GEOLOGY AND GEOCHEMISTRY OF GRANITES IN KAMPUNG GUNONG, BATU MELINTANG, JELI, KELANTAN

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DECLARATION

I declare that this thesis entitled Geology and Geochemistry of Granites in Kampung Gunong, Batu Melintang, Jeli, Kelantan 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.

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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 : _________________________________

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Geology And Geochemistry of Granites in Kampung Gunong, Batu Melintang, Jeli, Kelantan

Abstract

Kampung Gunong Batu Melintang, Jeli Kelantan is situated northwest in Kelantan and near Kampung Pelias and one of the attractions in Batu Melintang is Gunung Reng which is in this sub-district. An area of 5 km wide x 5 km high is covered during the study which covers a total area of 25km^2. The latitude and longitude of the study area are 5̊ 40' 00'' N to 5̊ 45' 30'' N and 101˚ 42' 30'' E to 101˚ 48' 30'' E. The study is focusing on general geology and geochemistry of granite. Objectives of this paper is to update the geological map of Kampung Gunong in 1:25,000 scale and to describe the petrography and geochemistry of granite with the distribution of rare earth element (REE) in granite rock. Methods used in this paper are preliminary study with fieldwork which is geological mapping and laboratory works that involved with analysis of geochemistry of granites using X-ray Fluorescent (XRF) and distribution of rare earth elements (REE) using Induced Coupled Plasma Mass Spectrometry (ICP-MS). Study involved with Telong Formation and lithology that have been identified are quartz and biotite in granite and schist. The study area is composed of S-type granite from two samples that were analyse which code are FF104 and FF203.

Keywords: geochemistry, x-ray fluorescent, induced coupled plasma mass spectrometry, Kampung Gunong.

Geologi dan Geokimia Batuan Granit Di Kampung Gunong, Batu Melintang, Jeli Kelantan

Abstrak

Kampung Gunong Batu Melintang, Jeli Kelantan terletak di barat laut Kelantan dan berhampiran Kampung Pelias dan salah satu tarikan di Batu Melintang ialah Gunung Reng yang terletak di mukim ini. Kawasan seluas 5 km lebar x 5 km tinggi diliputi semasa kajian yang meliputi keluasan keseluruhan 25km2. Latitud dan longitud kawasan kajian ialah 5̊ 40' 00" N hingga 5̊ 45' 30" N dan 101˚ 42' 30" E hingga 101˚ 48' 30" E. Kajian memfokuskan kepada geologi am dan geokimia granit. Objektif kertas kerja ini adalah untuk mengemaskini peta geologi Kampung Gunong dalam skala 1:25,000 dan menghuraikan petrografi dan geokimia granit dengan taburan unsur nadir bumi (REE) dalam batuan granit. Kaedah yang digunakan dalam kertas kerja ini ialah kajian awal dengan kerja lapangan iaitu pemetaan geologi dan kerja makmal yang melibatkan analisis geokimia granit menggunakan X-ray Fluorescent (XRF) dan taburan unsur nadir bumi (REE) menggunakan Induced Coupled Plasma Mass Spectrometry (ICP). -CIK). Kajian yang terlibat dengan Pembentukan Telong dan litologi yang telah dikenal pasti adalah kuarza dan biotit dalam granit dan schist. Kawasan kajian terdiri daripada granit jenis S daripada dua sampel yang dianalisis yang mana kod FF104 dan FF203.

Kata kunci: Geokimia, pendarfluor sinar-x, spektrometri jisim plasma gandingan teraruh, Kampung Gunong.

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LIST OF ABBREVIATIONS

XRF	X Ray Fluorescent Spectrometry
ICP-MS	Induced Coupled Plasma Mass Spectrometry
REE	Rare Earth Elements
LREE	Light Rare Earth Elements
HREE	Heavy Rare Earth Elements
BRSZ	Bentong-Raub Suture Zone
WNW	West North West
ESE	East South East
K:Ar	Potassium-argon dating
Rb:Sr	Rubidium-strontium dating

CHAPTER 1

INTRODUCTION

1.1 Background study

Geology is the study of Earth including its exterior and interior, evolution, structure and natural minerals with energy resources. Geology also includes the process of how Earth shaped over the years of history and how rocks records are useful to unfold the history. Mineral is an inorganic solid chemical compound with a distinctive crystal structure and a well-defined chemical composition that naturally occurs in pure form. Rocks are solid masses or aggregates of minerals or mineraloid matter that occur naturally in nature. Rocks can be classified according to the minerals it contains, its chemical composition, and how it was formed. The whole of the Earth's outer layer, the crust, and most of its interior is composed of rocks, except for the liquid outer core and magma pockets in the asthenosphere.

Geochemistry is one of the branches of geology that uses principles and chemistry tools to describe the major geological system. From geochemistry, Earth is discovered to have layered structures. Water, the gaseous atmosphere, and the thin outer crust can support life on Earth. Chemical elements that contain in the rocks can be derived. Major and trace elements can be analysed by X-ray fluorescence analysis (XRF). The result from geochemistry is important as it gives crucial information on how the rocks are classified based on the minerals.

This study is conducted to determine the granite rocks that are located in the Kampung Gunong. Petrography analysis appeal to this research study to determine rocks origin, composition, and classification. This study will involve the use of X-ray fluorescence spectrometry (XRF), Induced Coupled Plasma Mass Spectrometry (ICP-MS) and polarized microscope for observation of thin sections. With the aid of geological mapping and petrology analysis, the geology area of Kampung Gunong, Bukit Melintang can be useful for clearer understanding.

1.2 Study area

1.2.1 Location

Research study area is located in Kampung Gunong, Batu Melintang, Jeli, Kelantan. It is situated northwest in Kelantan and near Kampung Pelias and one of the attractions in Batu Melintang, Gunung Reng is in this sub-district. An area of 5 km wide x 5 km high is covered during the research which covers a total area of 25km^2. The coordinate latitude of this area is 5° 40’ 00’’ N to 5° 45’ 30’’ N and the longitude is 101˚ 42’ 30’’ E to 101˚ 48’ 30’’ E.

Base map of this research study is digitized and prepared by using ArcGIS 10.8 software. Three types of landscape can be found in the study area: mountainous, hilly and plain. It has a maximum elevation of 600 meters and a minimum of 3 meters, close to Gunung Reng. Sungai Pergau is the main river that is located in the research area. Figure 1.1 shows the study area in Kelantan map and Figure 1.2 shows the base map of the study area.

Figure 1.1: Location of study area in Kelantan map

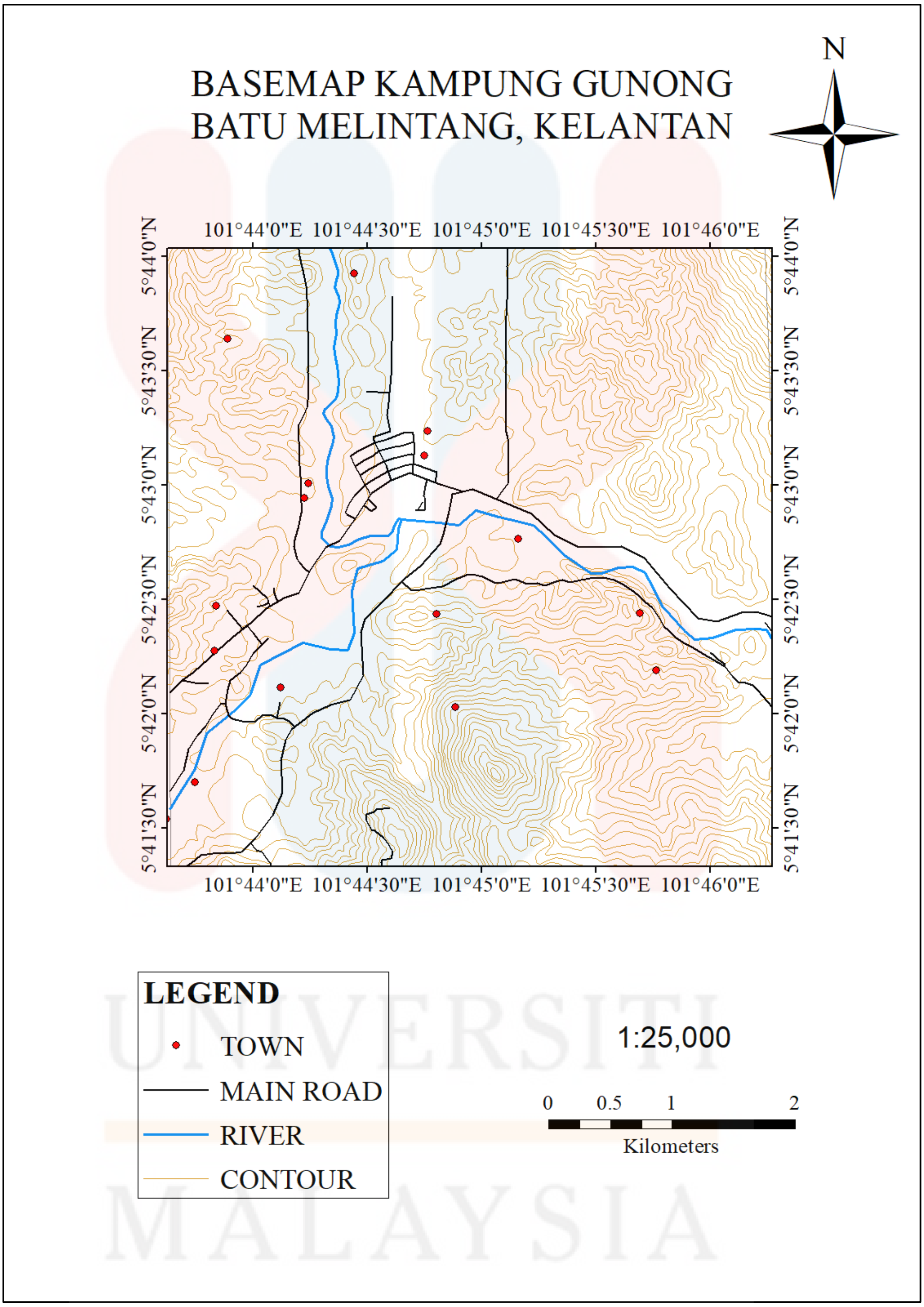


Figure 1.2: Base map of the study area

1.2.2 Accessibility

Jeli to Batu Melintang is 15.2 km and it is via Lebuhraya Timur-Barat and it can easily be accessible by two-wheeled and four-wheeled vehicles. Roads are paved for the most part, but there are also unpaved roads or small trails that extend deeper into rural areas, such as rubber plantations. By using Lebuhraya Timur-Barat Road, it takes 15 minutes to reach the study area. Figure 1.3 shows the accessibility from Jeli to Batu Melintang.

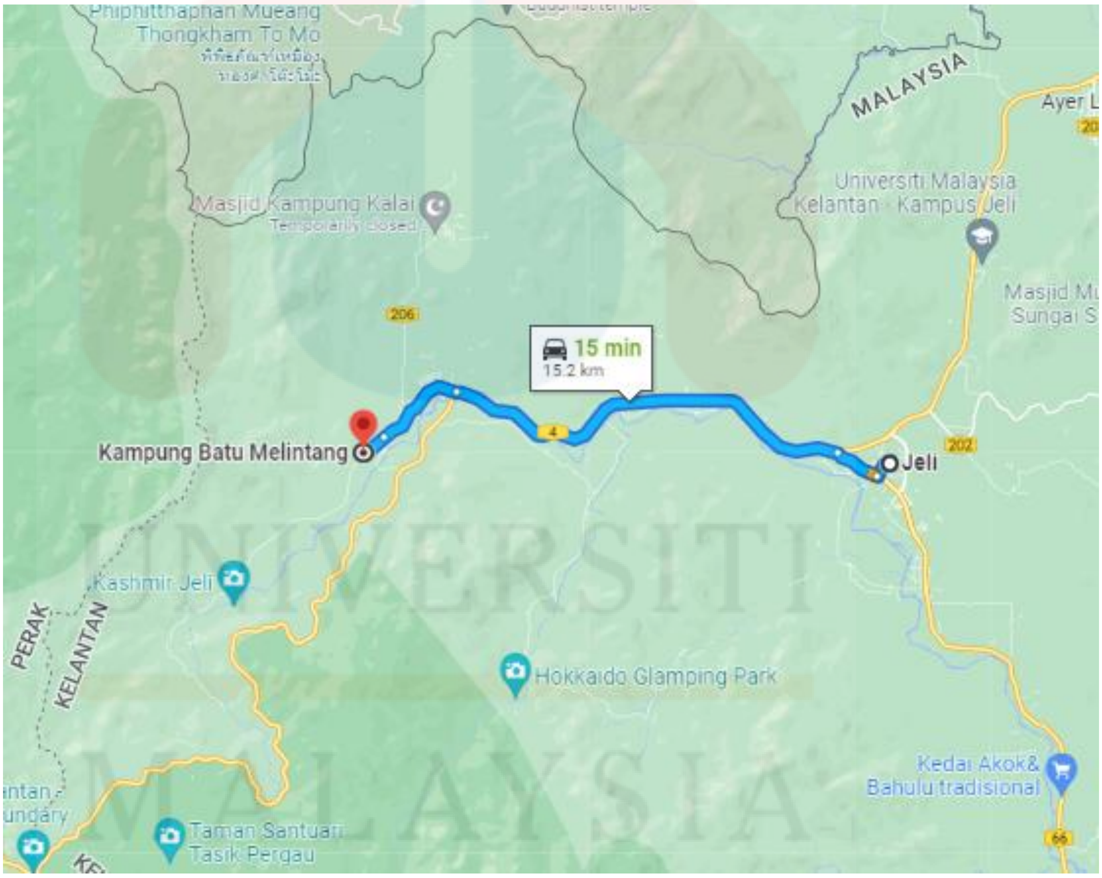


Figure 1.3: Accessibility from Jeli to Batu Melintang

1.2.3 Demography

Demography is the study of human populations based on statistics. In demography, the size, structure, and movements of populations over space and time are studied. Table 1.1 shows the population of Batu Melintang represent by gender (Department of Statistics Malaysia Official Portal, n.d.).

Table 1.1: Total population of Batu Melintang by Genders

Gender	Male	Female
Population	4,419	4,037
	8,456	

Batu Melintang has a remarkably high population distribution as it is surrounded by forests and situated far from town. As Batu Melintang surrounded by forests, majority of residents earn their living by rubber tapping and plantations.

1.2.4 Land Use

In study area, the land mostly been covered by rubber plantation and small scales of fruit plantation such as banana and durian plantations. Some infrastructures and facilities are developed mostly located in Jeli district such as police station, hospitals, school, fire station and others. Public facilities also available like mosque, public phone, and bus stations.

Some attraction also happens to occur in the study area such as Gunung Reng, Lata Janggut.

1.3 Problem Statement

The previous geological map of the study area that been provided has less and undetailed informations thus the map is not updated after the years. There might be huge changes especially the geomorphology of the study area as it is not updated. As for research related with petrography and geochemical analysis, by far there were no update and latest research regarding the petrography and geochemistry analysis of granite rocks in the study area.

The previous undergraduate study by Khalida (2019) focused on the petrography of general igneous rocks in Kampung Gunong but not on granite rocks in study area. Preliminary studies have been conducted and the information on this study area Kampung Gunong, Batu Melintang, Jeli is limited. Geological mapping is carried out to update and record the new geological data with a geological map in scale 1:25,000. Main goal of this research is to study the petrology of granites and investigate the REE mobility in Kampung Gunong, Batu Melintang.

1.4 Objectives

a) To updating a geological map of the Kampung Gunong with scale 1:25,000.

b) To describe the petrography and geochemistry of granite rock in a study area.

c) To analyse the rare earth element distribution in granite rock.

1.5 Scope of Study

Detailed geology of the study area is determine by the geological mapping processes that includes geomorphology. Updated geological map will help other researchers to carry out their own research at the study area in the future. Petrography studies will provide information of the history and lithology of the study area. other descriptions like texture, mineral and chemical composition gives better understanding about the formation of rocks of the study area. For the geochemistry of granite rocks, trace elements and REE (Rare Earth Element) are identify and analyze by using XRF and ICP-MS respectively.

Investigations involving the petrography and geochemistry of rocks have continued to increase within the past years. this study is focusing on the geochemistry method that had been applied onto the granite rocks found in the study area. in order to prove the research activity, traversing the road was done by using a GPS (Global Positioning System) and map of the study are a updated and produced using ArcGIS application.

1.6 Significance of Study

Research is being conducted to provide an updated geological map of Batu Melintang, Jeli and its surroundings. The specification of the research area to determine the petrography and geochemistry analysis of the granite rocks of Kampung Gunong. Petrography analysis of granite rock enables the researchers to know the textures, mineral contents and physical and chemical properties of granite rocks of study area. Geochemical analysis will result to the percentages of trace, major elements and REE in the rocks. Thus, elements from granite rocks will provide information and results regarding the classifications of granite rocks in the term of IUGS classification, chemical classification of S-I-A-M classification, tectonic setting of granite rock and distributions of REE in the granite rocks in study area.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

For this chapter it comprises the sections that provides an understanding of the related information regarding the geological study on research area and petrology of granite. The first section is about an overview and understanding on the fundamental knowledge on the general geology. As for the other sections, it also explains all the details such as structural geology, tectonic setting, historical and stratigraphy.

2.2 Regional Geology and Tectonic Setting

Kelantan is a northern province of Peninsula Malaysia. The boundary of this state towards the north is Thailand, eastern part is Terengganu and the southern part is Pahang while western part is Perak and Kedah. Geologically Kelantan are including west Kelantan Olistostrom, Taku Schist and Gua Musang Formation. Igneous rock in Kelantan is granite, diorite porphire, andesite, and dolerite. Structurally Kelantan are bounded by olistostrom in the west and Lebir Fault Zone in east.

Gua Musang Formation is primarily separate in Kelantan. Principle overlay of Gua Musang in the center part towards north-south up to north-northwest south-southeast. The granite intrusion and pophiritic diorite in the main fold's northern region are oriented NE-SW. The dextral fault, with a strike of N30-45E and a dip of 60-70° to SE, and the sinistral fault, with a strike of N330-340E and a dip of 60-80° to ENE-WSW, are the main faults in the Gua Musang Arrangement.

Gua Musang Formation formed into a compact and highly folding zone in the area bounded by an igneous granite intrusion and a nearby main fault. The major fold of Gua Musang Formation must be terned to take after the intrusion of porphyritic diorite in the NE-SW direction (WARTA GEOLOGI, 2010).

Peninsular Malaysia is an integral part of the Eurasian Plate, the Southeast Asian part of which is known as Sundaland (Hutchison, 1989). The Sunda Shelf with less than 200-meter water depth, is a continuation eastwards and southwards and Sumatra, Natuna and western Borneo are integral parts of the same plate and Sunda Shelf is common to all.

The edge of Sunda Shelf extends N-S a short distance east of Vietnam and then curves eastwards as far as the West Baram Line (Hutchison, 2007). The shallow Straits of Malacca is of no tectonic significance and the geology of Peninsular Malaysia continues to Sumatra. There are several similarities but also so many differences between Peninsular Malaysia and Sumatra. Most obvious are the large Tertiary oil basins of North, Central and South Sumatra, indicating that Sumatra has been strongly downfaulted.

Geological features of Peninsular Malaysia disappear in Sumatra beneath these large Tertiary basins. Bentong-Raub suture was shown trending south-east from the vicinity of Gunung Ledang, to transect the gabbroid of south Johore and Singapore that extending south-eastwards through the Riau Archipelago. This exploration was based on the distribution of granite types. The Main Range biotite granite west of the suture is distinctly megacrustic and of the ilmenite series, whereas the granitoids of East Malaya are more equigranular, contain both biotite and hornblende, and many are the magnetite series.

The Bentong-Raub suture defines the western margins of the Central Basin of Peninsular Malaysia, dominated by folded predominantly Carnian-Norian strata. In Peninsular Malaysia, the boundary between Sibumasu and IndochinaGondwana continental fragments is represented by the Bentong-Raub Suture zone. The suture zone resulted from northward subduction of the Paleo-Tethys oceanic crust beneath the Indochina continental block during the late Paleozoic and late Triassic collisions and under thrusting of the Sibumasu continental fragment with and beneath Indochina. Figure 2.1 shows the Bentong-Raub suture zone.

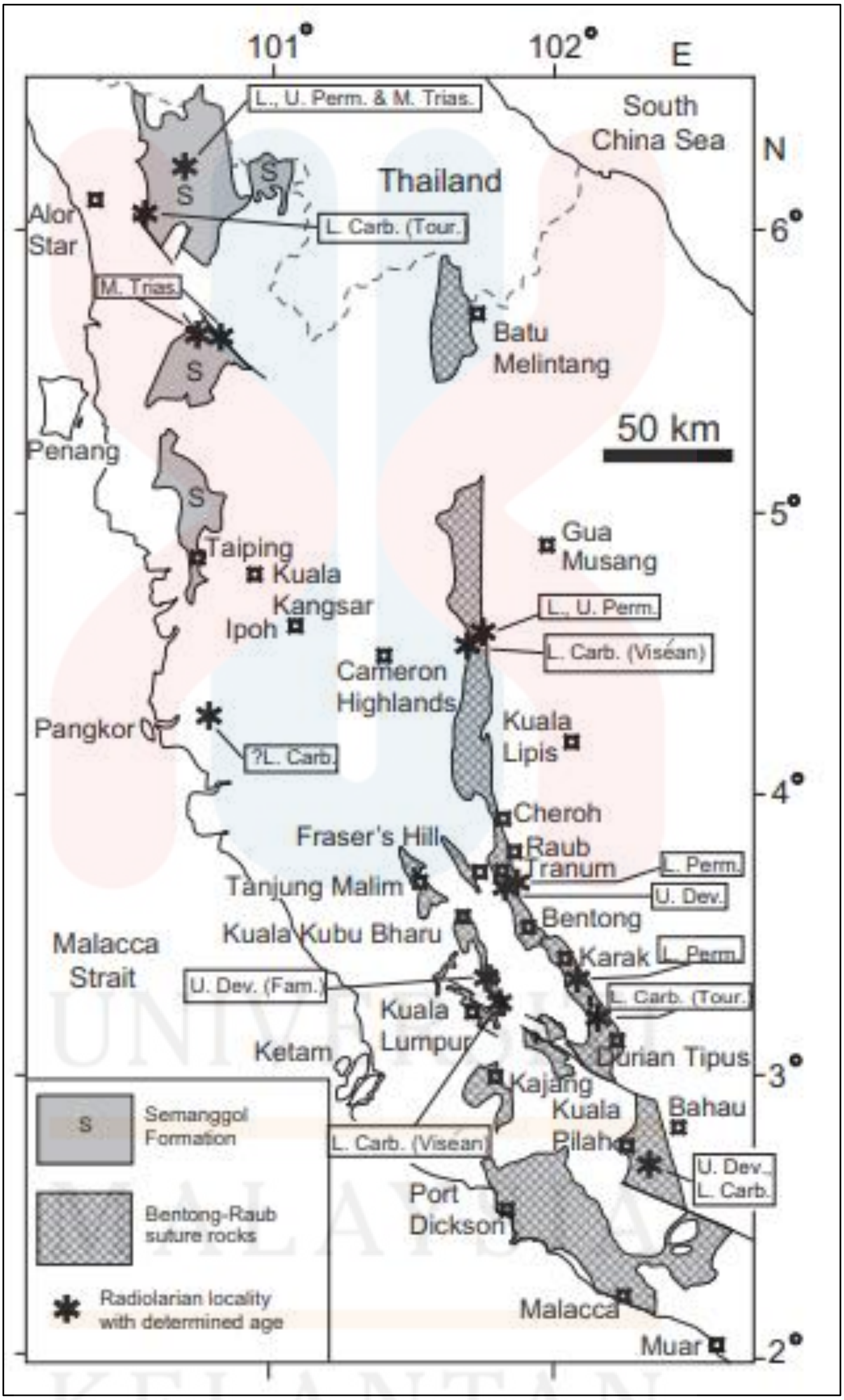


Figure 2.1: Bentong-Raub suture zone (Hutchison, 1989)

2.2.1 Geology of Kelantan

The state of Kelantan is located in the northeast of Peninsular Malaysia. A variety of rocks consisting of igneous, sedimentary and metamorphic rocks are distributed in the state of Kelantan on a north-south trend. Four types of rocks are typically classified in the region, including granitic rocks, sedimentary or metasedimentary rocks, volcanic rocks and unconsolidated sediments.

Figure 2.2 shows geological map of Kelantan. Distributed to the west are granitic outcrops forming the Main Range granite and the eastern boundaries known as the Kelantan State Boundary Range granite. The Main Range granite is located in the western part of the state, extending along the western Kelantan to the border of the states of Perak and Pahang and Thailand. The Main Range Granite is located on the western margin of the Bentong-Raub Suture Zone (BRSZ) and extends north to Thailand (Metcalfe, 2000).

The north-south trending Bentong-Raub suture, approximately 13 km wide, extends from Thailand through Raub and Bentong to east of Malacca in Peninsular Malaysia. Small bodies of mafic to ultramafic rocks that are frequently serpentinite and a sequence of parallel topographic north-south trending lineaments are features of the BRSZ. One of Peninsular Malaysia's main lineaments, the Lebir Fault Zone is situated in the eastern section of the state of Kelantan. It is thought to be post-Cretaceous and a sinistral strike-slip fault.

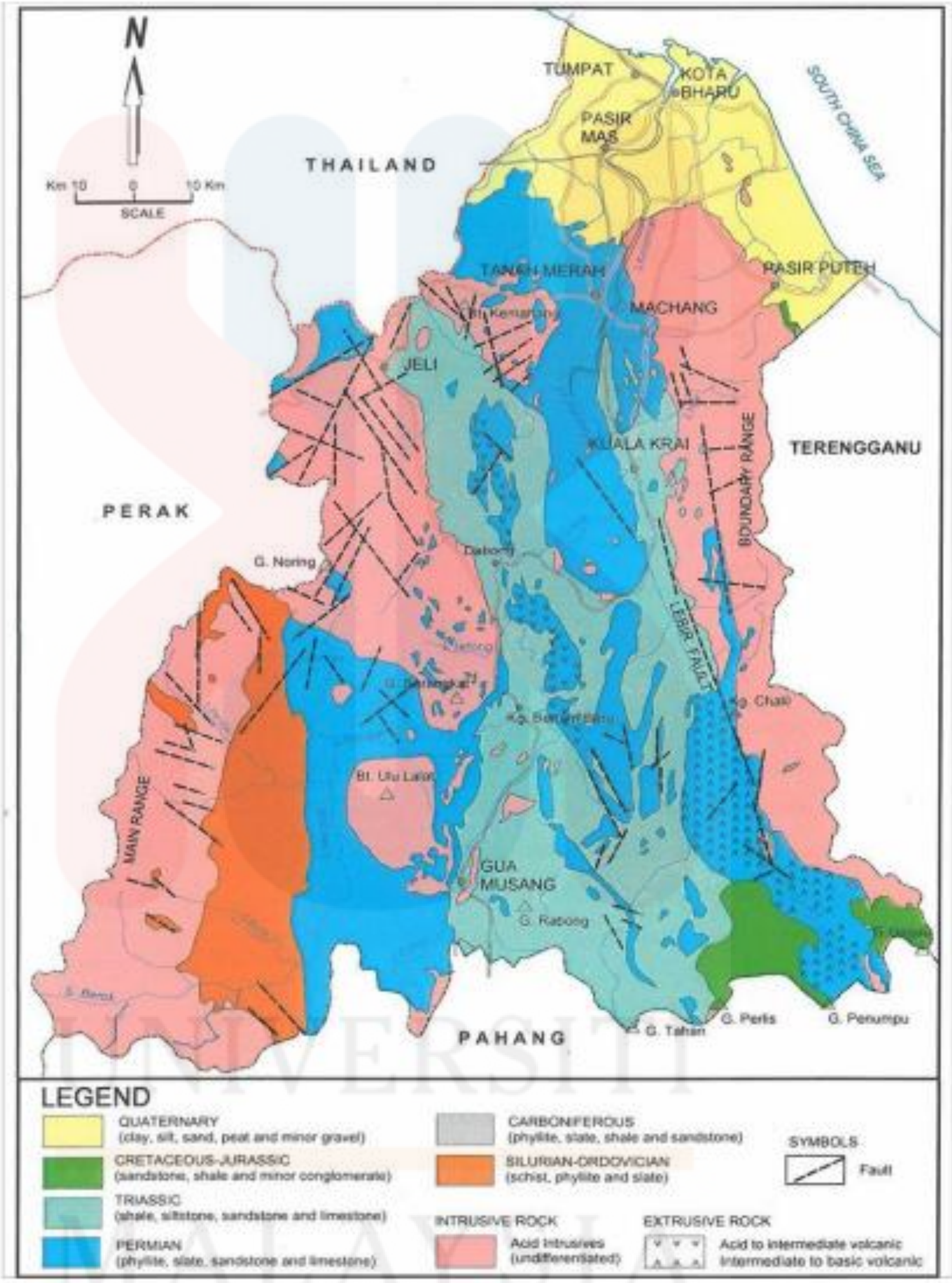


Figure 2.2: Geological map of Kelantan state (Hashim,2017)

There are two reasons why the suture extension's far north is somewhat different. The metasediment has experienced a higher grade of metamorphism than in the south, and the Main Range Granites intrudes the suture zone rocks considerably more extensively. The northern portion of the Peninsula appears to have been lifted. The rocks in the Kampung Batu Melintang region of western Kelantan at 101˚ 42’ E along the east-west route.

Figure 2.3 shows the distribution of rocks at Kampung Batu Melintang. The lower amphibolite facies to upper greenschist metamorphic grade range. Muscovite, biotite, andalusite, and garnet are minerals found in the schist and gneisses rocks. Quartz mica schists frequently contain quartz veins. Hornblende and amphibolite can be incorporated into pelitic schist.

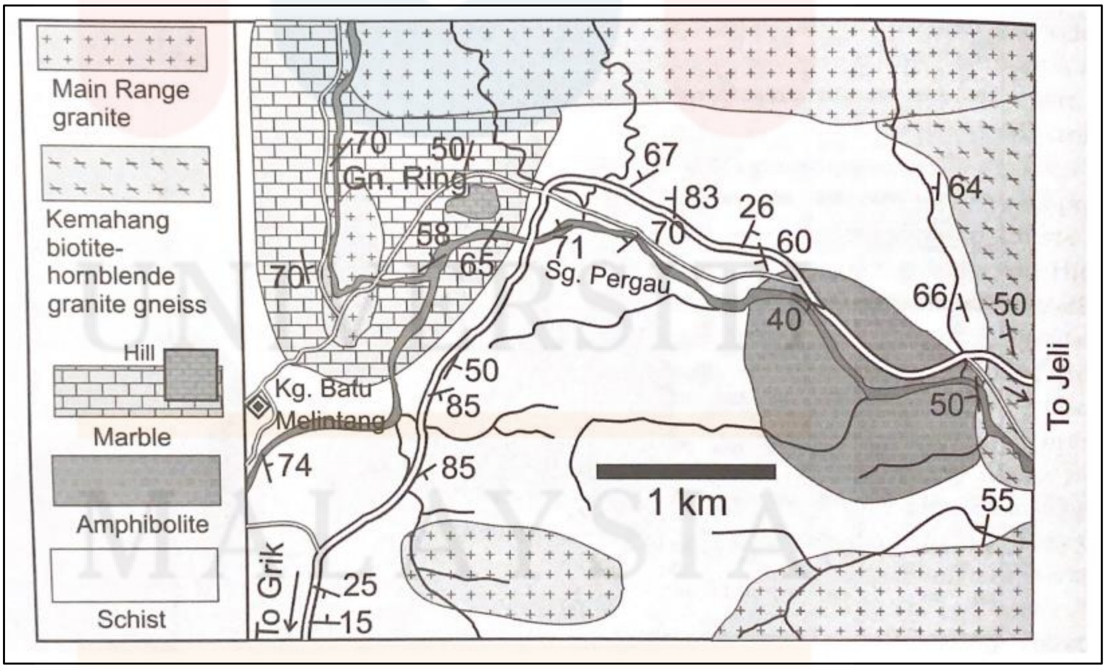


Figure 2.3: Distribution of rocks in Kampung Batu Melintang (Hutchison, 1989)

2.3 Stratigraphy

The Western Belt, Central Belt, and Eastern Belt division of Peninsular Malaysia demonstrates the remarkable contrasts in stratigraphy, volcanism, magmatism, and the formation of geological formations (Metcalfe, 2013). Between the Lower Paleozoic Bentong Group deposits in the eastern foothills of the Main Range Batholith (Bentong-Raub Suture) and the Lebir Fault to the western margin of the Dohol Formation, which marks the western boundary of the Eastern Belt, is where the Central Belt is found. Figure 2.4 shows geological map of Peninsular Malaysia.

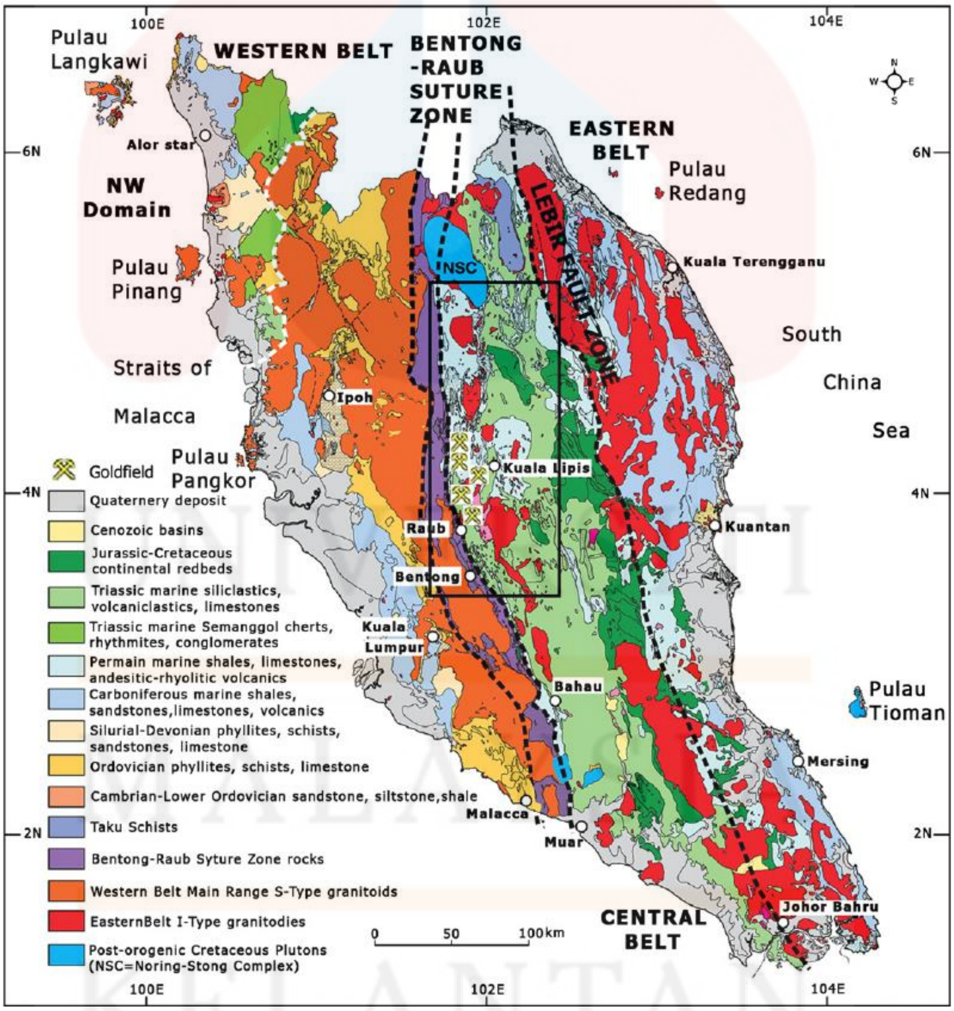


Figure 2.4: Geological map of Peninsular Malaysia. Modified from Metcalf (2013)

Geology of Kelantan consists of formations which are Koh Formation, Gua Musang Formation, Gunung Rabong Formation, Taku Schist Formation, Aring Formation, Telong Formation and Nilam Marble Formation. Gua Musang area consists of two geological formations that has been identified as Gua Musang Formation and Gunong Rabong Formation.

The argillite units in the area of Gua Musang town gradually metamorphosis into slate or phyllite, limestone that primarily crystallizes into marble, sandstone, and some conglomerates, and limestone that is crystallized into slate. A mostly argillaceous and calcareous sequence interbedded with volcanics and arenaceous rocks in the Gua Musang area of south Kelantan is known as the Gua Musang Formation, according to Gobbeit, 1968).

North Pahang and north Kelantan are included in the unit's reach. Pelecypod and ammonoid fossils point to a middle Permian to middle Triassic age. It is named after the village of Gua Musang in south Kelantan and is irregularly overlain by the Gunong Rabong Formation. The majority of argillic strata and sandstone contain tuff and were formed volcanically.

Argillite units are more common than limestone units. In contrast, limestone outcrops are more noticeable, constitute karst topography, and are simple to identify. Another Triassic rock formation, the Gunung Rabong Formation, is located east of the Gua Musang Formation. The Gua Musang Formation's upper limit is covered by the Koh Formation, while its lower boundary is unclear. Semantan Formation, Telong Formation, and Gunung Rabong Formation are all interfingered with the upper section of the Gua Musang Formation. Gua Musang consists of carbonate facies and argillaceous facies.

Gua Musang Formation calcareous rocks, which underwent extensive development in the Middle Permian and Triassic, were deemed by Yin to be its most expensive facies. From Gua Musang in the north to Gua Panjang in the south, they create karstic hills with a N-S incline. Depending on the number of carbonaceous components present, the limestone frequently exhibits variable degrees of recrystallization with colors ranging from light to dark grey.

The limestone may be large or bedded, with the latter often sinking moderately to steeply in either the WNW or ESE and generally striking N-S. There were around 1 km of Triassic strata found in the Telong Formation type section. These strata are lithologically quite similar to the argillaceous rocks of the Gua Musang Formation. The Telong Formation contains isolated regions with deeper water facies while being primarily of shallow water deposits. The Telong Formation was deposited concurrently with the Gua Musang Formation from the Permian to the Late Triassic.

2.4 Historical Geology

Within Sundaland central region is the Malay Peninsula. The closing of Palaeo Tethys along the Raub-Bentong Suture during the Permo-Triassic collocate two North-South trending basement terranes over the area. The Sibumasu terrane, which is derived from Gondwana, is dominated to the west by faunas from the Cambro-Ordovician and cool-water Permian periods. The Indochina Terrane, which was part of the Cathaysian continent for much of the Permian, is east of the suture zone and is home to wholly diverse, warm water faunas.

Few regions, including the Malay Peninsula, Sumatra, Java, Borneo, and Palawan, are included in Sundaland. This area, which is situated on the shallow water Sunda Shelf, was exposed during the Pleistocene Sea level stands. Since fault movement, epeirogeny uplift and tilting, and local moderate downwards are the dominant earth processes, the Peninsular has primarily remained extant throughout the Cenozoic and is thought to have been rather stable tectonically.

These granitic rocks, which make up to fifty percent of the region's geology, are commonly separated into the Western, Main Range, and Eastern Provinces. Additionally, there are sediments and metamorphic rocks from the Mesozoic, particularly in the northwest and in a north-south trending strip that runs up the middle of the peninsula.

The accretionary complex is still expanding as the Sibumasu terrane and Paleo-Tethys Ocean being subducted obliquely beneath the Indochina volcanic arc, and argillo-carbonate sediments are being deposited inside the shallow marine Gua Musang platform. (Mohamed et al., 2016) has stated that Gua Musang Group contains volcanics because of adjacent volcanic arcs concurrent supply of pyroclastics or volcanics input. Up to the Early Triassic, shallow marine sedimentation developed throughout the Permian.

2.5 Rock Petrology

The study of rocks, including igneous, metamorphic, and sedimentary ones, as well as the processes that create and alter them is known as petrology. Petrology is also used to study the genesis of accessory minerals like REE phosphates in all rock types, the origins of economic concentrations of minerals and petroleum, the composition of the atmosphere, ocean, and life on Earth over time, as well as the geological processes that take place on other planets. Geological process includes the formation of volcanoes and their magmatic sources, the evolution of continental crust during the growth and destruction of mountain belts, the evolution of accessory minerals like REE phosphates in all rock types (Petrology & Mineralogy, n.d.).

2.5.1 Geochemistry of Granite in Peninsular Malaysia

Granite batholiths, which are extensively scattered in Southeast Asia, are a result of the region's extensive plate tectonic activity. Three belts, the Western Belt, the Central Belt, and the Eastern Belt—can be distinguished among the granites of Peninsular Malaysia. Peninsular Malaysia has good exposure to the Bentong-Raub suture, which divides the Eastern and Main Range Granite provinces.

The terms S-, I-, and A-type granites have certain significance for the parental magma. According to (Chappell & White, 2001), granites with igneous melt sources are classified as I-type, whereas granites with sedimentary melt sources are classified as S-type. Hornblende is a mineral characteristic of I-type granites, while muscovite, andalusite, and garnet are characteristic of S-type granites. The I-type granites that formed during the Middle Permian to Late Triassic dominate the Eastern provinces, whereas the S-type granites that formed during the Triassic to Early Jurassic dominate the Main Range provinces. Each variety of granite exhibits a varied mineralogy. The Kemahang Granite, a cataclastic porphyritic biotite granite which outcrop extends across the border into southern Thailand as the Buke pluton, occupies the northern section of the schist body. The Taku Schist has been injected into the granite and has been extensively absorbed.

S-type granites have low levels of Na, Ca, and Sr because these elements are depleted in their source rocks when feldspar is weathered into clay particles. Because potassium is absorbed into clays during chemical weathering whereas sodium is eliminated in solution along with Ca, Sr, and Pb, the high K2O/Na2O ratio in S type rocks can be justified. Because the source rocks are frequently reduced due to the presence of graphite, the Fe3+/Fe2+ ratios of the S-type rocks are much lower than those of I-type (Ghani, 2005). 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 (Chappell & White, 1992).

2.5.2 Rare Earth Element Distribution in Peninsular Malaysia

Based on the patterns of Rare Earth Elements (REEs), Peninsular Malaysian granites are divided into two major categories. It can be separated between groups with abnormal Europium (Eu) values and a group without or with a slight Eu anomaly, according to Wan Hassan & Hamzah, 1999. The "bird-wing" REE pattern, which is spread in the West Coast Triassic and is a part of the Central and East Coast Provinces, is displayed in a group with an unusual Eu content.

On the granite areas from the East Coast Provinces, the Gua Musang granites, and the Cretaceous granites of the West Coast, the non-anomalous or with tiny Eu anomaly is seen. The Cretaceous granites of the southern Peninsular, which resemble the Noring granite, can be linked to the non-anomalous Gua Musang granites.

The I-type granite, which is thought to have come from an oceanic or early mantle source with a poor plagioclase source, can be linked to the distribution of the non-anomalous East Coast granite. Granite from the southern Peninsular that dates to the Cretaceous originates from a primitive core source. It exhibits similarities to the Main Range of the S-type for the group in the province with aberrant individuals. When anomalies are present, it means that the parent materials, which originate from a sialic basement that is naturally rich in plagioclase feldspar, either partially melt or fractionally crystallized.

With the notable exceptions of Ce^{4+} and Eu^{2+}, which are stable under appropriate oxidizing and reducing conditions, the lanthanide or rare earth elements REE create nearly all trivalent ions with increasingly diminishing ionic radii. La-Sm, a light rare earth element (LREE), and Gd-Lu, a heavy rare earth element, were the different types of rare earth elements (HREE). Normalizing the findings to the reference standard, such as chondrite and average shales, makes it easier to compare REE. When chondrite or shale average normalized, some fractionation effects could lead to an increase in LREE concentration in relation to HREE concentration.

2.5.3 Granite Rock Classification

Granite is generally made up of muscovite, hornblende, quartz, plagioclase and orthoclase feldspar, biotite and minor accessory minerals such as apatite, magnetite, zircon and garnet. A pyroxene is infrequently present. Fayalite, an extremely rare form of iron-rich olivine, does exist.

Granite is categorized using the QAPF diagram for coarse-grained plutonic rocks granitoids and given a name based on the diagram's A-Q-P half's proportions of quartz, alkali feldspar, and plagioclase feldspar. The QAPF diagram of the granitoids and phaneritic foidolites is shown in Figure 2.5. On the A-F-P portion of the picture, granite-type rocks that are silica undersaturated may contain a feldspathoid like nepheline (Misni et al., 2015.).

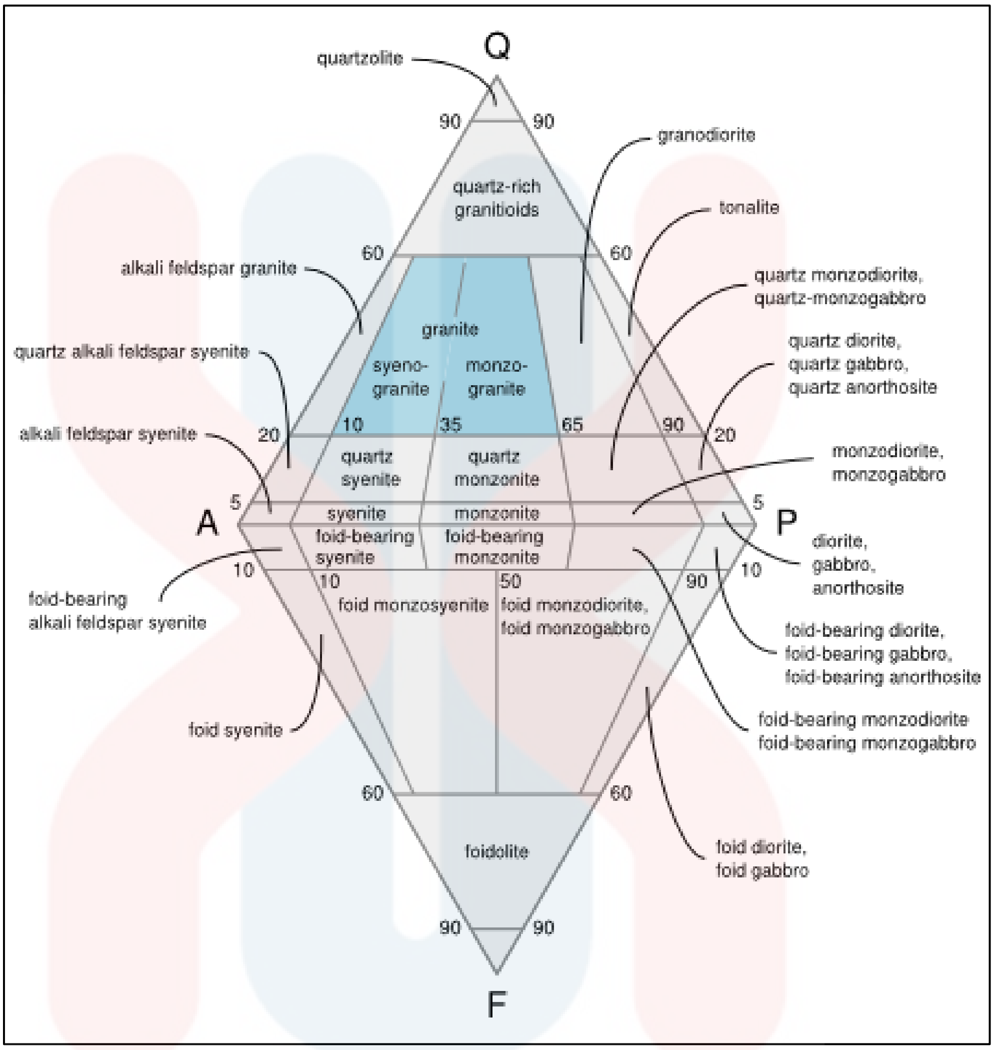


Figure 2.5: The QAPF diagram of the granitoids and phaneritic foidolites. Streckeisen (1974)

An alphabetic categorization that takes the origin of the granitoid precursor into account was first developed by Chappell, B.W. and White, A.J.R. 1974. S-type granitoids are created when sedimentary potolith, which is prevalent in collision zones, partially melts. In general, biotite, muscovite and greater silica content are characteristics of peraluminous granite. The partial melting of igneous rock that results from the upwelling of mantle material to higher levels gives rise to I-type granitoids. These granites are meta luminous and contain biotite as well as hornblende or alkali amphiboles.

A-type granitoid are either deposited in plate-anorogenic environments or during the culmination of an orogenic event. It is distinguished by its high silica content and fluorite content. According to Johannsen, 1911) the rocks that fall into this category include rhyolites, comendites and quartz syenite. The last type of granitoids are M-type granitoids, which are relatively rich in plagioclase and formed by the fractional crystallization of basaltic magma. It has the traits of a subduction zone and is related with tonalite and gabbro.

CHAPTER 3

METHODOLOGY AND MATERIALS

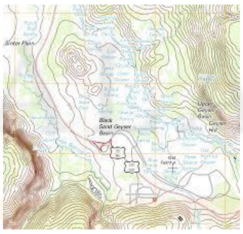
3.1 Introduction

This chapter covers the materials aspects, research methods, and the petrology of the rocks in the study area. This chapter also focuses on the steps of research methods that are crucial to making sure that geological mapping can proceed as planned and without error.

3.2 Materials

For the preparation of fieldwork, materials are important as it is one of the requirements for the data collection. For geological mapping, materials used are GPS that are useful for pinpoint the position on earth's surface. Compass, hammer, hand lens, hydrochloric acid, base map, notebooks and stationery, and plastic samples are important materials that are used.

Table 3.1: Materials used for research

1.		Brunton Compass: A compact pocket instrument that consists of an ordinary compass, folding open sights, a mirror, and a rectangular spirit-level clinometer, which can be used to calculate the strike and dip of the outcrop.
2.		Tip point Hammer: Used for taken samples from the outcrops or fields.
3.		Hand lens: A tiny magnifying lens that geologists use to examine rocks more closely. Geologists use hand lenses to examine the textures and structures of rocks as well as to aid detect minerals and fossils in them.
4.		Hydrochloric acid: Most popular acid used by geologists to determine whether a rock has any calcite.
5.		Base map: A base map is a background layer that contains geographic data. For features like boundaries, rivers, lakes, roads, and highways that don't change frequently, base maps typically offer location references.

6.		Notebook and stationery: Used for jotted down the information during fieldwork.
7.		Plastic samples: Used for storing the samples during fieldwork.

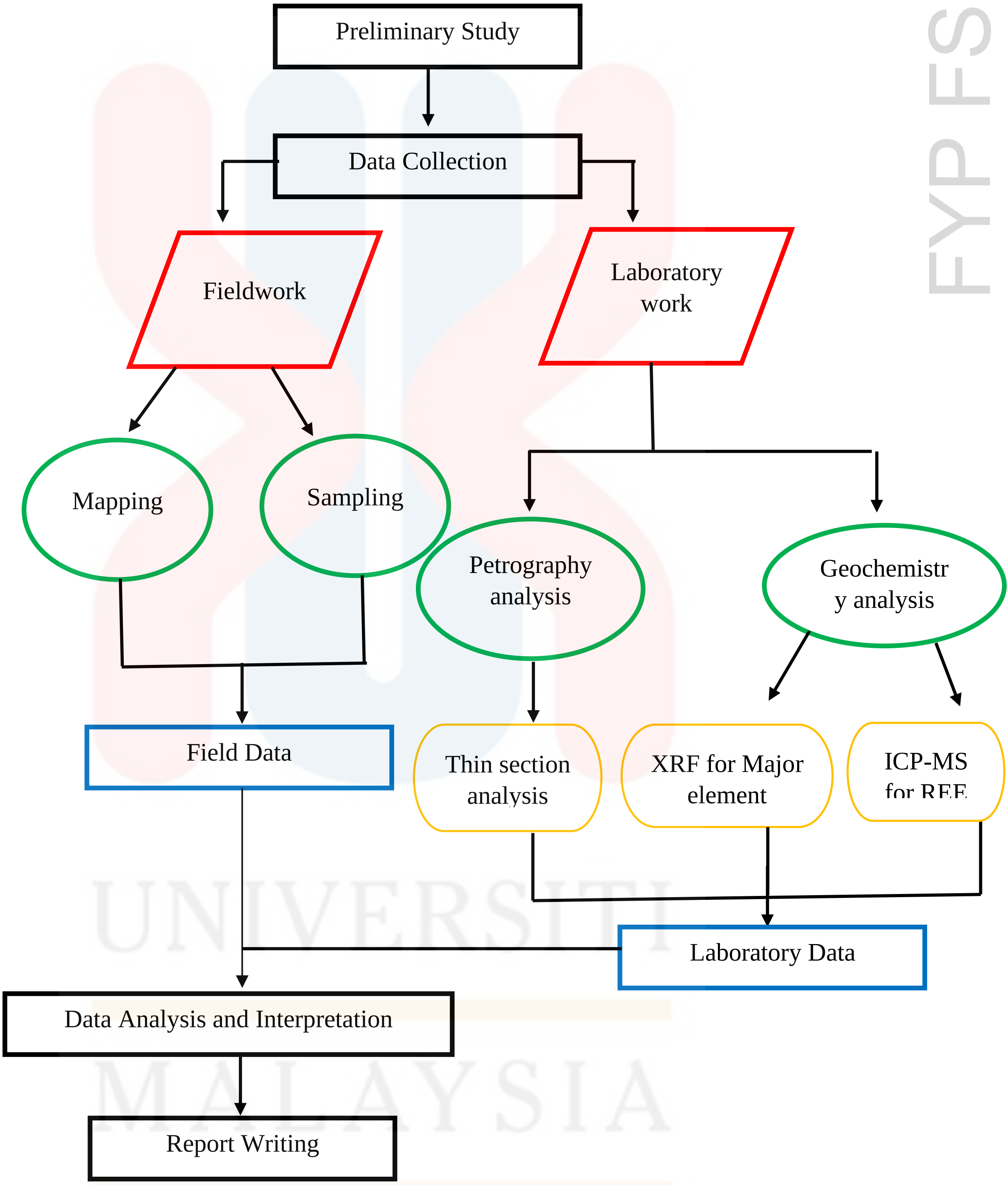


Figure 3.1: Research flow chart of research topic

3.3 Methodologies

In this section, it covered all the methodologies that might be conducted throughout this research activity. The research is incomplete if one of the methods is skipped. Figure 3.1 above shows the research flow chart of the research topic.

3.3.1 Preliminary Study

Preliminary study will be the first to be done as it is a preparation for the study to further research. In mapping, geological mapping is the observation of structural geology, stratigraphy, lithology and geomorphology of the outcrop in the study area.

3.3.2 Fieldwork

A traverse map is gained by traversing in the study area. It involves the equipment of base map, GPS and compass. Compass is used to read the strike and dip reading and appearance of joints and faults on structure. All outcrops that were found during traversing must be marked in GPS and notebook. Rock samples are taken from the fresh outcrop by using a hammer for sampling. It is important to take rock samples as it is used to identify the properties and mineral characteristics of the rocks.

3.3.3 Laboratory Work

Laboratory investigation includes petrography and geochemistry study. Rock samples that have been prepared are examined under cross polarized light (XPL) and plane polarized light (PPL). Rock samples are observed to investigate the rocks properties and minerals. X-ray Fluorescent (XRF) and Induced Coupled Plasma Mass Spectrometry (ICP-MS) are used for the determination of the element.

3.3.3.1 Thin section

The thorough information on the arrangement of the elements and relationships between each specific feature is provided by the petrographic study of thin sections. There are a few procedures involved in the preparation of thin sections, commencing with section, porosity sealing, grind and polish.

Sectioning is necessary to produce a section that is around 3 mm thick for thin section preparation. The samples must be free of debris, vacuum-impregnated to seal any pores, and physically supported by the specimen materials. The area of concern samples was ground so that it had a smooth surface and was free of obvious distortion. A properly grounded surface will have a uniformly reflecting surface. Afterwards, an epoxy-coated glass slide is attached to the chip on the slab's overlapped side. The specimen must be dry and spotless. The specimen's top surface was mounted, and the air bubbles were expelled.

3.3.3.2 XRF

The elemental composition of materials can be ascertained using the non-destructive analytical method known as XRF (X-ray fluorescence). By detecting the fluorescence or secondary X-ray that a sample emits when it is activated by a main X-ray source, XRF analyzers may determine the chemistry of a sample.

To be an accurate representation of the target rock mass, the sample must be able to show the form and general composition of the entire molecule. Information on the samples origin and history was needed to prevent compositional changes during transport and storage. To reduce the likelihood of contamination, the sample must first be kept clean and dry. The rock sample was crushed and ground into a powder with an optimal grain size of <60 µm using a rock crusher. To create a homogeneous sample pellet, the mixture was pressurized under 20 kpa using a press pellet compressor and a binding aid. The samples were subsequently examined using an XRF equipment. Ppm and ppb levels were used to record and detect the outcome of a main and trace element.

3.3.3.3 ICP-MS

An analytical method called inductively coupled plasma mass spectrometry (ICP-MS) can be used to analyses components in biological fluids at trace levels. ICP-MS detection limits are within the part per trillion (ppt, 10-12) range, and it is simple to realize isotopic analysis ratios. The ICP-MS apparatus creates the ionization state for elements using inert argon gas as a plasma source. Mass spectrometer (MS) and a quadrupole mass filter are employed in parallel to separate the generated ions for detection and research. Most elements in the periodic table have analytical concentrations that can be calculated at the ppb and ppt levels.

In general, primary standard solutions and internal stock standard solutions were used to generate working standard solutions. The sample introduction system was examined before the instrument was turned on and the substance was stabilized. The unidentified samples were measured using standardization blanks, working standard solution drift control samples, and quality control samples. By considering the standardization blanks, drift correction, and application of the dilution factor, the results were corrected. The internal reference standard was used to standardize the results.

3.3.4 Data Analysis and Interpretation

Analyses and interpretations will be made from the laboratory results. The distribution of rare earth element, major and trace elements were deduced from the results of XRF and ICP-MS analysis. Data that is collected from mapping will be analyzed. The data will be analyzed and interpreted by using the related software or by self-interpretation to represent the general geology of the study area. Joint and fault data can be processed by GeoRose software that tells the major force that caused the rock to deform.

3.3.5 Report Writing

A complete report that contains an introduction, objectives, literature review, materials and methods, data analysis and result with conclusion will be used to record all the field study data analysis.

CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

This chapter discusses the geology of study area and detailed geological information on lithostratigraphy, geomorphology, petrology, geological structure and history based on field observations, data collection, sampling and analysis. Maps were presented to help understand the study area characteristics. Such maps that were presented are drainage map, traverse and geomorphological map. To achieve the study's objective and produce a detailed geological map for the study area, all the data and geological information that had been gathered from the field were studied. On the geological map, all the results were plotted and documented at a precise scale of 1:25,000.

4.1.1 Accessibility

Accessibility defined how approachable and simple it is to get to a location in comparison to another location. Accessibility is also determined by people and has an impact on regional growth of development, transportation policies and infrastructure. The land use system and road network in Jeli area are directly related geographically. All the locations are connected by the roads.

There are two different sorts of roads: the main paved that accessed by large car and the unpaved road that small vehicles like motorbikes or pickup car such as four by four can use. Main paved route connecting Kampung Gunong is known as Ayer Lanas-Batu Melintang. Figure 4.1 and 4.2 shows the accessible road in study area. Palm oil and rubber plantation area is accessible through unpaved road. The study area communication network is accessible, but it still relies on local factors and there might be some area that have poor coverage.

Figure 4.1: Street along Kampung Gunong. Source, Goggle Map

Figure 4.2: Small street along the village in Kampung Gunong. Source, Timestamp application

4.1.2 Settlement

Settlement covers the locations and regions that are populated by a community of people. The primary village that are located and covered in the study area are Kampung Gunong. Figure 4.3 shows the housing area in study area. Majority of the resident in the area manage rubber and palm oil plantation. Malay races make up the majority of the population in Kampung Gunong area. Figure 4.4 shows tower located in Bukit Salor.

Figure 4.3: House in Kampung Gunong village

Figure 4.4: Tower in Bukit Salor, Kampung Gunong

4.1.3 Vegetation

Nearly all the vegetation in the study area is forest primarily palm oil and rubber plantation. About 80% of the study area is made up of rubber plantation and the other 20% being mostly made up of palm oil plantation. The oil palm and rubber plantation in Kampung Gunong area are what support the local population. Figure 4.5 and 4.6 shows rubber plantation in study area.

Figure 4.5: Rubber tree plantation in study area

Figure 4.6: Rubber tree plantation along the study area

4.1.4 Traverse and Field Observation

During mapping process, traversing and observing are used to gather rock sampling and geological data. Before entering site of study area, a well-planned traverse path was prepared to ensure the success and efficiency of the geological mapping processes. For study area, the entire geological fieldwork approach takes about 7 days to complete and collect the geological data. Observations were made while traversing by keeping an eye out for any variations from the lithological and geological structure's set patterns. Notebook was used to record each observation and GPS device was used to track the traverse path.

4.2 Geomorphology

Geomorphology is the study of landforms, their formation, processes, and deposits at the Earth's surface. Study involves examining landscapes to determine how processes on the earth's surface, including as air, water, and ice, can shape the landscape. As rock and sediment are eroded away by these processes on the earth's surface and transported and deposited to various locations, landforms are created. Various kinds of landforms are produced by the various climatic settings. Sand dunes and ergs are examples of desert landforms that are very different from the glacial and periglacial characteristics that can be found in polar and sub-polar regions. To better comprehend these landforms existence, geomorphologists chart their distribution. Landforms are currently being created by earth surface processes, albeit they frequently do so extremely slowly.

The origins and nature of the surface characteristics of the Earth are studied in geomorphology. literary analysis of the Earth's form. The study of land shapes and landscapes is often referred to as geomorphology. Man has developed theories about the creation of the Earth and its landscapes for as long as he has walked the earth, tilled the soil, and sailed the seas. The genesis of landforms has been a subject of debate ever since the days of the ancient philosophers because they are the most common geomorphic phenomenon.

4.2.1 Geomorphological Classification

Geomorphological landforms are classified depending on relief elevation, states Van Zuidam (1985). The importance of defining a landform according to its relief elevation is to define how the morphology and morphogenetic landforms are present. According from the landform classification, Kampung Gunong area can be classified into two unit of morphology: medium and low morphology unit. In contrast to the low relief morphology unit, which consists of low-lying plain landform, the medium relief morphology unit is made up of low hills and hills. Table 4.1 shows the geomorphological landform that been categorized according to relief elevation.

Table 4.1 Relief Elevation for Classification

Landform/Relief	Elevation (meter)
Lowland	< 5
Low hill	100-200
Hill	200-500
High hill	500-1500
Mountain	1500-3000

The medium relief morphology unit has topographic relief values ranging from moderate to high, topographic texture properties ranging from moderate to rough, and slope properties ranging from slightly slope to steep. Figure 4.7 shows hill landform in study area. Figure 4.8 shows the elevation map.

Figure 4.7 Hill landform in study area.

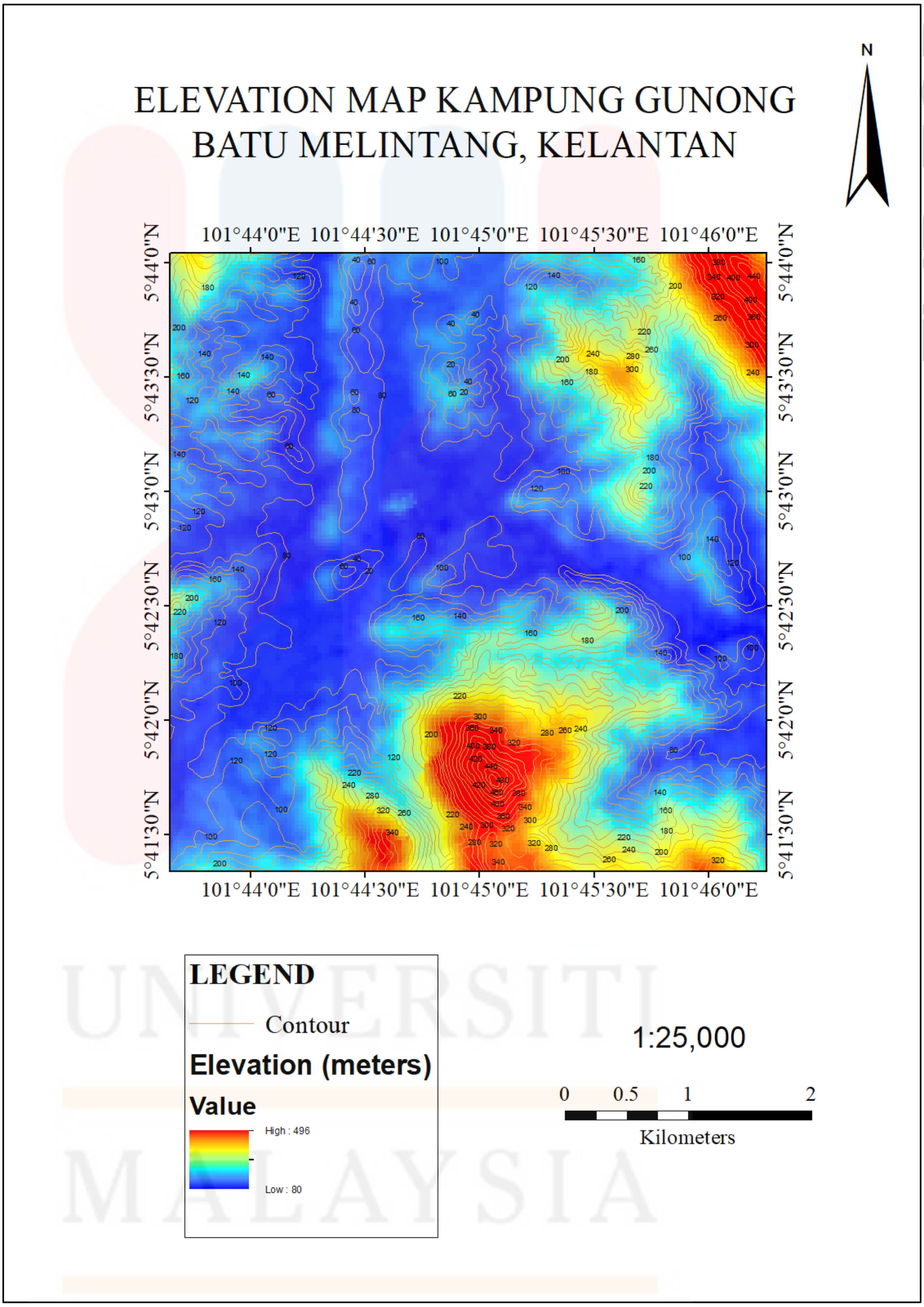


Figure 4.8 Elevation Map

4.2.2 Weathering

In the research region, the effects of weathering can be seen. The exposed outcrop that has been going through the weathering process is shown in Figure 4.9. Due to this, the sample taken from the outcrop was not fresh, and some of the outcrops had been transformed into soil and sediments. This is also related to Malaysia's tropical climate, which has been hot and humid for many years.

Figure 4.9 Physical weathering of the outcrop

Aside from it, chemical weathering can be seen in the study region. The surface of the limestone rock at Gunung Reng has developed holes, as shown in Figure 4.10. This shows that, because of the rock's dissolving processes, dissolved material is transported and creates a void on the surface. The water dropped from the cave's ceiling, which was formed of acidic solutions, also caused the construction of holes and pits.

Figure 4.10 Dissolving on limestone Gunung Reng

4.2.3 Drainage Pattern

Drainage systems are the patterns formed by streams, lakes, and rivers in a certain drainage basin where water discharges naturally to form a pattern and a specific lane on the surface. According to field observations at Kampung Gunong, there were two different types of drainage patterns: dendritic and trellis drainage patterns. Thirty percent of the research area is taken up by the dendritic flow pattern. Most of the contributing streams are joined together to form the main river's branches, giving it a structure resembling the branching pattern of tree roots. The "V"-shaped valley created by dendritic drainage is made up primarily of igneous rocks, which are impermeable, non-porous, and very resistant to erosional weathering processes.

About forty percent of the study area is taken up by trellis drainage patterns. When parallel streams erode a valley along the strike of a less durable rock, a trellis drainage pattern develops. It appears as parallel valleys of weak rock between ridges of strong rock and develops in folded topography. Metasediments are the predominant rock types in the area. figure 4.11 shows the drainage pattern in study area.

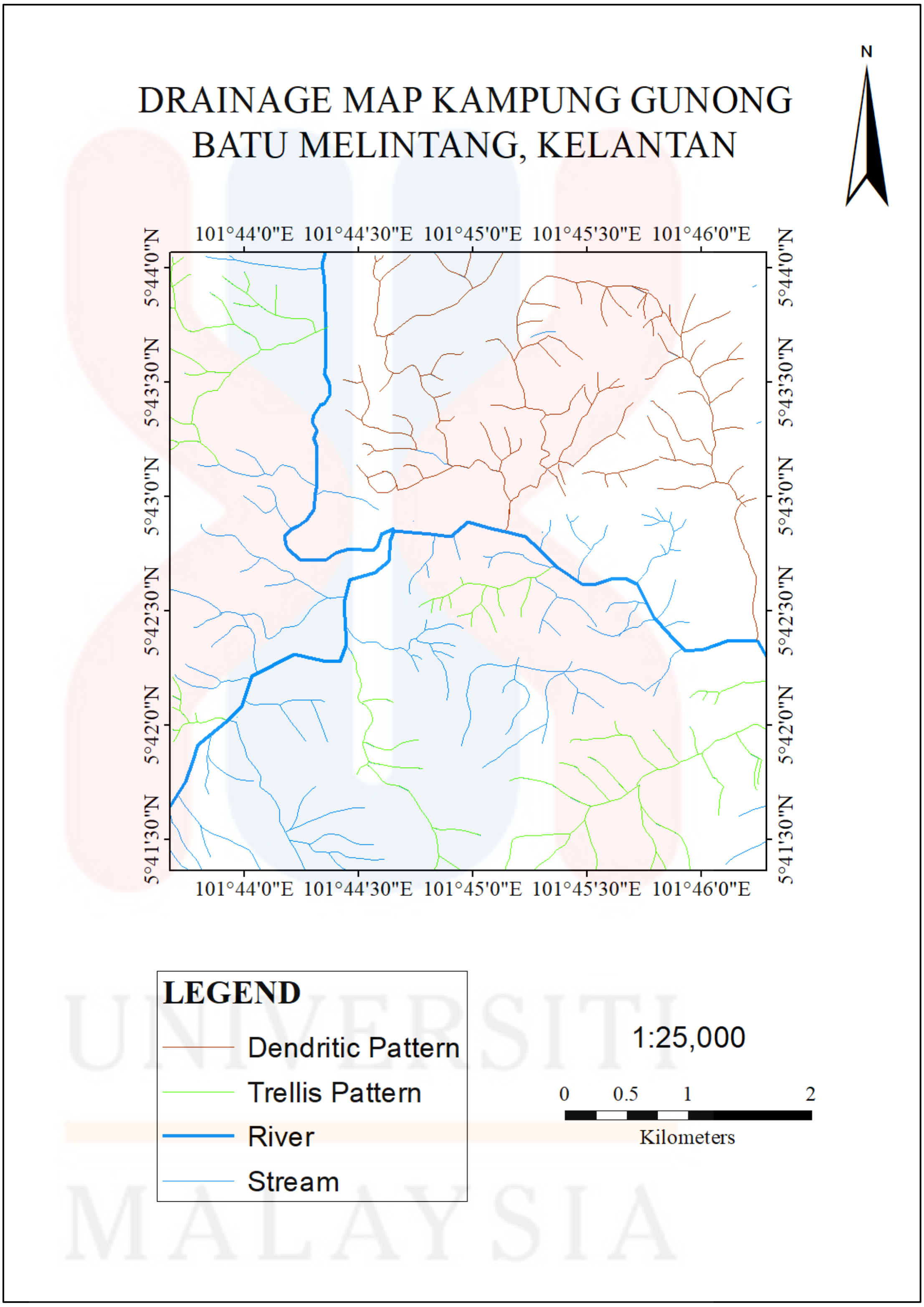


Figure 4.11 Drainage pattern map of study area

4.3 Lithostratigraphy

Most of the rocks in the study area are igneous and marble. The study area is divided lithologically into three major lithologic units: granite, marble, and schist. Based on their dominating lithological distributions, the units are determined. The geological map contains information about each unit in detail.

4.3.1 Stratigraphic position

Granite, schist and marble units were the three main lithologic types found in the study area. The stratigraphy is presented chronologically from the oldest to the youngest and is based on lithostratigraphic units. Figure 4.12 presents the stratigraphic column, which illustrates the relationships between the units in the studied area. The study areas north-south the granite unit, was determined to be the oldest unit. The second oldest rock in the study area is the schist unit, which in the west. The youngest unit is marble.

Age		Formation	Unit	Lithology	Description
Era	Period				
Late Paleozoic to Early Mesozoic	Triassic	Telong Formation	Marble		When limestone is subjected to the heat and pressure of metamorphism, light colored rock, and formation results. Other minerals such clay minerals, micas, quartz, pyrite, iron oxides, and graphite are commonly found in it.
			Schist		Schist is a metamorphic rock of medium grade. It was formed by the metamorphose of mudstone, shale, or an igneous rock type. Mica minerals typically crystallize better there. This is referred as schistosity texture because they are biotite, chlorite, and muscovite.
			Granite		Granite is light grey in color and have a phanaretic texture with coarse grains. It was made up of opaque minerals like quartz, biotite, opaque minerals, and plagioclase. This rock is intrusive.

Figure 4.12 Stratigraphic column of study area

4.3.2 Description of Rock Unit

Knowing the chronologically of the lithologic rock units, from the oldest to the youngest is crucial for discussing lithologic units. The distribution of each lithology, the thickness of the rock units, and the relationships between the units are also discussed. The identification of the minerals and their compositions depends on the petrographic study of each lithologic unit.

A rock of intrusive igneous origin is granite. The granite in the study area is grey in color. It is made of acidic magma composition that exists beneath the surface of the Earth. The granite's texture was phaneritic, with medium-sized to coarse grains. According to the hand specimen and observations made with the naked eye, the granite includes mica and biotite as minor minerals in addition to phenocrysts of feldspar quartz. The granite rocks in the research region are a part of Jeli granite, one of the granitic formations in peninsular Malaysia's eastern belt.

Rock that has undergone metamorphic foliation is schist. Schist with a foliated structure and colours ranging from lighter to darker was discovered in the study area during the Triassic period. With the naked eye, the grain size is generally fine to medium grain. The rock is known as schist based on the hand specimen.

Calcium-magnesium carbonate, which has been recrystallized by the effects of heat, pressure, and aqueous solutions, makes up marble. The calcite grains that make up marbles are enormous rather than thinly layered, and they rarely exhibit any signs of crystalline form when examined under a microscope. Figure 4.13 shows the geological map of the study area.

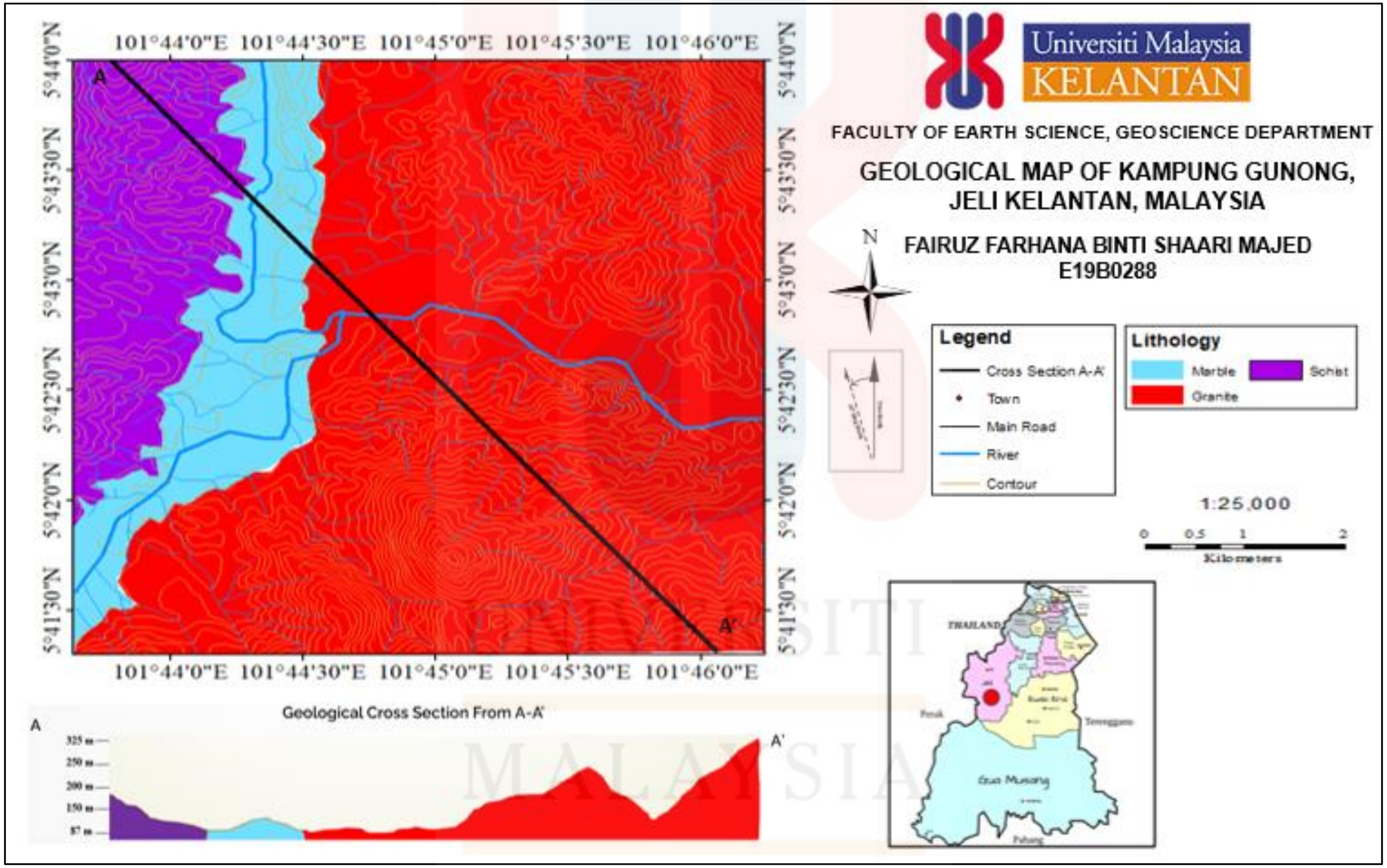


Figure 4.13: Geological map of study area

4.3.3 Petrography

A subfield of petrology known as petrography focuses on providing thorough descriptions of rocks in thin sections that have been examined under a microscope using two different types of polarised light. The primary focus of petrographic studies is on the precise classification and description of rocks.

To determine the composition and mineralogy of the hand specimens collected during the geological mapping, thin sections were made. Based on the dominant minerals that were seen under a microscopic perspective, rocks will be named. From figure 4.14 to figure 4.20, the thin section from each sample obtained at the outcrop were analysed.

Thin section

Sample 1

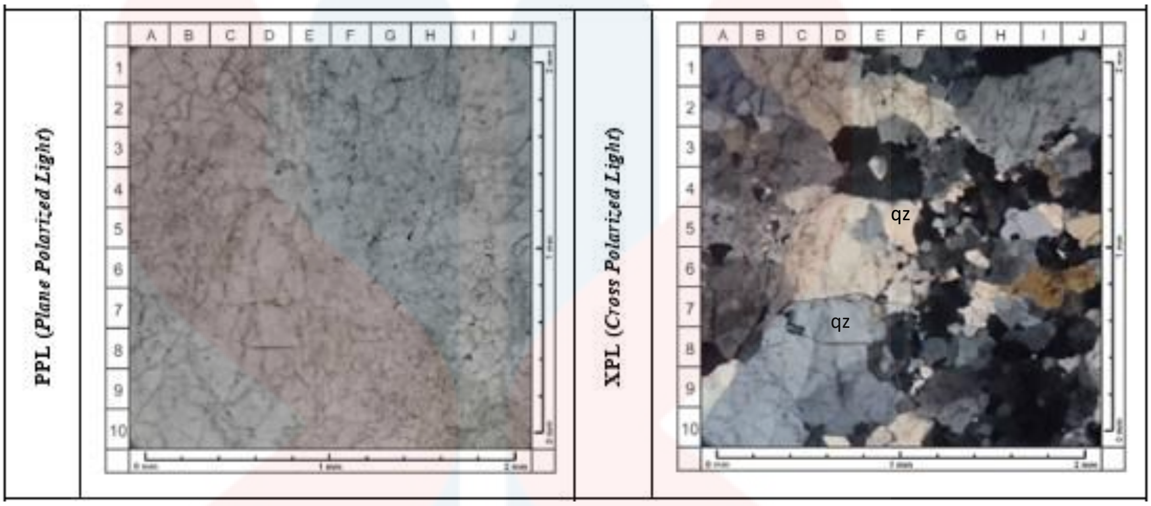


Figure 4.14: Quartzite in thin section

Microscopic Observation: The observation was carried out at 10x ocular magnification and 5x objective magnification and on the observation of non-foliated (granulose) structures, crystalloblastic (granoblastic) textures including grain size 1/128 - 1mm, moderate sorting.

Mineral Composition: Quartz– 100%: At PPL the absorption color is colorless, low relief, no pleochroism, anhedral crystal form, no cleavage. In XPL the interference color is order 1 gray – white, the dark corners are wavy, there is no twinning.

Sample 2

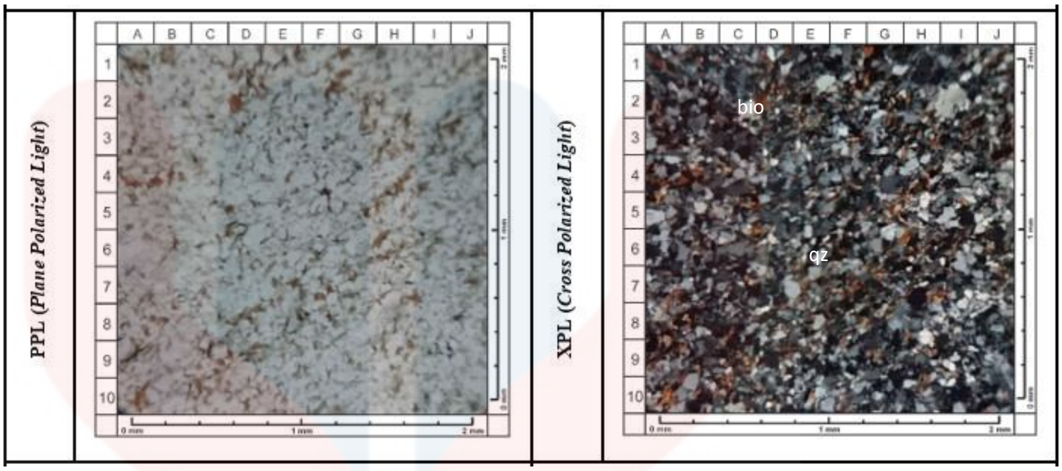


Figure 4.15: Granite in thin section

Microscopic Observation: The observation was carried out at 10x ocular magnification and 5x objective magnification and the observations revealed a massive structure - weak foliation, texture covering grain size <1/256 - 1/5 mm, good sorting, closed packaging.

Mineral Composition: Quartz– 83%: At PPL the absorption color is colorless, low relief, no pleochroism, anhedral crystal form, no cleavage. In XPL the interference color is order 1 gray – white, the dark corners are wavy, there is no twinning.

Biotite– 6%: At PPL absorption color is brown – greenish, moderate relief, strong pleochroism, subhedral – euhedral crystal form, 1 way cleavage. In XPL, the interference color is green – orange order 3, there are no twinning parallel dark angles.

Silica Clay– 10%: At PPL the absorption color is colorless – brown. In XPL the interference color is dark gray – black. Consists of micron-sized silicate material.

Opaque Mineral– 1%: At PPL the absorption color is black, low relief, no pleochroism, euhedral – anhedral crystal form. In XPL color interference black order 1, there is no twinning.

Sample 3

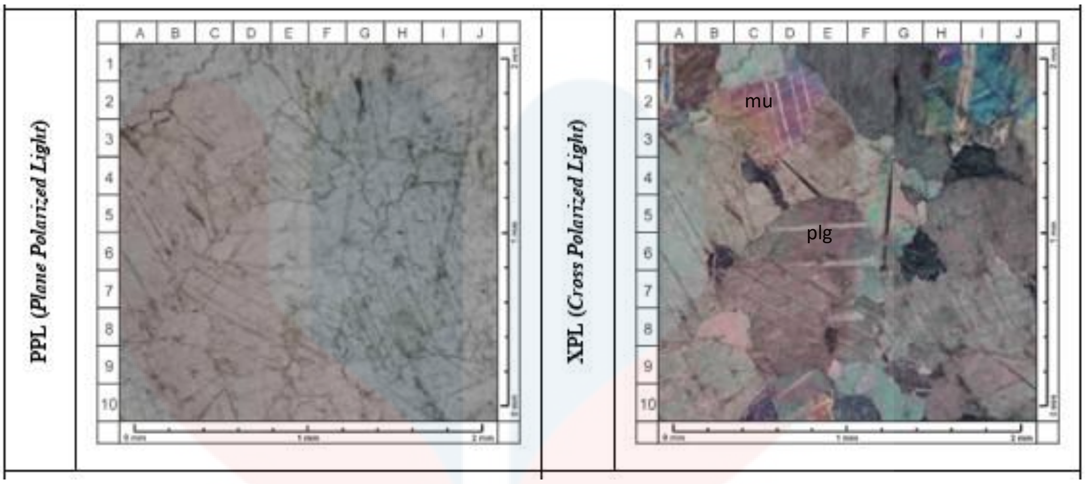


Figure 4.16 Marble in thin section

Microscopic Observation: The observation was carried out at 10x ocular magnification and 5x objective magnification and the observations revealed a massive structure, texture covering grain size <1/256 – 1 mm, moderate sorting, closed packaging.

Mineral Composition: Calcite– 25%

At PPL the absorption color is colorless, the relief is low-moderate, pleochroism is absent, anhedral crystal form, cleavage in 2 directions is absent. In XPL, interference colors pink – green order 4 – order 5, dark angles are symmetrical, twins do not exist – polysynthetic.

Opaque Minerals– 1%: At PPL the absorption color is black, low relief, no pleochroism, euhedral – anhedral crystal form. In XPL color interference black order 1, there is no twinning.

Sample 4

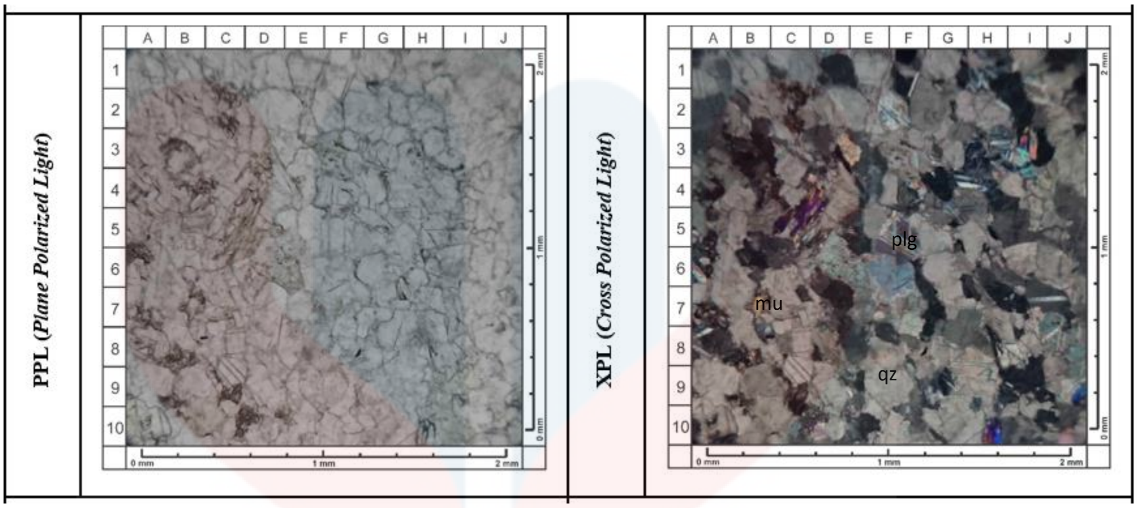


Figure 4.17 Marble in thin section

Microscopic Observation: The observation was carried out at 10x ocular magnification and 5x objective magnification and the observations revealed a massive structure, texture covering grain size <1/256 – 1/3 mm, good sorting, closed packaging.

Mineral Composition: Calcite– 97%: At PPL the absorption color is colorless, the relief is low-moderate, pleochroism is absent, anhedral crystal form, cleavage in 2 directions is absent. In XPL, interference colors pink – green order 4 – order 5, dark angles are symmetrical, twins do not exist – polysynthetic.

Muscovites– 3%: At PPL the absorption color is brownish, moderate relief, strong pleochroism, subhedral – euhedral crystal form, 1 way cleavage. In XPL the interference color is yellow – orange order 3, there is no twinning parallel dark angle.

Sample 5

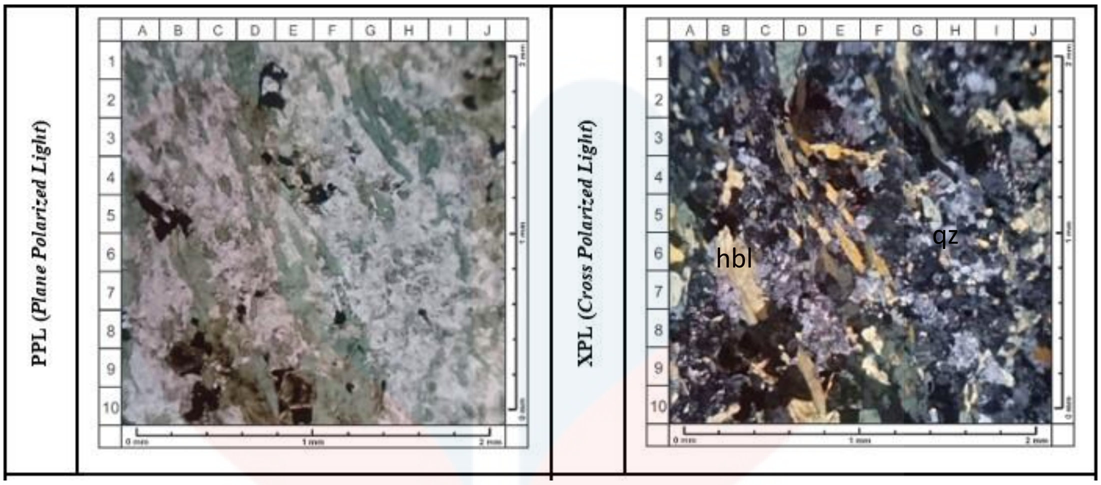


Figure 4.18 Schist in thin section

Microscopic Observation: The observation was carried out at 10x ocular magnification and 5x objective magnification and the observations revealed a massive structure - weak foliation, texture covering grain size <1/256 - 1/2 mm, moderate sorting, closed packaging.

Mineral Composition: Quartz– 57%: At PPL the absorption color is colorless, low relief, no pleochroism, anhedral crystal form, no cleavage. In XPL the interference color is order 1 gray – white, the dark corners are wavy, there is no twinning.

Chlorite– 30%: In PPL the absorption color is green, the relief is low-moderate, the pleochroism is weak-moderate, the crystal form is anhedral-subhedral, 1-way cleavage is absent. In XPL, the interference color is gray – dark green order 1 – order 2, the dark angle is slanted, there is no twinning.

Silica Clay– 10%: At PPL the absorption color is colorless – brown. In XPL the interference color is dark gray – black. Consists of micron-sized silicate material.

Opaque Minerals– 3%: At PPL the absorption color is black, low relief, no pleochroism, euhedral – anhedral crystal form. In XPL color interference black order 1, there is no twinning.

Sample 6

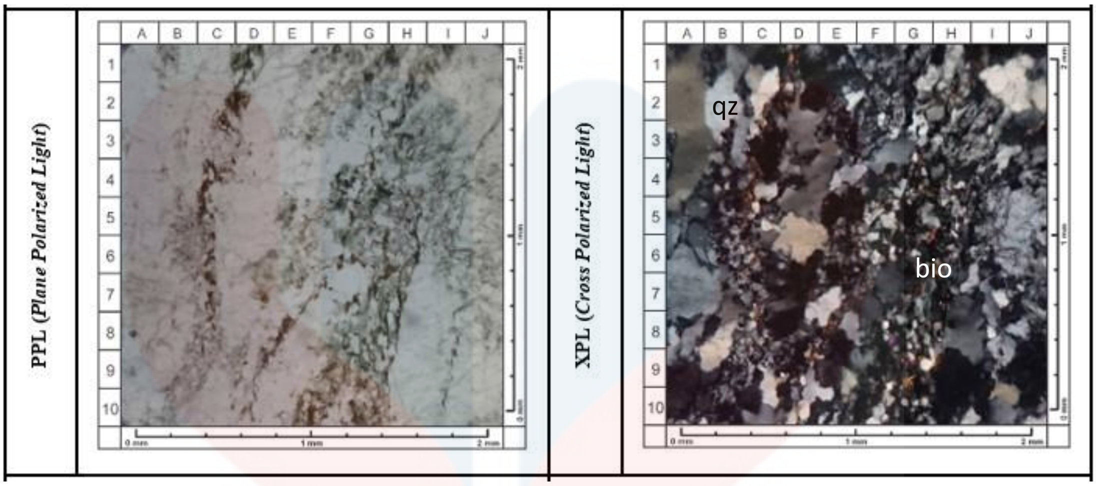


Figure 4.19 Granite in thin section

Microscopic Observation: The observation was carried out at 10x ocular magnification and 5x objective magnification and the observations revealed a massive structure - weak foliation, texture covering grain size <1/256 - 0.8 mm, moderate sorting, closed packaging.

Mineral Composition: Quartz– 90%: At PPL the absorption color is colorless, low relief, no pleochroism, anhedral crystal form, no cleavage. In XPL the interference color is order 1 gray – white, the dark corners are wavy, there is no twinning.

Biotite– 2%: At PPL absorption color is brown – greenish, moderate relief, strong pleochroism, subhedral – euhedral crystal form, 1 way cleavage. In XPL, the interference color is green – orange order 3, there are no twinning parallel dark angles.

Silica Clay– 7%: At PPL the absorption color is colorless – brown. In XPL the interference color is dark gray – black. Consists of micron-sized silicate material.

Opaque Minerals– 1%: At PPL the absorption color is black, low relief, no pleochroism, euhedral – anhedral crystal form. In XPL color interference black order 1, there is no twinning.

Sample 7

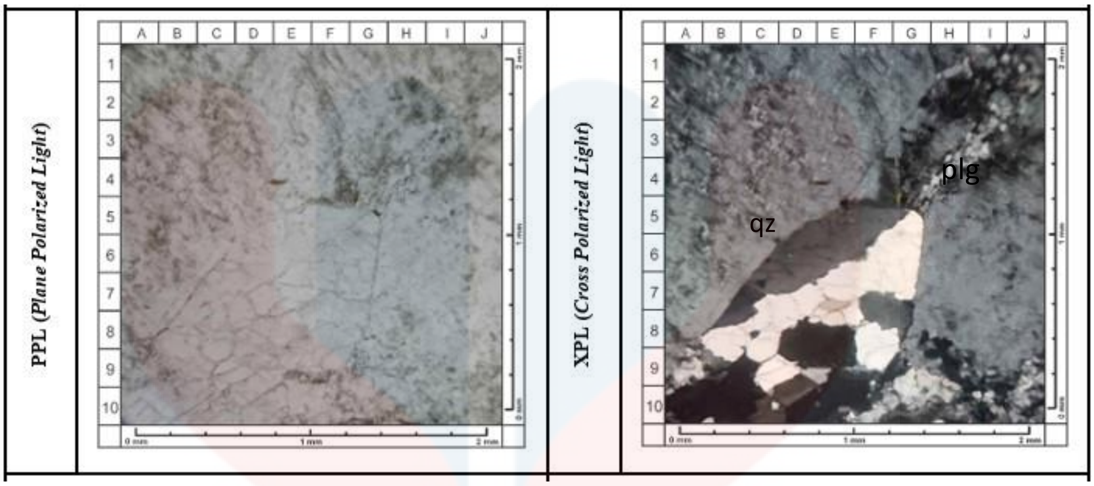


Figure 4.20 Alkali feldspar in thin section

Microscopic Observation: This observation was carried out at 10x ocular magnification and 5x objective magnification and observed massive structure, faneric texture - weak foliation, coarse - medium mineral size.

Mineral Composition: Microclin– 75%: Some turn into sericite. In PPL, the absorption color is colorless, low relief, no pleochroism, subhedral – anhedral crystal form, 1-way cleavage. In XPL the interference color is order 1 gray – white, the dark angle is slanted, polysynthetic twinning

Quartz– 25%: At PPL the absorption color is colorless, low relief, no pleochroism, anhedral crystal form, no cleavage. In XPL the interference color is order 1 gray – white, the dark corners are wavy, there is no twinning.

4.4 Structural Geology

A scientific field called structural geology explains the causes and effects of rock deformation in relation to the distribution of rock units. The mechanisms that cause the formation of geologic structures and how these structures can impact rocks are also included. It is crucial to map the local structure while conducting fieldwork since the regional structure frequently corresponds to the local structures. The lineament that was mapped during the preliminary investigations stage is connected to the local structures as well.

Geological structure patterns that were seen in the field, such as identifying the kind of structure, regional stratigraphic studies, and interpretation of the formation mechanism of geological structure, were discussed in relation to the research area's geological structure.

The following geological features were observed in the study area:

i. Lineament Analysis

ii. Joint Structure

4.4.1 Lineament Analysis

A lineament is defined as linear surface of the earth reflect the tectonic faults and fractures in the bedrock that are highlighted on the earth surface by drainage, topography, and vegetation, which can be determined using photo interpretation method. The term "subsurface datum" refers to defined stratigraphy, structure, and geophysics (Christopher et al., 1981). The approach for photo interpretation that was used made use of a topography map, Google Maps, and data collected through remote sensing. One technique for identifying distortion zones in the bedrock and a geological structure's faults, folds, and other deformation is lineament analysis.

Lineament analysis should be done at the preliminary stage. Based on the topography of the study area shown in Figure 4.21, the lineaments segments that are visible from the satellite imageries range in length from 500 m to 5 km and are primarily located at rivers, ridges, and valleys.

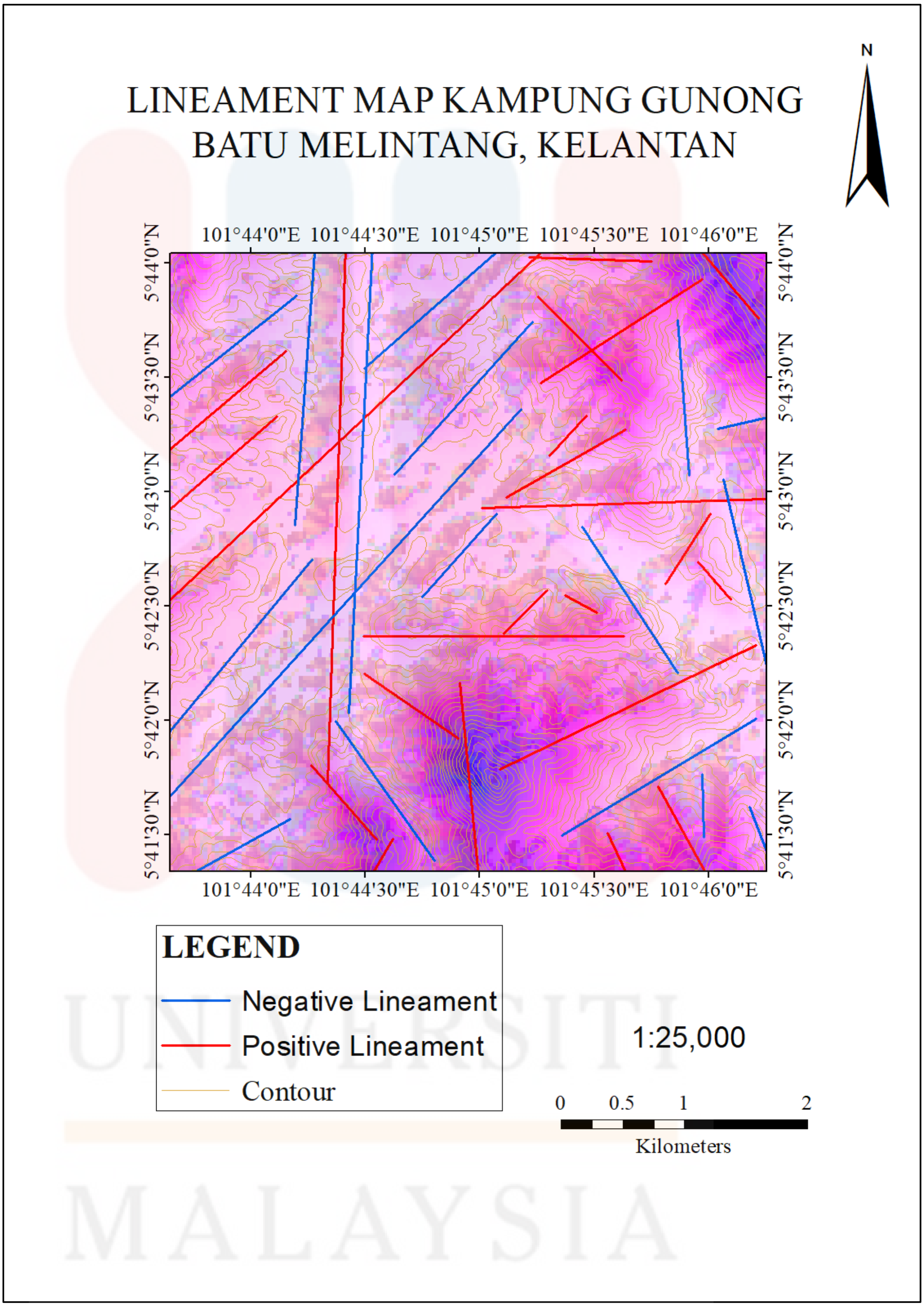


Figure 4.21 Lineament Map of study area

4.4.2 Joint Structure

Joint is described as the secondary structure that emerged from the formation of the rock. The brittle structure of a rock body or layer caused by tensile stresses can be used to identify a joint. If the tensile strength is greater than the rock strength, the rocks will break. The fractures and fold structure in the rock are the result of forces acting on it. Joint analysis was done at the river where, as shown in Figure 4.22, the outcrop is distributed along the river. Location of the joint is at coordinate 05° 44 56.4 N 101° 44 50 E.

The GeoRose Diagram method in Figure 4.23 was used to interpret the measurement results to identify the direction and magnitude of the main force direction.

Figure 4.22 (a) location of joint structure and (b) joint in outcrop

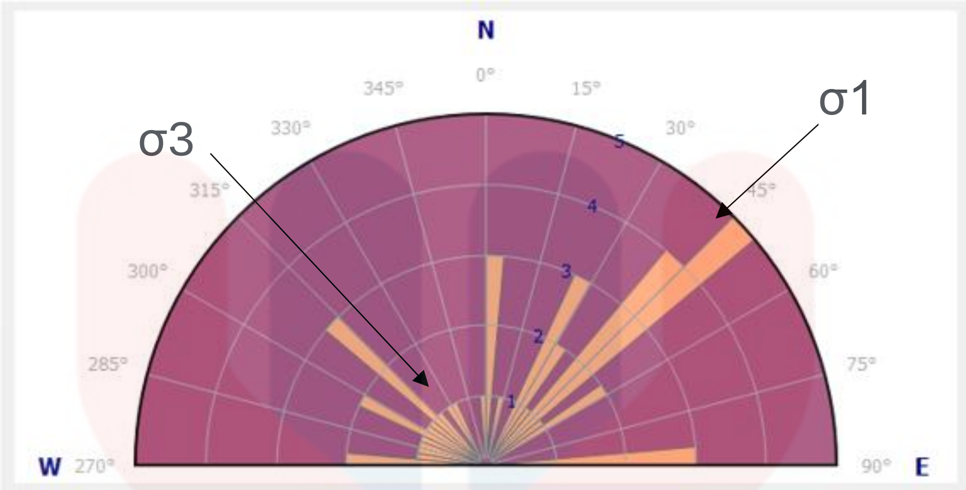


Figure 4.23 Joint analysis using GeoRose Diagram

Based on the joint analysis above, we can see that joint analysis have the direction of σ1 and σ3. We can conclude that Kampung Gunong area had undergo major stress from σ1 direction and minor stress from σ3 direction. From the stress direction we also can predicted other structures formations like fault formation.

Joints are important in the natural resource development, safe design of structures and safety of environment. Joint has huge control on weathering process and erosion of rock in the study area as a result, they exert a strong control on how topography and morphology of landscape develop (Blanckenburg, 2006).

4.5 Historical Geology

The field of historical geology aims to understand and recreate the Earth's geological past. This is accomplished by applying geological principles and methods. Geologic processes that alter the Earth's surface or subsurface are described in historical geology. To describe the sequence of events based on the geological timescale, the knowledge of stratigraphy and structural geology is important.

Slates, schists, and gneisses are examples of metamorphic rocks with significant foliation that are typically formed as a result of regional metamorphism. Since the Triassic period, the igneous body has dominated the creation of rock units in the study area.

Due to the metamorphism that occurs in some areas of the study area because of a significant change in temperature and pressure, marble rock units are formed. Metamorphism, a geological process, is responsible for this. Metamorphism can be classified as regional, contact, or dynamic.

Telong Formation is the name of the rock formation in the study area. Late Paleozoic to early Mesozoic is the time when Telong Formation first occurs.

CHAPTER 5

GRANITE GEOCHEMISTRY

5.1 Introduction

This chapter focused on applying geochemistry method to granite data analysis and interpretation. XRF analysis and ICP-MS analysis are two geochemistry method employed in this research. Because the major elements, trace elements, and rare earth elements in granite may be identified, it is important to apply the geochemistry method. To classify rocks, create variation diagrams, and compare experimentally obtained rock compositions with known formation conditions, geochemistry uses major element data in these three main ways. Additionally, to determine the tectonic context of igneous and sedimentary rocks, significant elements are combined with trace elements.

Two samples from study area are examined and geochemistry analysis of granite rocks were conducted. Samples taken are labelled as FF104 and FF203 respectively. All the outcomes will be graphed and discussed further. Major and trace elements are obtained for XRF analysis to classify granite using the S-I-A-M classification, the alumina saturation standard, and the tectonic setting classification. While REE was obtained for ICP-MS analysis to understand the distribution of REE in the study area, which is the third objective.

5.2 Major elements

Two samples of granite rock are shown in Table 5.1 as the result of the major elements. The XRF analysis determines that there are only four major elements. To minimise the loss or error of weight elements, all major elements are 100% normalised. All four major element weight percentages (wt%) are shown against the major element weight percentage of SiO2 using the Harker diagram. From Table 5.1, four major elements were detected by XRF analysis. This major element is being examined to understand patterns in the fractionation of the elements in granite.

Table 5.1: Major element normalized to 100%

Granite	**Major Elements normalized to 100% (wt%)**				**Total (wt%)**
	SiO_2	MgO	Al_2O_3	K_2O	
FF104	80.565	1.782	16.134	1.519	100.000
FF203	81.03	0.782	16.328	1.861	100.000

Figure 5.1 shows slightly difference that might assumed that the two rock samples are mostly in the same area (Finger et al., 2008) presented by the Harker diagram, with the highest major elements, SiO2 observed in rock samples range from 81.03% to 80.565%. This result signifies that total amount of SiO2 were made up of silica minerals. Al2O3 also shows highest percentage, 16.134% and 16.328%

respectively for two samples. K2O range from 1.519% to 1.861%, and MgO had the lowest distribution, 1.519% to 1.861% in the study area.

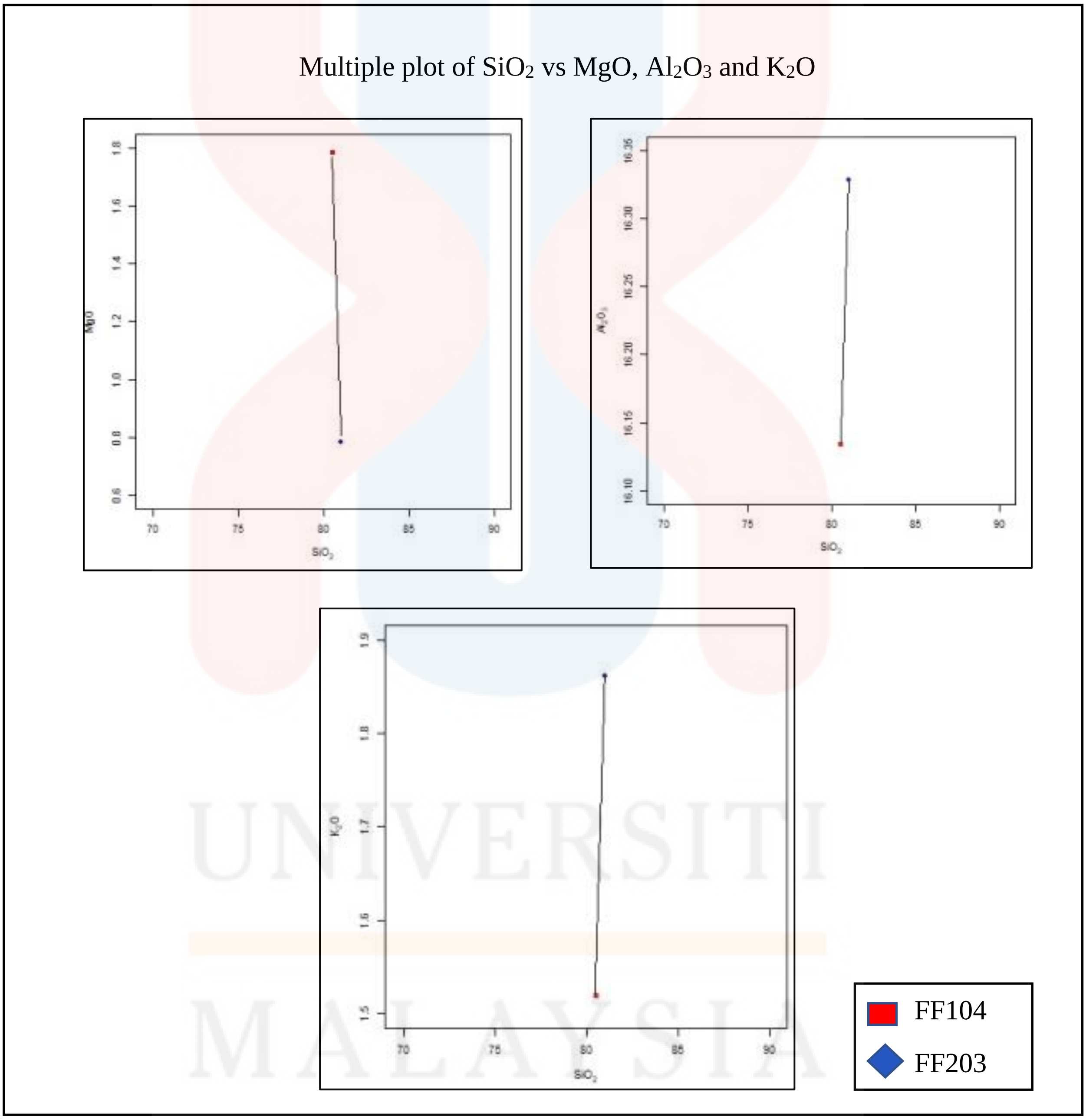


Figure 5.1: Harker diagram of major elements

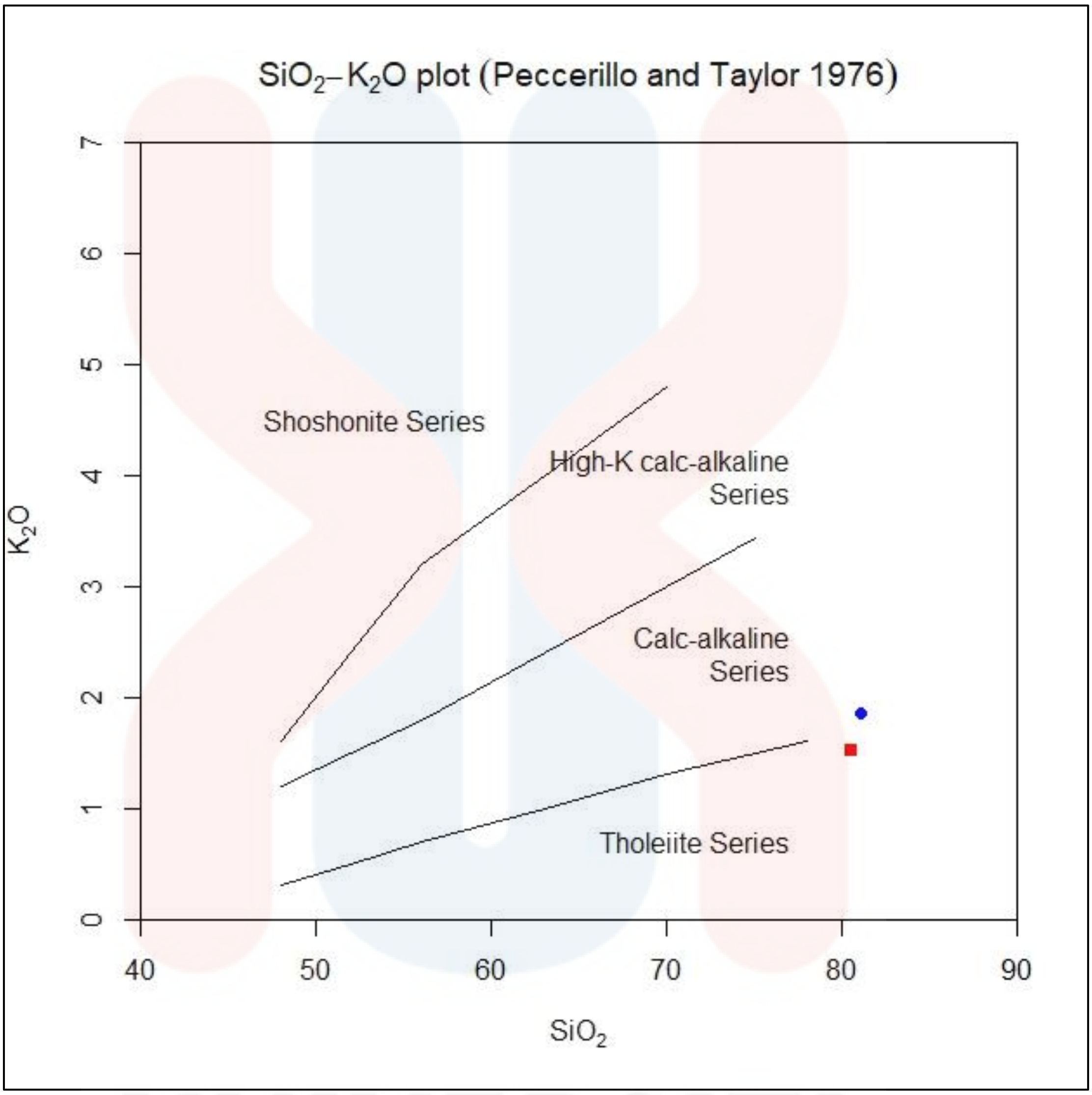


Figure 5.2: SiO2 vs K2O diagram (Peccerillo and Taylor 1976)

The oxidation state of the magma they crystallized from distinguishes rocks in the calc-alkaline magma series from those in the subalkaline tholeiitic magma series, which are categorized as subalkaline. The iron content of tholeiitic magmas rises when the melt is drained of iron-poor crystals because the basalt parent magmas prefer to crystallize the more magnesium-rich and iron-poor forms of the silicate minerals olivine and pyroxene. The iron content of a calc-alkaline magma, as compared to a tholeiitic magma, cools more steadily because it is sufficiently oxidized to precipitate large amounts of the iron oxide magnetite.

In relation to Figure 5.2, the SiO2-K2O plot (Peccerillo & Taylor, 1976) was used, and the plot demonstrates that the two samples are in the same series but have some visible variations. FF203 is seen to be close to the calc-alkaline series when it is plotted between that field and the tholeiite series. Sample FF104 shows higher SiO2 and K2O values. For the two samples of K2O and SiO2, there is a tiny change in slope.

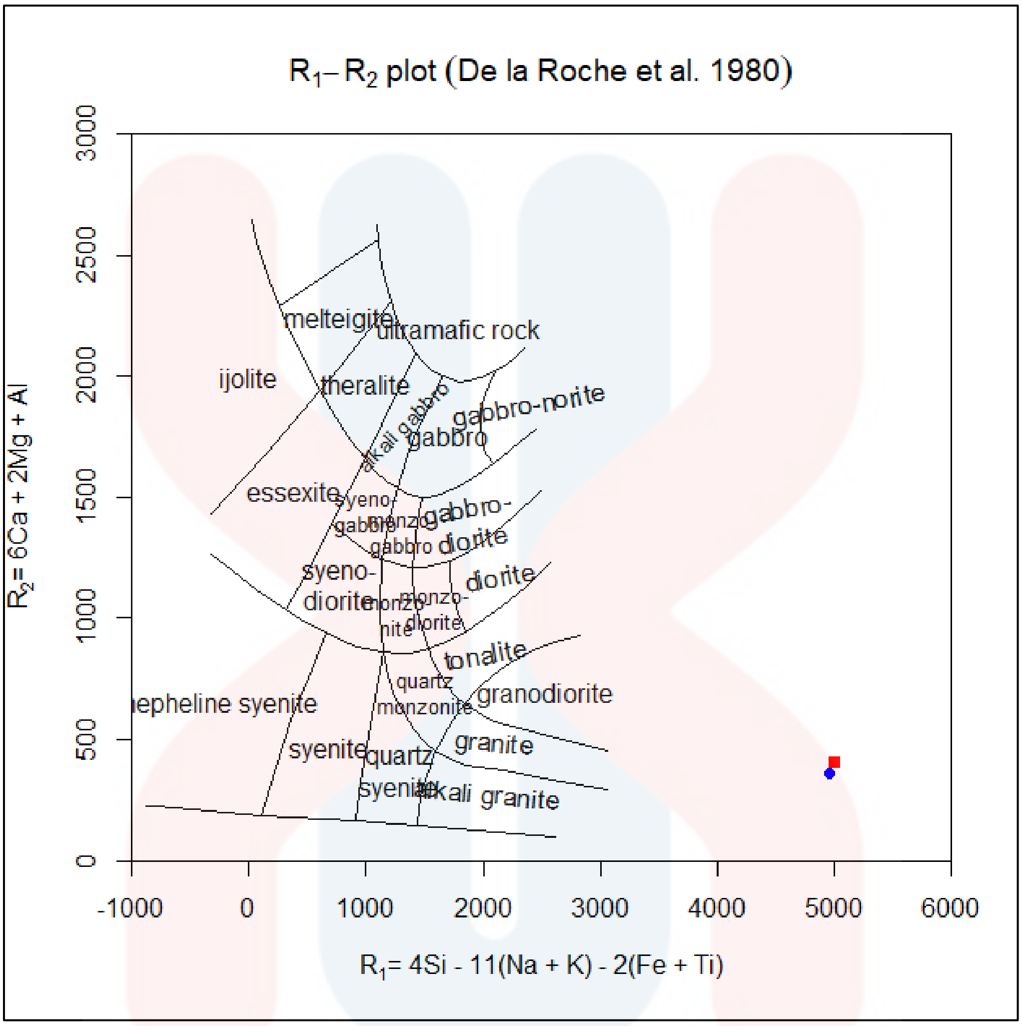


Figure 5.3: R1-R2 plot (De La Roche et al. 1980)

Based on Figure 5.3, both samples were plotted in R1-R2 plot by De La Roche et al. (1980) diagram. Both samples are found in granite fields and at the end of granite members, which indicates that the area is abundant in alkali feldspar. Samples FF104 and FF203 in the field of granite belong to the same group.

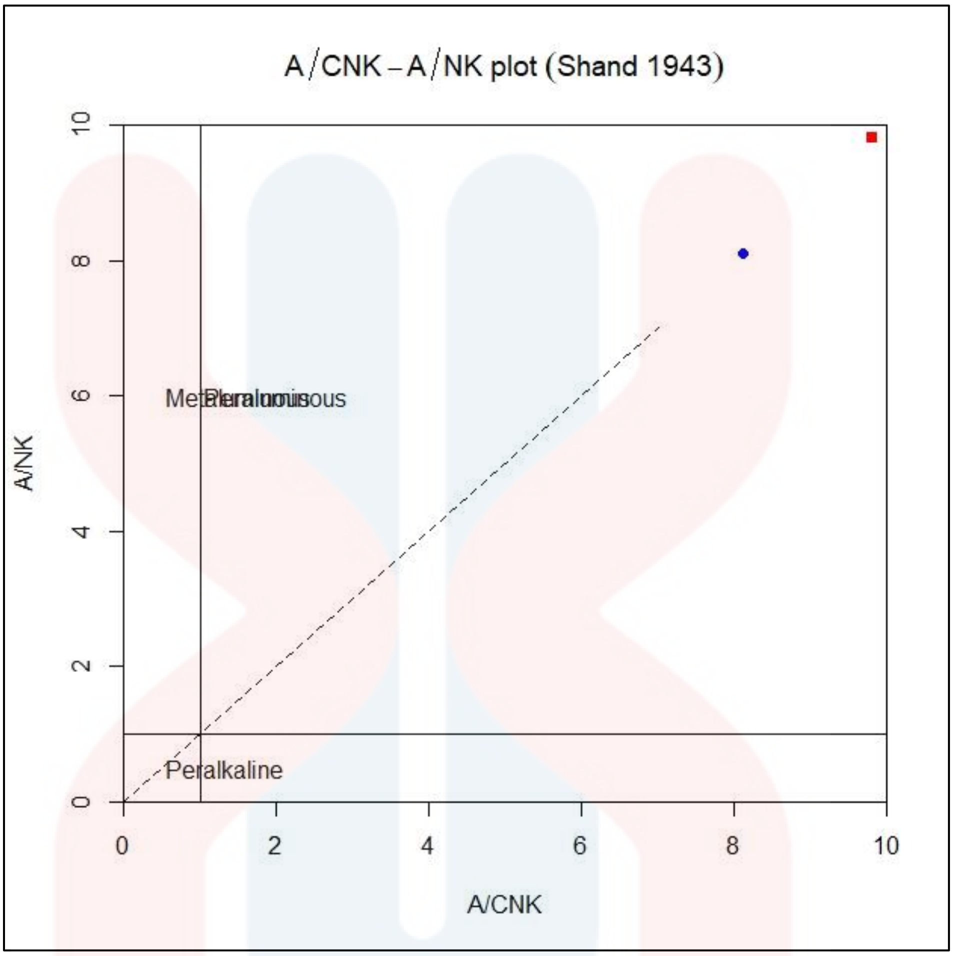


Figure 5.4: A/CNK vs A/NK plot of granites.

The most generally used metric to define the nature of granitic magma is the molecular proportions of the ratio Al2O3/(CaO+Na2O+K2O), abbreviated as A/CNK. Granite rocks were divided into peraluminous, peralkaline, and meta luminous groups by A/CNK based on their alumina saturation. Depending on the alumina saturation, both samples exhibit A/CNK values larger than 2.2, which classifies them as peraluminous. The granite rocks in the peraluminous section can be classified as S-type rocks, which are connected to intra-crustal melting, according to (Clemens, 2003).

5.3 Rare Earth Element

ICP-MS techniques were used to gather two samples of granite for the purpose of identifying rare earth elements. Table 5.2 displays the results of REE analysis in unit ppb using ICP-MS.

Table 5.2: REE analysis using ICPMS in unit ppb

No	Sample ID	Elements	RESULTS (ppb)
1	F 304PG	Ce	2614.42
		Dy	291.62
		Er	170.25
		Eu	120.45
		Gd	363.62
		Ho	240.82
		La	2224.20
		Lu	490.38
		Nd	1631.30
		Pr	662.47
		Sc	581.19
		Sm	458.17
		Tb	443.31
		Th	442.83
		Tm	188.84
		Y	4010.94
		Yb	564.88
2	F 301Gg	Ce	3432.11
		Dy	223.98
		Er	152.13
		Eu	116.92
		Gd	243.81
		Ho	234.35
		La	1061.66
		Lu	488.78
		Nd	809.91
		Pr	418.20
		Sc	523.65
		Sm	277.91
		Tb	430.32
		Th	375.14
		Tm	186.72
		Y	3972.20
		Yb	552.94
3	FF 104	Ce	2184.88
		Dy	327.00
		Er	245.12

Table 5.3 REE element in sample FF 104 and FF 203 in unit ppb

Samples	FF104	FF203
Light Rare Earth Element (LREE) in ppb		
Lanthanium (La)	907.78	2375.67
Cerium (Ce)	2184.88	2105.10
Praseodyium (Pr)	361.42	501.59
Neodymium (Nd)	768.55	786.98
Samarium (Sm)	247.43	317.74
∑LREE	**4,470.06**	**6,087.08**
Heavy Rare Earth Element (HREE) in ppb		
Europium (Eu)	115.02	123.35
Gadolinium (Gd)	268.85	270.46
Terbium (Tb)	439.28	438.02
Dysprosium (Dy)	327.00	286.18
Holmium (Ho)	251.79	240.25
Erbium (Er)	245.12	185.66
Thulium (Tm)	194.72	193.39
Ytterbium (Yb)	658.21	606.45
Lutetium (Lu)	503.92	496.29
Thorium (Th)	499.42	691.31
Yttrium (Y)	7954.34	3714.79
∑ HREE	**11,457.67**	**7,246.15**

From Table 5.3, the data shows the distribution and amount of both LREE and HREE in two samples of granite in ppb. The data obtained from ICP-MS analysis varies in two samples. FF203 has highest amount of Light rare earth elements (LREE) while for FF104, Heavy rare earth elements (HREE) are the highest compared to FF203. From five among seventeen rare earth elements, lanthanum has the highest amount of concentration in samples FF203 with the value 2.37567 ppb. Lanthanum is roughly 0.0018% in the earth crust, and currently is behind neodymium and cerium.

Rare earth elements are believed to be resistant to fractionation in supracrustal environments because of their relatively similar chemical characteristics. The distribution of REE can be used to determine the primary elements of a rock formation. Figure 5.5 shows the rare earth element patterns of these two categories of granitic rocks. LREE and HREE are two general categories for the REE. Both samples in this plot have a similar pattern, which suggests that both granites experienced the same process during their formation.

ICP-MS was applied to look at the distributions of rare earth elements in the two chosen samples. The ICP-MS raw data is shown in Table 5.2, and Table 5.3 classifies REE into two groups: HREE and LREE. Both samples included the same five of the six LREE, but at various concentration. The concentration of REE in both samples is represented by the graph in Figure 5.5, with Lanthanum (La) having the greatest concentration 2.37567 ppb, which was found in sample FF203.

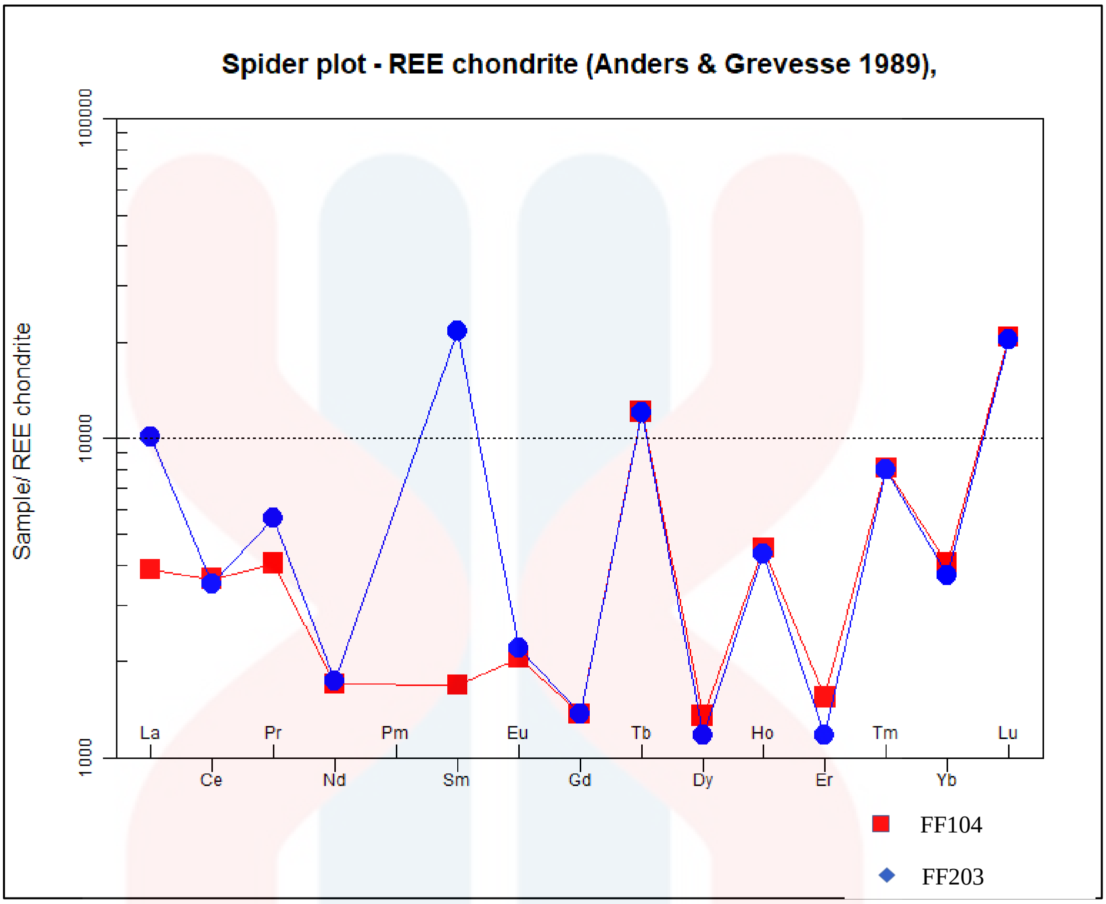


Figure 5.5: Chondrite REE abundances for the granites

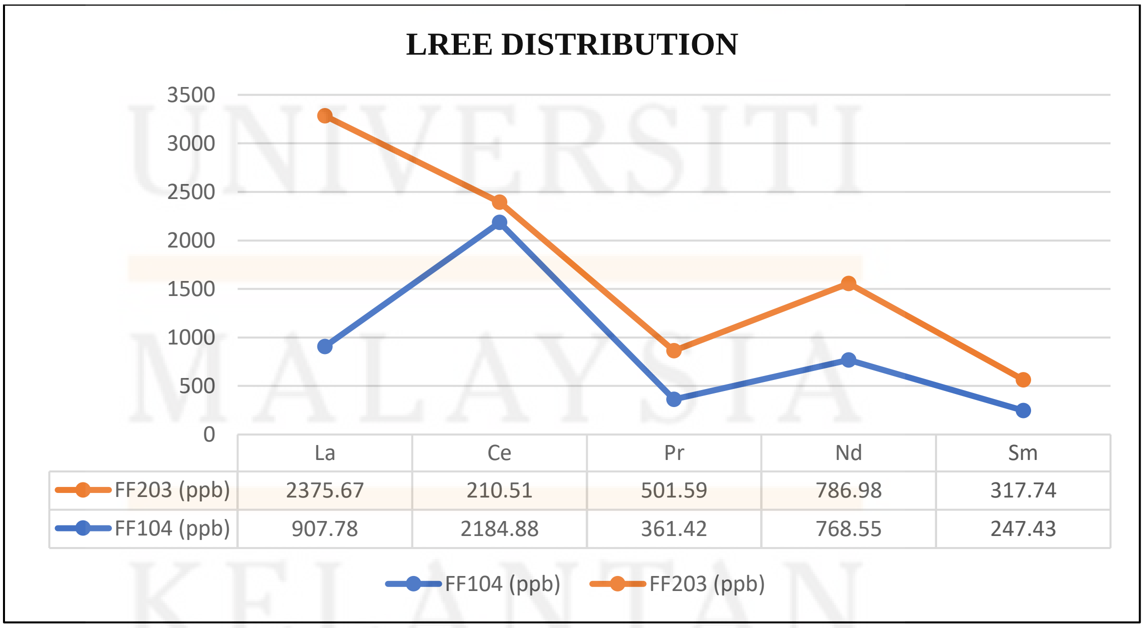


Figure 5.6: LREE distribution of samples

FF203 displays the highest concentrations among all LREE, according to the graph in Figure 5.6 depicting the distribution of LREE on two samples. La has a value of 2375.67 ppb, which is the highest, and Sm has a value of 317.74 ppb, which is the lowest. For FF104, the trend is similar to FF203, although the values for each concentration are slightly different. As an example, the amounts of Samarium measured in FF104 are the lowest across the range at 247.43 ppb.

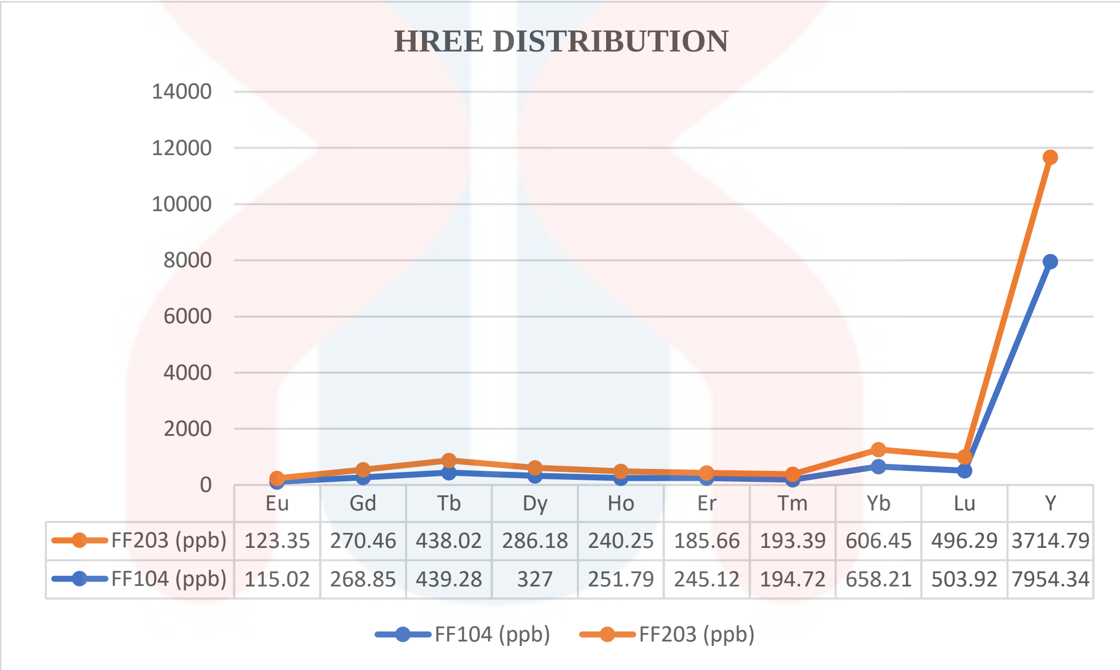


Figure 5.7: HREE distribution of samples

From Figure 5.7, HREE concentrations for both samples show the same trends and FF203 most likely the dominant compared to FF104. There is slightly difference between both samples and Yttrium shows the highest concentration for both samples with 7954.34 and 3714.79 respectively.

5.4 Discussion

Samples that were chosen has been analyse at Great Laboratory in UMK Jeli campus. The samples were examined for their major and trace elements by using XRF Spectrometer. ICP-MS were used to determine the distribution of rare earth elements for each sample that were chosen. XRF Spectrometer were the first method used in order to get the result of rare earth elements. Rock samples that had been pulverized into powder were weighed, mixed for three minutes, and then molded into pellets for analysis.

The granite in the analysis has a variety of geochemical compositions, indicating that the rocks came from different sources. The data, however, indicate that the two rock samples under analysis originated from the same magmatic source, as proven by the linear trends of the major oxides in the Harker diagrams in Figure 5.1, which show the major element concentrations for both samples, with SiO2 being the dominant major element in both rocks with values 81.03% to 80.565 wt%.

Despite a slight compositional difference, the SiO2-K2O diagram (Peccerillo and Taylor 1976) in Figure 5.2 clearly shows that the two samples belong to a close series. This can be taken to suggest that sample FF203 is plotted between the Tholeiite series and the field of calc alkaline series. SiO2 and K2O levels are greater in sample FF104. There is a slight difference in slope between the two samples of K2O and SiO2.

Samples have been further classified during petrography analysis in chapter four based on the granitic rock groups studied. Therefore, the samples have been plotted as shown in Figure 5.3 to further explain the type of granite in these two samples using the R1-R2 plot (De La Roche et al., 1980) diagram. As a result, the

A/NK vs A/CNK diagram (Shand, 1943) was drawn for the classic discrimination of metaluminous, peraluminous, and peralkaline compositions as shown in Figure 5.4.

Both samples have been categorised as having peraluminous composition, and in that regard, the study region rock is claimed to be S-type granites that source from partial melting sedimentary rocks. FF104 has highest value than FF203 which is greater than 4 of A/CNK value. Samarium (Sm) has a value of 0.31774 ppb, which is the lowest for FF203. For conclusion, FF203 shows highest concentrations of elements than FF104.

HREE distribution for two samples are illustrate in graph. Yttrium has the highest concentration in FF104 with 7.95434 ppb value and FF203 with 3.71479 ppb value.

CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

In summary, Final Year Project effort has resulted in the accomplishment of all objectives. A 1:25,000 scale geological map of the study area was able to be updated. From the comparison of geological map of previous researchers and my research, it can conclude that there is not much different from analyses of geomorphology, lithology, geological structure, and other geological information. In accordance with the study title, the studies tend to focus on the geochemistry of granite rocks in the studied area. To determine the geochemistry of granite rocks in the research area, geochemical analysis and petrography analysis were used. All granite samples were classified according to their characteristics based on their granite classification through the geochemistry analysis. Granite rocks from Kampung Gunong are thus classified as S-type rocks.

6.2 Recommendation

Outcrops sampling is the most important things to complete Chapter 5 for specification part. For more accurate data, number of samples to analyse should be at least five samples or above as this will eventually help the researcher to get the ideas and elaborate more on the specification part. Further research also should be conducted in the study area in the future as there were lacking information regarding the geological information there.

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APPENDICES A

XRF Report

GOLD, RARE EARTH & MATERIAL TECHNOPRENEURSHIP CENTRE

Company info: Gold, Rare Earth and Materials Technopreneurship Centre, Faculty of Bioengineering and Technology, Universiti Malaysia Kelantan

XRF REPORT

Instrument info:

Type	S1 TITAN
Model	800
Serial number	800N10467
Last calibration check	

Measurement info:

Acquisition time	28/12/2022 11:56:22 AM	Application	GeoExploration
Calibration	Oxide3phase	Measurement time	60
Type standardization set		Operator	Supervisor
ID	FF104		

Result table:

Element/Compound	%	±2σ
MgO	1.537	0.525
Al2O3	13.913	0.353
SiO2	69.475	0.610
P	0.030	0.012
K2O	1.310	0.020
Ca	2.950	0.022
Ti	0.261	0.006
Mn	0.085	0.005
Fe	3.590	0.024
Co	0.014	0.004
Ni	0.001	0.001
Cu	0.001	0.001
Zn	0.005	0.001
Ga	0.002	0.000
Rb	0.008	0.001

Printed: 29.12.2022 13:31 00239-GeoExploration.pdz Page no: 1 of 2

GOLD, RARE EARTH & MATERIAL TECHNOPRENEURSHIP CENTRE

Company info: Gold, Rare Earth and Materials Technopreneurship Centre, Faculty of Bioengineering and Technology, Universiti Malaysia Kelantan

Element/Compound	%	±2σ
Sr	0.012	0.001
Y	0.002	0.000
Zr	0.008	0.000
Ba	0.009	0.005
Th	0.001	0.001

Excitation parameters:

Phase	1	2	3
Time [sec]	20	20	20
Voltage [kV]	30	50	15
Current [µA]	13.6	18.4	9.7
Filter	Blank	Blank	Blank
Collimator [mm]	8 / 8		

Company info: Gold, Rare Earth and Materials Technopreneurship Centre, Faculty of Bioengineering and Technology, Universiti Malaysia Kelantan

Instrument info:

Type	S1 TITAN
Model	800
Serial number	800N10467
Last calibration check	

Measurement info:

Acquisition time	28/12/2022 12:01:12 PM	Application	GeoExploration
Calibration	Oxide3phase	Measurement time	60
Type standardization set		Operator	Supervisor
ID	FF203		

Result table:

Element/Compound	%	±2σ
MgO	0.640	0.473
Al2O3	13.362	0.337
SiO2	66.312	0.590
P	0.035	0.012
K2O	1.523	0.021
Ca	1.908	0.018
Ti	0.163	0.005
Mn	0.058	0.004
Fe	1.931	0.018
Co	0.005	0.003
Cu	0.002	0.000
Zn	0.005	0.001
Ga	0.001	0.000
As	0.001	0.001
Se	0.000	0.000
Rb	0.010	0.001
Sr	0.024	0.001

Company info: Gold, Rare Earth and Materials Technopreneurship Centre, Faculty of Bioengineering and Technology, Universiti Malaysia Kelantan

Element/Compound	%	±2σ
Y	0.002	0.000
Zr	0.016	0.001
Nb	0.002	0.000
Ba	0.033	0.006
Pb	0.004	0.001
Th	0.001	0.001

Excitation parameters:

Phase	1	2	3
Time [sec]	20	20	20
Voltage [kV]	30	50	15
Current [µA]	13.6	18.4	9.7
Filter	Blank	Blank	Blank
Collimator [mm]	8 / 8		

APPENDICES B

ICP-MS Report

3	*FF 104*	Ce	2184.88
		Dy	327.00
		Er	245.12
		Eu	115.02
		Gd	268.85
		Ho	251.79
		La	907.78
		Lu	503.92
		Nd	768.55
		Pr	361.42
		Sc	635.27
		Sm	247.43
		Tb	439.28
		Th	499.42
		Tm	194.72
		Y	7954.34
		Yb	658.21
4	*FF 203*	Ce	2105.10
		Dy	286.18
		Er	185.66
		Eu	123.35
		Gd	270.46
		Ho	240.25
		La	2375.67
		Lu	496.29
		Nd	786.98
		Pr	501.59
		Sc	843.35
		Sm	317.74
		Tb	438.02
		Th	691.31
		Tm	193.39
		Y	3714.79
		Yb	606.45

FF 104	Ce	21.85	0.50	50.00	2184.88
	Dy	3.27	0.50	50.00	327.00
	Er	2.45	0.50	50.00	245.12
	Eu	1.15	0.50	50.00	115.02
	Gd	2.69	0.50	50.00	268.85
	Ho	2.52	0.50	50.00	251.79
	La	9.08	0.50	50.00	907.78
	Lu	5.04	0.50	50.00	503.92
	Nd	7.69	0.50	50.00	768.55
	Pr	3.61	0.50	50.00	361.42
	Sc	6.35	0.50	50.00	635.27
	Sm	2.47	0.50	50.00	247.43
	Tb	4.39	0.50	50.00	439.28
	Th	4.99	0.50	50.00	499.42
	Tm	1.95	0.50	50.00	194.72
	Y	79.54	0.50	50.00	7954.34
	Yb	6.58	0.50	50.00	658.21
FF 203	Ce	21.05	0.50	50.00	2105.10
	Dy	2.86	0.50	50.00	286.18
	Er	1.86	0.50	50.00	185.66
	Eu	1.23	0.50	50.00	123.35
	Gd	2.70	0.50	50.00	270.46
	Ho	2.40	0.50	50.00	240.25
	La	23.76	0.50	50.00	2375.67
	Lu	4.96	0.50	50.00	496.29
	Nd	7.87	0.50	50.00	786.98
	Pr	5.02	0.50	50.00	501.59
	Sc	8.43	0.50	50.00	843.35
	Sm	3.18	0.50	50.00	317.74
	Tb	4.38	0.50	50.00	438.02
	Th	6.91	0.50	50.00	691.31
	Tm	1.93	0.50	50.00	193.39
	Y	37.15	0.50	50.00	3714.79
	Yb	6.06	0.50	50.00	606.45