GEOLOGY OF BALEENDAH, BANDUNG REGENCY, WEST JAVA AND GEOCHEMICAL ANALYSIS OF SOIL FERTILITY

BY

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

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APPROVAL

"I/ We hereby declare that I/ we have read this thesis and in 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 Honors"

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DECLARATION

I declare that this thesis entitled “Geology of Baleendah and Geochemical Analysis of Soil Fertility” 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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Name	:	RAJA AININ SOFIYA BINTI RAJA HANIFF
Date	:	

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Geology of Baleendah, Bandung Regency, West Java, Indonesia And Geochemical Analysis of Soil Fertility

ABSTRACT

The research studies about geology of Baleendah in Bandung Regency, West Java and geochemical analysis of soil fertility. Soil fertility also depends on the concentration level of the major nutrients and minor nutrients in it. Therefore, soil fertility provides useful information to farmers or land developers to design appropriate agricultural activities and land use in certain areas. The purpose of the research is to produce a geological map of Baleendah area with the scale of 1: 25,000, to determine element distribution in soil and to investigate fertility of soil from volcanic products. Coordinate of the study area lies between the longitude of 107° 36’ 00’’ E to 107° 38’ 43’’ E and the latitude of 07° 00’ 00’’ S to 07° 02’ 42’’ S with the total dimension of 25 km^2. The study area is dominated by volcanic rocks from late Miocene to Quaternary Holocene of lake sediment deposits. Geomorphology of study area dominantly steep hilly areas. Method used in the research are geological mapping method and geochemistry analysis by using X-Ray Fluorescence (XRF) Spectrometer and Atomic Absorption Spectroscopy (AAS). The main lithology unit in the study area Lake Deposit Unit, Andesite Lava Unit, Volcanic Breccia Unit and Pyroxene Andesite Lava Unit. Eight soil samples were collected randomly at the depth of 25 cm to investigate the major nutrient and minor nutrient. Major nutrient tested are P, K, Ca and Mg. Meanwhile minor nutrient tested are Fe, Zn, Cu, and Mn. From the findings, volcanic soil from sample 7 tends to be the most fertile because of balance concentration between major and minor nutrient which suitable for agriculture purpose. The soil has the characteristic of tuff and belongs to Pyroxene Andesite Lava units. Plus, there is banana plantation and other crop in the area of the soil. Most of them grow well and exhibits green leaves.

Keywords: West Java, geological mapping, volcanic soil, major nutrient, minor nutrient, geochemistry, soil fertility

Geologi Baleendah, Kabupaten Bandung, Jawa Barat, Indonesia Dan Analisis Geokimia Untuk Kesuburan Tanah

ABSTRAK

Kajian penyelidikan ini mengenai geologi Baleendah di Kabupaten Bandung, Jawa Barat dan analisis geokimia kesuburan tanah. Kesuburan sesuatu tanah bergantung kepada tahap kepekatan nutrien utama dan nutrient minor di dalamnya. Oleh itu, kesuburan tanah memberikan maklumat yang berguna kepada petani serta pemaju tanah untuk merancang aktiviti pertanian yang sesuai serta penggunaan tanah di kawasan-kawasan tertentu. Kajian penyelidikan ini bertujuan untuk menghasilkan peta geologi kawasan Baleendah dengan skala 1: 25,000, untuk menentukan pengagihan unsur di dalam tanah dan untuk menyiasat kesuburan tanah hasil dari produk gunung api. Koordinat kawasan kajian terletak di antara longitud 107 ° 36 '00' 'E hingga 107 ° 38' 43 '' E dan latitud 07 ° 00 '' S '' hingga 07 ° 02 '42' 'S dengan jumlah dimensi 25 km2. Kawasan kajian didominasi oleh batuan gunung api berumur dari akhir Miosen hingga endapan danau Holosen Kuarter. Geomorfologi kawasan kajian adalah kawasan berbukit yang curam. Kaedah yang digunakan dalam penyelidikan adalah kaedah pemetaan geologi dan analisis geokimia dengan menggunakan X-Ray Fluorescence (XRF) Spektrometer dan Spektroskopi Penyerapan Atom (AAS). Lithology utama di kawasan kajian terbahagi kepada empat iaitu Unit Endapan Danau, Unit Lava Andesit, Unit Breksi Vulkanik dan Unit Lava Andesit Piroksen. Lapan sampel tanah telah diambil secara rawak pada kedalaman 25 cm untuk mengkaji nutrien utama dan nutrien minor. Nutrien utama yang diuji ialah P, K, Ca dan Mg. Sementara itu, nutrien minor yang diuji adalah Fe, Zn, Cu, dan Mn. Hasil dari kajian, tanah gunung berapi dari sampel 7 cenderung menjadi tanah yang paling subur kerana kepekatan nutrien utama dan nutrient minor adalah seimbang dan sesuai untuk tujuan pertanian. Tanahnya mempunyai sifat tufa dan dimiliki oleh unit Lava Andesit Piroksen. Tambahan pula, terdapat tanaman pisang dan tanaman lain di kawasan tanah 7. Kebanyakan mereka tumbuh dengan baik dan mempamerkan daun hijau.

Kata kunci: Jawa Barat, pemetaan geologi, tanah gunung api, nutrient utama, nutrient minor, geokimia, kesuburan tanah

TABLE OF CONTENT

	PAGE
APPROVAL	i
DECLARATION	ii
ACKNOWLEDGEMENT	iii
ABSTRACT	iv
ABSTRAK	v
TABLE OF CONTENT	vi
LIST OF FIGURES	ix
LIST OF TABLES	xi
LIST OF ABBREVIATION	xii
LIST OF SYMBOLS	xiv
CHAPTER 1: INTRODUCTION	
1.1 Background of Study	1
1.2 Problem Statement	3
1.3 Objective	3
1.4 Scope of Study	4
1.5 Significance of Study	4
1.6 Study Area	5
1.6.1 Demography	8
1.6.2 Social economic and land use	10
1.6.3 Rainfall and climate	10
1.6.4 Accessibility	12

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction 13

2.2 Regional geology and tectonic setting 14

2.3 Stratigraphy 17

2.4 Structural geology 20

2.5 Historical geology 21

2.6 Geochemical approach in soil fertility 22

2.6.1 Geochemistry of soil 22

2.6.2 Volcanic soil 22

2.6.3 Major nutrient and minor nutrient in soil 23

2.6.4 Soil fertility 24

2.7 Geochemical Analysis 26

CHAPTER 3: MATERIAL AND METHOD

3.1 Introduction 28

3.2 Material/ equipment 30

3.3 Methodology 36

3.3.1 Preliminary study 36

3.3.2 Field study 36

3.3.3 Laboratory work 37

3.3.4 Data processing 40

3.3.5 Data Interpretation and Data Analysis 41

3.3.6 Report writing 42

CHAPTER 4: GENERAL GEOLOGY

4.1 Introduction 43

4.2 Geomorphology 45

4.2.1 Geomorphology classification 45

4.3 Weathering 55

4.4 Drainage pattern 61

4.5 Structural geology 64

4.5.1 Lineament analysis 66

4.6 Lithostratigraphy 68

4.7 Geology history 86

CHAPTER 5: GEOCHEMICAL ANALYSIS OF SOIL FERTILITY

5.1 Introduction 89

5.2 Result 92

5.3 Discussion 98

CHAPTER 6: CONCLUSION AND RECOMMENDATION

6.1 Conclusion 108

6.2 Recommendation 109

REFERENCES 111

APPENDIX 118

LIST OF FIGURES

Figure 1.1	Indonesia territory map	6
Figure 1.2	Location of Bandung in West Java Island	6
Figure 1.3	Base map of Baleendah	7
Figure 1.4	Population chart in West Java	8
Figure 1.5	Accessible road in the study area	12
Figure 2.1	Regional map of Indonesia	14
Figure 2.2	Structural cross section across West Java	15
Figure 2.3	Physiographic map of West Java region	16
Figure 2.4	Topography of Bandung Basin	17
Figure 2.5	Stratigraphic correlation of volcanic rock in South Bandung area	19
Figure 3.1	Research flow chart	29
Figure 3.2	Geological equipment	30
Figure 3.3	X-Ray Fluorescene analysis machine	33
Figure 3.4	Atomic Absorption Spectrometry (AAS) analysis machine	34
Figure 3.5	Polarizing microscope	35
Figure 4.1	Andesite quarry in Baleendah, Bandung	44
Figure 4.2	Paddy field in Baleendah, Bandung	44
Figure 4.3	Traverse map	47
Figure 4.4	Topography map based on elevation	48
Figure 4.5	3D topographic map of the study area	49
Figure 4.6	View of Baleendah mountain	50
Figure 4.7	Geomorphology of study area from the peak of Batu Kincir Resto	50
Figure 4.8	Geomorphology of the study area	53
Figure 4.9	Geomorphology map of Baleendah	54
Figure 4.10	Physical weathering	56
Figure 4.11	Biological weathering	57
Figure 4.12	Example of biological weathering process	57
Figure 4.13	Rusting effect due to oxidation process	58
Figure 4.14	Type of drainage patterns	61

Figure 4.15	Map of drainage pattern in the study area	63
Figure 4.16	Example of columnar joint	65
Figure 4.17	Quaternary lava with flow structure	65
Figure 4.18	Lineament map of the study area	67
Figure 4.19	QAPF diagram for volcanic rock classification	69
Figure 4.20	The method of determining the extension angles in albite twins for plagioclase feldspar (Michel-Levy method)	70
Figure 4.21	Michel-Levy diagram curve	70
Figure 4.22	Pyroclastic rock classification diagrams	71
Figure 4.23	Lake deposit unit	72
Figure 4.24	Outcrop and hand specimen of Andesite Lava unit	73
Figure 4.25	Outcrop and hand specimen of tuff rock in Andesite Lava Unit	76
Figure 4.26	Outcrop and hand specimen of Volcanic Breccia Unit	76
Figure 4.27	Outcrop and hand specimen of Pyroxene Andesite Unit	81
Figure 4.28	Stratigraphy column of the study area	83
Figure 4.29	Lithological map of Baleendah, Bandung Regency	84
Figure 4.30	Geological map of Baleendah, Bandung Regency	88
Figure 5.1	Map of soil sampling location	91
Figure 5.2	Concentration of major nutrient in soil sample in mg/kg	98
Figure 5.3	Minor nutrient concentration in mg/kg	101
Figure 5.4	Soil profile at sample 7 sampling area	107
Figure 5.5	Soil profile at sample 3 sampling area	107

LIST OF TABLES

Table 1.1	Population in Bandung in 2011 to 2016	9
Table 1.2	Population by group and age gender in Bandung City 2016	9
Table 1.3	Rainfall and temperature data of Bandung Regency in 2017	11
Table 1.4	Rainfall and temperature data of Bandung Regency throughout 5 years	11
Table 2.1	Rating Chart for Soil Test Values and their Nutrient Indices	27
Table 2.2	Nutrient Fertility Index	27
Table 4.1	Relationship between absolute elevation and morphography	51
Table 4.2	Terminology used to describe slope angle	52
Table 4.3	Weathering classification system for volcanic rock (Burns et al., 2005)	60
Table 4.4	Description of Andesite	74
Table 4.5	Description of Tuff	77
Table 4.6	Description of Volcanic Breccia (matrix)	79
Table 4.7	Description of Volcanic Breccia (component)	80
Table 4.8	Description of Andesite	82
Table 4.9	Lithostratigraphy column of the study area	85
Table 5.1	Element distribution in all soil sample in mg/kg by using XRF	94
Table 5.2	Fe, Mn, Zn and Cu concentration in mg/kg by using AAS	97
Table 5.3	Concentration of major and trace element in agriculture soils	99
Table 5.4	The average mineralogical and nutrient element composition of common rocks on the Earth's land surface	105

LIST OF ABBREVIATION

Al	Aluminium
Ar	Argon
Ba	Barium
Ca	Calcium
Co	Cobalt
Cr	Chromium
Cu	Copper
Fe	Iron
Ga	Gallium
K	Potassium
La	Lanthanum
Mg	Magnesium
Mn	Manganese
Na	Sodium
Ni	Nickel
P	Phosphorus
Sc	Scandium
Si	Silicon
Sx	Sulphur trioxide
Ti	Titanium
V	Vanadium
Y	Yttrium
Zn	Zinc
Zr	Zirconium
AAS	Atomic Absorption Spectrometry
XRD	X-Ray Powder Diffraction
XRF	X-Ray Fluorescence Spectrometer
ICP-MS	Inductively Coupled Plasma Mass Spectrometry
Plag	Plagioclase
Pyx	Pyroxene
Hb	Hornblende

meq /100g	Milliequivalent/100g
kg/ha	Kilogram per hectare
dS/m	deciSiemens per metre
ppm	Parts per million

LIST OF SYMBOLS

%	Percentage
>	More than
<	Less than
°C	Degree sign

CHAPTER 1

INTRODUCTION

1.1 Background of Study

This research is to study about the geology of Baleendah, Indonesia and geochemical analysis of soil fertility. Objective of this research is to produce a geological map of Baleendah with the scale of 1:25,000, to determine element distribution in soil and to investigate fertility of volcanic soils in that area. The study area takes place in Baleendah district, located in the southern part of Bandung Regency in West Java, Indonesia.

West Java Province has impressive topography as in the north the land is flat, while the south is hilly with beaches and the central region is mountainous. Furthermore, the occurrence of volcanoes activities highly distributed in West Java especially in Bandung Basin. Thus, the soils derived from volcanic materials turn to be fertile soils which very suitable for agriculture activities.

Bandung Basin has very rich and highly fertile volcanic soil. Agriculture activities especially traditional dry rice cultivation has become the social economic of Sundanese people. Rapid agriculture activities is believed to take place in volcanic soil area due to its fertility. However, the information about soil fertility in Baleendah area is very limited. Thus, this research is conducted as an attempt to provide new information regarding soil fertility in Baleendah area by using geochemistry approach.

The investigation of the study area is carried out through geological mapping method which covers several processes such as traversing, geomorphological studies, outcrop description, geological structures analysis and rock sampling. The rock sample will be brought back to laboratory for further petrographical analysis. On the other hand, the specification in this research is to analyse soil fertility in Baleendah area by using geochemistry approach.

Geochemistry of soil is quite important to find out the quality of the soil by using some related geochemical method and laboratory instruments. Elemental distribution and their concentration in soils provides useful information regarding the fertility status of soil in the study area. Furthermore, geochemical studies of soil will enhance better understanding on the environment and soils in an area. Soil sampling will be conducted through geochemical fieldwork. The soil samples will be test through analysis of elemental composition by using Atomic Absorption Spectrometry (AAS) and X-Ray Fluorescene (XRF). Soil fertility will discuss about the availability of major nutrient and minor nutrient in every soil sample from XRF and AAS results. The result of this research is expected to provide a new updated geological map with new information about soil fertility in Baleendah area that can be used for future references.

1.2 Problem statement

Plant nutrients are very important for the plant growth and development. However, plant nutrients in soil might affected by the increase of urbanisation and development in the study area. Heavy metal accumulation might occur in soil due to uncontrolled sewage from the residents nearby. The presence of heavy metal will affect the fertility of soil and its quality. Thus, the research is conducted to determine the fertility of soil in Baleendah by observing the nutrient element distribution in soil and which elements that might affect the fertility of soils. Besides that, based on a research by (Rina, 2012), geological map of Bandung used still in the large scale of 1:100,000. The geological map of Bandung with scale of 1:100,000 was last updated in 2003 by (Silitonga, 2003). The study area only included in a geological map of Bandung with scale of 1: 100,000. Thus, a detailed geological map of Baleendah area need to be produced with smaller scale which is 1: 25,000. Small scale of geological map provides more detailed data and information in the study area that will be useful for future references compare to bigger scale map. In addition, this research is proposed to update the geological information about Baleendah area.

1.3 Objective

1. To produce a geological map of Baleendah area with the scale of 1:25,000.
2. To determine element distribution in volcanic soil in Baleendah, Bandung Regency, West Java.
3. To investigate fertility of volcanic soils based on the abundance of major and minor nutrients.

1.4 Scope of study

The scope of research will cover on two major component which are geological mapping and geochemical analysis of soil fertility in Baleendah, Bandung. Before conducting the geological mapping, the preparation of base map of Baleendah is done by using ArcGIS Version 10.2 Software. The interpretation of lineament in the study area is done before going to fieldwork. After the base map is ready, geological mapping is carried out in Baleendah to study about lithology, stratigraphy and geomorphology, observation of geological structures and outcrop description and rock sampling. Then, all the information will be used to produce a detailed geological map of Baleendah with the scale of 1: 25,000. The rock sample will be brought back to the laboratory for thin section and petrography analysis. The specification of this research focuses on geochemistry soil analysis. Geochemistry method will involve fieldwork and laboratory analysis. Seven soil samples from seven different location were collected randomly through geochemical fieldwork. Geochemistry of soil will observe about elements in soil from volcanic product which contribute to soil fertility. The tested soil are volcanic soils from different lithology. Element in soil will be test using X-Ray Fluorescene (XRF) and Atomic Absorption Spectrometry (AAS).

1.5 Significant of study

The research is conducted to provide a detailed geological map of Baleendah area with the smaller scale which is 1:25,000. More information and new data will be updated in the map through geological mapping. Thus, it will be useful for future references and researches. Furthermore, the specification of research is to investigate soil fertility in the study area by using geochemistry approach. Fertility of soil is observed based on distribution of elements which acts as major and minor nutrients for the soil. The study of soil fertility can provide new information on soil land use potential and development in the study area. Moreover, it can be references for economic purpose such as agriculture planning, soil conservation and soil management in the future.

1.6 Study area

The study area takes place Indonesia. Figure 1.1 shows the map of Indonesia. The name of the study area is which located on the south of Bandung Regency in West Java. Figure 1.2 show the map of West Java Island. The study area lies on the longitude of 107° 36’ 00’’ E to 107° 38’ 43.0’’ E and the latitude of 07° 00’ 00’’ S to 07° 00’ 43.0’’ S with the dimension on 5 km x 5 km. The base map of the study area is shown in Figure 1.3. The lowest elevation in the study area is approximately 700 meters and the highest elevation is approximately 1100 meters. The main access in Baleendah are Jalan Raya Banjaran and Jalan Siliwangi. The main river in Baleendah is Citarum River flowing in the northern east of the study area. There are many streams in the study area which are suitable to obtain the fresh rock samples. Baleendah is a district which has good geomorphological features to study about geology.

Figure 1.1 Indonesia territory

Figure 1.2 Location of Bandung in West Java Island

(Source: http://www.nusaduabalitours.com/Java.php)

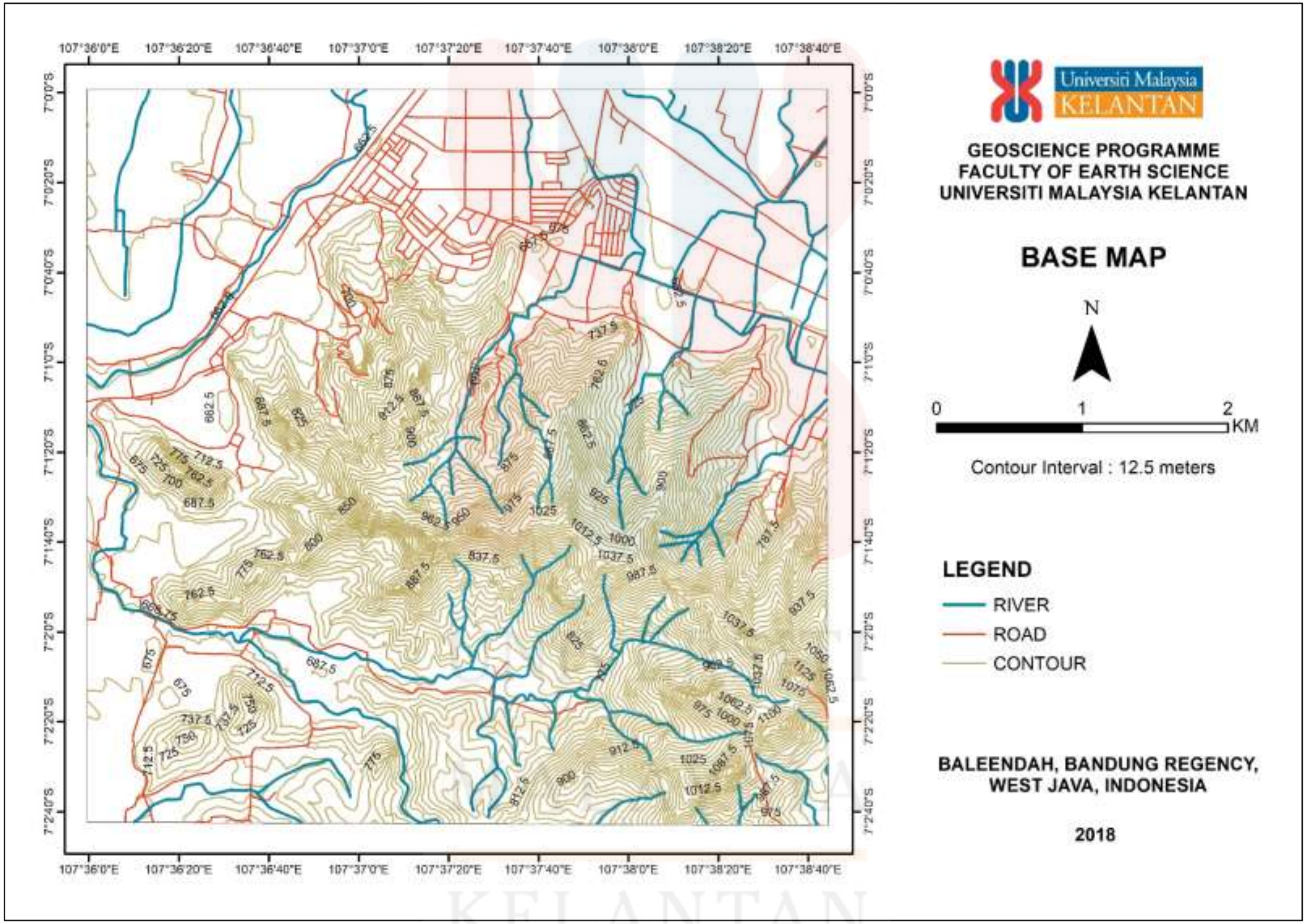


Figure 1.3 Base map of Baleendah

1.6.1 Demography

According to Badan Pusat Statistik Indonesia, (2013), the population of West Java Province is estimated at 43, 053, 732 people which in urban area, the population is 28 282 915 people (66 percent) and in rural areas is 14 770 817 people (34 percent). The data is shown in Figure 1.4. The statistics data in Table 1.1 shows total population in Bandung had increased from 2015 to 2016 from 2,481 469 to 2,490 622 million people. Table 1.2 shows the population in Bandung city according to gender and age.

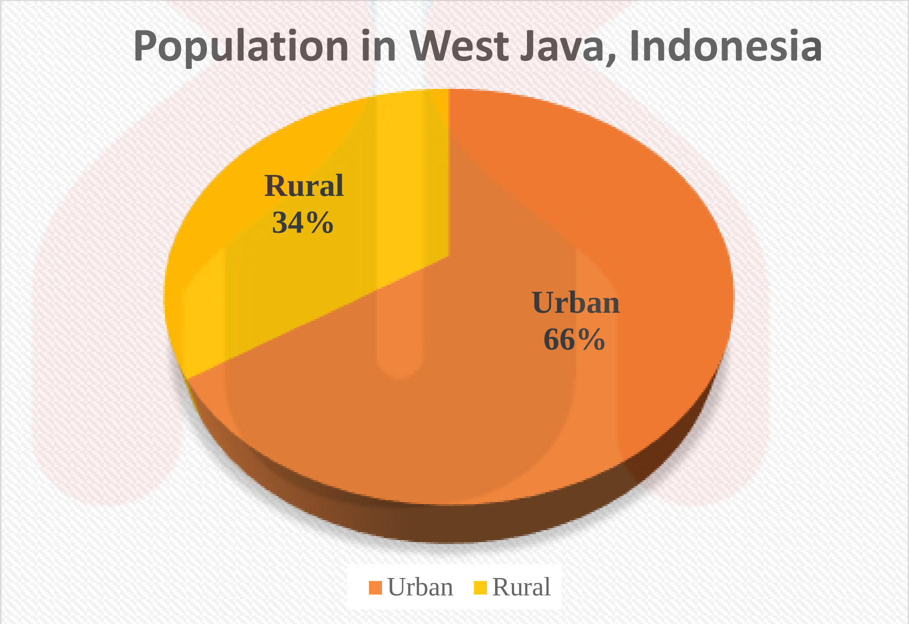


Figure 1.4 Population chart in West Java

Table 1.1 Population in Bandung (Source: Badan Pusat Statistik Indonesia, 2013)

Jumlah Penduduk dan Laju Pertumbuhan Penduduk di Kota Bandung 2011 - 2016

Tahun Year	Jumlah Penduduk Population	Laju Pertumbuhan Penduduk per Tahun Annual Population Growth Rate (%)
-1	-2	-5
2011	2 429 176	0,71
2012	2 444 617	0,64
2013	2 458 503	0,57
2014	2 470 802	0,50
2015	2 481 469	0,43
2016	2 490 622	0,37

Table 1.2 Population by group and age gender in Bandung City 2016 (Source: Statistics of Bandung City, 2018)

Jumlah Penduduk Menurut Kelompok Umur dan Jenis Kelamin di Kota Bandung 2016

Kelompok Umur Age Group	Jenis Kelamin/Sex Laki-laki Male	 Perempuan Famale	 Jumlah Total
-1	-2	-3	-4
0–4	104 902	100 864	205 766
5–9	98 508	93 126	191 634
10–14	88 699	85 562	174 261
15–19	110 047	112 442	222 489
20–24	133 694	125 767	259 461
25–29	119 981	110 133	230 114
30–34	110 668	103 220	213 888
35–39	99 556	97 814	197 370
40–44	92 623	92 183	184 806
45–49	80 276	82 214	162 490
50–54	69 264	70 530	139 794
55–59	56 285	57 289	113 574
60–64	37 156	35 864	73 020
65-69	25 307	27 163	52 470
70-74	16 271	17 599	33 870
75+	13 939	21 676	35 615
Jumlah/Total	1 257 176	1 233 446	2 490 622

Sumber /*Source*: Proyeksi Penduduk Indonesia 2010–2035/
Indonesia Population Projection 2010–2035 (diolah)

1.6.2 Social Economic and Land Use

West Java Province economy is dominated by agriculture activities and cultivated lands are extensively irrigated and double cropped. The Editor of Encyclopedia Britannica, (2013) mentioned that the most plantation to be discover in West Java region are such as paddy, sugarcane, maize, cassava, sweet potatoes, groundnuts, quinine, and tea. Rubber is grown at elevations of 300 to 1,500 feet. According to the report from Dinas Pertanian Perkebunan Dan Kehutanan, & Kabupaten Bandung, (2014) , soybean plantation has been developed in Cimaung District, Cikancung, Cicalengka, Baleendah, Margaasih and Kutawaringin with the total planting area in 2014 covering an area of 295 ha and harvested area reaching 275 ha. The province's industrial products include textiles, processed food, wood carvings and furniture, paper, tanned goods, printing, chemicals, and the machinery for the manufacture of leather goods, metal goods, and transport equipment.

1.6.3 Rainfall and climate

Bandung is situated on a plateau 768 meters above sea level with a cool climate throughout the year. Due to its topology, climate in Bandung is relatively cooler throughout the year than most of Indonesian cities. Table 1.3 shows statistic data of rainfall and temperature in 2017. Meanwhile, Table 1.4 shows rainfall and temperature in Bandung Regency in previous five years. In September 2017, Bandung regency records the highest maximum temperature at 30.5°C while the highest minimum temperature was in July 2017.

Table 1.3 Rainfall and temperature data of Bandung Regency in 2017
(Sources: Badan Meteorologi dan Geofisika Bandung)

Month	Average temperature (°C)	Maximum temperature (°C)	Minimum temperature (°C)	Amount of rainfall (mm)
January	24.2	29.1	21	65.3
February	23	28.3	20.4	199.3
March	23.3	29.2	20.2	389.3
April	23.6	28.2	20.7	220.2
May	23.9	29.5	20.2	222.3
June	23.4	28.6	20	106.4
July	23.4	29.2	19.5	39.1
August	23.3	29.8	18.8	48.4
September	23.7	30.5	19.4	90.8
October	23.4	29.8	20.2	345.3
November	23.1	28.7	20.4	442.2
December	23.9	29.3	20.7	129.9

Table 1.4 Rainfall and temperature data of Bandung Regency throughout 5 years
Sources : (Laporan Iklim Kota Bandung, Badan Meteorologi dan Geofisika Bandung)

Year	Minimum temperature (°C)	Maximum temperature (°C)	Average temperature (°C)	Amount of rainfall (mm)
2013	20	28.9	24.4	7.9
2014	19.8	29	24.4	9.4
2015	19.5	29.9	24.7	8.6
2016	20.6	29.2	24.9	12.2
2017	20.4	29	24.7	9.9

1.6.5 Accessibility

Baleendah has good accessibility as there are many roads that connect the rural area with the urban areas. The main access in Baleendah are through two main road which are Jalan Raya Banjaran and Jalan Siliwangi. Most of the rural road connect with these major roads such as Jalan Laswi, Jalan Langonsari, Jalan Bukit Mulya, Jalan Puradinata, Jalan Ciketik, Jalan Jasanaranata, Jalan Pasir Paros, Jalan Situsipatahunan, Jalan Andir Muara, Jalan Langon Sari, Jalan Cikupa, Jalan Simaluyu, Jalan Sampok Condong And Jalan Cibiuk.

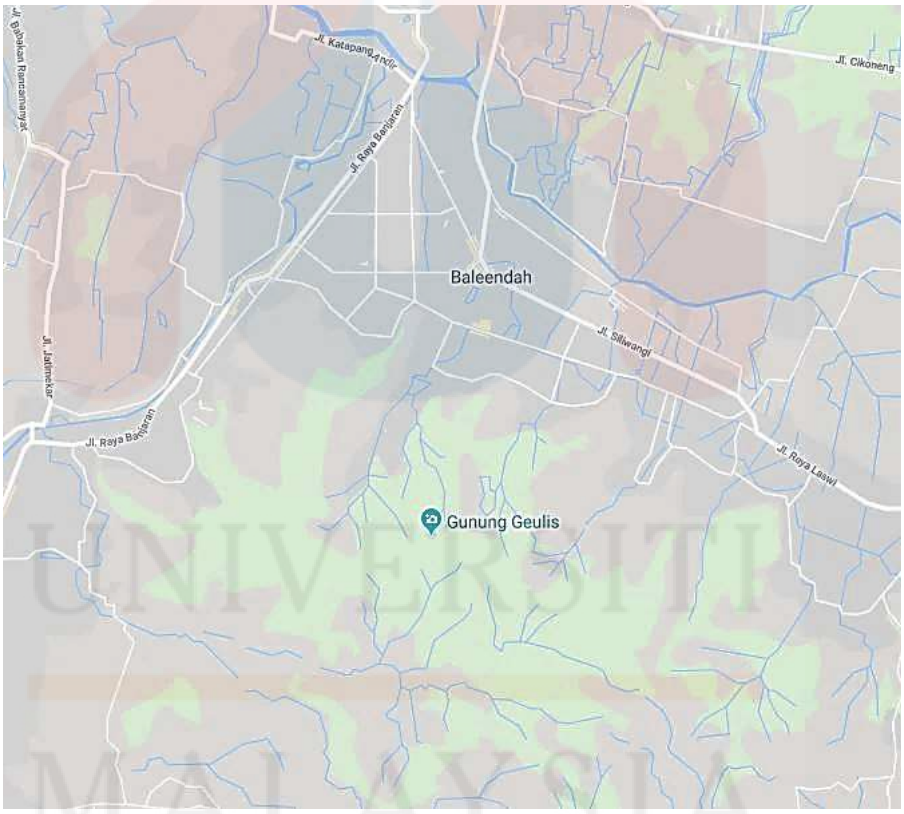


Figure 1.5 Accessible road in the study area (Sources : Map Google, 2018)

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will describe about Indonesia in aspects of regional geology and tectonic settings, stratigraphy, structural geology, and geology history and followed by literature review on specification of the research. Literature review is written through references from previous sources such as research papers, journals, newspapers, website, proceeding, articles and etc.

Republic of Indonesia is a huge equatorial archipelago that lies on the crossroad between Pacific Ocean and the Indian Ocean as well as the connector between two continents, Asia and the continent of Australia. It stretches from the latitude of 6°08′ N to 11°15′ S, and the longitude of 94°45′ E to 141°05′ E. Indonesia archipelago extends about 5,120 kilometres from east to west and 1,760 kilometres from north to south, comprising 17,000 islands, some of which only 6000 islands are inhabited.

The largest islands are Sumatra, Java, Kalimantan, Sulawesi, and the Indonesian part of New Guinea commonly known as Papua or Irian Jaya. The major cities in Indonesia are Jakarta, the capital of Indonesia, Surabaya, Bandung, Yogyakarta, Medan, Makassar and Jayapura. Strategically lies on the Ring of Fire, Indonesia predominantly is mountainous region with over 400 volcanoes, of which 100 are still active. Indonesia is the fourth most populous nation in the world with population record of approximately over 238 million people. The most densely populated island is Java with approximately 140 million people.

2.2 Regional Geology and Tectonic Setting

Indonesia has a very complex tectonic setting because it involves several tectonic plates meeting boundaries, the Australian Plate, the Eurasia Plate, the Indian Plate, the Sunda Plate, the Caroline Plate, the Philippine Sea Plate, and the Pacific Plate. Java is part of a volcanic island arc located in the Indonesian archipelago at the southern margin of the Eurasian Plate. Haryanto, (2006) states that collision activities between Hindi-Australia plate and Eurasian plate had influence the formation of regional structure in Java. The area of Java Island is about 12,700km^2 and length of 100 km long. Figure 2.1 shows regional map of Indonesia.

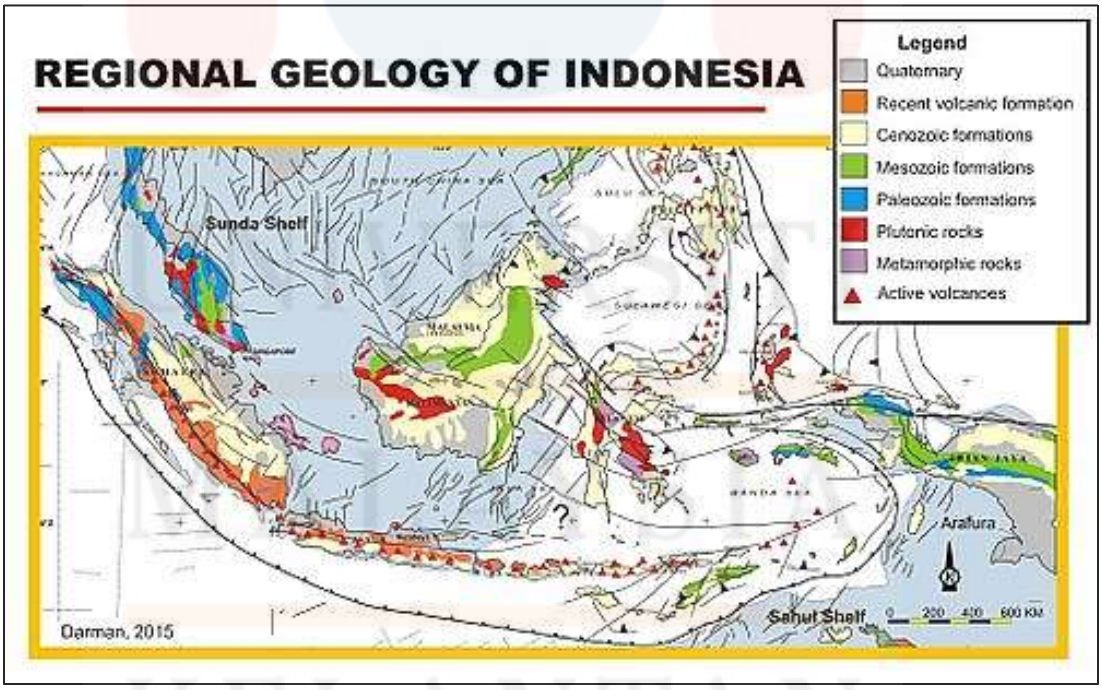


Figure 2.1 Regional map of Indonesia

(Clements et al., (2009) mentioned that Java is separated into three distinct structural sectors that broadly correspond to the regions of West, Central and East Java. The characteristic of division is based on physiographic and structural differences (Van Bemmelen, 1949). Figure 2.2 shows structural cross section of West Java. Febriani, (2014) explained that the subduction zone imposes tectonic stresses on the fore-arc region offshore and on land of Java and trigger the formation of earthquake fault zones to move the plates. There are three major faults which West Java region which are active, Lembang fault, Baribis fault and Cimandiri faults.

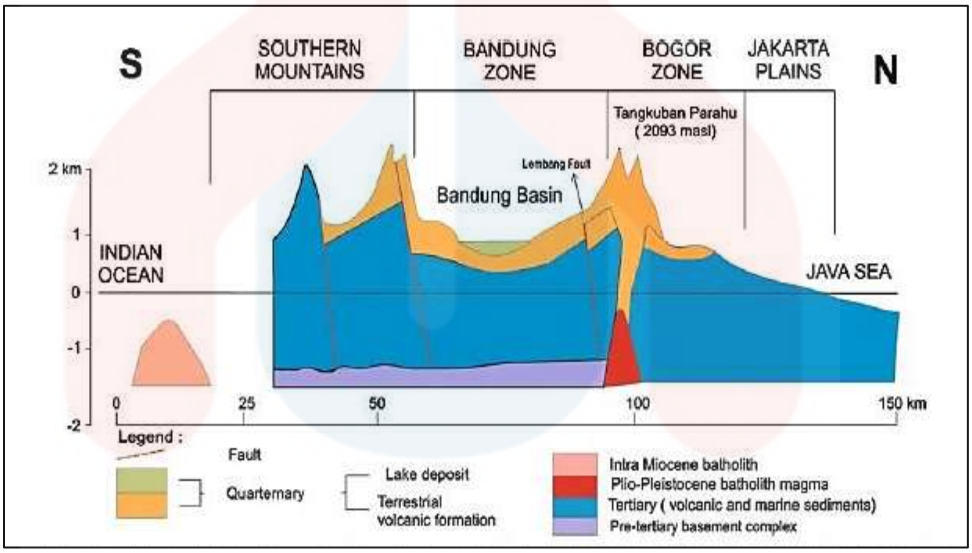


Figure 2.2 Structural cross section across West Java (Sources: Delinom, 2009)

Van Bemmelen, (1949) divided West Java into four distinct unit based on morphological and structural unit consists of the plain of Jakarta, the Bogor zone, the Bandung zone, and the southern mountain of West Java. West Java is 150-175 km wide and formed by an alluvial lowland plain in the northern part and mountainous chain in the south. Figure 2.3 shows physiographic map of West Java region.

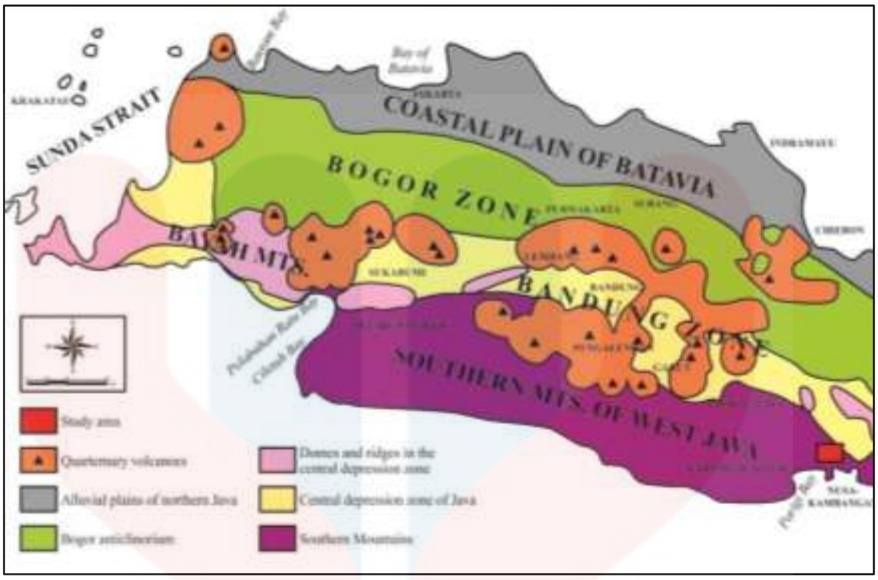


Figure 2.3 Physiographic map of West Java region (Source: Van Bemmelen, 1949)

The study area is the Bandung zone, located in south of the Bogor Zone. The Bandung zone is the depression zone in the West Java, which surrounded by up to 2400 m high Late Tertiary and Quaternary volcanic terrain, some of which are still active, and form the intra-montane basin known as the Bandung Basin (Gumilar et al., 2015). It is mostly filled by deposit of young volcanic products from surrounding volcanoes. The volcanoes lie in the lowlands between the two zones and they formed two rows at the edge of the Bandung zone (Haryanto, 2006). Figure 2.4 shows topography of Bandung Basin.

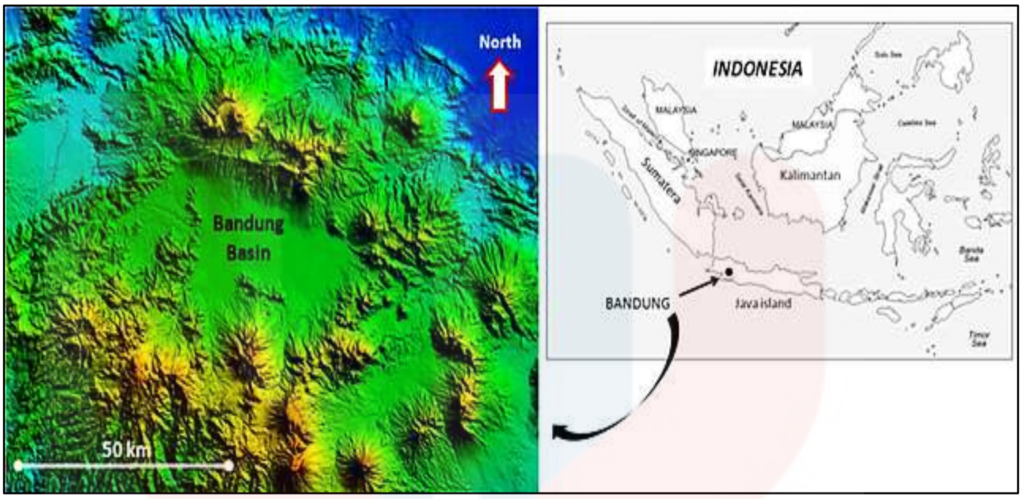


Figure 2.3 Topography of Bandung Basin (Source: Gumilar et al., 2015)

2.3 Stratigraphy

From the research paper by (Gumilar et al., 2015), geologically Bandung basin is dominated by various Quaternary volcanic rocks consisting of andesitic to dacitic lava, breccia, agglomerate, tuff, lahar, and intrusive rocks, and the western side of the basin was filled by older Tertiary sediments as shown by Figure 2.3. Based on Geological map of Garut and Pameungpeuk by (Alzwar et al, 1976), there are three formations in Baleendah which are lake deposit (Qd), Beser Formation (Tmb) and Andesit Waringin-Bedil Malabar Tua (Qwb).

Lake deposit consists of clay, silt, sand to coarse gravel which are generally tuff. The surrounding rock forms a horizontal layer with the insertion of breccia, containing the remains of freshwater mollusk and vertebrates. This sediment forms the plain of Bandung and reaches more than 100 m thick as mentioned by Silitonga, (2003). Waringin Bedil Andesite lava, breccia and tuff intercalation of pyroxene and andesite hornblends andesite. Lava is composed of pyroxene and hornblende andesite, bombs and is thickly polished. Breccia, lava and tuffs contain lapili-sized pumice. Waringin Mountain and Bedil Mountain is thought to be the volcanic remains of the body that tends to be the result of the formation of volcanic depression or old Malabar caldera. Mount Geulis is the bodies of parasites that grow on the slopes of the old Malabar volcano.

Beser Formation consists of tuffaceous breccia and lava, composed of andesite to basalt. Masses of floating rocky tuffs are rather compressed. This breccia is interspersed with rather rough and gray interrupted tuffs. Tuffaceous breccia with andesite and basalt components, lapilli sizes to bombs, basal components are generally porous. Andesite lava up to basalt and pyroxene andesite, showing a stocky structure.

According to (Ridwan et al, 2017), distribution of rock units in South Bandung region is made up through volcanic stratigraphy in the Stratigraphic Code Indonesia by (Martodjojo, 2003) with determines the sources of volcanic eruptions. Figure 2.5 represents stratigraphic of volcanic rock unit in South Bandung. South Bandung region can be divided into nine rock units based on the centre of volcanic eruption:

1. Soreang Volcano Unit (SV),
2. Baleendah Volcano Unit (BV),
3. Pangalengan Volcano Unit (PV)
4. Tanjaknangsi Volcano Unit (TV)
5. Kuda Volcano Unit (KV)
6. Kendang Volcano Unit (KdV)
7. Dogdog Volcano Unit (DV)
8. Wayang-Windu Volcano Unit (WV)
9. Malabar Volcano Unit (MV)

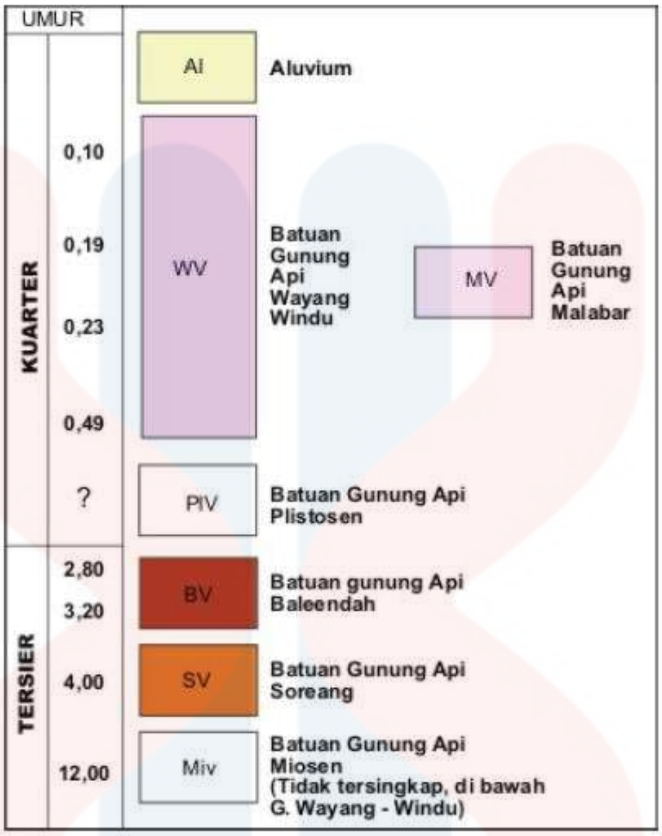


Figure 2.5 Stratigraphic Correlation of Volcanic Rock Units in South Bandung Area (Sources: Sutikno et. al, 2006)

Based on regional geology map, Baleendah area are dominated by three different lithology which are lake deposit (Qd), Beser Formation (Tmb) and Andesit Waringin-Bedil Malabar Tua (Qwb). Lake deposit consists of clay, silt, sand to coarse gravel which are generally tuff. The surrounding rock forms a horizontal layer with the insertion of breccia, containing the remains of freshwater mollusk and vertebrates. This sediment forms the plain of Bandung and reaches more than 100 m thick (Silitonga, 2003).

2.4 Structural Geology

Fault lines in Bandung Basin are generally trending east-west, north-south, northeast-southwest and northwest-southeast (Bronto & Hartono, 2006). The study area is located in the southern part of the Bandung Zone. (Gaffar, 2017) states that the boundary between Southern Mountain Zone and Bandung Zone is separated by Cimandiri Valley which is Cimandiri fault. Cimandiri fault is interpreted by (Dardji et al., 1994) as a sinistral based on the calculation of paleostress, meanwhile (Haryanto, 2014) argues that Cimandiri fault was a normal fault. Different opinions are stated by (Haryanto, 2014), which suggests that the Cimandiri fault zone is an upward fault.

According to (Katili & Sudradjat, 1984), Southern Bandung area includes in Quaternary volcano groups which are limited by three major faults. In the northwest, a shear fault zone is found in the direction of Sukabumi – Padalarang, in the northeast the shear fault zone acts Cilacap-Kuningan and to the south are down fault which borders the Mountains South. From the geological map of the Garut sheet by (Alzwar, et al., 1992), the fault pattern in Malabar mountain, Wayang- Windu mountain and Tilu mountain are oriented in east sea-southwest and slightly northwest-southeast direction. At the boundary between Quaternary volcanic rocks with Tertiary volcanic rocks in the north have faults going down east-west. According to (Gumilar et al., 2015), the east-west direction fault in is the Mount Geulis and Citarum faults.

2.5 Historical geology

The mechanism of formation of the geological structure of West Java is basically influenced by the collision activity of the Indo-Australian Plate which subduct beneath the Eurasia Plate (Haryanto, 2006). Due to this plate collision activity, the main tectonic elements happened in West Java in the form of troughs, non-volcanic outer arcs, front arc basins, magmatism pathways, arch-arc basins and Sunda Shelf (Katili, 1974).

According to (Hall, 2002), Indonesia basins was formed due to this subduction of Eurasian Plate. The subduction occurred during Cretaceous age produced many geological structures related to subduction and rifting in the arc and back-arc regions until in Cenozoic era (Yulianto et al., 2007). (Martodjojo, 2003) divided West Java into four structural trends which represent different tectonic episodes which are Meratus trend, the Sunda trend, the Java trend and the Sumatran trends. Regionally, the fault structure trending northeast-southwest is grouped as the Meratus Pattern, the north-south direction fault is classified as the Sunda Pattern and the east-west fault is grouped as the Javanese Pattern. The structure of the fault with the east-west direction is generally a type of upward fault, while the structure of the fault with the other direction is a horizontal fault.

Due to tectonic and volcanic activity during the Quaternary, the morphology of Bandung basin is surrounded by several mountains and active volcanoes. In Late Quartenary, the basin was deposited by thick lake sediments which probably these deposits might conceal several buried faults. A gravitational collapse from the builds up of Sunda Volcano destroyed the volcanic cones, while the depressurization of the main magma reservoir led to normal fault and the formation of the Lembang fault

(Afnimar et al, 2015). In their research, they stated that this fault, both older dip-slip and younger strike-slip displacement had occurred.

2.6 Geochemistry approach in soil fertility

2.6.1 Geochemistry of soil

Geochemistry approach is very important to provide soil information governing many physicochemical processes in soil (Ruffell et al., 2002). The concentrations of trace and major elements in residual soils depend mainly upon the bedrock type from which the soil parent material is derived and pedogenic processes acting upon it (Huang et al, 2011). The influence of the parent material on trace and major elements tends to decrease with soil development (Alloway, 2013). Pedogenesis influence the behaviour of trace and major elements from the aspect such as the release of metals from the parent material by weathering, the translocation and accumulation of sorbents such as clay minerals, oxides and organic matter.

2.6.2 Volcanic soil

Volcanic soil was formed from volcanoes ejection that being carried downwind from volcanoes sources and deposits at sufficient depth for soil formation to take place over the time. It has unique physical, chemical and mineralogical properties that are rarely contain in soils derived from other parent materials. These physical properties made the volcanic soil as the effective environment for plant growth (Narwal, 2002). Volcanic soils can be highly fertile due to their content of nutrient. The unique chemical properties of Andisols are basically due to their the highly aluminum-rich elemental composition, reactive nature of their colloidal fractions (Harsh et al., 2002).

2.6.3 Major nutrient and minor nutrient in soil

Kaleeswari et al., (2013) indicates that major nutrient is the nutrient which highly required by the plants in large quantity for their growth and development. Major nutrient in soil are Carbon (C), Hydrogen (H), Oxygen (O), Nitrogen (N), Phosphorus (P), Potassium (K), Calcium (Ca), Magnesium (Mg). Sulphur (S). Phosphorus has been called the "Master key to agriculture" according to (Singh et al., 2016) because low crop production is attributed mainly to the deficiency of phosphorus, except nitrogen, than the deficiency of other elements Crop needs Phosphorus for growth, cell division, root growth, fruit development and early ripening events. Amara Denis et al. (2016) in her papers mentioned black soils were higher in available potassium status than red soils which might be due to the predominance of K rich micaceous and feldspars minerals in parent material.

Micronutrient is the nutrient required by plant in smaller quantity for their growth and development, however it is equally crucial and demands for the plants as the macronutrients. Micronutrient in soil are Fe, Mn, Zn, Cu, B, Mo, Cl and Ni (Kaleeswari & Prabhaharan, 2013). According to (Singh et al., 2016), zinc uptake by plants decreases with increased soil pH. Uptake of zinc also is adversely affected by high levels of available phosphorus in soils as mentioned by (Pulakeshi et al., 2012). In a study conducted by (Vijaya Sekhar et al., 2000), sufficient content of manganese due to high organic matter content was observed in Upper Krishna Command Area. According to (Patil, PL, Dasog, 1999), poorly aerated or compacted soils also reduce iron uptake by plants. In addition, uptake of iron decreases with increased soil pH, and is adversely affected by high levels of available phosphorus, manganese and zinc in soils (Ravikumar & Somashekar, 2013).

The abundance of elements in soil largely depends upon the nature of bedrocks, climatic conditions and mobility. Interaction between lithosphere, hydrosphere, atmosphere and biosphere causes the distinct of soil from their parent material (Singh, 2015). The rock information in an agricultural field not only provides basic lithology for the soil but also contribute to the availability of major and minor elements in the soil.

Background concentration of an element in soil is related to the mineralogy of its parent material from where the soil has been developed and modified through pedogenic processes. Moisture content in soil and temperature are drivers for pedogenesis and give influences on elemental distribution ranging from accumulation of elements such Ca, Mg, Na, B and Mo in a region (Balwant, 2015). Plant uptake, leaching, runoff, erosion and gaseous losses are all possible pathways for elemental redistribution. Trace elements occur from primary soil minerals. For instance, Cu, Co, Ni, and Zn are all present in a variety of silicate and aluminosilicate minerals such as olivines, amphiboles, micas, and feldspars.

2.6.3 Soil fertility

Singh & Mishra, (2012) states that evaluation of fertility status of the soils of an area is very important factor in the context of sustainable agriculture. A fertile soil will contain most the macronutrients for basic plant nutrition such as nitrogen, phosphorus, and potassium, as well as micronutrients such as calcium, magnesium, sulphur, iron, zinc, copper, boron, molybdenum, nickel.

There are various factors which affect the soil fertility such as pH, soil organic matter, available major nutrient and available micronutrient. The measure of soil pH is an important parameter which helps in identification of chemical nature of the soil as it measures hydrogen ion concentration in the soil to indicate its acidic and alkaline nature of the soil (Shalini et al., 2003). A soil pH of 7.0 is considered neutral. A soil pH of less than 7.0 is considered acidic and a soil pH of less than 5.0 is considered very acidic.

Organic matter plays an important role in agricultural soils as it helps to maintain plant nutrients in the soil and the soil structure itself. Johnston, (2007) states that organic matter supplies plant nutrients, improves soil structure, improve water infiltration and retention, feeds soil micro flora and fauna, and enhance the retention and cycling of applied fertilizer. Moreover, (Kavitha & Sujatha, 2015) in their research revealed that high levels of organic matter not only provides part of the N requirement of crop plants, but also enhance nutrients in the soil.

However, when agricultural crops are planted in newly reclaimed Andisols, they show inferior growth to that in young alluvial soils. The reasons for this are often their low content of plant-available nutrient elements, especially P, and some micronutrients, sometimes their high toxic Al content, the highly sorptive properties of the nutrient ions and stabilization of soil organic N.

The reactive Al and Fe in these components are called active Al and active Fe, respectively (Wada, 1980). The major form of phosphorus in fresh rhyolitic to andesitic tephras is apatite (Nanzyo et al, 1998). This mineral plays an important role in crop production without phosphorus fertilization and in revegetation of areas with thick deposition of volcanic ash. Biotite is also a minor component of volcanic ash, but, it can readily release K, one of the major essential plant nutrients, from an interlayer site resulting in formation of trioctahedral vermiculite (Nanzyo et al., 2001).

2.7 Geochemical Analysis

From article written by Ravikumar et al, (2013), soil fertility status can be evaluated using nutrient index methods and fertility indicators. The nutrient index of soils is evaluated using organic carbon, available P and available K concentrations to measure soil fertility. Ravikumar et al., (2013) used atomic absorption spectrometry (AAS), inductively coupled plasma optical emission spectrometry (ICP-OES), and inductively coupled plasma mass spectrometry (ICP-MS) as the method for chemical analysis to determine micronutrient in soil.

Parker et al. (1951) introduced the nutrient availability index determination which later on edited by (Pathak, 2010) and (Ravikumar et al., 2013)A previous paper by (Amara Denis et al., (2016), nutrient index value and physico chemical fertility indicator are the method used to evaluate the soil fertility. A total of 118 surface samples were collected on grid basis with an auger from a depth of 0-20 cm. Soil fertility is determined by using analysis for pH, electrical conductivity, organic carbon, available nitrogen, P2O5 and K2O, available sulphur and available micronutrients (Zn, Mn, Fe & Cu) using standard analytical methods. Available micronutrient cations (Zn, Fe, Cu & Mn) were determined by using Atomic Absorption Spectrophotometer. (Amara Denis et al, 2016) used the rating chart as shown in Table 2.1 and Table 2.2 to determine soil fertility.

Table 2.1 Rating Chart for Soil Test Values and their Nutrient Indices (Source: Denis et al, 2016)

Soil Property	Unit	Range		
Soil pH	pH unit	< 6.0 (Acidic)	6.1-8.0 (Neutral)	>8.0 (Alkaline)
Electrical conductivity	dS/m	<1.0 (Normal)	1.0-2.0 (Critical)	>2.0 (Injurious)
Organic Matter	%	<0.5 (Low)	0.5-0.75 (Medium)	>0.75 (High)
Available Nitrogen (N)	kg/ha	<280 (Low)	280-560 (Medium)	>560 (High)
Available Phosphorus (P_2O_5)	kg/ha	<10 (Low)	10-25 (Medium)	>25 (High)
Available Potassium	kg/ha	<110 (Low)	110-280 (Medium)	>280 (High)
Available Sulphur	ppm	<10 (Low)	10-30 (Medium)	>30 (High)
Exchangeable Calcium (Ca)	meq/100g	<1.5 (Low)	1.5-4.5 (Medium)	>4.5 (High)
Exchangeable Mg	meq/100g	<1.5 (Low)	1.5-4.5 (Medium)	>4.5 (High)
Available Zinc (Zn)	ppm	<0.6 (Low)	0.6-1.0 (Medium)	>1.0 (High)
Available Manganese (Mn)	ppm	<2.0 (Low)	2-3 (Medium)	>3.0 (High)
Available Iron (Fe)	ppm	<0.2 (Low)	0.2-0.6 (Medium)	>0.6 (High)
Available Copper (Cu)	ppm	<4.5 (Low)	4.5-5.5 (Medium)	>5.5 (High)
Nutrient Index		I	II	III

Table 2.2 Nutrient Fertility Index (Source: M.K Amara Denis, et. al 2016)

Nutrient Index	Range	Remarks
I	Below 1.67	Low
II	1.67-2.33	Medium
III	Above 2.33	High

CHAPTER 3

MATERIAL AND METHODOLOGY

3.1 Introduction

All the methods used by a researcher during a research study are termed as research methods Research method are the procedures, schemes and algorithms used in research. They are essentially planned, scientific and value-neutral. They include theoretical procedures, experimental studies, numerical schemes, statistical approaches, etc. Research methods help researcher to collect samples, data and find a solution to a problem. Particularly, scientific research methods need explanations based on collected facts, measurements and observations and not on reasoning alone. They accept only those explanations which can be verified by experiments.

Research methodology is a systematic way to encounter a problem. It is a studying how research is to be conducted. Essentially, research methodology involves the procedures by which researchers go about their work of describing, explaining and predicting phenomena are called research methodology. It is also defined as the study of methods by which knowledge is gained. Its aim is to give the work plan of research. the research is conducted by following the component of research methodologies which are preliminary studies, material and method, field study, sampling laboratory analysis, data analyses and interpretation and final report writing.

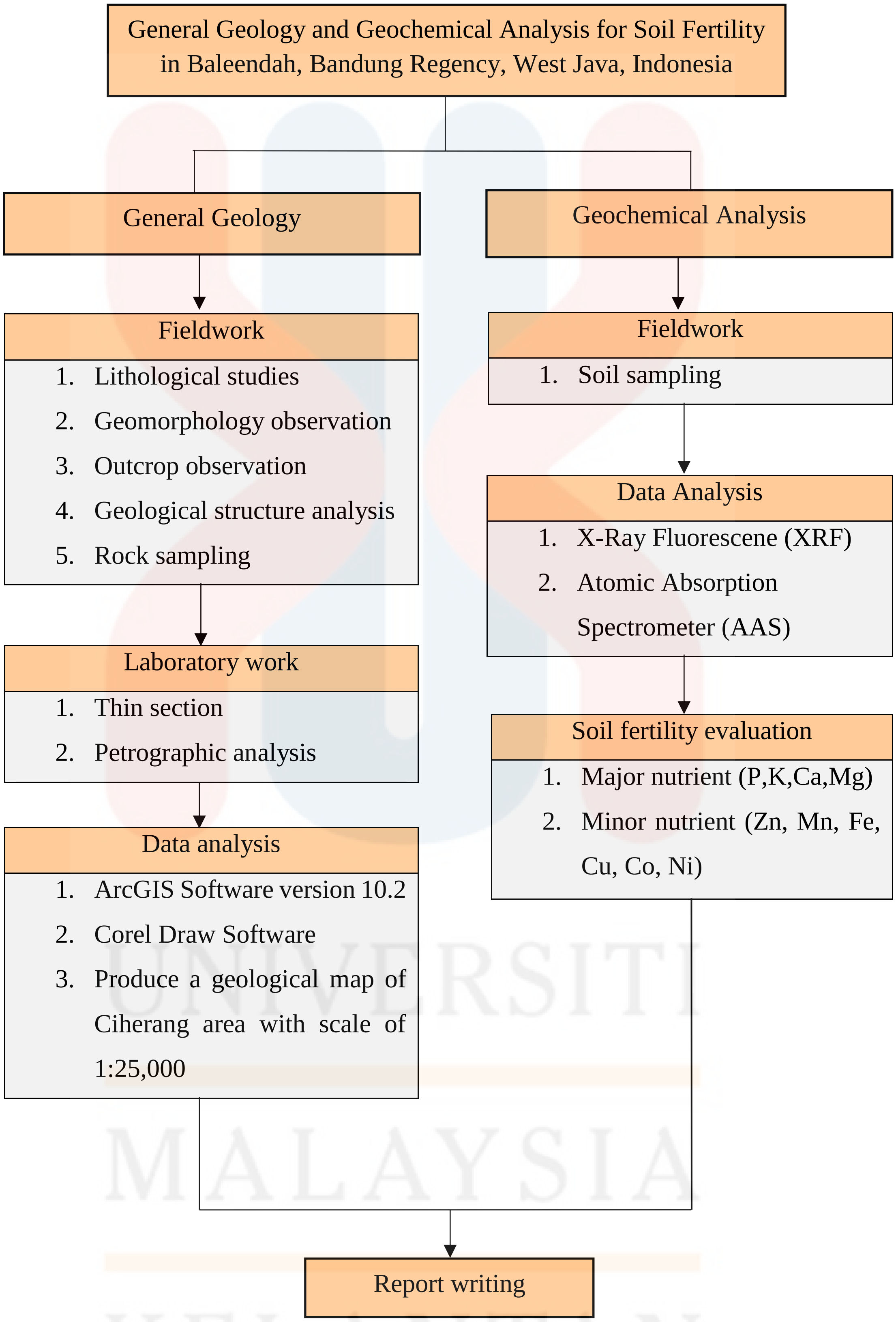


Figure 3.1 Research flow chart

Figure 3.1 shows the research flowchart to study about geology and geochemical analysis of soil fertility in Baleendah. The flow chart clearly summarized the work plan in order to complete the research. The research in conducted in systematic order to obtain the good result.

3.2 Material and Equipment

Several material and equipment have been used in this research to ensure that all the process of collecting data and sample run properly. Geological tools have been used during geological fieldwork as shown in Figure 3.2. Therefore, laboratory machines also have been used to analyse soil samples. All the equipment involve are explained below:

Figure 3.2 Geological equipment

1. **Geological hammer**

Geological hammer is used to break the rock. It is very important for geologist to take the fresh sample of rock from the outcrop for further analysis of its mineral composition and physical characteristics to predict the history of rock formation.

2. Brunton compass

It is used during fieldwork to measure the orientation of geological structures. In this research, Brunton compass were used to measure the bearing of outcrop, read the strike and dip of the outcrop bedding plane, metamorphic foliation planes or lineation, orientation of fault plane and orientation of joints.

3. Hand lens

Hand lens is an essential tool that geologist often need to closely examine rocks and minerals. By viewing sample or mineral crystals with naked eyes, geologists can properly classify, describe, and characterize rock in order to understand their origin and geology history. Typically, most of geologist used hand lens with magnification of 10x, 15x, or 20x. High magnification allows geologist to see trace minerals, tiny crystals, and grain surfaces more clearly.

4. Global positioning system (GPS)

Global positioning system (GPS) applications are categorize into 5 major scope:

1. Location - to determine a position
2. Navigation - getting from one location to another
3. Tracking - monitoring object or personal movement
4. Mapping - creating maps of the world
5. Timing - bringing precise timing to the world

The research used GPS for traversing along the study area and to obtain coordinates of the rock sample location, soil sample location and the coordinate of geological structures when taking the measurements.

5. Digital camera

Digital camera is commonly used for proofing materials. Camera is used to capture all related photos during geological fieldwork such as outcrop, rock samples, fossils, geological structures or geomorphological features. These pictures help geologist to make better report about the study area.

6. Measuring tape

Measuring tape is a flexible ruler in mapping aids that commonly used to measure distance. In geological survey, measuring tape is used to measure the dimension (height and width) of the outcrop or boulders, measure the thickness of beddings and others.

7. Hand shovel

Hand shovel is a tool for scooping loose materials such as soil, sand and gravels. In the research, hand shovel is used for digging the soils. An ideal size of hand shovel was chosen to ensure it is easier to put the soil into the sample bag.

8. ArcGIS 10.2 Software

ArcGIS is a software which operates with geographic information system (GIS) to create maps, gathering geographic data, analysing, sharing and managing all geographic information into a database. ArcGIS is used to create the base map, some related map to the study area and also to produce the geological map of the study area. on the other hand, it is also used to create the soil sample map for research specification.

9. X-ray Fluorescence (XRF) Spectrometer

An X-ray fluorescence (XRF) spectrometer is a laboratory instrument used for non-destructive chemical analysis of rocks, minerals, sediments and fluids. XRF is widely used methods to analyse major and trace elements in rocks, minerals, or sediment due to relative ease and low cost of sample preparation, and the stability to run the machine itself. In the research, XRF is used for analysis of major element in each soil samples. Figure 3.3 show XRF analysis machine.

Figure 3.3 X-Ray Fluorescence analysis machine

10. Atomic Absorption Spectrometry (AAS)

Atomic absorption spectrometry (AAS) is an analytical technique that measures the concentrations of elements. Atomic absorption is so sensitive that it can measure down to parts per billion of a gram in a sample. Figure 3.4 show picture of AAS analysis machine. The technique makes use of the wavelengths of light specifically absorbed by an element. They correspond to the energies needed to promote electrons from one energy level to another, higher, energy level. this research used AAS to detect trace elements in each soil samples.

Figure 3.4 Atomic Absorption Spectrometry (AAS) analysis machine

11. Polarizing Microscope

It is a polarizing microscope that feature polarizing light with transmitted and incident illumination that is used by geologist to determine the nature of rocks and minerals. Figure 3.5 shows picture of polarize microscope. Microscope examination of a rock specimen through thin section slide is the principle technique used to identify the rock specimen. Further study can determine the components and features of the rock along with its composition, geology history and its tectonic settings. petrology microscope is used to examine thin section slide of rock in the study area to study about mineral composition within the rock itself. Petrological analysis is also conducted to determine the lithology within the study area.

Figure 3.5 Polarizing microscope

On the other hand, some materials also have been used in order to complete the research such as sample bags, stationaries, laboratory apparatus and laboratory chemicals. Sample bag is used to store the rock sample or soil samples. It helps the geologist to secure the sample from contamination before being brought back to laboratory for further analysis. Field notebook is very important to write down all information in the fields. All the data should be jot down according to the locations. Field notebook made easier to geologist to sketch the outcrop or geomorphology of the study area.

3.3 Methodology

3.3.1 Preliminary studies

Preliminary research will be conducted to gather information and data about the research, study area and other additional information through studies from previous researches through many different sources such as journal, newspapers, articles, internet, books, proceedings and other resources. Desk study is also done through maps. The map of study area can be access through Google Earth application in order to observe the lineament within the study area and get to know the distribution of geological structure in the study area. These preliminary studies were done before planning traverse of study area before going to field mapping. Base map of study area will be prepare using ArcGIS Software Ver. 10.2 to determine the geomorphological features, lineament, contour, river, streets, town, and the other resources.

3.3.2 Field studies

Field studies is conducted to observe about geology of the study area. Geological mapping is conducted to gather data about the geomorphology, weathering events, geological structures, lithology and stratigraphy of the study area and all these data jotted in the field notebook. The research will use base map and GPS for the purpose of traversing, outcrop observation and sampling. Traversing process also take place along the river because outcrop there is more fresh compare to the roadside. Then, the traverse track will be recorded in the GPS.

Sampling method in the research were collecting the fresh rock sample from the outcrop and soil samples in order to fulfill the objective of the research. Rock samples were collected from every lithology units present in the study area. Geological hammer was used to break the rock. The samples then were put into sample bag and seal tight to avoid contamination.

For geochemical study, eight soil sample have been collected through random sampling method that depends on lithology unit in the study area. Hand shovel has been used to dig the soil. The soil sample collected at the depth of 25 cm from the upper layer in order to prevent surface contamination and effect of humus in topsoil. The samples were put into a sample bag and sealed properly to avoid contamination. Sample bag were labelled and the coordinate of the sampling location were jotted down in a field notebook.

3.3.3 Laboratory work

Laboratory work for the research involve rock sample preparation for thin section of analysis soil sample by X-Ray Fluorescence (XRF) and Atomic Absorption Spectrometry (AAS). Analysis by XRF and AAS cover method used for sample preparation and their procedures.

Petrography analysis

Petrography analysis of rock sample was done through thin section. Thin section of rock sample provided detailed analysis for mineralogy, chemical composition, structure, texture, and the origin of the rock.

Preparation of thin section

Firstly, the rock sample were broken into small pieces to be cut by diamond saw and cut into rectangular shape and smaller than the size of glass slide. Next, the rock sample were labelled on one side, while another side was lapped flat and smoothen on cast iron lap with 400 grit corundum. Then, the rock chip was grind on a glass plate of 600 grit corundum to smooth the surface again. After grinding, a glass slide was put onto the lapped surface of the rock chip with epoxy, after drying on the hot plate. Then, a thin section saw was brought close to the glass slide to cut off the chip, followed by thinning the chip on the glass slide using thin section grinder. The thin section was lapped by hand on a glass plate with 600 grit corundum until approximately 30 microns of its thickness were obtained. Lastly, cover slip was cemented on top of the glass slide and ensured that no air bubbles present in the thin section.

X-Ray Fluorescence (XRF) Analysis

Sample preparation method

Sample preparation method used for elemental analysis by XRF is pressed powder pellet method. This method is used to observe low concentration elements of high atomic number, also known as trace elements (10 to 100s ppm). The samples will not be diluted by flux to achieve the maximum intensity. All the sample sieved through a 125 µm mesh and ensure that the whole sample goes through. The whole sample should be homogeneous, because certain different minerals in geological material have different hardness, thus the process of crushing them will vary.

Sample preparation procedure

Sample preparation starts by inserting 10 g of pressed rock sample (finely grounded <125 µm) into an agate mortar and add 2 ml Elvacite or Paraloid-solution (purely organic compound of Methyl-butyl methacrylate). Next, mix them thoroughly with a pestle until the powder is completely dry and a very thin film of Elvacite had around each grain. then, place your sample in the form and press it with a load of 20 ton. Release the sample from the form. After that, put the sample into an oven at temperature of 80 ˚C for one hour to harden it. After that, the form must be cleaned with ethanol to avoid oxidation. Lastly, wrap the different parts of it in paper for storage.

Atomic Absorption Spectrometer (AAS) Analysis

Firstly, the hot plate was turned on and bring to the temperature. Next, dry soil samples were sieved. then, 1 g of dried soil sample was weighed and put into 100 ml beaker and added with 10 ml of concentrated hydrochloric acid (HCL). The beaker then was covered with watch glass. The sample was placed onto the hot plate and refluxed at approximately 90° C for 15 minutes. Then, the soil solution was removed from the hot plate and allowed to cool down for a while. After that, the soil solution was filtered through Whatman No. 41 filter paper into 100 ml volumetric flask. The soil solution was diluted to a final volume of 100 ml. The soil solution was ready to be inserted into Atomic Absorption Spectrometer (AAS).

3.3.4 Data processing

Petrographic analysis

Petrographic analysis has been done by using polarizing microscope to obtain more detailed information about the lithology unit in the study area. The information has been used to make a new geological map of the study area. The geological map of the study area was created by using ArcGIS 10.2 software.

XRF analysis

Quantitative XRF data gives information of absolute quantity of an element present in a sample. Tabulation of data contains a number and a unit, usually ppm (parts per million) or % weight. Calibrations are also made by using samples with known concentrations of elements of interest to create a calibration curve that relates the specific known concentrations to peak heights. This curve can then be used to quantify samples of unknown concentrations by relating the peak height to the curve built from the known samples.

AAS analysis

To measure quantities of chemical elements, AAS method is used by measuring the absorbed radiation by the chemical element of interest in samples. This is done by reading the spectra produced when the sample is excited by radiation. Atomic absorption methods measure the amount of energy in the form of photons of light that are absorbed by the sample. wavelengths of light transmitted by the sample is measured and compared to wavelengths which originally passed through the sample. Every atom has its own pattern of wavelengths at which it will absorb energy, due to configuration of electrons in its outer shell.

From the spectra, qualitative analysis of a sample can be done. The concentration is calculated according to the Beer-Lambert law. A graph of absorbance value which directly proportional to the concentration of the analyte is produced. The concentration is usually determined from a calibration curve, obtained using standards of known concentration. In analytical chemistry, AAS is used to determine the concentration of specific metal element within a sample up to over 62 different metals in a solution.

3.3.5 Data interpretation and analysis

Petrography analysis interpretation

Interpretation of mineral composition and rock texture from petrographic analysis of thin section can be done by using polarized microscope. The interpretation also supporting by physical description of the rock sample for further understanding about the rock name.

Geochemistry analysis

Analysis by XRF was used to detect the presence of all major and minor elements in each soil samples. The elements are such as Si, Al, Fe, Mg, Ti, Ca, Mn, P, Na, K, V, Zn, Cu and Cr. After screening test by XRF, the soil sample is moved to undergo AAS analysis. Minor nutrient such as Fe, Zn, Cu and Mn are selected to determine their concentration as supporting data to the XRF result. All the element concentration has been tabulated in the form of graph, charts, and tables for easier interpretation. Then, the result is used to evaluate soil fertility based on the abundance of major nutrient and minor nutrient within the soil samples.

3.3.6 Report writing

Report writing is the final step to complete this research. Report writing cover the whole information about the geology of the study area and the specification of the research in order to complete the objective of the research. Suggestion and recommendation were also put after the conclusion for improvement of further researches.

CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

This chapter will briefly discuss about the geology aspect of the study area based on information from geological mapping fieldwork. Geological aspects will cover information regarding geomorphology, lithostratigraphy, stratigraphy and geology history about the study area.

Baleendah has very good accessibility because it can be access through two major road which are Jalan Raya Banjaran and Jalan Siliwangi. There are also many rural roads that connect the rural areas in Baleendah such as Jalan Puradinata, Jalan Ciketik, Jalan Jasanaranata, Jalan Pasir Paros, Jalan Situsipatahunan, Jalan Andir Muara, Jalan Langon Sari, Jalan Cikupa, Jalan Simaluyu, Jalan Sampok Condong And Jalan Cibiuk. Most of them are paved. However, the unpaved roads are also available in the study area.

Social economic in Baleendah are concentrated with urbanisation and agriculture activities by the local people there. Lands in Baleendah are rapidly filled with residential, small towns and quarries. Figure 4.1 shows andesite quarry in the study area. In addition, agriculture activities in Baleendah takes place from the flat lands to hilly land surface. Due to suitable climate and temperature, forest grows at the hilly and mountains areas in Baleendah and agriculture activities also positively expanding. Paddy fields are widely found in Baleendah which indicate that it is the main agriculture activities by people who live there. Figure 4.2 represent the picture of main agriculture activities in Baleendah.

Figure 4.1 Andesite quarry in Baleendah, Bandung

Figure 4.2 Paddy field in Baleendah, Bandung

Traversing has been done during geological fieldwork in order to gather all related data for the research by riding motorcycle and walking. During traversing, the rock sample are collected to be described. From all the data that has been interpreted, a geological map of Baleendah area is finally produced. Figure 4.3 shows traverse map during geological mapping in the study area.

4.2 Geomorphology

Geomorphology is the study of topographical features of the Earth surface which concerned about the origin, development of different types of landforms and the processes modifying those landforms. Geomorphology knowledges help ones to understand natural landform changes and the potential of hazards. Baleendah in West Java is a rural area which has very clear geomorphology features to be observed. According to (Ridwan et al, 2017), mostly slopes in Baleendah are dominantly steep and it consists of Late Miocene to Pleistocene volcanic rocks.

4.2.1 Geomorphological classification

As shown in the topographic map based on elevation in Figure 4.4, the lowest elevation recorded in the study area is 700m while the highest elevation recorded is 1100m. Figure 4.5 shows 3D topographic map of the study area. The lowest elevation comprises the land of settlement and agriculture activities while the highest elevation comprises of peak of hills and mountain ranges in the study area. Mountain ranges, namely Mount Kromong dominates half of the study area and it is connected with Mount Geulis located in the south eastern part of the study area. Figure 4.6 shows Baleendah mountain range. The study area is described as hilly to mountainous area as the contour patterns are packed and the spacing between contour lines are very tight to each other. Figure 4.7 shows panorama view of the study area.

Most of agriculture activities by local people can be found near the foothill of Mount Kromong. There are also many quarries in the study area which operated at the sloping to hilly area in Baleendah. The mountainous area for example Mount Kromong consists of thick forest where there is no accessible road to reach the peak.

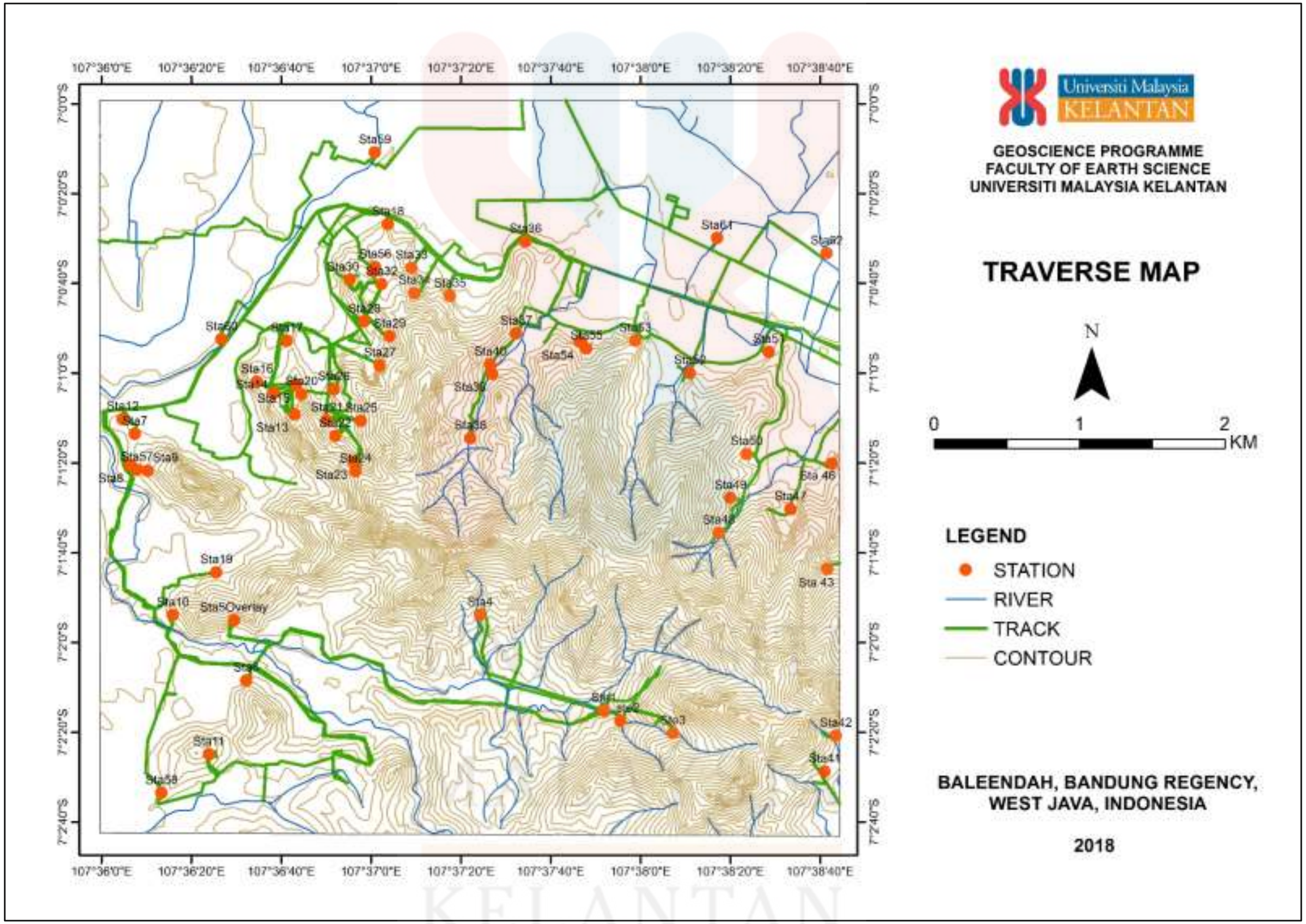


Figure 4.3 Traverse Map

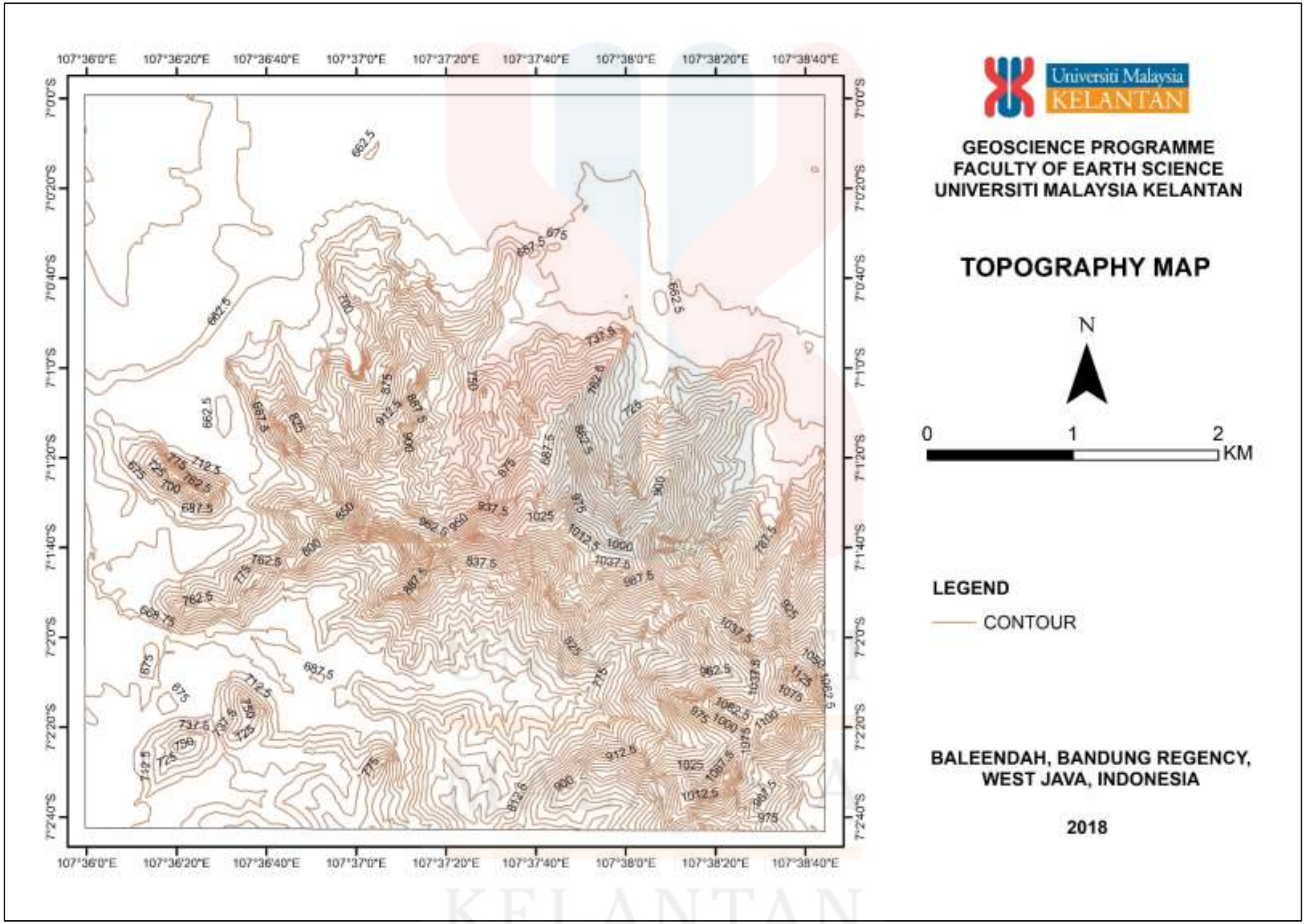


Figure 4.4 Topography map based on elevation

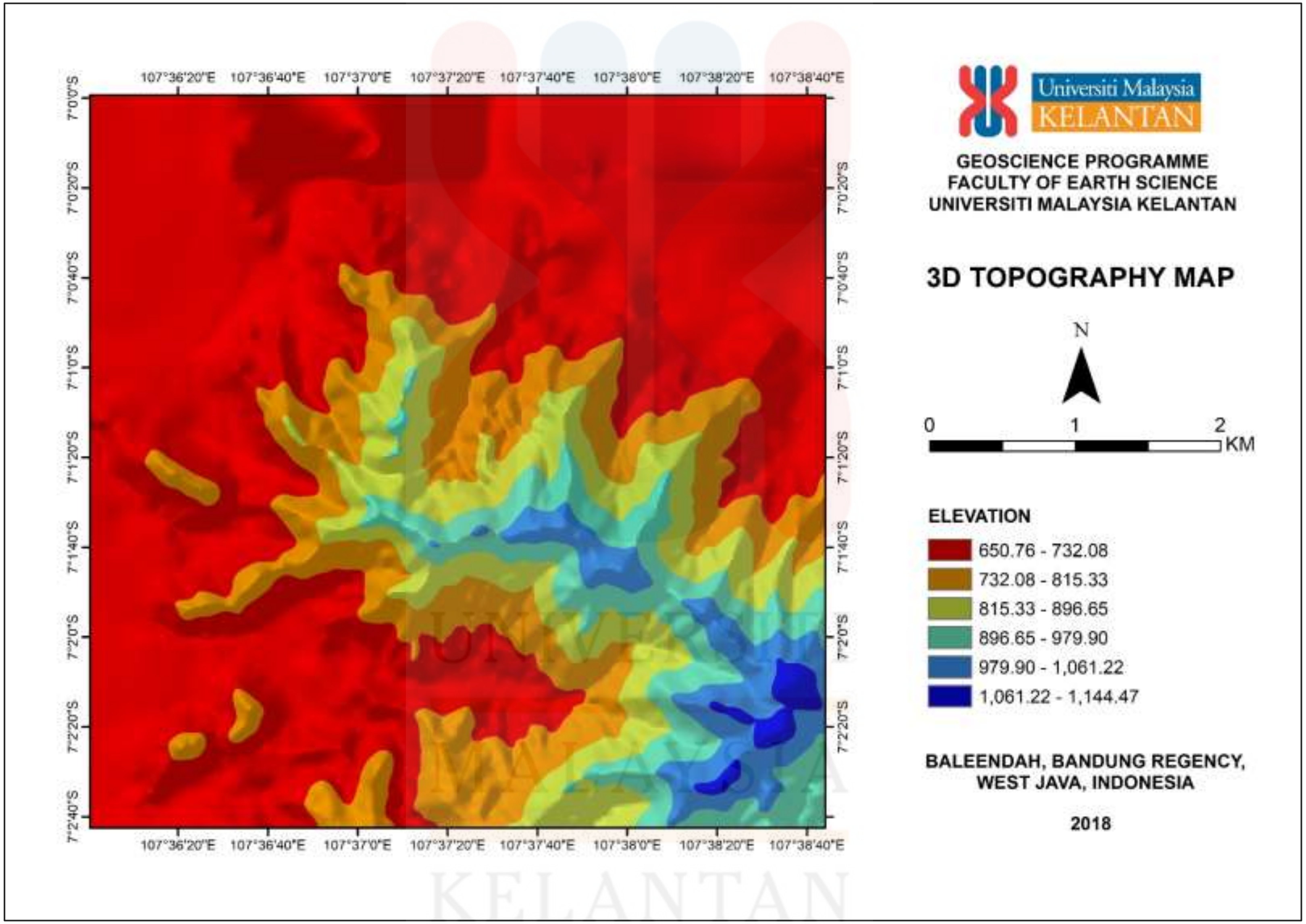


Figure 4.5 3D topographic map of study area

Figure 4.6 View of Baleendah mountain

Figure 4.7 Geomorphology of study area from the peak of Batu Kincir Resto

Geomorphology classification of the study area is determined by using Van Ziudam Classification (1985). Table 4.1 shows relationship between absolute elevation and morphography of Van Ziudam Classification (1985). Table 4.2 shows the terminology used to describe slope angle based on Van Ziudam Classification (1985).

Equation 4. 3

$$S_{xy} = \frac{(n-1)I_c}{D_x \cdot S_p} \times 100\%$$

where

n = total number of underlined contour

I_c = interval contour

D_x = length of straight line

S_p = scale of map

Table 4. 1 Relationship between absolute elevation and morphography

Absolute elevation (mean sea level)	Morphography element
< 50	Lowland
50-100	Low-lying plain
100-200	Low hill
200-500	Hill
500-1500	High hill
1500-3000	Mountain
>3000	High mountain

Table 4.2 Terminology used to describe slope angle

Slope	Explanation	Classification USSSM (%)
0-2	Flat-almost flat	0-2
3-7	Undulating/ gentle sloping	2-6
8-13	Undulating-rolling/sloping	6-13
14-20	Rolling hilly/ moderately steep	13-25
21-55	Hilly-steeply dissected/ steep	25-55
56-140	Steeply-dissected mountainous/ very steep	>55

Based on Van Ziudam Classification (1985), elevation in Baleendah is approximately hilly areas consists of five geomorphology class which are steeply-dissected mountainous, hilly-steeply dissected, rolling-hilly, undulating-rolling and fluvial low-lying plain. Figure 4.8 shows the picture of related geomorphology. Fluvial plain shows flat, horizontal lands and has river flows. The contour spacing are relatively loose to each other. Housing area and small towns are dominantly found in this area. Therefore, the soil is fertile enough as there are many paddy field and other vegetation found in this area. The outcrop in this area are difficult to be found due to high weathering process. in the area of Baleendah mountain range, the contour pattern become very tight to each other which indicate the slope are steep. Figure 4.9 shows geomorphology map of Baleendah region.

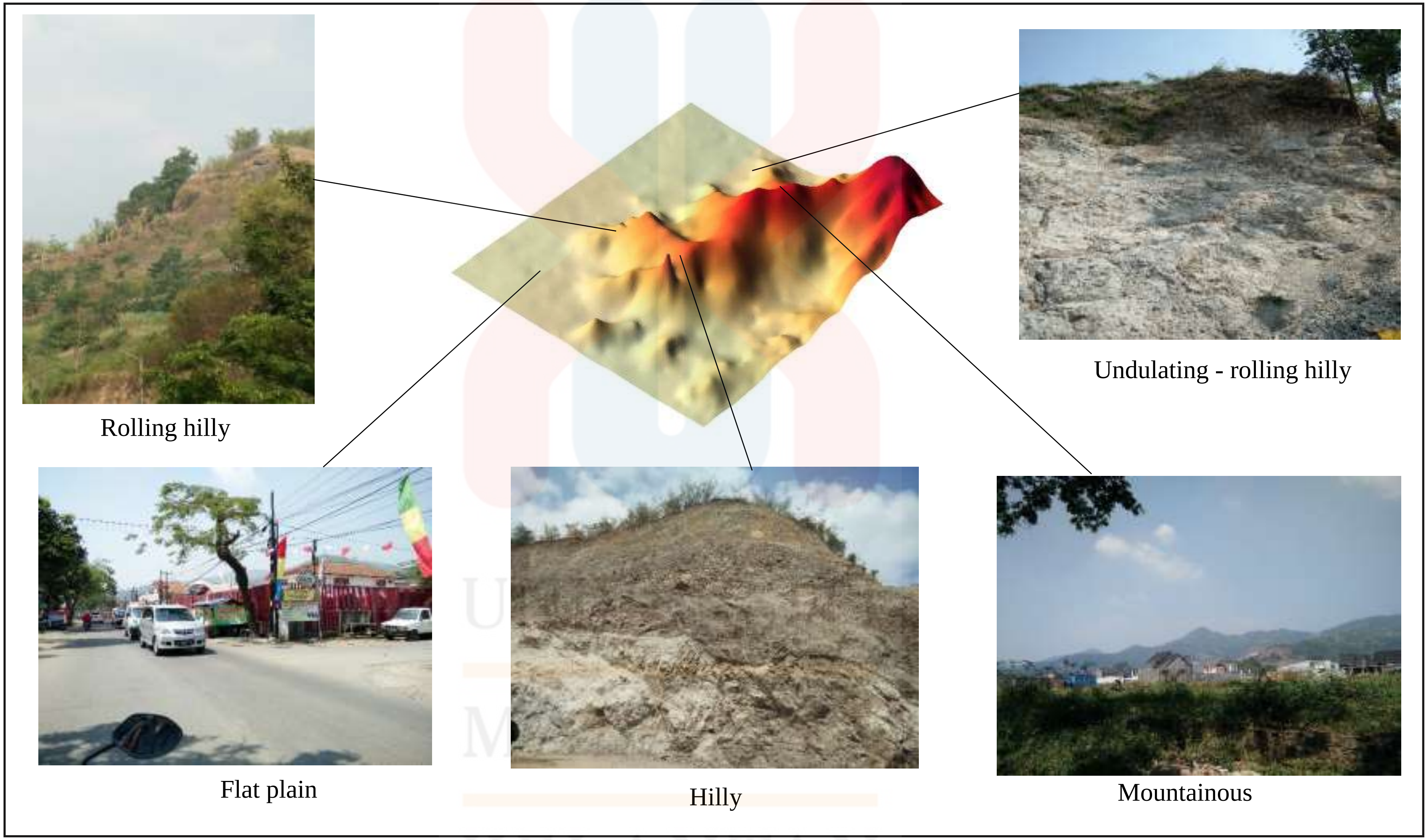
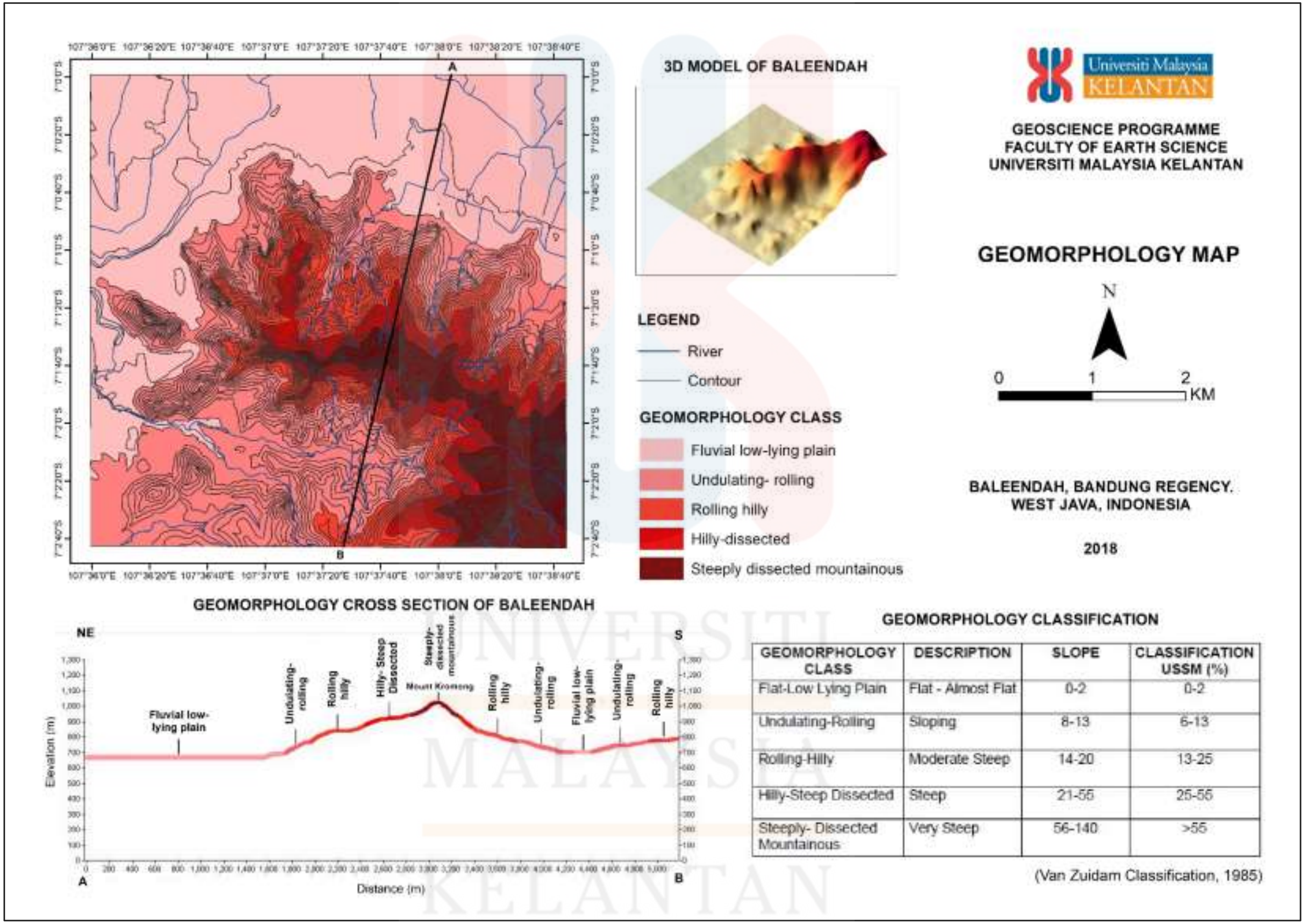


Figure 4.8 Geomorphology in the study area



GEOMORPHOLOGY CLASS	DESCRIPTION	SLOPE	CLASSIFICATION USSM (%)
Flat-Low Lying Plain	Flat - Almost Flat	0-2	0-2
Undulating-Rolling	Sloping	8-13	6-13
Rolling-Hilly	Moderate Steep	14-20	13-25
Hilly-Steep Dissected	Steep	21-55	25-55
Steeply- Dissected Mountainous	Very Steep	56-140	>55

(Van Zuidam Classification, 1985)

Figure 4.9 Geomorphology map of the study area

4.3 Weathering

Weathering is the disintegration of rocks near the Earth's surface, soil and its mineral content through natural, chemical or biological process. In the other hand, weathering also is described as the breaking down process of rocks, soil and minerals through interaction between Earth's atmosphere, lithosphere, hydrosphere and biosphere. Weathering process dissolves and loosens the rock and soil causes them to change their structure into smaller pieces and easily being transported away. This process is caused by several environmental forces. Biological activity, weather and agent of erosion such as water, wind and ice are the environmental forces which involve in weathering events. Rate of weathering depends on some controlling factor such as rock structure, rock composition, climate, surface area and time. Weathering types can be divided into three which are physical weathering, chemical weathering and biological weathering.

In the study area, the rate of weathering can be described as moderate to high. The weathering factor which influence the rate of weathering in Baleendah are the climate, the rock type and time. Weathering occurs through time where the parent rock had turned into soils.

According to statistic data of Baleendah, the amount of rainfall and the temperature in Baleendah have a significant effect on rate of weathering in the study area. Baleendah experiences a tropical climate which warm and cold, dry and moist condition are included. Moisture speeds up chemical weathering. Weathering occurs fastest in hot, wet climates. Physical weathering, chemical weathering and biological weathering are found within the study area.

Physical weathering

Physical weathering is break down of rock caused by the effects of changing temperature on rocks without changing its chemical properties. Changes in temperature caused uneven contraction and expansion effect to the rock, which make the rocks crack apart and disintegrate into smaller pieces. Figure 4.10 show the example of physical weathering in the study area.

Figure 4.10 Physical weathering

Biological weathering

As shown by Figure 4.11, the outcrop undergoes biological weathering. Biological weathering is the weakening and subsequent disintegration of rock by plants, animals and microbes. In the study area, tree roots grow through the rock fissure to find water sources for growth and they exert pressure within the rocks. Then pressure developed wider and deeper joints and cracks into the rock as shown in Figure 4.12.

Other than that, biological weathering also caused by burrowing animals such as moles, squirrels and rabbits. They speed up the development of fissures by secreting acid forming chemicals that dissolve the rock and eventually caused weathering.

Figure 4.11 Biological weathering

Figure 4.12 Example of biological weathering process

Chemical weathering

Chemical weathering is the breakdown of rock by chemical mechanisms. It does not break rocks into smaller fragments through erosion agent, instead it changes the chemical composition of the rock, usually through carbonation, hydration, hydrolysis or oxidation. Gradual and ongoing chemical process changes the mineralogy of rock over time which eventually will make them dissolve, break and disintegrate.

Rainwater is the most common agent involved in chemical weathering. Rainwater can become acid at times when it mixes with acidic materials in the atmosphere. Acidic materials in the atmosphere can probably come from fossil fuel combustion which releases oxides of nitrogen, sulfur and carbon. The acid water from precipitation reacts with the rock's mineral particles producing new minerals and salts that can readily dissolve or wear away the rock grains. Chemical weathering depends on the rock type and temperature. Higher temperatures increase the rate of chemical weathering. In the study area, the rock exposed by oxidation process. The interaction between rock, oxygen and water gives a rusty-coloured weathered surface as shown in Figure 4.13.

Figure 4.13 Rusting effect due to oxidation process

According to weathering classification by (Burns et. al, 2005) in Table 4.3, there are three classes of weathering has been identified in the study area which are Grade VI, Grade V and Grade IV. In Grade VI, the rock has thoroughly turned into soil with original color and texture from its parent materials. In the study area, the soil has different texture according to its lithology. For example, dark brown color, with some clastic rock inserts comes from the weathered breccia rock mass, while soil from andesite rock has brown color with medium loamy texture. tuff soil has reddish brown color and loamy texture while lake deposit exhibit clay texture.

In grade V, the rock is completely weathered as it loses its strengths to where some rock fabric is preserved while the rock mass changed to a soil by chemical decomposition or physical disintegration. At this grade, the rock breaks faster when being hit by geological hammer. Therefore, Grade IV shows the rock highly weathered. The rock material is discoloured and more than half the rock mass changed to a soil. Defects such as cracks and fissures at the surface of rock penetrates deeply into the rock material. However, some corestones of slightly weathered rock also present.

Table 4.3 Weathering classification system for volcanic rock (Burns et al., 2005)

Grade	Term	Characteristic
VI	Residual Soil	Rock is completely changed to a soil with the original fabric destroyed.
V	Completely weathered rock	Original rock strength is lost and the rock mass changed to a soil either by chemical decomposition (with some rock fabric preserved) or by physical disintegration.
IV	Highly weathered rock	Most of the original rock mass strength is lost. Material is discoloured and more than half the mass changed to a soil by chemical decomposition or disintegration (increase in density of defects/fractures). Decomposition adjacent to defects and at the surface of clasts penetrates deeply into the rock material. Lithorelicts or corestones of unweathered or slightly weathered rock may be present.
III	Moderately weathered rock	The rock mass is significantly weaker than the fresh rock and part of the rock mass may have been changed to a soil. Rock material may be discoloured, and defect and clast surfaces will have a greater discolouration, which also penetrates slightly into the rock material. Increase in density of defects due to physical disintegration process such as slaking, stress relief, thermal expansion/ contraction and freeze/thaw.
II	Slightly weathered rock	The rock mass is not significantly weaker than when unweathered. Rock may be discoloured along defects, some of which may have been opened slightly.
I	Fresh rock	Rock mass shows no loss of strength, discolouration or other effects due to weathering. There may be slight discolouration on major rock mass defect surfaces or on clasts.

4.4 Drainage pattern

Drainage pattern is formed by streams, rivers and lakes in a drainage basin. Drainage pattern develops in response to the bedrock structure and surface topography. In another meaning, they are governed by the topography of the land whether a particular region is dominated by hard or soft rocks and gradient of land. There are several types of drainage pattern for example dendritic pattern, parallel pattern, trellis pattern, rectangular pattern and radial pattern as shown in Figure 4.14.

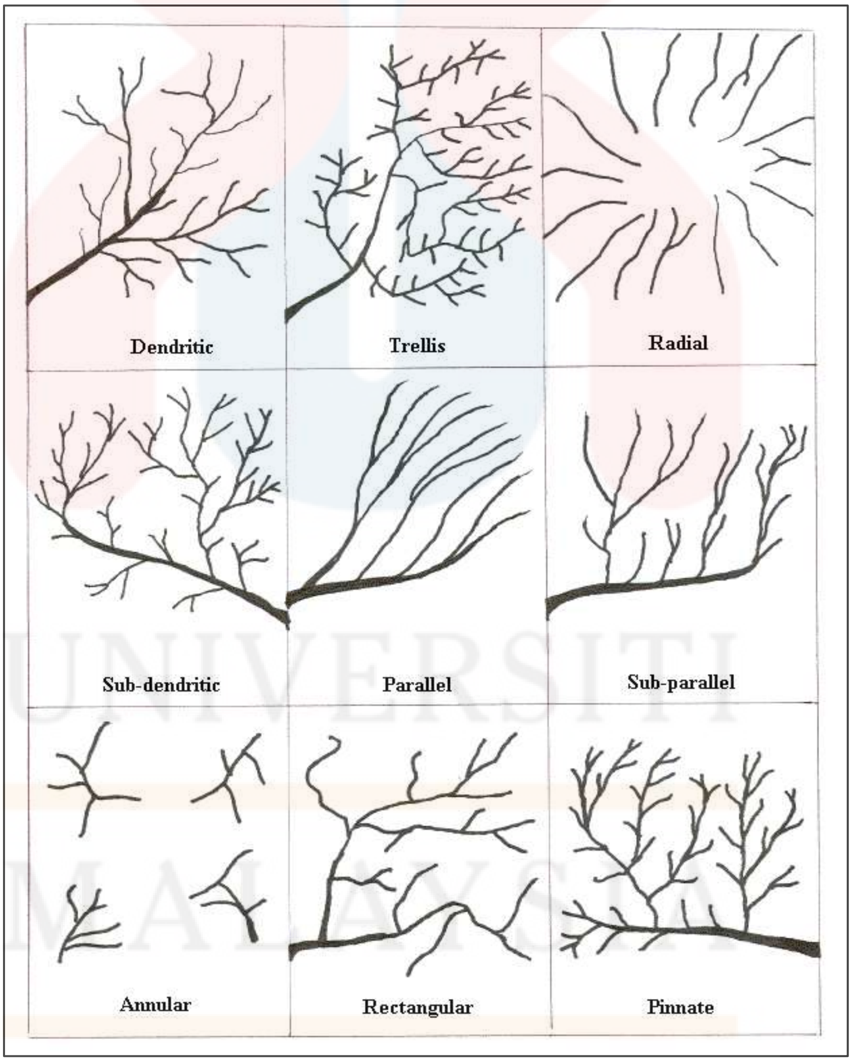


Figure 4.14 Type of drainage patterns

Characteristics of underlying rock, steepness of slope, fault and joints, the specific shape of particular geological formations and the soil susceptibility to erosion are among the factors that affect the pattern established for the flow of water in a particular area. Charlton, (2008) in his paper states that factor such as topography, bedrock type, climate and vegetation cover may influence the flow pattern of water.

From the drainage pattern map in Figure 4.15, there are three type of drainage pattern which developed in the study area. types of drainage pattern are anastomotic pattern, sub dendritic pattern and sub trellis pattern. Anastomotic drainage pattern is characterized by two or more interconnected channels which enclose flood plains. The drainage pattern forms under relatively low-energetic conditions near a base level in restricted areas. Dendritic drainage pattern in the study area appears to look like network of tributaries which resemble branches and rootlets of a tree. The tributaries developed in gentle sloping regions. As mentioned by in his paper, dendritic patterns commonly develop in areas where the rock beneath the stream has no particular structure and can be eroded equally easily in all directions such as volcanic rock.

The dendritic pattern is associated with the areas of homogeneous lithologies, horizontal, gently dipping strata, flat and rolling extensive topographic surface having extremely low reliefs. It develops in a variety of structural and lithological environments such as in the mountainous and hilly areas. A subtrellis drainage pattern appear to be tributaries with long and straight and often parallel to each other and to the main stream. Numerous short, stubby secondary tributaries join the primary tributaries approximately at right angles.

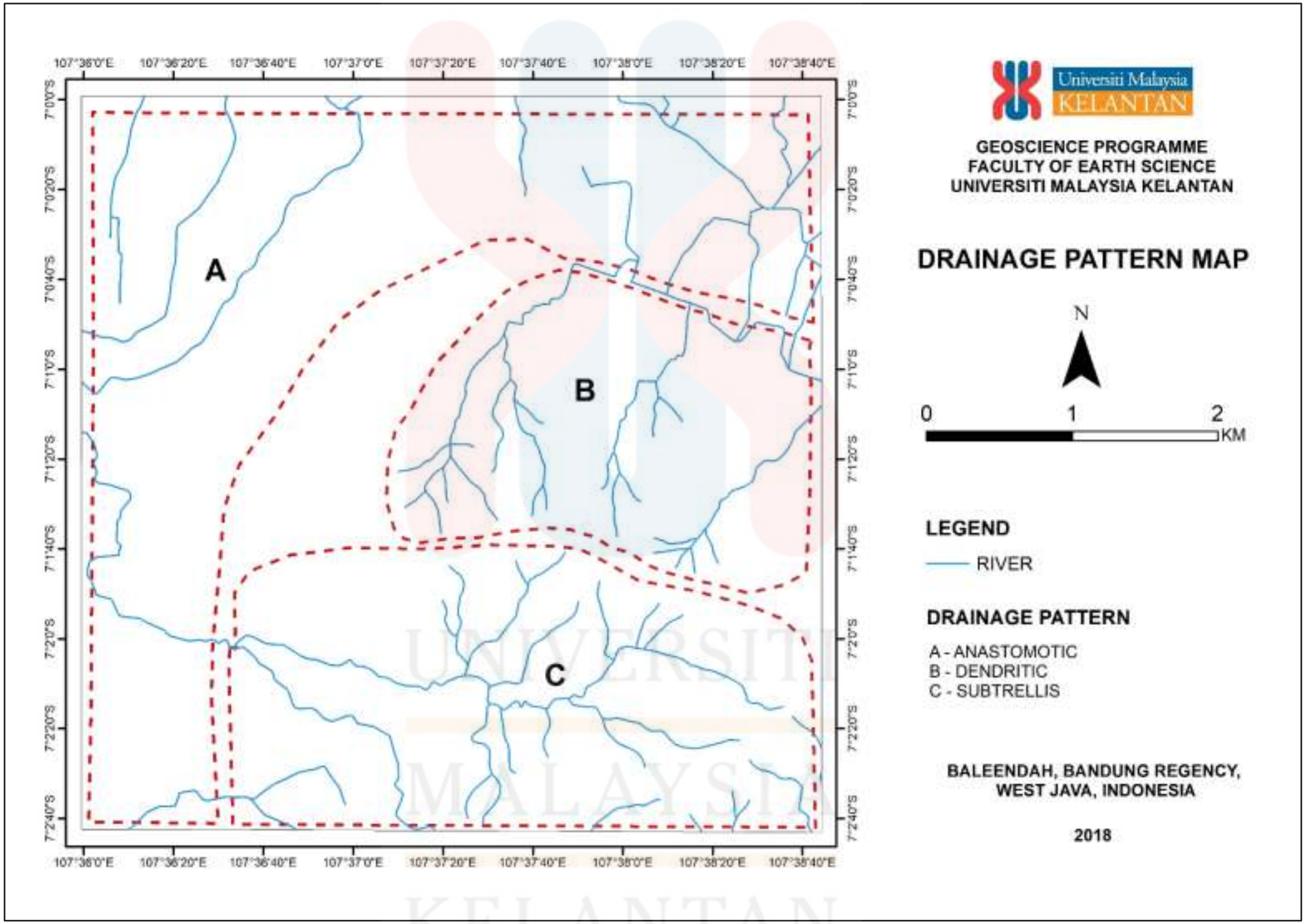


Figure 4.15 Map of drainage pattern in the study area

4.5 Structural Geology

Structural geology is the study of how rocks deform and the processes of deformation. Deformation is the change in shape, position or volume of an object that caused by forces acting on the rock body. These forces exist due to tectonic plate movement and influence of gravity. The rock may response to stress in a brittle or ductile form.

In the study area, there were less geological structures to be found. This is probably because of the structures had been overlain by volcanic product from the previous volcanic eruption. Moreover, according to stratigraphy column from the regional geological map of Garut and Pameungpeuk, the study area was predominantly filled by Quaternary age of volcanic products. Probably, the existed geological structures had been overlain by Quarternary volcanic product in the study area. However, some minor structures such as lava flow structure and columnar joints had been found in the study area.

Columnar joint is a straight parallel, prismatic column which form in shallow intrusive or extrusive igneous bodies such as sills, dykes, lava flows and ignimbrites. (Spry, 1962) mentioned that these columns occur due to the stress exerted during the cooling of lava. Thermal contraction during lava cooling causes these column joint sets to develop and propagate perpendicular to the surface of the flow. In the study area, columnar joints are found made up of andesitic rock composition as shown by Figure 4.16. Therefore, lava flow structure is a parallel or sub parallel bands or streaks which are caused by the flow of magma or lava during cooling and crystallization. Lava flow structure in the study area is found at the outcrop located at Kampung Batu Malakasari as shown in Figure 4.17. The lava composition is andesitic.

Figure 4.16 Example of columnar joints

Figure 4.17 Quaternary lava with flow structure

4.5.1 Lineament Analysis

Lineaments are large linear features which can possibly extending up to hundreds and thousands of kilometres on the Earth's surface. Generally, lineaments in an area represent the presence of geological structures such as joints and faults. Thus, lineament analysis is the common method used to observe and classify those relief structures. Lineament analysis is done through interpretation by using satellite and aerial imagery. The dominant lineaments orientation will show the direction of the force applied in an area. Figure 4.18 shows lineaments in the study area. According to aerial imagery in the map, mostly lineament concentrated at the Baleendah mountain range.

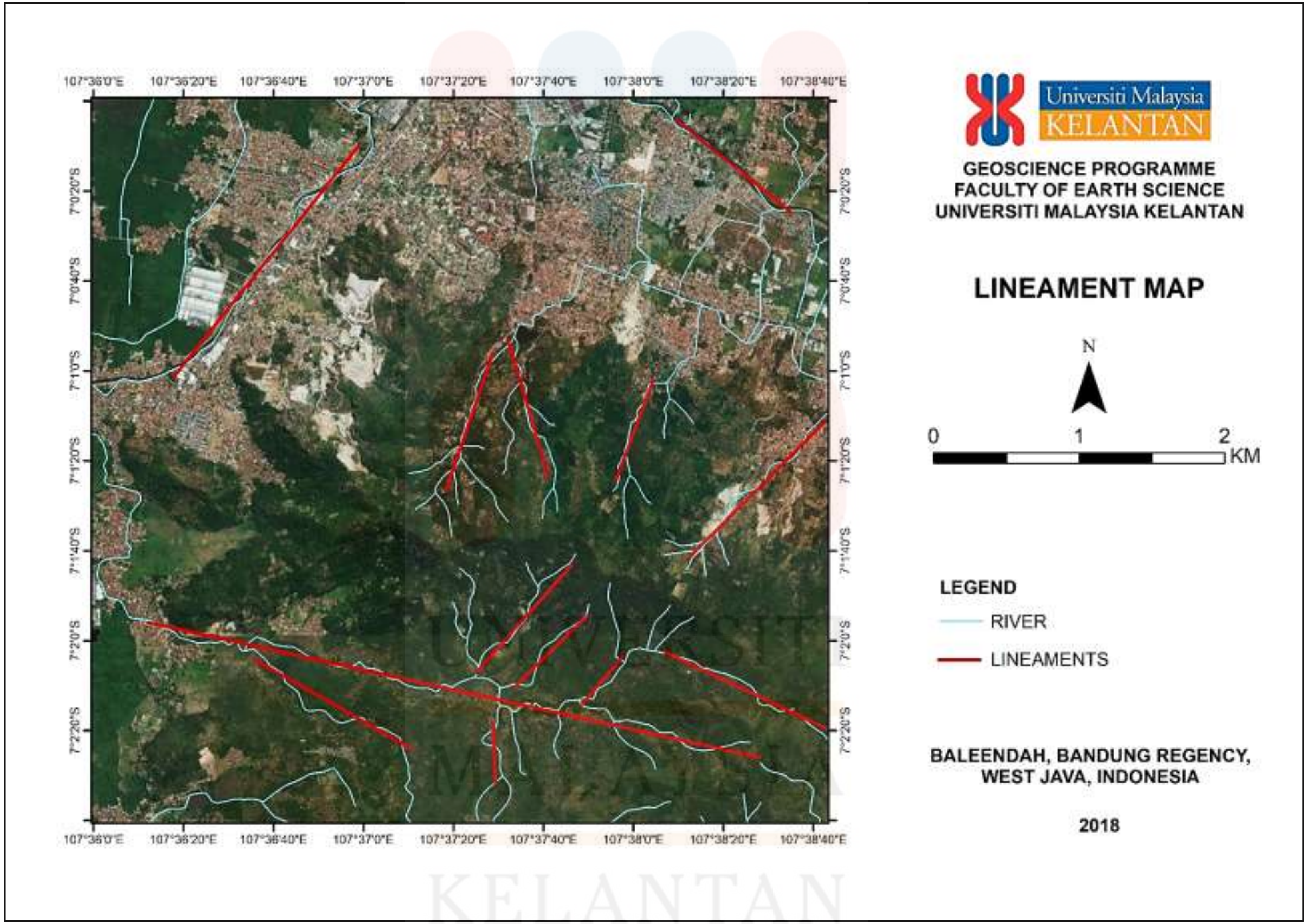


Figure 4.18 Lineament map of the study area

4.5 Lithostratigraphy

Lithostratigraphy is the study about sequences of strata based on physical lithologic characteristics and stratigraphic relations. Lithology characteristics include rock type, colour, mineral composition, grain size and overall texture.

The study area consists of igneous rock, volcanic rock and volcanic sediments. Based on geological mapping, there were four lithology units in the study area which are (A) Lake Deposits Unit, (B) Lava Andesite Unit, (C) Volcanic Breccia Unit and (D) Pyroxene Andesite Lava Unit. These four units are deposited in the Late Miocene to Quaternary age as mentioned by (Ridwan et al., 2017) in their paper. A stratigraphy column for the study area was made with references from the previous research and recent geological fieldwork. Figure 4.28 shows stratigraphy column for the study area and further description in Table 4.9. Lithology map of the study area has been produced and shown in Figure 4.29.

A QAPF diagram by Streckeisen, (1978) has been used for classification of igneous rocks in the study area. A QAPF diagram is a double triangle diagram which is used to classify volcanic rocks, which are usually too fine-grained or glassy for their mineral composition to be observed without the use of a petrographic microscope. They were observed based on percentage of mineralogic composition. The acronym, QAPF, stands for mineral groups which are Quartz, Alkali feldspar, Plagioclase, Feldspathoid (Foid). Q, A, P, F percentage usually recalculated so that their sum is 100%. Figure 4.19 shows the QAPF diagram classification for volcanic rock.

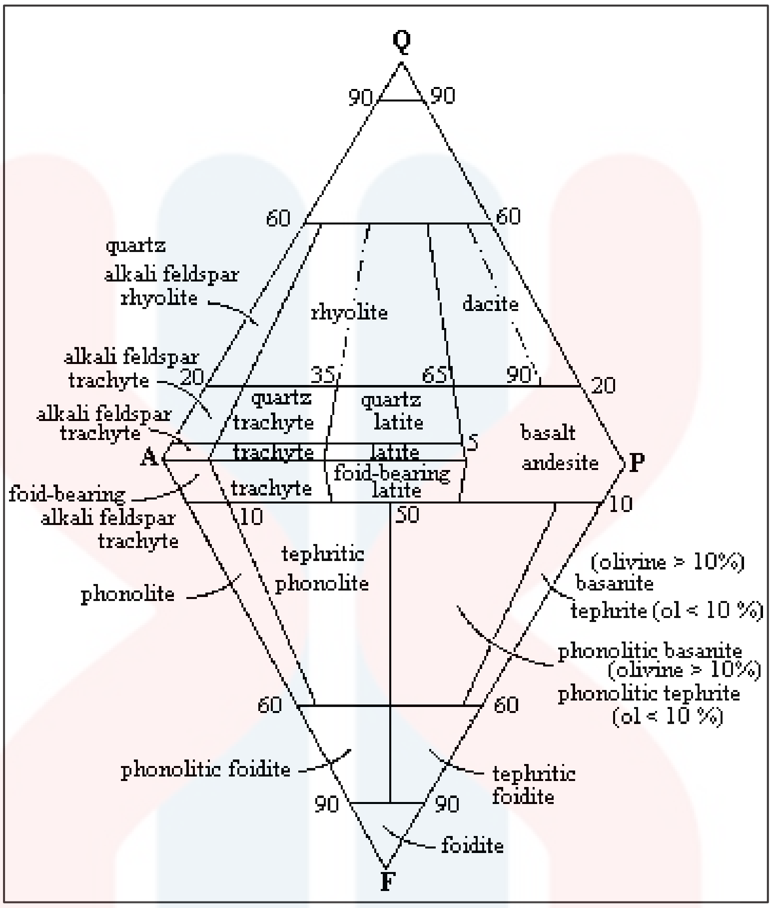


Figure 4.19 QAPF diagram for volcanic rock classification (Streckeisen, 1978)

Besides, classification of rock also used Michel-Levy method from Optical Mineralogy book by Paul, (1933). Michel-Levy method observe the orientation of albite twins of plagioclase under thin. Each orientation of the specific plagioclase compositions will have a slightly different extinction angle. Type of plagioclase composition was determined by calculating the maximum extension angle of twinning plagioclase and the final value was inserted into Michel-Levy plotting diagram as shown in Figure 4.20 and Figure 4.21 to determine the rock type.

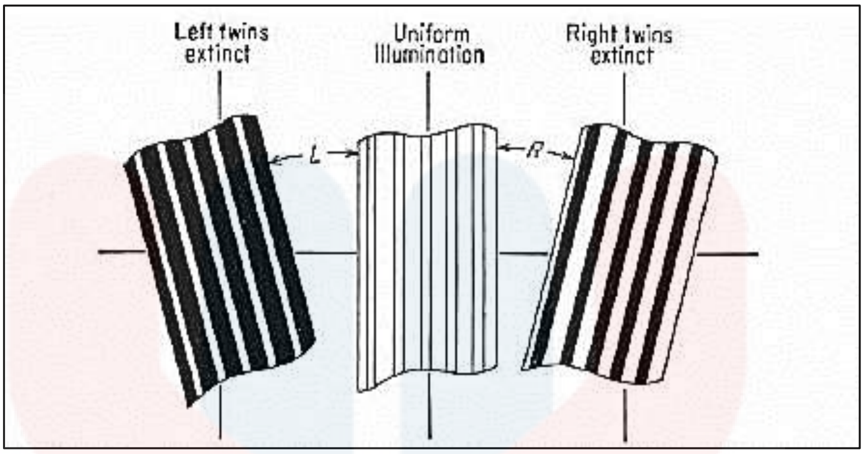


Figure 4.20 The method of determining the extension angles in albite twins for plagioclase feldspar (Michel-Levy method)

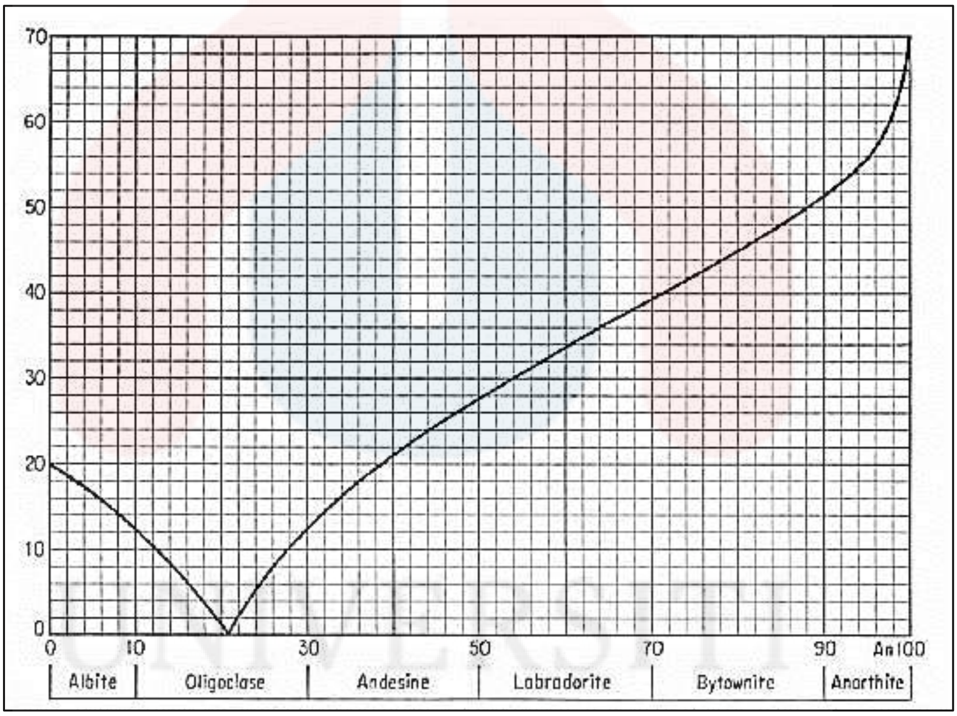
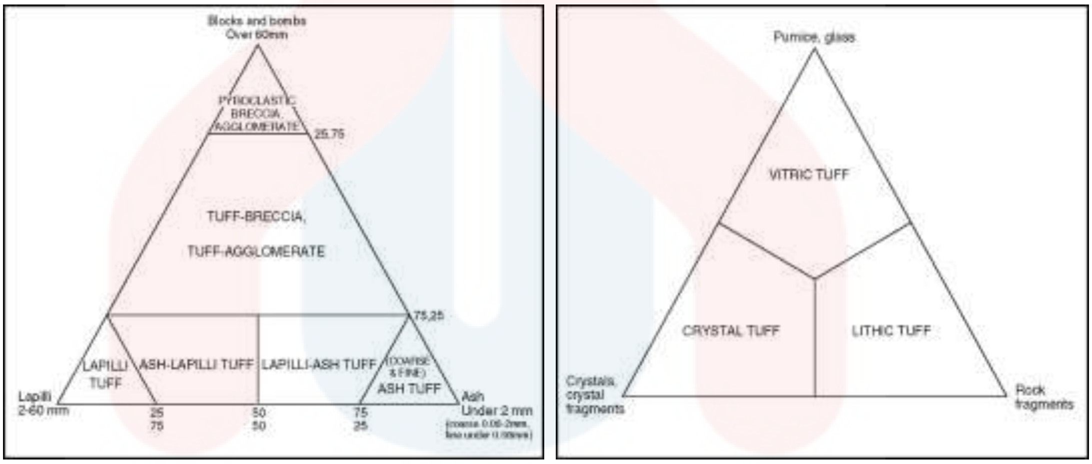


Figure 4.21 Michel-Levy diagram curve

For nomenclature and classification of pyroclastic rock, two ternary plot diagrams by (Schmidt, 1981) as shown by Figure 4.22 has been used. Pyroclastic rocks are composed of fragmented volcanic products ejected from explosive volcanic eruptions of viscous silica-rich magmas. Individual eruptive fragments are called pyroclasts. Once pyroclasts have fallen to the ground they remain as unconsolidated tephra unless hot enough to fuse together or lithify through compaction and cementation process into a pyroclastic rock, a tuff. After using all the classification diagram, the rock unit was done to produce the geological map of the study area.



(a) (b)

Figure 4.22 Pyroclastic rock classification diagrams (A) Based on size of material After (Fisher, 1966) (B) Based on type of material (Schmidt, 1981)

A. Lake Deposit Unit

Lake deposit unit consists of lake deposit mixture composed of clay, silt, fine sand, coarse sand, gravels and breccia inserts. the mixture is grey to brown colour and it feels sticky when touched by hands. According to (Alzwar et al, 1976), it generally consist of tuffs. Lake deposit unit in the study area are mostly filled with housing areas and agriculture activities. Figure 4.23 shows lake deposit unit in the study area. (Silitonga, 2003) in Geological Map of Bandung Sheet mentioned that this units formed Bandung Basin during Quaternary age with the thickness more than 100 m.

Figure 4.23 Lake deposit unit

B. Andesite Lava Unit

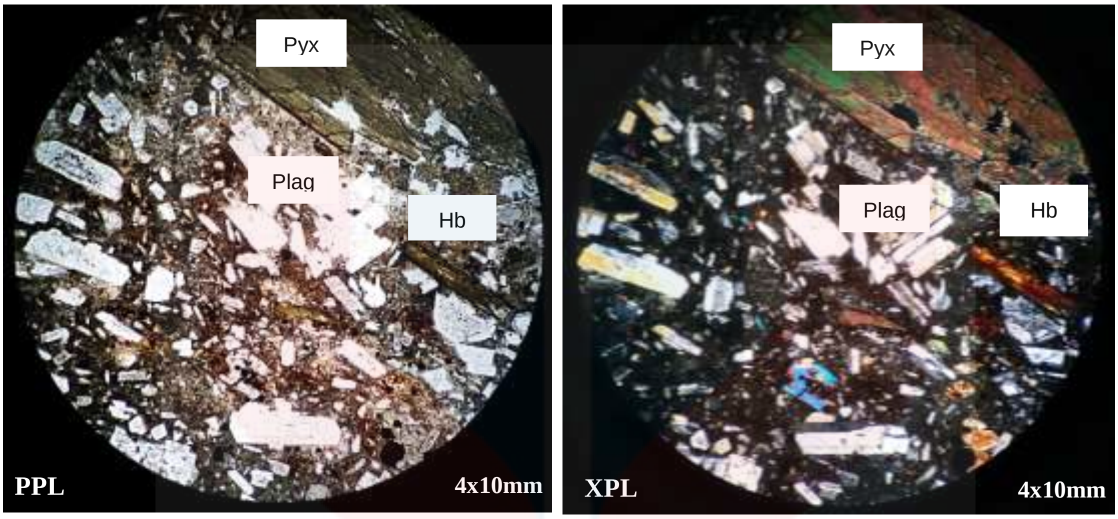
Andesite lava unit composed of flowing layer of andesitic lava with interbedded tuff. Andesite lava exhibits fine grained texture, aphanitic grain size, light grey to dark grey colour and degree of crystallinity is hypocrystalline and shows sheeting and columnar joint in several places. The rock is described based on its physical texture and mineral composition from petrographic analysis. From the petrography analysis, andesite lava has plagioclase, pyroxene and hornblende mineral composition. The outcrop and the hand specimen of this rock unit is shown in Figure 4.24. Table 4.4 shows petrography description of andesite rock in the study area.

Figure 4.24 Andesite lava rock unit (A) Outcrop of andesite (B) Hand specimen

Table 4.4 Description of Andesite Lava Unit

Date	8/8/2018	Location	Baleendah
Coordinate	07° 00’ 29.9’’ S, 107° 38’ 17.1’’ E	Sample code	STA 51
Rock name	Andesite		
Color	Light grey		
Structure	Massive		
Mineral	(%)	Description	
Plagioclase	20	Present as phenocrysts. Colorless clear, subhedral, has cleavage one direction, low relief, extinction angle 25°, has twinning, interference color from white to greyish color, has zoning texture, Andesine (An42). Present in groundmass as plagioclase microlite. Colorless in XPL mode, light grey in PPL mode, subhedral to anhedral shape, low relief	
Pyroxene	10	As phenocrysts. Pale yellowish – pale green color, subhedral prismatic, cleavage 2 direction perpendicular, medium to high relief, interference color yellow and green, most altered to opaque minerals and vitrification. As present in groundmass. Pale yellowish – pale green, subhedral to anhedral shape, medium to high relief, interference color yellow and green.	
Opaque mineral	10	Black color in PPL and XPL, isotropic, present as phenocrysts and groundmass, an inclusion in plagioclase and as altered mineral from pyroxene.	
Clay mineral	5	White- greyish color, cloudy appearance, anhedral, cleavage absent, medium relief, interference color white and grey, comes from altered mineral from plagioclase.	
Volcanic glass	5	Isotropic, colorless, form by vitrification from plagioclase and pyroxene.	
Description Thin section shows black color incision, porphyritic texture, degree of crystallinity hypocrystalline, which rock consists of crystals and glass, hypidiomorphic and inequigranular packs. The groundmass consists of microcrystalline plagioclase, pyroxene, opaque minerals and clay minerals, subhedral to anhedral. Phenocryst composed of plagioclase, pyroxene and hornblende. Type of plagioclase is andesine. Thus, according to classification by using Michel-Levy method and Streckeisen, (1978), the rock is andesite.			

Photo:

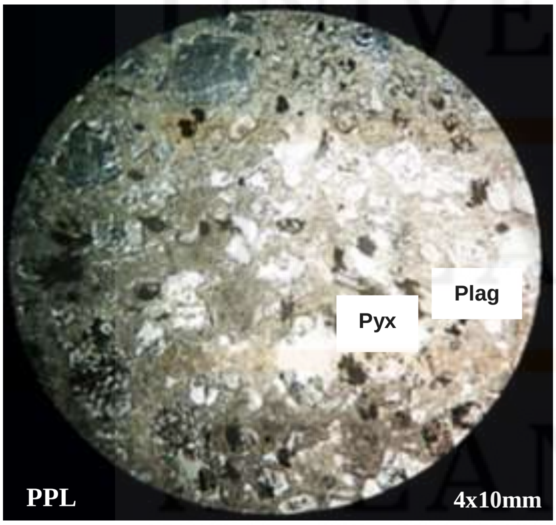


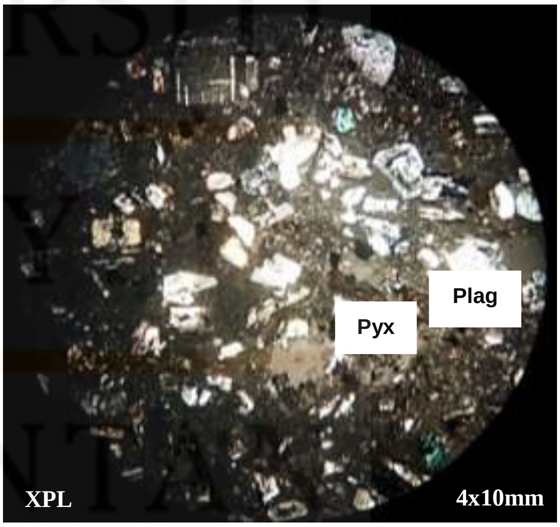
The tuff rock has whitish, dull grey colour, tuff grain size and good sorting. From the petrography analysis, the rock has phenocrysts of quartz minerals, plagioclase, pyroxene, opaque minerals and glass fragments. The groundmass consists of volcanic glass and small crystals. From the petrographic analysis, tuff rock is grain supported. The outcrop and the hand specimen of tuff rock is shown in Figure 4.25. Table 4.5 shows petrography description of tuff rock in the study area.

Figure 4.25 Tuff rock (A) Outcrop of tuff contact with andesite (B) Hand specimen of tuff

Table 4.5 Description of tuff

Date	8/8/2018	Location	Baleendah
Coordinate	07° 01’ 30.4’’ S, 107° 38’ 33.4’’ E	Sample code	STA 47
Rock name	Crystal tuff		
Color	White ash		
Texture	Fine grained		
Mineral	(%)	Description	
Plagioclase	50	Present as phenocrysts. colorless, subhedral, low relief, has zoning texture. Also present in groundmass as plagioclase microlite. Colorless in XPL mode, light grey in PPL mode, subhedral to anhedral shape, low relief.	
Pyroxene	20	As phenocrysts. Pale yellowish – pale green color, subhedral, medium to high relief, interference color blue and green, most altered to opaque minerals. As groundmass. Pale yellowish – pale green, subhedral to anhedral shape, medium to high relief, interference color yellow and green.	
Opaque mineral	20	Black color in PPL and XPL, isotropic, present in groundmass, an inclusion in plagioclase and as altered mineral from pyroxene.	
Volcanic glass	10	Isotropic, colorless, form by vitrification from plagioclase and pyroxene.	
Description Thin section shows phenocryst consists of plagioclase, feldspar, pyroxene and opaque minerals. In the groundmass, there is volcanic ash, volcanic glass and clay minerals. Some of the pyroxene altered into opaque minerals. The rock is classified as crystal tuff because it is dominated by crystal and crystal fragments.			
Photo:			





C. Volcanic breccia unit

Volcanic breccia unit composed of breccia, light grey, brownish colour, bad sorting and fragment supported. Components of volcanic breccia are angular to sub angular size. The component consists of andesite and the breccia matrix composed of crystal tuff. The degree of weathering is moderate to high. Figure 4.26 show volcanic breccia outcrop and hand specimen. The detailed description about volcanic breccia component and its matrix are shown Table 4.6 and Table 4.7.

Figure 4.26 Volcanic breccia (A) Outcrop in the study area (B) Matrix of volcanic breccia (C) Component of volcanic breccia

Table 4.6 Description of volcanic breccia matrix

Date	7/8/2018	Location	Baleendah
Coordinate	07° 01’ 14.5’’ S, 107° 37’ 22.1’’ E	Sample code	STA38

Rock name	Crystal Tuff (Volcanic breccia matrix)
Color	White ash
Texture	Fine grained

Mineral	(%)	Description
Plagioclase	40	Present as phenocryst, colorless, prismatic, euhedral, low relief. Also present in groundmass as plagioclase microlite, subhedral shape.
Pyroxene	10	As phenocryst, medium to high relief, brownish color, interference color yellow, blue and green. Also present in groundmass, subhedral, brown color, medium relief. Some of it altered into opaque minerals.
Opaque mineral	20	Black color in PPL and XPL, isotropic, present in groundmass, an inclusion in plagioclase, some of it as altered minerals.
Clay mineral	10	Brown to dark brown color, cloudy appearance, anhedral, no cleavage, medium relief, comes from altered mineral from plagioclase.
Volcanic glass	20	Isotropic, colorless, form by vitrification from plagioclase and pyroxene.

Description

Thin section shows phenocrysts of plagioclase, pyroxene and quartz. The groundmass consists of volcanic glass and microcystalline plagioclase. Small anhedral crystals also present in the groundmass. It is matrix supported. According to (Schmidt, 1981), it is crystal tuff.

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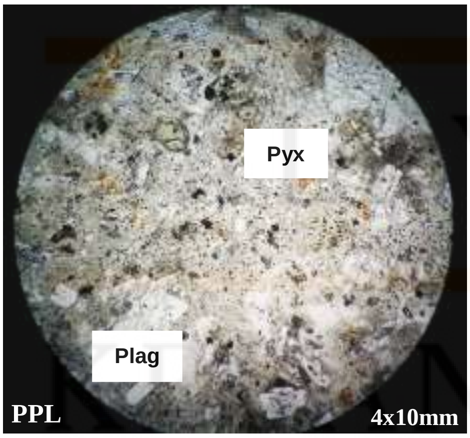


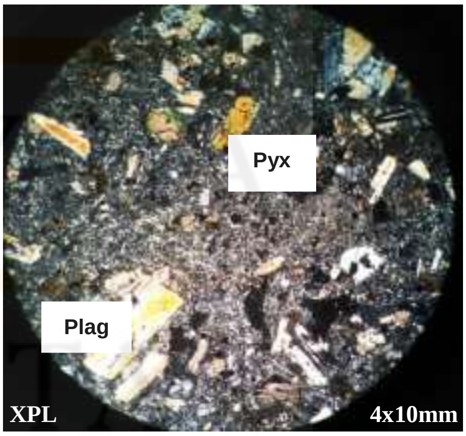
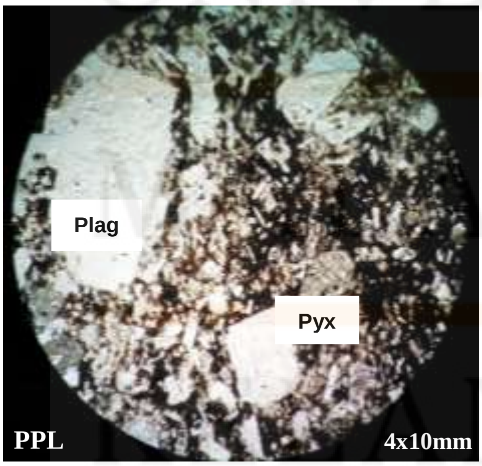
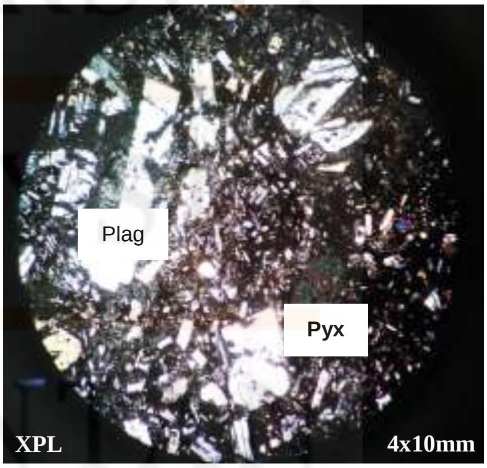


Table 4.7 Description of volcanic breccia component

<table>
<tr><td>Date</td><td colspan="2">7/8/2018</td><td>Location</td><td>Baleendah</td></tr>
<tr><td>Coordinate</td><td colspan="2">07° 01’ 14.5’’ S, 107° 37’ 22.1’’ E</td><td>Sample code</td><td>STA38</td></tr>
<tr><td>Rock name</td><td colspan="4">Andesite (Volcanic breccia component)</td></tr>
<tr><td>Color</td><td colspan="4">Dark grey</td></tr>
<tr><td>Mineral</td><td>(%)</td><td colspan="3">Description</td></tr>
<tr><td>Plagioclase</td><td>40</td><td colspan="3">Present as phenocryst, colorless, low relief in PPL, euhedral prismatic, has cleavage one direction, has zoning texture, Andesine (An40).
Also present in groundmass as plagioclase microlite, colorless, subhedral and low relief.</td></tr>
<tr><td>Pyroxene</td><td>20</td><td colspan="3">Present as phenocryst, pale yellowish or pale greenish color, medium to high relief, has cleavage 2 direction, subhedral.
Also present in groundmass, subhedral, medium to high relief.</td></tr>
<tr><td>Opaque mineral</td><td>20</td><td colspan="3">Black color in PPL and XPL, isotropic, present as phenocrysts and groundmass, an inclusion in plagioclase and as altered mineral from pyroxene.</td></tr>
<tr><td>Volcanic glass</td><td>20</td><td colspan="3">Isotropic, colorless, form by vitrification from plagioclase and pyroxene.</td></tr>
<tr><td colspan="5">Description
Thin section shows porphyritic texture, inequigranular pack, degree of crystallinity hypocrystalline, hypidiomophic. Phenocrysts composed of plagioclase, pyroxene, quartz and opaque minerals. The groundmass composed of microcrystalline plagioclase and pyroxene along with opaque mineral and volcanic glass. Plagioclase exhibits twinning and zoned texture. According to Michel-Levy method, plagioclase is andesine. Thus, it is andesite rock.</td></tr>
<tr><td colspan="5">Photo:</td></tr>
</table>





D. Andesite Pyroxene Lava Unit

Lava composed of andesite rock with fresh grey colour, porphyritic texture, degree of crystallinity is holocrystalline, subhedral crystal form, hypidiomorphic, showing sheeting joints. The degree of weathering is moderate to high. Figure 4.26 show the outcrop and the hand specimen of the rock unit. Table 4.8 shows petrography description of the rock unit.

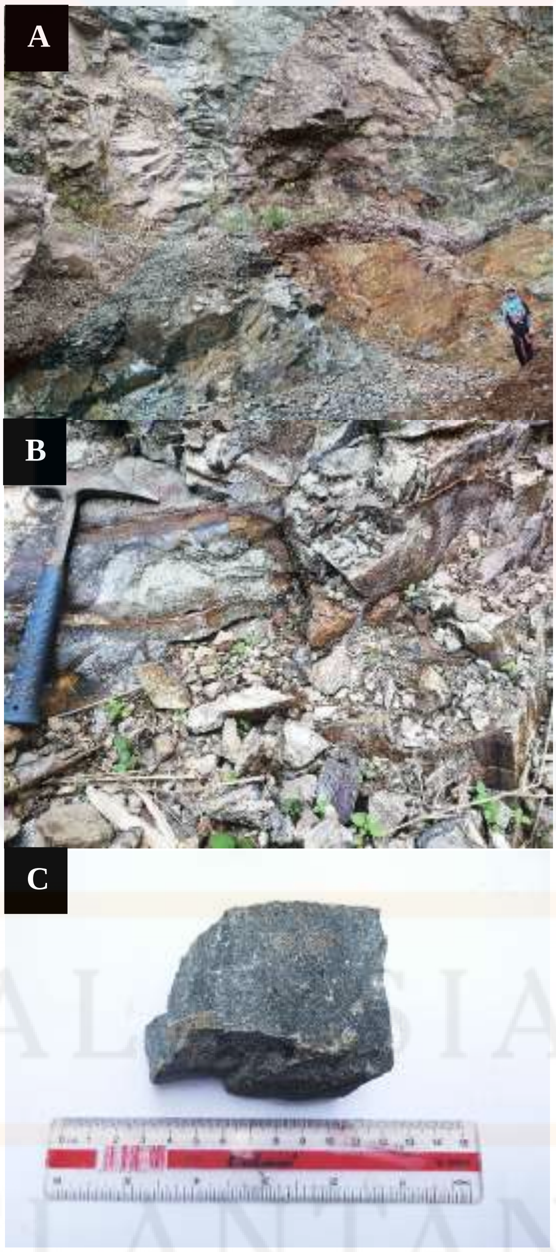
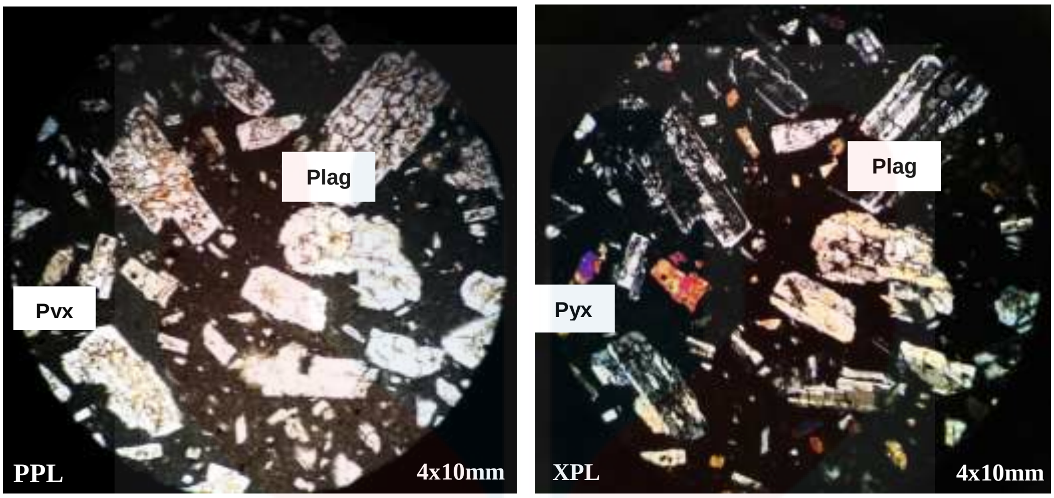


Figure 4.27 Andesite pyroxene lava unit (A) Outcrop in the study area (B) Close-up photo of outcrop (C) Hand specimen

Table 4.8 Description of lava andesite pyroxene

<table>
<tr><td>Date</td><td colspan="2">5/5/2018</td><td>Location</td><td>Baleendah,</td></tr>
<tr><td>Coordinate</td><td colspan="2">07° 01’ 54.8’’ S, 107° 36’ 29.7’’ E</td><td>Sample code</td><td>STA05</td></tr>
<tr><td>Rock name</td><td colspan="4">Andesite pyroxene</td></tr>
<tr><td>Color</td><td colspan="4">Dark grey</td></tr>
<tr><td>Texture</td><td colspan="4">Coarse grained</td></tr>
<tr><td>Mineral</td><td>(%)</td><td colspan="3">Description</td></tr>
<tr><td>Plagioclase</td><td>60</td><td colspan="3">Present as phenocrysts. Colorless clear, subhedral, has cleavage one direction, low relief, has twinning, has zoning texture. Present in groundmass as plagioclase microlite. Colorless in XPL mode, light grey in PPL mode, subhedral to anhedral shape, low relief. Andesine (An_{46}).</td></tr>
<tr><td>Pyroxene</td><td>18</td><td colspan="3">As phenocrysts. Pale yellowish – pale green color, subhedral prismatic, cleavage 2 direction perpendicular, medium to high relief, interference color yellow and green, most altered to opaque minerals and vitrification. As groundmass. Pale yellowish – pale green, subhedral to anhedral shape, medium to high relief, interference color yellow and green.</td></tr>
<tr><td>Opaque mineral</td><td>10</td><td colspan="3">Black color in PPL and XPL, isotropic, present as phenocrysts and groundmass, an inclusion in plagioclase and as altered mineral from pyroxene.</td></tr>
<tr><td>Clay mineral</td><td>2</td><td colspan="3">White- greyish color, cloudy appearance, anhedral, cleavage absent, medium relief, interference color white and grey, comes from altered mineral from plagioclase.</td></tr>
<tr><td>Volcanic glass</td><td>10</td><td colspan="3">Isotropic, colorless, form by vitrification from plagioclase and pyroxene.</td></tr>
<tr><td colspan="5">Description
Thin section shows black color incision, consists of crystal and glass, porphyritic texture, degree of crystallinity hypocrystalline, hypidiomorphic and exhibit inequigranular pack. The groundmass consists of microcrystalline plagioclase and pyroxene. Form of individual grain is subhedral. In groundmass also has anhedral tiny crystals. Phenocryst composed of plagioclase and pyroxene.</td></tr>
</table>

Photo:



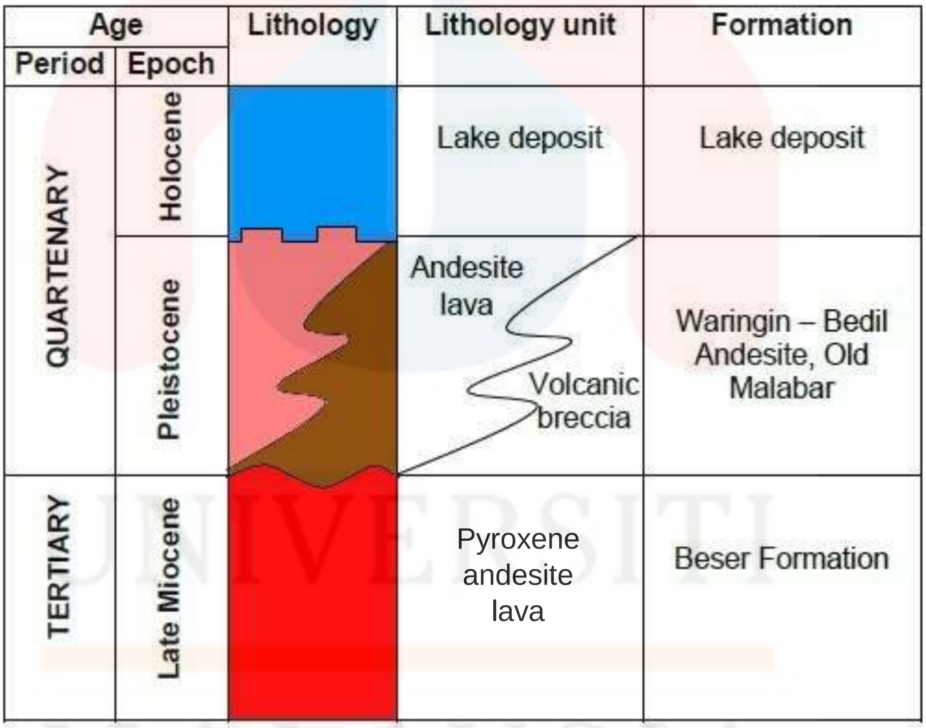


Figure 4.28 Stratigraphy column of the study area

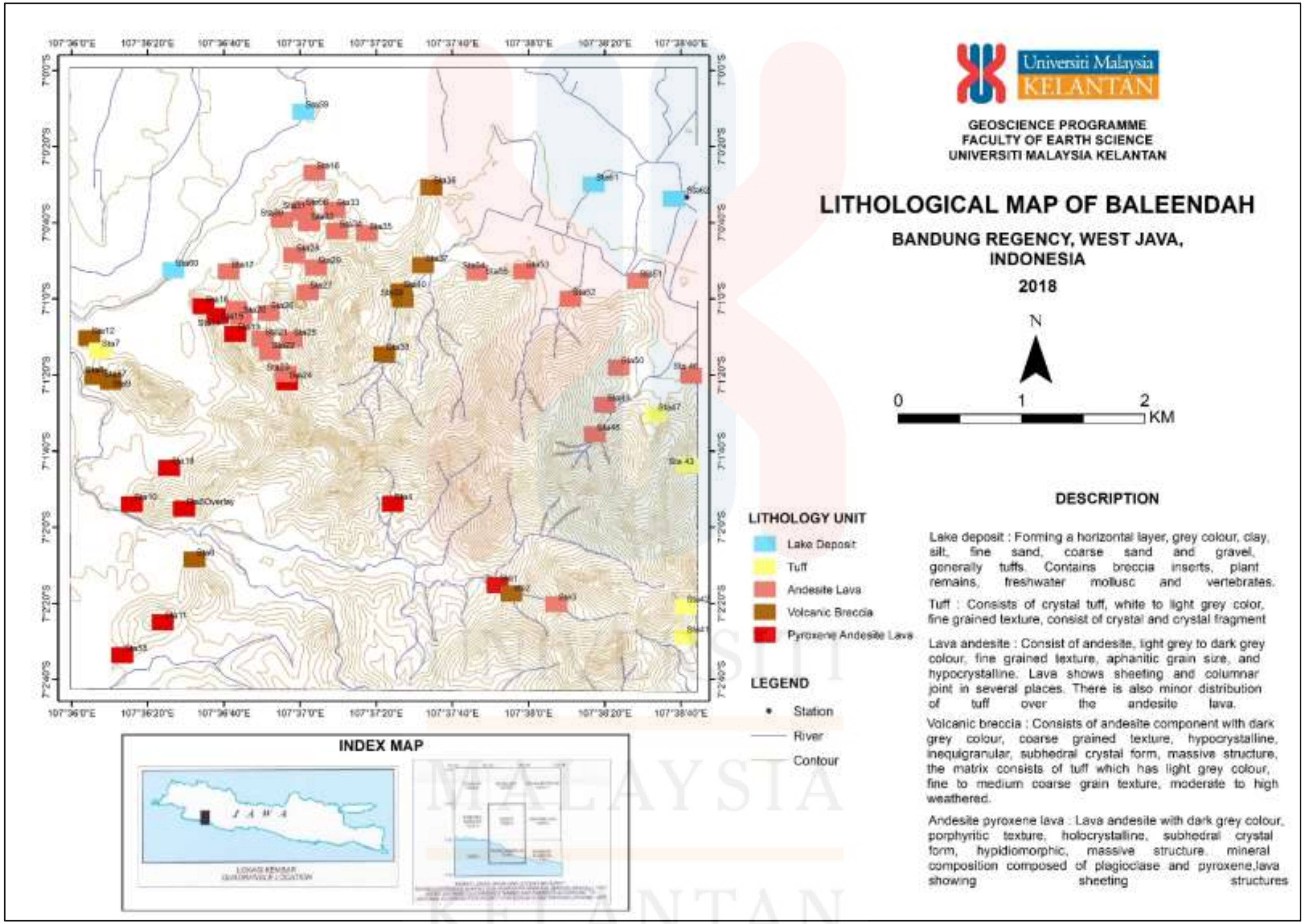


Figure 4.29 Lithological map of Baleendah

Table 4.9 Lithostratigraphy the study area

Age		Lithology unit	Description
Period	**Epoch**		
QUATERNARY	**Holocene**	Lake deposit	Forming a horizontal layer, grey colour, clay, silt, fine sand, coarse sand and gravel, generally tuffs. Contains breccia inserts, plant remains, freshwater mollusc and vertebrates.
	Pleistocene	Andesite lava	Consist of andesite lava and tuff rock. Lava has light grey to dark grey colour, fine grained texture, aphanitic grain size, and hypocrystalline. Lava shows sheeting and columnar joint in several places. Tuff has light color, fine grained and crystal dominated.
		Volcanic breccia	Consists of andesite component with dark grey colour, coarse grained texture, hypocrystalline, inequigranular, subhedral crystal form, massive structure. the matrix consists of crystal tuff which has light grey colour, fine to medium coarse grain texture.
TERTIARY	**Late Miocene**	Pyroxene Andesite Lava	Andesite lava, fresh grey colour, coarse grain texture, holocrystalline, subhedral crystal form, hypidiomorphic, massive structure. Lava also show sheeting structure.

Geology history

In Late Miocene period, the volcanic activities start to happen in South Bandung region. These volcanic activities produced pyroxene andesite lava flow. Based on Pertamina drilling data, (Soeria-Atmadja, R. et al, 1994) states that the analysis of K-Ar of lava andesite pyroxene has the age of 12,000 million years ago which same as Miocene age. In Geological Map of Garut by (Alzwar et. al, 1992), the oldest rock unit in Southern Bandung is Beser Formation and intrusive igneous rock. Beser Formation spread in northwest direction from Garut Map, including Soreang, Arjasari, Baleendah and Ciparay district.

In quaternary age, volcanic product from Wayang- Windu volcano overlaid the Tertiary andesite lava. The next volcanic eruption occurs in Pliocene age about 4 to 2.6 million years ago. This eruption formed Soreang Mountain with dacite composition and Baleendah Mountain with andesite composition. During Pliestocene, volcanic activities from Pangalengan volcano caused the formation of Windu Mountain and Malabar Mountain. Windu Mountain has andesitic composition and Malabar Mountain has basaltic andesite composition.

From geological map by (Alzwar & Akbar, 1976), there is lineament which cut off the northwest slope of Mount Tanjaknangsi, showing the existence of parallel straightness. A fairly obvious fault is found the proof in the field is Sesar Tarikolot where is the block south relative to the north block. This Tarikolot is believed had cuts the southern body of the mount Baleendah, which then become down blocks and covered with Malabar volcano product in Quaternary age (Sutikno et al, 2006).

The existence of Tertiary volcano rocks together with quaternary volcanic rocks in the South Bandung area is due to Super Imposed Volcanisms Concept as proposed by (Bronto, 2006).

In quaternary Holocene, the materials from series of volcanic eruption in Bandung distribute more widely and deposited in the Bandung Basin. These materials clogged the main river which drained Bandung Basin, thus forming lake deposits. Bandung lake deposit consists of mainly fluvio-volcanic materials. According to (Silitonga, 1973), lake deposit that filled Bandung Basin has the thickness of above 125 m. Figure 4.30 shows geological map of Baleendah.

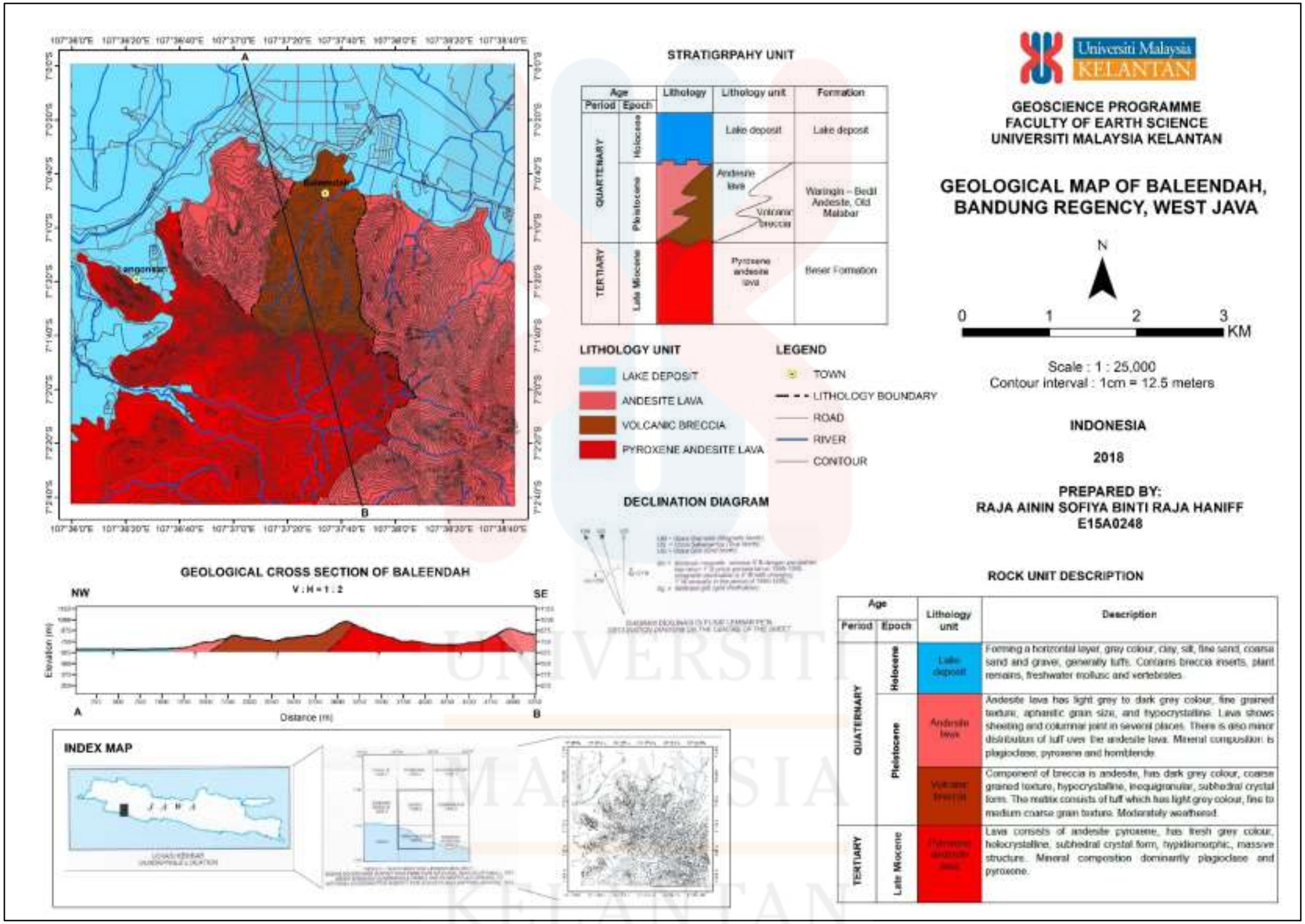


Figure 4.30 Geological map of Baleendah

CHAPTER 5

GEOCHEMICAL ANALYSIS OF SOIL FERTILITY

5.1 Introduction

Geochemistry for soil fertility encompasses about the geochemistry of element available in soil which act as major and minor nutrient required for the plant growth and development. The distribution of these chemical elements had been tested through some experiments. The abundance of elements in soil largely comes from the nature of its parent rock, climate condition and element mobility. (Aghazadeh et al, 2010) states that physicochemical environments below the earth surface might affect distribution of ion which later form the elements in the upper soil. Soil is a major source of nutrients needed by plants for growth. The main nutrients for plants growth are such as Phosphorus (P), Potassium (K), Calcium (Ca) and Magnesium (Mg). However, plants also need small quantities of Iron (Fe), Manganese (Mn), Zinc (Zn), Copper (Cu), Aluminium (Al), Cobalt (Co) and Nickel (Ni). These elements are known as trace elements or minor nutrients because only traces are needed by the plant.

Soil investigation is done through elemental analysis by using geochemistry approach in order to understand and provide information about soils and land use of the study area. Eight soil samples had been randomly collected from different lithology present in the study area. However, soil sample from lake deposit unit is ignored because it has been completely mixed and the origin of its soil cannot be determined. Soil sample 1 was collected from the tuff soil in the fruit plantation area. Soil sample

2 was collected from the breccia soil at the banana plantation area. Soil sample 3 was collected from the tuff soil at the tapioca plantation area behind the residential area. Meanwhile, soil sample 4 was collected at the grassland besides the residential area and near the road. Next, soil sample 5 was collected in the forest from breccia mixed with andesite soil near the bamboo plant. For the soil sample 6, it was collected in the small garden near the mining area. It is tuff soil. For the soil sample 7, it was collected from the andesite soil in the small chilli garden owned by the villagers. Lastly, soil sample 8 was collected at the grassland next to the roadside which there is not much plant grows there.

Figure 5.1 shows the soil sampling location in the study area. Generally, soil type in the study area is Andisol. Andisol is the soil formed from volcanic materials which formation of noncrystalline material such as active Al and Fe compound and accumulation of organic matter are dominant (Ugolini et al, 2002). Volcanic ejecta becomes the parent material for the formation of these noncrystalline materials. High proportion of glassy minerals, colloidal materials, high porosity and permeability of volcanic ejecta had enhanced rapid chemical weathering which contribute to the release of Al, Si and Fe element into the soil (Ugolini & Dahlgren, 2002). In Indonesia, agriculture activities are rapidly developed in the Andisol area due to its fertility and provide better condition for plant growth. Soil sample preparation involve all the soil were air-dried and oven-dried before further with soil test using XRF and AAS. After that, the geochemistry result was presented in the form of graph for easier comparison of element concentration among all the soil samples.

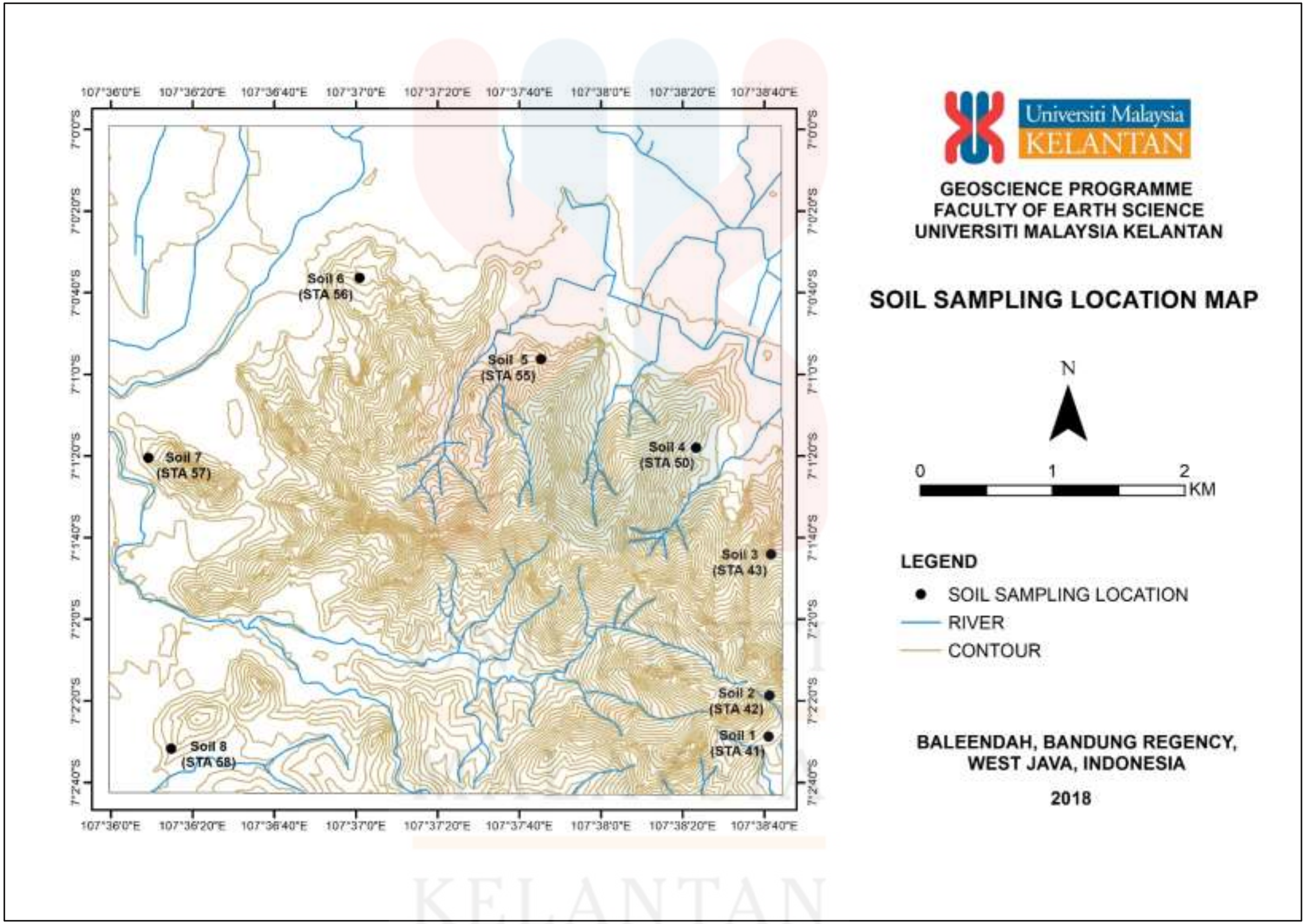


Figure 5.1 Map of soil sampling location

5.2 Result

From the XFR analysis, the distribution of elements in all eight soil samples were determined. The concentration of each element has been measured in the unit of mg/kg and has been tabulated in Table 5.1. The soil sample were collected from different lithologies present in the study area. Soil sample 1,2,3,4 and 6 were collected from lava andesite units. Soil sample 5 were collected from volcanic breccia units. Meanwhile, soil sample 7 and 8 were collected from pyroxene andesite unit.

In general, XRF results proved the existence 24 elements in the soil sample. The elements are Ca, Mg, K, P, Na, Fe, Mn, Zn, Cu, Co, Al, Ni, Si, Ti, V, Sx, Cr, La, Y, Ga, Sc, Br, Zr, Ba. Each of the soil sample seems appeared by almost the same elements. However, there were also certain elements that do not appeared in certain sample samples. This might because of the element has very small concentration and below the detection limit of the XRF. Based on Table 5.1, total of 23 elements were found in the soil sample 2 and 4. Soil sample 8 contains 21 elements while soil sample 1,6 and 7 contain 20 elements. Soil sample 3 and 5 exhibit the least element distribution among all eight samples.

The most prominent element in all the soil sample are Aluminium (Al), Iron (Fe), and Silicon (Si) as their concentration higher compared to the other elements. In all soil samples, Tarbuck et al, (2000) states that earth's crust is made up of several elements such as silicon, aluminum, iron, calcium, sodium, potassium and magnesium. In other words, the abundance of these chemical element might be a reason on the high concentration of Al, Fe and Si in the soil samples. In addition, all the soil sample are Andisol type which it is originated from volcanic materials. Dahlgren et.al, (2002) in their paper discussed that weathering process of volcanic materials causes the accumulation Al and Fe and with some clay minerals which contribute to the high proportion of Al and Fe content in volcanic soils.

Concentration of Al in soil samples range from 118 600 mg/kg to 130 100 mg/kg while concentration of Zn ranges from 79 700 mg/kg to 121 700 mg/kg. For Silicon, the minimum concentration is 193100 mg/kg and the highest concentration is 232 300 mg/kg. The least element concentration is expected to be Bromine (Br). Br only appear in soil sample 2, 7 and 8 with concentration below 20 mg/kg. Barium (Ba) is rare because it is only present in andesite soil from lava andesite unit and absence in the rest of soil samples.

Table 5.1 Element distribution from XRF analysis in mg/kg

Lithology unit	Lava andesite				Volcanic breccia	Lava andesite	Pyroxene andesite	
Characteristics	Tuff soil	Volcanic breccia soil	Tuff soil	Andesite soil	Volcanic breccia soil	Andesite soil	Tuff soil	Andesite soil
Elements	SAMPLE 1	SAMPLE 2	SAMPLE 3	SAMPLE 4	SAMPLE 5	SAMPLE 6	SAMPLE 7	SAMPLE 8
Phosphorus (P)	491	477	197	373	463	408	540	452
Calcium (Ca)	4780	549	268	2140	4600	2260	7800	5800
Magnesium (Mg)	4000	5800	4500	2700	3360	2900	3980	3130
Potassium (K)	585	1784	168	278	1004	461	596	666
Sodium (Na)	542	1041	319	247	771	n.d	693	821
Iron (Fe)	100100	94400	79700	94100	9640	121700	97700	103200
Manganese (Mn)	1780	2760	670	2340	220	1810	1820	1720
Zinc (Zn)	94	67	72	85	66	44	72	71
Copper (Cu)	63	49	27	56	54	64	42	58
Cobalt (Co)	34	35	n.d	48	35	44	40	37
Aluminium (Al)	119100	111300	120800	130100	118600	124100	123200	112700
Nickel (Ni)	n.d	25	n.d	28	20	23	n.d	n.d
Silicon (Si)	202300	223900	232300	207900	213100	193100	205100	213200
Titanium (Ti)	7800	7200	4800	7000	7000	9100	6700	8600
Vanadium (V)	221	198	118	150	148	281	181	235
Sulphur trioxide (Sx)	319	218	145	192	191	261	246	290
Chromium (Cr)	51	60	n.d	28	n.d	47	n.d	23
Lanthanum (La)	40	43	n.d	50	45	n.d	n.d	n.d
Yitrium (Y)	29	31	26	57	35	28	28	30
Gallium (Ga)	28	29	28	27	27	25	31	27
Scandium (Sc)	22	14	19	22	n.d	20	14	16
Bromine (Br)	n.d	14	n.d	n.d	n.d	nd	15	18
Zirconium (Zr)	n.d	93	58	115	n.d	110	74	91
Barium (Ba)	n.d	n.d	n.d	320	n.d	n.d	n.d	n.d

*n.d = not detectable

Under lithology unit of lava andesite, there are five soil sample with consists of different characteristics. Sample 1 and 3 has tuff characteristic, sample 2 has breccia characteristic and sample 4 and 6 is from andesite. Table 5.1 shows that sample 2 and sample 4 have the most elements by having a total of 23 elements. The least element was found in sample 3 by on 18 elements in total. Sample 1 show the highest concentration of P and Ca and Zn compared to another four samples with the concentration of 491 mg/kg, 4780 mg/kg and 94 mg/kg respectively. Sample 2 has the highest concentration of Mg, K, Na, Mn and Cr elements compared to the rest of the samples for this lithology units. However, sample 2 also has deficiency in elements of Al, Sc and Zr.

Sample 3 has the most lack of element concentration such as P, Ca, K, Fe, Mn, Ti, V and Sx where their concentration is the lowest among those five samples. Element such as Co, Ni, Cr, La, Br and Ba are not found in sample 3. In sample 4, most of the element still has high range of concentration. Obviously, Co, Al and Ni seems to be high abundance in sample 4. The concentration of Co, Al and Ni are 48 mg/kg, 130100 mg/kg and 28 mg/kg respectively. In addition, there is no bromine element was found within this sample. Sample 4 has lowest concentration of Mg and Na among the other four samples. For soil sample 6, concentration of Fe and Cu are clearly seen which the value is 121700 mg/kg and 64 mg/kg. Since sample 6 and 4 has the same characteristic, thus by comparing both of the sample, it is found that sample 6 contains higher value of element concentration than sample 4 although sample 4 seem to have more element distribution than sample 6.

Through comparison of tuff soil between sample 1 and sample 3, sample 3 seems to have low distribution of element and low concentration of element compared to soil sample 1. Meanwhile, sample 1 shows more element contents compared to sample 3. However, both of the sample shares similarity which both of the sample do not contain Ni, Br and Ba element respectively. For soil sample 5, it is belonged to volcanic breccia unit and exhibit characteristic of its parent rock. Based on Table 5.1, 19 elements were found within the sample. it is clearly shows that concentration of Fe, Mn, Ni and Ti in sample 5 were the lowest among all eight samples. Therefore, element such as Cr, Sc, Zr and Ba do not appear in this sample.

According to Table 5.1, soil sample 7 and soil sample 8 belong to pyroxene andesite lava lithology unit. Soil sample 7 has the characteristic of tuff while soil sample 8 has the characteristic of andesite. By comparing element distribution between both soil, it can be seen that concentration of P, Ca, Mg, Mn, Zn, Co, Al and Ga in soil sample 7 are higher than soil sample 8. In contrast, soil sample 8 shows higher concentration of K, Na, Fe, Cu, Si, Ti, V, Sx, Y, Sc, Br, and Zr elements compared to soil sample 7. However, both of the sample have the similarity which neither both of them has Ni, La, Ba elements. It can be seen also that Cr element only present in soil sample 8 but not in soil sample 7.

Table 5.2 shows the concentration of Fe, Zn, Cu and Mn by using Atomic Absorption Spectrometry in all the samples. The result indicates that Fe has the highest concentration among the all elements. The concentration of Fe ranges between 72300 mg/kg to 96 100 mg/kg in all eight samples. The second highest concentration is Mn. Mn appear in all soil sample with concentration range from 628 mg/kg to 2344 mg/kg. The third highest concentration is follow by Zn. The minimum concentration of Zn is 63 mg/kg while the maximum concentration reached to 114 mg/kg. besides, Cu is found with lowest concentration compared to Fe, Mn and Zn. Minimum concentration of Cu appears to be 27 mg/kg and the maximum concentration is 62 mg/kg.

Table 5.2 AAS result of Fe, Mn, Zn and Cu concentration in mg/kg

Minor nutrient		Concentration (mg/kg)			
		Iron (Fe)	Manganese (Mn)	Zinc (Zn)	Copper (Cu)
Soil Sample	Sample 1	77000	1421	114	60
	Sample 2	83000	2344	94	51
	Sample 3	72300	628	93	27
	Sample 4	81600	2178	110	57
	Sample 5	89500	2009	89	44
	Sample 6	95000	1442	63	62
	Sample 7	85400	1632	98	45
	Sample 8	96100	1445	84	59

5.3 Discussion

From geochemical analysis data, eight element which are Phosphorus (P), Potassium (K), Calcium (Ca), Magnesium (Mg), Zinc (Zn), Copper (Cu), Iron (Fe) and Manganese (Mn) have been selected to complete the third objective of the research. The investigation of soil fertility will observe the abundance of major nutrient and minor nutrient contents in soil sample. Major nutrient are P, K, Ca and Mg while minor nutrient are Zn, Fe, Cu and Mn. Concentration of major nutrient in all soil sample is shown in the graph in Figure 5.3. each of the element concentration is compared with the world average value for agriculture soil as provided in Table 5.5 to interpret the soil fertility.

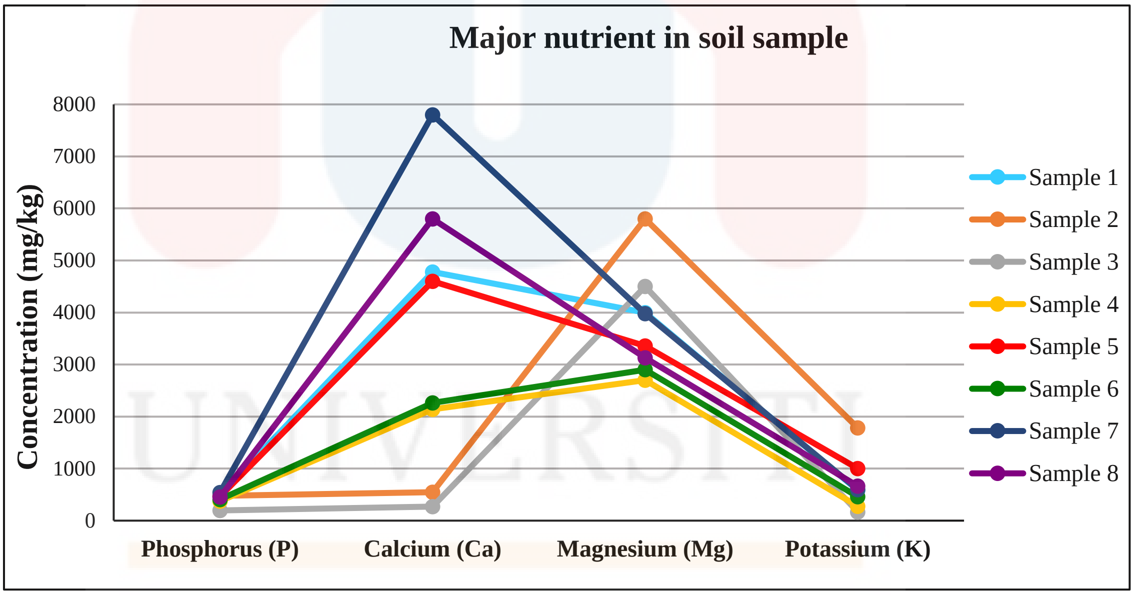


Figure 5.2 Concentration of major nutrient in soil sample in mg/kg

Table 5.3 Concentration of major and trace element in agriculture soils (After Alloway, 2005).

Element	Range in agriculture soil (mg/kg)	World average in agriculture soil (mg/kg)
Na	750 -7500	6300
K	400-30000	8300
Ca	7000-500000	13700
Mg	20-10000	5000
Fe	5000-500000	3800
Cu	1-20	13-24
Pb	3-189	32
Ni	0.2-450	20
Zn	17-125	64
Co	0.1 – 70	7.9
Cd	0.01-2.5	0.06-1.1

According to the graph, the highest concentration of P was found in tuff soil in sample 7 with concentration value of 540 mg/kg. Sample 7 belongs to pyroxene andesite unit. The lowest concentration of P comes from sample 3 which is tuff soil in lava andesite units. Adequate quantities of phosphorus in soil helps plants to stimulates early root. Phosphorus also play an important part of proteins, enzymes and DNA. When plant can uptake phosphorus, it helps in development of fruits and seed. According to (Alina Kabata-Pendias, 2011), the only source of P in agriculture soil is phosphate rock. Most of the phosphate is derived from apatite group minerals.

From the graph, concentration of Ca seems highly preferred in sample 7 and sample 8. Ca is moderately distributed in sample 5. Green, yellow, orange and grey line represent sample from lava andesite unit which exhibit lower concentration of Ca compared to pyroxene andesite unit and volcanic breccia unit. Ca promotes the root health, growth of new roots and root hairs, and the development of leaves. Thus, a healthy plant required amount of Ca to form new cells so especially for roots, stems and leaves to grow. It is also used by plants when they respond to pest and disease attacks. The need of Magnesium is importance for the plants chlorophyll, the green coloring material of plants, and is vital for photosynthesis. According to world average in agriculture soil, soil sample 1, 2, 3 and 7 have the nearest value to the average value stated in Table 5.3.

The fourth major nutrient is Potassium (K). For potassium, it is highly found in soil sample 2 and sample 5. The concentration of K in soil sample 2 is 1784 mg/kg while soil sample 5 is 1004 mg/kg. Soil sample 2 has been collected in banana plantation while soil sample 5 was collected at bamboo plant. World soil average for K in agriculture soil is 8300 mg/kg. However, the concentration of K in all soil sample are below the limit value. K is an essential nutrient required by plant. Adequate level of K helps plants to increase the disease resistance of plants, form and move starches, sugars and oils in plants, and improve the fruit quality. K also controls a plant's ability to cope with drought and helps plants combat disease and insect damage.

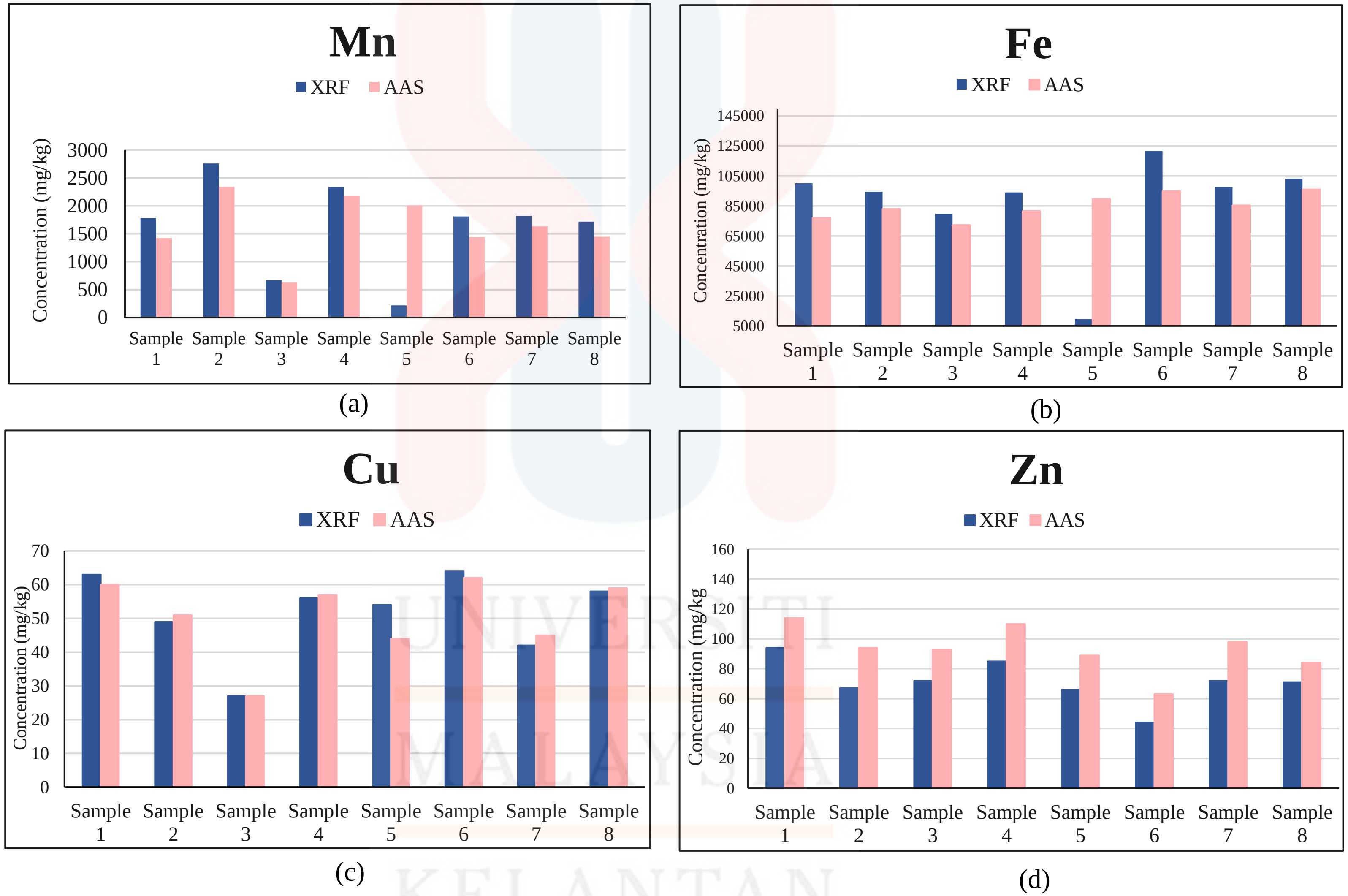


Figure 5.3 Minor nutrient concentration in mg/kg

Figure 5.3 shows comparison of concentration of minor nutrient from XRF and AAS analysis. Minor nutrient that involved are Fe, Mn, Cu, Zn are micronutrient which taken up by plants in their cationic forms. Fe and Mn elements are often present in large quantities in many soils due to oxidation and precipitation reactions.

Figure 5.3 (a) show Manganese (Mn) concentration. Analysis by using AAS shows Mn content actually appeared in lower concentration compared to screening result by using XRF. The concentration ranges from 628 to 2344 mg/kg. According to the book by (Alina Kabata-Pendias, 2011), it states that Mn content in worldwide soil vary from 411 to 550 mg/kg. However, in the book by (Alina Kabata-Pendias, 2011) also states that Mn content is estimated at the range of 1500 – 3000 mg/kg if there is agriculture activities. By comparing the Mn in worldwide soil, all the soil sample seems to have excessive amount of Mn content. But, by comparing to Mn content for agriculture soil, all the soil samples are still in range.

So, the higher concentration of Mn in every soil samples can be argued that probably the soil had been used for agricultures activities by the farmers in the study area. Thus, the application of fertilizers in agriculture might altered the actual content of Mn which derived from the parent rock in the study area. Manganese is an essential micronutrient required by plant for photosynthesis process. It also has a role in synthesis of chlorophyll and nitrogen absorption as well as the synthesis of riboflavin, ascorbic acid and carotene.

Next, Zn ranked the third highest nutrient present among the four elements. The world average in agriculture soil for Zn content is 64 mg/kg. Based on graph (d) in Figure 5.3, only sample 6 is in the range of world average for agriculture soil. Meanwhile, the other samples exceed the world average value. Zinc is another important plant micronutrient as it encourage the secretion of growth hormones in plants and proteins which involved in sugar consumption. Maintaining adequate zinc levels is highly needed for better root development. Based on Figure 5.3, analysis of concentration by using AAS show higher concentration compared to analysis by XRF. Soil sample 1, 4 and 7 shows the higher content among eight samples. Soil sample 1 and 7 are tuff soil while soil sample 4 are andesite soil.

Figure 5.3 (c) shows concentration of Copper (Cu). (Alina Kabata-Pendias, 2011) mentioned copper occurrence in Earth's crust at average concentration of 55 mg/kg and Cu abundance pattern in rock shows more tendency in mafic igneous rock. An article written by (Hunt, 2008) states that for healthy and productive soil, the concentration of copper should be in range between 2 to 50 mg/kg. Hence, soil sample 2, 3 and 7 has the ideal concentration of Cu which match the statement made by (Hunt, 2008). Copper has the function to build cell wall in plant for plant strength. Instead of that, copper will also influence the flavour, sugar content and storage life of fruit.

Graph (b) from Figure 5.3 shows concentration of Iron (Fe). By referring Table 5.5, the world average for Fe in agriculture soil is 3800 mg/kg. all the soil samples exceed the world average value. The concentration of Fe in all the sample are very high with the range between 9640 mg/kg to 103 200 mg/kg. Fe is required in small amounts for plant development and function of chlorophyll and a range of enzymes and proteins. But, the excessive of iron concentration in soil might affects the uptake of other nutrients by plants.

The variation of element concentration in each soil sample might be affect by pedogenesis process or anthropogenic activities in the sampling area. For example, rate of weathering, climatic condition, the application of fertilizers or the usage of pesticides. The application of fertilizers and pesticide commonly will affect the element distribution in soil and their concentration level. Thus, the availability of major and minor nutrient also being affected by usage of fertilizers and pesticide according to the interest of soil use for certain farming purpose.

Therefore, the element distribution in soil sample can be relate with type of lithology in the study area from petrography analysis in Chapter 4. During petrography analysis, some minerals were identified which may contribute to the formation of element in the soils. Generally, all soil sample were collected from different lithology in the study area which cover andesitic soil, breccia soil and tuff soils. Schulze et.al , (2015) explained that mostly primary minerals constituents comes from weathering process of feldspar, micas and quartz minerals. Pyroxene and hornblende also release certain mineral constituents but in small quantities. Table 5.6 shows data of average mineralogical and nutrient element composition of common rocks on the Earth's land surface by Klein et. al, (1999).

Table 5.4 The average mineralogical and nutrient element composition of common rocks on the Earth's land surface.

Mineral constituent	Igneous rock	Shale	Sandstone	Nutrient element constitutents	
	%			Major	Minor
Feldspars	59.5	30.0	11.5	K, Ca, Na	Cu, Mn
Amphiboles & pyroxenes	16.8	–	sm	Mg, Fe, Ca	Ni, Co, Cu, Mn, Zn, Mo
Micas	3.8	–	sm	K, Ca, Na, Mg, Fe	Ni, Mn, Co, Zn, Cu
Titanium minerals	1.5	–	sm	Ti, Fe, Ca	Co, Ni
Apatite	0.6	–	sm	Ca, P	
Clay	–	25.0	6.6	K, Mg, Fe, Ca, Na	
Iron oxides	–	5.6	1.8	Fe	Mn, Zn, Ni, Co
Carbonates	–	5.7	11.1	Ca, Mg, Fe	
Other minerals	–	11.4	2.2	–	–

According to Schulze et.al, (2015), primary minerals such as K-feldspars (orthoclase, sanidine, and microcline), micas (muscovite, biotite, and phlogopite), and clay-size micas (illite are widely distributed in most soil types, except in highly weathered and sandy soils. These primary minerals are the important source for K, with over 90% of K in soils comes from the structure of these minerals. Significant amounts of Ca, Na, and Si and smaller amounts of Cu and Mn are also present in the feldspars. Micas is one of the major source of K in many soils, plus it also contains other mineral such as Mg, Fe, Ca, Na, Si and few minor nutrients for plants.

Amphiboles and pyroxenes are vital reservoirs of Mg, Fe, Ca, Si, and most of the micronutrients. The physical, chemical, and biological weathering of primary minerals releases a number of nutrient elements into the soil solution. Although the weathering rates of primary minerals for certain elements may not be fast enough to meet plant nutrient requirements on a short-term basis, particularly in managed cropping systems, mineral weathering is an important and long-term source of several geochemically derived nutrients.

The abundance of nutrient such as K, Ca, Cu and Mn in andesitic soil probably can be correlate with the occurrence of felspar in andesite rock. Meanwhile, distribution of pyroxene in andesite also might contribute to the presence of element such as Mg, Fe, Ca, Ni, Co, Mn and Zn in its soil.

For the tuff soil, the abundance of Ca, K, Cu and Mn is due to plagioclase feldspar mineral in tuff rock. When these felspar undergoes weathering, hence the elements are released and spreading into the soil. Clay content in tuff rock also causes the formation of element such as Mg, Fe, Na and Ca. Next, degradation of pyroxene and amphibole minerals in tuff rock might lead to the release of nutrient element such as Co, Cu, Mn and Zn, Mg, Fe and Ca into its soil.

For the breccia soil, the abundance of nutrient element does not have much difference from andesitic soil and tuff soil. This is because breccia itself composed of tuff as the matrix and its component is andesite rock. So, the element present are similar but only have differences in concentration.

Among the overall soil samples, soil sample 7 seems to have potential to be the most fertile soil. Soils sample 7 is characterized by tuff soil which belong to pyroxene andesite units. This is because the concentration of its major nutrient is higher compared to the other soil sample. Plus, this major nutrient concentration also approximately balance with the concentration of its minor nutrient. Moreover, most of major and minor nutrient concentration in soil sample 7 are near and in range of world average for agriculture soil. Plus, concentration of element which can be toxicity to the plants such as Cr, La, and Br appeared very low concentration in soil sample 7 compared to the other soil samples. Figure 5.4 shows soil profile at sampling area of soil sample 7.

Figure 5.4 Soil profile at sample 7 sampling area

Soil sample 3 is selected to be the least fertile soil among all eight samples. Soil sample 3 has the characteristic of tuff which belong to andesite lava units. this is due to it contains the lowest concentration of major nutrients. Similar to minor nutrient, its concentration appeared to be very low. By comparing the concentration of existing major and minor nutrient with the concentration value of world average for agriculture soil, most of the nutrients are below the value which preferred for agriculture purpose. Figure 5.5 show the picture of soil profile at the soil sampling area.

Figure 5.5 Soil profile at sample 3 sampling area

CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

The objective of this research is to study about the geology of Baleendah area located in Bandung Regency, West Java. The study about lithology, structural geology, geomorphology has been done to complete the first objective. All the data obtained from field during geological mapping has been used to update the new geological map of Baleendah area with the scale of 1: 25,000. For specification of the research, geochemical analysis for soil fertility, the second objective is to determine element distribution in soil and the third objective is to investigate soil fertility for volcanic soil in Baleendah area based on the concentration of major and minor nutrients.

The concentration of each element in soil samples was determined in order to observe the abundance of major nutrient and minor nutrient available in soil that required by plant for growth and development. From the findings, soil sample 7 tends to be the most fertile soil because the content of major and minor nutrients in it are in range of world average for agriculture soil. the adequate level of major and minor nutrient in soil sample 7 made it suitable for agriculture purpose. Soil sample 7 has the characteristic of tuff soil and belongs to the lithology unit of pyroxene andesite lava. there is banana plantation and many other crops grow in the sampling location of soil sample 7. Most of the crop exhibits fresh green color of leaves.

Meanwhile, high concentration of Al and Na could be toxicity to the soil and may cause the deficiencies of certain major and minor nutrient concentration. Hence, the treatment and remediation of the soil should be intensified in order to control the nutrients balance in the soil and maintain the maximum soil fertility and productivity. It is suggested that the application of fertilizers should be in accordance with the type of cultivation to be done. This helps to control the excessive of certain element in the soil that may interrupt the uptake of other major and minor nutrients by plants and the soil enrichments too.

6.2 Recommendation

Recommendation is stated for improvement for further research. The geological mapping for this research was conducted within a very limited time. Thus, for the recommendation, a detailed geological mapping need to be done within a sufficient period so that the researcher could gain more precision data and findings about the study area especially lithology of the study area. For petrography analysis, more references and time needed to describe more detailed mineral under thin section. Hence, a proper work plan and time management should be take care by student so that they can finished the work according to the deadline.

Other than that, the further research regarding soil fertility should focuses on the other chemical parameter instead of available of major and minor nutrient. For example, soil pH and soil organic matter. This parameter will support the geochemistry data in investigating the quality of soil. it is also recommended to do geochemical analysis of plant such as leaves and plant tissues in further research so that the correlation with the abundance of element in the area and the element found in the plant can be done.

Therefore, the use of advanced analysis instrument such as ICP-MS can be used to analyze the soil sample as ICP-MS can give more precision and accurate result of the distribution of element in soil samples. Other than that, the analysis of rock sample by using XRD also can be used as the supportive data to correlate the geochemistry of soil with the geochemistry of the parent rock itself.

Next, the instrument should be check properly before starting the analysis of the soil samples. This is to make sure that the instrument is free from contaminations in order to minimize the standard error of the geochemical result. To conduct soil fertility in future research, it is suggested to focus on the physical properties of soil in order to correlate with the nutrient available to obtain more detailed information of soil fertility. Based on this suggestion, it can improvise in the future research.

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APPENDIX

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HASIL UJI KIMIA METODE AAS-KONVENSIONAL
(*AAS-CONVENTIONAL METHOD CHEMISTRY ANALYSIS RESULT*)
Nomer lab. (*lab. number*) : 060/L/GL/2.1/09/2018
Tanggal (*date*) : 7 September 2018

Kode sampel (*sample code*) : STA 41	Tanggal diterima (*received date*) : 20 Agustus 2018
Kode lab. (*lab. code*) : 204/2.1/18/0933	Tanggal diuji (*analyzed date*) : 4 September 2018
Lokasi (*location*) : Jelekong, Bandung Selatan	Metode uji (*method*) : GL-MU-2.1.1
Kedalaman (*depth*) : -	Metode preparasi (*preparation method*) GL-MU-2.0
Pemilik (*property*) : Nouval Mu'amar Asrial, Universitas Padjadjaran, Fakultas Teknik Geologi	

Unsur (*elements*)	Satuan (*unit*)	Metode (*method*)	Jumlah (*value*)	Batas Kuantifikasi
Cu	ppm	GL-MU-2.1.1	60	4
Zn	ppm	GL-MU-2.1.1	114	15
Fe*	%	GL-MU-2.1.1	7.77	-
Mn*	ppm	GL-MU-2.1.1	1421	-

Keterangan:
*Belum Terakreditasi

BADAN GEOLOGI
KEMENTERIAN ENERGI DAN SUMBER DAYA MINERAL

Kepala Subbidang Geologi Dasar dan Terapan
selaku Manajer Teknis,

Aries Kusworo, ST., MT.
NIP. 197203112006041001.

LABORATORIUM PUSAT SURVEI GEOLOGI
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HASIL UJI KIMIA METODE AAS-KONVENSIONAL
(*AAS-CONVENTIONAL METHOD CHEMISTRY ANALYSIS RESULT*)

Nomor lab. (*lab. number*) : 060/L/GL/2.1/09/2018
Tanggal (*date*) : 7 September 2018

Kode sampel (*sample code*) : STA 42	Tanggal diterima (*received date*) : 20 Agustus 2018
Kode lab. (*lab. code*) : 204/2.1/18/0934	Tanggal diuji (*analyzed date*) : 4 September 2018
Lokasi (*location*) : Jelekong, Bandung Selatan	Metode uji (*method*) : GL-MU-2.1.1
Kedalaman (*depth*) : -	Metode preparasi (*preparation method*) GL-MU-2.0
Pemilik (*property*) : Nouval Mu'amar Aurial, Universitas Padjadjaran, Fakultas Teknik Geologi	

Unsur (*element*)	Satuan (*unit*)	Metode (*method*)	Jumlah (*value*)	Batas Kuantifikasi
Cu	ppm	GL-MU-2.1.1	51	4
Zn	ppm	GL-MU-2.1.1	94	15
Fe*	%	GL-MU-2.1.1	8.30	-
Mn*	ppm	GL-MU-2.1.1	2166	-

Keterangan:
*Belum Terakreditasi

Kepala Subbidang Geologi Dasar dan Terapan
[illegible] Manajer Teknis,

[illegible] Kusworo, ST., MT.
NIP. 197203112006041001.

Catatan (*notes*):
Hasil pengujian ini hanya berlaku untuk sampel yang diuji (*this analysis result is only valid for the tested sample*).

LABORATORIUM PUSAT SURVEI GEOLOGI
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HASIL UJI KIMIA METODE AAS-KONVENSIONAL
(*AAS-CONVENTIONAL METHOD CHEMISTRY ANALYSIS RESULT*)

Nomer lab. (*lab. number*) : 060/L/GL/2.1/09/2018
Tanggal (*date*) : 7 September 2018

Kode sampel (*sample code*)	: STA 43	Tanggal diterima (*received date*)	: 20 Agustus 2018
Kode lab. (*lab. code*)	: 204/2.1/18/0935	Tanggal diuji (*analyzed date*)	: 4 September 2018
Lokasi (*location*)	: Jelekong, Bandung Selatan	Metode uji (*method*)	: GL-MU-2.1.1
Kedalaman (*depth*)	: -	Metode preparasi (*preparation method*)	GL-MU-2.0
Pemilik (*property*)	: Nouval Mu'amar Asrial Universitas Padjadjaran Fakultas Teknik Geologi		

Unsur (*elements*)	Satuan (*unit*)	Metode (*method*)	Jumlah (*value*)	Batas Kuantifikasi
Cu	ppm	GL-MU-2.1.1	27	4
Zn	ppm	GL-MU-2.1.1	93	15
Fe*	%	GL-MU-2.1.1	7.23	-
Mn*	ppm	GL-MU-2.1.1	628	-

Keterangan:
*Belum Terakreditasi

Kepala Subbidang Geologi Dasar dan Terapan
selaku Manajer Teknis,

BADAN GEOLOGI

...Kusworo, ST., MT.
NIP. 197203112006041001.

Catatan (*notes*):
Hasil pengujian ini hanya berlaku untuk sampel yang diuji (*this analysis result is only valid for the tested sample*).

LABORATORIUM PUSAT SURVEI GEOLOGI
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HASIL UJI KIMIA METODE AAS-KONVENSIONAL
(AAS-CONVENTIONAL METHOD CHEMISTRY ANALYSIS RESULT)
Nomer lab. (*lab. number*) : 060/L/GL/2.1/09/2018
Tanggal (*date*) : 7 September 2018

Kode sampel (*sample code*)	: STA 50	Tanggal diterima (*received date*)	: 20 Agustus 2018
Kode lab. (*lab. code*)	: 204/2.1/18/0936	Tanggal diuji (*analyzed date*)	: 4 September 2018
Lokasi (*location*)	: Jelekong, Bandung Selatan	Metode uji (*method*)	: GL-MU-2.1.1
Kedalaman (*depth*)	: -	Metode preparasi (*preparation method*)	GL-MU-2.0
Pemilik (*property*)	: Nouval Mu'amar Asrial Universitas Padjadjaran Fakultas Teknik Geologi		

Unsur (*elements*)	Satuan (*unit*)	Metode (*method*)	Jumlah (*value*)	Batas Kuantifikasi
Cu	ppm	GL-MU-2.1.1	57	4
Zn	ppm	GL-MU-2.1.1	110	15
Fe*	%	GL-MU-2.1.1	8.16	-
Mn*	ppm	GL-MU-2.1.1	2178	-

Keterangan:
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BADAN GEOLOGI KEMENTERIAN ENERGI DAN SUMBER DAYA MINERAL

Kepala Subbidang Geologi Dasar dan Terapan
Selaku Manajer Teknis,

Aries Kusworo, ST., MT.
NIP: 197203112006041001.

Catatan (*notes*):
Hasil pengujian ini hanya berlaku untuk sampel yang diuji (*this analysis result is only valid for the tested sample*).

GL-F-PL-13-2.1-01-b

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HASIL UJI KIMIA METODE AAS-KONVENSIONAL
(*AAS-CONVENTIONAL METHOD CHEMISTRY ANALYSIS RESULT*)

Nomer lab. (*lab. number*) : 060/L/GL/2.1/09/2018
Tanggal (*date*) : 7 September 2018

Kode sampel (*sample code*)	: STA 55	Tanggal diterima (*received date*)	: 20 Agustus 2018
Kode lab. (*lab. code*)	: 204/2.1/18/0937	Tanggal diuji (*analyzed date*)	: 4 September 2018
Lokasi (*location*)	: Jelekong, Bandung Selatan	Metode uji (*method*)	: GL-MU-2.1.1
Kedalaman (*depth*)	: -	Metode preparasi (*preparation method*)	GL-MU-2.0
Pemilik (*property*)	: Nouval Mu'amar Asrial Universitas Padjadjaran Fakultas Teknik Geologi		

Unsur (*elements*)	Satuan (*unit*)	Metode (*method*)	Jumlah (*value*)	Batas Kuantifikasi
Cu	ppm	GL-MU-2.1.1	44	4
Zn	ppm	GL-MU-2.1.1	89	15
Fe*	%	GL-MU-2.1.1	8.95	-
Mn*	ppm	GL-MU-2.1.1	2009	-

Keterangan:
*Belum Terakreditasi

Kepala Subbidang Geologi Dasar dan Terapan
Selaku Manajer Teknis,

BADAN GEOLOGI KEMENTERIAN ENERGI DAN SUMBER DAYA MINERAL

Agus Kusworo, ST., MT.
NIP. 197203112006041001

Catatan (*notes*):
Hasil pengujian ini hanya berlaku untuk sampel yang diuji (*this analysis result is only valid for the tested sample*).

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HASIL UJI KIMIA METODE AAS-KONVENSIONAL
(AAS-CONVENTIONAL METHOD CHEMISTRY ANALYSIS RESULT)

Nomer lab. (*lab. number*) : 060/L/GL/2.1/09/2018
Tanggal (*date*) : 7 September 2018

Kode sampel (*sample code*)	: STA 56	Tanggal diterima (*received date*)	: 20 Agustus 2018
Kode lab. (*lab. code*)	: 204/2.1/18/0938	Tanggal diuji (*analyzed date*)	: 4 September 2018
Lokasi (*location*)	: Jelekong, Bandung Selatan	Metode uji (*method*)	: GL-MU-2.1.1
Kedalaman (*depth*)	: -	Metode preparasi (*preparation method*)	GL-MU-2.0
Pemilik (*property*)	: Nouval Mu'amar Asrial Universitas Padjadjaran Fakultas Teknik Geologi		

Unsur (*elements*)	Satuan (*unit*)	Metode (*method*)	Jumlah (*value*)	Batas Kuantifikasi
Cu	ppm	GL-MU-2.1.1	62	4
Zn	ppm	GL-MU-2.1.1	63	15
Fe*	%	GL-MU-2.1.1	9.50	-
Mn*	ppm	GL-MU-2.1.1	1442	-

Keterangan:
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BADAN GEOLOGI

Arief Kusworo, ST., MT.
NIP. 197203112006041001.

Catatan (*notes*):
Hasil pengujian ini hanya berlaku untuk sampel yang diuji (*this analysis result is only valid for the tested sample*).

GL-F-PL-13-2.1-01-b

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HASIL UJI KIMIA METODE AAS-KONVENSIONAL
(AAS-CONVENTIONAL METHOD CHEMISTRY ANALYSIS RESULT)

Nomer lab. (*lab. number*) : 060/L/GL/2.1/09/2018
Tanggal (*date*) : 7 September 2018

Kode sampel (*sample code*)	: STA 57	Tanggal diterima (*received date*)	: 20 Agustus 2018
Kode lab. (*lab. code*)	: 204/2.1/18/0939	Tanggal diuji (*analyzed date*)	: 4 September 2018
Lokasi (*location*)	: Jelekong, Bandung Selatan	Metode uji (*method*)	: GL-MU-2.1.1
Kedalaman (*depth*)	: -	Metode preparasi (*preparation method*)	GL-MU-2.0
Pemilik (*property*)	: Nouval Mu'amar Asrial Universitas Padjadjaran Fakultas Teknik Geologi		

Unsur (*elements*)	Satuan (*unit*)	Metode (*method*)	Jumlah (*value*)	Batas Kuantifikasi
Cu	ppm	GL-MU-2.1.1	45	4
Zn	ppm	GL-MU-2.1.1	98	15
Fe*	%	GL-MU-2.1.1	8.54	-
Mn*	ppm	GL-MU-2.1.1	1632	-

Keterangan:
*Belum Terakreditasi

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Arief Kusworo, ST., MT.
NIP. 197203112006041001.

Catatan (*notes*):
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HASIL UJI KIMIA METODE AAS-KONVENSIONAL
(AAS-CONVENTIONAL METHOD CHEMISTRY ANALYSIS RESULT)

Nomer lab. *(lab. number)* : 060/L/GL/2.1/09/2018
Tanggal *(date)* : 7 September 2018

Kode sampel *(sample code)*	: STA 58	Tanggal diterima *(received date)*	: 20 Agustus 2018
Kode lab. *(lab. code)*	: 204/2.1/18/0940	Tanggal diuji *(analyzed date)*	: 4 September 2018
Lokasi *(location)*	: Jelekong, Bandung Selatan	Metode uji *(method)*	: GL-MU-2.1.1
Kedalaman *(depth)*	: -	Metode preparasi *(preparation method)*	GL-MU-2.0
Pemilik *(property)*	: Nouval Mu'amar Asrial Universitas Padjadjaran Fakultas Teknik Geologi		

Unsur *(elements)*	Satuan *(unit)*	Metode *(method)*	Jumlah *(value)*	Batas Kuantifikasi
Cu	ppm	GL-MU-2.1.1	59	4
Zn	ppm	GL-MU-2.1.1	84	15
Fe*	%	GL-MU-2.1.1	9.61	-
Mn*	ppm	GL-MU-2.1.1	1445	-

Keterangan:
*Belum Terakreditasi

Kepala Subbidang Geologi Dasar dan Terapan
selaku Manajer Teknis,

Arif Kusworo, ST., MT.
NIP. 197203112006041001.

Catatan *(notes)*:
Hasil pengujian ini hanya berlaku untuk sampel yang diuji *(this analysis result is only valid for the tested sample).*

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HASIL UJI KIMIA METODE XRF
(XRF METHOD CHEMISTRY ANALYSIS RESULT)
Nomer lab. (*lab. number*) : 073/L/GL/2.2/10/2018
Tanggal (*date*) : 12 Oktober 2018

Kode sampel (*sample code*) : STA 41	Tanggal diterima (*received date*) : 20 Agustus 2018
Kode lab. (*lab. code*) : 204/2.2/18/0933	Tanggal diuji (*analyzed date*) : 10 Oktober 2018
Lokasi (*location*) : Jelekong, Bandung Selatan	Metode uji (*method*) : GL-MU-2.2
Kedalaman (*depth*) : -	Metode preparasi (*preparation method*) : *Pressed Pellet*
Pemilik (*property*) : **Nouval Mu'amar Asrial UNPAD**	

Compound	m/m%	StdErr	El	m/m%	StdErr
------	--------	-------	--	--------	-------
SiO2	43.29	0.25	Si	20.23	0.11
Al2O3	22.51	0.23	Al	11.91	0.12
Fe2O3	14.31	0.16	Fe	10.01	0.11
TiO2	1.30	0.05	Ti	0.78	0.03
MgO	0.67	0.03	Mg	0.40	0.02
CaO	0.669	0.028	Ca	0.478	0.020
MnO	0.230	0.010	Mn	0.178	0.008
P2O5	0.1126	0.0070	Px	0.0491	0.0030
Na2O	0.0730	0.0062	Na	0.0542	0.0046
SO3	0.0796	0.0040	Sx	0.0319	0.0016
K2O	0.0704	0.0033	K	0.0585	0.0028
V2O5	0.0394	0.0020	V	0.0221	0.0011
ZrO2	0.0142	0.0014	Zr	0.0105	0.0010
ZnO	0.0117	0.0007	Zn	0.0094	0.0005
CuO	0.0079	0.0007	Cu	0.0063	0.0005
Cr2O3	0.0075	0.0007	Cr	0.0051	0.0005
La2O3	0.0047	0.0011	La	0.0040	0.0010
Co3O4	0.0046	0.0010	Co	0.0034	0.0007
Ga2O3	0.0038	0.0003	Ga	0.0028	0.0003
Y2O3	0.0037	0.0005	Y	0.0029	0.0004
Sc2O3	0.0034	0.0005	Sc	0.0022	0.0004
LOI	16.38				

Kepala Subbidang Geologi Dasar dan Terapan
selaku Manajer Teknis,

Arief Prabowo, S.T., M.T.
NIP. 197203112006041001.

BADAN GEOLOGI · KEMENTERIAN ENERGI DAN SUMBER DAYA MINERAL

Catatan (*notes*):
Hasil pengujian ini hanya berlaku untuk sampel yang diuji (*this analysis result is only valid for the tested sample*).

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HASIL UJI KIMIA METODE XRF
(*XRF METHOD CHEMISTRY ANALYSIS RESULT*)
Nomer lab. (*lab. number*) : 073/LAGL/2.2/10/2018
Tanggal (*date*) : 12 Oktober 2018

Kode sampel (*sample code*)	: STA 42	Tanggal diterima (*received date*)	: 20 Agustus 2018
Kode lab. (*lab. code*)	: 204/2.2/18/0934	Tanggal diuji (*analyzed date*)	: 10 Oktober 2018
Lokasi (*location*)	: Jelekong, Bandung Selatan	Metode uji (*method*)	: GL-MU-2.2
Kedalaman (*depth*)	: -	Metode preparasi (*preparation method*)	: *Pressed Pellet*
Pemilik (*property*)	: Nosival Mu'amar Aurial UNPAD		

Compound	m/m%	StdErr	El	m/m%	StdErr
SiO2	47.90	0.25	Si	22.39	0.12
Al2O3	21.04	0.22	Al	11.13	0.12
Fe2O3	13.50	0.16	Fe	9.44	0.11
TiO2	1.20	0.05	Ti	0.72	0.03
MgO	0.97	0.04	Mg	0.58	0.03
CaO	0.769	0.033	Ca	0.549	0.023
MnO	0.356	0.016	Mn	0.276	0.012
K2O	0.2149	0.0100	K	0.1784	0.0080
Na2O	0.1404	0.0090	Na	0.1041	0.0060
P2O5	0.1094	0.0070	Px	0.0477	0.0029
SO3	0.0544	0.0027	Sx	0.0218	0.0011
V2O5	0.0353	0.0018	V	0.0198	0.0010
ZrO2	0.0126	0.0014	Zr	0.0093	0.0011
Cr2O3	0.0088	0.0007	Cr	0.0060	0.0005
ZnO	0.0083	0.0007	Zn	0.0067	0.0005
CuO	0.0061	0.0006	Cu	0.0049	0.0005
La2O3	0.0050	0.0012	La	0.0043	0.0010
Co3O4	0.0048	0.0009	Co	0.0035	0.0007
Y2O3	0.0039	0.0005	Y	0.0031	0.0004
Ga2O3	0.0039	0.0003	Ga	0.0029	0.0003
NiO	0.0032	0.0007	Ni	0.0025	0.0005
Sc2O3	0.0021	0.0005	Sc	0.0014	0.0003
Br	0.0014	0.0003	Br	0.0014	0.0003

LOI [illegible]

Kepala Subbidang Geologi Dasar dan Terapan
selaku Manajer Teknis,

[illegible], S.T., M.T.
NIP. 19720311200604100[illegible]

Catatan (*notes*):
Hasil pengujian ini hanya berlaku untuk sampel yang diuji (*this analysis result is only valid for the tested sample*).

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HASIL UJI KIMIA METODE XRF
(XRF METHOD CHEMISTRY ANALYSIS RESULT)
Nomer lab. (*lab. number*) : 073/L/GL/2.2/10/2018
Tanggal (*date*) : 12 Oktober 2018

Kode sampel (*sample code*)	: STA 43	Tanggal diterima (*received date*)	: 20 Agustus 2018
Kode lab. (*lab. code*)	: 204/2.2/18/0935	Tanggal diuji (*analyzed date*)	: 10 Oktober 2018
Lokasi (*location*)	: Jelekong, Bandung Selatan	Metode uji (*method*)	: GL-MU-2.2
Kedalaman (*depth*)	: -	Metode preparasi (*preparation method*)	: *Pressed Pellet*
Pemilik (*property*)	: **Nouval Mu'amar Asrial UNPAD**		

Compound	m/m%	StdErr	El	m/m%	StdErr
SiO2	49.70	0.25	Si	23.23	0.12
Al2O3	22.82	0.23	Al	12.08	0.12
Fe2O3	11.39	0.14	Fe	7.97	0.10
MgO	0.74	0.03	Mg	0.45	0.02
TiO2	0.79	0.03	Ti	0.48	0.02
CaO	0.375	0.016	Ca	0.268	0.011
MnO	0.086	0.004	Mn	0.067	0.003
P2O5	0.0452	0.0027	Px	0.0197	0.0012
Na2O	0.0430	0.0052	Na	0.0319	0.0038
SO3	0.0363	0.0018	Sx	0.0145	0.0007
V2O5	0.0210	0.0011	V	0.0118	0.0006
K2O	0.0203	0.0010	K	0.0168	0.0008
ZnO	0.0089	0.0006	Zn	0.0072	0.0005
ZrO2	0.0078	0.0014	Zr	0.0058	0.0011
Ga2O3	0.0037	0.0003	Ga	0.0028	0.0002
CuO	0.0034	0.0006	Cu	0.0027	0.0005
Y2O3	0.0033	0.0005	Y	0.0026	0.0004
Sc2O3	0.0029	0.0005	Sc	0.0019	0.0003

LOI 13.69

Kepala Subbidang Geologi Dasar dan Terapan
Selaku Manajer Teknis,

Arief Koswoto, S.T., M.T.
NIP 197203112006041001.

BADAN GEOLOGI KEMENTERIAN ENERGI DAN SUMBER DAYA MINERAL

Catatan (notes):
Hasil pengujian ini hanya berlaku untuk sampel yang diuji (*this analysis result is only valid for the tested sample*).

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HASIL UJI KIMIA METODE XRF
(*XRF METHOD CHEMISTRY ANALYSIS RESULT*)
Nomer lab. (*lab. number*) : 073/L/GL/2.2/10/2018
Tanggal (*date*) : 12 Oktober 2018

Kode sampel (*sample code*)	: STA 50	Tanggal diterima (*received date*)	: 20 Agustus 2018
Kode lab. (*lab. code*)	: 204/2.2/18/0936	Tanggal diuji (*analyzed date*)	: 10 Oktober 2018
Lokasi (*location*)	: Jelekong, Bandung Selatan	Metode uji (*method*)	: GL-MU-2.2
Kedalaman (*depth*)	: -	Metode preparasi (*preparation method*)	: *Pressed Pellet*
Pemilik (*property*)	: **Nouval Mu'amar Asrial UNPAD**		

Compound	m/m%	StdErr	El	m/m%	StdErr
------	--------	-------	--	--------	-------
SiO2	44.48	0.25	Si	20.79	0.12
Al2O3	24.58	0.23	Al	13.01	0.12
Fe2O3	13.45	0.15	Fe	9.41	0.11
TiO2	1.18	0.05	Ti	0.70	0.03
MgO	0.46	0.02	Mg	0.27	0.01
MnO	0.302	0.013	Mn	0.234	0.010
CaO	0.299	0.012	Ca	0.214	0.009
P2O5	0.0854	0.0050	Px	0.0373	0.0022
SO3	0.0479	0.0024	Sx	0.0192	0.0010
Na2O	0.0333	0.0054	Na	0.0247	0.0040
BaO	0.0357	0.0062	Ba	0.0320	0.0055
K2O	0.0335	0.0016	K	0.0278	0.0013
V2O5	0.0268	0.0013	V	0.0150	0.0008
ZrO2	0.0155	0.0013	Zr	0.0115	0.0010
ZnO	0.0106	0.0007	Zn	0.0085	0.0005
Y2O3	0.0072	0.0005	Y	0.0057	0.0004
CuO	0.0070	0.0006	Cu	0.0056	0.0005
Co3O4	0.0065	0.0009	Co	0.0048	0.0006
La2O3	0.0059	0.0011	La	0.0050	0.0009
Cr2O3	0.0041	0.0006	Cr	0.0028	0.0004
Ga2O3	0.0036	0.0003	Ga	0.0027	0.0003
NiO	0.0035	0.0006	Ni	0.0028	0.0005
Sc2O3	0.0034	0.0005	Sc	0.0022	0.0003
		LOI	[illegible]		

Kepala Subbidang Geologi Dasar dan Terapan
selaku Manajer Teknis,

[illegible] Kusworo, S.T., M.T.
NIP. 197203112006041001.

Catatan (notes):
Hasil pengujian ini hanya berlaku untuk sampel yang diuji (*this analysis result [illegible] valid for the tested sample*).

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HASIL UJI KIMIA METODE XRF
(XRF METHOD CHEMISTRY ANALYSIS RESULT)
Nomer lab. (*lab. number*) : 073/L/GL/2.2/10/2018
Tanggal (*date*) : 12 Oktober 2018

Kode sampel (*sample code*)	: STA 55	Tanggal diterima (*received date*)	: 20 Agustus 2018
Kode lab. (*lab. code*)	: 204/2.2/18/0937	Tanggal diuji (*analyzed date*)	: 10 Oktober 2018
Lokasi (*location*)	: Jelekong, Bandung Selatan	Metode uji (*method*)	: GL-MU-2.2
Kedalaman (*depth*)	: -	Metode preparasi (*preparation method*)	: *Pressed Pellet*
Pemilik (*property*)	: **Nouval Mu'amar Asrial UNPAD**		

Compound	m/m%	StdErr	El	m/m%	StdErr
SiO2	45.58	0.25	Si	21.31	0.12
Al2O3	22.41	0.23	Al	11.86	0.12
Fe2O3	13.78	0.16	Fe	9.64	0.11
TiO2	1.17	0.05	Ti	0.70	0.03
CaO	0.65	0.03	Ca	0.46	0.02
MgO	0.557	0.024	Mg	0.336	0.014
MnO	0.284	0.012	Mn	0.220	0.010
P2O5	0.1060	0.0060	Px	0.0463	0.0028
Na2O	0.1039	0.0060	Na	0.0771	0.0048
K2O	0.1209	0.0060	K	0.1004	0.0047
SO3	0.0477	0.0024	Sx	0.0191	0.0010
V2O5	0.0265	0.0013	V	0.0148	0.0007
ZrO2	0.0126	0.0014	Zr	0.0093	0.0010
ZnO	0.0082	0.0006	Zn	0.0066	0.0005
CuO	0.0067	0.0006	Cu	0.0054	0.0005
La2O3	0.0053	0.0012	La	0.0045	0.0010
Co3O4	0.0048	0.0009	Co	0.0035	0.0007
Y2O3	0.0044	0.0005	Y	0.0035	0.0004
Ga2O3	0.0036	0.0003	Ga	0.0027	0.0003
NiO	0.0025	0.0006	Ni	0.0020	0.0005

LOI 14.91

Kepala Subbidang Geologi Dasar dan Terapan
selaku Manajer Teknis,

[illegible]sworo, S.T., M.T.
NIP. 197203112006041001.

Catatan (notes):
Hasil pengujian ini hanya berlaku untuk sampel yang diuji (*this analysis result is only valid for the tested sample*).

LABORATORIUM PUSAT SURVEI GEOLOGI
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Telp. 022-7203205, 6032207. Fax. 022-7202669, 6127941. E-mail: labgeologi@grdc.esdm.go.id

HASIL UJI KIMIA METODE XRF
(XRF METHOD CHEMISTRY ANALYSIS RESULT)

Nomer lab. (*lab. member*) : 073/L/GL/2.2/10/2018
Tanggal (*date*) : 12 Oktober 2018

Kode sampel (*sample code*)	: STA 58	Tanggal diterima (*received date*)	: 20 Agustus 2018
Kode lab. (*lab. code*)	: 204/2.2/18/0838	Tanggal diuji (*analyzed date*)	: 10 Oktober 2018
Lokasi (*location*)	: Jelekong, Bandung Selatan	Metode uji (*method*)	: GL-MU-2.2
Kedalaman (*depth*)	: -	Metode preparasi (*preparation method*)	: *Pressed Pellet*
Pemilik (*property*)	: **Nouval Mu'amar Asrial UNPAD**		

Compound	m/m%	StdErr	El	m/m%	StdErr
SiO2	41.32	0.24	Si	19.31	0.11
Al2O3	23.45	0.23	Al	12.41	0.12
Fe2O3	17.40	0.17	Fe	12.17	0.12
TiO2	1.51	0.05	Ti	0.91	0.03
MgO	0.47	0.02	Mg	0.29	0.01
CaO	0.317	0.013	Ca	0.226	0.010
MnO	0.233	0.010	Mn	0.181	0.008
P2O5	0.0935	0.0060	Px	0.0408	0.0025
SO3	0.0653	0.0033	Sx	0.0261	0.0013
K2O	0.0556	0.0026	K	0.0461	0.0022
V2O5	0.0501	0.0025	V	0.0281	0.0014
ZrO2	0.0148	0.0013	Zr	0.0110	0.0010
CuO	0.0080	0.0007	Cu	0.0064	0.0006
Cr2O3	0.0068	0.0007	Cr	0.0047	0.0005
Co3O4	0.0060	0.0011	Co	0.0044	0.0008
ZnO	0.0055	0.0007	Zn	0.0044	0.0005
Y2O3	0.0035	0.0005	Y	0.0028	0.0004
Ga2O3	0.0034	0.0004	Ga	0.0025	0.0003
Sc2O3	0.0031	0.0006	Sc	0.0020	0.0004
NiO	0.0029	0.0007	Ni	0.0023	0.0005
		LOI	14.77		

Kepala Subbidang Geologi Dasar dan Terapan
selaku Manajer Teknis,

Arief Risworo, S.T., M.T.
NIP. 197203112006041001.

Catatan (note):
Hasil pengujian ini hanya berlaku untuk sampel yang diuji (this analysis result is only valid for the tested sample).

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HASIL UJI KIMIA METODE XRF
(XRF METHOD CHEMISTRY ANALYSIS RESULT)
Nomer lab. (*lab. number*) : 073/L/GL/2.2/10/2018
Tanggal (*date*) : 12 Oktober 2018

Kode sampel (*sample code*)	: STA 57	Tanggal diterima (*received date*)	: 20 Agustus 2018
Kode lab. (*lab. code*)	: 204/2.2/18/0939	Tanggal diuji (*analyzed date*)	: 10 Oktober 2018
Lokasi (*location*)	: Jelekong, Bandung Selatan	Metode uji (*method*)	: GL-MU-2.2
Kedalaman (*depth*)	: -	Metode preparasi (*preparation method*)	: *Pressed Pellet*
Pemilik (*property*)	: **Nouval Mu'amar Asrial UNPAD**		

Compound	m/m%	StdErr	El	m/m%	StdErr
SiO2	43.87	0.25	Si	20.51	0.11
Al2O3	23.28	0.23	Al	12.32	0.12
Fe2O3	13.96	0.16	Fe	9.77	0.11
CaO	1.09	0.05	Ca	0.78	0.03
TiO2	1.11	0.04	Ti	0.67	0.03
MgO	0.661	0.028	Mg	0.398	0.017
MnO	0.236	0.010	Mn	0.182	0.008
P2O5	0.1236	0.0070	Px	0.0540	0.0033
Na2O	0.0934	0.0070	Na	0.0693	0.0049
K2O	0.0718	0.0034	K	0.0596	0.0028
SO3	0.0615	0.0031	Sx	0.0246	0.0012
V2O5	0.0323	0.0016	V	0.0181	0.0009
ZrO2	0.0100	0.0014	Zr	0.0074	0.0010
ZnO	0.0090	0.0007	Zn	0.0072	0.0006
Co3O4	0.0055	0.0009	Co	0.0040	0.0007
CuO	0.0052	0.0006	Cu	0.0042	0.0005
Ga2O3	0.0042	0.0003	Ga	0.0031	0.0003
Y2O3	0.0036	0.0005	Y	0.0028	0.0004
Sc2O3	0.0022	0.0005	Sc	0.0014	0.0003
Br	0.0015	0.0003	Br	0.0015	0.0003

LOI 15.16

Kepala Subbidang Geologi Dasar dan Terapan
selaku Manajer Teknis,

Aries Kusworo, S.T., M.T.
NIP. 197203112006041001.

Catatan (*notes*):
Hasil pengujian ini hanya berlaku untuk sampel yang diuji (*this analysis result is only valid for the tested sample*).

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HASIL UJI KIMIA METODE XRF
(XRF METHOD CHEMISTRY ANALYSIS RESULT)
Nomer lab. (*lab. number*) : 073/L/GL/2.2/10/2018
Tanggal (*date*) : 12 Oktober 2018

Kode sampel (*sample code*)	: STA 58	Tanggal diterima (*received date*)	: 20 Agustus 2018
Kode lab. (*lab. code*)	: 204/2.2/18/0940	Tanggal diuji (*analyzed date*)	: 10 Oktober 2018
Lokasi (*location*)	: Jelekong, Bandung Selatan	Metode uji (*method*)	: GL-MU-2.2
Kedalaman (*depth*)	: -	Metode preparasi (*preparation method*)	: *Pressed Pellet*
Pemilik (*property*)	: **Nouval Mu'amar Asrial UNPAD**		

Compound	m/m%	StdErr	El	m/m%	StdErr
SiO2	45.61	0.25	Si	21.32	0.12
Al2O3	21.30	0.22	Al	11.27	0.12
Fe2O3	14.76	0.16	Fe	10.32	0.11
TiO2	1.44	0.05	Ti	0.86	0.03
CaO	0.81	0.03	Ca	0.58	0.03
MgO	0.519	0.022	Mg	0.313	0.013
MnO	0.222	0.010	Mn	0.172	0.008
Na2O	0.1106	0.0070	Na	0.0821	0.0051
P2O5	0.1036	0.0060	Px	0.0452	0.0028
K2O	0.0802	0.0038	K	0.0666	0.0032
SO3	0.0725	0.0036	Sx	0.0290	0.0015
V2O5	0.0420	0.0021	V	0.0235	0.0012
ZrO2	0.0123	0.0014	Zr	0.0091	0.0011
ZnO	0.0088	0.0007	Zn	0.0071	0.0006
CuO	0.0073	0.0007	Cu	0.0058	0.0006
Co3O4	0.0050	0.0010	Co	0.0037	0.0007
Y2O3	0.0038	0.0005	Y	0.0030	0.0004
Ga2O3	0.0036	0.0004	Ga	0.0027	0.0003
Cr2O3	0.0033	0.0007	Cr	0.0023	0.0004
Sc2O3	0.0024	0.0005	Sc	0.0016	0.0003
Br	0.0018	0.0003	Br	0.0018	0.0003

LOI 14.67

Kepala Subbidang Geologi Dasar dan Terapan
selaku Manajer Teknis,

Aries Kusworo, S.T., M.T.
197203112006041001.

Catatan (*notes*):
Hasil pengujian ini hanya berlaku untuk sampel yang diuji (*this analysis result is only valid for the tested sample*).

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HASIL UJI KIMIA METODE XRF
(XRF METHOD CHEMISTRY ANALYSIS RESULT)
Nomor lab. (*lab. number*) : 073/L/GL/2.2/10/2018
Tanggal (*date*) : 12 Oktober 2018

Kode sampel (*sample code*)	: STA 42	Tanggal diterima (*received date*)	: 20 Agustus 2018
Kode lab. (*lab. code*)	: 204/2.2/18/0934	Tanggal diuji (*analyzed date*)	: 10 Oktober 2018
Lokasi (*location*)	: Jelekong, Bandung Selatan	Metode uji (*method*)	: GL-M01-2.2
Kedalaman (*depth*)	: -	Metode preparasi (*preparation method*)	: *Pressed Pellet*
Pemilik (*property*)	: **Noural Mu'amar Aurial UNPAD**		

Compound	m/m%	StdErr	El	m/m%	StdErr
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SiO2	47.90	0.25	Si	22.39	0.12
Al2O3	21.04	0.22	Al	11.13	0.12
Fe2O3	13.50	0.16	Fe	9.44	0.11
TiO2	1.20	0.05	Ti	0.72	0.03
MgO	0.97	0.04	Mg	0.58	0.03
CaO	0.769	0.033	Ca	0.549	0.023
MnO	0.356	0.016	Mn	0.276	0.012
K2O	0.2149	0.0100	K	0.1784	0.0080
Na2O	0.1404	0.0090	Na	0.1041	0.0060
P2O5	0.1094	0.0070	Px	0.0477	0.0029
SO3	0.0544	0.0027	Sx	0.0218	0.0011
V2O5	0.0353	0.0018	V	0.0198	0.0010
ZrO2	0.0126	0.0014	Zr	0.0093	0.0011
Cr2O3	0.0088	0.0007	Cr	0.0060	0.0005
ZnO	0.0083	0.0007	Zn	0.0067	0.0005
CuO	0.0061	0.0006	Cu	0.0049	0.0005
La2O3	0.0050	0.0012	La	0.0043	0.0010
Co3O4	0.0048	0.0009	Co	0.0035	0.0007
Y2O3	0.0039	0.0005	Y	0.0031	0.0004
Ga2O3	0.0039	0.0003	Ga	0.0029	0.0003
NiO	0.0032	0.0007	Ni	0.0025	0.0005
Sc2O3	0.0021	0.0005	Sc	0.0014	0.0003
Br	0.0014	0.0003	Br	0.0014	0.0003
		LOI			

Kepala Subbidang Geologi Dasar dan Terapan
selaku Manajer Teknis,

[illegible] Wiwoho, S.T., M.T.
NIP. 19720311200604100[illegible]

Catatan (*notes*):
Hasil pengujian ini hanya berlaku untuk sampel yang diuji (*this analysis is [illegible] valid for the tested sample*).