GEOLOGY AND GEOCHEMISTRY OF GRANITE AT DABONG, KUALA KRAI, KELANTAN

By

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DECLARATION

I declare that thesis is entitled General Geology and Geochemistry of Granites at Dabong, Kuala Krai, Kelantan is a result of my own research except as cited as 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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Signature : ____________________

Name of Supervisor : ____________________

Date : ____________________

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GEOLOGY AND GEOCHEMISTRY OF GRANITE AT DABONG, KUALA KRAI, KELANTAN

ABSTRACT

The research area is located at Dabong, Kuala Krai, Kelantan which cover 25 km^2 dimensions. The purpose of this research study is to produce updated geological map of the study area in scale of 1: 25 000, to investigate the distribution element of granite using observation of petrographic analysis from secondary data and to study the types of granite based on a geochemical study. Secondary data and previous research was the main source and method for this research either for geological information and the specification study. Three lithological unit was identified which is granite, interbedded sandstone, siltstone and shale and phyllite, slate and shale subordinate sandstone and schist. For geochemistry of granite, it can be observed various type of granite like tonalite, granodiorite, monzodiorite and leucogranite.

Keywords: Dabong, granite, geological, geochemistry, petrography

GEOLOGI DAN GEOKIMIA GRANIT DABONG, KUALA KRAI, KELANTAN

ABSTRAK

Kawasan penyelidikan terletak di Dabong, Kuala Krai, Kelantan yang meliputi dimensi 25^2. Tujuan kajian penyelidikan ini adalah untuk menghasilkan peta geologi kawasan kajian yang dikemas kini dalam skala 1: 25 000, untuk menyiasat unsur taburan granit menggunakan pemerhatian analisis petrografi dari data sekunder dan mengkaji jenis granit berdasarkan analisis geokimia. Data sekunder dan penyelidikan sebelumnya adalah sumber utama dan kaedah penyelidikan ini sama ada untuk maklumat geologi dan spesifikasi kajian. Tiga unit litologi dikenal pasti iaitu granit, batu pasir bersilang, batu lumpur dan serpih dan batuan, batu pasir dan syal bersilang batu pasir dan serpih. Untuk geokimia granit, dapat dilihat pelbagai jenis granit seperti tonalit, granodiorit, monzodiorit dan leukogranit.

Kata kunci: Dabong, granit, geologi, geokimia, petrografi

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LIST OF ABREVIATION

Al	Aluminium
ASI	Aluminium Saturation Index
Ca	Calcium
cm	Centimetre
E	East
Fe	Ferum
GIS	Geographic Information System
GPS	Global Positioning System
IUGS	International Union of Geological science
K	Potassium
km	Kilometres
Km^2	Kilometre square
m	meter
Mg	Magnesium
NNW	North-Northwest
P	Phosphorus
Pb	Lead
QAPF	Quartz-Alkali Feldspar-Plagioclase-Feldspathoid
SiO_2	Silicon dioxide
Sr	Strontium
SSE	South-Southeast
Ti	Titanium
TIN	Triangulated Irregular Network
XRF	X-ray fluorescence

LIST OF SYMBOL

<	Less than
>	Greater than
%	Percentage

CHAPTER 1

INTRODUCTION

1.1 General Background

The research is about general geology which is concerned with the earth surface and it's interior. Geology is including the study of planet and the space. It also describes the earth structure on the surface and beneath it. Geology also can determine the relative and absolute age of rock or fossil found. General geology is like geomorphology, lithology, stratigraphy, structural geology and others that relate. This data information is essential for this research and future research.

Study of granite is more specific which involving petrographic analysis by the study from secondary data. The percentage of individual mineral and the type of mineral content are observed. Determining the trace element is one of the objective. Trace elements are those which occur in very low concentrations in common rocks usually <0.1% by weight (Ugbe et al., 2016).

The main chemical components that will be analyse is, SiO_2, Al_2O_3, Fe_2O_3, Na_2O, K_2O, TiO_2, P_2O_5, SO_3 , MnO, MgO. This research would like to know the evolution of magma by plotting the main elements data from the SiO_2 vs K_2O igneous rock model. These two elements always have the opposite pattern. The increasing of SiO_2 means decreasing in K_2O and vice versa. From the geological and geochemistry study, the data is managed in various method in order to display in proper way. Hacker diagram is use to view the major and minor elemental of sample.

Several method is used in this research like the study and collecting data from previous research and secondary data. Proper and organise way of handling data are practiced to make sure the best result is produced. Various of the map will be created in this study such as base, drainage pattern, topography, and geological map. All the map will be develop using all data collected from secondary data within the study area with the aid of ArcGIS software.

1.2 Study Area

1.2.1 Location

Kelantan is one of the states in Malaysia located in the north eastern corner of peninsular Malaysia. Narathiwat which belongs to Thailand is a border to Kelantan. For local, Kelantan is a border with Perak to the west, Pahang to the south and Terengganu to the south east. This state is facing the South China Sea in the north east.

Kuala Krai is an inland district serving as the focal point of Kelantan states in the north-east of Malaysia which dominated with the hills and the whole region denoted as tropical rainforest prior to the 20th century. The area retains the junction of two famous rivers, Sungai Lebir and Sungai Galas, to form the Kelantan River, which at that point flows somewhere within 70 km north across a prominent one of the most heavily populated flood plains on the Malaysian Peninsula to its South China Sea estuary near Kelantan's state capital.

In specific, the study area located at Dabong, Kuala krai which one of the Kelantan districts. Dabong is situated between Jeli and Kuala Krai, which links the two districts where the main road to Gua Musang is mainly used by people. Dabong is a small town surrounding by hills. Gunung Stong is a popular place in Dabong where people came to hike. The study area will be covered 25 km^2. Figure 1.1 show base map of study area to see the feature. From the base map that create from the ArcGIS, the highest elevation recorded is 340 m and the lowest elevation is 40 m.

The morphology is considered a hill but eroded as time passing by human activities. The research area consists of two types of vegetation which is palm plantation and rubber plantation. Besides that, there are Kampung Sri Maju which accommodates a number of residents located at south-east of the study area. A river that located in the study area is Sungai Serong which is just a small river.

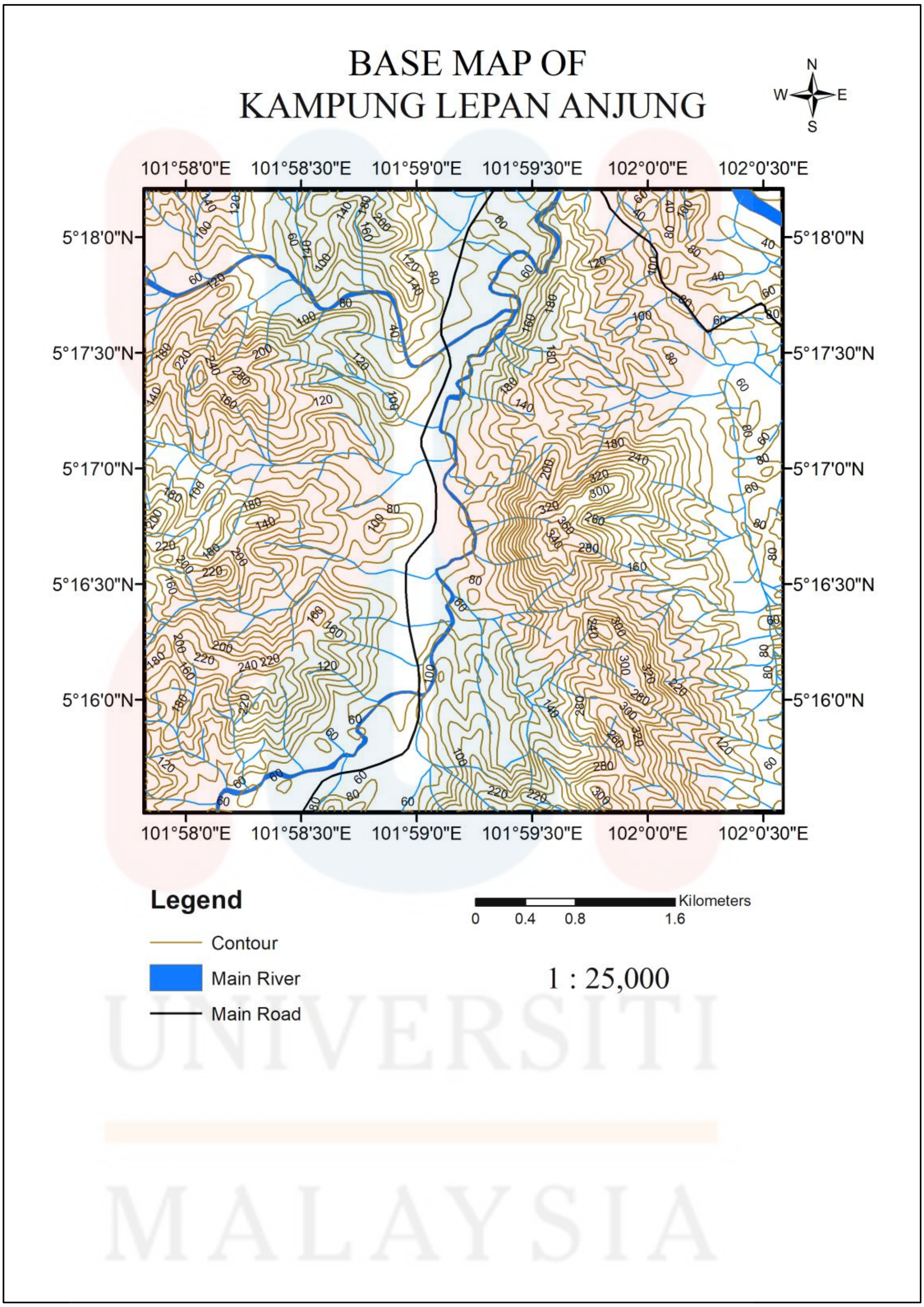

Figure 1.1: Base map of study area.

1.2.2 Road Connection/Accessibility

Road is a crucial aspect of a residential area, as the road will connect one location to another. There are certain kinds of road networks like bridges, highways, and river channels. The driving routes can also be reached from Kuala Lipis – Merapoh main road if the driver is from southern Malaysia Peninsula and from Pahang downtown. The road type is the federal road and place of residence.

The federal priority is on connecting two areas and less crowded compared to highways. In the meantime, the rural roads connect short-distance between the two areas and are not usually crowded. This train operates from the south to the last Tumpat Kelantan station. Numerous services and housing have been given to support Dabong people.

Road of Gua Musang to Dabong is one of the accessibility along the study area which is the common road people use. There also has road that connect to surround area. Figure 1.2 show the road connection between Gua Musang and Dabong.

Figure 1.2: Road connection between Gua Musang and Dabong.

1.2.3 Demography

The distribution of people in the Dabong area is classified by ethnic group. The residents live in a Dabong area with various ethnic groups such as Malay, Chinese, and Indians. Malaysian ethnicity is the largest ethnic group in the district of Dabong, while Chinese and Indian ethnicity have only a minor group in the district.

According to Department of Statistic Malaysia (web), in 2010 Dabong was populated by a total of 13 173 people, 12 130 of which are Malaysians, 15 of whom are Chinese, 49 of whom are Indians, 4 of whom are from other groups and 975 of whom are non-Malaysian nationals, such as immigrants from Bangladesh, Myanmar and Indonesia who have settled in this state as palm and rubber workers. More details for this was show at Table 1.1 that have distribution of people in Dabong (2010).

City government districts have the largest local population. Urbanisation is one of the ways in which rural living conditions can be changed. Meanwhile, Dabong gets the source of agricultural plantation profits, such as palm oil.

The nearest main road from Dabong to Gua Musang lies one of the palm oil plantations. It shows that in Dabong town, Malay ethnics still predominate. They usually work as a rubber tapper, live on an oil palm plantation, and are self-employed.

Table 1.1: Distribution of people in Dabong (2010).

Jajahan/ Local Authority Area	Total	Age Group							
		0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39
M.D,Dabong	40,659	4,418	4,581	5,573	5010	3929	2688	2251	2161
Dabong	1,356	132	143	175	155	93	96	75	66
Kemubu	1133	123	133	161	136	58	48	53	55
Manek Urai	1638	133	195	241	228	111	94	63	75
Remainder	36532	3760	4110	4996	4491	3030	2450	2060	1965

Jajahan/ Local Authority Area	Total	Age Group							
		40-44	45-49	50-54	55-59	60-64	65-69	70-74	75
M.D,Dabong	2045	2018	1982	1454	1235	900	900	705	616
Dabong	65	58	75	75	43	34	59	47	40
Kemubu	59	57	55	55	50	28	38	53	26
Manek Urai	96	79	94	94	55	47	39	3961	37
Remainder	1825	1824	1758	1758	1293	791	569	1293	565

(Source: Local Authority and State Malaysia)

1.2.4 Landuse

Information on land use can be accessed from Google Earth applications and from Dabong District Council. This land use is being prepared, as it impacts town planning effectiveness. The small town will be provided with the necessary facilities to boost the economy and trade, based on the Rancangan Tempatan Jajahan Kuala Krai 2020.

The land uses in the Dabong are used for rural and urban development. The infrastructure is like Hospital, and school. The soil and landuse around us have given the huge influences to the human being in state of natural resources.

There are several types of land use at Dabong such as residential area, plantation area, transportation area, infrastructure and service and forest areas. In the center of the town of Dabong the residential area was dominated. The Dabong area is home to public transport and the Safe Care Centre.

Other than that, the Dabong area was also dominated by plantation areas, such as palm oil plantations, rubber plantations and residents planting vegetables. Figure 1.3 show the land use map of study area. Based on previous studies, the Dabong area shows in good condition the improved facilities of such as the road.

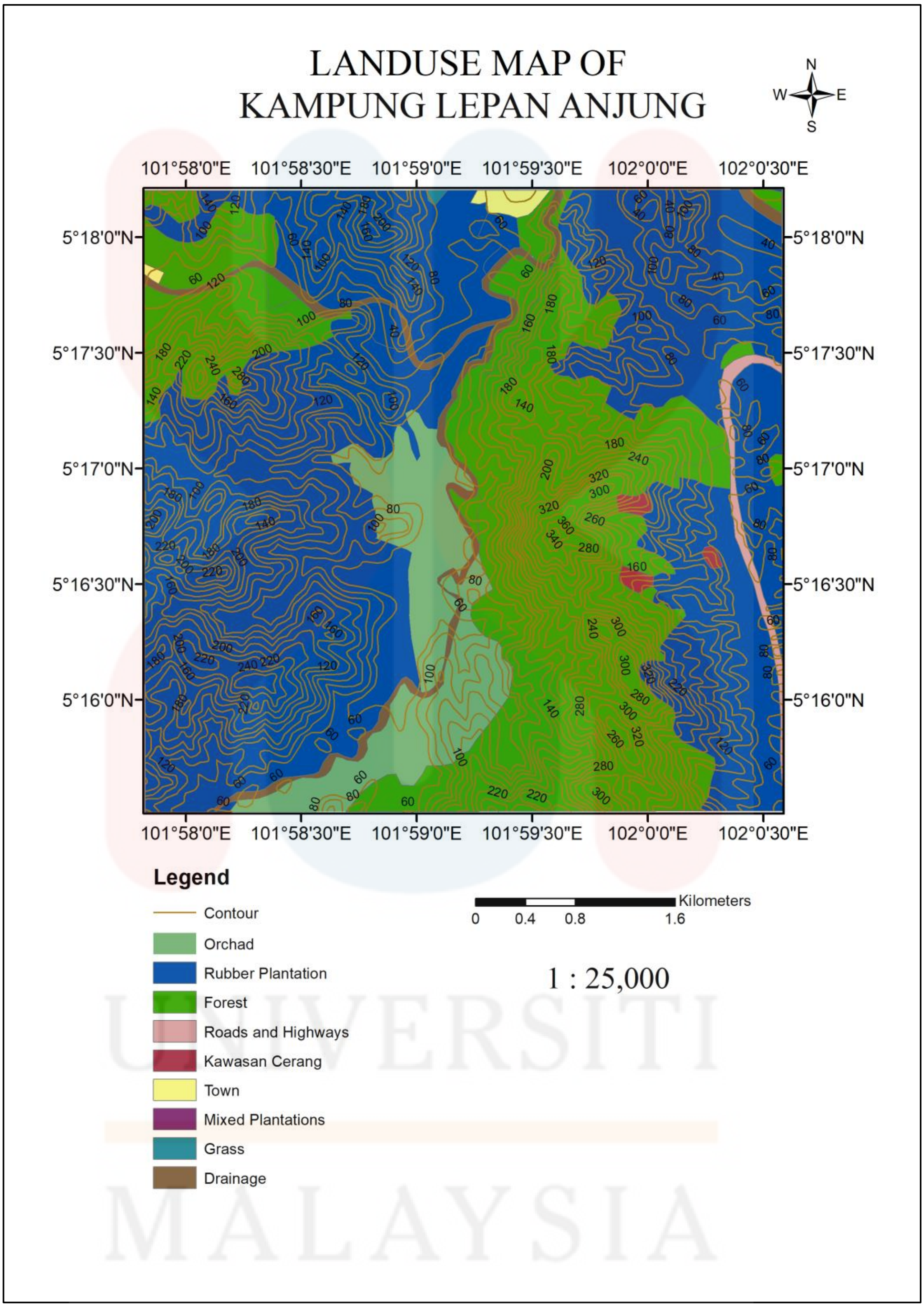

Figure 1.3: Land use map Kampung Lepan Anjung.

1.2.5 Social Economic

Socio-economics is the social science that examines how social forces influence and shape economic behaviour. In general, it analyses how societies advance, stagnate or regress due to their local or regional economy or the global economy. In other words, it may simply refer to "the use of economics in social research". More broadly, contemporary research discusses individual and group interpersonal relations through social capital and social "markets" (not excluding, for example, marriage sorting) and social norms creation.

From the land use map produce, the social economic at the study area is from agriculture activity. Palm oil plantation and rubber plantation are the main agriculture there. Malay residents is the major population at Dabong. Based on demography study, there are worker from other country like Indonesia, Bangladesh and Myanmar also the part of people live there. Local residents continued to engage in traditional economic activity such as fishing, hunting, herbal harvesting to produce traditional medicines and others.

1.3 Problem Statement

At Dabong, there is no recent map at the specific study area. Hence the geological map of the study area must be generated in 1:25000 scales during this research. Significant geological information according to the significance of the Dabong is provided from this research. It may define the general geologic details from the geological map. Geological problem can be identified based on geological map. As many geological process that occur at the study area, the geological study is must to redoing.

The data collected are used to analyse then classifying the rock sample. From the geochemistry data also, geological process would be study along. There are no studies about geology recently in the study area so it would be beneficial to other researchers or other people in the future.

1.4 Objective

- To produce a geological map of the study area in scale 1:25 000.
- To investigate the distribution element of granite using observation of petrographic analysis from secondary data.
- To study the types of granite based on a geochemical study.

1.5 Scope of Study

The reach of this research should concentrate on the analysis from the perspective of geology involving geomorphology, lithology, stratigraphy, geological structure, petrology, sedimentology, and depositional environment of the study area.

The specification of this research focus on geochemical of granite. The alternative method that use for replacing XRF analysis is using secondary data from previous research and other agencies data. This method also uses in geological research.

From all the data collected and analysed, a geological map was produced in the scale 1: 25 000.

1.6 Significance of Study

This research study gives benefits like the geological map of the study area are updated to the latest map of the area. From geological mapping, the latest information about the geological feature of the study area is also updated.

From the updated map and data, it can be useful to see the potential area for any purpose of development that is suitable. All this valuable information can benefit other researchers, students or any people relate that use for their references.

Geochemical survey and data collected generally can benefit to economy, environment and society through information support in the application such as mineral exploration, agriculture or forestry, and land use development. Another benefits from geochemistry survey is understanding in human health problems from natural contamination of the source rock.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

To obtain a better understanding, this chapter provides an overview of the literature research. This deals with the study of previous papers, journal, book, published papers and scientific reports to complete this research. It reviews the different literature which provide the definitions for the term geochemistry of granite itself followed by it elements and classification.

Regional geology, tectonic setting, stratigraphy, historical geology, structural geology, distribution of granite, element distribution of granite, IUGS classification, type of granite, geochemistry and petrography analysis are the focusing aspect for this chapter. Dabong town will more concern in this research.

2.2 Regional Geology and Tectonic Setting

Malaysia is a part of south east Asian continental which in Sundaland core. Sibumasu and Sukhothai is terranes that form Malaysia from the tectonic plate movement at Late Triassic. Kelantan located at the north-east corner of Peninsular Malaysia. Kelantan 's provincial geology consists of a core zone of sedimentary and metasedimentary rocks in the Main Range and Boundary Range granites in the west meanwhile dominate the east (Pour & Hashim, 2017). The granite can be seen intruding the central zone with its more prominent presence of windows in the batholite Ulu Lalat (Setting), Stong Igneous Complex and Kemahang pluton.

Granite and country rock belts have trended north-south that continues northern geology of the Pahang region. It continues to flow into Kelantan in the central and west part until it arrives in southern Thailand, but with its coastal alluvial, Sungai Kelantan has overlaid the granite boundary range. The Kelantan River is the region's main important river. It appears near Kuala Krai at the convergence of the Galas River and Lebir River and meanders over the coastal plain until it finally degrades into the South China Sea (Pour & Hashim, 2017).

Stong Migmatite Complex was located in the area around Dabong. This magmatite complex has been developed into a mountainous country about 8 km west of Kemubu and Dabong railway town. Through the Gunung Stong railway line it is readily known and the great outcrops that exist along Sungai Kenerong and Sungai Semuliang from Kemubu. Three forms of plutonic constituents exist. It has two earliest occurring phases (Berangkat Tonalite and Kenerong Leucogranite), which are strongly deformed by the marginal country rock. The third phase is under-formed Noring Granite.

Medium-coarse grained, gray color and large feldspar phenocrysts dominate the area's regional geology. Mostly gray, medium to coarse-grained megacrsytic biotite-hornblende granite to granodiorite where the lineage of feldspar phenocrysts on the western side can be seen with vigorous shear. They are named Kemahang granite, which is rich in the composition of the biotite. Gneiss is a shear substance with a composition of schistosis that deforms and bends feldspar, shattered quartz, twisted polarization and mylonization.

At the north-south of Kelantan, there is a variety of rock distributed like an igneous, sedimentary and metamorphic rock. Generally, the region has four types of rocks, including granite rocks, sedimentary/metasedimentary rocks, extrusive rocks (volcanic rocks) and unconsolidated sediments.

Four types of rock are observed consisting of sedimentary/metasedimentary, granitic rock, volcanic rock and unconsolidated sediments. Granitic rock is widely spread along the west of Kelantan which in the Main Range Granite that stretched to the boundary of Perak, Pahang and Thailand. Bentong-Raub suture zone is a part of the Main Range Granite at the west and extends to the north and to Thailand. The study area of Dabong which is part of Kelantan has geological data from Permian to Triassic age. The type of rock that can observe is shale, sandstone, limestone, phyllite and siltstone.

2.3 Stratigraphy

The Paleozoic Formation was found in Kelantan, in Peninsular Malaysia's central belt. The majority of the Upper Paleozoic sediment consists of coastal Permian strata, which occur in the Central Belt as longitudinal belts flanking Mesozoic sediments. Gua Musang Formation and Aring Formation in south Kelantan is from the Upper Peleozoic rock. Meanwhile at eastern Kelantan, Taku Schist is the major there.

Approximately 20 % of Peninsular Malaysia consists of the quaternary period of sediments that are the origin of Cenozoic. Peninsular Malaysia underlying above

Cenozoic is in stable condition for its tectonic activity related to fault or tilting and uplifting movement.

Peninsular Malaysia is divide into three belts known as the North, Central and Eastern Belt. Clastic and carbonates from Carboniferous and Permian are the rock type at the Eastern belt, while sediments from Permian and Mesozoic age dominated at the Central Belt.

Based on the fossils discovered in the region of Kuala Krai, it is denoted that the sedimentary rock belongs to Triassic Carboniferous period while most of the related volcanic and sedimentary rocks belong to Permian Carboniferous in period.

2.4 Structural Geology

A Stong Complex was the main structure that formed at this area. It located at the north Kelantan and consist of three type of components which is Berengkat tonalite, Kenerong micrograniteand Noring granite. This three component is formed in decreasing age order.

The Lebir Fault Zone was formed and can be traced along Sungai Lebir near Manek Urai in Kelantan by the RADARSAT imagery as an embroidery of NNW-SSE trending curvilinear lineament zones. The lineament was continually tracked to the south, running around the granite batholiths east of Sungai Lebir and west of the Gagau Formation, as well as the Koh Formation's eastern margin.

Along Sungai Lebir traced from Lebir Fault Zone can be found curving in linear lineaments near Manek Urai with path from North-North-West to South-South-

East. The lineaments flow in south direction until it intersects with Lepar Fault at Pahang.

Between Sungai Lebir and Taku Schist margin near Kuala Krai, the fault zone gapping happens at least 10 km wide. The rocks were deformed into brecciated metasediment, flasered granites, and mylonites within the fault zone. Slickensides are the structure that can be created, and it was uncovered by road cutting on the fault surfaces and showed the sinistral motion. This fault is known as the Lebir Fault Zone, where it passes through the Jurassic-Createaceous basins which contain Koh, Tembeling, and Gagau formation. The fault occurred in the current Triassic to Jurassic-Createaceous basin, where it was deformed due to the strike slip movement in the fault zone.

2.5 Historical Geology

Southeast Asia contains accreted Precambrian continental terranes that ripped off from Gondwana successively after the Early Devonian, when the Paleo-Tethys Ocean started to open. Biogeographic terrane known as Sundaland are created cause by the reassembled of terranes on the Eurasian plate with suture. The tectonic evolution of Sundaland may limit temporally and spatially because of the different terranes both fossil record and paleomagnetic evidence. Late Permian Gigantopteris flora similar to Cathaysia is found in Indo China – East Malaya and Northern Thailand east of the Nan-Uttaradit line. At the Sibumasu Terrane west of Nan-Uttaradit line, which was not isolated from Gondwana until the Early Permian, there also found a Permian Glossopteris flora similar to Gondwana.

Only the Nan-Uttaradit line and the Bentong-Raub line are split between these two floral provinces. Such divisions were historically assumed to represent the position of the Paleo-Tethys Sea, whereas the existence of the Nan-Uttaradit line was a large suture. The presence of the arch Sukhothai Terrane between the terranes of Indochina and Sibumasu, while the Nan-Uttaradit line was defined as a parallel suture responsible for the closure of the back-arc suprasubduction basin between the terrane of Sukhothai and the terrane of Indochina. Some research proposed that this island arc could stretch to the Malay Peninsula and be responsible for the Eastern province's I-type magmatism.

Like the metaluminous island, the granitoids are usually peraluminous Granites in the arc. The parental magma of the granitoids in the Eastern Province would need sedimentary source data, which an island arc terrane could not supply enough (Ng et al., 2014). The parental magma of the granitoids in the Eastern Province would need sedimentary source data, which an island arc terrane could not supply enough. Granitoids of the "I-type" Eastern province were related to Andean-type magmatism and located in the terrane of Indochina – East Malaya. In the subsequent continental crustal thickening environment, granitoids were formed of the "S-type" Main Range province.

The crustal is believed to be rocks similar to the Ordovician Kontum amphibolite could give the Malaysian granitoids a signature of the enriched high field strength element (HFSE). Approximately 20 % of sedimentary melt was mixed into the parental melt that produced granitoids in the eastern province while, 40 % engaged in the production of granitoids in the Main Range region. The higher occurrence of sedimentary melting in the Main Range province was due to the compositional disparity between the two continental terranes, whereby Sibumasu terrane may be more dominated by sedimentary protoliths than Indochina – East Malaya terrane (Ng et al., 2014).

The crust of Indochina and Sibumasu contains Lower Paleozoic sedimentary and carbonate rocks, but the succession of the Sibumasu terrane is more complete, resulting in a 13 km thicker Sibumasu crust. The absorption of sedimentary material into the parental magma may be inferred from the existence of granitoids of the ilmenite-series in the Eastern and Main Range provinces, and this also indicates that granitoids of the Eastern province are lower than standard granitoids of the Cordilleran I type.

Noring granite is the bulk of the Stong Group, produced in oval-shaped pluton. The components consist of carrying facies such as a Terang and Belimbing hornblende. The Noring granite is formed and broken down by distinctive pink K-feldspars.

2.6 Research Specification

2.6.1 Geochemistry and Petrographic analysis

To analyse the composition of a rock, a petrography process is followed. Petrology is the study about rock details like its composition, texture and structure. This analysis is a must to determine the class of rock. The petrographic analysis involves in the laboratory to do microscopic analysis. The mineral detail will be analyse in thin section form including the observation of the texture and structure. X-ray fluorescence spectrometer is useful in determining the individual mineral content. The best way to classify the igneous rock is by arranging its silica content in the order.

The crystallization process will take place in various tectonic settings. By defining the minerals that make up the igneous rock it is possible to determine the process the rock undergoes under the earth's crust. Mineral structures are crucial in deciding the geological tectonic and also in deciding the phase that the molten rock undergoes in the centre of the earth.

2.6.2 IUGS Classification

QAPF diagram is another term for IUGS classification. This QAPF is stand for quartz, alkali feldspar, plagioclase and feldspathoid. The traditional IUGS petrographic classification of granitoid based upon their modal abundance of quartz, plagioclase and alkali feldspar (Streckeisen, 1967).

IUGS classification concentrate on differences in abundances and compositions of feldspar and also for a wide variety of granitic rock. QAPF diagram aid in the classification of mineral of igneous rock. The percentage of minerals must be determined to classify the rock.

The first step to make this by calculating the mineral or rock sample percentage. The descriptive attributes of a rock must be distinguished from interpretative attributes. QAPF and ultramafic classification fit well for most plutonic and coarse grained rocks but not for all (Bas & Streckeisen, 2012). For the feature, figure 2.1 show the QAPF diagram.

To determine the chemical properties and tectonic conditions of granitoid rocks, the S-I-A-M classification may be used. I-type and S-type granitoid may be differentiated by their origin, with the I-type deriving from igneous-sourced melt and the latter deriving from sedimentary melt. For the demarcation between granitoids of type I and granitoids of type S, the Aluminum Saturation Index (ASI) is used.

The western and eastern provincial granitoids can be distinguish from one another by calculating the Al_2O_3/(CaO + Na_2O + K_2O), molar proportion. In analysis of fractionation pattern in Eastern and Western province granitoid, Harker Diagram is use to plot the major elements versus SiO_2.

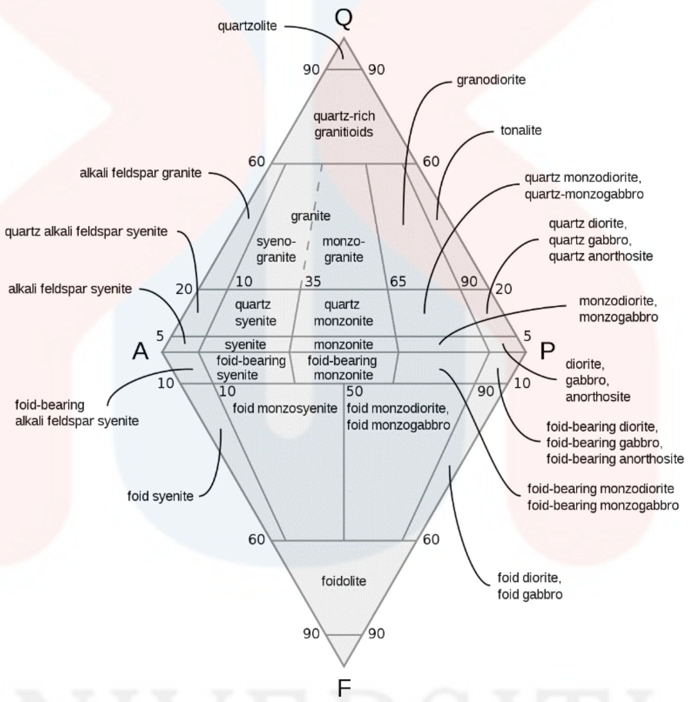

Figure 2.1: QAPF diagram.

2.6.3 Distribution of Granite

Widespread magmatic activity developed in Peninsular Malaysia during the Permian – Late Triassic period following a continental collision between the blocks Sibumasu and Indochina (Ghani, Yusoff, et al., 2013).

The Malaysian peninsular granites are divided into three parallel belts, the western belt, the central belt and the eastern belt (Azman, 2000). They were split into two granite provinces, the western province of which consisted of granites confined to the western belt with an age range of between 200 and 230 Ma and the eastern province of granites of both the eastern and central belt and between 200 and 264 Ma.

Granitic rocks are distributed in the western (Main Range granite) and eastern borders (Boundary Range granite) of Kelantan state. The Main Range Granite is situated in the west of the state, extending along western Kelantan up to the Perak and Pahang states and Thailand borders (Pour & Hashim, 2017).

The Malay Peninsula's Permo-Triassic tectonics were interpreted as the east-dipping subduction of Permian – Early Triassic oceanic lithosphere below the Indochina – East Malaya Andean type margin accompanied by the closing of Paleo-Tethys along the Bentong-Raub suture zone during the Middle – Late Triassic period. Malay Eastern Province granitoids are Cordilleran I-type granites formed above the east subduction zone in the Bentong- Raub suture line, while the Malay Main Range Province granitoids were S-type granites found west of the suture in the Sibumasu terrane.

Malaysian granitoids originated from similar igneous parental protoliths mixed in different sedimentary protolith proportions. The trace element geochemistry of these granitoids suggests that they are more fractionated and enriched than standard granitoids of the Cordilleran I and S types.

2.6.4 Element distribution of granite

Granite is the most abundant disruptive rock in continental crust. The granite colour also ranges from purple, brown, white and black to mottled. Granite texture is moderate to coarse-grained. The three main minerals associated with granite are feldspar, quartz, and mica. Granite crystallizes hundreds of kilometers deep in the crusts of Earth, from the silica-rich magmas.

At the Eastern Belt, the composition of granite ranges from diorite to granite but commonly of granodioritic composition. The mineral composition observed is quartz, plagioclase, K-feldspar, hornblende, sphene, magnetite, ilmenite and low AI biotite.

S-type granites have a limited SiO_2 content which is 65 to 75% that is typical of SiO rich sources. This compares with the I-types granites, which generally display a wide variety of composition as commonly seen in magmatic calc-alkaline arcs. There are numerous petrological and geochemical parameters which can further distinguish both granite types. Higher Na_2O content, lower original Sr isotopic ratios and the occurrence of hornblende and titanite are distinguished by I-type granites (Ghani, Searle, et al., 2013)

S-type granites are low in Na, Ca and Sr which are depleted by weathering during the conversion of feldspar to clay minerals in their source rocks. Strong K_2O / Na_2O in rocks of the S-type is explained by the chemical weathering potassium is incorporated into clays whereas sodium is removed in solution together with Ca, Sr and Pb. The S-type rock Fe 3+/Fe ratios are significantly smaller than those of I-types, since the source in the presence of graphite, rocks are usually diminished.

To the east of the Bentong-Raub line are granitoids containing hornblende and biotite. Other than biotite, tourmaline, muscovite, andalusite, garnet and low-Al biotite which S-type minerals presented locally at the west. Some Eastern province granites has close characteristics to Bintang Batholith at the Main Range province (Ng et al., 2014). Some of the granitoids in the Main Range province are hornblende-free biotite granites, such as those also found in the Eastern province. The geochemistry of the trace elements of the Malaysian granitoids reveals that both Eastern province and Main Range province granitoids adopt the same pattern of accumulation and degradation of trace elements while their liquid lines of decline in crystal fractionation are parallel and essentially overlapped.

2.6.5 Type of granite

Chappell and White (1974) initially established the I- and S-type granite classification in south-eastern Australia where they stressed the importance of source rock structure and the principle of melt separation and refractory residue during felsic magma growth. The scheme considers I – type granites as the melting products of meta-igneous source rocks mainly by hornblende breakdown at high temperatures, whereas S-type granites result from the melting of meta-sedimentary source material mainly by dehydration reactions of muscovites or biotites (Ghani, Searle, et al., 2013).

In general granite can be divided into orogenic granite, syncolisional granite, volcanic arc granite and oceanic granite (Qazi et al., 2018). In geochemical aspect, granite is divide into two types which are S-type and I-type that also relate to mineralogy analysis. The mineral composition of granite at the West and Eastern Belt

Granite is the same based on the modal distribution of the felsic end members. Monzogranite and syenogranite is the range for both granites at a different belt.

Classification of granite is according to their magmatic origin result in the formation of two contrasting groups (Ghani, 2005). S-type is categorised by the partial melting of metasedimentary from the source rock. The Western Belt granite of Peninsular Malaysia has been regarded to be constituted by S-type granite (Liew, 1983; Azman A Ghani, 2005). The Eastern Belt granite is dominated by I-type with subordinate S-type granite. (Liew, 1983). The study area is included in the Eastern Belt granite.

CHAPTER 3

MATERIAL AND METHODOLOGIES

3.1 Introduction

Material and method is very important in order to complete this research project. There are several methods use in this research for the geological and specification study. To get more precise information or data related to this research, a reading from previous research papers, books or journal as reference. For better understanding in geomorphology of study area, base map is use in the geological part.

Geological mapping is undertaking in identifying any geological features and rock types in the study area. This mapping includes collecting rock sample, taking the picture and informative data. Several software will be used to process the data collected.

Due to the current issue which is covid-19 pandemic all the outside work is disallowed. So the mapping will not be conduct. The alternative given is using secondary data from previous research and data from geology agencies.

Suitable material is use for this research that can related with the method. All the topics of interest were listed, and the best method and idea for the current situation were chosen. In the first step all the material and method required was sorted. Figure 3.1 show the research flowchart of all step in making this thesis.

3.2 Materials

Using ArcGIS which is Geographic information system (GIS) is a cloud-based mapping, analysis, and data storage system capable of producing, sharing, and managing maps, scenes, layers, applications, and other geographic content. A series of geographical datasets which model geography using a simple and generic data structure are used to represent geographical information. GIS framework also provides a variety of robust resources suitable for dealing with geographic data. Use of ArcGIS is crucial in the preparation of geological maps and in the presentation of data in the form of a geological database.

Next is geological map, map of geographic distribution of the rock units and structures. It is used to select an area of interest and to identify all the geological aspects of the area in order to prepare a detailed geological report and a map to summarize the report.

Microscopic analysis is conduct for the sample in thin section form to observe the mineral grain. In geochemical analyses, x - ray fluorescence spectrometer (XRF) will be used to determine the major and trace elements of the rock samples. For current situation, this method will be replaced with interpretation from secondary data.

3.3 Methodology

3.3.1 Preliminary study

A preliminary study is important to know the research project direction. This study includes getting knowledge about study area, rock type and distribution, the formation and the geological condition and geomorphology.

The data is collect from secondary data from previous research and geology agencies like JMG, USGS and JUPEM. The data collected including general geology information like structural geology, lithology, geomorphology and stratigraphy. Geochemical and petrographic analysis also will study from secondary data. Another data and information source is collect from internet, journal and books.

3.3.2 Data processing

After data is collected, it must be use for analysis. It has to converted in any suitable form to analyse. To get better result, it must analyse in good way. Uses of software and other relates are use in this processing data.

The main recommendation for data analysis is to follow the base map to classify lithology and geological details such as geomorphology and research area drainage patterns. Usage of the data details to build a base map using ArcGIS tools. Finally, the data used in the ArcMap will update to the presentable map.

For specification of this study, the data and information are review from other research article and journals. The data was collected then comparison and observation was made for all the data that suitable for the uses in this study research.

3.3.3 Data analysis and interpretation

When the data was completely collected, it continues with data analysis and interpretation. Geological map was produced based on the objective by the data collected. This are done by using ArcGis software in the proprietary Esri format. By using Arc Gis, it includes the accuracy and precise about geology such as morphology, lithology, drainage patterns and others was ensuring accurated.

In making map, there are three standard of validation. U.S Geological Survey (USGS), American Society for Photogrammetry and Remote Sensing (ASPRS) and National Map Accuracy Standard (NMAS).

The benefit of this standard was providing correct field data and map data to prevent system error. ASPRS, for example, was a modern technique to ensure the map is correct. Current ASPRS specifications now accommodate the new advancements innovation of optical imaging and non-imaging cameras, airborne GPS and aerial triangulation (AT) systems.

The new standard was independent of size and contour length, and had a higher degree of precision obtained by the newest innovations such as handheld LIDAR. The map users and map creators will also adopt standard maps in order to generate maps of great precision between field data and original data.

For the specification study, the collected data and information was interpreted. Some data was used to make Harker diagram which in form of distribution graph which then can interpreted more from the graph. Table also was generated to summarise some information that was extracted from referred journal.

Research Flowchart

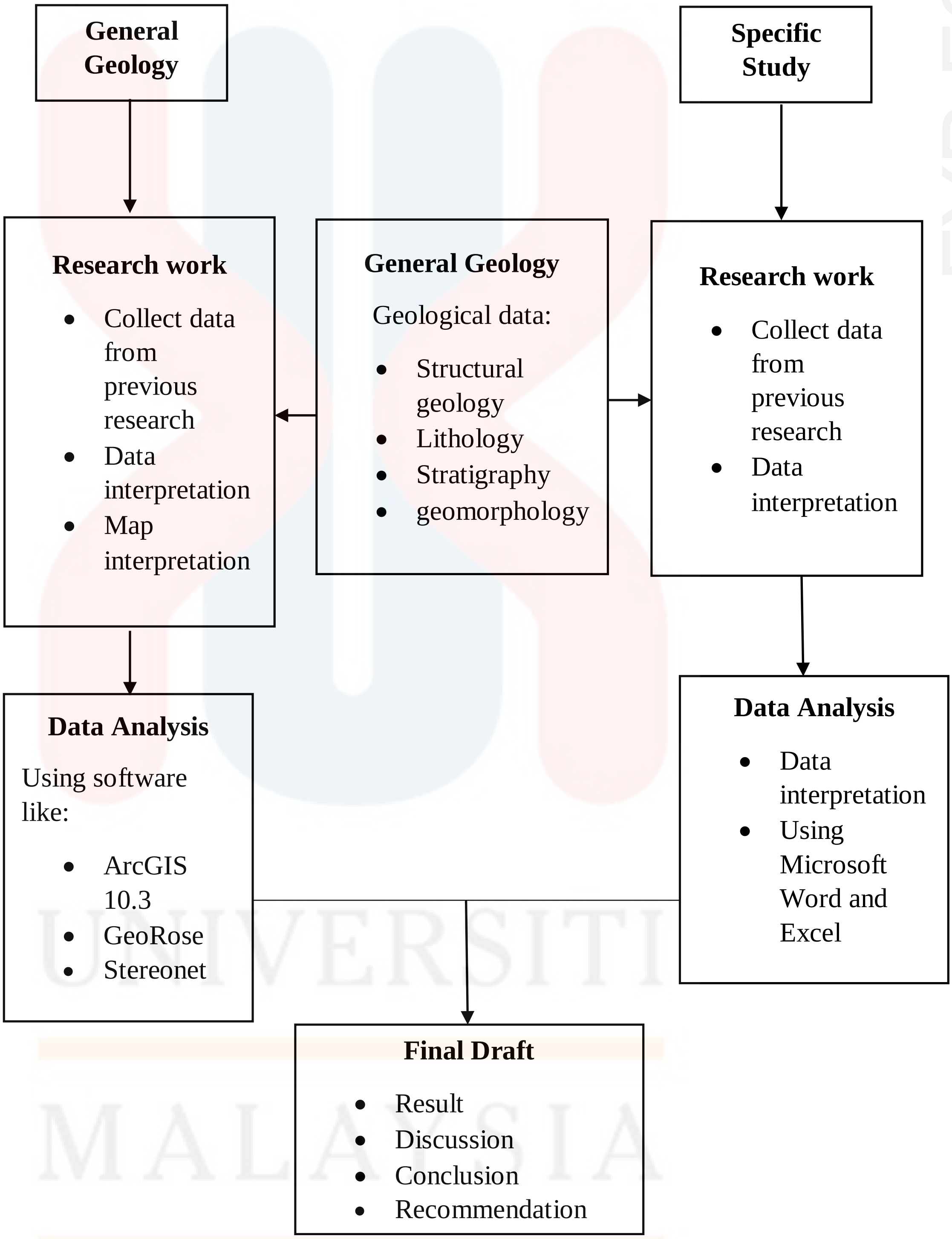

Figure 3.1: Research Flowchart.

CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

This chapter will be more focused on general geology in the study area. All the collected geological information was gathered in this chapter that helps in working out the research. General geology includes geomorphology, stratigraphy, structural geology and historical geology. In this research, a few kinds of related map need to be covered. A lot of geological knowledge used to perform this study will be provided by general geology.

Several aspects will be discovering such as how the site is accessible, what type of land use is used in the study area, the morphology and the settlement style in the study area.

Geomorphology is characterised as the study of characteristics, the origin and evolution of the landforms. The study of the topography and drainage pattern of the study area was included in the geomorphology part.

Stratigraphy consists of observing the strata and layering (stratification) layer of rock. This section was split into many subfields, such as Lithostratigraphy, rock sequence, biostratigraphy, and chronostratigraphic.

The process or product of rock deformation is structural geology. This section is conducted to describe the formation that occurs during mapping, such as fault, fold fracture and joint, to the outcrop. The structural analysis is carried out by plotting all the data into the Rose diagram for joint analysis and Streonet software for streonet analysis before heading to mapping, ArcGis is often used to evaluate topography and lineament as a structure indicator.

For historical geology, the aim was on the chronology of events in the field of research. This also included research on the lithology series of the field of analysis and deformation produced due to formation.

4.1.1 Accessibility

For the access to the study area, there is one major road to reach there. The major is a connection road that connects between Jelawang and Gua Musang. It is convenient to access to the study area because the main road is inside the mapping box area. For access to other parts of the study area, it us by walking across the forest, rubber plantation and other landuse. In Figure 4.1, the accessibility map was shown to demonstrate the study area's accessibility.

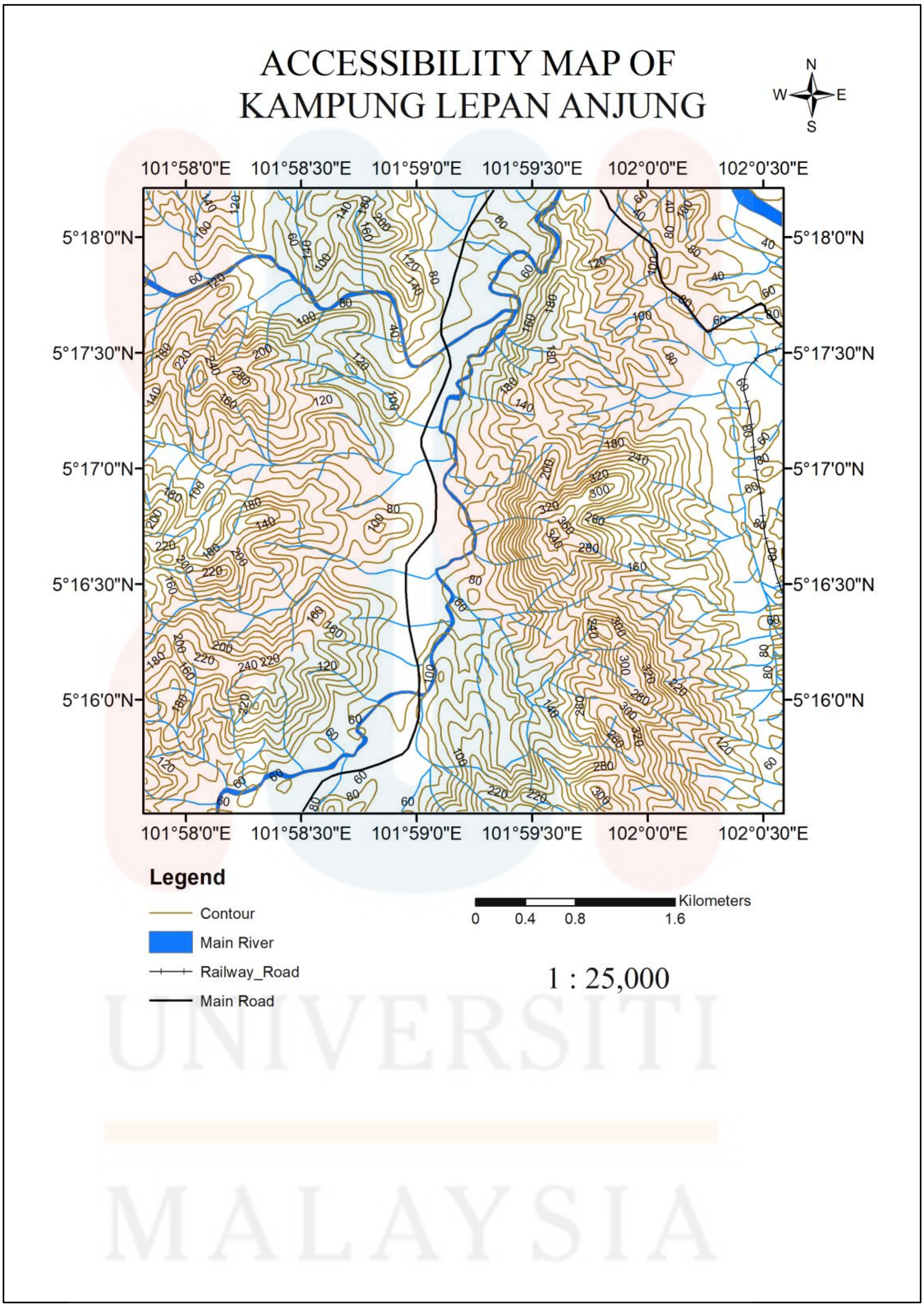

Figure 4.1: Accessibility map of Kampung Lepan Anjung.

4.1.2 Settlement

A settlement is related to human-settled activities. In the study area, there are several village areas. There are different populations in each village. According to the data provided by Department of Statistic Malaysia (web), in 2010 Dabong was populated by a total of 13 173 people. Table 1.1 in chapter 1.2.3 shows the distribution of people in Dabong.

4.1.3 Forestry

Among the villagers in the study area, the main activities are the vegetation which also their main primary of earnings. Forests are natural occurrences and the area is mainly still protected by forests since the population is small.

The coverage of land use indicates that much of the research area is covered with mixed vegetation and thick trees. It proposed that a limited percentage of impermeable areas compose this rural landscape and stated that the region is facing human interference.

As shown in Figure 4.2, land use coverage is summarised into four sections for this study, which are agriculture, forestry, mixed vegetation and village areas. The land-cover review reveals that within a largely naturally vegetated landscape, the study region is a relatively remote rural area.

The villagers act primarily as rubber tappers because in the study area the rubber plantation area can be identified. The landscape itself is related to the plants in the study field Economic activities focused on subsistence agriculture activities were eventually traded with other communities. The natural process of farm land re-vegetation indicates declining labour and other human activity requirements.

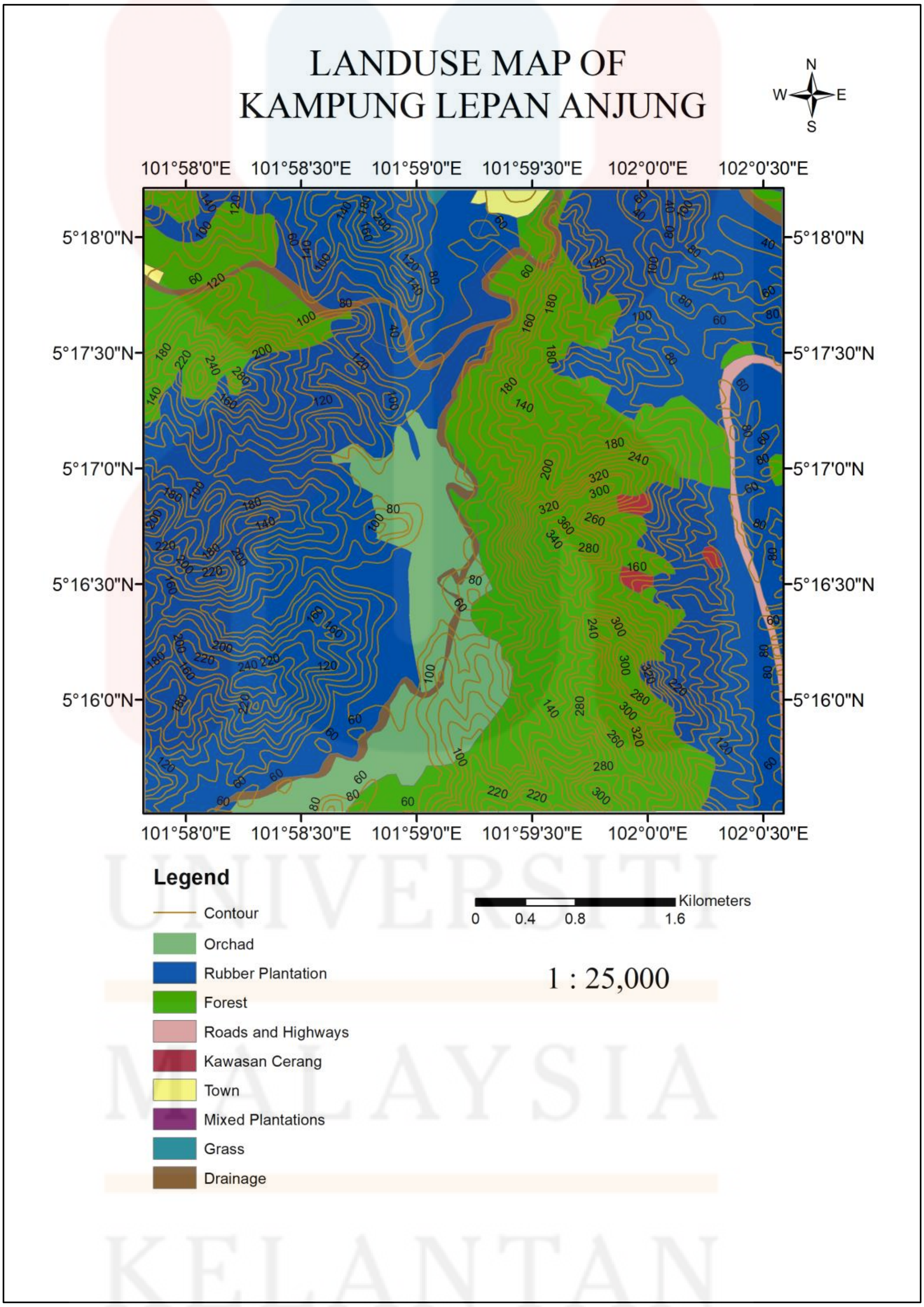

Figure 4.2: Landuse map of Kampung Lepan Anjung.

4.2 Geomorphology

Geomorphology focused on the classification of geomorphology, topography and drainage patterns of the study area. Geomorphology differentiates on the basis of elevation and is important for water motion to be an indicator. It is an analysis of the existing landform and the form of the earth and the associated process that influences the landforms.

Geomorphology is an aspect that may prove the transition and testify to the correlation between variations in landforms. The variables and processes correlated with current geomorphology may also be defined.

One of the known processes is the phase of weathering where it can be seen everywhere. Other than that, the erosion mechanism also influences the landform of the earth, along with balance and temperature variations. Different techniques have distinct effects on the landform.

4.2.1 Geomorphologic Classification

There are four components to the geomorphic classification system which geomorphic process, landform, morphometry and geomorphic generation (Haskins et al., 1999).

Geomorphic Process is the dominant internal or external geologic force that has interacted with the existing geologic structural framework to shape the earth's surface. A landform is defined as any physical feature of the earth's surface having a characteristic, recognisable shape and produced by natural causes. The geomorphic classification landform component is closely related in a hierarchical way to the Geomorphic Process component.

Bates and Jackson (1995) defined morphometry as the measurement and mathematical analysis of Earth surface configuration and landform's shape and dimensions. Elevation is a part of the element which is included in a geological morphometry map classification. Geomorphic Generation is a part of the classification that allows more than one geomorphic form at any given position on the ground to be recognised and reported. The determination of each landform's geomorphic generation will define the genesis of each of the landforms, the relationship between the landforms, and the status of the phase that created the landforms or continues to form them.

Triangulated Irregulated Network (TIN) map was created for the study area to show the elevation differences in the study area. The topographic unit is hills at several places due to the elevation is more than 301 m. The rest of the study area is mainly low hills with elevation up to 200 m. The features can be observed on the TIN map of study area in Figure 4.3.

Slope map of the study area can be observed on Figure 4.4. It can be seen that with the slope percentage, some areas are known to be moderately steep, although most of it are areas with flat or nearly flat landform characteristics.

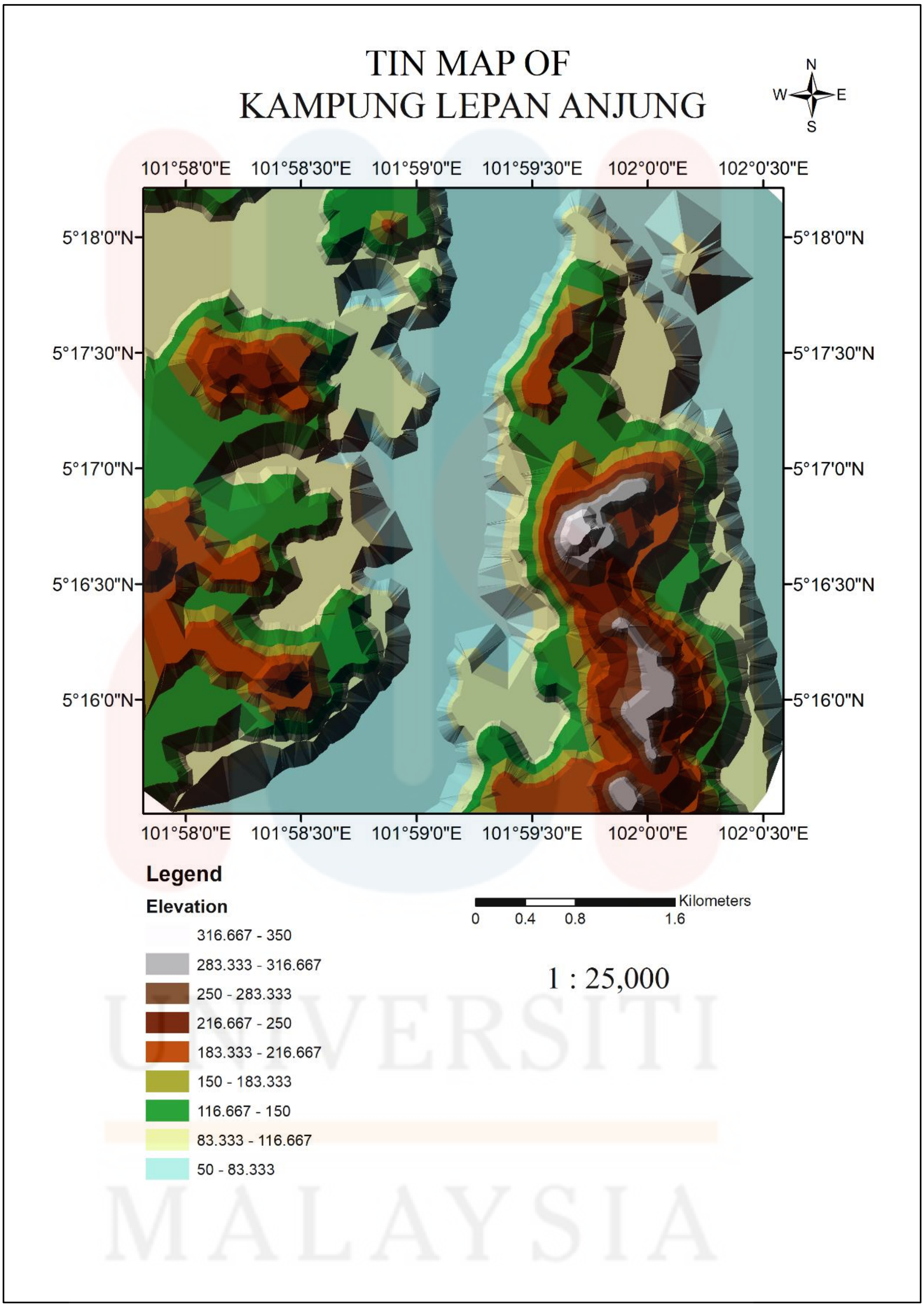

Figure 4.3: Triangulated Irregular Network (TIN) map of Kampung Lepan Anjung.

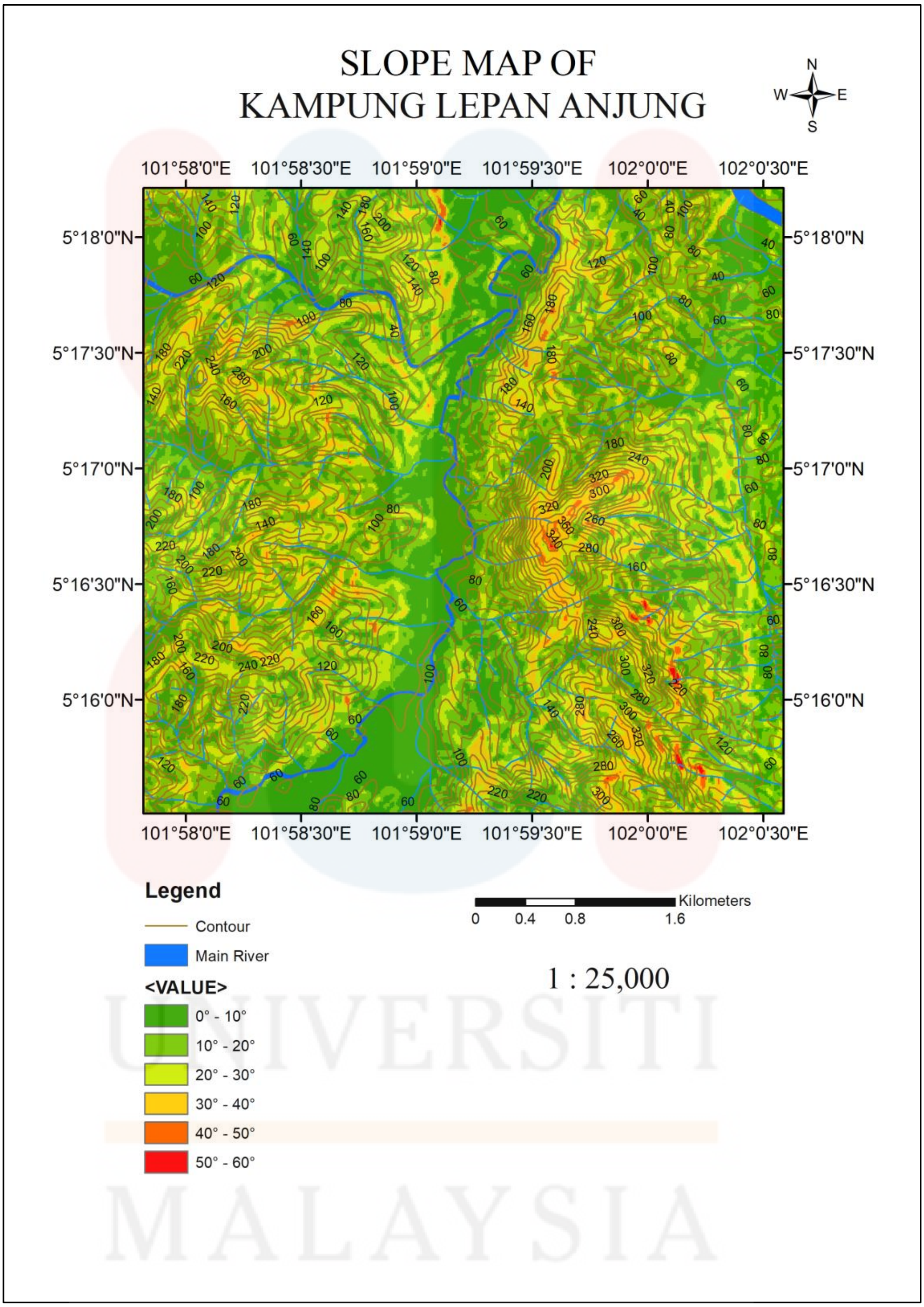

Figure 4.4: Slope map of Kampung Lepan Anjung.

4.2.2 Drainage Pattern

Drainage system is the pattern formed by streams, rivers and lakes in a drainage basin (Zhang & Guilbert, 2012). The pattern influences both the presence of bedrock and structures through topography and land gradient. A stream is also known as a drainage basin through which the topographical area receives groundwater flow, runoff and the through flow. The type of drainage pattern are dendritic, parallel, rectangular, radial, trellis, centrifugal, centripetal, distributary and annular.

From the Arc Gis data interpretation, the study area consisted of two types of drainage patterns. It is recognised as parallel and dendritic. This feature can be seen in Figure 4.5 that show drainage pattern map of study area. Dendritic pattern is the stream tributaries that are known as having a tree-like pattern that is unusual in its branching, almost expanding at every angle. Dendritic forms, both on the unconsolidated sedimentary strata and on igneous rocks, may be found occurring in almost horizontal and even resistant strata.

On a common slope down linear ranges or rivers between linear series of escarpments, parallel, elongated landforms such as outcropping resistant rock bands, a parallel drainage system usually occurs after natural faults or erosion such as prevailing wind scars. The patterns are commonly formed in uniformly resistant strata, such as in igneous landforms.

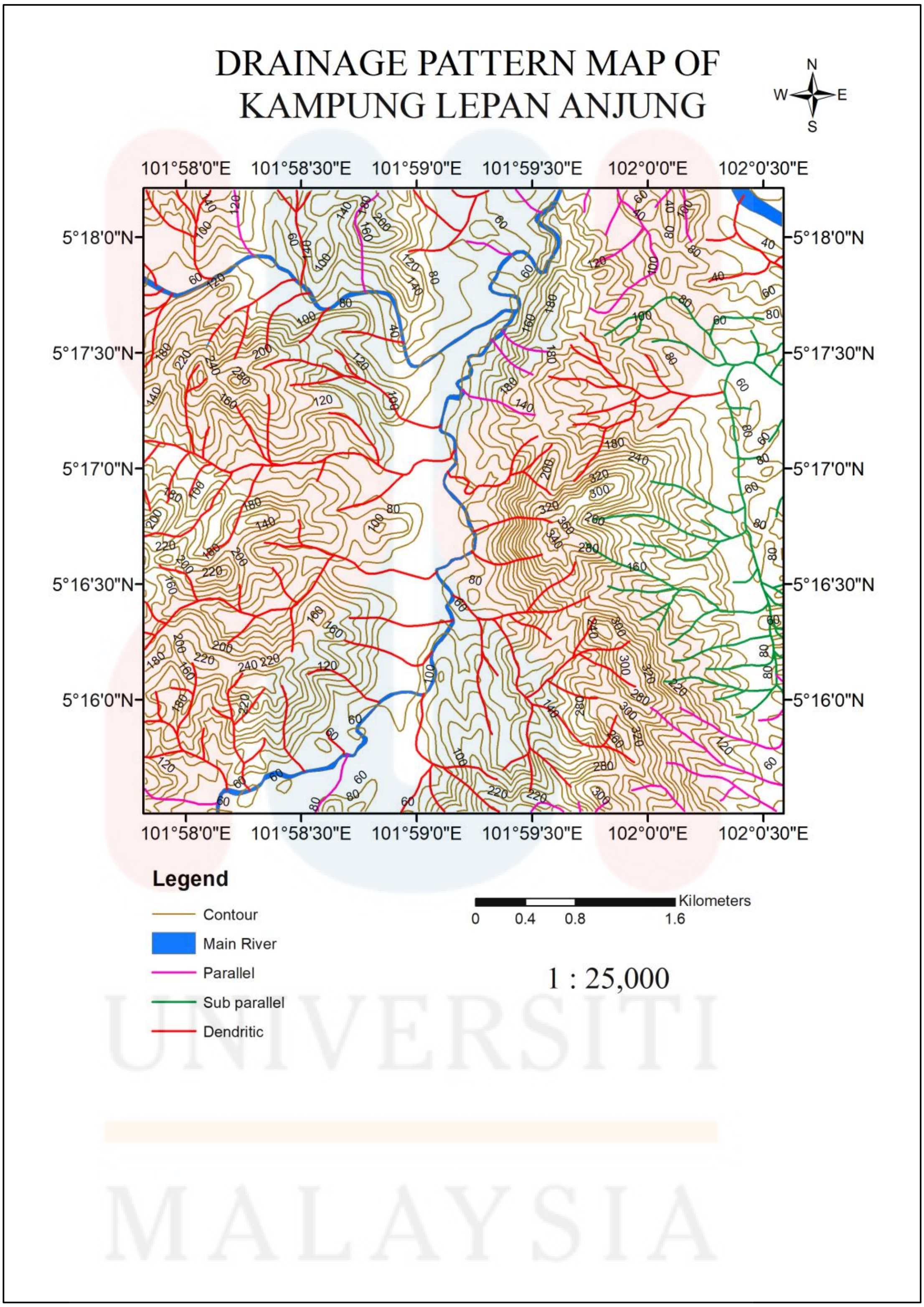

Figure 4.5: Drainage pattern map of Kampung Lepan Anjung.

4.3 Lithostratigraphy

Lithostratigraphy is define as a sub-discipline of stratigraphy, geological studies about strata and rock layers. Lithostratigraphy focuses on geochronology, petrology and comparative geology. In the lithostratigraphy discipline, the lithological properties of the visible strata and their respective stratigraphic positions are the components that include the classifications of rock bodies. From the previous research, the study area is including in Gua Musang Group that have several rock type. Gua Musang Group includes the current (i) Gua Musang formation, (ii) Aring Formation, (iii) Telong formation, and (iv) Nilam marble (Mohamed et al., 2016).

It also includes diverse properties, such as geological processes and ranges, as well as past events' paleo - environment profiles. The studies carried out are attempts to establish chronological sequences of the geological activities of a geographic area.

4.3.1 Stratigraphic Position

Table 4.1: Stratigraphic position of rock unit in study area.

Era	Period	Lithology	Description
Cenozoic	Tertiary		Intrusive rock, mainly granite with minor granodiorite.
Mesozoic	Triassic		Interbedded sandstone, siltstone and shale
Paleozoic	Permian		Phyllite, slate and shale subordinate sandstone and schist.

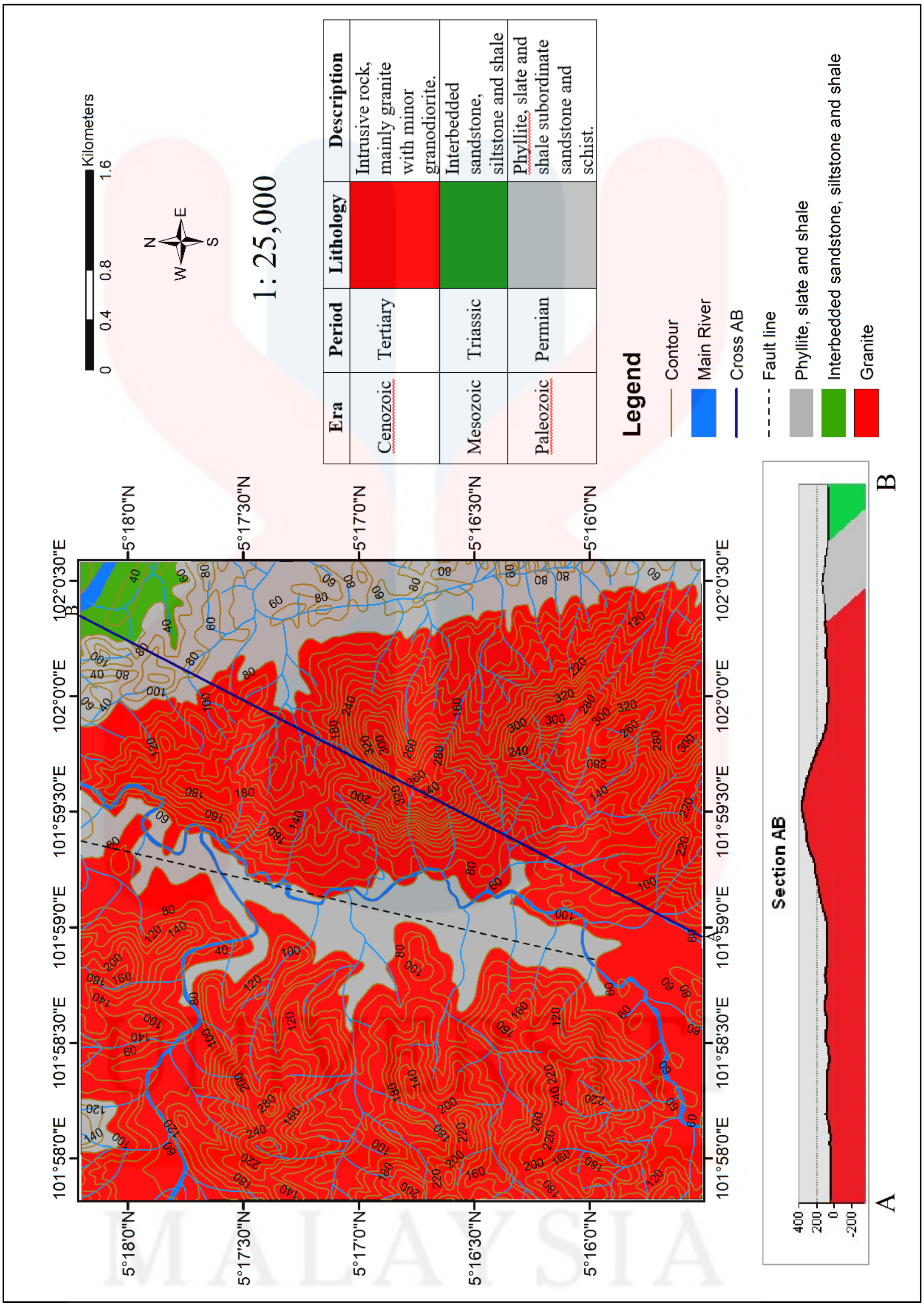

Figure 4.6: Geological map of Kampung Lepan Anjung.

The distribution of rock type with the geological features at study area are shown as map at Figure 4.6.

4.3.2 Unit Explanation

Details of the lithological units starting from these sections being clarified from the oldest unit of rock to the youngest unit of rock. The description of the horizontal and vertical distribution of each lithological unit is also included in this part. The classification is related to the thickness of the units of rock, the distribution of the area of the analysis, and the relationship between the units of lithology.

4.3.2.1 Sandstone

Sandstones are made up of particle sizes ranging from 2 mm to 0.06255 mm. Quartz is typically the most common mineral in sandstone since it is the hardest of the minerals that form rock and also the most resistant to abrasion during transport. Potassium feldspar is the second most common mineral found in the study and is followed by micas. These minerals are also the minerals that under conditions of the earth's crust, chemically most stable among the rock mineral formation.

4.3.2.2 Phyllite

Phyllite is one of the foliated metamorphic rocks that the metamorphism system creates from the slate. Due to the orientation of mica mineral, phyllite has a similar tendency to break into sheets or slabs, but grains are larger than slate. The appearance of foliation is usually crinkled or wavy. It is typically classified by the regional metamorphic as a low-grade metamorphic state. Usually, the colour is black to grey or greenish grey.

The colour of the phyllite is greenish based on the hand sample, and the size of the grain is a fine grain. It has a wavy foliation which is thin. This foliation is a parallel with a shiny or glassy lustre. This can be defined as the foliation of phyllites. Quartz and Muscovite mica are the minerals that can be identified. Because of its large mica crystals, Phyllite has a glossy sheen than slate.

4.3.2.3 Shale

Shale is a sedimentary rock made up of very small fragments of clay. Clay forms for through the decomposition of a feldspar mineral. Generally, in very deep shale types, water from the ocean, lagoons, lakes and swamps where the water is already adequate to make the extremely fine particles of clay and silt can fall on the surface. The particles are composed of clay that have a size of less than 0.004 mm.

4.3.2.4 Slate

Slate is a shale-derived metamorphic rock and is foliated and readily broken into thin, smooth and parallel planes. This is a fine-grained, foliated species, the homogeneous metamorphic rock produced by low-grade regional metamorphism from an initial shale consisting of clay or volcanic ash. The mineral composition contains quartz and mica. Slaty cleavage is not necessarily in the same position as the initial sedimentary bedding plans, depending on the sample.

4.3.2.5 Granite

Granite is an intrusive rock. It is recognised to be molten pink, white, grey and black. The name of the granite specification depends on its mineral percentage and the use of the IUGS triangle. For the classification of plutonic rock, the IUGS triangle is used. Quartz, alkali feldspar and plagioclase are the predominant minerals. By using the naked eye, the mineral can be seen and the size of the mineral is greater than 1 mm.

Potassium feldspar, alkali feldspar, quartz, mica and sodium are usually the primary minerals found in the granite rock. The minor minerals are sodium, plagioclase, and hornblende. Tertiary age is the age of this rock unit in the study area based on the literature analysis. This granite unit is thus, an intrusive rock.

4.4 Structural Geology

4.4.1 Lineament analysis

Lineaments are straight or gently curving properties of the surface of earth, which are generally represented as ridges and depression on earth's surfaces. Figure 4.7 shows the lineament that is considered in a large scale area around the study area. To determine the direction of force, line’s orientation is measured and plotted in the rose diagram. The result of the lineament analysis in Figure 4.8 shows that the major direction force (σ1) is NNE-SSW.

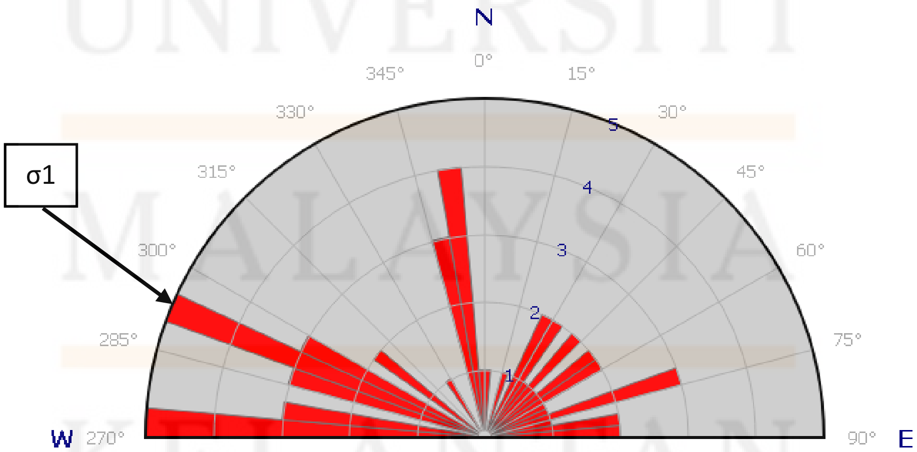

Figure 4.7: Rose Diagram of lineament analysis.

A strike-slip fault can be recognised in the study area from the linear analysis of the study, using the GIS method. The fault surface is usually near vertical and with very little vertical motion, the footwall moves to the right. Dextral faults are also referred to as strike-slip faults with right-lateral motion.

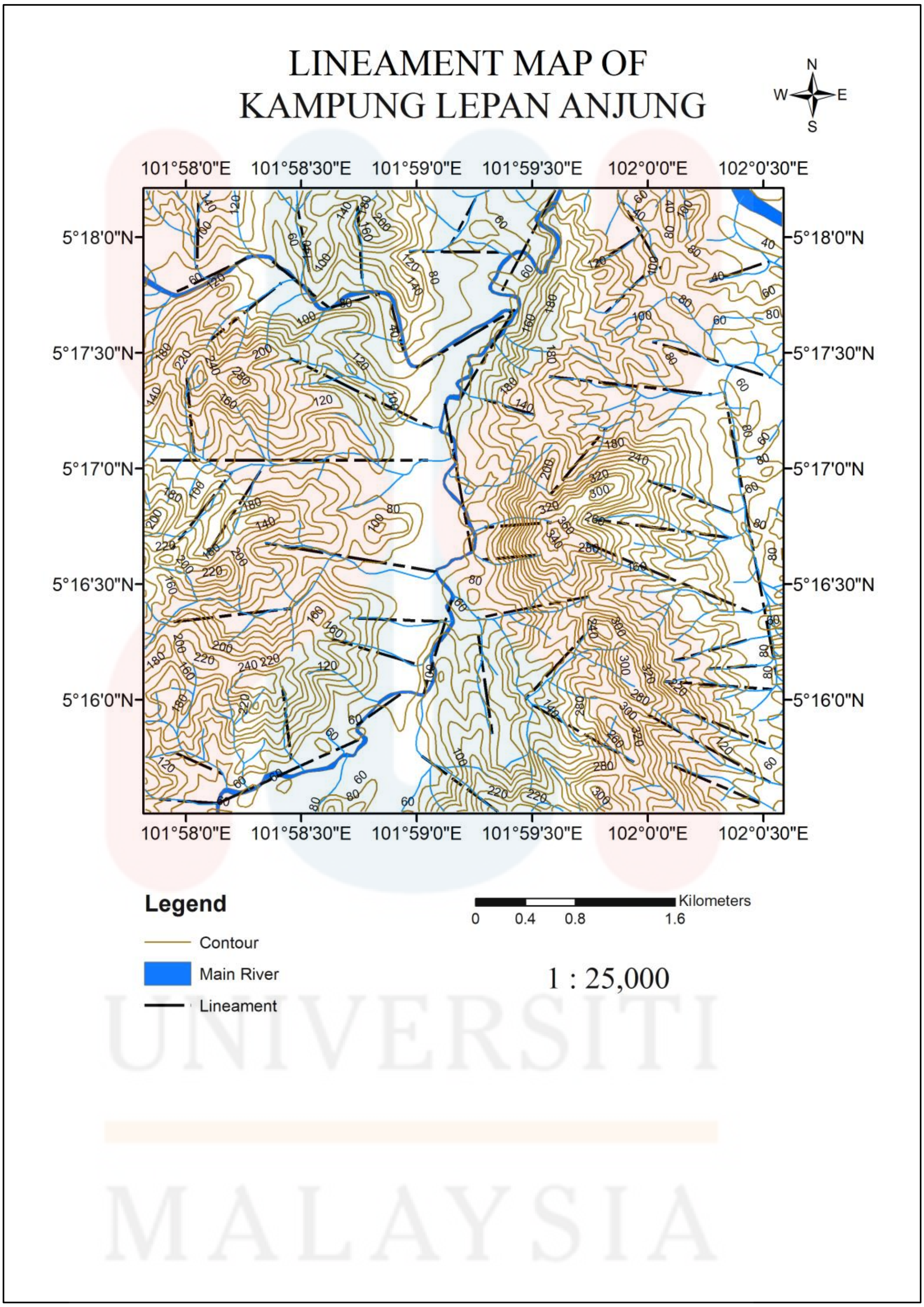

Figure 4.8: Lineament map of Kampung Lepan Anjung.

4.5 Historical Geology

The study of changes in the earth and its life forms is historical geology. Over time, most of the geological processes currently operating are close to those that it has worked in the past. In addition, historical geology offers valuable knowledge on ancient climate changes, volcanic eruptions, and earthquakes to provide a scientific basis for interpreting the earth's evolution over time, which can be used to predict the sizes and rates of possible events.

The granitic element of the complex was viewed from the Main Range Granite Batholith as an eastern protrusion and was identified as a highly complex injection complex. At least in Late Cretaceous the age of the last part of this granitic body took place and the earlier stages are uncertain but within the period from Triassic to Cretaceous.

Categorized as the oldest, Berangkat Tonalite and Kenerong Leucogranite are although the youngest pink Noring Granite is undeformed, it is deformed (Muzakkir, 2019). The Kenerong Leucogranite is known as the ages of the Cretaceous.

The characteristic of Kenerong Leucogranite is recognised as a complicated small intrusive network that is found in pelitic, magmatic metasedimentary (Ghani, 2009). Kenerong Leucogranite modifications of three generations from unfoliated to intensely foliate.

During the Triassic period, the metamorphic rock and granite formed associated with Stong Migmatite Complex as the granite intrudes the metamorphic rock, which is shicst, phyllite and marble.

CHAPTER 5

GEOCHEMISTRY OF GRANITE AT DABONG

5.1 Introduction

This chapter provides the specifications for the geochemical analysis specification study conducted on the granites of the study area of Dabong. Data were obtained from the interpretation of other research article. Moreover, this chapter was focus on granite petrographic and geochemistry properties. The classification used for the petrographic study of granites in the IUGS classification by applying the Quartz-Alkali Feldspar-Plagioclase-Feldspathoid (QAPF) diagram and the naming process.

The study area includes in Stong complex. The term complex in stratigraphy refers to a group of rocks or a mixture of two or more types of rocks of different origin classes with complex structures (Umor et al., 2019). Three pluton of rocks, the Berangkat Pluton, Noring Pluton, and Kenerong Pluton, may characterise the Stong complex.

Berangkat Pluton which is one of the pluton in Stong Complex. This pluton can be divided into three units which are Sg. Lah Granite, Bertam Granodiorite and Dabong Tonalite. The pluton term is used to name the rock unit because it includes a number of types of rock where the use of the term tonalite is descriptive of the natural rock.

As an isolated body, Dabong Tonalite was identified and locally revealed. It is situated in the northeast of Berangkat Pluton and consists of medium-grained coarse, textured same grain size, bright grey tonalite-granodiorite biotite hornblende has shown a strong setting or foliation. It comprises mafic enclaves with a diameter of 5-15 cm, oval to lenticular with indistinct boundaries. Pink pegmatite veins with diameter sizes from 10 cm to 50 cm are intruded into these rocks.

Bertam Granodiorite is the most dominant unit of rock in Berangkat Pluton. In colour, it is light grey to black, has a basic porphyry texture and is grained from medium to coarse. Sg. Lah Monzodiorite is surrounded by Bertam Granodiorite and is in the centre of the Berangkat Pluton. With a greater K-feldspar megacrist than Bertam Granodiorite, this unit is dark grey.

Kenerong Pluton contains Sg Kenerong Migmatite and Stong Leucogranite Litodemic. The main outcrop representing the Stong Leucogranite rock is the outcrop on Gunung Stong. It is characterised by a rock of the same grain size of the medium granular granite composition.

5.2 Petrographic analysis

Plagioclase, k-feldspar mainly orthoclasts, biotite, quartz, hornblende, sphinx, apatite, chlorite and sericite minerals are the mineral content of tonalite according to abundance. In these rocks, the texture of myrmekite is usually found. Many subhedral plagioclasts form an arrangement on a continuing process. K-feldspar was found to have major cracks that were assumed during its development to be under stress.

Plagioclase, K-feldspar, biotite, quartz, sphinx, apatite, epidote, alanite, chlorite and sericite minerals are composed of Bertam granodiorite. Sericitation and distortion have been experienced in most tabular shaped elongated euhedral plagioclase. Nearly the entire hike, K-feldspar orthoclase, nature micropertite and plagioclase inclusions often occur within it. A more mineral gap is filled by Anhedral quartz. Biotite, converted to secondary epidotics and chloride, undergoes grain distortion. As secondary minerals, Sphen euhedral and alanite are also found. Based on the presence of abundant secondary minerals, the rate of weathering of these rocks is high.

Quartz by Monzodiorite for Monzodiorite Sg. Lah is made up of minerals such as plagioclase, K-feldspar, biotite, hornblende, quartz clinopyroksene, sphinx, apatite and sericant. Plagioclase is euhedral-subhedral, spontaneously and independently distributed. K-feldspar is subhedral, with biotite and hornblende inclusions. Myrmekite texture can be found. Biotite and hornblende have a high ratio of about the same. The form of Clinopyroksene augite can be found in hornblende association and is subhedral. Individually, anhedral quartz occurs. As accessory rocks, the sphinx and apatite occur.

According to the QAP triangle name plot shows that Dabong Tonalite is categorized as Tonalite, while Bertam Granodiorite is categorised as granodiorite to tonalite and Monzodiorite Sg. Lah is known as monzodiorite quartz to Granodiorite.

Stong Leucogranite rock has light grey leucocratic, with a dominant mineral composition of quartz, plagioclase and alkaline feldspar. Two groups of rock, the igneous and metamorphic rocks, consist of the Leucogranite Pluton. Igneous rocks are represented by granite rich in quartz. Quartz-rich granite is considered Leucogranite with a quartz mineral percentage of almost 70 percent of the rock volume. Alkaline feldspar, plagioclase and muscovite are other felsic minerals, while mafic minerals are composed of biotite.

The size of the quartz varies from 0.2 mm to 2.5 mm, with an average of 1 mm. Feldspar alkali is a type of orthoclast that ranges between 0.5 mm and 1 mm. Plagioclasts vary from 0.1 mm to 1 mm in height, and 0.5 mm in rock on average. It was found to have undergone weathering forming minerals of sericite. Biotite is found in less than 5% of the rock thickness, uniformly distributed in the rock, with an average size of 0.2 mm. The feature can be observed at figure 5.1.

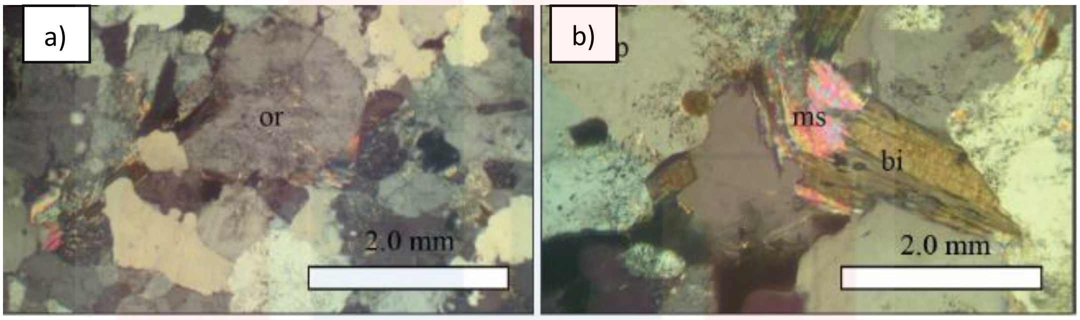

Figure 5.1: a) Microscope view of the mineral content of Stong Leucogranite. b) Biotite in Leucogranite which has undergone alterations (Umor et al., 2019)

Table 5.1: Summary of characteristics of rock units in the field within Berangkat Pluton.

Rock Type	Dabong Tonalite	Bertam Granodiorite	Sg. Lah Monzodiorite
Colour	Light grey	Light grey – dark grey	Light grey – dark grey
Grain size	Medium coarse, same size	Rough (2 mm - 20 mm), porphitic simple	Very rough (3 mm - 30 mm), porphyritic strong
Phenocryst	Nothing	Consists of colored K-feldspar gray - slightly pink, border phenocrystals with	Consists of K-feldspar color faded gray, clear borders, twins clear, euhedral

		surrounding minerals do not clear, subhedral	
Quartz	Bright, size 1 - 2 mm, elongated shape, form continuous, 10 - 15% isipadu	Bright, size 1 - 3 mm, anhedral, sometimes when connected, 5 - 10% volume	Bright, size 1 - 3 mm, anhedral, shape individually, 1 - 10% of rock volume
Plagioclase	White, usually connected form foliation, size 3 - 5 mm long, 1 - 2 mm wide, 40 - 50% rock volume	White, continuous forming foliation, size 4 - 12 mm long, 2 mm wide average, 30 - 40% of rock volume	White, individual shape, size 2 - 4mm length, 1 mm average width, 20 - 25% rock volume.
K – feldspar	Faded white, size 5 - 10 mm length, 1 - 5% volume, forming foliation	Faded white, size 10 - 20 mm long, to be phenocritic, scattered according to the foliation, uneven boundaries, 10 – 15 % of rock volume	Faded white, size 30 - 70 mm long, 15 - 25 mm wide, becoming phenocritic, scattered randomly, clear twins, euhedral, 20 - 35% rock volume.
Biotite	Black pieces, continuous, size 1 - 3 mm length, 1 mm average width, fill 15 - 20% of the volume rocks	Black clustered, connected, size 2 - 10 mm long, 2 mm average width, fill 10 - 15% of the volume	Black clusters, sometimes continuous, size 2 - 5 mm long, 1 mm average width, filling 15 - 20% rock volume

Hornblende	Hard to know	Hard to know	Tabular black, hexagonal face euhedral, size 2 mm - 4 mm long, 1 mm wide, filling <5%
Xenolith	Oval to lenticular shape, size 5 - 15 cm, no borders clearly, foliation is still seen	Square shape, size 10 - 50 cm diameter, clear border	Round shape, size 10 - 15 cm diameter, clear border.
Characteristic	Foliation is very well formed by plagioclase, biotite, quartz and K-feldspars	Simple foliage is formed by plagioclase and biotite	Unfoliated, some places applicable grouping of K feldspars

(Source: Umor et al., 2012)

5.2 Geochemical analysis

The outcomes of the analysis of the major elements of the Berangkat Tonalite and Leucogranite Kenerong are present as in Tables 1 and 2. In general, in the Kenerong Leucogranite rock, the percentage of concentration is found to be high with a concentration range between 71-74 % weight, whereas the percentage of silica in the Berangkat Tonalite rock is low between 65-70 % weight. These two rocks are more characterised as acid or felsic based on silica content, which is more than 65 % heavy.

Harker's diagram of the major element is plotted against SiO_2 as shown in figure 5.3. Two correlations are seen in Harker diagram which is positive correlation and negative correlation. Positive correlation is indicated by elements such as Na_2O and K_2O which the distribution trend is increasing against increased concentration of SiO_2. For Berangkat Tonalite rocks, positive correlation is indicated by the elements Na_2O and K_2O. Kenerong leucogranite is indicated by element K_2O against increased concentration of SiO_2.

From the hacker diagram, major element indicates negative patterns on the elements TiO_2, MgO, CaO, P_2O_5, Fe_2O_3, MnO and Na_2O which the distribution trend decreased against increased SiO_2 concentration. For Tonalite Berangkat rocks, negative correlation showed by the element Al_2O_3 TiO_2, MgO, CaO, P_2O_5, Fe_2O_3, MnO. Elements like Al_2O_3, TiO_2, MgO, CaO, P_2O_5, Fe_2O_3, MnO and N_2O_3 showed for Kenerong Leucogranite which against increased SiO_2 concentration.

5.2.1 Major element

Table 5.2: Concentration values of major elements of Leucogranite rocks.

Sample	1	2	3	4	5	6	7	8	9	10
SiO_2	72.99	73.97	72.08	72.64	71.46	71.6	72.05	72.77	73.49	72.79
TiO_2	0.21	0.18	0.24	0.17	0.28	0.26	0.23	0.23	0.19	0.17
Al_2O_3	15.37	14.11	15.47	15.38	15.95	14.56	15.51	15.29	15.27	14.91
Fe_2O_3	1.39	1.49	1.56	1.21	1.85	2.12	1.9	1.76	1.38	1.4
MnO	0.04	0.03	0.03	0.03	0.03	0.03	0.05	0.05	0.03	0.02
MgO	0.19	0.04	0.26	0.02	0.36	0.27	0.2	0.16	0.16	0.21
CaO	2.16	1.08	2.28	1.66	2.29	1.68	1.61	1.76	1.72	1.7
Na_2O	3.96	3.21	3.95	4.1	4.09	3.17	3.9	3.58	3.85	3.85
K2O	3.18	5.45	3.6	4.26	3.13	4.82	3.93	3.95	3.79	3.84
P_2O_5	0.04	0.04	0.06	0.03	0.08	0.08	0.07	0.07	0.05	0.06
Total wt %	100.3	100.3	99.99	99.97	99.97	99.24	99.95	100.03	100.35	99.34

(Source: Ramdanshah et al., 2001)

Table 5.3: Concentration values of major elements of Berangkat Tonalite rocks.

Sample	1	2	3
SiO_2	70.03	65.33	68.37
TiO_2	0.3	0.73	0.51
Al_2O_3	14.96	14.95	14.85
Fe_2O_3	2.17	4.6	4.03
MnO	0.04	0.07	0.07
MgO	1.04	2.57	1.74
CaO	1.93	3.2	3.11
Na_2O	3.01	2.65	2.63
K2O	5.87	4.66	3.88
P_2O_5	0.15	0.3	0.19
Total wt %	100.04	99.84	99.96

(Source: Ramdanshah et al., 2001)

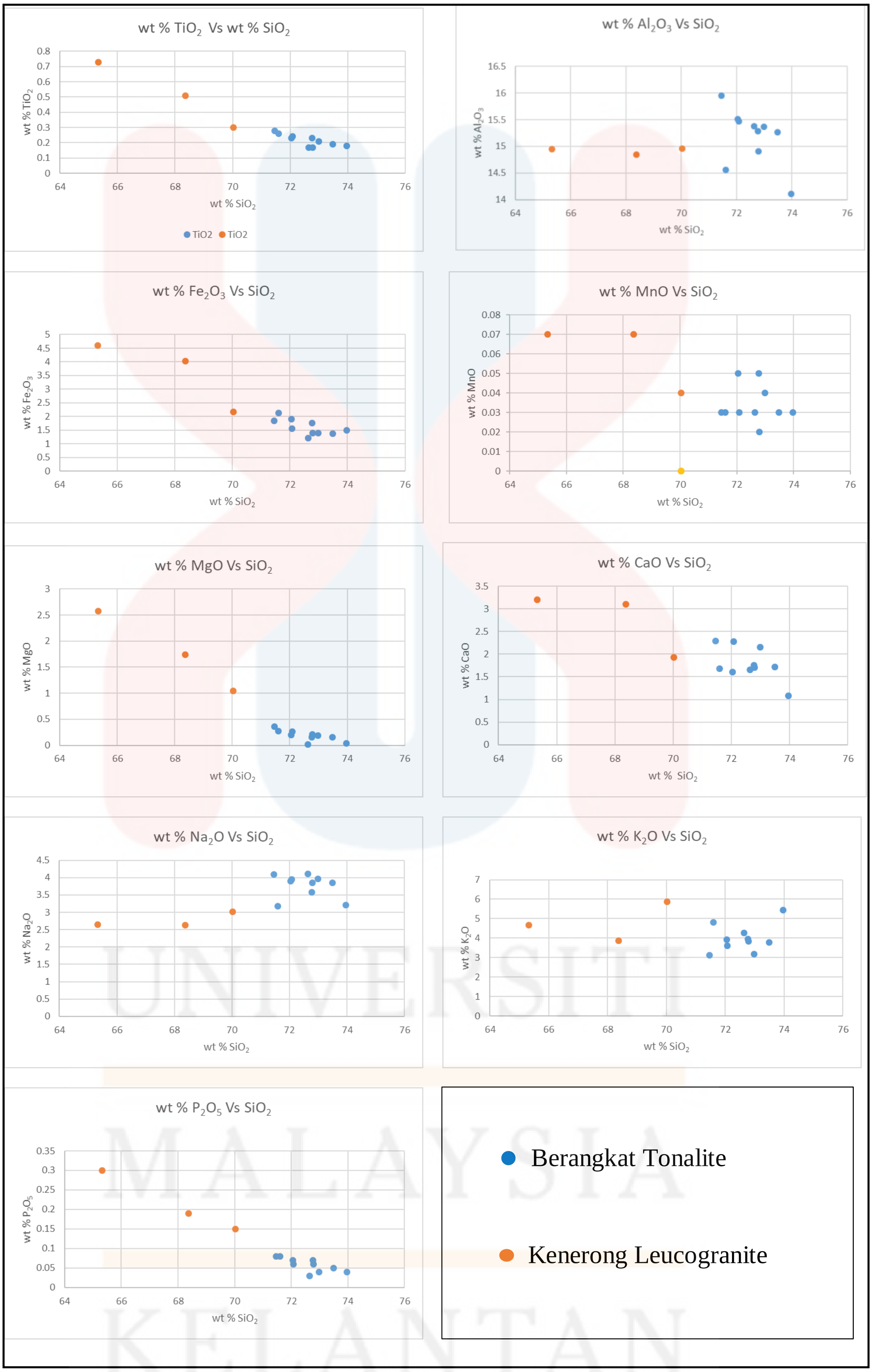

Figure 5.2: Major elements Harker Diagram of Berangkat Tonalite and Kenerong Leucogranite.

5.4 Discussion

These three rock units have a genetic association based on mineral content and geochemical patterns, and are derived from a similar magma source. Since the rock differentiation direction based on quartz abundance suggests that rocks evolved from Sg. Lah Monzodiorite to Dabong Tonalite, Enclave Microdiorite and Bertam Granodiorite. However, all units of rock crystallise at various locations in one intrusive body at around the same time.

This is because all the rock units are found to be classified inside the same rock series and the same magma series, all of which are metallurgical rock series, classified as shoshonite calk-alkali series. Due to its simple porphyritic existence, Sg. Lah Monzodiorite unit is interpreted as a core unit granite body rich in mafic minerals and some outcrops contain K-feldspar clusters that characterise the flow and isolation of minerals during magma uptake in the breakthrough.

It is said that Dabong Tonalite is a rock unit that is near the boundary with the surrounding rocks. It has a simple foliation, granules of almost the same size and, based on the presence of xenolith and high K_2O and Sr values, shows a relatively important assimilation effect.

Enclave Microdiorite was found to have a mineral content close to that of Bertam Granodiorite, but as a result of mingling interactions between Bertam Granodiorite's molten magma with these rocks, it displayed a possible rapakivi texture.

CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

In conclusion, the first objective of creating a geological map of the study area of Dabong on a scale of 1:25000 was achieved. Study area was covered with variety type of landuse like mixed vegetation, agriculture and forest. The drainage pattern mostly is parallel and dendritic type which had been observed and study. Most of study area has low topographic which is low hills below 200 m. The main access to the study area is by the road which is Gua Musang to Jelawang road.

The stratigraphy at the study area consisted of three lithological units which are granite (Tertiary), interbedded sandstone, siltstone, and shale (Triassic), phyllite, slate and shale subordinate sandstone and schist (Permian). The formation involves is Telong Formation and Stong Formation. For the structural geology, there are lineament analysis conducted. Observation of fault was identified based on data interpretation.

Research area is including in Stong Complex. Leucogranite Pluton consist of igneous and metamorphic rock type. Leucogranite is the granite that rich in quartz.

6.2 Recommendation

For lineament analysis, use the latest ArcGIS tools, a recent and improved technique may be used as the GIS approach is an effective tool to locate geological formations such as fault segments in urban environments where access is difficult. This will decrease the time spent on the field and save a lot of time.

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