GEOLOGY OF DABONG AND CHARACTERISATION OF IGNEOUS ROCK IN KELANTAN

by

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

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DECLARATION

I declare that this thesis entitled “Geology of Dabong and Characterisation of Igneous Rock in Kelantan” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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APPROVAL

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

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GEOLOGY OF A DABONG AND CHARACTERISATION OF IGNEOUS ROCK IN KELANTAN

ABSTRACT

Abstract: The study of geology is conducted at Kampung Berangan, Dabong. This research is focused on geology of chosen area with reviewing the characterisation of distribution of igneous rock in Kelantan. In this regard, the objective of research study are to produce a geological map at the selected area in Dabong, followed by determination of the petrographic data of igneous rock from the previous data with the review on geochemical analysis result from previous study by interpret the existing data. The steps of fulfil the result are by using several software such as ArcGis and Google Earth on updated the geological data which show distribution of lithology of acid intrusive, phyllite, slate and shale. The igneous rock in Kelantan such as Main Range Granite, Main Boundary Range, Stong Complex and Kemahang Granite being discussed for the by compilation of previous data researches that already been investigated and published. The previous data of petrography in thin section has vary types of minerals such as quartz, k-feldpar, plagioclase and biotite, yet also for the geochemical analysis on the composition of each sample that been found. The result of discussion of this research will be appropriate in references for any uses.

Keywords: Dabong, Kelantan, geological map, igneous rock, petrography, geochemical analysis.

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ABSTRAK

Abstrak: Kajian geologi dilakukan di Kampung Berangan, Dabong. Penyelidikan ini difokuskan pada geologi kawasan terpilih dengan mengkaji ciri-ciri batuan igneus di Kelantan. Oleh itu, objektif kajian adalah untuk menghasilkan peta geologi di daerah terpilih di Dabong, diikuti dengan hasil kajian data petrografi batuan igneus dari data sebelumnya dan dari segi tinjauan hasil analisis geokimia dari kajian sebelumnya dengan menafsirkan data yang sedia ada. Langkah-langkah mendapatkan hasil kajian in adalah dengan menggunakan beberapa perisian seperti ArcGis dan Google Earth untuk mengemas kini data geologi yang menunjukkan sebaran litologi seperti yang terdapatnya “acid intrusive”, phyllite, slate dan shale. Batu igneus di Kelantan seperti Main Range Granite, Main Boundary Range, Stong Complex dan Kemahang Granite sedang dibincangkan untuk penyusunan data sebelumnya yang telah disiasat dan diterbitkan. Data petrografi daripada hasil keratan nipis mempunyai pelbagai jenis mineral seperti kuarza, k-feldpar, plagioklas dan biotit, tetapi juga untuk analisis geokimia mengenai komposisi setiap sampel yang telah dijumpai. Hasil perbincangan penyelidikan ini akan sesuai dijadikan rujukan untuk kegunaan apa pun.

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LIST OF ABBREVIATIONS

N	North
E	East
GIS	Geological Information System
IUGS	International Union of Geological Sciences
Km	Kilometres
mm	Millimetres
S	South
PALSAR	Phased Array type L-band Synthetic Aperture Radar
QAPF	Quartz, Alkali feldspar, Plagioclase, Feldspathoid (Foid)
W	West
XPF	X-Ray Fluorescence
XRD	X-Ray Diffraction

Elements

A	Alkali feldspar
Al_2O_3	Aluminium oxide
CaO	Calcium oxide
F	Feldspathoid
FeO	Iron(II) oxide
Fe_2O_3	Iron(III) oxide
K_2O	Potassium oxide
MgO	Magnesium oxide
Na_2O	Sodium oxide
Q	Quartz
P	Plagioclase
P_2O_5	Phosphorus pentoxide
SiO_2	Silicon dioxide
Sr	Strontium
TiO_2	Titanium dioxide

List of symbols

Wt%	weight percent

CHAPTER 1

INTRODUCTION

1.1 Background of Study

This research is about geology of Dabong and characteristics of igneous rock in Kelantan using secondary data of petrographic and geochemical analyses. This study will cover several works including map interpretation with the scale of 1:25 000 for about 5x5 kilometre square of Dabong area. The rock lithologic units can be clarified at the study area using previous study lead to make a better understanding and identifying the origin of rocks.

A comprehensive analysis on the existing data throughout the miscellaneous research from any researchers, which may be consist varies input of rock types that might be igneous rocks. The extraction of data is expected to be obtained using petrographic and geochemical analysis of preceding result as well as providing information on the involved geological system and processes. Petrography deals with the identification and classification of rocks in detail. A petrological description includes definition of the unit in which the rock occurs, its attitude and structure, its mineralogy and chemical composition, and conclusions regarding its origin (Haldar & Tisljar, 2014).

The secondary data of previous research using instruments which apply to prepared the mineral detection analysis results. The instruments mentioned are X-ray fluorescence (XRF) and X-ray diffraction (XRD). The geology of Dabong and classification of igneous rock in Kelantan through secondary data will be generated at the end of the study.

1.2 Problem Statement

Kelantan is located in the Main Range Granite of the Peninsular Malaysia which consist several types of granite due to its mineralogy, occurrence, chemical and etc. The Granite grouping according to their magmatic origin resulted in the formation of four opposing groups called as Alphabetic (S-I-A-M) classification of granitiods which divided to S-types, I-types, A-types and M-types. Selected references were referred to identify the types of granitoids as well as distinguished of each type and correlate it to their Main Range Granite within the study area.

Next, the classifications of igneous rock types in the study area were determined through its formation and effects of each type which associated with the types of granites belt formation. The history of the formation of this study sites such as depositional environment or geological structure can be related and analysed the distribution of mineral in the igneous rock from the secondary data of petrographic and geochemical analysis of previous researches.

1.3 Expected Outcomes

Based on the previous research, the study area of Dabong consist granite, limestone and phyllite, slate with subordinate sandstone and schist (Daud, 2013). This finding can be compared with other researches that related or similar to the study. Thus, the

petrographic of igneous rock and geochemical analysis result can show classification of igneous rocks in study area.

Regarding the secondary data which the identification of minerals and elements based on petrographic and geochemical analysis, such as granite can be conclude by the distribution of rocks and minerals. Finally, the igneous rock in Kelantan or study area can be analysed from this research study where the data is interpreted and used to correlate with the relevant area from previous study.

1.4 Objectives

The objectives for this research study are: -

1. To produce a geological map at the selected area in Dabong.
2. To determine the petrographic data of igenous rock from the previous data.
3. To review the geochemical analysis result from previous study by interpret the existing data.

1.5 Scope of Study

This research study focuses mainly on extraction of secondary data in geological result from the previous research and also on identifying types of igneous rocks. Lithology of rock can be analysed through the existing lithology input which help to understand the rock unit and composition. In this area of research, lithology is characterized with refer to the data of lithology for the area yet the geological structure analysis which help to emphasize the process of historical geology. For example, some of the geological structures which clearly visible such as unconformity, contact between layers of different rock unit, fault, folds and others structure in the maps.

Moreover, many rock forms are collected for the petrographic research through the result in the previous study. The focus for this work is on the igneous body of rock that had been found by the researchers and the distribution of the elements and a geological sample's mineralogical composition provide crucial information for understanding the geological structures and processes. The sampling method for the study under a polarizing will not be conducted but it will be using the secondary sources that already been gathered and obtained. It is used to analyse the mineral component in the rock forming which then the rock found by the researchers will turn out to be comparison and interpretation within some different studies.

Next, the geochemical analysis from the results of the data input by the researchers can be compiled to make an interpretation especially from the igneous rock. This is because geochemical can divided into several types which are major, trace, and rare earth elements. Geochemical analysis is now a vital instrument in most geological and environmental study areas. Then, the data references will generate an understanding of the classification in study area of igneous rock.

1.6 Significance of Study

This research is essential to provide comprehensive geology of the study area by examining current geomorphology, geological structure and lithology. Identification of lithology forms and other important features such as geomorphology and geological structure can bring the benefit to the mineral industry and development in Dabong, Kelantan. Igneous rock petrographic and geochemical studies may provide not only a scientific contribution, but also a more essential analysis of economic values.

Geological survey involves interpretation of landform and earth processes with a view to define potential geologic and man-made hazards. This could have an effect on the civil structure and the growth of urban areas such as buildings and residences. In addition, this work also presents new findings on non- geological structures in the past. In addition, it will help the community identify the chemical element of any igneous rock for construction purposes by performing chemical analysis in the study area. The chemical element analysed also revealed the relationship between the lithology in the study field. Therefore, this research will give good values and benefits to academics and references to complete any study which relevant to the topic.

1.7 Study Area

a) Location

Geological mapping in the study area is located at Dabong which in Kelantan area. The map given at 1:25,000 where the area is about 5X5km². Dabong is a very strategic city and could be chosen as Kelantan's new capital as its location in the center of the state of Kelantan and accessible from all parts of Kelantan. It is a tiny town in the district of Kuala Krai. It possesses a railway station. The popular Gua Ikan is on the Galas River, nearby. Dabong is one of four Kuala Krai constituency seats in the parliament. It is bordering of Jeli and Gua Musang.

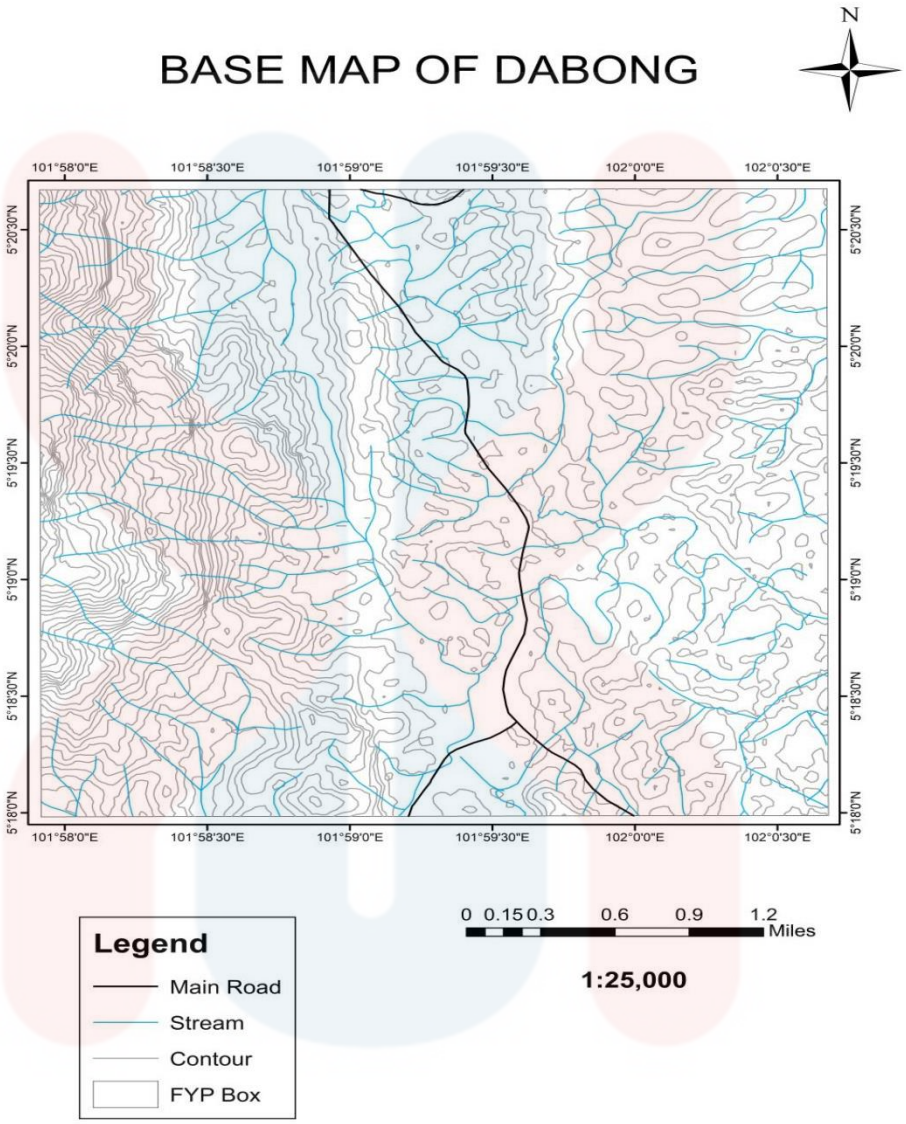


Figure 1.1 Base Map of study area.

b) Road Connection/Accessibility

There seem to be a road connection that heading from the north to south part of the study area. The map of study area (Figure 1.1) show that the main road connected is Jelawang-Gua Musang road. Hence, it is a road facility that connects from the north part that is Jeli or Bandar Dabong to the south part that is to Gua Musang or Bertam.

Figure 1.2 The road connectivity in the study area and connecting roads in nearby areas.

There are the borders of district of Kelantan nearby the research study which can be seen through figure 1.2. The border of district at north part is Jeli-Kuala Krai while the south part is Kuala Krai-Gua Musang. The study area is located at the area of Kampung Berangan, Dabong. Moreover, the distance between the study area and Dabong town is about 4.60km where it is located at direction of north-northeast of research study. The estimated road connectivity distance from the study area for the town of Gua Musang is approximately 46.8 km. Gua Musang town is further than the distance from Dabong town.

c) Demography

Demography is the study of data on the population, their variability and their influences. Dabong is the largest area with an area of 84,007.06 hectares. Although Dabong is the least developed district, it is the second administrative center for Kuala Krai District. The population of the study area involves the number of all the multi-

racial population such as Malay, Indian, Chinese and others ethnics. There are overall quantities of population (Table 1.1) including of Kelantan and Dabong part which in Kuala Kerai, Kelantan.

Table 1.1 Total population of Kelantan (2017) and Dabong, Kuala Kerai (2010)

States	Total population
Kelantan	1,829,700
Kuala Kerai (Dabong)	1,356

Population figures in Kelantan can be rates by using according to the number of ethnic groups, gender, household and living quarters. Change in population is simply a change in the number of people in a given area during a specific time period. The births, deaths, and migration are the main constituents of population change.

Table 1.2 Total population of Dabong ethnics group in 2010 at Kuala Krai, Kelantan.

	Malaysian citizens			Non-Malaysian citizens
States	Malay	Chinese	Indians	
Dabong	1,353	-	-	3
Kemubu	1,130	2	-	1
Manek Urai	1,613	8	-	17

The Local Authority at Kuala Krai can be divided to three areas which are Dabong, Kemubu and Manek Urai (Table 1.2). Based on each different area, most of the people residing in 2010 majority were Malay. Then, follow by the population of Chinese ethnic which is in the area of Kemubu and Manek Urai but not as much as the Malay population while there were no settlements for the Indian population at that year

d) Land use

Dabong is the region where it surrounded by hilly forest areas which at northern, southern, western, and eastern part of area. The land use may be different on categories where it depends on the suitability of the place. The areas of Dabong land have uses in agricultural, residential, recreational and even transportation. The agricultural on crop types plantation such as rubber tree, palm tree and fruit orchard. Dabong also famous on the natural recreational which is Gunong Stong State Park that for the outdoors activities. Hence, with the possibility of a place of interest, the development of land use to increase attractiveness such as building resorts in that area.

e) Social Economic

Southern Kelantan is a hilly area with nearly 50 percent of the land at gradients above 25°, and only 10 percent with gradients below 15°. Given the broad land mass, for the agricultural sector, only 20% of the land has potential to be created. The social economic of residents around this area had their activities on agricultural, small business and yet for natural recreational. For example, the plantation of rubber tree and palm tree in the area develops the socio-economic to extracts the sustenance. Next, the local take the opportunity from the recreational activities at the Gunong Stong site by becoming outdoor hiking venture guides in the area.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter is a crucial section review of the related topics discussed by past research studies on the knowledge and information given. It includes all the research conducted which is related to this study of research.

2.2 Regional Geology and Tectonic Setting

According to Bignell and Snelling, (1977) that in the meantime, they consider it was convenient to divide Malaya into three provinces for descriptive. The three provinces are the East Coast Province, the Central Province and West Coast Province.

The East Coast Province covers East Kelantan, Terengganu, East Pahang and East Johore. The western boundary of this province is marked by the fault zone of Lebir to the north. South of latitude 5°N the boundary is the junction of Upper Palaeozoic (mainly Carboniferous) rocks to the east with Permian to Jurassic (mainly Triassic) rocks to the west which is a fault zone in places. Granites interfere between the Upper Palaeozoic rocks in the east and the Upper Triassic rocks in the west from around 3N to Singapore. These granites are incorporated in this province of the East Coast.

The Central Province lies to the west of the province's East Coast. South of about 5°10'N, the eastern margin of the batholite of the Main Range marks a convenient continuation of the western boundary to this province. North of those latitudes the geology is much less well known and the western boundary along the 101°30'E meridian seems convenient to continue. The so-called province comprises central Johor, eastern half of Negeri Sembilan, central Pahang and Kelantan.

The West Coast Province third province constitutes all of Malaya west of the Central Province. It includes the Perlis, Kedah, Selangor and Malacca states, and comprises the western parts of Kelantan, Pahang, Negeri Sembilan and Johor.

Kelantan's regional geology consists of a central zone of sedimentary and metasedimentary rocks, bordered by Main Range and Boundary Range granites on the West and East respectively. There are windows of granitic intrusives within the central region, the more prominent of which are the batholite, the Stong Igneous Complex, Dlu Lalat (Senting) and the pluton Kemahang. Such granite and country rock belts have a north-south pattern, and are basically the northern continuation of northern Pahang's regional geology. In central and western Kelantan, the belts extend north to southern Thailand, however in the East; the coastal alluvial plain of Sungai Kelantan overlaps the granite border zone.

The state's oldest rocks are of Lower Paleozoic age, outcropping as a northerly-trending belt bordering the Main Range foothills and extending eastward to Sungai Nenggiri. They are primarily metapelites with smaller arenaceous and calcareous intercalations with lesser volcanic fragmentary and minor. Uncommon occurrences of amphibolite and serpentinite have been documented mostly on eastern side of the Lower Paleozoic sequence in southwest Kelantan, mainly Permian volcanic-

sedimentary rocks occur extensively and uncomfortably overlying. The Taku Schist, whose age remains dubious but definitely pre-Triassic, pervades part of the north Kelantan.

Triassic rocks are primarily restricted to Kelantan in the center and south. Such rocks are predominantly argillo-arenaceous sediments with volcanic and calcareous intercalations. Within this veneer of Triassic sediments, some inliers of Permian rocks crop up. The youngest rocks are the Jurassic-Cretaceous volcanic rocks covering the Gunung Gagau area's Border Range of Granite and Triassic sediments at the shared state boundary between Pahang, Kelantan and Terengganu and the Gunung Pemumpu and Gunung Perlis areas to the west. This series consists of conglomerates overlaid by eastern granitoid sandstone bodies (Boundary Range Granite) which it intruded in the eastern site of Kelantan and typically triggers of skarn formation along contact zones (Goh et al, 2006).

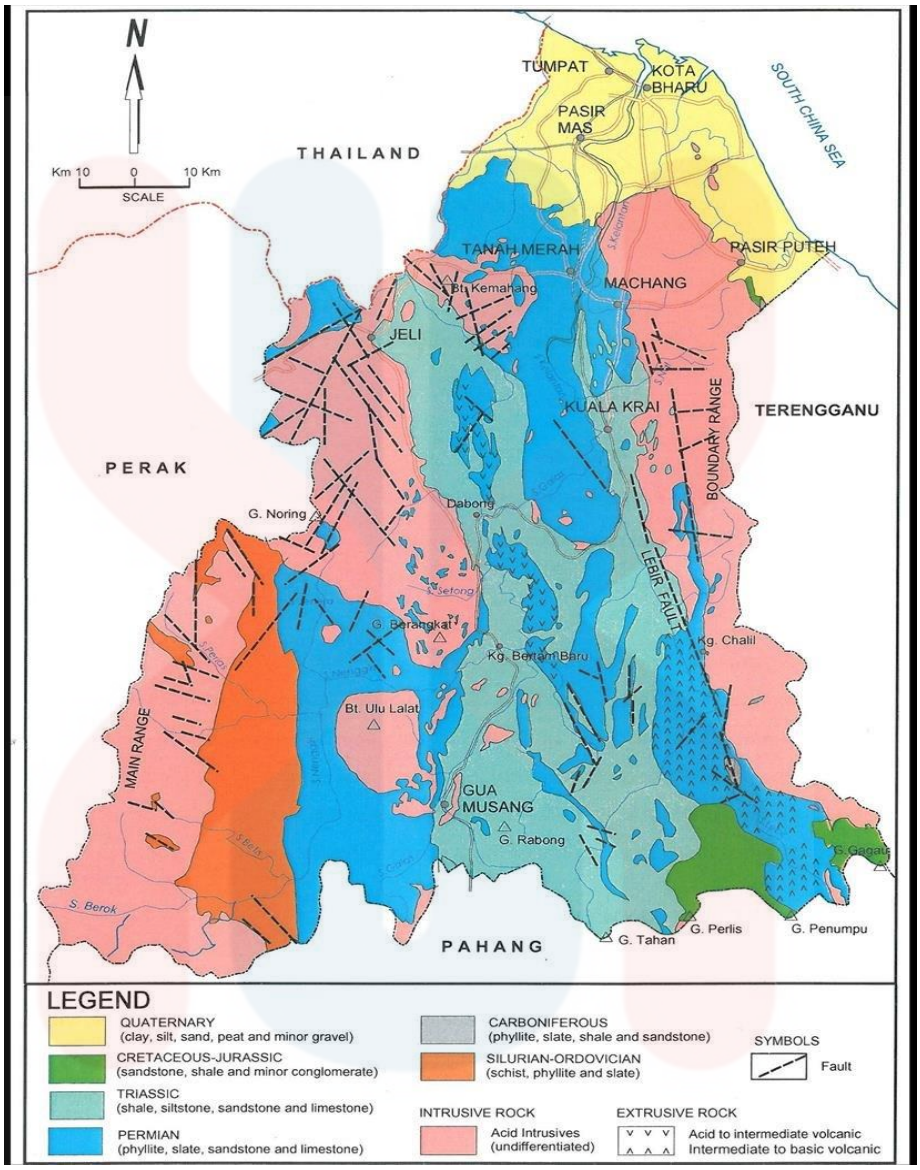


Figure 2.1: Geological map of Kelantan (modified from Department of Minerals and Geoscience Malaysia, 2003)

2.3 Stratigraphy

The Central Belt is largely underpinned by Mesozoic and Permian rocks. The oldest rocks in the Central Belt are those which border the Main Range Granite's eastern side. The rocks here were named in different ways. For example, the Formation at Foothills, Bentong Group and etc. They compose of schists, amphibolites, conglomerates and some other related clastics, and small serpentinite bodies affiliated with the schists. Rocks at the edge of the rock group formed Devonian and Silurian

graptolites. Some Carboniferous rocks are exposed elsewhere in Kuala Lipis, and may include metamorphosed Carboniferous or older rocks in Taku Schists. The most part of the Belt is covered by coastal Permian and triassic rocks. Shale, mudstone, fine sandstone, limestone, and volcanics represent them. There seems to be no reason to indicate that these are not legal. The marine rocks in the late Triassic gave way to the deposition of continental Tekai Group deposits ranging from Jurassic – Cretaceous. (Khoo & Tan, 1983)

2.3.1 Igneous Rock Formation

Osinski et al, (2018) stated that igneous rocks are among three lithological rock classes of fundamental importance. The Greek work "ignis," meaning "fire," describes igneous rocks as "solidified from molten or partially molten materials such as magma. Whereas the existing concept of "magma" states that the "Earth" produces these molten materials, the tacit presumption is that it often applies to similar situations on other solar system bodies. Igneous rocks are the components of other lithological such as sedimentary and metamorphic rock groups. These remain the dominant type of rock on planetary bodies with no subsequent volcanic activity, and igneous processes on Earth and other active planetary objects continue to the present day. The characterization of igneous rocks and their properties of structure, petrography, and texture is well understood and documented. The formation of magmas within the planetary interiors by decompression melting and/or wet melting of protolith lithologies is fairly well-known physical processes. However, the relative importance of these processes is a matter of some controversy about the creation of such igneous rocks on Earth.

In the Kelantan province, a large variety of rocks consisting of igneous, sedimentary and metamorphic rocks is distributed in a north – south direction. Four types of rocks are usually classified in the area, comprising sedimentary or metasedimentary granitic rocks, extrusive rocks or volcanic rocks and unconsolidated sediments (Figure 2.1). Regionalized geological characteristics include faulting and joining in granite rocks and rolling, defecting and joining in sedimentary rocks. Granitic rocks are divided up in the western (Main Range granite) and eastern frontiers (Boundary Range granite) of Kelantan state. The Main Range Granite is situated in the west of the state, extending along western Kelantan to the Perak, Pahang and Thailand borders (Pour & Hashim, 2017).

Kelantan's granites are similar to those of the other parts of the Peninsula that of the Main Range, which is the predominant type, is typically a coarsely textured variety with large porphyry feldspar crystals. In some districts non-porphyritic granite and finer textured granite are found. Porphyritic granite includes large orthoclase phenocrysts in a quartz and biotite soil and often a green hornblende (Savage, 1925).

2.4 Structural Geology

Peninsular Malaysia provides detailed characterization of Bentong-Raub Suture Zone lineaments and curvilinear structures along with their involvement in tropical sediment-hosted or orogenic gold exploration. Major structural lineaments such as the Bentong-Raub Suture Zone (BRSZ) and Lebir Fault Zone, ductile deformation associated to crustal shortening, fragile disjunctive structures such as faults and fractures and also the collisional mountain range (Main Range granites) were detected and mapped at regional scale using PALSAR ScanSAR data. The Bentong Raub

Suture Zone's main geological structural directions were N – S, NNE – SSW, NE – SW, and NW – SE, which extracted fine and polarimetric data from the spatial filtering application to PALSAR. The widespread array of N – S faults in the Central Gold Belt and surrounding terrain is primarily connected to the Suture Zone N – S pattern.

Major failures in Peninsular Malaysia strike N–S, NNW–SSE, NW–SE, WNW – ESE, E–W, ENE–WSW and NE–SW and have undergone complex repeated movements, which include evidence of microstructure for both sinistral and dextral movements along numerous strike-slip errors. Reactivation of these faults as sinistral strike-slip faults occurred in the Late Cretaceous, synchronous with emplacement of granitoids, and deformation of Jurassic–Cretaceous red bed sequences. Further reactivation of these faults occurred in the Cenozoic (Shuib, 2009).

Dating of faults in Peninsular Malaysia is poorly constrained, but major N–S trending faults are interpreted as the earliest faults. They are related to the oblique amalgamation of Sibumasu and the Sukhothai Arc in the Permian–Triassic. The NNW–SSE major dextral faults are interpreted to be Late Triassic–Jurassic and to have resulted in the opening of the Jurassic–Cretaceous continental pull-apart basins (Metcalfe, 2013b).

2.5 Historical Geology

Nazaruddin et al. (2014) presented that the geomorphology of study area is related to the geomorphology development of Peninsular Malaysia. Although the Peninsula is

considered to have been relatively stable tectonically, it has still been influenced by regional events of Sundaland. Its present-day landforms thus result in part from its prolonged sub-aerial exposure throughout the Tertiary period, with predominance of weathering and erosion.

The Kelantan state surface lithology consists of igneous, sedimentary, and metamorphic rocks that occur in a north-south pattern that affects the mineralization zones profile. Along the western and eastern frontiers there is igneous rock forming the central granite range and granite boundary range, respectively. Granites of the main range belong to the middle Triassic age which comprises intermediate intrusive igneous rock. The state's central belt consists of both Triassic and Permian-age sedimentary and metasedimentary rocks. The Triassic sediment is a conglomerate of interbedded sandstone, siltstone, and shale, while the Permian equivalent includes subordinate sandstone and schist with phyllite, slate, and shale. The central belt is also intersected by intermediate to simple volcano, mainly pyroclastic sediment (Koume et al, 2017)

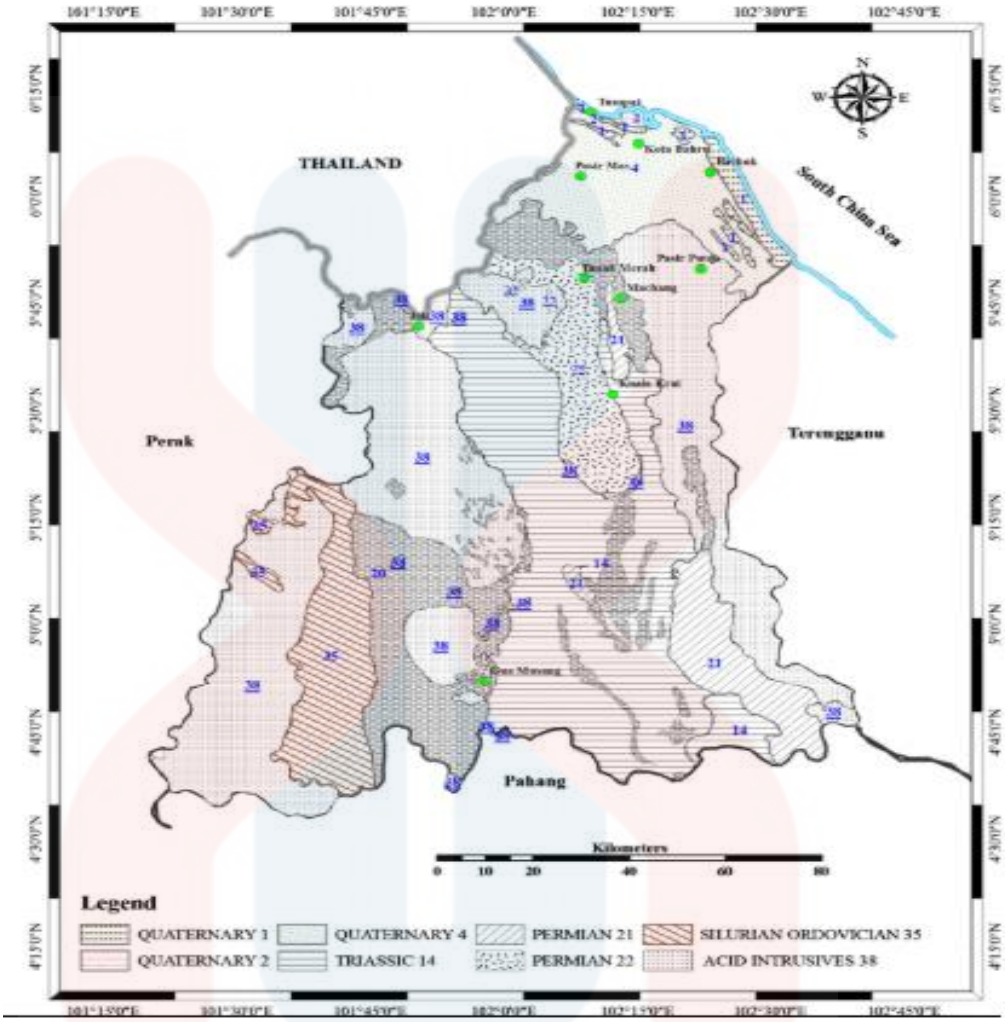


Figure 2.2 Geological formation of Kelantan state (Garba et al, 2014)

2.6 Research Specification

2.6.1 IUGS Specification

To construct a reliable classification of igneous rocks which could be used by all geologists, the IUGS created an international body: the IUGS Subcommittee on Igneous Rocks Systematics. The Subcommission has developed ten principles for its construction and for establishing a suitable nomenclature in the course of creating the classification. The guidelines are use of concise characteristics, use actual properties, ensure suitability for all geologists, use current terminology, identify rock species boundaries, make it easy to apply, follow natural relationships, use modal mineralogy,

use chemistry, and use terminology from other IUGS advisory bodies if not feasible. Such concepts and their reasoning have not been enunciated before.

The division distinguishes and classifies the pyroclastic, carbonatitic, melitic, lamprophyric and charnockitic rocks separately before joining the principal QAPF division for plutonic and volcanic rocks based on the modal mineral proportions of alkali feldspar (A), quartz (Q) and plagioclase (P) or alkali feldspar (A), feldspathoids (F) and plagioclase (P). Rocks with mafic content >W% have their own classification (Le Bas & Streckeisen, 1991)

2.6.2 General geology of igneous rock in Kelantan

The minerals in igneous rock types were discussed through reviewing the previous research such as journal, articles and books. The characterisation of igneous rock is identified through the physical properties such as their texture, colour, mineral composition and also the density while through the geochemical properties which it show the distribution of the chemical composition that have greatly in vary characterisation.

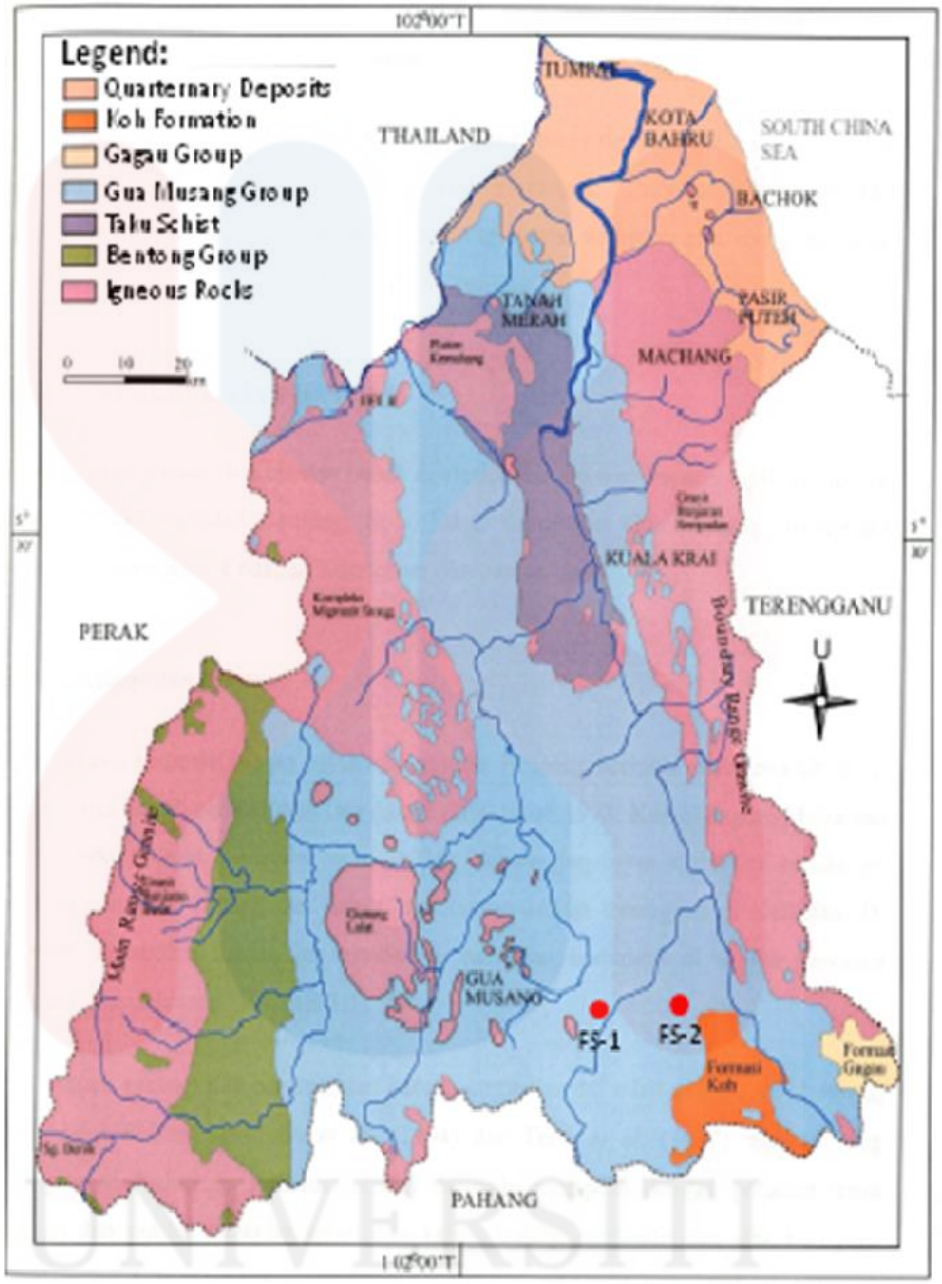


Figure 2.3 the map of general geology of Kelantan. (Nazaruddin & Othman, 2014)

The types of igneous rock is scattered in Kelantan where it is in the different zone and can be refer at figure 2.3. There are the Malaysian granites which each parallel belt can be divided into three distributions that are Western belts, Central belts and Eastern belts. Each types of granites belts included into Kelantan state where the part of Western belts is known as Main Range Granite that located at

Perak-Kelantan boundary which more specified in the western of Gua Musang part while Eastern belts that encountered the part of called as Boundary Range Granite that located at Terengganu-Kelantan boundary.

- Main Range Granite

  Western Belt or known as Main Range Granite has the features of predominantly in transitional I-S types of granite which primarily it was regarded by Liew, (1983) which mainly the main range classified as an S-type granite that it is dominant of biotite granites. However, others researcher discovered that, there are also characteristic features of I-types in the main range granite that found by Chappell & White, (1992).

- Boundary Range Granite

  The Boundary Range Batholith in the northern part of the granite belt is one of the main granite batholiths of the Eastern Belt Granite. The batholith is the largest granite body in the Terengganu-Kelantan area of the Eastern Belt. It separated the batholith into two main parts, the 100 x 20 km Machang batholith and the smaller Kerai batholith on the western flank. (Ghani & Abadi, 2005)

  According to Ahmad et al, (2002) that the batholith has been split up into different granitic bodies, such as Panchor, Bidang, Jawa, Buloh, Terekak, Manik, Kapis, Bidang, Kerai, Peria, Tunggil, Lata and Rek Red, which are from north to south. The batholith has a complex texture of granite, varying from coarse to fine primary to microgranite and secondary magmatic variants. The granite probably is cut by several Albian-age basaltic dykes.

- The Stong Complex

The term complex in stratigraphy refers to rock groups or mixtures of two or more types rocks of different classes of origin with a structure complex according to the Malaysian Stratigraphic Guide (1997).

Referred to Umor et al, (2015) the Stong Complex, in the Central Belt of Peninsular Malaysia, is the northern most plutonic complex. The complex consists of Berangkat Tonalite, Kenerong Leucogranite and Noring Granite at a reduced age. The first two are, in part, severely deformed and extensively foliated. The Berangkat Tonalite consists of grey megacrystic tonalite to monzonite, partially foliated. In Berangkat Tonalite, fine to medium grained diorite also occurs as a small facies. The megacrysts of alkali feldspar range from 10 to 55 mm which they are gray-white in colour, normally euhedral, covering almost 20-30 percent of the whole rock and usually cataclastically deformed.

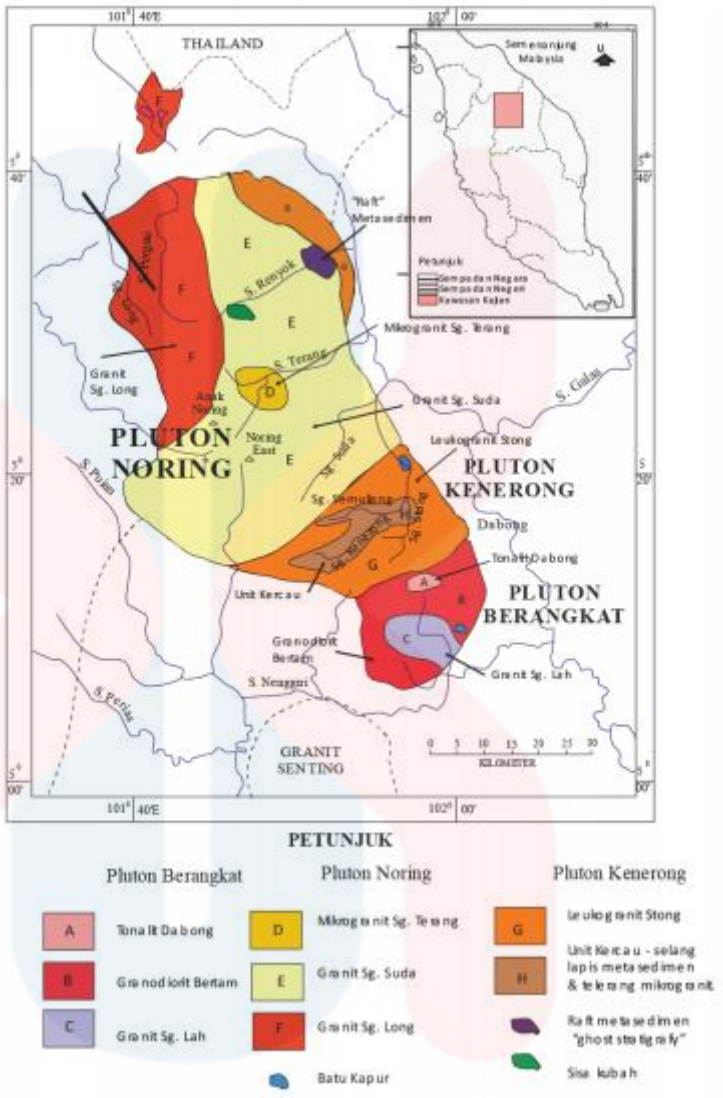


Figure 2.4 show the naming of lithodemic units in Stong Complex.

CHAPTER 3

MATERIALS AND METHODS

3.1 Introduction

All materials and methods which involve in the study of geology and characteristics of igneous rock in Dabong, Kelantan will be discussed in this chapter. First of all, the materials need to be searched as the referring data before starts the comprehensive works. After that, the result and interpretations can be done by following the methods which started from the preliminary and desktop study, data compilation and the last one is by data interpretation.

3.2 Materials

The main references or materials were used in this study are bulletins and previous journals from Geological Society of Malaysia publications, any articles obtained from internet such as Science Direct and another thesis books references obtained from Universiti Malaysia Kelantan (Jeli Campus) Library. The illustrations on study area

will be produced using the data of U.S. Geological Survey (USGS) of aerial photographs, satellite images and cartographic product.

Next, the software uses as the materials are ArcGis and Google Earth Pro. This software is crucial to create various maps such as Topographic Map, Fluvial System Map and Surface Analysis Map. Based on those map produce, it can be applied on referring to the pattern of map which can describe the study area.

3.2.1 ArcGIS software

ArcGIS is geographic information system that working as a tool for the production and analyse of spatial data by ESRI. This platform are use to create information geological data which in forms of various map for further interpretation of study area. The varieties of map that been produced are base map, geomorphology map, drainage pattern map, lineament map and geological map.

3.2.2 Topographic map or Base map

Base map is useful as a reference map where come from the existing map which overlay map of database. It one of fundamental map where it is given background of geographic information such a connection or roads, rivers, boundaries and name of town. As mentioned above, this map is used for the remark or source of study map which more specific on the geographic data information that provide detailed background image for study area.

3.2.3 Secondary data

The existing or previous data can be included as a secondary data that refers as materials that has already been obtained from primary sources and can be accessible for other researchers to use for their own study. It is a type of knowledge that has

already been gathered in the past. For example, secondary data that being used are previous researches that in forms of books, journal, website and previous Final Year Project thesis.

3.3 Methods

First of all, previous studies relating to the geology of the area of Kelantan or close to the area of study will be reviewed. Next, result of secondary data can be related through similar research and be examined for this research. Finally, the stage of interpretation, correlation and comparison is made to summarize the topic of igneous rock characterization.

3.2.1 Preliminary and Desktop Study

Preliminary and desktop study is conducted to have a general overview of the study area. Therefore, by surveying existing topography map, geological map and illustration of satellites is involves. Other uses materials are by the comparison and references of journals, documents, books, previous research or thesis and other relevant information about the research area. These medium of researches is the main study to get the secondary data of characterisation of igneous rock in Kelantan area. The move on discovering this preceding research to make the data more comprehensive and simplify the next move of methods. The secondary data will be discussed and clarify through the data given based on the previous studies.

3.2.2 Data Compilation

Petrographic is the key method for the data processing of the research study followed by geochemical analysis. Therefore, the sample collection of thin section in the result of previous study will be use as a secondary data for both references and the discussion. The part of discussion will be review varies of minerals in the igneous rocks that been found by other researchers. From that, the minerals can indicate the types of igneous rock in somewhere in Kelantan area and the characterisations of rocks especially for the igneous rock can be evaluated. The geochemical analyses also yet be compiled together by multiple researchers and both analyses of petrography and geochemical will be interpreted.

Moreover, the part of the general study area of Dabong will be created to the different kind of map by using the ArcGis and also by referring Google Earth Pro. The maps of study area are needed in geography, geomorphic process, lithology and structural geology where it describes the comprehensive of that area. The example of map that being produced are: -

- Base map
- Geomorphology map
- Drainage pattern map
- Geological map
- Lineament map

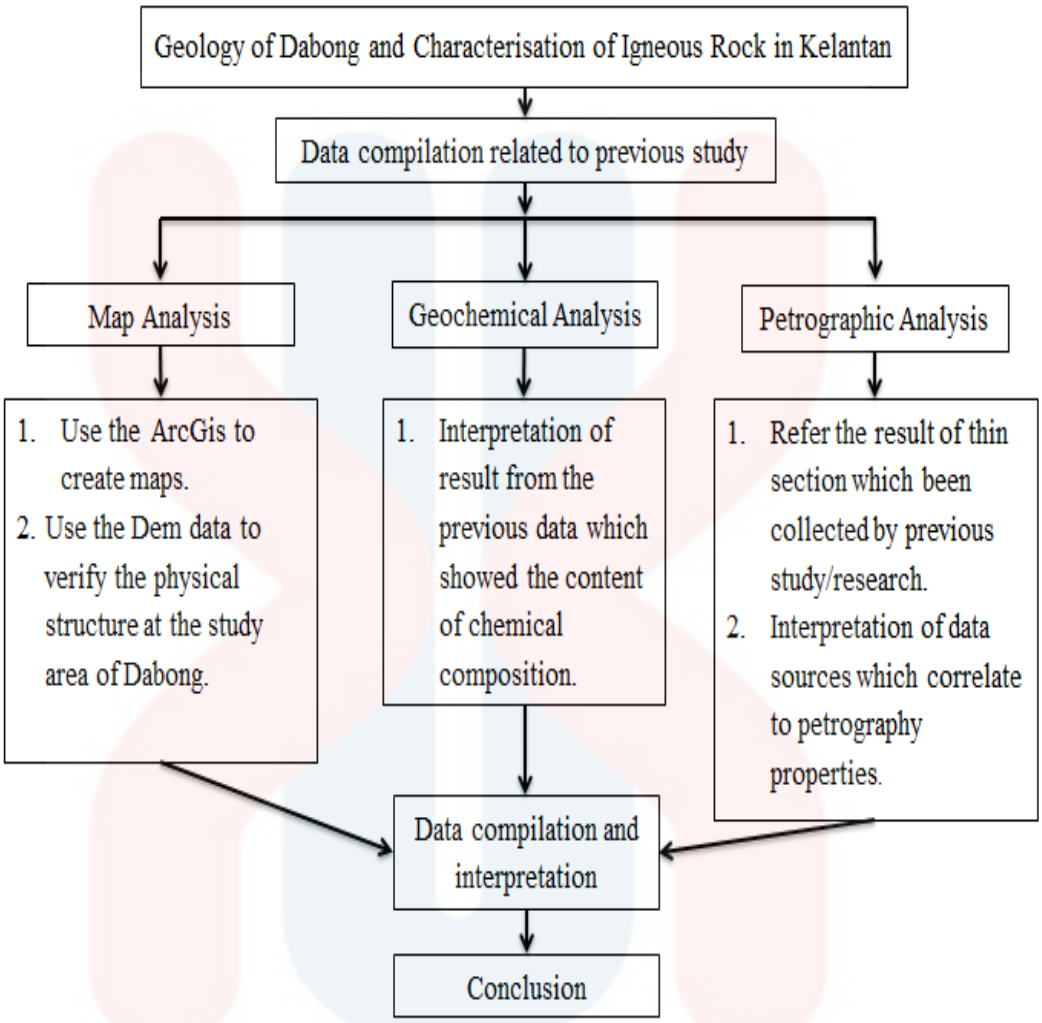
3.2.3 Data Interpretation

There are two parameter that being used for the data interpretation that are by petrographic and geochemical analysis result from secondary data. The result of previous researches where in terms of petrographic analysis is analyse from the thin section under the microscope. It can be in two types of microscopic view of results either in the plane polarized light (PPL) or crossed polarized light (XPL) image or can included for both result of image. Therefore, the results from petrographic data will be used as a data analysis where discussion can be made by referred the mineral component and then being categorized through their classification. Moreover, second parameter is specified to the geochemical analysis in the forms of Harker Diagram where it is diagram that showing the concentration of each of a rock's chemical constituents as a percentage of the major or necessary component versus silica or SiO_2.

From those methods, the results from study research can been analyses and investigated. These help the interpretations of this study by reviewing from previous result of petrographic and geochemical analyses. Therefore, interpretation can be done through the both result and can be compare through the granite classifications. chemical composition of minerals in the igneous rock and comparison within different secondary data.

Based on created maps pattern from the study area, the general geology of Dabong will be describes and be interpreted. Finally, the report writing is conducted by amalgamate altogether the results interpretation and the geological map will be produced.

RESEARCH FLOW CHART



CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

The general geology will be discussing on some aspects in this chapter where it related with the study research. All aspects of general geology will be covered in geomorphology, lithostratigraphy, structural geology and historical geology with few types of map that presented the geological information. Generally, a range of maps products will show the solving problem where it represents the distribution of different data that involving Earth resources such as types of rock, lineament and drainage pattern. This research is focusing on the Dabong, area at Kampung Berangan.

The study area is located at Dabong, Kelantan where the longitude is 101°57'49.29"E to 102° 0'35.32"E and the latitude is 5°20'39.29"N to 5°17'57.70"N. The area was approximately around 5km x 5km that covered the Jelawang jungle, which known as Gunung Stong State Park and include Kampung Berangan and Kampung Setong.

a. Accessibility

The accessibility in the study area is road facilities which for main road and small road in settlement area. There seem to be a road connection that heading from the north to south part of the study area. The map of study area (Figure 1.1) show that the main road connected is Jelawang-Gua Musang road. Hence, it is a road facility that connects from the north part that is Jeli or Bandar Dabong to the south part that is to Gua Musang or Bertam.

b. Settlement

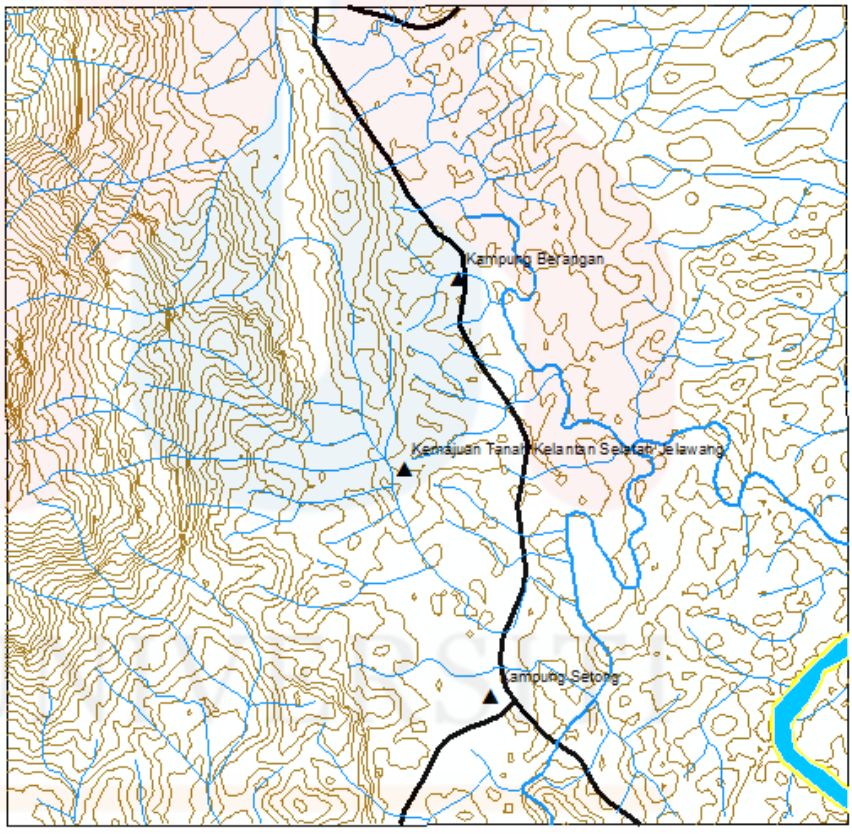


Figure 4.1 The settlements that locate at the study area.

The study area is a small rural area which has several settlements that can be seen at Figure 4.1. The settlements that included in study area are Kampung Berangan and Kampung Setong. Kampung Berangan is located at the centre of the map area while Kampung Setong is located at South of the map.

c. Forestry/vegetation

Generally, the vegetation can be described as a patchwork of species of plants scattered around the region of area. It may represent as the indicator of geologic formation and able to contribute in consequence to he physical environment. The study area can be included as high forestation and agricultural where Dabong is famous as small rural area in Kelantan.

4.2 Geomorphology

a. Geomorphologic classification

The characterisation of the Earth's surface relief according to its morphology features. Generally, the physical features part is cover by the landform which represented the landscape of an area and known as topographic. It is classified by distinctive physical characteristics such as slope, type of soils, elevation, rock exposure, stratification and orientation. Hence, geomorphology can be interpreted through the relationship between the types of features and process it happened.

From the Table 4.1, the landform of study area can be classified through the elevation of terrain by referring Van Zuidam (1985) source where it classified with the relationship between height differences and morphographic elements. The difference in elevation (elevation) is usually measured from sea level, because sea level is considered as a plane that has an elevation of zero. The importance of recognizing the difference in height is to state the circumstances morphography and morphogenetics of a land form, such as hills, mountains or plain.

Table 4.1 The relationship between absolute height and morphography

Absolute height	Morphography elements
< 50 metre	Low land
50 metre – 100 metre	Inland low land
100 metre – 200 metre	Low hill
200 metre – 500 metre	Hill
500 metre – 1,500 metre	High hill
1,500 metre – 3,000 metre	Mountains
➢ 3,000 metre	High mountain

Source: Van Zuidam, (1985)

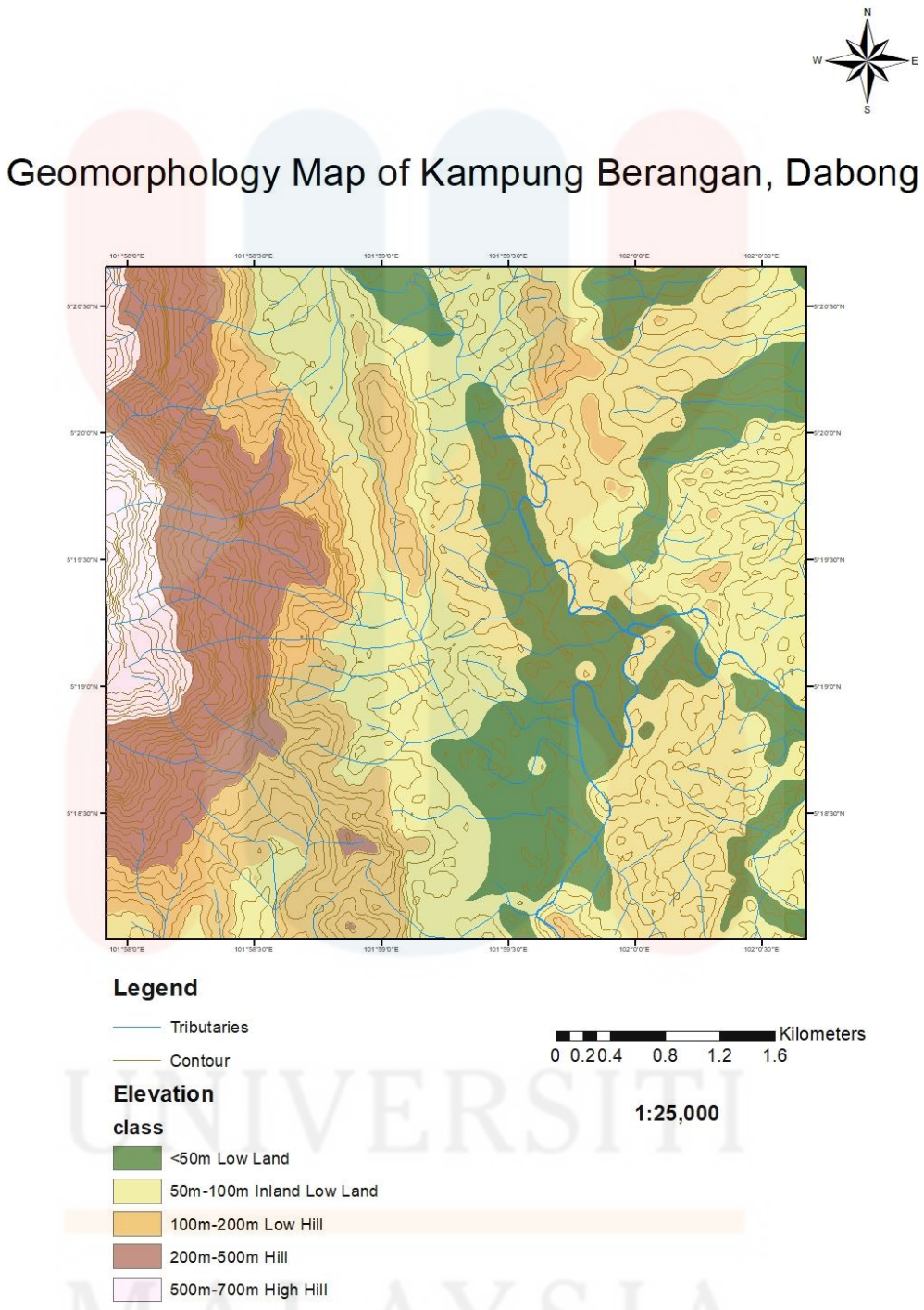


Figure 4.2 The geomophology map that in elevation from lo land and high hill

The geomorphology map of Figure 4.2, shown the classification of different elevation where it is presented the particular type of relief. The elevation of relief has displayed in distinctive colours such as in green, yellow, orange and white colours where it is divided into each sort of morphology. Firstly, the lower elevation through the study area covered about 20% of low land which it is >50 metre above the sea level. Next, the type of landform that mostly covered about 45% of the region is inland low land where in 50 metre to 100 metre while there is only 5% of high hill of landform that at 500 metre to 700 metre. Next, the classification of elevation in between 100 metre to 200 metre above sea level is presented as low hill whereas for 200 metre to 500 metre presented as hill type of landform. Hence, both of the reliefs are covered about 15% in the research study of Dabong.

b. Drainage pattern

Drainage pattern can be represented the multiple types of stream or river systems that provided geological information of study area. It is can be influenced by the erosion of particular characteristics such as rock resistance, slope and geologic structures. The pattern of drainage is categorized on the basis of its shape and texture where it developed from the subsurface of Earth and.

Based on the drainage pattern of map in Figure 4.3, it showed that there are three types of drainage system in the study area. The tributary of study area is major with the dendritic types of pattern where it is in the shape of branching form that in all directions and at almost any angle. The dendritic system at the west direction of study area located at the hill area where can be assume topography that it formed at V-shaped valley and the system pattern of dendritic river shown that it indicative of complex crystalline of rock such as the Gunong Stong Complex of granite. Next, the

drainage pattern that located at north direction of map represented the rectangular pattern of tributary. The angle of joint set is typically high when it intersects to each other and it can be developed in a single rock of type that become more resistant to erosion however it will be eroded more easily when it has contact in sets of parallel of joints. There is sub-parallel of drainage system that in west direction where the tributaries are run off parallel to each other along a sloping surface in a uniform rock resistance. Hence, the occurrence of this type of drainage pattern is commonly in down linear of slope such as an escarpment that by erosion and separates two level of elevations in study area.

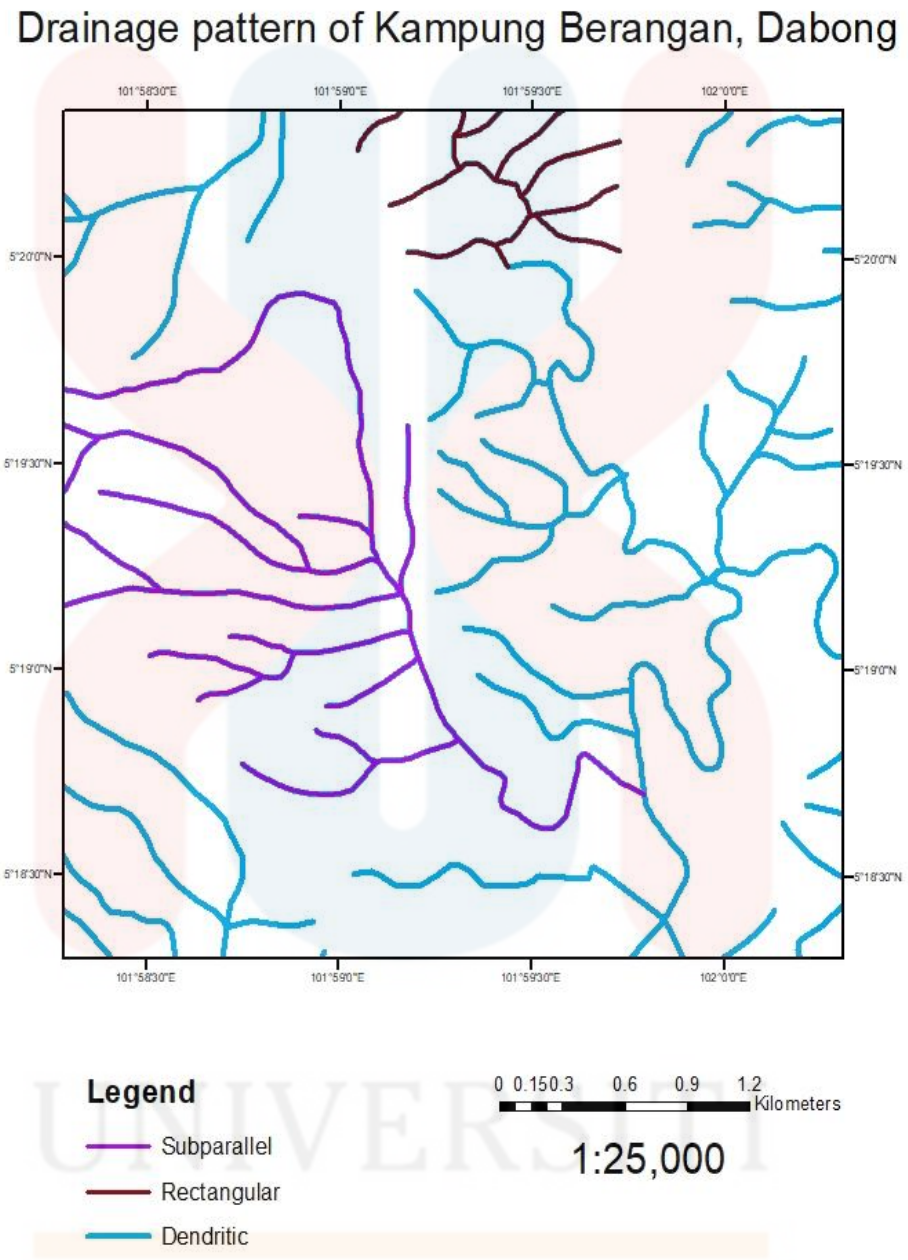


Figure 4.3 the map of drainage pattern where represented the types of river or tributaries in study area.

4.3 Lithostratigraphy

a. Stratigraphic position

Table 4.2 the layers of lithology in study area.

ERA	PERIOD	FORMATION UNIT	STRATIGRAPHIC COLUMN	LITHOLOGY
Cenozoic	Quaternary			Alluvium unit
Mesozoic	Cretaceous	Kenerong Leucogranite		Granite units
	Triassic	Gua Musang Formation		Meta-sediment units
Palaeozoic	Permian			

b. Unit explanation

The stratigraphy position indicates the layer types of rock units in the research study area where it has the relationship with the geological time ages. Based on Table 4.2, there are three types of rock that located as the lithologic unit of study area which are igneous rock unit and meta-sediment unit of rocks.

A. Alluvium unit

The unit of alluvium is deposited at Sungai Galas which is the main river of the research study. It is the unconsolidated material that deposited in recent geologic time ages which is quaternary period and sorted by running water such as river, rain and frost.

B. Granite unit

Singh et al. (1984), considered the stong Complex consists of three components, in order of decreasing age was named as Berangkat Tonalite, Kenerong Leucogranite and Noring Granite. Generally, the study area given is included in one of the formation which is Kenerong Leucogranite. There are granitoid rocks in the elements of Kenerong Leucogranite where it distinct of the composition units of each of rock and the distribution at the area such as biotite granite and fine to medium grained of leucogranite. Moreover, the biotite granite is an intrusive igneous rock which has a coarse grained texture and composed of high concentration of biotite than quartz and feldspar minerals. Yet, the leucogranite is an igneous rock types which about no dark of minerals and a light coloured of granitic rock.

The ages of this rock unit is in late cretaceous period where it deposited and intruded within the host rock of meta-sediment at that area.

C. Meta-sediment unit

The meta-sediment can be indicated as country rock of the area where it is located at the intruded magma of stong Complex of granite. Thus, due to the fluctuating state of metamorphism, the origin of meta-sediment rocks has been affected through the alteration. It was deposited at Late Permian to Early Triassic period and the oldest layer of strata.

Phyllite is metamorphic of rock types that in low metamorphic grade conditions and being through metamorphosed from slate. Basically, it has well-developed of foliation have fine-grained of texture because it undergoes the low pressure and low heat.

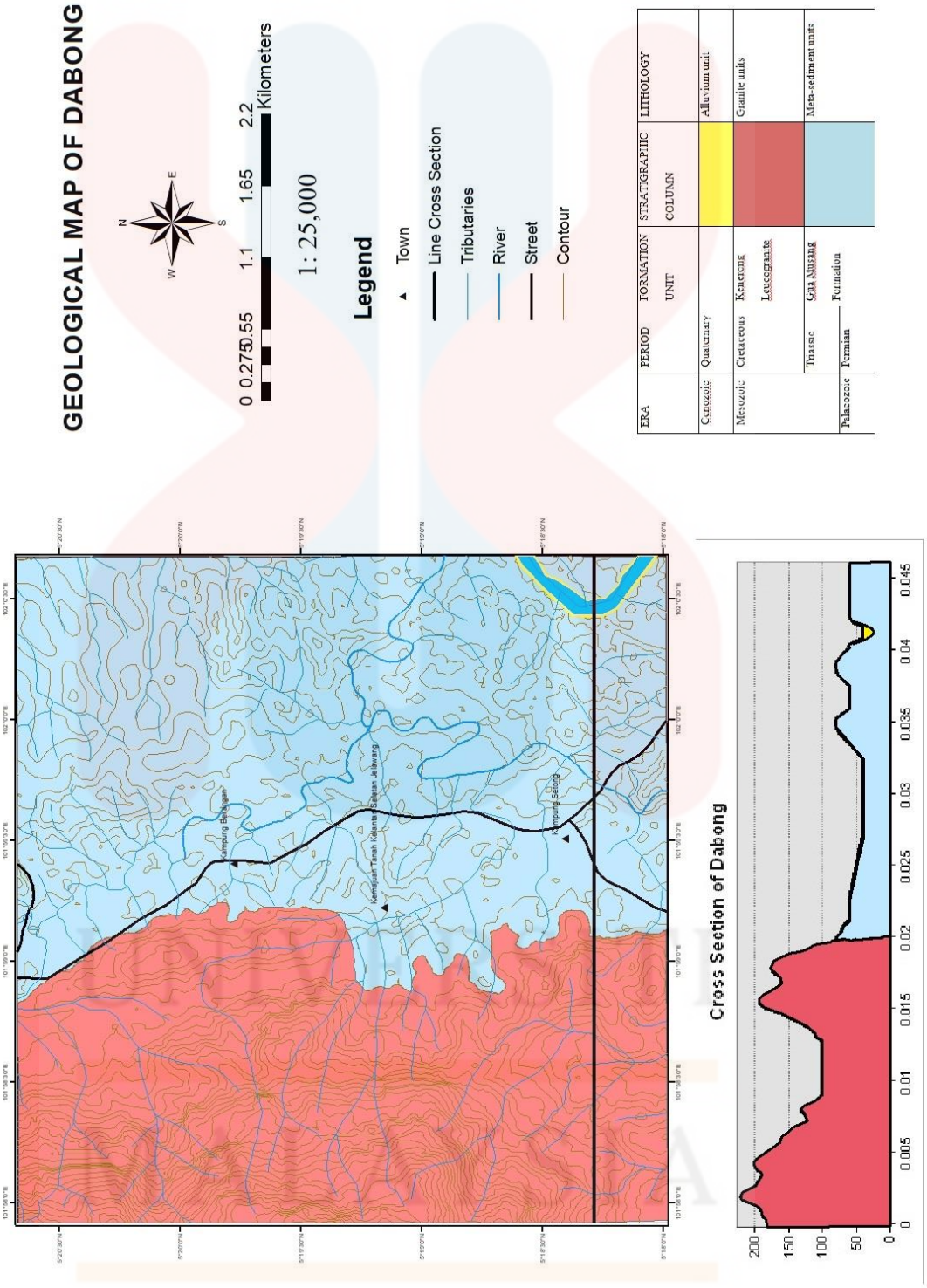
- Slate unit

  Slate is still under the type of metamorphic rocks where it is low grade of metamorphism product. The rock unit is formed through the metamorphism under the low pressure and heat condition which from sediments rock such as shale or mudstone. Hence, slate is has finest foliation from the other metamorphic rock and famous with the slaty cleavage of texture.

- Shale unit

  Shale is under the fine-grained of clastic sedimentary rocks that which composed from the mud that consisted clay and silt size particles. It is laminated and has fissile texture which the bedding plane is thin and can break easily.

Figure 4.4 depicted of geological map of study area which included the cross-section.



4.4 Structural Geology

Structural geology is processes of deformation of bodies of rock either in large scale or in small scale where Earth are being continually subjected by any types of stress that may affected the origin size or shape of plate margins. The factor for the deformation happened on the plate of margins because of the changes of rock body where the rocks exceed their strength that can be called as strain. It is known as the secondary structures which there are particular characteristics of origin, classification, occurrence and type for the geologic information. Generally, the study of the three-dimensional distribution of rock units can be the reference for their deformation histories of structures such as fault, joint, folds and fractures.

Based on the study area, structural geology is been presented in forms of map which as negative lineament and positive lineament of map. The lineament through topographic map can be described by obvious linear features which be able in indicate the geological structure from the landscape. Each of positive and negative lineament indicates of different geological information which for negative lineament represent of faults or fracture by rivers, and valley features while positive lineament represent the features of ridges or range that indicates of bedding. The Figure 4.5 is depicted as produced map of negative lineament where there is major straight-line feature can be identified from the study area in the direction of NW whereas for positive lineament is more linear trends that from the ridges at North study area. Hence, Raj, (1983) stated that the negative lineament for straight features of valleys is considered as non-resistant of rock units and for the positive lineament represents as exposure of resistant rock units.

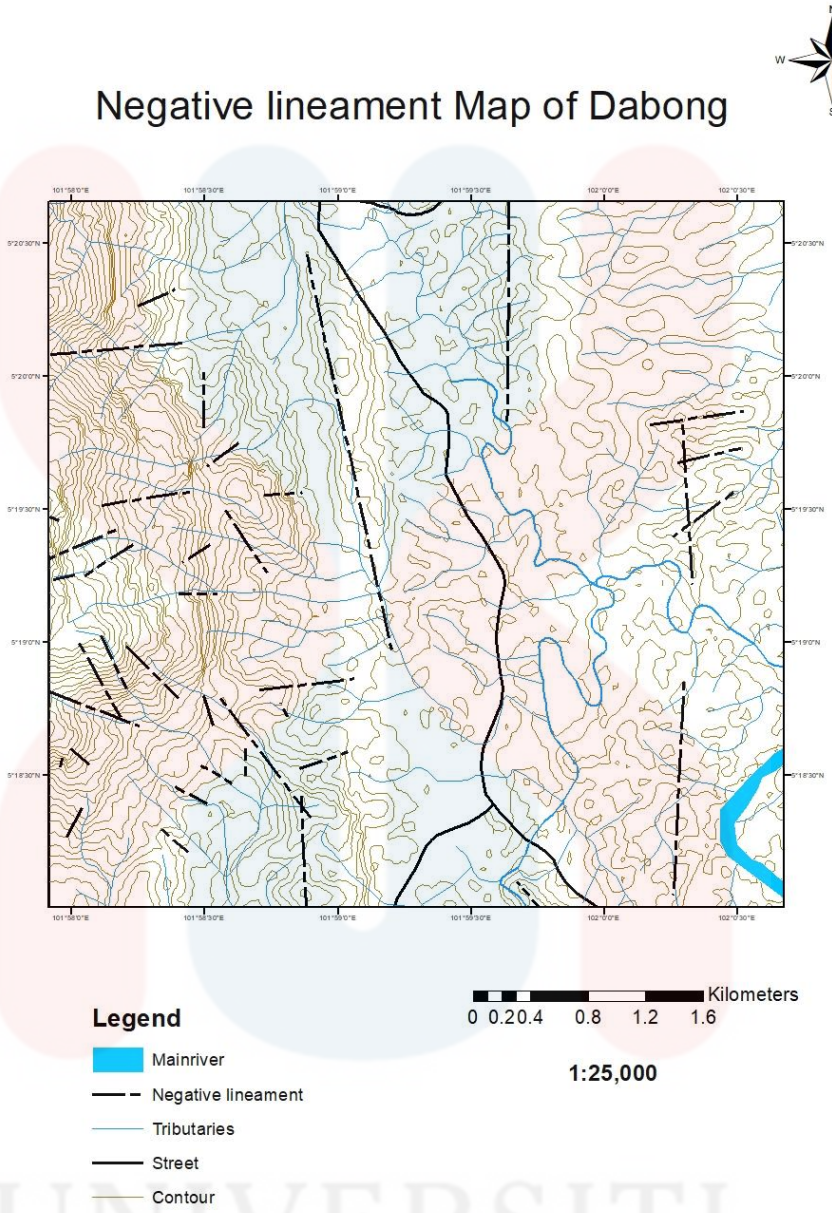


Figure 4.5 The negative lineament that indicated the structural of geology such as joint and fault.

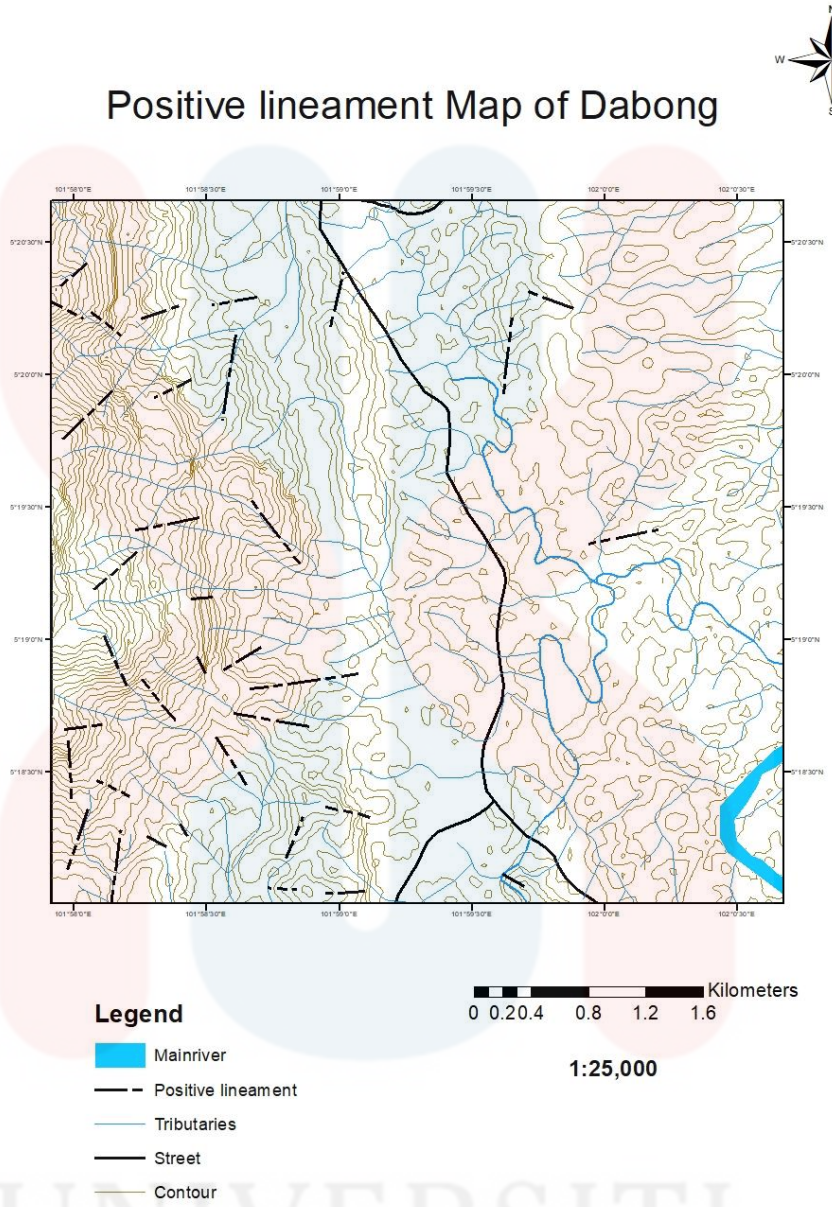


Figure 4.6 showed the positive lineament that represents the exposure of resistant in rock units.

a. Fault

Fault is one of the types of discontinuities which occur because of the deformation in bodies of rock or crust of Earth when force is applied. The exceed stress enforce to the body of a material can become fractures and resulted as two blocks of rock. This happen because the material of rock bodies is in brittle condition which it is fragile and easily to altered when any of movement of plate tectonics.

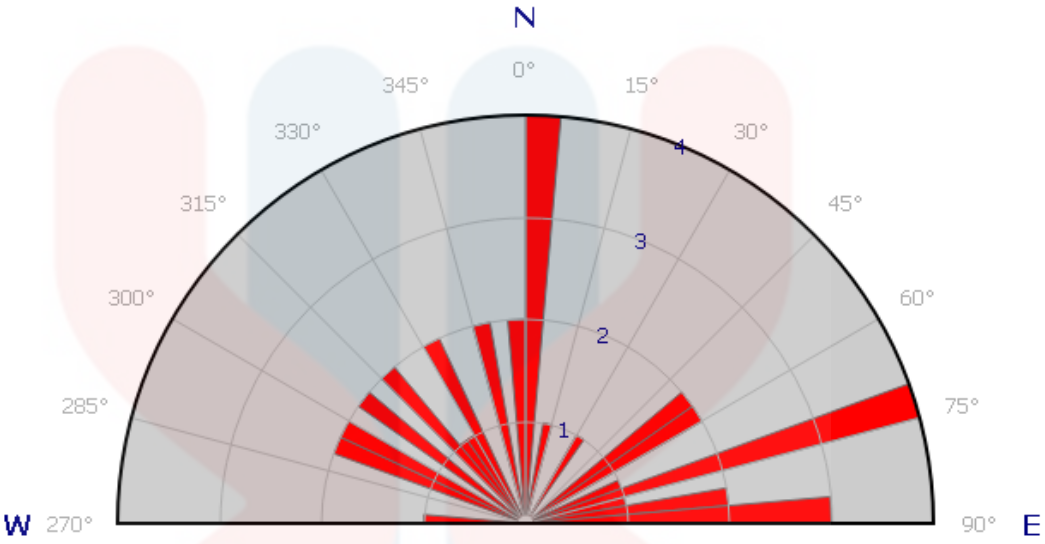


Figure 4.7 the rose diagram show direction of stresses that from lineament of study area.

Based on Figure 4.7, the maximum stress can be defined as sigma 1 where it comes from the direction of NE˚. Sigma 1 is acute angle which it is measured less than 90˚ and can be seen through direction of the stress. Next, this primary force is affected by the direction of the main stress NE˚ which it can assumed corresponds to the Peninsular Malaysia structural direction directed NNW˚ - SSE˚.

CHAPTER 5

CHARACTERISATION OF IGNEOUS ROCK IN KELANTAN

5.1 INTRODUCTION

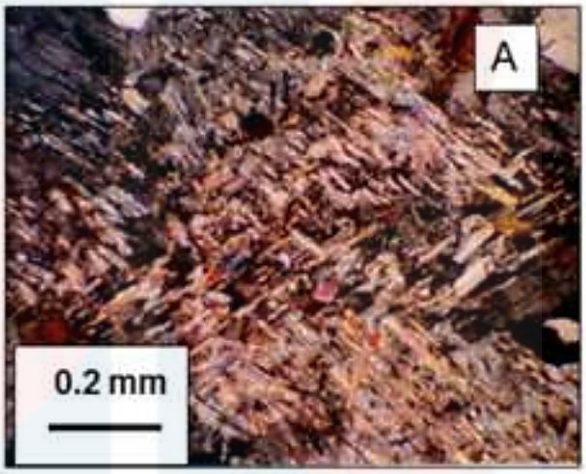
This chapter discussed about the characteristics of igneous rock that around Kelantan using the method of reviewing and analysing the research study. The method use is refers based on previous research study that have been studied and investigated related to the relevant topic of characterisation of igneous rock. The output of this method will be determined from the correlation of igneous rock in Kelantan which the secondary data has been compiled and interpretation will be made.

5.1.1 Petrography

The petrography is focuses on the description of the rocks by identify the mineral contents which called as petrographic analysis. A petrographic study is an in-depth examination of a single rock sample's chemical and physical characteristics. Macroscopic to microscopic studies of the rock sample does provide a complete analysis.

i. Main Range Granite

Table 5.1 show the viewed under crossed polarized light (XPL) thin section sample found as biotite granite

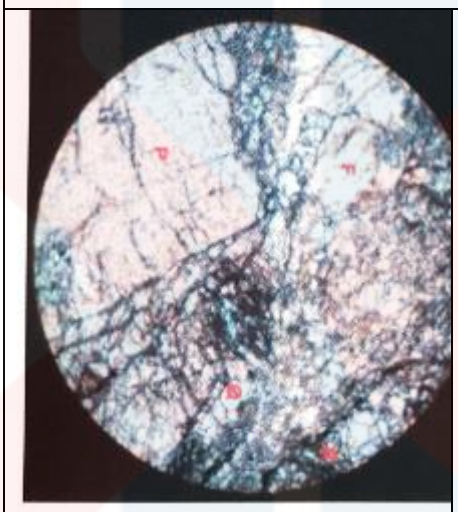
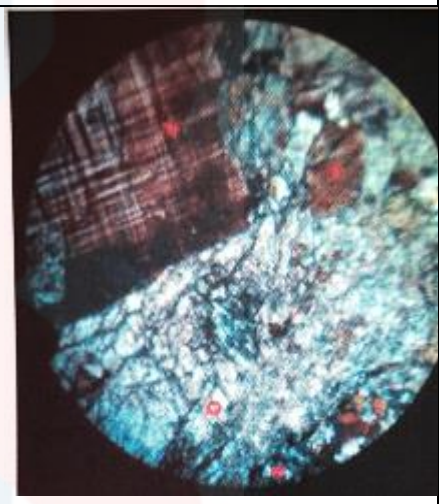
Thin section image

Name: Biotite granite

Source: Ghani et al, (2013)

The petrographic analyses showed the appearance of several mineral such as K-feldspar, plagioclase, quartz, muscovite and an accessory mineral which are zircon and apatite. The texture of microperthitic and microcline of K-feldspar is obviously can be seen through the thin section. The size of other minerals is seen compacted such as quartz mineral which in the shape of anhedral where it not well formed. The biotite is in the formed of small flakes and in range of 0.2mm size.

ii. Boundary Range Granite

Table 5.2 show the viewed under crossed polarized light (XPL) thin section sample as granite rocks.

Thin section image	
	
PPL	XPL
Name: granite	

Source: Ismail, (2015)

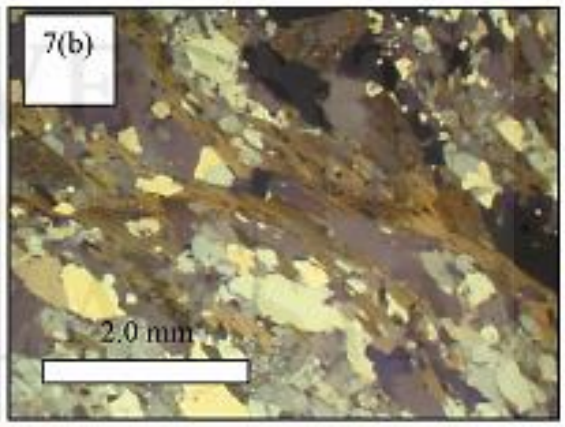
The mineral of thin section appeared in the rocks are plagioclase, quartz, feldspar, biotite. It is more dominant with plagioclase mineral where it size can be in the range of 2mm to 3mm. The mineral has visible twinning that called as microcline and in subhedral shape of mineral. Biotite mineral present in scattered distribution where the range sizes is around 1mm in dark colour. The shape of biotite mineral formed in the anhedral shape where the plane faces in unwell developed while feldspar and quartz is present with associated together with others.

iii. The Stong Complex

The Noring granite and the Kenorong granite are similar in their felsic compositions. The Berangkat granodiorite has a more mafic composition. The results using QAP triangle according to Umor, Ghani & Muda, (2019) previous research proved that the Berangkat Suite consists of monzonite quartz biotite and granite biotite, while Noring Suite consists of biotite granite, hornblend granite and microgranite, and Kenerong Suite contains rocks that named as quartz-rich granite.

a) Berangkat Suite

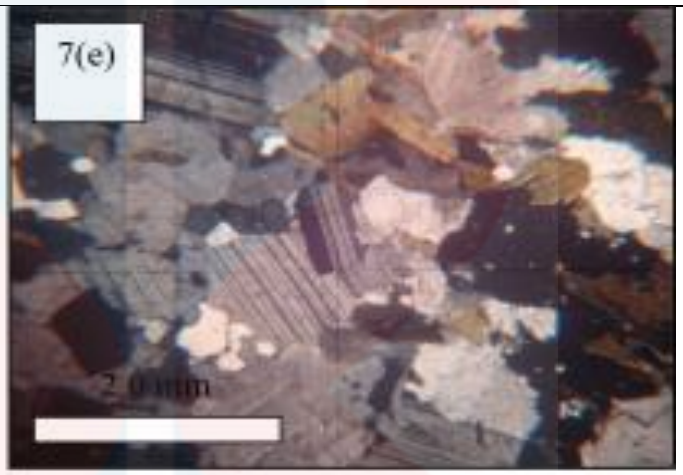
Table 5.3 show the viewed under crossed polarized light (XPL) thin section sample of quartz monzonite

Thin section image

Name: Quartz monzonite and Biotite granite

Source: Umor, Ghani & Muda, (2019)

There are several types of mineral can be seen in this sample of thin section that are quartz, hornblende, biotite, plagioclase and other accessory mineral such as zircon and sphene. Quartz mineral is shown in the light grey colour and it is in curved shape which it filled in the gaps of other minerals. Based on Umor et al, (2019) it filled 20% of matrix volumes range in size between 0.5 - 2 mm and average 1.5 mm and there are myrmekite texture in the sample that formed because of experiencing a strong contagion, supported by orientation regular quartz is almost parallel to its biotite and size which is relatively small. Plagioclase mineral is in 1st order interference and colourless which it range between 2-5 mm and average 3 mm. Next, the mineral of hornblende that shown in colour of green and has two intersecting grain and shape hornblende is usually a rectangular or hexagonal prism while for biotite is elongated of mafic-shaped mineral and it has brown to golden to dark brown in colour. The presence of biotite is more than hornblende mineral. Hence, the accessory mineral that mentioned in previous research is it has the present of sphene and zircon in the monzonite rock.

Table 5.4 show the viewed under crossed polarized light (XPL) thin section sample of granodiorite.

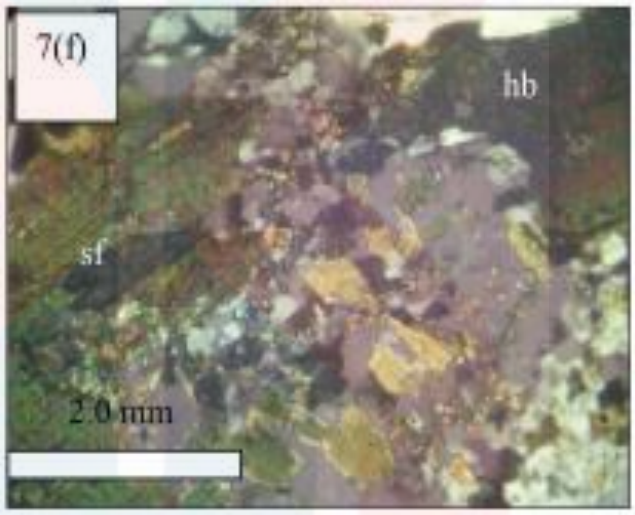
Thin section image

Name: Granodiorite

Source: Umor, Ghani & Muda, (2019)

The image of thin section for table 5.4 under the XPL is shown the minerals of quartz, alkali feldspar, plagioclase and biotite. The apparent of euhedron shape banding which called as polysynthetic twinning in plagioclase is shown where it in colourless or grey colour. Quartz mineral is covers almost 40% rock volume, having a range of mineral sizes between 0.2 mm to 2.5 mm. Moreover, the alkali feldspar that consist of orthoclase is to be seen in colourless colour however it mineral size is quite same with quartz mineral. Biotite is seen through the darkest colour appearance which it is scattered around other minerals. From this minerals content that has been found refers to the

granodiorite rock which it is medium to coarse-grained that most abundant in igneous rock types.

Table 5.5 show the viewed under crossed polarized light (XPL) thin section sample of tonalite

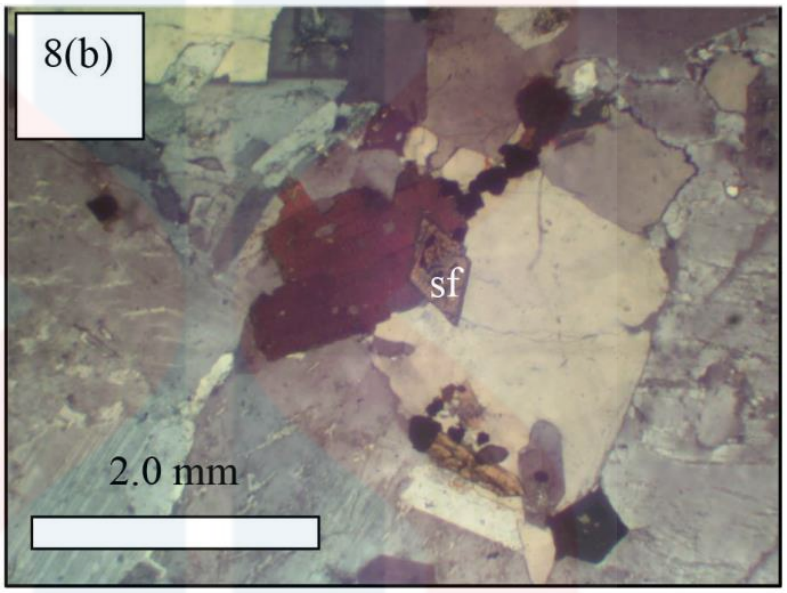
Thin section image

Name: Tonalite

Source: Umor, Ghani & Muda, (2019)

The mineral composition that in other sample rock found are contain of quartz, plagioclase and also pyroxene and amphibole as accessory minerals. The quartz content is >20% where it is in the grey colour of mineral while plagioclase present less than quartz mineral. Based on the table 5.5, the name of granodiorite and tonalite is made after detail the mineral content in the point counting mode is performed and it is refer to the name of lithodemic unit of Granodiorite Bertam and Tonalit Dabong.

b) Noring Suite

Table 5.6 show the viewed under crossed polarized light (XPL) thin section sample of biotite granite

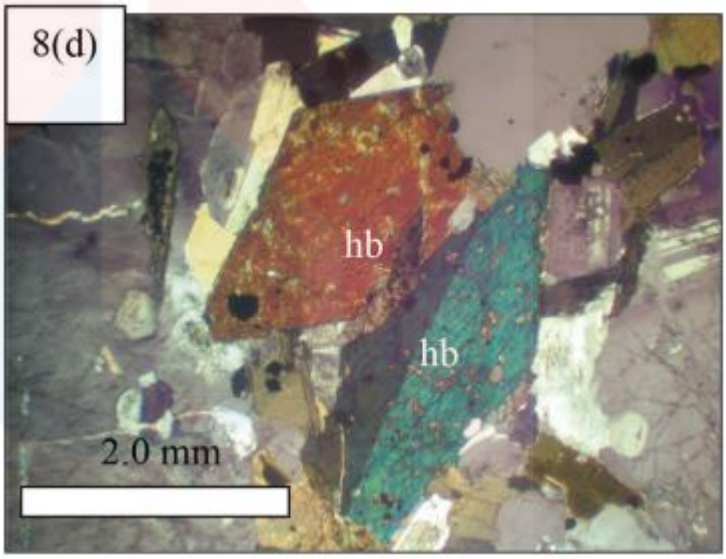
Thin section image

Name: Biotite granite

Source: Umor et al, (2019)

Mineral that can be seen are quartz, plagioclase, alkali feldspar, biotite and two types accessory mineral such as zircon and apatite. The quartz mineral which pale yellow in colour formed as anhedron shape that in the size of 3mm and some of the it can be seen the apatite needle-shaped which in range about 1mm. Another mineral that can be seen is plagioclase which it is also in shape of euhedron with an average size smaller than quartz and alkaline feldspar in 1 mm. Alkali feldspar that present in the type of microline that that shows the twin-striped texture of the iron grid It also formed as microperthite texture, which is

mutually exclusive microcline and plagioclase are usually albite type. Hence, the K-feldspar has shown the zoning within other minerals. The biotite mineral appeared in a group together with an accessory mineral such as zircon, tourmaline and sphene.

Table 5.7 show the viewed under crossed polarized light (XPL) thin section sample of hornblende granite.

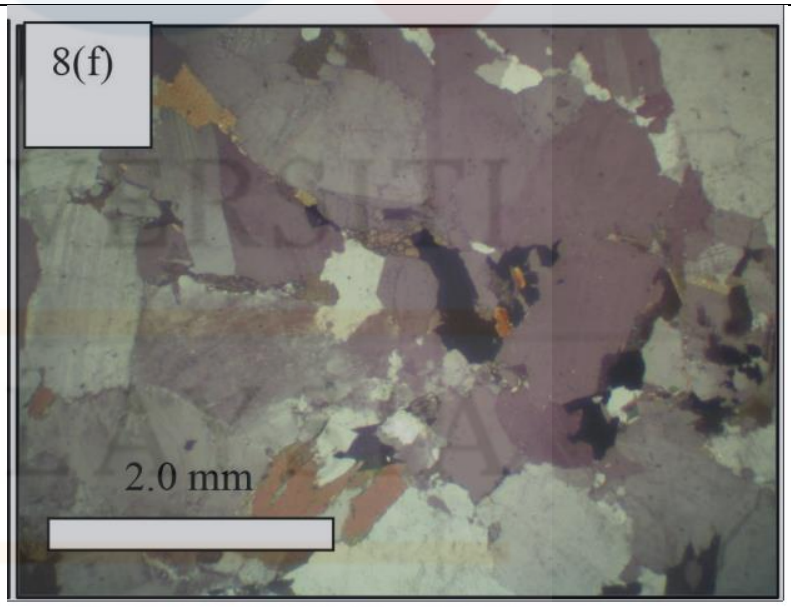
Thin section image

Name: Hornblende granite

Source: Umor et al, (2019)

The petrography of next thin section image under crossed polar light (XPL) consists of quartz, plagioclase, alkali feldspar, hornblende and biotite yet also other accessory minerals such as zircon, tourmaline and apatite. Firstly, quartz is mineral that present relatively smaller than alkali feldspar and plagioclase

where the range size is between 0.1mm to 1mm at shape of anhedral. Alkali feldspar mineral that formed is a typeof orthoclase and have a little bit present of microcline which the shape of mineral in shape of subhedron that range from 0.5 mm to 2 mm size. Next, the plagioclase can be seen through the albite twinning that clearly visible in the shape of subhedron. The present of hornblende, biotite and tourmaline is more than others mineral which covered about 30% from the rock volume which hornblende is more dominant follows by others. Thus, the selection names of rock according to the majority intensity of minerals.

Table 5.8 show the viewed under crossed polarized light (XPL) thin section sample of microgranite.

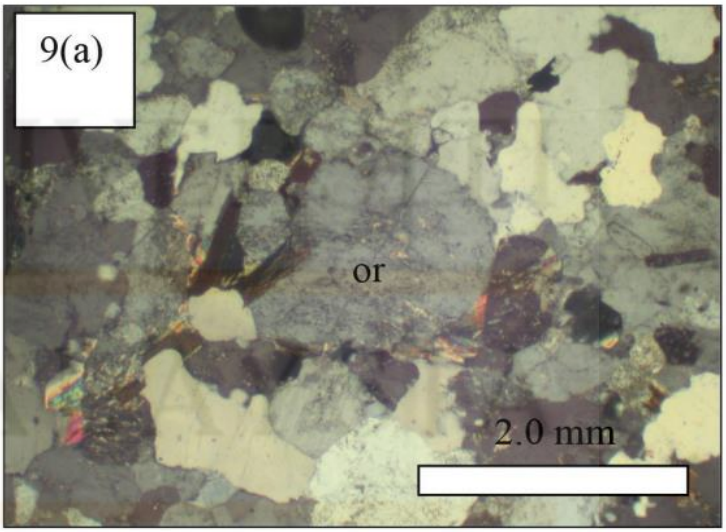
Thin section image

Name: Microgranite

Source: Umor et al, (2019)

The next sample that have been found was consists of quartz, alkali feldspar which orthoclase and microcline types, plagioclase, biotite, albite and together with accessory mineral which is apatite. Quartz mineral that present is in same grain size which in the shape of anhedron that ranges between 0.1mm to 0.3mm. Hence, there is an intrusion of biotite and apatite that in the quartz formed. Mineral of alkali feldspar appeared in range of 0.2mm to 2mm while plagioclase present in the shape of blade-shaped with length average 0.2 mm and euhedron-shaped.

c) Kenerong Suite

Table 5.9 show the viewed under crossed polarized light (XPL) thin section sample of quartz-rich granite

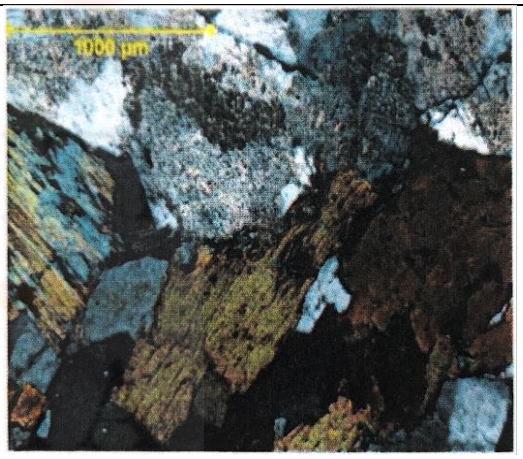
Thin section image

Name: Quartz-rich granite

Source: Umor et al, (2019)

The sample of thin section that been investigated by previous research in Kenerong suite consisted of quartz percentage is almost 70% of the volume of the rock. Other than that, there are vary mineral that presence in this rock which are alkali feldspar, plagioclase and muscovite for felsic mineral while biotite for mafic mineral. Quartz in the sample is in range of 0.2mm to 2.5mm, alkali feldspar in size of 0.5mm to 1mm and plagioclase is in of 0.1mm to 1mm. Yet, biotite mineral was less than 5% of the volume of rock that in size of 0.2mm and randomly scattered inside rocks.

iii. Kemahang Granite

Table 5.10 show the viewed under crossed polarized light (XPL) thin section sample

Thin section image	
	
PPL	XPL
Mineral: granite	

Source: Ramli, (2018)

The thin section of sample show that the present of several mineral that are quartz, alkali feldspar, biotite and hornblende. The quartz mineral covered about 10% of mineral content and is in anhedral shape. The colour of quartz is colourless in PPL while it in the greyish in colour. Alkali feldspar is dominant in the mineral content where it covered about 64% which it in the subhedral form. The shape can be seen the intermediate of plane faces. Next, biotite mineral appeared scattered in the mineral content that it has same range size and percentage while hornblende is more than the content of biotite mineral. It is seen in subhedral to euhedral shape where in the brownish colour.

5.1.2 Geochemical analysis

i. Main Range Granite

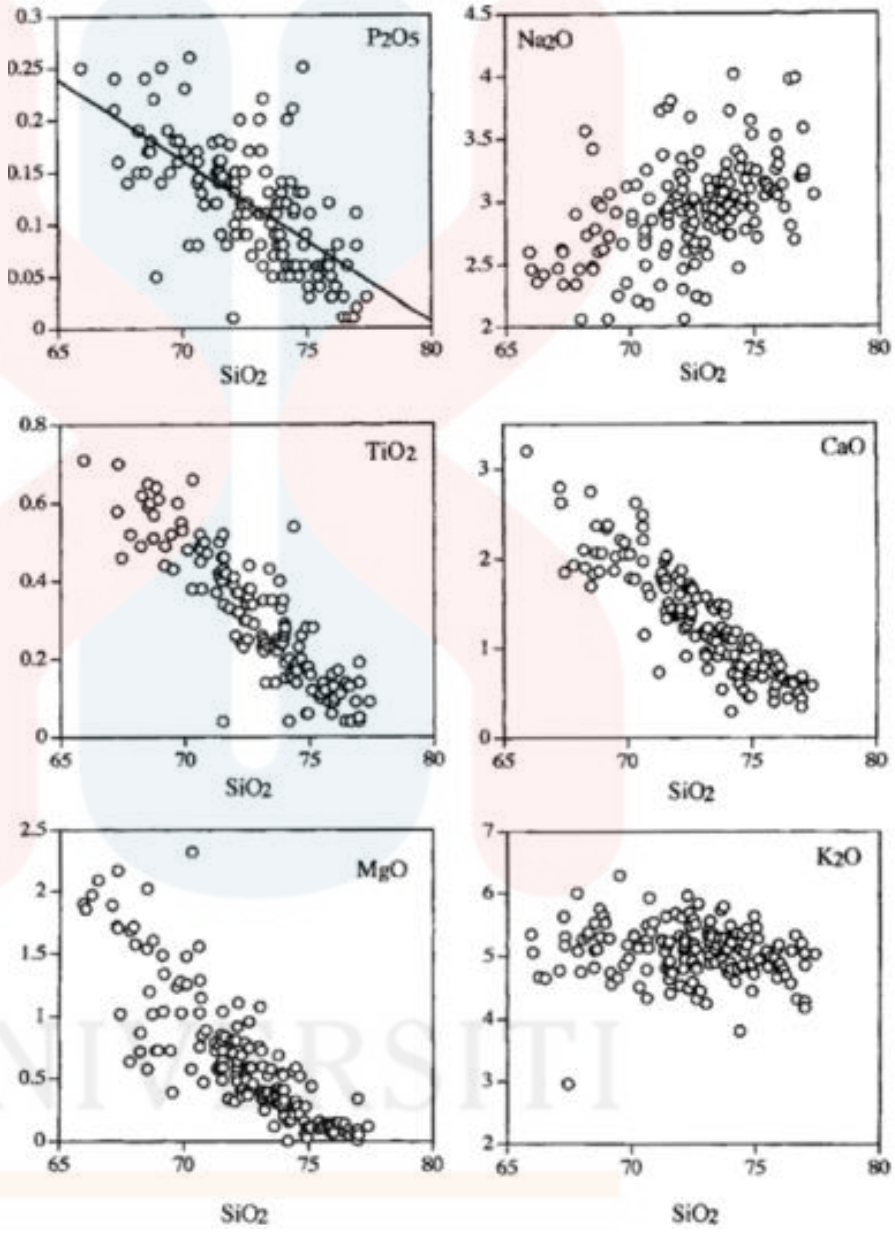


Figure 4.8 the different plots of major elements from the Main Range Granite. (Ghani, 2000)

Main Range Granite has shown different pattern of its major-element vs SiO_2 where it divided into 6 major-element such as P_2O_5, Na_2O, TiO_2, CaO, MgO and K_2O. Most of the element specify to the compatible element in high silica content where it

start off from high concentration and drastically decrease when rise in SiO_2. The example of elements that can be seen the changes are P_2O_5, TiO_2, CaO, and MgO while opposite to Na_2O which the trend is behave as incompatible element that increase in SiO_2 and assumed to form in magma by different chemical. Hence, the K_2O show slightly changes of the trend of element concentrations.

ii. Boundary Range Granite

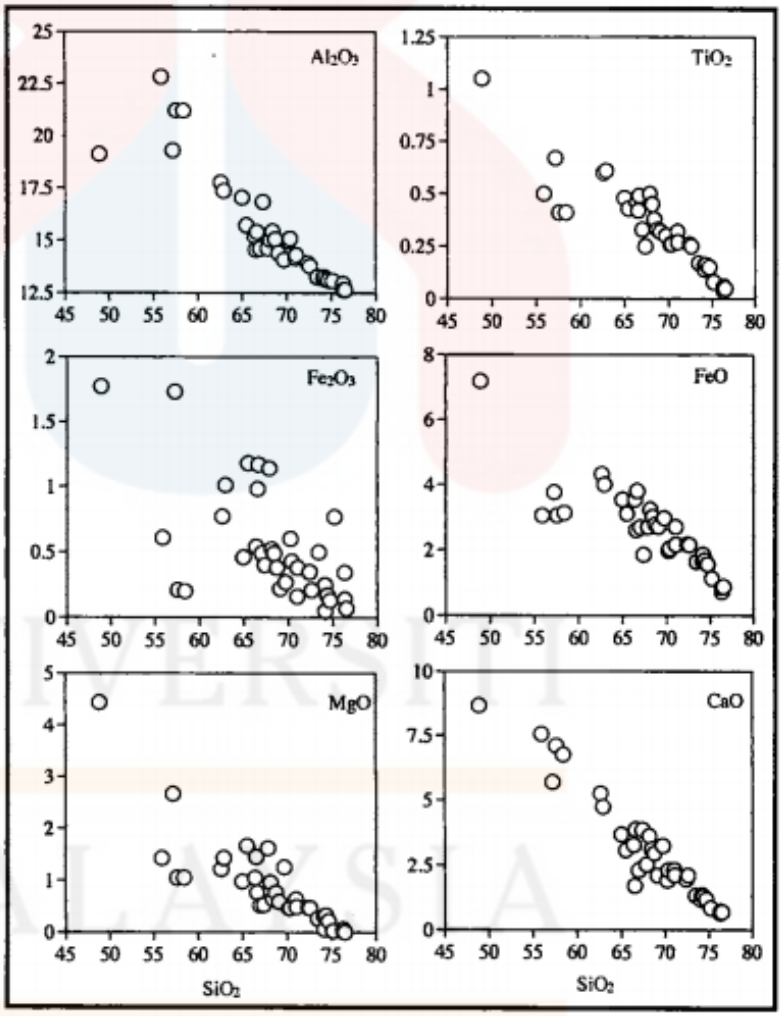
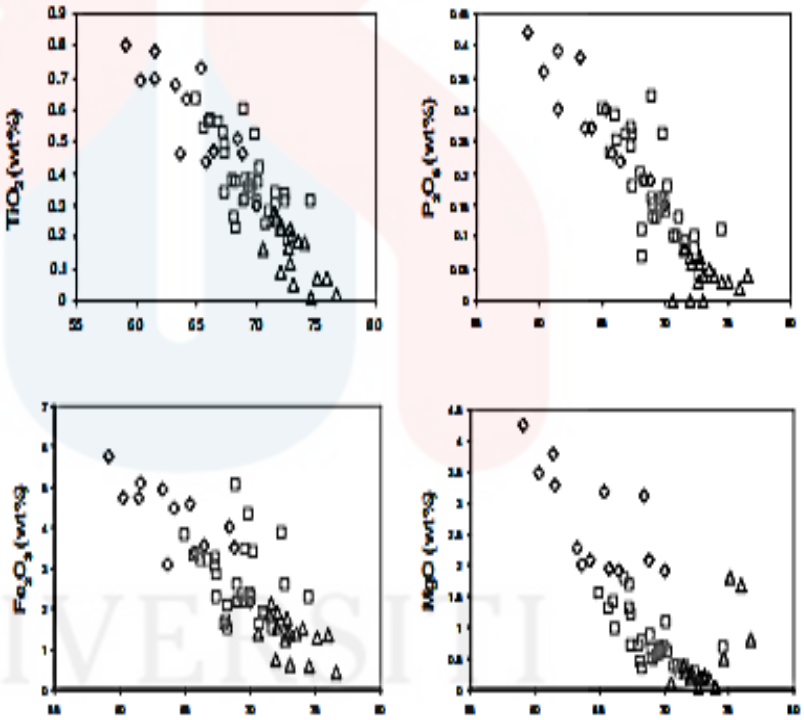


Figure 4.9 the trends of plot in different major-element at Boundary Range Granite. (Ahmad et al., 2002)

The trends of Main Boundary Range are characterised by major-element vs SiO_2 which in Harker Diagram. Based on figure 4.8, show that are similar trends of each element of Al_2O_3, TiO_2, Fe_2O_3, MgO and CaO where the pattern is decreasing when SiO_2 increase. Hence, the entire elements are behaving as compatible element that in high silica content.

iii. The Stong Complex



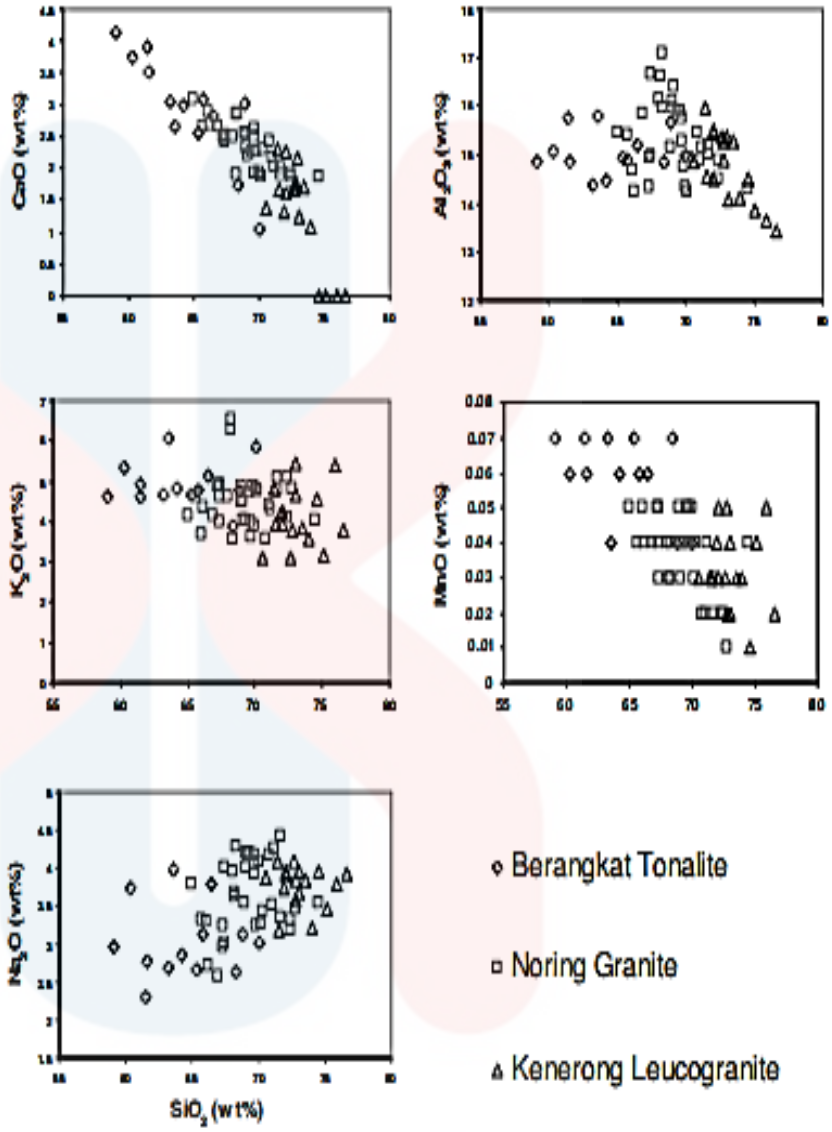


Figure 4.10 the trend element which represent the plots for the Stong Complex in between major element vs SiO_2. (Umor et al., 2015)

Based on the result Harker diagrams which show plot in major element of only vs SiO_2. The pattern of elements in the diagrams represented the amount of percentage of difference compositional such as TiO_2, Fe_2O_3, CaO, K_2O, Na_2O, P_2O_3, MgO, Al_2O_3, and MnO. For the TiO_2, Fe_2O_3, CaO, MgO, and P_2O_3, show from the high concentrations to decreasing pattern when the SiO_2 increase. Hence, it is proved that the element is compatible and followed by

Al_2O_3, MnO and K_2O which it decreases intermediately. However, Na_2O is the only element show different pattern which increasing patterns trend and it as incompatible constituent changes.

5.1.3 Discussion

The characterisation of igneous rock in Kelantan can be classified into two types of granitoids or granite provinces which well-known as I-types and S-types of granite classifications. The study considered I-type granites mainly by high-temperature hornblende dissolution as the melt products of meta-igneous source rocks, while S-type granites are the result of melting meta-sedimentary source material mainly through muscovite or biotite dehydration reactions.

Table 5.11 the comparison of I-S types granite.

Characteristics	I-types granites	S-types granites
SiO_2	53-76%	65-79%
$Al_2O_3/(Na_2O+ K_2O + CaO)$	<1.1, increase with increasing of SiO_2.	>1.1, increase with increasing of SiO_2.
Na_2O in silicic rocks	>3.2%	variable
P_2O_5	Decrease with increasing of SiO_2	Increase with increasing of SiO_2
Main enclaves	Mafic microgranular enclave, dioritic	Metasediments

Key modal minerals	Biotite, magnetite, hornblende, titanite	Biotite, muscovite, ilmenite, sillimanite, garnet
Common range of rock types	Granite to granodiorite and gabbro	Leucogranite to granodiorite

Source: Ghani et al, (2013).

4The Main Range Granite is more likely to S-types granite classification. According to Ghani, (2005) the 'S' type features can be specify by, high initial S7Sr/~Sr isotope ratio, >0.710, low Na_2O content, <3.2% Na_20 in rocks with ~5% K_20, have narrow range of felsic rock which SiO_2 is at 65.95% to 77%, and lastly, have high K_20 or Na_20 ratio. From that, the element of Na_2O increases with increasing of rise of SiO_2 whereas it also can be classified as I-types granite where based on figure 4.7 it show the increases of P_2O_5 when increases of SiO_2. Moreover, the Boundary Range of Granite is similar to Eastern belt granite than Western belt granite where it has the characteristics of I-Types granite classification. This is because referred to Ahmad et al, (2002) that even though most of the granite rocks from the Boundary Range have SiO_2 content that about > 65% of SiO_2 comparable to that of granite from the Western Belt, some elements such as P_2O_5, Ba, Sr and Na_2O_5 are quite distinct. The granite of the Boundary Range can be graded as granite of the I-type as the granite has high Na_2O content than Western belt granite.

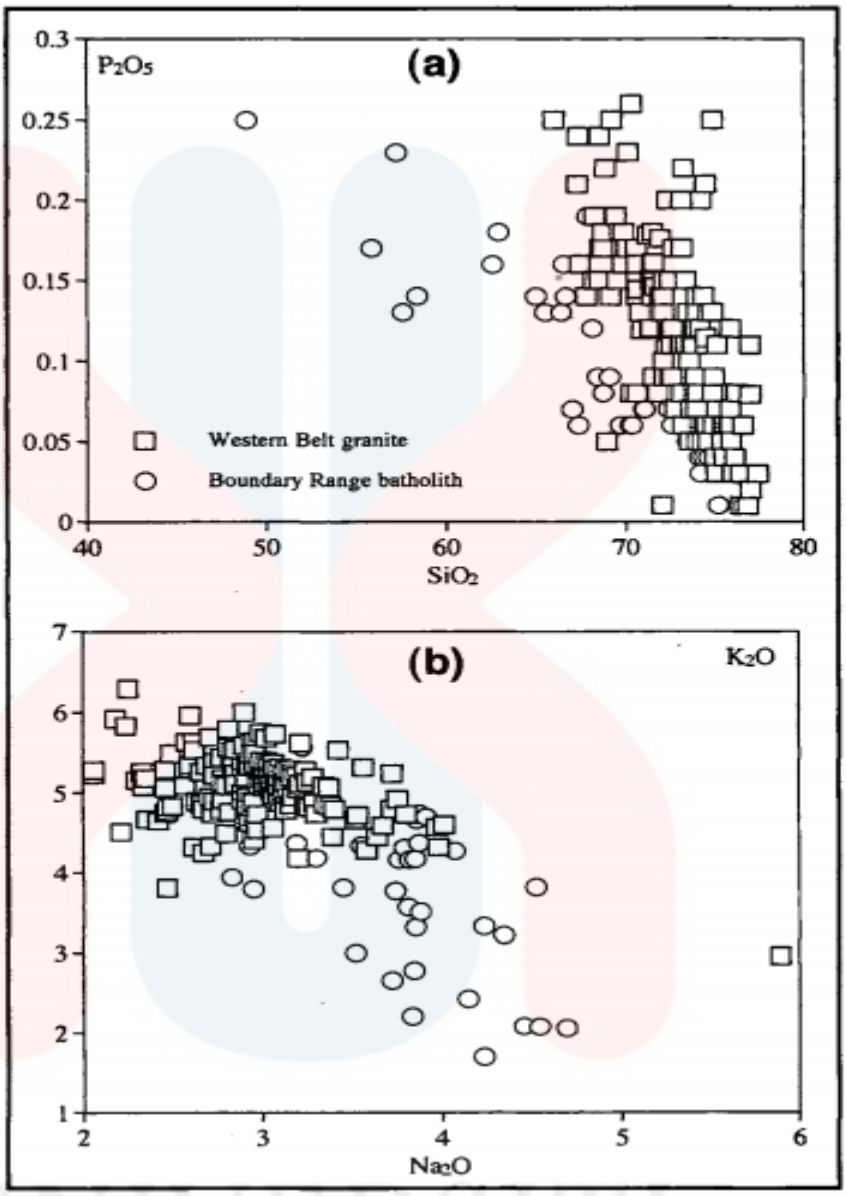


Figure 4.12 the comparation of element between Boundary Range Granite and Western Belt granite (a) P_2O_5 vs SiO_2 and (b) Na_2O vs SiO_2.

The Stong Complex is included in Central belt of granite where it is in the between of Western Belt granite and Eastern Belt granite. According to Chappel & White, (1974) where the rock types of Stong Complex of granite can be classified as I-types granite classification. This is because the trend Na_2O element is higher when Si_2O increase.

CHAPTER 6

CONCLUSION AND SUGGESTION

6.1 CONCLUSION

Based on this chapter, the result from the analysis of Geology of Dabong and Characteristation of Igneous Rock in Kelantan can be concluded. The study area of Kampung Berangan, Dabong has several lithologies of the rock type's distributions that consist of acid intrusives of granite, phyllite, slate and shale. This research is done by made the geological mapping such as base map, drainage pattern and lineament map where all the information of geological data can be produced.

The characterisation of igneous rock in Kelantan is more focuses on the granite formation which it is divided into two granite provinces which are I-S types of granite classification. The varies of mineral content and chemical composition in particular location presented the different types of igneous rock such as Biotite Granite, Tonalite and Granodiorite was found at Berangkat Suite. From the result reviewed previous data research, the granite belt of Western Belt, Central Belt and Eastern Belt that included of igneous rock types had been identified. The Western belt has Main Range granite that classified into transitional of I-S Types of granite while Eastern belt is in categories of I-Types granite and have some sub-ordinated

of S-Types. The Stong Complex is located in Central Belt where it also classified in I-Types of granite classification. Hence, Kelantan has several types of igneous rock which major in the granitoids types of rocks.

6.2 RECOMMENDATION

Based on the research that has been done, I would like to suggest about the research for the petrography of igneous rock in scattered location in Kelantan especially at the Main Range Granite. I assumed that the Main Range Granite for the previous data is lack of research peculiarly for petrography and geochemical analysis which at the Kelantan area. Moreover, this research can be improved mainly for the pandemic season by doing more advance technique as to get more detailed geological information and data.

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