GEOLOGY OF KAMPUNG LAWAR AND WATER QUALITY ASSESSMENT OF JELI AND TOK BOK HOT SPRINGS

by

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UNIVERSITI MALAYSIA KELANTAN

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DECLARATION

I hereby declare that the work embodied in this report entitled "Geology of Kampung Lawar and Water Quality Assessment of Jeli and Tok Bok Hot Springs" is the result of my own research except as cited in the references. The thesis has not been approved for any degree and is not simultaneously submitted in candidature of any other degree.

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APPROVAL

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GEOLOGY OF KAMPUNG LAWAR AND COMPARATIVE WATER QUALITY ASSESSMENT OF JELI AND TOK BOK HOT SPRINGS

ABSTRACT

The present research is focused on geological mapping and water quality assessment in hot springs of Jeli and Tok Bok which situated in Jeli and Machang districts in Kelantan respectively. The objective of this research is to update the geological map of study area with scale of 1:25000 and to compare the hydro-geochemical data of Jeli and Tok Bok hot springs. The methodology was applied for geological mapping based on secondary data from previous researchers, websites and remote sensing to observe the geomorphological features, structures and drainage pattern of study area. All these field related data were processed in GIS based platform to generate geological and other thematic maps. For the comparative water quality assessment, physical parameters were studied such as pH, total dissolved solid (TDS), dissolved oxygen, temperature and electrical conductivity (EC). In addition, few chemical parameters including chloride, calcium, sodium, magnesium, potassium, bicarbonate, sulphate, fluoride and iron were also analysed from both the hot spring water. Geologically the study area mainly consists granite and schist rock units in Jeli hot spring area. The granite was aged back to Cretaceous and known as Lawar Granite while the schist was Tiang Schist from the Silurian-Devonian period. Based on the water quality data, Jeli hot spring water represents the magnesium-bicarbonate type whereas the Tok Bok hot spring water represents the calcium- chloride type of Piper Trilinear Diagram.

Keyword: Geological mapping, water quality, hot spring

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PEMETAAN GEOLOGI DI KAMPUNG LAWAR DAN PENILAIAN KUALITI AIR MATA AIR PANAS JELI DAN TOK BOK

ABSTRAK

Penyelidikan ini difokuskan pada pemetaan geologi dan penilaian kualiti air di mata air panas Jeli dan Tok Bok. Objektif utama penyelidikan ini adalah untuk menghasilkan peta geologi kawasan kajian dengan skala 1: 25000 dan untuk membandingkan data hidro-geokimia mata air panas Jeli dan Tok Bok. Metodologi ini digunakan untuk pemetaan geologi berdasarkan data sekunder dari penyelidik sebelumnya, laman web dan penginderaan jauh untuk melihat ciri, struktur dan corak saliran kawasan kajian. Semua data berkaitan bidang ini diproses dalam platform berasaskan GIS untuk menghasilkan peta tematik geologi dan lain-lain. Untuk penilaian kualiti air perbandingan, parameter fizikal dikaji seperti pH, pepejal terlarut total (TDS), oksigen terlarut, suhu dan kekonduksian elektrik (EC). Selain itu, beberapa parameter kimia termasuk klorida, kalsium, natrium, magnesium, kalium, bikarbonat, sulfat, fluorida dan zat besi juga dianalisis dari kedua sumber air panas. Secara geologi kawasan kajian terutama terdiri dari unit batu granit dan batu schist di kawasan sumber air panas Jeli. Granit itu berusia kembali ke Cretaceous dan dikenali sebagai Lawar Granite sementara schist adalah Tiang Schist dari zaman Silurian-Devonian. Berdasarkan data kualiti air, mata air panas Jeli mewakili jenis magnesium-bikarbonat sedangkan air panas Tok Bok mewakili jenis kalsium-klorida dari Piper Trilinear Diagram.

Kata kunci: Pemetaan geologi, kualiti air, mata air panas

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CHAPTER 1

INTRODUCTION

1.1 General Background

Geoscience is a very broad field that includes many branches of geology such as hydrogeology, mapping, environmental geology etc. Geology can be defined as the knowledge of physical matter that makes up the earth, materials of the earth, all its geomorphological structures, the processes that contributes to the formations, movement and its changes. On the other hand, hydrogeology discusses about the interconnections between geological processes and how it affects water. Since students were not allowed to go for field mapping the research has to be completed based on secondary data. There is another issue here as the information found on internet sources and previous studies were from some time back and not very updated yet.

The present research is focusing on "Geology of Kampung Lawar and Water Quality Assessment of Jeli and Tok Bok Hot Springs". This research particularly focusses in parts of two distinct perspectives which are general geology and specification part. The

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geology mainly covered the geological mapping which incorporates the geomorphological landforms, tectonic settings, structural geology, lithostratigraphy and regional geography.

Geological mapping is the process of a geologist physically going out into the field and recording geological information from the rocks that outcrop at the surface. Information the geologist looks for will include: boundaries between different rock types and structures e.g. fault-lines and evidence of the rocks undergoing deformation. Mapping is an extremely important step in many investigations, as understanding the nature of the underlying rocks in an area is the foundation of all geologically related studies. Geologic mapping is a profoundly interpretive, scientific procedure that can create a scope of maps to show different features of geology including surveying ground-water quality and pollution threats (David R. Soller, 2004). It is additionally basic for all work to be performed inside a geological data framework called geographical information system (GIS) so as to guarantee that input imagery and deciphered data sets keep up the equivalent geographical coordinate system. Primary input data utilized for geomorphological planning incorporate satellite imagery, DEMs and aerial photos (Smith, 2011).

Spring water can be defined as the water beneath ground that moves naturally above Earth surface (Glennon, 2002). Spring that rises to the surface as warm water is otherwise called hot spring where the groundwater is warmed by the magmatic barging in from the earth crust (Lianko, 2001). The quantities of hot springs are generally relying upon the quantity of dynamic volcanoes in the nations like Indonesia, Korea and Japan (Erfurt-Cooper and Cooper, 2009). As indicated by Chow et al. (2010), there are 60 natural hot springs in Western Malaysia which have been recorded up until now and there are as yet numerous hot springs that are unfamiliar because of not very notable area. Abdul et

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al. (1997) expressed the hot springs in Malaysia are not very well known contrasted with different nations. The hot springs in Malaysia are for the most part basic to happen at the swamp territories, stream regions and bedrock surfaces which are classified as the spot that is close to the ground. In view of geological study, it is recommended that the hot springs in Malaysia are happened when groundwater close by to granite gets in contact with the warmth from the rock beneath the Earth surface (Abdul et al., 1997).

Not just for entertainment purpose, the hot springs are generally utilized for some many different purposes for example, aquaculture, and electric power (Kotzé, 2013). Because of their wide usage to the general population, it is important to examine the water nature and quality of the hot springs. Water quality investigation as characterized by Novotny and Olem in (1994) as referred to in Pharino (2007) is deciding if the water is reasonable to be utilized. This is finished by estimating the nature of the water quality that is influenced by natural causes and human induced exercises so the purity of the water can be ensured and several sicknesses may be precluded.

As per Gupta (2011), the water utilized for residential purposes must adhere to the guideline esteems and standard values that have been initiated in numerous nations. The measures are stricter for the water that is utilized by people contrasted with those implied for any agricultural purposes. As in the river and lake, hot spring likewise is the picture of its close-by territory. The encompassing activities are important to mull over in deciding the quality and cleanliness of the hot spring water. Nevertheless, there are not many studies identified with water quality in the Malaysia's hot spring regions. For instance, Abdul et al., (1997) have contemplated a few hot springs in Malaysia on the reasonableness for its turn of events. As of lately, Chow et al., (2010) also scrutinized the origin just as the water quality of the hot springs located in all over Peninsula Malaysia.

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Be that as it may, information is hardly accessible for the water quality investigations of certain rural hot springs. Such investigation is fundamental for better comprehension about the hot springs and to guarantee whether it is appropriate and safe for public recreational area.

Water quality monitoring and testing is a significant part for monitoring the environment. At the point when water quality is poor, it influences aquatic life as well as the encompassing environment too. These segments detail the entirety of the boundaries that influence the quality of water in the surrounding environment. These properties can either be biological, physical or chemical elements.

Turbidity and temperature falls under the physical properties of nature of water. The chemical properties include parameters, for example, dissolved oxygen and pH. Lastly, the biological factors of water quality incorporate growth of phytoplankton and algae. These boundaries are applicable not exclusively to surface water investigations of the sea, lakes and streams, yet also to groundwater and mechanical procedures such as industrial process too.

Water quality can assist specialists with foreseeing and gain from naturally occurring processes in the surroundings and decide human effects on an ecosystem ("Water Quality - Environmental Measurement Systems," n.d.).

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1.2 Study Area

1.2.1 Location

The geological mapping was focused in and around Jeli hot spring in order to recognize all the geological features and also vital geomorphological landforms. It lies between the latitude N 05°41’31.09’’ and N 05°39’1.21’’and the longitude E 101°42’2.03’’ and E 101°44’47.95’’ and covers an area of about 25 km2 (Figure-1.1).

Jeli hot spring is found at Jajahan Jeli that is located around 20 km from Jeli town. Jeli hot spring is situated nearby the river valley of the Helai River and encompassed by the hills around Bendang Lawar village, Batu Melintang sub-district, which is located about 1 km from the East-West Highway. It is situated at the west area of Jeli district and the location also encloses Pergau Dam.

Furthermore, another hot spring which is also a part of this research situated in Machang district of Kelantan state. It is located toward the north of Kota Bharu, Pasir Puteh toward the east, Tanah Merah toward the west and Kuala Krai toward the south. Among the fascination that get frequented a great deal in Machang District are the hot springs that are arranged in Kampung Rengas Tok Bok. It is surrounded by latitudes

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05°50’42” N and longitude 102°14’ 32.84” E (Fig 1.2).

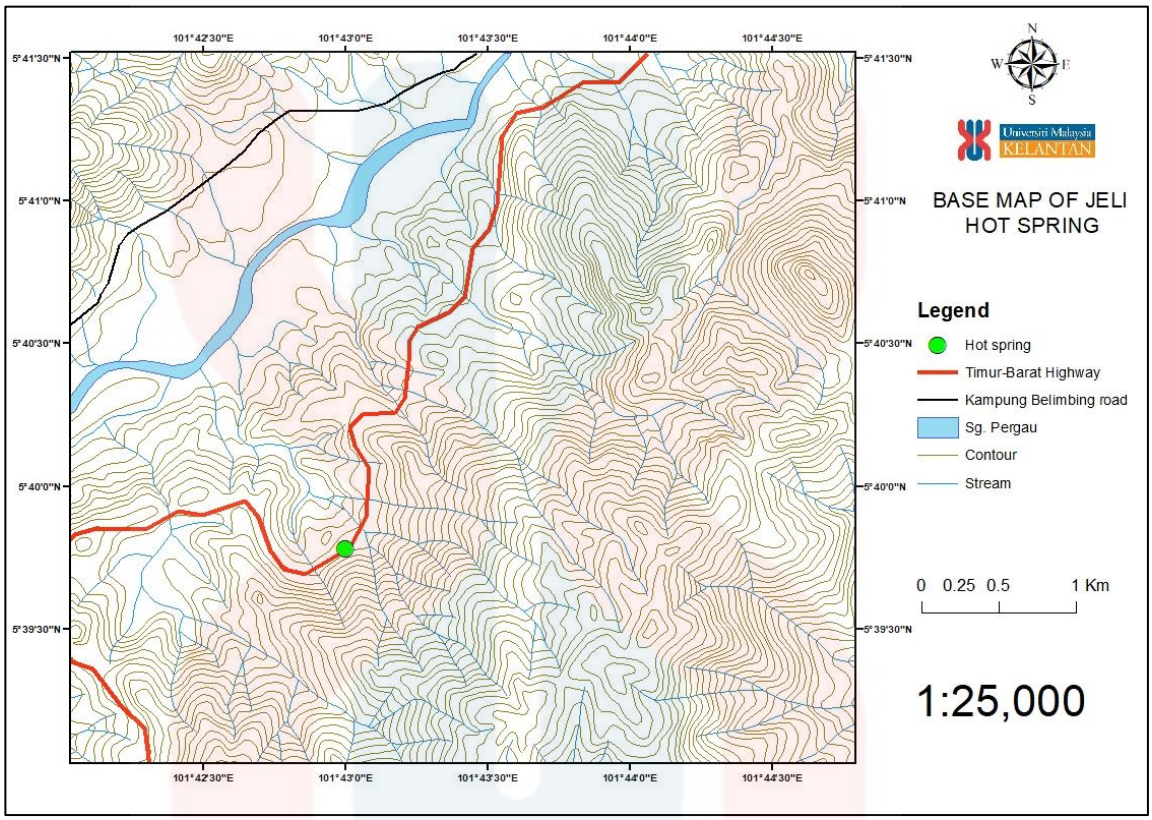

Figure 1.1: Base map of study area at Jeli hot spring

This hot spring is situated in Kampong Rengas, Labok approximately around 20 km from Bandar Machang. It is also nearby to Tok Bok's state road to Selising, Pasir Puteh. The base map of Machang study area can be seen in Figure 1.2 below.

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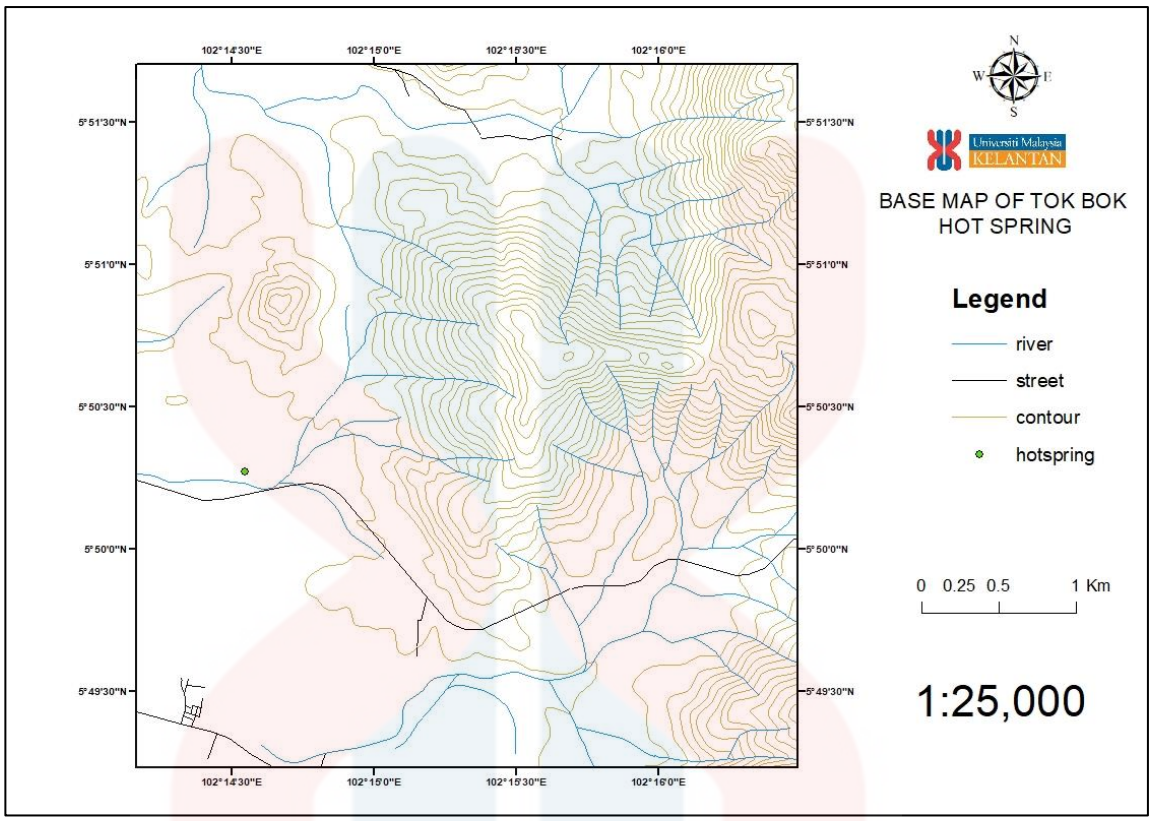

Figure 1.2: Base map of study area at Tok Bok hot spring

1.2.2 Road connection /Accessibility

The main road in the research area at Jeli is the East-West Highway. Based on the study area, there are a few roads leading to the residential areas and town. The main road is the East-West highway that lies next to the Jeli hot spring. It connects the state of Kelantan and Perak. Most of the roads found in the study area are paved tar roads that connects one village to another but there are also certain unpaved sand roads in Kampung Pendok and Kampung Lawar. There are likewise a couple of little streets that associate the study area to the villages close by the region. Besides that, there is another called the Kampung Belimbing road which connects to the village Belimbing. The accessibility map of Jeli study area can be seen in Figure 1.3 below.

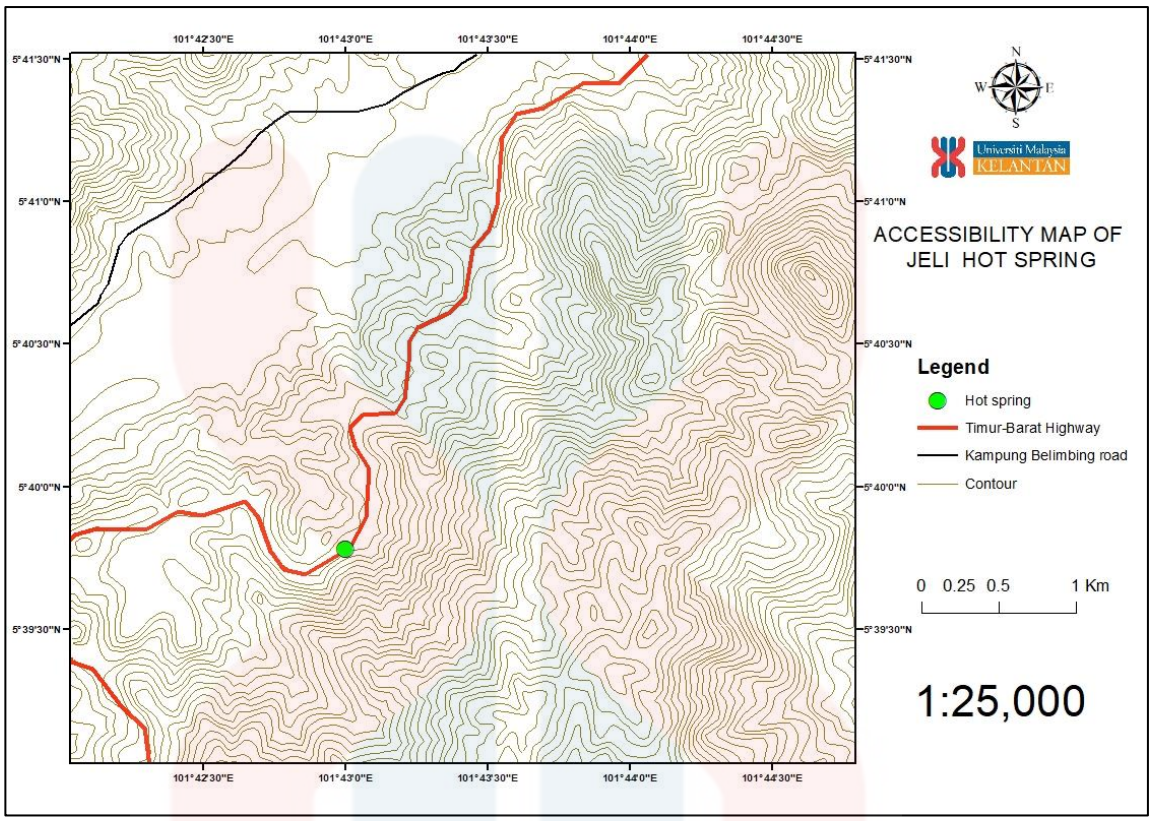

Figure 1.3: Accessibility map of the study area in Jeli hot spring

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1.2.3 Demography

The total people population in Jeli is roughly about 33,186 that consists of Bumiputera (Malays and other Bumiputera), Indians, Chinese and others according to the Department of Statistics Malaysia (2010) as shown in Figure 1.4 below. There are approximately 31,606 Malays in Jeli district that symbolises it as the main ethnic group. Next, is followed by the Bumiputera clan with about 520 people, 91 Chinese, 58 Indians and other races of around 21 people. Furthermore, there are also about 890 foreigners staying in Jeli district. The areas of Air Lanas, Berdang, Batu Melintang and Bukit Lakota area included in the district of Jeli. The people distributions in Jeli significantly affects the economic activities that mostly takes place in rubber plantation, oil palm estate and quarry. Furthermore, there are even certain small business activities lead by local people commonly by setting up hawker stalls by roadside.

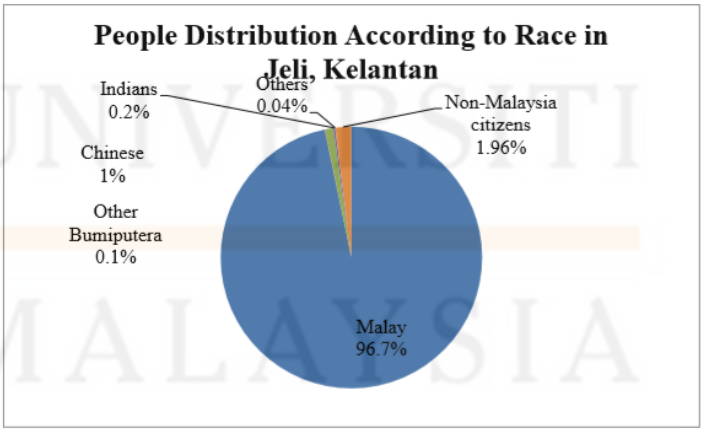

Figure 1.4: People distribution according to race (Source: Department of Statistics of Malaysia, 2010.

1.2.4 Land use

Land use shows how individuals utilize the area for advancement, preservation, or mixed purposes. The land use in Jeli regions are significantly used for vegetation. For instance, oil palm plantation and rubber plantation. The forestry and plantations are the examples of non-developed land use, whereas developed land use are for example, streets and residential areas.

1.2.5 Social Economic

Jeli area is still in on its way to turn into a much developed urban city. The social economy in Jeli incorporates horticulture, farming and little to medium enterprises. Individuals generally work in oil palm, rubber plantation and fruit orchards under the field of agriculture. Furthermore, in animal farming the people sell ruminants and poultry related items. The models are ducks, cows, chickens and goats. In the meantime, in little and medium business endeavors, there are selling of chips called 'keropok lekor' and custom made delicacies. The business is mostly ruled by the housewives.

1.3 Problem Statement

The information in the previous geological maps of Kampung Lawar, Jeli District, Kelantan was already outdated and therefore this study had been conducted to produce the updated geological map so that the information shown in the map is accurate. Besides that, hot spring areas at Jeli and Machang district in Kelantan are rich with

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geological features but many people are not aware of this as there were only a few studies which have been carried out within the area. Even though there had been few researches taken place but all those are outdated and many years back. Besides recreational and leisure purpose, hot spring water can also be beneficial for aquaculture, medicinal value and also to generate electricity. But, the quality analysis of hot spring water is not common in everyday life. Therefore, there are no previous comparative studies for both the Jeli and Tok Bok hot springs. This research helps to provide the updated map of study area and sufficient information about the comparative water quality using remote sensing data so that the geological settings in both the hot spring areas will be known and the water can be used for beneficial purposes.

1.4 Objectives

i. To update geological map with scale of 1:25000 of study area

ii. To compare the hydro-geochemical data of Jeli and Tok Bok hot springs

1.5 Scope of Study

Due to the Covid-19 pandemic, the overall scope of this study is affected as all the data used secondary data and previous researches. This particular study was focused on geological mapping in Jeli and comparative water quality assessment in Jeli and Tok Bok hot springs. The Geological mapping aspect was mainly based on primary data of samples from fresh outcrops, recording structural trends in rocks, and other field observations such as geomorphological features, drainage pattern and so on.

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All these field related data were processed in GIS based platform including the petrographic studies to generate geological and other thematic maps. In addition, the specific study is water quality assessment based on certain parameters. The water quality of Jeli hot spring and Tok Bok hot spring were analyzed comparatively by referring to previous research data in those two areas. Moreover, the various aspects of the present investigation had given an idea about hot springs in general and its water quality assessment.

1.6 Significance of Study

The geological mapping was to give new current updates about the geological data and details of the study area. Besides that, this information will be helpful to residents as well as students about the quality hot springs at the study area. It also can improve social economic condition of the surrounding area when tourists get to know more about these two hot springs, especially by exploring the potentiality of the area to be developed as recreational parks and assessing the quality of hot springs. Lastly, this research can contribute details of water quality for future researchers. As of lately, created and modernized hot springs can add to the person's salary or should add to the economy of the nation as their demand expanded among the individuals for their regular wellbeing industry and contributes to hydrotherapy (Olivier, 2008).

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CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, there are previous study that used such as about regional geology and tectonic setting, lithology, structural geology, hot spring, general geology of hot spring, groundwater and water quality parameters.

2.2 Regional Geology and Tectonic Setting

The state of Kelantan covers 14 922km square area with 10 local districts that are situated in the north-east of Peninsular Malaysia. Regional geology alludes to geological study which involves a huge scope territory or district. Tectonically, certain portions of the Sunda Shield which is shaped by Peninsular Malaysia consists of Borneo, Sumatra and Java including mediating shallow oceans from which various little islands were developed (Raj, 2009). Peninsular Malaysia was formed as the outcome of collision that occurred between the blocks of Sinoburmalaya towards the western part and Eastmal-Indochina towards the eastern region.

The regional geology of Kelantan comprises of a central zone of sedimentary and metasedimentary rocks encompassed on the west and east by stones of the Main Range and Boundary Range individually (Goh et al., 2006). Jeli area is situated in the Kelantan state, explicitly at Main Range, the foundation of Peninsular Malaysia. The Main Range rock is found generally in the western part of Kelantan extending along west of the state up to the Perak and Pahang border line. Granitic rocks and a few enclaves of sedimentary or potentially metasedimentary rocks for the most part secured the range (Ashikin, 2016). Machang is a domain of Kelantan, Malaysia that is circumscribed by the regions of Kota Bharu towards the north, Kuala Krai toward the south, Pasir Puteh towards the east and Tanah Merah toward the west. Machang is likewise the middle part in Kelantan. It was discovered in 1880 by a gathering of locals from Pasir Tumboh and got its title from the town of Kampung Machang. Primary occupation in Machang is dominated by farming and small scale business in the earlier days. The distribution of rocks in Kelantan can be seen in Figure 2.1 as shown below.

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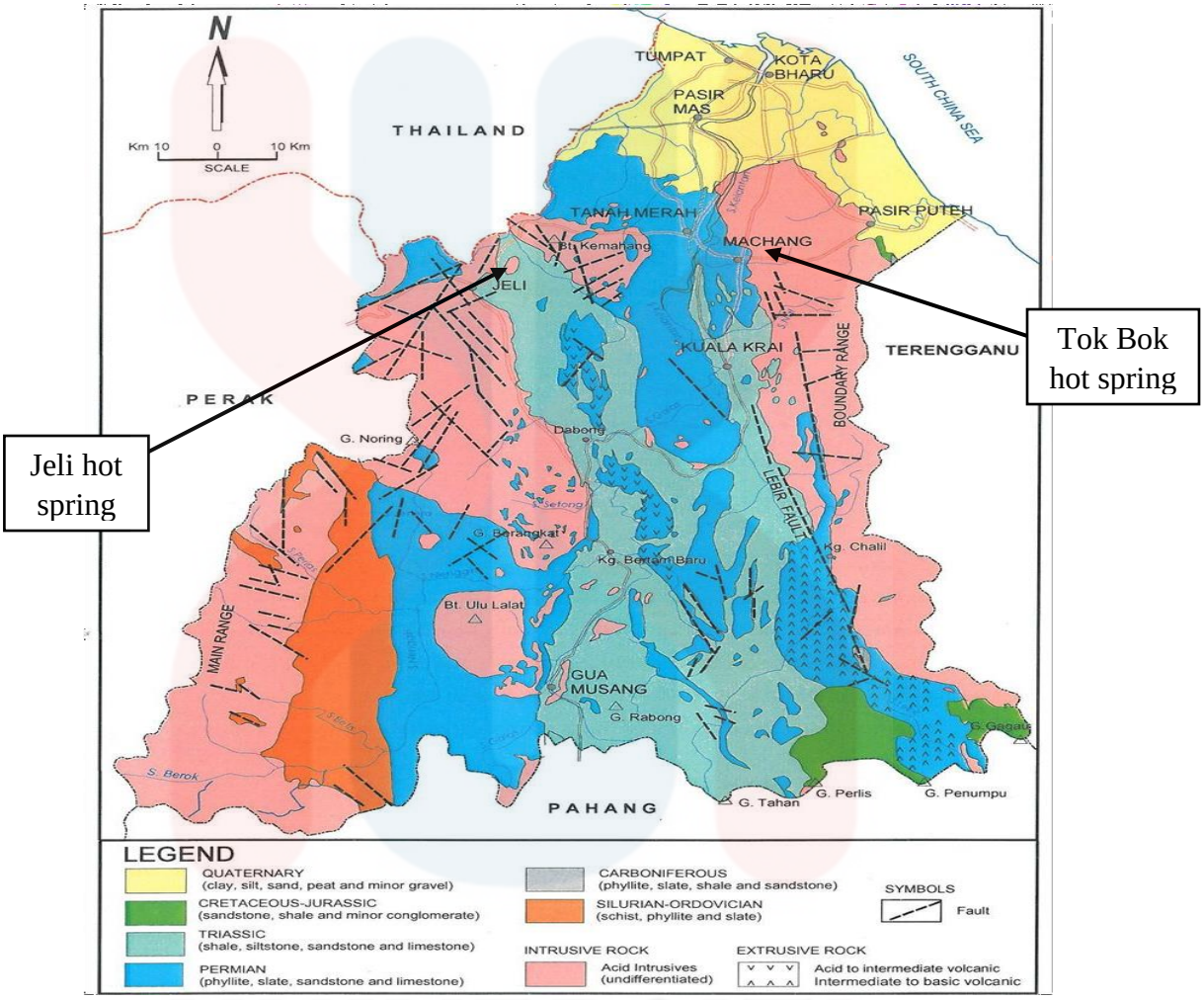

Figure 2.1: Geological map with distribution of rocks in state (Department of Minerals and Geoscience, 2003).

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2.3 Stratigraphy

Stratigraphy is the science of rock strata. It is concerned not only with the original succession and age relations of rock strata but also with their form, distribution, lithologic composition, fossil content, geophysical and geochemical properties and their interpretation in terms of environment or mode of origin and geologic history. All classes of rocks, consolidated or unconsolidated, fall within the general scope of stratigraphy.

2.3.1 Stratigraphy of Jeli Hot Spring

The study area of Jeli hot spring is situated in the Mangga formation and the granite is known to be Lawar Granite. Tiang Schist is a part of the study area as well. The Mangga formation is exposed well in the upper parts of Machang River and extends south towards the Kampung Gunung which is located in Batu Melintang. According to the research done by Mohamad Hussein Jamaluddin *et al*. who was the earliest person that came up with the term Mangga formation. This is to categorize the sequences with low-grade metamorphism such as the argillaceous, arenaceous, pyroclastic, marble, hornfels and the schistose rocks found along the Belum area.

The formation consists of two argillaceous facies layers which are lower and upper parts. The upper part comprises of hornfelsic rocks, for example the calc-silicate hornfels. The outcrop can be found close to the Felda Tumbi Rapat junction, nearby Gunung Reng, Batu Melintang. The colour of the rocks are light greyish, extremely fine-grained, somewhat foliated and recrystallised with both quartz and calcite veinlets. Petrographically, the primary minerals are quartz with minor muscovite, biotite, diopsite and iron oxide. The chert is light grey to medium grey with some cherts of thin bedding.

There are no radiolarian fossils were found. The slate and phyllite are dark grey and inter bedded with metasiltstone (Che Aziz Ali, 2016).

2.3.2 Stratigraphy of Tok Bok Hot Spring, Machang

MacDonald, 1967 and Hutchinson, 1973 found that the Taku Schist that stretches from the Thailand border close by Tanah Merah to the central east of Kelantan nearby Manik Urai consists of garnet-mica schist and quartz-mica-garnet schist. Furthermore, narrow lines of amphibolite, quartz, schist, and serpentinite are also found.

According to Welbourn (1917), the primary peninsular volcanic rocks are present in Kelantan and Pahang, thus the earlier name is 'Pahang Volcanic series'. They consisted of dominantly pyroclastic, agglomerate with minimum lava flow and tuff. The magma composition varies from acidic to intermediate types.

Based on Kelantan Quarry Data (2003), Machang has a very huge granite deposit and the granite body is composed of Buloh Microgranite, Nal Granite, Machang Granite and Bidang Granite which continues to be a part of the Boundary Range Granite and extended to Terengganu.

2.4 Structural Geology

Structural geology studies about any geological structures that was shaped during the rock formation. There are numerous elements that add to the development of structural geology, for example, tectonic activity, the energy forces, sediment deposition and others. The structural geology can take place either before the development of rocks, during and

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after the rock formation. Structures happen in various settings and have encountered numerous changes in strain and stress.

Primary and secondary geologic features are noticeably found in the central and Northern Kelantan. The most dominant geologic structures are beddings, dykes, veins, joints, folds and brecciation. These structures represent the discontinuities of rock mass (Hutchison and Tan, 2009).

According to the research done by Khalid *et al*. (1996), Tija & Liew (1996), Mazlan & Watts (1998), Tija (1998b, 1999b), and Mazlan *et al*. (1999a), the regional gravity and structural analyses concludes the axial deep of Malay basin continental crust is around 25 to 30km thick and was formed during early Tertiary crustal extension because of strike-slip movement following a major shear zone trending NW-SE. Several proofs suggest the crustal extension are normal faults and also half-graben features.

Lineament is a simple or complex linear feature that can be mapped, whereby the parts are arranged in a rectilinear or curvilinear form and said to be reflected by a subsurface phenomenon (O' Leary *et al*., 1976). Based on Shake and McHone (1987), lineaments are straight or gently curving features found at the surface of Earth.

2.4.1 Structural Geology of Jeli Hot Spring

The location of Jeli district is rightly on the Main range which is also known as the Peninsular Malaysia's backbone. The Main Range granite is situated approximately at the western part of Kelantan and stretches along the western region till the Pahang and Perak's state boundary. The range is dominated by granitic rocks and certain sedimentary and/or metasedimentary rocks (Nur Diyana, 2017).

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According to the Kelantan state's general geology (Department of Minerals and Geoscience Malaysia, 2003), Jeli district is basically composed of three types of rocks where the first is Triassic sedimentary rocks known as (Gunong Rabong Formation), that composed of siltstone, shale, limestone and sandstone. The second type is the Permian sedimentary rocks called (Gua Musang Formation) that is composed of phyllite, sandstone, slate, limestone and sandstone. Finally, the third type is the Granitic rocks or the acidic intrusive rocks. (Adriansyah *et al.*, 2015).

During the Paleozoic and Mesozoic era, tectonic activities which occurred in Peninsular Malaysia impacted on the land mass primarily on the fault and fold formations. Folding and faulting were observed in as regional and also localised features. Folding, faulting and jointing of the sedimentary rocks and faults where by the joints and faults in the granitic rocks are categorized under localized structures. (Department of Minerals and Geoscience Malaysia, 2003). The north-south to northwest- southeast directions are known as the prominent structural design in Kelantan state. But, the major structures in district of Jeli are located along northeast-southwest direction and northwest-southeast direction.

2.4.2 Structural Geology of Tok Bok Hot Spring, Machang

Taku Schist formation which is commonly scattered around Malaysia generally forms Machang. The formation is used to describe a metamorphic rock sequence pinching out in the central part of Kelantan. Machang is located particularly alongside the Taku River,

nearby the Temangan and Machang granite. (Khoo and Lim,1983) stated that the Taku Schist which is non-fossiliferous might be during Permo-Triassic age although it is unsure.

According to Dawson et al., (1968), Aw (1964) and Hutchison (1973), the Taku schist produce non symmetrical anticline, with the eastern part plunging significantly more extreme than the western part. The trend of fold axis south-east (145°) is facing toward the north because of the Kemahang Granite intrusion. The south part of outcrop plunges around 7° facing 170°. The western part whereas undergoes gentle dipping below greenschist facies during Permo-Triassic strata and consists of acid to intermediate lava flow and tuffs.

During the Cenozoic time, the Peninsula has been to a great extent or totally developed and is viewed as tectonically steady; action being restricted to epeirogenic uplift and inclining, certain movement of faults, and local delicate down warps (Stauffer, 1973, Gobbett and Tjia, 1973).

2.5 Historical Geology

Historical geology is known as the study of geological history of the earth that happened many years before. it is essential to understand the historical geology of the study area as all the geomorphological land forms and geological processes that modified the earth is said to be occurred in the past as well as in the present and even future (Skinner et al., 2002). It is also related to the Principle of Uniformitarianism that says the present is the key to the past. Similarly, in this research the geological events and land forms found at Jeli and Tok Bok Hot spring areas are definitely believed to be related to pre-historic ages.

2.6 Water Quality Specification

2.6.1 Hot spring

Hot Spring is mostly considered to be utilized as recreational and for leisure purposes in most of the countries. It additionally might be utilized as the fundamental wellspring of drinking water on the grounds that the water is certified as safe to be consumed (Haki and Gezmu, 2012). There is certain culture that believes the hot spring water has the ability to fix ailments without even referring to modern clinical treatment (Olivier et al., 2008). But nowadays with all the globalization and construction works going on, the quality of the hot spring water may be negatively affected and is not advised to consume. This is because of expanding anthropogenic activities close by the hot spring areas (Diyanah, 2014).

2.6.2 Hot spring Water Quality Study in Malaysia

Abdul et al. (1997) considered water nature of a few hot springs in Peninsula Malaysia that possibly be created to induce the travel industry businesses in the nation. The parameters of water quality, for example like the stream rate, minerals and temperature were explored in their investigations. So as to build up the hot spring, the rate of flow and the temperature ought to be high. Nonetheless, these parameters are relying upon the season where during the wet rainy season the stream rate is higher while the temperature is somewhat diminishing due to the blending in of rain water in hot spring water. The minerals for most of hot springs becomes generally low. The outcomes acquired acclaimed the hot springs in Malaysia are appropriate to bathe and can be in contact with human body as the water is classified into Class II of the Malaysian Interim National Water Quality Standards (INWQS) (Abdul et al., 1997).

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Javino et al. (2010) expressed that in Tawau, Sabah, the Mineral and Geoscience Department had done the examination identified with geothermal vitality assets which incorporates the hot springs region. Javino et al. (2010) further explained that in past investigation, the reservoir beneath the Southeast of Maria Peak, Tawau is thought to have inflow from hot spring at Apas Kiri, Tawau because of the presence of ion hydrogen sulfide (H2S) and the hot spring's geo chemical highlights. besides that, Roslan (2006) underlined that the amount of arsenic should be controlled as it might ascend in future as it is being derived from the rocks which may be connected with the volcanic stone or arsenic rich materials.

2.6.3 Water Quality Parameters

a) Temperature and pH

Temperature and pH acts as significant roles in numerous biological and also chemical reactions. In a warm state framework, temperature as characterized by Michalski et al. (2001) is the measurement of capacities to transfer the warmth to different systems. Temperature is a regular physio-chemical parameter that can be widely utilized in hydrogeological studies (Baena, 2009). In hot springs the temperature is higher than the encompassing environment where just certain living organism known as extremophiles can accommodate in this ominous condition. Such living beings incorporate certain bacteria and microorganisms where their chemical reaction can happen in temperature extending from 74 ºC to 76 ºC (Alters, 1999). Besides that, pH is estimation of free hydrogen particles in the water [H+] which can be categorized from 1-14 where pH = 7 shows that the water is in neutral structure, whereas the pH < 7 shows that the water is in

acidic structure and pH > 7 shows that the water is in alkaline state (Brönmark and Hansson, 1998).

The pH that is unbalanced in water segment may create harmful condition and could be unsafe for the aquatic life that dwells in the water (Ting, 2001). Commonly, the pH of the water is relying upon the kinds of rocks, soil properties, carbonate frameworks, temperature and the level of released contaminants. Ordinarily the pH in the hot spring water is ranged from neutral to alkaline where the basic hot spring water for the most part contain dominant sulfide compound (Strahler, 2006). The temperature of hot springs that situated close to the area of volcanic activity is truly elevated which right around 100 ºC and the pH of the water are acidic because of essence of sulfate that it absorbed from the magma (Yoshike, 2003).

b) Dissolved oxygen (DO)

Dissolved oxygen is used to measure the concentration of disintegrated oxygen with nature of water and the presence of aquatic organisms. DO is identified with amount of nutrients in the water. In hot springs, as the nutrient level increases, the DO in the water may diminish because of the utilization by extremophiles. An investigation done by Anupama and Baghwan (2011) demonstrated that the dissolved oxygen concentration in one of the hot springs found at Maharashtra, India is high. There are a few suspicions that cause higher convergence of DO in that hot springs generally. These incorporate the absence of photosynthetic creatures' activities and maybe the high temperature water from the natural aquifer was blended in with cold water underneath the reservoir (Anupama and Baghwan, 2011).

c) Electrical Conductivity

Conductivity is the estimation of the capacity of the water to conduct electrical power from the disintegrated minerals and ion particles. As indicated by Dojlido and Best (1993), more significant level of conductivity can be anticipated when there is a high measure of particles found in the water and generally, in freshwater there may be less particles distinguished contrasted with ocean water. Abdul et al. (1997) clarified that the conductivity in hot spring water in Malaysia is relatively low. In any case, at the hot spring in Kg Air Hangat, Langkawi there is interruption from salt water that leads to a higher conductivity in the underground aquifers and hot springs there (Abdul et al., 1997).

d) Total Suspended Solid

The fine compounds that suspended in the water body that is made up from particulate matter and suspended solid of plankton and detritus area named as suspended solid where it tends to be related with turbidity and can cause effects on the temperature, light infiltration, just as aquatic living beings (Ting, 2001). High measure of suspended solids may give terrible impacts towards the living things in the water for instance the constraint of light infiltration into the water that can restrain the photosynthesis and furthermore diminishing the broken up oxygen molecules in the water column (Blaber, 1997).

e) Major Ions

Hot spring water generally differs in mineral content, depending on the nature of the geological setting by which it passes through. When immersing oneself in hot springs,

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the pressure and heat effects helps in promoting the blood circulation, reduce swelling and relieve acute pain. Furthermore, the mineral contents of the hot spring water provide certain essential health benefits. Hot springs are usually categorized by their common ions such as HCO_3^-, SO_4^{2-}, Cl^-, Na^+, Ca^{2+}, Mg^{2+}; gases like carbon dioxide, radon, hydrogen sulphide and some tract elements for example Iodine, Iron, and Bromine.

It is strongly believed that hydrogen sulphide aids in body function, sodium carbonate is good for digestive tract disorders, chloride ions can help to stimulate production of blood and the reduction of ovarian cysts, potassium and calcium ions improve cardiovascular functions and even activates endocrine while magnesium ions tend to calm nervous system and sodium ions promotes contraction of muscles (Diyanah, 2014).

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CHAPTER 3

MATERIALS AND METHODS

3.1 Introduction

This section will clarify about materials and techniques done in order to accomplish the research targets. The methods depict the preliminary studies, field studies, laboratory work, analysis, interpreting and processing data acquired. Since fieldwork was not done the flowchart represent the outline to obtain both primary data that included all hands on field work and secondary data of this research. Figure 3.1 indicates the flow chart of primary data collection whereas Figure 3.2 indicates the secondary data flow chart of the study.

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RESEARCH FLOW CHART FOR PRIMARY DATA

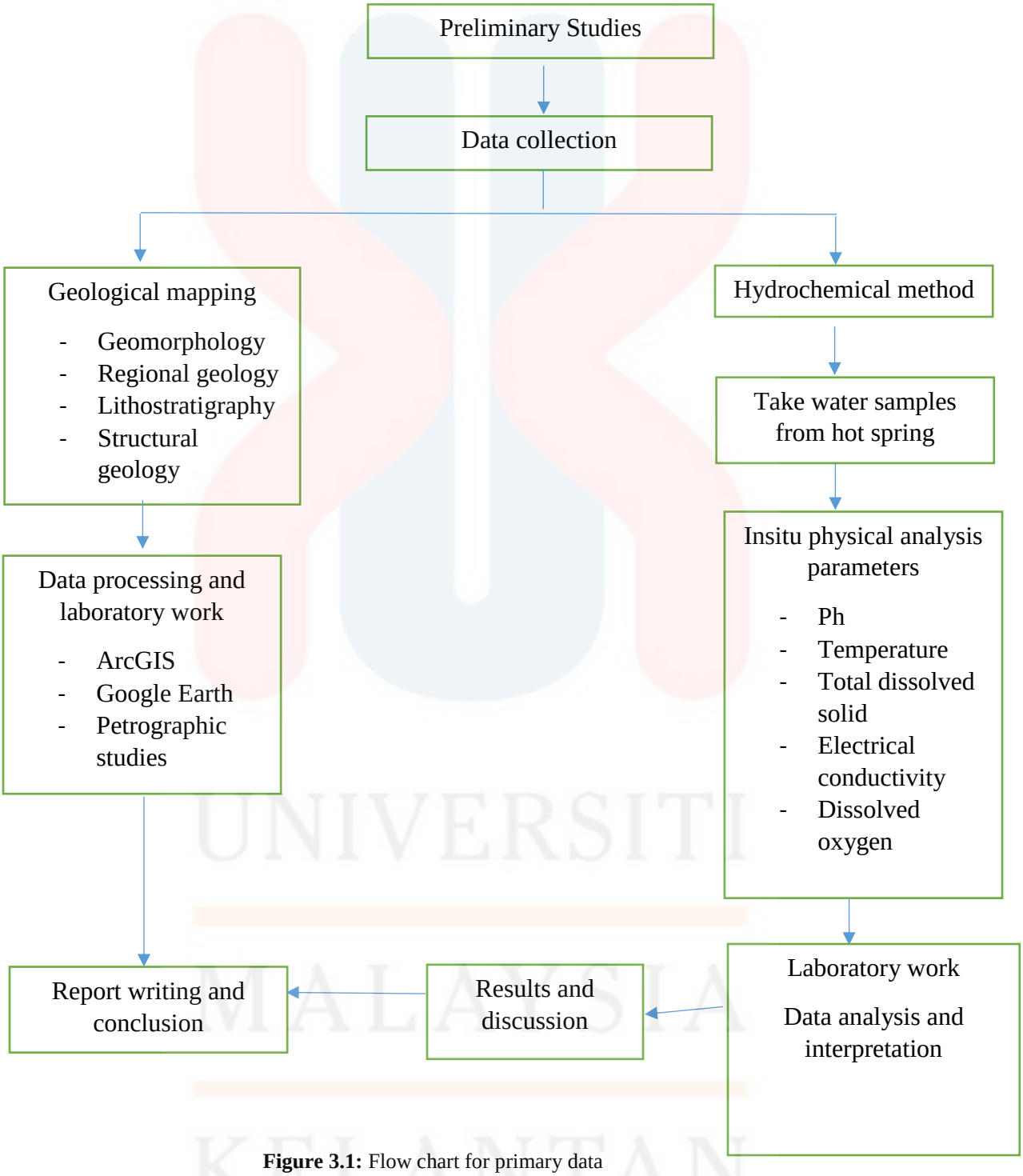

Figure 3.1: Flow chart for primary data

RESEARCH FLOW CHART FOR SECONDARY DATA

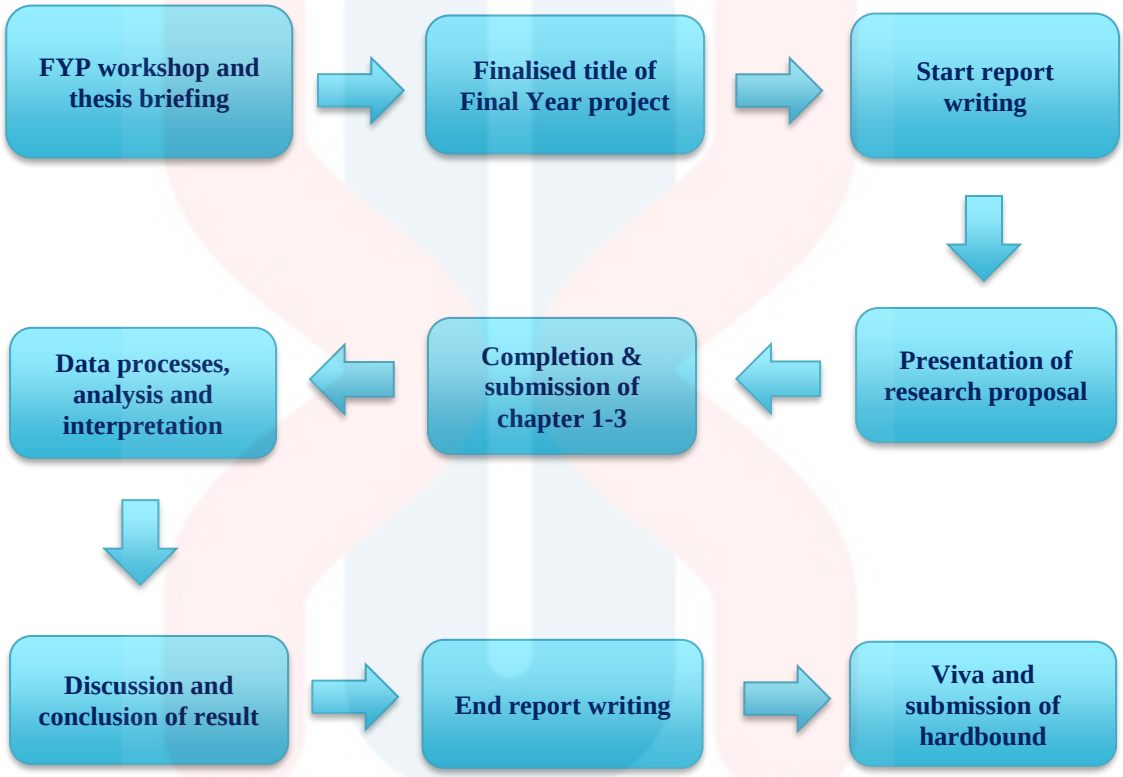

Figure 3.2: Flow chart for secondary data

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3.2 Materials/Equipment

In this section, the materials and equipment utilized during the study are considered. Since students were not permitted to go for field, additional information were utilized in the investigation, for example, reference from past specialists, proposal papers of previous studies and furthermore assortments of articles and websites from the web. The information gathered were analysed, processed and interpreted with the help of Google Earth and ArcGIS programming. For the information to be collected, there were various kinds of gear required for both the general geology mapping part in Jeli hot spring just as for the specification parts in comparison between Hot Spring Jeli and Hot spring Tok Bok in Machang. The following is the list of materials and equipment that is required to complete this study.

Table 3.1: Materials/equipment used for the research

Materials/Equipment	**Use**	**Photo**
Hammer	To break down the outcrops in order to take rock samples.	
Measuring Tape	Helps to measure the dimension of the outcrops.	
Laptop	Enable to search for information, use soft wares to process the data collected and to prepare the full thesis report.	

Stationaries	To jot down all necessary observation in field that needed to be converted to laptop later on.	
Hydrochloric Acid	To test for the presence of calcium carbonate in order to determine the type of rocks.	
Global Positioning System(GPS)	GPS helps to detect the elevation of the location and can identify the coordinates of location using satellites and to track the travelled journey.	
Atomicabsorption spectroscopy (AAS)	Determine major cations and major anions in water sample.	
Multi parameter	Measures In-situ parameters of water such as pH value, temperature and electrical conductivity.	

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Turbidity meter	Turbidity meter determines the turbidity of water sample.	
Portable TSS meter	Portable TSS meter identifies the total suspended solids in water.	
Total Dissolved Solids (TDS) meter	A TDS meter determines the total dissolved solids (TDS) of a solution, such as the concentration of dissolved solid particles	
Plastic samples and bottles	Sampling bottle and plastic bag store water sample and rock sample	 
ArcGIS software	ArcGIS software enable to produce geological and drainage maps.	
Google Earth software	Provide 3D representation to view Earth landscapes based on satellite imagery.	

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3.3 Methodology

3.3.1 Preliminary Studies

Preliminary studies are the first basic steps which include gathering data such as journal articles, previous reports and other references that can prepare the base map of the study area. The topographic map was used in order to distinguish the landforms, land use, lithology, drainage pattern and vegetation. The base map produced by GIS were utilized for fieldwork to have a basic knowledge of the geomorphology features in the study area.

3.3.2 Field studies and Sampling

Materials and equipment:

- Hammer, GPS, compass, plastic samples, laptop, hydrochloric acid, measuring tape, stationaries, ArcGIS and Google Earth software

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Based on the previous researches, these were some of the things done under field studies to obtain the primary data.

a) Geological mapping

The Geological mapping part is depending on hands on work in field inputs including assortment of collected samples from fresh outcrops, recording basic structural patterns in rocks, and other field perceptions, for example, highlighting geomorphological features, lithostratigraphy, regional geology and structural geology. All the mentioned field related data was prepared in GIS based stage to produce thematic and geological maps.

b) Water sampling and Insitu tests

The collection of water samples of Jeli and Tok Bok Hot springs were taken for analysis. Insitu analysis parameters which are pH, total dissolved solid (TDS), temperature, dissolved oxygen and electrical conductivity were measured for the samples. Multi parameter, turbidity meter and portable TDS meter were used for the in-situ chemical analysis parameters. All the necessary were recorded and the water samples were studied for further comparison between chemical and physical parameters of Jeli and Tok Bok hot springs.

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3.3.3 Laboratory Work

Equipment and materials:

- Multi parameter, turbidity meter, Total Dissolved Solids (TDS) meter, portable Total Suspended Solids (TSS) meter, sampling bottles and bag, Atomic absorption spectroscopy (AAS).

a) Petrologic studies

The granite and schist rocks observed via satellite imagery was identified its texture, mineral, clasts, matrix and rock classifications.

3.3.4 Data Processing

The information obtained from geological mapping were processed in ArcGIS application to create a few types of maps for example base map, drainage pattern maps and geological map. Besides that, a few charts and graphs were developed using Microsoft Excel for interpretation and further understandings of the research.

3.3.5 Data Analysis and Interpretation

Piper Trilinear Diagram

Piper trilinear outlines are significant appliances for deciding the relative abundance of ion particles in water tests. To utilize the Piper plot, the concentration of cations and anions was set in the triangles firstly.

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At that point, an opposite line must be drawn from the sample point in one triangle to the diamond and redo it from the other triangle till they tend to intersect. This chart was designed to distinguish the sort of Jeli and Tok Bok hot spring water samples which had been taken from the study areas. Diagram 3.1 shows the three segments of the piper plot.

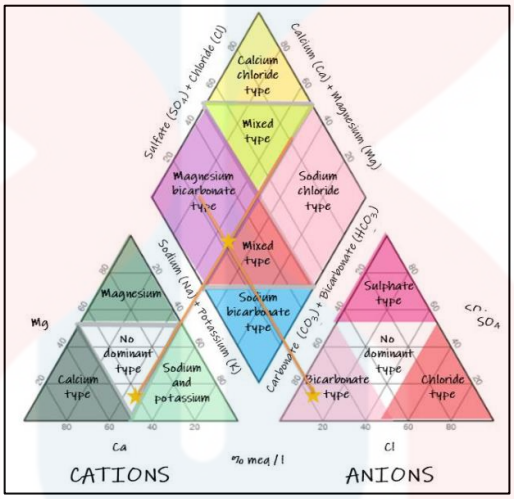

Diagram 3.3: Piper trilinear diagram

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CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

This chapter is about the general geology of the study area that was gathered by the data obtained from remote sensing and google imagery. Some of the subtopics discussed in this part are geomorphology, land use, accessibility, structural geology, lithostratigraphy, historical geology and also the rock unit found in study area. Geomorphologic study explains about all the processes that shape the landforms and landscape of earth today. Some of the geomorphologic processes discussed are topography, landforms and drainage system identified in study area. Furthermore, the discontinuities such as joints and lineaments because of tectonic activities fall under the structural geology category. Next, stratigraphy explains about formation and process that occurred in the past. Moreover, unit explanation and type of rocks found in the study area are discussed in the lithostratigraphy part. Lastly, historical geology explains about the geological processes of the study area happened in the past that leaded to the current formation and geomorphological patterns.

4.1.1 Accessibility in the study area

Accessibility can be identified by looking at the road connections leading in and out of the study area. The roads help to connect one place to another and make transportation easier. The accessibility map of study area is shown in Figure 1.3 on previous chapter 1.

4.1.2 Settlement

Settlement refers to the community in where people live. Hence, there are three known settlements in the study area namely Kampung Belimbing, Kampung Pendok and Kampung Lawar. Kampung Belimbing is the most populated followed by Kampung Pendok and Kampung Lawar. The villagers live mostly in wooden houses and some in huts. They lead a low profile life among themselves and survive by doing small businesses.

4.1.3 Forestry/Vegetation

Majority part of the study area were mostly covered by dense forest and hilly mountains. The northwest region of the study area consisted of housing areas and the rest of it were undeveloped forests. The vegetation observed at Kampung Pendok and Kampung Belimbing was banana plants and coconut trees.

4.2 Geomorphology

Geomorphology is generally known as the study of land forms, definition of evolution, origin and also the varieties of physical landscape. Due to weathering, depositional or erosion processes that broadly affect the surface of our earth, the

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geomorphology of a certain area can be said to be affected. By causing tremendous danger, some of the geomorphological changes undergone by the earth will also impact living beings. Volcanic eruptions, landslides, earthquakes that leads to tsunami are examples of such occurrences.

Geohazards can be predicted and the past occurrences involved in climate changes can also be interpreted by researching geomorphology. By studying the remaining sediments and landforms present, that can be achieved. The secret to geomorphology in the field of science is to understand why landscapes look the way they do to understand the history of landforms and to predict changes through data from remote sensing. There are four types of geomorphological landscape in Kelantan, based on (Hamza et al, 2001), which are mountainous, plain, hilly and coastal regions. But the northern part of Kelantan was mostly developed by the coastal region. It will include drainage pattern, topography and landforms of study area in this segment.

4.2.1 Geomorphologic classification

(i) Topography

Topography is the study of the appearance and characteristics of the surface of the earth. Mountains, valleys, plains, and bodies of water are physical elements that make up the topography of a region. The position of the altitude characteristics is shown by topography.

As per Raj (2009), based on the mean elevation, topographic units could be divided into five units. The range of the elevation of study area was within 100 m to 820 m height. The study area contains low lands, low hills, hilly and mountainous topographic unit

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overall. The classification of mean elevations was given in table 4.1 and the topography map is shown in Figure 4.1.

Table 4.1: Mean elevation topographic unit (Raj, 2009)

Class	Topographic Unit	Mean Elevation (above sea level, m)
1	Low lying	< 15
2	Rolling	16 – 30
3	Undulating	31 – 75
4	Hilly	76 – 300
5	Mountainous	> 301

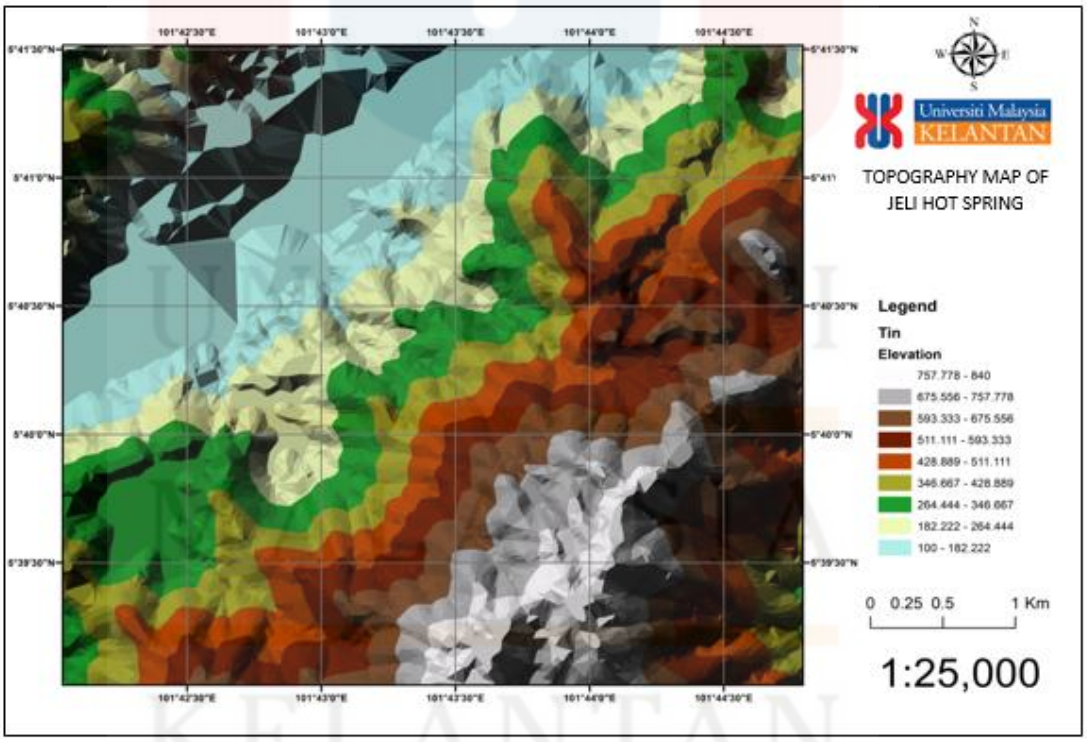

Figure 4.1: Topography map of study area

ii) Landforms

Landforms are land surface structures that take diverse features and are formed by natural erosion, destruction, and deposition processes. Landforms are the product of processes of geology and geomorphology that exist on the surface of the earth. As used by geoscientific modellers, the concept 'landform' signifies a part of the earth that combines the characteristics of relatively homogenous and continuous relief due to the occurrence of traditional geological and geomorphological processes. In the context of hydrology and geomorphology, the study of landscapes in a drainage basin has become increasingly relevant for understanding surface and subsurface water conditions. Geomorphology, in fact, is found to have very strong connections with the conditions of both surface and subsurface water. A terrain's geomorphological characteristics generally impact the value of precipitation and the amount of precipitation that is attributed to both runoff and groundwater recharge.

Landforms can be divided into two main sections of the landscape of our world, by the first large landform and the second small landform. Mountains, plains and hills are examples of large landforms. The small landforms are made up of valleys, basins, and the like. The explanation for the creation of these landforms is due to the tectonic activity of the plate, deposition of erosion and weathering processes. In the formation and evolution of landscape and landforms, this tectonic reorientation plays a significant role. Structural hills and lineaments are the most notable aspects of this group found in the study field. It takes a very long time to construct some type of landform (Nazaruddin et al., 2015).

Fluvial landforms were among the prominent landforms found in the study area. There was a meandering river as well as many streams were found in the study area at several places. Sungai Pergau is the main river that flows through the study region. The

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flood plain in the study region was discovered along the meandering river. A land that is generally flat and parallel to a stream can be defined as the flood plain. If a stream moves laterally and there is an overbank deposition phase, this will create flood plains. There can be no floodplain in that region when down cutting occurs dominantly. The rest were only random hilly areas and forests found in the study region, apart from mountains and fluvial landforms.

Figure 4.2: Sungai Pergau in study area (source: google earth image)

Figure 4.3: Forest in study area (source: google earth image)

Figure 4.4: Hilly area and mountain valley in study area (source: google street view)

4.2.2 Drainage pattern

The pattern created by streams and rivers is known as the drainage system. As they move downhill, it is the stream finding the lowest course, and they begin to erode their beds in places where the ground is hard. Therefore, the route stream is influenced by both topography and geological structure. Natural drainage patterns are created where streams adopt the geological history and features of the landscape. The factors influencing the pattern are the underlying rock, the steepness of the slope, the joints or faults on the surface of the Earth, the particular shape of the specific geological structure and the vulnerability of the soil to erosion. Every region varies in number, size and shape of the drainage pattern. Figure 4.2 below shows drainage pattern of the study area and the Figure 4.3 shows Pergau River in study area.

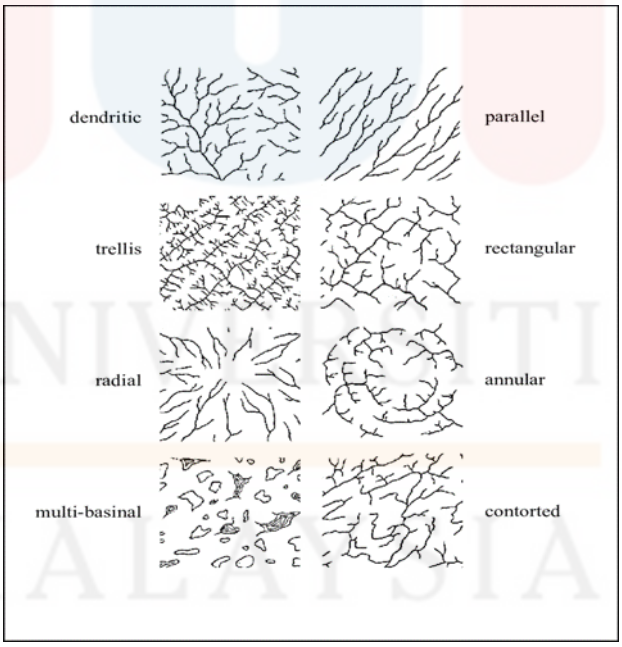

Figure 4.5: Types of drainage pattern (source: google images)

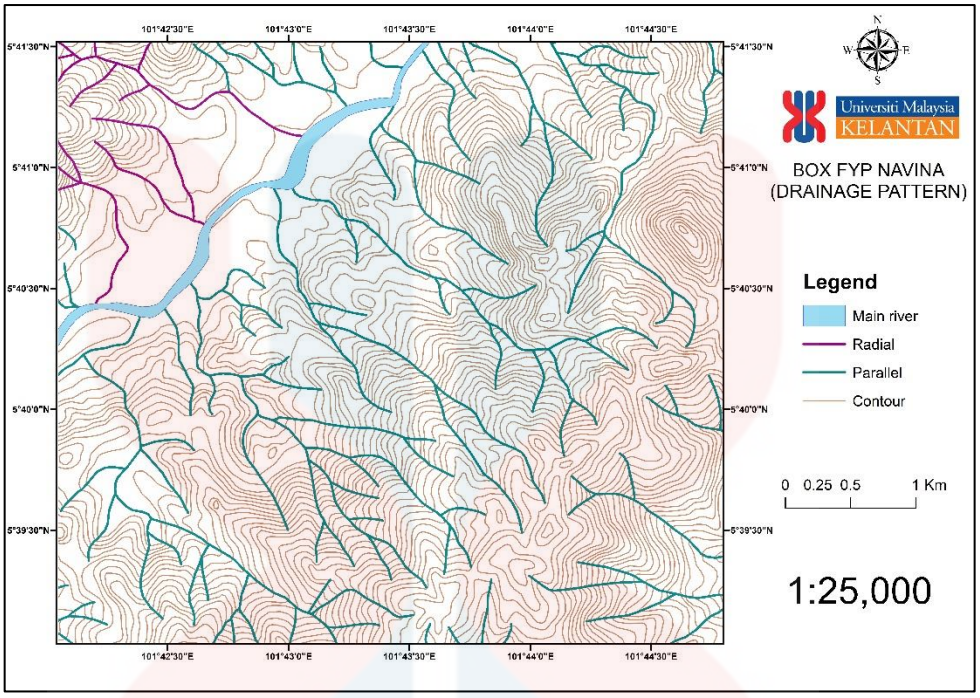

Figure 4.6: Drainage pattern map of study area

Based on the drainage pattern map of study area, it is found that the streams are in majority as parallel and a small region towards the northwest corner as radial patterns. Parallel drainage patterns form where the surface has a prominent slope. It was also caused, with some relief, by steep slopes. The streams are swift and straight because of the steep slopes, with very few tributaries, and all flow in the same direction. In regions with parallel, elongated landforms, such as outcropping resistant rock bands, a parallel pattern often emerges. Tributary streams appear to spread out following the slope of the soil in a parallel-like manner. Often a parallel pattern suggests the existence of a significant fault that slices through a region of steeply folded bedrock.

The streams radiate outwards from a central high point in a radial drainage framework. Typically, volcanoes show excellent radial drainage. Often, they can also be found on mountain tops. Domes and laccoliths are other geological features on which

radial drainage typically occurs. A combination of radial patterns can be shown on these features of drainage. The radical pattern emerges as streams flow from a central peak or dome like structure in various directions.

The stream's relative size is known as the order of the stream. The lowest tributary size is the first order source, while the twelfth order is the largest tributary. First order streams are perennial streams that have no permanently flowing tributaries, which are the streams that bring water during the year. The orders are defined within a stream network according to their relative location (Andy et. al, 2008) and streams typically increase their depth and width as the amount of water they discharge rises. The importance of categorizing the order of streams is to make it easier to research the amount of sediment in an environment and to make more efficient use of rivers as natural resources.

The drainage density demonstrates the closeness of the linear spacing, thus providing a quantitative indicator of the average stream order length for the entire catchment area. In response to precipitation and discharge of stream flow, drainage density also represents land use and infiltration rate. The total length of all streams and rivers in a drainage basin, divided by the total drainage basin area, is the drainage density. It is a measure of how well or how badly stream channels drain a watershed. Figure 4.4 and figure 4.5 shows the stream order and stream density map of study area.

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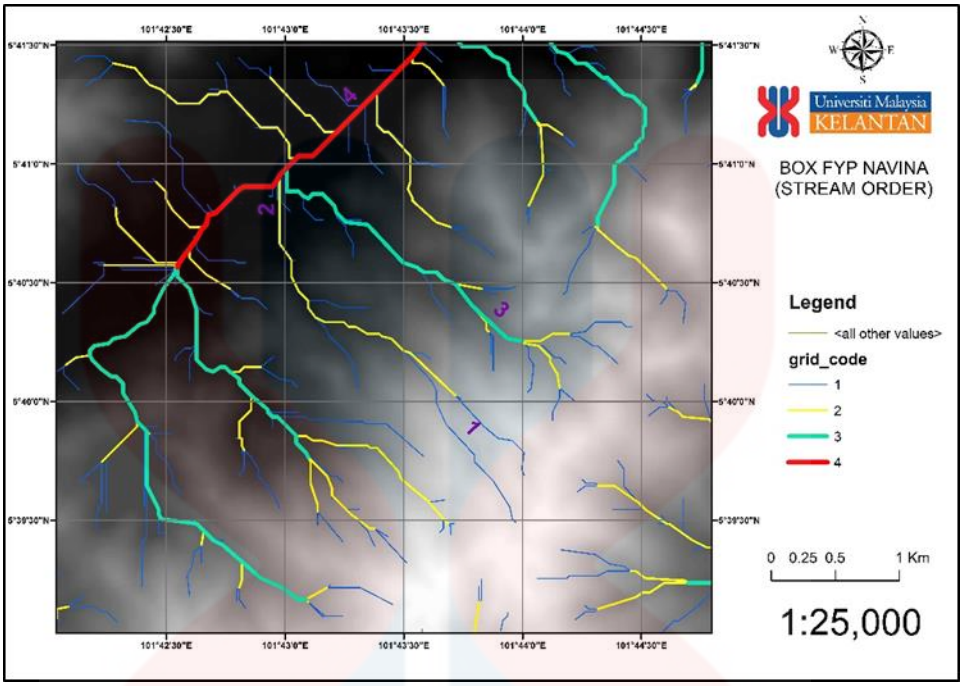

Figure 4.7: Stream order map of study area

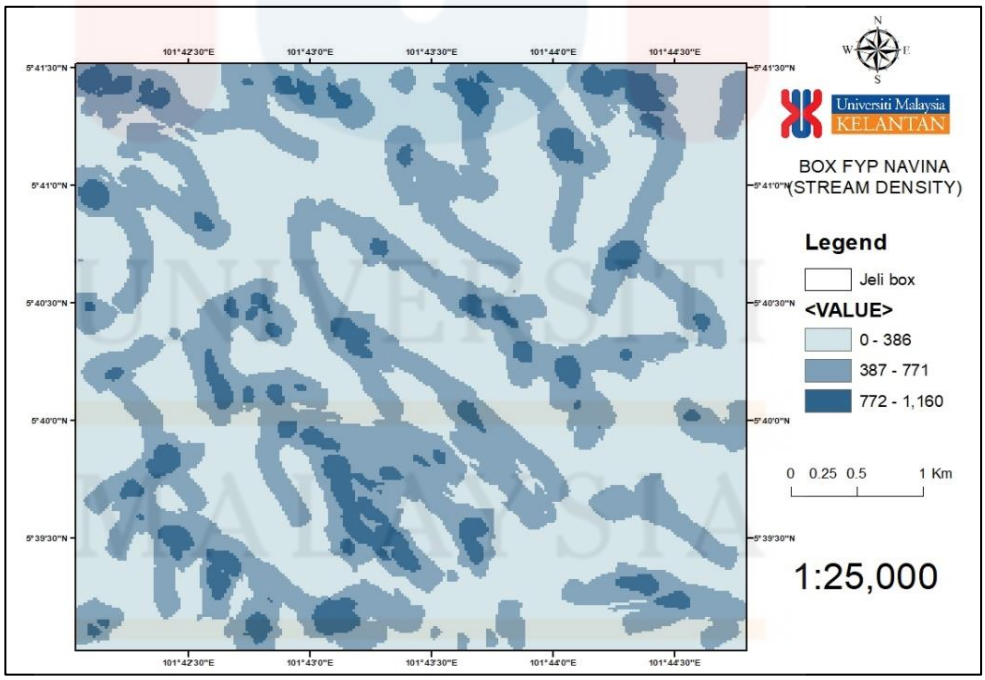

Figure 4.8: Stream density map of study area

4.3 Lithostratigraphy

Lithostratigraphic units are assortments of rocks that are characterized and defined on the basis of their lithological characteristics and their stratigraphic connections, whether bedded or non-bedded. Furthermore, based on this research, the relationship between igneous, sedimentary and metamorphic rocks is also defined. In addition, it is also possible to classify the age differentiation depending on the vertical orientation of the rock layer and rock layering. The fundamental units of geological mapping are lithostratigraphic units.

In the study area, particularly the granite rocks, igneous rock is prevalent. Granite is a common type of intrusive igneous rock structured beneath the earth's surface by the mild crystallization of magma. With minor measurements of mica, amphiboles and other minerals, granite is mainly produced from quartz and feldspar. Given the magmatic theory, the precious stone fractionation of magma decides rock.

The texture of the igneous rock (fine-grained or coarse-grained) depends on the cooling rate of the melt: slow cooling allows the formation of large crystals, and small crystals are formed by rapid cooling. Magmas cool and crystallize steadily with their corresponding plutonic rock bodies, and are distinguished by a coarse-grained texture through which the mineral crystals are transparent to the naked eye. Lavas, on the other hand, cool easily on the surface of the earth and are distinguished by a fine-grained texture in which the crystals are too small for the naked eye to see. The cooling rate for finer mineral grains is rapid.

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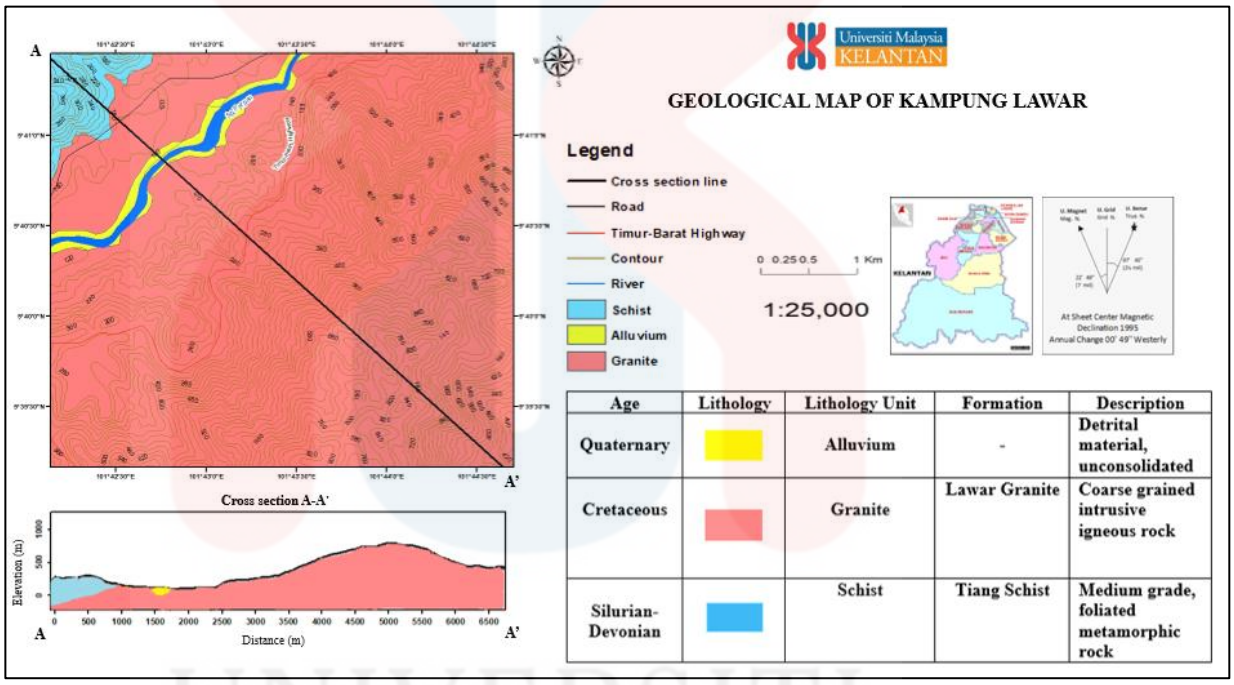
4.3.1 Stratigraphic position

To assess and describe the vertical column of the rock's age, the stratigraphic location can be used. The youngest rock layer is at the top of the strata, and as per the law of superposition, while the oldest rock is situated at the bottom of the chain of the rock strata. However, because of many other variables dependent on various stratigraphic rules, the location of rocks may be altered. Figure 4.6 show the geological map of study area.



Age	Lithology	Lithology Unit	Formation	Description
Quaternary		Alluvium	-	Detrital material, unconsolidated
Cretaceous		Granite	Lawar Granite	Coarse grained intrusive igneous rock
Silurian-Devonian		Schist	Tiang Schist	Medium grade, foliated metamorphic rock

Figure 4.9: Geological map of study area

Table 4.2: Lithostratigraphy of study area

Era	Period	Lithology	Unit	Description
Cenozoic	Quaternary		-	Detrital material which is unconsolidated
Mesozoic	Cretaceous		Lawar Granite	Granite is among the intrusive igneous rocks that have been discovered under the surface of the Earth. The texture mainly comprises of coarse grains and micro granites.
Paleozoic	Silurian-Devonian		Tiang Schist	Schist is a foliated metamorphic rock. Schist is formed from the shale's parent rock. Depending on the degree of heat and pressure, shale can metamorphose into slate, phyllite, schist or gneiss.

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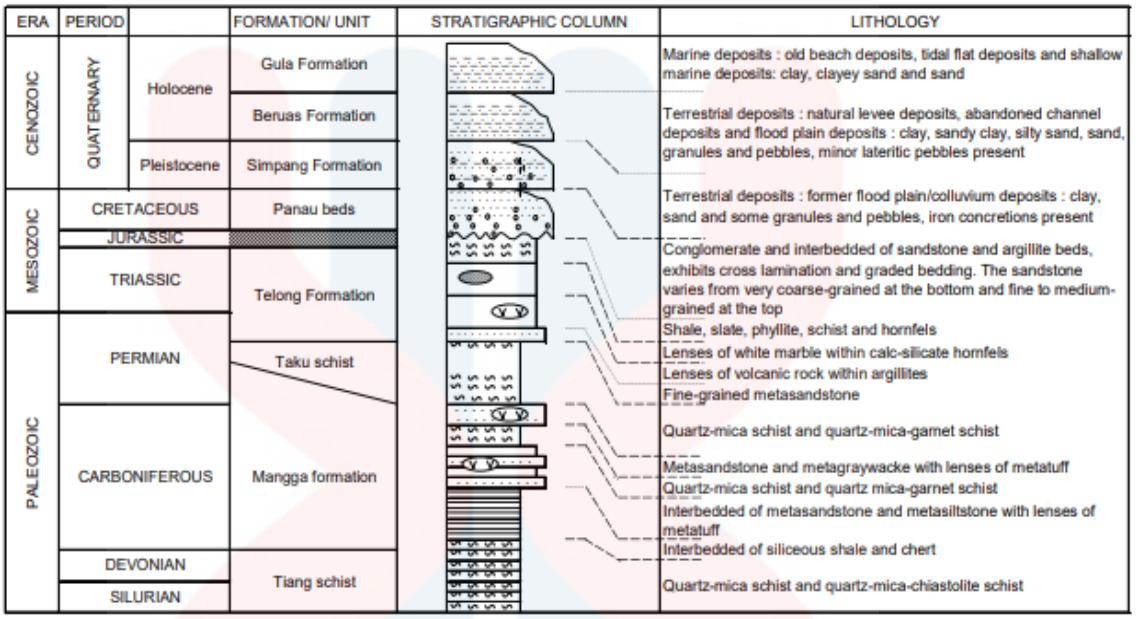
Table 4.3: Stratigraphy column of Batu Melintang (source: Malaysian and Thai Working Groups, 2006)



4.3.2 Unit explanation

Based on its horizontal and vertical distribution, the lithology unit defines the rocks from the oldest to the youngest. The unit of rock defines the thickness of the rock, the relationship and its area of distribution.

i) Alluvium

Alluvium is loose, unconsolidated soil or sediment that has been eroded, reshaped by water in some form, and redeposited in a non-marine setting. Alluvium is typically made up of a variety of materials, including fine particles of silt and clay and larger particles of sand and gravel (Brittanica, 2014). It was found around the main river, Sungai Pergau in the study area of Jeli. As a stream flows down a hill, it picks up sand, gravels and other unconsolidated particles called alluvium. The rushing water carries alluvium to a flat plain, where the stream leaves its channel to spread out.

ii) Granite

The Lawar granite is characterized by a partially sheared and modified fine grained, light grey, equigranular biotite-hornblende granite. However, it is evident that contact metamorphism of the country rocks was triggered by intrusions as dykes and sills and progressively mineralization of gold was initiated within the contact aureole.

Based on the previous thin section prepared by Siti Nabilah, 2016, it is granite to granodiorite in composition, microscopically. The primary minerals are with quartz (30-35%), plagioclase (20-30%) and biotite (<10%), and Hornblende sometimes. Epidote, chlorite and sericite are some of the secondary minerals. Moreover, quartz is typically sheared and crushed, while chlorite has been modified by biotite. This rock is the one that is sheared and crushed extensively to such a degree that it can be known as cataclasite.

Various forms of hypabyssal rocks have been initiated by the Lawar granite intrusion in Thailand, forming long tabular shaped N-S trending bodies and are widespread in the north of the To Mo granite pluton. Dacite and andesite dykes are comprised of the above mentioned hypabyssal rocks. It is noted that these intrusive shallow rocks often contain a significant percentage of rich silica materials, which are restrictively represented by vugs. The Lawar granite is therefore assigned to be Cretaceous I-type granite by the Malaysian and Thai Working Groups.

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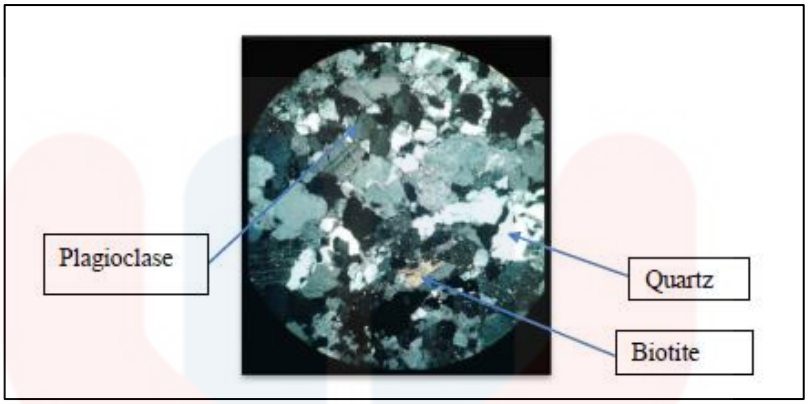

Figure 4.10: Granite thin section under XPL (source: Siti Nabilah, 2016)

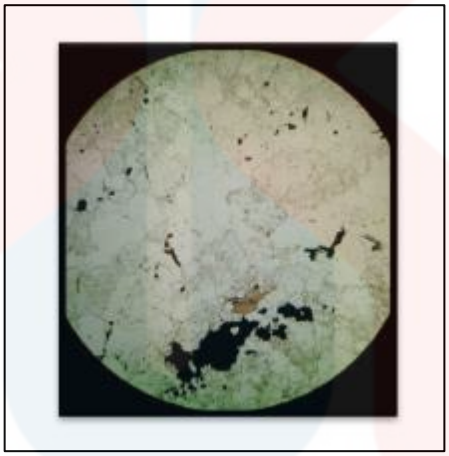

Figure 4.11: Granite thin section under PPL (source: Siti Nabilah, 2016)

iii) Schist

In Malaysia, the Tiang schist formation is composed of quartz schist and quartz-mica schist. The quartz-mica schist is extremely schistose, well foliated, consisting predominantly of quartz and mica (commonly muscovite) with mineral accessory chlorite, calcite and pyrite. Biotite is fairly common, although muscovite is prevalent. Muscovite, quartz and biotite were the main minerals identified in the Schist found from study area in previous thin section done by Siti Nabilah, 2016. There are many locations along Sungai

Tiang containing quartz-actinolite-tremolite schist and quartz-hornblende schist. No fossil assemblage is reported and the succession's thickness is indeterminable.

However, since only the Main Range Granite is separated by the Tiang schist and a well-documented Silurian-Devonian Kroh formation (about 20 km west of the Tiang schist in Malaysia), it is suspected that both of them could be of the same age.

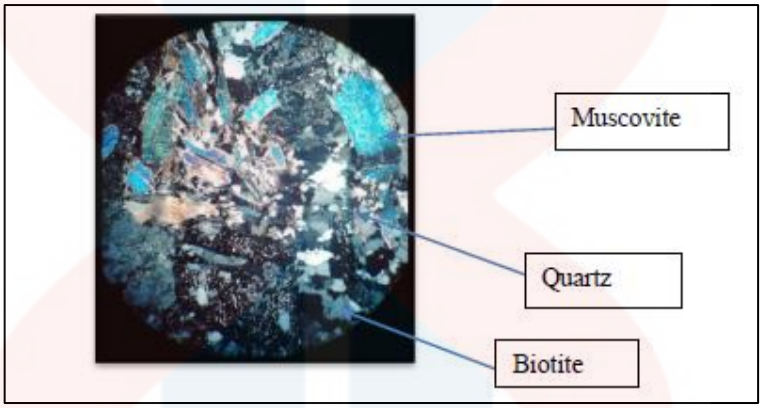

Figure 4.12: Schist thin section under XPL (source: Siti Nabilah, 2016)

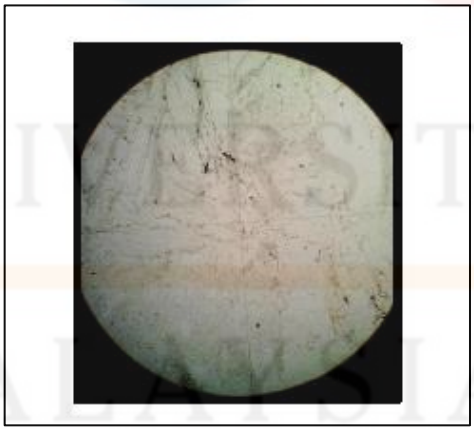

Figure 4.13: Schist thin section under PPL (source: Siti Nabilah, 2016)

4.4 Structural Geology

Structural geology, a key concept that, on a broad and a limited scale, is associated with deformation of rock. Its field of research is broad, ranging from sub microscopic crystal lattice defects to fault structures and crust folding systems of the Earth (Britannica, 2006).

The strong tectonic forces that exist within the earth are typically the product of geologic structures. These forces are folding and fracturing rocks, creating profound faults and constructing mountains. Repeated applications of force may produce a very complicated geological image that is difficult to interpret, such as the folding of already folded rocks or the faulting and offsetting of already defective rocks. Most of these powers are related to the activity of plate tectonics.

4.4.1 Lineament

Lineament assessment is the interpretation of, for example, faults of long characteristic components on the Earth's surface, particularly exposed by aviation imagery. It is a direct local-grade topographic feature that is agreed to represent the basic structure of the crustal. A significant local area is considered to determine the force and stress of the lineament for identifiable proof of lineament.

Based on Figure 4.7 and 4.8, rose diagram revealed that the maximum stress force which is σ1 is N 60º E while minimum tension σ3 is at E 150º N. Therefore, the direction of the lineament can be said pointing towards NE – SW.

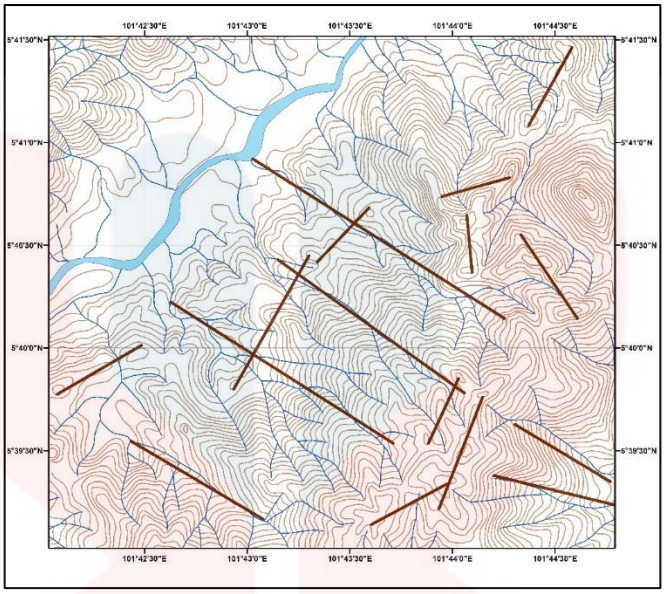

Figure 4.14 Lineament of study area

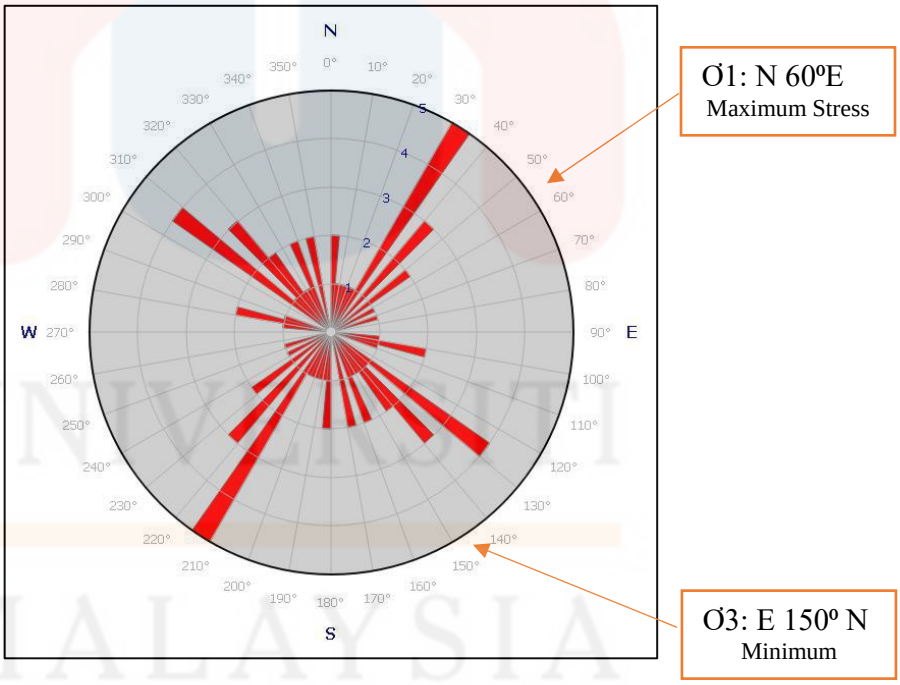

Figure 4.15: Rose diagram of study area

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4.5 Historical Geology

The subduction of a continental crustal plate (the western part) and an oceanic crustal plate (the eastern part) that is followed by the granite locations is assumed by the Malayan orogeny. The granites are distributed geologically parallel to the Bentong-Raub Suture as linear masses. Hutchison (1977) classified the granites in Malaysia into three belts based on granite lithology and petrochemistry: The Main Range Belt, the Central Belt and the Eastern Belt. The Main Range granite consists of granitoids of the S-type, ilmenite series, which during the Permo-Triassic period intruded into Paleozoic host rocks. The Central Belt granite consists predominantly of Triassic era S-type, ilmenite series granitoids with slight intrusion of granitoids of the Cretaceous I-type, magnetite series. The Eastern Belt granite consists predominantly of granitoids of the I-type, magnetite series and intruded during the Permo-Triassic period into Paleozoic host rocks. Later, the granite was split into two provinces by Cobbing et al. (1986): Main Range granite and Eastern granite, with the presumption that the Central and Eastern Belts are identical.

At Kampung Lawar, the granite found in the study region extends northward to the To Mo field of Thailand. It is associated with the granite of Cretaceous Lawar (Cobbing et al. 1992) where the intrusion of granite would have occurred. Mohamad Hussein Jamaluddin et al. (in manuscript) stated that it is assumed that this I-type granite is an offshoot body of the Cretaceous Noring Granite cultivated south of the Transect area.

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CHAPTER 5

WATER QUALITY ASSESSMENT OF JELI AND TOK BOK HOT SPRINGS

5.1 Introduction

In this chapter, the water quality assessment of both Jeli hot spring and Tok Bok hot spring will be discussed based on the physical and chemical parameters. In the study area of Jeli hot spring and Tok Bok hot spring, 13 samples from hot spring ponds, rivers and groundwater wells were collected by previous researchers. However, in this study only two water samples were taken for comparison from Jeli and Tok Bok hot springs in order to assess the physical and chemical parameters. Both the Jeli and Tok Bok hot springs are shown in Figure 5.1 and 5.2 respectively. The physical parameters analysed were temperature, total dissolved solid, pH, dissolved oxygen and electrical conductivity. In addition, for the chemical parameter, the major anions studied such as chloride, bicarbonate, fluoride, and sulphate, this analysis also evaluates major cations such as sodium, iron, calcium, potassium and magnesium (Astel, 2104).

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Figure 5.1: Hot spring of Jeli (source: google street view maps)

Figure 5.1: Hot spring of Tok Bok (source: google images)

5.2 Physical Parameters

In terms of geochemistry, physical parameters play a prominent part in water sources. It would affect the water quality of the water body system if there are alterations in its physical conditions. As a consequence, nutrient distribution or biological ecosystems can be influenced by physical changes. It is possible to connect each parameter to one another.

A multiparameter was the main tool used to collect the data based on certain physical parameters. Generally, thirteen parameters can be measured by the multiparameter water quality meter which are pH, ORP, temperature, dissolved oxygen, conductivity, total dissolved solids (TDS), salinity, resistivity, specific conductance, ammonium, chloride, nitrate, and barometric pressure. The multiparameter water quality meter featured a powerful sensor probe and state-of-the-art functions, making it easy to obtain highly accurate water quality data simply and quickly by submerging the sensor in the water. The multiparemeter water quality meter is sufficiently versatile to be used to verify the quality of a wide variety of water samples, from factory waste to urban runoff, river water, hot springs, lake and marsh water, aquatic tanks, sources of agricultural water, and marine water (Xylem Inc., 2016).

However, in this study, only certain physical parameters were discussed which were Total Dissolved Solid (TDS) pH, Electric Conductivity (EC) Temperature and Dissolved Oxygen (DO).

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5.2.1 Temperature

The temperature was measured for all the samples collected from both hot spring areas. As for the water sample in Jeli hotspring, it has the highest temperature compared which is 49.69°C compared to Tok Bok hotspring that has reading of temperature that was 41°C. Hence, it is proven that the water from Jeli hot spring area has the higher temperature compared to the water from the Tok Bok hot spring location and shown in Figure 5.3.

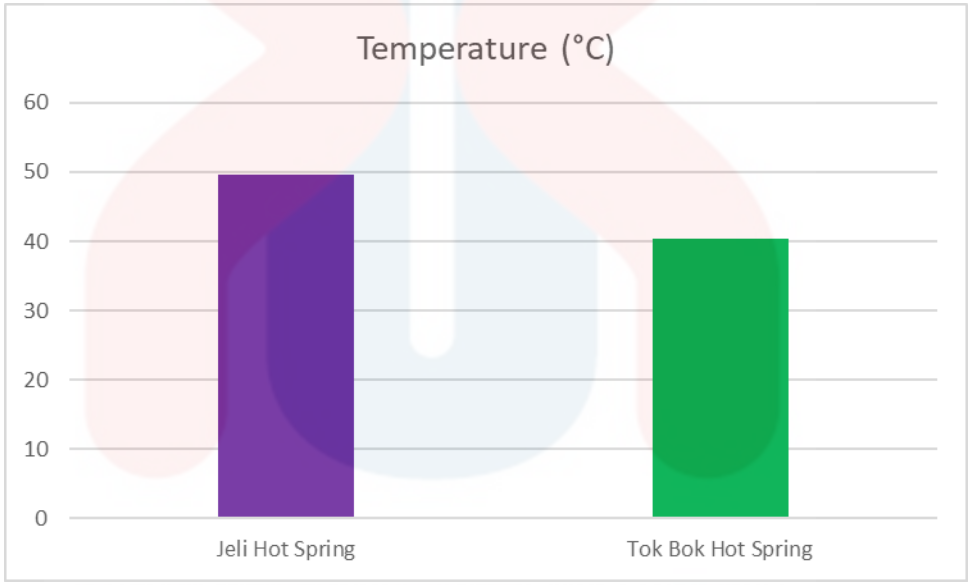

Figure 5.3: Temperature of water samples in study area

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5.2.2 pH

Another important parameter analysed from both the hot springs data is the pH value. pH is generally used in order to know the amount of hydrogen ion. The values ranges from 0 to 14. The pH can regulate the availability of nutrients, biological functions, microbial activity, and the behavior of chemicals. In other words, pH is necessary to measure the acidity or basic quality of water. If the reading is from 0 to 6 is considered as acidic, pH value of 7 is neutral 8 -14 is categorised as alkaline (Gaurab, 2018).

The high acid or high alkaline content of water may have a negative impact on the use of water. Highly alkaline waters give a bitter taste, while metals and other substances can corrode or dissolve at a very low pH. Water for drinking and domestic use should have a pH range from 6.5 to 9.5, according to World Health Organization (WHO, 1993) guidelines. While pH normally does not have a direct effect on customers, it is one of the most significant parameters of operational water quality.

As for the water sample from Jeli hot spring, the pH is 8.11. Besides that, the pH water in Tok Bok hot spring recorded 8.77. This show that the hot spring water is slightly alkaline and can be considered a weak basic as in Figure 5.4.

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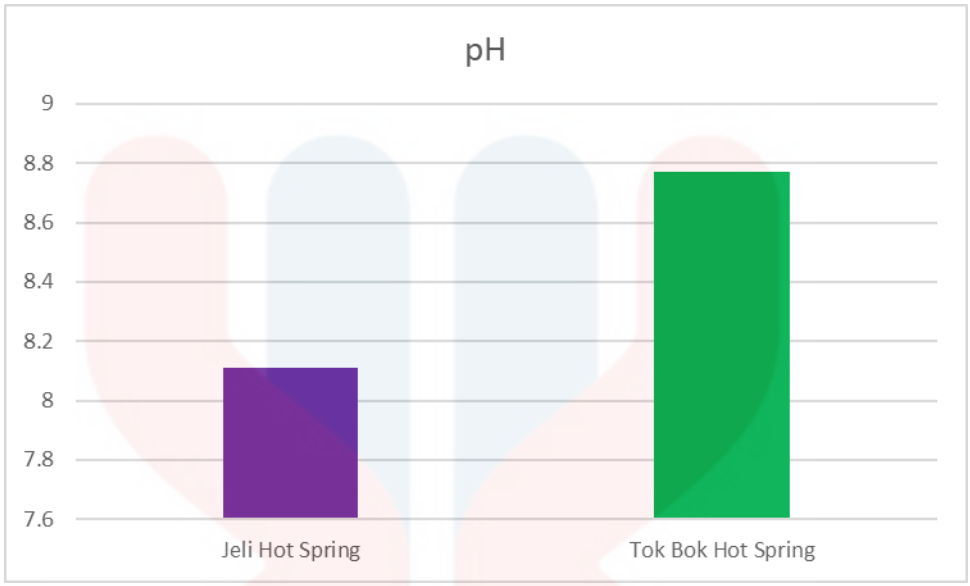

Figure 5.4: pH of water samples in study area

5.2.3 Total Dissolved Solid

Total Dissolved Solids (TDS) can be designated as the total concentration of substances in water. Inorganic salts and organic matter dissolved in a volume of water are included. Both dissolved solids are either ions charged positively or ions charged negatively. The total negative charge of the anions is always equal to the cations' total positive charge. Inorganic salts such as calcium, magnesium, potassium, sodium, bicarbonate, chloride, sulphate and tiny quantities of organic matter dissolved in water constitute the TDS. Furthermore, TDS is specifically related to water quality and water viability for drinking and irrigation purposes.

In particular, the TDS values for bedrock aquifer systems are greater than those for unconsolidated deposits. This is because the solubility of various groundwater-contact minerals affects the TDS values in the water samples (Hem, 1985). TDS can be correlated

with the Electrical conductivity (EC) of the water. That is because the water grows increasingly likely to transfer electricity as more cations and anions dissolve in the water. Thus, the rise in TDS increases the value of the EC.

As for the Jeli hot spring, the reading gathered was 0.221ppm while the Tok Bok hot spring measures the reading as 0.198 ppm. Therefore, the Tok Bok hot spring has minimal value of TDS compared to hot spring water of Jeli as shown in Figure 5.5.

A maximum contamination level (MCL) of 500 mg/liter (500 parts per million (ppm)) for TDS is recommended by the EPA Secondary Regulations. If the value of TDS reaches 1000 mg/L, it is not considered healthy for human consumption. Since TDS levels in water are below 500 mg/L, water is safe for human consumption.

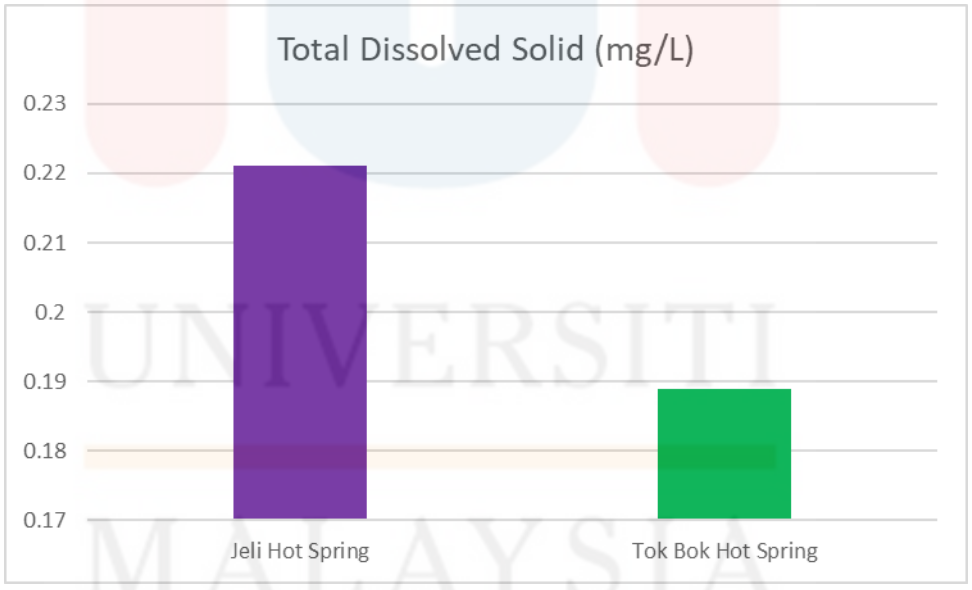

Figure 5.5: Total dissolved solid of water samples in study area

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5.2.4 Electrical Conductivity

Electrical conductivity (EC) of water refers to water's ability to conduct an electrical current. The reason that water conductivity is significant is because it can tell you how much water is present in dissolved substances, chemicals, and minerals (Gaurab, 2018). The electrical conductivity of Jeli hot spring is 0.499 mS/cm while for the Tok Bok hot spring EC value is 0.376 mS/cm. The electrical conductivity depends on the total dissolved solid in the water. The more the TDS concentration in the water sample, the greater the conductivity value of the water. So this theory is proved as Jeli hot spring has higher amount of TDS in comparison with the Tok Bok hot spring and shown in Figure 5.6.

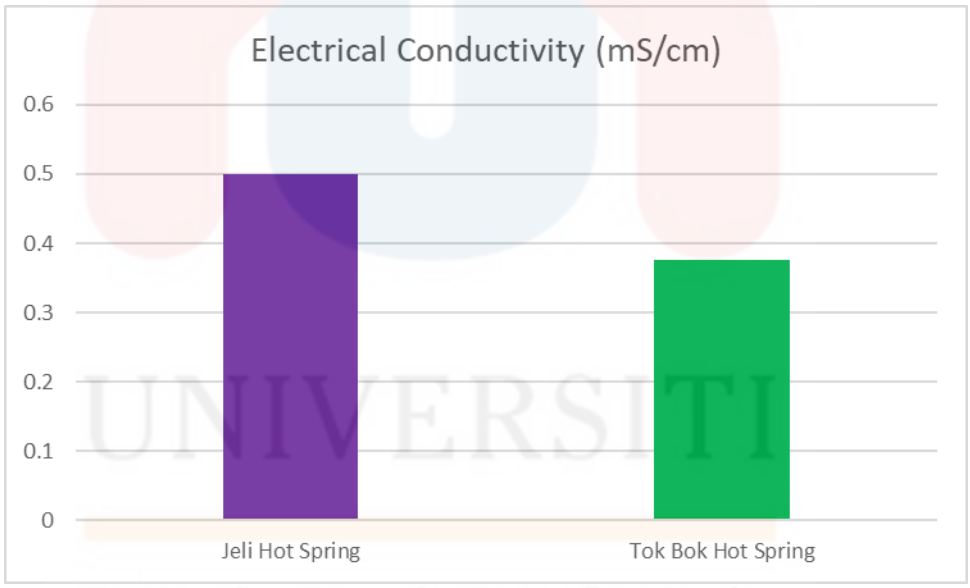

Figure 5.6: Electrical conductivity of water samples in study area

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5.2.5 Dissolved Oxygen

Dissolved oxygen (DO) is the measurement of oxygen in water. Oxygen is very important for the function of respiration and also important for some chemical reactions and has become a health indicator for the aquatic environment. The dissolved oxygen content in surface water is influenced by temperature and has a seasonal cycle as well as a normal cycle. More dissolved oxygen than warm water will carry cold water. In a stream or lake, the concentration of dissolved oxygen will say a lot about its water quality.

The DO value for Jeli hot spring is very much higher compared to Tok Bok hot spring where Jeli hot spring recorded 59.1 % while Tok Bok hot spring measured 26.8 % and can be seen in Figure 5.7. The oxygen level is also affected by temperature, salinity and pressure of hot spring water. the higher the pressure, the higher the DO will be and the lower the salinity, the greater the oxygen will be dissolved.

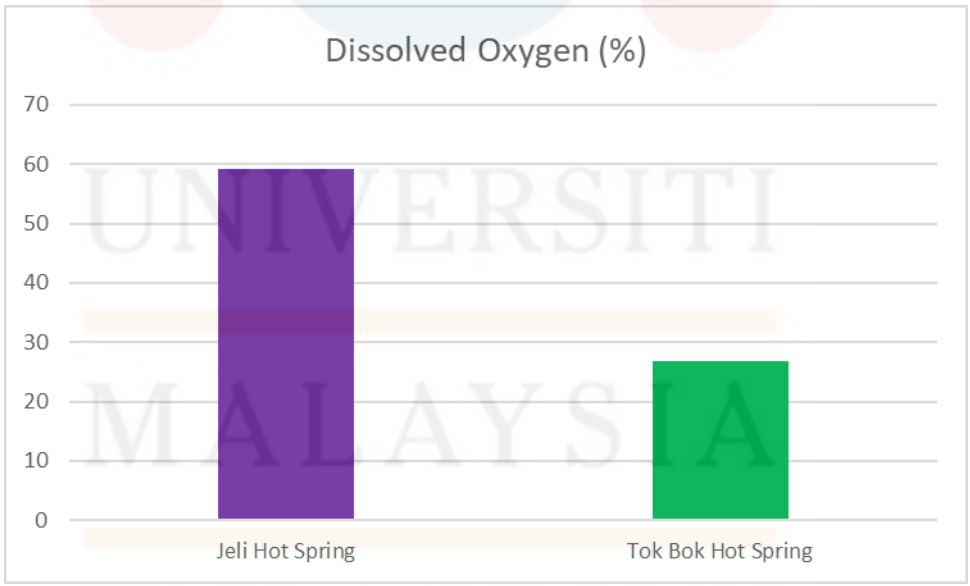

Figure 5.7: Dissolved oxygen of water samples in study area

5.3 Chemical Analysis

One of the important step for evaluating the anions and cations in the water is through water chemical analysis. The quality of water and the effect of human actions on the body of water can also be measured by conducting this chemical analysis. It indicates that the lakes, rivers, ocean and groundwater are safe according to Natural Water Quality Assessment Program (NAQWA). From water chemistry, the function of water bodies can be completely exploited.

The chemical constituents that are discussed and compared in this study are categorized into two major parts which are cations and anions. The positively charged cations are Sodium, Potassium, Calcium, Magnesium and Ferum. Besides that, the negatively charged anions area Chloride, Sulphate, Fluoride and Bicarbonate ions. All their concentrations are measured in milligram/Liter units. Major cations are shown in Table 5.1 while the major anions are indicated in Table 5.2. The graph of chemical analysis of cation is shown in Figure 5.6 and in Figure 5.7 for anions.

Major Cations

Table 5.1: Major cations found in study areas

Cations (mg/L) / Water Sample	Sodium	Calcium	Magnesium	Potassium	Iron
Jeli Hot Spring	52.65	0.602	0.66	0.28	0.823
Tok Bok Hot Spring	4.216	3.953	0.111	1.493	0.083

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5.3.1 Sodium

Sodium is an element that is a member of the alkali metals family in group 1 of the periodic table. Sodium components are quite hard to break off because they bind themselves very tightly. As almost all sodium compounds dissolve in water, all natural water contains sodium ions (Na+). Halite, or rock salt, is the most abundant source of sodium on earth.

The level of sodium in Jeli hot spring is 52.65 mg/L while for Tok Bok hot spring is 4.216 mg/L. Minerals such as feldspar and clay are the natural sources of sodium. In the study area of Jeli hot spring, the probability of high sodium is from rock-water interaction. High sodium concentrations in water are often usually associated with contamination from industrial wastewater discharges.

Natural springs that flow through salt-bearing geologic formations can have as much as 200,000 parts per million (PPM) of dissolved materials. Some streams that flow over rocks with low solubility can have as little as 50 parts per million (PPM) of dissolved materials (Battaglin, 2002). Since the concentration of sodium is not more than 200 mg/L as stated by WHO, 2011, both the samples are sufficient for the purpose of drinking.

5.3.2 Calcium

Calcium is an alkali earth metal found in the periodic table in Group 2. With the exception of alkali metal in Group 1, alkaline earth metal is not chemically active like other metals. The most prominent natural occurrence for Calcium are from, feldspar, amphiboles pyroxene, dolomite, aragonite, calcite, marble, chalk, gypsum limestone, travertine, shells and coral and clay minerals.

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The Jeli hot spring has only 0.602 mg/L of calcium while the Tok Bok hot spring recorded higher which is 3.953 mg/L of calcium. The concentration of calcium in drinking water is not more than 200 mg/L, according to the WHO. Both calcium levels in the study area are below 200 mg/L, and therefore it is fine to consume depending on calcium concentrations.

5.3.3 Magnesium

Magnesium is an element of Group 2 in the periodic table. Abundance in the lithosphere is believed to be approximately 2.1%. Magnesium is also present in coastal waters. Many naturally occurring magnesium minerals are magnesite, dolomite, carnallite and also epsomite.

The magnesium concentration for Jeli hot spring is 0.660 whereas for Tok Bok hot spring is 0.111. The WHO-based magnesium concentration for drinking water is 150 mg/L. Both the magnesium concentrations of Jeli and Tok Bok hot springs are very small which was only less than 2 mg/L. Therefore, it is considered safe to consume the water from both the samples.

5.3.4 Potassium

Potassium ion is a monoatomic alkali cation derived from potassium element in group 1 of periodic table. It is a valuable cofactor and metabolite for humans. Feldspar minerals and some mica and clay minerals are the natural sources of potassium in groundwater. The possibility is from water contact with the bedrock as the region of analysis is dominant with granite containing high feldspar amounts (Nayla, 2019).

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The potassium concentration for Jeli hot spring is 0.280 mg/L while for Tok Bok hot spring is 1.493 mg/L. According to the WHO, the allowable potassium concentration level for drinking is 200 mg/L. Based on potassium concentration from both hot spring areas, all samples are sufficient for drinking purposes.

5.3.5 Iron

Ferum which is Latin word for iron. The element is a transition metal of the first series lies on group 8 in the periodic table. Iron can be found naturally in waterbodies such as rivers, lakes, groundwater and hot springs. There can be two types of iron found in water, which are soluble ferrous iron or insoluble ferric iron. Iron mineral sources include magnetite, siderite, hematite, and goethite.

The iron present in Jeli and Tok bok hot springs are veery minimum where 0.823 mg/L in Jeli and only 0.083 mg/L in Tok Bok. In human nutrition, iron is an integral element. Minimum daily demand estimates for iron depend on age, gender, physiological state, and bioavailability of iron and vary 10 to 50 mg/day, roughly (WHO, 1996).

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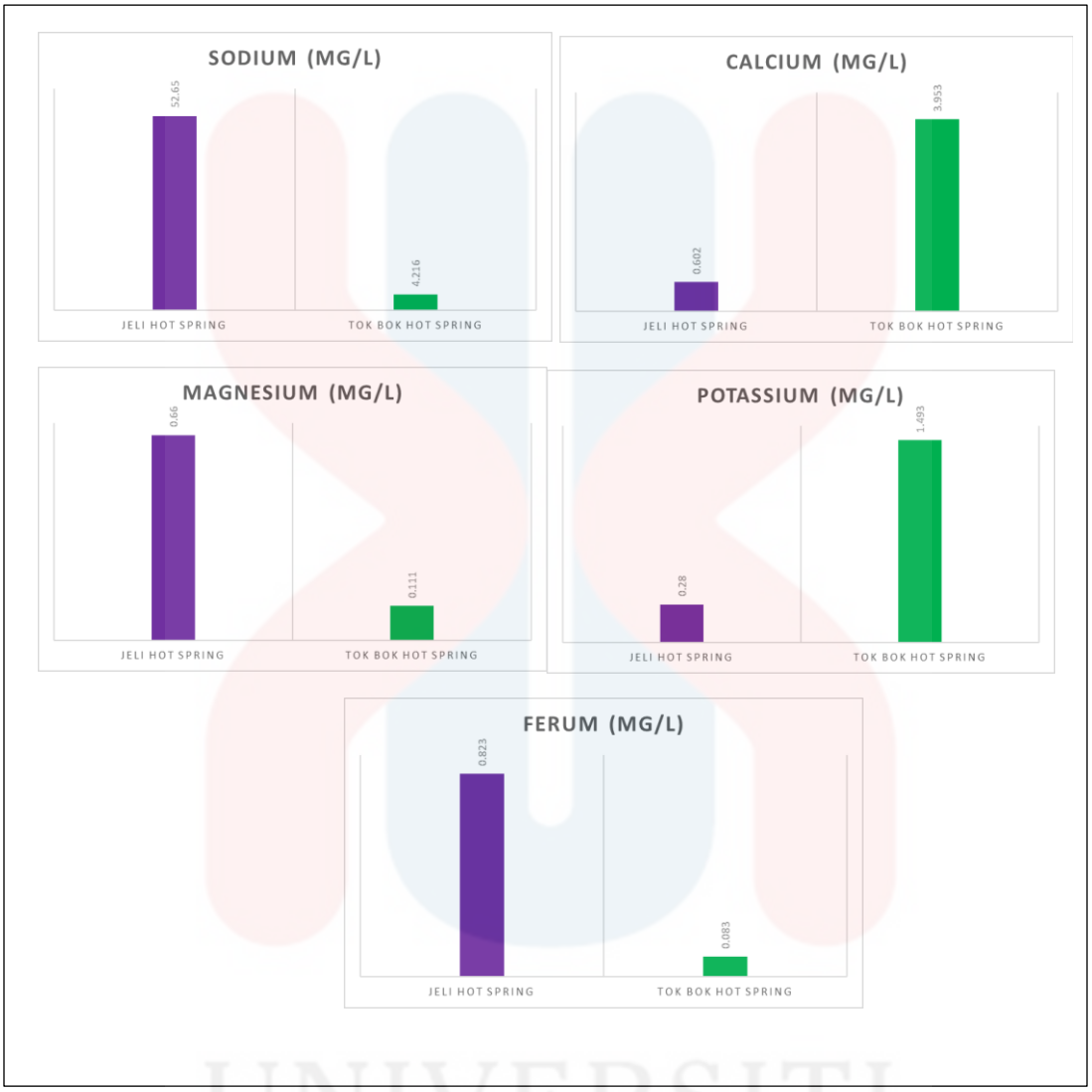

Figure 5.8 The graph of chemical analysis of cations

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Major Anions

Table 5.2: Major anions found in the study areas

Anions (mg/L) / Water Sample	Bicarbonate	Chloride	Fluoride	Sulphate
Jeli Hot Spring	322.50	12.07	1.07	13.20
Tok Bok Hot Spring	34.50	7.10	1.04	9.49

5.3.6 Bicarbonate

Water concentrations of carbonates and bicarbonates have a significant influence on both the hardness and the alkalinity (acid neutralization capacity) of water. In natural waters, bicarbonate concentrations vary from less than 25 mg/L in non-carbonate rock areas to more than 400 mg/L where carbonate rocks are present (Apollaro, 2019).

The bicarbonate value for Jeli hot spring is 322.50 mg/L comparatively higher than Tok Bok hot spring with the value of just 34.50 mg/L. Limestone and dolomite are the main natural sources of bicarbonate. There is no limestone or dolomite lithology in the study field, and this is the reason why the bicarbonate concentration is not that high. The acceptable drinking level for bicarbonate concentrations is 500 mg/L (WHO, 2003). As this bicarbonate concentration is below 500 mg/L for both water samples, this makes it ideal for human consumption.

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5.3.7 Chloride

Chloride is a naturally occurring component common in most natural waters, most commonly contained as a salt component (sodium chloride) or in conjunction with potassium or calcium in some instances. The existence of chloride in water may be the result of a variety of causes, including soil weathering, salt-bearing geological formations, salt spray deposition, salt used for road de-icing, drainage and coastal contributions, salty ocean water intrusion into fresh groundwater sources (Igor, 2019).

The chloride concentration in Jeli hot spring is higher compared to Tok Bok hot spring where 12.07 mg/L measured in jeli and 7.10 mg/L measured in Tok Bok hot spring. According to the WHO, the chloride concentration limit is no more than 250 mg/L. As all concentrations are below 250 mg/L, the water is fit for consumption.

5.3.8 Fluoride

Fluorine occurs in almost all soils and is a normal trace element. Fluoride with another element is known as any binary compound of fluorine. Probably the most commonly known application of fluoride for the purpose of reducing tooth decay is its addition to public drinking water sources (Ran T, 2016).

The fluoride concentration for Jeli hot spring is not much different from Tok Bok hot spring. For Jeli the value is 1.07 mg/L while for Tok Bok is almost similar as 1.04 mg/L. The restriction of fluoride concentration for drinking purposes is not more than 1.5 mg/L, depending on the standards of WHO. While this concentration of fluoride is reduced to all water samples, the water is safe for drinking.

5.3.9 Sulphate

In hard water sources, sulphate is second to bicarbonate as the main anion. Sulphates (SO4--) can occur naturally or can be the product of discharges from municipal or industrial sources. They are also the result of the breakdown of leaves falling into a stream, of water passing through rock or soil containing gypsum and other common minerals, or of atmospheric deposition as it naturally occurs. Sulphates are also contributed to water bodies through runoff from fertilized agricultural lands.

The concentration of sulphate in Jeli hot spring 13.2 mg/L and in Tok Bok hot spring 9.49 mg/L. The recommended concentration of sulphate appropriate for domestic use is not more than 250 mg/L, depending on the WHO. Because the concentration of fluoride is limited to both water samples, the water is safe for consumption.

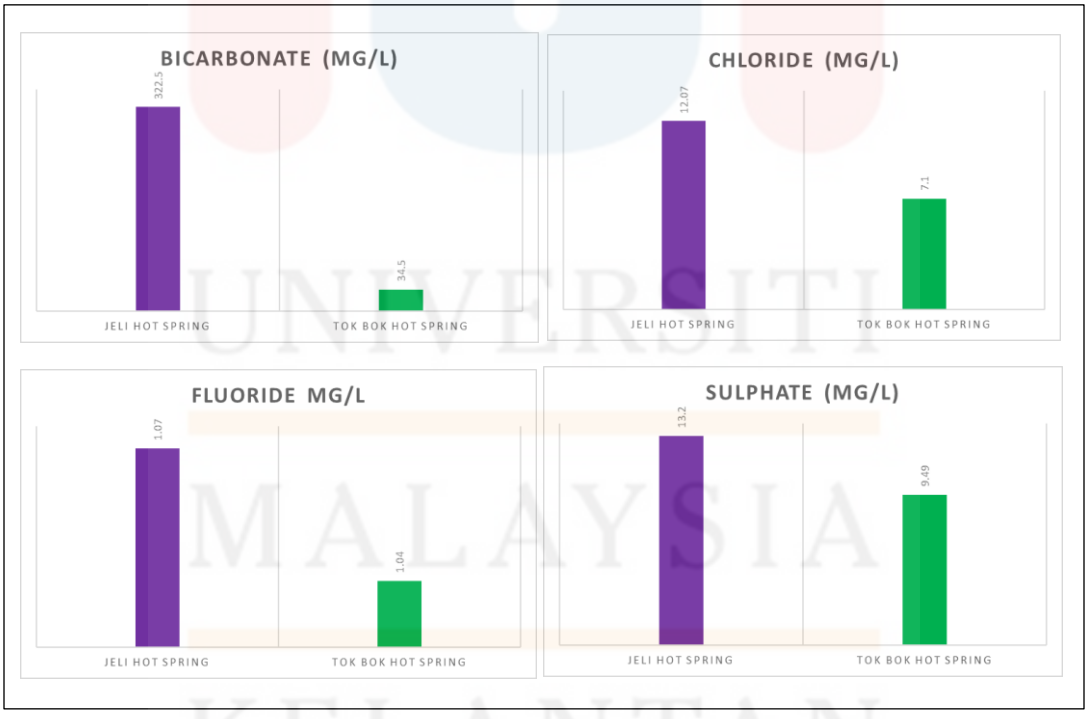

Figure 5.9 shows the graph of chemical analysis for anions

5.4 Rock Type

Thermal springs with water at temperatures far higher than the surrounding area's air temperature is called as hot springs. Most hot springs discharge groundwater that is heated in volcanic areas by shallow intrusions of magma (molten rock). Geothermally, that is, with heat generated from the mantle of the Earth, water from a hot spring is heated. The temperature of rocks within the earth in general increases with depth. The rate of rise in temperature with depth is called the geothermal gradient. It will be heated when it comes into contact with hot rocks if water percolates deeply enough into the crust.

Based on the study conducted in Jeli and Tok Bok, both the areas of hot spring present are known to have granite rock outcrops. The granite in Jeli hot spring area is said to be the Lawar Granite during Cretaceous period and the granite found in Tok Bok hot spring area is Machang Granite that deposited during the Triassic period. However, it is believed that both granites are different in composition due to the varied results of water quality analysis.

The fundamental controls on natural water quality, water not impacted by the activities of humans, are the types of organic and geologic materials it contacts and the duration of this contact. This is known as geogenic process. As water moves through geologic materials, it dissolves them. The influence of geology on water quality is indicated by the quantity and kinds of dissolved materials contributed from an area and the amount of sediment carried by streams. Natural water can vary greatly in the dissolved materials that it carries (Battaglin, 2002).

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5.5 Piper Trilinear Diagram

Piper (1994) proposed drawing two triangles corresponding to the cations and anions, respectively, and one diamond that illustrates both triangles, to construct a graph with the main water constituents. The cations represent the left triangle and the anions represent the right one. The axis for calcium, the left side for magnesium and the right one for sodium plus potassium are the center of the cation triangle. The base is the axis for chloride for anion one, the left side for carbonate plus bicarbonate and the right side for sulfate for anion one. The hydro chemical facies can be identified according to the sample location.

According to the water samples in both Jeli and Tok Bok hot springs, Piper Diagram is used to plot and determine the major type of water. The red plots represent Jeli hot spring while the blue plots represent the Tok Bok hot spring water. Therefore, it can be concluded that the red Jeli hot spring water represents the magnesium-bicarbonate type whereas the blue Tok Bok hot spring water represents the calcium- chloride type. The Figure 5.8 indicates the piper plot diagram.

Based on the Piper Trilinear Plot the water samples from Jeli and Tok Bok hot springs belong to totally different group because of the variety of granite composition found in both study areas. The changes that occur in water quality of hot springs are affected by geogenic process. The concentration of ions was majority higher in Jeli hot spring compared to Tok Bok hot spring. This indicates that the granite in Jeli has higher concentration of sodium, magnesium, iron, bicarbonate, sulphate, fluoride and chloride compared to Tok Bok granite. The granite in Tok Bok has higher concentration of calcium and potassium that Jeli granite.

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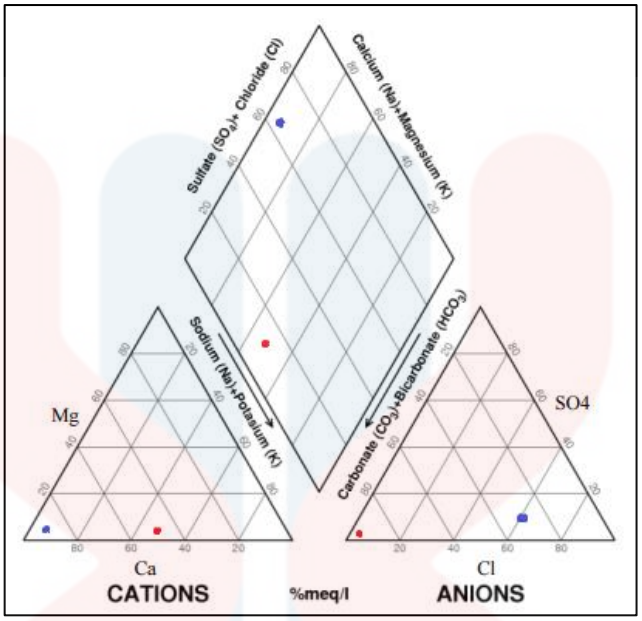

Figure 5.10: Piper Trilinear Plot

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CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

This study had been conducted in order to determine the geology of the study area is conducted at Jeli Hot Spring by using remote sensing data. The geological map was produced in scale 1:25000. The rock types identified in Jeli hot spring area were granite and schist. The granite aged Cretaceous and known as Lawar Granite while the schist was Tiang Schist of Silurian-Devonian period. Moreover, the interpretation using GIS had enhanced knowledge of interpreting contour, geomorphology and drainage pattern of the study area.

In addition, the study was also conducted to compare the water quality assessment of Jeli and Tok Bok hot springs. Based on the findings, the Jeli hot spring water represents the magnesium-bicarbonate type whereas the Tok Bok hot spring water represents the calcium- chloride type when referred to Piper Plot. Since lithology of both hot springs were granite rock, it can be concluded that the difference in water quality was because of the different composition of granite and geogenic process. Therefore, the second objective had been achieved where the hydro-geochemical data of Jeli and Tok Bok hot springs were interpreted and compared with one another.

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In conclusion this study had overall provide students with various knowledge about the rock distributions, formations, lithostratigraphy, tectonic settings of the overall study area and how it related with other places all over Kelantan and Peninsula Malaysia. Lastly, this research can also contribute some valuable details of water quality for future researchers.

6.2 Recommendation

The geological features of the study area should be more precise and publicize in detail so that it will be easier for future researchers to conduct their study as some of the data were difficult to obtain in this study especially for Tok Bok hot spring because not many research had taken place there. Besides that, both the Jeli and Tok Bok hot spring water are permissible for human consumption and domestic use according to the standards of WHO, so it is suggested to make those two locations as a main tourist attraction spots. Since there are housing areas in the neighbourhood, the hot spring water can be helpful for them in times of need for their daily activities. Furthermore, based on the study by previous researchers and online resources, it was mentioned that both the Jeli and Tok Bok hot springs are not very well maintained and rubbish can be found nearby. So initiatives should be taken by the authorities to maintain the hot springs and prevent from any contamination that can lead to harmful effects.

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