GEOLOGY AND FELDSPAR CHARACTERISATION IN KUALA BALAH, JELI KELANTAN

by

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APPROVAL

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

Signature :

Name of Supervisor :

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DECLARATION

I declare that this thesis entitled Geology and Feldspar Characterisation in Kuala Balah, Jeli Kelantan is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

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GEOLOGY AND FELDSPAR CHARACTERISATION IN KUALA BALAH, JELI KELANTAN

ABSTRACT

The study area is located at Kuala Balah, Jeli lies at latitude 05°27’30” N to 05° 30’00” N and longitude 101°54’00” E to 101°56’30” E which covered 25 km^2. The study area is predominantly cultivated area. The objectives of this study are to update geological map with scale 1:25000 and to determine the properties of feldspar as well as to compare it with the industries. Generally this study area consists of phyllite and slate. Muscovite was found dominant in the phyllite rock. The characterisation of feldspar was done using X-ray fluorescence (XRF) and X-ray diffraction (XRD). The result XRF showed the silica content in the samples range between 70-75 % while XRD analysis clearly shown the peak of feldspar. As conclusion, feldspar from the study area has potential to be used as raw material in ceramic and glass manufacture.

GEOLOGI DAN PENCIRIAN FELDSPAR DI KUALA BALAH, JELI KELANTAN

ABSTRAK

Kawasan kajian terletak di Kuala Balah, Jeli terletak di latitud 05°27’30” N hingga 05°30’00” N dan longitud 101°54’00” E hingga 101°56’30” E meliputi 25 km^2. Kawasan kajian kebanyakannya telah diusahakan. Objektif kajian ini adalah untuk mengemaskini peta geologi dengan skala 1: 25000 dan untuk menentukan pencirian feldspar dan kesesuaian untuk industri. Secara amnya, kawasan kajian ini terdiri daripada filit dan sabak. Muskovit didapati dominan di dalam batuan filit. Pencirian feldspar dilakukan menggunakan sinar X pendaflour (XRF) dan sinar X difraksi (XRD). Keputusan XRF menunjukkan kandungan silika dalam sampel antara 70-75 % manakala analisis XRD dengan jelas menunjukkan feldspar. Sebagai kesimpulan, feldspar dari kawasan kajian mempunyai potensi untuk digunakan sebagai bahan mentah dalam pembuatan seramik dan kaca.

CHAPTER 3: Material and methodology

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LIST OF ABBREVIATIONS

AFM	Atomic Force Microscope
Al_2O_3	Aluminium Oxide
BaO	Barium Oxide
BDL	Below Detection limit
CaO	Calcium Oxide
cm	Centimetre
Fe_2O_3	Iron (III) Oxide
g	gram
Ma	Mega annum
MgO	Magnesium Oxide
mm	Millimetre
Na_2O	Sodium Oxide
NNW	North-northwest
K:Ar	Potassium Argon
$KAlSi_3O_8$	Potassium Aluminium Silicate
K_2O	Potassium Oxide
km	Kilometre
km^2	Kilometre Square
SSE	South-southeast R:Sr Rubidium strontium
SiO_2	Silicon Dioxide
TiO_2	Titanium Dioxide
XRF	X-ray Fluorescence
XRD	X-ray Diffraction

LIST OF SYMBOLS

α	Alpha
°	Degree
/	Division Slash
‘	Minute
%	Percentage
“	Second
σ	Sigma
θ	Theta
λ	Lambda
wt%	Weight Percentage

CHAPTER 1

GENERAL INTRODUCTION

1.1 General Background

This research study was conducted to explain about the geology and feldspar characterisation for industrial mineral in Kuala Balah. The study that conducted involved a geological mapping, sampling and laboratory work. The geological mapping was conducted to identify the distribution of rocks, the geomorphology and structural geology. Geological mapping also conducted to generate a new geological map that shows the latest geological characteristic with 1: 25000 scales. Sampling for this study was carried out in two types which are in rock sample and soil sample. Laboratory works were conducted to identify and classified the characterisation of feldspar mineral using the sample obtained.

The study area for this research is located in Kuala Balah, Jeli Kelantan in Peninsular Malaysia. Kuala Balah area is part of Stong Migmatite Complex Formation. The geomorphology, landform, rivers stream and structural geology in this study area are complex. The rocks are exposed to form mountainous landscape that is interpreted as young geomorphology based on the presence of several waterfalls and rapids on the steep slopes drainage. The geology of Stong Migmatite Complex consists of three major igneous rocks which are Berangkat Tonalite, Noring Granite and Kenerong Leucogranite.

This study also conducted to determine the feldspar properties to be use commercially. The characterisation of the feldspar mineral was carried out in laboratory using XRF Analysis and XRD analysis. Aside that, petrography of mineral also has been studied using optical microscope. The obtained results were interpreted and compared with the mineral's feldspar specification for industrial used based on the previous study cases. It is hoped that the characterisation of feldspar within the study area will help to identify the prospect of the study area.

1.2 Study Area

1.2.1 Location

The study area is Kampung Kuala Balah, Dabong, Jeli Kelantan. Kuala Balah town is a town located in the district of Kuala Balah, one of the small districts of the Jeli district. It is bounded by latitude 05°27'30" N to 05°30'00" N and longitude 101°54'00" E to 101°56'30" E. Kuala Balah district capacity is 62,159.76 hectare. **Figure 1.1** shows the base map of Kuala Balah.

1.2.2 Road Connection

Kuala Balah town is a town located in Kuala Balah districts. It is located about 32 km from, Jeli City. It is also located 20 km from Dabong Kuala Krai Town, 145 km from Kota Bharu City Center, 100 km from Kuala Krai City Center via Jeli-Dabong-Sam-Kuala Krai Road and 85 km from Gua Musang City Center via Jeli-Jelawang-Gua Musang Road.

It is a town located in the heart of Malaysia Federal Route 66 which connects Jeli and Dabong Town in Kuala Krai district, Kelantan. Federal Route 66 is part of the road route connecting the Jeli-Gua Musang route which is an alternative route from Gua Musang to Kota Bharu as well as the Kuala Krai-Gua Musang Highway (Federal Route of Malaysia 8).

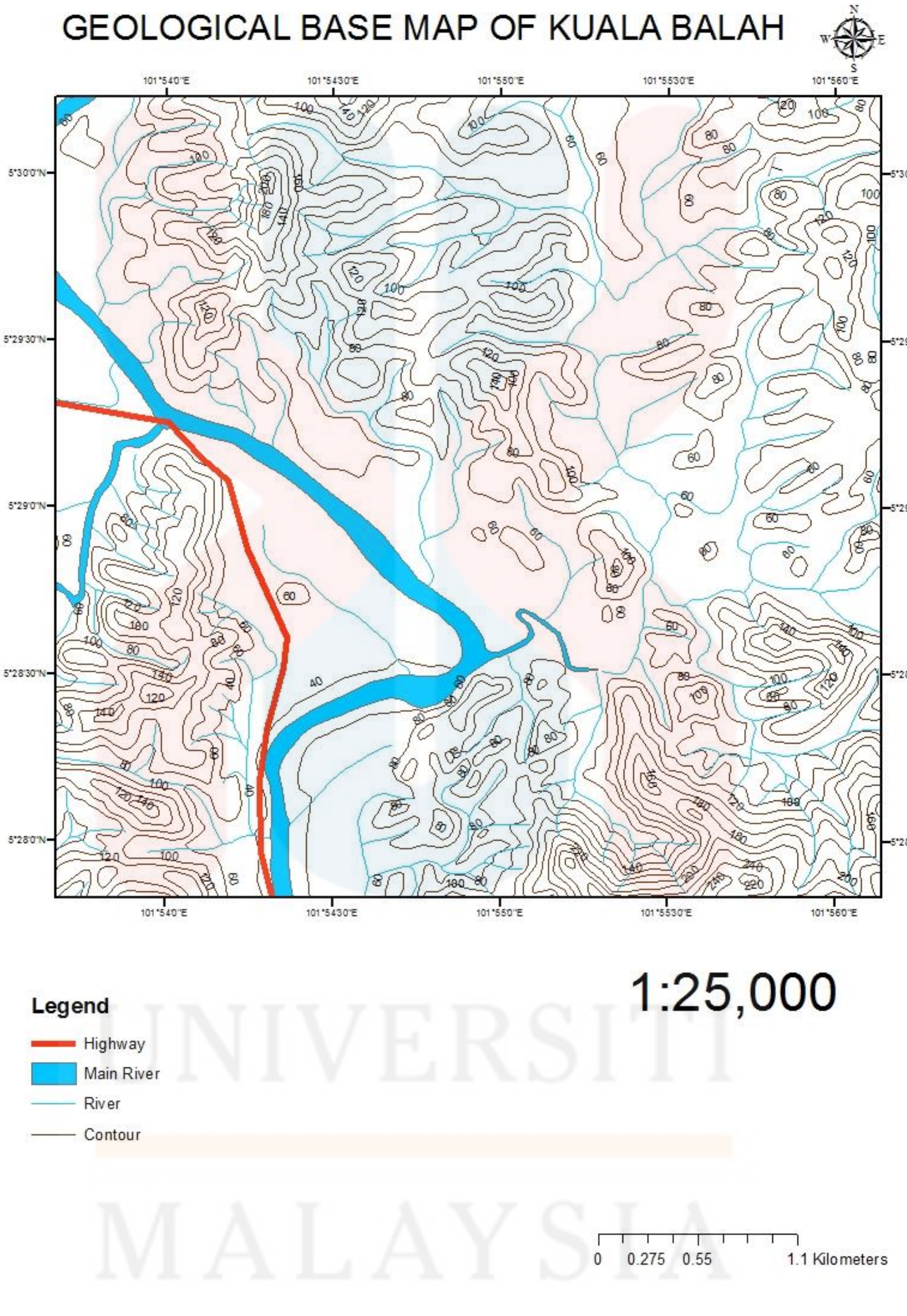


Figure 1.1 The Geological Map of the study area, Kuala Balah.

1.2.3 Demography

It is estimated that the total population of Kuala Balah district is 13,700 people. Its population is Malays. Generally, the people in the district of Kuala Balah live in densely populated villages along the Malaysian Federal Route 66 and also on the riverfront. **Table 1.1, 1.2, 1.3, 1.4** & **1.5** shows the population figures of Kuala Balah based on Department of Statistics Malaysia, 2010.

Table 1.1 Genders

Gender (2010)	
Males	5,281
Females	5,104

Table 1.2 Ages

Age (2010)	
0-14 years	3,675
15-64 years	6,088
65+ years	622

Table 1.3 Age Distribution

Age Distribution (2010)	
0-9 years	2,308
10-19 years	2,625
20-29 years	1,213
30-39 years	1,130
40-49 years	1,116
50-59 years	998
60 -69 years	586
70+ years	409

Table 1.4 Nationality

Nationality (2010)	
Malaysia	10,197
Other Nationality	188

Table 1.5 Ethnic Group

Ethnic Group (2010)	
Malay & other indigenous (Bumiputra)	10,177
Chinese	9
Other group	11

1.2.4 Land Use

Generally, land use pattern in Jeli district were classified into two categories which are build-up land use and non-build-up land use. The build-up land use covers an area of 2,104.90 hectare or as much as 1.62 %. While the non-build-up land use covers an area of 127,575.36 hectares or of 98.38 %. Overall, Jeli covers an area of 129,980.26 hectares. **Table 1.6** shows the main soil use in Jeli district as of 2010.

Table 1.6 The main land use in Jeli district as of 2010

Land use	Existing	Percentage
BUILD-UP LAND USE		
Residence		
Planned	45.80	0.04
Unplanned	553.28	0.43
Business and services	58.96	0.05
Industry	37.68	0.03
Institution and community facilities		
Education	270.19	0.21
Health	11.34	0.01
Religious	14.92	0.01
Cemetery	20.27	0.02
Security	39.43	0.03
Homeless shelter	0.80	0.01
Government use	35.77	0.03

Other community facilities	6.02	0.01
Open space and recreation	33.33	0.03
Transportation		
Road	965.69	0.74
Transport facilities 9	2.11	0.01
Infrastructure and facilities		
Electricity	4.58	0.01
Water supply	6.73	0.01
Landfill	1.51	0.01
Telecommunication	2.29	0.01
Sub total	2110.70	1.63
NON-BUILT-UP LAND USE		
Empty land	405.85	0.31
Agriculture		
Agriculture	46,921.03	36.18
Wasteland	570.22	0.44
Animal husbandry and aquaculture	15.81	0.01
Body of water	2,097.78	1.62
Forest	77,558.37	59.81
Sub total	127,569.56	98.37
TOTAL (Overall)	129,680.26	100

(Source: Draft local plan of Jeli district, 2010)

1.2.5 Social Economic

Table 1.7 The Gross Domestic Product (GDP) and GDP per capita for Kelantan state

State	Kelantan	Malaysia
GDP per capita	RM 13,593	RM 42,228

(Source: Department of Statistics Malaysia, 2017)

The main contributor to the Gross Domestic Product is the wholesale and retail trade, hotel and restaurant sub-sector which is 29.0 % followed by agriculture sector 15.2 %. The largest employer of the labour force in Kelantan state is in agriculture sector. The main agriculture crops are rubber, oil palm, paddy, tobacco, fruits and vegetables. Forestry and fishery are also important sub-sectors of agriculture sector. For manufacturing sector produces mainly wood-based, food-based, textiles, electrical and non-metallic mineral products.

1.3 Problem Statement

Geological map is very important to show a correct picture of altitude and structure of rock formation, with detailed information at scale 1:25000 of study area. Plus, there is lack information about the geological condition at study area.

The problem of this study is to locate the feldspar location that can be commercially uses in the study area. Feldspar is important in industrial mineral and about 70 % of feldspar has been used in the glass manufacturing while 30 % in ceramic. The properties of feldspar in term of physical and chemical properties were examined and compared with the industrial requirement for feldspar.

1.4 Objectives

This research was conducted to achieve several objectives. The objectives of this research are:

- To produce a geological map with scale 1:25000
- To determine the properties of feldspar in Kuala Balah, Jeli.

1.5 Scope of Study

The study aims to investigate the characterization of the mineral feldspar deposits. The studies includes the in its scope as X-ray Fluorescence (XRF) Analysis, X-ray Diffraction (XRD) Analysis and Petrography Analysis used by entire world and does not limited in Malaysia only. The studies include all the method and specifications that can be use and available in Malaysia according to various standard sources in Malaysia.

1.6 Significance of Study

This study is imperative as an opportunity to recognize the attribute of feldspar deposits of rock in the study area. The chemical composition that will be examined will turn into a key guide for industrial minerals investors and company. This study is important to the administration, public sector and private division. For the government this study is important to raise the economic income whereas for public sector and private division, this will likewise help them to begin a potential mining location.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this section, deep reviews on previous study that have the most related aspect to the research were carried out. The review usually related to the objective, problem and the methods used by the previous research. This review that had been made during this research was analysed to get a better result and as a reference to run the method precisely.

On this literature review, the information was collected according to the related subject of research. The basic about regional geology of Kelantan, was being the indicator in finding the rock distribution in study area, and as a reference to do geological mapping on study area. Other than that, this review covers the related subject of the research which is about the distribution of feldspar, sources of feldspar and its industrial application.

2.2 Regional Geology and Tectonic Setting

As expressed by Raj (2009), Peninsular Malaysia, with an aggregate land region of 130,268 km^2, shapes some portions of Sundaland, which incorporate Borneo, Java and Sumatra, and in an addition the interceding shallow seas from which raise various littler islands.

Raj (2009) also mentioned the Peninsula is elongated in general NNW-SSE direction with the greatest length of 750 km and breadth of 330 km. To the south, it is separated from Singapore Island by the narrow Johor Strait, whilst, to the west, it is separated from Sumatra Island by the Straits of Malacca. To the southeast and east of the South China Sea separates the Peninsula from Borneo Island.

Kelantan one of the states in Malaysia located in Peninsular Malaysia which is part of Sibumasu and East Malaya blocks. Peninsular Malaysia was divided into three tectonic belts. *Western belt* is located at western part of Bentong Line. It covers Perlis, Kedah, Perak, Selangor, Negeri Sembilan and Melaka. Western belt shows Paleozoic and Mesozoic a rock which is in Kedah and Northern part of Perak. The other dominant rocks are clastic and carbonate rocks. The igneous was distributed throughout Main Range aged Late Triassic. There is also less volcanic rocks within this belt.

Central Belt as shown in **Figure 2.1** is covered most of Kelantan, Centre and West of Pahang, East of Negeri Sembilan, and West of Johor. Permo-Triassic rocks spreads in high amount and the rest are Jurassic-Cretaceous rocks. The volcanoclastic rocks in Central Belt were spread North-Southward of Central Belt. The third belt *Eastern belt* covered by Terengganu, Eastern of Pahang and Johor. The Upper Palaeozoic which sedimentary rocks dominant Perm-Carbon with volcanoclastic, siliciclastic, less carbonate can be found.

Kuala Balah is a part of the Stong Migmatite Complex that was formed by rocks in three units which are Tonalite Berangkat, Granite Noring and Leucogranite Kenerong. Stong Complex is located at the northern part of the central belt, in the state of Kelantan, Peninsular Malaysia. It occupies an area of almost 300 km^2, from Jeli in the north to Kemubu in the south, forming a mountainous region centered on Gunung Stong and Gunung Berangkat at the south (Hutchison, 2009).

The Central Belt extends from Kelantan to Johor between the eastern lower regions of the Main Range, shaping its western boundary, to its eastern boundary set apart by the Lebir Fault in the north down toward the western boundary of the Dohol Formation in the south (Lee, 2009).

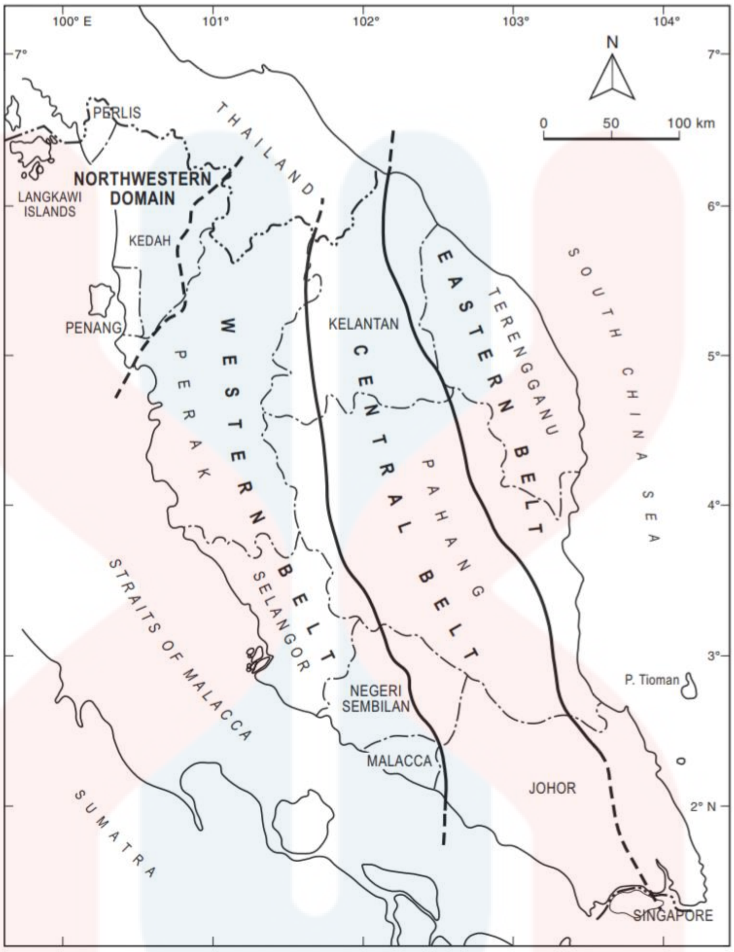


Figure 2.1 Map of Peninsular Malaysia showing the three belts. (Lee, 2009)

2.3 Stratigraphy

Three plutonic components were found for granitoids (Singh *et al.*, 1984). The earliest two phases (Berangkat Tonalite and Kenerong Leucogranite) are in part highly deformed in a manner similar to that of the marginal country rocks. The third phase, the distinctive pink Noring Granite, is undeformed.

The Berangkat Tonalite, at the southern end, is a coarse grey K-feldspar megacrystic biotite-horblende tonalite that locally is highly deformed. It may be of Permo-Triassic age, but no dating has been carried out and the similar abundance of enclaves to the Kenerong Leucogranite suggests that a Cretaceous age may be appropriate. The tonalite is cut by the Kenerong leuco-microgranite. It forms a complex network of small intrusives and vein systems emplaced into the predominantly politic amphibole-facies metasedimentary envelope. Three samples define an Upper Cretaceous Rb:Sr age of 79 ± 3 Ma, with an initial ratio of 0.70801. The pink Noring Granite is undeformed megacrystic bitite-horblende granite. It is a larger pluton extending northwards to intersect the East-West Highway west of Jeli. The Rb:Sr data define an isochron of 90 ± 30 Ma with an initial ratio 0.70865. The Noring Granite intrudes the earlier Kenerong Leucogranite. The following K:Ar ages: 65±2 for muscovite and 70±2 Ma for biotite in the Noring Granite at Batu Melintang, and 69±2 Ma for for the Kenerong Leucogranite of the Stong Complex. These dates reinforce the interpretation of a Cretaceous age (Hutchison, 2009).

The metamorphic rocks of the enclaves within the granitoids comprise meta-pelites, within the granitoids comprise meta-pelites, impure meta-arenites, impure to pure marble, and amphibolites in the southern part of the complex (Singh *et.al*., 1984). The following rock types are common; (1) finely banded hornblende-quartz schist. Bands rich in quartz, oligoclase-andesine and orthoclase alternate with hornblende-rich bands. MacDonald (1967) made a tentative identification of cordierite, (2) staurolite-garnet-biotite schist. This rock occurs along the Sungai Tool (Singh *et.al*, 1984), (3) fine-grained biotite-muscovite schist. The rock is of biotite, muscovite and quartz, with a common tourmaline accessory, (4) fine-grained hornblende-biotite-quartz schist. In addition, the main minerals include plagioclase, (5) diopside-phlogopite marble. The main mineral is calcite and quartz is an accessory, (6) silimanite-garnet-biotite gneiss. This rock outcrops along the Sungai Kenerong.

The presence of cordierite is critical to the allocation of a metamorphic facies. MacDonald (1967) was rather tentative about the identification of cordierite. Hutchison (1969) also tentatively identified the mineral but the identification was not convincing. Additional research is needed involving microprobe analysis. If the cordierite is not actually present, then the mineralogy suggest Barrovian amphibolite facies. If the cordierite has been correctly identified, then the facies is amphibolite facies of the Intermediate facies series (Winkler, 1967).

A general conclusion from the facies allocation is that the temperature-pressure regime was high enough for some anataxis at the presently exposed level, so that at least Kenerong Leucogranite was derived, in part, from in-situ partial melting. The existing evidence suggests continuity between the Stong Complex and the Taku Schist beneath the Dabong-Kemubu greenschist facies synclinal area. K:Ar radiometric dates from the Taku Schist indicate that the biotite was crystallized at 215 and 219 Ma and muscovite at 212 Ma (Bignell and Snelling, 1977). It is realistic to assume that the similar amphibolite facies of the Stong Complex is likewise Triassic. The similarity also extends to the granitoids and the Kemahang Granite, that intrudes the Taku Schist, gave a Creataceous K:Ar age of 107±3 Ma (Bignell and Snelling, 1977). However, the Kemahang Granite continues across the border into south-east Thailand, where it is known as the Buke Granite, K-Ar dated Jurassic on biotite at 190±9 Ma by Hughes and Bateson (1967), quoted by Cobbing *et.al* (1992).

The tectonic implications are that the amphibolite facies metamorphism of both the Stong Complex and the Taku Schist were products of the Late Triassic Indosinian Orogeny when Sibumasu collided with East Malaya-Indochina. The Cretaceous event that resulted in emplacement of granitoids into the uplifted Stong and Taku schist amphibolite facies terrain has been given sparse emphasis in the tectonic scheme of Peninsular Malaysia. The granitoid emplacements occurred in a strongly deforming region resulting in migmatization, boudinage and ptygmatic folding.

2.4 Structural Geology

Stong is an injection migmatite of great complexity. There are three main types of migmatites that are well presented with transition with them; (1) Agmatite, in which angular enclaves of darker gneiss and schist are surrounded by more homogenous granitic material. It appears to have formed by magmatic injection. Some contacts are concordant while others are discordant. (2) Venite, in which discrete layers and patches of granitic material occur in schist. The individual layers are narrower than in agmatite. (3) Nebulite, in which there is a more complete mixing of granitic material and schist. They are more homogenous but contain schlieren generally enriched in biotite and horblende, giving the rock a crude gneissic texture. Good examples occur along the Sungai Kenerong.

The granitoid layers have been spectacularly deformed into boudins as well into the most remarkable examples of ptygmatic folds. This development was caused when layers of different mechanical properties were subjected to layer-parallel stresses. Both boudinage and intense buckling occur in the same granitoid layer as enclosing metasedimentary envelope was being folded. Since the granitoids have been dated Cretaceous, it follows that metamorphic folding was also Cretaceous.

The Kenerong Leucogranite at the Sg. Renyok waterfall consists of sequence of sub-parallel stretched leucogranite veins and metasedimentary enclaves. The structure includes isoclinal folds of the metasedimentary layers, well developed foliations in the metasediments, and some veins. There are symmetric and rotated boudins, pinch and swell structures, a range of folds from assymetric to pygmatic, and kink bands. The faults may be reverse, oblique-slip and conjugate strike-slip, with slickensided surfaces.

Ibrahim Abdullah and Jatmika Setiawan (2003) concluded that the rocks had undergone at least four phases of deformation. The first was responsible for the development of isoclinal folding of the metasediment and the development of foliations and reverse sinistral oblique-slip faults that were concentrated along the contact between the metasediments and the veins, as indicated by vein-parallel narrow shear zones and slickensides. This deformation caused the veins to undergo extension and rotation into asymmetric and rotated boudins and pinch-and-swell structures. This earliest deformation occurred during the emplacement of the Kenerong Leucogranite, suggesting that the Late Cretaceous deformation was intense and involved a sinistral transpressive regional stress system.

The second and third deformation, with compression in the NE direction, was related to the formation of conjugate strike-slip faults, pinch-and-swell structures boudinage, drag and pygmatic folds. Small-scale kink folds might be related to the stress system that may have continue from the first sinistral tranpressive deformation, followed by the emplacement of the nearby granite. Some of the earlier faults were reactivated as normal faults. This latest deformation could be due to the relaxation after granite emplacement, as suggested by Ibrahim Abdullah & Jatmika Setiawan (2003) or to a later regional stress system during the Tertiary.

2.5 Historical Geology

Based on the previous study, the variety of the rocks in this area is formed by rocks in three units consisting of Tonalite Berangkat, Granite Noring and Leukogranite Kenerong. This diversity study also identified Stong mountainous landscape is formed by igneous rock that unique and rarely found in the country.

The Stong Migmatite Complex represent by granitic rocks which are known as Noring Granite. Xenoliths are widespread within the Noring Granite. Petrography study shows close similarity between the xenoliths and meta-sediments. Besides, the petrographic study also shows the granite consists of quartz, alkali, feldspar, plagioclase and biotite. Xenoliths which exist within the Noring Granite were suggested as originated from the Gua Musang Formation.

There are two main components of the Stong Complex in the order of decreasing age are Berangkat Tonalite and Kenerong Leucogranite. Samples from these two components were analysed using X-ray fluorescence (XRF) with purpose to determine the origin of magma, whether from Main Range Granite Batholith or from the Eastern Belt Granite. Analysis of major elements were carried out using harker, AFM and A/CNK diagram, while trace elements were divided into two groups, the LIL elements (large ion lithopile elements) and the trace transition metal (Bacho *et.al.,* 2001).

These analyses lead to suggestion that Berangkat Tonalite and Kenerong Leucogranite originated from the same magma that had undergone differentiation. Both Berangkat Tonalite and Kenerong Leucogranite are more felsic in nature containing high alumina (peraluminous) and magma is of calcalkaline series. The Stong Complex is from I-type granite suggesting that they are part of the Eastern Belt Granite (Bacho *et.al.,* 2001).

2.6 Occurrence of Feldspar

Feldspar is the most critical single group rock-forming silicate minerals. The mineral name feldspar is gotten from the German words field + spar. The word (field) will be field in German and (spar) is a term for light shaded minerals that break with a smooth surface. Feldspars crystallize from magma as veins in both intrusive and extrusive igneous rocks and are also present in many types of metamorphic rock. Rock formed almost entirely of calcic plagioclase feldspar is known as anorthosite. Feldspars are also found in many types of sedimentary rocks.

2.7 Source of Feldspar

The commercial source of feldspar is generally from pegmatites and aplites. Pegmatites are very coarse-grained igneous or metamorphic rocks, generally of granitic composition. Those of granulite and some amphibolite facies terranes are frequently indistinguishable mineralogically from the magmatic leucosomes associated with them, but those developed at higher structural level and often spatially related to intrusive, late tectonic granite plutons, are often marked by minerals with volatile components (Evans, 1993).

Although both are commonly associated with granitoids in Peninsular Malaysia, most of the occurrences are of limited size to be of any commercial significance. Granitic rocks are appropriate source materials, particularly that medium- to coarse-grained, leucocratic varieties containing more than 60 % feldspar and less than 10 % iron-bearing minerals. (Md.Slar *et al.*,1996).

2.8 Application of Feldspar in Industry

Md.Slar *et al.* (1996) stated the feldspar specification of > 18 % Al_2O_3, > 11 % (Na_2O + K_2O) and < 0.3 % Fe_2O_3 that is ideal for commercial use. They deduced that regardless the positive and encouraging indication that the extracted feldspar samples of different chemical compositions which discovered reasonable for making ceramic bodies and glaze, the feldspar's chemical content come what may could be critical for the fabricate of particular final results.

The size for glass making range about 0.85 mm while for ceramic application is 0.075 mm or finer for most ceramic and filter applications. Feldspar is used in the manufacture of glass products (70 %), in ceramic and other products (30 %). Feldspar is an important ingredient in the manufacture of glass. The raw material for glass consists of silica sand, soda ash (sodium carbonate) and limestone (calcium carbonate). Evans (1993) also explained that some dolomite and/or feldspar are also added to improve chemical durability and resistance to devitrification. Feldspar adds certain qualities to the process. Alumina up to 4 % is acceptable for common glass production but it must be < 0.1 % for optical glass, although a small amount does help prevent devitrification. Iron oxides can be tolerated only for green and brown bottle glass; otherwise iron as Fe_2O_3 must be < 0.05 % or even < 0.015 % for some purposes. Alumina provides hardness, workability, strength, and makes glass more resistant to chemicals .Na_2O and K_2O from feldspar are fluxes. Fluxes reduce the melting temperature so less energy is used and decrease the amount of soda ash needed. About 110 pounds of feldspar are used to produce one ton of container glass (soda bottles, e.g.), and 100 pounds are required to produce one flat glass.

According to Sadeq *et al.* (2015), they also stated that in the fabrication of ceramic material, feldspar serves as a flux to form a glassy phase at low temperatures, and as a source of alkalis and alumina in glazes. It improves the strength, toughness, and durability of the ceramic body and cements the crystalline phase of other ingredients.

The composition of commercial glass grade feldspar and ceramic grade feldspar are shown in **Table 2.1** below.

Table 2.1 Chemical analysis of the main elements of commercial glass grade feldspar & ceramic grade feldspar

Constituent	Glass (%)	Ceramic (%)
CaO	1.85	-
SiO_2	68.9	75
Al_2O_3	18.75	15
Fe_2O_3	0.07	0.3
K_2O	3.85	3.3
Na_2O	7.15	4.5

(Source: Amaireh *et al.*, 2014)

Ahmed *et.al*., (2016) told that another classification of commercially acceptable feldspars are typically as follows: the summation of Na_2O and K_2O is about 11–13 %, the summation of CaO and MgO is < 1.5%, the total amounts of Fe_2O_3 and TiO_2 are about 0.07–0.3 % and the free quartz is nearly 8–10 %.

Evans (1993) explained that sepiolite or attapulgite with very minor amounts of montmorillonite, quartz, mica and feldspar uses in special papers making. . One of the main elements in feldspar which is TiO_2 is used as fillers in papermaking. Paper fillers are pigment powder that is produced mainly from natural minerals. Jarkko Grönfors (2016) mentioned that the titanium dioxide is a pigment that has high optical efficiency. The small particle TiO_2 has very high brightness. It scatters light well compared to other fillers. Titanium dioxide is used in such grades that require superior opacity such as lightweight opaque offset papers or bible papers. Show-through is also very well reduced by the use of TiO_2. However, high price and the abrasiveness of particles restrict broader use of titanium dioxide. Feldspar is also used in paint, in mild abrasives, urethane, latex foam, and as a welding rod coating.

CHAPTER 3

MATERIALS AND METHODOLOGY

3.1 Introduction

This chapter explains about the material and method used for this research. This research has involved several material and methods to collect and analyses the collective data from several resources.

3.2 Materials

During the research, there are several material were used. The material was mainly used in the fieldwork, field observation and collecting data process. **Table 3.1** shows the material that had been used during the research.

Table 3.1 The materials used in the research studies

Equipment	Description
• Global Positioning System (GPS) 	This equipment is used to measure elevation and mark the track on the map.
• Compass/clinometer 	Compass is an instrument to determine direction. Clinometer is use to determine inclination, tilt, and elevation for rock outcrops.
• Geological Hammer 	This instrument use to take sample from a rock mass. The hammer is different with normal hammer where it got chisel head made of hard steel and rubber covered at the handle.
• Hand lens 	This instrument uses for analysis the rock before getting the detail information inside the laboratory. Hand lens is a must at the field to make easier to recognize the rock outcrop as sometimes the outcrop weathered.

Equipment	Description
• Measuring tape 	The measuring tape is use to estimate the size of the rock outcrop. It is necessary for in doing the lithology of rock.
• Camera 	A camera is necessary to take a photo of the study area as it becomes clear evidence other than the sample study at the study area. It can provide information which cannot be taking away from the study area.
• Hydrochloric acid (HCI) 	Dilute (5 % to 10 %) hydrochloric acid use during acid test where acid drop on a rock or mineral and watching for bubbles of carbon dioxide gas to be released. The bubbles signal the presence of carbonate minerals such as calcite.
• Sample bag 	Sample bag usually carried around to study area. It is for sample collection when sampling like rock and soil material is needed. When taking the sample, it is really important to make a labelling.

3.3 Methodology

Figure 3.1 illustrates the methodology of geological and characterisation of feldspar in Kuala Balah, Jeli.

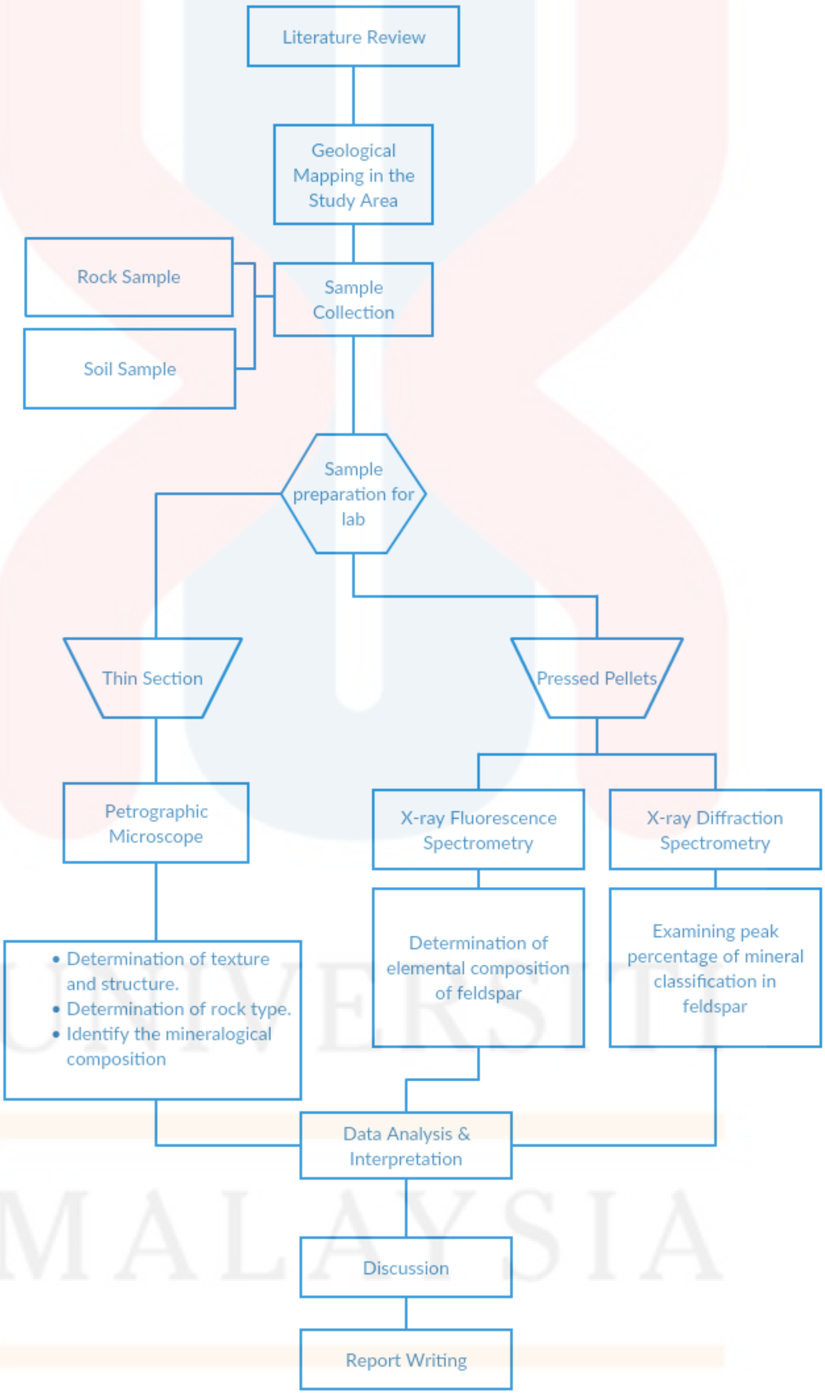


Figure 3.1 Flow chart of research

3.3.1 Preliminary Studies

The preliminary study is a fundamental first step in any site investigation programme, the purpose is to access published information and other available records related to the region. This would include an investigation of geology, geomorphology, aerial photographs and other archival data. This general information is available from previous studies that published as memoir district, articles, books, thesis, previous report and maps.

Apart from that, a preliminary study through the Google maps to get the satellite view of the recent condition of the study area. This is as the additional data to be added up to in the making of the base map. Literature review was also conducted to obtain an overview of the topography, lithology and structures found in this area.

3.3.2 Field Studies

Field work is carried out to obtain information that is more detailed in making observations and interpretations. This method also is a process of identifying all the geological aspect of the study area/interest area with the purpose to prepare the detailed geological report and a map to summarize the report. During the field work, all the geological information was recorded and also a photo about the geological features was taken. The activities in the field covering the bedrock boundary mapping, rock type, lithology and study of geological structure.

In order to mapping rock types, plan the exact interest location so that traverse can be done appropriately without leaving out some areas. As outcrop is observed, all the on seen information is collected and noted down. Even the slighter information has to be taken as it may help in the interpretation of the data later. The field observation includes the lithology, texture, rock, colour, bedding, sedimentary structure, the weathering grade and the fabric of the outcrop. The technique of strike and dip is also important which usually applied to the orientation tilted layers of rocks.

3.3.3 Sampling

Sampling is important in this research study. A sample, by definition, is a subset of the population that were studied that is selected for the actual research study. A good sampling will produce accurate results in the research. For this study there is two types of sample were taken; (1) rock sample. The rock samples were collected on the surface, in outcrop based on the type of rocks that existing within the study area such as granite and pegmatite rocks. These hand samples were collected using a rock hammer or sledge. The rock samples collected to identify the structure and the texture of the rock, (2) soil sample. A sample is obtained by digging a small hole with a long handled pick, usually down to weathered rock. A device for collecting an undisturbed sample is a thin walled tube 3 to 8 cm and 15 to 30 cm long. This tube sampler is pressed or hammered into the soil and then is pulled out, bringing up a core sample which preserves differences in the soil composition with depth.

The sample is then placed into the top sieve with a small garden spade. This coarsest sieve removes organic matter such as leaf litter and charcoal as well as coarse sand and gravel. The sample is sieved on-site using an 80 mesh sieve, 178 micrometres, using a stack of sieves with progressively finer mesh sizes. The samples used to identify the element composition of the mineral.

3.3.4 Sample Preparation

The purpose of sample preparation is the production of homogeneous sub-sample, representative of the material submitted to the laboratory. Correct sample preparation allows for representative sub-sampling, this is the foundation of quality analysis. Sample preparation is also critical for the liberation of elements of interest for representative sub-sampling, in order to facilitate decomposition techniques and to reduce particle size effects in techniques such as XRF. Strict adherence to handling, safety and quality protocols ensures quality standards within sample preparation are maintained.

Thin Section

Standard thin section was prepared from outcrops samples collected from the study area. Thin section is used in petrographic analysis. A rock-section should be about one-thousandth of an inch (30 micrometres) in thickness, and is relatively easy to make. A thin splinter of the rock, about 1 centimetre may be taken. It should be as fresh as possible and free from obvious cracks. Then it will be grinded on a plate of plate of plane steel or cast iron with a little fine carborundum it is soon rendered flat on one side and is then transferred to a sheet of plate glass and smoothed with the very finest emery till all minute pits and roughness are removed and the surface is a uniform plane. The rock-chip is then washed, and placed on a copper or iron plate which is heated by a spirit or gas lamp.

Pressed Pellets

Pressed pellets were used for XRF and XRD Analysis. Pressed pellets are prepared by pressing loose powder filled in a ring using set of dies and a press machine. The sample size used is 63 micron with weight of 7 g. As for minimal pre-treatment, it was grinded to be filled in the slot in the sample holder, homogenized and pressed into pellets so that the powder packing in the holder slot does not move or slide and carried out the semi-quantitative and quantitative results. Pellets were pressed with 15 to 20 tons per square inch. The pellets were around 3 mm thick.

3.3.5 Data Processing

Petrographic Analysis

Petrographic microscopes are also known as polarizing microscopes. The petrographic microscope is the perfect choice for viewing minerals with an optical technique using polarized light. The thin section undergoes the observation and examination using the petrographic microscopes. The data focus primarily on the study of the minerals in rock thin section. Addition with the determination of texture, structure, rock type and document deformation history.

X-ray Fluorescence Analysis

XRF is a non-destructive analytical technique used to determine the elemental composition of materials. Quantitative XRF data informs the absolute quantity of an element present in a sample. This sort of data contains a number and a unit ppm (parts per million) or % weight. Calibrations are created in order to make raw qualitative data into quantitative data. Calibrations are made by using samples with known concentrations of elements of interest to create a calibration curve that relates the specific known concentrations to peak heights. This curve then used to quantify samples of unknown concentrations by relating the peak height to the curve built from the known samples. There are some significant differences in how exactly these calibrations are created and how they work depending on the calibration type. The data that were carried out in the form of percentage weight of the main element that present in feldspar mineral were presented in the table form. The data then compared with the commercial industries specification.

X-ray Diffraction Analysis

X-ray diffraction is a versatile analytical technique for examining crystalline solids which in this study is the geological samples prepared in the form of pressed pellets. The samples were sent for data processing. The intensity of diffracted X-rays is continuously recorded as the sample and detector rotate through their respective angles. A peak in intensity occurs when the mineral contains lattice planes with d-spacing appropriate to diffract X-rays at that value of θ. Although each peak consists of two separate reflections (Kα1 and Kα2), at small values of 2θ the peak locations overlap with Kα2 appearing as a hump on the side of Kα1. Greater separation occurs at higher values of θ. The 2λ position of the diffraction peak is measured as the centre of the peak at 80 % peak height. The data were presented in the form of diffractogram pattern of the mineral mixture indicated.

3.3.6 Data Analysis and Interpretation

For petrography analysis, the interpretation was made based on the association of the mineral. The texture and structure of the mineral that was analysed were interpreted to identify the origin of the rocks.

For the chemical analyses, the concentrations of major elements (SiO_2, Al_2O_3, TiO_2, Fe_2O_3, BaO, K_2O, CaO, and Na_2O) were determined in the laboratory using X-ray Fluorescence (XRF) Analysis and X-ray Diffraction (XRD) Analysis. The final data obtained during the data processing were analysis and interpreted based on the specific criteria.

CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

This chapter will discuss about the general geology of the study area. The information and data in this chapter is accumulated by geological mapping and literature review. The general geology of the investigation region is separated into geomorphology, stratigraphy, structural geology and historical geology.

4.1.1 Accessibility

Kuala Balah is accessible to any kind of transportation. Kuala Balah town is a town located in Kuala Balah districts. It is located about 32 km from, Jeli City. It is also located 20 km from Dabong Kuala Krai Town, 145 km from Kota Bharu City Center, 100 km from Kuala Krai City Center via Jeli-Dabong-Sam-Kuala Krai Road and 85 km from Gua Musang City Center via Jeli-Jelawang-Gua Musang Road.

Car and motorcycle dominantly used by local as it is the most convenient mobile transportation as the villagers is major in livelihood. As for the public transportation there are bus services that connect the Kuala Balah route with Jeli City. There are also taxi services that available in Kuala Balah which not limited to reach the town of Jeli only.

4.1.2 Settlement

It is estimated that the total population of Kuala Balah district is 13,700 people. Its population is Malays. Generally, the people in the district of Kuala Balah live in densely populated villages along the Malaysian Federal Route 66 and also on the riverfront.

The study area covers a several villages that existed in Kuala Balah. Those villages are Kampung Kubur Datu, Kampung Bukit Selar, Kampung Bukit Beranga, Kampung Relak, Kampung Bukit Jering and Kampung Bukit Tok Ali.

4.1.3 Vegetation

Vegetation is collections of plant species and the ground cover their supplier. It is a general term, without particular reference to specific taxa, living things, structure, spatial degree or some other particular herbal or geographic trademark. There are two kinds of vegetation which are natural vegetation and artificial vegetation. The natural vegetation is the sort of vegetation that we get in an area without human aggravation. Natural vegetation relies upon the climatic and soil condition whereas artificial vegetation is the other way around.

The predominant kind of the vegetation in the study area is artificial vegetation which is palm tree plantation, rubber tree plantation, and corn ranch. This is a result of little settlement territory. We can see the natural vegetation is the minority type like wild plant on the hills, outcrop and forest because in light of the fact that the vast majority of the natural vegetation habitat have been utilized by human to turn it out as a plantation for source of income.

4.1.4 Traverse and Observation

Mapping has been done through traversing the study area and the traverse route is mapped on **Figure 4.1**. Outcrop station is taken along the research area when there are important outcrop and geology structure is found. Samples are taken in different station with different lithology. This sample is used for lithology identification through petrography analysis. There are two sample station in the study are labelled as red circle. **Table 4.1** shows the locations of sample station and observation station.

Table 4.1 Location for Sample Station and Observation Station

Sample Station	Observation Station
1) 05°29’21.9” N, 101°54’01.1” E	1) 05°29’24.6” N, 101°54’00.9” E
2) 05°28’11.9” N, 101°55’56.9” E	2) 05°29’24.7” N, 101°54’12.6” E
	3) 05°30’16.9” N, 101°54’10.1” E
	4) 05°30’11.6” N, 101°54’08.5” E
	5) 05°28’43.8” N, 101°54’10.9” E
	6) 05°8’14.5” N, 101°55’43.5” E
	7) 05°29’11.5” N, 101°54’01.0” E

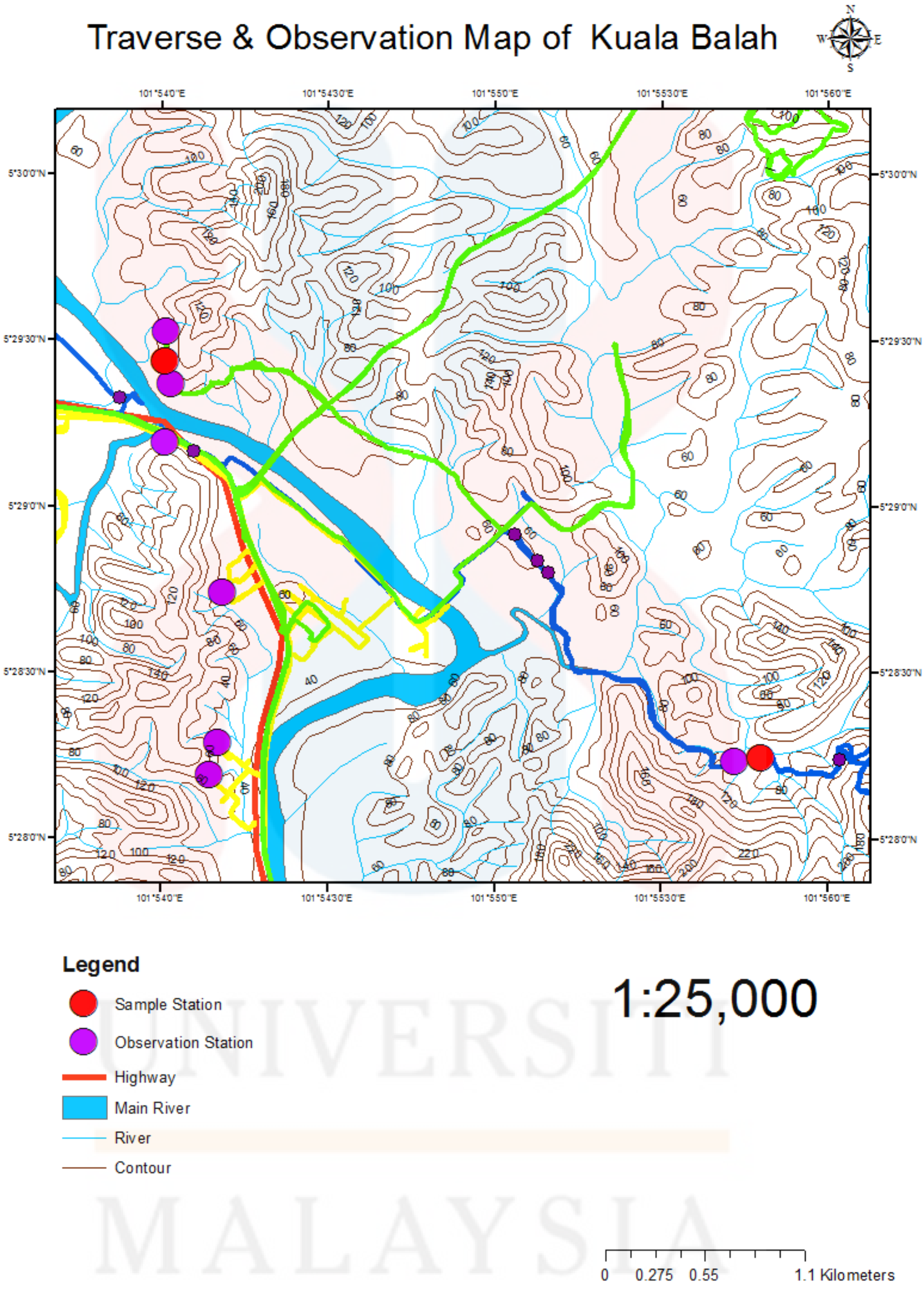


Figure 4.1 Traverse map of study area

4.2 Geomorphology

Geomorphology is the investigation of landforms, their processes, frame and sediments at the surface of the Earth. We can know the process that prompted the earth changes from the geomorphological study. To work out how the earth surface processes, the study includes looking at landscapes such as air and water which can mould the landscape.

This study focused on the geological mapping and the geomorphologic of Kuala Balah and nearby area. At Kuala Balah and nearby area, it consists of flat and hill part. It still surrounded by forest. It is because some area develops as industrial area such as workshop and residential area. Geological map in **Figure 4.2** shows the lithology unit in study area. This area mostly covered by meta-sediment unit such as phyllite and slate.

The study area is prominent with phyllite (meta-sediment), with some areas of slate (meta-sediment), shale, meta-shale, tufficious mudstone, meta-mudstone and quartz.

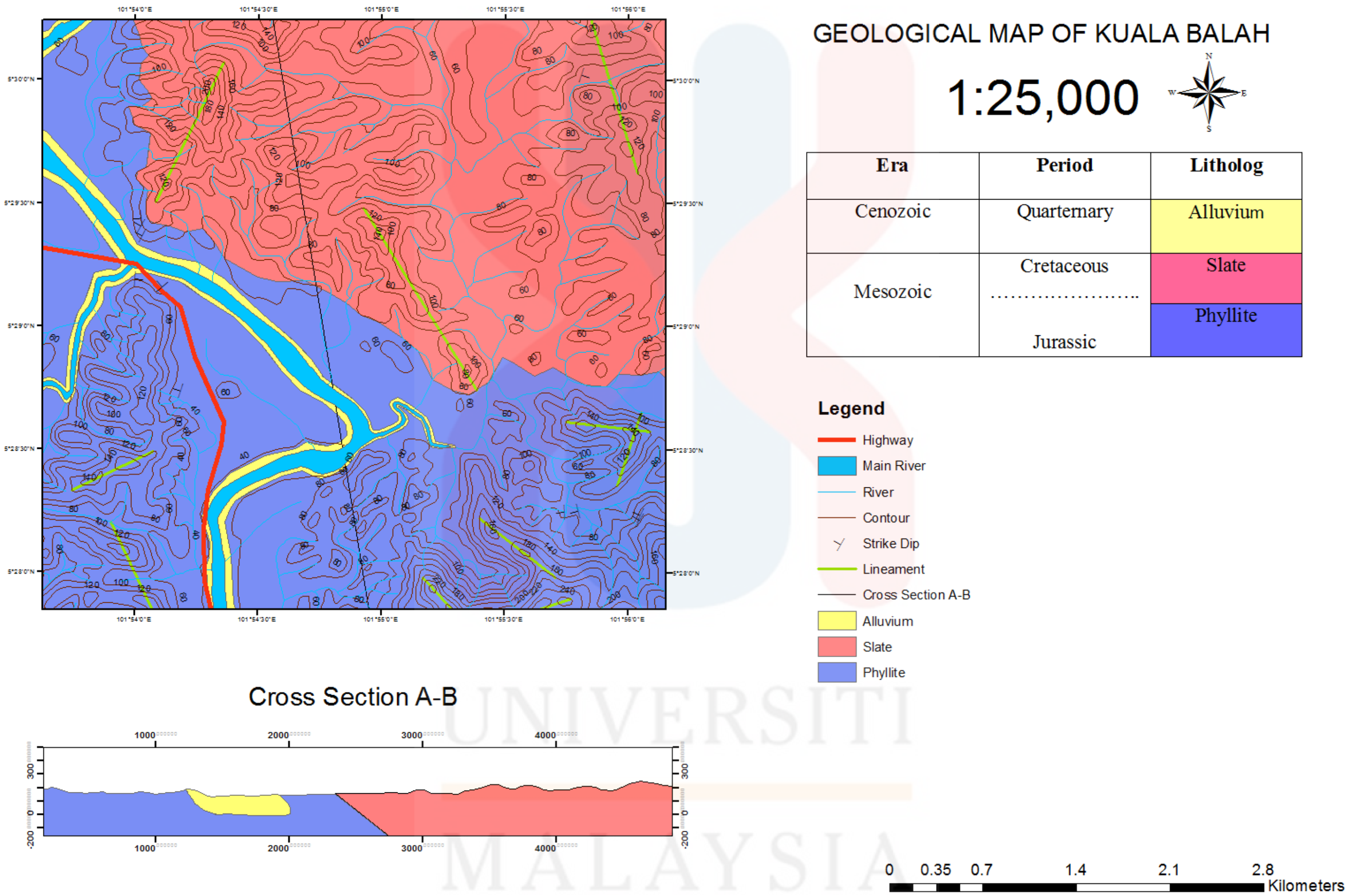


Figure 4.2 Geological map of study area

4.2.1 Drainage

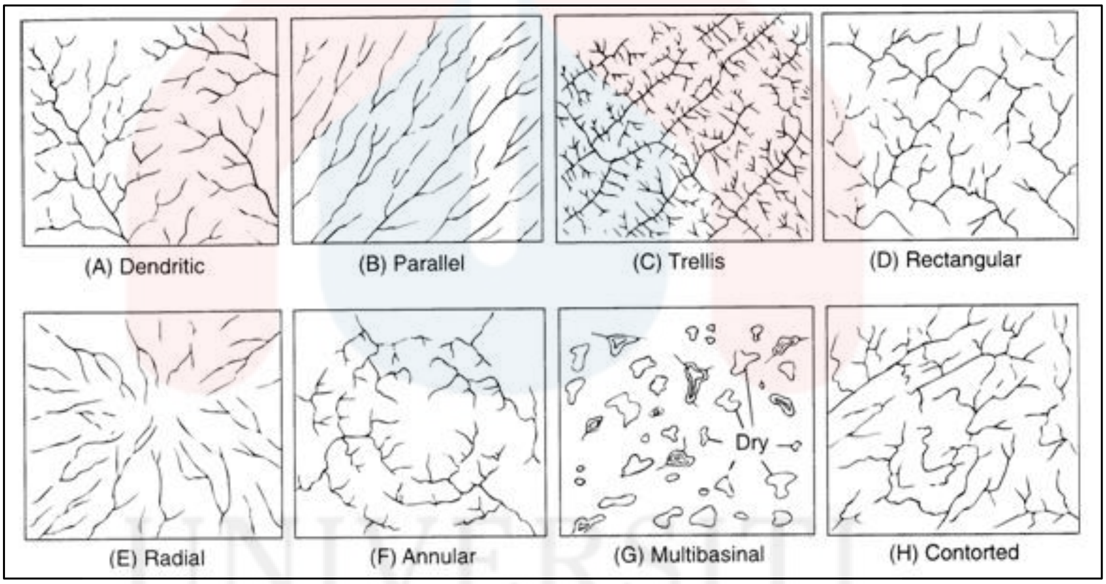
Drainage pattern is the pattern formed by the stream, rivers, & lakes in a particular drainage basin. Drainage basins are divided from each other by topographic barriers called a watershed. Based on **Table 4.2**, there are eight drainage pattern which are dendritic, radial, rectangular, trellis, parallel, annular and others. Dendritic is a randomly developed, tree-like pattern composed of branching tributaries and a main stream. It is the most common drainage pattern and is characteristic of essentially flat-flying or relatively homogenous rock and impervious soils. Radial drainage is composed of streams radiating outward from a central peak, dome, or volcanic cone.

Another drainage pattern such as parallel is characterized by major streams trending in the same direction. Tributaries usually join the main stream at approximately the same angles. Besides that, trellis pattern is a modified version of the dendritic pattern. It formed in area folded rock strata. Furthermore, annular pattern is a primary streams develop in the concentric, circular joints surrounding an uplifted dome of sedimentary rocks.

Based on map in **Figure 4.3**, only one drainage patterns are identified in the study area which is dendritic. Dendritic drainage pattern is dominant in the research area. Two main dendritic patterns located at northeast and northeast respectively of study area. The direction of water flow is to the west. Dendritic drainage pattern associated with flat and uniform bedrock.

The main river in the study area is known as Pergau River which flows to Kelantan River. There are only one rivers existed at this study area which are Terang River. Basically **Figure 4.4** shows difference in the energy flow. Erosion process occurred when water flow in high rate make sediment transport to another area. The rate of the river flow reflects the surrounding environment and the process occur along the river. When the river's pattern is straight, it indicated high energy flow and associated with erosion process.

Table 4.2 Type of drainage pattern



(Source: International Association of Geomorphologists, 2018)

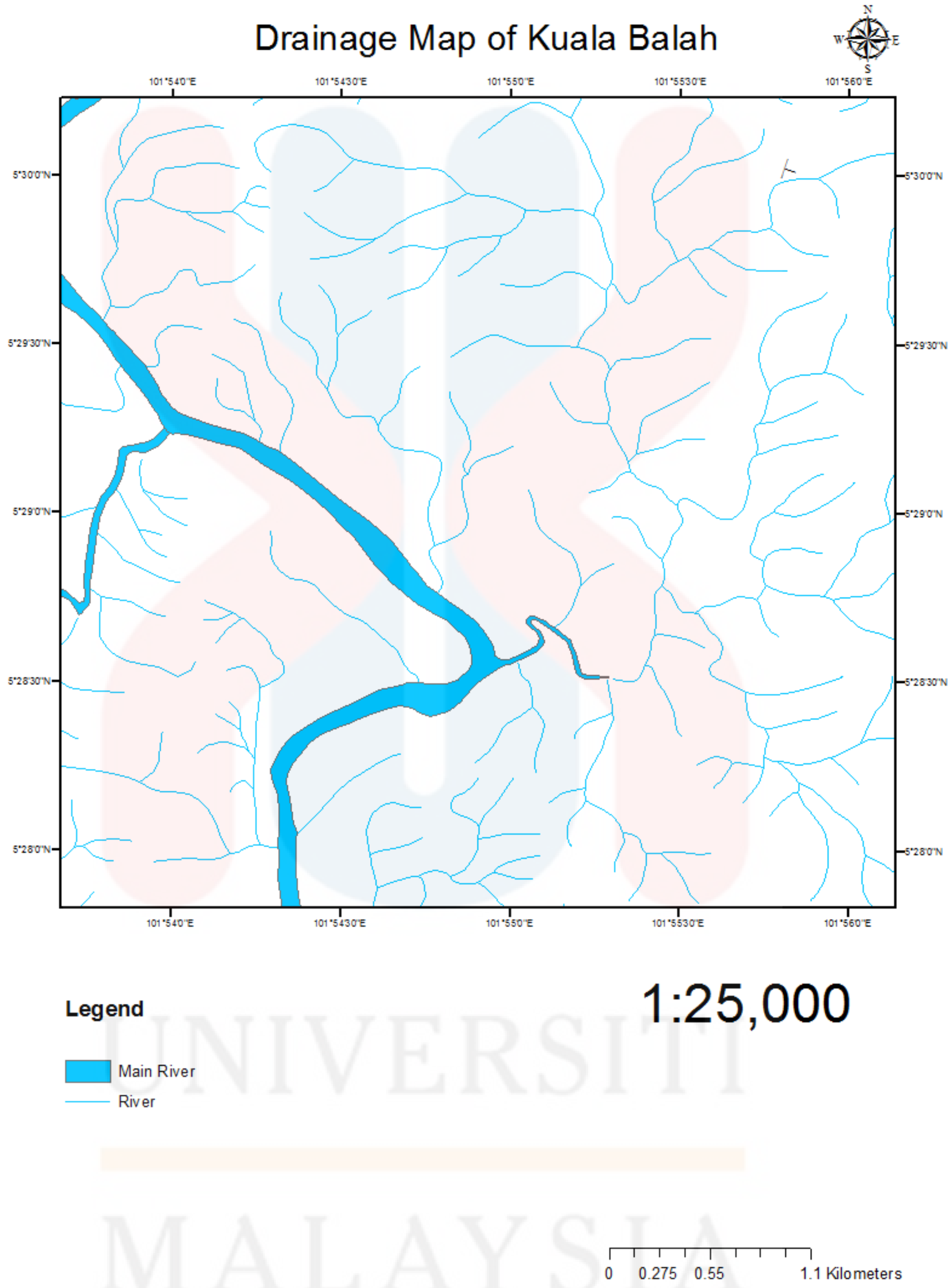


Figure 4.3 Drainage map of study area

Figure 4.4 The main river in the study area is known as Pergau River

4.2.2 Topography

Based on topography map in **Figure 4.5**, it can explain the landform or geomorphology in study area. Area with high contour can be interpreted as hilly landform. In the study area the hilly landform were utilized as plantation site for palm tree.

Refer to the 2D topography map in **Figure 4.5**; the highest part is located at southeast and northeast respectively. It's stated around 200 metre to 240 metre from sea level. Also, the flat land stated at the southwest area indicated the lowest part. The flat area refers to the residential area, a several villages at the study area stated as previous subchapter. It covers around 10 % of study area.

Based on digital topography map **Figure 4.6**, it shows elevation part with colours. The highest elevation, 240-270 metres cover only 4 % in study area shown as pale purple colour. The lowest part with elevation 27-60 metres about 45 % with shown as dark green colour.

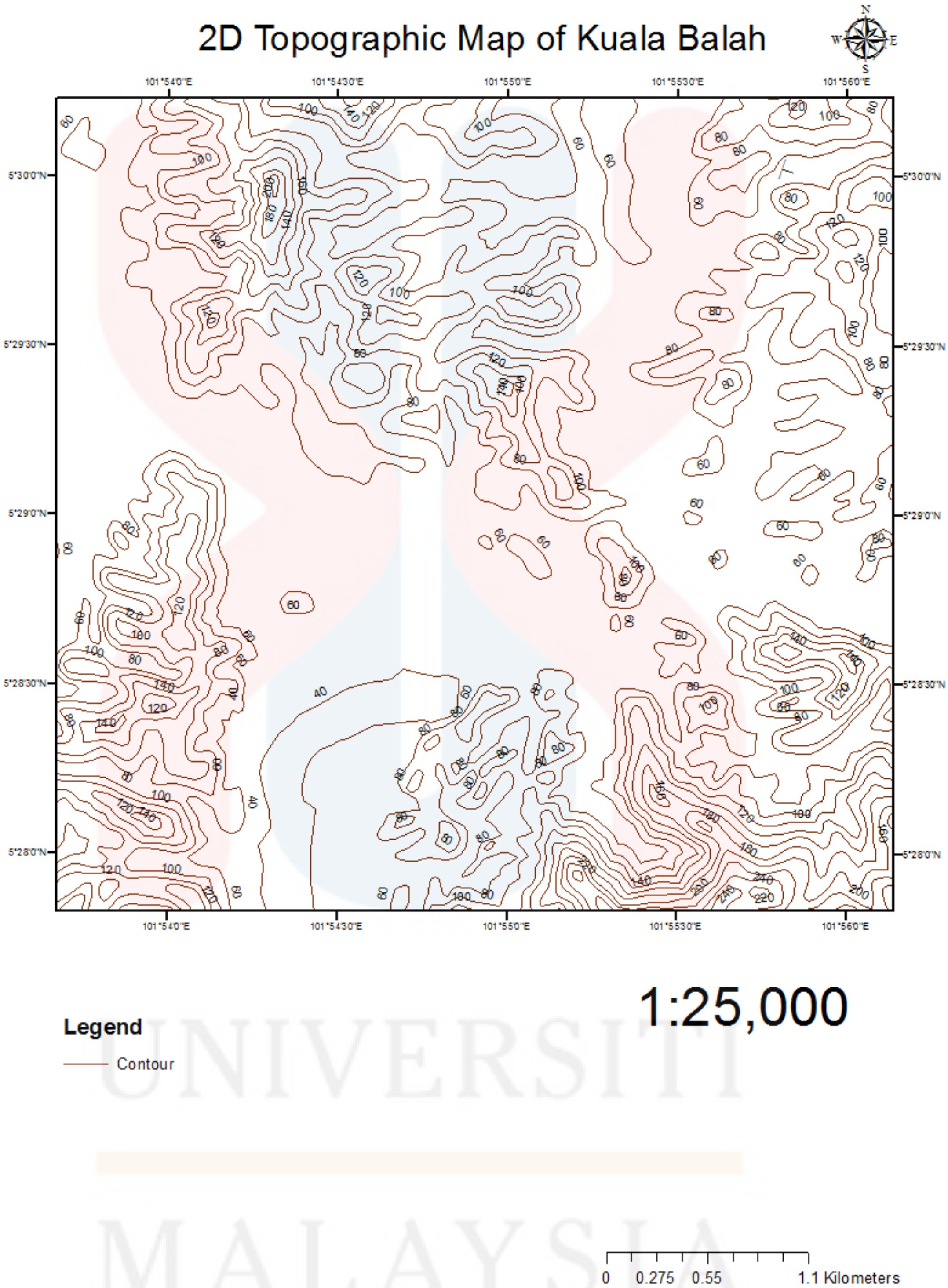


Figure 4.5 Topography map of the study area

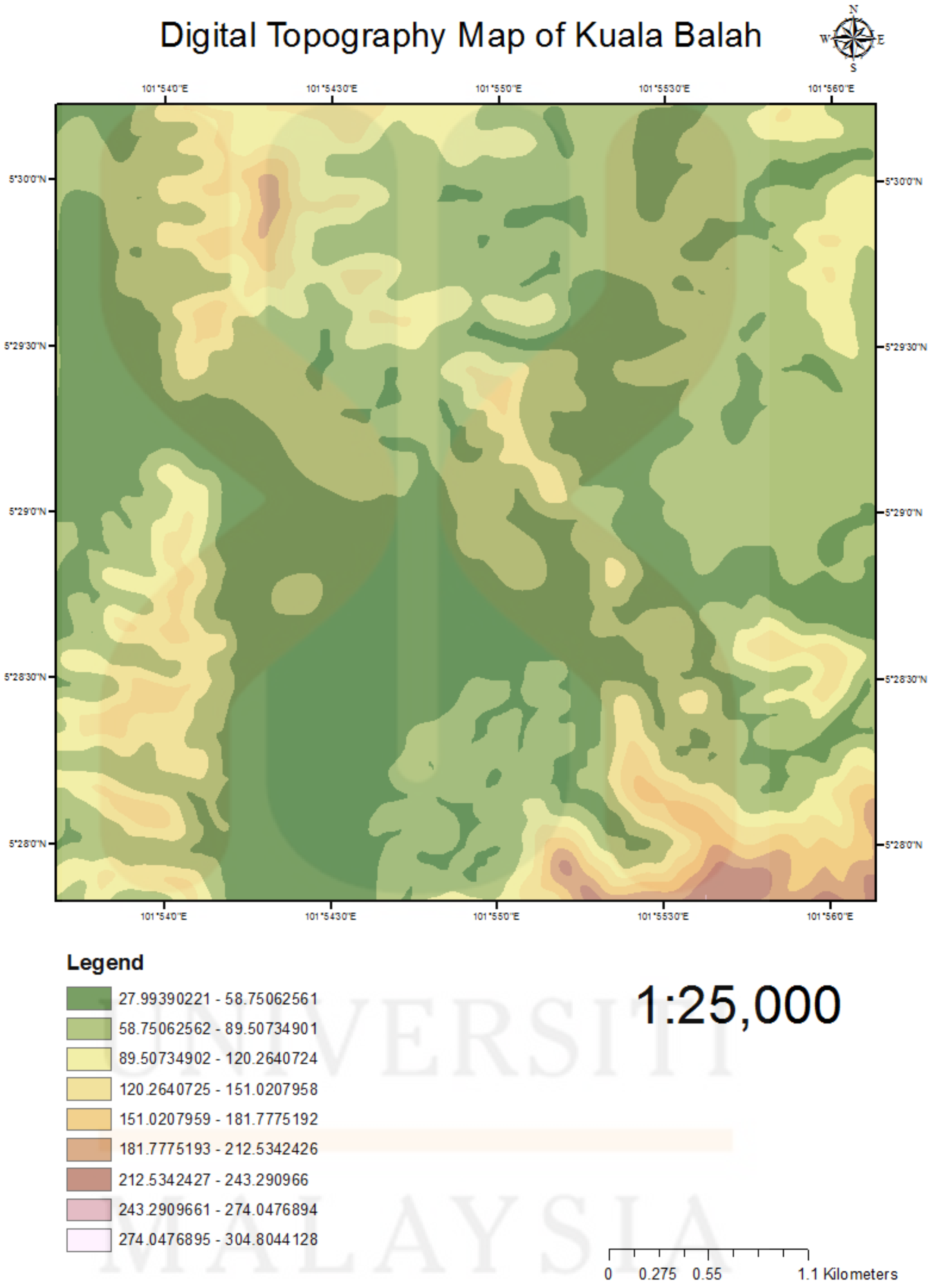


Figure 4.6 Digital Topography map of the study area

4.2.3 Weathering

Weathering process was the process where the breakdown of rock into smaller fragments. It has two kind of weathering process which is physical and chemical weathering. Physical process happened when the rock breakdown without chemical reaction process. For chemical process, the changes of rock composition or mineral.

In the study area, two types of weathering process are found. For physical weathering process, there are several agents mechanical weathering such as plant growth and abrasion by wind, water or gravity. Based on **Figure 4.7**, the physical weathering occurred in one of the location in the study areas and it is and it is distinguished as the plant wedging. Recognizable that tree convey root framework, the fine roots discover their way into cracks of the rock.

Another type of weathering is known as the differential weathering which meaning that the rock does not weather consistently. In sedimentary it is commonly caused by varieties in the degree or kind of cementation restricting the grains of the rock together. At the point when diverse rocks in an outcrop experience weathering at various rates, it is assumable that the outcrop has experienced differential weathering as in **Figure 4.8**.

Figure 4.7 Plant wedging

Figure 4.8 Sheeting Joint

4.3 Lithostratigraphy

Stratigraphy is the study of rock layers which we call strata, their relatives and absolute age and relationship between strata. It also is the study of the process that leads to the creation of these layers called stratification. In this research, lithostratigraphy is used to recognize the connection between strata whereas the petrography analysis is utilized by thin section process for naming the rock purpose.

4.3.1 Stratigraphy Column

Table 4.3 Stratigraphic column of Kuala Balah

Era	Period	Litholog
Cenozoic	Quarternary	Alluvium
Mesozoic	Cretaceous	Slate
	…………………..	
	Jurassic	Phyllite

Based on the **Table 4.3** the sediment log of study area can be correlated with Stong Migmatite Complex formation stratigraphy. Based on lithology section, the oldest rock age in Jurassic is phyllite. Slate was expected to be younger than phyllite. Any loose sediment and gravel that deposited in the river and stream area is in the age of Quaternary in Cenozoic Era.

4.3.2 Petrography

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

4.3.2a Sample 1

Coordinate: 05°30’18.2” N, 101°55’41.2” E

For sample 1, the location is located at the northeast of the study area with coordinate of 05°30’18.2” N, 101°55’41.2” E. **Figure 4.9** shows the outcrop photography of sample 1. From the outcrop in this **Figure 4.9**, it can be seen that the rock is highly weathered. From the primarily observation using hand lenses on the hand specimen as in **Figure 4.10**, it is predicted that the rock sample 1 is slate.

Figure 4.9 Location sample taken

Figure 4.10 Hand specimen sample

4.3.2b Sample 2

Coordinate: 05°29’21.9” N, 101°54’01.1” E

For sample 2, the location is located at the centre of the study area with coordinate of 05°29’21.9” N, 101°54’01.1” E. **Figure 4.11** shows the outcrop photography of sample 2. From the outcrop in this **Figure 4.11** it can be seen that the rock is highly weathered, however fresh rock from the outcrop is taken in photography analysis as in **Figure 4.13**. From the primarily observation using hand lenses on the hand specimen as in **Figure 4.12**, it is predicted that the rock sample 2 is metasedimentary phyllite.

The fresh sample 2 was then undergoes petrographic analysis in the form of thin section for identification minerals. The identification mineral was done using microscope in cross and plane-polarised lenses. **Figure 4.13** shows sample 2 under cross-polarised and lenses plane-polarised lenses.

Figure 4.11 Location sample taken

Figure 4.12 Hand specimen sample

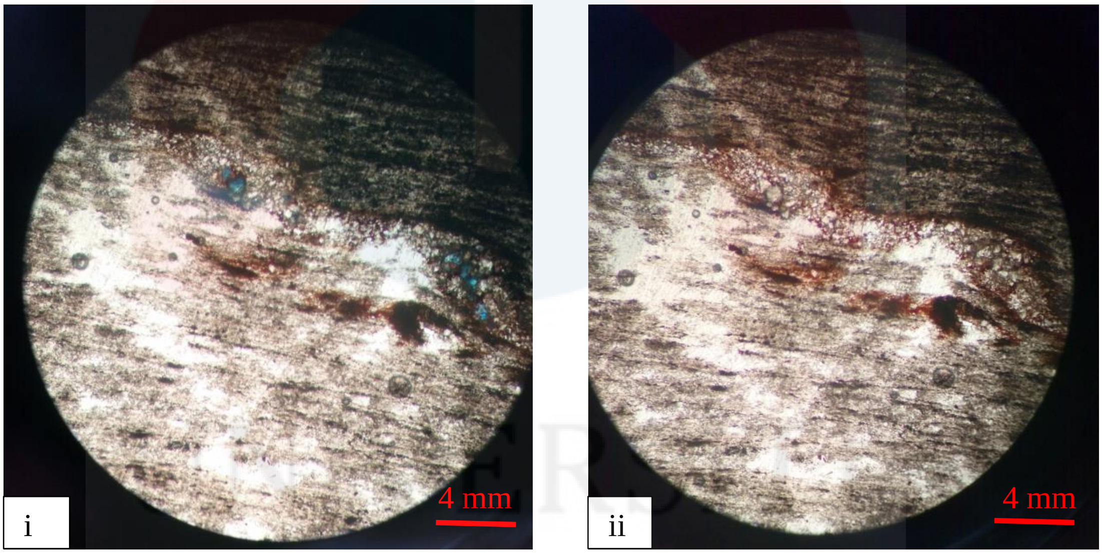


Figure 4.13 i) specimen under cross-polarised and ii) specimen under plane-polarised

Due to observation by hand specimen, this outcrop is shiny and smooth to touch. The colour are greyish and black. Under microscope shown in **Figure 4.13**, this sample mostly formed by quartz and feldspar. The colour of quartz are colourless or clear and have weak relief. Feldspar with black colour and streak white. It contain laminations in which quartz and feldspar are more abundant and represent original sedimentary layering. It have a silky lustre on their pervasive cleavage planes. It also exhibit a crenulation cleavage which can be seen as a crenulation on the cleavage surface.

4.4 Structural Geology

Structural geology concerned on rock formation, rock geometries to know about the deformation history. The data assembled are critical to comprehend the past occasions. All information from geomorphology, stratigraphy and structural geology is consolidated to uncover the historical geology events.

Structural features such as lineament, joint, fold, fault and fracture are the result of past geological events such as plate tectonic or earthquake. This structure is formed due to the force acting on the rock's bodies or tectonic plate. Under this subtopic, the joint analysis and fold analysis will be interpreted. This research discovered the three-dimensional distribution of large bodies of the rock, their surface and the composition of their inside.

4.4.1 Joint Analysis

During mapping progress, 100 reading of joints value were collected at one check point. The data collected then were analysed by using the GeoRose software to produce rose diagram. Joints formed when rock are stretched to their breaking point. This pattern helped in interpreting much precisely the direction forces. It is structure which there has been no appreciable displacement parallel to the fracture and only slight movement to the fracture plane.

The station refer to **Figure 4.14**, is located at 05°28’16.9” N and 101°54’10.1” E. The type of joints was non-systematic because does not share a common orientation and have curved and irregular fractures surfaces. Result of reading taking interpreted by rose diagram. Based on rose diagram shown in **Figure 4.15**, the maximum force or σ1 direction come from W 285 N. Minimum force or σ3 comes from direction N 22 E.

Figure 4.14 The station

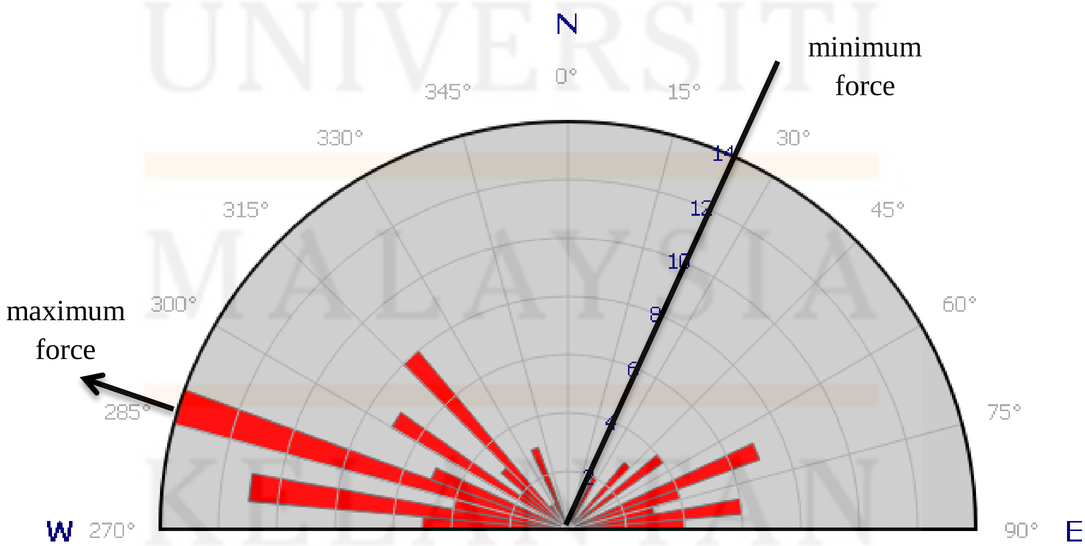


Figure 4.15 Rose diagram for station

4.4.2 Fold Analysis

Fold is a rock formation that has been made by flat rock becoming deformed due to stress and pressure. Fold are created when two plates that make up the earth collide. As the plates are forced together, it will bend, curve or jagged pattern in the rock. Based on **Figure 4.16** at coordinate 05°28’14.3” N and 101°56’2.1” E, the type of folding is plunging fold. Folds with inclined fold axis are called plunging folds. The strike and dip direction of the folding are 161/32.

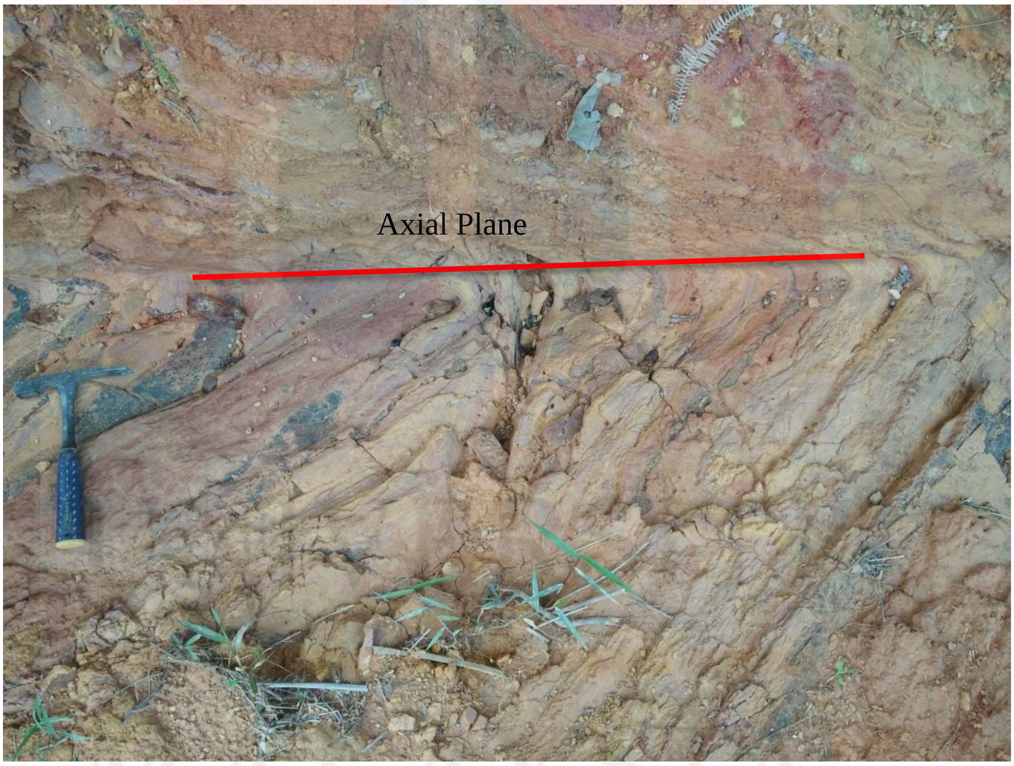


Figure 4.16 Folding

4.4.3 Bedding Analysis

Beds of rock are forms and spatial position of rocks in the earth's crust. Sedimentary and metamorphic rocks usually occur in the form of layers or strata bounded by roughly parallel surfaces. In their original, undisturbed bedding sedimentary rocks are arranged almost horizontally. In **Figure 4.17** shown is cross-bedding located at coordinate 05°28'43.8" N, 101°54'10.9" E.

Cross-bedding is formed by the downstream migration of bedforms such as ripples or dunes in a flowing fluid. When a depositional environment has sand in it and water or air moves the sand grains around, those grains can build up into piles of sediment.

Figure 4.17 Bedding

4.5 Historical Geology

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

The geological formation of Kelantan ranges from Palaeozoic to Quaternary. The study area is part of Stong Complex. In Stong Complex Formation, the lithologies that can be found in Jurassic age are phyllite follow by slate in Cretaceous age. There were Cretaceous granites of Stong Complex have been dated 96 to 60 Ma. The complex consists of Berangkat Tonalite, Kenerong Leucogranite and Noring Granite was emplaced into metasedimentary rocks comprised of silimanite and calc-silicates gneisses the oldest

The Cenozoic Era is mainly represented by Quaternary sedimentary deposits. The Quaternary sediment consists extensively of unconsolidated to semi-consolidated boulders, gravel, sand, silt and clay that underlie the coastal and inland plain.

CHAPTER 5

STUDY OF FELDSPAR

5.1 Introduction

This chapter discuss about the percentage of elements that indicate the existence of minerals feldspar that ideal for industrial uses especially ceramic and glass industry. The soil sample collected undergoes X-ray Fluorescence analysis and X-ray Diffraction analysis. The result percentage of the elements is interpreted.

5.2 Sampling

The usual method for soil sampling is using grid method. Since, the sampling is in a small scale the soil is picked randomly. Based on the **Figure 5.1**, shown the sample that were collected in the study area. The total of five samples is collected.

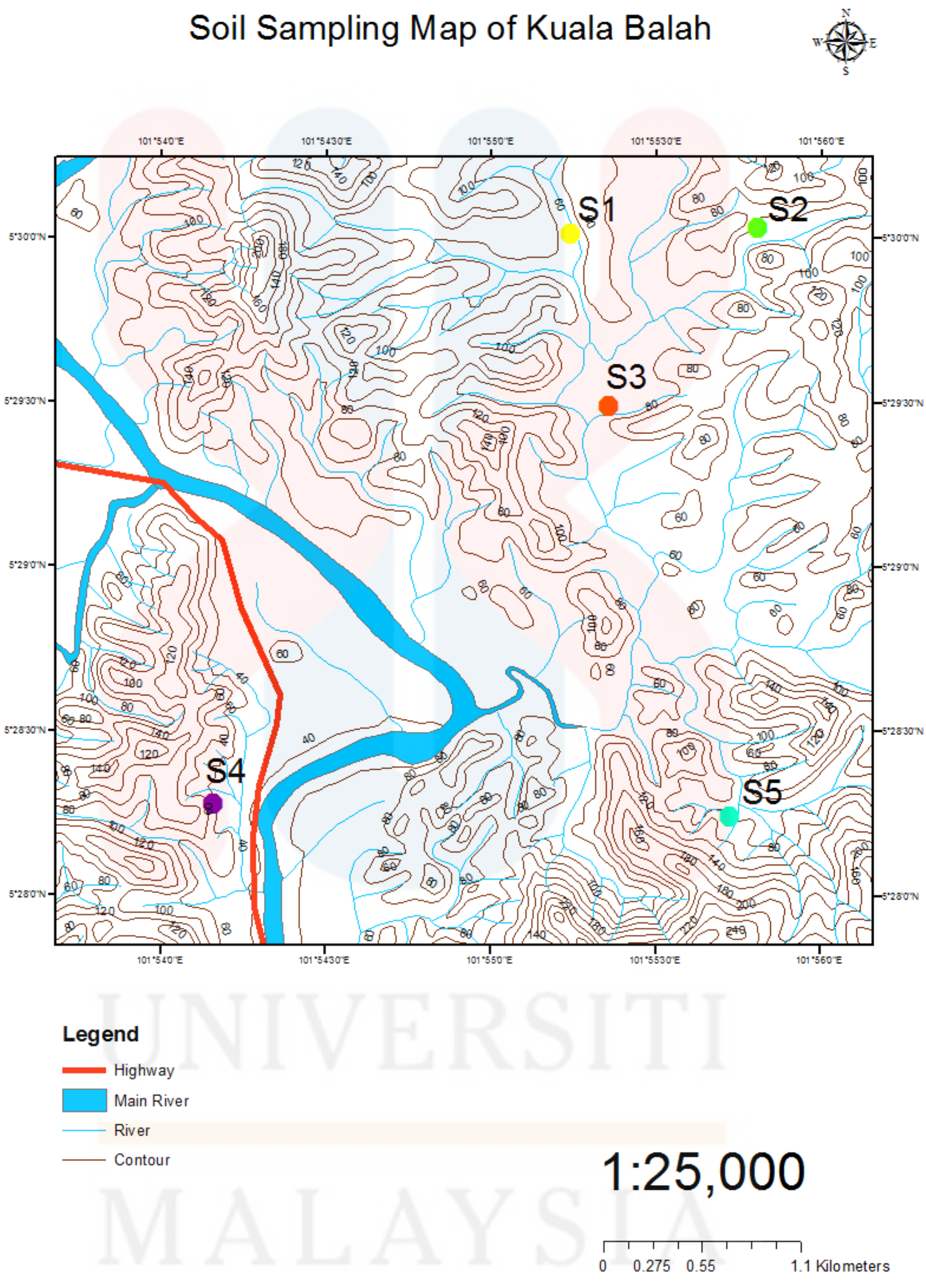


Figure 5.1 Soil sampling map

5.2.1 Sample Description

Table 5.1 The description of soil sample

Sample	Description
1	Texture: Coarse/crumb Colour: Lighter coloured soils Brown colour
2	Texture: Fine Colour: Lighter coloured soils Light brown colour
3	Texture: Coarse/crumb Colour: Lighter coloured soils Brown colour
4	Texture: Coarse/crumb Colour: Dark coloured soils Dark brown to red colour
5	Texture: Fine/Smooth Colour: Dark coloured soils Reddish colour

5.3 Result and Discussion

Major and trace element in soil were identified by using X-Ray Fluorescence (XRF) Analysis and X-Ray Diffraction Analysis. Five locations were selected as stated to determine the compositional element in the collected sample

5.3.1 Characterisation of Feldspar Samples by XRF Analysis

Table 5.2 shows the composition of element in oxide that found in five samples. The unit were presented in weight percentage (wt%).

Table 5.2 Concentration of composition of element in oxides for each sample

Concentration (wt%) / Composition of Element in Oxide	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Glass Industrial Uses (Amaireh *et.al.*, 2014)	Ceramic Industrial Uses (Amaireh *et.al.*, 2014)
SiO_2	71.04	84.38	77.40	70.52	70.36	68.9	75
TiO_2	0.91	2.04	BDL	2.19	BDL	-	-
Fe_2O_3	19.09	10.19	16.10	21.95	17.50	0.07	0.3
K_2O	8.10	3.09	3.56	4.85	6.67	3.85	3.3
BaO	0.86	BDL	2.72	BDL	2.48	-	-

Based on **Table 5.2** . SiO_2, Fe_2O_3 and K_2O are present in all samples. Among these samples, the concentration of SiO_2 shows the highest concentration. Concentration of SiO_2 in sample 2 showed the highest concentration with 84.38 % followed by sample 3 which with 77.40 %. The lowest concentration of SiO_2 was in sample 5 with concentration 70.36 %. The concentration of SiO_2 of all five samples met with the requirement percentage in both glass and ceramic industrial uses as stated in the **Table 5.2.**

The concentration of Fe_2O_3 in all of five samples shows a greater difference concentration compared with the specification for glass and ceramic use which is 0.07 % and 0.3 %. The concentration of Fe_2O_3 in sample 1 until sample 5 respectively are 19.09 %, 10.19 %, 16.10 %, 21.95 %, 17.50 %.

As for the K_2O concentration, sample 2 and sample 3 have a slightly less percentage than the industrial specification; 3.85 % for glass and 3.3 % for ceramic, where sample 2 has concentration of 3.09 % and sample 2 is 3.56 % while sample 4 concentrations is slightly higher with concentration of 4.85 %. For sample 1 and sample 5 it has a quite big difference of concentration which is 8.10 % and 6.67 % respectively.

TiO_2 only present in sample 1, sample 2 and sample 4 with the concentration 0.91 %, 2.04 %, 2.19 % respectively. BaO only present in sample 1, sample 3 and sample 5 with the concentration 0.86 %, 2.72 % and 2.48 % respectively.

The concentration of element in oxide of all soil samples are presented in a bar chart graph as shown in **Figure 5.2**

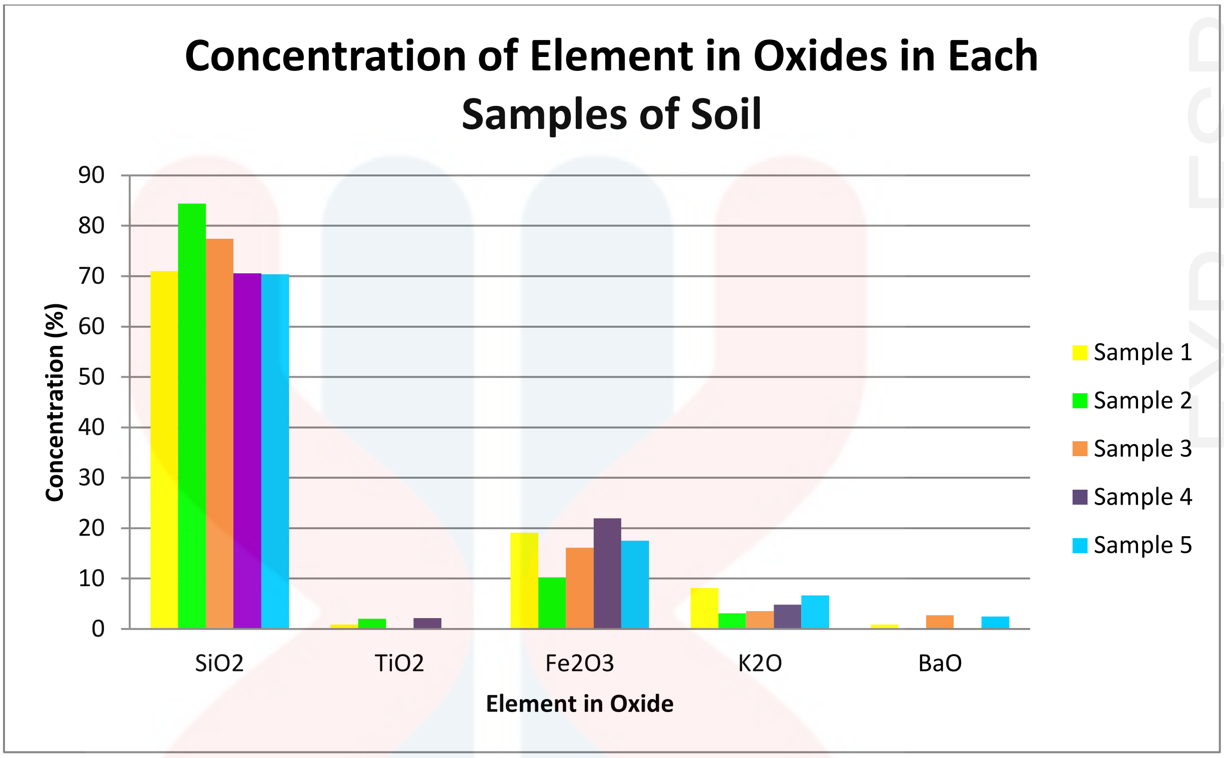


Figure 5.2 The concentration of selected element in oxide of all soil samples

5.3.2 XRD Analysis

Figure 5.3 until **Figure 5.7** show that XRD pattern of five samples. The results of XRD analysis revealed that the main minerals in feldspar are quartz and the secondary minerals are mica's minerals which is muscovite.

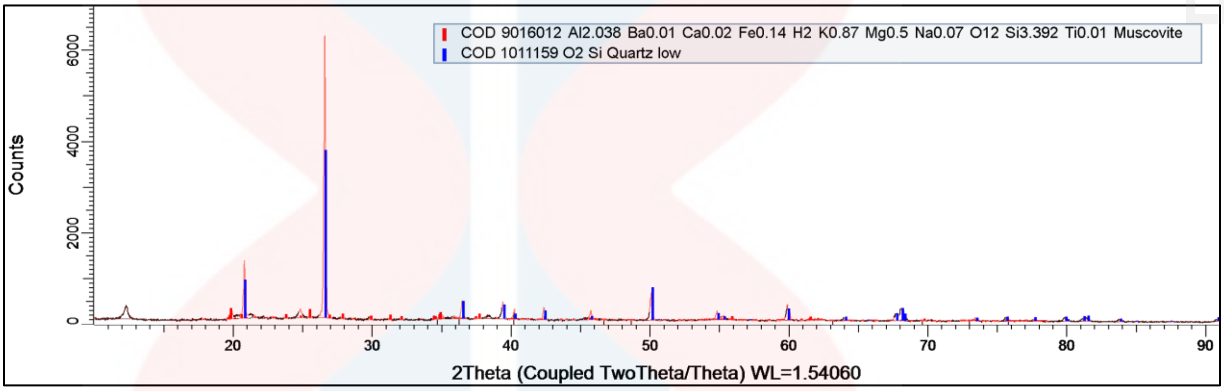


Figure 5.3 XRD pattern of sample 1

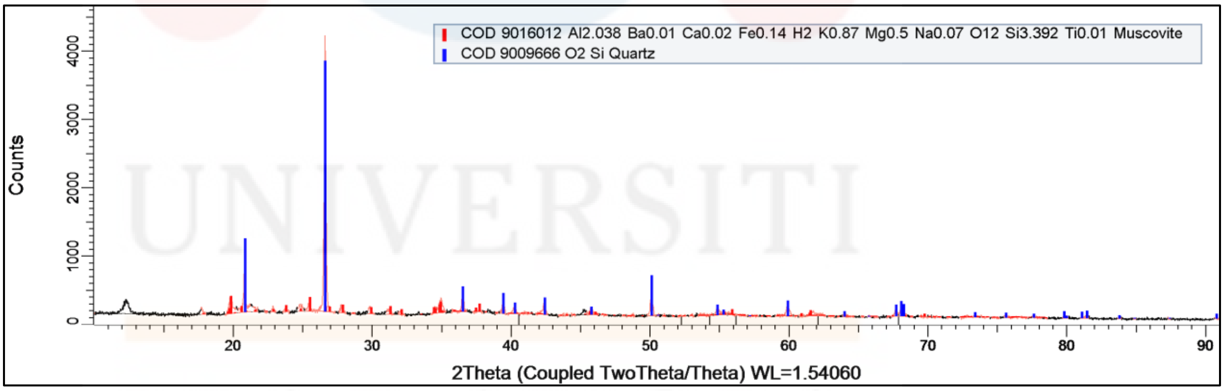


Figure 5.4 XRD pattern of sample 2

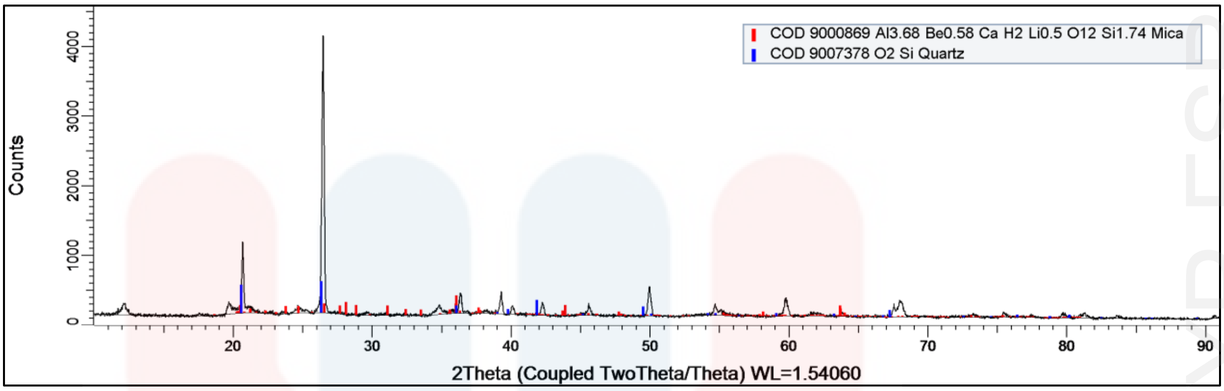


Figure 5.5 XRD pattern of sample 3

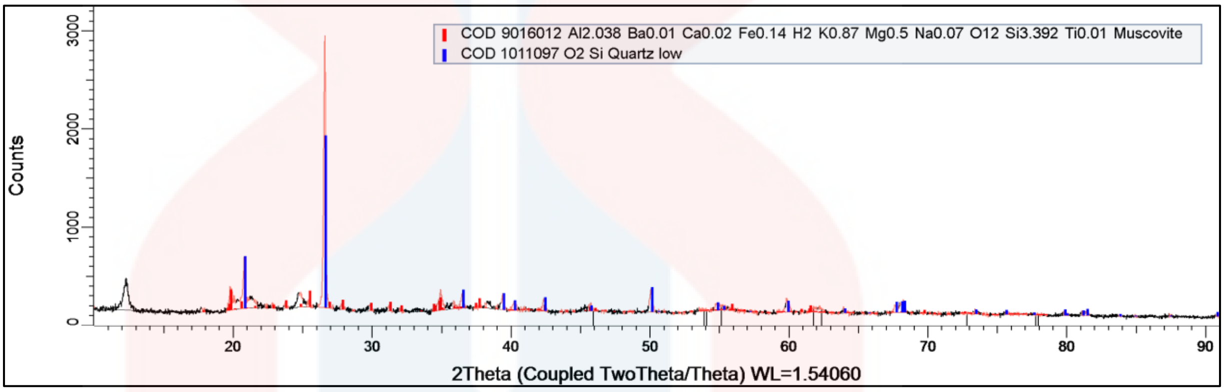


Figure 5.6 XRD pattern of sample 4

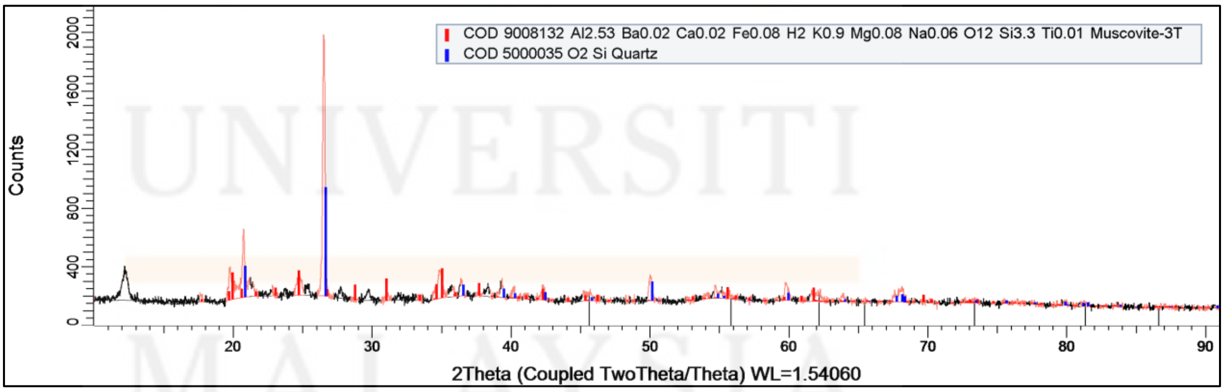


Figure 5.7 XRD pattern of sample 5

Characterisation of the feldspar by XRD spectra showed that the main peak of the sample pattern was identified as $KAlSi_3O_8$ (K-Feldspar). XRD pattern showed intense sharp diffraction peaks at low angle position within 2θ = 25 to 30º for all sample according to **Figure 5.3, 5.4, 5.5, 5.6 & 5.7**. Silicate with representative quartz has the highest intensity in the most of the sample followed by muscovite and mica.

5.4 Comparing with Commercial Ceramic Grade Feldspar and Commercial Glass Grade Feldspar

The main ingredients affecting the ceramic processing and the product quality are K_2O, Na_2O, Al_2O_3, SiO_2 and Fe_2O_3 while the main elements affecting the glass processing and the product superiority are K_2O, CaO, Na_2O, Al_2O_3, SiO_2 and Fe_2O_3. The composition of commercial ceramic grade feldspar and ceramic grade feldspar are given in **Table 2.1** in previous subchapter.

A comparison between the percentages of the main ingredients of the raw feldspar at study area with the commercial ceramic grade feldspar is depicted in **Figure 5.8**. The results presented in **Figure 5.8** indicate that the chemical composition of the raw sample from study area is suitable as a raw material for ceramic industries. However, it contains large Fe_2O_3 percentage of range from 10.1982 % to 19.0875 %. The maximum Fe_2O_3 percentage must not be more than 0.3% based on the industrial uses specification as in **Table 5.1**. Augmented Fe_2O_3 percentage affects the quality of the final product. The presence of Fe_2O_3 more than the allowed limits will contribute in unwanted variations of the colour towards grey rather than white due to forming a black spot in the product body during firing process.

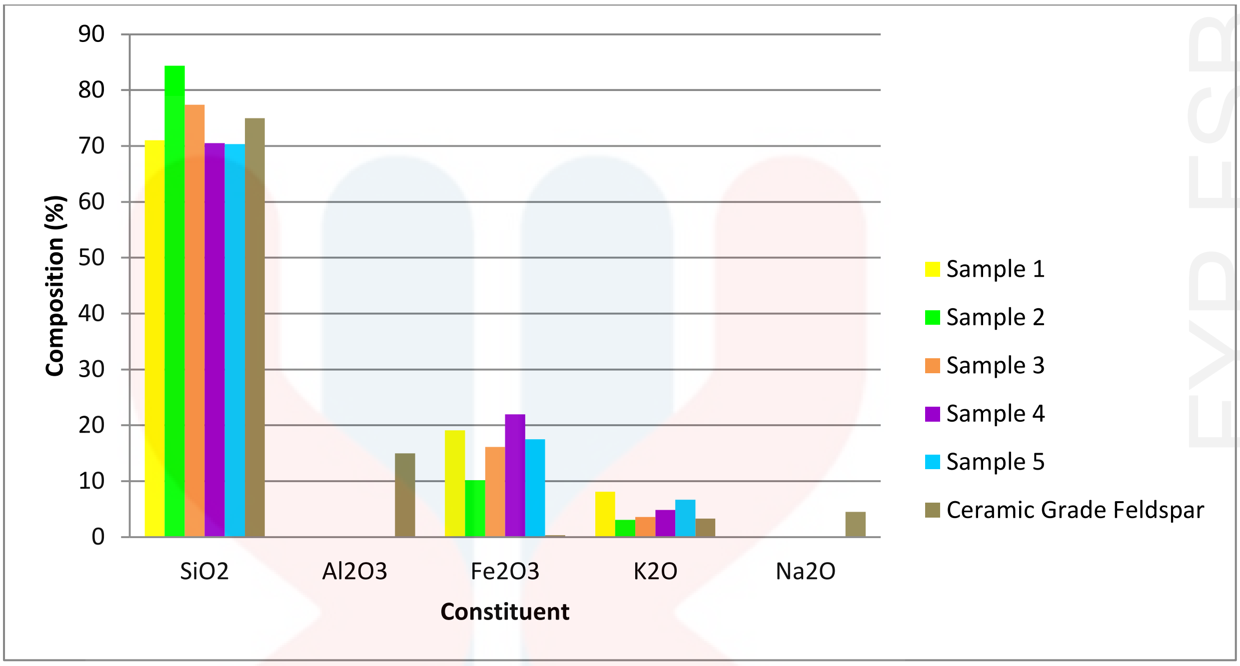


Figure 5.8 Comparison between the percentages of the main ingredients of the sample at study area with the commercial ceramic grade feldspar

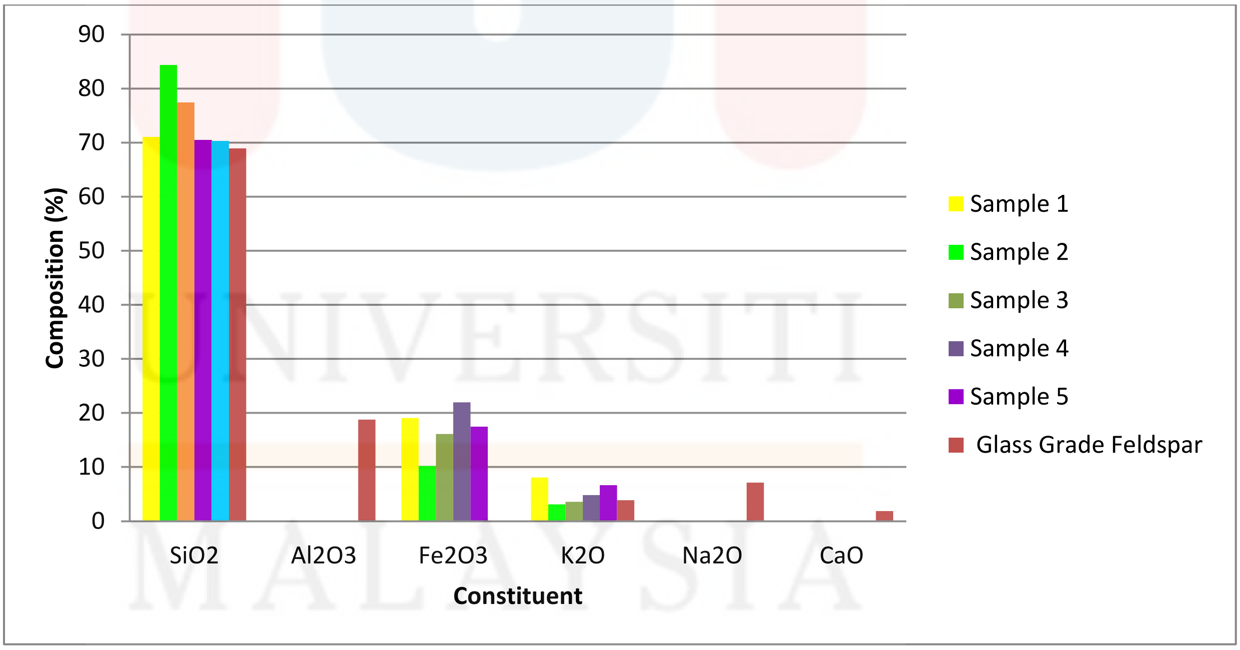


Figure 5.9 Comparison between the percentages of the main ingredients of the sample at study area with the commercial glass grade feldspar

A comparison between the composition of the sample at study area and the commercial glass grade feldspar are shown in **Figure 5.9** which demonstrates the components of raw feldspar are suitable for glass industry.

CHAPTER 6

CONCLUSION AND SUGGESTION

6.1 Conclusion

According to the both XRF and XRD analysis, the feldspar can be classified as potassium feldspar as its components is dominated by potassium other than the main components which is silicon and oxygen. The sample feldspar also shows the absent of calcium and sodium. The silica content in the samples range between 70-75 %. As conclusion, feldspar from the study area has potential to be used as raw material in ceramic and glass manufacture.

6.2 Suggestion

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

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APPENDIX A

Table A Joint reading at Station 1

278	318	222	231	288
286	221	305	233	278
310	205	323	249	269
271	207	302	280	247
300	285	335	269	250
318	286	254	271	275
319	288	269	251	262
318	287	293	207	280
319	278	277	259	277
284	279	248	286	272
327	289	207	262	278
254	248	304	263	286
291	286	338	304	310
288	271	285	302	277
260	294	275	335	288
275	333	246	300	259
317	270	288	310	317
225	304	261	277	285
260	286	293	308	221
288	224	259	318	288