Last but not least, I want to express my thankfulness to my all my supportive friends and other lecturer for helping and giving me support directly or indirectly throughout the final year research. Despite of their busy schedule, they still taught and shared their knowledge in completing this project.

Nur Farhana Binti Ab Malik Marwan

GEOLOGY AND GEOCHEMISTRY OF GRANITE ROCK OF KAMPUNG LAWAR, BATU MELINTANG, JELI, KELANTAN

ABSTRACT

Granite of Triassic magmatism can be identified in the Central and Eastern Belts of Peninsular Malaysia. This research focussed on the geology and geochemistry of granite rocks in Kampung Lawar, Batu Melintang, Kelantan. The Kampung Lawar, Batu Melintang, Jeli, Kelantan granites was located at the northwestern part of Kelantan near the Gunung Reng close to the border area of the Thailand which is in the granite provinces Western Belt granite. It lies between the latitude of 5̊ 43’ 46’’ N until 5̊ 41’ 46’’ N and longitude of between 101̊ 42’ 40’’ E until 101̊ 45’ 46’’ E. The objective of the research is to produce the geological map of 1:25000 scales of the study area, to investigate the petrography and geochemistry of granite in study area. and to analyse the rare earth element (REE) distribution in granite rock. To achieve the objectives, few methods have been applied such as geological mapping, petrography and geochemistry approach which is X-ray fluorescence spectrometer (XRF) and Inductively coupled plasma mass spectrometry (ICP-MS). The study area consists of Telong Formation. The lithology found in the study area are metasediments of slate, schist, granite unit, and pyroclastic rock. The minerals that are identified in the lithology are mostly quartz, muscovite, k-feldspar and biotite in granite, slate and schist. Based on the geochemistry result for four granite sample with code F309G, F302Gg, F304PG, and F307PGM, the study area are composed of exclusively S-type granites. The distribution of LREE is higher than that of HREE in the granite rocks of Kampung Lawar, Batu Melintang, Kelantan. In conclusion, granite samples were classified as S-type granite with LREE majorities.

Keywords: Geological map; granite; petrography; Kampung Lawar; geochemical analysis

GEOLOGI DAN GEOKIMIA ANALISIS KEATAS BATUAN GRANIT DI KAMPUNG LAWAR, BATU MELINTANG, JELI, KELANTAN

ABSTRAK

Granit magmatisme Triassic boleh dikenal pasti di Jalur Tengah dan Timur Semenanjung Malaysia. Penyelidikan ini tertumpu kepada geologi dan geokimia batuan granit di Kampung Lawar, Batu Melintang, Kelantan. Granit Kampung Lawar, Batu Melintang, Jeli, Kelantan terletak di bahagian barat laut Kelantan berhampiran Gunung Reng juga berhampiran dengan kawasan sempadan Thailand iaitu dalam wilayah granit Jalur Barat. Ia terletak di antara latitud 5° 43' 46" N hingga 5° 41' 46" N dan longitud antara 101° 42' 40" E hingga 101° 45' 46" E. Objektif kajian adalah untuk menghasilkan peta geologi berskala 1:25000 di kawasan kajian, untuk menyiasat petrografi dan geokimia granit di kawasan kajian. dan untuk menganalisis taburan unsur nadir bumi (*Rare Earth Element* (REE)) dalam batuan granit. Untuk mencapai objektif, beberapa kaedah telah digunakan seperti pemetaan geologi, petrografi dan pendekatan geokimia iaitu spektrometer pendarfluor sinar-X (*X-ray fluorescence spectrometer* (XRF)) dan spektrometri jisim plasma berganding induktif (*Inductively coupled plasma mass spectrometry* (ICP-MS)). Kawasan kajian terdiri daripada Formasi Telong. Litologi yang terdapat di kawasan kajian ialah metasedimen batu loh, syis, unit granit, dan batuan piroklastik. Mineral yang dikenal pasti dalam litologi kebanyakannya adalah kuarza, *muscovite*, *k-feldspar* dan biotit dalam granit, batu batu loh dan syis. Berdasarkan keputusan geokimia bagi empat sampel granit dengan kod F309G, F302Gg, F304PG, dan F307PGM, kawasan kajian adalah terdiri daripada granit jenis S secara eksklusif. Taburan LREE lebih tinggi berbanding HREE di batuan granit Kampung Lawar, Batu Melintang, Kelantan. Kesimpulannya, sampel granit dikelaskan sebagai granit jenis S dengan majoriti LREE.

Kata kunci: Peta geologi; granit; petrografi; Kampung Lawar; analisis geokimia

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LIST OF ABBREVIATION

Al	Aluminium
Al_2O_3	Aluminium oxide
Ag	Silver
As	Arsenic
Au	Gold
Ba	Barium
Be	Beryllium
Bi	Bismuth
CaO	Calcium oxide
Ce	Cerium
Cr	Chromium
Cs	Caesium
Cu	Copper
Dy	Dysprosium
Eu	Europium
Er	Erbium
F	Feldpar
FeO	Iron oxide
Fe2+	Ferrous ion
Fe3+	Iron(III) ferric iron
Gd	Gadolinium
GIS	Geographic Information System
GPS	Global Positioning System

HCL	Hydrochloric acid
Hf	Hydrofluoric acid
HREE	Heavy rare-earth elements
ICP-MS	Inductive Coupled Plasme-Mass Spectometry
IUPAC	International Union of Pure and Applied Chemistry
K2O	Potassium oxide
La	Lanthanium
LFB	Lachlan Fold Belt
Li	Lithium
LREE	Light rare-earth elements
MgO	Magnesium oxide
Mo	Molybdenum
MnO	Manganese(II) oxide
Na2O	Sodium oxide
Nb	Niobium
Nd	Neodymium
Ni	Nickel
P2O5	Phosphorus pentoxide
P	Plagioclase
Pb	Lead
PPL	Plane polarized light
Pr	Praseodyium
Q	Quartz
REE	Rare Earth Elements

Rb	Rubidium
SiO2	Silicon dioxide
Sm	Samarium
Sn	Tin
SO3	Sulfur trioxide
Sr	Strontinium
Ta	Tantalum
TiO2	Titanium dioxide
Th	Thorium
U	Uranium
W	Tungsten
wt	Weight percentages
XPL	Cross polarized light
XRF	X-Ray Fluorescence
Y	Yttrium
Zn	Zinc
Zr	Zircon

LIST OF SYMBOLS

°	Degree
E	East
km	Kilometre
m	Metre
′	Minute
µm	Micrometre
N	North
%	Percentage
ppb	Part per billion
”	Second
Ơ	Sigma
S	South
W	West

CHAPTER 1

INTRODUCTION

1.1 General Background

This chapter briefly describes the study field, the study's purpose, the methodology, and the general thesis structure. The objectives outlined in this chapter are the important aspects for the subjects that will be extensively covered in the following chapters.

1.2 General background of the study

Geology is the study of the Earth, including its history, activities that affect it, its physical composition and compositional components. Rocks and minerals are examples of earth materials. Natural inorganic substances with a crystalline form and a known chemical makeup are known as minerals. while rocks are characterised as naturally occurring mineral assemblages.

Geology's application of chemical principles is known as geochemistry. Geochemistry is the study of how chemical elements, found in rock-forming minerals and their byproducts, came to be on Earth and how they have changed over time. Rock is often chemically analysed to identify major and trace elements. X-ray fluorescence was used to analyse the chemical composition of the major and trace elements in rock (XRF). All of the geochemical results are crucial data that can support other data and demonstrate how the rocks in the research region are classified.

The current study focuses on the geology of Batu Melintang, Jeli, Kelantan, and includes the preparation of an updated geological map, a study of the geochemistry of the granite rock in the study area, and a study of the surface's structure, the history of Earth's composition, and the processes that led to the formation of rocks and minerals. As for this thesis the main target is to figure out the granitic rocks at specific area at Kampung Batu Melintang, Jeli District, Kelantan. The igneous rock known as granite has light-colored granules large enough to be seen with the unaided eye. It is created when magma beneath the surface of the Earth slowly crystallises. Quartz and feldspar make up the majority of granite's chemical makeup, with only trace amounts of mica, amphiboles, and other minerals.

This project mainly located at the northwestern part of Kelantan near the Gunung Reng and geologically consist of Gunung Reng and covered several villages near the project area such as Kampung Gunung, Kampung Belimbing, Kampung Lalat, Kampung Tapong, Kampung Pelias, Kampung Tanjung Kasek, and Kampung Dendong.

Geochemistry can be defined as the study of the process, which controls the abundance, composition, and distribution of compounds and isotopes in the global environment (H. Dembicki, 2016). The Western Belt granites of Peninsular Malaysia are characterized by a huge mountain range extending from Malacca in the south to Thailand in the north (Cobbing, 1992). The granites mostly penetrate isoclinal folded phyllitic Lower Paleozoic metasedimentary rocks, such as marble, and less severely folded Upper Paleozoic formations. The granites were thought to be only of the type 'S'. (Metcalfe, 2017).

Research and reviews of granitoid batholiths (Azman, 2000) revealed that 'S' type granitoids can have a wide variety of mineralogical and chemical features and that the criteria used to identify granitoid type in one terrain may not be as rigorous in another. According to current petrochemical and field data, the Western Belt granite also has several 'I' type characteristics (B. W. and W. A. J. R. Chappell, 1974). The characteristics are (a) the absence of Al-rich minerals such as sillimanite and cordierite, (b) the presence of primary wedge sphene and pale green amphibole, notably in the northern portion of the batholith, and (c) the presence of pinkish K-feldspar crystals (typically as phenocrysts), (d) the presence of mafic, hornblende bearing enclaves, and (e) rising peraluminosity towards the most differentiated rocks ('S' type granite: increasing peraluminosity towards the most mafic variations), and (f) P205 vs. Rb and A-B (Barbero et al., 1995) plots show a similar tendency to the 'I' type granite.

In this study, granite rock is chosen as the target rock to investigate its elemental composition, and field mapping and geochemical analysis are applied to describe and analyse the elements contained in the rock. Accuracy in identifying the rock's constituents is intermediate. X-Ray Fluorescence (XRF) and Inductively Coupled Plasma Mass Spectrometry (ICP-MS) are used to analyse trace elements and significant elements in granite rocks' geochemistry. Every tool used for geochemical analysis has its own benefits. The major and trace elements in geological materials are analysed using the XRF, which involves bulk chemical analysis of significant elements including SiO2, TiO2, and MgO in rock and silt. In addition, it was used to examine trace elements found in rock and sediment that were greater than 1 ppm, such as Ba, Cr, Cu, Nb, Ni, Rb, and Zn (Center, 2018).

While Inductively Coupled Plasma Mass Spectrometry (ICP-MS), sample preparation techniques that result in the complete dissolution of the sample were necessary in order to successfully employ ICP-MS for the direct measurement of trace elements in granites.

The current work on the categorization, geochemistry, modeling, and petrogenesis of felsic magmatism in Peninsular Malaysia's Western Belt granite could be considered potential reserves for future exploitation in the research region. This work will briefly describe the rock distributions, petrography, and geochemistry of the Western Belt granite rock in the study area at Kampung Lawar, Batu Melintang, Jeli, Kelantan.

1.3 Study Area

1.3.1 Location

The research area is situated in Kampung Lawar in the Jeli, Kelantan, Malaysia district of Batu Melintang. It is situated close to the Thai border in the northwest of Kelantan State. The study area was 25 km2. It is located between latitudes of 5°43'46" and 5°41'46" north and longitudes of 101°42'40" and 101°45'46" east. A number of nearby villages, including Kampung Batu Melintang, Kampung Gunung, Kampung Belimbing, Kampung Lalat, Kampung Tapong, Kampung Pelias, Kampung Tanjung Kasek, Kampung Dendong, and Gunung Reng, are also covered in the study.

There are three sorts of landscapes in the research area: mountainous, hilly, and plain. The study area's mountainous areas are largely covered in the northwest and southeast. Around Gunung Reng, the maximum elevation is 600 meters, and the lowest elevation is 20 meters. Gunung Reng is a limestone outcropping that can be seen from low-lying locations. Its stunning geological scenery, as well as several unique geological features found in the area, provide geoheritage value in the form of scientific, aesthetic, recreational, and cultural qualities. It also offers geotourism, which can pique geologists' and the general public's curiosity. The region in the low-lying area is largely used for plantation. The Pergau River, one of Kelantan's principal rivers, is also included in this research area. Figure 1.1 depicts the study area's imagery map, while Figure 1.2 depicts the study area's base map, Kampung Lawar, Batu Melintang.

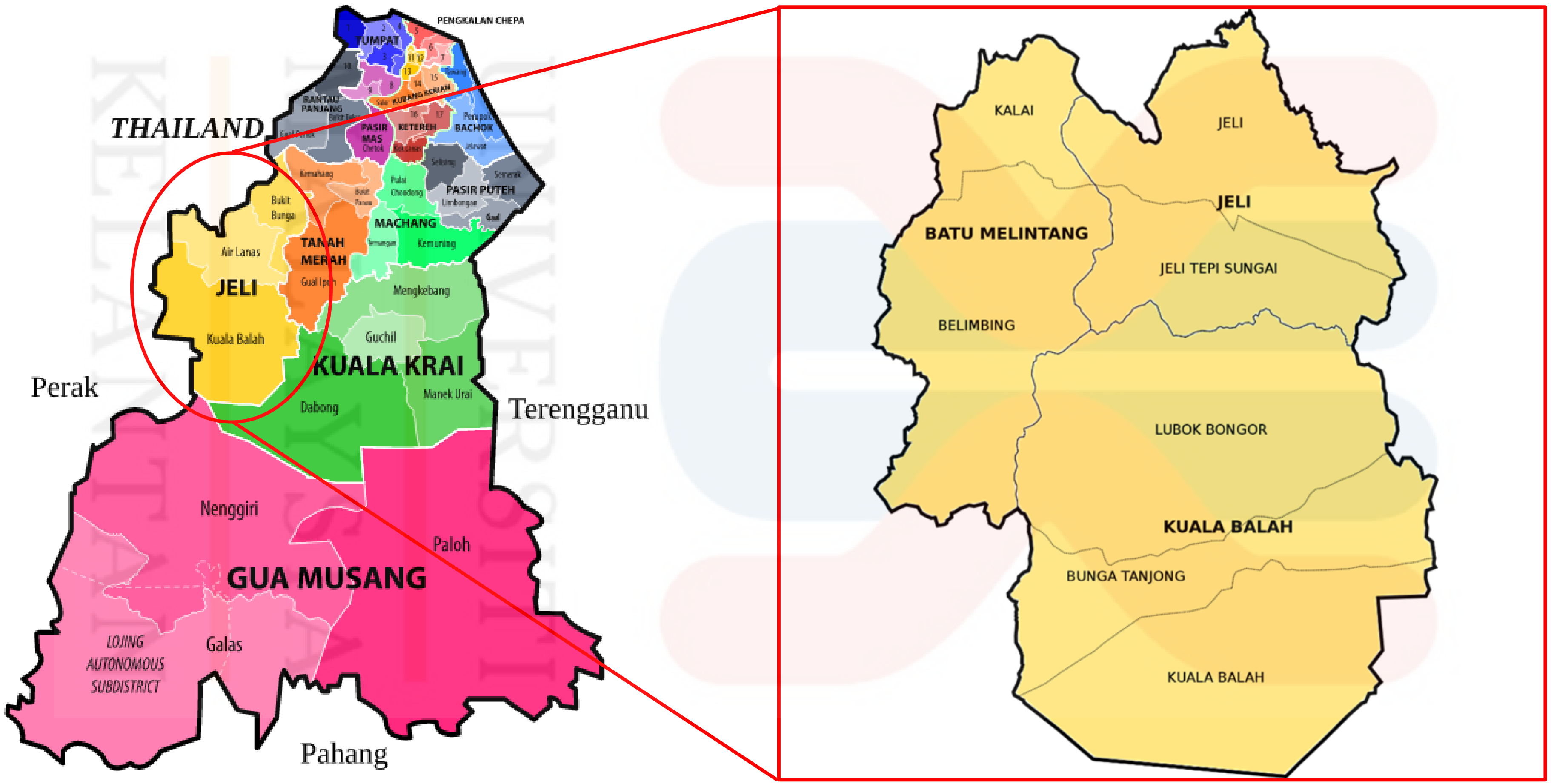


Figure 1.1: Map of Kelantan (Batu Melintang). Modified by Derkommander0916, 2017

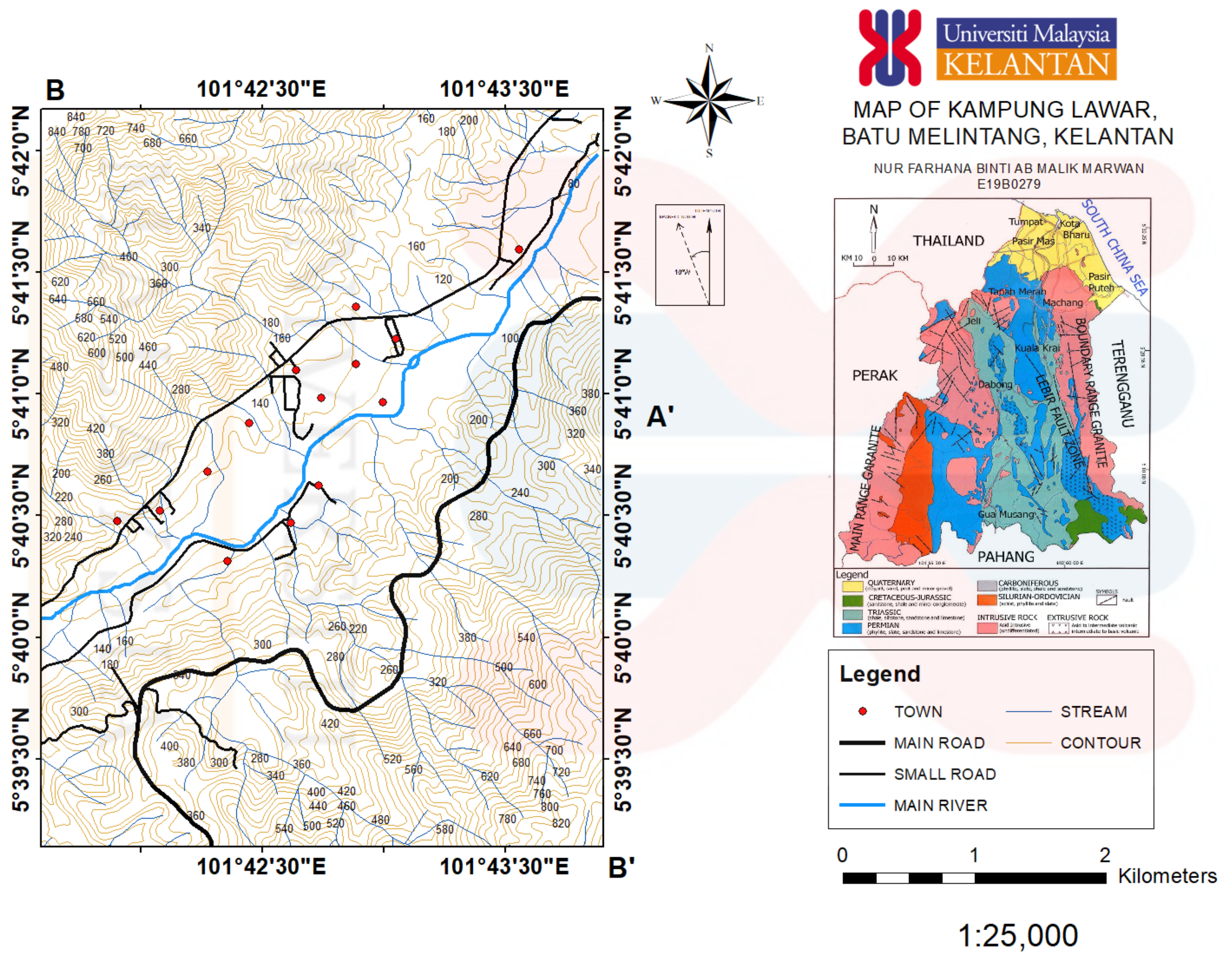


Figure 1.2: Base map of the study area, Kampung Lawar, Batu Melintang

1.3.2 Accessibility

The Jalan Jeli-Batu Melintang is the primary road leading to the study area Batu Melintang. The research area is then accessible from this major access through a short trail route that also serves as a transect between the borders of Malaysia and Thailand. The majority of the roads are paved, however further into the countryside, where some plantations, like rubber plantations, are located, there are some gravel roads or short trails. In general, the majority of the study area is simple and has good access, allowing for the passage of vehicles for both social and business objectives. However, due to their elevation, several study locations were also inaccessible.

1.3.3 Demography

In the state of Kelantan, Jeli is the third-largest colony. Three districts make up the colony: Jeli, Batu Melintang, and Kuala Balah. The colony covers 1,280.21 km2 of land. Due to its remote location from Tanah Merah, the adjacent large town, the population density in the Batu Melintang area is notably quite high. Out of the 40,637 persons that called Jeli home in 2010, 8,456 were found in Batu Melintang. Males and females made up the two genders that made up the population. Males make up 4,419 of them, while females make up 4,037 of them. The gender distribution of the population in Batu Melintang is shown in Table 1.1 (Department of Statistics Malaysia, 2010), and the percentage of the population in Batu Melintang is shown in Figure 1.3.

The population that are consist of 8,327 of them Malaysians, 13 are Chinese, 2 are Indians, and 7 belong to another category, such as foreign nationals. The majority of the population is dispersed across many communities. Figure 1.4 displays the proportion of people distribution in Batu Melintang by ethnicity, while Table 1.2 displays the population distribution in Batu Melintang by ethnicity (Department of

Statistics Malaysia, 2010).

Table 1.1: People distribution in Batu Melintang by gender (Department of Statistics Malaysia, 2010)

DISTRICT	AREA (HECTARE)
Male	3,309
Female	2,300
JUMLAH / Total	**5,609**

Source: (Mohd Radi et al., 2018)

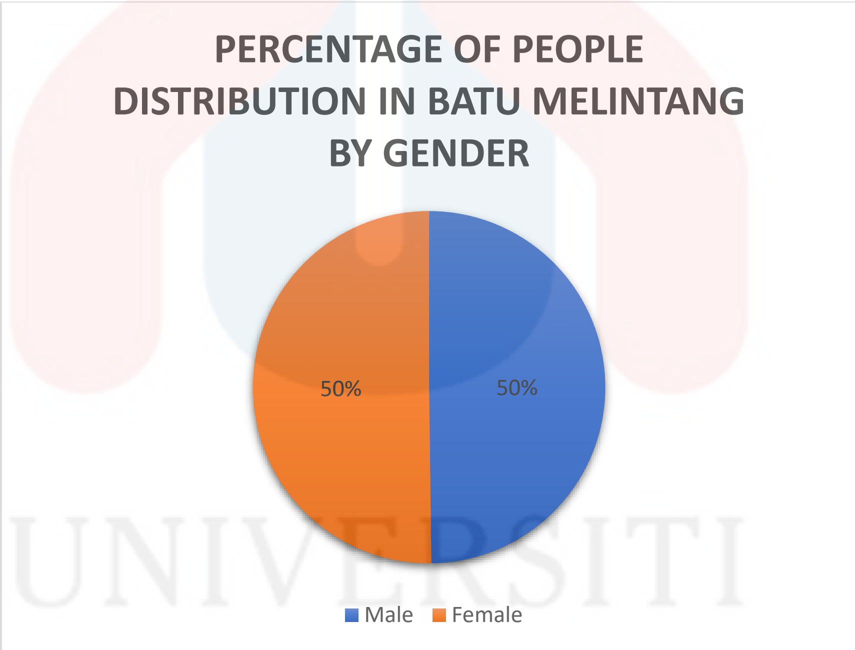


Figure 1.3: Percentage of people distribution in Batu Melintang by gender

Table 1.2: People distribution in Batu Melintang by ethnic (Department of Statistics Malaysia, 2010)

Ethnic Group (2010)	
Malay & other indigenous (Bumiputera)	8,327
Chinese	13
Indian	2
Other groups	7
	8,456

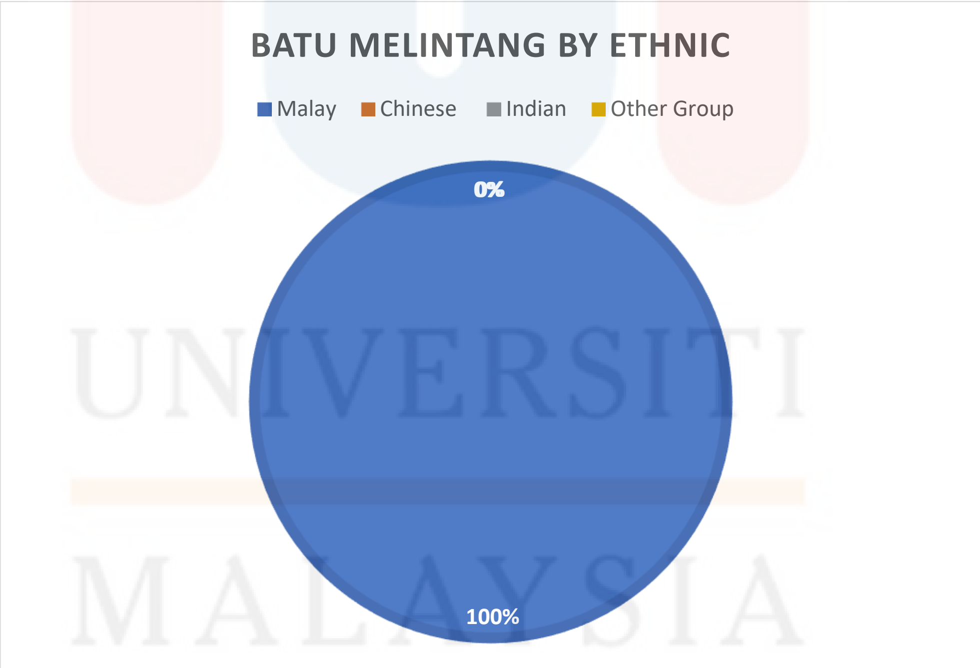


Figure 1.4: Percentage of people distribution in Batu Melintang by ethnic (Department of Statistics Malaysia, 2010)

1.3.4 Rain distribution

The weather in Batu Melintang is tropical. In general, Kelantan receives a significant amount of precipitation during the Northeast Monsoon season due to its location on Malaysia's East Coast. However, Kelantan continues to experience relatively high rainfall rates throughout the Southwest Monsoon and inter-monsoon. Compared to the Southwest Monsoon, the Northeast Monsoon, which occurs from November to March, is far more destructive because it causes tremendous ocean tides that could imperil people and occasionally cause disaster. In contrast, the Southwest Monsoon, which typically lasts from late May until September, is associated with generally drier weather (J. Suhaila, 2010).

1.3.5 Road connection

To get to Batu Melintang, one road connection is available. Using Jalan Jeli-Gerik, it takes around 15 kilometres and 16 minutes to drive from Jeli to Batu Melintang. Since there was a main road that cut across the study area, it is possible to access the road in the Kampung Lawar area. The primary thoroughfare in the study area is Jalan Kampung Gunong-Batu Melintang-Kampung Lawar, which links Kampung Lawar with Gunung Reng. The tiny street that the people of Kampung Lawar typically use is another paved route that can be utilised in the research area. Due to the roadways' location in a residential area, vehicles other than cars and motorbikes can access the paved road that runs alongside the research area.

Due to the research area's abundance of plantation sites, including rubber tree and palm oil plantations, unpaved road connections can be found all around the study area. However, due to the area's irregular topography and the elevation of the plantation site, such as a palm tree plantation, it appears to be fairly difficult to access the unpaved road using normal transportation, such as cars. In order to make the process of geological surveying more quick and simple, the unpaved route can still be accessed by motorbikes, lorries, or Hilux despite its high elevation.

1.3.6 Land use

The land is majorly used for plantations in the study area. The two primary plantations in the research area are those rubber trees and palm oil trees. In small plots of land, native fruit trees including rambutan, durian, and banana are also being planted for home use. In addition, other land features use fills for development purposes, including shops, housing areas, rural health clinics that offer amenities to the public for healthcare, schools, and a variety of other uses. According to surveys and observations, a variety of buildings may be found close to the study area, including stores, government facilities, as well as local government and city offices.

1.3.7 Social economic

The social economy of the study area is largely dependent on rubber tapping and small-scale vegetable and fruit farming. Additionally, there are a number of stores in the study area, including a grocery store, a retail store, and a car wash. Next, the people of Batu Melintang have access to grocery stores and wet markets that were opened by villagers who also resided in Batu Melintang and sell fresh produce, fruits, and raw meats. The locals themselves are cultivating fresh fruits and vegetables, as well as raw meats like chicken. The study area lacks any industrialised areas and mining prospects, and because Batu Melintang is a small district, local spending power and energy consumption are also low.

1.4 Problem Statement

This project will include a geological, geomorphological, and landform structural analysis of the large area sections surrounding the purposed studies area in Kampung Lawar, Batu Melintang, Jeli, Kelantan. This will require examining granite rock to find REE minerals in laboratory tests. The main goal is to investigate the petrography and geochemistry of granite in study area and to analyse the rare earth element (REE) distribution in granite rock. The study of the composition, structure, dynamics, and other physical features of the Earth is known as geochemistry. This problem will look at how chemical elements are distributed in rocks and minerals and how they flow into soil and water systems. This will lead to the procurement of a certain type of granite rock to determine the rock's mineral composition by study the study area to investigate geological structure in the surrounding areas, such as collecting rock specimens.

1.5 Objective

This project focusing on the geology and geochemistry of the granite rock in Kampung Lawar, Batu Melintang, Jeli, Kelantan. To achieve this, a series of objectives have been formulated which include:

1. To produce the geological map of 1:25000 scales of the Kampung Lawar, Batu Melintang, Jeli, Kelantan.
2. To investigate the petrography and geochemistry of granite in study area.
3. To analyse the rare earth element (REE) distribution in granite rock.

1.6 Scope of Study

The different meanings and definitions of the two notions of scope and limitation of the study, as well as the importance of the study research, are explored in this section. The geological mapping techniques, which include geomorphology, determine the detailed geology of the research area. Other researchers will be able to conduct future research in the study region with the support of an updated geological map. Petrology research will provide information about the subject area's history and lithology. Another description, such as texture, mineral, and chemical composition, helps understand how the rocks in the studied area formed. Major elements and REE (Rare Earth Element) are detected and examined using XRF and ICP-MS, respectively, for the geochemistry of granite rocks.

The number of investigations into the petrography and geochemistry of rocks has increased in recent years. The area of Kampung Lawar, Batu Melintang, is well-known for its numerous pink granite outcrops that can be seen surrounding the waterfall. The focus of this research is on the geochemical approach that was used on the granite rocks in the study area. In addition, the study area's road connection was modified as a result of this investigation. To demonstrate the research activity, a GPS (Global Positioning System) was used to traverse the route, and an ArcGIS application was used to update and make a map of the study region.

1.7 Significance of Study

The reason for this project's in-depth investigation is that there hasn't been a lot of systematic research done in Malaysia on the granitic rock at Batu Melintang. Geochemistry approaches for the investigation regarding the geochemistry of granite are the methodological uses in this research. The integrated methods used in this project are to study topography and topographic maps of the area, to conduct a study of the lithology and geology of the area, and if possible, to conduct structure and geological mapping over the area, to investigate the geologic formation which is rock, of the subsurface, and to use Geographical Information System (GIS) to record the possibility of granite rock in the igneous rock area. On the other hand, the XRF and ICP-MS application are used for tracing the major element and REE present in analyses of the rock specimens data collection.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Before beginning the geological mapping and specification research into the geochemistry of the granite rocks of Kampung Lawar, Batu Melintang, preliminary studies are carried out. Before performing a study project, preliminary studies refer to techniques where literature reviews on the already published past studies, such as journals, papers, and books, are referred to and reviewed. These are particularly beneficial in broadening the researchers' comprehension and knowledge of the study area's research issue. Studies that were conducted on the granite in the study area and used as references in this study already exist. The literature review's goal is to provide direction for developing a thesis. It is crucial for determining the scope of the investigation as well. In this chapter will review the relevant literature in the areas of stratigraphy, structural geology, historical geology, and specification as well as regional geology and tectonic context.

2.2 Regional geology and tectonic setting

Peninsular Malaysia is a fundamental component of the Eurasian Plate, which also includes Sundaland in South-East Asia (C. S. Hutchison, 1989). Two North-South drift basement terranes that were positioned side by side towards the end of the Palaeo Tethys along the Raub-Bentong Suture during the Permo-Triassic underlie the region. Sumatra, Natuna, and western Borneo are the primary pieces of a similar plate that extend eastward and southward along the Sunda Shelf, which has a depth of less than 200 metres (C. S. Hutchison, 2005).

The Mesozoic granitoids of the SE Asian Tin Belt, which were deposited at the time of subduction-related orogenesis, are widely intruded into the basement rocks of the Thai-Malay Peninsula. These granitic rocks make up as much as half of the geology of Peninsular Malaysia, which is typically divided into the Western, Main Range, and Eastern Provinces. Additionally, Mesozoic silt and metamorphic rock are found, especially in the Northwest and as part of the North-South trending strip up the peninsula's central point (Metcalfe, 2013). Except for the basin along the constrained coastal plain, there are clearly no cenozoic rocks present from the peninsula. It is generally accepted that the Cenozoic was a time of emergence followed by breakdown, with Cenozoic material going into the vast sedimentary basins that surround the peninsula (van Hattum et al., 2013).

In view of varied stratigraphy, Peninsular Malaysia was divided into three belts, specifically the western belt, central belt, and eastern belt. Figure 2.1 depicts the geological geography of Peninsular Malaysia. The eastern belt extended from Kelantan to Johor between the eastern foothills of the main range Titiwangsa, while the central belt extended from Kelantan to Johor (Nur As-Syifa’, 2022).

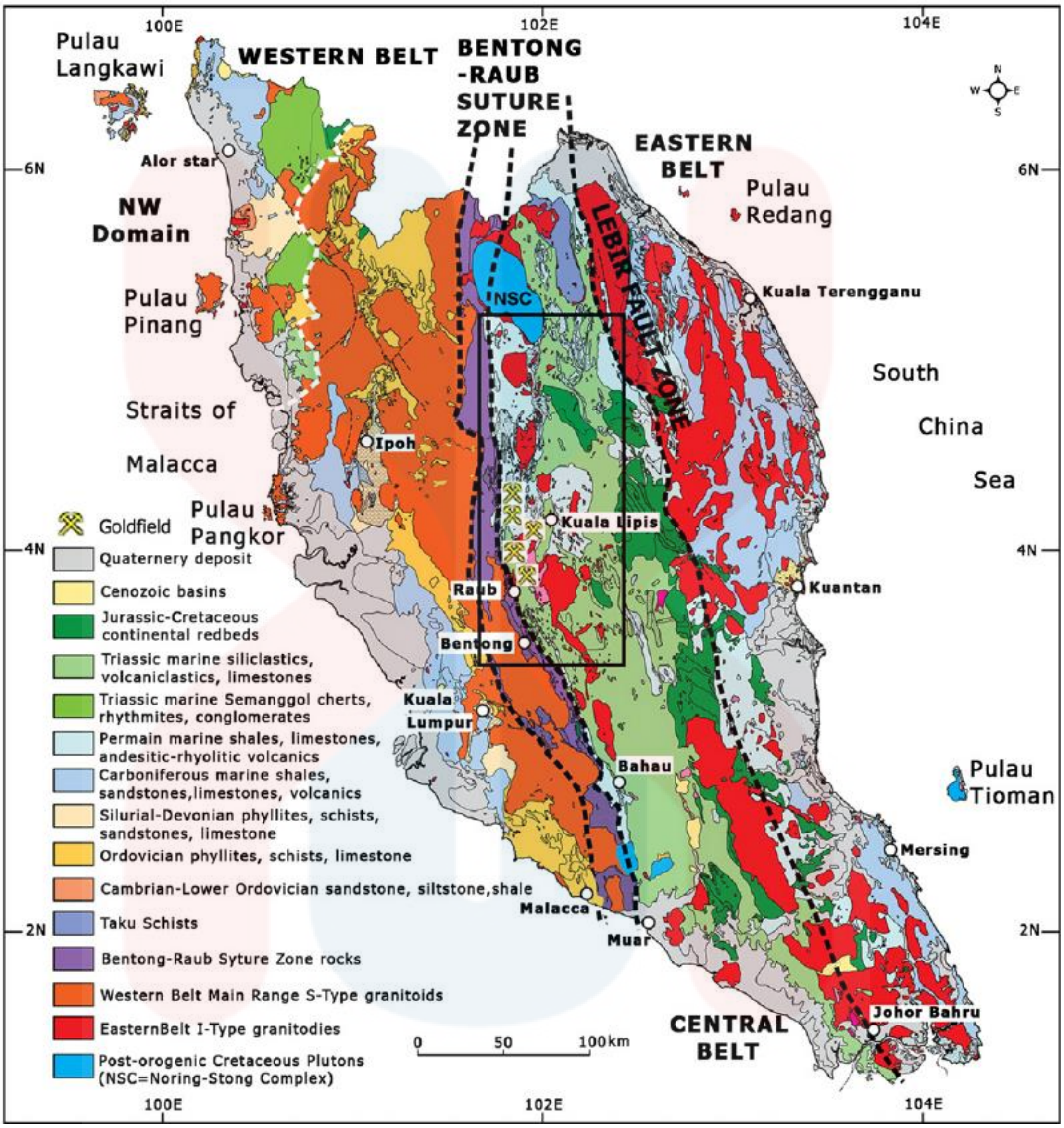


Figure 2.1: Geological map of Peninsular Malaysia (Metcalfe, 2013)

2.3 General Geology of Jeli District

The Jeli district is located at the base of Peninsular Malaysia's Main Range. Granitic rocks make up the majority of the range, with a few enclaves of sedimentary or metasedimentary rock. The granite of the Main Range is often found in the west of Kelantan, spanning along the western of the state up to the state boundary of Perak and Pahang.

The Jeli area predominantly consists of three types of rock, according to the general geology of Kelantan (Department of Minerals and Geoscience Malaysia, 2003). Shale, siltstone, sandstone, and limestone make up the Gunung Rabong Formation, which is made of Triassic sedimentary rocks. The second type is the Gua Musang Formation of Permian sedimentary rocks, which includes phyllite, slate, sandstone, and limestone. Granitic rock comes in third (acid intrusives). The geological map of Kelantan is seen in Figure 2.2.

According to geomorphology, Kelantan's territory may be divided into four types of landscapes: mountainous areas, hilly areas, plain areas, and coastal areas. Except for the coastline region, which only forms in the northern section of Kelantan, all types of terrain exist in the Jeli district. West and north of the district, mountainous terrain develops. The Stong, Migmatite Complex, Main Range granite, and schist make up this landscape. Mountain edges and mountain valleys are a couple of this landscape's attractions. At the base of the mountains, in Jeli, there are numerous mountainous areas. The geography gives rise to two different sorts of hills: extended hills and isolated hills. For instance, Gunung Reng is a limestone solitary hill that is typically visible in low-lying areas. Although they are ridges, elongated hills are typically lower than mountain ridge. East and the centre of the region have plain terrain.

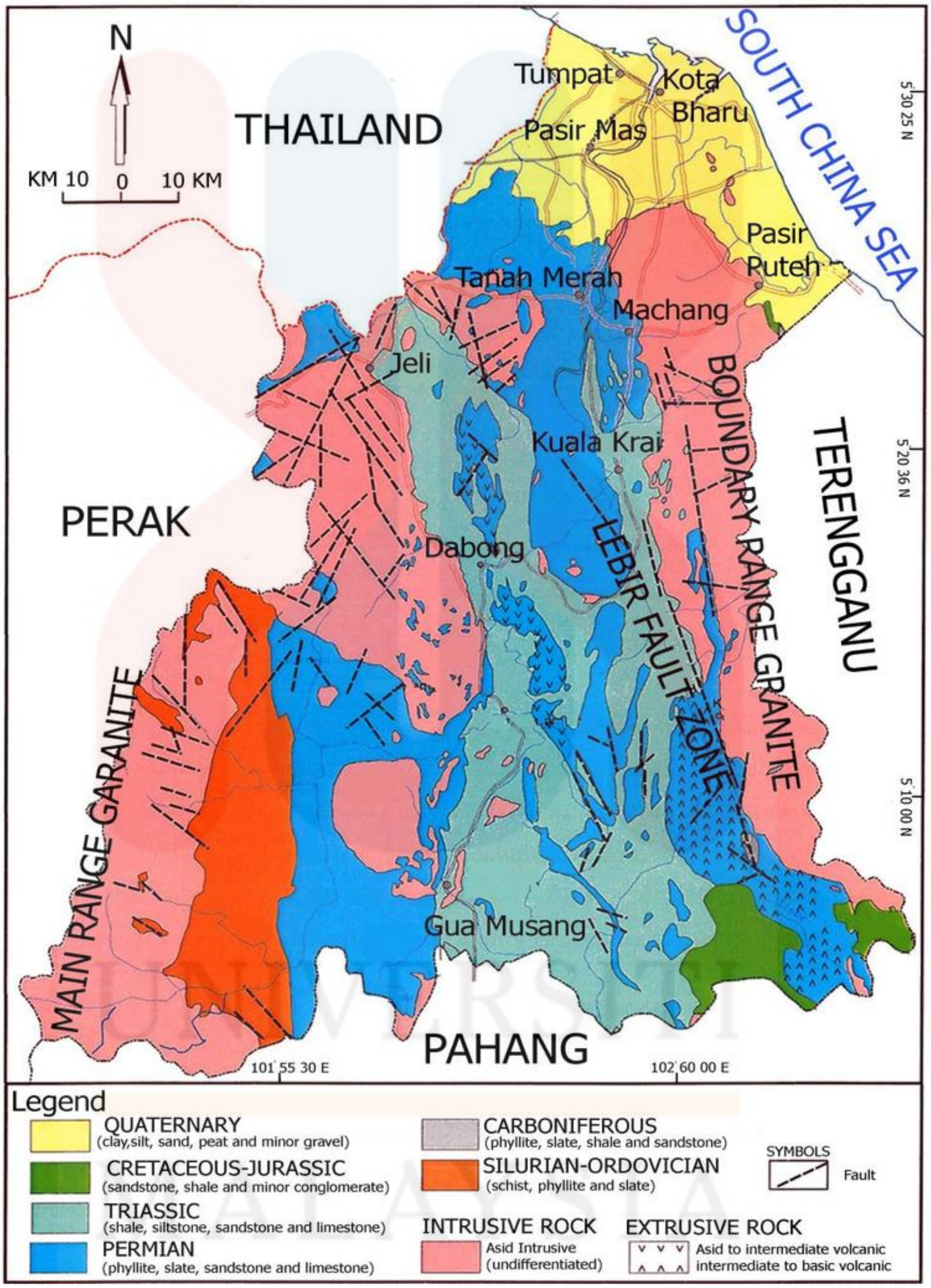


Figure 2.2: Geological map of Kelantan (Minerals and Geoscience Department Malaysia, 2003)

2.4 Stratigraphy

The research area's oldest lithostratigraphic unit is the Tiang schist formation. The term "Tiang schist," was used to describe the arrangement of metamorphic rocks that are emerging to the east of the Main Range Granite in the Belum area (The Malaysia-Thailand Working Group, 2009). It is called after the Tiang River, which is home to impressive outcrops. Quartz-mica-chiastolite schist and quartz-mica-schist make up the majority of the lithology.

The term "Mangga Formation" was introduced in to describe the low-grade metamorphic sequence comprising arenaceous, argillaceous, pyroclastic, hornfels, marble, and also schistose rocks in the eastern section of the Belum area (The Malaysia-Thailand Working Group, 2009). It is called after the Mangga River, where this rock unit's initial mapping and notable outcrop records occurred. Metasandstone, metagraywake, and siliceous shale are mostly interbedded in the lithology.

The Taku schist formation, according to (MacDonald, 1967), is the metamorphic rock equivalent to the Mangga formation. The phrase "Taku schist" was used to describe a group of metamorphic rocks that are emerging in central Kelantan (Malaysia). It was given the Taku River name since that is where large outcrops were seen. Quartz-mica-schist and quartz-mica-garnet schist make up the majority of the lithology.

The rock succession that emerged along a portion of the Telong River in the Aring River region, Kelantan, Malaysia, gave rise to the term Telong formation, which was first used by (Aw, 1990). Argillite, low-grade metasedimentary rocks, and metavolcanic rocks make up the Telong formation.

The Panau layers are made up of interbedded pebbly sandstone, paraconglomerate, covered fine-grained sandstone, and thin argillite strata. The maroon colouring of the argillite rocks. Within the sandstone strata, some of the argillite rocks are channel lenses. This demonstrates that the rocks were deposited in an oxygen-rich, continental environment during a channel lag.

Batu Melintang's quaternary deposits were formed in both marine and arid environments. Three formations in descending order can be used to split these deposits. Simpang formation, Beruas formation, and Gula formation make up the formation. Gravel, sand, silt, and laterite with significant iron concreation dominate the Simpang formation's Colluvium and Former Floodplain portions. Western Kelantan's stratigraphic column is depicted schematically in Figure 2.3.

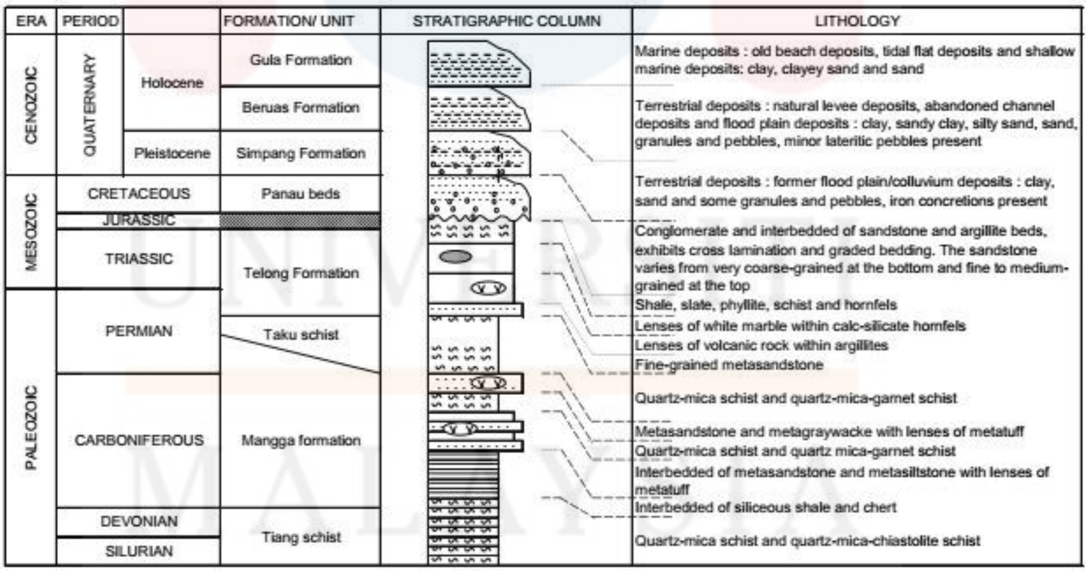


Figure 2.3: Schematic stratigraphic column of Western part of Kelantan (NF Asshari, 2019)

2.5 Structural geology

The western boundary of the Central Belt formed along the eastern foothills of the Main Range at the Bentong-Raub Suture Zone, according to detailed structural geology investigations. According to (C. S. Hutchison, 1982), the structures of the Peninsular are the result of a lengthy and intricate tectonic history that may have started as early as the Cambrian and continued all the way up to the Cenozoic. It is thought that during the upper Triassic Indosinian Orogeny, the western Gondwana portion of the Malay landmass (Sibumasu) collided with the Indochina continental block (East Malaya).

Kelantan is situated in Peninsular Malaysia's north and has a detailed geology. Thailand borders Kelantan on its northern border, Terengganu on its eastern border, Pahang on its southern border, and Perak and Kedah on its western border. According to the Geological Society of Malaysia (2010), the Gua Musang Formation, Taku Schist, and west Kelantan Olistostrom were all important geological features in Kelantan. Examples of Kelantan's igneous rock include dolerite, ignimbrite, andesite, diorite porphyry, and more.

Peninsular Malaysia's predominant shape is NNW-SSE protracted, and this shape is mostly affected by the Main Granite Range, often known as the backbone of Malaysia or the Titiwangsa Range, which has a distinct N-S lineament along its lower eastern section and is also known as the Bentong Raub Suture (Fischer, 1990). The Lebir Fault Zone, the primary fault zone located in Kelantan state, delineates the border between the central and eastern belts. Near Manik Urai in Kelantan, along the Lebir River, is a large zone of NNW-SSE trending curvilinear lineament known as the Lebir fault zone. In the Batu Melintang region, sedimentary successions typically fold into a sequence of synclines and anticlines.

Tight, deviating, and open folds that result in the recurring and overturn succession in older sedimentary rock are examples of folding. The majority of the bedding planes plunge eastward with various plunge edges, and the NW-SE and N-S drifting fold axes are sub-parallel to the Malay Peninsula's long pivot. Everywhere in the Transect region, there are faults. Fault zones are rarely exposed at more than a few locations along their tracks, as is seen by the dense soil cover and extensive tropical weathering. Typically, rocks that are cracked, sheared, or mylonitized show differences in fault width.

Due to tectonic or geological events that take place during the area's deformation, the pyroclastic rock formation units along the river area at Batu Melintang, Jeli, Kelantan has formed an overturned folding structure. A thorough explanation of the geological structure in Kampung Lawar, Batu Melintang, Jeli, and Kelantan is provided in chapter 4's subsection on geology.

2.6 Historical setting

In the past, blocks from East Malaysia-Indonesia and Sinobur Malaya collided to form the transect between Malaysia and Thailand, which is a component of the Batu Melintang area. The Bentong Raub Suture, which extends into Thailand to the north and the Banka nad Billiton Islands to the south, serves as a representation of the collision zone. Rock deformation has occurred in the Malay-Thai Peninsula as a result of this collision and the significant tectonic event that occurred in the Late Triassic (Metcalfe, 2013). The establishment of a research area Throughout the Paleozoic and Early Mesozoic eras, marine deposition took place constantly at Batu Melintang. During the Devonian-Carboniferous and Early Triassic periods, large fractures in the continent occurred as a result of the instability of the depositional basins in the Malay Basin and Thailand Basin.

Based on the results of the petrographic research, it was determined that the Bentong-Raub Suture was formed by schist, slate, phyllite, gneiss, hornfels, marble, and granite in Batu Melintang, Kelantan. The majority of the rocks displayed preferred rock mineral orientations, which suggested that they experience localised metamorphism. Gneiss, schist, and metasediment were the main lithologies found in the research area. The Telong Formation predominantly consisted of argillite, low-grade metasedimentary, and metavolcanic rocks, whereas the Mangga Formation consists of metamorphic sequences of arenaceous, argillaceous, pyroclastic, calcareous, and schistose rocks. The granite intrusion in Batu Melintang, which created N-S trends parallel to the Bentong-Raub suture, was also identified (S Sulaiman et al., 2018). Telong Formation is the middle between Gula Formation (youngtest formation) and Tiang Schist (oldest formation).

2.7 Geomorphology

Kelantan may be categorized into four categories of landscapes based on geomorphology: (1) mountainous areas, (2) hilly areas, (3) plain areas, and (4) coastal areas (Unjah T, 2001). Except for the coastal areas, which are only found in the northern section of Kelantan, all of these types of scenery may be found in the Jeli district. In the district's west and north, a mountainous environment emerges. The Stong Migmatite Complex, Main Range granite, and schist make up this landscape. In terms of geomorphology features in the study region, the study area has a variety of landforms, including hills and flat areas in the majority of the field area. The major part near the Perak and Thailand border of Kampung Lawar, Batu Melintang is surrounded by medium-high hills that range in elevation from 160 to 180 meters. Only a small portion of the village, town hall, police station, and the hospital are covered by flat land, specifically residential land or road land.

2.7.1 Drainage Pattern

A landscape region that is drained by streams develops drainage patterns as a result of stream erosion through time, which exposes characteristics of the types of rocks and geologic formations present. given drainage basin's stream, river, and lake drainage patterns. They are controlled by the topography of the ground, the gradient of the land, and whether a certain area is dominated by hard or soft rocks. Figure 2.4 shows the various drainage patterns and how they are often generated by earth landforms.

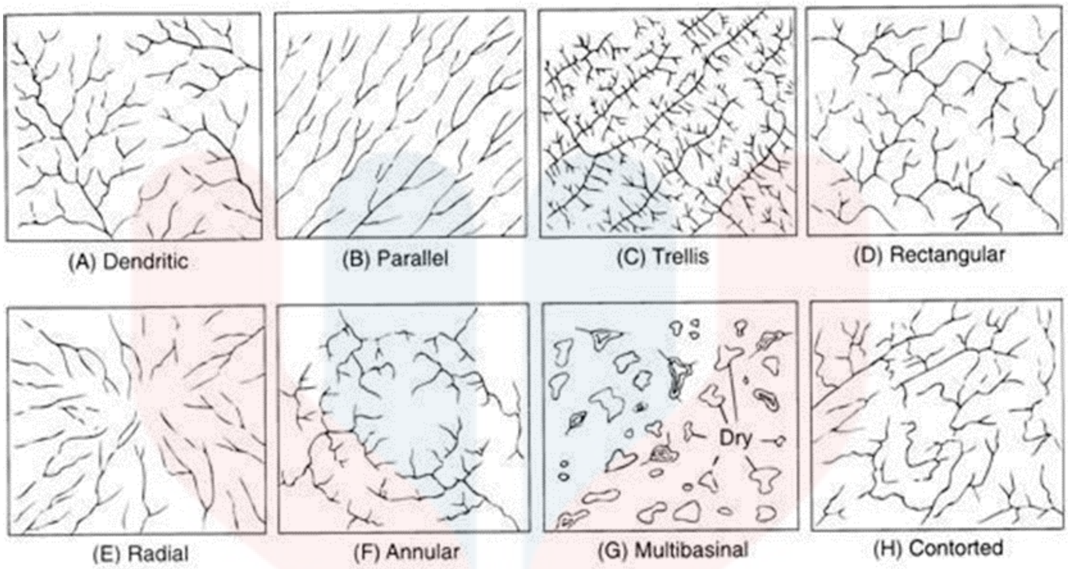


Figure 2.4: Types of drainage pattern (Lakdawalla, 2010)

2.7.2 Strike-slip fault

A strike-slip fault formed as a result of horizontal compression, and the energy was released as rocks were moved horizontally almost parallel to the compressional force as shown in Figure 2.5. The vertical fault plane of the fault is where the relative sliding occurs. The majority of these faults, which are widely scattered and situated near the meeting point of the continental and oceanic tectonic plates, are strike-slip faults. The geomorphology of the surrounding terrain indicates the presence of a strike-slip fault in the research area. This is due to the fact that there are no strike-slip faults in the study area; therefore, the strike-slip fault is located using the lineament map presented above. The granite and metasediment unit landforms were the focal point of the fault in the studied area.

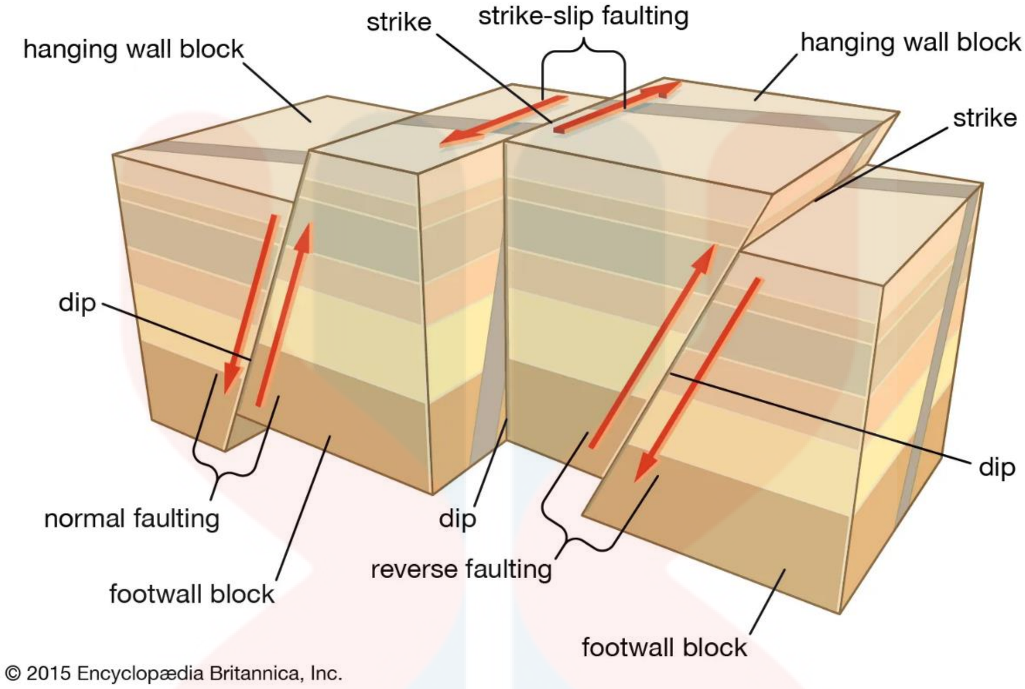


Figure 2.5: Strike-slip model. Modified by Encyclopedia Britannica, Inc. (2015)

2.8 Geochemistry of Granites

Granite rock may be the igneous rock that is best known. Granite rocks are an igneous rock type that is created from molten magma. They are grouped according to the minerals they contain. The following factors are used to categorise major elements and rare earth element (REE) based on their X-Ray Fluorescence and ICP-MS determinations.

In general, voluminous granites are generated when the crust is partially melted. The granite is rich in high silica ($SiO_2 = 71.1$ to 73.4 wt. %) and alkali contents ($Na_2O + K_2O = 8.10$ to 9.26 wt.%, $K_2O/Na_2O > 1$) and low Al_2O_3 (11.8 to 12.8 wt. %) and MgO (0.06 to 0.22 wt.%) contents and range from alkali-calcic to alkalic with high FeO_{tot} (1.56 to 4.02 wt.%) and high $(Na_2O + K_2O)/Al_2O_3$ ratios (0.68 to 0.72) in terms of geochemical composition (Wang et al., n.d.). Granite is mostly from the high-K calc-alkaline series (Li et al., 2019).

The terms S-, I-, and A-type granites have certain implications for the parental magma. According to (B. W. Chappell & White, 2001), granites with volcanic melt sources are classified as I-type, whereas granites with sedimentary melt sources are classified as S-type. Hornblende and sphene are mineralogically indicative of I-type granites, whereas muscovite, andalusite, cordierite, and garnet are indicative of S-type granites. Peninsular Malaysia has the highest concentration of the Main Range granites. Peninsular Malaysia's granites from the Main Range and Eastern Belt exhibit distinctly different petrological and geochemical variants. While the composition of the Eastern Belt granites ranges from 50 to 78 percent, that of the Main Range granites is more constrained (SiO_2 > 65 percent). Granites of both the I and S type can be found in the Eastern and Central belts.

Na, Ca, and Sr, which are depleted in their source rocks during the weathering of feldspar to clay minerals, are low in S-type granites. Because potassium is absorbed into clays during chemical weathering whereas sodium is eliminated in solution along with Ca, Sr, and Pb, the high K_2O/Na_2O ratio in S type rocks can be explained. Because the source rocks are frequently reduced due to the presence of graphite, the Fe^{3+}/Fe^{2+} ratios of the S-type rocks are much lower than those of I-types (Liew & McCulloch, 1985). S-type magmas are often corundum normative or peraluminous due to the lower Na and Ca, and they grow more strongly so as the rocks become chemically less developed (B. W. Chappell, 1990).

The Main Range Granite, the biggest granitic batholith in Peninsular Malaysia's Western Belt Terrane, has long been thought to be made entirely of S-type granites

(A.J.R. White et al., 1986). The Main Range granites have six characteristics that define them as S-type features: a narrow range of felsic rock (SiO_2 is 65.95 to 77.4 percent), ilmenite bearing, high initial 87Sr/86Sr isotope ratios (> 0.710), high K_2O/Na_2O ratios (1.4 - 2.8 - with S-types typically 0.9-3.2), low Na_2O content (3.2 percent) in rocks (Yang et al., 2018).

According to stratigraphy's article, the Main Range Granite shares several characteristics with SW North America granites of the S-type variety (B. W. Chappell, 1990; B. W. Chappell & White, 2001). The S-type characteristics are the presence of the vast majority of S-type granites in the Lachlan Fold Belt (LFB) are batholithic, near-surface granites that are frequently associated with S-type volcanics and are not related to local migmatites or metamorphic rocks. Because cordierite is present, we can infer that they are very peraluminous. Primary muscovite-containing granites are uncommon. As a result of chemical weathering during the development of the sedimentary sources, all are low in Na, Ca, and Sr. Peraluminous granites of various ages in southwestern North America are distinctly different. (A. J. R. White et al., 1987).

2.9 Rare Earth Element (REE)s

The International Union of Pure and Applied Chemistry (IUPAC) defines REE as a collection of 17 elements with comparable geological characteristics, which includes the lanthanides, yttrium (Y), and scandium (Sc) (Gunn, 2014). Most geoscientists, on the other hand, generally ignore Sc or both Sc and Y and divide REE into two groups based on their atomic weights: LREE (La-Eu) and HREE (Gd-Lu). All of the rare earth elements are metals, and the group is known as "rare earth metals." Due to their numerous comparable qualities, these metals are frequently found together in geologic deposits. Because many of them are sold as oxide compounds, they are also known as rare earth oxides. The use of REE in the defense, aerospace, medical, and automotive industries has expanded considerably as a result of technological advancements. REE concentrations have been observed in a variety of geological environments, including the production of residual deposits like a granitic rock in igneous (Chakhmouradian & Wall, 2012). In Malaysia, notably in Kelantan territory, granitoid and some extrusive volcanic rocks are widely exposed. Two separate granites, the grey granite with somewhat feldspar-phyric and the pink granite are exposed in Gua Musang to Batu Melintang (Shafiee et al., 2020).

CHAPTER 3

MATERIALS AND METHODOLOGIES

3.1 Introduction

For the purposed study of geological mapping, a variety of techniques and resources are taken into consideration in order to meet the goals of the research project. Figure 3.1 is a flow chart that depicts the procedures followed in order to conduct geological mapping in the specific study region.

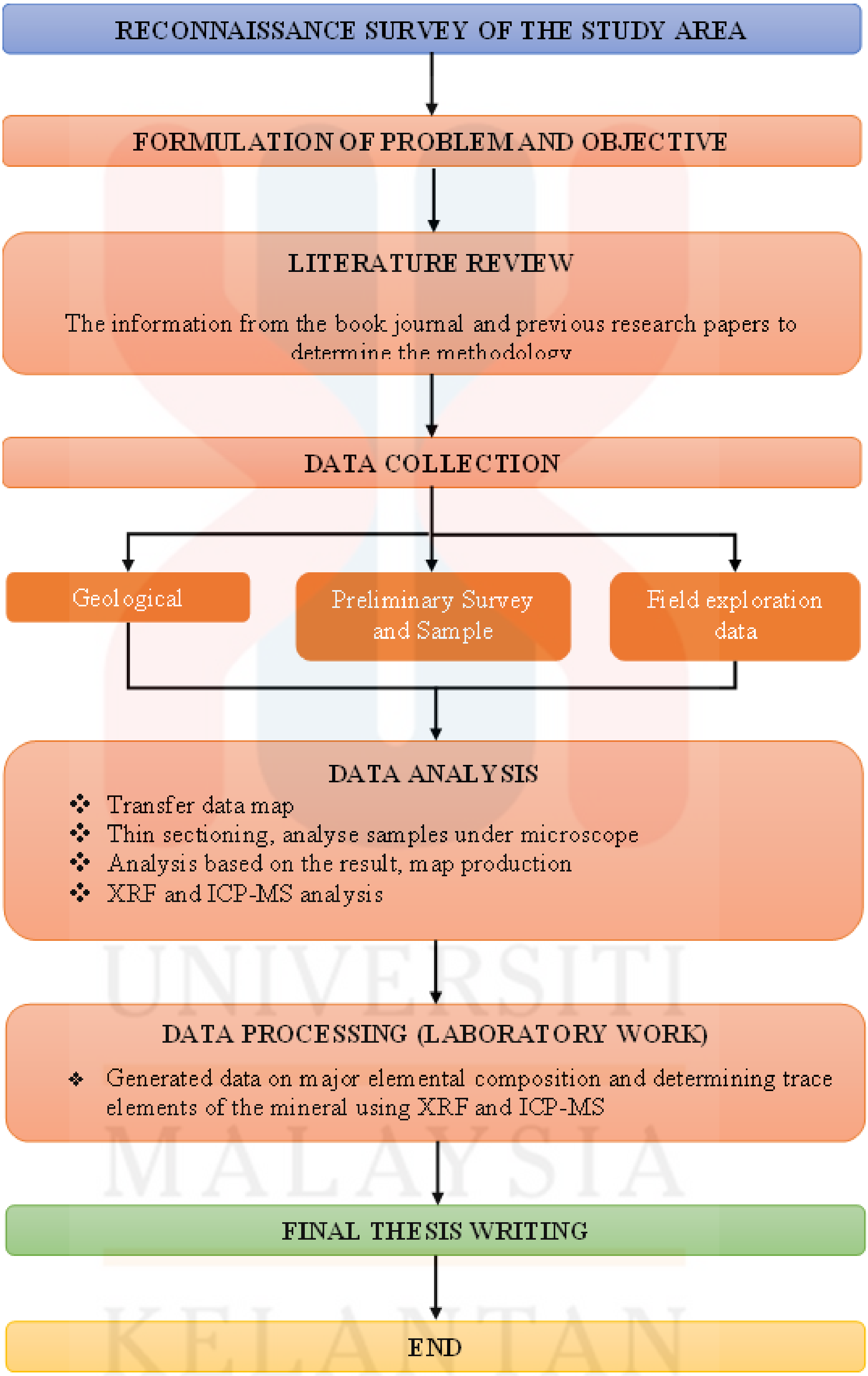
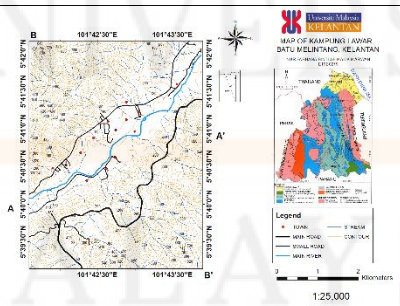


Figure 3.1: Research flow chart of the research topic

3.2 Materials

The right materials are absolutely necessary to carry out the fieldwork. The geological mapping process needs seven primary ingredients. The primary materials and their uses are shown in Table 3.1 below. The materials and a description of each are shown in Table 3.1.

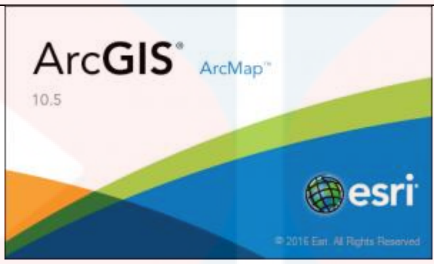
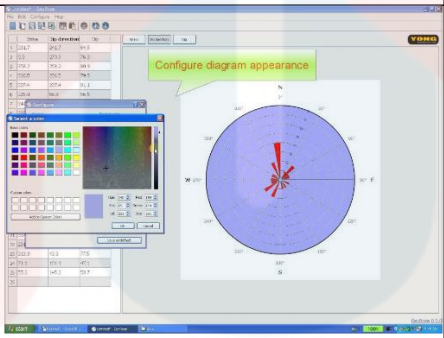
Table 3.1: List of materials and apparatus

MATERIALS	PICTURES	FUNCTION
Hammer		Any geologist should have a hammer because it is used to gather samples. The hammer's flat end is used for light chisel work and breaking rocks. Prying rocks and prospecting in loose rock debris and dirt are both done with the pointed end. Hammer can also function as a scale.
Map		A map is crucial for geological fieldwork as a reference. to learn more information about the area or location Stratigraphic contour lines can be used to depict the topography of a particular stratum's subsurface underneath its surface.

Compass		A compass is a device used to take precise bearings based on location-specific directional readings. Additionally, it used to measure the strike and dip of the bedding plane of the outcrop.
Measuring Tape		To measure the ground distance, tape can be used as a scale. Taking accurate measurements of lithology and structures is also vital.
Global Positioning System (GPS)		In addition to giving a GPS receiver anywhere in the world access to geolocation and time data, GPS is used to take precise coordinates of the research area.

<table>
<tr><td>Hydrochloric acid

(HCL)</td><td>
</td><td>For carbonate rocks like dolomite and limestone, HCL was used to measure how the specimens of the rocks responded to the HCL solution.</td></tr>
<tr><td>Hand Lens</td><td>
</td><td>to spot and count the minuscule rock flecks that the unaided eye cannot perceive. It is used to inspect small figures in silt, rocks, soils, minerals, sand, and other materials.</td></tr>
<tr><td>Field note book</td><td>
</td><td>All of the data and information that we gathered from the mapping field is recorded in a field note book.</td></tr>
<tr><td>Sample beg</td><td></td><td>Hand samples that were collected on-site during the mapping process are placed in sample bags.</td></tr>
</table>

Stationary		When mapping and analysing data, stationary such a pen, pencil, and protractor are used to jot down notes and plot data.
ArcGis		a programme used to produce, update, analyse, and distribute data so that a map might be built.
Software		The data is analysed using software both before and after the mapping operations. Software such as GeoRose, Stereonet, Sedlog, Microsoft Office, and Microsoft Excel are frequently used to complete theses.
Microscope		to see and classify rock minerals by looking at thin rock sample sections under PPL and XPL.

3.3 Methodologies

All the approaches that could be used for this research activity were mentioned in this section. If one of the methods is not used, the research is not comprehensive. The research flow chart for the research topic is displayed in Figure 3.1 above.

3.3.1 Preliminary research

Information on the study area was obtained through preliminary research. Desk research and the examination of topographic and geological maps of the study area are used for preliminary research. Numerous investigations or studies have been carried out in the Batu Melintang region. In Kampung Lawar, Batu Melintang, the prior research focused more on geological heritage, stratigraphy, sedimentology, general geology, and paleoenvironment than it did on geomorphology.

3.3.2 Field studies

Kampung Batu Melintang served as the site of the field study. Data must be collected correctly and using the right way in order for this study to be completed. The results are then generated by interpreting these data. Geological mapping, field measurements, travelling, and rock sampling are all part of a field research.

Geologic features, such as rock kinds, contacts, age relationships, and structural patterns, can be found and seen in three dimensions via geological mapping. A variety of geological maps can be created by observing the geology of Kampung Batu Melintang and recording the data. The data was gathered in accordance with the study's goals. In essence, traversing is a strategy of managing research progress throughout the subject area. Additionally, it is a way of going over everything in depth. Making a traverse involves travelling a roughly specified path between two points on a map while charting the geology along the way.

There are numerous techniques to do field measurements, and they must be plotted and recorded. Geological mapping is based on measurements of bedding strike and dip, cleavage, foliation, and jointing. Structures have been examined, samples have been gathered, and images have been taken during field measurement. With the aid of photos, sketches, and text descriptions, all the pertinent information, such as the variations in rock type or the structural properties of the outcrop observed, was also documented.

In field research, it is crucial to conduct rock sampling. One created on-site explains the granite exactly as it is, with measurements of distinctive features and factual remarks. Describe the ground's initial appearance, the rock's colour, and then the features visible in the hand specimen, both with and without a hand lens. Also take note to the grain size and texture. Rock samples were gathered in a specific quantity and placed in plastic bags. These samples were subsequently subjected to additional laboratory analysis.

3.3.3 Laboratory work

All of the sample's laboratory work is covered in this section. It also includes geochemical analysis, which examines the trace and main elements of granitoid rocks, as well as the thin section method.

a. **Thin section**

To understand and interpret the mineral makeup of the rocks, thin sections are performed. Thin section processes have three stages: sectioning, grinding, and lapping. The rock sample is sectioned using a rock cutter to achieve the desired size and thickness for thin section examination. After the rock has reached the desired size and thickness, additional grinding is required to provide a flat, smooth surface. Any deformation that occurred during the sectioning process was removed using the grinding process.

The glass slide was then attached to the flat surface using cement. After cementing the rock's flat surface to the glass slide, the lapping operation was completed. The rock chip, carborundum powder, and water were then pushed in a rotating motion against the glass plate as depicted in the image. This procedure, known as lapping, is carried out until the mineral's composition can be observed under a microscope. This process must be carried out properly because if it isn't, the rock's minerals may become distorted or inaccessible.

b. **Geochemistry analysis**

i. **X-ray Fluorescence (XRF)**

The concentration of major and trace elements in rocks can be found via whole-rock and selective analysis using X-ray fluorescence (XRF) research. In the lab, samples were ground into a fine powder. The compositions of the entire rocks were also identified. Using a Philips PW 1404/10 X-ray spectrometer, the major elements were identified by X-ray fluorescence (XRF), which involved melting the sample with lithium tetraborate and casting it onto glass discs. Based on the basic parameters method of conversion, X-ray counts were transformed into concentrations using a software program (de Jongh, 1973).

ii. Inductively Coupled Plasma Mass Spectrometry (ICP-MS)

Since granites can be directly tested for trace elements using inductively coupled plasma mass spectrometry (ICP-MS), it is necessary to adopt sample preparation techniques that cause the sample to dissolve completely. For a solution ICP-MS analysis to be accurate, analytes must be thoroughly dissolved. Digestion's objective is to dissolve analytes and break down materials without losing or contaminating the sample. The absence of digestion will result in inaccurate measurement of undissolved analytes. The rock sample needs to be homogenised and dried. In a 50 mL plastic tube that has already been cleaned, weigh 0.25 g of the sample. Nitric acid, 5 mL, is added. Cap the tube loosely to prevent gas explosions while allowing gas to escape. Give the sample at least an hour to respond at room temperature.

Samples are heated for 30 minutes at 90 °C. When no more brown fumes are released from the sample, let it cool, add 5 mL more nitric acid, and heat for another 30 minutes. When all but 5 mL have evaporated, heat the sample (still loosely cap) until they have. Add 3 mL of trace-metal grade hydrogen peroxide and 2 mL of DI water. until the effervescence stops, heat. Heat the sample until 5 mL are left in the tube while it is still closed. ultimate acid concentration should be between 2 and 5 percent. Two blank samples should be processed using the same steps as the sample samples and submitted as a method blank. 2 certified reference materials (with a similar composition to your sample) should be processed and submitted using the same method.

3.3.4 Analysis, result and discussion

The data gathered from the experiment and mapping are examined in this section. All mapping-related data will be analysed using ArcGis and GPS to create a 1:25,000 geological map. The data interpretation of granitoid mineral content was referred to for petrography analysis were generated. The data collected for geochemistry study will be evaluated using the XRF and ICP-MS results to identify the properties of the granite rocks.

3.3.5 Conclusion

Based on the findings and the discussion, conclusions are drawn in this section.

CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

This chapter discusses all of the data or information that was gathered and obtained from the mapping processes in Kampung Lawar, Batu Melintang. The information or data contains all of the studied area's geology, including geomorphology, lithostratigraphy, geological structure, historical geology, and structural mechanisms. This chapter includes maps of the research area's geomorphology, drainage, and traverse-and-observation systems to support interpreting the landform. Additionally, the data and details from this chapter were needed to produce the geological map of Kampung Lawar, Batu Melintang, which is presented on the next page. To accomplish the first goal of the research study, which is to update and develop a geological map of the study area at a scale of 1:25000, all the geological data was gathered.

For the geologist to learn about or recognise the historical occurrences that had taken place in the research area, this chapter is essential. Accessibility is pretty good since this research area is in Kampung Lawar, Batu Melintang, and most of the area is a palm oil plantation and a rubber tree plantation, having a main road and a by-road, respectively.

4.1.1 Accessibility

The ability of the research area to be reached from other locations was examined in the accessibility section. It required a road, such as a major road, by-roads, or a villager's footpath, as well as a certain mode of transportation, such as a motorcycle, four-wheel car, or other vehicles that were appropriate for the size and shape of the road and the telecommunication system. In the study area, the communications infrastructure is fairly decent. There is little coverage in all areas save for select rural and woodland areas. Additionally, the socioeconomic status of the residents of Kampung Lawar, Batu Melintang, is linked to accessibility. This is because the main roads, by-roads or off-roads, and railway accessibility were established as shown in Figure 4.1, and these features greatly contribute to the social and economic well-being of the Kampung Lawar, Batu Melintang people.

Due to the study area's abundance of plantation sites, including rubber tree and palm oil plantations, there are several unpaved road connections throughout it. The area's landform truly has something to do with how accessible the unpaved areas are. Based on previous mapping in the study area, it appears that access to plantation areas like those for rubber trees and palm oil is quite straightforward because those areas already had gravel small streets that the local villagers had built and used to access them. The mapping initiatives are therefore extremely successful.

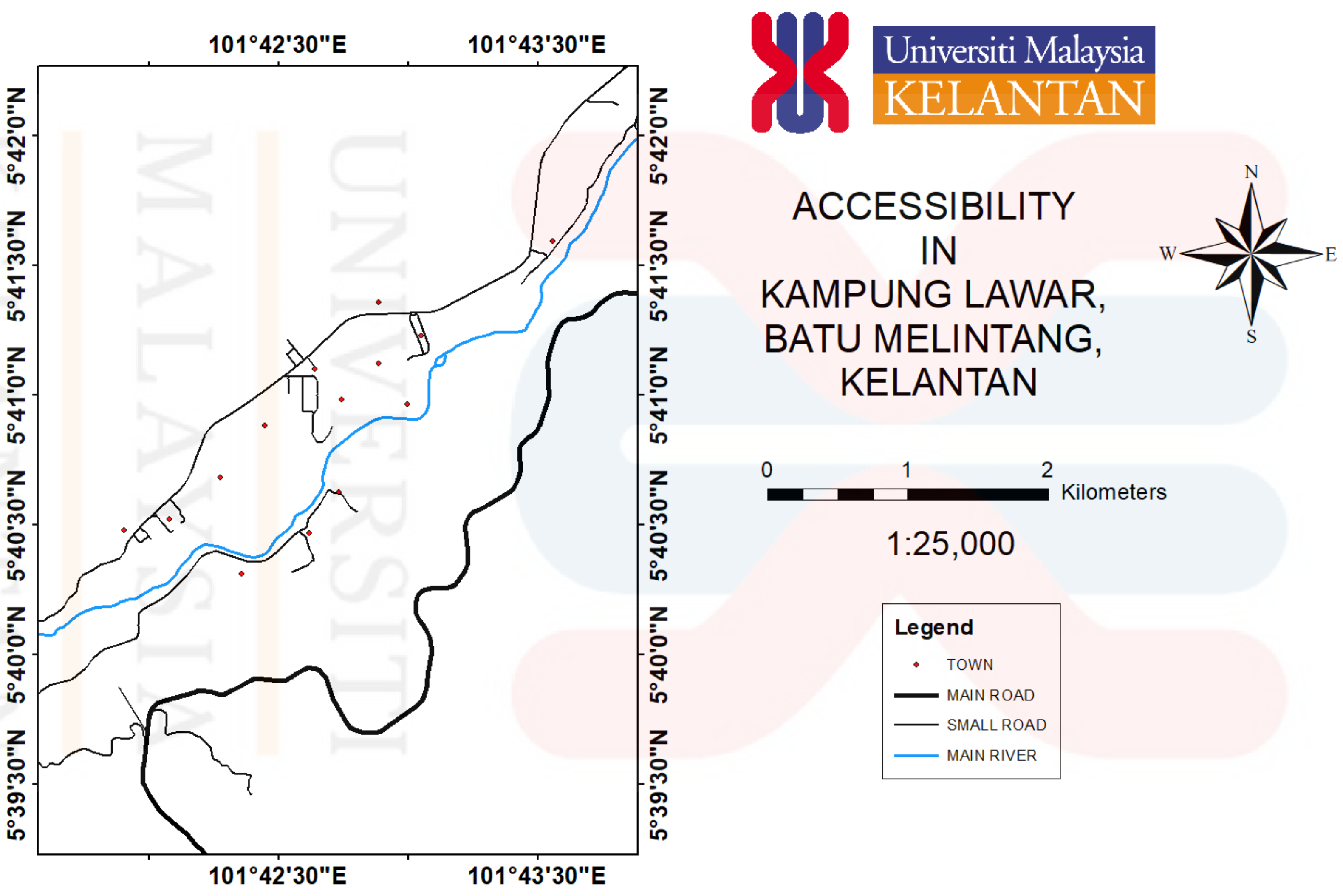


Figure 4.1: Accessibility map of the study area.

4.1.2 Settlement

According to statistics, the Jeli area can be divided into three subdivisions: Jeli, Batu Melintang, and Kuala Balah. According to Table 4.1, Jeli has a total population of 20,329 people out of the 39,170 people that live in the entire state of Jeli.

Table 4.1: Area by District of Kelantan by year 2022

DISTRICT	SUBDIVIDSION	AREA (KM^2)	POPULATION
Kota Bharu	Badang, Beta, Banggu, Kadok, Kemumin, Kota, Kubang Kerian, Ketereh, Limbat, Panji, Pendek, Peringat, Salor, Sering, Pusat Bandar Kota Bharu	402.7	555,757
Pasir Mas	Rantau Panjang, Kangkong, Pasir Mas, Gual Periok, Chetok, Alor Pasir, Lemal, Bunut Susu, Kubang Sepat, Kubang Gadong	569.5	230,424
Tumpat	Jal, Pengkalan Kubor, Sungai Pinang, Tumpat, Terbak, Kebakat, Wakaf Bharu	179.8	179,943
Pasir Puteh	Bukit Jawa, Padang Pak Amat, Limbongan, Jeram, Bukit Awang, Bukit Abal, Gong Datok, Semerak	423.3	136,157
Bachok	Mahligai, Telong, Gunong, Melawi, Tanjung Pauh, Tawang, Bekelam	278.6	157,288
Kuala Krai	Mengkebang, Dabong, Olak Jeram	2,275	105,007
Machang	Labok, Ulu Sat, Temangan, Pangkal Meleret, Pulai Chondong, Panyit	526.2	110,008
Tanah Merah	Bukit Panau, Ulu Kusial, Jedok	879.9	150,766
Jeli	Jeli, Batu Melintang, Kuala Balah	1,326	54,656
Gua Musang	Galas, Bertam, Chiku	6,361	101,886

Lojing	Autonomous sub-district under Gua Musang	1,817	10,609

Source: WIKIPEDIA, 2022

The Table 4.2 also provides the population breakdown by region according to Mukim Batu Melintang data. Jeli district is a district and a parliamentary seat in western Kelantan, Malaysia, according to the department of statistics' official website. The district had an estimated 42,150 residents as of 2010. They added that Jeli district now has authority over 1,326 km2 in total. The villages Kampung Batu Melintang, Kampung Gunung, Kampung Belimbing, Kampung Lalat, Kampung Tapong, Kampung Pelias, Kampung Tanjung Kasek, and Kampung Dendong are among those that have settled in the study area. These communities are all situated in the northwest region of the research area.

Table 4.2: Total population by ethnic group, district/mukim and state, Malaysia, 2010

Total / Mukim	Total	Malaysian Citizens: Total	Bumiputera: Total	Bumiputera: Malay	Bumiputera: Other	Chinese	Indian	Other	Non- District/ Malaysian Citizens
Jeli	**39,170**	**38,026**	**37,836**	**37,142**	**694**	**97**	**58**	**35**	**1,144**
Batu Melintang (Belimbing)	**8,456**	**8,349**	**8,327**	**8,167**	**160**	**13**	**2**	**7**	**107**
Belimbing	6,678	6,624	6,604	6,444	160	11	2	7	54
Kalai	1,778	1,725	1,723	1,723	-	2	-	-	53
Jeli	**20,329**	**19,480**	**19,332**	**18,802**	**530**	**75**	**56**	**17**	**849**
Jeli	10,981	10,655	10,567	10,564	3	32	47	9	326
Jeli Tepi Sungai	9,348	8,825	8,765	8,238	527	43	9	8	523

Source: Majlis Daerah Tumpat ,2010

4.1.3 Vegetation

In Kampung Lawar, Batu Melintang, there are three main types of vegetation that are found: forestry, rubber plantations, and palm oil plantations. 60% of the research area was forested, 30% was covered by rubber plantations, and 10% by palm oil plantations. The key factor in increasing Batu Melintang's economy and standard of living is the opening of job opportunities in the palm and rubber plantations.

The primary type of vegetation that covers almost all of the study area is forestry. The people own and operate this palm oil and rubber farm. The majority of the rubber and palm oil trees were planted in steep areas, changing the Batu Melintang scenery in some spots. The hill was chopped in order to plant the palm saplings, which resulted in a change in the scenery. As a result, the physical characteristics of the hill have changed, and Figure 4.2 illustrates how the hill now appears to be deserted.

The rubber plantation is located in the hilly area of Kampung Lawar, Batu Melintang, and the surroundings of the town along the pergau River. The rubber plantation and the palm oil plantation are shown in Figures 4.3 and 4.4, respectively.

Figure 4.2: Rubber plantation at hill area

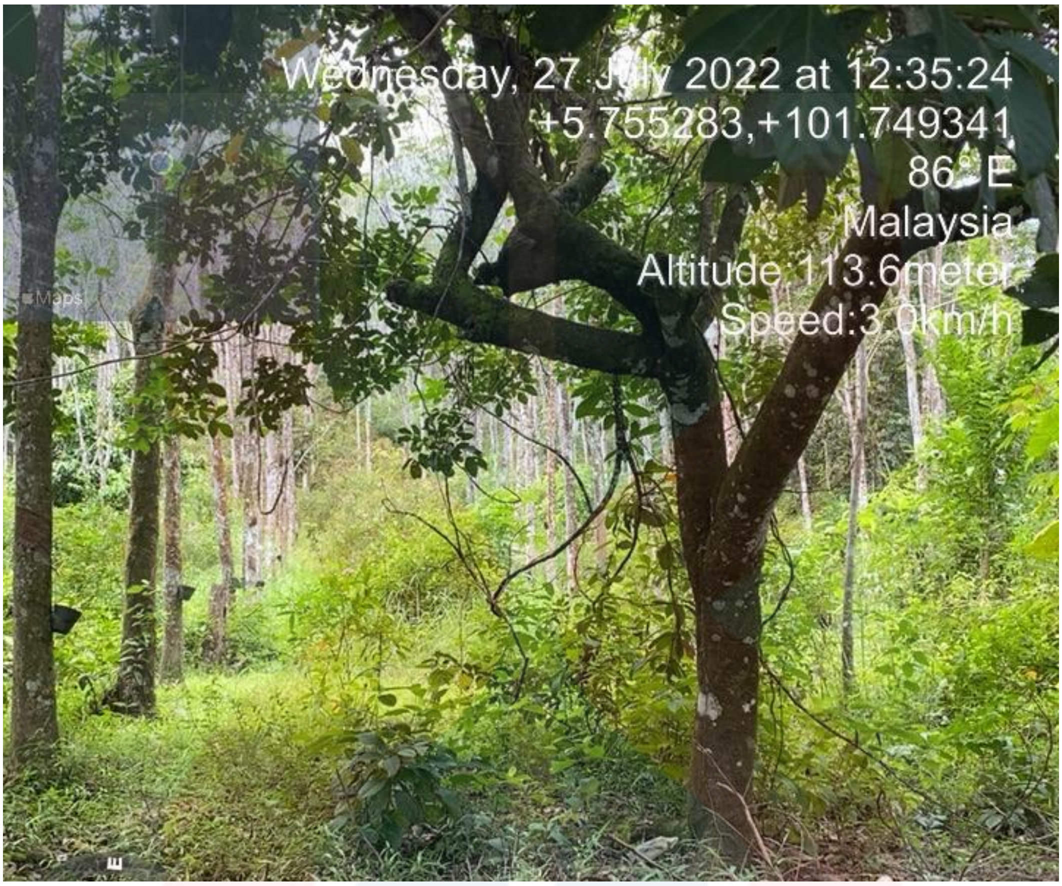


Figure 4.3: Rubber Plantation at Kampung Lawar, Batu Melintang

Figure 4.4: Palm Oil Plantation at Kampung Lawar, Batu Melintang

4.1.4 Traverse and observation

The majority of the study area is covered by a paved road, according to the traverse and observation. This is due to the paved roads, which connect the entire study area. The main road is Jalan Jeli-Batu Melintang. In addition, the housing area had paved roads that were accessible from the study area. The topographic units of the research area are also hilly to mountainous, with mean elevations ranging from 77 to 859 m, as shown by the geomorphology map in Figure 4.5. Consequently, unpaved roads were observed at the higher elevation areas of the study region, particularly in the rubber tree plantations, palm oil plantations, and forest areas. The majority of the traverse routes in higher elevation areas are unpaved roads, and half of these roads are inaccessible to vehicles other than motorcycles because they are highly difficult and slippery. Most of the paths in the research region can only be reached on foot because effective geological mapping necessitates further observation and measurement.

Based on the geomorphological analysis, outcrops sampling, lithology analysis, and structural analysis, observations are produced for the research area. The study site has a hilly to mountainous landform with a mean height of 77–859 m, making it suitable for geomorphological analysis. Then, for outcrops samplings, the sampling was carried out in various locations in accordance with each lithological unit because the study area was made up of four lithological units: granite, metasedimentary rock slate, igneous rock composed of pyroclastic rock and basalt, and metamorphic rock composed of schist.

4.2 Geomorphology

4.2.1 Topography

The study area is composed of two topography units, which are hilly and mountainous, with respective mean elevations of 77–859 meters above sea level, according to the topographic features of the study area that may be seen in the map of Figure 4.5 below. The research area's hilly portion is primarily made up of granite, metasedimentary rocks, and agricultural activity. The locals there eventually uncovered a tiny portion of the hilly land and developed it into a plantation area for palm oil and rubber trees. The higher elevation area, which is a mountainous region, was heavily forested, and mostly exposed rock types such granite unit, metamorphic rock, and metasediment rock were found there. Deforestation is the main activity being investigated in the mountainous, and some of the areas have also been developed as plantation sites, such as rubber tree plantations. The mean elevation above sea level (m) for the topographic units in Table 4.3 below is as follows:

Table 4.3: Topographic units classification

GEOMORPHOL-OGICAL UNIT	SYMBOL	DRAINAGE PATTERN	LANDFORM	ELEVATION (m)
Peak		Dendritic and Parallel	High Hill	600 – 840
Steephills		Parallel	Hill	420 – 580
Slopinghills		Parallel	Lowhill	300 – 360
Slightly sloping plain		Parallel	Lowland	140 – 280

The geomorphology landform from the mountainous area of elevation is shown in Figure 4.6. The image clearly shows the hilly landform and the greatest peak elevation, and Figure 4.7 also represents the same landform but in a panorama mode, taken from the same point of 101° 76' 10'' E, 05° 71' 65'' N.

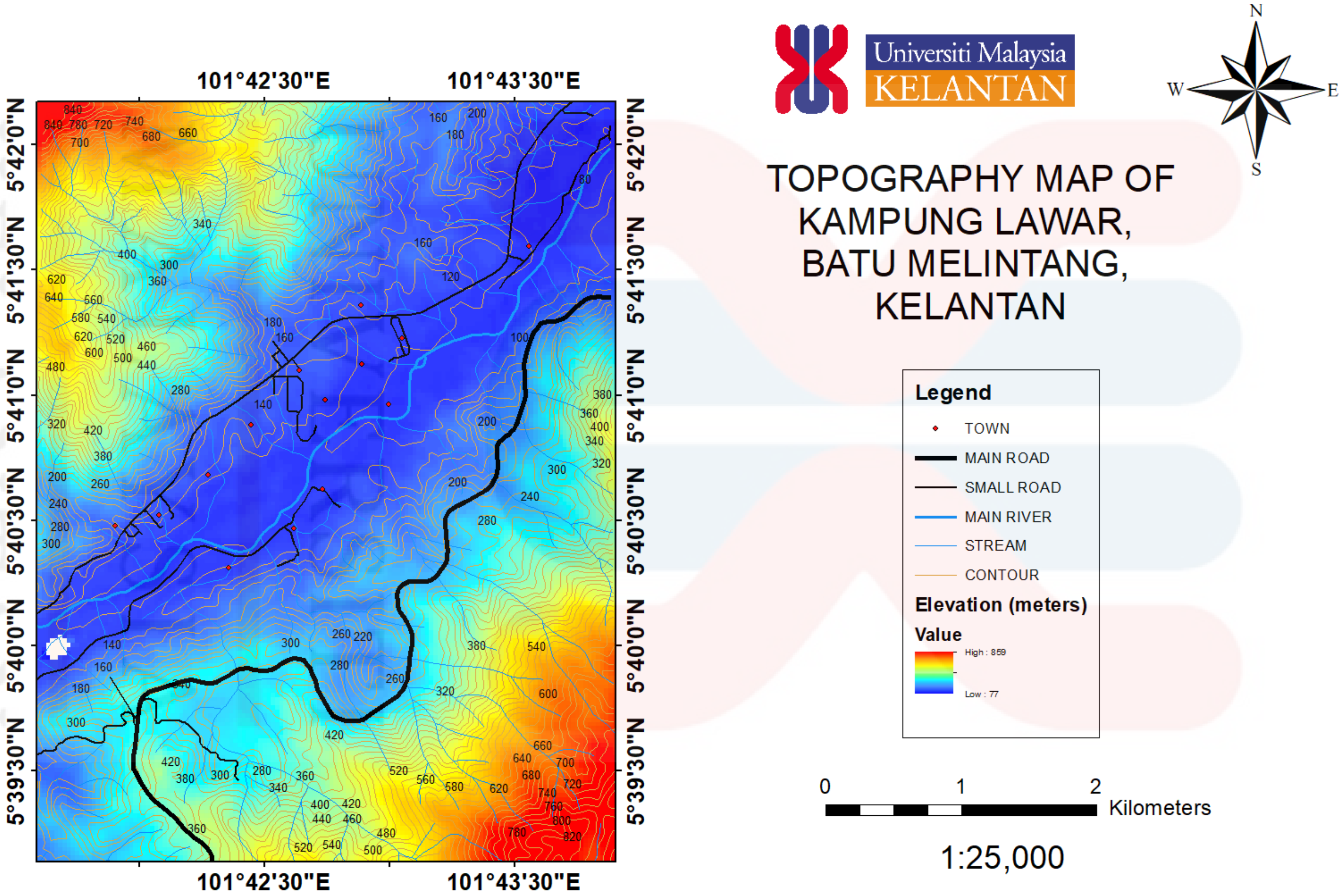


Figure 4.5: Topography map of Kampung Lawar, Batu Melintang

Figure 4.6: geomorphology landform

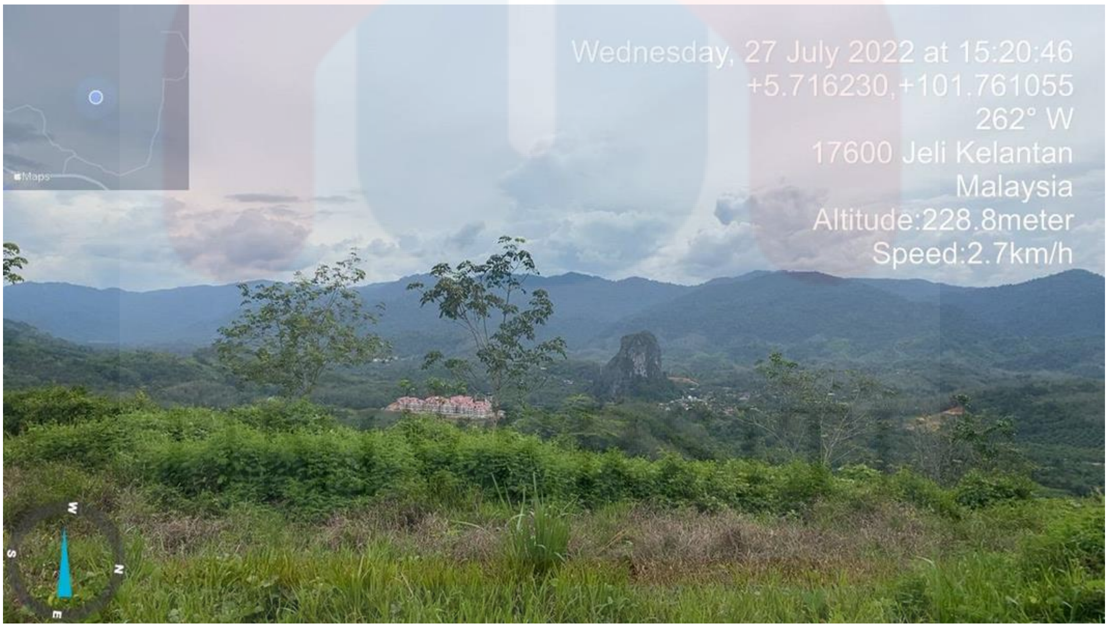


Figure 4.8: landform but taken via panorama mode

4.2.2 Weathering

Physical weathering, chemical weathering, and biological weathering are the three types of weathering processes that can be discovered in the study area. Any rock that weathers will eventually turn into alluvium or soil. Soil composition varies according to the type of parent rock that has undergone weathering. The weathering process has an impact on daily life because, after the rock transforms into the soil, the soil may be utilized to grow plants, build houses, mine stone, create clay, and other things.

a. Physical Weathering

The process of physically weathering involves breaking down rock into tiny pieces without altering the chemical makeup of the rock. Abrasions caused by water, wind, gravity, thermal expansion, and frost wedging are examples of physical weathering that can be found in the research area.

b. Chemical Weathering

Chemical weathering is the process of decomposing rock through chemical alterations, which alters the composition of the rock. As shown in Figure 4.8, the three types of chemical weathering that are present in the research region are carbonation, oxidation, and solution.

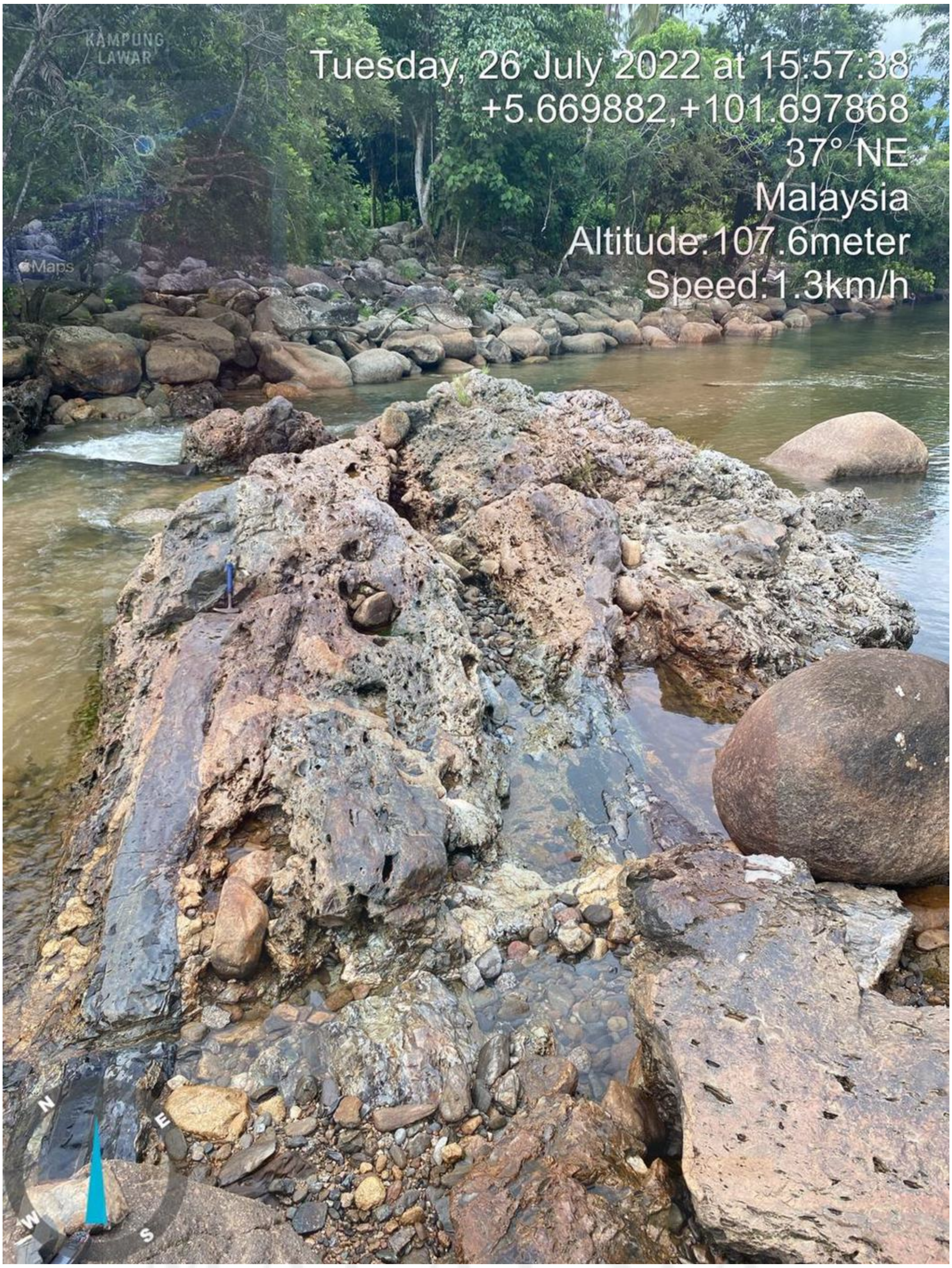


Figure 4.8: Chemical weathering of rock.

c. Biological weathering

The weathering process known as biological weathering occurs when microorganisms, animals, or plants break down the rock. As shown in Figure 4.9, two types of biological weathering are present in the research area. These are root penetration by trees into rocks and green algae growth on rock surfaces.

Figure 4.9: Biological weathering of rock.

4.2.3 Drainage Pattern

According to Figure 4.10, drainage pattern map, the area around Kampung Lawar and Batu Melintang has a dendritic and parallel drainage pattern. Red lines on the map indicate the dendritic drainage pattern. Dendritic patterns resemble trees and are made up of branching tributaries and the mainstream. The parallel pattern demonstrates how the streams diverge in the same manner. The parallel patterns typically signify beds with a topography that is gently dipping or uniformly sloping.

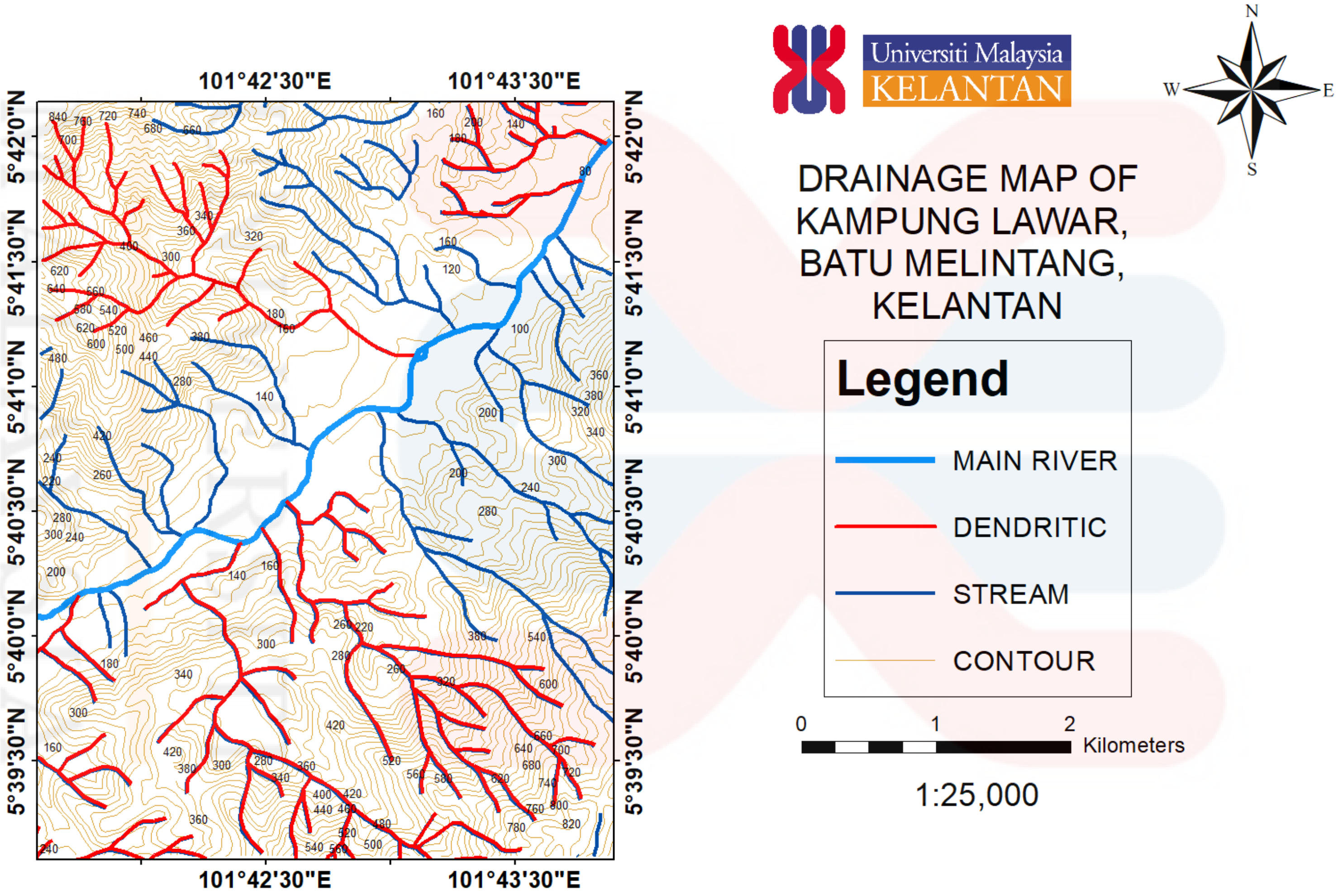


Figure 4.10: Drainage Pattern Map of Kampung Lawar, Batu Melintang

4.3 Lithostratigraphy

Lithological analysis was carried out in the study area as part of the geological mapping procedure to determine the lithological unit and strata of the rocks. According to the mapping results, there are four different lithologies that can be used to categorise the rock units in Kampung Lawar, Batu Melintang: metasedimentary rock (slate unit), schist, granite unit, and pyroclastic rock. Based on earlier research, the study area is connected to Batu Melintang. Pink and grey granite can be found in the research area because, in accordance with the characteristics of the Mangga Formation, it is exposed to the Bentong-Raub Suture Zone and the Central Gold Belt with their complex metamorphic rock structures. The cross-section map of the study area is shown in Figure 4.11.

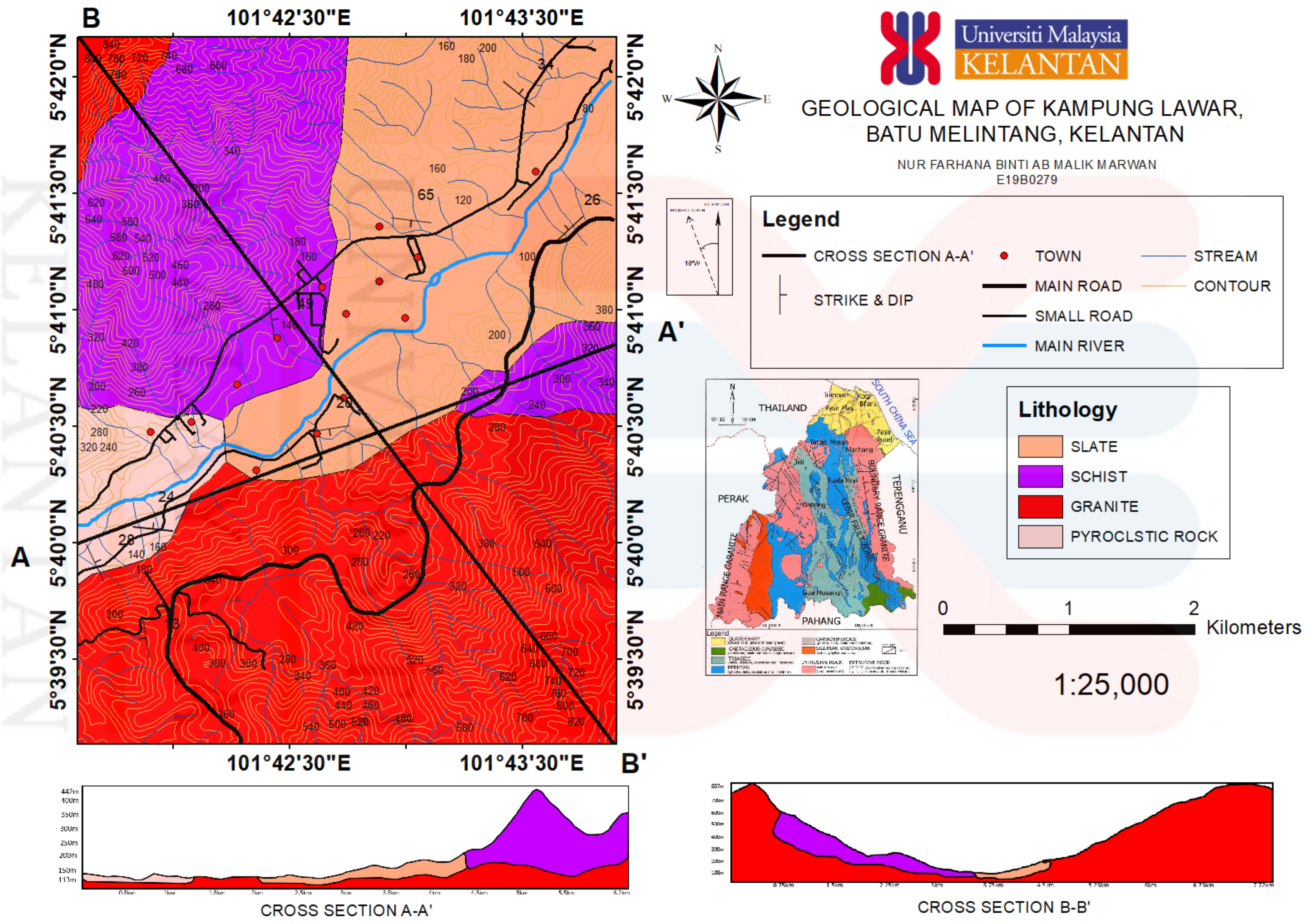


Figure 4.11: Geological Map of Kampung Lawar, Batu Melintang

4.3.1 Lithostratigraphy of Kampung Lawar

Four lithological units, including metasediments of slate, schist, granite unit, and pyroclastic rock, make up Kampung Lawar in the Batu Melintang region. The stratigraphy of the study area is shown in Table 4.4, and it can be seen from the table of stratigraphy below that pyroclastic rock, which is also present in the study area, is the oldest lithology unit. The study area's pyroclastic rock is composed of fine-grained volcanic ash that ranges in color from light grey to greenish, and the surrounding rock is a medium-grained igneous rock that contains mafic and (60–70%) muscovite minerals.

Pink and grey granite was discovered for a granite unit from the Kampung Lawar area. Pink granite outcrops are older than grey granite ones, according to an earlier study. Orthoclase is abundant in pink granite, while plagioclase is abundant in grey granite, hence the granite unit can be classified depending on the minerals it contains. In the study area's south and east, granite unit outcrops can be seen. Triassic-era granite is present in the research area. This research also discovered schist. Foliated metamorphic rock is schist. Triassic-era schist was discovered in the study region. The rock is glossy, varying in colour from lighter to darker, and has a foliated texture. With the naked eye, the grain size is generally fine to medium grain.

In the study area, metasediment rock (slate) with a recent age in the Cretaceous period was the youngest lithology. In the research area, slate was found in the Pergau River's main channel. Metasedimentary rocks formed from the Telong Formation revealed the metamorphism of greenschist into the amphibolite depositional environment, which may have been impacted by the interactions between contact and local metamorphism.

As a result, the metamorphic rock of phyllite is the oldest lithology unit in the Kampung Lawar, Batu Melintang area, followed by the granite unit, pyroclastic rock, schist, and the youngest lithology unit, metasediment.

Table 4.4: Stratigraphy of Kampung Lawar, Batu Melintang

<table>
<tr><th>ERA</th><th>PERIOD</th><th>FORMATION/ UNIT</th><th>STRATIGRAPHIC COLUMN</th><th>LITHOLOGY</th><th>PETROGRAPHY ANALYSIS</th></tr>
<tr><td rowspan="3">MESOZOIC</td><td rowspan="2">CRETACEOUS</td><td rowspan="3">TELONG FORMATION</td><td rowspan="3"></td><td>Quartzite intrusion with meta-sedimentary rock of slate, fine grain</td><td>The metamorphism of greenschist into the amphibolite depositional environment, which was revealed by metasedimentary rocks, may have been influenced by the interactions between a contact and local metamorphism.</td></tr>
<tr><td>The rock is glossy, varying in colour from lighter to darker, and has a foliated texture. With the naked eye, the grain size is generally fine to medium grain.</td><td>Medium-grained metamorphic rocks with prominent schistosity are known as schist. This indicates that the rock is made up of mineral grains that can be seen clearly using a low-power hand lens and are orientated to make the rock easily break into thin flakes or plates.</td></tr>
<tr><td>TRIASSIC</td><td>Coarse grain of igneous to metamorphic</td><td>Granite consists of light pink with brown Smokey</td></tr>
</table>

MESOZOIC	TRIASSIC	TELONG FORMATION		layered with pink and grey granite	quartz characteristics with major in biotite, plagioclase, and k-feldspar minerals.
				Light grey to greenish fine grain pyroclastic rock flow deposits ash layer of volcanic rock	The outcrop of this surrounding rock consists of medium-grain igneous rock with (60 – 70%) muscovite minerals as well as mafic minerals.

4.3.2 Unit explanation of rock lithology

a. Pyroclastic Rock Unit

A convective movement of hot gases, solidified lava, and volcanic ash is called a pyroclastic flow. It occurs during particular volcanic eruptions. A pyroclastic flow's extreme heat will burn anything in its path. The speed cap was 200 m/s. Pyroclastic texture is the result of the explosive fragmentation of volcanic material, including country rock, phenocrysts, and magma (typically the light, frothy pumice type and glass fragments known as shards). They have the same bits and grains as sedimentary rocks despite being totally composed of volcanic materials, and they can be changed by wind and water flow.

Figure 4.12: Pyroclastic Rock. (A) Pyroclastic Rock outcrop. (B) Pyroclastic rock hand specimen

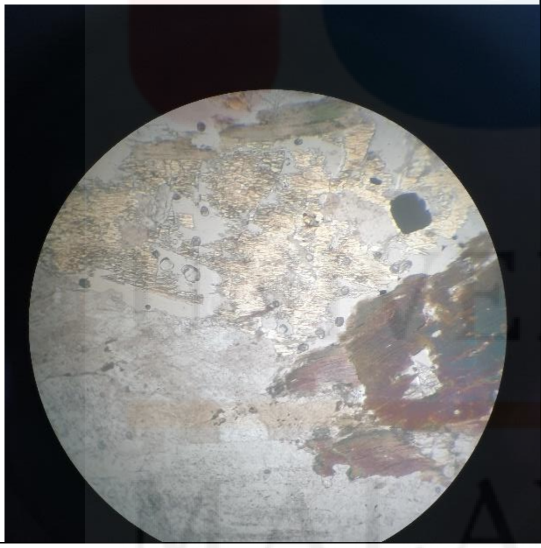
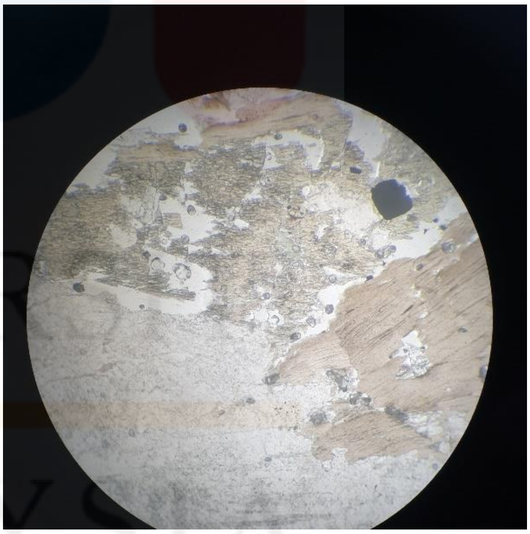
Table 4.5: Description of Pyroclastic Rock.

Sample code	F411PR	**Location**	Kashmir, Batu Melintang
Coordinate	N 5° 66’ 98’’ / E 101° 69’ 78’’		
Rock Name	Pyroclastic Rock		
Colour	Dark grey to greenish		
Texture	Fine grained volcanic ash		
Domination	Fragment dominant		

Thin section Analysis	
Minerals	**Description**
Volcanic fragment	show that the matrix consists of fine-grained vitric and lithic ash
Plagioclase	Colourless in PPL, black to white pleichroism, euhedral.
Pyroxene	Directions of cleavage cannot be seen clearly and dark brown and green colour in XPL and pale brown in PPL.
Quartz	Colorless in PPL, pale grey or white pleiochroism, low relief, and no twinning.
Apatite	Apatite crystals are small and hard to detect in thin section. high relief.
Description for minerals	Rapid cooling of magma during eruption prevents the formation of primary minerals and, therefore, pyroclastic materials contain mainly vesicular, volcanic glass. The physical and chemical properties of tuff are determined mainly by its mineralogical composition and weathering stages.

Description

A pyroclastic texture exhibits a mixture of volcanic ash, pumice, and rock pieces. Only the rock pieces and pumice, which contain vesiculated, low-density pumice formed from the collapse of an eruption column, may be distinguished from the extremely fine-grained ash.

XPL	PPL
	

Magnificent : 10x/0.25 P magnificent

b. Granite Rock Unit

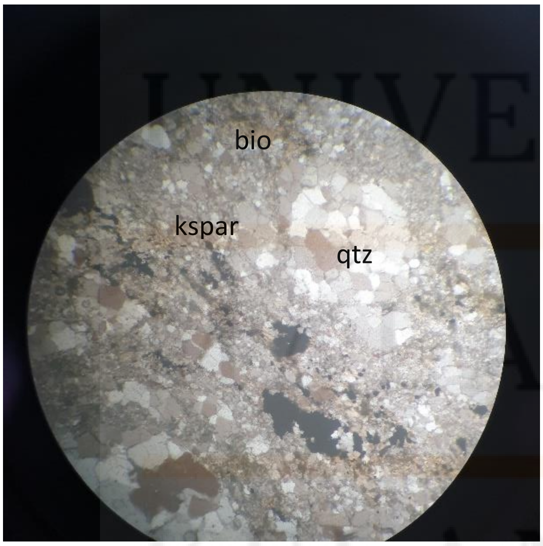
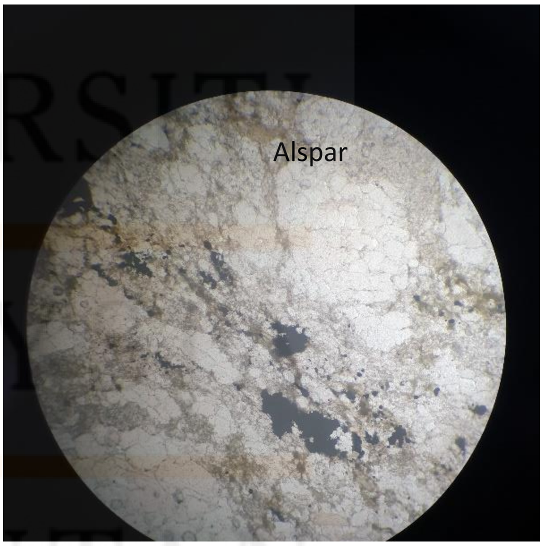
The lithology that was discovered is granite, according to the stratigraphy of Batu Melintang, which is connected to the Kampung Lawar area. In the research area, four different kinds of granite have been found. Physical properties have led to the classification of this granite type as pink granite because of its light pink colour. This outcrop can be seen near Khasmir in the Batu Melintang and Lata Turbo areas, as well as on the road leading there. Plagioclase accounts for 30% of the mineral makeup, biotite for 20%, and quartz for 50%. Pink and grey granite share a large portion of the same mineral makeup, however, grey granite differs significantly in volume %. The research area's biotite granite has a somewhat high plagioclase mineral concentration. The granite's grey colour is a result of the mineral plagioclase. As seen in the petrography analysis image in Table 4.6, there are also abundant amounts of quartz and biotite minerals.

F304PG

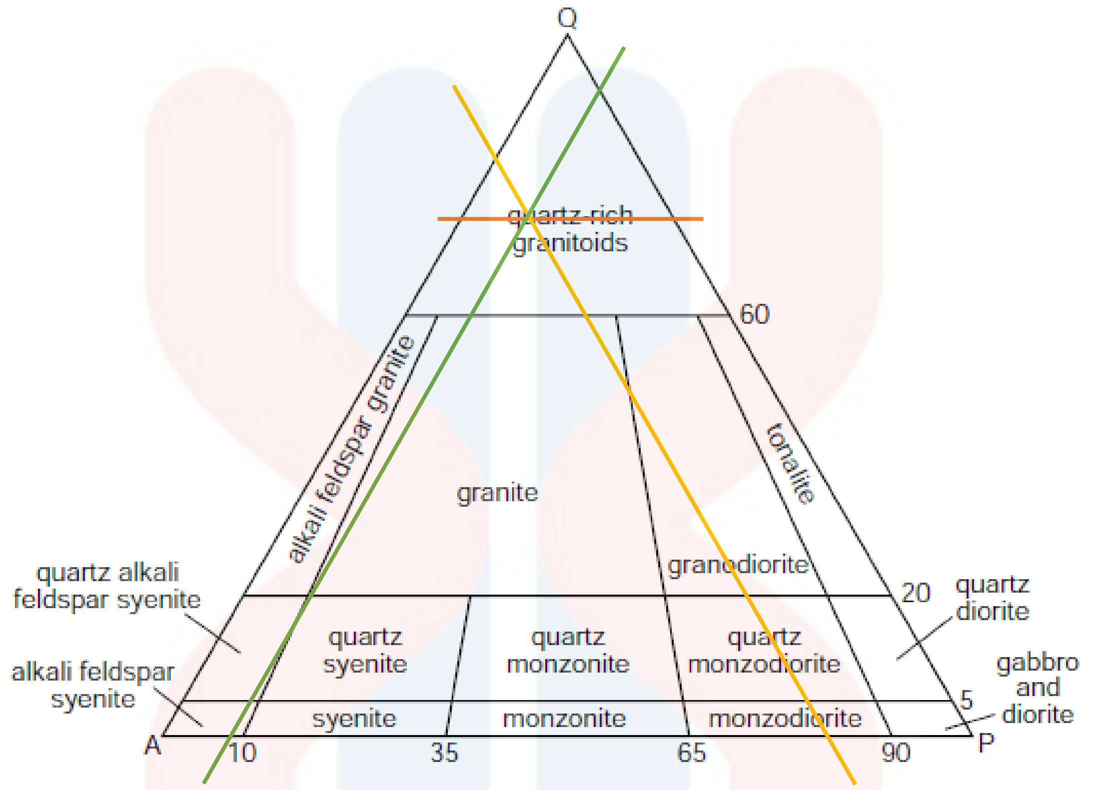
Figure 4.13: Pink Granite. (A) Pink Granite outcrop. (B) Pink Granite rock hand specimen

Table 4.6: Description of Pink Granite.

<table>
<tr><td>Sample code</td><td colspan="2">F304PG</td><td>Location</td><td>Lata Turbo, Batu Meintang</td></tr>
<tr><td>Coordinate</td><td colspan="4">N 5° 66’ 19’’ / E 101° 69’ 09’’</td></tr>
<tr><td>Rock Name</td><td colspan="4">Pink Granite</td></tr>
<tr><td>Colour</td><td colspan="4">Pink to greyish colour quartz</td></tr>
<tr><td>Texture</td><td colspan="4">Fine grained, Phaneritic with degree of crystallinity is holocrystalline. Subhedral and hypidiomorphic of crystal relationship.</td></tr>
<tr><td colspan="5">Thin section Analysis</td></tr>
<tr><td>Minerals</td><td colspan="4">Description</td></tr>
<tr><td>Quartz</td><td>77%</td><td colspan="3">Colorless in PPL, pale pinkish or white to dark black pleiochroism, low relief, and no twinning.</td></tr>
<tr><td>Biotite</td><td>10%</td><td colspan="3">Low relief, anhedral, and brownish to yellow with dark brown to black pleiochroic haloes.</td></tr>
<tr><td>Plagioclase</td><td>1%</td><td colspan="3">Colourless in PPL, black to white pleichroism, subhedral.</td></tr>
<tr><td>Feldspar</td><td>3%</td><td colspan="3">The twinning of altered feldspar is unclear, and the mineral appears to have been split into very fine crystal.</td></tr>
<tr><td>Alkali feldspar</td><td>9%</td><td colspan="3">Pleichroism from black to light grey, subhedral, with a 13° extension angle</td></tr>
<tr><td colspan="5">Description

High pleochroism is present in biotite. One of the minerals with the strongest colorations seen in thin sections when viewed under a microscope is biotite, which has pleochroism. Biotite has an extensional angle of 17. Additionally, some minerals exhibit fine grain features when examined under a microscope.</td></tr>
<tr><td colspan="3">XPL

</td><td colspan="2">PPL

</td></tr>
<tr><td colspan="5">Magnificent : 10x/0.25 P magnificent</td></tr>
</table>

QAP DIAGRAM



F302GG

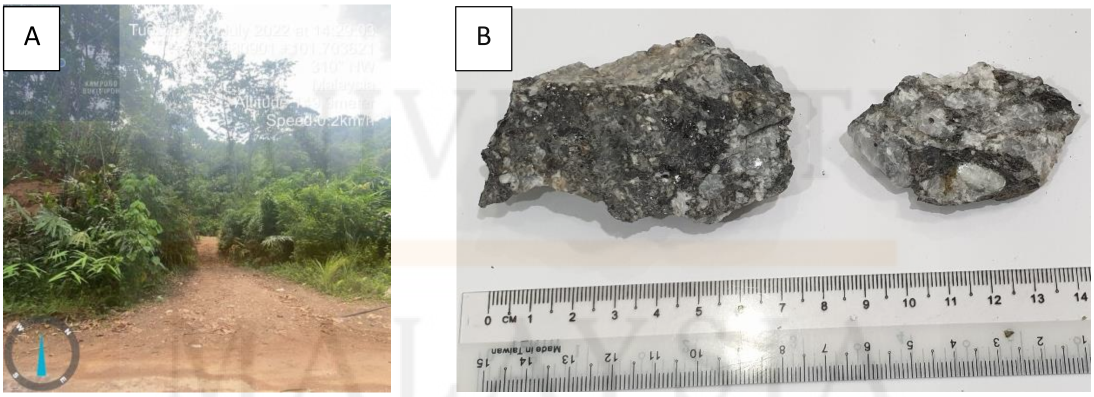


Figure 4.14: Grey Granite. (A) Grey Granite outcrop. (B) Grey Granite rock hand specimen

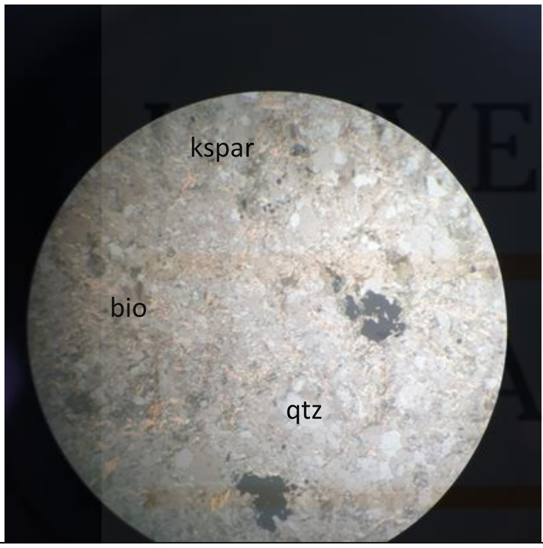
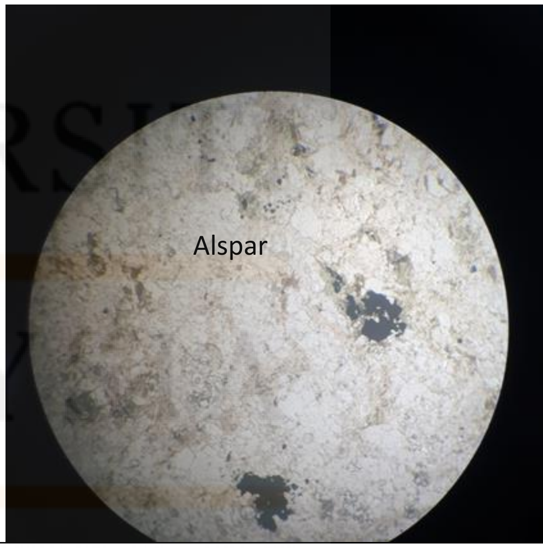
Table 4.7: Description of Grey Granite.

Sample code	F302GG	**Location**	Road to Kampung Lawar
Coordinate	N 5° 68’ 09’’ / E 101° 70’ 36’’		

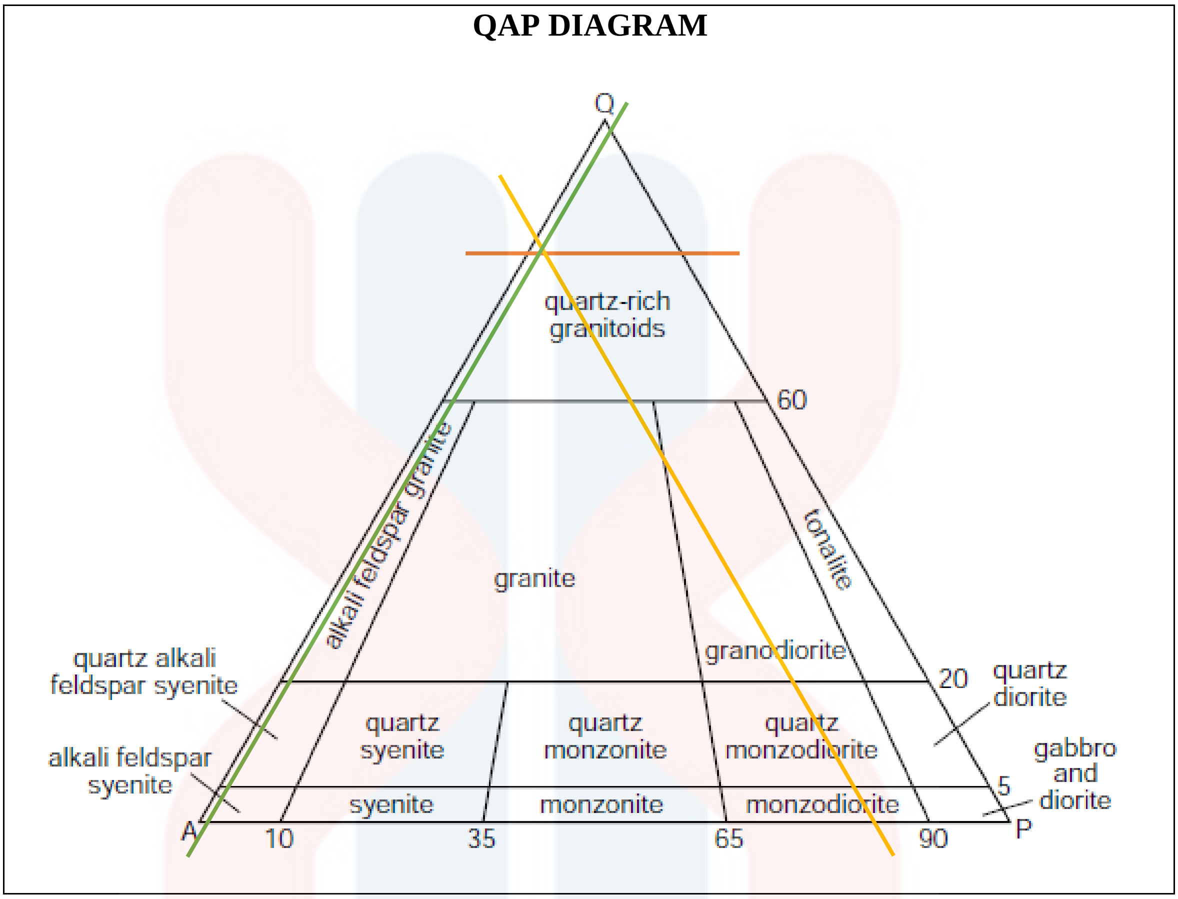
Rock Name	Grey Granite	
Colour	Grey colour quartz	
Texture	Fine grained, Phaneritic with degree of crystallinity is holocrystalline. Subhedral and hypidiomorphic of crystal relationship.	
Thin section Analysis		
Minerals	**Description**	
Quartz	78%	Colourless in PPL, light grey or white to dark black pleiochroism, low relief, no twinning.
Biotite	12%	Low relief, anhedral, and brownish to yellow with dark brown to black pleiochroic haloes.
Plagioclase	1%	Subhedral, colourless, black to white pleichroism in PPL.
Feldspar	5%	The twinning of altered feldspar is unclear, and the mineral appears to have been split into very fine crystal.
Alkali feldspar	4%	Pleichroism in the subhedral range of black to light grey, with a 37° extension angle.

Description

High pleochroism is present in biotite. One of the minerals with the strongest colorations seen in thin sections when viewed under a microscope is biotite, which has pleochroism. Biotite has an extensional angle of 29. Additionally, some minerals exhibit fine grain features when examined under a microscope.

XPL	PPL
	

Magnificent : 10x/0.25 P magnificent



F309GM

Figure 4.15: Granite Metamorph. (A) Granite Metamorph rock hand specimen

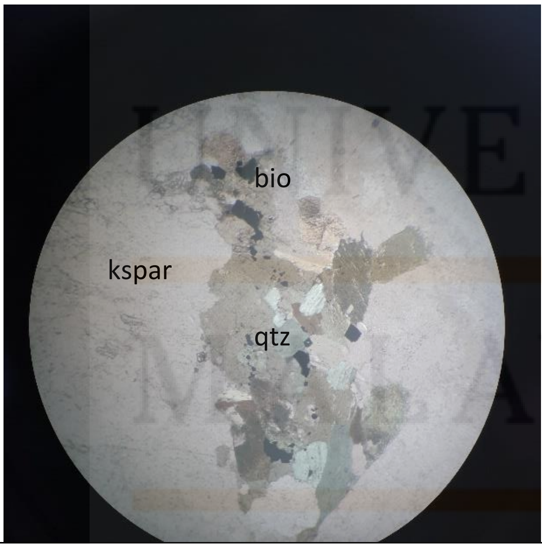
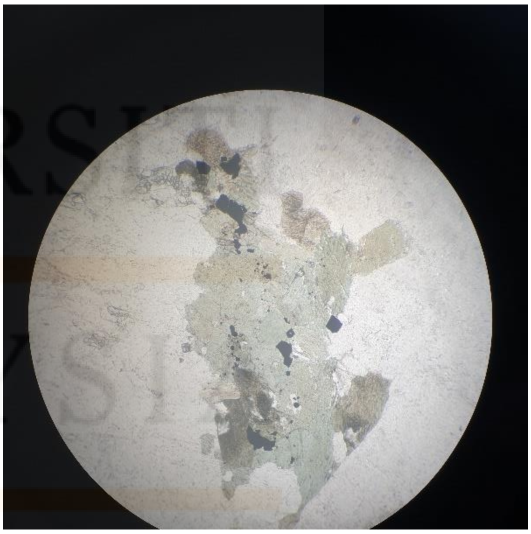
Table 4.8: Description of Granite Metamorph.

Sample code	F309GM	**Location**	Road near Kashmir
Coordinate	N 5° 68’ 09’’ / E 101° 70’ 36’’		

Rock Name	Granite Metamorph	
Colour	Grey colour quartz	
Texture	Fine grained, Phaneritic with degree of crystallinity is holocrystalline. Subhedral and hypidiomorphic of crystal relationship.	
Thin section Analysis		
Minerals	**Description**	
Quartz	45%	Low relief, no twinning, light grey or white to dark black pleiochroism, and colourless in PPL.
Biotite	12%	Low relief, anhedral, and brownish to yellow with dark brown to black pleiochroic haloes.
Plagioclase	2%	Subhedral, colourless, black to white pleichroism in PPL.
Feldspar	26%	The twinning of altered feldspar is unclear, and the mineral appears to have been split into very fine crystal.
Alkali feldspar	15%	Pleichroism in the subhedral range of black to light grey, with a 30° extension angle.

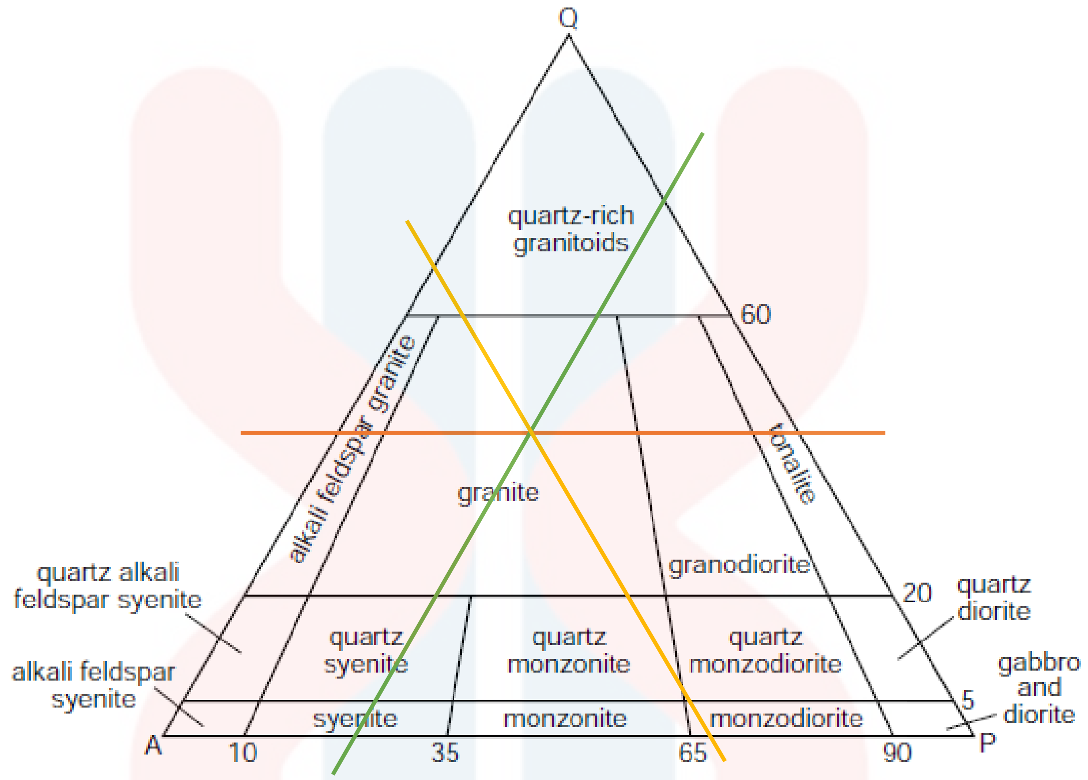
Description

High pleochroism is present in biotite. One of the minerals with the strongest colorations seen in thin sections when viewed under a microscope is biotite, which has pleochroism. Biotite has an extensional angle of 20. Additionally, some minerals exhibit fine grain features when examined under a microscope.

XPL	PPL
	

Magnificent : 10x/0.25 P magnificent

QAP DIAGRAM



F307PGM

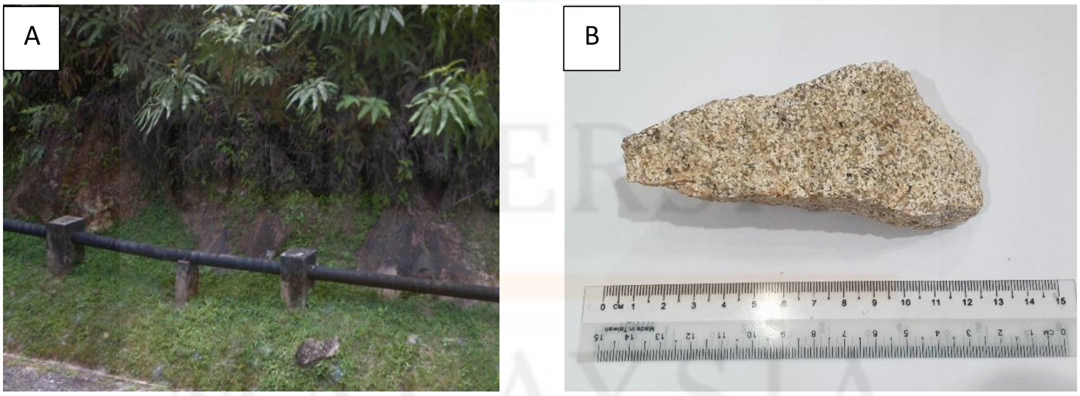


Figure 4.16: Pink Granite. (A) Pink Granite outcrop. (B) Pink Granite rock hand specimen

Table 4.9: Description of Pink Granite.

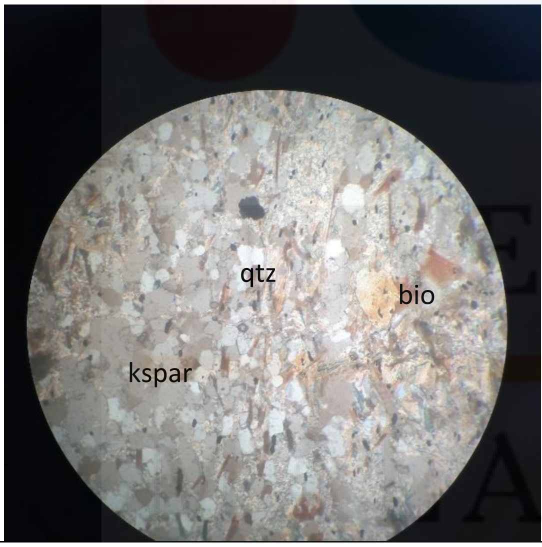
Sample code	F307PGM	**Location**	Road near Lata Turbo
Coordinate	N 5° 70' 18'' / E 101° 68' 10''		
Rock Name	Granite Metamorph		

Colour	Grey colour quartz	
Texture	Fine grained, Phaneritic with degree of crystallinity is holocrystalline. Subhedral and hypidiomorphic of crystal relationship.	
Thin section Analysis		
Minerals	**Description**	
Quartz	55%	Low relief, no twinning, light grey or white to dark black pleiochroism, and colourless in PPL.
Biotite	30%	Low relief, anhedral, and brownish to yellow with dark brown to black pleiochroic haloes.
Plagioclase	1%	Subhedral, colourless, black to white pleichroism in PPL.
Feldspar	7%	Unable to distinguish the twinning in altered feldspar, the mineral appears to have been fractured into very fine crystal.
Alkali feldspar	7%	Subhedral, 5° extension angle, pleichroism in the range of black to light grey.

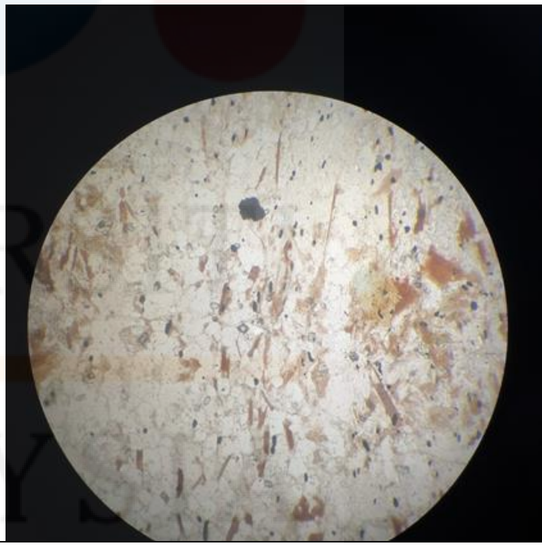
Description

High pleochroism is present in biotite. One of the minerals with the strongest colorations seen in thin sections when viewed under a microscope is biotite, which has pleochroism. Biotite has an extensional angle of 19. Additionally, some minerals exhibit fine grain features when examined under a microscope.

XPL

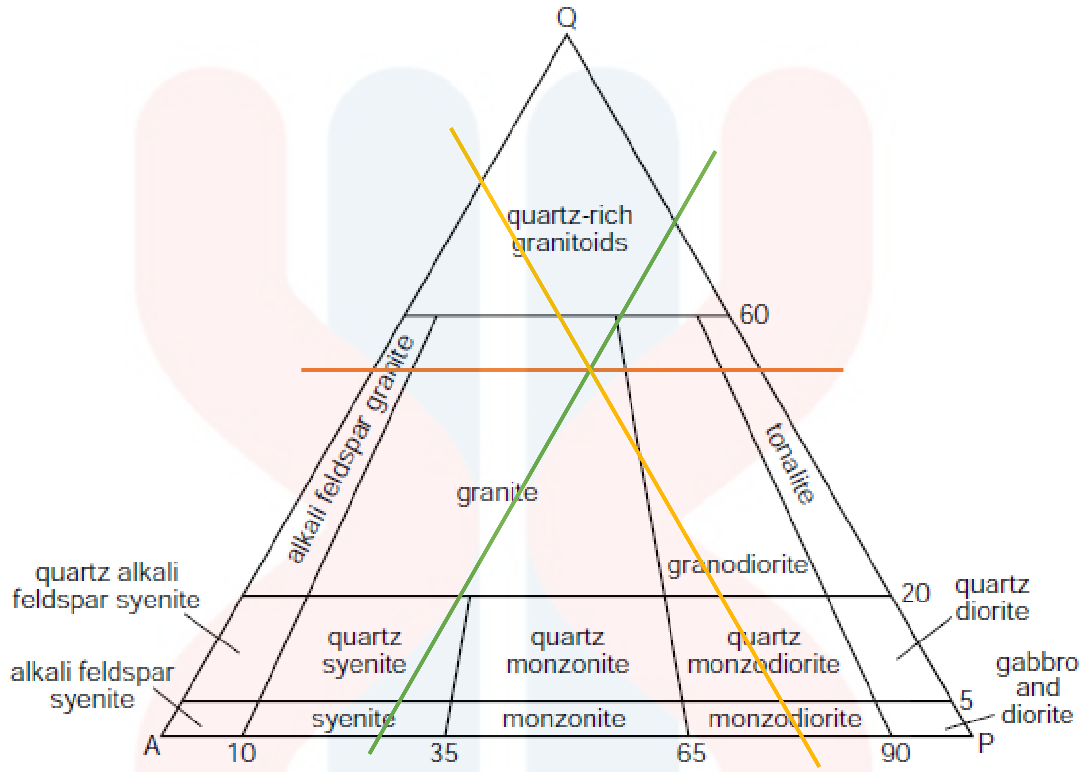


PPL



Magnificent : 10x/0.25 P magnificent

QAP DIAGRAM



Q
quartz-rich granitoids
60
alkali feldspar granite
tonalite
granite
granodiorite
quartz alkali feldspar syenite
20
quartz diorite
quartz syenite
quartz monzonite
quartz monzodiorite
alkali feldspar syenite
gabbro and diorite
5
syenite
monzonite
monzodiorite
A
10
35
65
90
P

c. Muscovite Schist Unit

Field observations indicate that the lithology is schist. The South-West Highway is close to where the sample was taken. Physical features indicate that the sample is brown to dark brown in colour from weathering. Schist has a foliated, medium- to coarse-grained texture. Quartz makes up 60% of the samples' mineral makeup, followed by plagioclase (30%) and muscovite (10%). Under a microscope, the minerals appear to be lined up parallel to one another and form a schistosity. When the plagioclase mineral is seen with cross-plane polarisation, the reflectivity is significant.

Figure 4.17: Schist. (A) Schist rock hand specimen

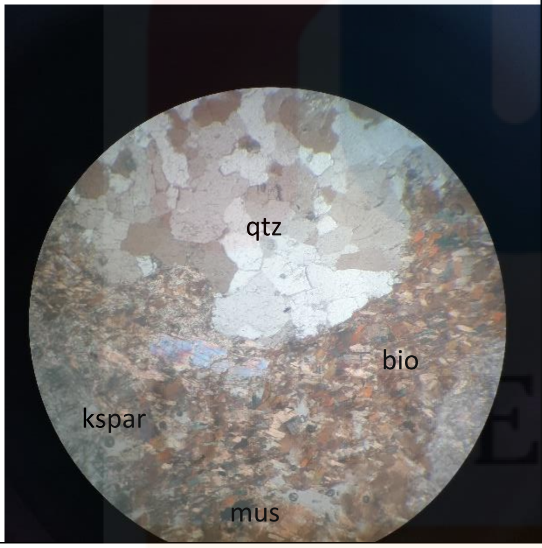
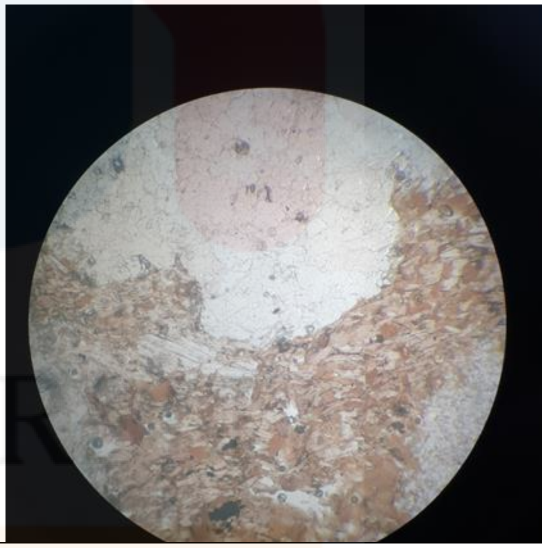
Table 4.10: Description of Schist.

Sample code	F101MS	**Location**	Road to Kampung Lawar
Coordinate	N 5° 67’ 38’’ / E 101° 69’ 42’’		
Rock Name	Muscovite Schist		
Colour	Silver to greyish colour		
Texture	Its platy grains are aligned in a common orientation, and that allows the rock to be split easily in the direction of the grain orientation.		
Domination	The dominant visible mineral in this schist is muscovite.		
Thin section Analysis			
Minerals	**Description**		

Muscovite	Basal cleavage may be seen as parallel lines and the material is colourless in PPL. It also has a monoclinic crystal habit.
Biotite	Brown, green, or reddish color, strong brown, yellowish brown, or greenish brown pleochroism in PPL, has a perfect cleavage, no twining
Quartz	Colourless in PPL, low relief, 1st order gray, undulatory extinction, will appear black through full rotation if looking down the C axis
Feldspar	The twinning of altered feldspar is unclear, and the mineral appears to have been split into very fine crystal.

Description

A medium-grained metamorphic rock with prominent schistosity is called schist. This indicates that the rock is made up of mineral grains that can be seen clearly using a low-power hand lens and are orientated to make the rock easily break into thin flakes or plates.

XPL	PPL
	

Magnificent : 10x/0.25 P magnificent

d. **Metasediment (Slate)**

Slate structures in the study area contain metasediment units. The outcrops were mostly discovered in the hilly landform that was made up of rubber tree and palm oil tree plantations in the northeastern corner of the research region. The stratigraphy of Batu Melintang indicates that the slate rocks in Kampung Lawar date from the Cretaceous period. The slate was identified by its slaty cleavage based on the observation of a slate outcrop in the research region. On every slate outcrop in the study area, slatey cleavages are clearly defined. On the slate outcrops, there were additional geological features like joints, fractures, and others. The slates in the study area range in colour from greyish-black to grey-greenish and some of them had undergone very severe weathering processes since some of the outcrops had already broken down and disintegrated due to biological and chemical weathering.

Figure 4.18: Metasediment (Slate). (A) Metasediment (Slate) outcrop. (B) Metasediment (Slate) rock hand specimen

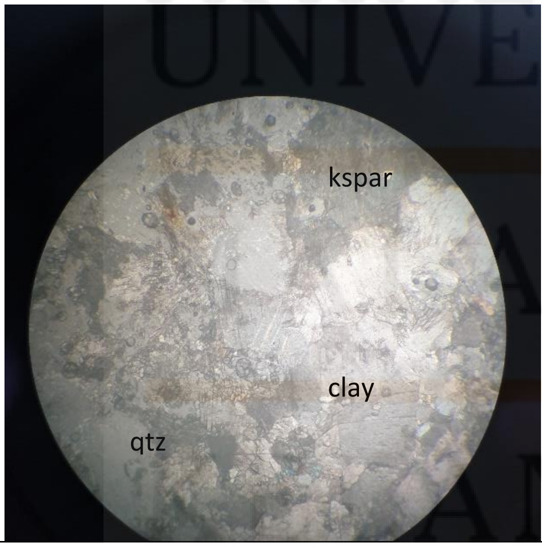
Table 4.11: Description of Metasediment (Slate).

Sample code	F305MS	**Location**	Kashmir, Batu Melintang
Coordinate	N 5° 69’ 35’’ / E 101° 72’ 27’’		
Rock Name	Metasediment (Slate)		
Colour	Dark grey		
Structure	In XPL, there is a folded structure (alternating of silty and clay materials)		
Texture	Very fine grained, foliated, the sortation is moderate sorted		
Domination	Matrix dominated		
Thin section Analysis			
Minerals	**Description**		
Feldspar	Lack of colour, no twinning, alteration (broken into fragments), anhedrality, and low relief		
Clay minerals	Very fine-grained feldspar mineral that has undergone modification.		
Quartz	Subhedral, low relief, no twinning, colourless in PPL, light grey or white to dark black pleiochroism.		

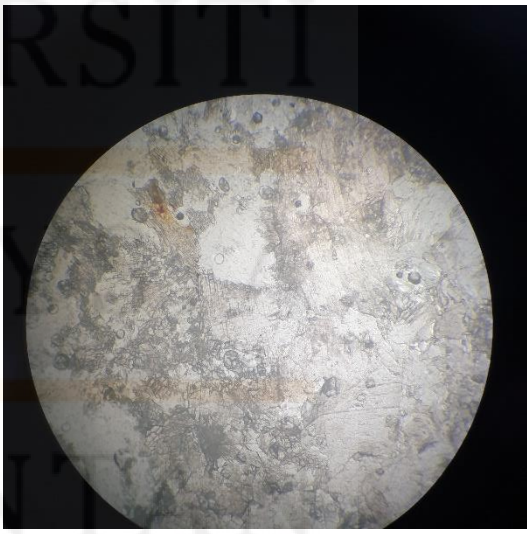
Description

Through low-grade regional metamorphism, slate is transformed from an original shale-type sedimentary rock made of clay or volcanic ash into a fine-grained, foliated, homogenous metamorphic rock. It is the foliated metamorphic rock with the finest grain size.

XPL



PPL



Magnificent : 10x/0.25 P magnificent

4.4 Structural geology

This section discusses all of the structural geology present in the research area, including joints, faults, folds, and contacts. This section is crucial to geologists because structural geology can reveal information about the tectonic history of the studied area, associated historical conditions, and the events that led to the deformation of the rock. Due to the forces that were applied to the rock, it changed shape, location, and volume as it deformed.

Any parallel line on the study map is referred to as a lineament. Based on the location of the lineament lines that we have plotted on the map, the parallel line will identify geological features. Figure 4.19 lineament maps show a number of lineaments that may be home to geological features. However, despite lineament research, it is difficult to locate geological features in our country because of its high rate of weathering due to exposure to hot, humid weather. To find the geological structures, the accurate geological mapping should be carried out.

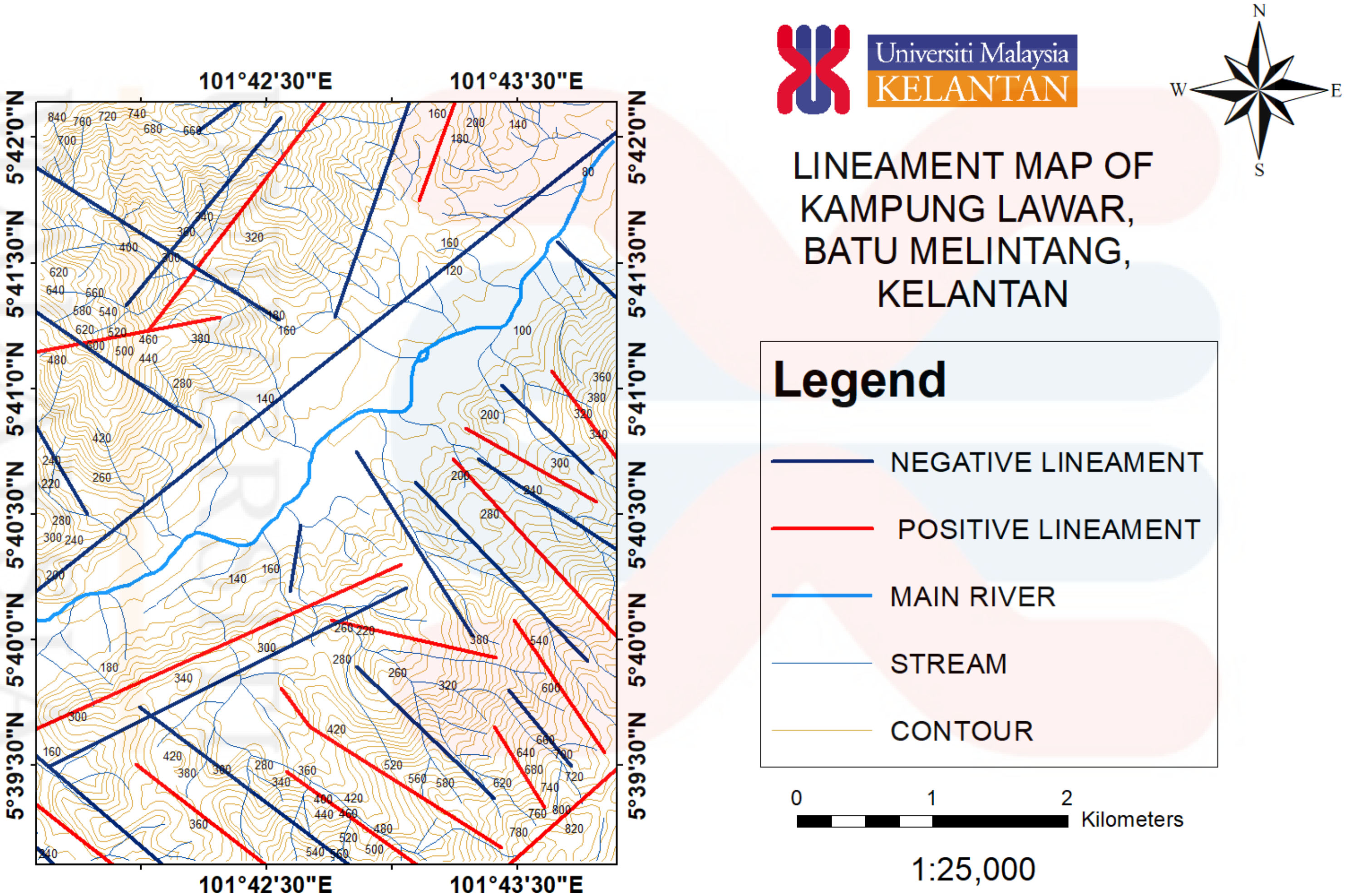


Figure 4.19: Lineament Map of Kampung Lawar, Batu Melintang

4.4.1 Folding

The coordinates of a slate rock unit were used to find a folding structure in the Kampung Lawar area. The formation of a bend or curve on the outcrop, which results in a long-lasting deformation, is known as folding. The bedding strata fold when a compressive force is applied on both sides of them, forcing the rock layers to flex freely. The fold is thought to be a syncline fold due to the severely worn outcrop in the fold area and the fact that the source of the fold cannot be determined. In an overturned fold, or overfold, where the axial plane is sharply inclined, the strata on one limb are flipped over. A recumbent fold has an axial plane that is almost horizontal. When two branches of a fold are nearly parallel to one another and hence roughly parallel to the axial plane, the fold is said to be isoclinal.

Figure 4.20: Folding structure in the study area

Figure 4.21: Overturned fold structure in the study area

4.4.2 Joint

The studied area contains a variety of joint structures. Joint analysis was carried out using GeoRose at locations in the coordinates N 05° 69' 36', E 101° 72' 71' in the Kampung Lawar Rekreasi Dendong, Batu Melintang River area of the North-East side of the study area based on the joints that were received during the fieldwork. The joint analysis of the research area and the directions of Ơ1 and Ơ3 (stress) are shown in Figure 4.22.

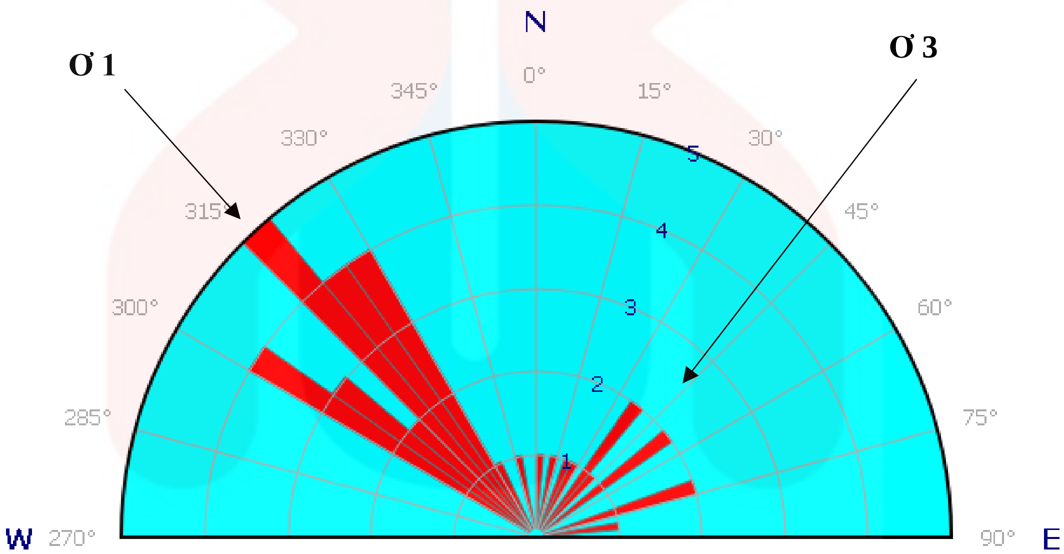


Figure 4.22: Joint analysis of slate outcrops in coordinates of N 05° 69’ 36’’, E 101° 72’ 70’’

The Kampung Lawar area experienced high tension from one direction and moderate stress from three other directions, according to the combined analysis displayed above. Based on the stress direction, we may also predict the creation of other structures, such as faults. Figure 4.23 shows the joint structures in the study area. Natural resource development, safe building construction, and environmental safety all depend heavily on joints. Due to their enormous impact on the weathering process and rock erosion in the research region, joints have a significant impact on the topography and morphology of landscapes.

Figure 4.23: Joint on outcrop in study area.

4.4.4 Vein

The quartz vein and dyke vein are the most types of vein structures in the study area. Veins typically form during the hydrothermal process and take the form of long, regularly formed open areas in the rocks. A vein is a site where crystals can develop on planar rock cracks and fill the empty spaces; this is why it is termed a vein. The quartz vein and dyke vein that developed in the research area's metasedimentary rock of the Pergau river and pyroclastic rock at Kashmir were depicted in Figures 4.24 and 4.25 below.

Figure 4.24: Quartz vein in metasediment rock unit

Figure 4.25: Dyke vein in pyroclastic rock unit

4.5 Historical geology

In order to reconstruct and comprehend Earth's geological history, the field of historical geology applies the theories and techniques of geology. Its focal point is the alteration of the Earth's surface and subsurface caused by geologic processes. Information on stratigraphy and structural geology will reveal the order of these occurrences. According to Kelantan's general geology, three types of rock make up the majority of the Jeli area (Department of Minerals and Geoscience Malaysia, 2003). The Triassic sedimentary rocks that make up the Gunung Rabong Formation are composed of shale, siltstone, sandstone, and limestone. The Gua Musang Formation of Permian sedimentary rocks, which consists of phyllite, slate, sandstone, and limestone, is the second kind. Third place goes to granitic rock (acid intrusives).

The quaternary deposits of Batu Melintang were created in both desert and marine environments. These deposits can be divided into three formations in descending order. The formation is composed of the Gula formation, the Simpang formation, and the Beruas formation. The Colluvium and Former Floodplain parts of the Simpang formation are dominated by gravel, sand, silt, and laterite with substantial iron concreation.

CHAPTER 5

GEOCHEMISTRY OF GRANITE ROCK

5.1 Introduction

This chapter of the study focuses on using geochemical techniques to analyse and evaluate data related to grey granite and pink granite. This analysis is essential since it serves one of the goals of this thesis. XRF analysis and ICP-MS analysis are two geochemical methods applied in this study. Because the major elements, trace elements, and rare earth elements in granite well be identified, it is important to apply the geochemistry approach. To identify the tectonic setting of the granite, the major and trace elements are identified, and the granite is then classed using the S-I-A-M classification. In contrast, the REE elements are identified in order to look into the distribution of the REE elements. Four granite rock samples that were being analyzed are F309G, F30GG, F304PG, and F307PGM.

5.2 Geochemical analysis

5.2.1 Major elements

In general, significant elements like SiO_2, $Al_2 0_3$, MgO, FeO, CaO, K_2O, Na_2O, P_2O_5, TiO_2 and MnO were distributed widely in plutonic rocks. All five major element weight percentages (wt%) are shown against the major element weight percentage of SiO_2 using the Harker diagram. This important element is being examined to understand trends in granite's elemental fractionation. To minimise the loss or error of weight elements in an XRF analysis based on a Harker diagram, all main elements are normalised to 100%. The results of the main elements in four samples of granite rock are shown in Table 5.1. The greatest main components found in the rock samples were SiO_2, which ranged in concentration from 74.91% to 79.83%, and Al_2O_3, which ranged in concentration from 16.03% to 17.51% (see Figure 5.1). The lowest distribution in the research region is found in K_2O, which has a weight percentage range of 2.66% to 7.07%, and MgO, which has a percentage range of 0% to 2.92%. MgO in the F307PGM sample, however, cannot be identified.

Table 5.1: Major elements in granite rocks of study area

Major Elements	Wt (%) Normalized 100%			
	F309G (Granite)	F302Gg (Grey granite)	F304PG (Pink granite)	F307PGM (Pink granite metamorph)
SiO2	76.873	74.911	76.693	79.832
Al2O3	16.742	16.176	16.032	17.505
MgO	2.918	1.842	1.254	nd
K2O	3.467	7.071	6.029	2.663
Total (wt%)	100.000	100.000	100.000	100.000

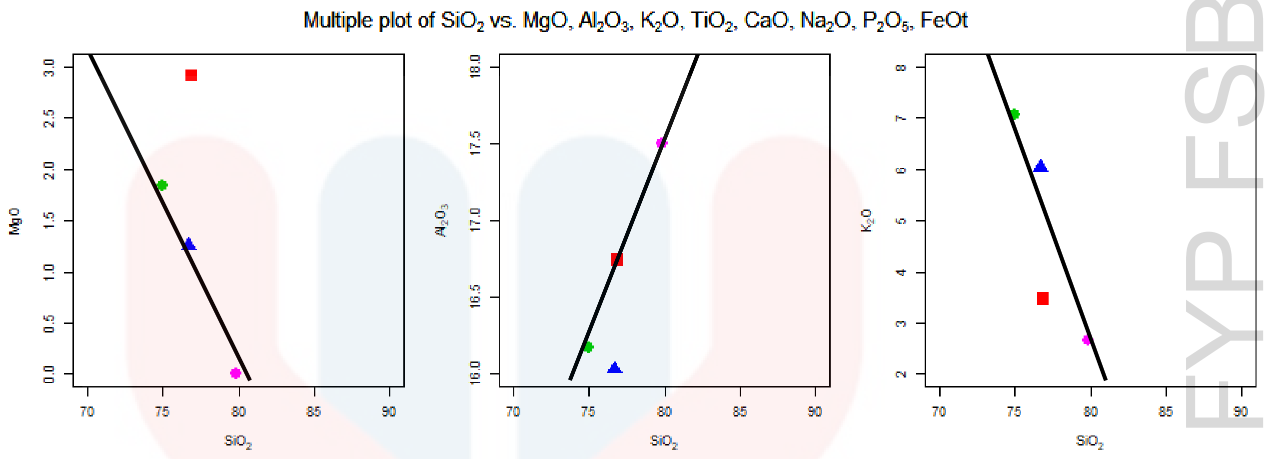


Figure 5.1: Major elements based on Harker diagram in Kampung Lawar area.

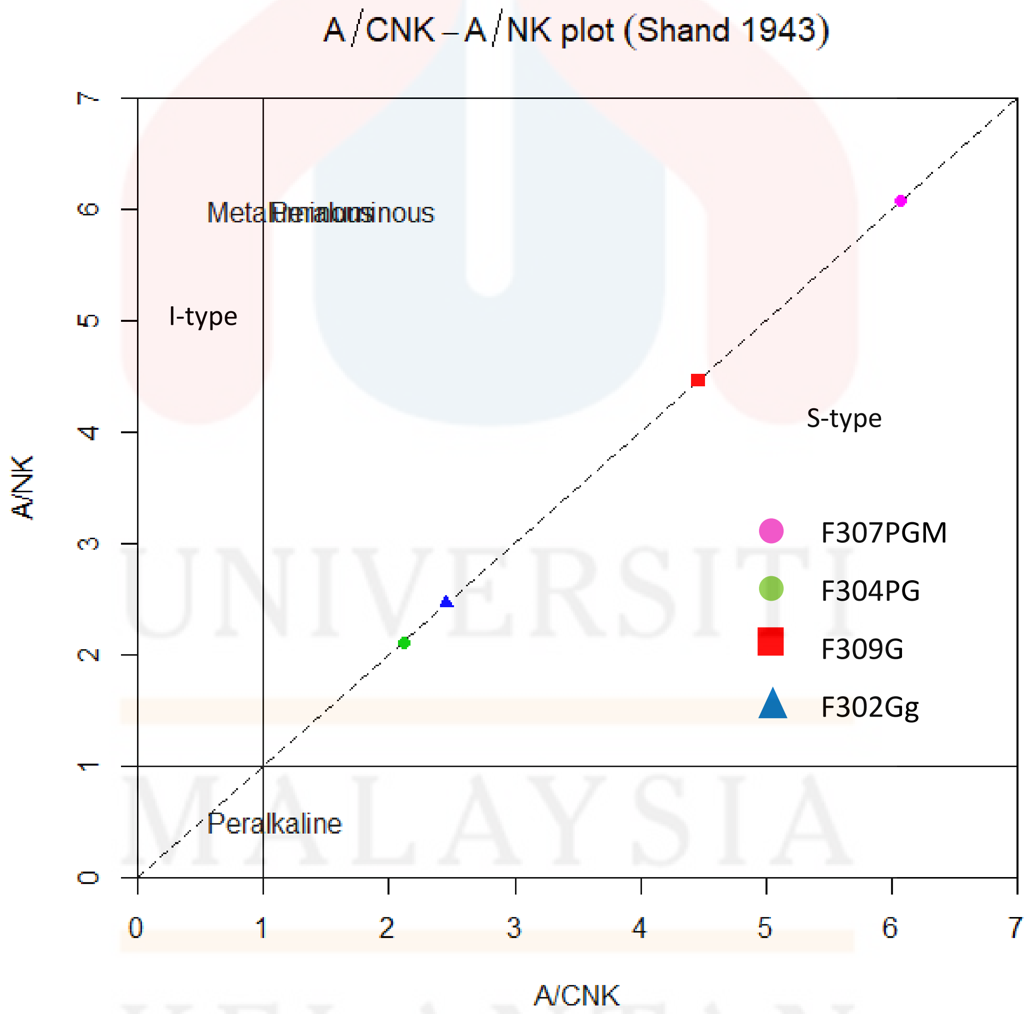


Figure 5.2: A/NK vs. A/CNK of the granite. The S-type and I-type division is after Shand (1943).

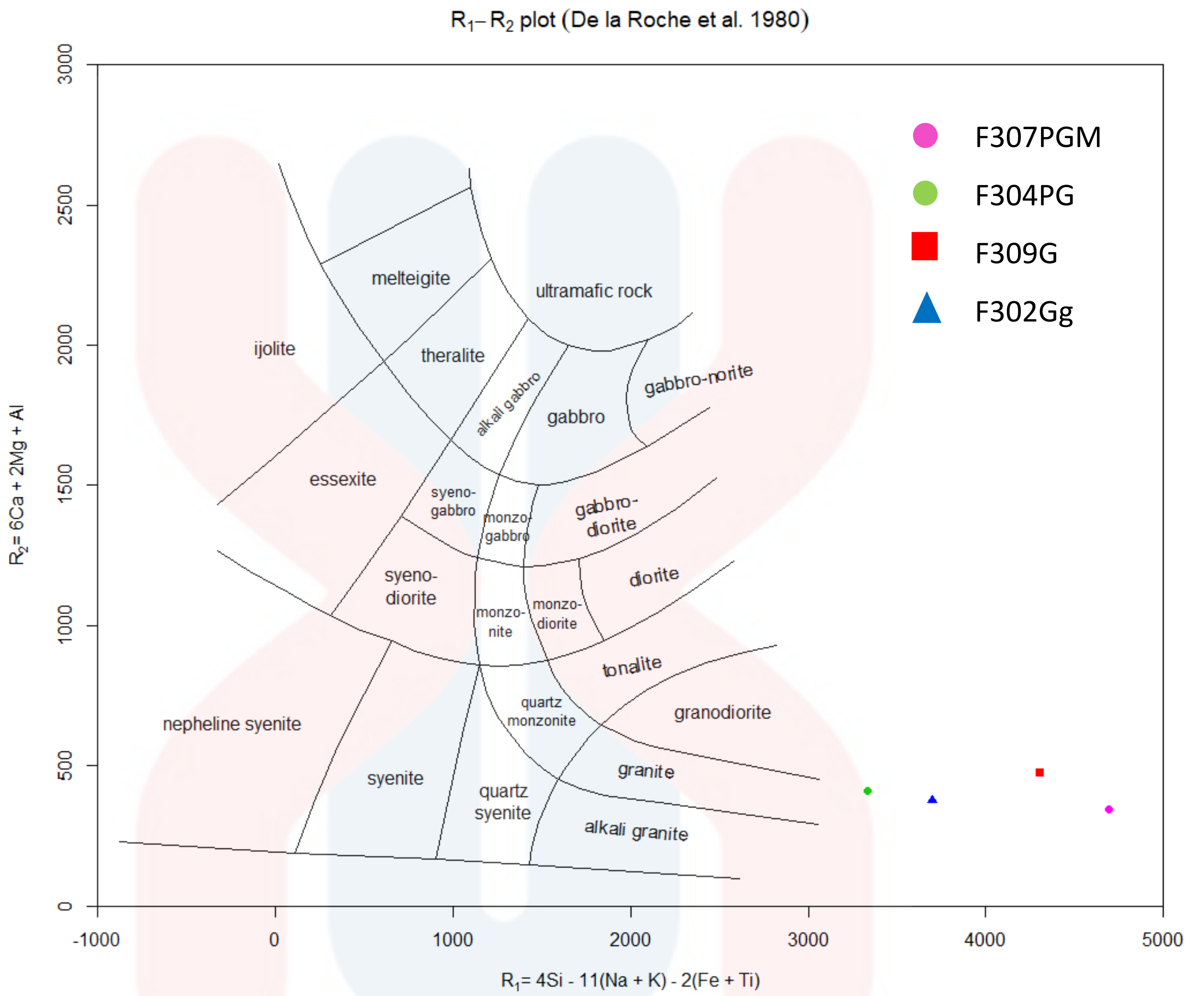


Figure 5.3: R_1-R_2 of the granite. The granite type division is after De la Roche et el. (1980).

The graph of A/NK vs A/CNK dividing the I-type or S-type granite can be seen in Figure 5.2. The outcome reveals that the S-type granite, which contains all of the key components, has the highest readings of 6 for both A/NK and A/CNK.

5.2.2 Trace elements

The number of trace elements found in rocks is reported to be less than 0.1% of parts per million (ppm), and they are measured in ppm, where 1% weight percent of an element equals 10,000 ppm. The two categories of trace elements are those that are compatible and those that are incompatible. K, Rb, Cs, Ta, Nb, U, Th, Y, Hf, Zr, and Rare Earth Elements (REE) La, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, and Lu are incompatible elements. Since they have smaller ionic radii, compatible elements like Ni, Cr, CO, V, and Sc fit easily into crystallographic positions that usually contain Mg and Fe. Table 5.2 below shows the trace elements that being obtained by granite samples of Kampung Lawar based on geochemical analysis of XRF.

Table 5.2: Trace elements in granite rocks of study area

Trace Elements	Wt (%) Normalized 100%			
	F309G (Granite)	F302Gg (Grey granite)	F304PG (Pink granite)	F307PGM (Pink granite metamorph)
P	nd	1.353	1.807	nd
S	1.894	0.328	nd	nd
Ca	23.986	29.124	42.163	53.716
Ti	8.236	8.346	5.393	2.262
V	nd	0.218	0.345	nd
Mn	1.071	0.633	0.770	1.535
Fe	62.425	54.250	42.163	37.237
Co	0.206	nd	nd	nd
Ni	0.021	0.022	nd	nd
Cu	0.062	0.022	0.027	nd

Zn	0.103	0.087	0.080	0.081
Ga	0.041	0.022	0.053	0.162
As	nd	0.022	nd	nd
Se	nd	0.022	nd	nd
Rb	0.247	0.568	0.505	2.504
Sr	0.432	0.524	2.365	0.323
Y	0.062	0.066	0.053	0.081
Zr	0.349	0.524	0.372	0.808
Nb	0.021	0.044	0.027	0.162
Sb	nd	nd	0.080	nd
Cd	0.021	nd	nd	nd
Ba	0.741	3.583	4.759	nd
La	nd	nd	0.213	nd
Hf	nd	nd	nd	nd
Pb	0.021	0.131	0.106	0.485
Th	0.062	0.087	0.106	0.404
U	nd	0.022	0.027	0.242
			nd : not identified	

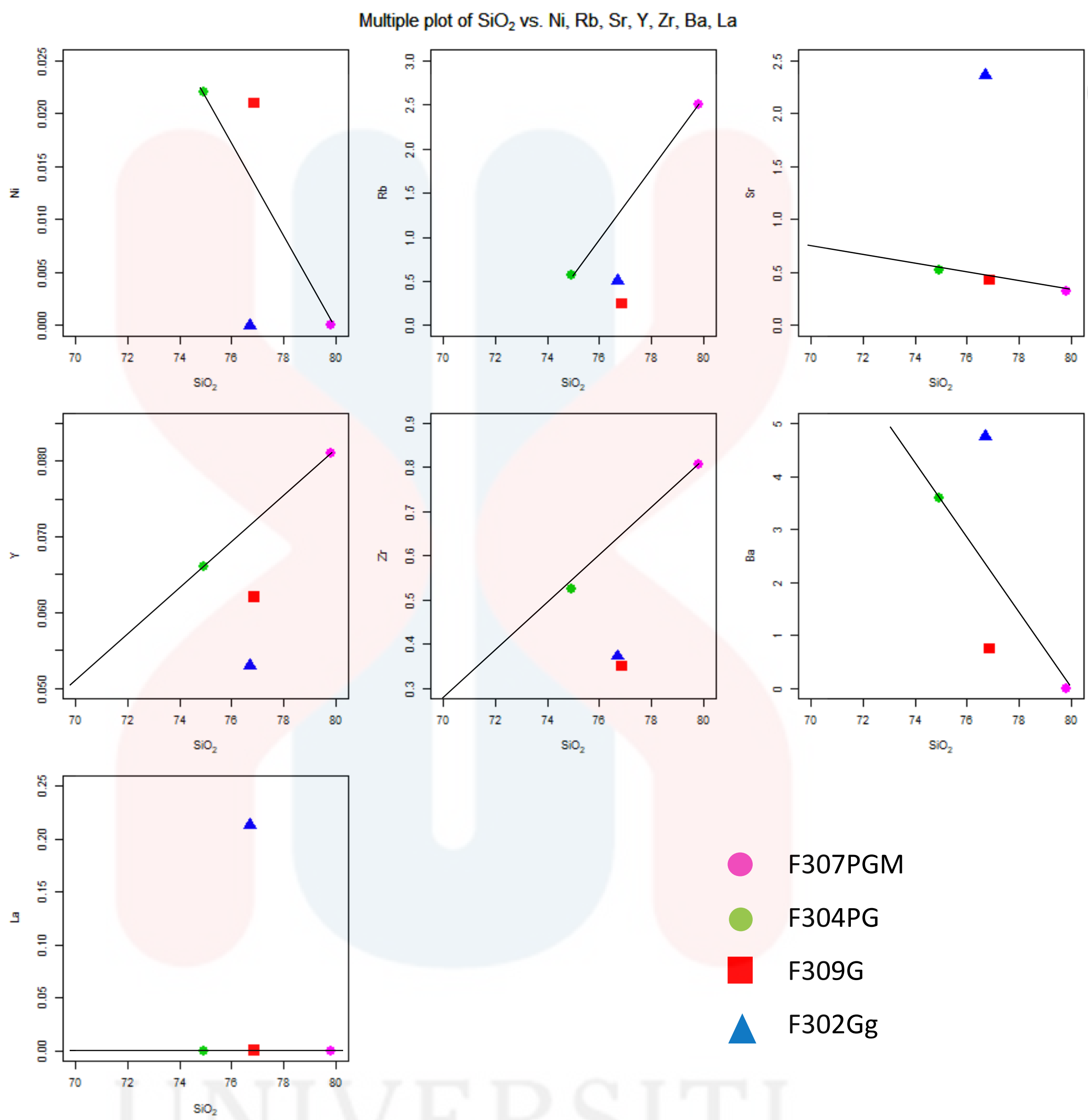


Figure 5.4: Trace elements based on Harker diagram in Kampung Lawar area.

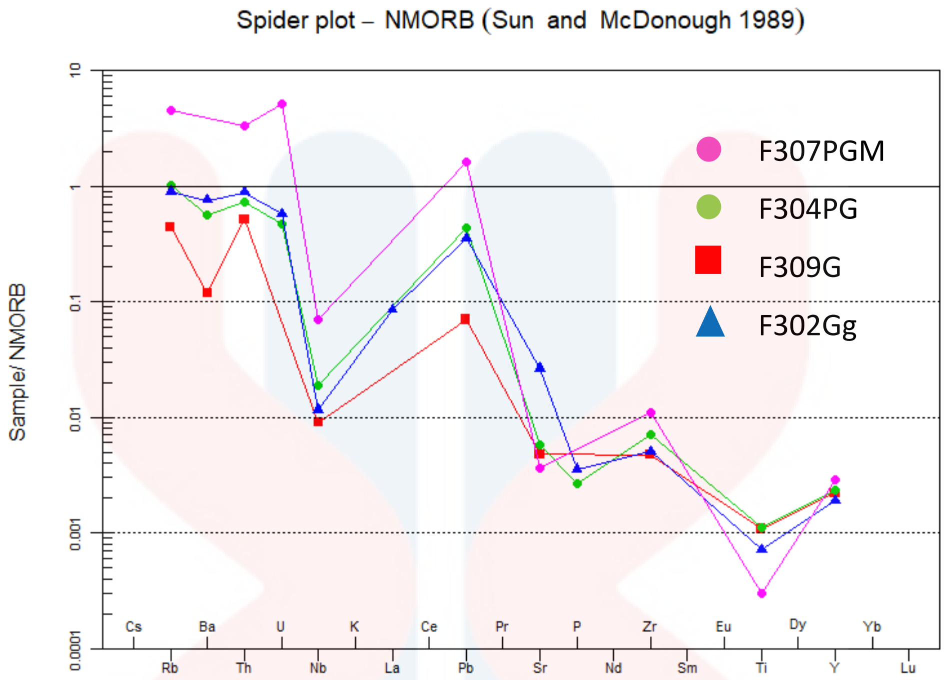


Figure 5.5: Spider plot of NMORB by Sun and McDonough 1989.

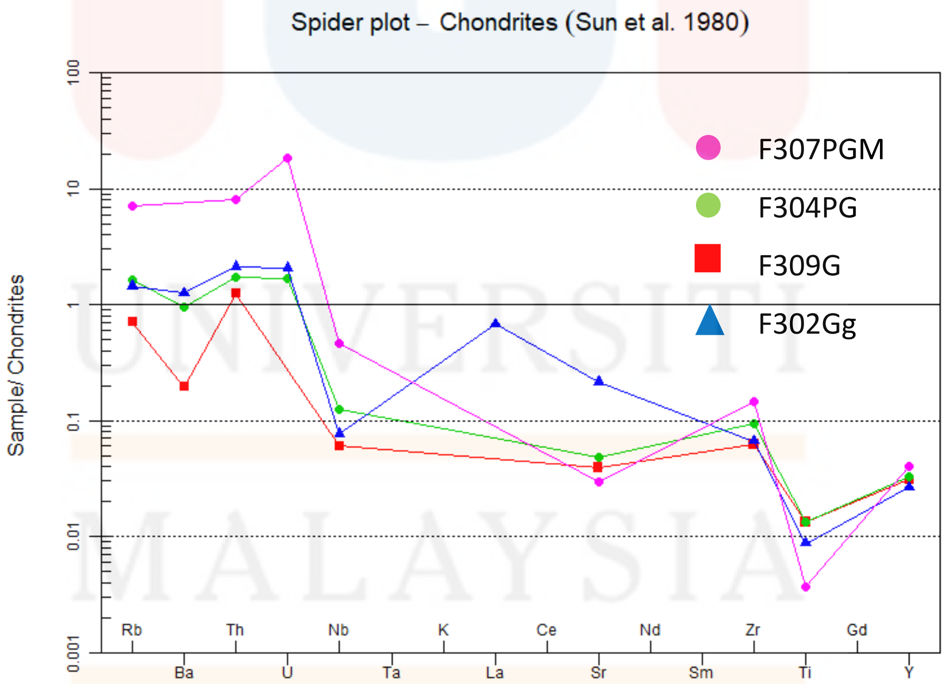


Figure 5.6: Trace element in spider plot of Sun et al. (1980), to detect the variation that indicates the magma source in subduction zone.

According to the Harker diagram in Figure 5.4 above, sample F302Gg exhibits the highest value of La, while the other three granite samples do not exhibit any La elements. Samples F302Gg and F304PG also exhibit the highest range of Ba elements, ranging from 4 to 5, while sample F307PGM exhibits the lowest Ba value, which is 0. The graph of trace elements plotted vs. chondrite, which is based on the spider plot above, demonstrates the magma characteristic of magma that formed from magma in a subduction zone environment (O'Neill, 2016). The features of trace elements are typically seen in areas that are low in Ti and enriched in LILE of Th, U, and Zr. This may demonstrate a magma S-type property. Ti and Nb values are depleted in both the spider plot for chondrites and the spider plot for NMORB.

5.2.3 ICP-MS Analysis

The Light REE (LREE) and Heavy REE groups of REE elements are separated (HREE). The HREE is made up of Europium (Eu), Gadolinium (Gd), Terbium (Tb), Dysprosium (Dy), Holmium (Ho), Erbium (Er), Thulium (Tm), Ytterbium (Yb), Lutetium (Lu), and Yttrium. The LREE is made up of Lantahnium (La), Cerium (Ce), Praseodymium (P (Y). The distributions of LREE and HREE in two granites, measured in ppm units, are shown in Table 5.3. The table demonstrates that the LREE are lower than the HREE. However, when comparing the abundance of the two elements, Table 5.3 reveals that for F302Gg, LREE is more abundant than HREE, while for F304PG, HREE is more abundant than LREE. The lowest LREE distribution is found in F304PG with a value of ppm of 3.97220, while the highest LREE distribution is found in F302Gg with a value of ppm of 4.01094 and the highest HREE distribution is found in F304PG with a value of ppm of 4.01094. F302Gg has the largest distribution of REE concentrations overall.

Table 5.3: LREE and HREE distribution in granite

Light Rare Earth Elements (LREE)		
LREE	**F302Gg (ppb)**	**F304PG (ppb)**
La	2224.20	1061.66
Ce	2614.42	3432.11
Pr	662.47	418.20
Nd	1631.30	809.91
Sm	458.17	277.91
Total	**7590.56**	**5999.79**
Heavy Rare Earth Elements (HREE)		
HREE	**F302Gg (ppb)**	**F304PG (ppb)**
Eu	120.45	116.92
Gd	363.62	243.81
Dy	291.62	223.98
Er	170.25	152.13
Ho	240.82	234.35
Lu	490.38	488.78
Sc	581.19	523.65
Tb	443.31	430.32
Tm	188.84	186.72
Y	4010.94	3972.20
Yb	564.88	552.94
Total	**7466.3**	**7125.80**

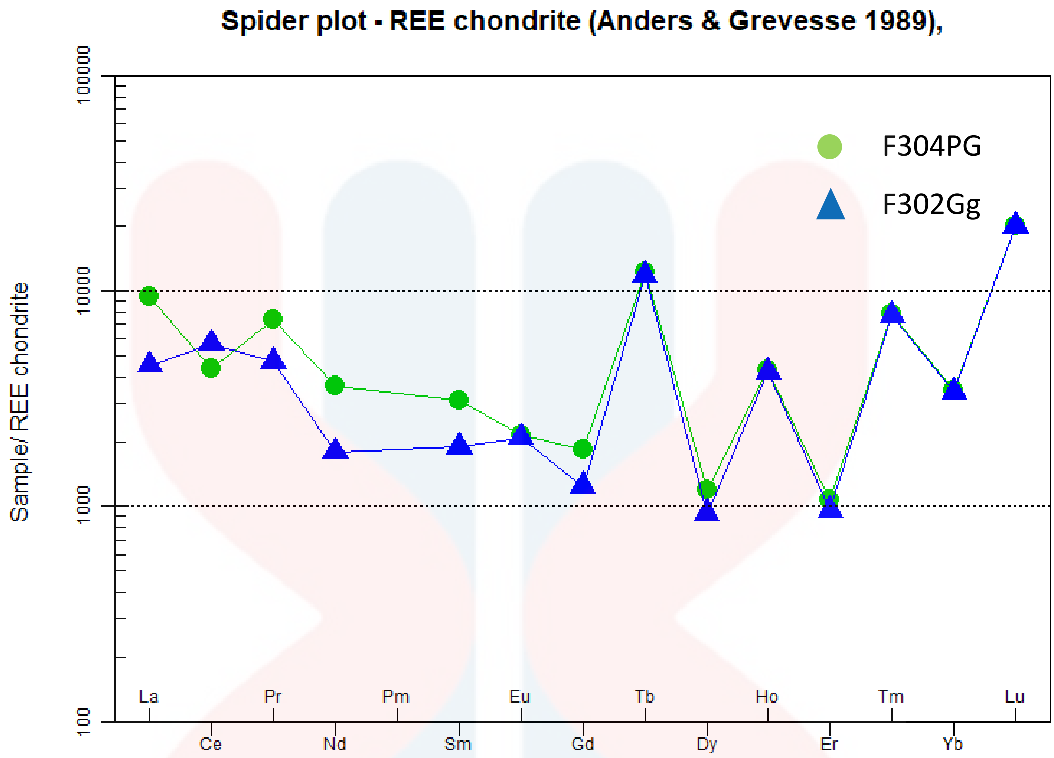


Figure 5.7: Distribution of REE in granite rock

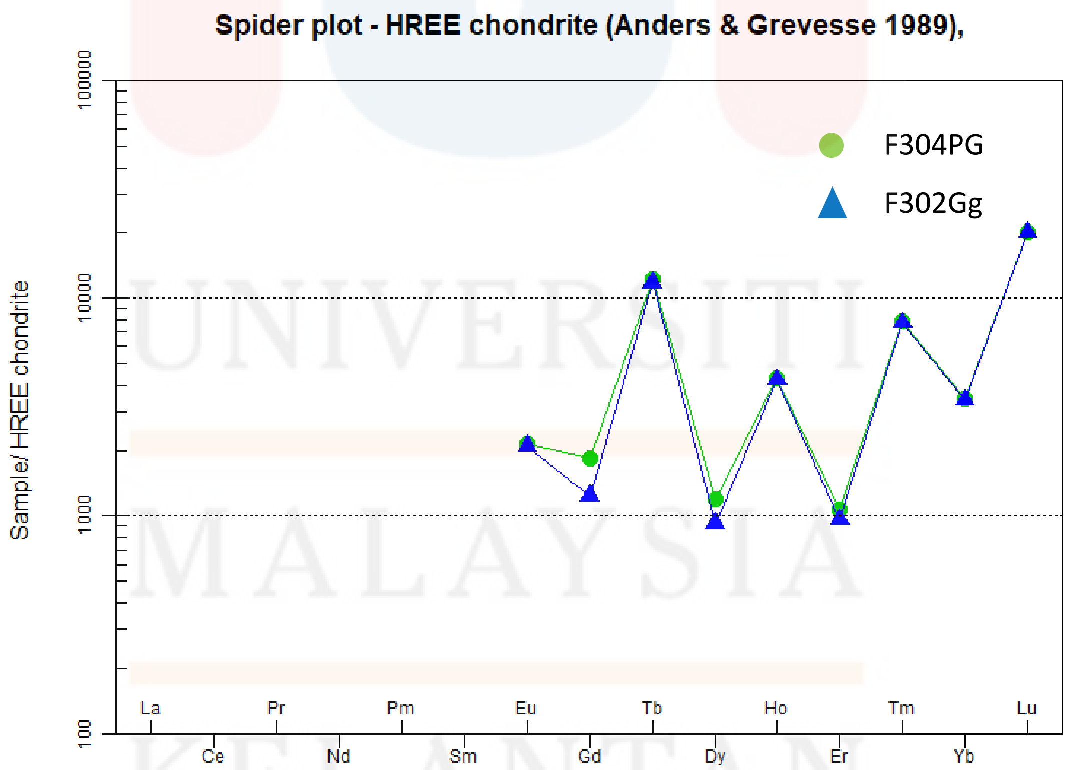


Figure 5.8: HREE distributions in granite rock.

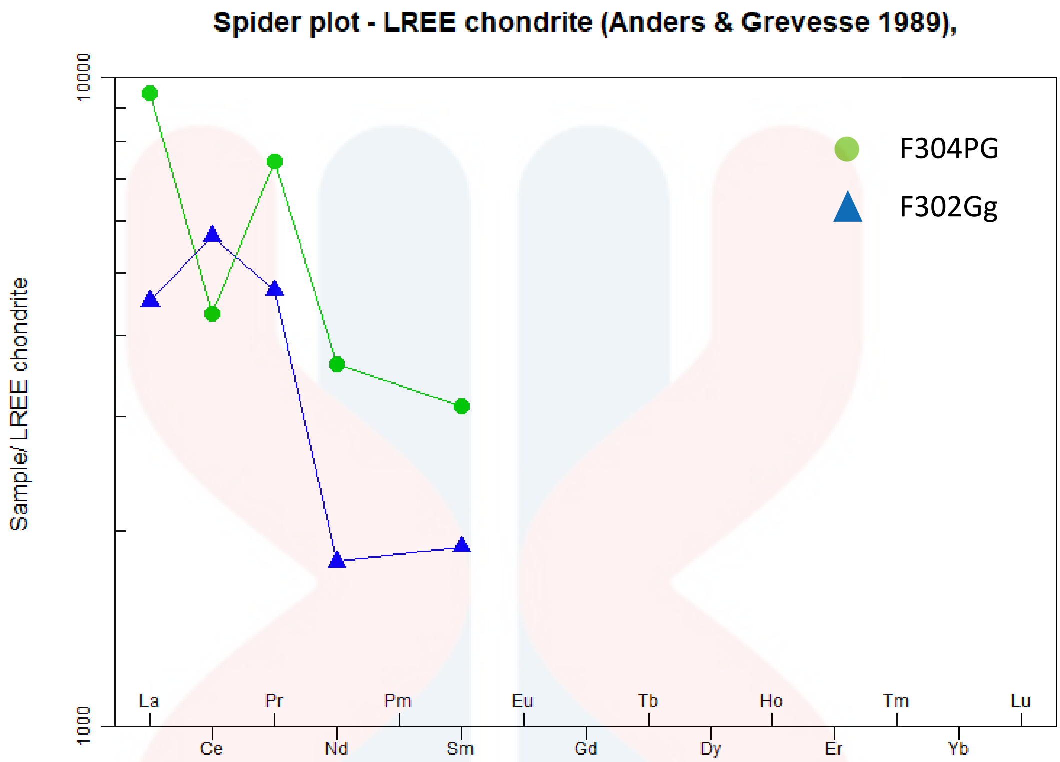


Figure 5.9: LREE distributions in granite rock

5.3 Discussion

Granite rock geochemical analysis research was carried out in Kampung Lawar, Batu Melintang, Kelantan due to a lack of research studies being undertaken there. The analysis was done to fulfil the study project's second and third goals. Granite classification was determined from the samples using the rocks' formation, which were used as a study sample for geochemistry analysis.

At the Great Laboratory UMK Jeli campus, a geochemical analysis of the selected material was conducted. With the aid of an inductively coupled mass spectrometer (ICP-MS), the composition of the sample's rare earth elements (REE) and minor and trace elements were evaluated. The major and trace element composition was examined using an X-ray fluorescence spectrometer (XRF). For analysis, powdered rock samples were weighed, mixed for an hour with an oxidation solution, and heated until crystallised. The study's granite suites' heterogeneous geochemical makeup suggests that the rocks were formed from a variety of sources.

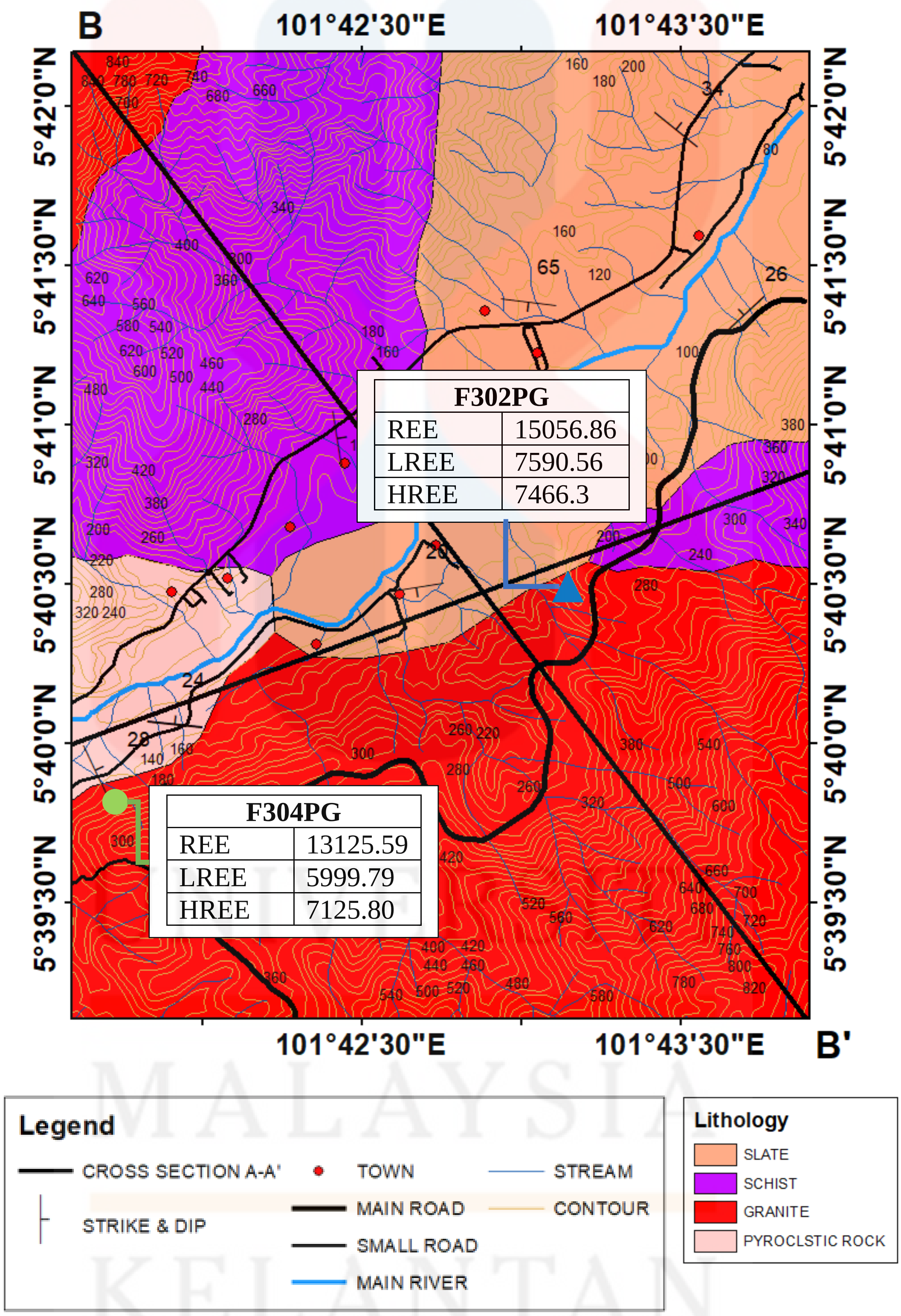
Based on the linear trends of the major oxides for Al_3O_2 and SiO_2, which are the dominant major elements in all the rocks sample and range from 70% to 89% wt% in the Harker diagram shown in Figure 5.1, the results show that the two rock samples under examination came from a single magmatic source but had a different magmatic temperature to form a rock.

In the analysis of the essential elements in section 5.2, SiO_2 has the largest range (74.91% to 79.83%), followed by Al_2O_3 with 16.03% to 17.51%. MgO's lowest distribution ranges from 0% to 2.92%, while K_2O has the lowest distribution is from 0% to 2.92%. The Harker diagram in Figures 5.1 and 5.2 displayed different outcomes from the granite samples because F309G, F302Gg, F304PG, and F307PGM are found in S-type granite. A specific range of felsic rock with high K_2O/Na_2O ratios (SiO_2 is 65.95 to 77.4%) may be used to describe the S-type features. (1.4-2.8; S-types commonly range from 0.9-3.2).

The data for trace elements are represented by a Harker diagram, which shows that while the Ba elements are decreasing as SiO_2 rises, the La elements are rising. The spider diagram of the trace elements demonstrates the depletion of Ti and Nb components. This would indicate that the plagioclase mineral had little impact on the development of magmas. This might point to a magma S-type feature. However, this conclusion is also not particularly trustworthy because the results of the XRF investigation show no Sr concentrations in the granite sample.

The distribution of LREE is higher than that of HREE in the granite rocks of Kampung Lawar, Batu Melintang. As shown in Table 5.3, the distribution shows that for F302Gg, LREE is higher than HREE with 3432.11 ppb, while for F304PG, HREE is higher than LREE with 4010.94 ppb. Overall, the distribution or abundance of REE elements is determined by their atomic weights and radii. The different value for both granite sample is shown in Figure 5.10 to shows the distribution of the light rare earth element (LREE) and heavy rare earth element (HREE).

Based on the outcomes of the full geochemical analysis carried out in the research area, the granite rock can be classified as S-type granite. It is proven that S-type granite exists when all of the granite samples exhibit strong peraluminous activity and have SiO_2 concentrations up to 79.832%. With an approximate SiO_2 composition of 60% to 79%, S-type granite often occurs in the subduction zone and places with a sedimentary provenance.



F302PG	
REE	15056.86
LREE	7590.56
HREE	7466.3

F304PG	
REE	13125.59
LREE	5999.79
HREE	7125.80

Figure 5.10: HREE and LREE distribution on site

CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

Last but not least, as the Final Year Project (FYP) carries through, all of the objectives are accomplished. The research area, Kampung Lawar, Batu Melintang, Kelantan, was able to produce and update a geological map at a scale of 1:25,000. The data from geomorphology analysis, lithology analysis, geological structure, and other geological information was analyzed by using the geological map as a reference. In accordance with the research's title, the study is focused on the geology and geochemistry of granite rocks in the research region. To determine the geochemistry of granite rocks in the research area, geochemical analysis and petrographic analysis were combined. The granite samples were categorised based on their characteristics through the geochemistry study based on their granite classification. As a result, the granite rocks in Kampung Lawar, Batu Melintang, are classified as S- type.

6.2 Recommendation

The most crucial step in completing Chapter 5 for the specification component is outcrop sampling. The number of samples to be analysed should be at least five or more in order to obtain more accurate results as this will eventually allow the researcher to analysis in this research and provide more detail in the specification section. The study area should also be the subject of additional investigation in the future because there was a lack of geological data there. In addition, there were a lot of additional geological features in the research area that geologists like Lata Turbo had not yet investigated thoroughly. Last but not least, given that the research area's soil fertility was so high, it should be further developed in the future, particularly in the geoheritage sector.

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