GENERAL GEOLOGY AND MINERALOGICAL STUDY OF FELDSPAR IN GUA MUSANG

by

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

FACULTY OF EARTH SCIENCE

UNIVERSITI MALAYSIA KELANTAN

2017

DECLARATION

I declare that this thesis entitled "General Geology and Mineralogical Study of Feldspar in Gua Musang "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 : _____

ACKNOWLEDGEMENT

Alhamdulillah. Thanks to Allah SWT, for giving me the opportunity to complete this Final Year Project entitled General Geology and Mineralogical Study of Feldspar In Gua Musang.

Firstly, I would like to express my deepest gratitude and appreciation to my supervisor, Dr Roniza Bt Ismail, who has guided me in finalizing my final year project in 2016.

Besides that, I would like to give my biggest appreciation to my family, especially my parents for supporting and encouraging me through all the ups and downs. Their encouraged, money, energy and time are the main reason I can complete this report.

Biggest thanks given to all the lecturers and staffs from the Department of Geoscience for their advices, suggestions, and guidance in completing my final year project.

Last but not least, I would like to declare my admiration to all my friends that has helped me completing this Final Year Project. This include Aza, Fatin, Ika, Munirah, Salwa, Fitri, Wanie and all of my classmates and everyone that has contributed by supporting, motivating, and helping me throughout the progress of my final year project.

General Geology and Mineralogical Study of Feldspar in Gua Musang

ABSTRACT

The study area is located in Kg Tanah Putih, Gua Musang. The starting point is from latitude N 4°45'50″ to N 4°48'35 ″ and longitude E 101°57'20″ to 102°0'10 ″ which is 5km x 5km with the dimension area of 25km². The area mostly covered by limestone and some subordinate of granite, sandstone, siltstone, mudstone and tuff. The objectives of the research are to update a geological map at scale 1:25 000, to identify the characteristic of feldspar and their distributions and lastly, to identify the major and trace elements in each rock samples. The data were collected by field investigations and laboratory analysis. Geological map in the study area have been update with scale1:25000. The study area is considered as a hilly area because there is karst landform. Based on the observation under microscope, the distribution of feldspar is mostly exposed in tuff pyroclastic rock. Feldspar present in megacrystal and microcrystal with the clast dominant in tuff sample. Result from laboratory analysis, XRF shows that sample 3 which is tuff (2) is an oligoclase.

Geologi Am Dan Kajian Mineralogi Feldspar Di Gua Musang

ABSTRAK

Kawasan kajian terletak di Kg Tanah Putih, Gua Musang. Kawasan kajian bermula di koordinat latitude N 4°45'50″ hingga N 4°48'35 ″ dan longitude E 101°57'20″ hingga 102°0'10 ″ dimana kawasan kajian berkeluasan 5km x 5km besamaan 25km². kawasan kajian didominasi oleh batuan batu kapur dan selebihnya batuan granit, batu pasir, batu lodak, batuan lempung dan tuf. Objektif kajian ini dijalankan ialah untuk megemaskini data peta geologi di kawasan kajian dengan berskala 1:25 000, untuk mengenalpasti ciri-ciri feldspar dan taburan mineral feldspar di kawasan kajian serta untuk mengenalpasti elemen utama dan surih dalam setiap sampel batuan. Data yang dikumpul daripada kerja lapangan dan analisis makmal. Peta geologi kawasan kajian telah dikemaskini berskala 1:25000. Kawasan kajian dikenalpasti sebagai kawasan berbukit kerana wujudnya bentuk muka bumi batu kapur. Berdasarkan pemerhatian melalui mikroskop, taburan feldspar terdedah di sekitar kawasan batuan piroklastik volkanik iaitu tuf. Feldspar mempunya saizgrain yg besar iaitu megakristal dan bersaiz kecil. Mikrokristal dengan dominan klas dalam sampel batuan bertuf. Hasil daripada analisis kimia, hanya sampel 3 sahaja boleh dikelaskan sebagai oligoclase.

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LIST OF ABBREVIATIONS

XRF	X-Ray Fluorescence
N	North
W	West
E	East
S	South
Na	Sodium
Ca	Calcium
K	potassium
Si	Silica
Rb	Rubidium
Ti	Titanium
Sr	Strontium
Al	Aluminium
Cs	Caesium
Fe	Iron
Mg	Magnesium
Pb	Lead
Ba	Barium
SiO_2	Silica Oxide
Al_2O_3	Alumina Oxide
Fe_2O_3	Iron Oxide
K_2O	Potassium Oxide
CaO	Calcium Oxide
Na_2O	Sodium Oxide
MgO	Magnesium Oxide
BaO	Barium Oxide
OPX	Orthopyroxene
B	Biotite
P	Plagioclase
A	alkali feldspar
Q	Quartz
Musc	Muscovite

LIST OF SYMBOLS

%	Percentage
°	Degree

CHAPTER 1

INTRODUCTION

1. 1 GENERAL BACKGROUND

Geology is the study about the Earth and its past history. Geology involve the study of the materials that made up the Earth, the characteristics and the structures that found on the Earth as well as the process that involve on them. In order to know further about the geology, the geological mapping needed to be done. Geological mapping for general geology is important for geologist. By conducting geological mapping, more details about the structure, lithology and geomorphology of study area can be obtained. From all the information, the geological process and history within the study area will be better known.

Mineralogy is the study of crystal structure and chemistry, identification, classification and genesis of minerals. Feldspar become important in industrial since it is becomes valuable and economic importance. According to Ariffin (2003), most common minerals that forming the rock is mineral feldspar. Feldspar is very abundance and mostly covered earth crust about 60%. The origin name of feldspar is comes from Jerman which is firstly from combination feld + spar. The actually means of feld is field while spar means the light coloured minerals that can be breaks to the smooth surface. Feldspar is characterized by chemical composition or structural state. Feldspar can be classified into two main groups which are alkali feldspar which is mainly Potassium and a bit present of Calcium, and plagioclase feldspar which is mainly of Sodium and Calcium. Example of alkali feldspar is

orthoclase while for plagioclase is albite. The classification is based on the proportion Potassium (K), Sodium (Na) and Calcium (Ca) (Radomír Sokolář, 2014).

Feldspar is in between series $NaAlSiO_3$ and $CaAl_2Si_2O_6$. Crystallization of feldspar tends to in igneous environment but also present in metamorphic rock environment (Badmus, 2013). Feldspar usually appeared in light coloured such as white or milky white, pink, blue, grey, brownish and brick red precipitate. According to Mohs' scale of hardness, the hardness of feldspar is 6. Feldspar also have perfect cleavage. Cleavage means the way a minerals breaks along a plane surface. Cleavage of feldspar can be observed in PPL (plane polarization). Mineralogy and chemical composition of rocks constitute a reliable means of rocks classification (Abel O. Talabi, 2013).

Kelantan is located in the East Coast of Peninsular Malaysia. Kelantan State is divided into ten districts they are given name Tumpat district, Pasir Mas, Kota Bharu, Bachok, Tanah Merah, Pasir Puteh, Machang, Kuala Krai, Gua Musang and Jeli. Gua Musang is well known with the limestone and caves. The study area is in Tanah Putih, Gua Musang. The study is focused on General Geology and Mineralogical Study of Feldspar in Gua Musang. Area of the study is 5km x 5km with a dimension of 25km². The study area is mostly covered with the sedimentary, meta-sedimentary, and igneous rock such as volcanic and granite. For general geology, it will involve lithology, geomorphology, and characteristic of feldspar at the study area, distribution, composition or structure of feldspar. Feldspar can be further identifying by the method of X-Ray fluorescence (XRF) and thin section.

1.2 PROBLEM STATEMENT

Map of Gua Musang especially study area are not updated. The map of area Gua Musang especially area of Kg Tanah Putih last updated since 2005 from Department of Mineral and Geosciences Malaysia. In 2005, the Department of Minerals and Geoscience Malaysia had done the research on the title "Survey the Source of Feldspar in Gua Musang". Lack of journal describe about the feldspar in Malaysia. Since the official data only can get from Department of Minerals and Geoscience, therefore the data are limited. Data or geological map may be not updated therefore the information about the location may be not accurate and limited. There is no research about the feldspar in study area except the research from Department of Minerals and Geoscience. Local demand for feldspar is largely met by foreign supplier as local production is low and not suitable for certain products. Only certain feldspars are suitable to be used for industrial purposes. In Malaysia, feldspar is normally used for glass making and ceramic industries (Razak, 2010)

1.3 RESEARCH OBJECTIVES

There are three main objectives need to be achieved in this research as follows:

I. To updated geological map of the study area at scale 1:25 000.
II. To identify the characteristic of mineral feldspar and their distribution.
III. To identify the concentration of trace element and major element in each rock samples.

1.4 STUDY AREA

Malaysia consists of fourteen states and Kelantan is one of these fourteen states that comprise Malaysia. Kota Bharu is the capital city of Kelantan. Kelantan

have the total area of 15,000km² and approximately people distribution is 1,640,000 people.

The study area is located in Kg Tanah Putih located in Gua Musang. Area of the study is covered by 5km x 5km with a dimension of 25km². Gua Musang is well known with the caves and limestone area. The study area is mostly covered by sedimentary, meta-sedimentary, igneous rock especially volcanic rock and granite. The area is covered by rubber plantation, surrounding quarry of feldspar, and urban area. The study area will be covered the area of Kg. Pulai, Kg. Tanah Puteh and Kg. Lepan Jaya which is believed that have potential of feldspar resources. For general geology, it involve geology occurrence of feldspar, lithology, geomorphology, characteristic of feldspar at the study area, distribution, composition or structure of feldspar and structural geology at study area. Base map of Kg Tanah Puteh, Gua Musang is shown in Figure 1.1.

1.4.1 Location

The study area is located between longitudinal 4°45’55″ N to 4°48’35″ N and latitude 101°57’25″ E to 102°0’5″ E in Gua Musang which is in between the Kg Pulai and Kg Lepan Jaya. Gua Musang area is mostly covered by limestone area and cave. Kg Tanah Putih is well known because have of quarry of Feldspar. Area of the study is 5km x 5km with the dimension of 25km². Figure 1.1 shows the base map of the study area.

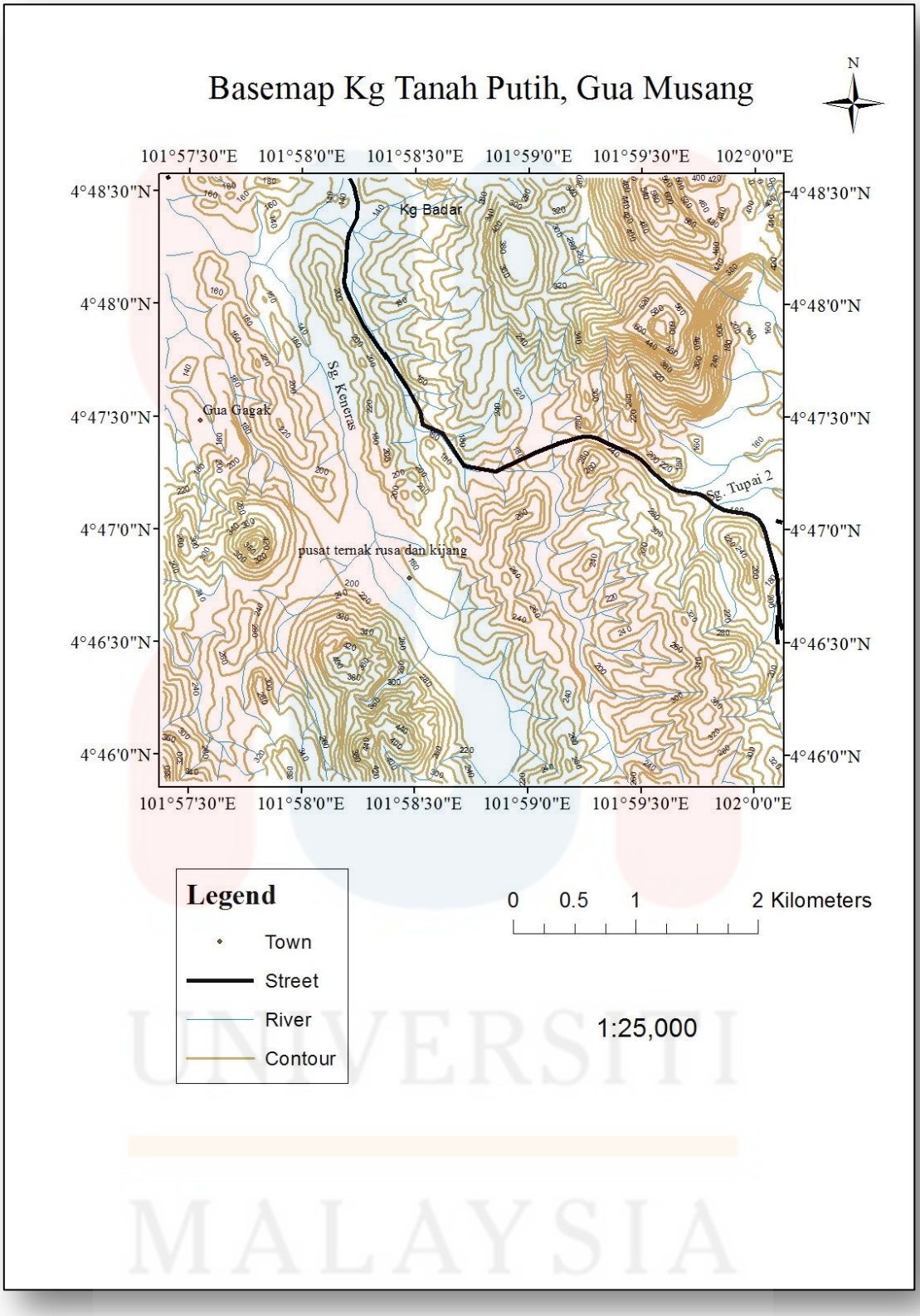


Figure 1.1: Base map of Kg Tanah Putih, Gua Musang

1.4.2 Demography

Demography is the study of human population or in other words is people distribution. The study area consists of various races which are Malays, Chinese, Indians and others. The statistic of people distribution in Gua Musang is shown in Table1.1.

Table 1.1: People Distribution of Gua Musang (Local Authority and District Area, 2010)

District/local Authority Area	Malay	Chinese	Indian	Others	Total
Majlis Daerah Gua Musang	64253	3870	350	17716	86189
Batu Papan	1512	883	132	67	2594
Bertam	1131	1	1	9	1142
Chegar Bongor	398	24	0	72	494
Gua Musang	15373	2217	155	763	18420
Kerinting	128	1	15	28	157
Limau Kasturi	893	5	0	77	975
Paya Tupai	325	0	0	12	337

Source: Local Authority and District Area (2010)

a) Rain Distribution

During the range of July until January, the areas that received more rainfall are Kelantan, Terengganu and Pahang. During these months, the area usually received a heavy rain. Rain is the precipitation of water that falls directly to the surface. Flood and drought caused by the imbalance amount of rainfall that received in that particular area. If the amount of rainfall received is exceed the outflow of water, it will cause flooding at the certain area especially area that have low latitude.

However, if the rainfall is less than the outflow of water, it will cause drought. Usually, Malaysia recorded the annual rainfall is ranges between 2000 up to 4000mm while the temperature are ranges from 25.5° to 32°C (J. Suhaila et al, 2011). Table 1.2 shows the average of Rain Distribution of Gua Musang area.

Table 1.2: Average of Rain Distribution of Gua Musang Area (Department of Irrigation and Drainage Malaysia, 2014)

Months	Average(mm)
January	136
February	3
March	196
April	169
May	225
June	215
July	90
August	618
September	489
October	313
November	175
December	591

Source: Department of Irrigation and Drainage Malaysia (December 2014)

From the graph, it can be concluded that in August and December shows the highest value which is average value is 618mm. Usually, it indicates that during these months heavy rainfall occurs and sometimes, it can cause flooding in that specific area. The lowest value that received the rainfall is during in February. From

the Table 1.2, in February the average rainfall is 3mm. The Figure 1.2 shows the average of rain distribution in Gua Musang 2014.

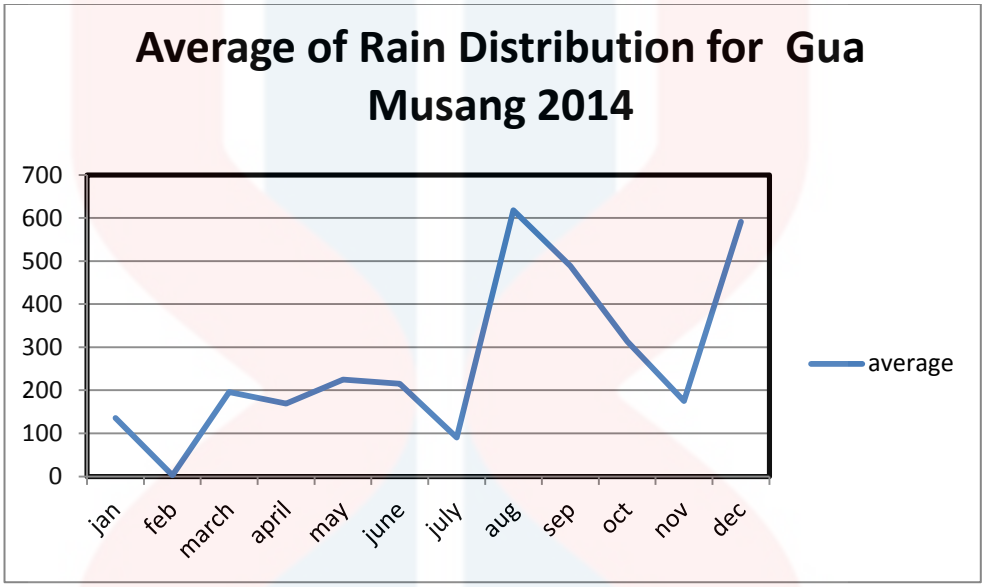


Figure 1.2: Average of Rain Distribution for Gua Musang (Department of Irrigation and Drainage Malaysia, 2014)

b) Land use

About 45% of the land in Kelantan is under state land status, which is 33% is under the reserved land, then 21% under alienated land and lastly 1% under other status (Department of Mineral and Geoscience, 2003). The category of land use is shown as in Table 1.3.

Table 1.3: Category of land use of Kelantan (Kelantan Socio-Economic Profile, State Economic Planning Unit, Kelantan, 2001)

Category	Area (hectare)	Percentage (%)
Forest Reserve	894,271	59.5%
Agriculture	335,660	22.3%
Urban	4,967	0.3%
Mining	3,737	0.3%
Others – river, water ways and dam reservoir areas – grazing areas – cleared areas -Secondary jungle	263, 263,565	17.6 17.6%
Total	1,501,502,200	100%

Source: Kelantan Socio-Economic Profile 2001, State Economic Planning Unit, Kelantan.

c) Social economic.

In Gua Musang, there are various types of social economic. First is mostly in the study area, people works as rubber tapper. Second, they also work as labours in quarry and two quarries very active in development. First one is produce granite while the other one is produce limestone aggregates. The active quarry of granite, is located in Sungai Berok, Lojing own by Pembinaan Mitrajaya Sdn Bhd. Second one

is active limestone quarry owner by Kuari Dinar Sdn Bhd, that located at Kampung Kala Star. The summarization of the quarry industry for the district is shown in Table 1.4.

Table 1.4: Summary of Quarry Industry in Gua Musang District (Department of Mineral and Geoscience, 2003)

No. of Quarries	1 active granite quarry 1 active limestone quarry 1 granite quarry under development 1 idle limestone quarry
Total Area	122 hectares
Land Status	3 quarries on TOL land 1 quarry on forest reserve land
Production	242,100 tonnes
Value of Production ex-site	RM5.08 million based on weighted average price of RM20.97 per tonne
Workforce	13 quarry employees 43 contractors' employees

d) Road Connection

There are two types of road connection. First is road connection between main road and alternative road. Main road usually used by various types of transportations. For alternative road usually used for small vehicles only such as motorcycle, and bicycle. Figure 1.3 shows the road connection in Kg Tanah Putih.

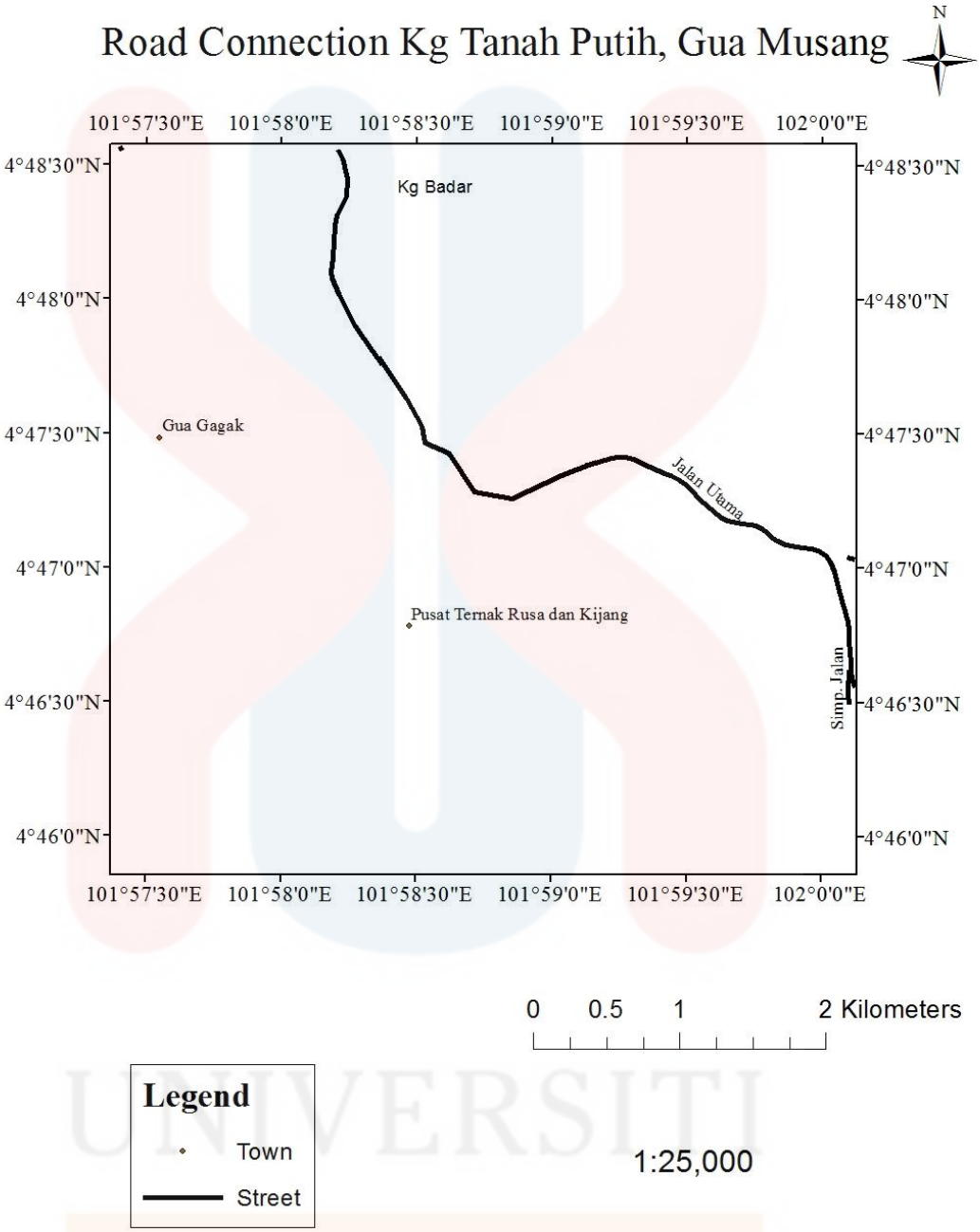


Figure 1.3: Road Connection of Kg Tanah Putih, Gua Musang

1.5 SCOPE OF STUDY

This study is more focusing on the mineralogical study of feldspar. For this research, details information for feldspar either in aspect of trace elements, characteristic under microscope and their distribution are obtained from geological mapping and laboratory investigation. This research is carried out to fills the gap about past researches about feldspar. Since the feldspar have importance especially in industry, hence it's become higher demand as new source.

1.6 RESEARCH SIGNIFICANCE

Feldspar in Malaysia is not a huge exploitation, but because of the increase of their uses in industrial therefore it is brings more benefit in future. There are several importance of feldspar. First is feldspar become important because great exploitation to generate new source in industrial. Feldspar has many uses in industry based on their suitable compositions. According to Amarante (1997), feldspar also acts as a raw material for the ceramic industry for manufacture of glass, white ware and porcelain enamel product. Feldspar has unique properties. According to Jaafar and Sulaiman (2003) it is found that tuff volcanic rock is the main source serves as a flux especially tuff that contain higher percentage of Na_2O and K_2O. From previous research, the author told about the function of feldspar in white ware bodies is as a flux and it take parts in physico-chemical reactions with other crystalline phases. Feldspar serves as a bond in a crystalline phase. Previous research also mentioned about the composition of feldspars and other bodies materials used is to estimate the quantities of ceramic bond (Joseph C. K and Ralph L. C, 2007).

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter describe about the previous researches that has been done on topic of feldspar. In this section, the previous researches explain in details about the types of feldspar and their trace elements, characteristic of feldspar and also the method that has been used in determining the characteristic by observe under microscope and how the X-ray Fluorescence works in order to identify and classify the types and concentration of feldspar. This section also described about the regional geology and tectonic setting, stratigraphy, historical geology, structural geology and petrography studies.

2.2 REGIONAL GEOLOGY AND TECTONIC SETTING

According to Hutchison (1989) and the further research development in 1996, Peninsular Malaysia was a part of the Eurasian Plate, South-East Asian that known as Sundaland. Continuation of eastwest and southwest with a less 200 meter from water depth of Sunda shelf while Sumatra, Natuna and Western Borneo are integral part are at the same plate and Sunda Shelf is common to all.

N-S is a short distance east of Vietnam is extended by the edge of the Sunda Shelf and then it becomes curved eastwards as far as the West Baram Line. Continental slope-rise at the East of the Shelf edge formed of continental crust that is increasingly attenuated eastwards.

No tectonic significance shows at the shallow Straits of Malacca and the Geology of Peninsular Malaysia continue into Sumatera. Oceanic part of India-

Indian ocean Australia plates is denser than if compared with the Sundaland. Therefore, oceanic part of India-Indian ocean Australia plates converges on to Sundaland towards exactly N 15°E at a rate of 53± mm (Milsom, 2005). Sumatera Island being dominated by a right-lateral fault system as a result from the highly oblique converges at the Sumatran Trench (Sunda Trench).

2.2.1 Stratigraphy

Stratigraphy is studies of rock layers which is strata and layering which is stratification. Usually stratigraphy deals with sedimentary layered of extrusive rock.

Paleozoic

Upper Paleozoic rocks of the Gua Musang are located in the western part of Central Belt, the south part of Kelantan is Aring Formation, at the east of Kelantan is Taku Schist, further south are Raub Group in the west of Pahang and Kebis Bed is in Negeri Sembilan.

These Upper Paleozoic rocks mostly dominated by argillaceous strata and volcanic rocks but also contain some arenaceous and calcareous sediment. These rocks are deposited in shallow marine environment with submarine volcanism that starting from Upper Carboniferrous and in the Permian To Triassic (Foo, 1983).

Mesozoic

In Kuala Betis area which is to the west Gua Musang town have similar rock as the Gua Musang Formation, there is overlie a conglomerate sandstone sequence comformably (Aw, 1974). The sequence of this conglomerate is called Gunong Ayam conglomerate and has been interpreted as basal conglomerate (Aw,1974) and it is oldest unit of the Gua Musang Formation (Aw,1974 ; Abdullah Rahim et al.,

1994). The conglomerate is unconformable with a metamorphic rock of Paleozoic. Basal conglomerate is not exposed and westernmost of formation is delimited by the Bentong-Raub Suture.

Sediment located at the east area is the sediment of the Nilam Marble and Telong Formation is similar with the rocks of the Gua Musang Formation. Telong Formation is same with the Gua Musang Formation. The age of the rock and the depositional environment of the Nilam Marble are samewith the carbonate rocks of Gua Musang Formation (Foo, 1983).

According to Nazaruddin et al., (2014), granite from Main Range is aged of Middle Triassic which is between from 200 up to 230 million years ago.

According to Yin (1965), Gua Musang Formation is not well understood and clear because of the during the Permian-Triassic transition, its development is still remain unclear. However, Table 2.1 shows the evidence of Gua Musang Formation that consist of several lithology.

Table 2.1: Sequence stratigraphy of Gua Musang Formation by Yin (1965)

Time	Lithology
Middle Triassic	Limestone, volcanic rock, shale
Early Triassic	Shale, volcanic rock, argillaceous limestone
Late Permian	Siltstone, shale
Middle Permian	Limestone and some part of shale

2.2.2 Historical Geology

Historical of geology is about the development of the natural science of geology. In historical geology part, the origin, and structure of earth and process of development of feldspar need explain further.

According to Frank et al., (2005), mineral formed is determined by the two cycles. First is the rock cycle. Heat from the Earth crust that caused some of the rock that is suitable with the temperature and pressure melts. The composition, suitable temperature and pressure and also how fast or slow cooling process are determined what the types of rock formed and their minerals. The rock formed either beneath the earth surface or the surface of the earth. The first rocks are igneous rock. Igneous rock contains the primary minerals. Second is plate tectonic process. The process also determined the minerals and rock formation. Plate tectonic can be defined as the process where the plate is moved. There are four types of plate boundaries. These boundaries are divergent boundaries, convergent boundaries, transform boundaries and plates boundary zones. Plate boundary is no or little effect of plate movement (Charles et al., 2010). Figure 2.1 shows the plate boundaries.

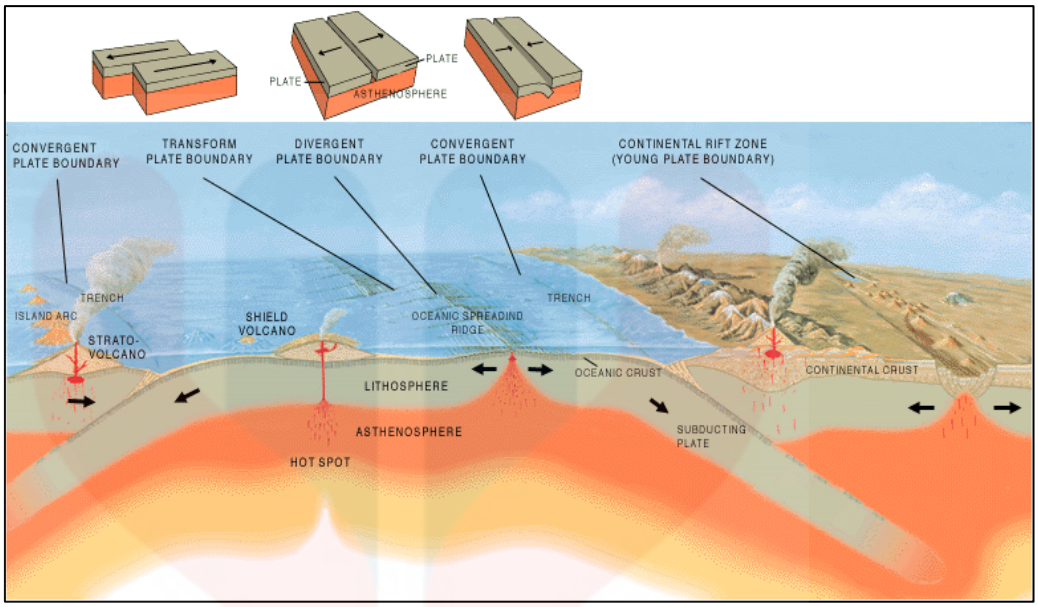


Figure 2.1: Plate boundaries

Source: Wikipedia

Second is based on the Bowen's reaction series. Bowen's reaction series is a sequence formation of minerals based on the cooling magma and their melting point. First mineral form is olivine and followed by plagioclase. The sequence is consists of two types of sequences which are continuous and discontinuous sequences. According to Arem (2011), when olivine sinks through the magma, plagioclase and pyroxene form. Figure 2.2 shows the plagioclase feldspar melting and cooling curves.

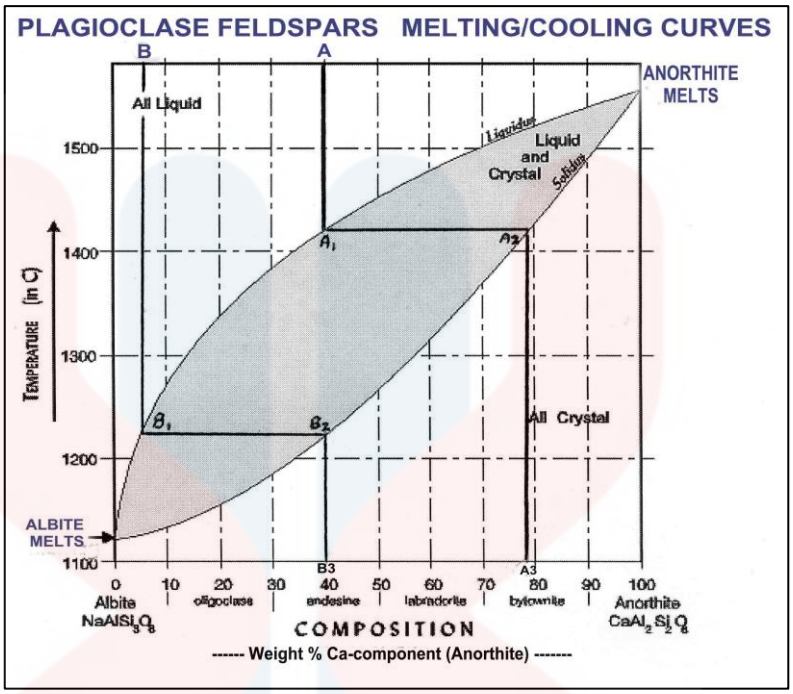


Figure 2.2: Plagioclase feldspar melting and cooling curves by Arem(2011)

Metal silicate was make up the crust of the Earth that primarily comprise about 75% of aluminosilicate in the outer layer of the crust about 13-17 km (Rahman et al., 2009). Area of Tanah Putih, Gua Musang, Kelantan (Malaysia) is abundantly have the aluminosilicate of feldspar and mica. These two minerals are widely used in large scale industrial production (Miao et al., 2005) especially in ceramic and tiles industries since they are easy to obtain and the price is reasonable. The Minerals and Geoscience Department has identified sodium rich feldspar deposit in Gua Musang, Kelantan

2.2.3 Petrography

According to Jaafar and Sulaiman (2003), rock sample of tuff that rich in flux are fine grained and appears in light grey. This rock sample shows consist of phenocryst of quartz and feldspar that 1mm in size. Based on thin section it is indicates the texture of phyroblast which phenocryst of feldspar either potassium or

plagioclase feldspar. The quartz shows shape of subhedron to anhedron with small pieces of quartz-feldsphatic.

By using the optical microscope, the mineral analysing is done after the raw sample undergoes cone crushing process. The sample characterized by mineralogical and grinding test and then chemical analyses. For the chemical analyse of raw materials and feldspar samples, undergoes further analysis by X-Ray Fluorescence (XRF).

2.2.4 Types of Feldspar

There are three types of feldspar which are Potassium feldspar (K), Sodium Feldspar (Na) and Calcium Feldspar (Ca) (Delia anne marie androne, 2006). Feldspar can be classified as members according the ternary system. They are $NaAlSi_3O8$ (albite, Ab), $KAlSi_3O8$ (K-feldspar, e.g. sanidine, orthose, microcline, Or) and $CaAl_2Si_2O8$ (anorthite, An). According composition, they are two types of feldspar which are alkali feldspar and plagioclase feldspar. Compositions between $NaAlSi_3O8$ and $KAlSi_3O8$ is same, thus they are referred to as alkali feldspars and those between $NaAlSi_3O8$ and $CaAl_2Si_2O8$ as plagioclase feldspars. The previous research show that the physical properties of feldspar such as colour, lustre or cleavage can be observed on the slides under optical microscope in polarized light. These physical characteristic enables to perform preliminary identification. Figure 2.3 shows a feldspar names based on their composition, amount of Sodium (Na), Calcium (Ca) and Potassium (K) (Arem, 2011).

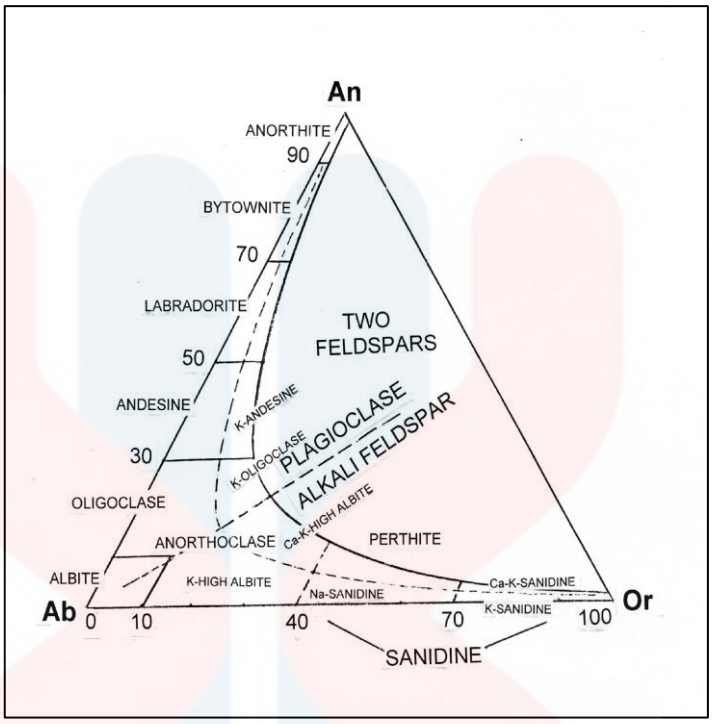


Figure 2.3: Feldspar names according their compositions of Na, Ca and K by Arem (2011)

Production of feldspar is increasing since it is useful in use of glass and ceramics (Osama Shakkour, 2002). From previous research, the author told about the function of feldspar in white ware bodies is as a flux in order to form a glassy phase at low temperature. According to Jaafar and Sulaiman (2003), tuffs from volcanic rocks are the main source of flux because they are rich in Na_2O and K_2O.

2.2.5 Trace Element and Major Element

In rock sample, it divided into two types of elements which are major and trace elements. Trace element also known as minor element. There are three factors that give characterization of to trace elements:

a) Characteristic of the elements. For example, size, charge or polarizing power.

b) Crystal structure and composition minerals that presence in particular minerals such as nature in chemical bond.

c) Physco-chemical conditions of the environment such as pressure, temperature or composition in minerals.

According to Heier (1960), there are many advantages study about the trace element of feldspar. Firstly, feldspar is abundance in many type of rock. Feldspar is the first minerals that crystallize out from basic magma, as well as quartz minerals that crystallize together. Secondly is, there is no condition about replacing the position of the lattice that can be occupied by any trace elements that presence in the feldspar structure.

2.3 Feldspar Characterization and Uses

There are three types of feldspar which are Potassium feldspar (K), Sodium Feldspar (Na) and Calcium Feldspar (Ca) (Androne, 2006). Feldspar can be classified as members according the ternary system. They are $NaAlSi_3O8$ (albite, Ab), $KAlSi_3O8$ (K-feldspar, e.g. sanidine, orthose, microcline, Or) and $CaAl_2Si_2O8$ (anorthite, An). According to composition, they are two types of feldspar which are alkali feldspar and plagioclase feldspar. Compositions between $NaAlSi_3O8$ and $KAlSi_3O8$ is same, thus they are referred to as alkali feldspars and those between $NaAlSi_3O8$ and $CaAl_2Si_2O8$ as plagioclase feldspars. The previous research show that the physical properties of feldspar such as colour lustre or cleavage can be observed on the slides under optical microscope in polarized light. The physical characteristic enables to perform preliminary identification.

Production of feldspar is increasing since it is useful for glass and ceramics manufacturing especially in white ware bodies which normally used as a flux to form a glassy phase at low temperature. According to Amarante (1997), for industry in making ceramic, manufacture of glass, white ware and porcelain enamel product, feldspar as a raw material. According to Jaafar and Sulaiman (2003), tuff is from

volcanic rocks are the main source of flux because they are rich in Na_2O and K_2O. It serves as a flux and it take parts in physico-chemical reactions with other crystalline phases. Feldspar serves as a bond in a crystalline phase. Previous research also mention about the composition of feldspars and other bodies materials can be used to estimate the quantities of ceramic bond (Joseph and Ralph, 2007).

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

Materials and methods are importance aspect in research. Sampling method and laboratory works for this study were discussed in details in this section. The flowchart of my methodology which is sequence of methods is shown in Figure 3.1.

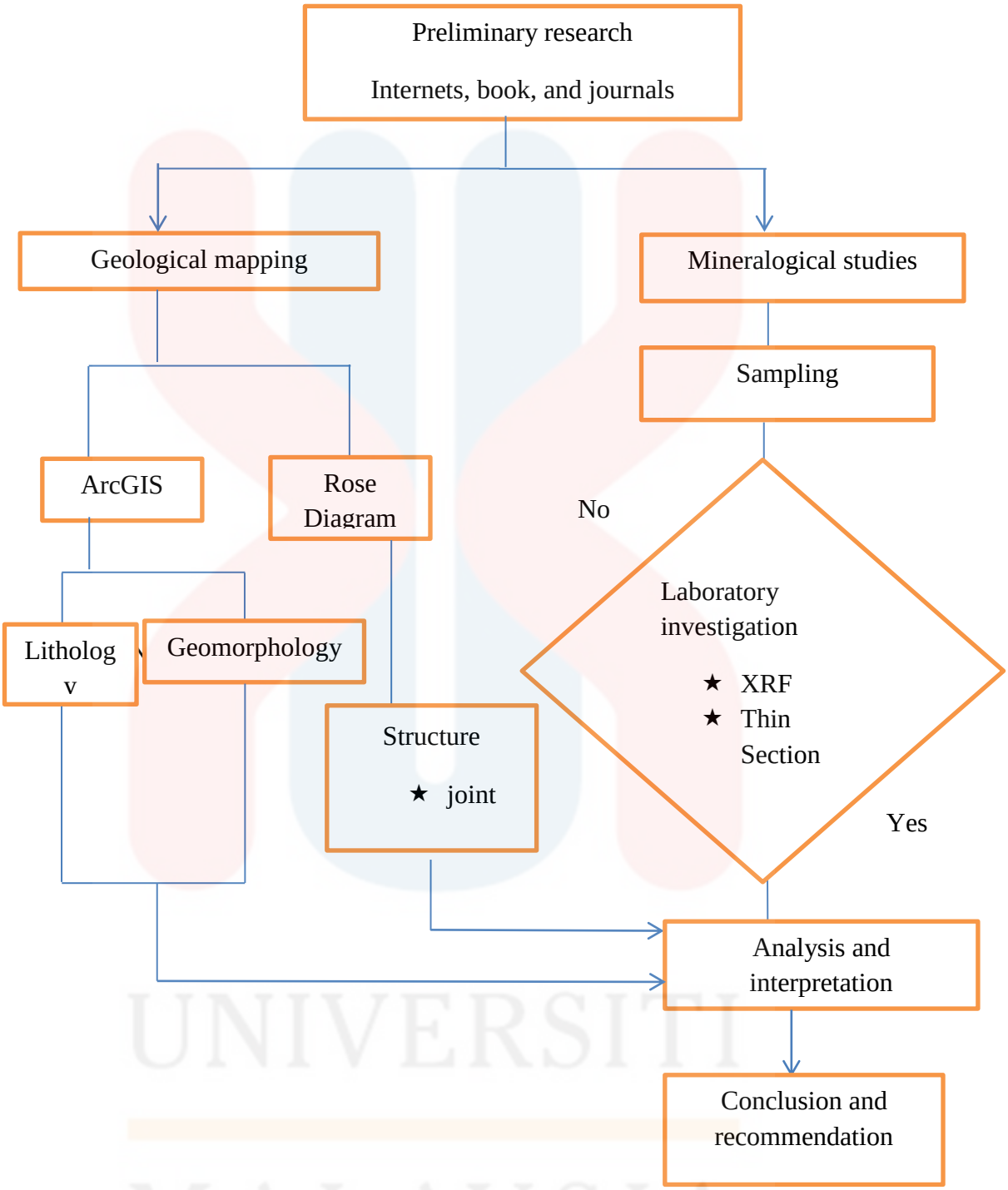
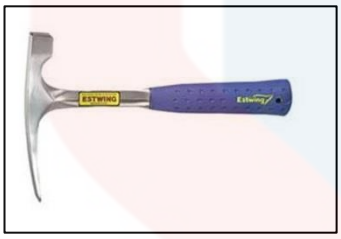


Figure 3.1: Flowchart of research methodology.

3.2 MATERIALS

Several materials that were used for field studies and laboratory investigation are listed as follow:

I. Geology hammer



Geology hammer was used to take the sample for further analysis. Fresh sample are taken.

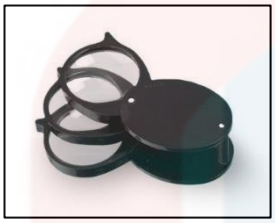
II. Compass (Brunton or Suunto compass)

Compass was used to record the orientation of strike and dip of the structure such as structure of foliation and joint of each locality in the study area.

III. Global Positioning System (GPS)

Main uses for Global Positioning System (GPS) are to marked all the point or location where the samples were collected, waypoint of transverse and to check the location if earlier sample was not collected.

IV. Hand lenses



Hand lenses used to identify the minerals which the grains of rocks can be seen by naked eyes.

V. Field Notebook

Field notebook important as it used to sketch the outcrop and record the data such as location, coordinate and observation at the field of study.

VI. Clipboard

Clipboard was used as the base when the strike and dip is measured.

VII. Camera

Camera used to take the photo of the outcrop and its surrounding for the evidence and recorded information.

VIII. Marker

Marker used as to mark the location, coordinate and number of sample at the sample bag.

IX. Base map

Base map is used as a guideline at the field. Basemap give the real environment picture of study area. Element included in base map are main road, river, contours and towns.

X. Optical Microscope

Optical microscope is important for this research to study of the mineralogy of the grains and the associations.

XI. Laboratory equipment (XRF)

The equipment used to determine the element in feldspar and helps in identification of the types of feldspar.

XII. HCL (Hydrochloric Acid)

HCL is functioning in helps to identify the carbonate rock. The bubbles will produce if carbonate rock is reacts with HCL.

XIII. Measuring Tape

The thickness of the bed can be measured by using measuring tape.

3.3 METHODOLOGY

Methodology is the step by step process on how to solve the problem that related with the topic. Before that, the preliminary research need to be done before carried out the field studies and laboratory analysis. Preliminary research is a first step in determining what is the past research told about the topics. After done preliminary research, we proceed with the field study which is mapping and laboratory analysis. In this section, the machine XRF was used in order to detect the major and trace element in samples. Thin section is using to identify the characteristic of minerals.

3.3.1 Preliminary Research

The information was collected from internet, books and journal. Internet is used as a first step to collect the information about the study area of Kg Tanah Putih and Gua Musang. References such as book and journal are a first step in gather information about the research topic of study area. The base map used during mapping as guideline about the location. The ArcGIS was used by inserting all the elements such as main road, river, contours and others information at the study area. The flowchart of research methodology which is sequence of methods is shown in Figure 3.1.

3.3.2 Field Studies

Mapping was done in order to analyse the general geology by using the base map at the area of the study. Mapping was done and covered the area of Kg Tanah Putih and geological data were acquired and then recorded in the geological map. These include lithology, stratigraphy, structural geology and type of rock found in the area. Measurement of strike and dip were taken by the compass and clipboard was used as the base while the readings of strike and dip are measured. Sample were collected using the geological hammer and then was keep into the sample bag and marked the location and coordinated by using the marker. The data about the sample and study area were recorded for mapping purposes.

3.3.3 Laboratory Analysis

Laboratory investigation is important to identify the minerals, content or characteristics of the samples. The sample was prepared for analysing which will involve thin section analysis under optical microscope. Sample preparation and analysing was described in details in methodology section. The petrographic analysis for sample of each location was done as well. All the texture and minerals

characteristic was determined and the distribution of feldspar was identified. The texture and minerals content of the rock that can be seen by naked eyes will be described accordingly based on hand specimen. The thin section used in order to determine the mineral content in the rock sample which is cannot be seen by naked eyes. Step preparation of thin section is as below:

1. Cut a slab

   Cut the rock into suitable size. Rock was cut from a piece of rock and their suitable edges. Rock will cut by using diamond saw.

2. Initial lapping of the slab

   The slide were labelled on one side and the slide surface and rock is flatten and smoothen.

3. Added on the glass slide

   The rock that cut into small pieces was glued into the glass slide.

4. Section of rock on slide

   Using the petro thin section thin section saw, the rock on slide is cut

5. Final lapping

   After finished the cut rock by using the specific thickness, the lapping section by the hand is finished.

6. Polishing

   The section is put on the slide after the polishing process is done.

7. Final inspection

Laboratory equipment such as X-Ray Fluorescence (XRF) was used in this research. The equipment used to determine the element in feldspar and helps in identification of the types of feldspar. Based on the mineral content and their composition observed by using thin section under microscope and X-Ray

Fluorescence (XRF), the name of rock is identified. X-Ray Fluorescence was used to identify the major and trace element in rock samples. The element that has been identified was classified and naming according their percentage. As the sample was clearly identified according to the feldspar group, it can be related with the uses of feldspar in industry.

3.3.4 Mineralogical Studies

Samples of rock were collected using the geology hammer. Rock sample must be fresh sample and not the weathered sample. The solid rock was undergoes the process of crushing in order to turn into powder for further process of X-Ray Fluorescence (XRF). Some of the solid rock were undergoes process step by step to turn in to small pieces and then prepared the slide for the thin section. For thin section part, the samples were examined under microscope to identify the characteristic of minerals feldspar.

3.4 SOFTWARE APPLICATION

Software application that used in this research are two. First is ArcGIS software and second is Rose Diagram Software. ArcGIS is a Geographic Information System (GIS). Base map is produced by using ArcGIS application. Base map is used as the guideline during field work investigation. GIS analysis is used to analyse the land use, geomorphology and drainage pattern. Land use, geomorphology and drainage pattern can be determined based on the base map of study area.

Rose diagram software is usually used to identify where the direction of fault occurs. One hundred of strike was taken at the site within the study area. The data acquire during geological mapping was transfer into laptop and key in all the data into the software. Then, the data will be interpreted.

3.4.1 Satellite Imagery

Satellite imagery helps geologist to covers the unexplored area of geology structure and key to minerals that indicate where the minerals deposit. Google Earth was used to get the clearly image of location study area. Satellite imagery functioning as an overview of landscape in which geological features of study area can be identifies. Satellite images cover the entire of the earth especially the study area that are available on internet from Google Earth.

3.5 DATA ANALYSIS AND INTERPRETATION

The collected data from preliminary research, mapping and laboratory analysis was interpreted and discussed accordingly. The data recorded include geology data, petrography data or hand specimen analysis. The data from XRF and thin section were discussed and interpret in order to know the characteristic and distribution of feldspar and the concentration of major and trace element of each rock samples. Based on the data, conclusion can be made.

3.6 REPORT WRITING

Last part for this research is report writing. After gather all the data from the preliminary research, field, and laboratory investigation, the report writing were done and submit to the coordinators.

CHAPTER 4

GENERAL GEOLOGY

4.1 INTRODUCTION

The study area is located between latitude 4°45’55″ N to 4°48’35″ N and longitude 101°57’25″ E to 102°0’05 ″ E in Gua Musang which is between the Kg Pulai and Kg Lepan Jaya. Gua Musang area is mostly covered by limestone area and cave. Kg Tanah Putih is well known because have of quarry Feldspar. Within the study area, there is sedimentary, meta-sedimentary and igneous rock, and pyroclastic volcanic rock. Data was acquired by the traverse method and field observation about the study area, samples and any structural geology. The area of the study was covered by karst landform, hilly area, quarry, flat area. In this chapter, it will discuss about the general geology within the study area.

Figure 4.1 shows a traverse map of Kg Tanah Putih. The locations of sample taken were plotted as follow.

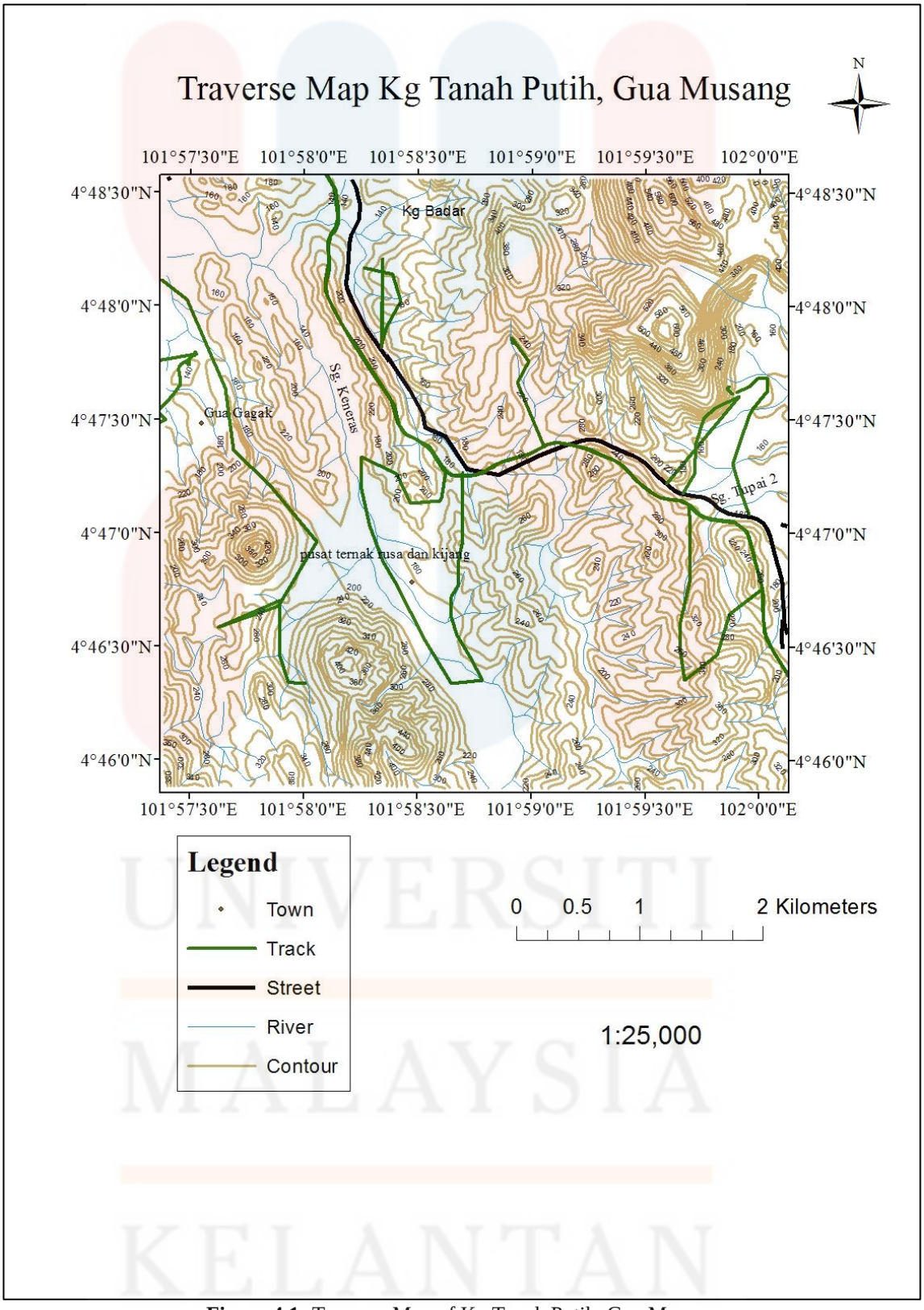


Figure 4.1: Traverse Map of Kg Tanah Putih, Gua Musang

4.2 GEOMORPHOLOGY

Geomorphology is the study of landform and its processes that related to the origin and evolution. Earth landform is influenced by endogenic and exogenic process. Geomorphological process is the process that leads to the changes on the Earth surface includes physical, chemical and biological process. The agents involved in this process are water, wind, glacier. In this chapter, water and wind are the common agents for weathering process. This geomorphological process is important to understanding more details about the Earth landform. The geomorphological process that related with topography, weathering process and drainage pattern will be discussed in this chapter.

4.2.1 Topography

Topography is the details description, position and elevation of the surface features in the study area. Natural and man-made including caves, valley, road, streams or other water bodies, towns, hills are include in topography. These features can be shown in the topographic map with shape and elevation. Topographic map is a type of map that shows the characteristic features by large-scales details and quantitative represent of relief. A contour line was used to shows that elevation in study area. Contour line is the lines that connect the line of the same elevation.

Within the study area, there is karst area. The only cave in the study area is Gua Gagak. The cave is known as limestone cave. This Gua Gagak is located at the north-west part of the map with the highest elevation 220m. The highest elevation in study area is 440m. . This part of area is mostly consists of limestone. Cave of Gua Gagak has pinnacle structure. Figure 4.2 below shows the pinnacle structure of Gua Gagak.

Figure 4.2: Pinnacle structure of cave of Gua Gagak area

There are many valleys in the study area since there is rubber plantation. Hill may be formed by the erosion or deposition process of sediment. This process occurred because of sediment that was brought by the geomorphological agents such as wind. Based on the topography map, the hilly area showed the highest resistant with the elevation 600m. The hilly area is located at the North East part. The type of rock within that hilly area is limestone.

The main road is starting from Sekolah Taman Wangi and extended to the Gua Musang-Merapoh road within the Lepan Jaya village. There are streams within the study area which has dentritic and radial type. Geomorphological map is provided as in Figure 4.3. In the geomorphological map, the geomorphology classification in study area is shown.

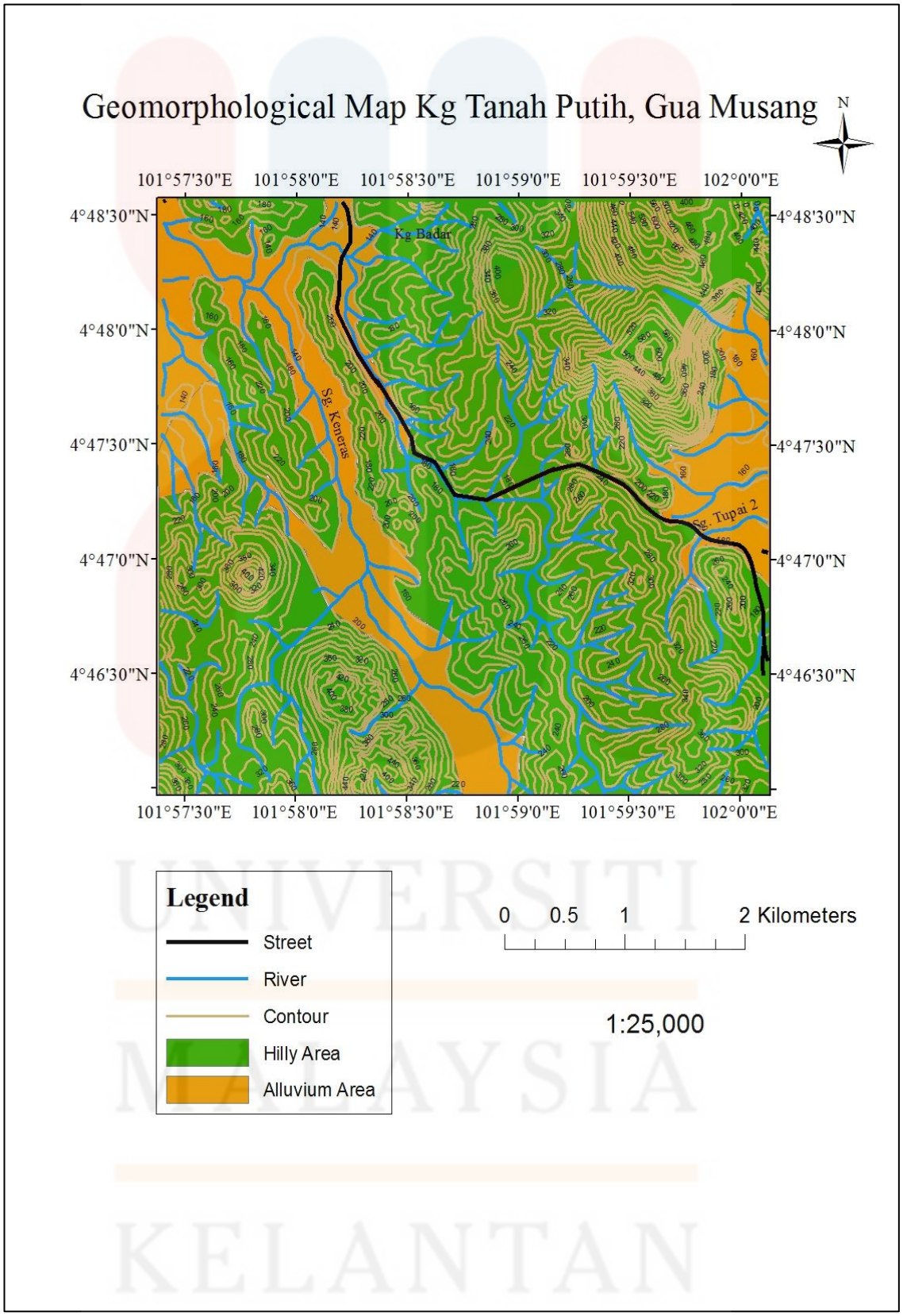


Figure 4.3: Geomorphological map of Kg Tanah Putih, Gua Musang

The study area is composed of hilly and vegetation area. Figure 4.4 and 4.5 shows that the geomorphology within area of the study.

Figure 4.4: Vegetation area near the hill cutting

Figure 4.5: Geomorphology at the elevation 224m

4.2.2 Geomorphological Classification

Larger landform may be caused the hill formed by the erosion or the deposited of sediment that brought by the geomorphological agent such as wind or may be caused by faulting.

4.2.3 Drainage Pattern

Pattern that formed by the streams or other water bodies in a drainage basin is called as drainage pattern. In drainage pattern, network is formed when streams or rivers connect together. According to Twidale (2004), in a drainage basin, different pattern can be observed and geological factors give the pattern of water bodies in drainage system. The factors such as topography, soil type, rock type, climate and transport of sediment and water (Chalton, 2008).

There are several types of drainage pattern. According to Guilbert and Zhang (2012), these type of drainage pattern is depends on topography and geology of study area. Drainage pattern also indicates the geomorphology of the area. The types of drainage pattern are dentritic, parallel, trellis, rectangular and reticulate.

Drainage pattern mostly found in study area is dendritic pattern. Dendritic pattern have shape looks like tree. The main river combined together to spreads within surrounding. This type of pattern commonly found in drainage system.

Radial also found in the study area. Radial pattern forms when there is a high elevation. According the base map, the highest elevation is 600m.

Water flows from the highest elevation to the lowest elevations area. Drainage map in Figure 4.6 shows that the types of drainage pattern found in the study area.

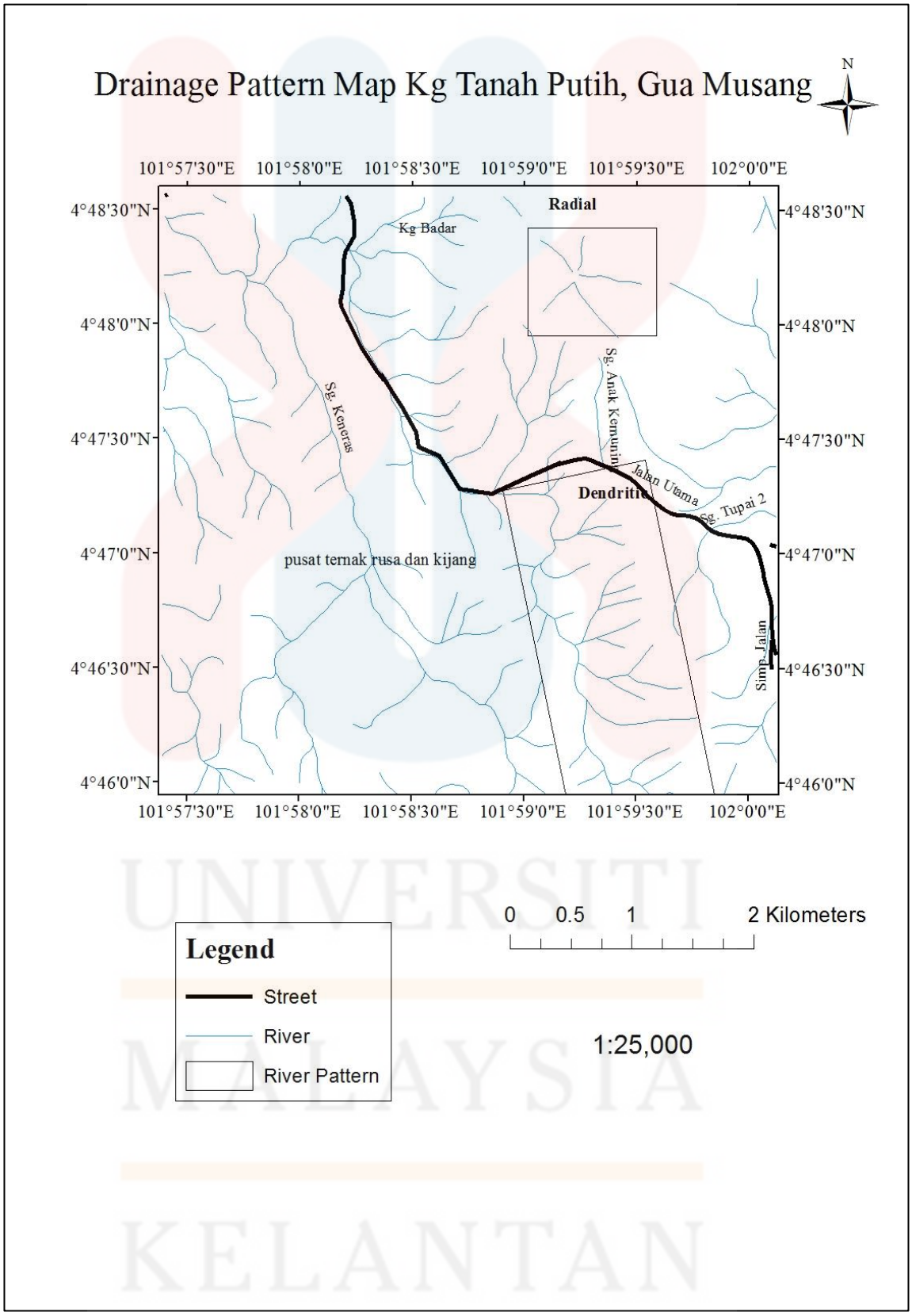


Figure 4.6: Drainage Pattern Map of Kg Tanah Putih, Gua Musang

4.2.4 Weathering

Weathering is a process of breaking down of rocks, soils and minerals into smaller pieces. The process of weathering is in situ means that weathering process occurs in one places and do not move. Weathering process change the harder rocks into softer rocks until it is easier to erode. Three are types of weathering. They are physical or mechanical weathering, chemical weathering and biological weathering.

Figure 4.7 shows the example of physical or mechanical weathering. Physical weathering occurred when there are changes in temperature. Changes in temperature causes the rock changes their shape for example their edges. When there is rain fall, the water fill in the cracks between rocks. It is cause that rocks loose the strength. When there is high temperature, the burning of forest caused the rocks fall to the ground. The picture below shows that rock is disrupt by rain and temperature.

Figure 4.7: Physical weathering cause by rainfall and hot temperature (burning)

Chemical weathering is a type of a weathering which the composition of rock changes due to the chemical reactions. This chemical reaction does not break the

rock into smaller pieces. Figure 4.8 shows that the example of chemical weathering in study area. Carbonation is the one of the types chemical weathering found in study area. Carbonation is occur when rain which is slightly acidic fall on limestone. It will cause that chemical composition and size of mineral in limestone changes. Figure 4.8 below shows the chemical weathering in study area.

Figure 4.8: Chemical weathering caused the shape of limestone changes.

Biological weathering is occurs when plants caused the rock to breaks. Plant grows between the crack of rocks and soil. The root of plants grows in order to find water usually groundwater. Figure 4.9 shows the biological weathering.

Figure 4.9: Biological weathering caused by plants grows between rocks

4.2.5 Weathering Profile

Figure 4.10 below is located on the upper part of base map in study area. This upper part of study area mostly composed of sediments that undergone the weathering and erosion process from igneous rock which originally granite. The picture above shows the weathering profile in Kg Tanah Putih. There are two types of weathering grade can be found within this area. These grades are grade IV and VI. Grade IV found within the top of layer. Grade IV are highly weathered which means that more than half of rock materials are in a degraded condition or in other words it can be broken down ito smaller pieces if the weathering process continue. Some of the original texture is destroyed. Grade VI can be found at bottom part of layer. Grade VI is residual soil means that all rock materials are in a weathered condition

and all the rock texture is completely destroyed. The samples can be taken by hand without using the hammer.

Figure 4.10: Weathering profile

4.3 STRATIGRAPHY

Stratigraphy is study of geologic rock that related with the geologic time. The lithology and age that shows in geological maps helps the geologist to understand the information in study area. The figure 4.11 shows the geological map in study area.

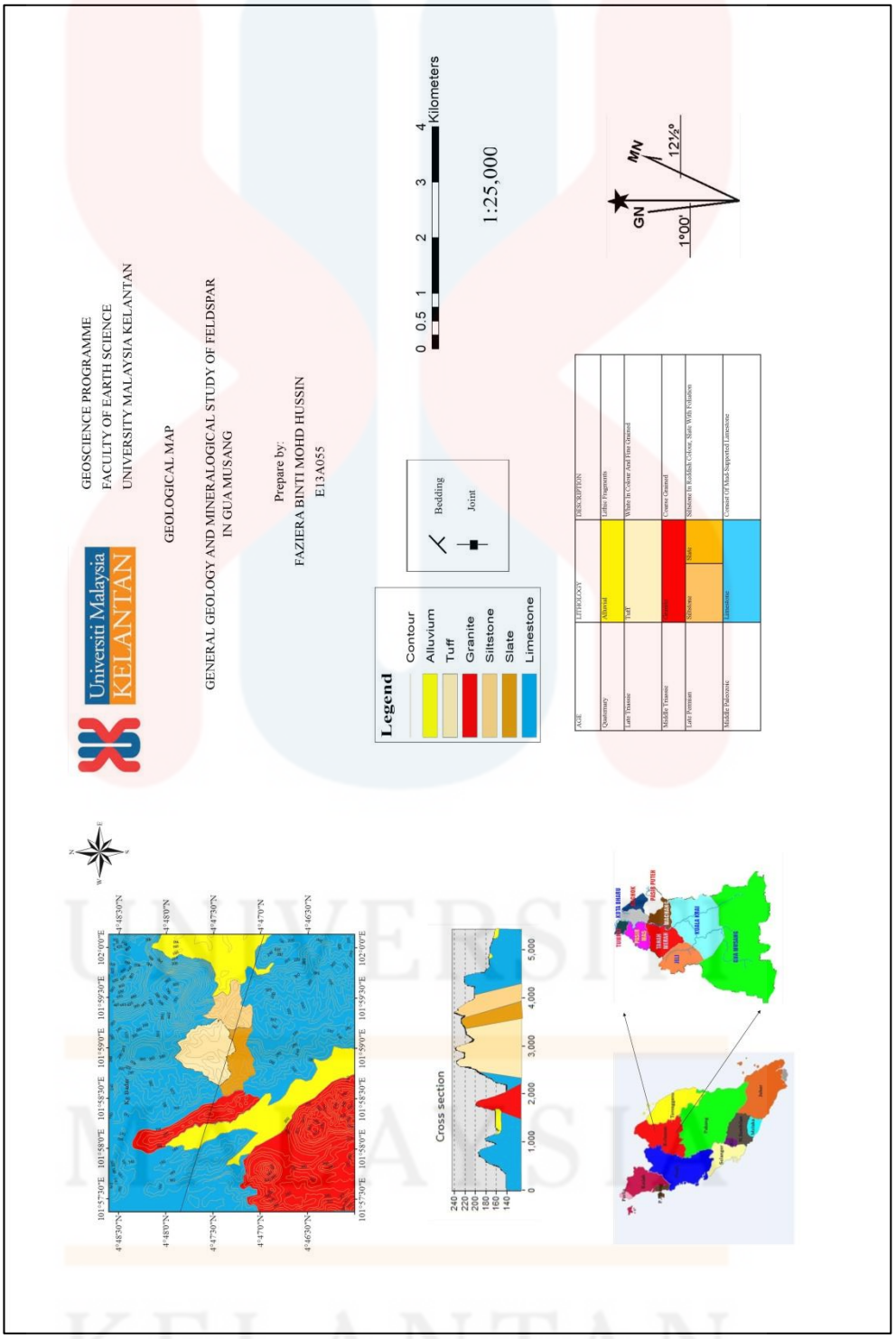


Figure 4.11: Geological Map of Kg Tanah Putih, Gua Musang

4.3.1 Lithostratigraphy

There are six types of lithology found in study area. There are granite unit, limestone unit, siltstone unit, siltstone interbedded with mudstone unit, slate unit, tuff unit and quaternary deposit unit. About 70% lithology of limestone was found in study area. 5% belongs to each lithology.

Figure 4.12 below shows that an outcrop was identified as interbedded of siltstone and mudstone. The range of thickness of siltstone is 2cm up to 5 cm while for mudstone is 2cm up to 3.5cm. The contact between this lithology is sharp contact. The colour of siltstone is light brown and grey while mudstone is grey. Some parts of these bedded is disappear because of weathering and debris flow occur in this area

Figure 4.12: Interbedded siltstone and mudstone

Figure 4.13 below shows that an outcrop where the interbedded of siltstone and mudstone found. The approximately size an outcrop is 3 m height and 4 m length. The bottom part of outcrop is weathered due to the weathering and erosion process.

Figure 4.13: an outcrop interbedded of siltsone and mudstone

Quaternary deposit can be found along the Keneras river. It may formed by the weathering erosion from its surrounding rocks which is near the river consist of sandstone. Quaternary deposit and pebbles can be found along the Keneras river. Figure 4.14 above shows the Keneras river where quaternary deposit found.

Figure 4.14: quaternary deposit in Keneras River

Yin (1965) stated that Gua Musang Formation is the Middle Permian to Upper Triassic. This formation is composed of crystalline limestone interbedded with thin bedded of shale, tuff, chert nodules and subordinate sandstone and volcanic. According to Lee et al., (2004), the deposition environment of Gua Musang Formation is a shallow marine shelf deposit with the present of active volcanic activity.

4.3.2 Stratigraphic Column

Based on the description of lithostratigraphy, the aged of the lithology can be summarized in stratigraphic column as shown in Table 4.1.

Age	Lithology	Description
Quaternary	Alluvial	Lithic Fragments
Late Triassic	Tuff	White In Colour And Fine Grained
Middle Triassic	Granite	Coarse Grained
Late Permian	Slate And Siltstone	Slate With Foliation And Siltstone Reddish In Colour
Middle Paleozoic	Limestone	Consist Of Mud Supported

Table 4.1: Stratigraphic column of lithology in the study area.

Based on the table 4.1, the oldest rock is limestone which is aged from Middle Paleozoic, (Ali, 2011). Siltstone, slate and mudstone was aged Late Permian while tuff and granite are aged Triassic. The younger strata are quaternary deposit which is composed of sand, silt, pebbles or any loose sediment. Limestone distribute to the North-West, North-East and South-East of base map. Siltstone, slate and mudstone located at line of West-East of map. Granite located at the South-West of the map while the quaternary deposit located at the South and middle part of South-West of the map.

4.3.3 Petrography

Petrography is a branch of geology which dealing with the description and classification of rock by examine under microscope for thin section part. Rock samples were taken from several locations within the study area and have been prepared in thin section for further investigation. Thin section was done in University of Malaysia Kelantan (UMK) and few samples were prepared in University of Malaya (UM).

4.3.3.1 Hand Specimen

Samples were divided into two categories which are hand specimen and petrographic section by thin section. Based on base map and field observations, it can be concluded that the study area mostly covered by limestone area. It was also found pyroclastic volcanic rock, sedimentary, metamorphic and metasedimentary rock within the study area. Some pyroclastic rocks are identified as tuff while metasedimentary is slate.

Limestone is a sedimentary rock that consists of calcium carbonate ($CaCO_3$). First sample were collected at Gua Gagak. The sample was identified as mud-supported of carbonate rock. Mud-supported means there is less than 10% of grains. It has fine grained and clast can be seen by naked eye. The colour of limestone is white. It is composed of mud which is mixture of particles of clay and silt size. The original component not bound together during the depositional. It is rough to touch and react vigorously with hydrochloric acid (HCL). Figure 4.15 shows an outcrop where limestone is taken. The outcrop has approximately 5m length and 7m height.

Figure 4.15: Hand Specimen for Limestone

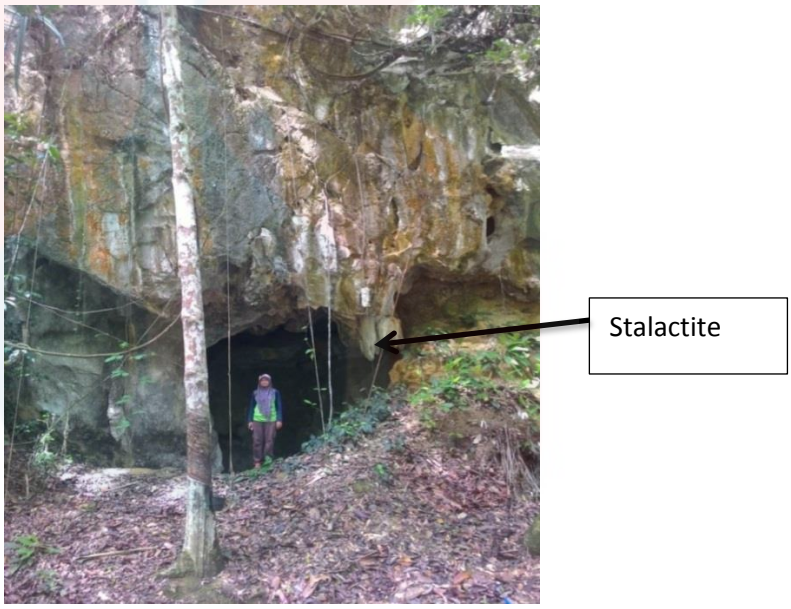


Figure 4.16: Outcrop of Limestone at Gua Gagak

Slate was found in metasedimentary rock (sample is shown in Figure 4.17 and Figure 4.18). It is originally from shale which is sedimentary rock that has been undergone the metamorphism process. Slate form when there is changes in temperature and pressure. Slate is very fine grain rock and it can be split or breaks along the planes of its foliation. The colour of slate is brownish due to the type of iron or organic materials that present in rock. Slate is composed clay minerals or quartz.

Figure 4.17: Hand Specimen of Slate

Figure 4.18: outcrop of slate with approximately size of 10m length and 7m height.

Tuff formed from volcanic ash that has been ejected during volcanic eruption through a vent. Rock that composed more than 50% tuff is called as tuffaceous. Tuff 1 was found at coordinate 4° 47’ 40.1” N and 101° 59’ 10” E while tuff 2 was found at 04° 47’ 24.2” N and 101° 58’ 52.5” E. Colour of tuff that found in study area is white and light green. Figure 4.19 and 4.20 shows the hand specimen of tuff.

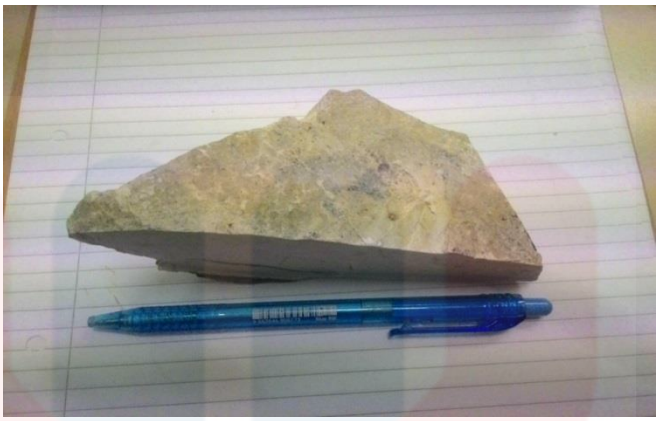


Figure 4.19: Hand specimen of tuff (1)

Figure 4.20: hand specimen tuff (2)

Granite is an igneous rock. From the observation, granite in study area is white in colour. The mineral of biotite and alkali feldspar clearly can be seen by naked eye. The location where granite found is located at N 4° 46’ 47.45” and E 101° 58’ 13.47”. Figure 4.21 shows the hand sample of granite.

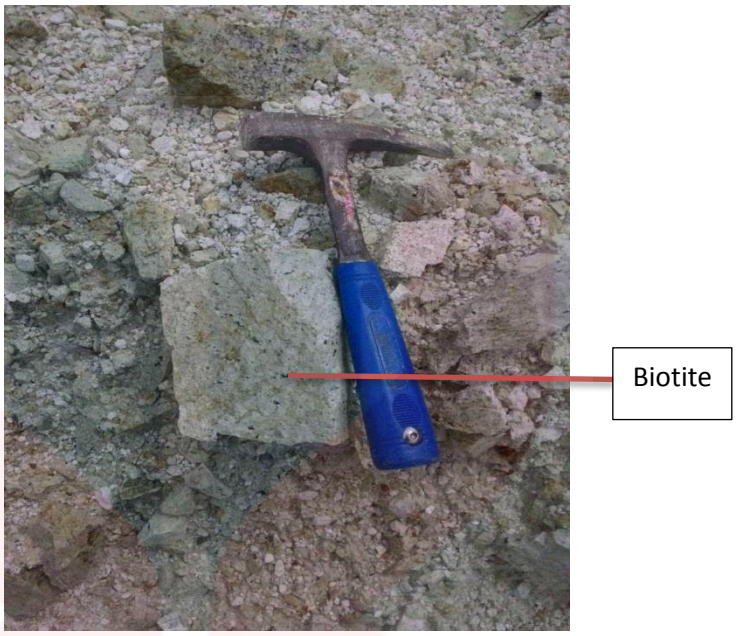


Figure 4.21: hand specimen of Granite

Siltstone is a fine grained clastic sedimentary rock. Siltstone formed by mechanical weathering. Figure 4.22 shows hand specimen of siltstone.

Figure 4.22: Hand specimen of siltstone

4.3.3.2 Thin Section

Thin section the samples were examined under microscope and the characteristic such as colour, pleochroism, the shape of minerals, relief, twinning and cleavage has been recognized and described accordingly. The samples from seven locations were examined under cross polarization (CPL) and plane polarization (PPL). Three represent limestone from different locations, whilst two samples comprised of tuffs and granite respectively.

Figures 4.23 shows the tuff at location N 4° 47’ 40.1” and E 101° 59’ 10” under microscope and observed under cross polarization (CPL) and plane polarization (PPL) with 10x10 magnification. The minerals present in tuff are plagioclase feldspar, alkali feldspar, quartz and muscovite. The plagioclase feldspar present in phenocryst and microphenocryst in fine grained groundmass of tuff. The differentiation between plagioclase feldspar and alkali feldspar is based on their twinning. Plagioclase feldspar have twin twinning while the alkali feldspar have single twinning. Quartz has anhedral shape while both types of feldspar have euhedral shape. Quartz appear in black, grey and white in colour. The relief of the feldspar is high when observed under cross polarization. Muscovite have various colour and “bird eye” when rotate. Muscovite is shiny compared to biotite. Under plane polarization, quartz has no cleavage while the feldspar has parallel cleavage. This tuff sample has a poor sorting.

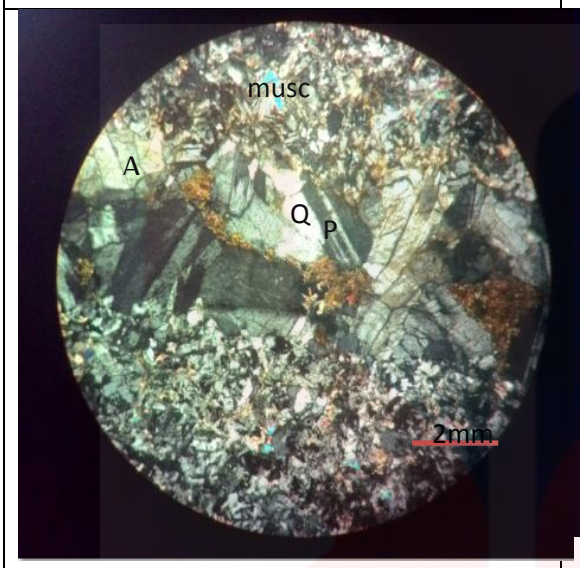
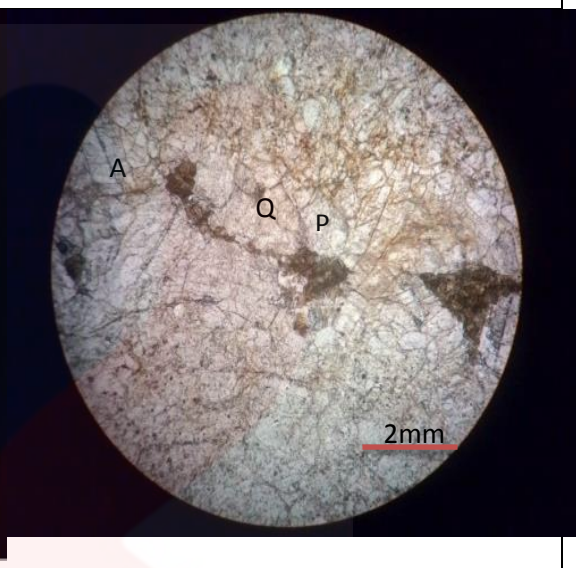
Cross polarization (CPL)	Plane Polarization (PPL)
	

Figure 4.23: tuff under microscope

Figure 4.24 shows a tuff (2) at coordinate N 04° 47’ 24.2” and E 101° 58’ 52.5” under cross polarization and plane polarization with magnification of 10x10. The mineral present in tuff is plagioclase feldspar, quartz and muscovite. These minerals are present in fine grained of tuff with the dominant of clast. The relief of plagioclase, quartz and muscovite with its surrounding is high. The shape of quartz is anhedral and plagioclase feldspar is subhedral. The sorting is poor because the grain size is not same. Figure 4.24 is shown as below.

Figure 4.25 shows a limestone (1) with coordinate N 04° 47’ 45.9” and E 101° 57’ 29.6” under cross polarization and plane polarization with magnification of 4x10. The minerals of megacrystal and microcrystal of quartz, plagioclase and alkali feldspar present in fine grained of limestone. Shape of plagioclase feldspar is euhedral and the colour is black and white. Plagioclase shows parallel cleavage when observed under plane polarization. Figure 4.25 is shown as in below.

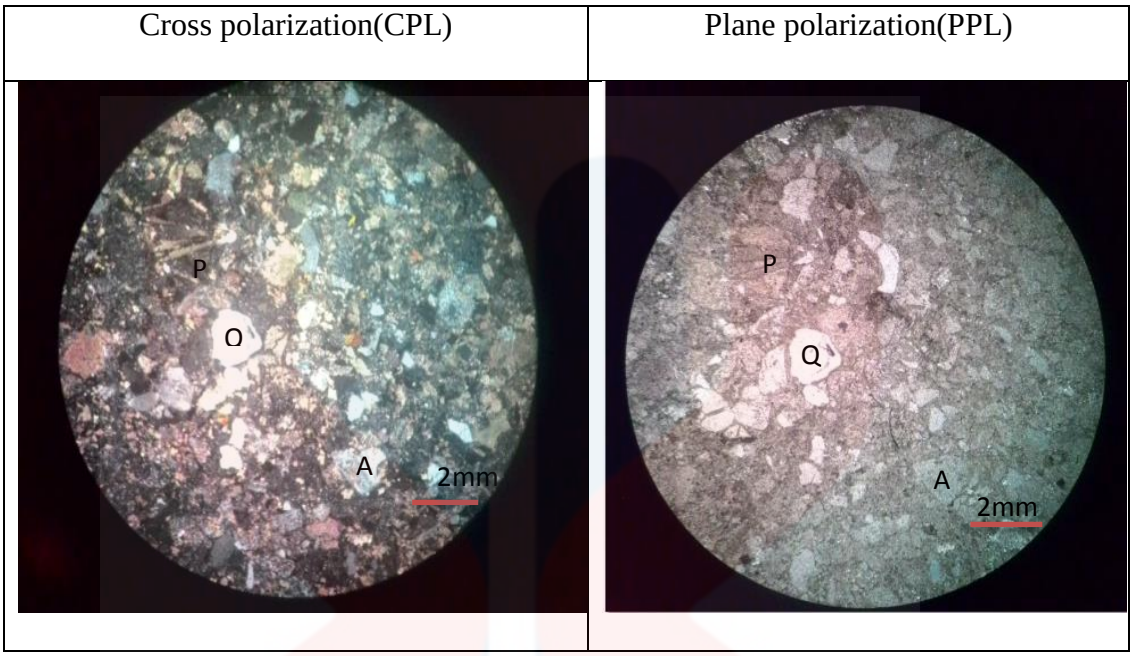


Figure 4.24: tuff under microscope

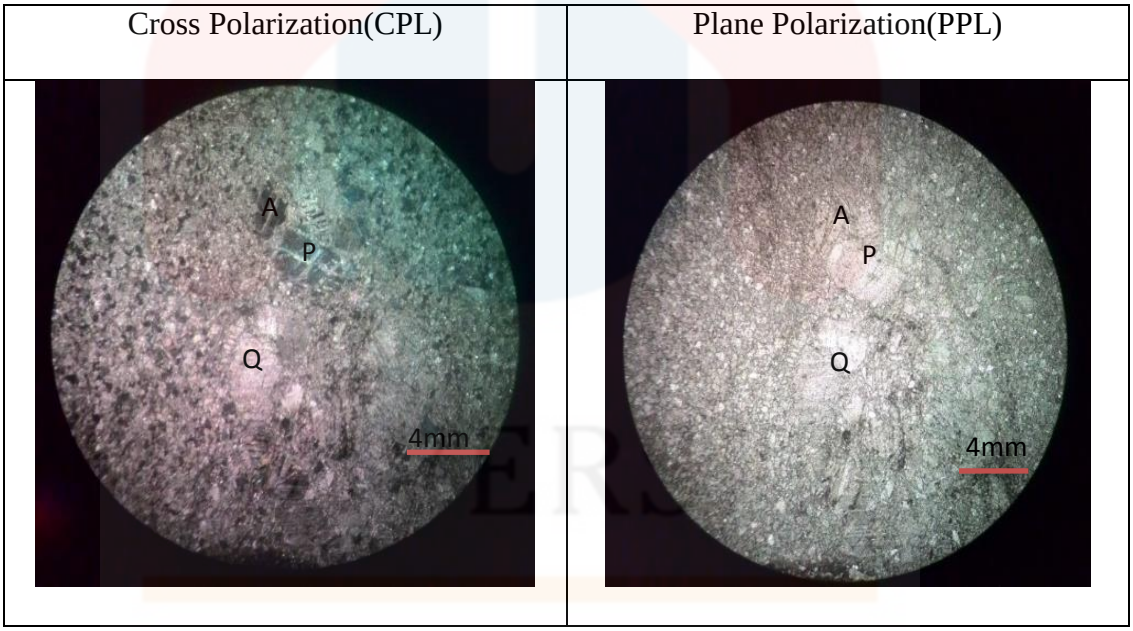


Figure 4.25: limestone under microscope

Figure 4.26 shows a limestone (2) at coordinate N 04° 47’ 35.1” and 101° 57’ 45.3” under cross polarization and plane polarization with 10x10 magnifications. Quartz, alkali and plagioclase feldspar are present in fine grained of limestone as

clasts. Shape of plagioclase feldspar is euhedral while quartz is anhedral. The mineral feldspar has poor sorting.

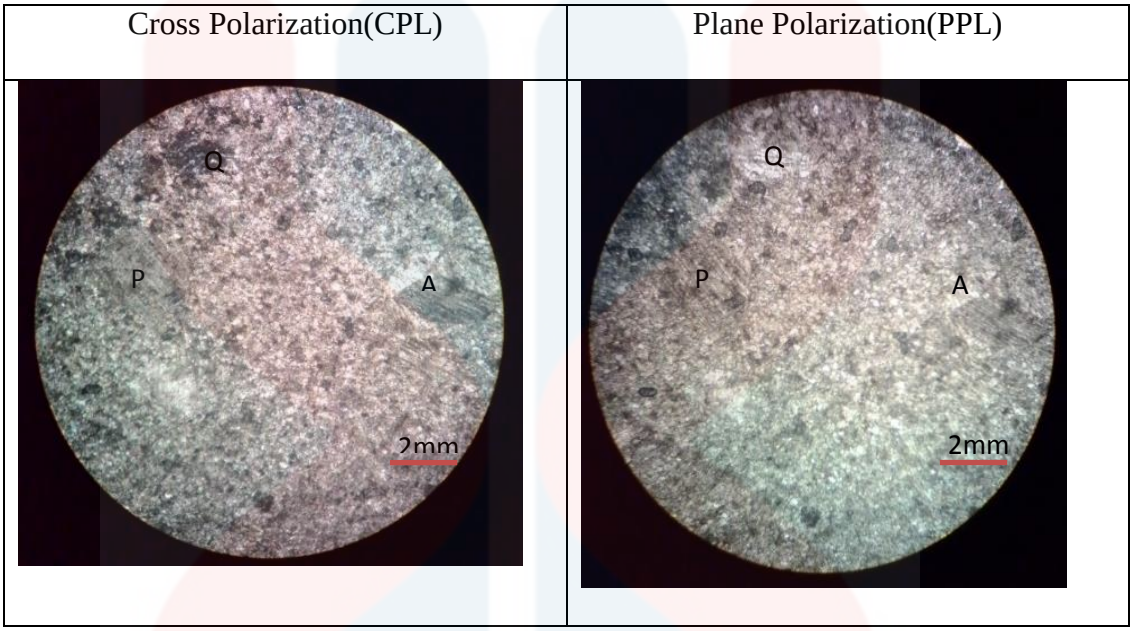


Figure 4.26: limestone under microscope

Figure 4.27 below shows granite under cross polarization and plane polarization with magnification 10x10. Based on the observation under microscope, granite consists of mineral alkali feldspar, plagioclase, biotite, orthopyroxene (OPX) and quartz. Shape of feldspar is subhedral. The sorting between feldspar and other minerals is poor sorting. Cleavage of plagioclase is parallel to the direction of its lamella. Relief of alkali feldspar with its surrounding is high while the relief of plagioclase feldspar with its surrounding is low. OPX also have high relief.

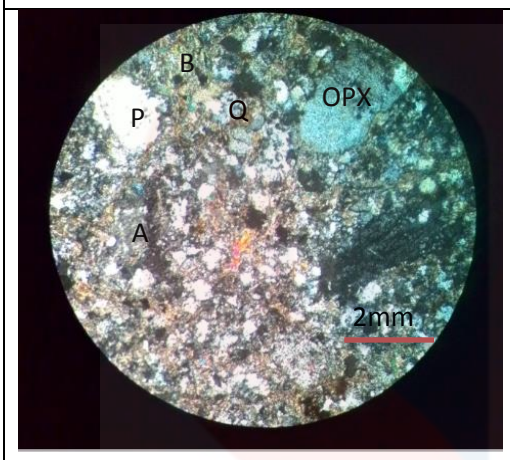
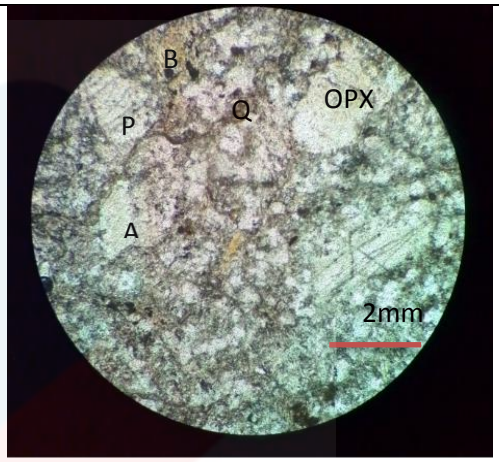
Cross polarization (CPL)	Plane polarization (PPL)
	

Figure 4.27: granite under microscope

4.4 STRUCTURAL GEOLOGY

Structural geology is the study of form, the arrangement and the internal structure of rocks that make up the Earth.

4.4.1 Joint Analysis

Joint were found within the study area. 100 reading of joints were taken in study area. The reading location 1 were taken at coordinate 4° 48’ 2.47”N and 101° 58’ 10.07” E was there is found the outcrop sandstone and clay. Table 4.2 shows the reading of joint where outcrop of sandstone and clay found.

Table 4.2: reading of joint analysis of sandstone

347	93	87	73	67	85	96	78	85	74
67	87	65	78	72	82	80	63	87	67
65	89	76	77	79	75	92	83	51	80
70	66	78	60	74	74	99	81	64	47
66	96	73	77	77	87	86	69	65	79

67	73	72	70	67	85	72	74	55	55
72	82	69	68	72	87	77	68	57	80
48	83	72	71	69	82	77	71	68	67
53	76	244	52	77	107	73	89	46	70
66	69	76	68	80	45	76	86	73	55

Figure 4.28 below shows the Rose diagram for the first location. From the result of Rose diagram, we can conclude that the major force, sigma one comes from the direction of N 70° E and S 245° W. the weakest force, sigma three, comes from S 200° W.

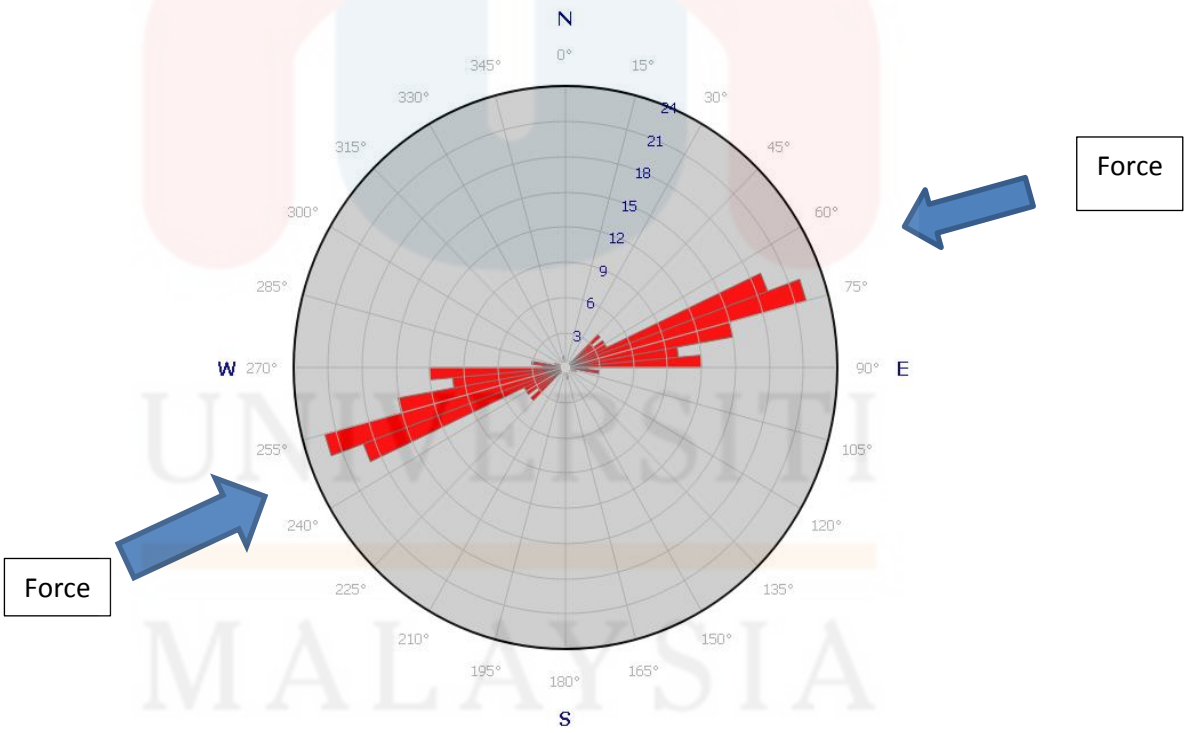


Figure 4.28: Rose diagram for joint of sandstone

Joint for location 2 were taken at coordinate 04° 47’ 20.9” N and E 101° 59’ 28.3” where the lithology is siltstone. Table 4.3 below shows the reading of joints in that area.

Table 4.3: joint reading for siltstone

21	68	80	62	80	71	70	75	80	86
42	105	125	231	251	251	279	76	79	81
46	70	61	71	79	73	73	74	83	88
51	111	130	235	255	247	269	78	86	89
53	72	64	74	77	61	80	80	90	90
58	115	208	245	243	263	283	61	93	93
87	75	73	75	76	63	72	63	98	95
61	119	225	249	248	270	291	64	97	97
81	78	71	79	80	65	71	66	99	96
101	120	229	250	258	271	310	67	85	100

Figure 4.29 below shows the Rose diagram for the second location of join analysis. From the result of Rose diagram, we can conclude that the major force, sigma one comes from the direction of N 70° E and S 245° W. the weakest force, sigma three, comes from S 200° W.

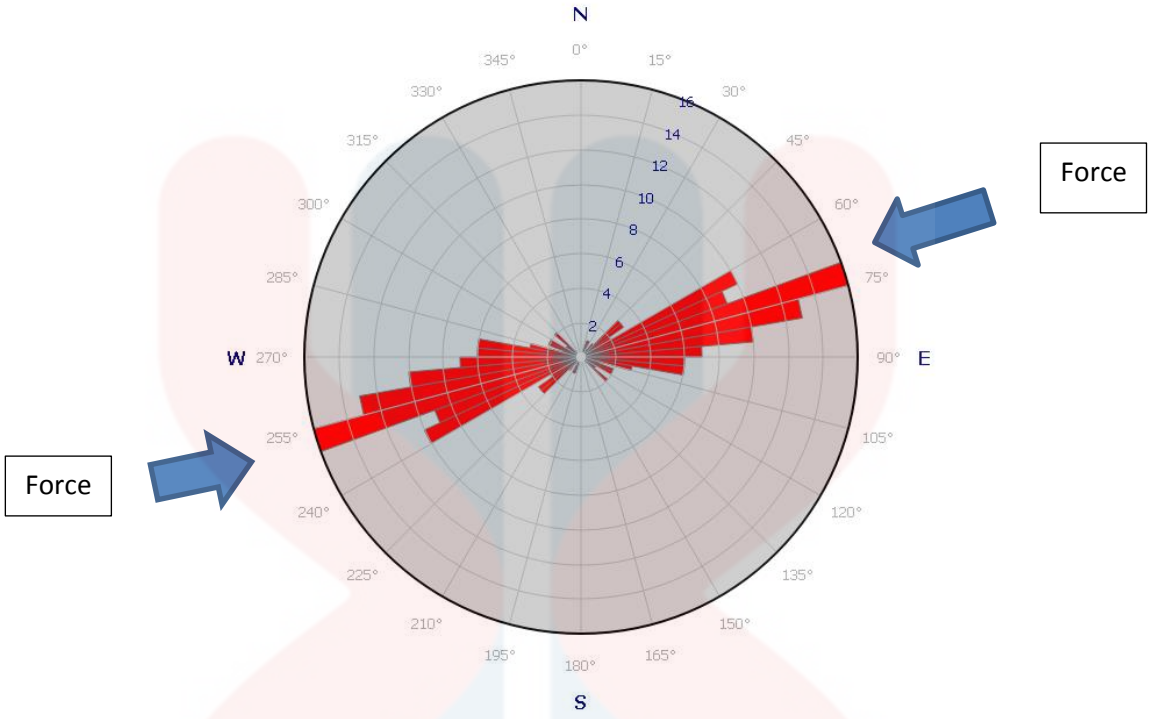


Figure 4.29: Rose diagram joint analysis for siltstone

Figure 4.30 below shows the location of outcrop where the joint reading for siltstone is taken.

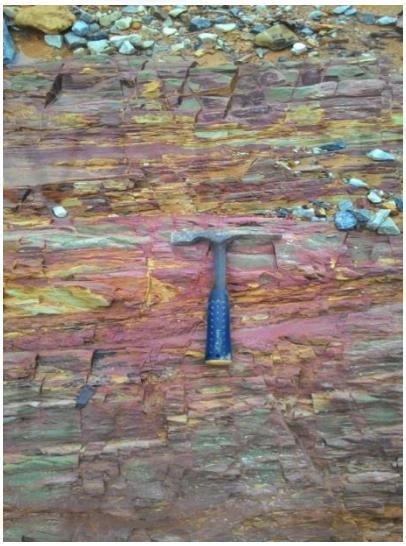


Figure 4.30: Joint in siltstone

4.4.2 Lineament Analysis

Lineament is a linear feature in a landscape. Lineament gives an expression of geological feature such as fault. Figure 4.31 below shows a lineament analysis of the study area and figure 4.32 shows the linement data based on Georose Diagram.Based on the data, major forces comes from 20° NE and 205° SW and the weakest forces comes from 110° SE.

Figure 4.31: lineament in study area

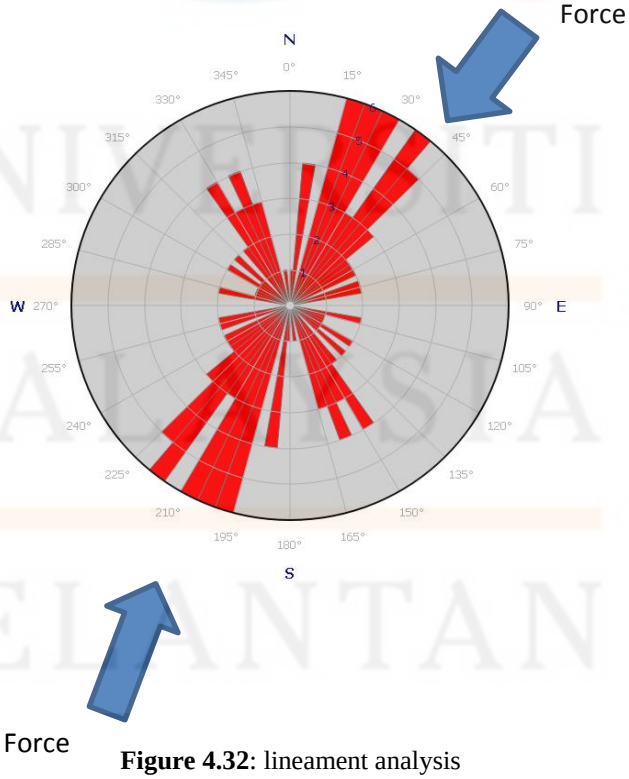


Figure 4.32: lineament analysis

4.5 HISTORICAL GEOLOGY

Historical geology is the study of of past history by using the stratigraphy record on how to derive the geological time record wcich related to the physical and biological evolution of earth.

According to Yin (1965), Gua Musang Formation is in Middle Permian to Upper Triassic. In Gua Musang Formation, the lithology that can be found were limestone interbedded with shale, tuff, chert and some part of sandstone and extrusive rock.

Based on Ali (2011), limestone is the oldest compared to other lithology. Middle Permian to Middle Triassic followed by siltstone, slate and mudstone which them categorized in Late Permian. Pyroclastic Volcanic rock which is tuff and granite are both aged Triassic. Quaternary deposit is aged quaternary which belongs to Cenozoic Era.

Lee et al., (2004) conclude that Gua Musang Formation is shallow marine shelf deposition environment because of the present volcanic acitivity.

CHAPTER 5

MINERALOGICAL STUDY OF FELDSPAR IN GUA MUSANG

5.1 `INTRODUCTION

This study was to identify the characteristic and distribution of mineral feldspar and to identify the concentration of major and trace element in each rock samples. For thin section part, seven locations were selected randomly within the study area. Alkali feldspar usually comes with light coloured minerals and has twinning when examine under microscope while plagioclase feldspar shows in light to dark coloured and have ‘zebra’ line. Feldspar is present in all rocks types but it is mostly abundant in igneous rock especially in plutonic rock.

Characteristic of feldspar can be identified using thin section under microscope. The characteristic of feldspar such as pleochroism, winning, colour, cleavage, birefringence was identified. By examine under microscope, the distribution of feldspar also can be determine.

Major and trace elements was identified by using the X-Ray Fluorescence method. The sample was crushed turn into powder. Then, the sample was put into the machine X-Ray Fluorescence in X-Ray Laboratory in University of Malaysia Kelantan. Elements such as K, Na, Ca, Si, Fe and Al were needed to identify which group of feldspar they formed. Since the feldspar have two types, based on the result of XRF, the naming and their potential uses in industry were identified.

5.2 RESULT AND DISCUSSION

5.2.1 Characteristics of Feldspar and Their Distribution

Basically, in igneous rock especially in plutonic rock, have large size of feldspar and usually shows a light colour such as milky white or pink and can be seen by naked eye. Pyroclastic volcanic rock which is tuff has rich of concentration of feldspar. But the characteristic of feldspar cannot be seen by naked eye because of the fine grained. The samples which have very fine grained were observed under microscope in order to identify their characteristic and their distribution.

Sample one (1) which is tuff was collected at the coordinate of N 4° 47’ 40.1” and E 101° 59’ 10” and Figure 5.1 below represents the image of grains under microscope. The phenocryst and microphenocryst of plagioclase were identified to be present in fine grained groundmass of tuff. Under microscope observation, about 75% of plagioclase feldspar is present in this sample. The clast is very dominant in tuff. Tuff is the pyroclastic volcanic rock. It has very fine grained thus the mineral feldspar cannot be seen by naked eye. The size of mineral feldspar is large compared to the clasts. Plagioclase feldspar shows the lamellar twinning characteristic. Colour of plagioclase feldspar at cross polarization is black and white. The shape of plagioclase is euhedral which means that it has a perfect shape or the crystal is completely shape. Plagioclase feldspar is first order of birefringence. Plagioclase shows the dark colour which is black near their extinction angle. When observed under plane polarized, it shows the poor cleavage or no cleavage but it has fracture. Differentiation between the plagioclase and alkali is their twinning. The alkali feldspar shows the single twinning or lamella while plagioclase feldspar shows twin lamella. Under cross polarization, alkali feldspar have grey and black colour as shown in the Figure 5.1. Grain shape of alkali feldspar is euhedral and shows high

relief. Under plane polarization, it exhibits nearly no cleavage. Feldspar distributions are quite abundant in this sample.

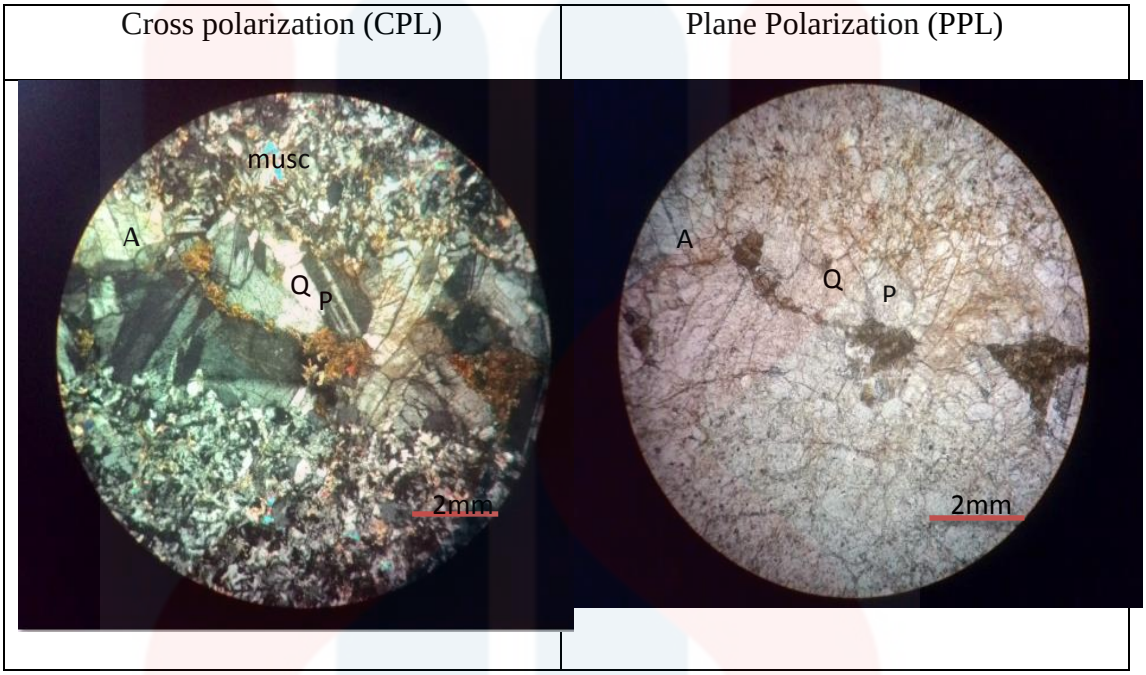


Figure 5.1: tuff under microscope with 10x10 magnifications

Sample tuff (2) was collected at the coordinate 04° 47’ 24.2” N and 101° 58’ 52.5” E. Figure 5.2 below shows the tuff sample under microscope. It shows that the tuff sample with the microphenocryst of plagioclase feldspar. About 45% of plagioclase feldspar and 15% of alkali feldspar found in this sample based on observation under microscope. The size of minerals is small because of this rock is pyroclastic volcanic rock. The plagioclase feldspar shows the twin twinning. The colour of plagioclase is black and white when observed under cross polarization. Shape of plagioclase shown as in Figure 5.2 was subhedral because the shape was not completely formed during crystallization. It has low relief. When observed under plane polarization, it shows no cleavage. Under plane polarization, colour of plagioclase feldspar is colourless.

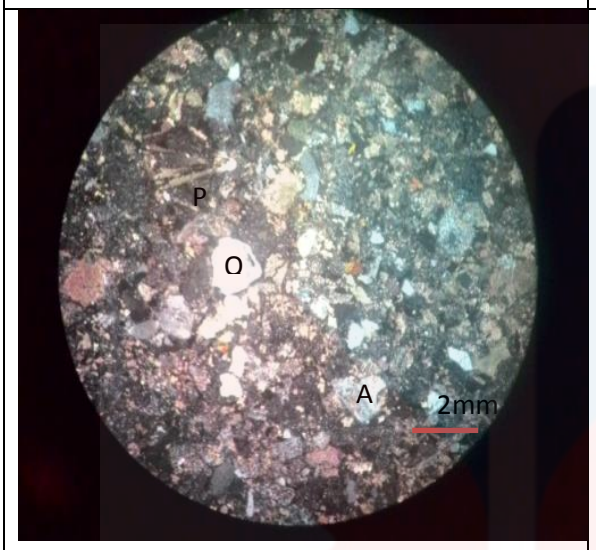
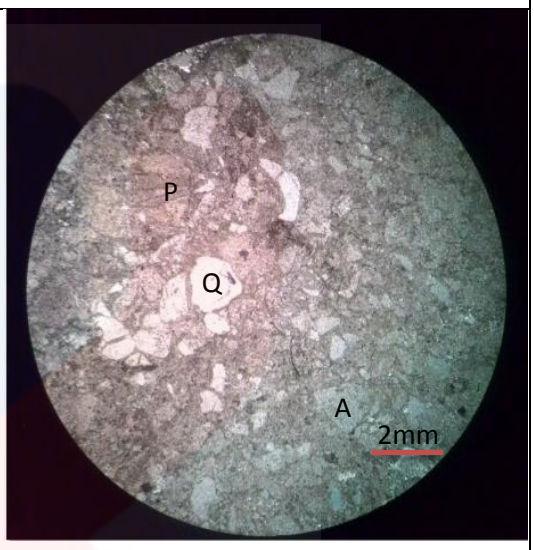
Cross polarization(CPL)	Plane polarization(PPL)
	

Figure 5.2: Tuff under microscope with10x10 magnification

The distribution of mineral feldspar in tuff is less abundant compared to the feldspar in tuff rock from the first location based on the observation under microscope. The size of mineral in tuff also small compared to the other tuff rock. Hence, this location can be classified as the less abundance of feldspar formed in the rock.

Sample three (3) was collected at Gua Gagak with coordinate 04° 47’ 45.9” N and 101° 57’ 29.6” E. Figure 5.3 below shows the sample of limestone under microscope. The plagioclase feldspar shows a euhedral shape as shown under cross polarization. Only 10% of plagioclase feldspar in this sample and the other rest is clast. It has high relief between other minerals. The plagioclase feldspar is aphanitic in size in fine grained groundmass of limestone. Under plane polarization, the cleavage is parallel to its twinning as shown in Figure 5.3.

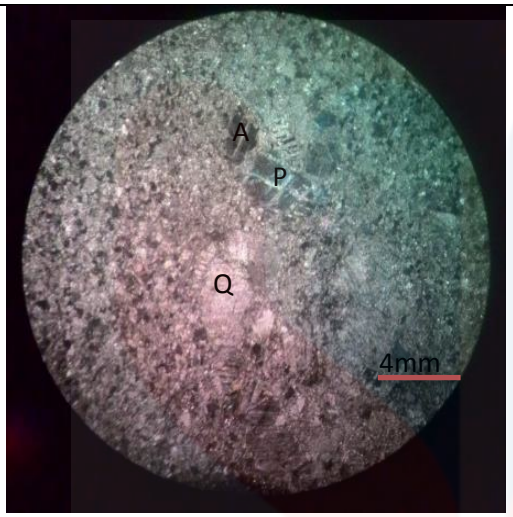
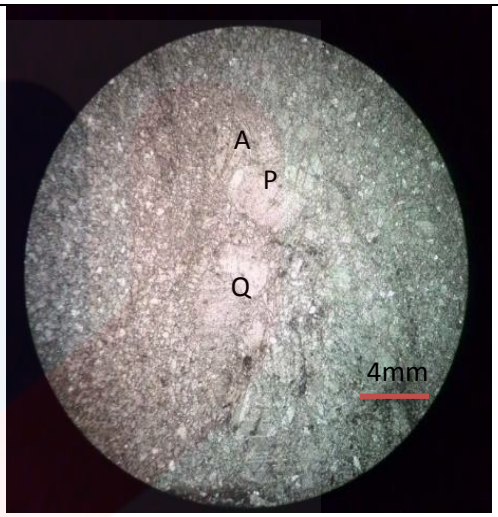
Cross Polarization(CPL)	Plane Polarization(PPL)
	

Figure 5.3: limestone under microscope with 4x4 magnifications

Figure 5.4 below shows a limestone (2) at coordinate N 04° 47’ 35.1” and 101° 57’ 45.3” under cross polarization and plane polarization with 10x10 magnifications. Quartz, alkali and plagioclase feldspar are present in fine grained of limestone. Shape of plagioclase feldspar is euhedral while quartz is anhedral. The mineral feldspar has poor sorting. Feldspar present in large size compared to other minerals.

Figure 5.5 below shows a granite under cross polarization and plane polarization with magnification 10x 10. Based on the observation under microscope, granite consists of mineral alkali feldspar, plagioclase, biotite, orthopyroxene (OPX) and quartz. Shape of feldspar is subhedral. The sorting between feldspar and other minerals is poor sorting. Cleavage of plagioclase is parallel to the direction of its lamella. Relief of alkali feldspar with its surrounding is high while the relief of plagioclase feldspar with its surrounding is low. OPX also have high relief. Feldspar

distributions are abundance in granite either observed under microscope or by hand specimen.

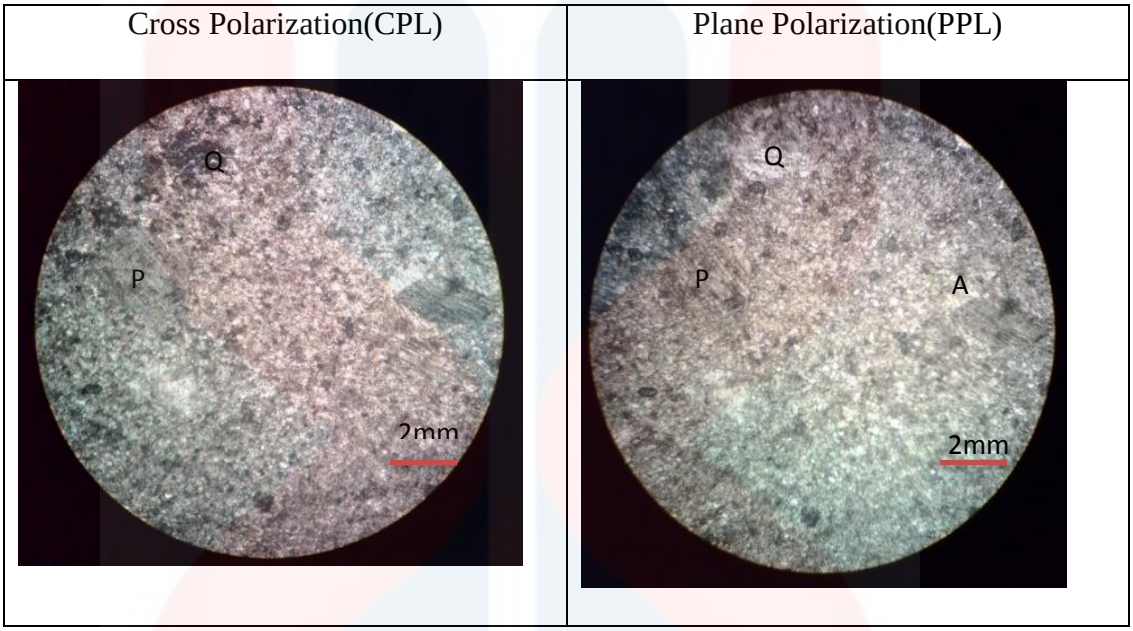


Figure 5.4: limestone under microscope

Figure 5.5 below shows a granite under cross polarization and plane polarization with magnification 10x 10. Based on the observation under microscope, granite consists of mineral alkali feldspar, plagioclase, biotite, orthopyroxene (OPX) and quartz. Shape of feldspar is subhedral. The sorting between feldspar and other minerals is poor sorting. Cleavage of plagioclase is parallel to the direction of its lamella. Relief of alkali feldspar with its surrounding is high while the relief of plagioclase feldspar with its surrounding is low. OPX also have high relief. Feldspar distributions are abundance in granite either observed under microscope or by hand specimen.

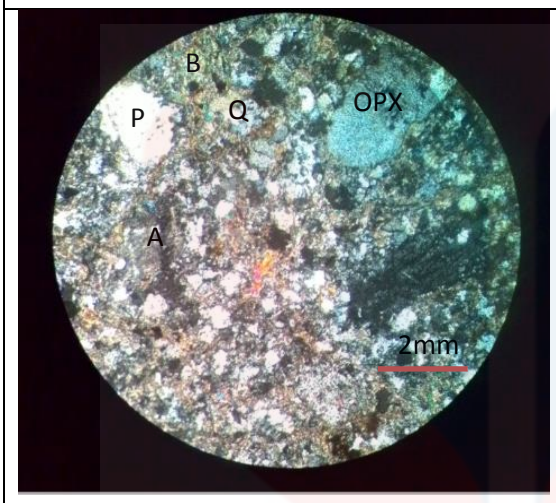
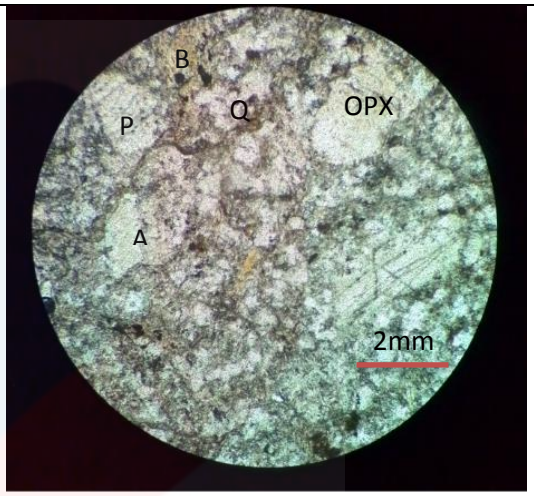
Cross polarization (CPL)	Plane polarization (PPL)
	

Figure 5.5: Granite under microscope

The distribution of feldspar is more abundance in granite and tuff. In limestone, slate, silt and alluvium area, the distribution of feldspar is less. Pink colour shows the lithology that has abundance of feldspar. They are granite and tuff while blue in colour shows that the area that has less abundance of feldspar. Figure 5.6 below shows the distribution map of feldspar in Kg Tanah Putih, Gua Musang.

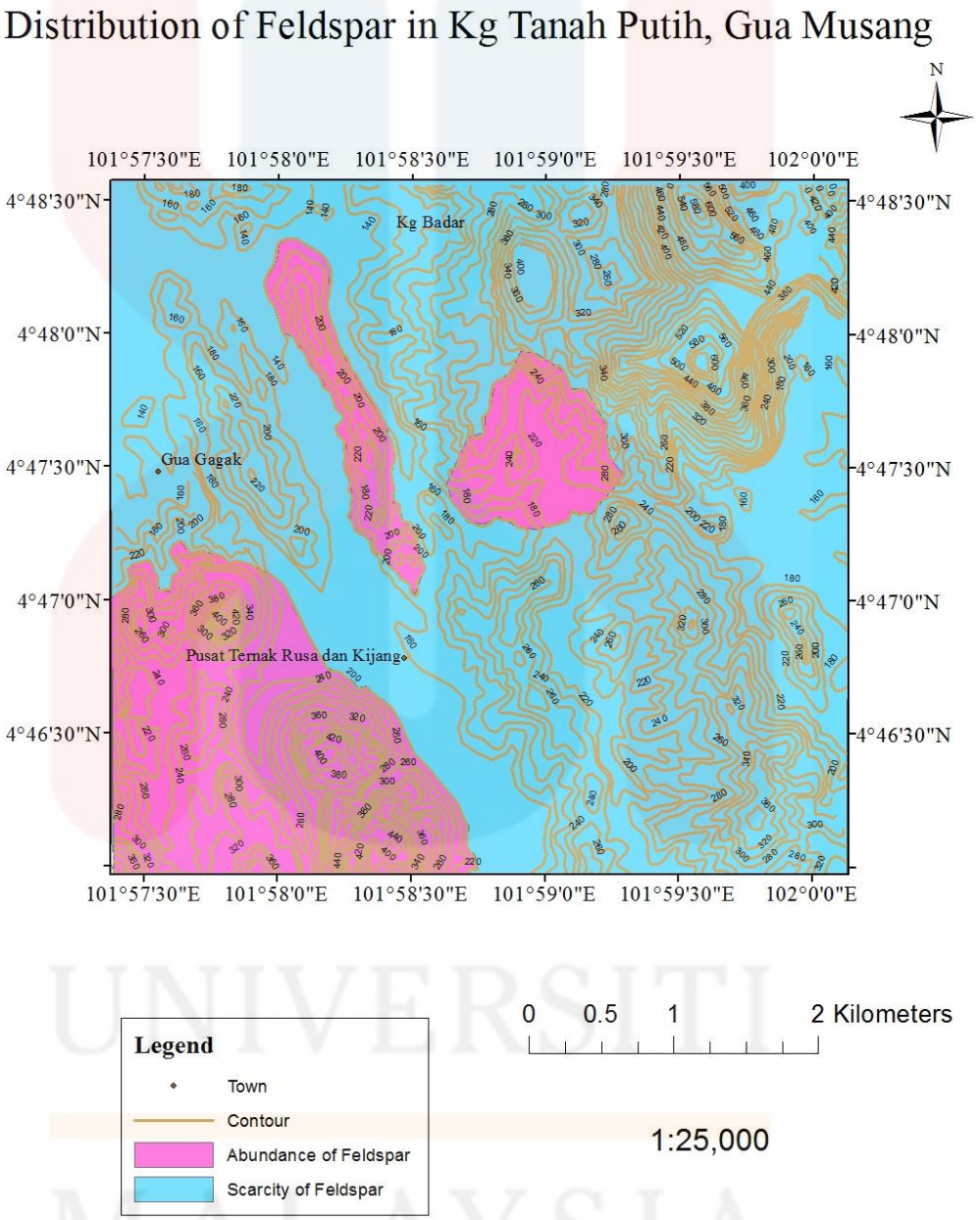


Figure 5.6: Distribution of Feldspar in Kg Tanah Putih, Gua Musang

5.3 MAJOR AND TRACE ELEMENT IN ROCK SAMPLE

Major and trace element in rock can be identified by using X-Ray Fluorescence (XRF) method. Five locations were selected to determine the major and trace element of rock. These rocks are slate, two samples of tuff, limestone and phylite. The rock sample was crushed into powder before running the XRF.

5.3.1 Trace and Major Element

Feldspar consists of two main groups. They are alkali feldspar and plagioclase feldspar. Table 5.1 below shows the selected oxide that found in the samples of slate, two samples of tuff pyroclastic volcanic rock, limestone and phylite while Table 5.2 shows the selected elements in each sample. The unit for data were in percentage (%).

Table 5.1: Concentration of oxides for each sample (%)

Oxide	Concentration (%) in sample 1 (slate)	Concentration (%) in sample 2 (tuff 1)	Concentration (%) in sample 3 (tuff 2)	Concentration (%) in sample 4 (metamorphic)	Concentration (%) in sample 5 (limestone)
SiO_2	67.4	68.6	50.3	36	51.1
Al_2O_3	12.5	14	11.2	10.1	11.4
Fe_2O_3	8.06	1.21	12.7	22	7.88
K_2O	7.02	5.09	3.8	4.04	7.19
CaO	0.376	0.5	12.9	14.6	8.17
Na_2O	0	6.58	0	0	7.9
MgO	0	0	4.09	7.06	1.64
BaO	0.161	0.169	0.165	0.531	0.358

Based on the Table 5.1, SiO_2, Al_2O_3, Fe_2O_3, K_2O, CaO and BaO are present in all samples. The concentration of the oxide in percentage (%) is shown in table 5.1. Among these samples, the concentration of SiO_2 shows the highest concentration. Concentration of SiO_2 in sample 2 which is tuff (1) showed the highest concentration with 68.6 % followed by sample 1 which is slate with 67.4 %. The lowest concentration of SiO_2 was in sample 4 which is phylite with concentration 36 %. Na_2O only present in sample 2 and sample 5 which are tuff (1) and limestone with the concentration 6.58 % and 7.9 % respectively. MgO only present in sample 3, sample 4 and sample 5 with the concentration 4.09 %, 7.06 % and 1.49 %.

Figure 5.7 shows the concentration of selected oxide in all samples of the rock.

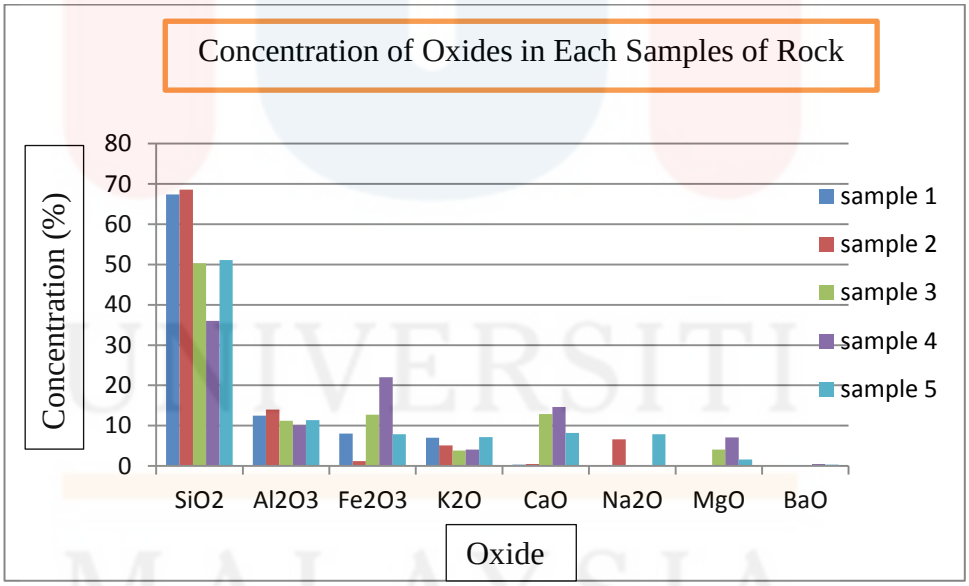


Figure 5.7: The Concentration of Selected Oxide in All Samples of The Rock.

Table 5.2 shows the concentration of elements in each sample in percentage (%).

Table 5.2: Concentration of elements in each sample (%)

Element	Concentration (%) in sample 1 (slate)	Concentration (%) in sample 2 (tuff 1)	Concentration (%) in sample 3 (tuff 2)	Concentration (%) in sample 4 (metamorphic)	Concentration (%) in sample 5 (limestone)
Si	53.2	66.2	36.8	25.5	41.7
Al	15.3	12.5	8.73	7.7	9.66
Fe	14.2	3.29	19.3	34.8	15.5
K	14.7	12.7	5.95	6.29	13.7
Ca	0.25	1.2	17.9	19	13.4
Na	0	0	4.28	0	0
Mg	0	0	2.62	0	0
Ba	0.296	0.388	0.806	1.57	1.44
Rb	0.163	0.495	0.0416	0.164	0.191
Cs	0.0607	0.269	0.156	0.126	0.172
Sr	0.0786	0.165	0.149	0.325	0.112
Pb	0.0384	0.049	0	0.0593	0.0669
Ti	1.09	0	0	1.56	0.802

Based on table 5.2, Silica (Si), Aluminium (Al), Iron (Fe), Potassium (K), Calcium (Ca) and Barium (Ba), Rubidium (Rb), Caesium (Cs) and Strontium (Sr) present in all samples. Lead (Pb) only absent in sample 3 which is tuff (2) at location 3 while Titanium (Ti) absent in sample 2 and 3 which them both are tuff volcanic rock. However, Sodium (Na) and Magnesium (Mg) only present in sample 3 which is tuff (2) at location 3 with concentration 4.28 % and 2.62 %. Si has highest concentration in all samples with the average 25.5-66.2 %. According to Arem (2011), if the percentage of calcium component up until 10%, it is consider as albite

that is sodium-rich plagioclase. Based on data, sample 1 and 2 can be considered as albite if their concentration of Na present because their concentration of Ca both are 0.25% and 1.2%. Range of composition between 10% until 30% is considered as oligoclase. Based on the data shown in Table 5.2, sample 3 is oligoclase because of the concentration of Ca is 17.9%. Sample 4 and 5 were not considered as oligoclase because Na absent eventhough the concentration of Ca in range of 10% to 30%.

Figure 5.8 shows the concentration of selected elements in all samples of rock.

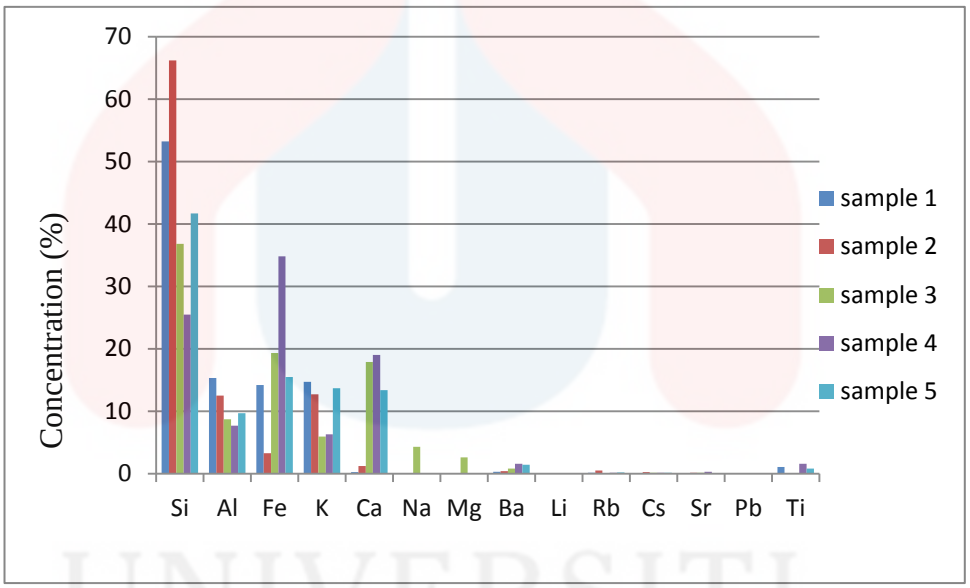


Figure 5.8: Selected elements in each samples of rock (%)

5.3.2 Application of Feldspar

Feldspar has many uses in industry. The higher demand of feldspar caused that feldspar become increase the exploitation in Malaysia. Generally, tuff that have higher content of Na_2O and K_2O and tuff can acts as a flux in a white ware bodies. Feldspar also acts as raw materials in ceramic industry. It is also involve in physco-chemical reactions with other crystalline phases.

CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1 CONCLUSION

An updated geological map of Kg Tanah Putih, Gua Musang at the scale 1:25000 has been updated after completing the field observation (mapping) and laboratory investigation. During the field investigation, all the lithology rock unit, structural geology such as joint and geomorphology classification either hilly or alluvium area were observed and data have been recorded. For petrography investigation, feldspar is found associated with quartz. Under plane polarization, feldspar seen more dirty compared to quartz due to the alteration. Feldspar is a less resistant compared to quartz. Based on Quartz, Alkali feldspar and Plagioclase (QAP) triangle, the percentage of these minerals determine the name and type of the igneous rock. The volcanic pyroclastic rocks have aphanitic grained size. Limestone from mud-supported consist of fine grained. Therefore, petrography section was done in order to get the absolute data by observing under microscope. Based on the petrography section, both tuff samples have abundance of feldspar especially plagioclase feldspar. In tuff (1), about 70% consist of plagioclase feldspar. In tuff (2), about 45% of plagioclase and 15% of alkali feldspar. The distribution of feldspar is abundant in tuff (1) compared to other samples. The results from X-Ray Fluorescence (XRF) have shown few samples of feldspar the major and trace element was identified in each samples. However, the data were not accurate since the systematic error occurred during the run samples. So, the conclusion made based on the data from XRF. Based on the data as mentioned in subtopic 5.3.1, if concentration of Sodium (Na) present in sample 1 and 2, it can be considered as

albite because of concentration Calcium (Ca) were 0.25% and 1.2% respectively. Only sample 3 can be considered as an oligoclase because the concentration Ca 17.9% and the actual composition is in between 10% until 30%. Sample 4 and 5 were not considered as an oligoclase eventhough Ca is in range 10% up to 30% because the Na absent in sample.

6.2 RECOMMENDATION

The research about the topic mineralogy should be continued by other researchers for detailed understanding about the process how minerals can be formed. This topic is one of the important topics to geologist, petrologist and mineralogist because the first identification and naming of the rock is by observing the minerals exist in hand specimen. Besides that, journal about the topic of feldspar is limited. Therefore, it can fill the gap of the past research and gives more information about the feldspar formation. Feldspar also has many uses in industry for example raw materials of ceramic and glass making. Therefore, it can be huge exploitation as well increase the economies in industry production.

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