GEOLOGY AND FAULT ANALYSIS OF TEMANGAN, MACHANG, KELANTAN

by

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

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DECLARATION

I declare that this thesis entitled **“GEOLOGY AND FAULT ANALYSIS OF TEMANGAN, MACHANG, KELANTAN”** is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Date :

APPROVAL

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

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Date :

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GEOLOGY AND FAULT ANALYSIS OF TEMANGAN, MACHANG, KELANTAN

ABSTRACT

The present work is a part of final year undergraduate research project which was focused on geological mapping in Temangan, Machang, Kelantan and fault analysis of Lebir Fault. Lebir fault form near to Sungai Kelantan with having a sinistral and dextral reverse fault. The regional structure in Temangan is from the division of the Peninsular Malaysia into 3 boundaries belts and Temangan is under Central Belt. Peninsular Malaysia is a part of Eurasian Plate and the South East Asian that also known as Sundaland. The research of the current project mainly based on the secondary data including previous study, journal, article and data from agency that related. This research include in the interpretation of the structural, geomorphological features, drainage pattern, lithostratigraphy, and lineament analysis. All the data was processed in GIS based platform to generate geological and other thematic maps. This study area was having Temangan Dextral Strike Slip Fault that being interpreted using the kinematic and dynamic analysis to know all those forces and the processes of the fault by using the strike and dip data. These dynamic and kinematic analyses were being compared with the lineament analysis. The dynamic analysis measures the force and stress that affected the rocks that occur a deformation and force comes from the NE-SW. While for the kinematic analysis is to know the evaluation of displacement, amounts of fault slip and distortion of rocks that have undergone deformation. Stereographic projection showing the visual kinematic analysis based on orientation of rock that toward the NNE-SSW. This fault crossing all the lithology that present in the study area with a length of 4.6km.

Keywords: Dextral Strike Slip Fault, Fault analysis, kinematic analysis, dynamic analysis, lineament analysis, Temangan

GEOLOGI DAN ANALISIS SESAR OF TEMANGAN, MACHANG, KELANTAN

ABSTRAK

Karya ini adalah sebahagian daripada projek penyelidikan tahun akhir yang difokuskan pada pemetaan geologi di Temangan, Machang, Kelantan dan analisis kesalahan Sesar Lebir. Bentuk Sesar Lebir berhampiran dengan Sungai Kelantan dengan sesar sinistral dan dekstral terbalik. Struktur wilayah di Temangan adalah dari pembahagian Semenanjung Malaysia menjadi 3 tali pinggang sempadan dan Temangan berada di bawah “Central Belt”. Semenanjung Malaysia adalah sebahagian daripada Plat Eurasia dan Asia Tenggara yang juga dikenali sebagai Selat Sunda. Penyelidikan projek semasa terutamanya berdasarkan data sekunder termasuk kajian sebelumnya, jurnal, artikel dan data dari agensi yang berkaitan. Penyelidikan ini merangkumi tafsiran ciri struktur, geomorfologi, corak saliran, litostratigrafi, dan analisis garis lurus. Semua data diproses dalam platform berasaskan GIS untuk menghasilkan peta geologi dan tematik lain. Kawasan kajian ini mempunyai Sesar Slip Jurus Dekstral Temangan yang ditafsirkan menggunakan analisis kinematik dan dinamik untuk mengetahui semua kekuatan dan proses sesaran dengan menggunakan data kejurusan dan kemiringan. Analisis dinamik dan kinematik ini dibandingkan dengan analisis garis lurus. Analisis dinamik mengukur daya dan tekanan yang mempengaruhi batuan yang berlaku ubah bentuk dan daya dari arah NE-SW. Manakala untuk analisis kinematik adalah untuk mengetahui penilaian perpindahan, jumlah slip sesar dan penyimpangan batuan yang telah mengalami ubah bentuk. Unjuran stereografik menunjukkan analisis kinematik grafik berdasarkan orientasi batuan yang menuju kea rah NNE-SSW. Sesar ini melintasi semua jenis litologi yang terdapat di kawasan kajian dengan panjang 4.6km.

Kata kunci: Sesar Slip Jurus Dekstral, Analisis sesar, analisis kinematik, analisis dinamik, Analisis garis lurus, Temangan

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LIST OF ABBREVIATION

ALOS	Advanced Land Observation Satellite
DEM	Digital Elevation Model
GIS	Geographical Information System
JMG	Jabatan Mineral dan Geosains
JPS	Jabatan Pengairan dan Saliran
LiDAR	Light Detection And Ranging
MDM	Majlis Daerah Machang
PALSAR	Phased Array L-band Synthetic Aperture Radar
ScanSAR	Scanning Synthetic Aperture Radar
UITM	Universiti Teknologi Mara
UMK	Universiti Malaysia Kelantan
USGS	United State Geological Survey

LIST OF SYMBOLS

%	Percentage
>	Greater than
<	Lesser than
=	Equal
σ	Sigma
°	Degree
'	Minute
"	Second
˚C	Degree Celsius
&	And
x	Multiplication

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CHAPTER 1

INTRODUCTION

1.1 General Background

This research with a title "Geology and Fault Analysis of Temangan, Machang, Kelantan" were using kinematic analysis and also dynamic analysis. The study area is located at Sungai Kelantan which continuous with Sungai Lebir. This area is having a dyke ignimbrite that intruded at the sedimentary rock which trending N-S. This research insists on two things which are geology and fault analysis.

Peninsular Malaysia can be distinguished into 3 boundaries belts which are Western, Central and Eastern Belts (Hutchison & Tan, 2009) which focused on the differences in stratigraphy, geological structural, magmatism and geological evolution to know the geologic time scale (Metcalfe, 2013). Based on Khoo & Tan (1983), the Western Belt having two sector which being split between Northwest and Kinta-Malacca sector. There was deposition of argillaceous and calcareous sediments in the early Palaeozoic, accompanied by more calcareous deposition in the Kinta region but by clastics in the Kuala Lumpur area in the Northwest sector, which is underlined by clastics, calcareous and minor volcanics and the Kinta-Malacca sector (Khoo & Tan, 1983). Metcalfe (2013) stated that the Western Belt is a part of the Sibumasu Terrane, formed in the Late Early Permian from the NW Australian Gondwana margin. It is primarily underlined by Permian-Triassic clastics, volcanics and calcareous for the Central Belt and is mostly underlined by Carboniferous and

Permian clastics and volcanistics for the Eastern Belt (Khoo & Tan, 1983). The Central and Eastern Belts reflect the Sukhothai Arc developed in the Late Carboniferous to the Early Permian at the margin of the Indochina Block which derived in the Early Devonian from the Gondwana Edge (Metcalfe, 2013).

The Bentong-Raub Line or Bentong Raub Suture Zone, which divides the western belt from the central belt, is a distinct north-south line along the eastern foothills of the main range (Hutchison & Tan, 2009). The boundary between the Central and Eastern Belts is marked by the Lebir Fault Zone (Hutchison & Tan, 2009), but the lineaments of Bentong and Lebir, which connect the Central Belt, can be extended in a southerly direction across the Straits of Malacca along the Central and South Sumatra lineaments of the North South trending Lalang and Berangkat (Hutchison & Tan, 2009).

Shuib (2009) proposed that all those structures are the expression of several brittle and ductile deformations ranging from the pre-late Lower Permian to the Tertiary. The general north-northwest to south-southeast structural trend is producing three main deformation phases which are an Upper Triassic-Lower Jurassic transpression and Upper Cretaceous and Tertiary strike-slip deformations (Shuib, 2009).

To determine the two aspects of the region which are geology and fault analysis, geological mapping should be done at the research area. As the final result for the research had been collected including all the data, a geological map of the study area will be produce with a map scale of 1:25,000.

1.2 Study Area

This study conducted at Temangan that located between Machang and Kuala Krai with the geographical coordinate that aligned at latitude 5° 40' 45'' N to 5° 43' 0'' N and longitude 102° 8' 0'' E to 102° 10' 45'' E. The study area covers 25km^2 with a dimension 5x5 km on the scale of 1:25,000. The study area covered a few minor fault that affect from the major active fault which is Lebir fault. Pour & Hashim (2017) with a resulted from polorization of ScanSAR Hv image is superimposed on a general map Kelantan topography state. It is clear that morphology of the field of research is much influneced by the rock type and structure. The hilly, plain and coastal regions is between 500 m to 50 m above sea level are related to sedimentary rocks (Pour & Hashim, 2017). The highest elevation is 300 m which located at the southeast of the study area. The lithologies of the research area consist of the sandstone, siltstone, shale, ignimbrite, pyroclastic rock, slate, shale, phyllite and schist. Lebir fault was detected from the ScanSAR that occurred at the Sungai Kelantan and having major forces which changed the shape of the river (Pour & Hashim, 2017).

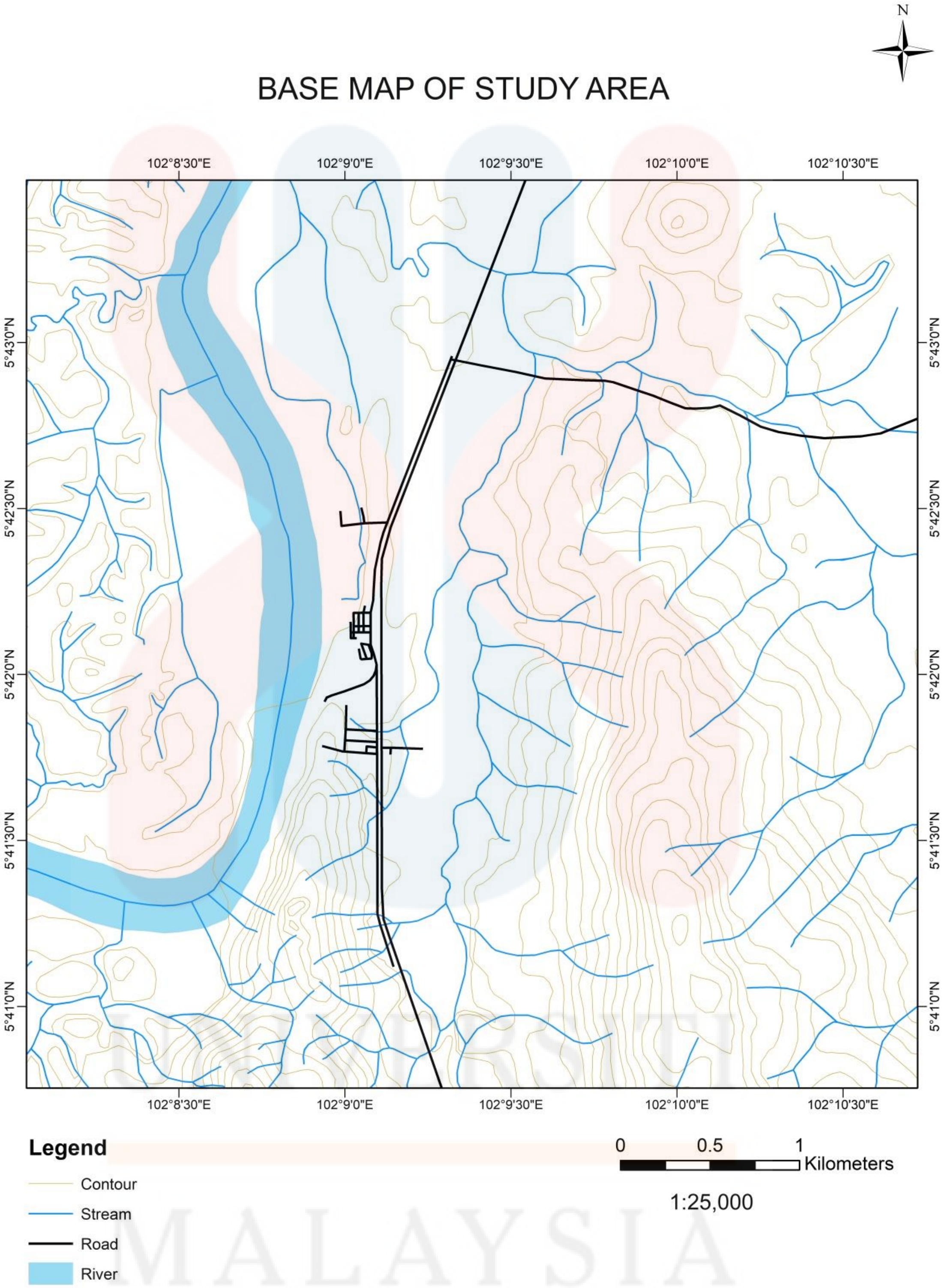


Figure 1.1: Base Map of the study area.

1.2.1 Location

Temangan is one of the areas that rich with high quality iron ore such as Geothite, Hematite, Limonite and Magnetite that lead to economic. It is located at Machang that located in the middle of Kelantan Darul Naim which bordering with Kota Bharu from the north, south of the Kuala krai, west of the Tanah Merah and Pasir Puteh to the east. Machang has an area of 546.26 square kilometres and 129 square kilometres lies within the Machang District Council. Temangan is situated between 200 m to 300 m above the sea level with temperature ranges between 24˚C to 35˚C.

1.2.2 Road Connection

Temangan is located at the south-west of Machang, Kelantan. The location of the research area is considered as highly accessible due to the several of road connection. The area can be easily access by motorcycle and even car.

Temangan is around 16 km south-west of the city of Machang. Main road that present in the study area is the road to travel from Temangan and Machang. The travel is just around 30 minutes and might be busy during working hours due to there are various government offices as shown in Figure 1.2. By using car or motorcycle, the study area also can be accessed from Universiti Malaysia Kelantan, Jeli Campus which is 56 km that will take around 1 hour that can be seen from Figure 1.3. Hence, the main sources of Temangan are iron ores so there is railway road that was built to transport the iron ores which name Jalan Keretapi Tumpat ke Gemas.

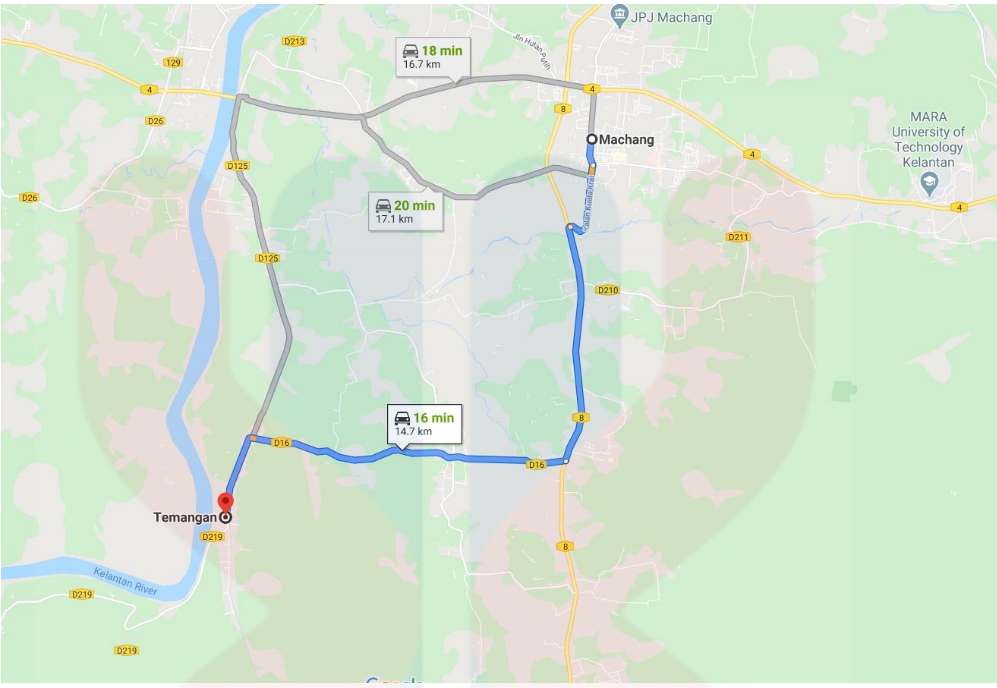


Figure 1.2: Route from Machang city to the study area via driving.
(Source: Google Maps, 2020)

Figure 1.3: Route from Universiti Malaysia Kelantan Jeli Campus to the study area via driving.
(Source: Google Maps, 2020)

1.2.3 Demography

Temangan was located under Jajahan Machang which having 5 district. Jajahan Machang having 74 781 people as shown in Table 1.1. As Machang is located between Kota Bharu and Kuala Krai, some of the people which at Pulai Chondong district and Pangkal Meleret district tend to work at Kota Bharu. Kota Bharu is an area which having medium cost of living. Kota Bharu is classified as cities area. Panyit resident, Temangan resident and Ulu Sat resident mostly work at Bandar Machang and few of them are work at Kuala krai.

The Temangan district consist of 4 sub-district that having Malaysian citizens and Non-Malaysian citizens. Table 1.2 shows the statistic of citizens with different races with majoring for Malay people. With the total amount of the Temangan people which is 5,786 in 2010, it contribute to the economies and works under the government as Temangan near to Jajahan Machang. Temangan contributed in economies sector since there is mining area at Bukit Besi.

There are 4 sub districts in Temangan district. Table 1.3 shows the statistic of Temangan population by sex in 2010. The ratio of both sexes is most equally in Temangan. As the total average age of Temangan people for 5-19 years old are around 1997, there are few school for the student and there is Universiti Teknologi Mara (UITM) Machang Campus which is 20.1 km northeast of Temangan.

Table 1.1: Number of population for Jajahan Machang in 2010.

District	**Population**		**Total**
	Male	**Female**	
Panyit	5,202	5,319	10,521
Jakar	674	661	1,335
Padang Kemuchut	687	628	1,215
Pek	1,145	1,172	2,317
Raja	1,322	1,358	2,680
Tengah	1,374	1,500	2,874
Pulai Chondong	6,383	6,515	12,898
Bagan	580	672	1,252
Ganding Galoh	2,041	2,043	4,084
Kerawang	1,576	1,543	3,119

Pulai Chondong	2,186	2,257	4,443
Pangkal Meleret	6,586	5,545	12,131
Kelaweh	3,480	2,419	5,899
Limau Hantu	3,106	3,126	6,232
Temangan	2,896	2,890	5,786
Bandar Temangan	914	975	1,889
Kerilla	914	871	1,785
Kuala Kerak	690	686	1,376
Temangan	378	358	736
Ulu Sat	15,496	17,949	33,445
Bakar	2,541	2,491	5,032
Bandar Machang	1,895	1,978	3,873
Machang	6,243	6,325	12,568
Pemanok	1,365	1,449	2,814
Ulu Sat	3,452	5,706	9,158

(Source: Maklumat Taburan Penduduk Mengikut Kawasan Pihak Berkuasa Tempatan dan Mukim, 2010)

Table 1.2: Number of population by ethnic group for Temangan in 2010.

Sub district	**Malaysian citizens**				**Non-Malaysian citizens**	**Total**
	Malay	**Chinese**	**Indians**	**Others**		
Bandar Temangan	1,446	375	13	6	49	1,889
Kerilla	1,585	99	38	9	54	1,785
Kuala Kerak	1,190	127	9	2	48	1,376
Temangan	676	-	1	14	45	736
Temangan Subdistrict	4,897	601	61	31	196	5,786

(Source: Maklumat Taburan Penduduk Mengikut Kawasan Pihak Berkuasa Tempatan dan Mukim, 2010)

Table 1.3: Number of population by sex for Temangan in 2010.

Sub district	**Population**		**Sex ratio**	**Total**
	Male (ratio)	**Female (ratio)**		
1. Bandar Temangan	914 (596.18)	975 (637.29)	1233.48	1,889
2. Kerilla	914 (563.36)	871 (537.97)	1101.33	1,785
3. Kuala Kerak	690 (327.85)	686 (326.62)	654.47	1,376
4. Temangan	378 (96.07)	358 (98.05)	194.12	736
Temangan Subdistrict	2896 (1583.46)	2890 (1599.93)	3183.39	5,786

(Source: Maklumat Taburan Penduduk Mengikut Kawasan Pihak Berkuasa Tempatan dan Mukim, 2010)

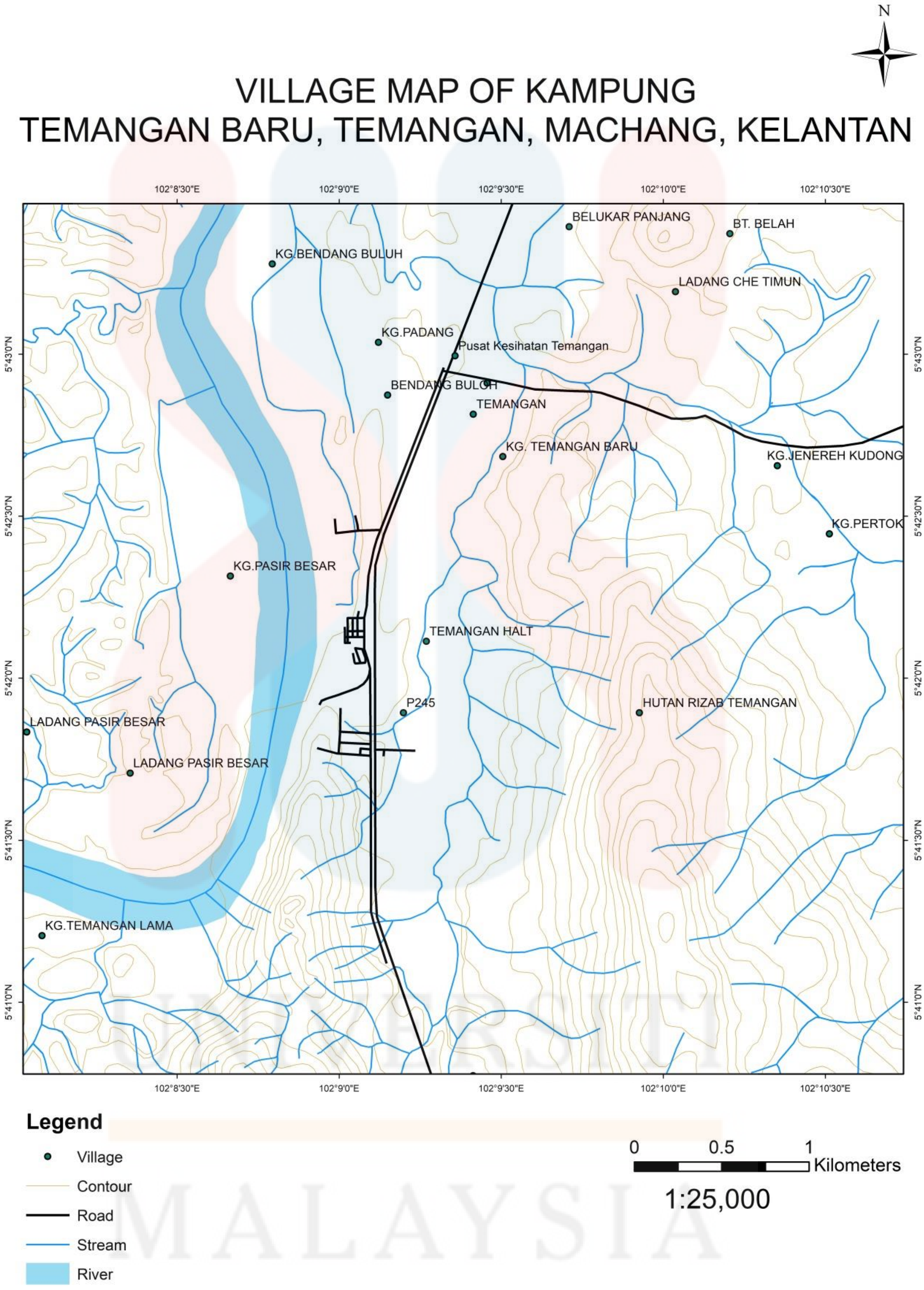


Figure 1.4: Village Map of Kampung Temangan Baru, Temangan, Machang,Kelantan.

1.2.4 Landuse

A research from Jusoff & Setiawan (2003), the total land area of Kelantan is approximately 1493,181 Ha. The land area was divided into three where 894,276 ha are classified as forested area, 626,372 Ha are forest reserves and the reminding are state land forest and Taman Negara (Jusoff & Setiawan, 2003). From a Landsat TM by Jusoff & Setiawan (2003) there are variety land cover for instant forest, rubber, oil palm, settlement and cleared land or known ad open area. Permanent Forest Reserve (PFR) in 1989 of Temangan was 1688 while in 1997 was 1171.66. This is showing the Permanent Forest Reserve of Temangan is having a losing around 516.34 or 35.52% (Jusoff & Setiawan, 2003).

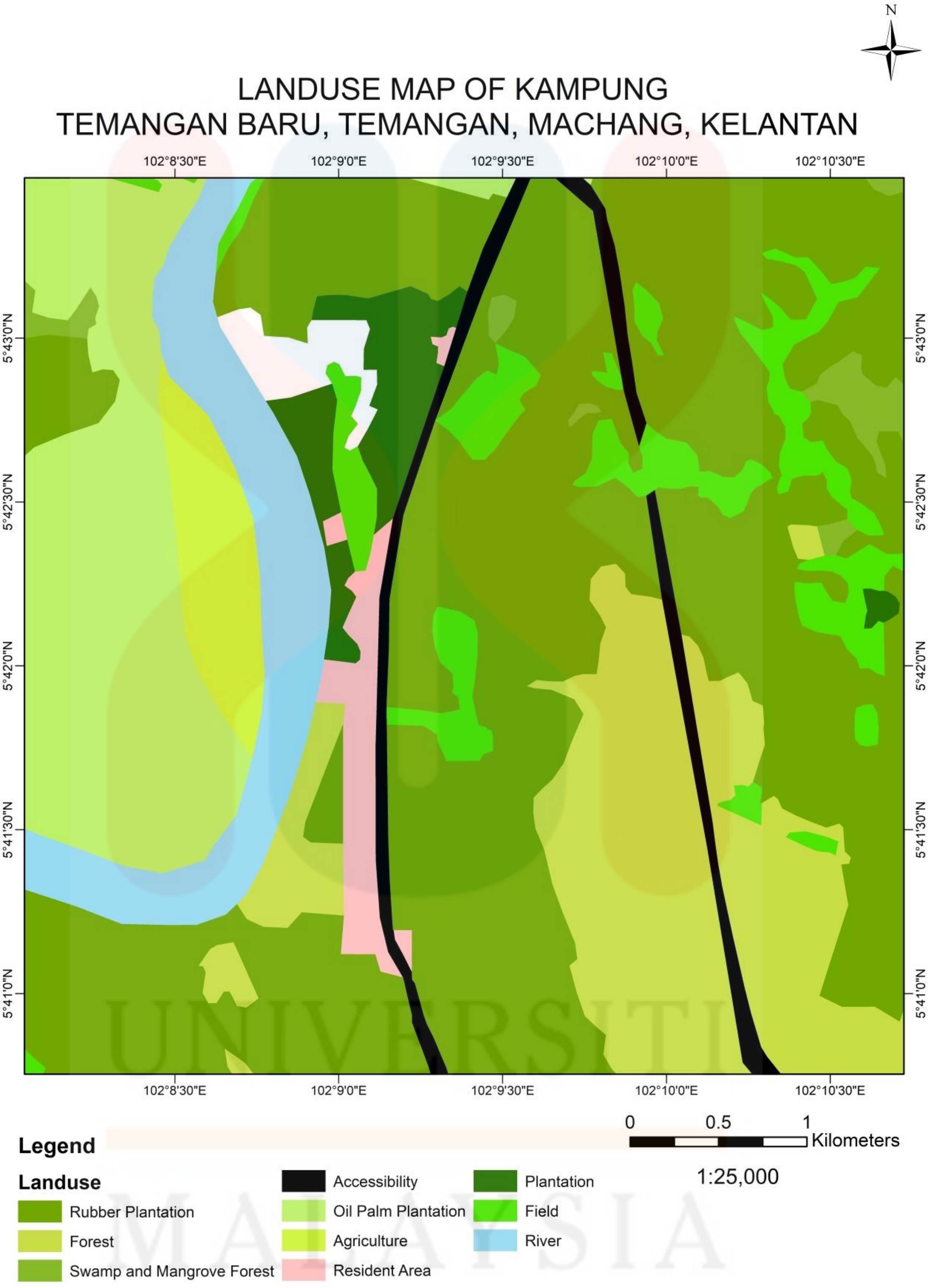
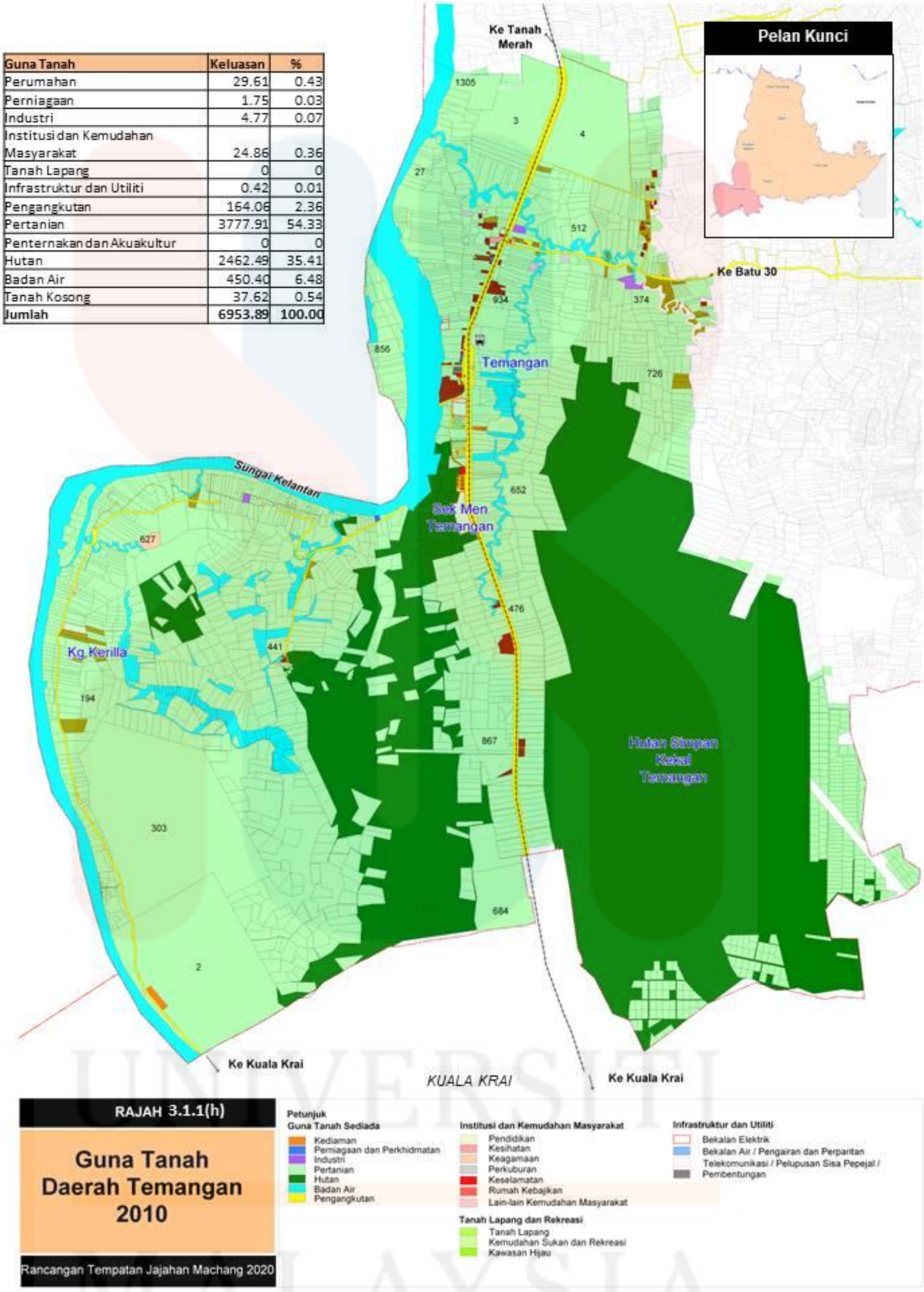


Figure 1.5: Landuse Map of Kampung Temangan Baru, Temangan, Machang, Kelantan.



Guna Tanah	Keluasan	%
Perumahan	29.61	0.43
Perniagaan	1.75	0.03
Industri	4.77	0.07
Institusi dan Kemudahan Masyarakat	24.86	0.36
Tanah Lapang	0	0
Infrastruktur dan Utiliti	0.42	0.01
Pengangkutan	164.06	2.36
Pertanian	3777.91	54.33
Penternakan dan Akuakultur	0	0
Hutan	2462.49	35.41
Badan Air	450.40	6.48
Tanah Kosong	37.62	0.54
Jumlah	**6953.89**	**100.00**

Figure 1.6: Landuse Map of Temangan, Machang, Kelantan.
(Source: Majlis Daerah Machang)

1.2.5 Social Economic

Base on a research from Al Mamun & Ibrahim (2018), in both an economic and geostrategic perspective, the importance of the iron ore in Malaya has been downgraded. Iqbal et al. (2014) stated that British rationale for Japan's mining of iron ore in the Non Federated Malay Sates was to assist the growth of these states. In 1910's until 1940's, the historical development of Japanese investment in Malaya as well as collecting all the data of Japanese investment during this period where the investment in Malaya was in rubber cultivation industry and iron ore Iqbal et al. (2014).

Due to the high vegetation area in Temangan there are rubber plantation area that being one of the sources of the economies for the Temangan residents. As the area of study is having iron ore, mining being one of the social economic for the residents.

1.3 Problem Statement

The study area is located at Temangan which near to the Sungai Kelantan. Based on the formation of the Peninsular Malaysia, it is having a belt would affect the formation of its geological structure which leads to the presences of fault at the river. From the study of PALSAR-2 by Pour & Hashim (2016), in this study area there is a lot of faulting that may be occur due to the Central Belt, Bentong Raub Suture Zone and also Lebir Fault Zone.

Setiawan & Abdullah (2005) stated that structural geology in Peninsular Malaysia being divided into four part of mandala which are East Mandala, Central

Mandala, West Mandala and Northwest Mandala. The present of Lebir Fault separated between the East Mandala and Central Mandala whilst the Bentong Raub Suture Zone separated the West Mandala and Northwest Mandala. There is Ignimbrite Dyke with a length of 20 km near to Temangan and the dyke become thicker toward North and parallel with Sungai Lebir with a length 150 km toward South (Setiawan & Abdullah, 2005). The Lebir fault is a left horizontal fault and the morphology of the area is a block displacement (Setiawan & Abdullah, 2005).

This research is to obtain data of the study area of fault analysis. As Kelantan occur a lot of geological structure which one of it is fault, the data need to be taken to identify the way of forces of the fault. If the results of this study are encouraging, it is imperative to ensure that this study area is having forces and also to updating the previous geological map of Temangan to see the effect of fault analysis.

The field identification from the previous study that measured the subsurface geological configuration found that the geological structure that develops in the form of a horizontal fault which is reverse fault (Pour & Hashim, 2017). The interpretation of map appearance of LiDAR at the research area carried out with analysing valley straightness, river straightness, vertical cross section reconstruction and processing solid data from the field that found lineament that can indicate faulting (Salleh et al., 2016). The previous study with only identify the fault by the LiDAR through the lineament which no kinematic and dynamic analysis. The strike and dip data was not taken so the forces of the fault analysis cannot be interpreted. The forces and stress will be interpreted the fault and know the ways of the forces.

1.4 Expected Outcome

Expected outcome for this research is the geological map and a fault analysis of Temangan area. The geological map will present the study area of Temangan. The forces of the fault can be interpreted using the kinematic and dynamic analysis. From the analysis the area of the forces can identify and the sources of the main fault can be related.

1.5 Objective

The objectives of this study are:

1. To update the geological map of Temangan, Machang, Kelantan with a scale of 1:25,000.
2. To analyse the fault present using kinematic and dynamic analysis.

1.6 Scope of Study

The study of the geology in Temangan, will be focused on identifying general geology which consist of structural geology, geomorphology and stratigraphy. Geological mapping will be done because a geological structure will be analysing during the research in the study area.

The fault analysis would be analysing using kinematic and dynamic by measuring its strike and dip. The kinematic analysis is to know the evaluation of displacement, Quantities of fault slip and distortion of deformed rocks while dynamic analysis measures the force and stress that affected the rocks that may occur a deformation and will know which area that the forces comes from. The strike and dip data was getting from previous study and also other agency likes JMG. Stereonet and stereographic projection were used to give visual of graphical kinematic analysis based on orientation of rock. The strike and dip would be plot at a lower hemisphere graph with help to know how the faulting forms.

1.7 Significance of Study

The study research was to conduct the geological mapping on the surface using topographic map with a scale 1:25,000. The research would provide the geological structure, rock confirmations and also formations of the study area. All the data will be used to produce latest geological map. Latest update of geological structure of fault analysis at Temangan will be update to recover the lacking of data by using the secondary data from agencies like JMG and USGS. The geological map can be used for the local society, geologist, and also government for the development of the area. Kinematic and dynamic analyses of fault were determined as the data will be used for proper planning and construction as the area is an active fault.

Besides, the application of science that applied in the mineral identification and also rock classification. As Temangan is an iron ore area so, the risk assessment is required and it should be aware with the sediment iron ore and the fault system that having illegal mining.

By producing the geological map, the amount of forces of the fault area can be identified. As fault also can lead to the disaster, the geological map can be used for the construction guideline in the building planner. Building development with tectonic deformation should mitigate the damage and improve the construction longevity. Mitigation is necessary to minimize the risk of life and properties that can impact human activities. Risk identification is important and should have been undertaken before the possible threats happened.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The main purpose of the literature review was to fetch this study research to the previous research of knowledge, suggestion and materials. It might be help in the report writing and summarize past study from the previous researchers. This chapter would cover the regional geology and tectonic setting, stratigraphy, structural geology and historical geology of Temangan and the specification that focused on fault analysis using kinematic analysis and dynamic analysis.

2.2 Regional Geology and Tectonic Setting

Based on Hutchison & Tan (2009), Peninsular Malaysia is part from the Eurasian Plate and the South East Asian that known as Sundaland. The edge of the Sunda Shelf extends N-S with a short distance toward the east of Vietnam (Hutchison & Tan, 2009). The formation started to curves eastwards as far as the West Baram Line (Hutchison & Tan, 2009). The tectonic Evolution of Peninsular Malaysia as shown in Figure 2.1, where the Sibumasu Terrane, formed in the Late Early Permian and the margin of the Indochina Block which derived in the Early Devonian from the Gondwana Edge (Metcalfe, 2013).

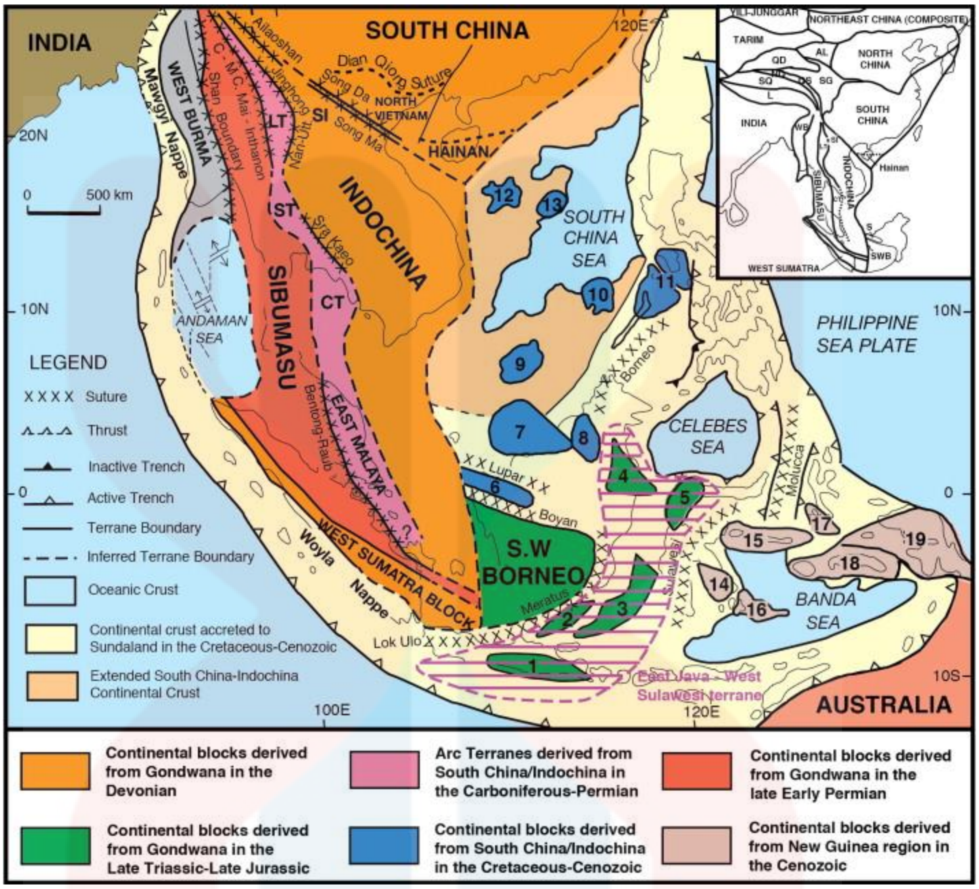


Figure 2.1: Tectonic evolution of the Peninsular Malaysia.
(Source: Metcalfe, 2013)

Shuib (2009) stated that the structures of the Peninsular Malaysia are the reflection from the tectonic evolution that started from the early Cambrian to the Cenozoic. During the Upper Triassic Indosinian Orogeny, the western Gondwana part of the Sibumasu of the Malay Peninsular collided with the Indochina continental block which is East Malaya Shuib (2009). There are three belts in the division of the Peninsular which are Eastern Belt, western Belt and Central Belt and the belt form from the tectonic setting during the Mesozoic based on (Shuib, 2009). Based on Hutchison (1989), the Bentong Raub Line is from a distinct N-S lineament that present along the eastern foothills of the Main Range. The Central Belt and the Eastern Belt was separated with the Lebir Fault zone which trending to NNW-SSE that curvilinear lineament that presents along the Sungai lebir. From the tectonic movement there is uplifting and subsidence that lead to the deposition during the Jurassic to Cretaceous Gagau and Koh Formaion (Shuib, 2009).

The study by Hussin (2011) show the lineament of Lebir Fault Zone continues to the south that end when there is the present of Lepar Fault in Pahang. The Sungai Lebir and the eastern margin of the Taku Schist near to Kuala Krai having a fault zone around 10 km wide which present a gap between the two locations. The tectonic setting starting to make deformation of the rock type which are brecciated metasediments, flasered granites and mylonites. From Hussin (2011) there is sinistral movement of the fault which can be identify from the slickensides on the faults surface and there is slickenlines that also knwon as lineation.

2.3 Stratigraphy

Heng & Potisat (2003) stated that the stratigraphy of Temangan Jatinangor is based on the Geological Map of Machang in Temangan. Temangan consist of ignimbrite which trending N-S. The ignimbrite presents at the ridge about 10 km long and with a wide 800 m. The N-S trending ridge that having contact and cutting the shale and sandstone. The ignimbrite was intruded along the Lebir Fault Zone during the intrusion nature process (Heng & Potisat, 2003). From Figure 2.2, it is being shown the geological map of Kelantan that consist of the geologic age and geological structure.

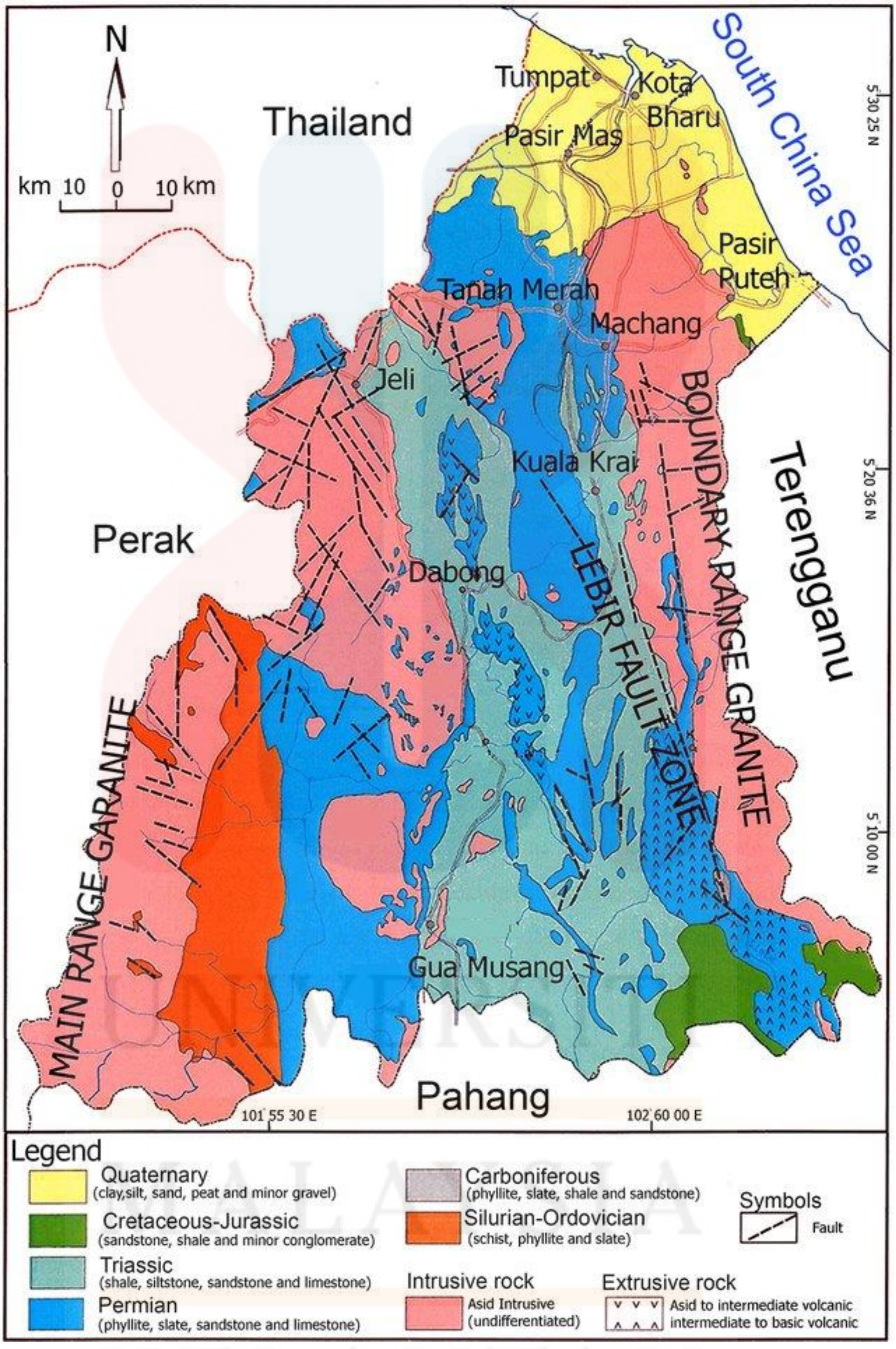


Figure 2.2: Geological map of Kelantan.
(Source: Hashim, M., Misbari, S., & Pour, A. B., 2018)

Based on a study by Daanen (2015), during the Permian there is sediment that being deposited at the north of the Taku Schist and within the Triassic meta-sediments. There are sedimentary rocks that can be found such as fine grained sandstone, interbedded clay and schist that often severely weathered. There is also volcanic rock that mainly pyroclastic rock. Hutchison & Tan (2009), the lithology of this stratigraphic unit resembles the possible protolith of the Taku Schists.

During the Triassic meta-sediments there are low grade metamorphic rocks and non-metamorphosed sediment such as sandstones and siltstone. The facies for the low graded metamorphic are sub-greenschist to lower greenshict facies that occur with high temperature from 250-350˚C. The metamorphism processes need a high pressure with a value 2-3 kbar. The low grade metamorphic rocks are slates and phyllites. The Permian and Triassic rcoks cover most of the Central Belt and during the late Triassic the rock started to deposit and having minor continental basin at the age (Daanen, 2015).

2.4 Structural Geology

A research from Fossen (2016) structural geology is a deformation structures that having tectonic forces that occurred within the Earth and a study on how the present rock structure, arrangement and formation of the earth's crust and the tectonic process of the formation of fault. The forces will break the rocks, having a fold, form faults and also can build a mountain. When the forces repeated there will have folded rock calling as syncline or anticline and the rock can be faulted. Plate tectonic activity contributes in force production. Through these geologic structures some of the natural resources or minerals will be deposited near it. The geologic structures also influence in the shape of landscape, bring old rocks to the surface while the young rocks will be bury, and shift during earthquakes (Fossen, 2016).

Rey, P. F., (2005) stated in his reseach, different amount of forces will having a different activity for instant the large forces will produce a stress in the tectonic plates that push against each other while the smaller forces is when the gravity pulling on a steep mountainside. With the three types of stress which are compression that pushing together, tensions that pulling apart and also shears that twisting or rotating. The rocks that lack of water tends to break and called as ductile while the rock that contains water is having a ductile.

A study from Pour & Hashim (2017) that stated, Temangan consist of main river of Kelantan which is Sungai Kelantan that is one of the factors in lineament contribution. Based on Pour & Hashim (2017), the result from PALSAR-2 Scan SAR that showing blue to dark blue image will indicate the lake and main river which is Sungai Kelantan. From Figure 2.3 there are lineaments that indicate the fault for Kelantan state. Most of the fault lines are occurring at the wetland area and drainage pattern area.

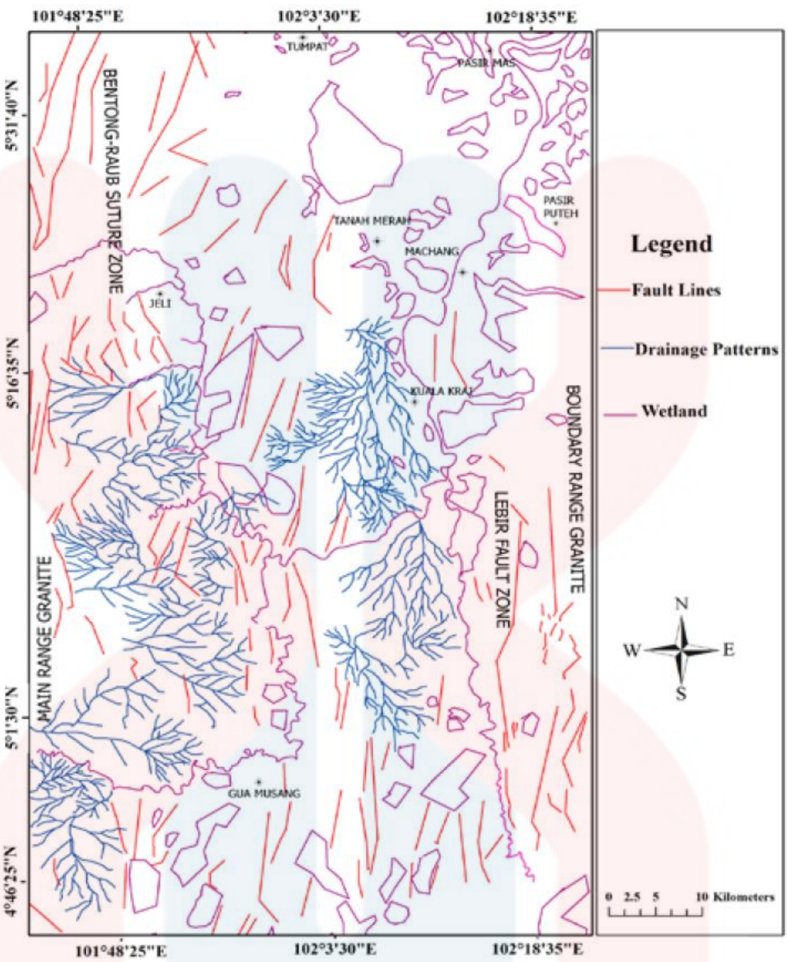


Figure 2.3: Structural Lineament Map of Kelantan.
(Source: Pour, A. B., & Hashim, M., 2016)

Pour & Hashim (2017), stated that the morphology of the area is controlled by the rock type and structure that the high elevation area is mountainous areas with Main Range Granite and Boundary Range Granite while the hilly, plain and coastal area indicate sedimentary rock. In the Eastern part there is brittle fabric between Lebir Fault Zone and eastern coastal that illustrates the curved shear zone that occupied several N-S and NW-SE striking faults, joints and fractures (Pour & Hashim, 2017). From the ScanSAR image map as shown in figure 2.4, the sahed black lines are referring to the major faults and the red lines are indicated the faults and also fractures.

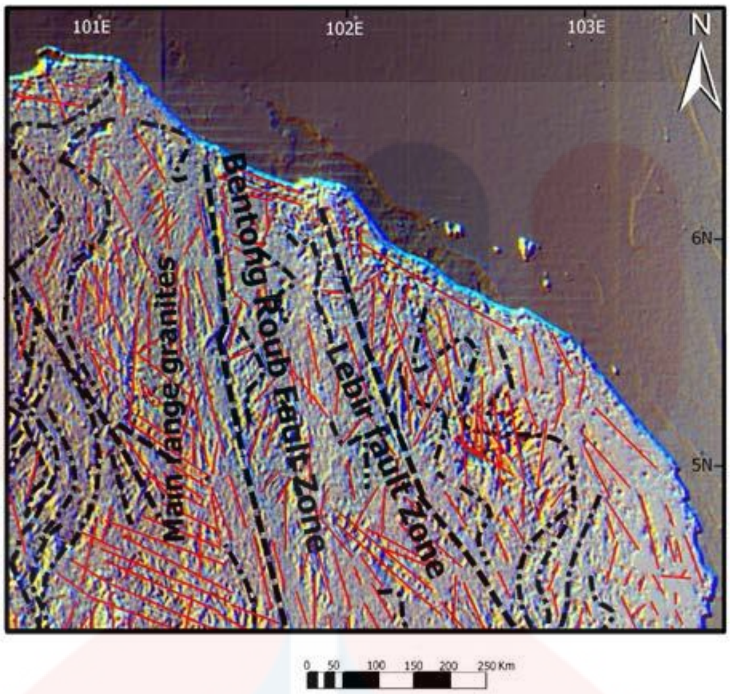


Figure 2.4: Structural Geology from ScanSAR image map of Kelantan state.
(Source: Pour, A. B., & Hashim, M., 2016)

2.5 Historical Geology

The stratigraphy of Temangan is classified based on the lithology of the area and customize by using the stratigraphy of Kelantan. A research from Daanen (2015) stated that the rifting during Early Permian periods resulted in the deposition on the edge of Gondwana of deep glacial sequences of coastal ones. The division of the Sibumasu terrane from Gondwana was the result of the Meso-Tethys opening in the late Early Permian. Metcalfe (2013), suggests the division of the Sukhothai arc from Indochina by back arc spreading. The eventual collapse of the back arc basin is attributed to the early Triassic collision between the Sibumasu Terrane and the Indochina terrane in the Late Permian (Daanen, 2015). Early Upper Triassic felsic volcanics had been deposited in the Central Belt on the Indochina Terrane. The historical geology of the tectonic formation for the study area shows in figure 2.5.

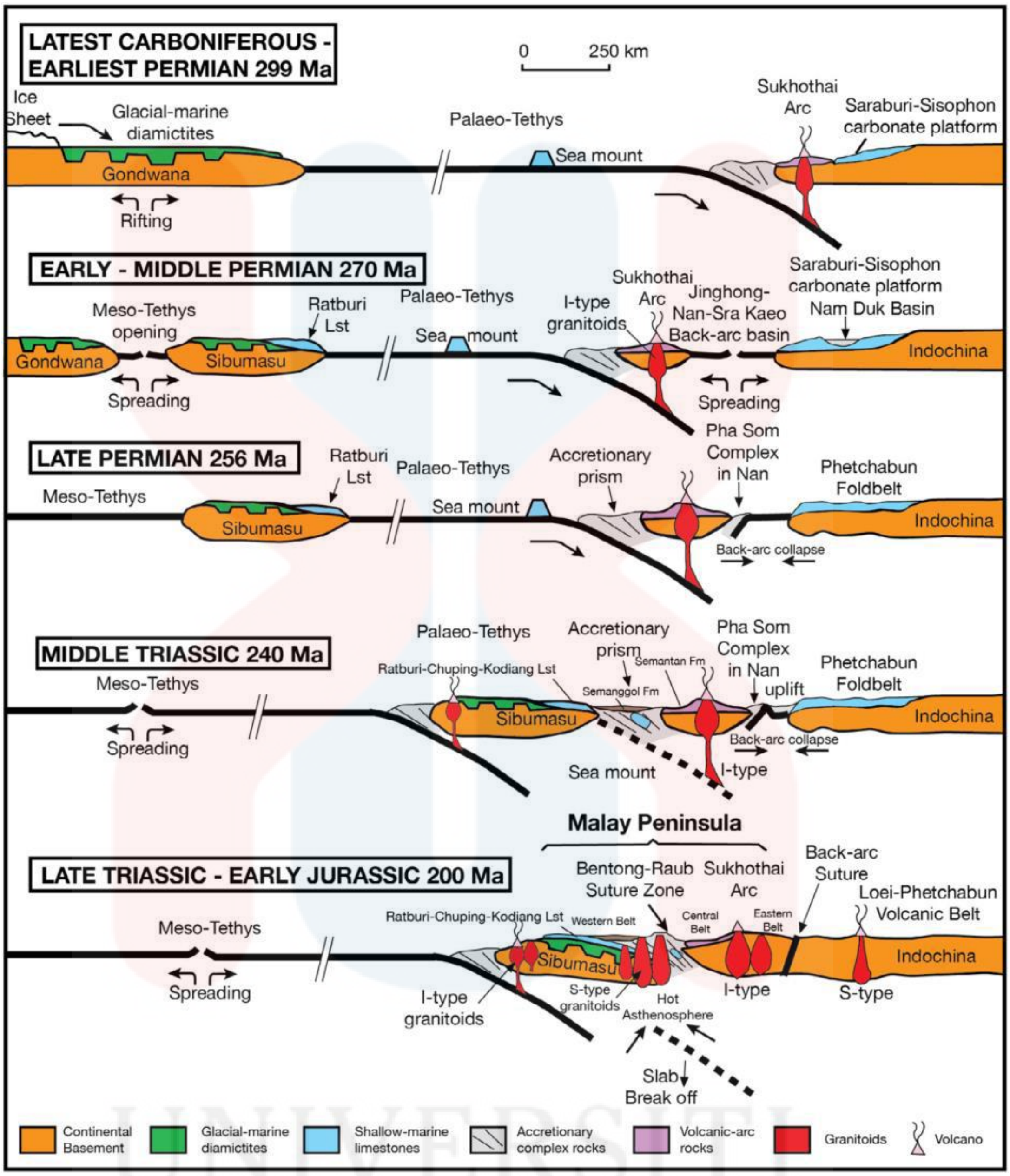


Figure 2.5: Tectonic evolution of Peninsular Malaysia.
(Source: Daanen, T. P., 2015)

Table 2.1: Stratigraphy of Temangan.

<table>
<tr><th colspan="2">Ages</th><th>Stratigraphic Unit</th><th>Lithological Unit</th><th>Explanation</th></tr>
<tr><td rowspan="4">Triassic</td><td>Late</td><td rowspan="4">Telong Formation</td><td>Thick Bedded Limestone</td><td>Thick bedded of lime-mudstone and recrystalline limestone</td></tr>
<tr><td rowspan="2">Middle</td><td>Well Bedded Limestone</td><td>Well bedded of lime-mudstone, grainstone and wackstone</td></tr>
<tr><td>Fine Grained Sediments</td><td>Mostly well bedded of mudstone siltstone and sandstone
Shale, slate, phyllite, schist and hornfels</td></tr>
<tr><td>Early</td><td>Volcanic Rock</td><td>Bedded tuff and lapilli tuff, intercalated by fine grained clastic sediment
Lenses of volcanic rock within argillites</td></tr>
<tr><td colspan="2">Permian</td><td colspan="2">Taku Schist</td><td>Quartz-mica schist and quartz-mica garnet schist</td></tr>
</table>

(Source: Malaysia-Thailand Border Joint Geological Survey Committee, 2006)

2.6 Fault Analysis

Fault is one of the geological structures that form of a fracture when there is a rock shifting that caused by the tectonic activity. By Roberts & Bally (2012) mentioned that stress that act upon the rocks have to be observed to understand the fault formation. To interpret the amount of stress that describes the forces, dynamic analysis has to be do. The relationship between stress and strain can be deriving and stereographic projection and Rose diagram is the way how to interpret the way of the forces. The high amount of forces will be the major stress and known as $\boldsymbol{\sigma_1}$. A study by Ragan & Ragan (1973) stated that the stress of fault having two dimensions which are shear failure is used to describe shear fractures and extensional fractures in rocks.

From Scarselli et al., (2020) in their book stated that the principal stress of rock can be defined as $\sigma_1 > \sigma_2 > \sigma_3$ and this will be identify using the dynamic analysis. Based on Rosenau (2004), through the kinematic analysis, reconstruction of movements can be identifying when there is formation or deformation of rocks.

Kinematic analysis is the study of the lithosphere's motion, including measurements of the rate of motion of the plate, the volume of fault slip, and the distortion of ductile deformation rocks. According to Waldron & Snyder (2020), there are 4 various movement of kinematic deformation which are translational that been measured as a displacement or change in position, rotation that been measured in degree or change in orientation, change in area or volume or known as dilation and the last type is change in shape which is distortion.

Kinematic analysis is a technique used to evaluate the potential of different rock slope failure modes due to the presence of unfavourably oriented discontinuities that having a potential to face with failure planes. According to Goodman (1989), a toppling failure requires the movement of inter-layer slips.

Based on the application of Landsat-8 and ALOS-2, the lineament indicates fault zone which major faults that are strike slip with both sinistral and dextral movement and trending to N-S and NW-SE Pour & Hashim (2017). The lebir Fault Zone having sinistral strike slip fault which trending NW-SE. Pour & Hashim (2017) stated that the movement pattern of sinistral along the Lebir Fault Zone is the main of the formation of folding and reverse fault that adjacent to the fault and the study area.

Based on Setiawan & Abdullah (2005), there may have three deformations that produce forces in Lebir Fault Zone. The main forces which is $\boldsymbol{\sigma_1}$ toward NE-SW that produce fault with a reading N(340˚ - 0˚)E/60˚ - 80˚ which indicate sinistral reverse fault toward SW-NE (Setiawan & Abdullah, 2005). The second force is compressional forces, $\boldsymbol{\sigma_1}$ toward NNW-SSE that produce conjugate fault toward E-W and ESE-WNW (Setiawan & Abdullah, 2005). The third force is compressional forces, $\boldsymbol{\sigma_1}$ toward W-E and produce dextral reverse fault and sinistral reverse fault that toward SE and NE with tilted to NW and SE (Setiawan & Abdullah, 2005).

There are three main fault types that occurred when there are kinematics and displacement as shown in Table 2.2. In each fault there will be two blocks which are hanging wall and foot wall.

Table 2.2: Types of faults.

Type of Fault		**Definition**
Normal fault		Occurred when the hanging wall moves downward, that relative to the footwall
Reverse fault	Reverse fault	Occurred when the footwall moves downward, that relative to the hanging wall at high angle of dip > 45˚
	Thrust fault	Occurred when the footwall moves downward, that relative to the hanging wall at high angle of dip < 45˚
Strike slip fault	Right lateral	Two blocks slide past one another which one of the displacement of the far block is moving to the right when viewed from the either side
	Left lateral	Two blocks slide past one another which one of the displacement of the far block is moving to the left when viewed from the either side

(Source: Tanner, D., & Brandes, C., 2019)

CHAPTER 3

MATERIAL AND METHODOLOGY

3.1 Introduction

Materials and equipment would be use in the method process. Six phases had been divided in these studies which are preliminary studies, data processing, data analysis and interpretation and report writing. All the material and method was important to ensure all the accurate data could be collect fulfilled.

3.2 Materials

Materials and equipment were important tools during the research study and would be used for data collecting. Topography map was used to identity and to interpret the geological structure. It also been used to see the elevation, vegetation and lineament that being the indicator of the presence of faulting. The note book should be used to ensure and guarantee that no data was lost, and to write down all the relevant information and necessary data that would be used along with stationary.

For making a geological map, ArcGIS or ArcMap 10.3 and MapInfo would be used to help in the updating of the map in the study area. Stereonet, GeoRose and Stereographic Projection would be used in the making of structural analysis in the 3D orientation of fault and joint analysis. The used of Google Earth Pro would help in the comparison of the latest updated map and to make the cross section. CorelDRAW would be used to the make drawings and sketches in the aid for the cross section.

3.3 Methodology

In a geology research, several methods were require to obtain and accurate data processing that having 4 phases. Phase 1 was for preliminary research of the research area and research proposal. Phase 2 would involve in data collection using the secondary data such as geological map and general geology. Phase 3 would be data processing and data analysis and Phase 4 required discussion, conclusion, report writing and submission for the evaluation.

To produce a geological map, all the secondary data could be obtained from website and agencies. USGS is one of the website that provides satellite images that could be processes using ArcGIS software to get the basic data for instant contour and river. The research flowchart in general, shows in Figure 3.1.

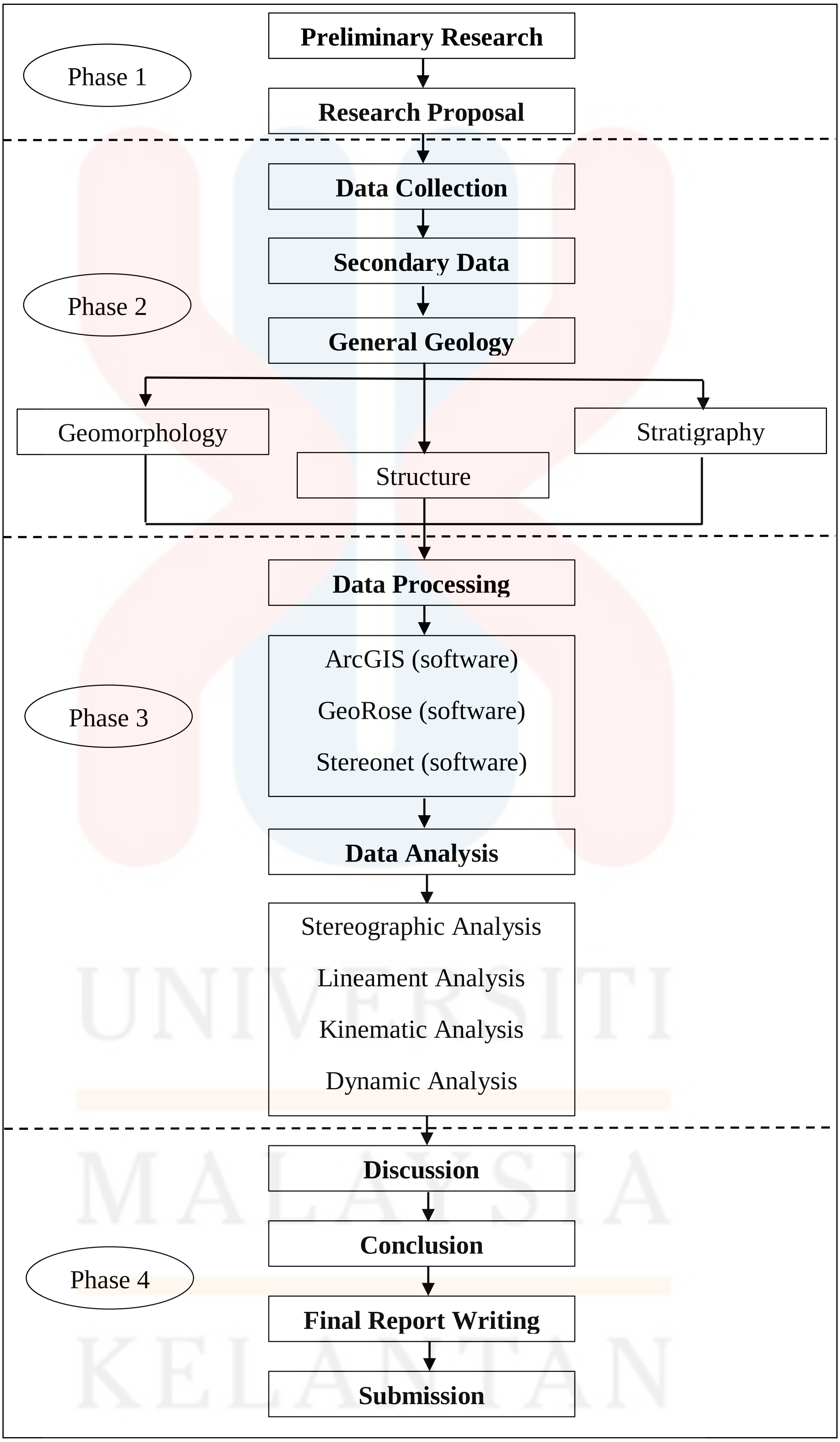


Figure 3.1: Flowchart of the research.

3.3.1 Preliminary Studies

Preliminary studies would be carrying out before the research at the study area is going. These include the study of the study area and map preparation for the research. All the layers of digital data would be adding into the ArcMap 10.3 to get the base map of the study area. Extras information could be get through previous reports, journal, article and thesis.

3.3.2 Secondary Data

The mapping had been covers 25km^2 of research area and had to get all the data. The area would be interpret using the secondary data and some of it been transferred to ArcGIS such as structural geology, stratigraphy and geomorphology and would be using to update the geological map. Any of geological structures that present in the research area from the previous study had to be analysed by using Stereographic Projection from the data of strike and dip to determine the σ_1, σ_2 and σ_3 forces. The data of strike and dip could be getting from the previous study that related and correlated with the study area. This could be referred to the thesis by Nur Shafiqah Shahman at Universiti Malaysia Kelantan (UMK) Library. The mapping method would be done by the remote sensing imaginary. For this study area digital elevation model (DEM) would be used in the interpretation of the fault analysis. The digital elevation model (DEM) from United States geological Survey (USGS). As the resolution of the LiDAR data is high so the Digital Elevation model of the LiDAR data can show the fault line.

3.3.3 Data Processing

Structural map and cross section of the study area need to be done. All the rock units and major geologic structure that present in the map need to be drawn in the cross section. Data of strike and dip from the previous study that can be get from thesis at Universiti Malaysia Kelantan Library, will be plotted in the Stereographic Projection, Stereonet and GeoRose for structural analysis. The stereographic projection method and the stereonet, along with the methods of plotting will be combining. Using the digital elevation model (DEM) from USGS will be transfer into GIS software. The DEM will produce fault delineation under dense vegetation, terrain elevation and lineament.

3.3.4 Data Analysis and Interpretation

An updated geological map of Temangan area with a scale of 5 x 5 km was produced by using the ArcGIS software that combining all the geological data. The geological data that would be insert into the geological map for instant strike and dip, fault line, lithology and rock boundary of the study area.

Analysing and interpretation process would be done using all the data that we have by the secondary data. From the terrain map by Google Map, lineament analysis for fault analysis could be done and satellite imagery can help in the determination of analysing of structural geology. Using the DEM the area of the fault could be interpreted and could be processes by using the tin to see the 3D Kinematic analysis and dynamic analysis was used to interpret the fault and also the forces and its directions.

By using the DEM, a lineament analysis could be interpreted and a lineament map could be produced. The lineaments were being identified by using the contour or topography and the drainage pattern of the study area. Lineament was one of the indicators of the fault analysis. This lineament analysis would be compared with the lineament analysis in the terrain map. All the lineament analysis would be compared with the kinematic analysis and dynamic analysis. As to strengthen the analysis and interpretation, the stereographic analysis would help to know the orientation of lines and planes those projects in a sphere.

Result from the lineament analysis, kinematic analysis, dynamic analysis and stereographic analysis show the types of fault that occur at the study area and also the ways of the major forces which was $\boldsymbol{\sigma_1}$ forces. All of this analysis would help in the updating of the geological map of Temangan area.

CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

In this chapter which was General Geology would discussed the geological mapping that covered the geomorphology, stratigraphy, Structural geology and historical geology of the research area. All the data obtained would be interpreted and a geological map would be produced that consist of structural, lithology and stratigraphic column.

4.2 Geomorphology

According to Hugget (2011) there are three Greek words that derive the term geomorphology which are γῆ, *gê*, that stand for "earth", μορφή, *morphḗ*, which stand for "form" and λόγος, *lógos* that refer to “discourse”. Geomorphology is the study of the Earth’s surface landforms, their processes, form and sediments that influenced by the tectonic activities, climate, ecology and also human activities. Constitution, configuration and mass flow are three facets in geomorphology or morphology. Geomorphic processes are having geological forces which occur inside the Earth or called as endogenic or endogene processes, forces which originate at or near the surface of the Earth and the atmosphere been called as exogenic or exogene processes and the last processes is extraterrestrial processes that occur from outside of the Earth and produce a forces from it. These involve temperature, gravity, water, wind, and ice-related processes of transformation and transition.

Based on Van Zuidam (1985), by describing the relief of the morphology, describing the origin and the morphogenesis the classification of the landforms can be determined at the geomorphological map. The geomorphological process can be identified from the topography, drainage pattern, weathering processes which classified into three main types of weathering and mass wasting.

4.2.1 Topography

Topography is the study of the surface of the planet, the shape of the surface of the earth and its physical properties. It lays the fundamental foundation of a landscape which showing the elevation, relief and landform of the study area. For instant the topography is referring to mountains, valleys, rivers, plateaus, basins or others craters on the surface. By pushing up mountains and hills, tectonic plate movement underneath the Earth will produce landforms. The formation of the valley is created by water and wind erosion, which takes a long time and sometimes millions of years. Vegetation occupies some of the landforms, although some are void of any plant at all. Landforms were produced by many variables, but they are all grouped into two primary processes that are constructive and destructive. The constructive process includes crustal deformation, volcanic activity and deposition of sediments, while weathering and erosion were involved in the destructive process.

"Topo" for "place" and "graphia" for "writing" derive from the roots of topography. It is closely related to geodesy and surveying, which was concerned with measuring the surface of the ground accurately. For topographic map, elevation was the differentiating factor as shown in Figure 4.1.

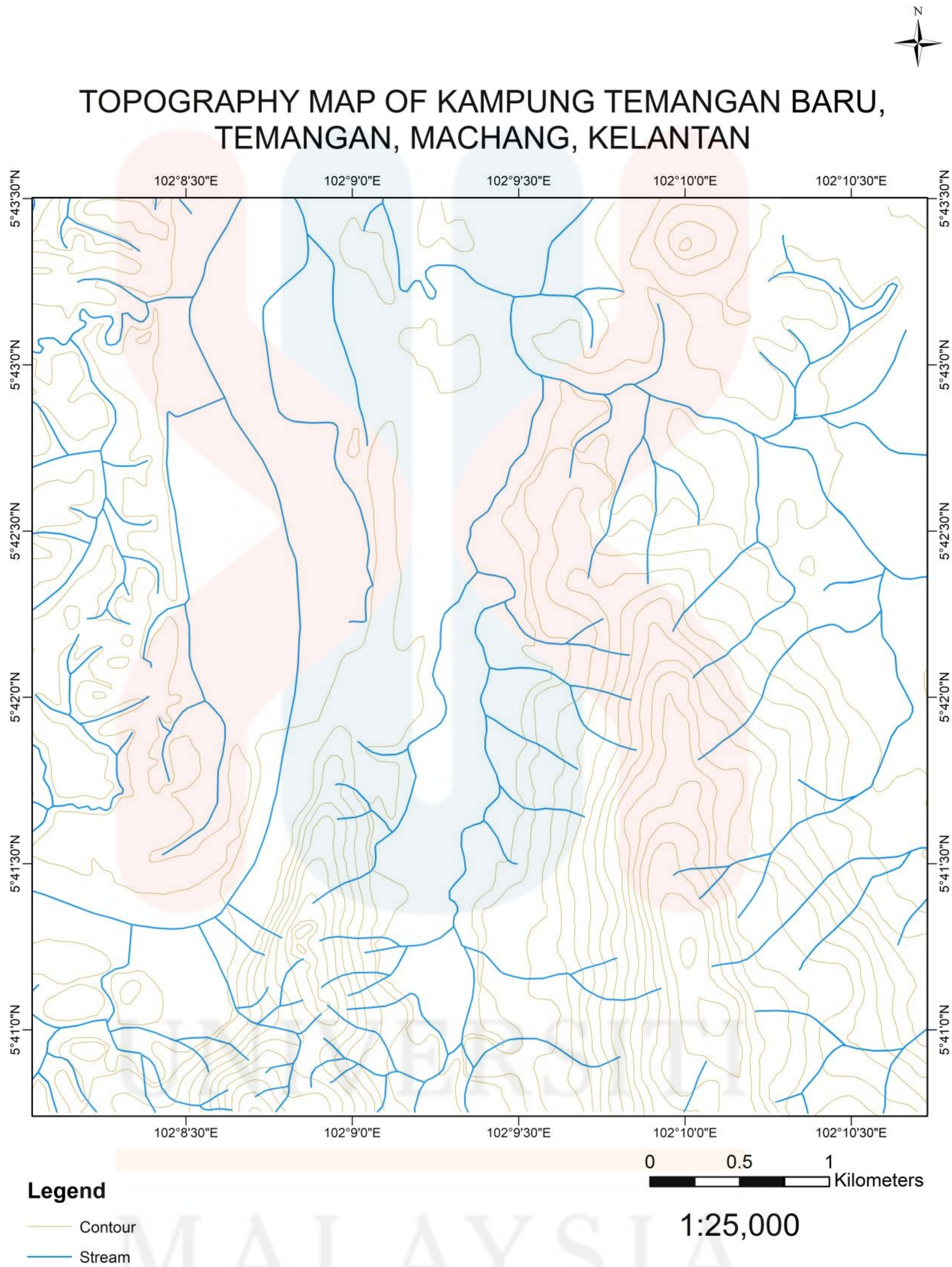


Figure 4.1: Topography map of Kampung Temangan Baru, Temangan, Machang, Kelantan.

In specific topography was the arrangement of the landforms. Topography was used to find the latitude and longitude and also the distance of different landforms above the sea level. Topographic map could be generated from the contour lines which a connect points of equal elevation. From the contour lines, elevation or height, slope, shape and also altitude could be interpreted in the topographic map and it was giving a different relationship of the morphology elements as can be seen in Table 4.1. The slope was steep if the contours were close together. But the slope was more gradual as the contours were spaced apart.

Table 4.1: Landform classification between the elevation (m) and the landform or relief.

Elevation (m)	Landform/Relief
< 5	Lowland
5 – 100	Low – Lying Plain
100 – 200	Low Hills
200 – 500	Hills
500 – 1500	High Hills
1500 – 3000	Mountains
> 3000	High Mountains

(Source: Van Zuidam, 1985)

The study area was having three main different topographies pattern which were hilly, flatty or plain and river area. The river landform area was the area of the water movement and occurred external processes. The highest elevation which is 300m was located at the Southeast of the study area which classify as hills landform. The lowest elevation is 20m that majoring covered by streams and resident area. This area was classified as low – lying plain and covered to the North area of the study research. The low hills areas majoring at the Southeast and Southwest of the study area as in Figure 4.2. As per percentage the low – lying plain and river area covered 70%, low hills having 20% and low hills only having around 10%.

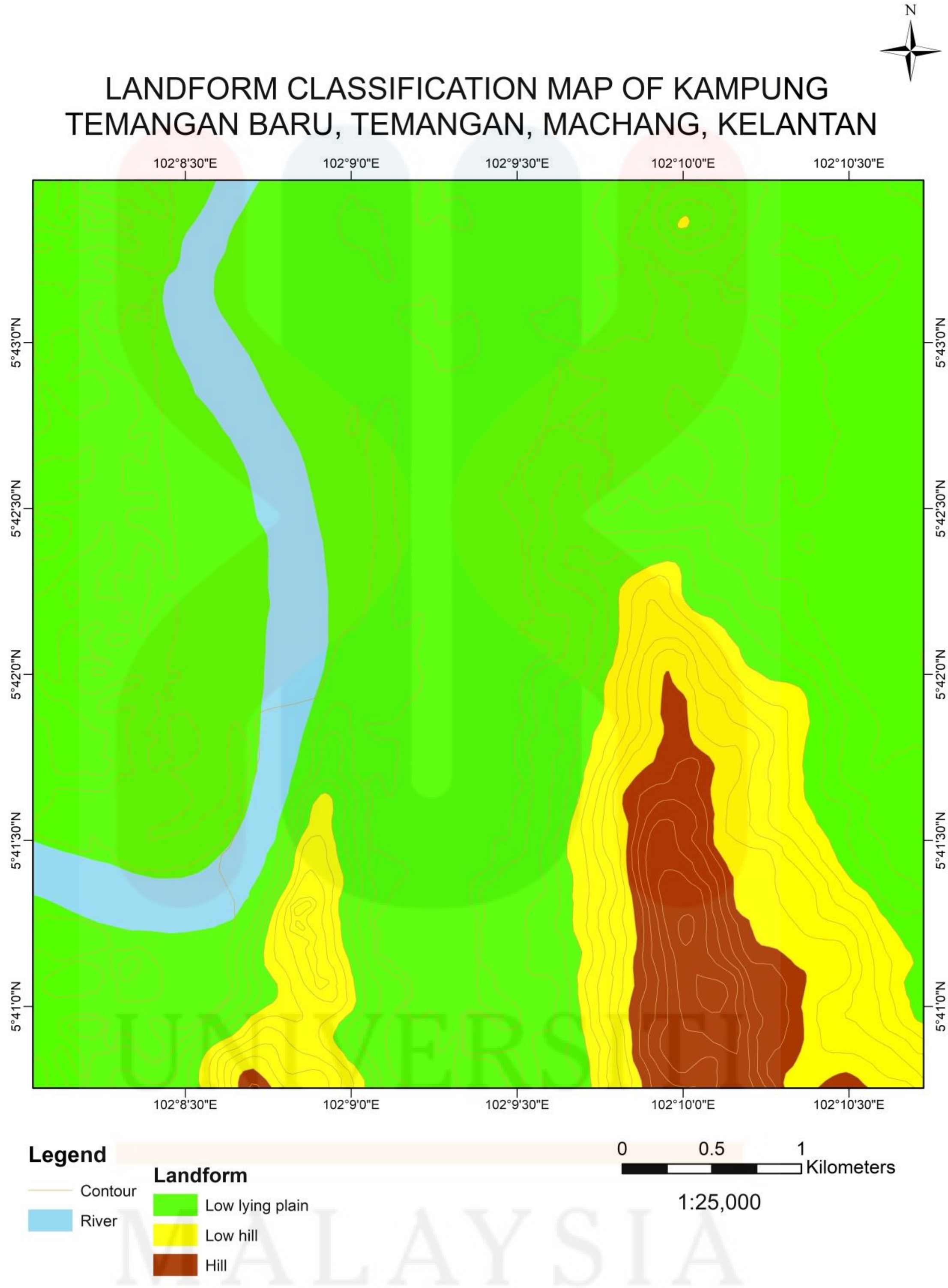


Figure 4.2: Landform classification map of Kampung Temangan Baru, Temangan, Machang, Kelantan.

4.2.2 Drainage Pattern

According to Thornbury (1969), stream flow pattern is a mixture of many river individuals that is linked to form a pattern in the spatial unity and still flows either it is affected or not by rainfall. Fluvial is connected to a stream or river that when an event occurs, may create a fluvial plain. There will be sedimentation in stream during the erosion, deposition and also transportation. To establish new landforms, the fluvial processes shape the landscape, eroding landforms, transporting sediment, and depositing it. Over time, the stream shifts and evolves, focusing in particular on how water flow interacts with the sediment movement of soil, sand, gravel, boulders and debris, such as fallen trees and branches. Sediment as well as water were found in rivers and they exert force on and release material to the environments surrounding them as they flow. When the water travels in a river, it pushes its bed and bank on the rocks, sands, and silts. Often it dislodges some of these sediments, and carries them into the channel and downstream. A river would erode and hold a lot of sediment, and bigger bits, when the water is swift and voluminous. Sediments settle out if a river slows or becomes shallow.

A simple landscape unit in fluvial geomorphology is the drainage basin or watershed. According to Monthgomery (1999), local geology, physiography and atmosphere are the watershed characteristics that essentially define the streamflow and sediment availability of a stream system. Regional regulation of the drainage system that forms on the surface of the Earth is slope, lithology, and its resistance, geological structure, type of vegetation, density, and other factors. The largest, or trunk, river and its tributes are included in a drainage basin. Floodplain landforms exist, and striking landforms are formed by the depositional habits of fluvial systems.

Fluvial deposits are sediment formed by a stream's flowing water. The relatively flat surface that adjoins the river or stream is a floodplain. During floods, water flows over the floodplain and deposits sediment when the stream overflows its banks. Streams create floodplains by fluvial processes that handle their full flood potential.

As shown in Figure 4.3 there were three main drainage pattern that possible to observe in the study field which were dendritic, radial and rectangular. The most common drainage pattern which joined together like a branch of trees is the dendritic pattern. This pattern was essentially flat-lying feature and the path taken by the river and its water channels flow between the ridge valleys. As the river channel follows the slope of the landscape, it was formed. It occur at the v-rule or or v-shaped valley which referring to homogeneous matter which the lithology underlying this pattern. The dendritic pattern was coloured by yellow and majoring the Northwest to Southwest.

Other than that, radial pattern that was coloured with green forms around a central elevated point where the direction of water flow is from high elevation point to low elevation contour point or the streams from a central high point radiate outwards. It was found on topographical domes, such as volcanic cones and isolated conical hills of other kinds. On a large scale, radial drainage networks form over mantle plumes on rifted continental margins that generate lithospheric domes or lacoliths.

The last draingae pattern is rectangular pattern which controlled at the zone that having a bit topography and a bedding planes, joint, fractures and fault that occurs on rocks that are of approximately uniform erosion resistance, but have two joint directions at approximately right angles. The joints are generally less erosion resistant than the bulk rock, so erosion tends to open the joints preferentially, and gradually streams build along the joints. The outcome is a stream system in which streams consist predominantly of straight line segments with right angle bends and tributaries at right angles join larger streams. The rectangular pattern majoring at the southeast and minor at the northeast of the study area which in red colour.

Watershed is a land area that captures precipitation and other rainfall and channels it to a lake, river or waterlands (Plan, 2003). According to Edwards et al. (2015), the border of the watershed is distinguished by its topographical high points. In mountainous or hilly terrain, watersheds are fairly easy to classify because their boundaries are defined by ridges. However, it can be very difficult to distinguish topographic high points in flatland watersheds since the highest and lowest elevations can only vary by a few centimetres.

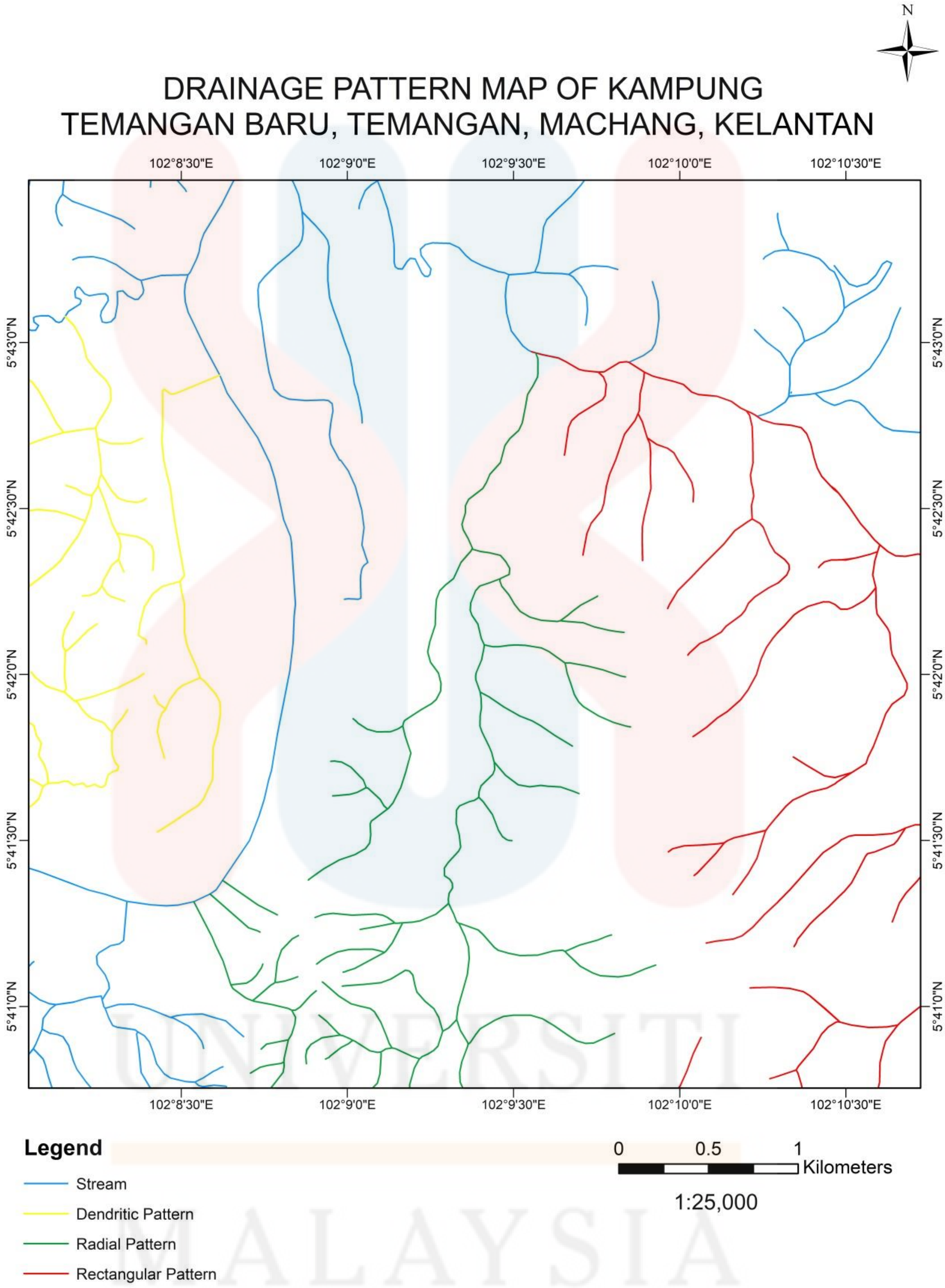


Figure 4.3: Drainage pattern map of Kampung Temangan Baru, Temangan, Machang, Kelantan.

4.2.3 Weathering

According to Hack (2020), weathering is the modification of surface materials under the influence of the Earth's atmosphere, hydrosphere, cryosphere and biosphere, by mechanical disintegration and chemical decomposition. According to Earle (2019), mechanical disintegration form rocks into smaller size of fragment and for the chemical decomposition is the change of mineral composition in a rock that stable with the surface environment. Weathering also enables the degradation of soil structure to a certain degree, the geotechnical consistency of the ground is due to a tight structure of particles and blocks of ground material. When weathering causes loss of part of the material or decreases the strength of particles or blocks, the tightness of the structure is decreased stated by Hack (2020). A study from Earle (2019) both of the processes produce important things, one being the solution of sedimentary clasts and ions that can eventually become sedimentary rock while the other being the soil that is required on Earth for our life.

There are there main type of weathering which are physical weathering or also known as mechanical weathering, chemical weathering and biological weathering. Based on Hack (2020), physical weathering can be clarified as results in the breakup of land masses into increasingly smaller parts without altering its elements. Differential expansion due to temperature changes, wetting and drying, freezing and thawing, water and ice pressures in pores between particles in intact soil and in discontinuities, (re-) crystallisation pressures, hydration, swelling and shrinkage of minerals due to water absorption are the key processes in the breakup of soil (Hack, 2020). The physical weathering also can be occurred when Lightning hitting the ground and fires can also cause fragment reduction based on study from Allison & Bristow (1999).

According to research from Panchuk (2019), chemical weathering is the result of chemical modifications to minerals that become unstable when they are exposed to conditions on the soil. The types of changes that occur are unique to the mineral and the condition for the climate. In a simple words, it is occurs when the minerals that make up a rock are chemically changed (Gifford, 2005). Gifford (2005) also stated that there a various types of chemical weathering which are oxidation, hydrolysis, hydration and Panchuk (2019) in her study also add on the dissolution process as the chemical weathering.

A study from Sattar et al. (2019), the breakdown of rock and landforms by processes that are organic in nature is biological weathering. This includes the penetrative growth of the tree root into established rock cracks, animal weathering where their decomposition of organic materials can contribute to the development of weathering-capable organic acids that forming chemicals, as well as lichen and microorganisms contributing their own weathering effects when located as a substratum on a rock. Biological weathering can lead to the further deterioration of rocks and rock particles, along with other weathering forms, by making them more vulnerable to other environmental factors, whether biotic or abiotic factors.

As in Figure 4.4 the average rainfall at Machang from January to December for 10 years are high intense. The rainfall would enter the streams and starting to flow to the watershed. As the fluvial starting to move, the landform starts to face with the erosion. According to the Lech & Trewin, (2013) rain falls on the ground and through the overland flow where, after it falls, rainwater travels through the ground and soil erosion occurs. Soil erosion is physical weathering processes that remove the land surface by forces that come from water. Soil erosion has three types which are cut rills, gullies and river channel. As in Figure 4.5 there was main river which is Sungai Kelantan that classified as meandering channels. The water flows through the meandering channel, encourage the erosion of banks and formation of point bars. The high intense of rainfall lead to the floodplain where the alluvium was carried during Quaternary and known as mass wasting.

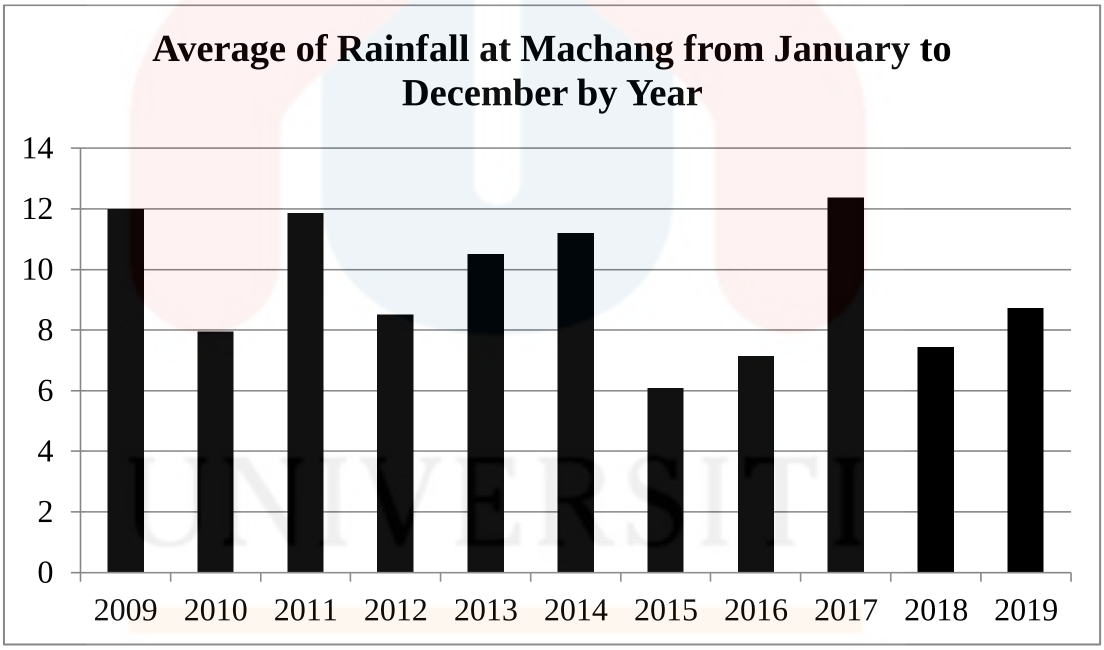


Figure 4.4: Average of rainfall at Machang from January to December by year.
(Source: Jabatan Pengairan dan Saliran)

Figure 4.5: Meandering Map of Machang Area.
(Source: Google Earth)

4.2.4 Mass Wasting

According to a study by Earle (2019), mass wasting or known as slope failure is the loss and downslope movement of rock or unconsolidated materials in reaction to gravity and mass phenomena that related to the weathering process. Geologically, landslide is a general term for mass wasting that includes geologic material that travels rapidly. Loose material is what usually moves during a mass-wasting event along with overlying soils. Depending on the prevailing motion of the rocks, shifting blocks of bedrock are called rock topples, rock slides, or rock falls. Flows are considered motions of a mainly liquid substance. Mass-wasting motion may be sluggish or fast. Rapid motion, such as during debris flows, can be hazardous. Areas with steep topography and rapid precipitation are particularly vulnerable to hazardous mass-wasting events. The classification of the slope failure can be seen in Table 4.2 and Table 4.3 from a different researcher.

As in Figure 4.6 the water level at the Machang area was high at the range between 15 to 24 for the ten years. The mass movement occur with the help of water as the agent due to the influence of the mass wasting phenomena that having a relationship with the weathering process where. From the high intense of rainfall the water level would be increase. This occurred due to the decreasing in the velocity of sediments carried by the stream that form alluvium. Large particles are deposited, and a great deal of this material is placed alongside of both banks.

Table 4.2: Classification of slope failures types based on material type and movement type.

Failure type	Type of material	Type of motion	Rate of motion
Rock fall	Fragments of rock.	Near-vertical or vertical dropping and can bouncing at some cases.	Very quick (>10s m/s)
Rock slide	A huge rock body.	Motion along a planar surface as a unit or known as translational sliding.	Typically very slow (mm/y to cm/y), but some can be quick
Rock avalanche	A huge body of rock that slides and then splits into tiny fragments.	The mass of rock fragments is suspended at high speeds on a cushion of air by flowwing.	Very quick (>10s m/s)
Creep or solifluction	Soil or other overburden; combined with ice, in some cases.	Flow with a sliding motion.	Very slow (mm/y to cm/y)
Slump	Thick deposits of unconsolidated sediment.	Motion along a curved surface as a unit or in rotational sliding.	Slow (cm/y to m/y)
Mudflow	Loose sediment with a significant silt and clay component.	Flow with a sand and water mixture travels down a pipe	Moderate to quick (cm/s to m/s)
Debris flow	Sand, gravel and huge fragments.	Flow as a mudflow but faster that it.	Quick (m/s)

(Source: Steven Earle, 2019)

Table 4.3: Classification of slope movement of Varnes (1978).

Type of movement		Type of material		
		Bedrock	Engineering soils	
			Predominantly coarse	Predominantly fine
Falls		Rock fall	Debris fall	Earth fall
Topples		Rock topple	Debris topple	Earth topple
Slides	Rotational	Rock slide	Debris slide	Earth slide
	Translational			
Lateral spreads		Rock spread	Debris spread	Earth spread
Flows		Rock flow (deep creep)	Debris flow (soil creep)	Earth flow
Complex		Combination of two or more various principle of major movement		

(Source: Jan Novotny, 2013)

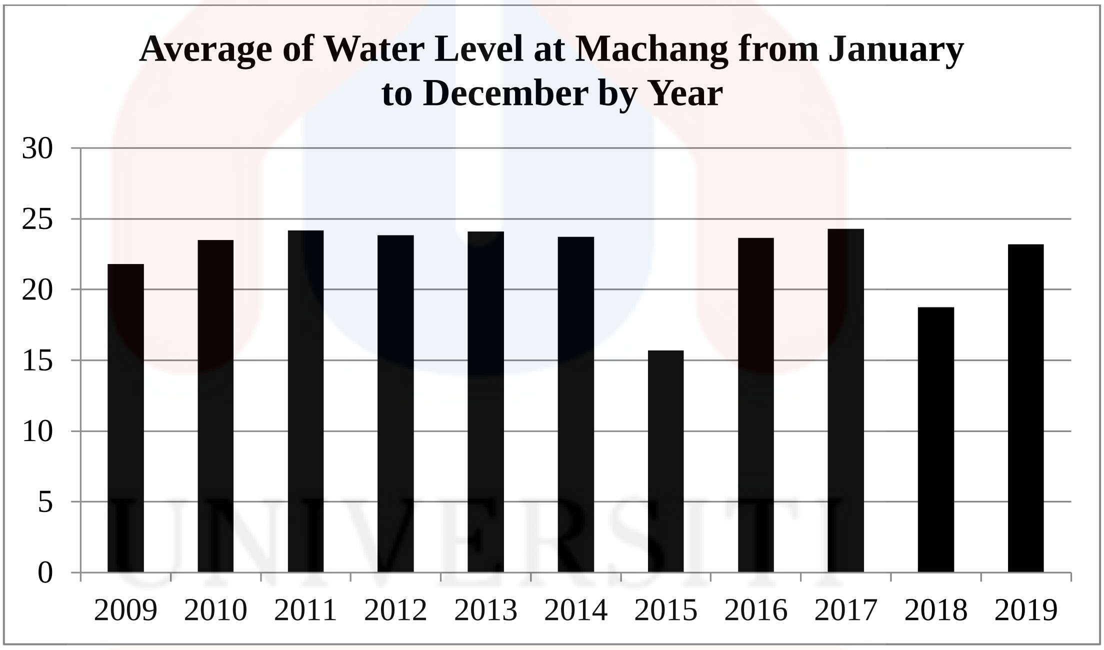


Figure 4.6: Average of water level at Machang from January to December by year.
(Source: Jabatan Pengairan dan Saliran)

4.3 Stratigraphy

According to Macleod (2005), stratigraphy is the field of geology concerned with sedimentary rocks and layers that discussed regarding formation, composition, sequence and correlation of stratified, and how they relate to geological time and it is an integral part of historical geology. Nichols (2009) stated in a research stratigraphy can be seen as the relationship between rocks and time, and in order to evaluate the past of the Earth, the stratigraphy is concerned with the study, definition and analysis of direct and tangible rock facts. Simple stratigraphic relationships may determine the relative ages of rocks, and hence the events reported in those rocks (Nichols, 2009).

4.3.1 Regional Geology of the Study Area

Temangan district which located between Machang and Tanah Merah was identified in Geological Map of Tanah Merah New Series L 7010 Sheet 22 (Hamzah & Hamzah, 2014). The geological map covered half of the study area. By referring to the geological map, the study area consist of three formations which where Temangan Ignimbrite, Telong Formation and Taku Schist.

- Temangan Ignimbrite = dyke intrusion that present during Late Triassic.
- Telong Formation = Argillite sedimentary rock, pyroclastic rock, arenite and metamorphosed limestone that turn to slate, phylite, low grade schist and crystalline marble where pyroclastic rock and lava are more dominant, bordered as volcanic facies that present during Triassic.
- Taku Schist = low grade metamorphic rocks that consist of quartz mica schist, quartz schist and amphibolite shict that occur during Permian.

Based on the previous study from Shaman (2017), the study area were having four main formation which are Alluvium, Temangan Ignimbrite, Telong Formation and Taku Schist. The formation occured during Quartenary to Permian. The study area with the coordinate 5° 40' 45'' N to 5° 43' 0'' N and 102° 8' 0'' E to 102° 10' 45''

E is overlap 30% with the previous study, 5° 39' 30" N to 5° 42' 0" N and 102° 7' 30" E to 102° 10' 0" E.

- Alluvium = The deposition of alluvium consists mainly of gravel, sand and clay where mostly from the sedimentation process. This occur by the transportation process that widely spread in flat river valleys.
- Temangan Ignimbrite = Occured as a dyke intrusion that having reddish to dark brwon colour with medium grained and consist of prophyritic.
- Telong Formation = Mainly consist of andesite and shale.
- Taku Schist = Mainly consist of Schist.

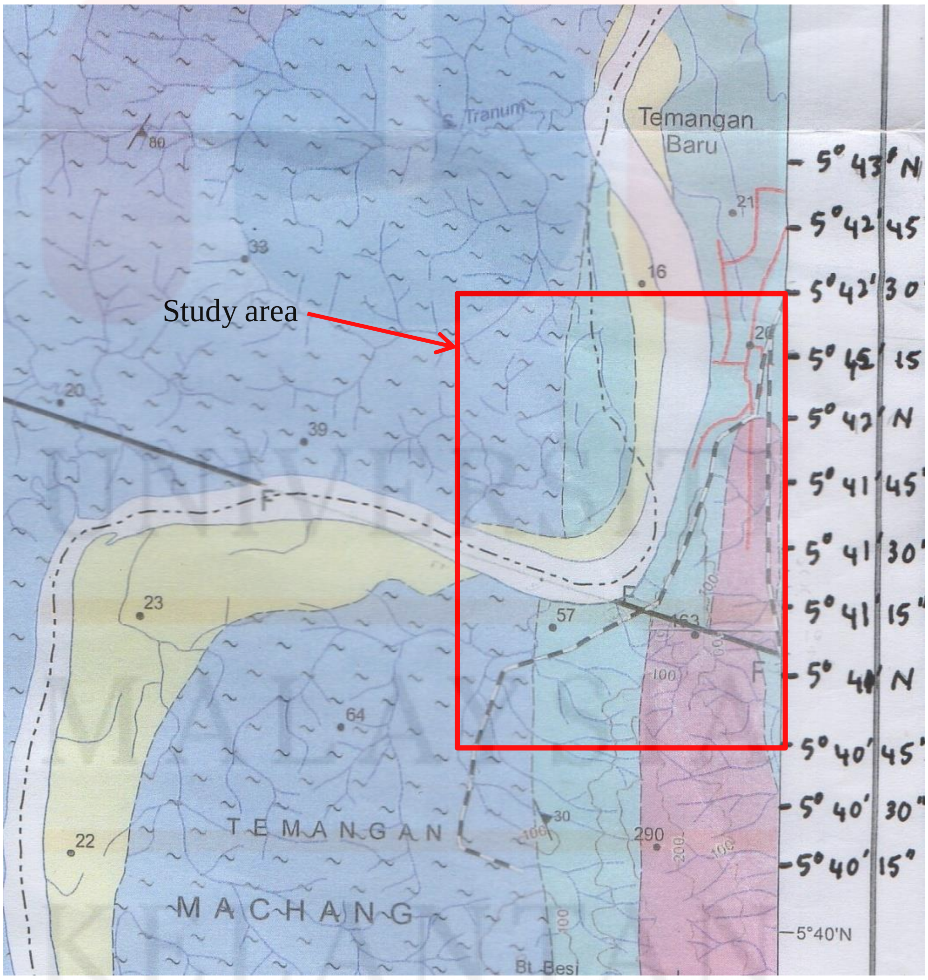


Figure 4.7: Geological map of Tanah Merah Area New Series L 7010 Sheet 22 with the study area. (Source: Ab. Halim Hamzah & Mustafar Hamzah, 2014)

4.3.2 Lithology

From a study by Bates & Jackson (1980), lithology relates to the analysis and description of rock physical characteristics, particularly in hand and outcrop specimens. According to Nichols (2009), in terms of the lithological features of the strata and their relative stratigraphic locations, rock units are called in lithostratigraphy. By considering geometric and physical relationships that indicate which beds are older and which ones are younger, the relative stratigraphic locations of rock units can be determined (Nichols, 2009). The units can be grouped into a hierarchical structure of members, formations and classes that provide a framework for lithostratigraphic terminology for categorising and describing rocks (Nichols, 2009).

There were five main lithologies that present in the study area which were Alluvium, Ignimbrite, Andesite, Shale and Schist as in Figure 4.8. All of the lithologies could be divided into four formations which are Alluvium, Temangan Ignimbrite, Telong Formation that consist of Andesite and Shale and Taku Schist.

The youngest formation in the study area was Alluvium which lies on Quaternary that having unconformity with the Temangan Ignimbrite. The alluvium located along the river where there was high sedimentation process. Alluvium present when the sedimentary rock that being transported from a higher place as a stream flows that down a hill and transport by water to a flat plain that composed of gravel, sand and clay. The study area was covered with floodplain along the main river of Sungai Kelantan.

Temangan Ignimbrite present during Late Triassic which contain iron ore. Based on the research by Harun, Kamal, etl, (2012), the iron ore deposits of Kelantan were popularly known in the Temangan region and had previously been mined for iron ore from 1935 to1965, with a total output of4, 856, 214 tonnes. In Table 4.4 Iron ore was found with the 56.2% of Fe.

Table 4.4: Iron ore that present near the study area.

Machang district	Longitude	Latitude	Resource (tonnes)	Grade Fe (%)
Kampung Bukit Besi, Temangan	102° 7' 50.885" E	5° 39' 53.122" N	20, 136, 214	56.2

(Source: Hamadi bin Che Harun, Kamal bin Daril, Zulkipli bin Che Kasim, et al, 2012)

Telong Formation consists of Andesite that interfingering with the shale during Middle Triassic to Permian. Andesite was extrusive rock where it was come from lava. The interfinger occurred when the andesite intrude at the shale rock. The rock was classify as andesite due to the previous research from Shahman (2017) found a hand specimen that having porphyritic phenocryst rock texture. A hand specimen found by Shahman (2017), shale at the research area found in sheets that easy to break. The finding found by Shahman (2017) was same as the geological map of Tanah Merah New Series L 7010 Sheet 22 (Hamzah & Hamzah, 2014).

According to Hamzah & Hamzah (2014), the authors agree with the view that their age was slightly older than the Telong Formation based on the resemblance of pre-metamorphic rocks and their conditions in line with the surrounding rocks which was as Permian. Schist is formed from the metamorphosis of mudstone or shale that having a foliation due to the high changes of temperature and pressure.

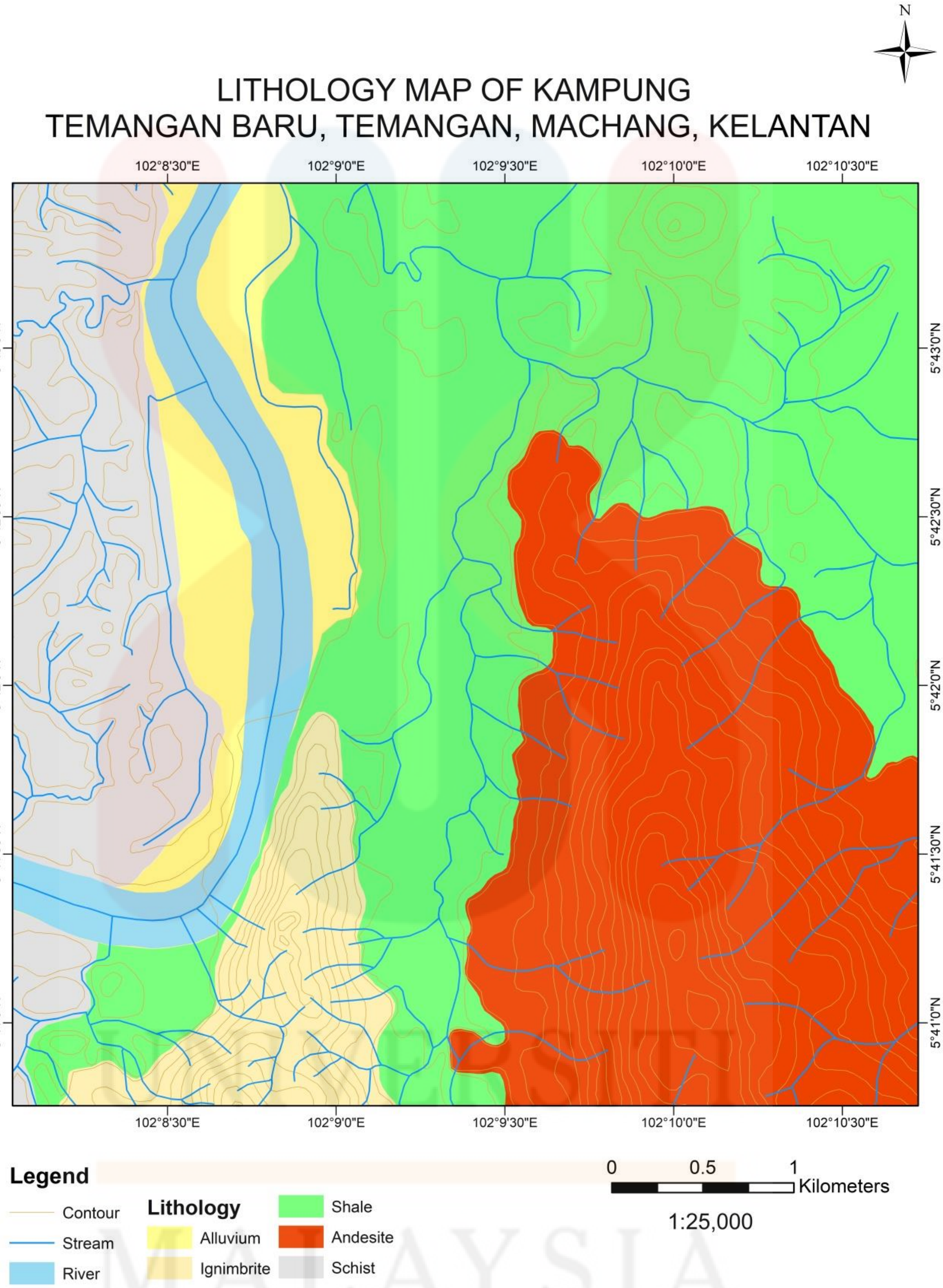


Figure 4.8: Lithology map of Kampung Temangan Baru, Temangan, Machang, Kelantan.

4.3.3 Stratigraphic Position

Stratigraphy or lithostratigraphy is the layer of rocks that defined the lithology and related with the geologic age. According to Moore & Wade (2013), lithostratigraphy, the organisation of rock units on the basis of their lithological character, and chronostratigraphy include stratigraphy, the organisation of rock units on the basis of their age or period of origin. Lithostratigraphy used to determine the age of the study area which important in a research. The stratigraphic aspect is the description and nomenclature, on the basis of their lithology and their stratigraphic relations, of the rocks of the Earth.

The oldest rock at the study area was the Taku Schist during Permian. A research from Hamzah & Hamzah (2014), they classified the Taku Schist as Permian after they had conclude from three main research which stated that Taku Schist had been unconformity with Telong Formation during Pre-Cambrian and Pre-Carbon, Taku Schist was same with metasedimentary rocks that overlap during Triassic to Late Palaeozoic and a radiometric study that determined age of Taku Schist that state it is from Early Triassic. Telong Formation that having interfingering between it lithology that having low grade metamorphosed. During the Late Triassic Temangan Ignimbrite was present. This rock unit named as Ignimbrite ridge and a detail research stated that this rock is an intrusive rock with Ignimbrite composition (Hamzah & Hamzah, 2014). The alluvium that occurred during the Quaternary covers flood plains, such as Sungai Kelantan, along major rivers. The deposits of alluvium have different widths and were not constant down the shore. Alluvium deposits were concentrated in the areas downstream where meandering river had been. The presence in the alluvium region of small rock outcrops that produce the thickness of the alluvium is only thin (Hamzah & Hamzah, 2014).

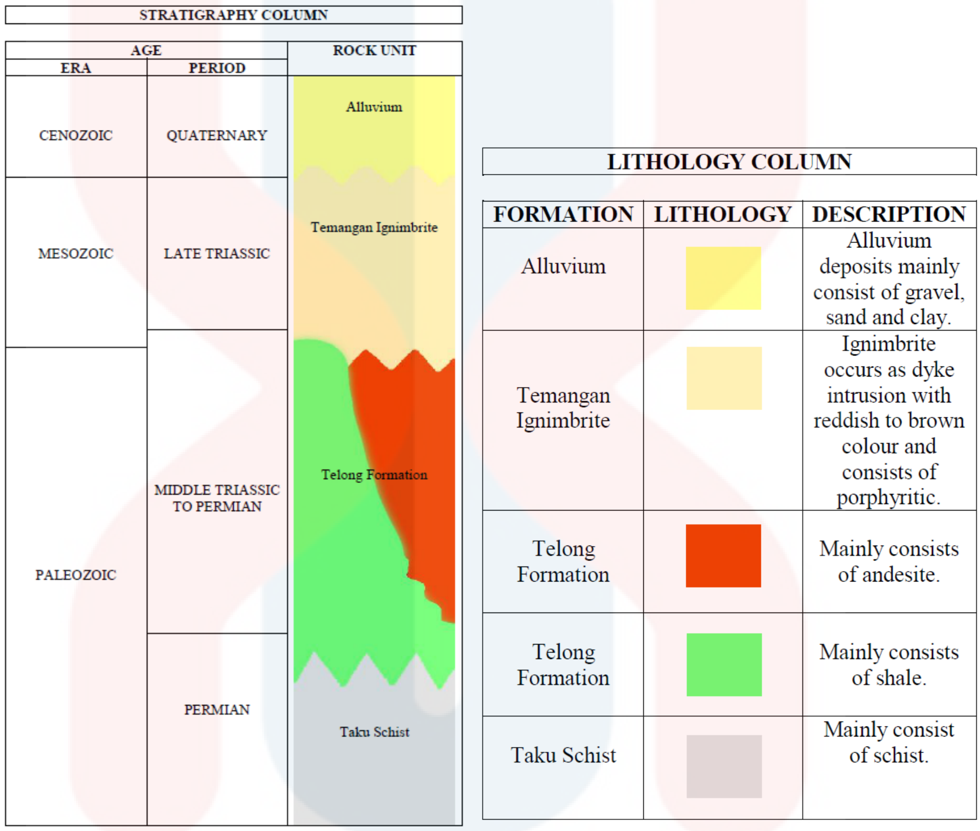


Figure 4.9: Stratigraphy column and lithology column

4.4 Structural Geology

4.4.1 Structural Geology of the Study Area

A research by Park (2013), structural geology is created by deformation through the action of forces on the surface of the earth and within it. Structures consist of planes, lines, surface bodies and rock bodies in a geometric arrangement. This arrangement's shape and orientation illustrate the interaction between the deforming forces and the pre-existing rock body. Structural geology is about the deformation structures in the lithosphere such as joint and fault that occur in various different settings and exciting improvements in stress and strain have taken place

Fossen, 2016). The deformation could be analysed using terrain map and did a lineament analysis that would be processed by rose diagram. Strike and dip data were really important for the structural geology.

4.4.2 Lineament Analysis

Lineament was defined by Hobbs (1904), as a major landscape lines triggered by joints and faults that expose the rock basement architecture. According to Parbu & Rajagopalan (2013), lineaments were classified as extended linear or curvilinear mappable features of a surface whose components align in straight or almost straight relationships that may be the expression of subsurface fractures or faults. They might be an expression of a fault or another failure in the sequence. These characteristics could be mapped on different scales, from local to continental.

Lineaments are common geomorphological expressions of straight stream valleys and aligned parts of a valley. A tonal line can be a straight boundary between contrasting tone regions. Lineament analysis of the research area was carried out before the fault analysis is done due to the determination of the potential area that having geological structures as the lineament are the indicator of faulting. Based on the research by Jamari (2018), the satellite image line on the map could be described as any of the linear characteristics of a valley-based landscape, mountain range, straight coastline, straight river line and any feature combination.

4.4.3 Joint Analysis

From a research by Ghosh et al. (2018), joints are the opening mode fractures or mode discontinuities with little or no shear displacement and some of the most frequently observed rock discontinuities in the near and deep subsurface, among others. Joints are classified in two main categories which are regional joints in widespread areas having almost constant orientations that result from a continuous state of stress, either paleo or present and tectonic joints that are related to a specific structure associated with a local tectonic occurrence. Tectonic joints can be further subdivided into fractures that are "fault-related" and "fold-related". Shear fractures oriented parallel or conjugate at 60˚ to the faults or extensional fractures can be fault-related joints Ghosh et al. (2018). According to Panchuk (2019), a joint set is formed by joints with a common orientation.

Joint having spatial relationship which are systematic joints that occurred in parallel or subparallel with a same average of spacing that normally a conjugate joint sets while the non-systematic joints that forms in irregular spatial distribution that is not parallel between the joint or normally having different average of spacing. Three common types of joints are tensional joints, shear joints and compressional joint.

Tensional joints formed when there is tensile forces which driven by shifts in the volume of rocks due to drying shrinkage in the cooling or dehydration phase and stretching of a strata's folding limbs. With jagged surfaces, the tension joints look rough and irregular. This joint type also occurred during the overlying strata being facing with weathering and expansion forces or stress.

According to Jain (2018), shear joint formed when there is shearing stress that tends to move one side of rock against the other side. These are joints, particularly folded rocks, associated with deformed rocks. At a high angle, these joints occur as intersecting or crisscrossing pairs. These joints are referred to as the joint system of conjugates. These joints are generated by the action of shear stresses that occur in phases of folding and faulting. They are intersection joints which are closely spaced.

Compressional joints was defined by Sankar (2018) as a rock that crush after being compressed and numerous joint may be produced with the effect of compressive forces. Along the compressional joints occurred there will be a joint set that produce such as cross joints. Compressive force dominates in the core fold region that deforms the rock to be bent.

4.4.4 Fault Analysis

According to Papp et al. (1998), a fault is a normal break in strata where displacement has been exposed to opposing blocks. Faults are discontinuities along which there is visible offset by shear displacement. Faults can occur as single discrete breaks along fractures, but where the rock has been repeatedly faulted, or where the rock is especially weak, no single, discrete fracture or discontinuity may be evident. From a study by Davis et al. (2011), faults are discontinuities along which shear displacement is visible offset. Faults may occur as single discrete breaks along fractures, but no single discrete fracture or discontinuity may be noticeable where the rock has been repeatedly faulted, or where the rock is extremely fragile (Davis et al., 2011).

4.5 Historical Geology

Temangan was located at the northwest part of the Kelantan state where having Ignimbrite ridge from the North to South. Ignimbrite was a high resistance rock compared with slate and phylite that easy to weathered. The study area was exposed with the Temangan Ignimbrite.

Based on Hamzah & Hamzah (2014), the geological structure was affected by the morphology of the study field. However, topography with steep cliffs and steep ridges typically shapes the region under Taku Schist. The taku schist facing with metamorphosed to medium grade of metamorphic rocks due to the tectonic setting.

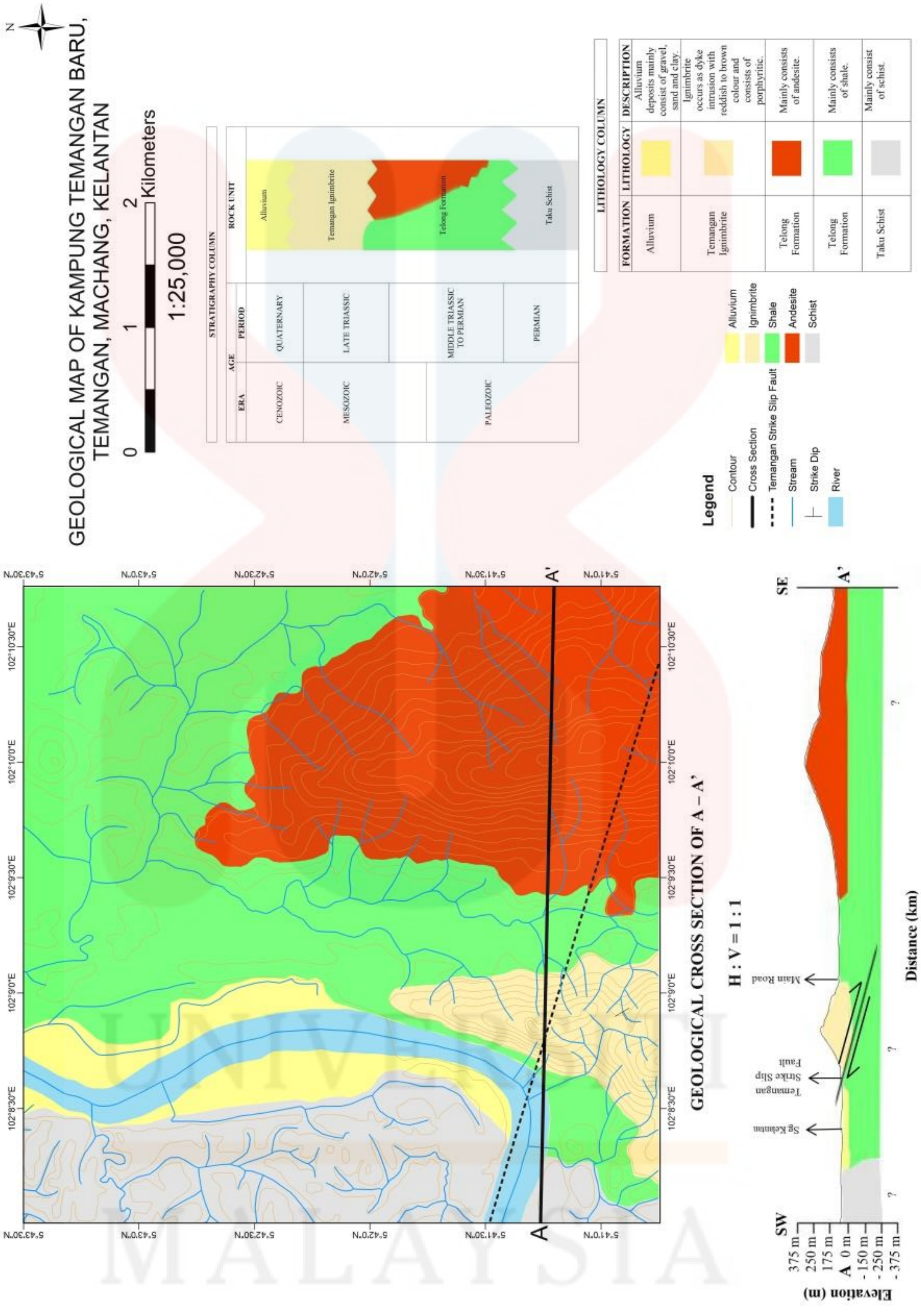


Figure 4.10: Geological Map of Kampung Temangan Baru, Temangan, Machang, Kelantan

CHAPTER 5

FAULT ANALYSIS

5.1 Introduction

This chapter would discuss regarding fault analysis which involve the fault interpretation using the lineament analysis, dynamic analysis and kinematic analysis. Fault was occurring between two blocks or planar of rock that having a fracture or zone of fractures or discontinuity in a rock volume where as a result of rock mass movement from the compressional or tensional forces causes relative displacement of the rocks. In order to determine the pattern and direction of fault present in the study area, fault analysis was done and would be explain in this chapter. The major fault that present at the study area was dextral strike slip fault and named as Temangan dextral strike slip fault with a length 4.6km.

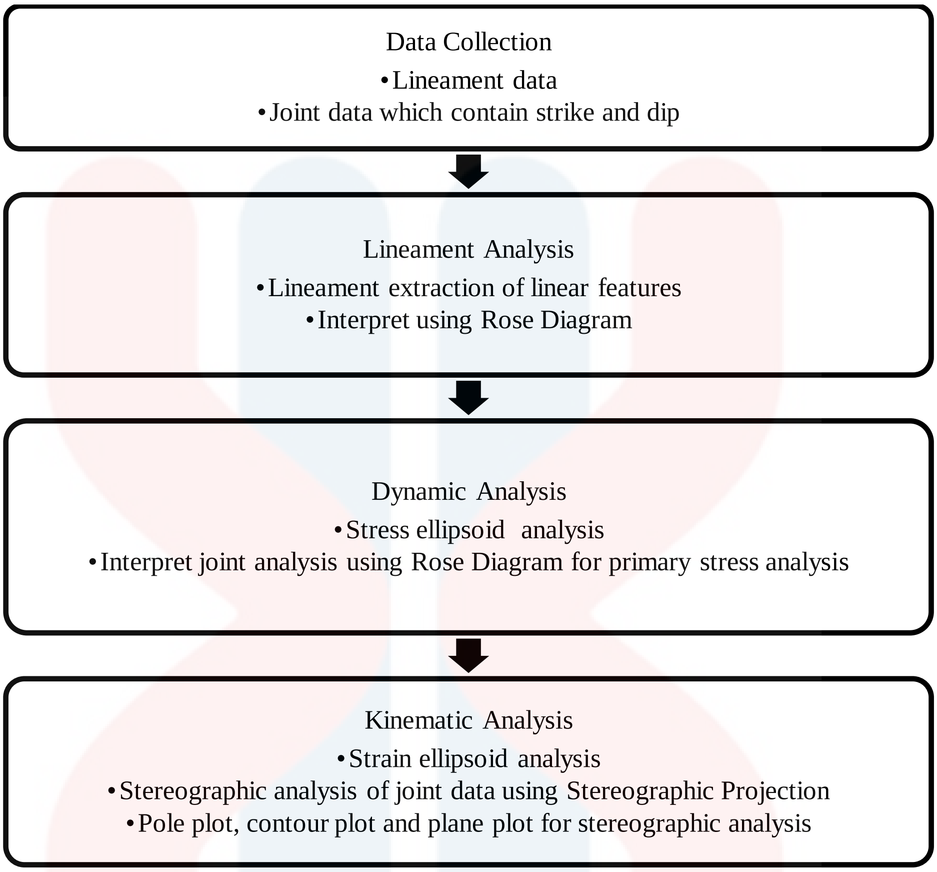


Figure 5.1: Flowchart of the fault analysis for the study area.

5.2 Lineament Analysis

According to a study from Muthumaniraja et al. (2019), lineament is an expression of an underlying geological structure that having a linear feature in a landscape such as fault, fracture or joint or in specific referring to the analysis of fractures or structures. It is commonly associated with fracturing faults and linear zones, bending deformation, and increased crust permeability based on a research from Florinsky (2016).

The analysis of linear features was done on terrain map of the study area as can be seen in Figure 5.2. All lineaments were represented as straight-line segments that obey the linear characteristics drawn on the lineament map.

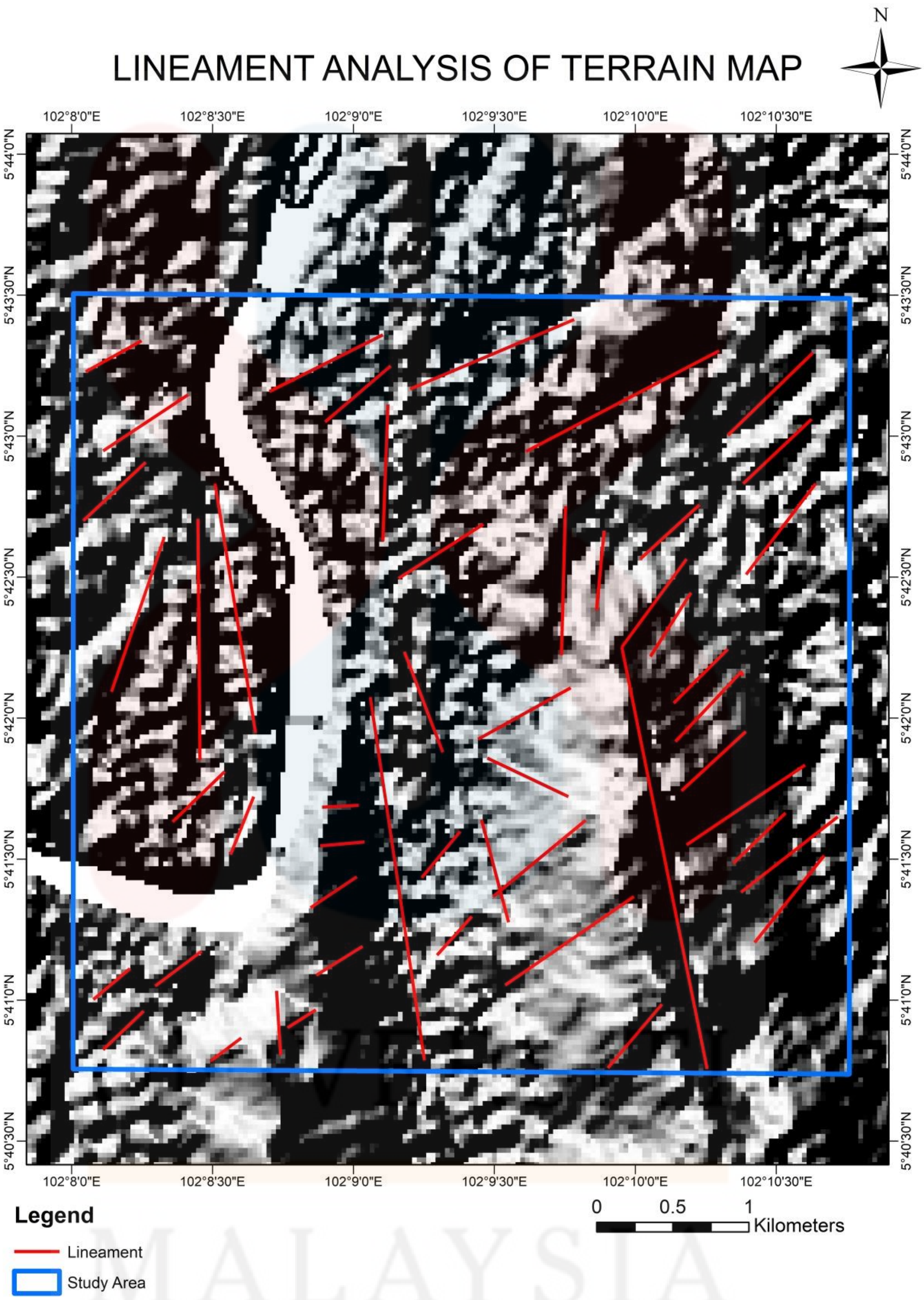


Figure 5.2: Lineament analysis of terrain map of the study area.

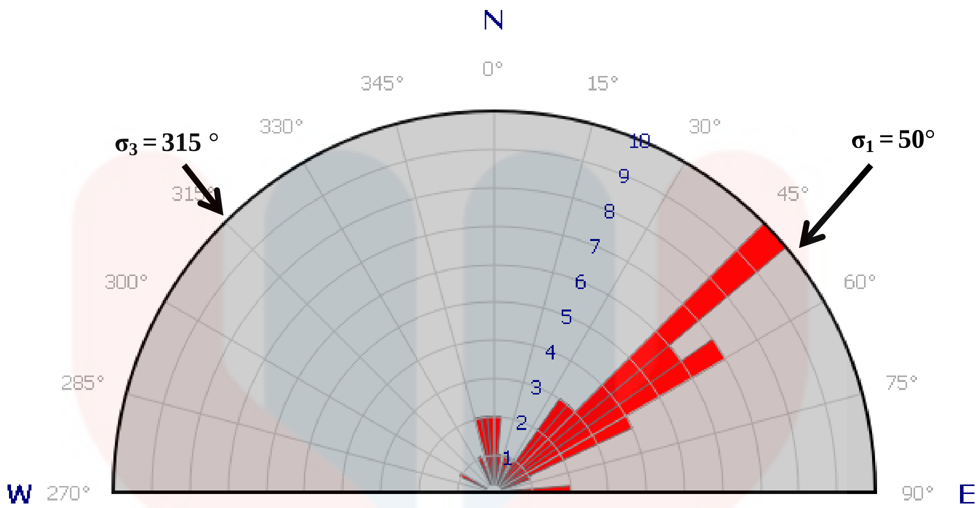


Figure 5.3: Rose diagram of lineament of terrain map.

Table 5.1: Lineament analysis reading of terrain map of Kampung Temangan Baru, Temangan, Machang, Kelantan.

No.	Reading	No.	Reading	No.	Reading
1	55	21	169	41	50
2	50	22	47	42	46
3	2	23	56	43	61
4	46	24	45	44	50
5	40	25	6	45	22
6	56	26	61	46	57
7	58	27	53	47	57
8	85	28	36	48	171
9	46	29	48	49	37
10	52	30	46	50	67
11	39	31	63		
12	32	32	2		
13	87	33	58		
14	172	34	116		
15	177	35	159		
16	46	36	166		
17	62	37	42		
18	18	38	40		
19	179	39	46		
20	47	40	53		

A lineament map was made based on the contour and also stream of the study area that having a scale of 1:25, 000 as in Figure 5.4. There were 60 reading of lineament and been interpret using rose diagram in Figure 5.5 that used to determine the ways of force based on the lineament.

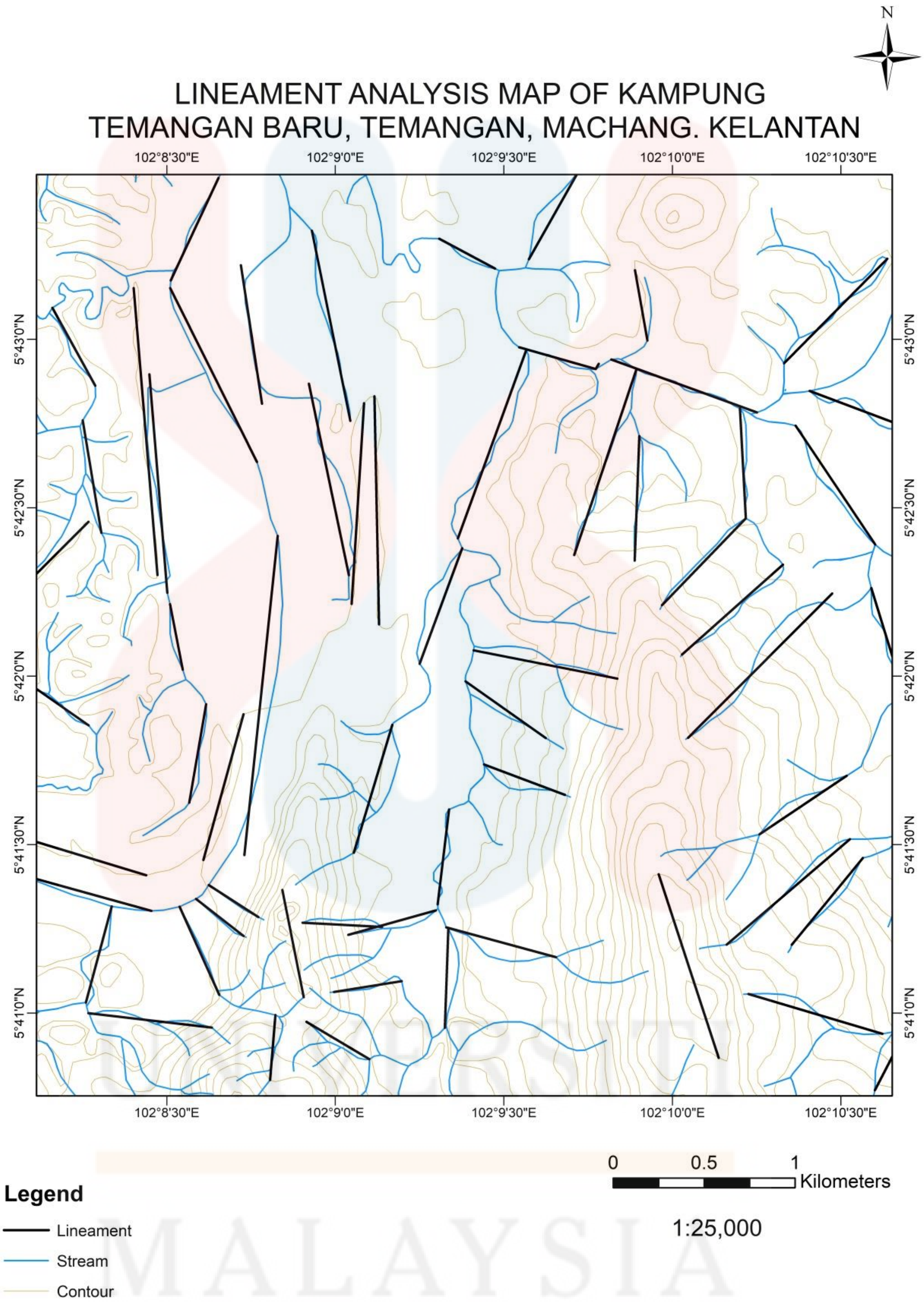


Figure 5.4: Lineament analysis map of Kampung Temangan Baru, Temangan, Machang, Kelantan.

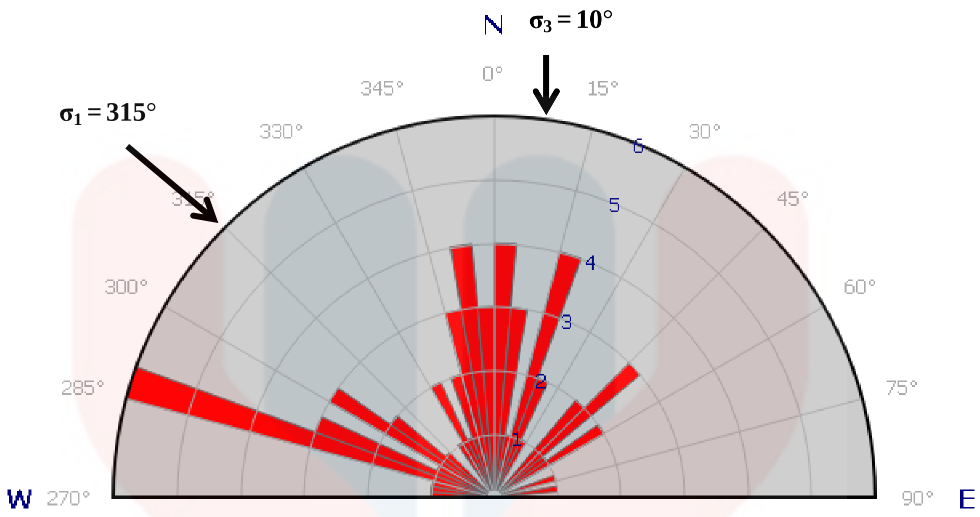


Figure 5.5: Rose diagram of lineament analysis map.

Based on the rose diagram as in Figure 5.5 that had been generate using the data as in Table 5.2, the direction of major force (**σ_1**) for lineament of the study area is NNW-SSE. The value of major force (**σ_1**) is 315° with indicate the presence of major fault in the study area or others geological structure.

Table 5.2: Lineament analysis reading of lineament analysis map of Kampung Temangan Baru, Temangan, Machang, Kelantan.

No.	Reading	No.	Reading	No.	Reading
1	195	21	200	41	351
2	279	22	285	42	197
3	288	23	206	43	197
4	229	24	287	44	190
5	230	25	301	45	305
6	236	26	299	46	182
7	341	27	347	47	199
8	224	28	352	48	286
9	227	29	332	49	288
10	224	30	355	50	274
11	291	31	332	51	301
12	348	32	180	52	186
13	327	33	184	53	350
14	294	34	347	54	187
15	225	35	355	55	182
16	355	36	350	56	261
17	290	37	237	57	254
18	306	38	202	58	336
19	282	39	186	59	310
20	287	40	344	60	304

5.3 Dynamic Analysis

According to Waldron & Snyder (2020), dynamic analysis is the analysis of the stress even though it is having the same meaning to strain, but strain is determined using kinematic analysis. Dynamic analysis means calculating or estimating the strength or stress that rocks have been affected by during the tectonic activities. In making an inference about the rheology, the deformation which was a kinematic concept need to be measured due to rheology is the stress and strain having a relationship, in order to explain the dynamic analysis.

5.3.1 Joint Analysis

Data were obtained from a previous study by Shafiqah (2017) that collected joint data from 4 check point. This study area is overlapping around 30% from the previous research, hence that the data being used to study the forces of the study area. All the data were interpreted using rose diagram to determine the dynamic analysis and using stereographic analysis to determine the kinematic analysis. The first checkpoint is 5° 40' 0.3" N, 102° 10' 10.25" E, that having 100 shear joint as in Table 5.3 and been interpreted using rose diagram in Figure 5.6.

The second joint at second check point identified as conjugate joint which found at the coordinate 5° 39' 31.4" N, 102° 9' 10.25" E. All the data as in Table 5.4 had been analysed using rose diagram as in Figure 5.7. For the third and fourth joint that found at 5° 40' 31.7" N, 102° 8' 27.9" E which is check point 3 and 5° 40' 10.7" N, 102° 8' 18.2" E that is check point 4, the joint types that found were extension joint. All the joint data in Table 5.5 been analysed in Figure 5.8 while the joint data in Table 5.6 is showing using rose diagram in Figure 5.9.

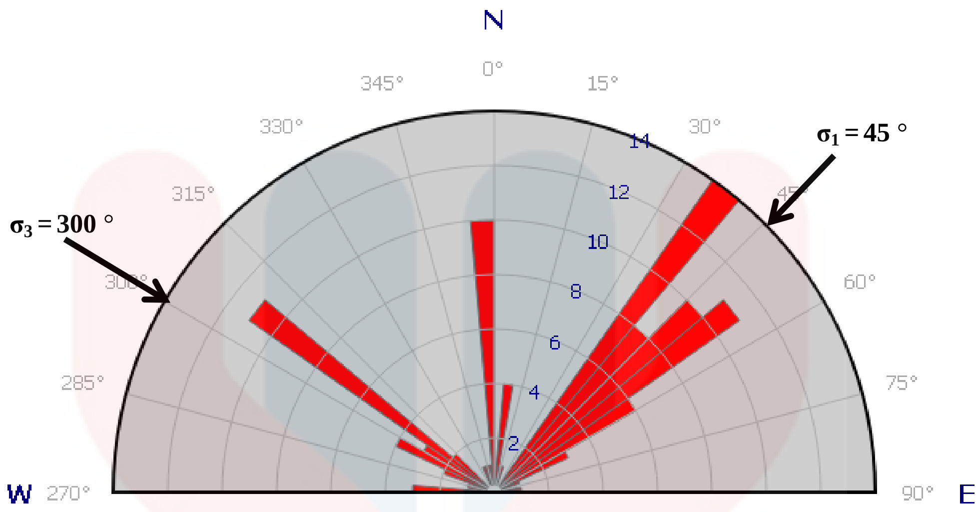


Figure 5.6: Rose diagram of joint at check point 1.

Based on the rose diagram as in Figure 5.6, the direction of major force (**σ_1**) for shear joint of the study area is NNE-SSW. The value of major force (**σ_1**) is 45°. Shear joint normally causing a slip movement where the major force tend to produce stress.

Table 5.3: Shear joint data reading of strike at check point 1.

No.	Reading	No.	Reading	No.	Reading	No.	Reading	No.	Reading
1	129	21	235	41	244	61	038	81	355
2	129	22	235	42	241	62	038	82	355
3	129	23	300	43	219	63	038	83	355
4	129	24	299	44	228	64	038	84	355
5	129	25	299	45	228	65	038	85	296
6	129	26	335	46	062	66	038	86	101
7	231	27	342	47	345	67	038	87	90
8	231	28	305	48	016	68	038	88	120
9	231	29	314	49	065	69	038	89	45
10	231	30	005	50	056	70	038	90	50
11	231	31	354	51	054	71	038	91	83
12	231	32	051	52	044	72	038	92	122
13	225	33	270	53	044	73	291	93	125
14	236	34	270	54	044	74	291	94	125
15	185	35	229	55	044	75	355	95	125
16	234	36	229	56	044	76	355	96	89
17	232	37	229	57	044	77	355	97	189
18	311	38	229	58	044	78	355	98	119
19	235	39	229	59	044	79	355	99	189
20	235	40	229	60	038	80	355	100	125

(Source: Nur Shafiqah Shahman, 2017)

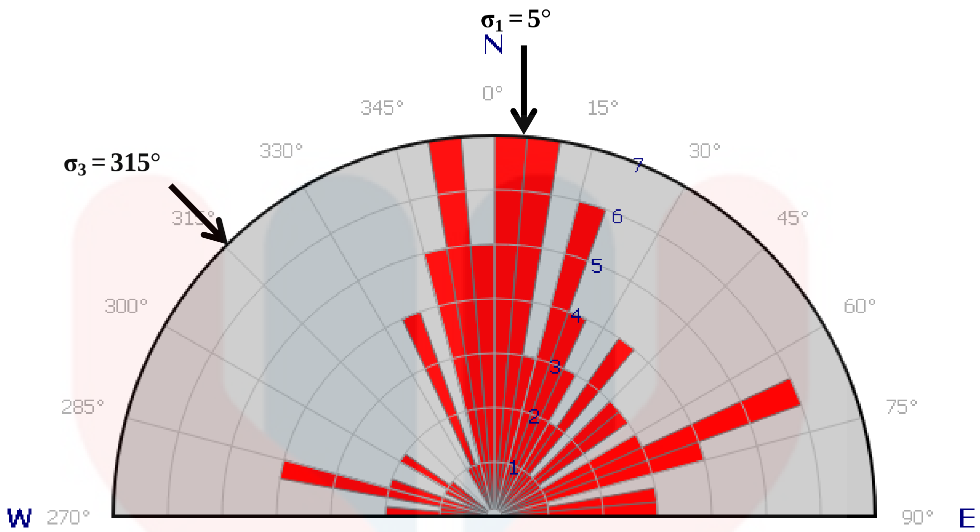


Figure 5.7: Rose diagram of joint at check point 2.

Figure 5.7 that analysed conjugate joint data and having major force (**σ_1**) with a value N 5°E – N **5**°W. The direction of this conjugate joint is NNE-SSW. This joint was affected by shear stress that having a principle stress acted from the North direction toward East.

Table 5.4: Conjugate joint data reading of strike at check point 2.

No.	Reading	No.	Reading	No.	Reading	No.	Reading	No.	Reading
1	122	21	189	41	176	61	256	81	184
2	206	22	168	42	167	62	302	82	245
3	173	23	185	43	188	63	249	83	197
4	184	24	240	44	210	64	015	84	286
5	185	25	153	45	159	65	265	85	197
6	188	26	240	46	165	66	265	86	159
7	182	27	153	47	200	67	243	87	282
8	215	28	236	48	042	68	045	88	285
9	167	29	179	49	283	69	198	89	201
10	176	30	195	50	174	70	271	90	197
11	178	31	157	51	228	71	251	91	305
12	206	32	251	52	064	72	066	92	280
13	172	33	186	53	275	73	206	93	166
14	159	34	194	54	246	74	230	94	192
15	193	35	163	55	216	75	260	95	295
16	263	36	248	56	045	76	068	96	217
17	173	37	174	57	270	77	178	97	202
18	172	38	180	58	284	78	234	98	216
19	189	39	184	59	250	79	253	99	184
20	265	40	260	60	050	80	200	100	210

(Source: Nur Shafiqah Shahman, 2017)

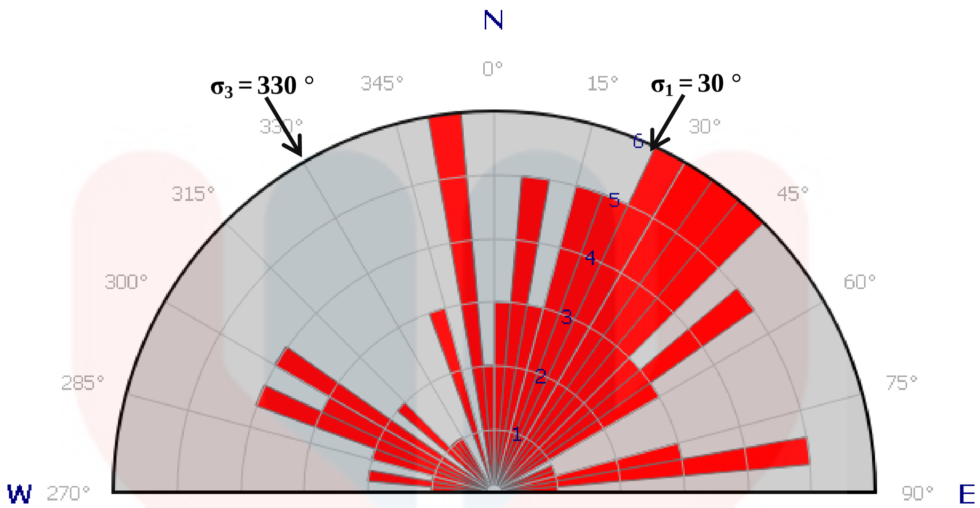


Figure 5.8: Rose diagram of joint at check point 3.

For the rose diagram at checkpoint 3 as in Figure 5.8, major force **(σ_1)** is trending NNE-SSW direction. Tensional joint occurred at this area hence that the forces that present at this check point are tensional force. The value of major force **(σ_1)** is 30° that can be indicator to the major fault.

Table 5.5: Extension joint data reading of strike at check point 3.

No.	Reading	No.	Reading	No.	Reading	No.	Reading	No.	Reading
1	218	21	174	41	096	61	267	81	187
2	221	22	134	42	225	62	162	82	147
3	221	23	174	43	195	63	187	83	138
4	222	24	134	44	235	64	196	84	170
5	223	25	174	45	115	65	197	85	215
6	211	26	117	46	106	66	195	86	212
7	233	27	231	47	225	67	215	87	213
8	234	28	121	48	164	68	213	88	201
9	216	29	122	49	191	69	050	89	201
10	202	30	260	50	183	70	066	90	201
11	209	31	260	51	207	71	058	91	203
12	144	32	255	52	109	72	189	92	196
13	208	33	257	53	160	73	214	93	191
14	227	34	211	54	205	74	251	94	170
15	239	35	209	55	192	75	176	95	208
16	234	36	188	56	171	76	110	96	279
17	261	37	093	57	183	77	081	97	282
18	263	38	112	58	217	78	076	98	290
19	222	39	115	59	183	79	178	99	302
20	114	40	122	60	217	80	187	100	222

(Source: Nur Shafiqah Shahman, 2017)

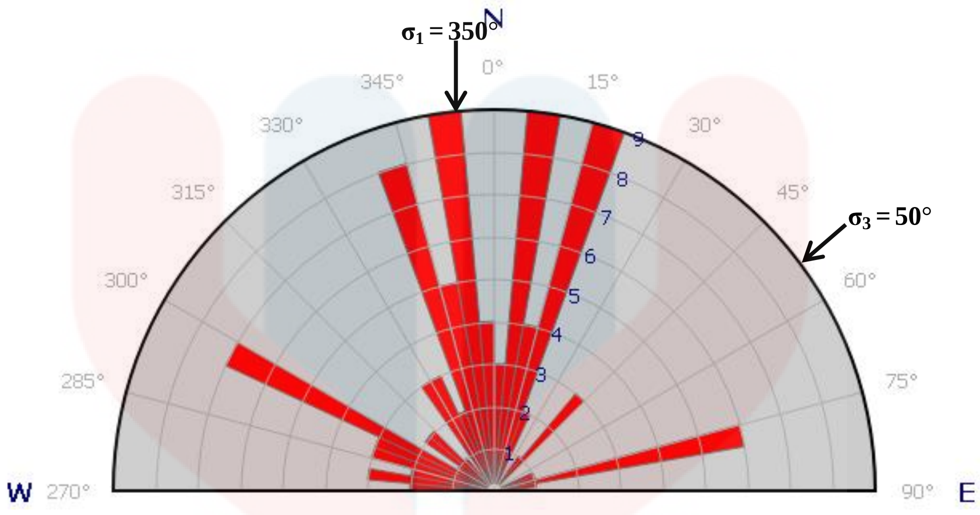


Figure 5.9: Rose diagram of joint at checkpoint 4.

Figure 5.9 that having rose diagram that trending to NNW-SSE with a major force (**σ_1**) value, 315°. The joint that present is extension joint that been recorded with 100 value of joint.

Table 5.6: Extension joint data reading of strike at check point 4.

No.	Reading	No.	Reading	No.	Reading	No.	Reading	No.	Reading
1	343	21	115	41	155	61	092	81	200
2	319	22	189	42	152	62	91	82	279
3	344	23	192	43	148	63	111	83	196
4	314	24	193	44	145	64	123	84	277
5	259	25	164	45	160	65	103	85	223
6	309	26	145	46	257	66	098	86	166
7	338	27	162	47	254	67	106	87	174
8	375	28	172	48	258	68	116	88	176
9	165	29	172	49	260	69	186	89	306
10	192	30	180	50	216	70	075	90	223
11	181	31	173	51	198	71	104	91	166
12	175	32	172	52	166	72	106	92	174
13	116	33	174	53	314	73	110	93	176
14	116	34	189	54	299	74	115	94	197
15	162	35	186	55	197	75	118	95	185
16	169	36	189	56	200	76	198	96	076
17	170	37	185	57	189	77	152	97	150
18	290	38	176	58	192	78	185	98	066
19	287	39	160	59	197	79	180	99	174
20	195	40	163	60	197	80	222	100	258

(Source: Nur Shafiqah Shahman, 2017)

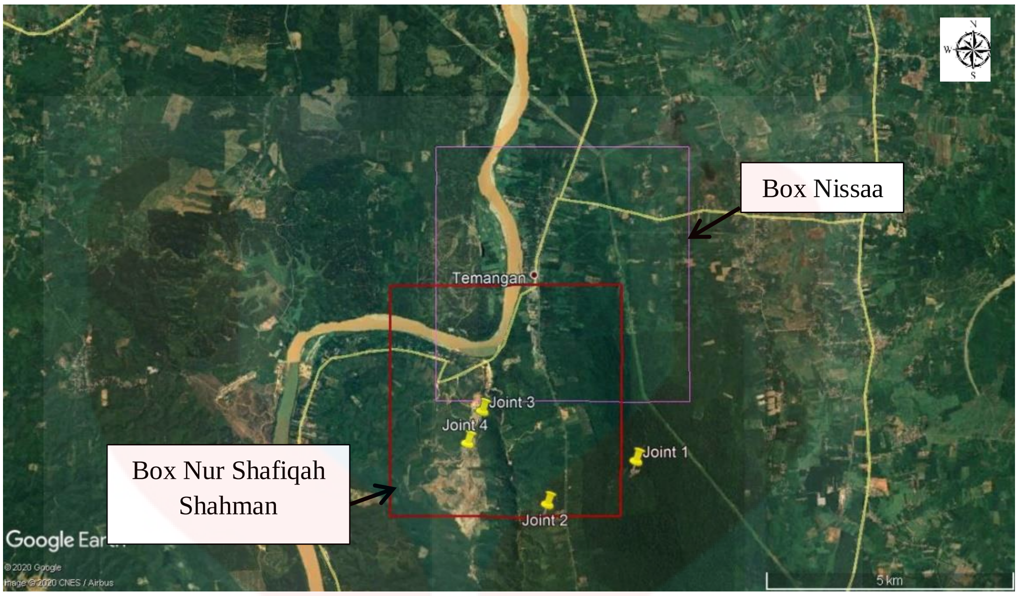


Figure 5.10: Location of joint data for 4 check point.
(Source: Google Earth)

5.3.2 Stress Ellipsoid Analysis

Stress force applied at to a region Stress with the sum of forces that work through the infinite number of planes that move through a point to form a deformation. Stress ellipsoid is the degree of stress in either direction relative to a point in a rock mass, and can be conceptualised as a stress ellipsoid in relation to a point in a rock mass. To be conceptualised as an ellipsoid of tension. The larger the ellipsoid stress, the larger the ellipsoid size, the higher the ellipsoid stress on the rock. The $\boldsymbol{\sigma_1}$ that having the highest forces would compressed or form a deformation of rock as in Figure 5.11.

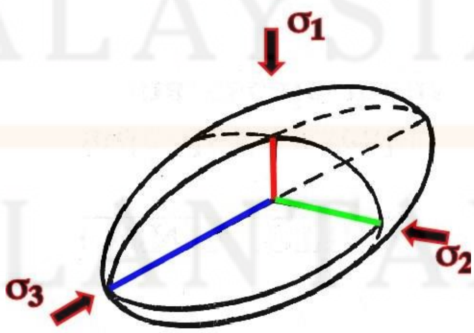


Figure 5.11: Forces ways of stress ellipsoid.

5.4 Kinematic Analysis

Stereonet or stereographic was used to provide rock orientation-based graphical kinematic analysis. The potential mode of rock failure triggered by the existence of oriented discontinuities was studied by kinematic analysis by plotting the stereographic projection in the pole plot, contour plot and plane plot. From the plane plot, the rock orientation of the rock that influence by the strain analysis represented the forces ways.

5.4.1 Strain Analysis

A research by Waldron & Snyder (2020), strain is describing the kinematic analysis that having changes in shape or volume. The strain ellipsoid is a solid conception or a three-dimensional one and the angle relationship between the compression axis and the no-distortion planes depends on the relative lengths of the three major axes (Link, 1929). Shear planes manifested as intersecting lines in the horizontal indicate that the greatest elongation was not upward but lateral. Parallel lines of shear in the horizontal suggest that the greatest elongation was upward. An application to an experimentally deformed mass as well as to a regional structure is made of the imaginary strain ellipsoid.

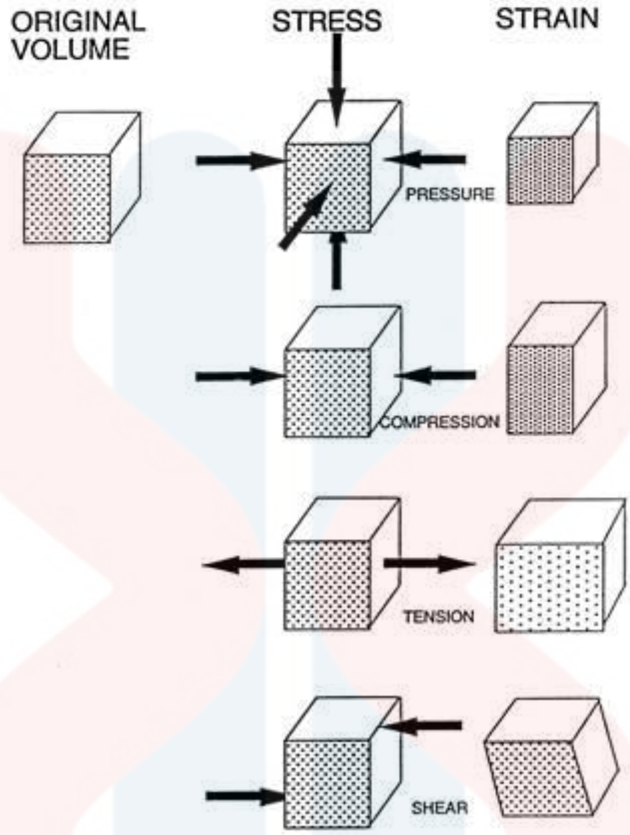


Figure 5.12: The changes of stress and strain from the rock origin.
(Source: http://ffden-2.phys.uaf.edu)

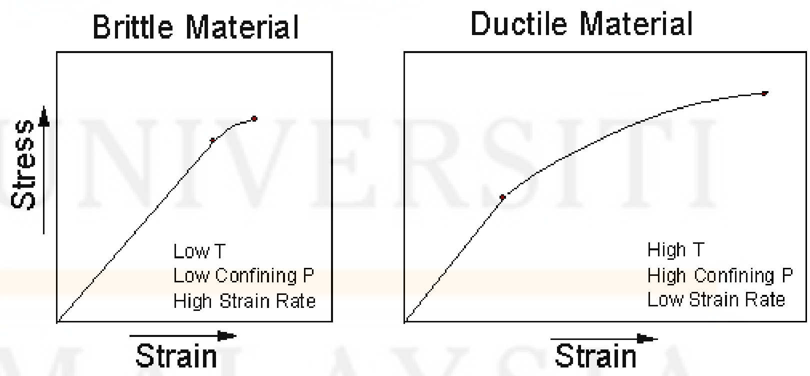


Figure 5.13: The relationship between stress and strain depending on the brittle and ductile material.
(Source: Stephen A. Nelson, 2015)

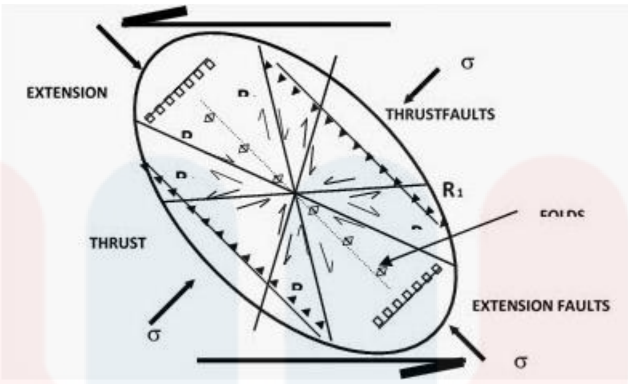


Figure 5.14: Strain ellipsoid that determined the ways of major forces direction.
(Source: Keller, Hall & McClay, 1997)

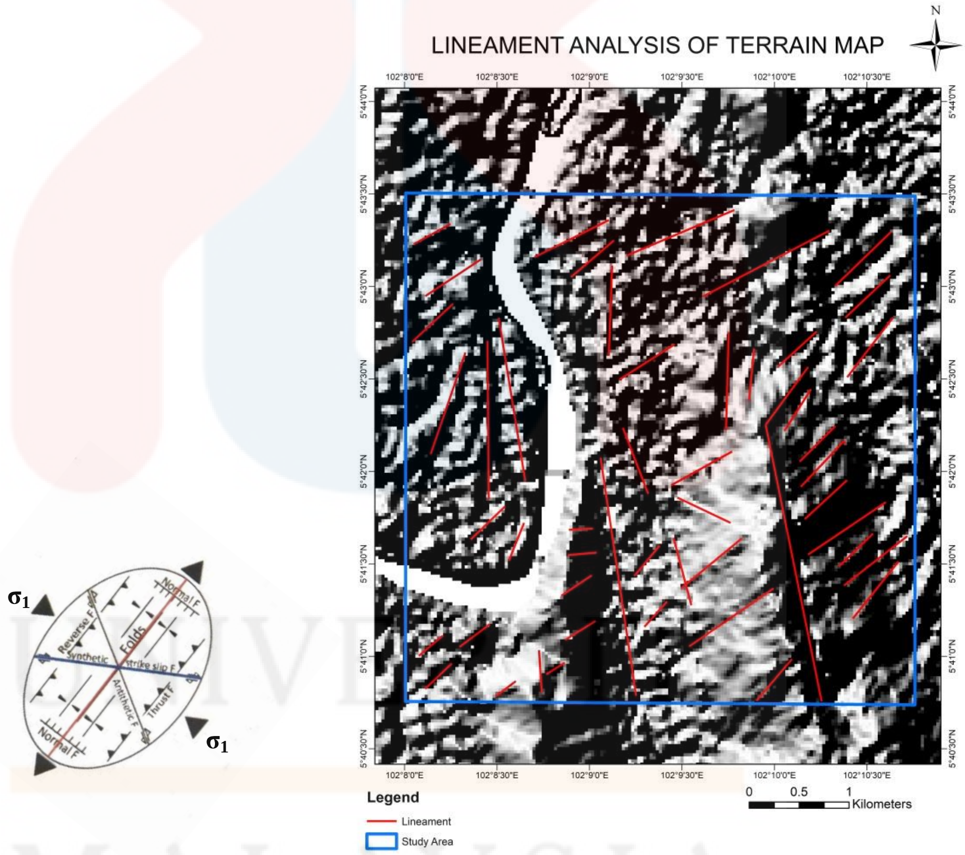


Figure 5.15: Strain ellipsoid from the lineament terrain analysis map

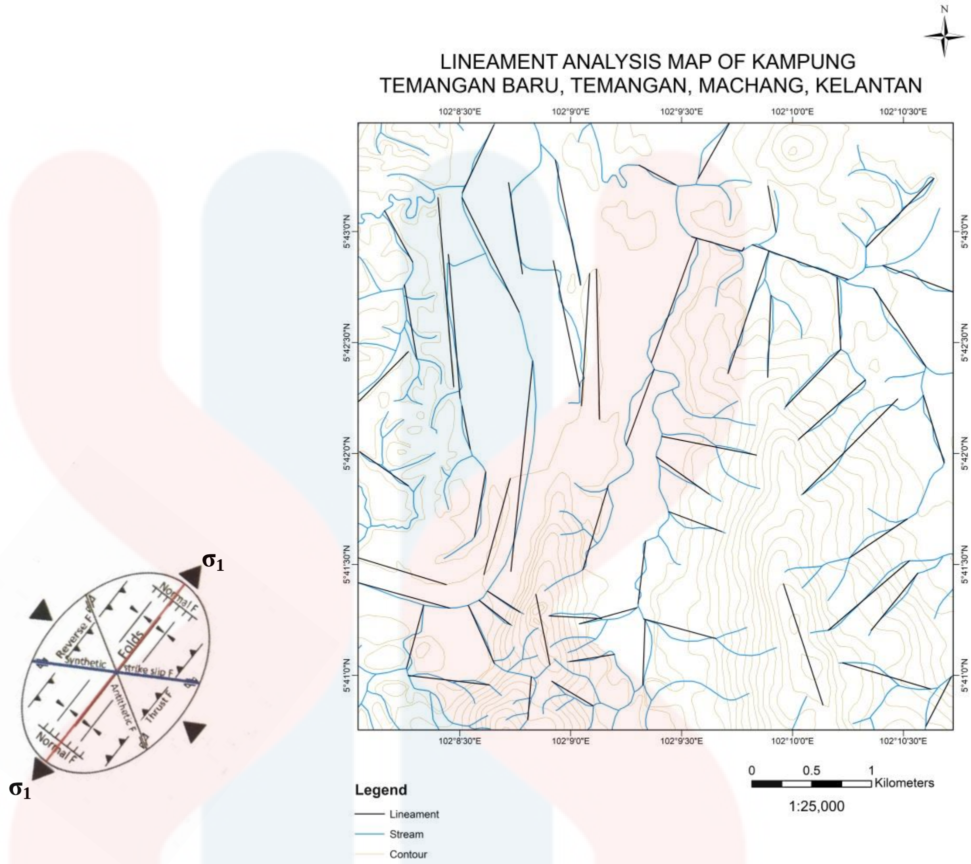


Figure 5.16: Strain ellipsoid from the lineament analysis map

From figure 5.15 and figure 5.16, there were two main stresses which area shear stress and tensional stress that caused the deformation of the rock. The red line represents the tensional stress while the blue line represents the shear stress. Tensional stress from the lineament terrain analysis comes from the North East and South West with a value of $\boldsymbol{\sigma_1}$ is 50°. The shear stress comes from North West and South East direction from the lineament analysis. The value of $\boldsymbol{\sigma_1}$ from the lineament analysis is 315° that caused the dextral strike slip fault.

5.4.2 Stereographic Projection

Stereographic projection by Fletcher (2017) is a mapping that projects the sphere onto a plane is a stereographic projection. Stereographic projection or known as stereonet is a method to display 3D geometry of lines and plane (Aber & Ber, 2007). There were three main types of stereographic projection plotting which were pole plot, contour plot and plane plot. From pole plot we could see the joint set as in Figure 5.17 there were 4 joint set and can be seen clearly in Figure 5.18 based on the contour pole. Figure 5.19 is showing the shear joint of the study area. Shear joint was indicating the strike slip fault that occurs trending at NW.

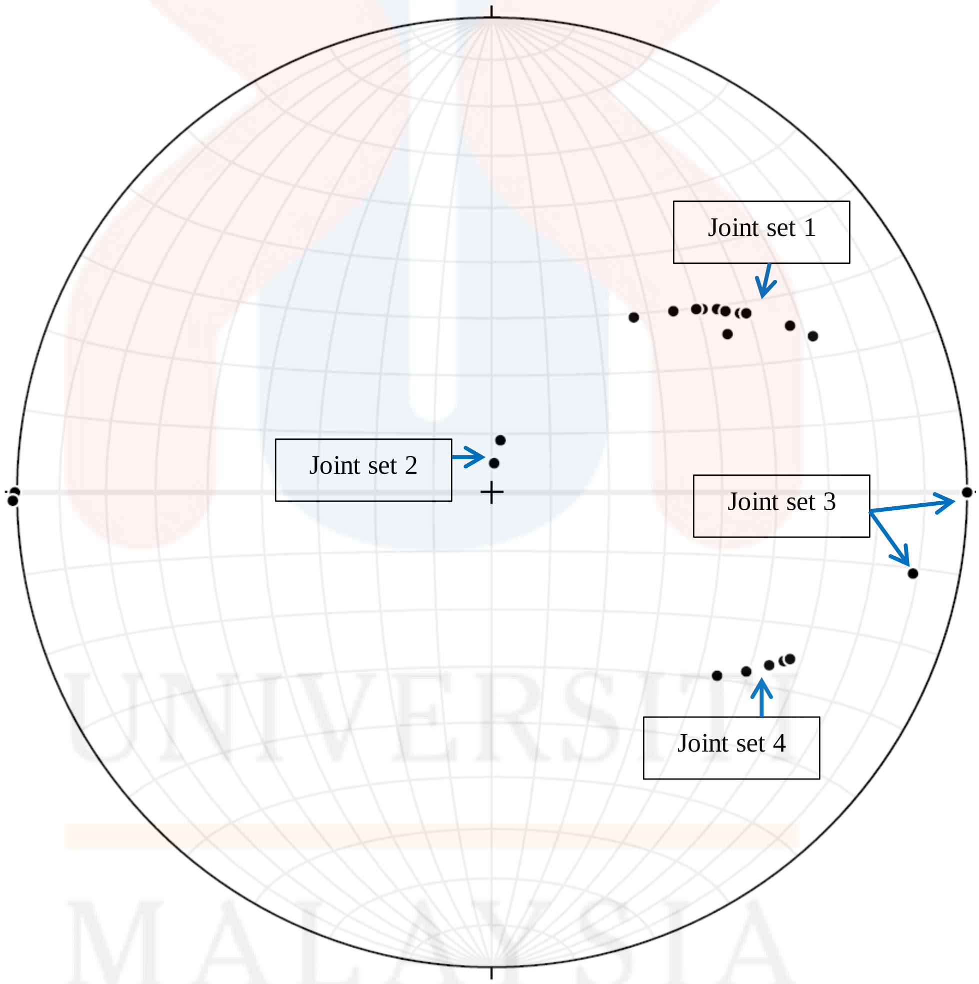


Figure 5.17: Pole plot of stereographic projection from joint data at check point 1.

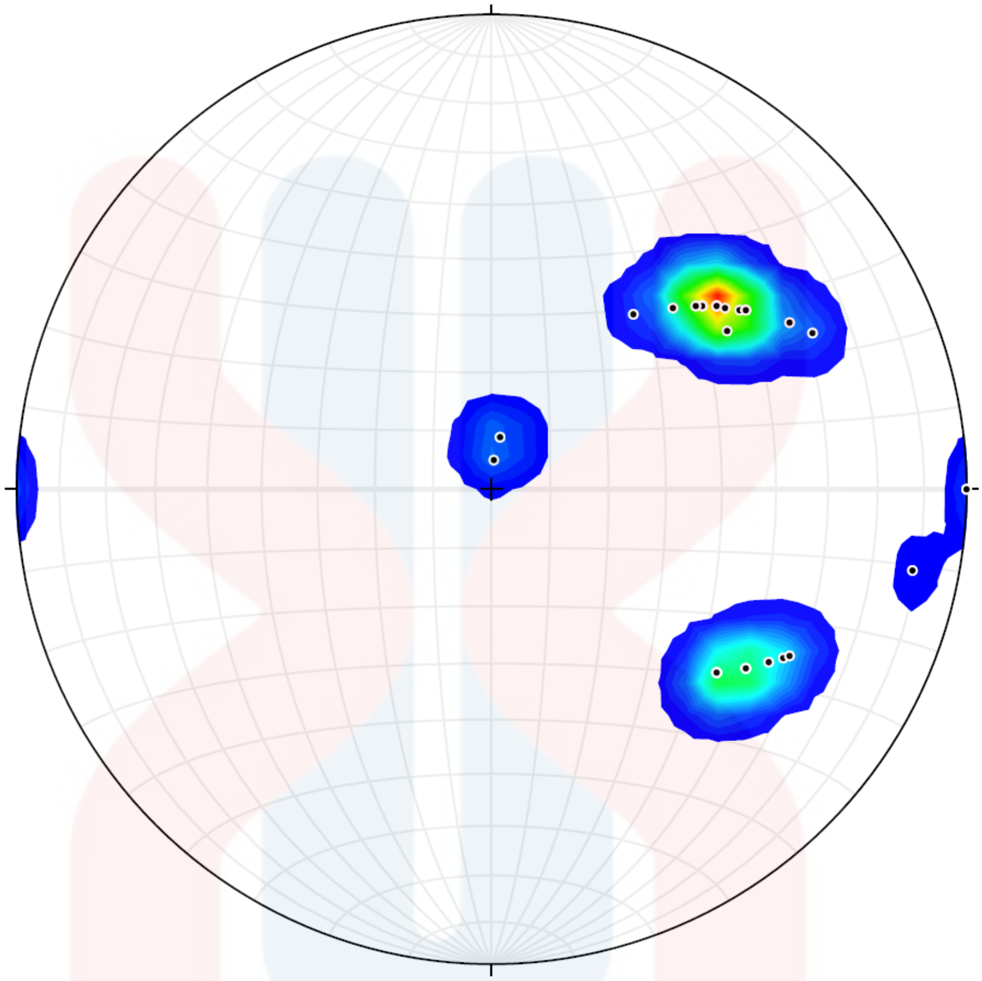


Figure 5.18: Contour plot of stereographic projection from joint data at check point 1.

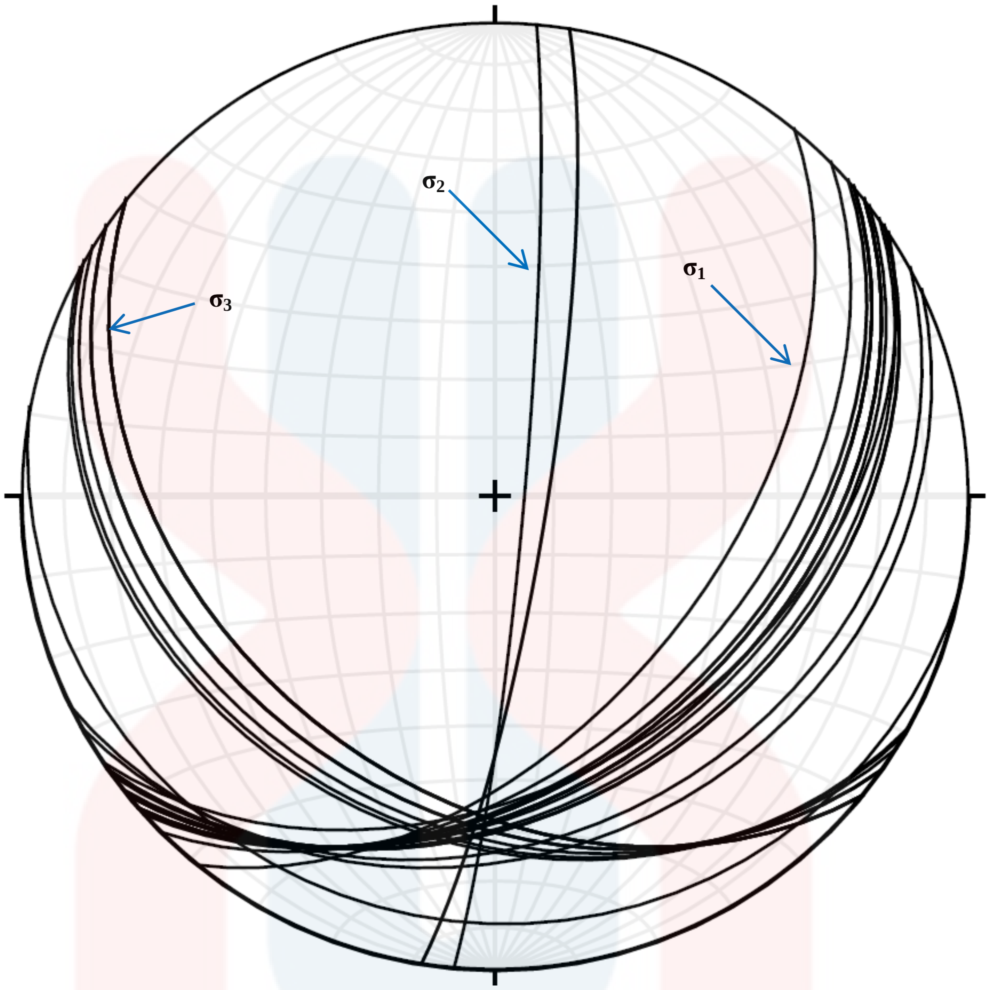


Figure 5.19: Plane plot of stereographic projection from joint data at check point 1.

Plane plot stereographic projection in Figure 5.19 show the σ_1 = N45°E/ N225°E, σ_2 = N12°E/ N192°E and σ_3 = N300°E/ N120°E. From the shear joint analysis that the major forces is from NE-SW with indicate the strike slip fault.

The second check point which was conjugating joint having three joint data sets as in Figure 5.20 that having a crossing between the joint data set. Normally conjugate joint occurred at the area that having compressional stress between two joints or more. As in Figure 5.21, the contour pole clearly showing the cutting of the contour that indicate there is a fault presence at the study area.

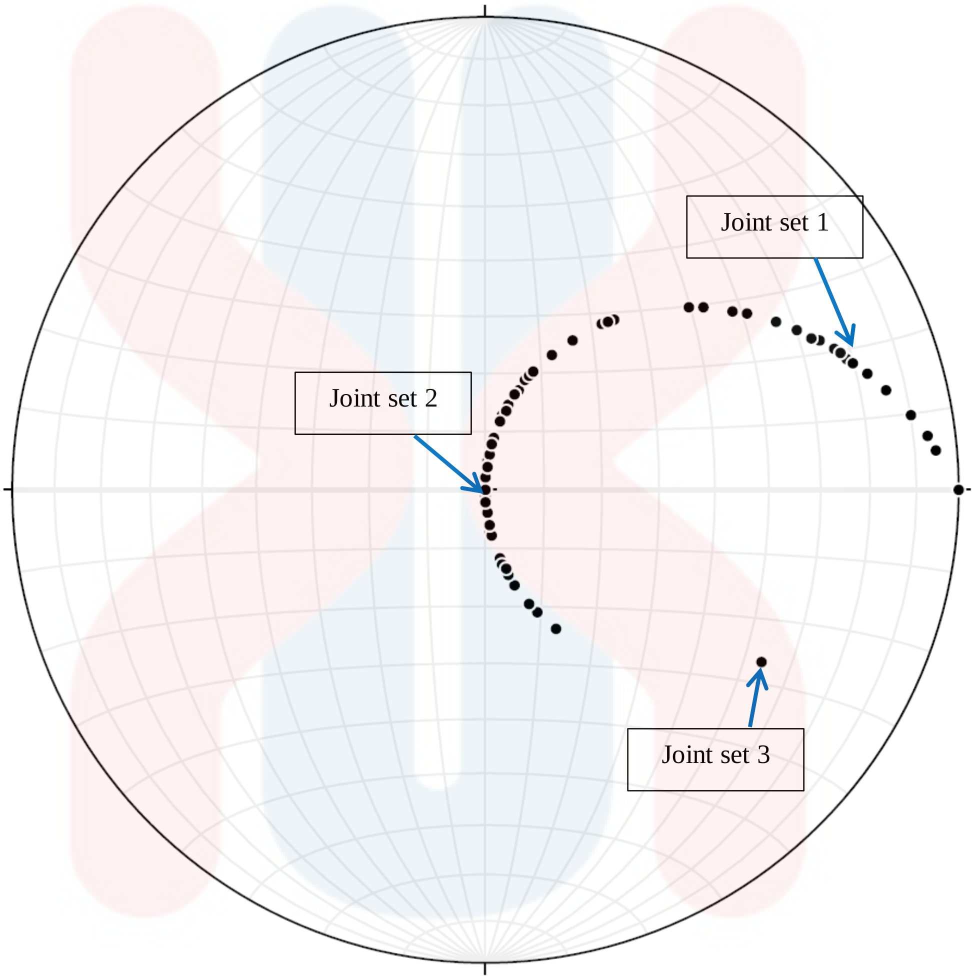


Figure 5.20: Pole plot of stereographic projection from joint data at check point 2.

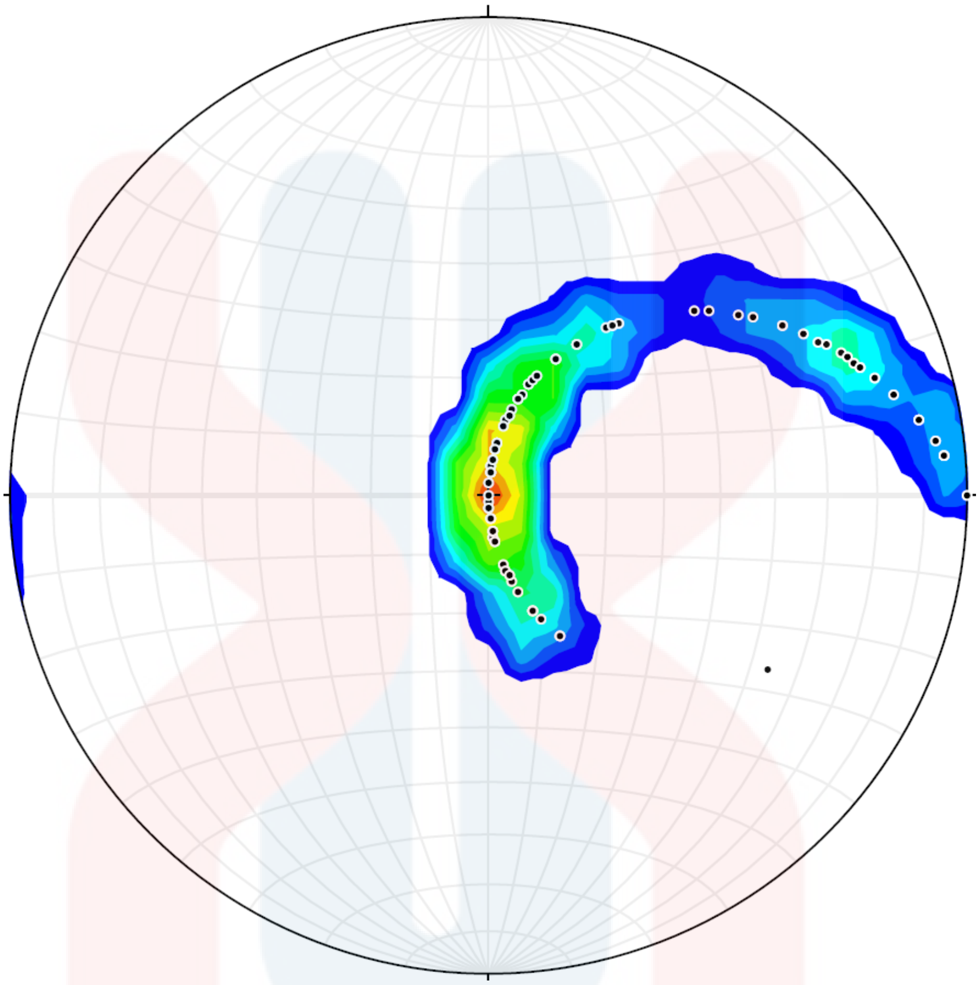


Figure 5.21: Contour plot of stereographic projection from joint data at check point 2.

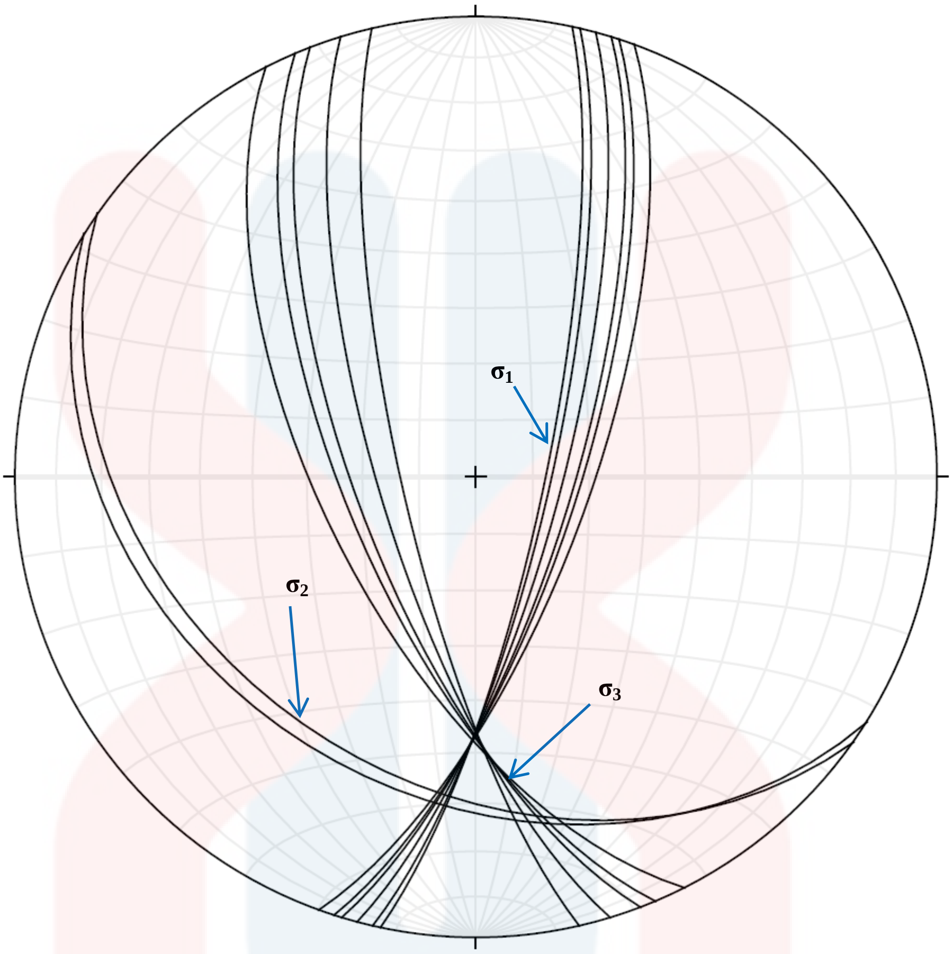


Figure 5.22: Plane plot of stereographic projection from joint data at check point 2.

Stereographic projection in Figure 5.22 show the $\boldsymbol{\sigma_1}$ = N5°E/ N185°E, $\boldsymbol{\sigma_2}$ = N302°E/ N192°E and $\boldsymbol{\sigma_3}$ = N315°E/ N135°E. From the shear joint analysis that the major forces is from NE-SW with indicate the strike slip fault.

The extensional joint as in Figure 5.23, there are 5 joint data set that been analysed using the stereographic projection. Extensional joint occurred with the help of tension stress. Contour plot of stereographic projection from joint data at check point 3, having two planes that being the indicator of the fault.

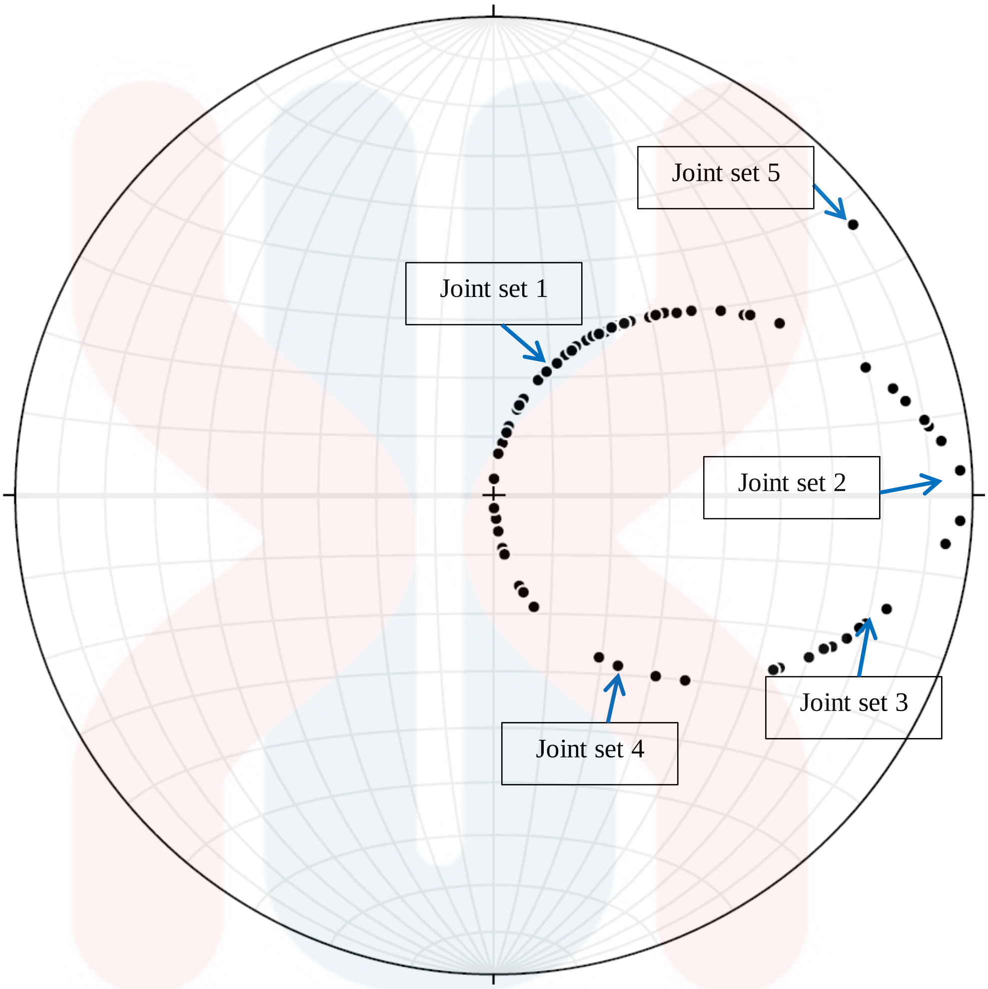


Figure 5.23: Pole plot of stereographic projection from joint data at check point 3.

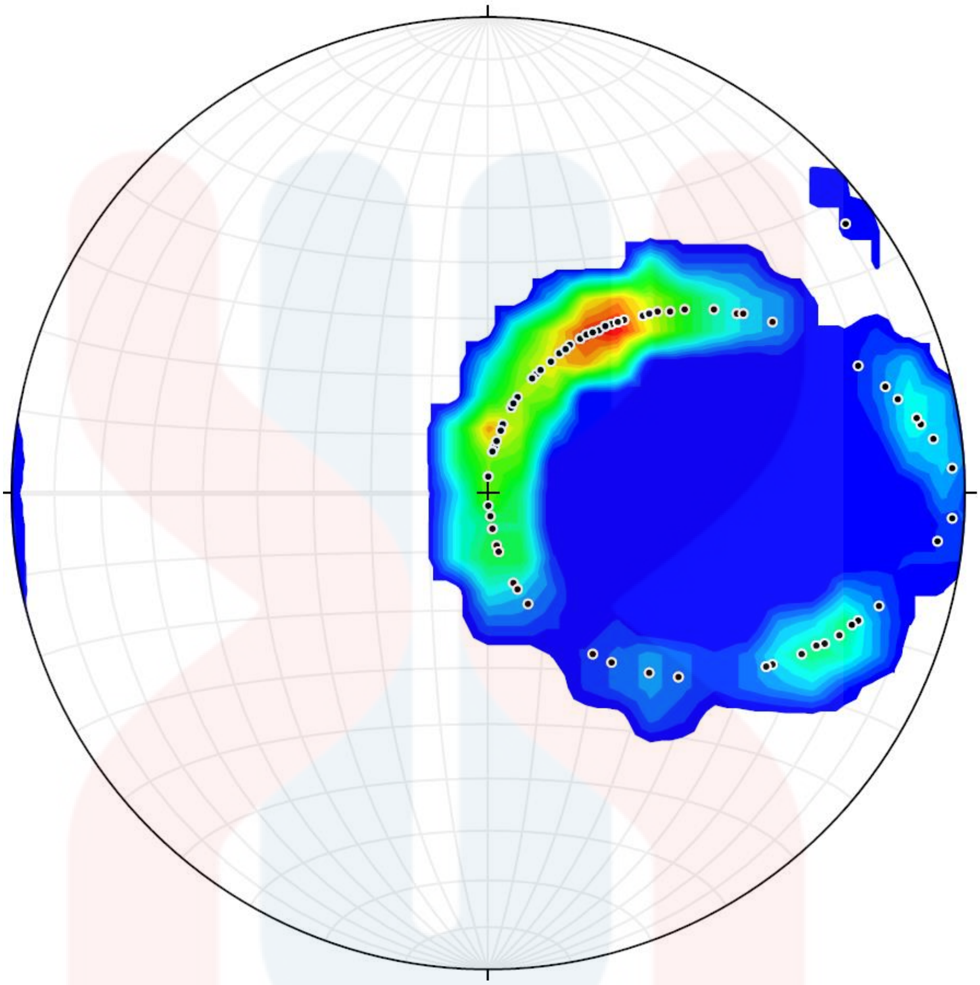


Figure 5.24: Contour plot of stereographic projection from joint data at check point 3.

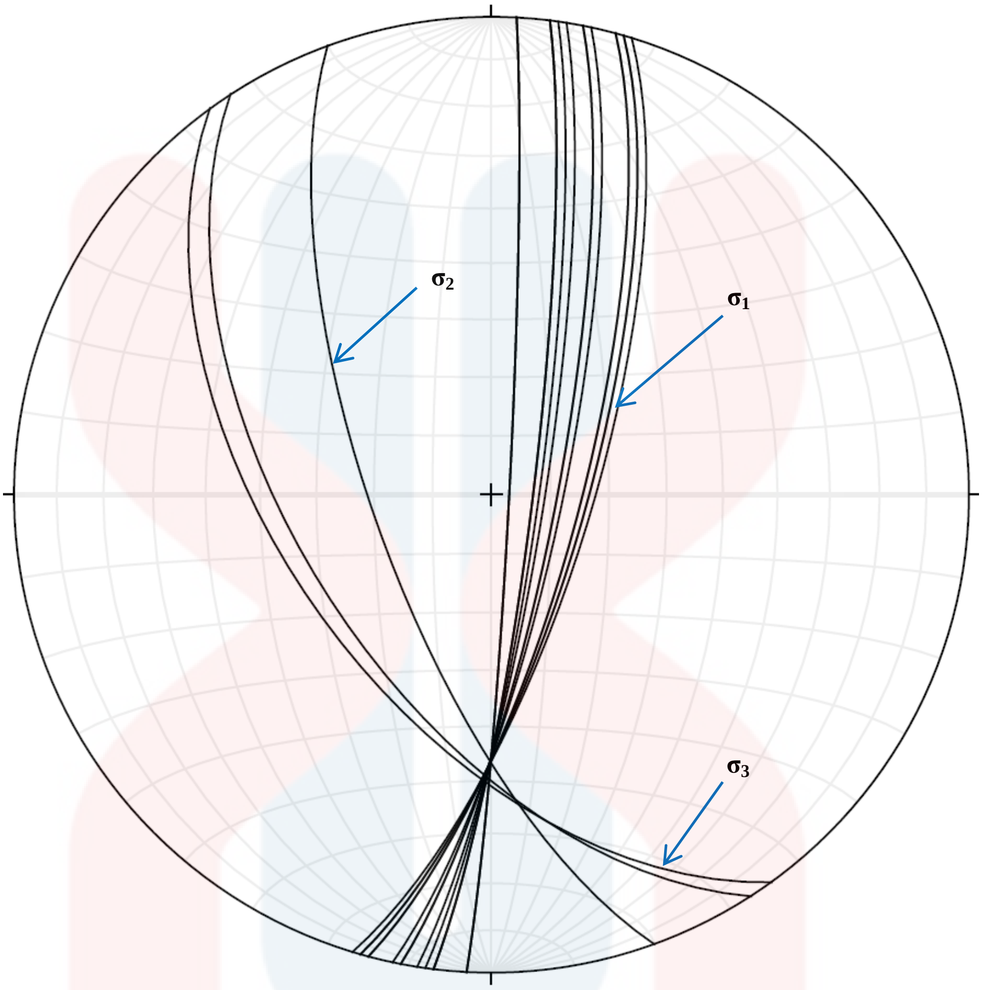


Figure 5.25: Plane plot of stereographic projection from joint data at check point 3.

Figure 5.25 that having plane plot Stereographic projection in show the $\boldsymbol{\sigma_1}$ = N30°E/ N210°E, $\boldsymbol{\sigma_2}$ = N160°E/ N340°E and $\boldsymbol{\sigma_3}$ = N330°E/ N150°E. From the extension joint analysis the major forces is trending from NE-SW.

The fourth check point that occurred extensional joint having 4 joint set at the study area as in Figure 5.26. As the fourth check point was the extensional joint, the ways of rock deformation can be seen in Figure 5.27.

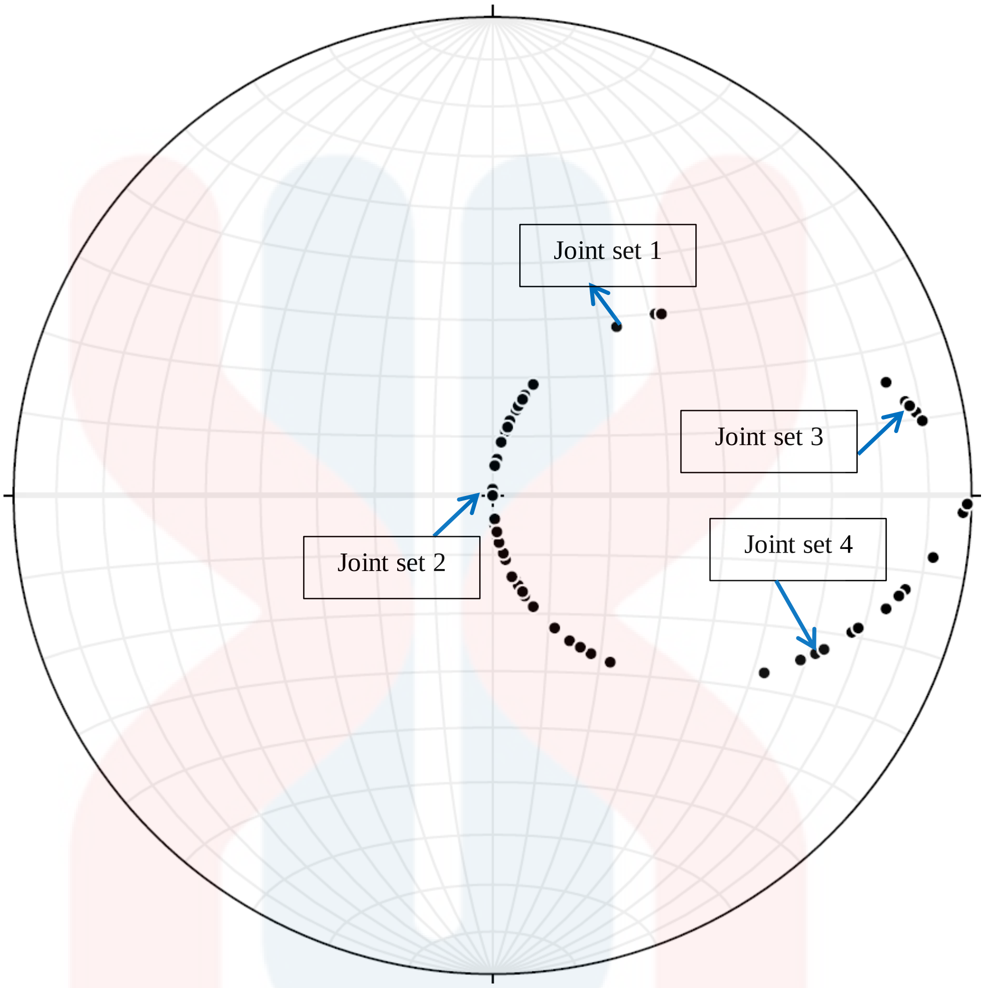


Figure 5.26: Pole plot of stereographic projection from joint data at check point 4.

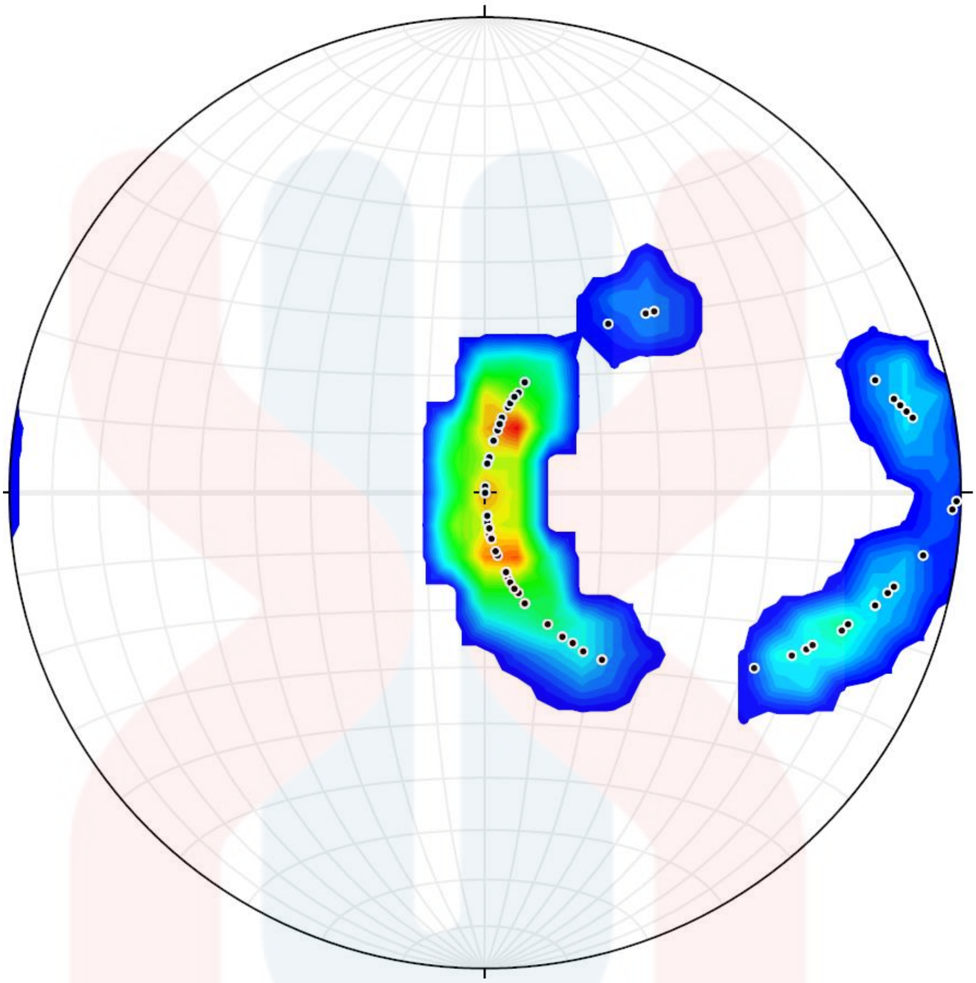


Figure 5.27: Contour plot of stereographic projection from joint data at check point 4.

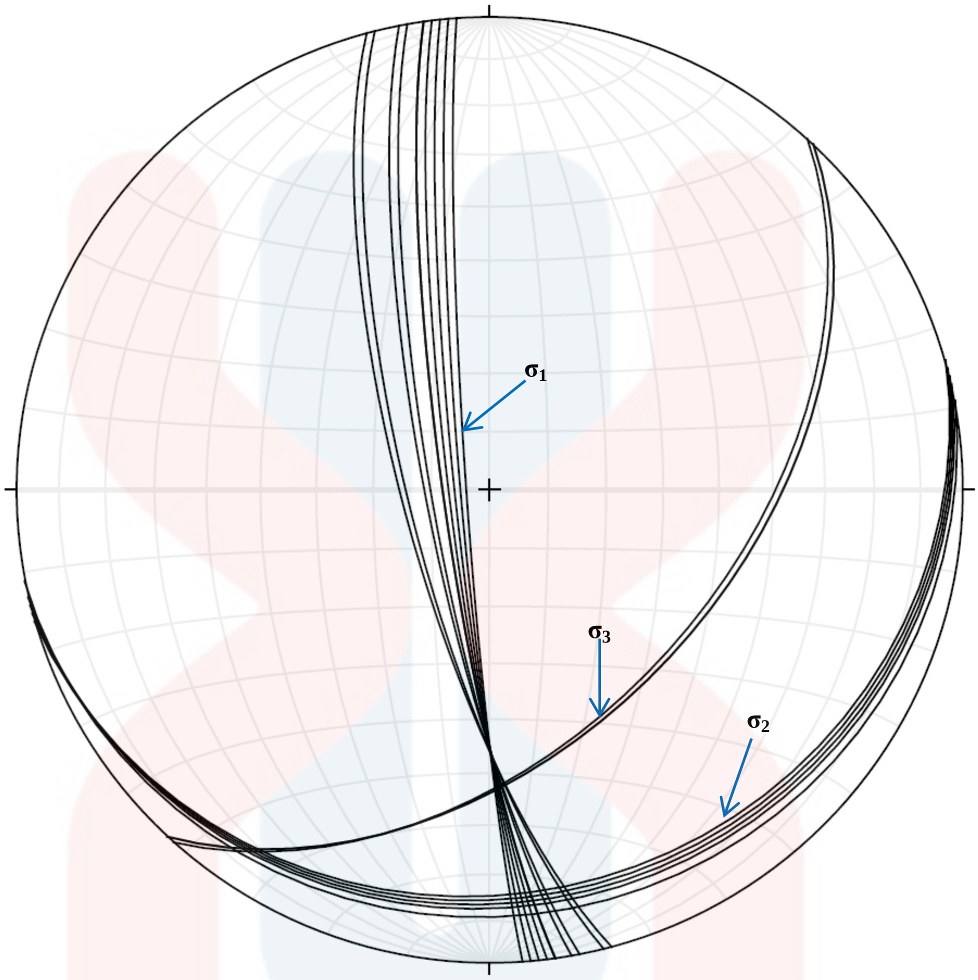


Figure 5.28: Plane plot of stereographic projection from joint data at check point 4.

Plane plot of stereographic projection from joint data at check point 4 in Figure 5.28 show the $\boldsymbol{\sigma_1}$ = N350°E/ N170°E, $\boldsymbol{\sigma_2}$ = N75°E/ N255°E and $\boldsymbol{\sigma_3}$ = N50°E/ N240°E. The fault was indicated by the extensional joint that occurred that trending to the NW-SE.

5.4.3 Geotectonic Process

Temangan dextral strike slip fault was having continues with Lebir Fault zone. Temangan dextral strike slip fault was exposed to fault scarp with a length 13km that trending with Sungai Kelantan and continues with Sungai Lebir as in Figure 5.29.

According to Basori et al. (2016), lebir Fault occurred during middle Triassic to early Jurassic. The faulting occurred between the central belt and eastern belt.

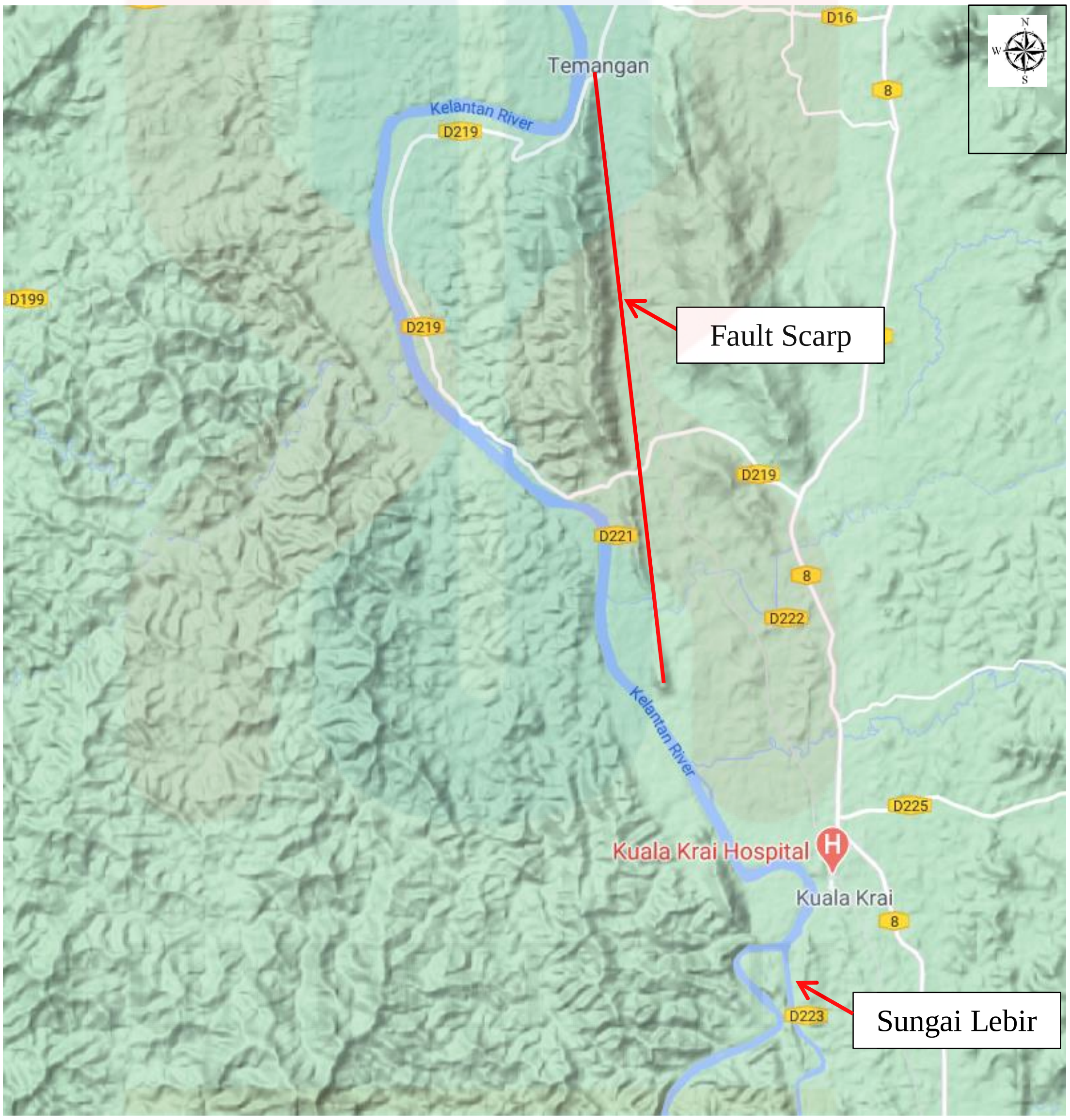


Figure 5.29: Terrain map of the study area at its surrounding.

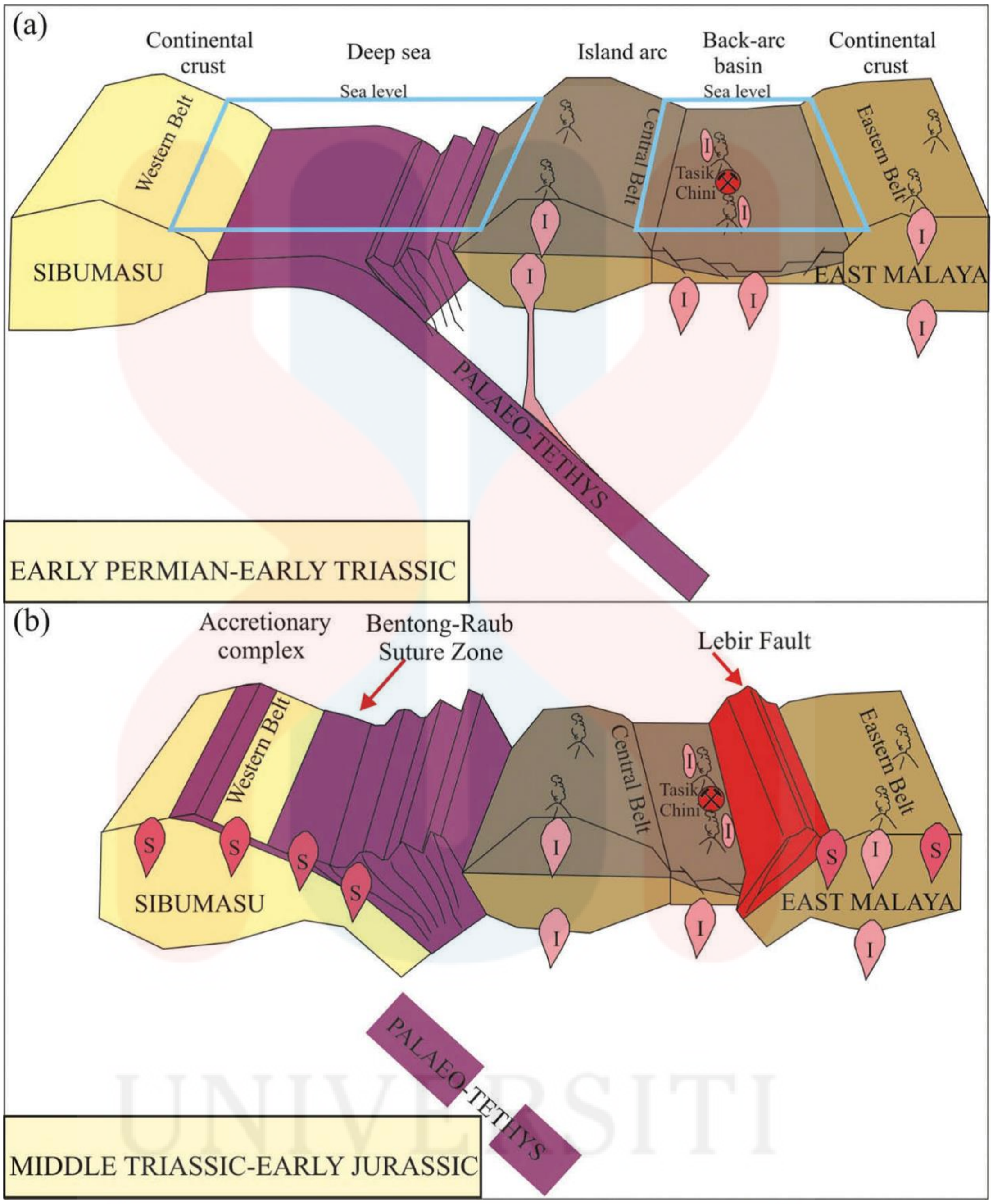


Figure 5.30: Tectonic movement with the changes and the geologic time age.
(Source: Mohd Basril Iswadi Basori, Khin Zaw, Sebastien Meffre & Robert Ross Large, 2016)

5.4.4 Rock Mechanic

According to Hoek (1996), the theoretical and applied study of the mechanical behaviour of rock is rock mechanics that having branch of mechanics that is concerned with the reaction of rock to its physical environment's force fields. The rock mechanics branches control the rock deformation and fracture processes.

Based on the rose diagram analysis of the entire checkpoints, the major forces (**σ_1**) are around N10°-45°E. As in Figure 5.31 the strike slip fault is having major force (**σ_1**) trending to NE. This minimum forces (**σ_3**) is trending at N300°-330°W that similar as in Figure 5.31 for strike slip fault that trending NW. This strike slip fault cause by the stress that present during the tectonic movement.

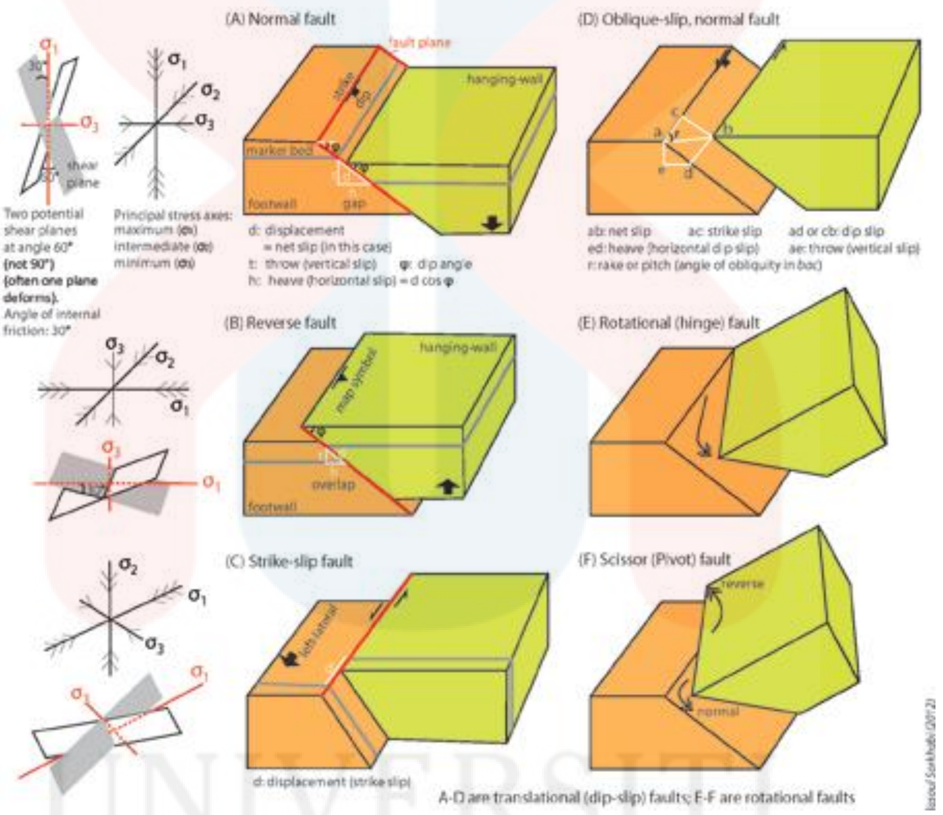


Figure 5.31: The principal stress axes and slip classification for type of fault.
(Source: Rasoul Sorkhabi, 2012)

5.5 Summary of Data

The major fault that present at the study area was dextral strike slip fault with a length 4.6km and name as Temangan Dextral Strike Slip Fault. This fault was crossing all the lithology which are Alluvium, Ignimbrite, Shale, Andesite and Schist that present at the study area as in Figure 5. Since the fault crossing the all the lithology, the age of the fault was classified as younger than Late Triassic. The offset of geomorphology that can be seen in Figure 5.32 where the main river which is Sungai Kelantan started to bend and there is a present of scarp.

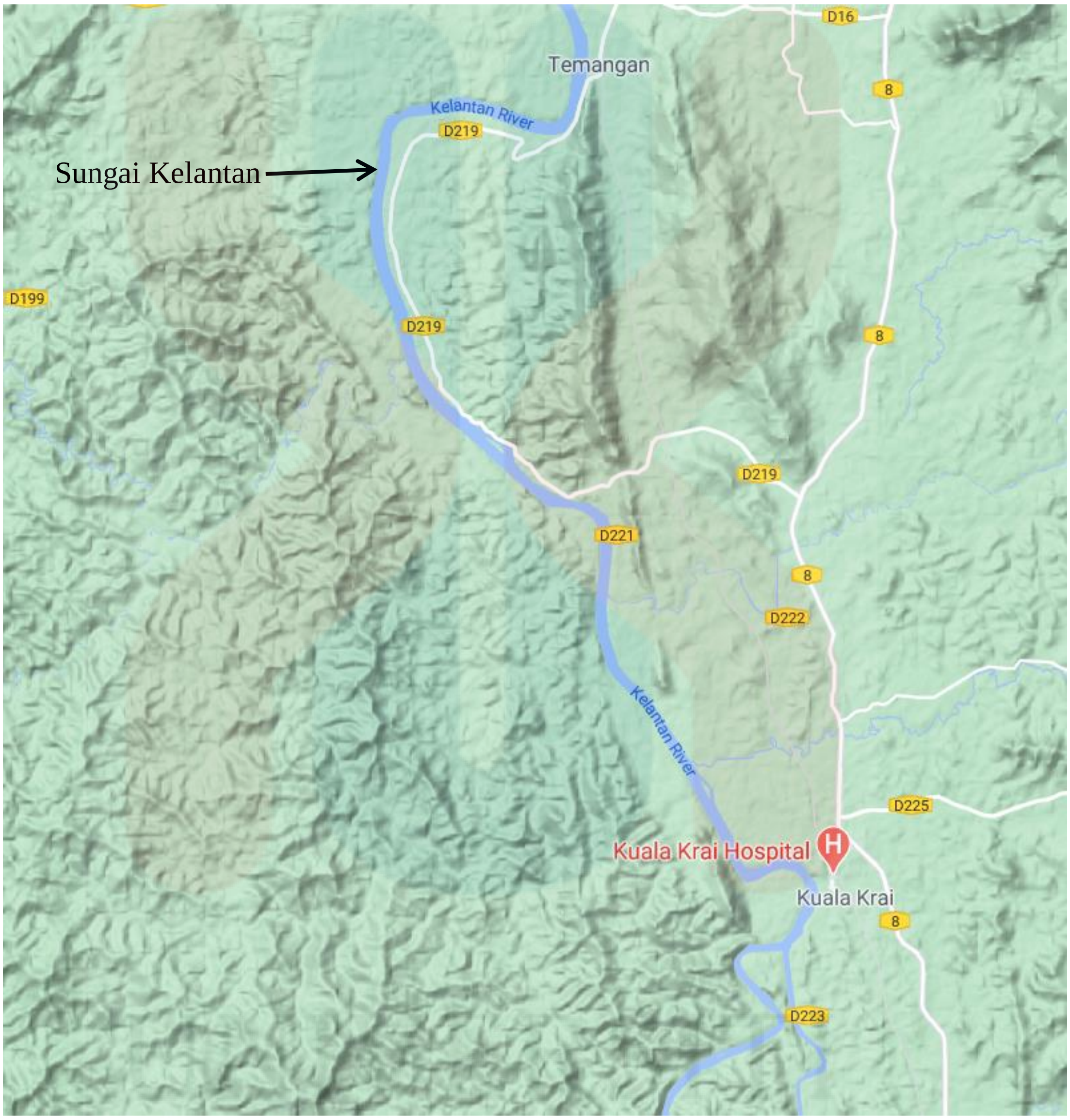


Figure 5.32: Terrain map of the study area with the Sungai Kelantan.

Table 5.7: Summary of data based on kinematic and dynamic analysis.

Checkpoint	σ_1	σ_3
1	N45°E/ N225°E	N300°E/ N120°E
	NE-SW	NW-SE
2	N5°E/ N185°E	N315°E/ N135°E
	NE-SW	NW-SE
3	N30°E/ N210°	N330°E/ N150°E
	NE-SW	NW-SE
4	N350°E/ N170°E	N50°E/ N240°E
	NW-SE	NE-SW

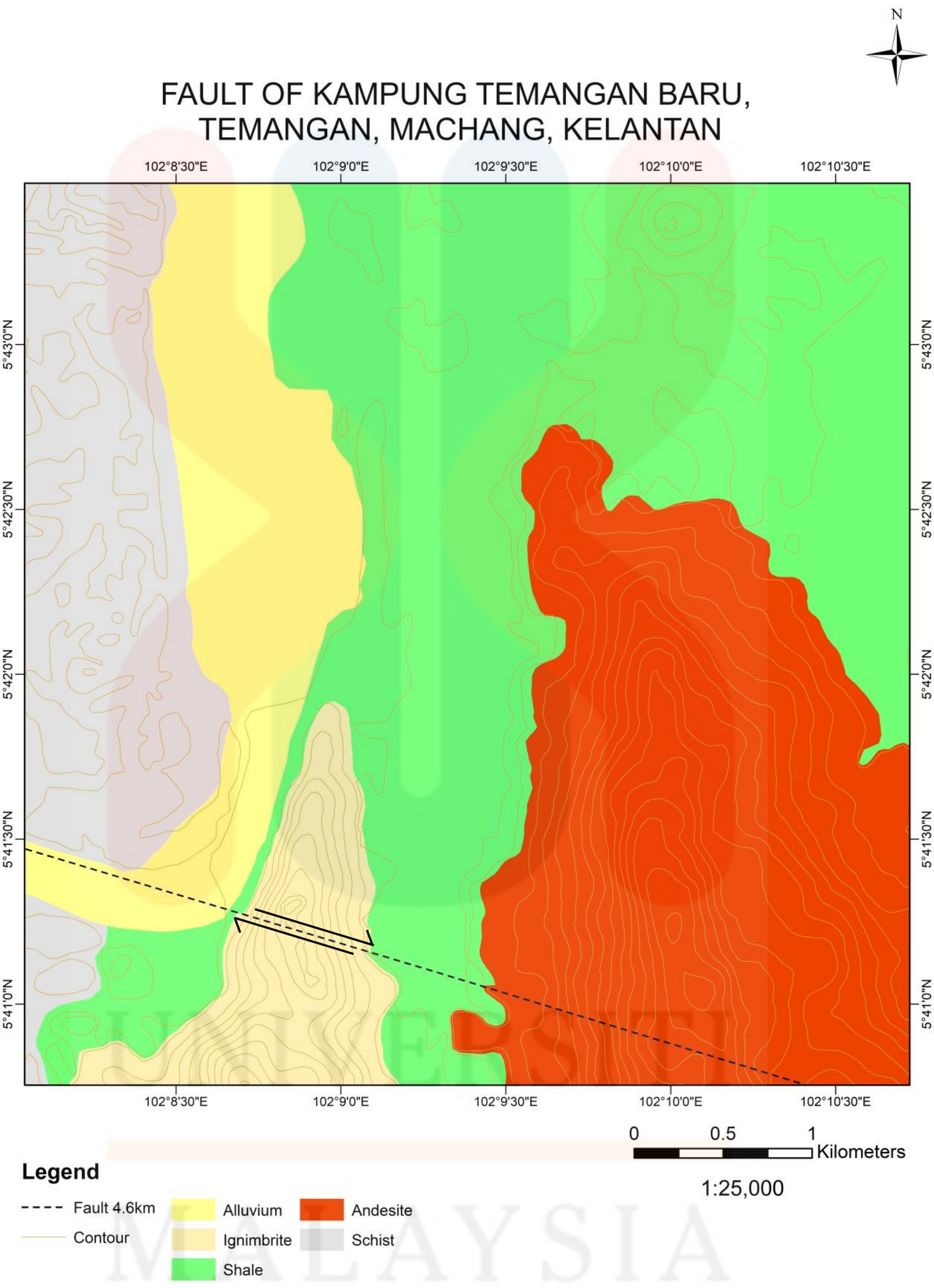


Figure 5.33: Fault map of Kampung Temangan Baru, Temangan, Machang, Kelantan.

CHAPTER 6

CONCLUSION

6.1 Conclusion

As conclusion, this chapter concludes the study of the geology and fault analysis of Temangan, Machang, Kelantan. All the research objectives as in chapter 1 were successful achieved. The first objective was accomplished by producing the updated geological map of Kampung Temangan Baru, Temangan, Machang, Kelantan with scale of 1:25 000. All of the data in producing the new updated geological map were obtained from the secondary data. This study area were comprised of hilly, flatty or plain and river area that having main river which is Sungai Kelantan. This study area was having four main formations which are Alluvium, Temangan Ignimbrite, Telong Formation and Taku Schist. The geologic time age of the study area occurred during Quaternary to Permian.

From the analysis using the rose diagram that indicated the dynamic analysis and stereographic projection for the kinematic analysis the main forces was trending toward the North East to South West with a value of $\boldsymbol{\sigma_1}$ is 5 - 45°. The forces from NE-SW caused the Dextral Strike Slip Fault that named as Temangan Dextral Strike Slip Fault. This analysis was help by the indicator of fault that was found in terms of geomorphology, lithology, structural geology and historical geology. The shear and extension joint help in doing the fault analysis that updated the geological map and the presence of the fault at the study area.

6.2 Recommendation

Further research of fault analysis need to be done in larger area of the surrounding because the area are having 23km of ignimbrite ridge at the study area toward North-South with a width 0.8km (Hamzah & Hamzah, 2014). Besides, this study area having previous exploration which regarding mining exploration need to be done in the surrounding was mining exploration area for Iron. There is Iron oxide that was found in the study area at the area of Ignimbrite.

To achieve a better result of fault analysis, resistivity method is needed as it helps to interpret the underground rock and give more information for the subsurface. As fault is form from the tectonic movement, the underground or subsurface is important.

6.3 Limitation

As this final year project was conducting during the COVID-19 pandemic, there are limitations in getting data especially field data. The field data is really important due to the specifications of the study. The exact and accurate data need to be processes to get a better result and to get the updated geological map.

Hereby, this limitations were overcome by tacking the secondary data from the previous research that overlapping the study area and also from the others agencies. Since to take the data from the other agencies taking a long time or tacking almost 6 months, some of the agencies cannot provide the data within the date needed. For the next final year project, the data can be starting to apply since Research Project I.

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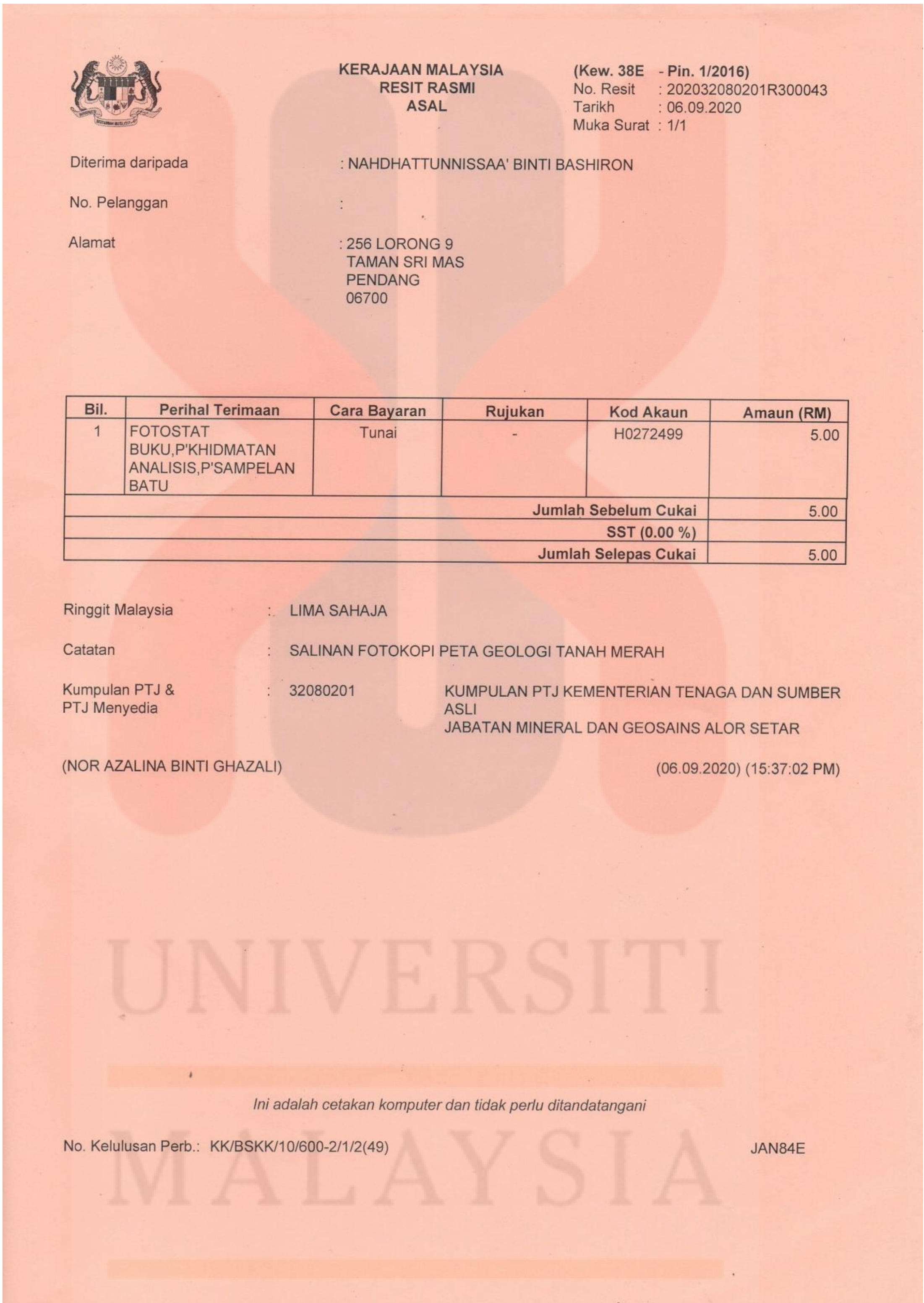
APPENDIX



KERAJAAN MALAYSIA
RESIT RASMI
ASAL

(Kew. 38E - Pin. 1/2016)
No. Resit : 202032080201R300043
Tarikh : 06.09.2020
Muka Surat : 1/1

Diterima daripada : NAHDHATTUNNISSAA' BINTI BASHIRON

No. Pelanggan :

Alamat : 256 LORONG 9
TAMAN SRI MAS
PENDANG
06700

Bil.	Perihal Terimaan	Cara Bayaran	Rujukan	Kod Akaun	Amaun (RM)
1	FOTOSTAT BUKU,P'KHIDMATAN ANALISIS,P'SAMPELAN BATU	Tunai	-	H0272499	5.00
				Jumlah Sebelum Cukai	5.00
				SST (0.00 %)	
				Jumlah Selepas Cukai	5.00

Ringgit Malaysia : LIMA SAHAJA

Catatan : SALINAN FOTOKOPI PETA GEOLOGI TANAH MERAH

Kumpulan PTJ & PTJ Menyedia : 32080201 KUMPULAN PTJ KEMENTERIAN TENAGA DAN SUMBER ASLI
JABATAN MINERAL DAN GEOSAINS ALOR SETAR

(NOR AZALINA BINTI GHAZALI) (06.09.2020) (15:37:02 PM)

Ini adalah cetakan komputer dan tidak perlu ditandatangani

No. Kelulusan Perb.: KK/BSKK/10/600-2/1/2(49) JAN84E

Figure 1: The receipt of the hard copy of geological map of Tanah Merah New Series L 7010 Sheet 22.

Figure 2: A visit to Majlis Daerah Machang for data application of Landuse map.

Figure 3: First visit to Jabatan Mineral dan Geosains Cawangan Utara for data application.

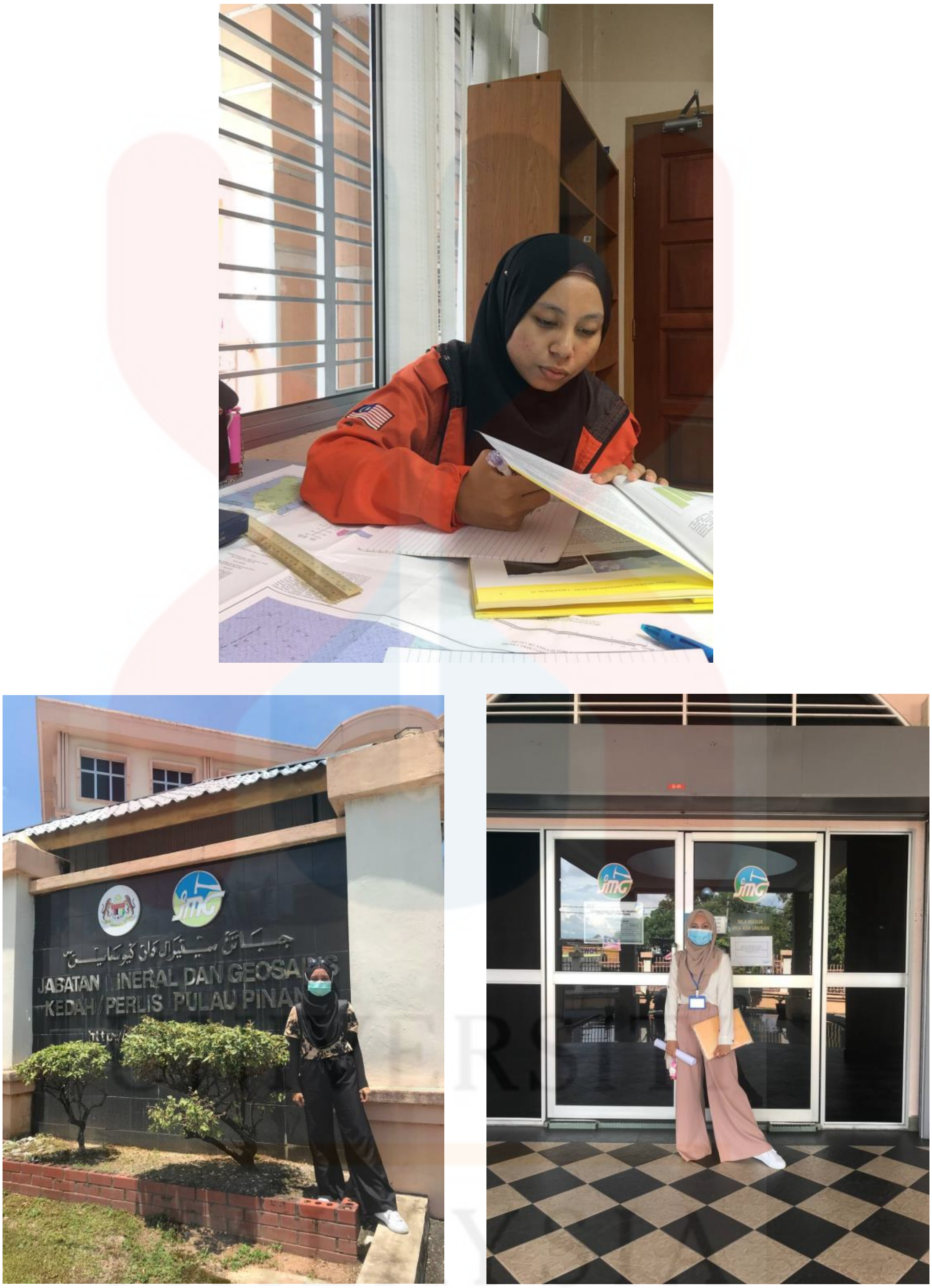


Figure 4: Data collection and get hard copy of geological map at Jabatan Mineral dan Geosains Cawangan Utara.