GENERAL GEOLOGY AND GEOCHEMISTRY OF GRANITE ROCKS IN KAMPUNG BATU GAJAH, TANAH MERAH, KELANTAN

by

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A thesis submitted in fulfilments of the requirements for the degree of Bachelor of Applied Science (Geoscience)

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DECLARATION

I declare that this thesis entitled General Geology and Geochemistry of Granite Rocks in Kampung Batu Gajah, Tanah Merah, 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.

Signature : ______________________________

Name : ______________________________

Date : ______________________________

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I wish to express my sincere thanks to my family for their continuous supports and encouragement for the whole time I am doing this research. I cannot thank my parents Mr. Berdal Bin Bahwanie and Mdm. Sofiah Binti Md Ali enough for their unconditional support over the years I am studying at UMK; it has meant everything to me.

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General Geology and Geochemistry of Granite Rocks in Kampung Batu Gajah, Tanah Merah, Kelantan

ABSTRACT

The study area is located in Kampung Batu Gajah, Tanah Merah, Kelantan. The study is focusing on granitic body existed around that area which is known as Kemahang Granite. It is well known as one of the biggest granitic body in Malaysia, particularly in Eastern Belt. This granitic body has a contact with a well-known metamorphic rock in Malaysia, the Taku Schist. From data analysis, it can be concluded that the major type of rock found in the study area is igneous rock, particularly granite. The main objective of this research is to produce an updated geological map of the study area and to run geochemistry analysis and interpretation on the granite rocks in the study area. To fulfill these objectives, several methods were used such as field work, thin section of rock and XRF method. The results showed that the granites in the study area have a high content of K-feldspar, quartz, biotite and other minerals. Thus, it can be concluded that the granites is from an acidic type of composition.

Geologi Umum dan Geokimia Batuan Granit di Kampung Batu Gajah, Tanah Merah, Kelantan

ABSTRAK

Kawasan kajian terletak di Kampung Batu Gajah, Tanah Merah, Kelantan. Kajian ini memberi tumpuan kepada badan granit yang wujud di sekitar kawasan itu yang dikenali sebagai Granit Kemahang. Badan granit ini adalah diketahui umum sebagai salah satu badan granit yang terbesar di Malaysia, terutamanya di Jaluran Timur. Badan granit ini mempunyai hubungan dengan batu metamorf yang terkenal di Malaysia, Syis Taku. Daripada analisis data, dapat disimpulkan bahawa jenis batuan utama yang dijumpai di kawasan kajian adalah batu igneus, terutamanya granit Objektif utama kajian ini adalah untuk menghasilkan peta geologi yang telah dikemaskini mengenai kawasan kajian dan untuk menjalankan analisis geokimia dan tafsiran terhadap batuan granit di kawasan kajian. Bagi memenuhi objektif-objektif tersebut, beberapa kaedah telah digunakan seperti kerja lapangan, seksyen nipis batuan dan kaedah XRF. Hasil kajian menunjukkan bahawa batuan granit di kawasan kajian mempunyai kandungan K-feldspar, kuarza, biotit dan mineral lain yang tinggi. Oleh itu, dapat disimpulkan bahawa granit ini adalah dari jenis komposisi yang berasid.

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CHAPTER 1

INTRODUCTION

1.1 General Background

Geology is the scientific study of the Earth that usually involves the study of the materials that make up the Earth and the processes acting upon them. These materials are known as minerals and rocks. Minerals can be defined as a naturally-occurring, inorganic homogeneous solid with a generally not fixed chemical composition and an ordered atomic arrangement while rocks are the aggregates of one or more minerals.

This research is basically about one of the igneous rocks abundant in the continental crust which is granite. Granite is a felsic plutonic rock which is light in colour, ranged from medium- to coarse-grained and majorly contains quartz and feldspar minerals. Just like any other plutonic rocks, granite forms when magma solidifies within the Earth’s crust. Slow cooling of the magma may take hundreds of thousands to millions of years for the crystal to grow.

In the current geological study, various methods are used and conducted such as field mapping and laboratory analysis. In this research, field mapping, petrography and X-ray Fluorescence (XRF) spectrometry were used in order to identify the elemental composition in the minerals. Field mapping was conducted by recording the regional distribution of the rocks belonging to different units and formations and its structures. Basically, field observation of the rock can lead to the general classification of the types of rock. It is important to be precise as an accurate geological map is the basis of most geological works.

A map showing the occurrence of structural features across a region, the distribution of rock units and their type and age relationship is termed a geological map (Njue, 2010). A geological map is the illustration of a place into a smaller scale size map which is reliable in interpreting certain area of study. During fieldwork, samples of rocks were being collected and later being analyzed using petrographic and geochemical analysis.

One of the methods which can be used in the classification of rocks is petrography. Petrography is a branch of geology that studies on describing and classifying the rocks which emphasizes heavily on the usage of polarizing microscope. The petrographic study is conducted using thin sections prepared from the rock samples obtained during the field mapping process. These thin sections will be observed under a polarizing microscope in order to distinguish the minerals present based on their optical properties and characteristics. XRF is a unique method that capable in analyzing the major and trace elements in the minerals that constitutes in the rock samples. It is an essential technique that can provide information which cannot be determined by any other method. Thus, by integrating the field observation and the petrographic study, a better understanding of the geology of the area especially the origin of the rocks and its tectonic settings will be occupied.

1.2 Problem Statements

The most important problem that faced in the study area is the previous study only focused on different scope which is water chemistry and on gold occurrence assessment in Ulu Sokor and petrography analysis in Kusial and Panau Hill which is near to the study area. Besides, only a few researchers have done research at particular part of the Tanah Merah district especially at Kampung Batu Gajah area.

Thus, a new detailed and updated geological map needs to be prepared in order to give information regarding the types of lithology, stratigraphy, geomorphology and geological structure around the study area. These will help in proper construction and development with cautions on the geological aspects exists at the area.

1.3 Research Objectives

Few objectives have been highlighted before the research is conducted. The objectives are:

i) To produce a detail geological map of the research area.

ii) To examine the geochemistry of the granite rocks.

1.4 Study Area

1.4.1 Location

The study area that has been preferred is in and around Kampung Batu Gajah area, which covers approximately 25 km² in Tanah Merah district. It lies between the latitude of 05° 49'54" N until 05° 47'11" N and longitude of between 101° 57'34" E until 102° 01'16" E. Some villages near Kampung Batu Gajah like Kampung Panglima Bayu, Kampung Bedah, Kampung Lawang, Kampung Repoh, Kampung Asahan Hilir and Kampung Banggol Jering are also included in the study area.

The topography of the study area is mostly covered with low lying plain which is flat with a few low hill surfaces which are not too high. Most of the lands are used for the purpose of plantation as it provides the main economic contribution for the villagers. In general, the topography features in most part of Tanah Merah district is low lying unit with mean elevation less than 80 metres. Located at the western part of Tanah Merah, Kemahang Hill is the highest peak in the district with 876 m elevation and it is part of granite intrusion. Figure 1.1 shows the location of Kelantan state in the map of Malaysia while Figure 1.2 shows the location of the study area in the map of Kelantan and Figure 1.3 is the base map of study area.

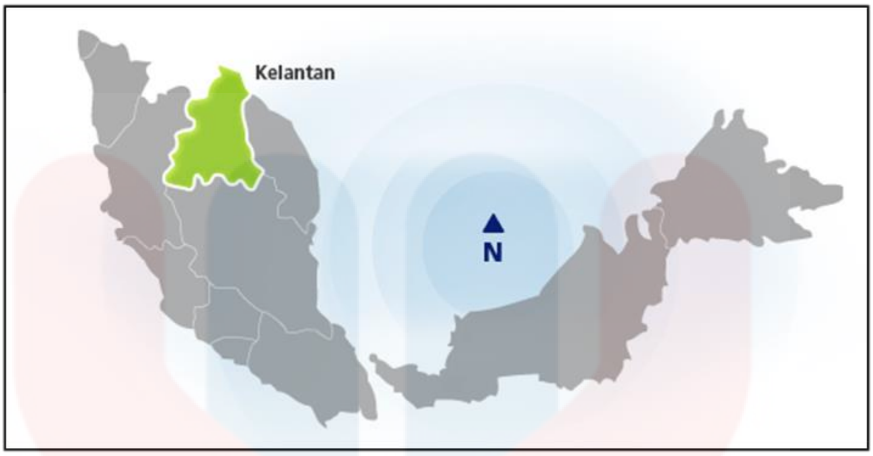


Figure 1.1: Map of Kelantan in Malaysia

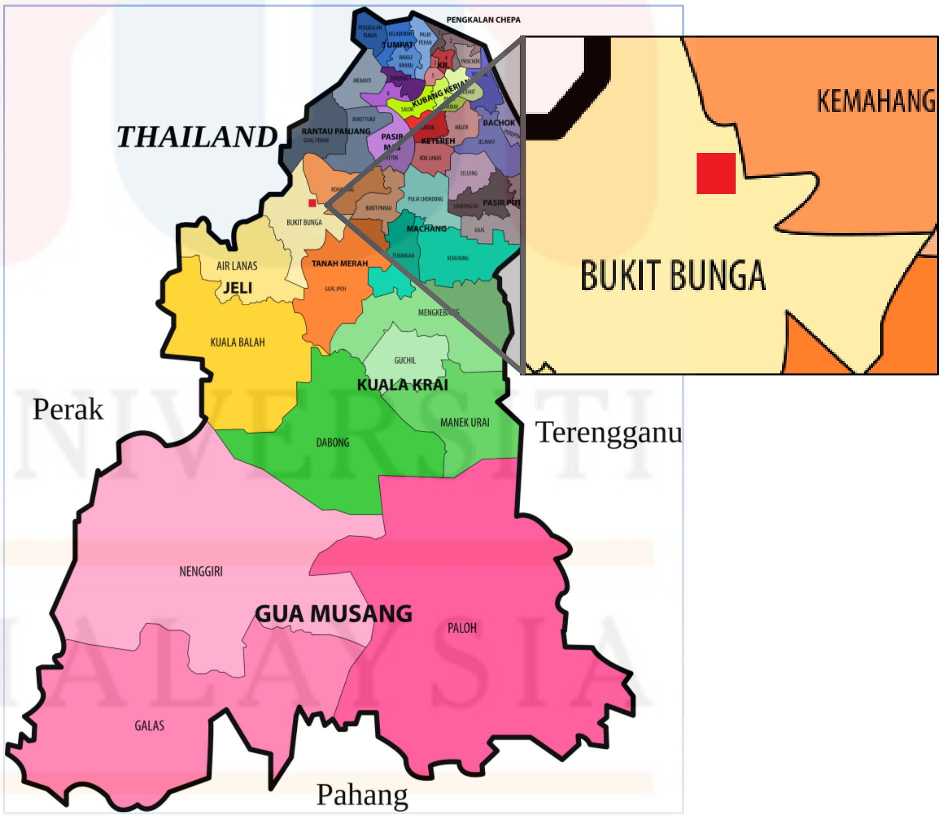


Figure 1.2: Map of study area in the Kelantan map

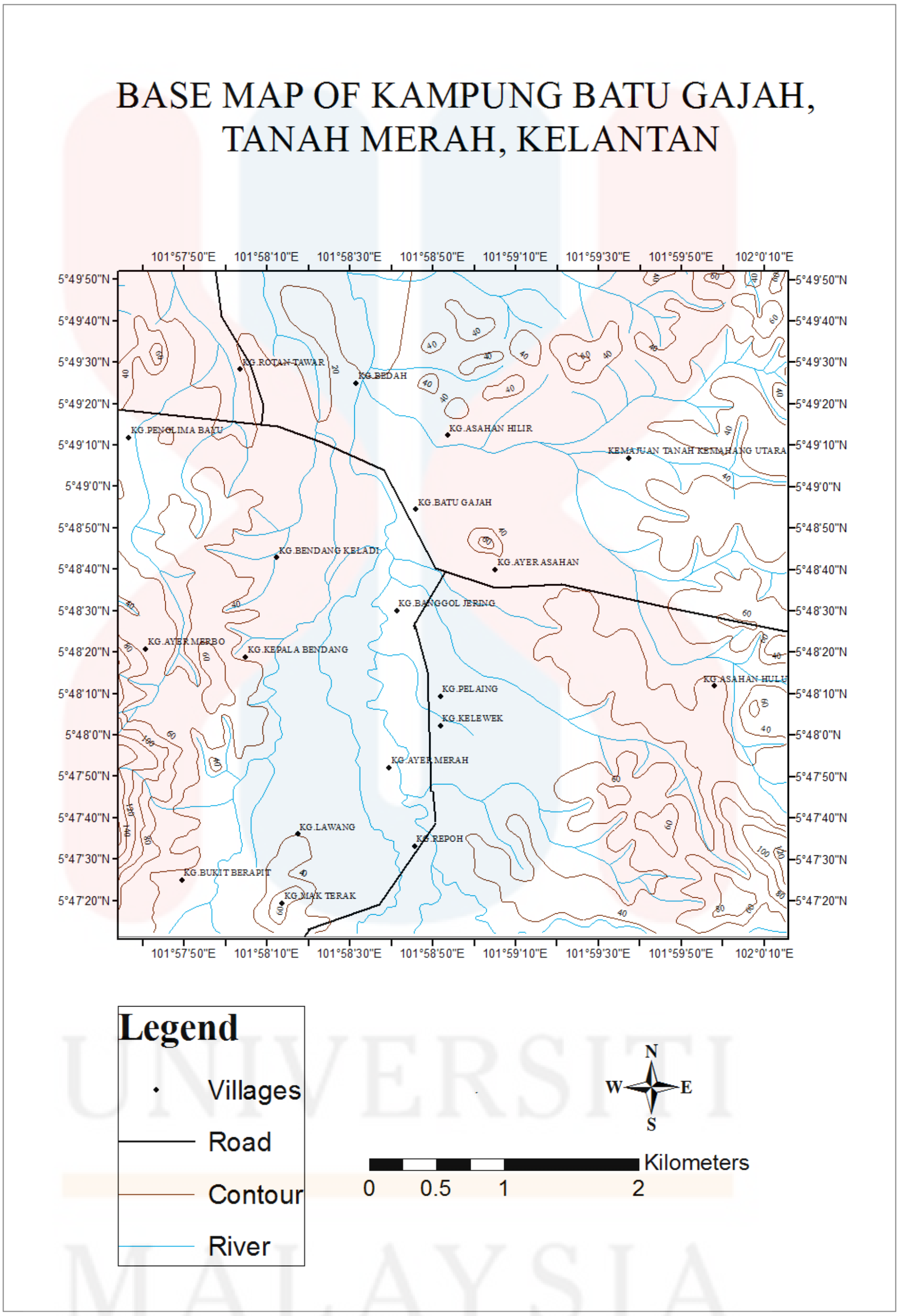

BASE MAP OF KAMPUNG BATU GAJAH, TANAH MERAH, KELANTAN
KG.ROTAN TAWAR
KG.BEDAH
KG.PENGLIMA BATU
KG.ASAHAN HILIR
KEMAJUAN TANAH KEMAHANG UTARA
KG.BATU GAJAH
KG.BENDANG KELADI
KG.AYER ASAHAN
KG.BANGGOL JERING
KG.AYER MERBO
KG.KEPALA BENDANG
KG.ASAHAN HULU
KG.PELAING
KG.KELEWEK
KG.AYER MERAH
KG.LAWANG
KG.REPOH
KG.BUKIT BERAPIT
KG.MAK TERAK
101°57'50"E
101°58'10"E
101°58'30"E
101°58'50"E
101°59'10"E
101°59'30"E
101°59'50"E
102°0'10"E
5°49'50"N
5°49'40"N
5°49'30"N
5°49'20"N
5°49'10"N
5°49'0"N
5°48'50"N
5°48'40"N
5°48'30"N
5°48'20"N
5°48'10"N
5°48'0"N
5°47'50"N
5°47'40"N
5°47'30"N
5°47'20"N
Legend
Villages
Road
Contour
River
N
W
E
S
Kilometers
0
0.5
1
2

Figure 1.3

1.4.2 Demography

People distribution in Batu Gajah area is notably not very high as it is located a little far from the nearby big town which is Tanah Merah. In 2010, out of 115, 949 people lived in Tanah Merah; Batu Gajah recorded 2, 281. A number of 2, 246 of them are Malays, 19 are Chinese, 4 for other Bumiputera and the rest is Non-Malaysian citizens as shown in Table 1.1. A total of 1, 119 of the people of Batu Gajah are male and 1, 162 are female as shown in Figure 1.4. These numbers are based on the Population and Housing Census of Malaysia in 2010 that was prepared and published by Department of Statistics, Malaysia.

Most of the population is distributed between different villages and suburban areas, while only a small proportion is located in the town. Batu Gajah is ideal to be chosen as the study area as there a lot of houses as well as big outcrops which well-defined and abundance. Some granite outcrops can be found even just a few metres away from villagers' houses.

Most of the people distributions in the study area are concentrated in the central part as there is a major road connection connecting the rural area to the nearby town. The south-eastern part of the study area is less populated as this area is hilly with contour as high as 80 to 240 metres and it is part of the Kusial Hill (723 m) which is located a few kilometres away from the south to the southeast of study area. Besides, there is no road connecting from that area to the nearby town. In addition, to the eastern part of the study area lies Jedok Forest Reserve.

Table 1.1: People distribution in Kampung Batu Gajah by ethnic groups and gender (Department of Statistics Malaysia, 2010)

Malay	Chinese	Indian	Other Bumiputera	Non-Malaysian Citizens
2, 246	19	0	4	12
Male			Female	
1, 119			1, 162	
Total				
2, 281				

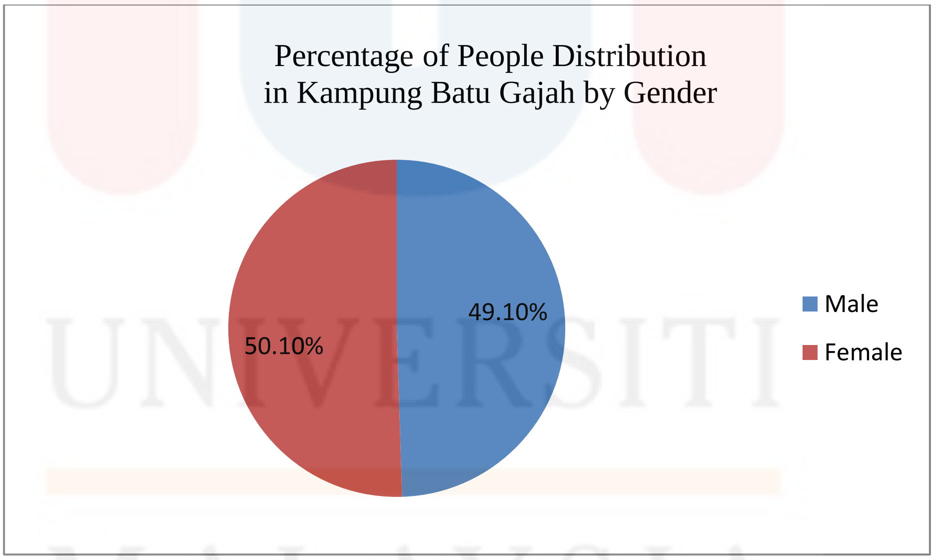


Figure 1.4

1.4.3 Rainfall

Generally, the precipitation design over malaysia may be considerably impacted by the wind design throughout those regular period and its local topography (Suhaila et al., 2010). In fact, the study also proves the foothills region of East Peninsula are influenced by the Northeast monsoon (Suhaila et al., 2010).

Generally, the location of Kelantan in the East Coast of Malaysia makes it generally receives a considerable measure for precipitation during the Northeast Monsoon period. However, during the Southwest Monsoon and inter-monsoon, Kelantan still receives rainfall rates which are relatively high. The Northeast Monsoon from November until March is highly devastating compared to the Southwest Monsoon as it results in enormous tides in ocean which could endanger the people and sometimes bring disaster. Meanwhile, the Southwest Monsoon from the late May until September normally signifies relatively drier weather.

Based on Figure 1.5, from year 2000 to 2012, the average rainfall that being recorded for Kampung Batang Merbau which is 3 km away from Kampung Batu Gajah shown that the average rainfall pattern increase from the early to the end of the year. February recorded the least average amount of rainfall with 24.5 mm of precipitation reading and only 3 days for average rainfall days. The highest amount of average rainfall is on November with 299 mm of precipitation reading and 22 days for average rainfall days. This pattern might be going gradually changing for the year after 2012.

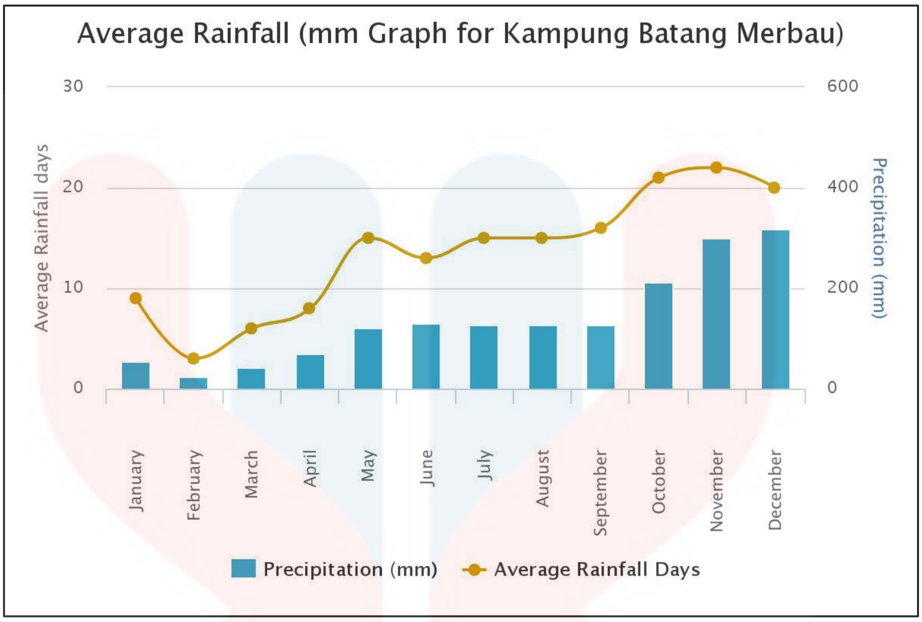


Figure 1.5

1.4.4 Land Use

The major land use in and around Kampung Batu Gajah area is for agricultural and plantation purpose as shown in Figure 1.6, Figure 1.7 and Figure 1.8. Most of the land in this area being used for plantation purpose mainly emphasize on oil palm at the northern part while rubber plantation at the eastern part of the study area as shown in Figure 1.9. A vast area of paddy field can be found at the centre of the study area. There are also local fruit tree which being plant for domestic purposes in a small scale land like banana, durian, rambutan and many more. Other than that, other features of the land use serves as construction purpose such as shop, housing area, hospital, school and many others. From surveys and observation made, there are variety of structure such as shops, government amenities as well as local authority and municipal facilities located nearby the study area.

Figure 1.6: Rubber plantation at the eastern part of study area

Figure 1.7: Oil palm plantation at the northern part of the study area

Figure 1.8: Banana trees are among other plantations in the study area

1.4.5 Social Economic

In Kelantan, most of the economic industry is based on food production. Restaurants and food stalls can be found anywhere around this state as it is the main income for the Kelantanese for everyday since a long time ago. Local cuisine are provided in every restaurants while the food stalls are providing with local fruits and fruit-based foods that can only be found in Kelantan and so does to Kampung Batu Gajah and around it as shown in Figure 1.10. Besides, there are also many shops in the study area like grocery shops, retail shops, book shops, flower shops, car wash shops and a lot more as shown in Figure 1.11 and Figure 1.12. Villagers can find fresh vegetables and fruits at the markets and raw foods at the wet markets. Fresh vegetables and fruits are being planted by the villagers themselves and so do for the raw foods like chicken. Seafood is very rare since it is far from the sea but freshwater fishes are common and could easily be found at the nearest river.

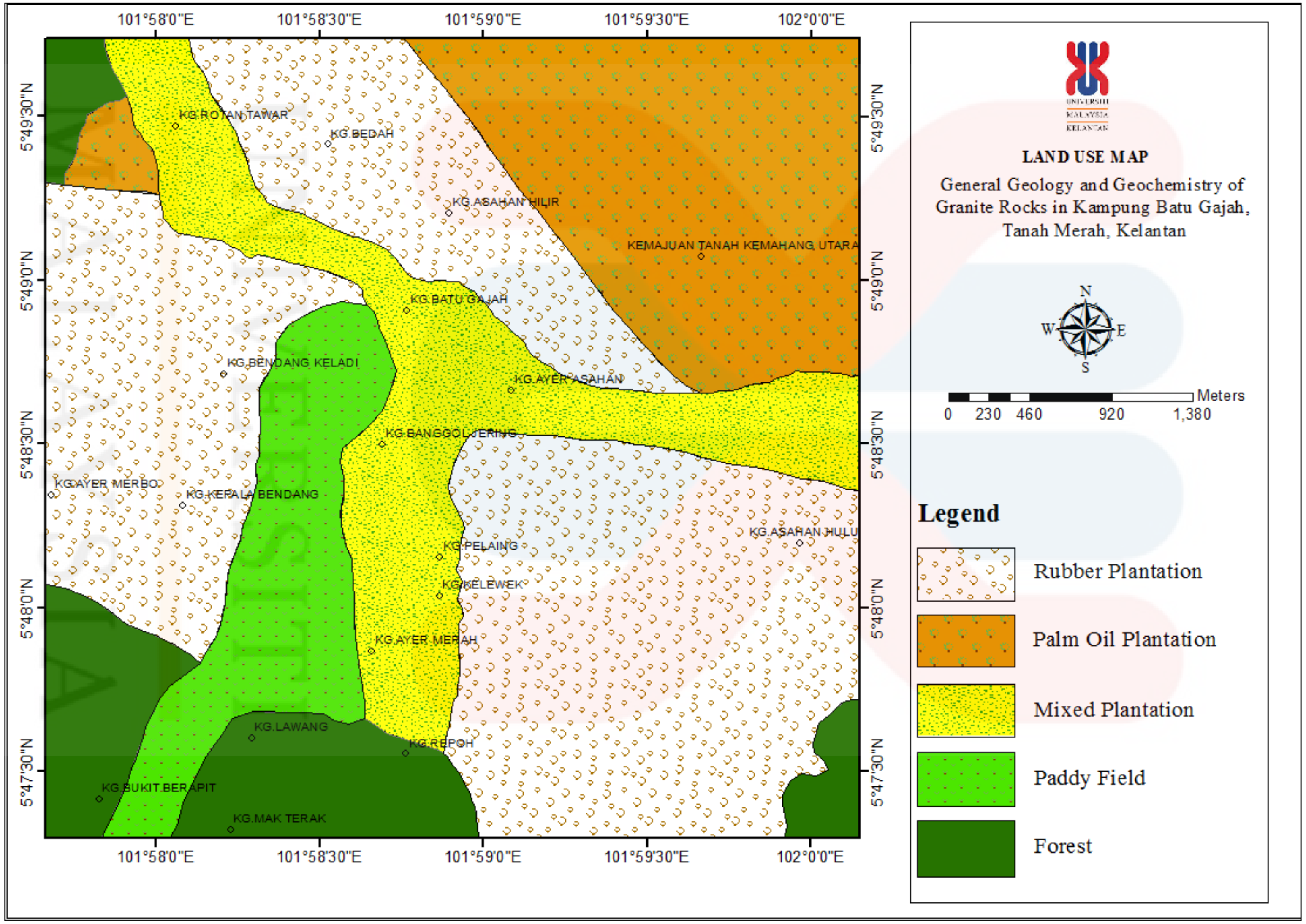

LAND USE MAP
General Geology and Geochemistry of Granite Rocks in Kampung Batu Gajah, Tanah Merah, Kelantan
N
W
E
S
Meters
0
230
460
920
1,380
Legend
Rubber Plantation
Palm Oil Plantation
Mixed Plantation
Paddy Field
Forest
101°58'0"E
101°58'30"E
101°59'0"E
101°59'30"E
102°0'0"E
5°49'30"N
5°49'0"N
5°48'30"N
5°48'0"N
5°47'30"N
KG.ROTAN TAWAR
KG.BEDAH
KG.ASAHAN HILIR
KEMAJUAN TANAH KEMAHANG UTARA
KG.BATU GAJAH
KG.BENDANG KELADI
KG.AYER ASAHAN
KG.BANGGOL JERING
KG.AYER MERBO
KG.KERALA BENDANG
KG.ASAHAN HULU
KG.PELAING
KG.KELEWEK
KG.AYER MERAH
KG.LAWANG
KG.REPOH
KG.BUKIT BERAPIT
KG.MAK TERAK

Figure 1.9

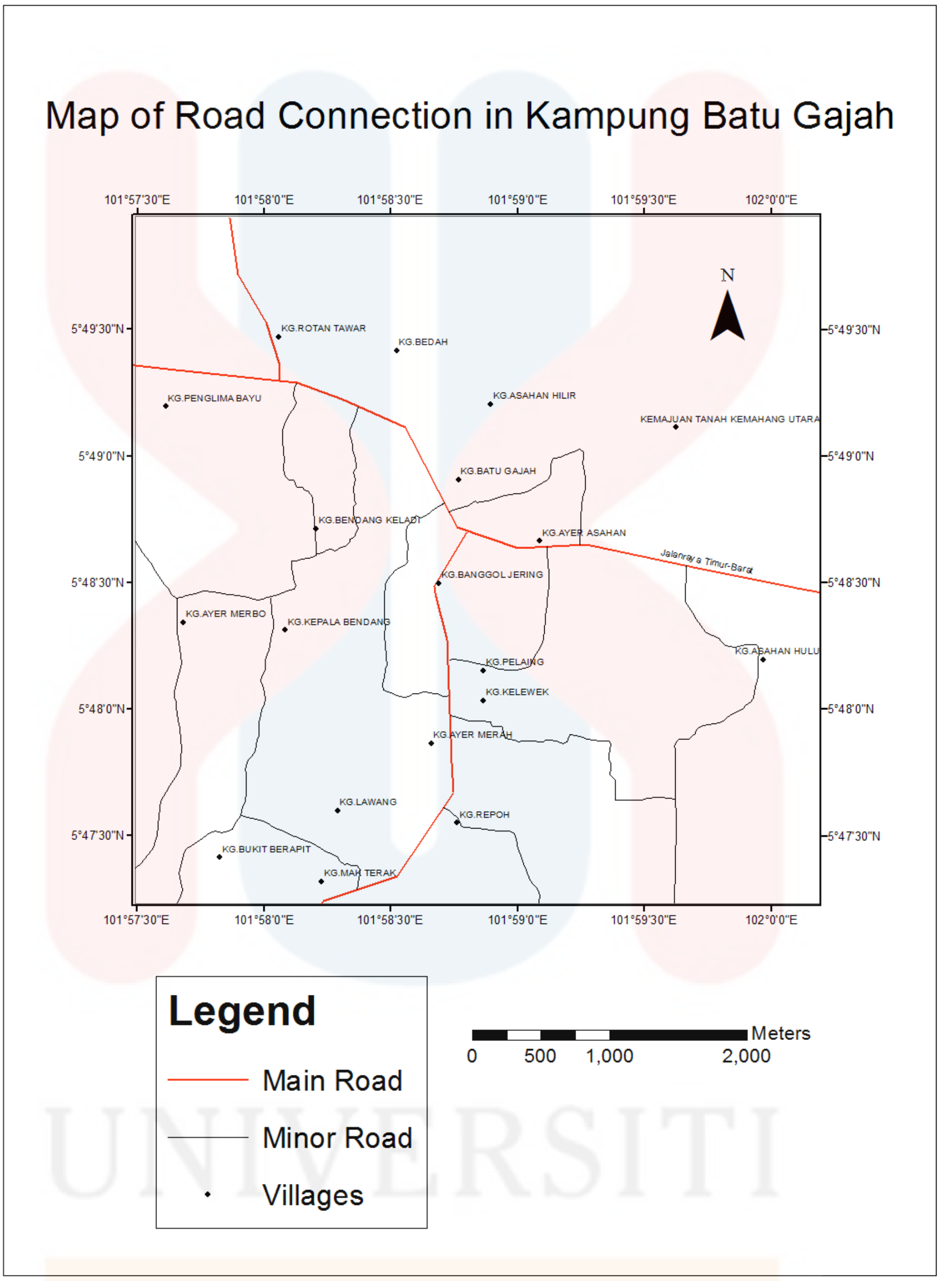
Figure 1.10: A 24-hours restaurant at Kampung Panglima Bayu

Figure 1.11: One of the grocery shops in the study area

Figure 1.12: A car wash shop

1.4.6 Road Connection

In the preferred study area, there are various roads connecting all parts of the study area as shown in Figure 1.13. These roads can be further divided into main road, small paved road as well as unpaved road or soil road farther deep into the rural area in which some of the plantation area is located including rubber plantation and oil palm plantation. The main road that lies horizontally on the study area is a part of the highway road called Federal Route 4 of the East-West Highway that connects the western part of Peninsular Malaysia to the eastern part as shown in Figure 1.14. This road also connects Rantau Panjang district through a road whereby its junction is near to Kampung Panglima Bayu in the study area. Basically, most parts of the study area have good ease of access in which vehicles can pass through for economics and other social purposes. However, there are some parts in the study area which is too deep and only sand road is available for connection. This can only apply for extreme vehicles to pass through like 4x4 vehicles or even a motorcycle only.



Map of Road Connection in Kampung Batu Gajah
101°57'30"E
101°58'0"E
101°58'30"E
101°59'0"E
101°59'30"E
102°0'0"E
5°49'30"N
5°49'0"N
5°48'30"N
5°48'0"N
5°47'30"N
N
KG.ROTAN TAWAR
KG.BEDAH
KG.PENGLIMA BAYU
KG.ASAHAN HILIR
KEMAJUAN TANAH KEMAHANG UTARA
KG.BATU GAJAH
KG.BENDANG KELADI
KG.AYER ASAHAN
Jalanraya Timur-Barat
KG.BANGGOL JERING
KG.AYER MERBO
KG.KEPALA BENDANG
KG.ASAHAN HULU
KG.PELAING
KG.KELEWEK
KG.AYER MERAH
KG.LAWANG
KG.REPOH
KG.BUKIT BERAPIT
KG.MAK TERAK
Legend
Main Road
Minor Road
Villages
Meters
0
500
1,000
2,000

Figure 1.13

Figure 1.14: A part of the East-West Highway road

1.5 Scope of Study

The study area is located at Kampung Batu Gajah, Tanah Merah, Kelantan which is a part of a large granitic body called Kemahang Granite. Kemahang Granite is one of the eastern belt granitoids that existed just near the Raub – Bentong suture. The area around Kampung Batu Gajah is popular with the existence of numerous big granite outcrops that can be seen easily just a few metres from settlements. This study is focusing on the geochemistry method that had been applied onto the granite rocks found in the study area. On a bigger scale, this study is focused on general geology of Kampung Batu Gajah which covers on its geomorphology, structural geology, stratigraphy and historical geology. An updated geological map was produced based on petrographic analysis and hand specimen sample found in the field.

1.6 Research Importance

This study is important as it can provide the detail geology of the Kampung Batu Gajah by analyzing lithology, geomorphology and geological structure present at the area. The lithology can be classified specifically and named by integrating both field and petrographic analysis. Identification of the types of lithology along with other important characteristics such as the geomorphology and structures will help in the proper development and minerals exploration at Tanah Merah area. This research will help future researcher by providing more information lithology and chemistry of the granitic rocks around the study area for proper research of its tectonic settings and evolution.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Literature review on the existing past studies need to be done before conducting a research. This may help in deeper understanding on the research's content and knowledge about the study area. There were some studies that have been done on the granite around the study area and also have been used as references in this study.

2.2 Regional Geology and Tectonic Setting

Malaysia contains various types of rock ranging from rocks such as igneous, metamorphic and sedimentary rocks. Some of these rocks range widely from granitic rocks originated from Titiwangsa Range. The backbone of Peninsular Malaysia is also known as Banjaran Titiwangsa or the Main Range. Extending long way from the Malaysia Thai border in the north to the southern state of Negeri Sembilan, this middle spine efficiently separates the eastern and western part of the Peninsular (MacDonald, 1968). A geological map of Peninsular Malaysia is shown in Figure 2.1.

The Peninsular Malaysian granites have been grouped into two provinces which are the Western Province and the Eastern Province. The main granite bodies is within the Main Range located somewhere in the western part of Kelantan. Major mineralization occurred during the granitic emplacement and commonly associated with faulting. Faulting is frequent in the entire rocks structure. No less than three sets of faults have been, throughout in the beginning of Cretaceous phase the youngest are predicted (Hutchison, 2009).

Generally, Kelantan located at the northeast of Peninsular Malaysia with an area of 15,099 km² confront with the South China Sea to the north-east, bordered by Narathiwat Province of Thailand to the north, Terengganu to the south-east, Perak to the west, and Pahang to the south. Kelantan is divided into ten districts which are Tumpat, Kota Bharu, Pasir Mas, Bachok, Tanah Merah, Machang, Pasir Puteh, Jeli, Kuala Krai and Gua Musang. Kelantan economic progress is dominated by the production of rubber, rice and palm oil.

Kelantan made of several sedimentary and metamorphic rocks at the centre, granite rock that known as Granite Besar Range at the west and Granite Sempadan Range at the east. Granite Sempadan Range has layering of alluvial deposit from Kelantan River. In the north part of Kelantan, it was overlay by Quarternary sediment. There are some intrusions like Batolith Ulu Lalat (Senting), Stong Igneous Complex and Kemahang Pluton at the centre part of Kelantan. Granite stripe and this bedrock projecting from north to south direction in which it connects with rock in the north of Pahang state. In the west part and centre part of Kelantan, this stripe continuously through north part until at the south part of Thailand.

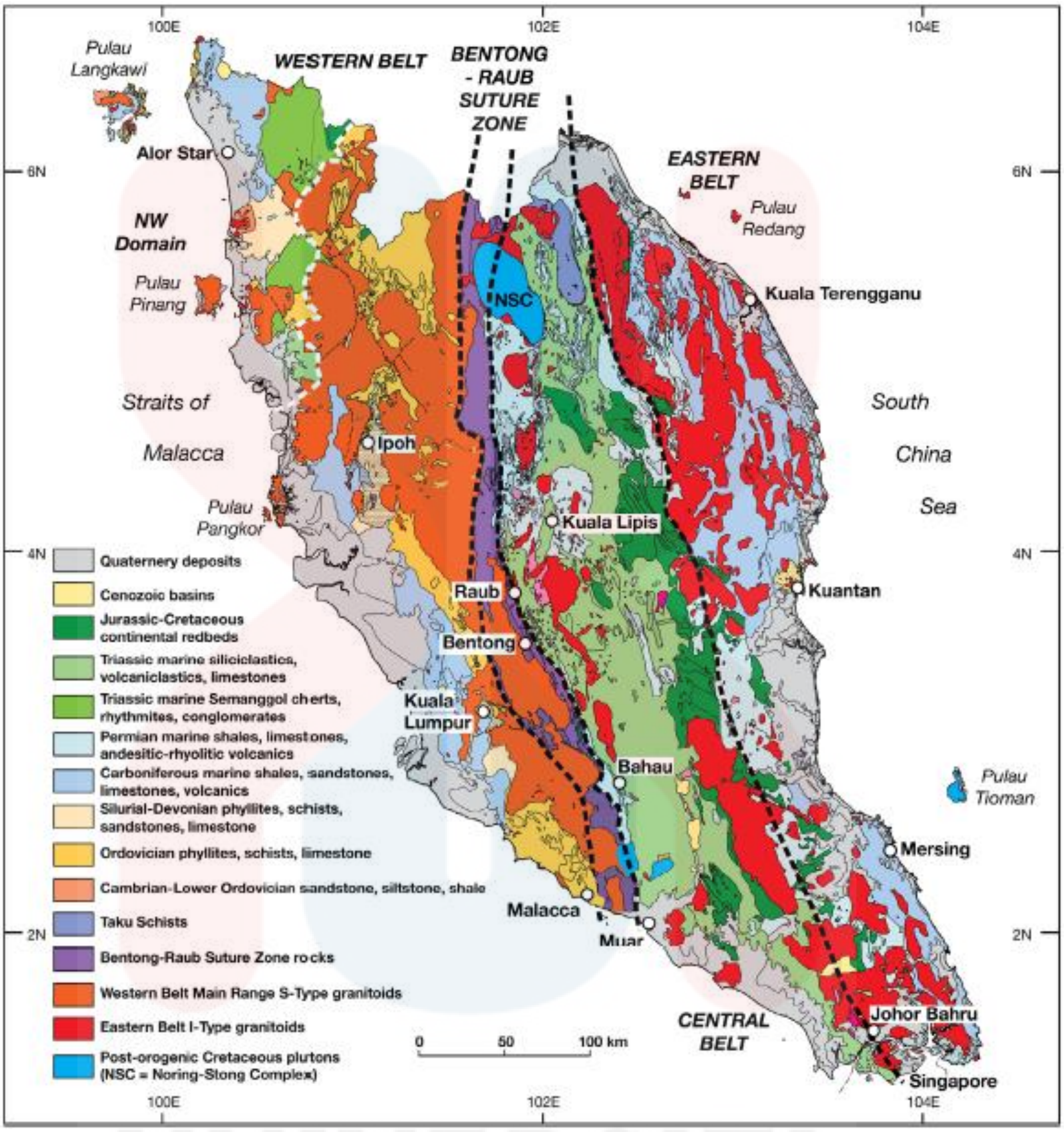


Figure 2.1: Geological Map of Peninsular Malaysia (Metcalfe, 2013)

The oldest rock in Kelantan has an age of Lower Paleozoic. Outcrop that found was stripe north to south and have boundary with foot hills of Besar Range and continuously towards east side until Nenggiri River. Most of the rock composed of meta-phyllite and minor mixture of volcanic fragments with minor arenite interbedded with calcareous material. Figure 2.2 shows the geological map of Kelantan.

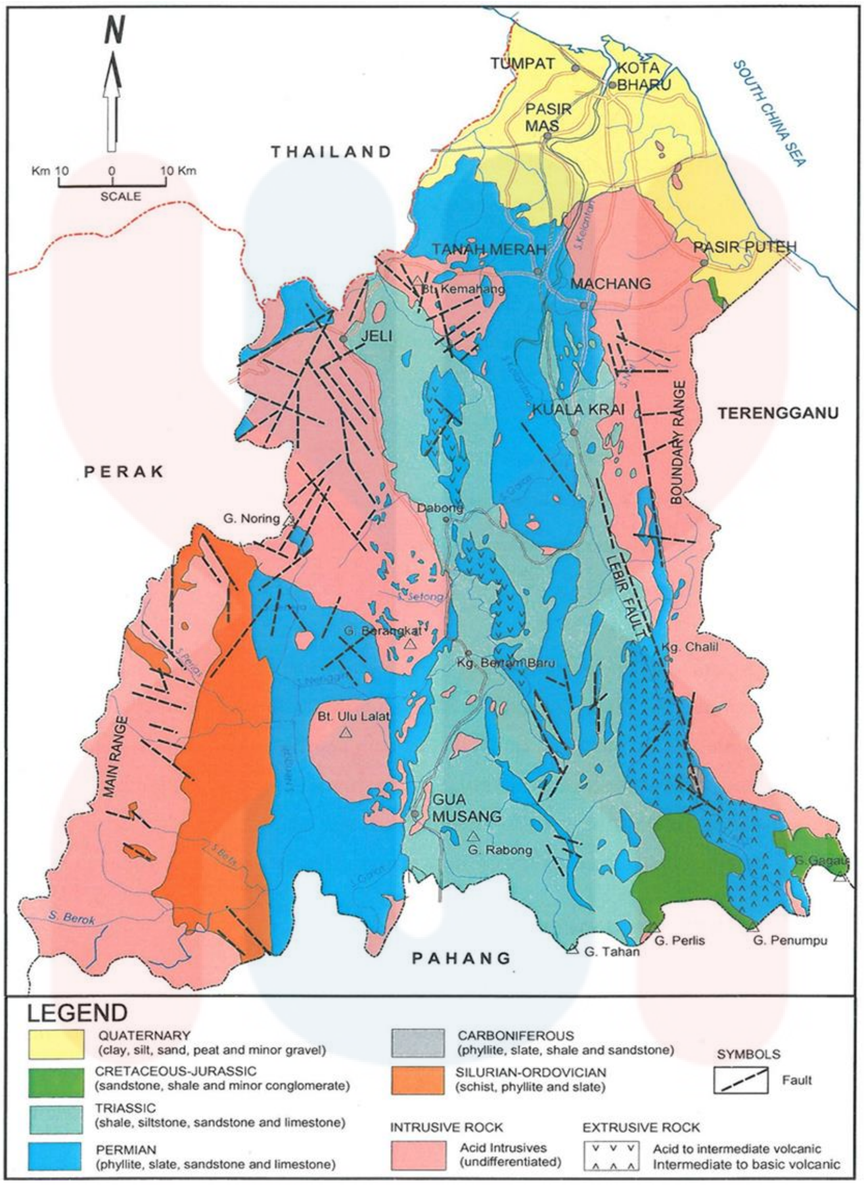


Figure 2.2: Geological Map of Kelantan (Minerals and Geoscience Department Malaysia, 2003)

2.2.1 Stratigraphy

In Eastern belt, Paleozoic sediments of predominantly Carboniferous to Permian age are distributed from east Kelantan through Terengganu and east Pahang into east Johor in the south. Large areas of Carboniferous sediments of the Charu and

Sagor Formations and Panching Limestone, belonging to the Kuantan Group, are found in east Pahang.

Southwards extensions of the Group are the Seri Jaya and Kambing Beds while the Sungai Perlis Beds in Terengganu are its northward extension. Most of these sediments are shallow marine argillo–arenaceous deposits with some isolated reefal limestone lenses and volcanics. Isolated occurrences of Carboniferous plant fossil – bearing beds and Permian conglomeratic deposits along the east coast point to restricted terrestrial to paralic sedimentation alternating with shallow marine deposition in a marginal marine setting.

Sedimentation was continuous from the Carboniferous to Early Permian in the northern part of the basin, Middle to Upper Permian sediments of the Dohol and Linggui Formations were deposited in east Johor. A marked reduction of volcanic facies in the northern part of the Eastern Belt, compared to the Central Belt, might indicate increased distance from the volcanic source (Foo, 1983).The absence of marine sediments younger than Permian suggest that the Eastern Belt was uplifted towards the end of Permian, coinciding with the explosive deposition of the largely Lower Triassic Johor ignimbrite. This set the stage for Mesozoic continental sedimentation within the mobile Central Belt and subsequent tripartite evolution of the Peninsula (Foo, 1983). Figure 2.3 shows a schematic stratigraphic column of western Kelantan area.

Panau beds is one of the formations in Tanah Merah and it crop out only at the Bukit Panau area. Nonconformity between the granite and the overlying Panau formation can be observed at an abandoned rock quarry at the foothill of Bukit Panau. Lithology and stratigraphy of Panau formation consist of interbedded thin argillite beds, laminated fine-grained sandstone, poorly-sorted pebbly sandstone and paraconglomerate. The argillite rock consists of maroon, sandy shale and some pebbly sandstone and light greyish to light brownish siliceous shale. The arenaceous rock consists of light grey poorly sorted sandstone, mostly pebbly and laminated fine-grained sandstone. At the foothill of Bukit Panau, laminated fine-grained sandstone interbedded with grey to reddish grey shale. Some of the argillite beds contain plant fragments.

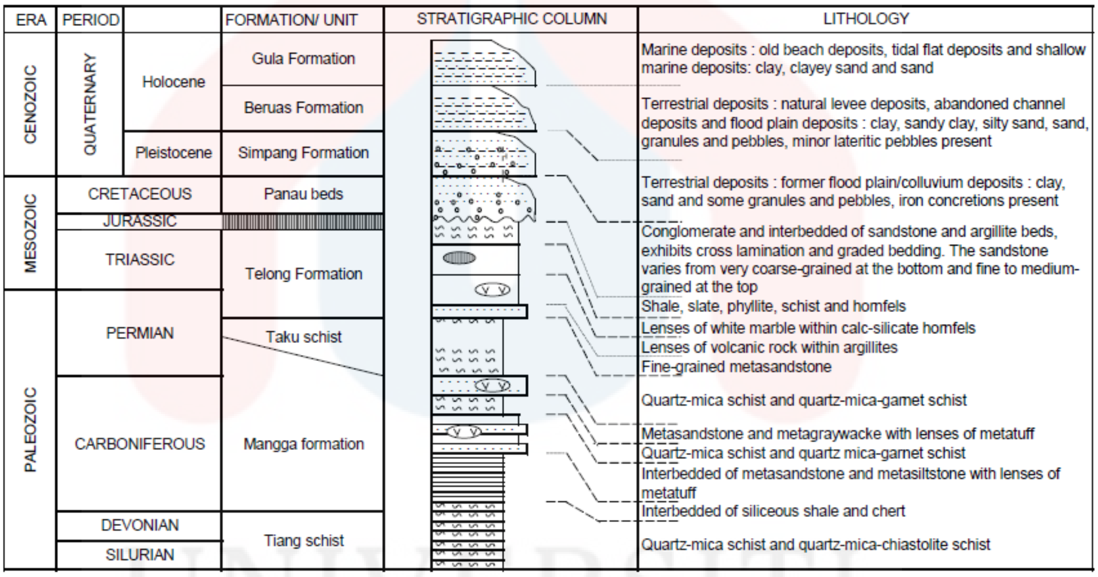


Figure 2.3: Schematic Stratigraphic Column of Western Kelantan Area (The Malaysian and Thai Working Groups, 2006)

2.2.2 Structural Geology

Located at the boundary between Malaysia and Thailand, the Kemahang Granite is the smallest of the granite sub-units in the Eastern Belt of Peninsular Malaysia and shows a clear intrusive character on the SIR-A imagery with high lineament density (Koopmans & Muenlek, 1983). The granite boundary is discordant with the structural trend lines in the surrounding sedimentary and metamorphic rocks. The granite pluton has no obvious length direction. Nevertheless, the longest lineament and longest cumulative length direction run approximately N-S, identical to the eastern belt granites.

The entire lineament distribution within the Kemahang granite clearly representing fractures developing as a result of the cooling process within granite and subsequent uplift (Koopmans & Muenlek, 1983). Observations made by Koopmans & Muenlek (1983) agree with McDonald (1968), who reviewed the Kemahang granite as intrusive and Khoo (1980), who described it as high-level emplacement granite.

The older structural grain present in the Carboniferous and older Taku schists is N-S which is parallel with the length directions of the granite plutons, whereas the Triassic-Jurassic sediments are folded in a NW-SE axial direction oblique to the eastern granite belt (Koopmans & Muenlek, 1983).

Galas Fault Zone is a distinct 80 km wide zone of NNW-SSE-trending tonal and topographic lineaments extends from across the Thailand border to the Tembeling area, cutting the Stong Complex, Kemahang granite and the Tahan Range (Mustaffa Kamal Shuib, 2009). It is expressed as a wide zone of sheared granite forming the western margin of the Kemahang granite. At the contact with the Taku Schist, granitic apophyses of the Kemahang granite commonly occur as closely-spaced veins parallel to the foliation, a lit-par-lit injection gneiss (MacDonald, 1968)

2.2.3 Petrography

Kemahang Granite is cataclastic porphyritic biotite granite whose outcrop extends across the border into southern Thailand as the Buke pluton occupying the northern part of the Taku Schist body (Cobbing *et al*., 1992). MacDonald (1967) reported that the Kemahang Granite contains varieties of granitic rocks; the predominant type is medium-to-coarse-grained, grey in colour, with large feldspar phenocrysts, abundant biotite, marked lineation of feldspar phenocrysts at a number of localities. The granite has injected the Taku Schist and incorporates large schist enclaves (Hutchison, 2009). Although Bignell and Snelling (1977) suggested that the Kemahang Granite may pre-date the metamorphism of the Taku Schists, a Cretaceous age seems therefore more likely (Hutchison, 2009).

The Taku Schist occurs as a north-south elongate body, about 80 km long and 8 to 22 km wide stretching from the Thai border near Tanah Merah to central east Kelantan near Manik Urai. It is mainly politic consisting of quartz-mica-schist, quartz-mica-garnet schist and garnet mica schist. Khoo and Lim (1983) suggested that the age of the Taku Schist is Permo-Triassic and may be older in the core of the schist outcrop.

2.2.4 Historical Geology

Hutchison (1977) clearly subdivided Peninsular Malaysia into four zones which are characterised by different tectonic histories. One of them is the Eastern Belt which is characterised by numerous elongate granitic plutons intruded through gently deformed, predominantly Permo-Carboniferous sedimentary formations with associated pyroclastic and volcanic rocks of acid to intermediate composition.

The Eastern Belt granites have not been significantly uplifted since their crystallization in the same way that the Main Range Belt granites have which concludes that a greater tectonic stability for the Eastern Belt than for the Main Range (Hutchison, 1977). Hutchison (1977) concludes that the major part of the granitic intrusive activity in both the Main Range and the Eastern Belts was in the Permian to Triassic as Bignell & Snelling (1977) indicated that the Late Carboniferous dates should now be re-interpreted as Permian based on the radiometric data of Bignell (1972).

Bignell (1972) suggested that the Eastern Belt granites were derived from a more oceanic type of basement whereas the Main Range granites were derived from a well-established sialic basement. The granites were emplaced throughout the Permian and Triassic in a high-level environment so that fairly rapid loss of water did not allow the alkali feldspar to attain a stable structural state (Hutchison, 1977).

The Kemahang granite of MacDonald (1967) is a granitic mass of batholitic dimension in north-west Kelantan close to the Thai border which is in contact with the Taku Schists on all sides except the west where it is in contact with Permo-Triassic sediments which also include metamorphics such as slates, phyllites, marble and metavolcanics (Khoo, 1980).

MacDonald (1967) interpreted the Kemahang granite to be an intrusive magmatic body and the shearing was suggested to be the result of adjustments within the granite during solidification and associated tectonic movements which took place during and after emplacement and solidification. Hutchison (1937b) said that the

Kemahang granite is an extensive parautochthonous granite body formed in part of foliated granite gneiss and in part of cataclastic granite and contains a number of schist relics.

Khoo (1980) said that the Kemahang granite is a high level emplacement considering features such as discordance to country rocks and the presence of contact metamorphism.

2.3 Geochemistry of Granites

The quartz-alkali feldspar-plagioclase plot, of modal proportions, discriminates three characteristics series among the large variety of granitic rocks associated in intrusions. The series are Calc-alkaline and its variants, Tholeiitic and Alkaline. Each of the series has its own chemical characteristics and some originate from different source material as shown by Bowden *et al.* (1984).

In general, the Eastern Belt Granites belong to the calc-alkaline granodioritic series (Azman A. Ghani, 2009). Some of the granite complexes however show a trend similar to the alkali series. The SiO_2 content of the Eastern Belt granite and associated mafic and intermediate rocks ranges from 50 to 78%.

There are two distinct plutonic associations can be recognized in the Eastern Belt which are the dominant granitic rocks and a mafic association. The granitic rocks are dominated by I-type and minor S-types (Liew, 1983). The major I-type plutons of the Eastern Belt are believed to be derived from partial melting of mafic to intermediate lower crust, which may, in part, comprise juvenile underplated material. This mode of origin is implied by the absence of rocks of intermediate composition.

CHAPTER 3

MATERIALS AND METHODS

3.1 Introduction

There are several methods and materials taken into account for the purposed study of geological mapping in order to achieve the objectives of the research project. Figure 3.1 is the flow chart which shows an outline of the methods that is conducted for the purpose of geological mapping in the particular study area.

3.2 Materials

In order to perform the fieldwork, proper equipment is strongly required. First and foremost is geological hammer. This instrument is used for breaking and splitting rocks sample. It can attain the rock sample to determine its mineralogy, composition and history factor. Occasionally, geological hammer can be used as the scale in a photograph. There are two type of hammer which are commonly used by geologist; chisel-head hammer and pick-head hammer.

Secondly, Brunton compass. This compass is much accurate than Suunto compass. Brunton compass is used on the field to provide hand level capability and can be used by waist and eyes level. Examples of the usage of Brunton compass are taking reading of azimuth, pinpoint location on map, folding and used in geological mapping.

Thirdly, a Garmin GPS (Global Positioning System) is a satellite based navigation system involving three parts, the satellite in space, monitoring stations and the GPS receivers. GPS provide latitude and longitude data. It also provides the altitude reading. In field, it has stored up our track movements and also acted as a compass.

Fourth, hand lens. It is used to identify the mineral on the volcanic rock by naked eyes on the field. Basically, it used to identify the physical properties such as colour, texture and identifiable mineralogy.

Fifth is hydrochloric acid (HCL). It is used to observe the reaction of the rock in order to differentiate between calcite and chlorite. It is also used to distinguish most common carbonate rock, dolomite and limestone.

Sixth is the measuring tape. It is used to take measurement of lithology and structure. As an example, in layering, it is necessary to measure the thickness of each layer precisely.

Last but not least, a base map of study area. It provides background detail necessary to orient the location of the map in the study area. Simple data can be recorded on the base map during the fieldwork by plotting the area that has been traversed or marking the point where the sampling takes place.

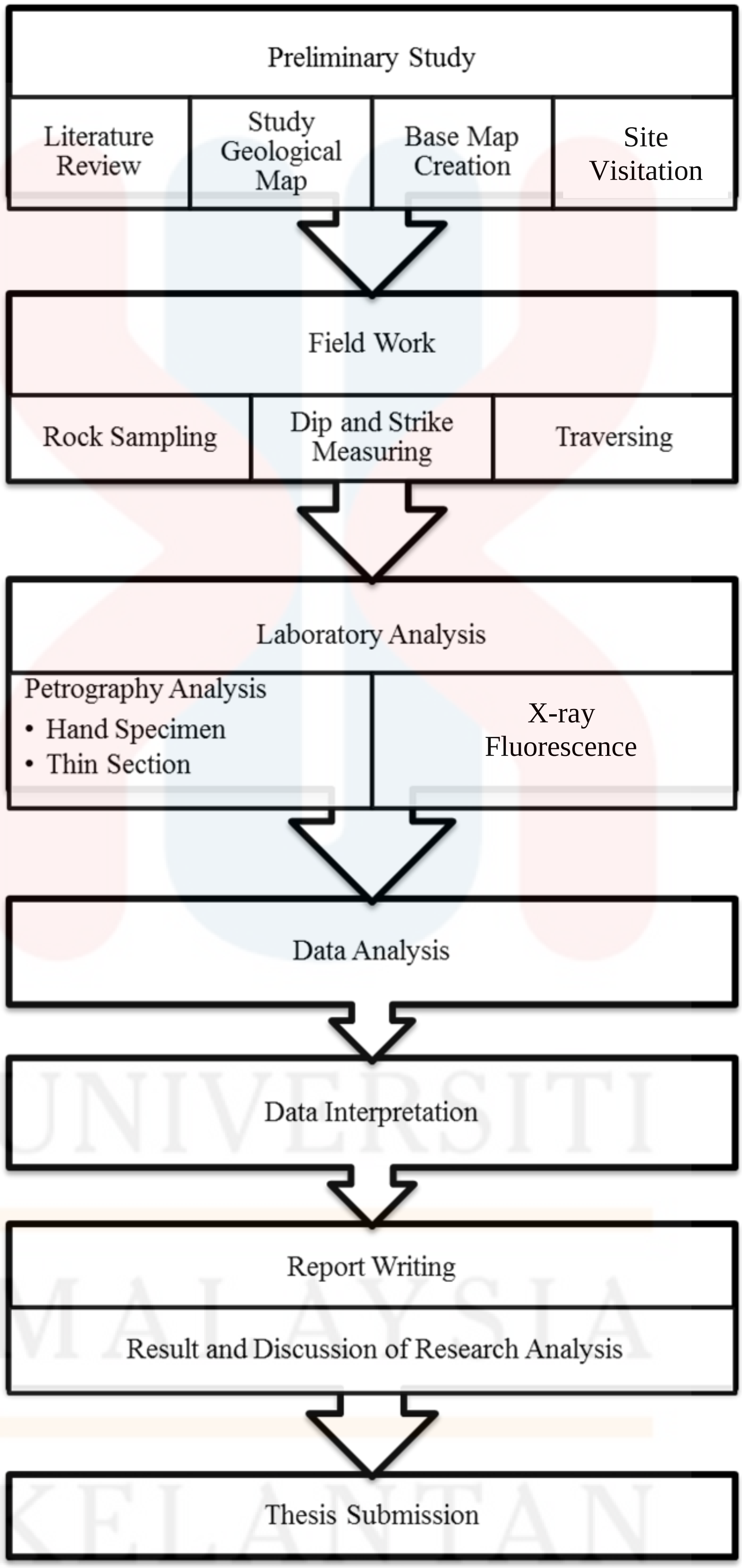


Figure 3.1: Research Flow Chart

3.3 Methodology

Methods that have been used for this research divided into preliminary study, field study, laboratory analysis, data analysis and interpretation, and report writing. Preliminary study consists of literature review, studying geological map, creating base map and site visitation. In field study, the data was collected by doing geological mapping which considered the lithology, geomorphology, structural geology, stratigraphy, strike and dip measuring, sampling, structure investigate, and photograph of area mapping.

Later on, laboratory analysis took place which divided into petrography analysis and X-ray Fluorescence spectrometry. These analyses describe the physical properties of the sample, the micro texture, optical properties and structure of the rock and identify the elemental composition of the minerals constituted on the rocks. In data analysis, the petrography data from the hand specimen analysis and thin section analysis has been used to determine the mineral composition and percentage to determine the rocks' name. The data have been interpreted using ArcGis software by creating a geological map of the study area as well as its geomorphology, topography and drainage pattern. Results and discussion of research analysis included in the report writing.

3.3.1 Preliminary Studies

This research began since February 2016. In preliminary study, the study area was investigated by reading and understanding theses, books, journals and internet research. One essential task when undertaking a research study is to review the existing literature on the topic and use it to inform the construction of own study. A literature review can bring clarity and focus to research problem and broaden knowledge base in study area. In addition, past studies can improve the methodology and help to contextualize findings. The literature review is crucial because an important responsibility in research is to add to a body of knowledge and to compare our findings with others.

Before going to the site, a map is a significant tool. It can interpret the study area by analysing the contour, drainage pattern and the structural features. Basically map can be divided to several such as topographic map, base map and structural map. By studying the map, we could clearly understand the setting of the study area, its geological features and other features that are useful for our fieldwork

3.3.2 Field Studies

Field study or field work is the most important thing in doing a research as it provides data that we cannot get during preliminary study. These data then are collected and interpreted to produce the outcomes. There are some observations and data collection techniques that have been done during on the field such as sketching, digital photography, GPS co-ordinates, note taking, and hand specimen sampling.

Geological mapping is the process of making observations of geology in the field and recording them so that one of the several different types of geological map can be produced. The information recorded must be factual, based on objective examination of the rocks and exposures, and made with an open mind since geology is too unpredictable to be approached with preconceived ideas. Obviously the thoroughness with which a region can be studied depends upon the type of mapping preferred.

Traversing is basically a method of controlling the progress across study area. It is also a method of covering the ground in the detail. A traverse is made by walking a more or less predetermined route from one point on the map to another, plotting the geology on the way. After traversing, trace contacts between different rock formations, groups and types, and shown on a map where they occur. One way of doing this is to follow a contact on the ground as far as it is possible to do so.

Field measurement is important in order to do analysis and interpretation. Measurements of strike and dip of bedding, cleavage, foliation and jointing are fundamental in geological mapping. Collect representative specimens of every formation and rock type shown on the map. Often, several specimens of the same formation are needed if it varies in composition over the region. A camera is essential in the field. After taking a photo, the scene of the outcrops locality was roughly sketched on the field book to show what to look for on the print.

Rock sampling included in field study and has been done in many ways. For this study, it is important to know the rocks that are need to be looking for to make a sample. Next, traverse along the road or river in the study area to find the outcrop. Granites were easily identified by looking to its texture that exhibit coarse grain and often has light colour due to the presence of quartz and feldspar as the major minerals. The outcrops were hammered into smaller size just like the size of a hand as the hand specimens. The rock samples were collected in plastic bag sample in a particular number. These samples then were further analysed in the laboratory.

3.3.3 Laboratory Work

The process of extraction of the samples was running in the laboratory. In this research, laboratory work can be divided into petrographic method and XRF method.

a) Petrographic Method

Petrographic method involved hand specimens and thin section. By hand specimens, the physical properties of the sample can be described whilst using thin section it is easy to describe the micro texture, optical properties and structure of the rock. There are five main tools that had been used to prepare a thin section which are the slab saw, the trim saw, the grinder, the cut-off saw and the lap wheels.

The first step in making a thin section is preparing the glass slide. The grinding wheels should be cleaned promptly to avoid from rust. After the glass slide was ready, it was frozen to flatten it out and roughen the surface so the epoxy can bind well. After that, a mark was made on the rock on where it should be cut. Next, cut a slab from the rock along the line that have been marked using the slab saw. In order to reduce the size of the slab to make it slightly smaller than a thin section, a trim saw was used.

Then, the frosted side of the slide was attached to the side of the chip that has been ground down. After that, most of the chip was cut off, leaving a thin slice attached before grinding away much of the rock that remains on the slide. Lastly, a cover slip was added to protect the section from damage, and increase the clarity observed in the microscope.

b) XRF Method

In this study, XRF method is used to determine the major elements and trace elements presence in rock samples. Before running the XRF, the rock samples were prepared in several steps to turn the solid rock into powder form. XRF sample preparation is very important for correct XRF analysis. Samples collected were as big as the size of a coin before being crushed by rock hammer to reduce it to an average grain size between a few millimetres and a centimetre with a weight of about a few tens to a hundred grams. Then, this small rock sample was ground into a fine powder by grinder machine. This step was done with care to be aware of contamination.

Bruker D2 Phaser is the name of the XRF spectrometry that was used to run the XRF technique. Basically, XRF is based on the principle that when an individual atoms excited by an external energy source, it emits X-ray photons of a characteristic energy or wavelength. The elements present may be identified and quantitated by counting the number of photons of each energy emitted from a sample.

3.3.4 Data Processing

The thin section samples then will be observed using the petrographic microscope to identify the minerals presence in the rocks samples with the aid of the lenses. The mineral composition of the rock is identified and listed according to its percentage. The identification of minerals under the polarized-light microscope is based on optical and morphological properties. Morphological properties involved grain shape and symmetry, cleavage and fracture, twinning, inclusions, intergrowths and alteration products. Colour and pleochroism, light refraction and angle of extinction are referred to the optical characteristics.

3.3.5 Data Analysis & Interpretation

The petrography data from the hand specimen analysis and thin section analysis had been used to determine the minerals constitute on the rock sample. Geochemistry data from the XRF analysis were used in determining the percentage of the elements presence in the rock. ArcGis software was used to create a geological map. By using this software, geomorphology, lithology and drainage pattern of study area were also been mapped.

3.3.6 Report Writing

Writing a report is crucial in order to collect and compile all the methods that have been done throughout the research together with other important data to support the study. The report includes the introduction and background of this research and study area, its literature review, detailed on methods and materials that have been applied in this research, general geology and specification of this research, a complete result together with its discussions, and lastly the conclusions as well as suggestions for future research.

CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

This chapter comprises generally on the main geological aspects such as geomorphology, structural geology, and historical geology. Geomorphology discussed on the landforms formed in the study area and its processes that include weathering and erosion. Weathering can be divided into three; physical, biological and chemical weathering.

4.2 Geomorphology

Geomorphology is defined as the science of landforms that studies on their origin, evolution, form, processes and sediments at the surface of the Earth. Study includes solving on how the earth surface processes by looking at landscapes that formed by the combination of landforms like hills, valleys, caves, sand dunes, etc. All physical, chemical and biological processes that occurred led to changes on the Earth's surface to form landscapes. These processes often operate at a slow rate, but sometimes causing rapid change to the environment and sometimes threatening lives as geological hazards such as landslide, earthquake, tsunami, flood and volcanic eruption might happen anytime. Geomorphological processes can be divided into three; exogenic, endogenic and extra-terrestrial. The main geomorphological agents that influence the process are water, wind and glacier.

Weathering and erosion are both apart of exogenic process that change the landform of the Earth’s surface. Weathering is a process of decomposition and disintegration of rocks, soils and minerals at the Earth’s surface through physical, chemical or biological processes (Thompson & Turk, 1997). Erosion is the removal of the exposed weathered rocks, minerals and soils by erosive forces such as moving water, wind, glaciers, and gravity (Thompson & Turk, 1997). These very same agents will then transport the eroded materials or called as sediment from its place of origin to certain places where the sediment is deposited.

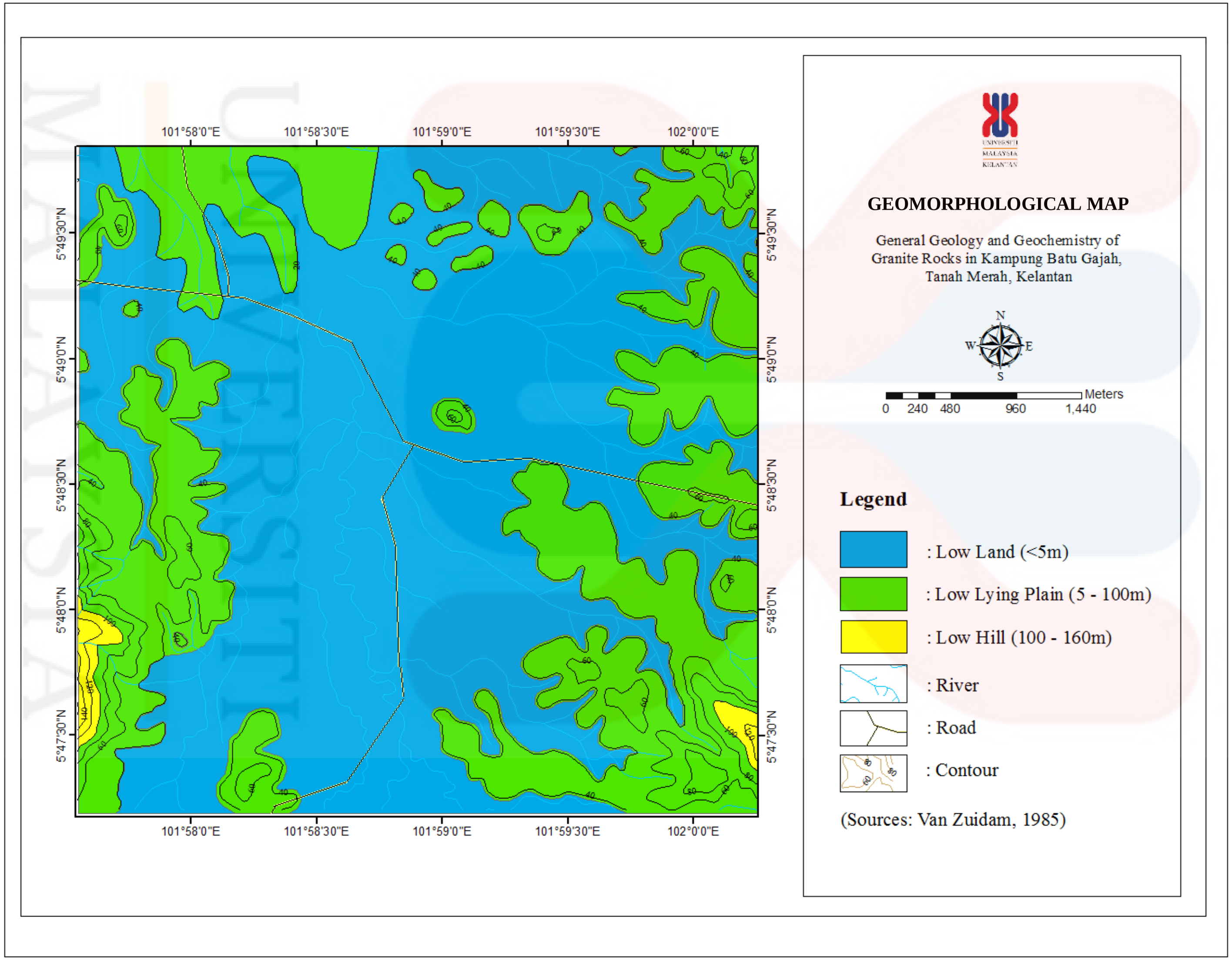
Observations by field mapping recorded physical, biological and chemical weathering can be found in the study area. Physical weathering results in breaking up large rocks into smaller ones without altering the rock’s chemical nature or its minerals which is caused by the changing of temperature on the rocks and sometimes assisted by water. Biological weathering or also known as organic activity is the process of weakening and subsequent disintegration of rock caused either by plants, animals or microbes. Chemical weathering is a chemical reaction between air and water with rock that alter its composition and mineral content.

The main reason the Earth's surface has gradational different because the crust composed by different rocks and structures, so it has a rock resistance against different geomorphological processes. A very small diversity of geomorphological process still has a very important meaning, except in recent diastrophism area where it can be estimated that the area which has a high topographic position is composed by hard rock, while the region with lower topographic position compiled by soft rocks. Differences in the rock composition and structure reflected the diversity of geomorphology and local topography.

The difference in elevation is usually measured from the sea surface, as sea levels considered as areas that have zero elevation number. The importance of identifying the difference in elevation is to state the morphography condition and morphogenetic of a landform, such as hills, mountains or plains. A geomorphological map shown in Figure 4.4 based on Van Zuidam (1985) on the relations between the differences in elevation with morphography elements in Table 4.1.

Table 4.1: Relations between the absolute elevations with the morphology elements (Van Zuidam, 1985)

Absolute Elevation	Morphology Elements
< 50 metres	Low Land
50 – 100 metres	Low Lying Plain
100 – 200 metres	Low Hill
200 – 500 metres	Hill
500 – 1500 metres	High Hill
1500 – 3000 metres	Mountain
> 3000 metres	High Mountain



101°58'0"E
101°58'30"E
101°59'0"E
101°59'30"E
102°0'0"E
5°49'30"N
5°49'0"N
5°48'30"N
5°48'0"N
5°47'30"N
GEOMORPHOLOGICAL MAP
General Geology and Geochemistry of Granite Rocks in Kampung Batu Gajah, Tanah Merah, Kelantan
N
S
E
W
Meters
0 240 480 960 1,440
Legend
: Low Land (<5m)
: Low Lying Plain (5 - 100m)
: Low Hill (100 - 160m)
: River
: Road
: Contour
(Sources: Van Zuidam, 1985)

Figure 4.1

4.2.1 Weathering

a) Physical Weathering

Physical weathering can be observed in the study area and has been identified as a pressure-release weathering as shown in Figure 4.1. During Triassic, the granitic pluton solidifies from the intruded magma at a certain depth of around 5 to 20 kilometres whereby the pressure from the weight of the overlying rocks is hundreds times greater than that at the Earth's surface. Over a long period of time, the pluton rose by tectonic forces to form batholith as the pressure is decreasing and the overlying rock erodes away. As the pressure depleted, the rock fractures as it expands because it is now in cool and brittle condition. This kind of weathering is very common to igneous rocks especially for granitic pluton.

Figure 4.2: Physical Weathering on Rock

b) Biological Weathering

A small crack on the rock is enough for a seed to fall and sprout if there is soil collected there. As it grows, the roots work their way down into the crack and expand before eventually push the rock apart. Figure 4.2 shows a granite outcrop that was undergone major fracture after being pushed by the growing tree and later by soils and sediments.

Figure 4.3: Biological Weathering on Rock

c) Chemical Weathering

Oxidation is one of the most important processes of chemical weathering. It refers to the reaction of oxygen with metal elements in a rock like iron, copper lead and zinc. One of the examples of oxidation reaction is rusting, the easily recognizable one. Iron tends to react with oxygen, turning the rock to reddish-brown. Figure 4.3 shows an outcrop that has been rusted due to oxidation process. The lithology of the rock cannot be identified as it is highly weathered.

Figure 4.3: Chemical Weathering on Rock

4.2.2 Drainage System

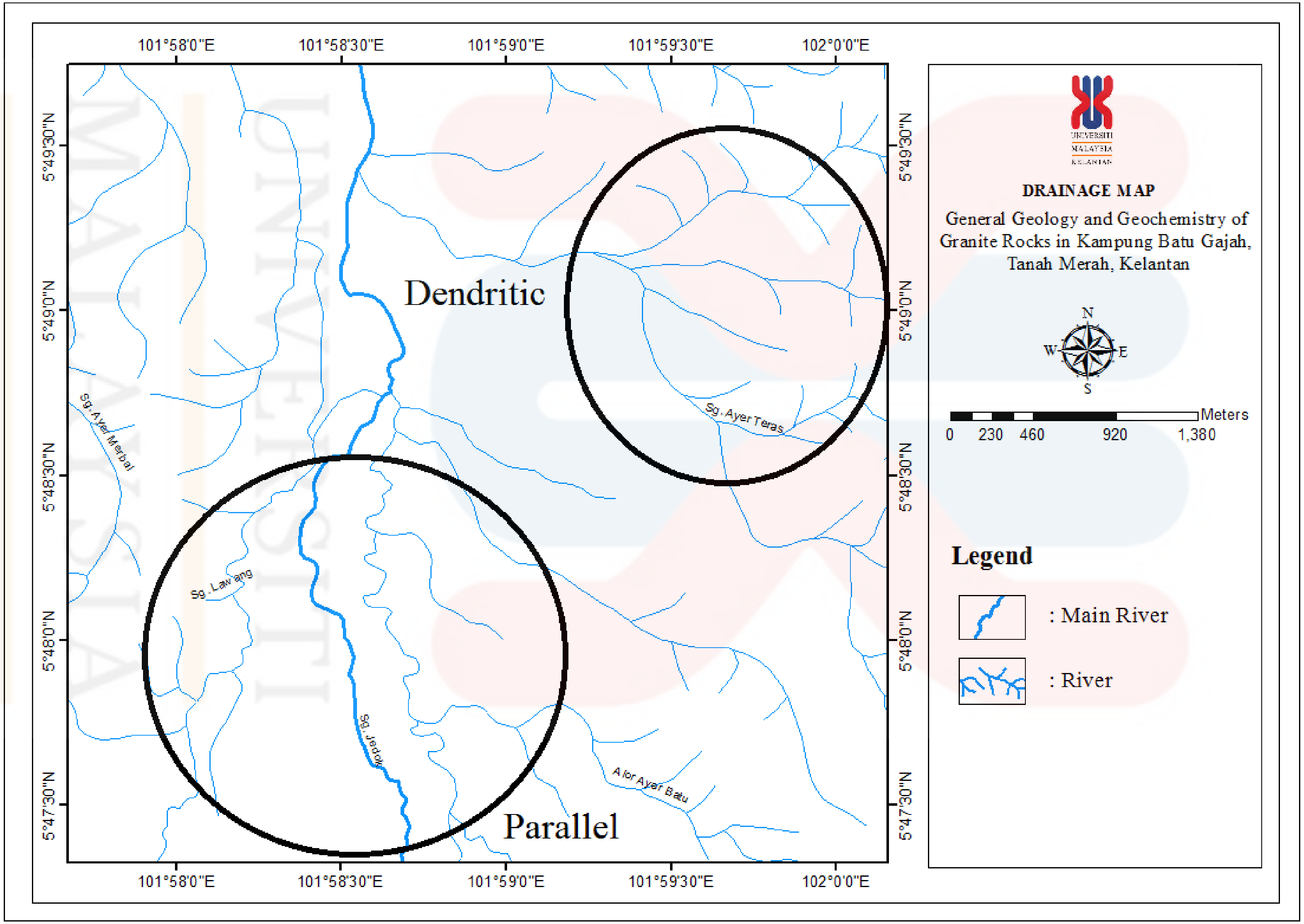
Drainage system is the pattern formed by the streams, rivers and lakes in a particular drainage basin. They are governed by the topography of the land, whether a particular region is dominated by hard or soft rocks and the gradient of the land. Streams are often viewed as being part of drainage basins. Drainage basins are the areas of land that are drained by a river system. They get their inputs from many processes like precipitation, snowmelt, and sediments. Drainage basins generally lose water and sediments through evaporation, deposition and stream flow. There are number of factors that influence the input, output, and the transport of sediments and water in a drainage basin which include the topography, soil type, bedrock type, climate and vegetation cover.

A drainage basin is the topographic region from which a stream receives runoff, through flow and groundwater flow. Drainage basins are divided from each other by topographic barriers called watershed. A watershed represents all of the stream tributaries that flow to some location along the stream channel. The number, size and shape of the drainage basins found in an area vary and the larger the topographic map, the more information on the drainage basin is available.

Drainages tend to develop along zones where rock type and structure are mostly eroded. Thus, various types of drainage patterns develop in a region and these drainage patterns reflect the structure of the rock. Dendritic, parallel, trellis, rectangular, radial, deranged and annular are the common drainage patterns found in a region. Based on the map shows in Figure 4.5, there are two types of drainage patterns can be found in the study area which are dendritic and parallel.

Dendritic pattern develops where the river channel follows the slope of the terrain. In this system, the streams intersect with a characteristic V-pattern in map view. The tip of the V points downstream and resembles the shape of a tree with many branches. This pattern formed through the layering of relatively flat sedimentary rocks or crystalline rocks that are uniform and resistant to weathering. Regionally, the watershed has gentle slopes and the drainage pattern forming branches that spread like a shady tree.

Meanwhile, a parallel drainage pattern forms where there is a definite slope to the surface. A parallel pattern also develops in regions of parallel, elongate landforms like outcropping resistant rock bands. Tributary streams tend to stretch out in a parallel-like fashion following the slope of the surface. A parallel sometimes indicates the presence of a major fault that cuts across an area of steeply folded bedrock.



101°58'0"E
101°58'30"E
101°59'0"E
101°59'30"E
102°0'0"E
5°49'30"N
5°49'0"N
5°48'30"N
5°48'0"N
5°47'30"N
Dendritic
Parallel
Sg. Ayer Teras
Sg. Ayer Merbal
Sg. Lawang
Sg. Jedok
Alor Ayer Batu
DRAINAGE MAP
General Geology and Geochemistry of Granite Rocks in Kampung Batu Gajah, Tanah Merah, Kelantan
N
W
E
S
0 230 460 920 1,380
Meters
Legend
: Main River
: River

Figure 4.5

4.3 Stratigraphy

Stratigraphy is a branch of geology which concerned with the studies of rock layers and their interpretation in terms of geological time scale. It provides a foundation for historical geology by correlating the rock successions with geological events and processes. It can be used to deduce past environments of an area based on the evidences of the physical characteristics of the rocks and the changes in environment that occurred over time.

4.3.1 Lithostratigraphy

Lithologic stratigraphy or lithostratigraphy is a subdivision of stratigraphy which studies the relationship among rock units based on the lithology (rock type), physical characteristics and petrographic features. There are three lithostratigraphic units existed in the study area as shown in Figure 4.7 which are schist, granite and alluvium.

Stratigraphic column is a representation which describes the vertical location of rock units in a particular area. A stratigraphic column shown in Figure 4.6 indicated that the area of Kampung Batu Gajah has three different lithologic units; schist, granite and alluvium. The age of the Taku Schist is suggested to be Permian-Triassic (Khoo and Lim, 1983) while the Kemahang Granite is believed to be intruded during Cretaceous (Hutchison, 2007). Alluvium is a deposit of clay, silt, and sand that abundant in the rivers around the study area. It is believed to be deposited during Quaternary age.

a) Schist

Schist is a medium grade metamorphic rock which is found in the study area particularly around the north-west part. The schist outcrop that was found in the study area is a part of the Taku Schist body. Taku Schist name is taken after the name of a river at eastern Kelantan named Sungai Taku. Rock sample taken from the field shows it is light grey in colour, has grains range from medium to coarse and it is foliated.

b) Granite

The study area is mostly covered by granite whereby the north-west part is the only exception. Granite is an igneous rock which is light-coloured due to its high silica content. It is formed from acidic magma composition under the Earth's surface. Granite rocks found in the study area is a part of the Kemahang granite which is one of the granitic bodies in the eastern belt of peninsular Malaysia. There are a lot of disagreements on determining the age of this granitic body. Based on the data collected from fieldwork, the rock sample taken shows it has light grey colour with texture from medium to coarse grain. Most of the rocks found contain megacrysts of plagioclase feldspar with size up to 3 cm in diameter.

c) Alluvium

Deposits of alluvium, mainly poorly sorted sands, gravels and boulders along the stream channels at the low and flat area. The upper reaches of stream channels contain coarse sands and gravels, with fine sands, silts and clay in the lower portions of streams. Alluvial deposits formed mainly from the small fragments to sediments of rocks that had undergone weathering and erosion process early on before being transported by the water flows in the river. These sediments deposited starting from the largest particles when the current slows down to the finest particles when the water stops which result in finer particles settle out on top of the large ones forming well-sorted deposits.

EON	ERA	PERIOD	LITHOLOGY
Phanerozoic	Cenozoic	Quaternary	Alluvium
	Mesozoic	Cretaceous	Granite
		Triassic	Schist
	Paleozoic	Permian	

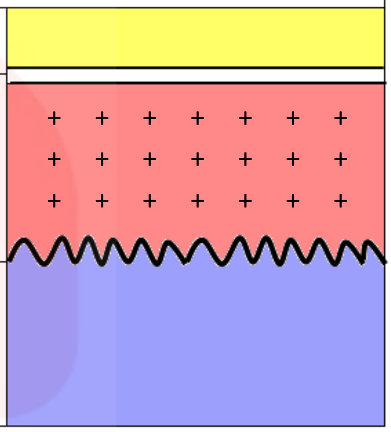
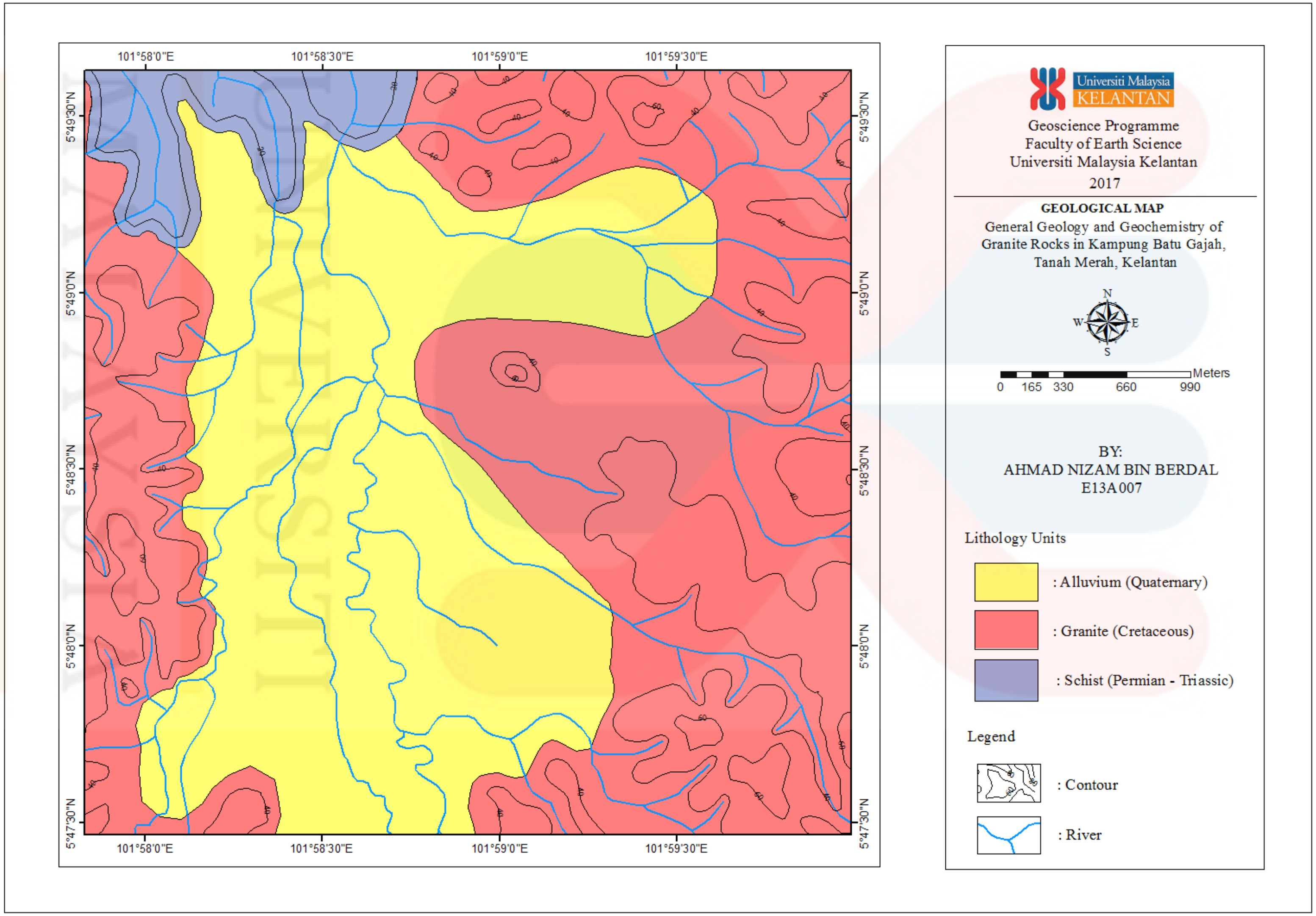


Figure 4.6: A Stratigraphic Column of the Study Area



101°58'0"E
101°58'30"E
101°59'0"E
101°59'30"E
5°49'30"N
5°49'0"N
5°48'30"N
5°48'0"N
5°47'30"N
Universiti Malaysia KELANTAN
Geoscience Programme
Faculty of Earth Science
Universiti Malaysia Kelantan
2017
GEOLOGICAL MAP
General Geology and Geochemistry of Granite Rocks in Kampung Batu Gajah, Tanah Merah, Kelantan
N
W
E
S
Meters
0 165 330 660 990
BY:
AHMAD NIZAM BIN BERDAL
E13A007
Lithology Units
: Alluvium (Quaternary)
: Granite (Cretaceous)
: Schist (Permian - Triassic)
Legend
: Contour
: River

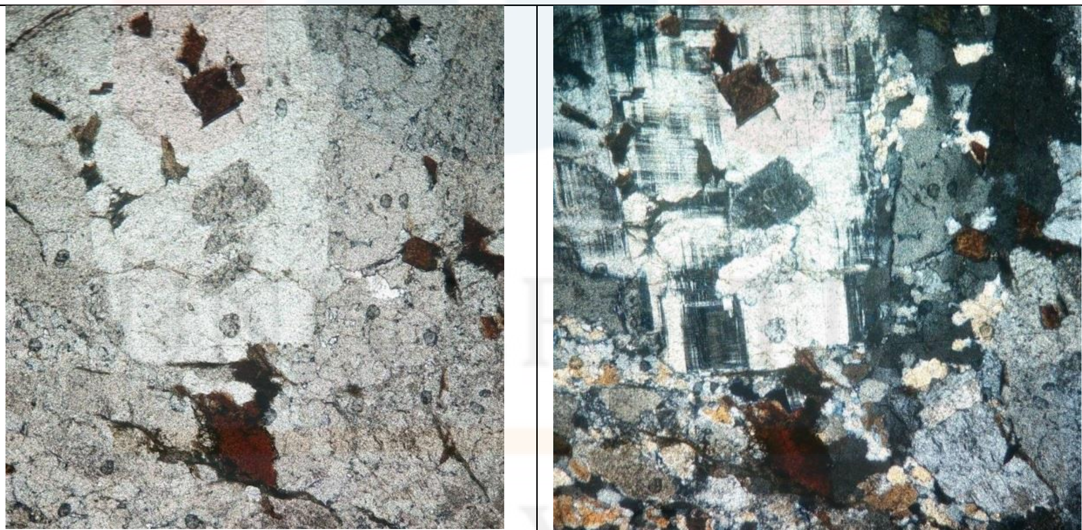
Figure 4.7

4.4 Petrography

In this study, there are two types of rock which have been analysed which are granite and schist. Thus, a detailed observation is done on the samples. There are a total of four samples that have been analysed through petrographic. Figure 4.8 shows the hand specimen of granite Sample 1 taken at 101°58’49.4” E, 05°48’42.1”N. Figure 4.9 is the thin section observation result. Figure 4.10 is the hand specimen of granite Sample 2 which was taken at 101°58’17.0” E, 05°47’24” N. Figure 4.11 is the thin section observation result. Figure 4.12 is the hand specimen of granite Sample 3 which was taken at 102°0’14.2” E, 05°48’43.5” N. Figure 4.13 is the thin section observation result. Figure 4.14 shows the hand specimen of the only schist sample which was taken at 101°57’50.2” E, 05°49’51.4” N. Figure 4.15 is the thin section observation result. Table 4.1 shows mineral composition for every sample with its percentage value. All samples taken were marked on the traverse map shown at Figure 4.18.

Sample 1

Figure 4.8: Hand specimen for Granite Sample 1

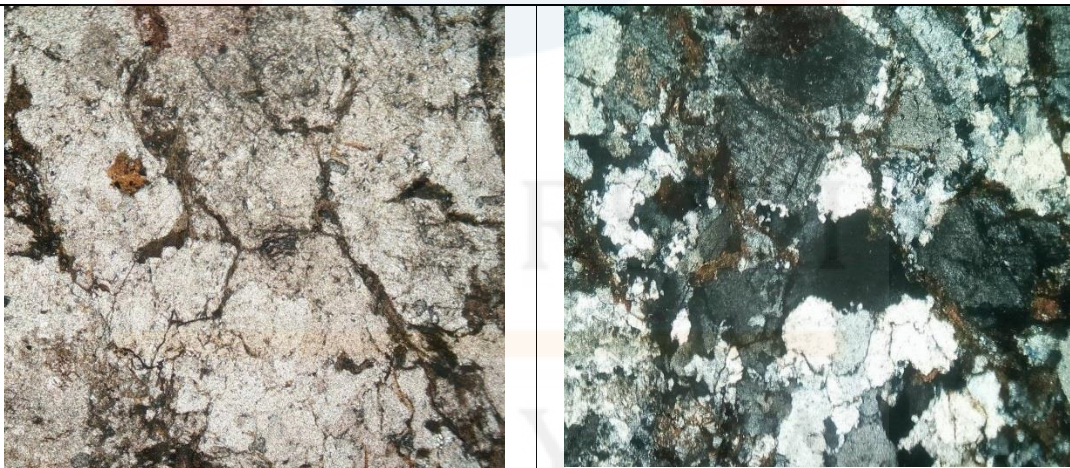


Plane-polarised	Cross-polarised

Figure 4.9: Microscopic view of Granite Sample 1

Sample 2

Figure 4.10: Hand Specimen for Granite Sample 2



Plane-polarised	Cross-polarised

Figure 4.11: Microscopic view of Granite Sample 2

Sample 3

Figure 4.12: Hand Specimen for Granite Sample 3

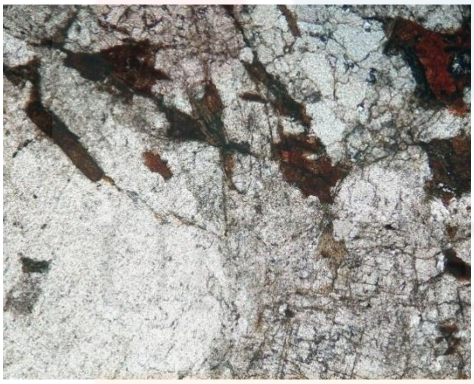
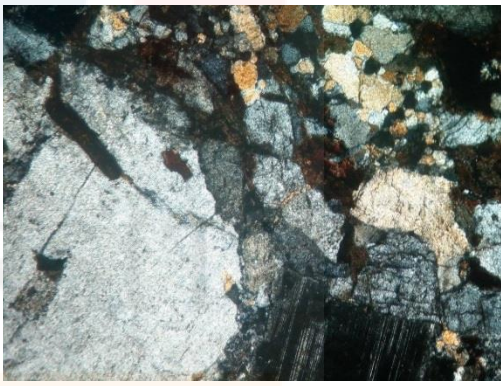
	
Plane-polarised	Cross-polarised

Figure 4.13: Microscopic view of Granite Sample 3

Sample 4

Figure 4.14: Hand Specimen for Schist sample

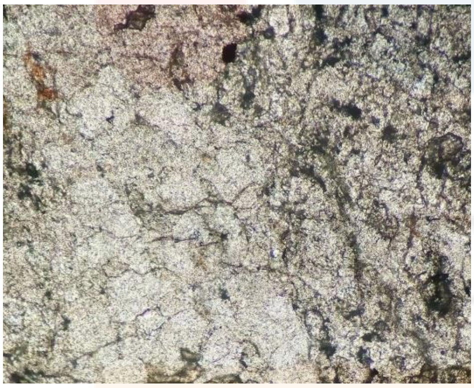
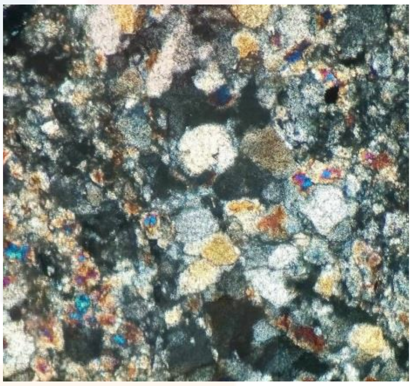
	
Plane-polarised	Cross-polarised

Figure 4.15: Microscopic view of Schist Sample

Table 4.2: Mineral Constituents in Samples

Samples	Mineral Composition	Other Minerals
Granite Sample 1	Alkali Feldspar: 50% Quartz: 20% Plagioclase Feldspar: 10% Biotite: 10% Amphibole: 5% Other Minerals: 5%	Pyroxene, Olivine
Granite Sample 2	Alkali Feldspar: 40% Quartz: 30% Plagioclase Feldspar: 10% Biotite: 10% Amphibole: 5% Other Minerals: 5%	Pyroxene, Olivine
Granite Sample 3	Alkali Feldspar: 45% Quartz: 20% Plagioclase Feldspar: 15% Biotite: 10% Amphibole: 5% Other Minerals: 5%	Pyroxene, Olivine
Schist Sample	Quartz: 45% Feldspar: 20% Muscovite: 15% Biotite: 10% Amphibole: 5% Other Minerals: 5%	Graphite, Chlorite, Garnet, Talc

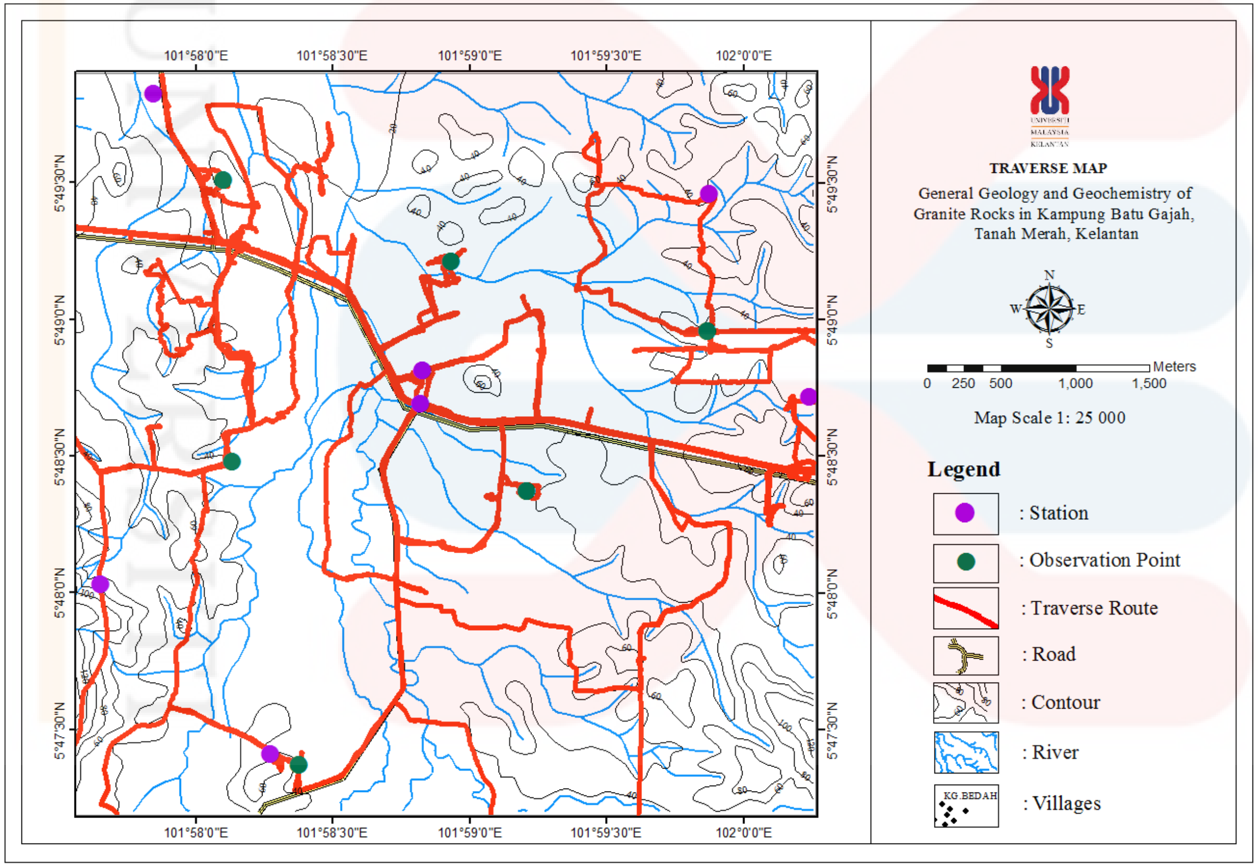

TRAVERSE MAP
General Geology and Geochemistry of Granite Rocks in Kampung Batu Gajah, Tanah Merah, Kelantan
N
S
W
E
Meters
0 250 500 1,000 1,500
Map Scale 1: 25 000
Legend
: Station
: Observation Point
: Traverse Route
: Road
: Contour
: River
: Villages
KG.BEDAH
101°58'0"E
101°58'30"E
101°59'0"E
101°59'30"E
102°0'0"E
5°49'30"N
5°49'0"N
5°48'30"N
5°48'0"N
5°47'30"N

Figure 4.16

4.5 Structural Geology

Structural geology is a method in geology aims to know the past geological environments by studying the processes and products of rock deformation and the three dimensional distribution of rock. In this study, a lineament analysis had been done in order to determine the historical deformation systems.

4.5.1 Lineament

Lineament is a linear topographic feature that is believed to reflect an underlying geological structure. In this research, the lineament analysis is done by using satellite imagery of the study area and its nearby region as it could give a brief idea on the direction of force that was exerted in the study area. Figure 4.7 shows the satellite imagery map with red-line marked that shows the lineament.

Readings were taken by measuring the angle of the lineament. The values were interpreted by using GeoRose software. Figure 4.8 is the result of the analysis which shows that the maximum force exerted on the area is 22.5° towards North-East.

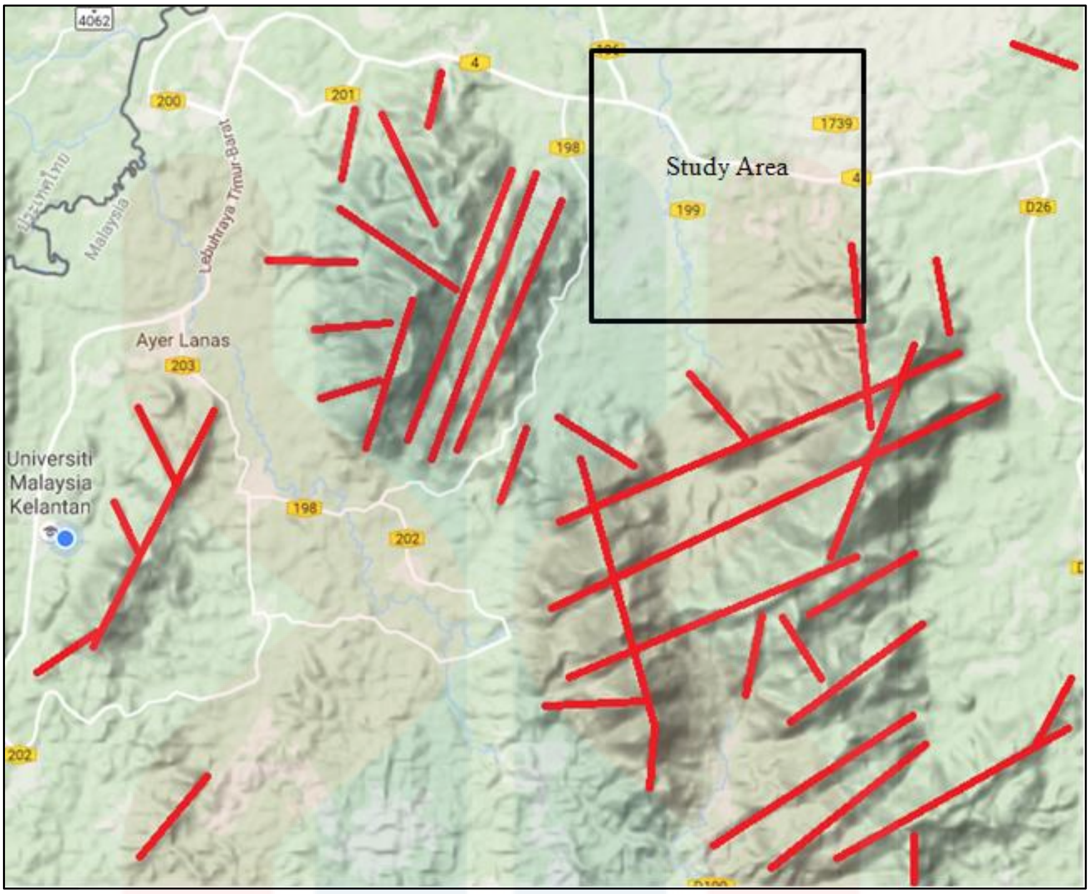


Figure 4.17: Satellite imagery of study area and its surrounding

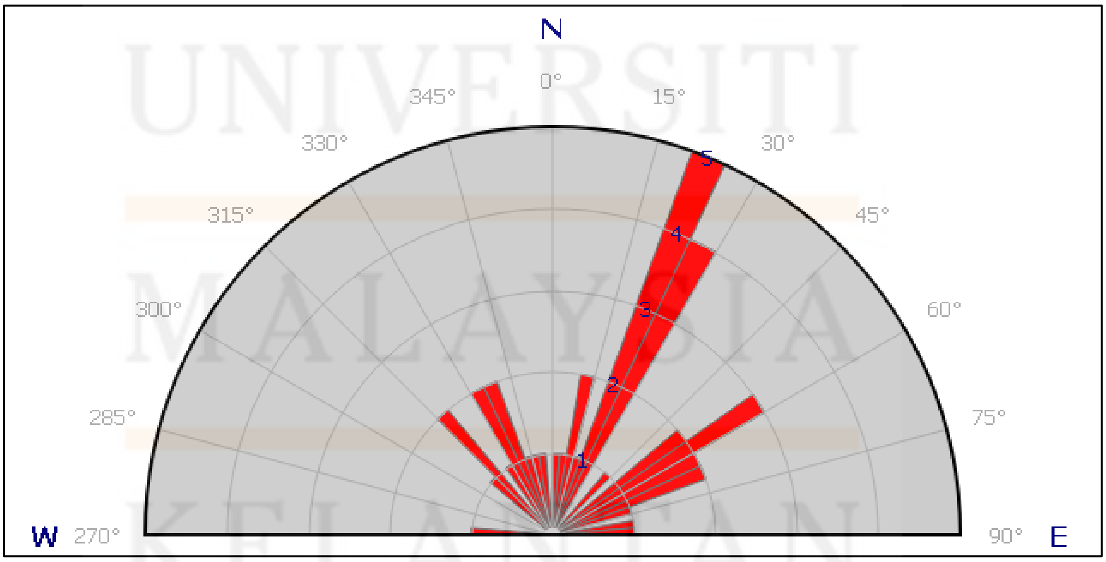


Figure 4.19: Rose Diagram of Lineament Analysis

4.6 Historical Geology

A discipline of geology that deals with reconstructing and understanding the geological history of the Earth is called historical geology. Historical geology uses the principles and techniques of geology and focusses on past geologic processes as well as the evolution of animals and plants that lived on this Earth since the early age.

The Kemahang granite of MacDonald (1967) is a granitic mass of batholitic dimension in north-west Kelantan close to the Thai border which is in contact with the Taku Schists on all sides except the west where it is in contact with Permo-Triassic sediments which also include metamorphics such as slates, phyllites, marble and metavolcanics (Khoo, 1980).

MacDonald (1967) interpreted the Kemahang granite to be an intrusive magmatic body and the shearing was suggested to be the result of adjustments within the granite during solidification and associated tectonic movements which took place during and after emplacement and solidification. Hutchison (1937b) said that the Kemahang granite is an extensive parautochthonous granite body formed in part of foliated granite gneiss and in part of cataclastic granite and contains a number of schist relics.

Khoo (1980) said that the Kemahang granite is a high level emplacement considering features such as discordance to country rocks and the presence of contact metamorphism.

CHAPTER 5

GEOCHEMISTRY OF GRANITE ROCKS IN KAMPUNG BATU GAJAH, TANAH MERAH, KELANTAN

5.1 Introduction

Geochemistry is the branch of Geoscience that utilizes science, its tools and chemistry principles with portray the components behind significant geological frameworks such as the Earth's crust and its systems. Geochemistry extends past the earth and encompasses the entire solar system and has made a lot of important contributions to the understanding of process occurred on the Earth and its systems including mantle convection, formation of planets and the origin of granite and basalt.

5.2 Kemahang Granite Formation

The Kemahang Granite is a granitic mass of batholitic dimension in North-South Kelantan close to Thai border. The body is in contact with the Taku Schist on all sides except the west where the body is in contact with Permo-Triassic metasediment lithology. The Kemahang Granite is aged Cretaceous forms a North-South trending mountainous area near Jeli town which is located in the central part of the transect area (The Malaysian and Thai Working Groups, 2006).

5.3 XRF Analysis

Table 5.1 and Table 5.2 shows the XRF result of major elements and minor elements respectively from a number of five granite samples taken in the study area. Based on previous study, geochemical analysis of the Lebowa Granite Suite which usually focussed on differentiations characteristics of the stratigraphic elements. This research was conducted with the objective of describing geochemical variations as a function of changing and mineralisation in the context of IOCG deposits and to differentiate these features from differentiation/crystal fractionation style or weathering effects

Extreme alteration occurs in the host rocks of iron oxide copper-gold (IOCG) deposits but the most alteration mineralogy and intensity might vary logically both between and within area depending on the host rock and depth of formation. Generally, a trend presents from sodic alteration at deep levels (albite-rich), to potassic alteration at intermediate levels (feldspar-sericite), to sericitic alteration and silicification at shallow levels (sericite + quartz). These more appear to exist an extreme Fe-metasomatism prevalent locally in the host lithology.

In the previous chapter, the lowest level sodic alteration was discussed petrographically, although was found to be of limited extent. Geochemical assessment of these similar rocks did not yield appreciable albite signs. On hand specimen it may be hard to recognise albitic alteration directly, which usually shows only as a relative hardening of affected rocks, perhaps due to the increased ordering of feldspar lattices. The absence of sodic aleration in the study area may be a shows that the stratigraphic position to the mineralisation; or that the results of early sodic alteration that have been occurred by slow alteration. It may also be presume that the system, generally may be too Na-poor for this alteration to be important and thus maybe unique with respect to other IOCG-type alteration.

Describing granites in terms of I-, S- & A-type makes some effects towards the host magma. Generally, I-type granites came from partial melting of predominantly igneous rock, results in granites of tonalitic to granodioritic composition. I-type granites also might to be more oxidised and associated normally with porphyry Cu-Mo mineralisation.

Table 5.1: Major Elements Composition in Samples

Elements (Oxides Compounds)	Value (%)			
	Sample 1	Sample 2	Sample 3	Sample 4
SiO_2	60.60	59.20	55.30	61.30
Al_2O_3	11.30	11.00	11.00	12.00
K_2O	9.40	13.20	8.66	11.10
CaO	5.57	3.61	4.69	3.88
Fe_2O_3	7.50	5.71	7.54	6.71
TiO_2	1.32	0.848	1.14	0.913
P_2O_5	1.04	1.41	1.29	1.12
SO_3	1.10	0.851	0.738	1.05
Cl	0.671	0.571	0.578	0.669
ZrO_2	0.502	0.216	0.251	0.173
BaO	0.337	0.681	0.297	0.597
Na_2O	-	-	6.20	-
Total	99.34	97.30	97.68	99.51

For sample 1, the granite sample contains silicon dioxide (SiO_2) with a percentage of 60.60%. The percentage of other elements in oxide compounds are aluminium oxide (Al_2O_3) with 11.30%; potassium oxide (K_2O) with 9.40%; iron oxide (Fe_2O_3) with 7.50%; calcium oxide (CaO) with 5.57%; titanium dioxide (TiO_2) with 1.32%; sulphur trioxide (SO_3) with 1.10%; and phosphorus pentoxide (P_2O_5) with 1.04%.

For sample 2, the granite sample contains silicon dioxide (SiO_2) with a percentage of 59.20%. The percentage of other elements in oxide compounds are potassium oxide (K_2O) with 13.20%; aluminium oxide (Al_2O_3) with 11.00%; iron oxide (Fe_2O_3) with 5.71%; calcium oxide (CaO) with 3.61%; phosphorus pentoxide (P_2O_5) with 1.41%; sulphur trioxide (SO_3) with 0.851%; and barium oxide (BaO) with 0.681%.

For sample 3, the granite sample contains silicon dioxide (SiO_2) with a percentage of 55.30%. The percentage of other elements in oxide compounds are aluminium oxide (Al_2O_3) with 11.00%; potassium oxide (K_2O) with 8.66%; iron oxide (Fe_2O_3) with 7.54%; sodium oxide (Na_2O) with 6.20%; calcium oxide (CaO) with 4.69%; phosphorus pentoxide (P_2O_5) with 1.29%; and titanium dioxide (TiO_2) with 1.14% and sulphur trioxide (SO_3) with 0.738%.

For sample 4, the granite sample contains silicon dioxide (SiO_2) with a percentage of 61.30%. The percentage of other elements in oxide compounds are aluminium oxide (Al_2O_3) with 12.00%; potassium oxide (K_2O) with 11.10%; iron oxide (Fe_2O_3) with 6.71%; calcium oxide (CaO) with 3.88%; phosphorus pentoxide (P_2O_5) with 1.12%; sulphur trioxide (SO_3) with 1.05% and titanium dioxide (TiO_2) with 0.913%.

Table 5.2: Trace Elements Found in Samples

Elements	Value (ppm)			
	Sample 1	Sample 2	Sample 3	Sample 4
Sr	60.70	37.10	37.10	43.10
Cu	139.00	15.60	-	21.90
Cs	3.93	-	1.95	5.01
Zn	123.70	31.10	33.10	31.20
Pb	30.00	15.80	17.60	18.40
I	4.96	1.70	-	6.11
Te	5.28	2.46	-	5.59
Nb	0.52	-	0.36	0.23
Sn	8.07	2.95	-	6.03
Ga	28.20	9.72	10.6	13.40
Bi	5.77	-	-	4.35

5.4 Discussion

From the petrography of granite rocks samples taken from different localities in the study area, it is observed that the granite has a large size of feldspar, abundant of quartz and biotite; meanwhile for the plagioclase it is also present as a megacryst in a small amount. The result from XRF analysis run at the X-ray Laboratory of UMK was not very well as expected. The composition of major elements in granite samples by percentage produced by the machine was not accurate and different if compared to the theoretical value. This is may be either due to the limitations of equipment or human error done by the laboratory assistant. Hence, from two analysis that have been done on the granite which are thin section analysis and XRF analysis, the results show no apparent relation between one and another.

The XRF result shows some major elements recorded (in oxides) were too high or too low from the value expected. For instance, the percentage of SiO_2 recorded from all samples was ranged 55 - 61% which is far from the normal value which is more than 70%. The recorded value for Al_2O_3 ranged 11 – 12% were slightly less than the normal value which is around 12 – 15%. On the other hand, some elements like K_2O, CaO, Fe_2O_3, MgO, TiO_2 and P_2O_5 record too high value compared to the normal value. Meanwhile, the value for Na_2O was unstated for sample 1, 2 and 4 and no value at all samples for FeO. These show that the result was not perfectly correct and chemical analysis was unable to be done in a proper way.

The observation is secured by using geochemistry analysis where the experiment is able to define the element of the minerals. Despite the poor result from XRF, the result still shows that the most abundant major element (in oxides) in the granite body is $SiO_{2.}$ $Al_2O_{3,}$ K_2O, CaO and Fe_2O_3 are also abundant but with lesser amount. These elements show that the samples contain minerals of quartz, alkali feldspar, plagioclase and biotite.

The presence of feldspar, quartz and biotite shows that the rock is an acidic type of igneous rock. From its texture, it can be categorised to be an acid intrusive igneous rock. The minerals composition of the rock secured that the rock is granite. Based on IUPAC nomenclature, the name of the rock is 'biotite granite porphyry'.

From XRF result, it shows that the total number of elements present in the sample 2 and 3 were below 98%. This might be due to the presence of some trace elements which cannot be detected by the machine. The machine has its own detection limit. Thus, those elements which are below the detection limit are unable to be detected.

CHAPTER 6

CONCLUSION AND SUGGESTION

6.1 Conclusion

From the starting of this research, the objectives that have been underlined are to produce a geological map of the study area and to examine the geochemistry of the granite rocks there. The geological map consists of three lithologies; schist, granite and alluvium; provided with its age. The age of the granite is Cretaceous while schist is aged Permo-Triassic and alluvium is aged Quaternary.

The granite rocks have been analysed using two analysis method; petrographic analysis and X-ray Fluorescence method of geochemistry analysis. From petrographic analysis, there are some minerals that have been identified as the major minerals which are quartz, alkali feldspar, plagioclase and biotite.

Through the XRF method, the occurrence of quartz, alkali feldspar, plagioclase and biotite are also abundant with quartz as the most among them. Quartz is well known as the most common mineral in granite. Though the composition of quartz in every sample can be seen scattered and sheared, it still become the highest composition of the major elements in the granite rocks.

From both analyses, the granite rocks of Kampung Batu Gajah which is the Kemahang Granite can be named as ‘biotite granite porphyry’. This is due to the highly percentage of biotite mineral in XRF and hand specimens.

6.2 Suggestion

The chemical investigation of a rock or any lithology is very important to confirm the occurrence of minerals especially for some minerals that cannot be identified under the microscope due to weathering on the samples.

In this research, a geochemistry method has been chosen to undergo the chemistry investigation of the granite rocks. A suggestion for further research is to test the granite rocks sample by using the Inductively-coupled Plasma Mass Spectrometry (ICP-MS) as the instrument is capable of detecting metals and several non-metals at concentrations as low as one part in 10^{15} (part per quadrillion, ppq) which is more precise compared to XRF method which has its own limitation.

ICP-MS experiment is the method that can help researchers to find out more information about the granitic body. More detailed and precise elemental composition of minerals can be identified using this method.

Besides, the institution should improve the staff's skills in running the XRF analysis so that there will be no more poor results produced. It is true that human error cannot be prevented, but yet it still can be reduced in order to get a good result and thus, a good analysis can be done for achieving the research objectives.

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