CHARACTERISTICS OF DIKES IN KINTA VALLEY, PERAK USING GEOPHYSICAL AND GEOLOGIAL APPROACHES

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by

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CIRI – CIRI DAIK DI LEMBAH KINTA, PERAK MENGGUNAKAN PENDEKATAN GEOFIZIKAL DAN GEOLOGIKAL

ABSTRAK

Pembentukan Simpang Pulai adalah sebahagian dari Lembah Kinta Perak di mana kawasan ini terkenal dengan aktiviti dan pengeluaran perlombongan bijih timah yang aktif pada abad ke-19. Pengambilan mineral yang berlainan dari perlombongan biasanya digunakan dalam pelbagai industri seperti pembuatan dan pembinaan. Oleh kerana wujudnya pelbagai jenis batuan dan struktur geologi yang berbeza, ini menunjukkan bahawa kawasan ini kaya dengan sumber mineral yang menjadikan industri ini sebagai kegiatan ekonomi utama di negeri Perak. Mineral yang berbeza diterokai dan dikendalikan oleh syarikat yang berbeza, tetapi tidak ada eksplorasi yang tepat dengan menggunakan kaedah geofizik sebelum menggunakan kekuatan manusia. Oleh kerana struktur geologi yang berbeza terbentuk di daerah ini, terdapat dua tanggul yang berlainan di kuari yang masih dikendalikan oleh Imerys Mineral Sdn Bhd dan asal-usul formasi ini masih belum dapat dikenal pasti. Penyelidikan ini memfokuskan pada penggunaan penderiaan jarak jauh sebagai salah satu kaedah geofizik dalam menjelaskan struktur permukaan yang terdapat dalam formasi ini. Kajian singkapan dan pemetaan dilakukan dengan menggunakan gambar penderiaan jarak jauh yang ditafsirkan dan ditangkap oleh perisian pemetaan ArcGIS dan Lidar dengan menggunakan analisis gambar berdasarkan objek (OBIA). Ketinggian dan penyebaran tumbuh-tumbuhan dipetakan dan didapati bahawa kawasan Simpang Pulai masih belum diterokai dan dipenuhi dengan bukit dan lembah. Taburan ketinggian di kawasan perlombongan berkisar antara 150m hingga 500m di atas permukaan laut. Sementara itu, mineralogi batu dibezakan dengan melakukan empat kajian makmal

yang berbeza iaitu XRD, EDX, SEM dan analisis bahagian tipis. Sampel batu yang berbeza diambil dari kawasan ini semasa melakukan pemerhatian fizikal. Kajian makmal yang berbeza seperti XRD, EDX, SEM dan analisis bahagian nipis digunakan untuk mengenal pasti dan memerhatikan sifat kimia dan fizikal pada setiap sampel batuan. Bagi hasilnya, tanggul pertama terdiri dari mineral kuarza dan tanggul kedua terdiri dari mineral yang berlainan seperti silikon, kuarza, aluminium, dan feldspar. Kedua-dua tanggul mempunyai sifat mineral, fizikal dan kimia yang berbeza berbanding batuan inang. Ini kerana tanggul terbentuk kemudian kerana batuan tuan rumah diceroboh dalam formasi yang ada. Oleh itu, kedua-dua tanggul adalah tanggul magmatik kerana kebanyakannya dibuat dari jenis batuan igneus. Tanggul pertama disusun oleh mineral kuarza membentuk tanggul kuarza dan tanggul kedua disusun dengan mineral utama dari tanggul granit membentuk batuan beku. Komposisi mineral untuk kedua tanggul adalah sumber mineral bagi syarikat operasi di kawasan Lembah Kinta. Walaupun data penderiaan jarak jauh yang diperoleh terbatas, kajian fizikal dilakukan untuk mendapatkan informasi tambahan mengenai eksplorasi mineral dengan tujuan untuk menentukan metode yang sesuai untuk melakukan penggalian dan pengekstrakan.

CHARACTERISTICS OF DIKES IN KINTA VALLEY, PERAK USING GEOPHYSICAL AND GEOLOGIAL APPROACHES

ABSTRACT

Simpang Pulai formation is part of Kinta Valley Perak where this area was well-known for its rigorous tin mining activity and production in the 19th century. The extraction of different minerals from the mining is commonly used in various industries like manufacturing and construction. Due to the existence of various rock types and different geological structures, it shows that this area is rich in mineral resources which makes this industry the main economic activity in Perak state. Different minerals were explored and operated by different companies, but there was no proper exploration by using geophysical methods prior to using human ability. Due to different geological structures formed in this area, two different dikes were found in the quarry that is still being operated by Imerys Mineral Sdn Bhd and the origin of this formation still remains unidentified. This research focuses on using remote sensing as one of the geophysical method in explaining the surface structures present in this formation. The outcrop and mapping studies were performed by using remote sensing images that were interpreted and captured by ArcGIS and Lidar mapping software by using object based image analysis (OBIA). Elevation and vegetation distribution were mapped and it was discovered that Simpang Pulai area is still unexplored and filled with hills and valleys. The elevation distribution in the mining area ranges between 150m to 500m above sea level. Meanwhile, the mineralogy of the rocks were distinguished by performing four different lab studies which are XRD, EDX, SEM and thin section analysis. Different rock samples were taken from this area while doing physical observation. The different lab studies such as XRD, EDX, SEM and thin

section analysis were used to identify and observe the chemical and physical properties on each of the rock samples. As for the outcome, the first dike mainly consists of quartz mineral and the second dike was composed with different minerals such as silicon, quartz, aluminum, and feldspar. Both dikes have different mineral, physical and chemical properties compared to the host rock. This is because the dikes were formed later as the host rock was intruded in the existing formation. Thus, both of dikes are magmatic dike because they were mainly made by igneous rock type. First dike was composed by quartz mineral forming quartz dike and second dike was composed with major minerals from igneous rock forming granite dike. The mineral composition for both dikes are the mineral resources for the operating companies in the Kinta Valley area. Even-though the remote sensing data obtained was limited, physical study was carried out in order to obtain additional information on the mineral exploration with the aim to determine the suitable method to perform excavation and extraction.

CHAPTER 1

INTRODUCTION

1.1 Background

Geology is the scientific study of the all constituents of planets, their internal and external forms and processes (Balasubramanian, 2017). Geology is the science that deals with the earth's activity and its nature formed and occur. It also describes as the structure of the earth and beneath its surface and the processes that have shaped that structure. The most compulsory information from geology category is providing the primary evidence of plate tectonic that occur on earth, the evolutionary history of life and the earths past climates. Geologist use variety of methods and ways to understand and determine the earth's structure and evolution by performing field work, rock description, geophysical techniques, chemical analysis, physical experiments and numerical modelling. All of this are vital methods that needed to be performed by a person with geology background.

Hydrothermal system is set of processes that redistribute energy and mass in response to circulating of water fluids (Chikanda *et al.*, 2019). Hydrothermal system is one of the events that occur on the earth and it's still on going until today. It still active on the oceanic crust and continental crust and their fossilized equivalents. By performing fluid circulation or as magma inside the earth, a several formations can occur and able to see on the surface such as dikes and sills. These formations are massive because of very large intrusive igneous body that occur beneath of the Earth.

Dikes or massive crystalline ridges are form as discordant igneous rock body that cuts across the pre-existing rock bed vertically (Geshi *et al.*, 2012). They frequently form from explosive eruptions that crack the area around a volcano then the magma filling the cracks forming a dike or sill. In general, Dikes formation will take place due to hydrothermal system processes and it occurs in several areas in Peninsular Malaysia. A basaltic dike of Peninsular Malaysia is confined to the Eastern Belt as compared with the Western Belt (Azman, 2013). This shows, dikes formation is quietly active in Peninsular Malaysia and can be seen in Simpang Pulai formation that is part of the Kinta Valley, Perak. Kinta Valley is made up by karstic limestone and it's very rare to be known that dikes were formed this area. A study needs to be carried out on several areas in Kinta Valley to understand the details information about the formation of dikes in this area. The mineral studies and photography studies remain understand in this area. That's why a laboratory and site study are vital method to understand about the dike formation. Several lab studies such as X-Ray Diffraction (XRD), Energy Dispersive X-Ray (EDX), Scanning Electron Microscopy (SEM) and Petrography Thin Section need to be done to compare and understand the formation of dikes in this area, Kinta Valley, Perak.

1.2 Problem Statement

Mineral exploration would be useful in various industries especially oil and gas and mining industries. Identifying type of minerals and volume would be important parameters before proceed with mineral excavation. This will prevent from environmental effect towards nature that will cause landslide, flood and climate changes. Minerals and condition of the formation that can be used as mineral resources can be determine by using remote sensing as geophysical method at first place. Further

studies using geophysical method could assist human in understanding details prior to mineral exploration avoiding waste, catastrophic environmental events and deforestation without control.

Massive crystalline formation or knows as dike were formed in one of the quarry part of Kinta Valley located in Perak. Both of dikes still poorly understood on its mineral, chemical and physical properties. This intrusion were observed in active quarry that still operating under Imerys Mineral Sdn Bhd. Furthermore, this area having high number of rainfall based on Che Ngah, Reid and Hashim in 2012. This will lead to weathering effect on the surrounding rocks in this area over time. Host rock would be the highest tendency in exposing of weathering effect that will cause physical properties to be change. Lab analysis such as XRD and EDX would be a perfect indicator and analysis in determining precise details identifying the mineral composition. SEM and thin section analysis as petrography study would be another test in showing morphology on the characteristics for each of the rock samples. Following analysis on the rock samples in determining its own characteristics would help in distinguishing general type of dike either this intrusion would be useful for mineral resources and how this event would be a major effect that will affect mineral exploration activity especially inside the oil and gas industries.

1.3 Research Objectives

The objectives of this research are:

I. To characterize the geological outcrop using remote sensing method as geophysical exploration.

II. To identify the characteristic of dikes using XRD, EDX, SEM and Petrography Thin Section studies.

III. To define the minerals that deposited along the dikes using XRD, EDX, SEM and Petrography Thin Section studies.

1.4 Research Questions

I. Massive ridges have been observed in the Kinta Valley areas which are the Main Range and Kledang Range and still remain poorly understood.

II. Mineral composition on each of the rock samples quite difficult to distinguish due to physical and chemical weathering effect throughout time in the location.

1.5 Scope of Study

The scope of this research is to study the dikes formation on its characteristic and its mineralization. The locations of the study area are mainly located at the Western part of Peninsular Malaysia, which is in the state of Perak. The dikes formation able to observe on Kinta Valley, Perak. Along the western part of Perak, numerous scenic karstic limestone hills can be observed on the eastern flank of the valley which means the dikes formed on the carbonate rock types. Details on this

location will be discuss further inside geophysical method in chapter 4 inside result and discussion which is remote sensing method that will be used to identify and locate the dike formation. Different method was proposed applying geophysical method and remote sensing is the best method for the mineral exploration. By using object based image analysis (OBIA) method, satellite images were obtain from the electromagnetic energy that release from the object on the Earth's surfaces. This mapping will be used in identifying the characteristics such as elevation, vegetation, location and mineral distribution in study area. ArcGIS and Lidar mapping software will convert the input into useful information as requested. Furthering with field study after using geophysical method prior to mineral exploration, samples can be obtain in locating and determining minerals that composed in the area. Geological studies can be applied after obtaining the mapping from geophysical method to understand more the activities that could happened in the study area. Locating two different dikes explaining there were intrusion happened in the formation of Simpang Pulai that can be used as mineral resources that could be generate as income. Rock samples has been collected that will undergoes four different lab studies in knowing the mineral composition, physical and chemical properties of this rock samples. This rock samples were collected from the host rock and dike itself.

Four different lab studies will be performed on the rock samples that were collected from field study. XRD, EDX, SEM and petrography thin sections will be conducted in identifying mineralization and characteristics of the rock samples. This dikes intrude the formation that mainly made by limestone and granite. From the definition of dike, this intrusion could be magmatic or sedimentary and it shows that the physical properties, chemical properties and mineral composition should be differ than the host rock. The important of knowing the characteristics of the rock samples

is to knowing the formation could be as mineral resources then proceed with specific method in excavation and extraction.

Afterwards EDX and XRD analysis on the rock samples will determine element and mineral composition on the rock samples. This will be important in knowing the characteristics of the rock formed in the formation. Different rocks having different physical and chemical properties that could be useful for manufacturing, medication, food industry and cosmetic. Next, performing SEM and thin section analysis were done to verify and classify the rock samples based on the features from the analysis. Different mineral having different type of features that only can be observe using microscope. Type of rock could be distinguish after performing these lab studies and would be useful information for miners before proceed with mineral excavation and extraction.

1.6 Layout of Thesis

Generally, the contents of this dissertation are organized as follows;

In Chapter 2, the geological background of Simpang Pulai formation which is a part of the Kinta Valley in addition to the lab studies were described in this chapter. This includes the general theory of geophysical exploration using remote sensing method and several lab studies XRD, EDX, SEM and petrography thin section methods and general description of the rock properties that might been observe in the dike formation. This chapter also includes general study of hydrothermal system that will relate with magmatic intrusion event that leading in forming of dikes.

Chapter 3 discusses the research methodology designed for this research. The early description is about the geological setting by performing site visit study for the selected area in Kinta Valley, Perak according to the location of the dikes as observed. There are several places that dikes formed and able to observe and make possible to take rock samples in the location. The rock samples were collected on the dike's formation and its surrounding rock for lab studies. Applying remote sensing method as geophysical studies for details explanations the exact location on the dike were formed. Remote sensing data was collected from Malaysia Space Agency (MYSA) and by using ArcGIS software for the interpretation on the images. For data acquisition, different lab studies were applied to identify and study the characteristic and mineralization of the rock samples. XRD, EDX, SEM and petrography thin section were conducted, and the data were compares for several locations and table were built as a result. Physical and chemical properties were tested to strengthen and provide more vital information to support the results. This chapter also explains the all the lab procedures from the XRD, EDX, and SEM in obtaining the results of the rock samples. For the petrography analysis, hand specimen and thin section also available in the section for the study area.

Chapter 4 presents all the results according to the flow of this research objectives. Remote sensing as geophysical method explaining the targeted areas that dikes formation were found from the field study. The details discussion in this area were discussed between geophysical method and field observation in Kinta Valley, Perak. The interpretation of the data by performing analysis on all the lab studies to make correlation on the rock samples able to make by identifying the characteristic and mineralization of the rock samples that obtains from the dikes formation and rock surrounding as a host rock. The images and results obtained from the test on the rock

samples were present in tables and figures for different location before comparing them. At the end of this chapter, physical and chemical properties of the rock samples were identified distinguished and details explanation about the targeted location has been described to relate between field observation and geophysical exploration.

Chapter 5 is the conclusion of the study of the dike's formation and its surrounding areas of the formation using remote sensing, geophysical exploration, lab studies and hand specimen study. Explanation on the dikes formation were mentioned in this chapter on the physical and chemical properties of the rock sample. Each of rock samples have been distinguished based on the results obtained throughout the study.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

As a human being, taking care of earth is our responsibilities for future generation to continue live on in this beautiful and peaceful place. Performing different geology studies help in interpretation and knowing the nature of the earth. Outcrop study can be defined as a visible exposure of bedrock on the surface and it's only covered the surface of the earth without knowing what is beneath the earth. Remote sensing is one of the methods allowing to interpret outcrop study on the earth that widely used until today as geophysical method (Hodgetts, 2013). It is a branch of natural science dealing with the earth on physical properties of the earth on this analysis. Sabins (1999) mentioned quantitative measurements from remote sensing as a technology nowadays for physical observations by interpreting images and related data acquired from aircraft and satellites. In addition, remote sensing images are widely used in mineral exploration because of limited exploration by human being (Roonwal, 2018). Due to that, remote sensing as method to do the survey first before human works in limited areas that hard to explore. Different type of remote sensing have different usage for example thematic mapping that widely used in mineral exploration. Capabilities in determining different mineral properties on the Earth's surface can be accomplished from electromagnetic energy emitted by the rocks and applying remote sensing method as geophysical method prior to data acquisition that can be used for human being.

Petrology is one of essential component of geology in evaluate the minerals composition inside the rocks by determine and distinguish its own physical and chemical properties (Deborah *et al.*, 2006). Applying lab studies such as XRD, EDX, SEM and petrography thin sections helps to interpret and gives relevant data in doing mineral interpretation that widely used in the world especially in mineral exploration. By determining the mineral composition of the rock in specific area, extraction of mineral resources can be made to provide minerals that used in a lot of sectors such as construction, manufacturing and even medicals (Deborah *et al.,* 2006). Performing different lab studies are the basic methods to interpret the mineral composition inside the rock samples.

2.2 Fundamental of geology

Geology is basically study of the Earth science specifically on the formation or any solid structure that was formed on the surface of the Earth. It's also included the changes of processes over time since this study will provide details and information about geology of Earth. Earth was shaped a million years ago, and it composed with different types of formation, rock and features. Combining these compositions, its help to interpret as a primary evidence of what happened on the Earth surfaces. Wide variety of methods will be applied to understand more details on Earth's structure and evolution including description of rock, field work, geophysical techniques, chemical and physical analysis and numerical modelling. The sector that using most of the geology study are hydrocarbon and mineral exploration, environmental and climate change (Caumon, 2018).

Geology of an area changes based on deposition and insertion of different rocks. This deformational process is happen based on shapes and locations of an area. Different features that formed on the surface of the Earth's are related with deposition and intrusion that happened million years ago such as fault, hills, river and volcanoes. Lithification of rocks will form overlying rock that deposit onto the surface and forming sedimentary rock and structure. Gigantic features such as batholiths, dikes, sills, volcanoes are form by igneous intrusions that push upwards due to geothermal activity inside the Earth. Earth's fill up with three different type of rocks which are igneous, sedimentary and metamorphic (Morgan, 2018). Each of type have their own structure and specifications that help to explain what happened in the location. Geology study will be applied and running to know the history of interest location by running geology studies (Dolphin *et al.*, 2019).

2.2.1 Earth's internal layers

Structure of the Earths is divided into few layers. Each layer has different specification in physically and chemically (Souriau and Calvet, 2015) . From the outer layer of the Earths is crust follow by mantle and core. Crust can be clearly seen by human eyes because human live on the outermost layer of Earth. In this layer, great variety of different rocks can be found which are sedimentary, igneous and metamorphic (Souriau and Calvet, 2015). For the mantle, it consists of high viscous layer and made mostly by oxygen, silicon and heavier element magnesium. Liquid are store in this layer due to high temperature and pressure (Souriau and Calvet, 2015). High pressure from the mantle will push upwards and form different features of rock formation on the surface of the Earth. Earth's inner core is the innermost layer of the

Earth that does not have any available direct for measurement. Analysis on the core have been made through seismic waves and Earth's magnetic field. It believed that the inner core composed by nickel alloy with other elements and estimated to be approximately 5700 K for the temperature. It equals to the temperature of the Sun (Barton, 1991).

Earth's crust consists of two different type's namely continental and oceanic crust where oceanic crust composed of high density of rocks compared to the continental that made the oceanic crust laying in the sea (Ben-Avraham and Nur, 2011). The oceanic crust also composed primarily of basalt, diabase and gabbro and this crust is formed because of collision of lithosphere of the Earth that located on the Earth's crust (Ben-Avraham and Nur, 2011). The result of the collision, the denser crust which is oceanic crust will be forced down into the mantle and forming oceanic crust while thicker and less dense crust will form a continental plate (Wortel *et al.,* 2009). The collision happened between oceanic and continental crust is near to mantle that will cause different features can exist such as volcanoes (Wortel *et al.,* 2009). In the other hand, two different continental crust have possibility to collide and form different feature such as mountain on the Earth's surface. In some cases, the continental crust might get pulled under the earth and turned to become volcanic features (Ben-Avraham and Nur, 2011). When continental crusts collide and folds between two plates, the rock at the boundary will be lifted leading to the formation of mountains and mountain ranges. One of the example mountain-building process because of crust collision is the Himalayan range in the southern Asia and they were formed by the collision of two different plates which are Indian and Eurasian (Jain, 2014).

2.2.2 Geologic time period

Geologic time scale (GTS) is a full system of chronological time scale that related with the stratigraphy based on different time and it has been widely used by Earth's scientists in describing the timing and the past events occurred on the Earth's surfaces (Gradstein *et al.,* 2012). The main divisions of GTS are eons where the sequence started from Hadean, Archean, Proterozoic and Phanerozoic where explanation on what happened to the Earth mostly formed in Phanerozoic eon (Gradstein *et al.,* 2012). This geologic eon represents where abundant animal and plant life has start existing in this era (Gradstein *et al.,* 2012).

Phanerozoic eon divided into three eras which are Paleozoic, Mesozoic and Cenozoic (Metcalfe, 2011). Paleozoic era was a time where drastic change happened in this time on geological, climatic and evolutionary. This era is divided into six period which are, from oldest to youngest, Cambrian, Ordovician, Silurian, Devonian, Carboniferous, and Permian (Metcalfe, 2011). This era began and ended with rise of mountains along continental and rifting and separation three different continental terranes forming Sundaland (Southeastern Asia) (Metcalfe, 2011). Carboniferous period took place at the late Paleozoic era forming large Paleozoic carbonate complex that covered most of the large parts of South-East Asia (Pierson *et al.,* 2014). Huge events and formation happened in between late Paleozoic and early Mesozoic era in the South East Asia especially towards stratigraphy (Metcalfe 2017). Figure 2.1 represented different features of stratigraphy formed in the South East Asia.

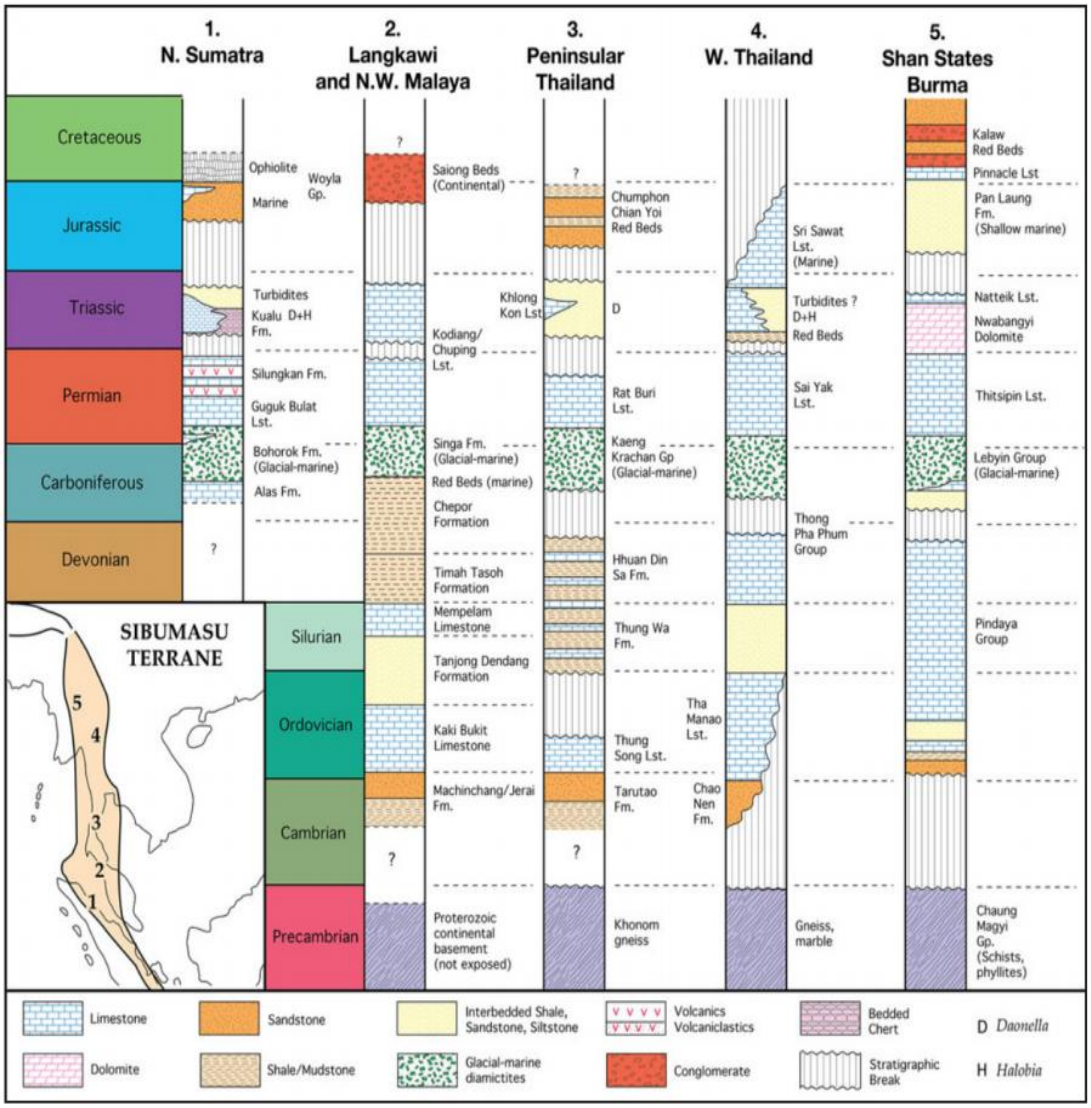

Figure 2.1: Stratigraphy of part of the South East Asia (Sibumasu) (Metcalfe 2017).

2.2.3 Type of rocks and minerals

Three different layers of rocks can be found on the continental crust layer which are igneous, sedimentary and metamorphic rocks. 95% igneous and metamorphic rocks and 5% of sedimentary rock (Souriau and Calvet, 2015). These rocks have different characteristics and classifications that can be distinguished easily. Basic definition of igneous rocks is a rock that form by cooling of magma and two most common types can be found on the Earth's surface is granite and basalt (Zhang,

2016). Sedimentary rocks are rocks that formed by lithification process of sediments, chemical precipitation or biogenic deposition where the common types of sedimentary rock are sandstone, shale, coal, limestone and coral. Lastly, metamorphic rocks are rocks that change or alter by high pressure, temperatures and chemically which will change the characteristic of rock while still in the solid state (Zhang, 2016). Two common types for metamorphic rocks are marble that changed from limestone and slate that changed from shale (Zhang, 2016).

Igneous rock is any various crystalline or glassy rocks that were formed by the cooling and followed by solidification of molten earth material called as magma and other name for igneous rock is a magmatic rock. Eruption of active volcanoes will allow magma to come out from the mantle or below the crust to the surface of the earth and it is called lava and this process called as magmatic intrusion (Mibei, 2014). The lava flow out from the volcanoes and undergoes cooling and solidification process to form magmatic rocks (Mibei, 2014). Tectonic plate's activity around the areas can cause the igneous rock to travel from certain place to another place and extrusive igneous rocks are igneous rocks that been found on the Earth's surface because they are formed outside of the crust (Mibei, 2014). Intrusive igneous rocks are igneous rocks that has been found below Earth's surface because they are formed under the crust of Earth. Classification and characteristics are different between these two rocks and the igneous rocks divided into four groups which are felsic, intermediate, mafic and ultramafic and the main parameters to classify and identify this group by looking on the mineral percentage on the rock (Mibei, 2014). Different mineral composition on the rock are caused by temperature and pressure of the rocks while cooling and solidification, also known as crystallization process (Gao and Liu, 2001).

On the other hand, sedimentary rocks are formed by the accumulation or deposition of small rock particles where the rock particles undergo process of cementation over time on the floor of the oceans or bodies of water on the Earth's surface (Mibei, 2014). Sedimentary rocks are related with sedimentation of different particles that will form solid rocks after they settle in a place and its Composed of different geological detritus (minerals) or biological detritus (organic matter) on the sedimentary rocks (Boggs, 2009). Weathering and erosion will be factors of changing the rocks composition before it will be transport to deposition place by wind, mass movement, glaciers, water, and wind as denudation agent. Sedimentary rocks can be divided into four different groups based on the classifications and properties. These are clastic sedimentary rocks, biochemical sedimentary rocks, chemical sedimentary rocks and sedimentary rocks that formed by impacts, volcanic activities and minor processes (Mibei, 2014).

Lastly, metamorphic rocks are the existing rocks such as sedimentary or igneous that have been modified by heat, pressure and chemical processes (Bucher and Grapes, 2011). If the rocks located deep below Earth's surface, the rocks will expose to the extreme conditions that cause changing in mineralogy, texture and chemical composition of the rocks (Bucher and Grapes, 2011). The rocks will go metamorphism process to change it state by temperature greater than 150 to 200 °C and pressure greater than 1,000 bars where most of the metamorphic rocks are in the lower part of continental crust because of the heat and pressure. The classification and characteristic of the metamorphic rocks is defined by texture, chemical composition and mineral assemblage where two basic types of metamorphic rocks are foliated metamorphic rocks and non-foliated metamorphic rocks and the difference between

this two types is layered or branded appearances on surface of the rocks (Bucher and Grapes, 2011).

Minerals are the fundamental component in forming a rock and its possible to form a rock with one or more minerals (Beard, 2019). Common minerals that widely can be found on the Earth are quartz, feldspar, mica, olivine, amphibole and calcite and most of the minerals that easily to be found on the Earth's surface is made by molten magma that form at specific temperature while undergo crystallization process (Beard, 2019). The crystallization of minerals based on Bowen's reaction series and it explain why certain types of minerals tend to be mixed together while others almost never associated with each other. The basic minerals exist that make up granite are feldspar, quartz, mica and plagioclase therefore, most of the Earth surface covered by granite rock type (Beard, 2019).

2.2.4 Weathering effect

Weathering is a process of breaking down and disintegrate of rocks, soil and minerals near or at the Earth's surface where water, ice, snow, wind, waves and gravity are the factors that lead to weathering process. Weathering will cause the rocks, soil and mineral being transported and deposited in other locations (Jain, 2014). Two different classification of weathering which are physical and chemical weathering, and both have different properties that lead on changing of rock physical and chemical properties (Jain, 2014).

Physical or mechanical weathering happen to break downs rocks due to environmental factors including heat, cold, water and wind (Matsumoto *et al.*, 2017). Disaggregation process on rocks because of physical weathering will not influence its

chemical properties (Matsumoto *et al.,* 2017). The main process of physical weathering is abrasion where the rocks will reduce in size and change the physical appearance, moreover cracking and breaking are parts of the physical weathering effect that will physically breaks down rocks (Matsumoto *et al.,* 2017).

Chemical weathering basically changes of composition of rocks that will affect minerals composed in the rocks and various chemical reactions will happen when the minerals interact with water. This process will degrade a rock by altering the chemical composition from the processes. This chemical weathering will cause the rocks to be weaker from it should be and more vulnerable towards physical weathering (Chigira and Oyama, 2000). Moreover, hydrolysis and oxidation due to chemical process can be happened and this will act as agents to develop new or secondary minerals on the rock. Hydrolysis process on feldspar will change the mineral into clay and rainwater with high contain of carbon dioxide will produce carbonic acid will break down and erode carbonate mineral such as calcite (Miščević and Vlastelica, 2014). Acid react with carbonate minerals to produce fizz sounds on its reaction. Carbonate minerals will become unstable when contact with acid and the reaction produce carbon dioxide gas (CO_2), water (H_2O), dissolved calcium (Ca^{++}) and dissolved acid (Worsfold *et al.,* 2019). Erosion and deposition because of weathering effect will change the behavior of rocks on its physical and chemical properties (Miščević and Vlastelica, 2014). These processes work together over time and form different features that widely existed on the Earth's surface (Miščević and Vlastelica, 2014).

2.2.5 Magmatic intrusion

Intrusive rock is formed by intrusion event of magma when penetrates existing rock and the magma will be crystallize and change into solid (Harker, 2011) The natural history of igneous rocks. Example of intrusive rock that can be found are plutons, batholiths, dikes, sills, laccoliths and volcanic necks (Harker, 2011). The other term for this intrusive rock is plutonic rock and they are divided by crystal size and grained type (Harker, 2011). Batholiths and other plutons are the coarse-grained plutonic rock because it formed deeper in the Earth's crust, on the other hand, dikes and sills are medium-grained plutonic rock because it formed higher in the crust (Harker, 2011).

Three common types of magmatic intrusion are sills, dikes and batholiths that mostly can be found and see on the Earth's surface (Breitkreuz and Petford, 2004). Sills is formed when magma from below of the Earth's surface intrudes between rock layers horizontally or gently dipping and at the end of the formation the magma form sheet of igneous rock that cuts through pre-existing rock (Breitkreuz and Petford, 2004). Dikes also undergoes same process as sills, but the magma intrudes vertically and pushed up towards the surface through pre-existing layers of rocks and sheet of igneous rock formed vertically or steeply-dipping inside the Earth. Next batholiths are a large formation of deep-seated magma intrusions that flow from below of the Earth's surface (Breitkreuz and Petford, 2004). The viscous magma flows slowly intruding the Earth's crust and the magma will cool down and forming large mass of plutonic rocks (batholiths). It's clearly shows after the intrusion happened, the mineral surrounding will be change because of new rocks will be introduced compared with existing rocks (Breitkreuz and Petford, 2004).

2.2.6 Dike formation

In geological term, dike is a sheet of rock that is formed in fracture of pre-existing rock body by cutting through it vertically or highly stepped position (Albino *et al.*, 2019). It divided into two types which are magmatic dikes and sedimentary dikes where magmatic dikes form when the magma runs and cut through pre-existing layer vertically then solidifies as a sheet intrusion (Albino *et al.*, 2019). Magma that flow upwards and will turn into solid after its cool down due to change in temperature and pressure (Gudmundsson, 2011). Meanwhile, sedimentary dikes are formed when sediments fill into a fracture of pre-existing crack, sediments will turn into solid due to pressure, temperatures and time to turn into dikes (Gudmundsson, 2012).

Magmatic dikes usually made up of magmatic rocks with a very high aspect ratio on the body where the thickness of the dikes can be varying from sub-centimeter scale to many meters. The length of the dikes can be extending over many kilometers based on how long it cuts through pre-existing rock in the location and the rocks that formed the dikes always younger than the host rock. Usually, magmatic dikes are dark in color due to the mineral exist inside the magma where after the magma undergoes cooldown process, the magma will turn to black solid rocks. Texture and composition can range for this dike from diabase or basaltic to granitic or rhyolitic. In some cases, the magma will melt surrounding rocks that will introduce new mineral composition on the area (Emerman and Marrett, 1990).

Sedimentary dikes or clastic dikes formed when unconsolidated sediments fill into fracture or crack of pre-existing layers of the host rock and the process forming sedimentary dikes start when the unconsolidated sediments composed alternating with impermeable clay layers that contain fluid pressure inside it. The layers will reach a

critical values where the fluid pressure will breaks through overlying layers and forms a dike due to lithostatic overburden (Larsen and Mangerud, 1992). Other conditions to form sedimentary dikes when soil in a location is under permafrost conditions where water inside the pore is totally frozen and this will lead to crack on the soil and it's allowed sediments to fill up in from above and this will form vertical body of sediments that cuts through pre-existing rocks and forming a dike. Usually sedimentary dikes are formed within sedimentary host rocks because of sediments from the surrounding will fill up the fracture and forming a dike. Finally, sedimentary dikes can also be formed form within an igneous or metamorphic mass host rock (Svensen *et al.*, 2010).

2.3 Remote Sensing

Earth observation or remote sensing is the technique which includes the obtaining information on objects or certain areas at the earth's surface (Blaschke, 2010). This method is used without being in direct contact with the object or interested area and this can be accomplished by replacing human sense by eyes, smell or hearing this remote sensing help to accomplish human need to obtain information of the Earth's surface (Blaschke, 2010). Basic principle of this remote sensing is recording data and information by measuring object's transmission of electromagnetic energy from reflecting and radiating surfaces (Blaschke, 2010). In every living and nonliving object emitting their own electromagnetic wave that can be detect through remote sensing that will convert to information (Allan and Curran, 2006). This information will help to solve problems and provide data especially on what happened on the Earth's surface. There are two different system are used in remote sensing which are

active and passive (Allan and Curran, 2006). Active remote sensing is the energy measured that capture from the earth's surface in form of microwave sources while passive remote sensing is measurement of external energy source dependently such as sun (Allan and Curran,, 2006)

Numerous sectors in the world are using remote sensing to collect data and information from geography, land surveying, hydrology, ecology, meteorology, oceanography and most of earth science disciplines (Fan, 2017). In addition, it also can be used for military purposes, intelligence, commercial, economic and planning this is because by using remote sensing makes thing possible especially by human exploration to collect data in dangerous or inaccessible areas such as Amazon Basin and Arctic glacial features. Its ensure in the process of collecting data without disturb the ground and save cost (Rees, 1990). Object based image analysis (OBIA) is one of method that will be used by remote sensing in capturing images from reflection and emission of radiation energy produce by objects or surface materials that will be recorded and interpreted into useful information. The following stages are in need for remote sensing to obtain information by Rees (1990):

1. Electromagnetic radiation emission by objects or self-emission
2. Absorption and scattering of energy from the source to the surface of the earth in form of transmission
3. Interaction of electromagnetic radiation with the Earth's surface by reflection and emission
4. Reflection and transmit of electromagnetic radiation from the Earth's surface to the remote sensor (receiver) as input
5. Electromagnetic radiation will convert into useful sensor data as output
6. Data will be transmitting, process and analyses.

2.3.1 Cameras for remote sensing

These types of cameras are used specifically for topography studies, aerial survey cameras, multispectral cameras and panoramic cameras will be used to provide relevant data especially for mapping of the Earth's surfaces (Read and Torrado, 2009). Light emitted by the object on the Earth's surfaces will be collected and focused through an optical system on a receiver the input will be converting its intensity and frequency of the electromagnetic radiation by the light into output (Kreveld, 2017). This input will convert to the output by chemical or electronic processes and this data will be store into geographic information system that used broadly (Kreveld, 2017). Electromagnetic radiation by the object such as sun is the major energy source that act as input data for passive remote sensing. Basic airborne cameras need long time to measure the reflection of light off earth features before becoming able to convert into mapping information. However, technologies of satellite have become a major change in remote sensing that will receive different visible and near-infrared wavelength including solar radiation wavelength for the mapping. On the other hand, not all passive sensors use energy directly from the sun. Source from thermal radiation and microwave can be detected and can be measure as natural earth energy emissions (Kerrigan and Ali, 2020). Thermal infrared detect electromagnetic spectrum emitted as radiation before deals with data acquisition, processing and interpretation of data as results that will used by end user. By heat emission as radiation in a location, the spectrum that produce because of heat able to detect and locate by mapping the heat distribution in a interested location. In geological study, mapping terrain especially areas that still having volcanoes will be important using this method in interpreting and mapping earth surface based on the temperature surrounding (Kerrigan and Ali, 2020).

Three main features on earth surface which are vegetation, water and soil have their own spectral characteristics. Each feature will be discussed below (Aggarwal, 1973):

1. Vegetation: Variation of wavelength is the one of the spectral characteristics for the vegetation. Presence of chlorophyll on the leaves for each of the plant strongly absorbs radiations from the sunlight. The chlorophyll present in the plant will reflects green wavelength but absorb red and blue wavelength. It is also will be used to determine the conditions of the plants by measuring and monitoring the near infrared reflectance. Healthy leaves tend to diffuse reflector of near infrared wavelengths.

2. Water: For the water, radiation will be either absorbed or transmitted not by reflection. Its difference compared to vegetation, longer visible and near infrared radiation will be absorbed by water compared visible wavelengths. Due to stronger reflectance of water, shorter wavelength will show the water looks blue or blue green. Meanwhile, it will look darker when it is viewed at red or near infrared wavelengths. Reflectance of water are caused by different factors such as depth of water, materials within water and surface roughness of water. This factor will change the effect of absorption and transmission of water on radiation.

3. Soil: Incident radiation by soil mostly either by reflection or absorption and little of transmission. Reflectance properties of the soil are caused by different factors which are moisture content of the soil, content of organic matter, texture and structure of the soil and iron oxide content. Presence of moisture content in the soil will decrease the reflectance and will affect the radiation.

In conclusion, building up spectral signature will help to distinguish different features on the Earth's surface. Variety of different wavelengths will be measured on energy that is reflected by the targets to describe and determine presence of different features on the Earth's surface. This theory has been used widely in image processing to interpret and give clear picture for topography and image studies.

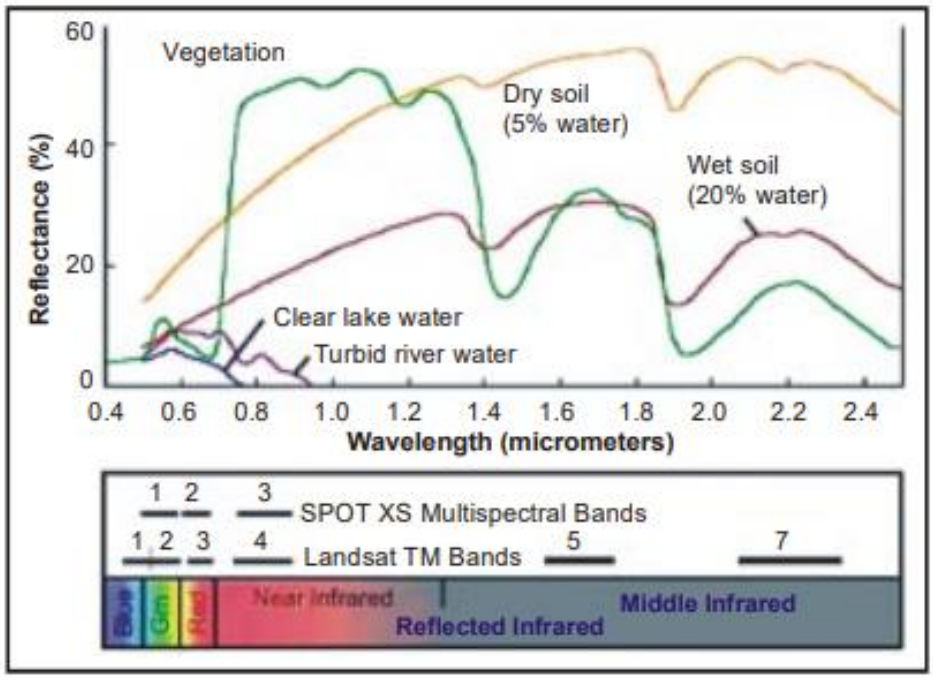

Figure 2.2: Spectral reflectance curves for different features on Earth's surfaces (Aggarwal, 1973)

Image processing and analysis techniques were developed to assist the interpretation of remote sensing images (Silva and Mendonca, 2005). From this technique, extraction of information through image processing will be done by remote sensing. Imaging system and conditions captured by the remote will undergo standard radiometric and geometric correction before the data is delivered to the end-user (Silva and Mendonca, 2005). ArcGIS software will be use as package to process both geospatial and imagery data as output. Radiometric correction is to correct uneven