



Universiti Malaysia
KELANTAN

**GEOLOGY AND GEOSITE POTENTIAL OF GUA
IKAN KARST COMPLEX, DABONG DISTRICT,
KELANTAN**

by

NURUL NAJWA BINTI MOHAMMAD SAAD

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

**FACULTY OF EARTH SCIENCE UNIVERSITY
MALAYSIA KELANTAN**

2023

THESIS DECLARATION

I declare that this thesis entitled **“GEOLOGY AND GEOSITE POTENTIAL OF GUA IKAN KARST COMPLEX, DABONG DISTRICT, KELANTAN”** is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :
Name : Nurul Najwa Binti Mohammad Saad
Date :

UNIVERSITI
MALAYSIA
KELANTAN

APPROVAL

“I/We hereby declare that I/ we have read this thesis and in my/our opinion this thesis is sufficient in terms of scope and quality for the award of Bachelor of Applied Sciences (Geosciences) with Honours”.

Signature :
Name of Supervisor : Dr Hafzan Eva Binti Mansor
Date :

UNIVERSITI
MALAYSIA
KELANTAN

ACKNOWLEDGEMENT

Alhamdulillah, first I would like to thanks to Allah S.W.T for giving me the opportunity and blessing to finish this final year project successfully. In fact, I am also grateful to the God for the good health and wellbeing that were necessary to complete this thesis within a given period.

Besides that, I would like to thank my final year project supervisor, Dr Hafzan Eva Binti Mansor, for providing me with such wonderful ideas, counsel, constant support, and some valuable information, which has led to me having enough resources for this final year research. I'd also want to take this occasion to thank my dear parents, who have supported me during the entire process, both by keeping me harmonious and assisting me in putting things together, and who have never given up on me and have always supported me morally and financially. Those encouragements and support have become my driving factors in completing my final year project. I shall be eternally thankful for your love.

Finally, I want to express my gratitude to all of my friends for their assistance, bravery, and support when I was writing the thesis. All of their contributions inspire me to encourage myself to generate higher-quality work. Finally, I would want to express my gratitude to everyone who was involved, either directly or indirectly, in the completion of this final year project.

Geology and Geosite Potential of Gua Ikan Karst Complex, Dabong District, Kelantan

ABSTRACT

The study area in the Gua Ikan Complex, Dabong District, Kelantan, is located at a latitude $5^{\circ}21'15.35''\text{N}$ to $5^{\circ}22'27.78''\text{N}$ and the longitude is $102^{\circ}1'33.38''\text{E}$ to $102^{\circ}3'8.64''\text{E}$. It is a part of the Gua Musang formation and Stong Migmatite Complex which is made up of Permian to Triassic rocks. The main objective of the study is to produce a geological map of the Gua Ikan Karst Complex, Dabong District, Kelantan, with a scale of 1:25,000 and research involves lithology, stratigraphy, structural geology, geomorphology, and petrography and evaluate geosite by M-GAM method. Marble rocks contain calcite minerals, according to laboratory and petrography analysis; their colours are pink, green in XPL and PPL, and colourless. Phyllite has quartz, which is grey and white in XPL and colourless in PPL; silica clay, which is dark grey in XPL and colourless brown in PPL; and opaque minerals, whose colour is black in XPL and PPL. Quartzite has quartz. In XPL, the colours are grey and white, while in PPL, the colours are colourless. In terms of lithology, the most common rock unit found is marble. The drainage pattern that can be analysed is the dendritic pattern. M-GAM is a method of evaluating the geosite potential of karst in the Gua Ikan Complex. The method involved both tourists and experts, and neither side was favoured in the assessment. Modified Geosites assessment model (M-GAM) is a model for assessing geosite and have same structure of indicators and sub indicators consisting of main and additional values. M-GAM is evaluating the perspective of two target groups whose divergent views on the value of sub indicators can influence the position of geosites in the M-GAM matrix. The geological map of Gua Ikan has been revised, the geological map of Gua Ikan has been updated, and the M-GAM evaluation of high values indicates the suitability of geosite with a high value indicator of scenic and aesthetic views due to their distinctive geomorphological characteristics.

UNIVERSITI
MALAYSIA
KELANTAN

Geologi dan Potensi Geotapak di Kompleks Gua Ikan Karst, Daerah Dabong, Kelantan

ABSTRAK

Kawasan kajian di Kompleks Gua Ikan, Daerah Dabong, Kelantan, terletak pada latitud $5^{\circ}21'15.35''\text{U}$ hingga $5^{\circ}22'27.78''\text{N}$ dan longitud $102^{\circ}1'33.38''\text{E}$ hingga $102^{\circ}3'8.64''\text{E}$. Ia adalah sebahagian daripada pembentukan Gua Musang dan Kompleks Migmatit Stong yang terdiri daripada batuan Permian hingga Triassic. Objektif utama kajian adalah untuk menghasilkan peta geologi Kompleks Karst Gua Ikan, Daerah Dabong, Kelantan, dengan skala 1:25,000 dan penyelidikan melibatkan litologi, stratigrafi, geologi struktur, geomorfologi, dan petrografi serta menilai geosite oleh M-kaedah GAM. Batu marmar mengandungi mineral kalsit, mengikut analisis makmal dan petrografi; warnanya merah jambu, hijau dalam XPL dan PPL, dan tidak berwarna. Phyllite mempunyai kuarza, iaitu kelabu dan putih dalam XPL dan tidak berwarna dalam PPL; tanah liat silika, yang berwarna kelabu gelap dalam XPL dan coklat tidak berwarna dalam PPL; dan mineral legap, yang warnanya hitam dalam XPL dan PPL. Kuarzit mempunyai kuarza. Dalam XPL, warna adalah kelabu dan putih, manakala dalam PPL, warna tidak berwarna. Dari segi litologi, unit batuan yang paling biasa ditemui ialah marmar. Pola saliran yang boleh dianalisis ialah pola dendritik. M-GAM ialah kaedah menilai potensi geosite karst di Kompleks Gua Ikan. Kaedah ini melibatkan kedua-dua pelancong dan pakar, dan kedua-dua pihak tidak diutamakan dalam penilaian. Model penilaian Geosites Modified (M-GAM) ialah model untuk menilai geosite dan mempunyai struktur penunjuk dan sub penunjuk yang sama yang terdiri daripada nilai utama dan tambahan. M-GAM sedang menilai perspektif dua kumpulan sasaran yang pandangan berbeza terhadap nilai sub penunjuk boleh mempengaruhi kedudukan geosites dalam matriks M-GAM. Peta geologi Gua Ikan telah disemak, peta geologi Gua Ikan telah dikemas kini, dan penilaian M-GAM nilai tinggi menunjukkan kesesuaian geosite dengan penunjuk nilai tinggi pemandangan indah dan estetik kerana ciri geomorfologinya yang tersendiri

TABLE OF CONTENTS

	PAGES
ACKNOWLEDGEMENT	iii
ABSTRACT	iv
ABSTRAK	v
TABLES OF CONTENTS	vi-viii
LIST OF TABLES	ix-x
LIST OF FIGURES	xi-xiv
LIST SYMBOL	xiv
LIST ABBREVIATIONS	xiv
CHAPTER 1 INTRODUCTION	
1.1 General Background	1
1.2 Study Area	2
1.3 Problem Statement	7
1.4 Objective	7
1.5 Scope of Study	8
1.6 Significance of Study	9
CHAPTER 2 LITERATURE REVIEW	
2.1 Introduction	10
2.2 Regional Geology and Tectonic Setting	11
2.3 Stratigraphy	15
2.3.1 Stong Migmatite Complex	16
2.3.2 Gua Musang Formation	17
2.4 Structural Geology	19
2.5 Historical Geology	20
2.6 Geosite Concept	21
2.7 Geoheritage Concept	22

2.8	Geotourism Concept	22
2.9	Geomorphosite Concept	23
2.10	Methods for Geosie Evaluation	23
2.11	Karst and Caves	24
CHAPTER 3 MATERIALS AND METHODOLOGIES		
3.1	Introduction	26
3.2	Materials	27
3.2.1	Material and Equipment	27
3.3	Methodology	27
3.3.1	Preliminary Studies	27
3.3.1.1	Internet Resources	27
3.4	Field Study of geology	28
3.5	Geosite potential analysis	29
3.5.1	M-GAM Method	29
3.5.2	Data Processing	33
3.6	Laboratory Analysis	35
3.6.1	Petrography Analysis	35
CHAPTER 4 GENERAL GEOLOGY		
4.1	Introduction	36
4.1.1	Geography	36
4.1.2	Accessibility	37
4.1.3	Population distribution or settlement	39
4.1.4	Forestry and Vegetation	40
4.1.5	Traverse and observation	45
4.2	Geomorphology	43
4.2.1	Topography/ Morphography	46
4.2.2	Weathering	47

4.2.3	Drainage Pattern	51
4.3	Stratigraphy	55
4.3.1	Lithostratigraphic unit	58
4.3.1.1	Phyllite unit	58
4.3.1.2	Marble unit	61
4.3.1.3	Quartzite unit	63
4.4	Structural geology	66
4.4.1	Lineament Analysis	67
4.4.2	Bedding	70
4.4.3	Joints	71
4.5	Historical	74

CHAPTER 5: EVALUATION OF GEOSITE POTENTIAL OF GUA IKAN KARST COMPLEX, GUA KERIS, GUA GELAP, GUA PAGAR, DABONG DISTRICT, KELANTAN

5.1	Introduction	75
5.2	M-GAM Analysis of Gua Ikan Karst Complex	77
5.3	The description of Gua Ikan Karst Complex, Gua Pagar, Gua Keris and Gua Gelap	96
5.4	Comparison of Geosites Potential of Gua Ikan Complex, Dabong, Districts based on M-GAM model and systematic studies.	104

CHAPTER 6: CONCLUSION AND SUGGESTIONS

6.1	Conclusion	111
6.2	Suggestions	112
	REFERENCES	113
	APPENDICES	117
	Questionnaires based on M-GAM	

LIST OF TABLES

NO	TITTLE	PAGE
3.1	Structure of M-GAM model values	32-33
4.1	Types of rock found in study area.	41
4.2	Classification of Topographic Unit based on elevation.	43
4.3	Classification of topography	46
4.4	Types of drainages	53
4.5	Lithostratigraphy column of Gua Ikan Karst Complex	56
4.6	Mineral Properties of Phyllite	60
4.7	Mineral Properties of Marble	63
4.8	Mineral Properties of Quartzite	65
4.9	The data joint taken in the study area	72
5.1	The pie chart of 4 caves based on gender, age (year), level of education.	76
5.2	Sub-indicator of M-GAM analysis in Gua Ikan Complex	78
5.3	Values assigned to each sub indicator in the M-GAM model by experts and visitors	81
5.4	Overall geosites by M-GAM (Assessment done by Expertise) Gua Ikan	83
5.5	Overall geosites by M-GAM (Assessment done by Tourists) Gua Ikan	83
5.6	Sub-indicator of M-GAM analysis in Gua Pagar	84
5.7	Values assigned to each sub-indicator in the GAM model by experts and visitors.	87

5.8	Overall geosites by M-GAM (Assessment done by Expertise)	88
5.9	Overall geosites by M-GAM (Assessment done by Tourists)	89
5.10	The sub-indicator of M-GAM analysis in Gua Keris	90
5.11	Values assigned to each sub indicator in the GAM model by experts and visitors.	93
5.12	Overall geosites by M-GAM (Assessment done by Expertise)	95
5.13	Overall geosites by M-GAM (Assessment done by Tourists)	99
5.14	Values assigned to each sub indicator in the GAM model by experts and visitors.	99
5.15	Overall geosites by M-GAM (Assessment done by Expertise)	101
5.16	Overall geosites by M-GAM (Assessment done by Tourists)	102
5.4.2.1	Evaluation systematic study	107

LIST OF FIGURES

NO	TITTLE	PAGE
1.1	Basemap of Kelantan	4
1.2	Gua Ikan Complex, Dabong	5
1.3	The fish shaped of Gua Ikan Complex	5
1.4	Basemap of Gua Ikan Complex, Dabong	6
2.1	Geological map of Peninsular Malaysia	11
2.2	The Bentong-Raub Suture line in Peninsular Malaysia	12
2.3	Conceptual cross-section during Middle-Late Triassic illustrating the formation of Central Belt to the east of Bentung-Raub Suture line as accretionary complex modified after Metcalfe, 2000)	12
2.4	Regional Geology of Kelantan State, Malaysia. Gua Musang District.	14
2.5	Geological Map of the Stong Migmatite Complex	16
2.6	Distribution of the Gua Musang Group. Modified from (Mohamed,1995)	18
2.7	Permo-Triassic stratigraphic correlation chart of Central Belt Peninsular Malaysia.	19
2.8	The karst formation in Gua Ikan Complex by image drone.	25
2.9	The karst formation in Gua Ikan Complex	25
3.1	Flow Chart of the methodology in the study area.	26
3.2	The data processing of drone using Agisoft Metashape	34
4.1	Accessibility of Gua Ikan Complex, Dabong. (Source: maps, 2023)	37

4.2	Dabong Road	37
4.3	Accessibility Map of the Gua Ikan Complex	38
4.4	The population distribution of ethnic according to the local authority area	39
4.5	Land use/cover map of the Kelantan state	40
4.6	Traverse and observation map of the Gua Ikan Complex	42
4.7	Topography map of the Gua Ikan Complex	45
4.8	The process of Chemical Weathering	47
4.9	The Chemical Weathering occurs change colour of outcrops.	48
4.10	Equation of weathering rock	48
4.11	A) The stalactites feature in the Gua Ikan Complex, B) The stalagmites feature in the Gua Ikan Complex, C) The columns feature in the Gua Ikan Complex	49
4.12	The Physical weathering	50
4.13	The wedging by roots of Gua Ikan due to biological weathering	51
4.14	The types of drainages patterns	52
4.15	Drainage Maps of study area	54
4.16	Geological Maps of study area	57
4.17	Phyllite rock bodies in the study area	58
4.18	Hand specimen of Phyllite	59
4.19	The thin section photo-micro of phyllite sample on (a) XPL (b) PPL.	59
4.20	Marble rock bodies in the study area	61

4.21	Hand specimen of marble in the study	62
4.22	The thin section photo-micro of marble sample on (a) XPL (b) PPL. Calcite = Cl, (a , b) ; Magnification of 60×0.80P	62
4.23	Quartzite rock bodies in the study area	64
4.24	Quartzite hand specimen in the study area	64
4.25	The thin section photo-micro of quartzite sample on (a) XPL (b) PPL.Quartz = Qz (a , b) ; Magnification of 60×0.80P	65
4.26	Positive Lineament	68
4.27	Negative lineament	68
4.28	Positive and negative lineaments of Gua Ikan Complex	69
4.29	Bedding structure in study area	70
4.30	Joint structure in the study area	71
4.31	Data Joint Interpret using the rose diagram	73
5.1	M-GAM Analysis	77
5.3	The scatter plot diagram of 4 caves	102
5.4	Stall in study area	105
5.5	Playground study area	105
5.6	Stall and tour guide services	106
5.7	Signboard Gua Ikan Karst Complex	107
5.9	Column Formation	108
5.10	Stalactite and stalagmite	109

5.11	Seaweed fossil	109
5.12	Monkey head stone	110
5.13	Formation of dagger at Gua Keris	110

LIST OF SYMBOLS

%	Percentage
Σ	Total
°	Degree

LIST OF ABBREVIATION

E	East
W	West
N	North
S	South
GIS	Geographic Information System
GPS	Global Positioning System
KM	Kilometre
M	Metre
PPL	Plane Polarized Light
XPL	Cross Polarized Light

CHAPTER 1

INTRODUCTION

1.1 General Background

The research specific idea on the geosite potential of karst in Gua Ikan Complex, Dabong District, Kelantan using the modified geosites assessment model (M-GAM). The study of landforms, formations, processes, and sediments at the Earth's surface and the interactions between environment of study area and awareness of people to the geosite.

The geosite can be described as rock exposure or landscapes which indicates a highly heritage value. There are several features at particular site, region or nation but generally hard to find elsewhere (Komoo, 2000) while "potential" means having the ability to develop into something in the future. Generally, the Gua Ikan Karst Complex, which has great potential and value as a geosite and geoheritage.

Gua Ikan Karst Complex is an "Aspiring Strong Geopark" (ASG) area that has been identified by the Department of Mineral and Geoscience (JMG) and has the potential to be appointed as the National Geopark in Kelantan due to its geological uniqueness and limestone hilly landscape covered with various types of green plant ecosystems (daily, 2022)

M-GAM model which derived from GAM (geosite assessment model) that emphasized the opinion of experts and visitors. The method is based on evaluate on

the respondent's opinion and the evaluate of the study area. It is important method to analyse the study area have high potential as a geosite or not. Meanwhile, the Geological Map is the maps created for showing the geological features that occurred in the study area. The geological characteristics that can identified in the study area are interpret on maps include structural geology, lithology, the areas covered in the study and others. Varieties of unit rocks are identified, utilizing separate colors based on the code for each standard of lithology. Besides, the investigation of the general geology of the study area is significances in order to update a geological map with scale of 1:25000.

The Gua Ikan Complex is a famous natural recreational area that has many caves such as Gua Ikan, Gua Pagar, Gua Keris, and Gua Gelap that can attract visitors. The Gua Ikan Karst Complex, Dabong exhibit spectacular geological features. For example, mountains, rivers, and caves. Gua Ikan Karsts Complex has a very noticeable and exciting uniqueness, likeave life, including bats and spiders.

In addition, by conducting the research, it can gain knowledge about the geological information and features. Gua Ikan Karst Complex, Dabong, Kelantan, is the study area, and it has many geological types, an environment, and unique features such as limestones and caves. Furthermore, the research can expose people to important of geological knowledges which can gain a variety of geological formation and scientific information. Thus, this area is very important to be conserved, as it serves the public interest for tourism and geotourism purposes.

1.2 Study Area

Gua Ikan Complex is located in Dabong, a town in Kuala Krai District, Kelantan, nearby the Galas River. The main village here is Kampung Slow Pak Long, located 95 km from Kuala Krai town. The name "Gua Ikan" derives from the structure of the limestone cave depicted in the Figure 1, the fish-shaped start extends from west to east. The age of the cave is more than 150 million years.

The study area covers latitude of the study area is $5^{\circ}21'15.35''\text{N}$ to $5^{\circ}22'27.78''\text{N}$ and the longitude is $102^{\circ}1'33.38''\text{E}$ to $102^{\circ}3'8.64''\text{E}$. There are four caves including Gua Ikan, Gua Pagar, Gua Keris and Gua Gelap that are suitable for natural recreational, picnic and have many geological features such as limestone karst, a clear river and flora and fauna. The study area occurred karst can be potentially developed as geosite.

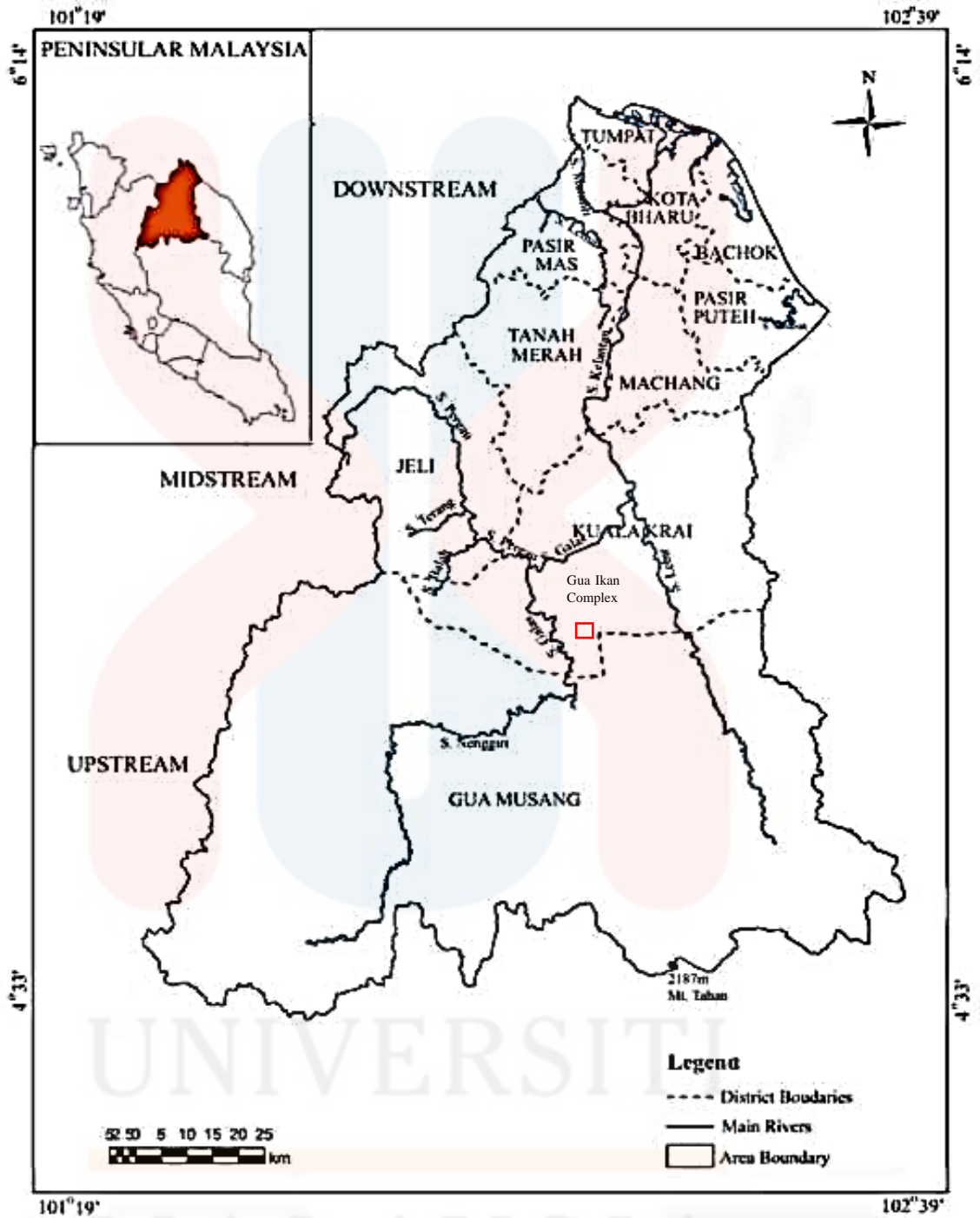


Figure 1.1: Basemap of Kelantan (Sources: Mohd Talha Anees et al, 2017)



Figure 1.2: Gua Ikan Complex, Dabong



Figure 1.3: The Fish shaped of Gua Ikan Complex (Source: (David, 2011))

KELANTAN

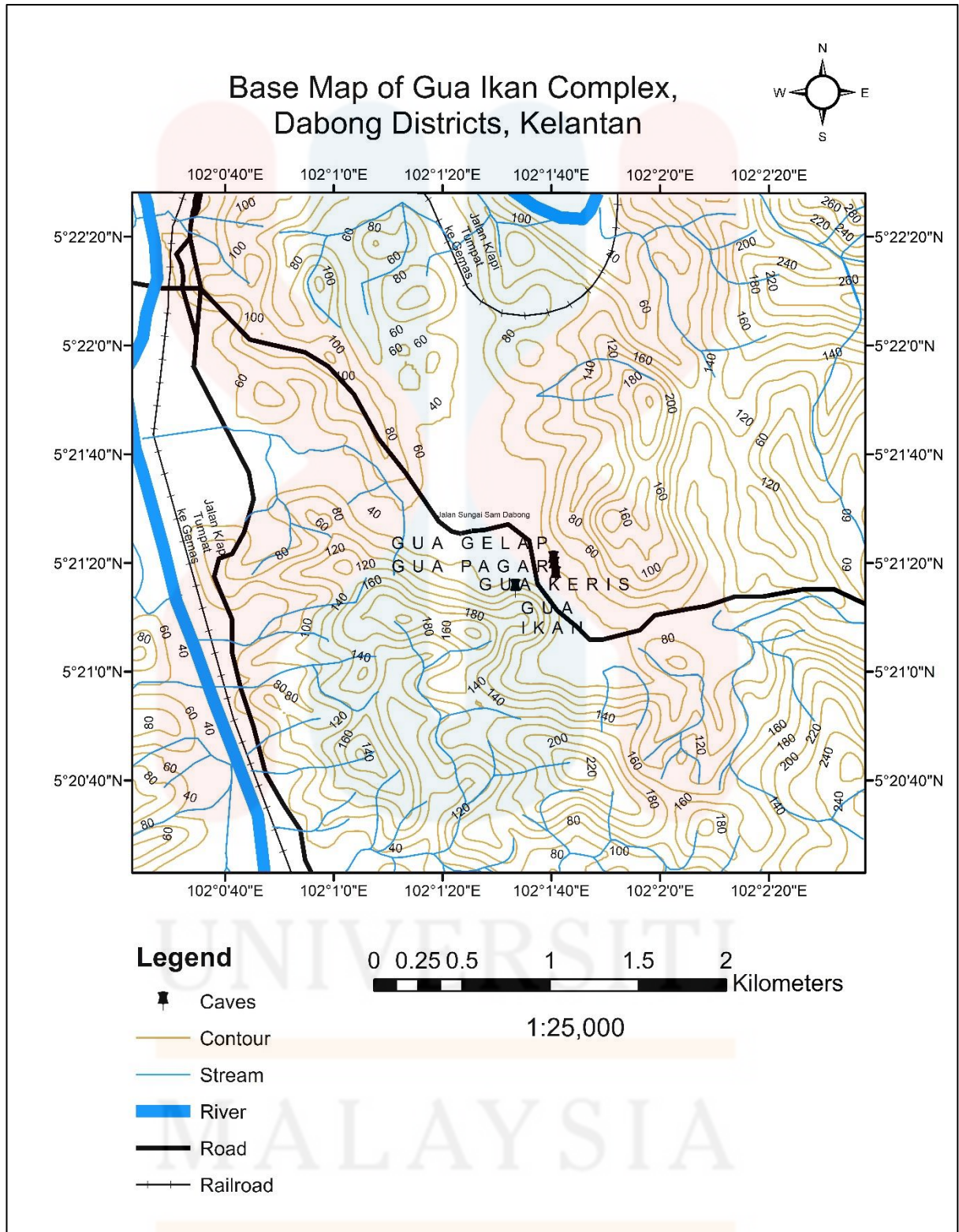


Figure 1.4: Base map of Gua Ikan Complex Dabong, Districts

1.3 Problem Statement

According to previous research the study methods are based on systematic studies of potential geoheritage or geosites, which include inventory, characterization, classification, assessment, and evaluation. The identification of potential geoheritage or geosites in the study area is known as "inventory. Hence, the previous research in the Gua Ikan Karst Complex conducted extensive geosite analysis through systematic studies and SWOT analysis, but not so much through MGAM analysis (Sulaiman, 2021).

In addition, based on previous research, a lot of study has been done on the evaluation analysis of the Gua Ikan Karst Complex compared to geological aspects lithology, geological features, and formation analysis is less of previous research. It causes difficult for researchers to find reference sources because they are limited regarding geological formations, geological features in the Gua Ikan Complex, Dabong.

1.4 Objective

The objectives of this research are:

1. To produce a geological map of Gua Ikan Karsts Complex, Dabong District, Kelantan, with a scale of 1:25000.
2. To quantify the geosite potential of three caves in the Gua Ikan Karsts Complex using the M-GAM method.

1.5 Scope of study

This study aims to create a complete geological map of the study area at a scale of 1:25000. To analyse structural geology, lithostratigraphy, and geomorphology, the area has undergone geological investigation. After that, based on interpretation, the geological map is produced using ArcGIS Software. The study area's historical geology is carried out using a literature evaluation based on prior studies. The scope of study for this research is to quantify the geosite potential of four caves in the Gua Ikan Karsts Complex. It is because of the existence of some specific characteristics that will be evaluated in the study area.

Some parameters will be evaluated based on the criteria of conservation, scientific and intrinsic value, economical value, educational value, and added value. Several methodologies were used to conduct this research, including the preliminary study, mapping, some quantitative assessment, laboratory analysis, and data analysis. This study is also concerned with evaluating and conserving nature or geosite features in the Gua Ikan Karsts Complex, Dabong, based on M-GAM analysis, which is divided into two elements: main value (MV) and additional value (AV), both of which play important roles in educating the public about the importance of nature and conservation.

1.6 Significance of study

The geology community can better comprehend the study area's history and processes due to the complete geological information provided by this research, which is shown in the form of a geological map of the study area. Authorities, agencies, or

governments can use the information provided, such as lithostratigraphy, structural geology, weathering, and geomorphology, as a reference when adequate management and development plans which related to study area.

Furthermore, landscapes, scientific, cultural, and socioeconomic values in the study area should be preserved. It is very suitable to do the quantitative assessment in this area since it has special characteristics that can be evaluated for the suitability of a geosite. In Malaysia, karst landscapes have been observed in several locations, including the Kinta Valley in Perak, the Gua Ikan Complex one the famous area of karst formations. Several studies have been conducted on the karst landscapes in these areas, focusing on their geology, geomorphology, and hydrology.

The importance of geosites assessment in the study area is to show that the formation of geology such as karsts contains valuable geological elements for humans. The study's research was intended to aid in understanding and raising awareness to conserve geological resources in the study area not only among the geology community but, more importantly, among the authorities and the local community.

Last but not least, this research is providing educational benefits to people such as student, community and government about geological information. In addition, recreation and tourism were the most frequently mentioned benefits associated with natural beauty and scenery. Because the Earth is dynamic, it is useful in providing information about geologic structures, their occurrence, and their history in the context of geology.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The chapter is a literature review that discusses regional geology, stratigraphy, structural, historical geology and geosite. All the information gathered during the research is from journals, articles, books, the internet and other references related to the research. The references can help strengthen the information related to research at Gua Ikan Karst Complex, Dabong Districts, Kelantan.

2.2 Regional Geology and Tectonic Setting

Malaysia is positioned on the Sunda tectonic block, which encompasses much of Southeast Asia (Simons et. al, 2007). Malaysia was once considered to reside on a reasonably stable continent, far of catastrophic events caused by plate tectonics such as earthquakes and volcanic eruptions. Generally, Malaysia is part of eastern Malaysia and the Sibumasu tectono-stratigraphic terrain. Peninsular Malaysia is a part of the east Eurasian Plate and tectonically located to the north of currently active subduction arc zones of the Sunda arc. Gold discovery distinctly in this region is always associated with Tertiary volcanic and hydrothermal activities and appears to be very broadly related to tectonic boundaries in this region.

Peninsular Malaysia, the South-East Asian portion of Sundaland, is a crucial component of the Eurasian plate (Hutchison, 1989,1996). Sumatra, Nauna, and

western Borneo are all part of the same plate, and the Sunda Shelf, which has less than 200 metres of ocean depth, extends eastwards and southward (Hutchison, 2009). There are three belts in Peninsular Malaysia: The Western Belt, the Central Belt, and the Eastern Belt. From Kelantan to Johor, the central belt runs between the eastern slopes of the Main Range (Hutchison, 2009). Volcanic activity is quite prevalent in the Central Belt. It was considered that Permian and Triassic marine sediments with an acidic to andesitic composition came from volcanic rock. According to Khoo & Tan (1983), the Central Belt has more mafic and ultramafic intrusive than in the Western Belt.

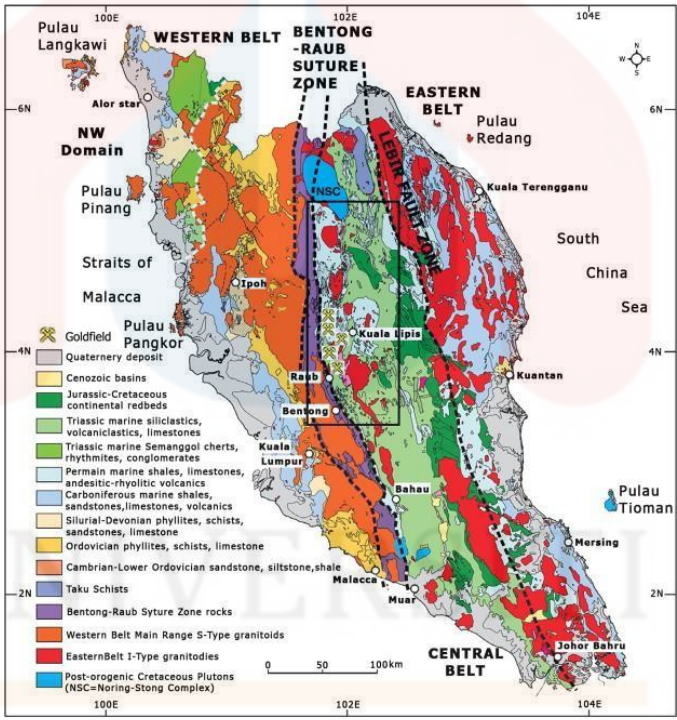


Figure 2.1: Geological map of Peninsular Malaysia (Amin Beiranvand Pour, 2015)

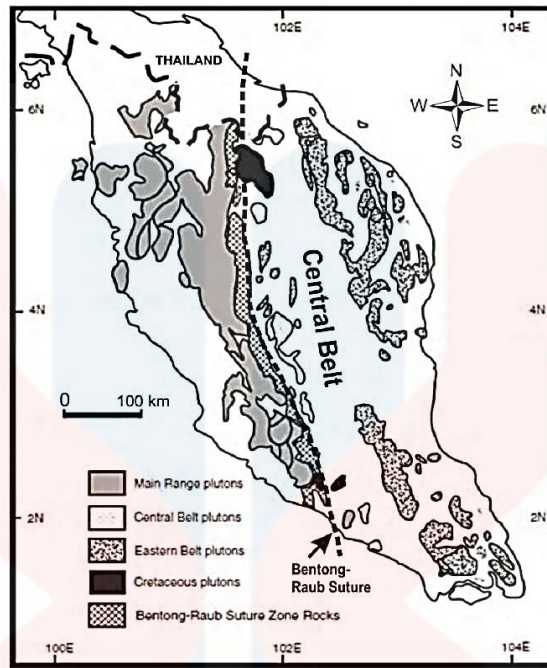


Figure 2.2: The Bentong-Raub Suture line in Peninsular Malaysia (Sources: Ariffin, 2012).

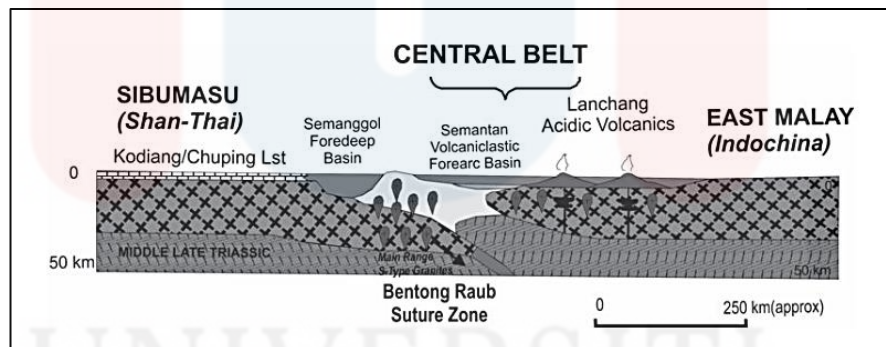


Figure 2.3: Conceptual cross-section during Middle-Late Triassic illustrating the formation of Central Belt to the east of Bentong-Raub Suture line as accretionary complex modified after Metcalfe, 2000)

The Bentong-Raub Suture is a line that separated Western Belt from Central Belt that represents the closure of Palaeo Tethys ocean due to the collision of Sibumasu and Indochina terranes. In regional geology, the Central Belt is primarily composed of Permo-Triassic, low-grade metasediments, deep to shallow marine clastic sediments, and limestone with abundant intermediate to acidic clastic sediments.

It is a North-South long line lineament extending from Thailand towards East of Malacca which also produced a trend of deformed rocks (Hutchison & Tan, 2009)

The sedimentary and metasedimentary rocks that make up Kelantan's regional geology are in a central zone that is surrounded on the west and east by granites from the Main Range (Titiwangsa Range) and Boundary Range, respectively. There is granite intrusive within the Central zone, such as the Senting batholith, the Kemahang pluton, and the Stong Igneous Complex.

It is of Palaeozoic age and is a northerly-trending strip that borders the Main Range's foothills and extends eastward. The Lower Palaeozoic series is unconformably beneath Permian volcanic-sedimentary rocks on the eastern edge of Kelantan in the southwest. The granite belts in central and western Kelantan contribute northward to south Thailand, whereas the granite in the Boundary Range (east of Kelantan) is overlain by the coastal alluvial flat of Sungai Kelantan.

UNIVERSITI
MALAYSIA
KELANTAN

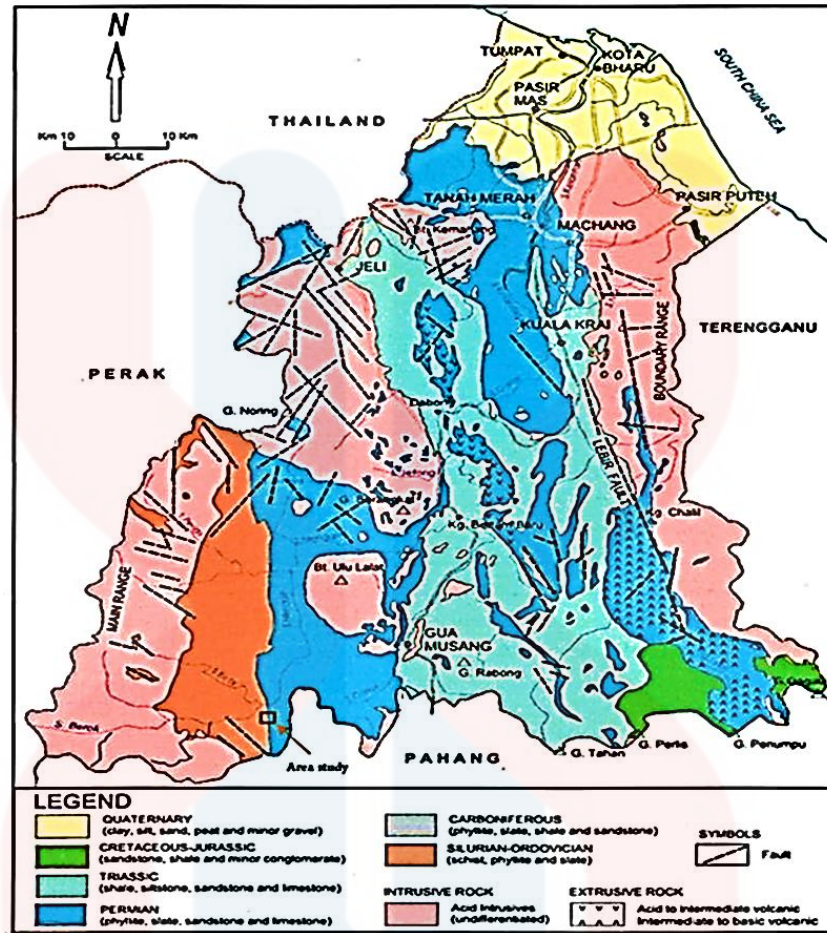


Figure 2.4: Regional Geology of Kelantan State, Malaysia. Gua Musang District.

According to Metcalfe, I., and Azhar, H. (1994), the typical formation in Peninsula Malaysia from the Permian to the Triassic was deep marine. Thus, Gua Ikan Complex, Dabong Districts is classified as Permian to the Triassic. The Triassic Semantan and Semanggol formations are recognised as deep-sea sediments based on sedimentology and palaeontology studies. Gua Ikan Complex is surrounding area in Dabong District, Kelantan, have a complex history of tectonic activity and sedimentation. Peninsular Malaysia is located on the Sunda Plate, which is the southern extension of the Eurasian plate. Peninsular Malaysia is located on the boundary of the Sunda plate and the Eurasian plate and has been subjected to extensive tectonic activity throughout its history (Hutchinson & Tan, 2009).

2.3 Stratigraphy

Stratigraphy is about branch of geology to description and interpret the geologic time scale. Kelantan is rural state in northeast of Peninsular Malaysia. The geological formation of Kelantan is ranges between Lower Palaeozoic to Quarternary Age. This states also consider as a unique territory that have three belts, Western, Central and Eastern. The belts that mention is divided in some formations which are Western Belt (Main Range Granite), Central Belt (Jeli Granite, Kemahang Granite, Noring Granite, Kenerong Leucogranite, Berangkat Tonalite and Senting Granite) and Eastern Belt (Boundary Range Granite) (Patah, 2021).

2.3.1 Stong Migmatite Complex

This migmatite complex is located about 8 kilometres west of the railway towns of Kemubu and Dabong. The reclining spine-like protrusion at Gunung Stong's summit is easily identified from the railway line. Excellent outcrops can be found in rapids along the Sungai Kenerong and Sungai Semuliang, both of which are accessible from Kemubu.

Stong migmatite is of geological features that categorised of young mountain region. This terrain is significant for its geological uniqueness, such as the presence of a variety of magmatic rocks, enclave structure, and vein diversity, as well as its distinctive scenery, such as the formation of tors and rapids with high aesthetic, recreational, and scientific value. The formation of this terrain is attributed to

magmatic and rare dynamo thermal phenomena, which resulted in the formation of a distinctive and picturesque landscape feature through of exogenic processes.

Singh (1963) identified the Stong Complex as having a granitic core that is partially migmatitic and associated with a large enclave of metasediments. Hutchison (1973) described the complex's rocks as predominantly metamorphic. Stong Migmatite Complex made up of agmatite, venite, and nebulite. Many authors have discussed aspects of the complex (e.g., Singh et al. (1984), Azman Abd. Ghani): (1998).

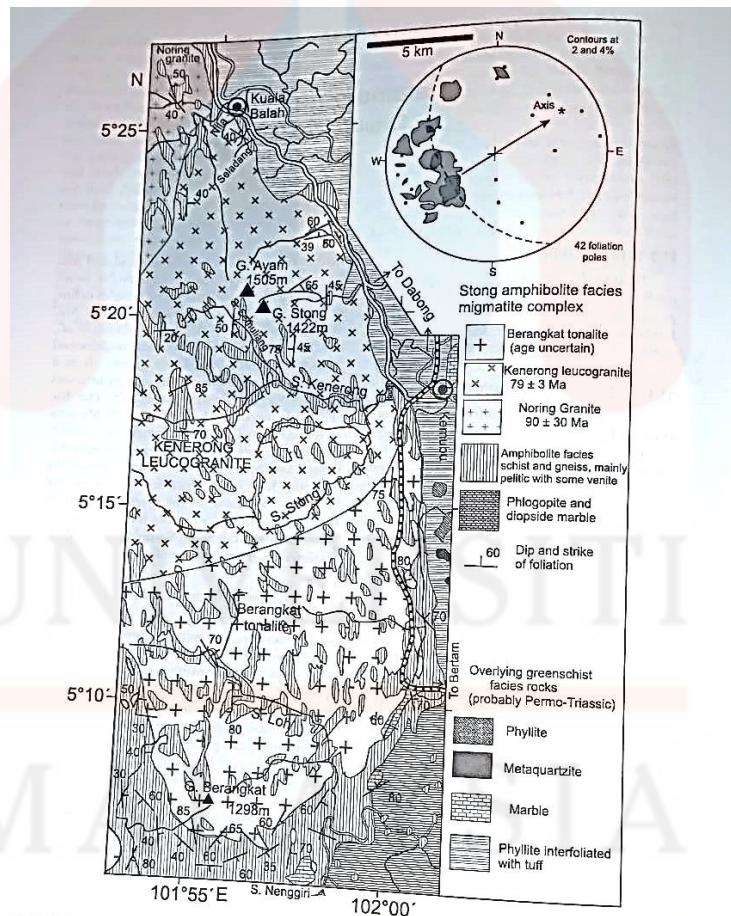


Fig. 11.1: Geological map of the Stong migmatite complex, Kelantan, after Dawson et al. (1968). Lower hemisphere equal-area stereogram of foliations in the complex. Granitoids from Singh et al. (1984), radiometric dates from Cobbing et al. (1992). The Sungai Renyok, where a smaller body of Kenerong Leucogranite borders the Noring Granite along its eastern margin, is ~17 km along the road north of Kuala Balah.

Figure 2.5: Geological Map of the Stong Migmatite Complex (Source: (Hutchison, 2014))

2.3.2 Gua Musang Formation

The formation was named after the town of Gua Musang in south Kelantan. The age ranges from the Middle Permian to the Upper Triassic. Gua Musang, south Kelantan (extended to north Kelantan and north Pahang) is the type of area. The formation's boundaries are the lower boundary is unknown; the upper boundary is overlain by the Koh Formation (the nature of the boundary is unknown) (Lee,2004).

According to Kamal et al. (2016), Gua Musang, Kelantan is composed of the following facies: (i) argillaceous; (ii) carbonate; and (iii) volcanic or pyroclastic. The Argillaceous facies, which includes shale, siltstone, mudstone, slate, and phyllite, is the dominant facies in the Gua Musang and Telong formations and can be found as interbeds or lenses in the Aring Formation and Nilam marble. According to Yee (1983), carbonate is the dominant facies in Nilam marble, as well as widespread facies in the Gua Musang formation, and forms beds or lenses within the Telong and Aring formations. In the Aring Formation, the volcanic facies are dominant, and it is interlayered with carbonate and argillite in other formations studied.

Gua Musang Formation is located in the Central Belt, at the northern end of the Gua Musang-Semantan depocenter, east of the Bentong-Raub Suture. The Gua Musang Formation is made up of crystalline limestone that is interbedded with thin beds of shale, tuff, chert nodules, subordinate sandstone, and volcanic rock. In the formation, structures such as bedding, cross-lamination, and oolites can be seen (Hutchison & Tan, 2009).

The Gua Musang Formation is primarily made up of calcareous and argillaceous rocks, with arenite, pyroclastic, and lava flows. They are platform facies

in shallow water. Calcareous rocks are the most common facies in the Gua Musang Formation.

Aring Formation is related to Gua Musang Formation in Pahang. Southeast Pahang's volcanic series and metasediments. The Aring Formation is primarily composed of volcanic rock, primarily pyroclastic with minor lava, dolomitic marble, and argillite. Aw (1990) discovered a thick basal section of dolomitic marble with tuff and calcareous argillite overlain.

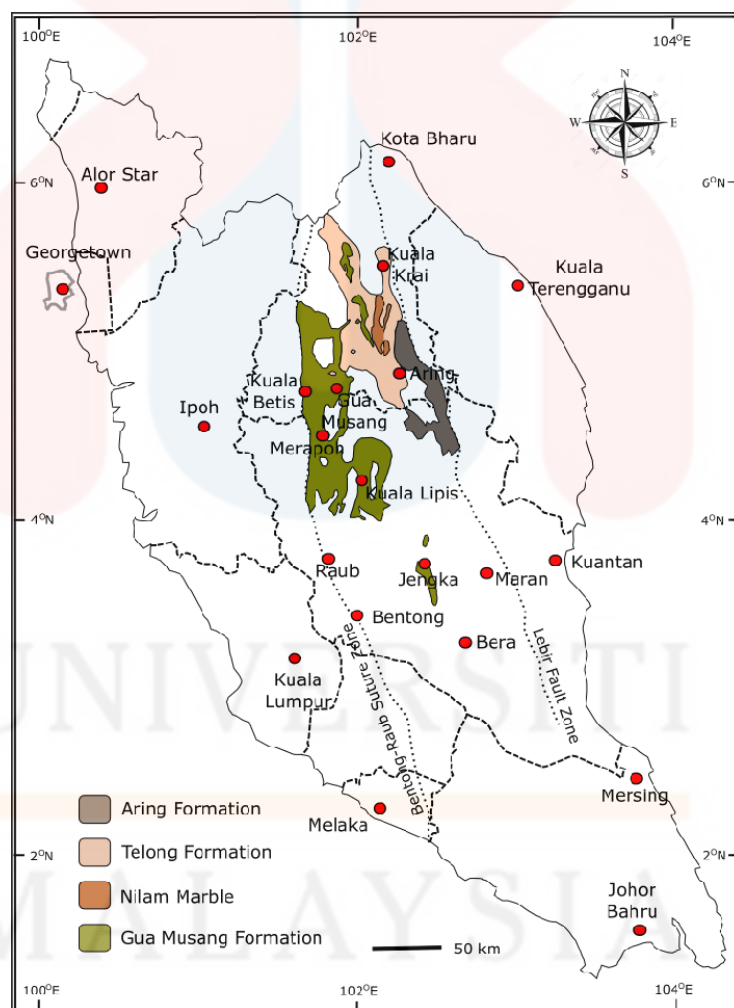


Figure 2.6: Distribution of the Gua Musang Group. Modified from (Mohamed,1995)

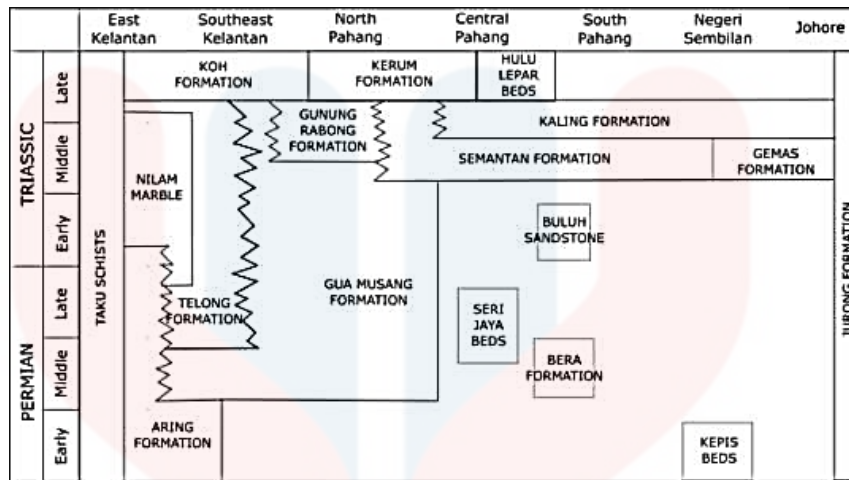


Figure 2.7: Permo-Triassic stratigraphic correlation chart of Central Belt Peninsular Malaysia. (Sources: Kamal et al., 2016)

2.4 Structural Geology

The Malay Basin is considered a basin at the end of a fault. It is created at the termination of a strike-slip fault under transtensional stress. Rivers dominate the sediment supply into the basin along the strike-slip fault. Subsidence of the basin has been caused by both tectonic depression and significant surface heat flow (Noda, 2013).

The Central Basin of Peninsular Malaysia is an extensional graben bordered by significant faults along the Bentong-Raub Line in the west and by the Lebir fault zone at the east. It happens during the Triassic when a massive normal faulting which possibly originated in the Permian occurred along the Bentong-Raub Line and Lebir Zone and finally produced a graben (Metcalf, 1989). According to Metcalfe (1989), the Triassic rocks in Central Basin exhibits mainly upright or moderately plunging folds (both symmetrical and asymmetrical) that represent a single folding phase. The state of Kelantan is in the north-eastern portion of Malaysia. During the Paleozoic and

Mesozoic ages, the tectonic activity in Peninsular Malaysia impacted the land mass, causing the folding and faulting that are seen today (Sulaiman et al., 2020). Folding, jointing, and faulting have been recognised as localised structures in sedimentary and granitic rocks (Sulaiman et al., 2020). In Kelantan, the dominant pattern of local structures was along the North to South and from Northwest to Southeast directions. Based on the stong migmatite complex, the structural that occurred is foliation, stong amphibolite facies migmatite complex, berangkat tonalite, there are also occurred the overlying greenschist facies rocks (probably Permo-Triassic) and Noring Granite.

2.5 Historical Geology

Kelantan is in the Central Basin, which contains the youngest rocks. Most of the Upper Paleozoic sediments consist of the marine Permian strata of the Central Belt, which are found in linear bands surrounding Mesozoic layers (Farhafiezah, 2017). To begin collecting sediments from the Triassic period, a basin was created. Throughout the earliest stages of deposition, only fine-grained marine sediment is deposited; subsequently, during the Jurassic and Cretaceous periods, coarser continental sediments are produced (Metcalf, 1989).

During the Permian epoch, the Malay Basin exhibited sinistral strike-slip fault activity, which caused the extension of the crust (Tjia, 1994). This causes the formation of graben, the basins that have been torn apart, which is known as Central Basin. The basin began to deposit sediments during the Triassic era.

Unconsolidated sediments are layers formed by secondary sedimentation and repositioning of eroded rocks, or by biochemical deposition and chemical solutions. They were not compressed, therefore lithification occurred. The coastal region that spans from the border of Thailand to the border of Terengganu and encompasses the northern portion of the state of Kelantan is composed of unconsolidated sediments. During the Quaternary period, the sediment reflects the alluvial plain that lies over the granite bedrock.

To the north and south, the extrusion rocks formed an extended structure. Most of the rocks are sedimentary or metasedimentary and range in age from the Ordovician to the Cretaceous period. They are Permian in age. (Geology and Mineral Distribution Map of Kelantan, 2000).

2.6 Geosite concept

Geosite or call as geological site originally from Greek, geo stated for Earth while the situs is site. The combination was formed geosite that related geological site or location. Geosite is natural features because geology is related to nature and the study of Earth's history. It is the natural features which is demonstrates the relationship between the processes that have shaped of the Earth. The result, the product of the past that occurs still affect the present or future. For instance, the natural treasures that occurred in some location such as caves that formed in Gua Ikan give advantages for commercial as a geosite. Generally, geosite represent as geoheritage resources should be studied and survived and developed to future generation about learn, can get knowledges about natural treasures (Bruno, 2015).

2.7 Geoheritage concept

Besides that, the geoheritage or geological heritage concept is in situ and ex situ which occurs the elements of geodiversity with high values (Brilha, 2016), likes scientific, educational and recreational cultural. In addition, geoheritage is defined as applied on specific discipline which is focuses about the potential of site such as unique, and special. Geoheritage is part of natural heritage which have the special or related to the history of the earth. For instance, rocks, minerals, fossils and landscapes. The Geological Society of America, define the ‘geoheritage’ is generic but descriptive terms applied to areas of geological features with significant scientific, educational, cultural and also has element of aesthetic values (GSA, 2012).

2.8 Geotourism Concept

Geotourism is related to geological concept for tourism development all over the world. The definition of geotourism is a specialized form of tourism that focusing the attention of geosite (Dowling, 2005). Geotourism also is a vehicle that need to appreciate the geodiversity and geosites. It is to understands the geoheritage and foster the geoconservation. The ways to protect their important geosites as natural heritage resources through geoconservation, many countries have been conducting efforts likes a new emerging geosciences field which focused on the management and protect the geological elements with exceptional values (Henriques et al., 2011). While developing the tourism sector, through create geoparks to include in UNESCO Global Geoparks (Henriques, 2017).

2.9 Geomorphosite Concept

Geomorphosite is a landscape of land which has potential for development as tourism sites and have their values on human evaluation. The geomorphosite have provide any values such scientific approach value, educational value, economic value, value of conservation, in addition the geomorphosite has provide beauty culture, geological features and it can observe beauty of nature in addition to gaining knowledge about appreciating the value of natural treasures (Habib Nur, 2017).

2.10 Methods for Geosite Evaluation

“Modified Geosite Assessment Model” (M-GAM) is developed by (Tomić and Božić). This method is based on the previous geosite assessment that was development by different researcher before and it is combination of the GAM Model that created by (Vujičić et al, 2011). The model is combination both of tourists and experts neither side is favored in the assessment. M-GAM model has two key indicators that are main values (MV) and additional values (AV), which are divided into 12 and 15 indicators, each of them individually marked from 0 to 1.

$$\text{M-GAM} = \text{MV} + \text{AV}$$

GAM of Vujii et al. (2011) to evaluate the potential for geotourism. M-GAM differs from GAM in that it includes an Importance (Im) weight that was established by interviews with geotourists at various geosites regarding their individual perceptions

of the significance of various model indicators. The I_m values were then averaged across all geosite and applied to the evaluation as weights, with values ranging from 0 to 1, for each indicator.

2.11 Karst and Cave

Karst is a terrain made up of sinkholes, sinking streams, caves, and streams that are caused by bedrock dissolving. Karst is connected to soluble rocks like marble and limestone. Karst landscapes develop when a significant amount of water that falls on the surface interacts with, enters, and dissolves the bedrock subsurface. There was karst in the Gua Ikan Complex. Gua Keris, one of the Gua Ikan Complex's unique Karst landforms, is subject to moderate chemical weathering. When rocks came into touch with the atmosphere, weathering took place. The process was triggered by rain that reacted with mineral grains in rock form soluble and water that continuously seeped into cracks and expanded, eventually rupturing the rocks. (Sulaiman N. S., 2020).

Karst landscapes are attributed to the chemical weathering of limestone rocks by slightly acidic precipitation. Calcium carbonate (CaCO_3), the primary component of limestone, dissolves readily in mildly acidic solutions, resulting in the creation of solution channels and caverns. As a result of dissolution, the rock disintegrates and erodes, resulting in the production of karst characteristics such as sinkholes and caves.



Figure 2.8: The karst formation in Gua Ikan Complex by image drone

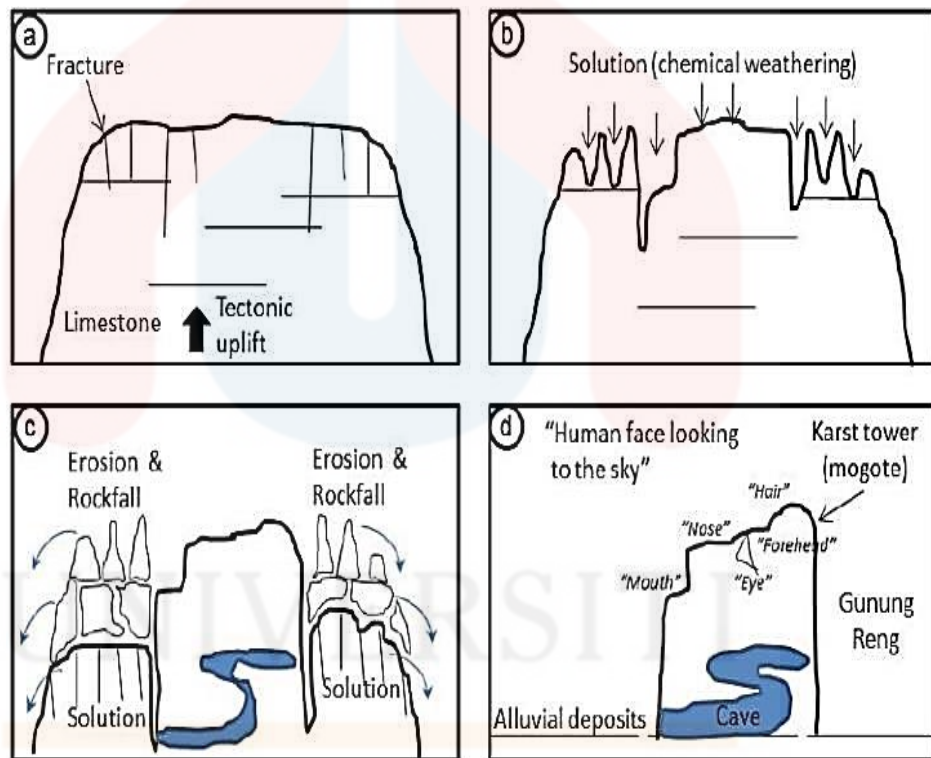


Figure 2.9: The karst formation in Gua Ikan Complex

MALAYSIA
KELANTAN

MATERIALS AND METHODOLOGIES

3.1 Introduction

Materials and methods used in this study for geological mapping and tools that use during conduct the research. The Global Positioning System (GPS) used for locating the tracks and complete the geological map. In part is about tool and steps use for achieved objectives of study area,

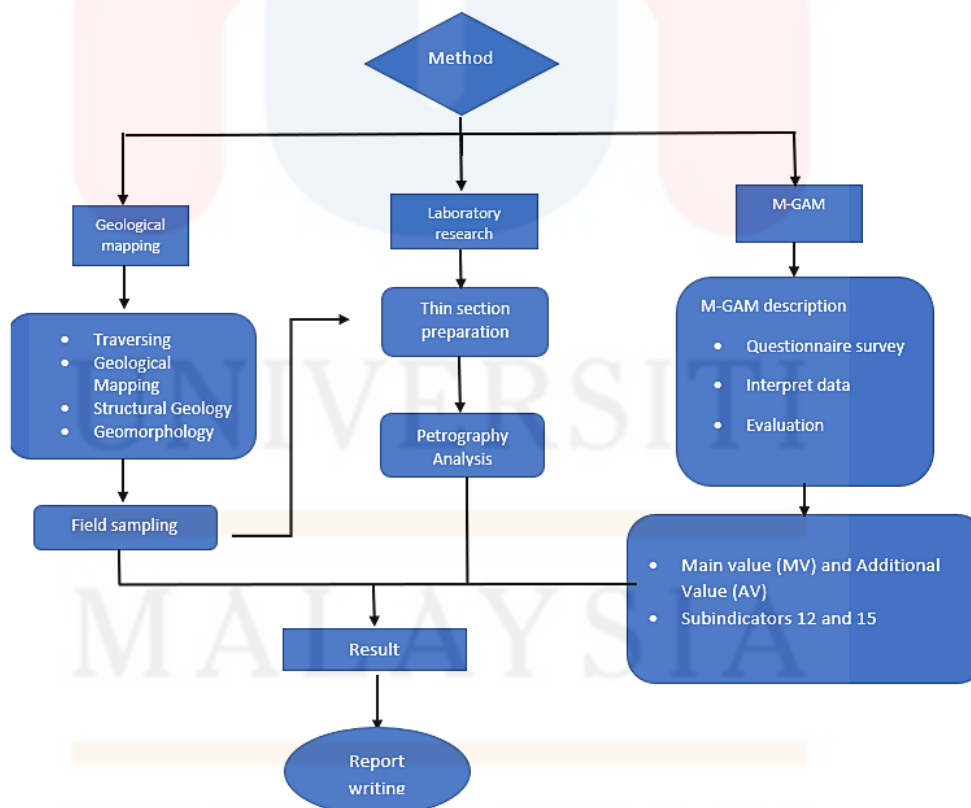


Figure 3.1: Flow Chart of the methodology in the study area

3.2 Material and Equipment

3.2.1 Field Equipment

Several materials and equipment's used during fields studies are mobile devices, Field book, Sample bag, measuring tape, Bruton Compass, Global Positioning System (GPS), Hydrochloric acid (HCL), Hand lenses, Stationery Topographic map (base map), Geological maps, sample bags, laboratory equipment, geological hammer, ArcGIS Software and Agisoft Metashape Software.

3.3 Methodology

3.3.1 Preliminary studies

Preliminary studies are conducted prior to beginning research. In such a way, collect some information about the research area or specific research want to conduct and some references to previous studies that are related to the topic of the research. It can be used for collecting data using and supporting other data, like secondary data that can be found in e-books, websites, journals, and articles. The qualitative method can be obtained at a library by referring to a case study, journal, or article, and it can be observed during the study process. The secondary data is an addition to or backup for the primary data, which you collect on your own through a field study in the study area. This data includes physical methods that are based on the study areas in (Gua Ikan Complex, Dabong District, Kelantan).

3.3.1.1 Internet Resource

Internet resources are the sources that get information about the research from the internet or use the website for free but use network data. There are numerous examples of internet resources where you can obtain for research. There are online articles, online case studies, journals, and e-books. Google website can also be used to find images related to a study area for further research. The image associated with the research area that is Gua Ikan Karsts Complex. thus, internet resources can help researchers add ideas or information to the research.

3.4 Field studies of geology

Geological and geosite mapping were used in the research to acquire the data that was then analysed based on the parameter. The research region has undergone geological mapping in order to provide an accurate and current geological map. The process of geological mapping required field measurements and observation. Petrology, structural geology, geomorphology, palaeontology, stratigraphy, and sedimentology of the study were all included in the collaborative process known as geological mapping.

3.5 Geosite Potential Analysis

3.5.1 M-GAM

A technique for assessing the geosite potential of the karst in the Gua Ikan Complex is M-GAM. It is a technique that combines evaluation of the geosite with a human perspective survey. Both tourists and experts were part in the procedure, and neither group is given preference in the evaluation. Main Value (MV) and Additional Values (AV), which are further broken into 12 and 15 indicators, respectively, are the major indicators that were used in the analysis. The Gua Ikan Complex as a whole was evaluated using the Main Value done with evaluate and do assessment based on geosite's natural attributes. Next, analyse (AV) from a human perspective so that it can be modified to better suit visitor needs. the 12 Main Values sub-indicators and the 15 Additional Values sub-indicators, each graded from 0.00 to 1.00.

The division is caused by two primary categories of values: main values, which are mostly produced by a geosite's inherent qualities, and supplementary values, which are primarily produced by human intervention and adaptation to a geosite's intended usage by visitors. The supplementary values are broken down into two categories of indicators, functional (VF_n) and touristic values, while the major values are separated into three groups of indicators: scientific/educational (VSE), scenic/aesthetical (VSA), and protection (VPr) (VTr). Table 1 provides more information on the primary and supplementary values. M-GAM is defined as a simple equation by the following 12 subindicators of main values and 15 subindicators of supplemental values, which are evaluated from 0 to 1:

$$M\text{ GAM} = MV \text{ plus } AV \quad (1)$$

where the letters MV and AV stand for the main and auxiliary values, respectively. We can obtain the following two equations because main and additional values are composed of three or two groups of subindicators, respectively:

$$(2) \quad AV = VF_n + Tr. \quad MV = VSE + VSA + VPr \quad (3)$$

Equations (2) and (3) can be expressed as follows to represent how many subindicators each group of indicators comprises of:

$$\text{Where } 0 \leq j \leq 12 \quad MV = VSE + VSA + VPr$$

$$0 \leq SIMVi \leq 1$$

$$(5) \quad j-1 \leq AV = VF_n + VTr \leq SIAV, \text{ where } 0 \leq SIAV \leq 1.$$

Values $SIMVi$ and $SIAVj$ stand for 12 subindicators of primary values ($I = 1, \dots, 12$) and 15 subindicators of secondary values ($j = 1, \dots, 15$). The primary difference between M-GAM and other assessment methods is that it places more emphasis on the opinions of experts and visitors and tourists regarding the significance of each indicator.

In order to include visitors and tourists in the assessment process, a survey asking respondents to rank the significance (Im) of each of the 27 subindicators in the M-GAM model (from 0.00 to 1.00) is administered. In Gua Ikan Karsts Complex, Dabong, a survey using the M-GAM method was conducted with 30 respondents. The Im value is implied in the M-GAM equation for each sub indicator separately rated by

the visitors. The I_m value will then be multiplied separately with the value determined by the experts. The output will be a matrix of MV plotted on the x-axis and AV plotted on the y-axis. The matrix is then divided into 9 fields: $Z I_j$, $I_j = 1, 2, 3$ (Brati et al., 2020). The I_m and M-GAM equations are defined below:

$$I_m = \frac{\sum_{k=1}^k I_{V_k}}{K}$$

$$M - GAM = MV + AV$$

$$AV = \sum_{i=1}^n I_{m_i}^* MV_i$$

$$AV = \sum_{j=1}^n I_{m_j}^* AV_j$$

Table 3.1. Structure of M-GAM model values (Marija Bratić et.al., 2020)

Main values (MV)	
Scientific/educational value (VSE)	
Rarity	Number of closest identical sites
Representativeness	Didactic and exemplary characteristics of the site due to its own quality and general configuration
Knowledge on geoscientific issues	Number of written papers in acknowledged journals, thesis, presentations, and other publications
Level of interpretation	Level of interpretive possibilities on geological and geomorphologic processes, phenomena and shapes and level of scientific knowledge
Scenic/aesthetic (VSA)	
Viewpoints	Number of viewpoints accessible by a pedestrian pathway. Each must present a particular angle of view and be situated less than 1 km from the site.
Surface	Whole surface of the site. Each site is considered in quantitative relation to other sites
Surrounding landscape and nature	Panoramic view quality, presence of water and vegetation, absence of human-induced deterioration, vicinity of urban area, etc.
Environmental fitting of sites	Level of contrast to the nature, contrast of colors, appearance of shapes, etc.
Protection (VPr)	
Current condition	Current state of geosite
Protection level	Protection by local or regional groups, national government, international organizations, etc.
Vulnerability	Vulnerability level of geosite
Suitable number of visitors	Proposed number of visitors on the site at the same time, according to the surface area, vulnerability, and current state of geosite
Additional values (AVs)	

Functional values (VFns)	
Accessibility	Possibilities of approaching to the site
Additional natural values	Number of additional natural values in the radius of 5 km (geosites also included)
Additional anthropogenic values	Number of additional anthropogenic values in the radius of 5 km
Vicinity of emissive centers	Closeness of emissive centers
Vicinity of important road network	Closeness of important road networks in the in radius of 20 km
Additional functional values	Parking lots, gas stations, mechanics, etc.
Touristic values (VTr)	
Promotion	Level and number of promotional resources
Organized visits	Annual number of organized visits to the geosite
Vicinity of visitors centers	Closeness of visitor center to the geosite
Interpretative panels	Interpretative characteristics of text and graphics, material quality, size, fitting to surroundings, etc.
Number of visitors	Annual number of visitors
Tourism infrastructure	Level of additional infrastructure for tourist (pedestrian pathways, resting places, garbage cans, toilets, etc.)
Tour guide service	If exists, expertise level, knowledge of foreign language(s), interpretative skills, etc.
Hostelry services	Hostelry service close to geosite
Restaurant service	Restaurant service close to geosite

3.5.2 Data Processing

Data processing was collected data from the study area and secondary data. The data was processing or translated into usable information. Based on the study area, the drone or known as an unmanned aerial vehicle (UAV), is tool use to capture and video the study are Gua Ikan Karsts Complex, Gua Pagar, Gua Keris and Gua Gelap for capture picture of geological features for instance, the formation of karst in high

elevation. From the drone picture were used the Agisoft metashape software to processing the data images shown in Figure. It valuable for produced a high accuracy of spatial resolution of image processing with accurate diameter, height and depth. 3D modelling provides the management a clearer view of the whole of Gua Ikan Karst Complex, Gua Pagar, Gua Keris and Gua Gelap, However the processing of data in study area is a bit less clear because technical problems cause the pictures not synchronize was effect processing the images.

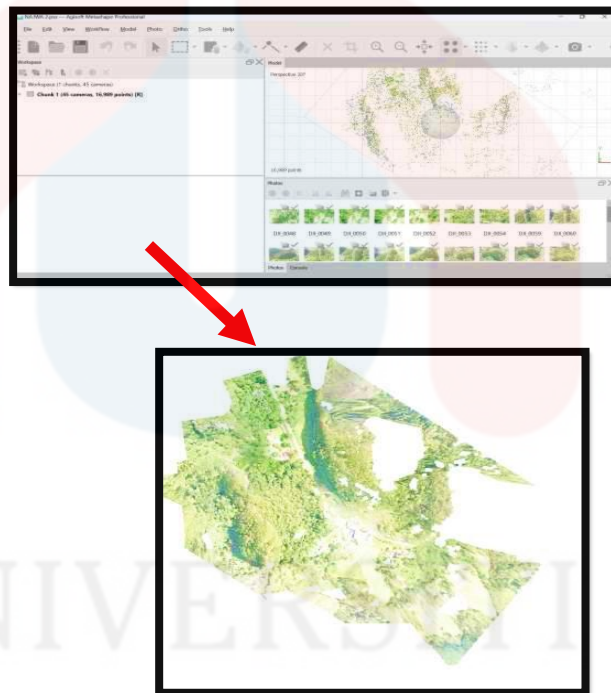


Figure 3.2: The data processing of drone using Agisoft Metashape

In addition, the research is about the evaluation of study areas to be potential as geosite. The data collected is survey data from the site were interpreted in statistics data. The data collection such as the number of tourists visit the study areas in weekends then, the data was interpreted in pie chart, bar chart and other methods.

3.6 Laboratory Analysis

3.6.1 Petrography Analysis

Laboratory analysis from primary data collection from Gua Ikan Karsts Complex is rock sample and fossils. The samples must be perfect and ready to test in Geology laboratory in University Malaysia Kelantan (UMK). The types of rock are limestone, fossil like Gastropods fossil (Krishnaswamy, 2013). The fossil found in study area is observe using hand lenses. It is easier the researcher to identify types of fossils there because can see clearer and bigger.

First the thin section analysis is sample be flat of piece to examination by microscopic to identify the types of rock or minerals that found. Thin section rock samples are including petrography analysis, examine under polarized microscopic to see characteristics of mineral such colour, relief, and shapes. One of the caves of study area at Gua Ikan Karst Complex, is analyse using hydrochloric acid for determine types of outcrops. The limestones outcrops are reacting to hydrochloric acid, can see reaction of rock like bubbles is come out. Meanwhile the others rock there is take the sample to test in laboratory for observe the mineral that contain inside.

The sample taking from the caves is process to be flat of piece before examining in microscope. After the sample flat it can observe in microscope to identify the mineral of rock, colour of the rock and types of rocks and cleavages. There are the properties that refer to identify the in laboratory works.

CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

General geology is an important chapter that involves the geography and geology in the study, including lithology, stratigraphy, structural geology, geomorphology, and petrography, which is the information collected based on the study area. All the aspects are important to understand because they are related to past events that occur in the geological formations in the study area nowadays.

4.1.1 Geography

Based on the study area, the geography was discussed about accessibility, population distribution or settlement, rain distribution, forestry (or vegetation) and traverse and observations.

UNIVERSITI
MALAYSIA
KELANTAN

4.1.2 Accessibility

The road connection that found to the study area is paved road. The main road goes to the study area already tarred road. The main road of study area link to highway Kota Bharu and Kuala Krai. From the, University Malaysia Kelantan (UMK) to the Gua Ikan Complex (study area) approximately taken more than one hour. the available roads can connect residents with several facilities such as clinics, grocery store and restaurants. The area of Gua Ikan Complex also has non paved road that connect some housing area and some plantations. The railway also found in this study area.

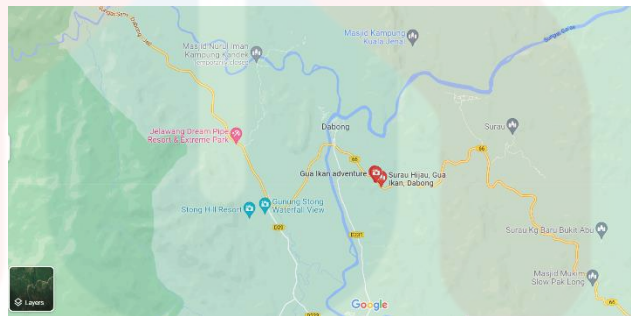


Figure 4.1: Accessibility of Gua Ikan Complex, Dabong. (Source: (maps, 2023))



Figure 4.2: Dabong Road (Source: (foursquare, 2023))

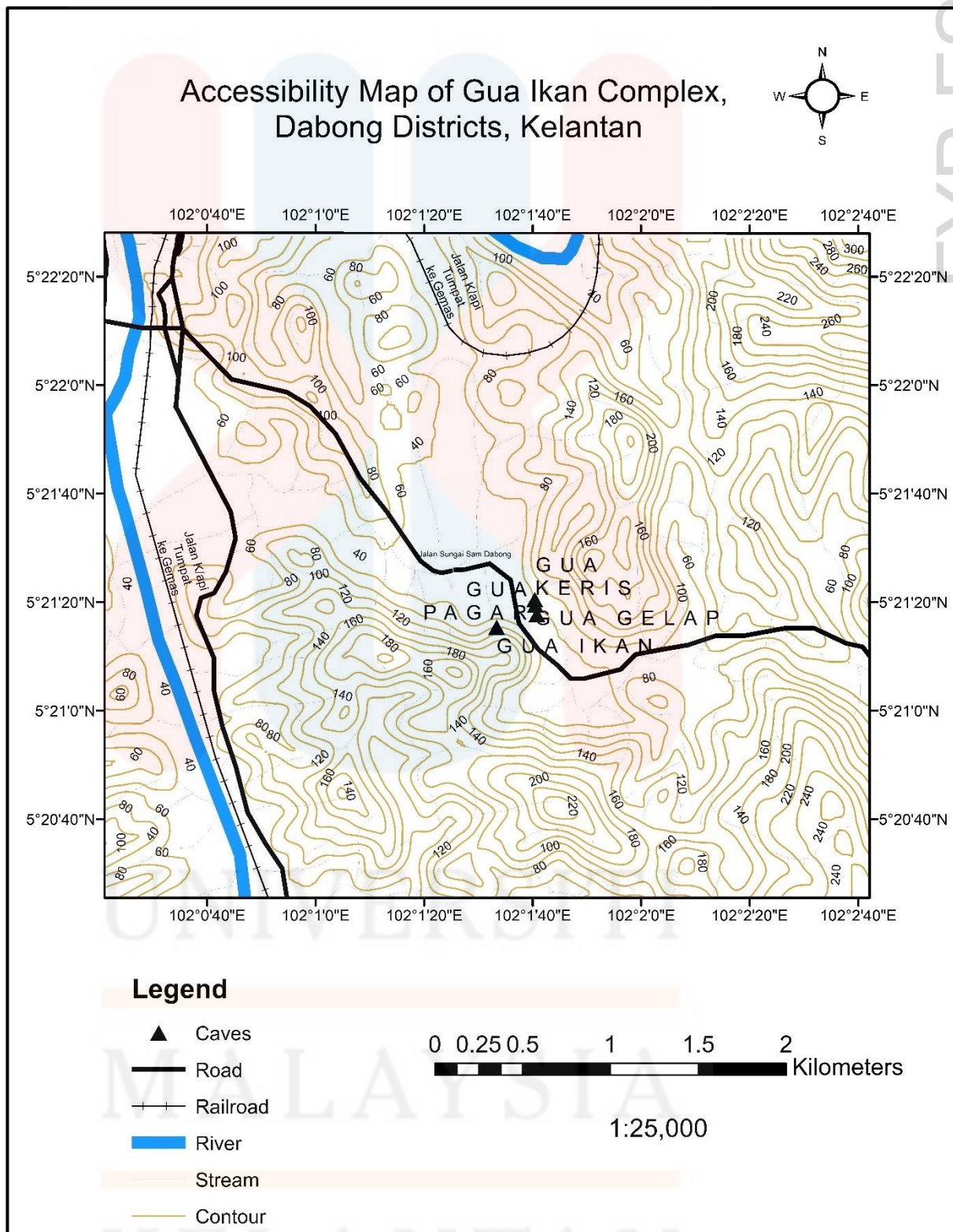


Figure 4.3: Accessibility Map of the Gua Ikan Complex

4.1.3 Population Distribution or Settlement

Jajahan/ Kawasan Pihak Berkuasa Tempatan Jajahan/ Local Authority Area	Jumlah Total	Warganegara Malaysia Malaysian citizens							Bukan Warganegara Malaysia Non-Malaysian citizens		
		Jumlah Total	Bumiputera					Cina Chinese		India Indians	Lain-lain Others
			Jumlah Total	Malayu Malay	Bumiputera lain Other Bumiputera						
PASIR PUTEH											
M.D. Pasir Puteh	113,191	112,337	110,642	110,597	45	808	17	870	854		
Cherang Ruku	2,212	2,195	2,136	2,132	4	53	-	6	17		
Pasir Puteh	2,115	2,084	1,829	1,826	3	243	-	12	31		
Selising	129	128	60	59	1	62	-	6	1		
Kawasan selebih M.D.	108,735	107,930	106,617	106,580	37	450	17	846	805		
Remainder of M.D.											
TANAH MERAH											
M.D. Tanah Merah	115,949	112,132	107,201	107,010	191	4,043	425	463	3,817		
Batang Merbau	2,446	2,333	2,317	2,303	14	15	1	-	113		
Batu Gajah	2,281	2,269	2,250	2,246	4	19	-	-	12		
Bukit Bunga	2,958	2,754	2,746	2,743	3	5	2	1	204		
Gual Ipoh	1,642	1,634	1,624	1,622	2	8	2	-	8		
Kuala Tiga	1,714	1,599	1,597	1,597	-	-	1	1	115		
Kualiti Baharu	621	599	594	594	-	5	-	-	22		
Tanah Merah	16,188	15,940	14,789	14,765	24	1,095	17	30	248		
Kawasan selebih M.D.	88,099	85,004	81,284	81,140	144	2,896	402	422	3,095		
Remainder of M.D.											
TUMPAT											
M.D. Tumpat	143,793	142,094	130,962	130,922	40	6,227	121	4,784	1,699		
Tumpat	8,916	8,871	8,554	8,545	9	276	23	18	45		
Wakaf Baru	2,502	2,450	2,166	2,166	-	282	-	2	52		
Kawasan selebih M.D.	132,375	130,773	120,242	120,211	31	5,669	98	4,764	1,602		
Remainder of M.D.											
GUA MUSANG											
M.D. Gua Musang	86,188	81,204	76,823	64,253	12,570	3,870	350	161	4,985		
Batu Papan	2,594	2,543	1,520	1,512	8	883	132	8	51		
Bertam	1,142	1,133	1,131	1,131	-	1	1	-	9		
Chagar Bongor	494	426	398	398	-	24	-	4	68		
Gua Musang	18,420	17,775	15,373	15,285	88	2,217	155	30	645		
Karinting	157	144	128	128	-	1	15	-	13		
Limau Kasturi	975	905	893	893	-	5	-	7	70		
Paya Tapal	337	325	325	325	-	-	-	-	12		
Kawasan selebih M.D.	62,070	57,853	57,055	44,581	12,474	730	47	112	4,117		
Remainder of M.D.											
KUALA KRAI											
M.D. Dabong	40,659	38,283	38,161	38,155	6	42	71	9	2,376		
Dabong	1,356	1,353	1,353	1,353	-	-	-	-	3		
Kerimbu	1,133	1,132	1,130	1,130	-	2	-	-	1		
Mamak Ural	1,638	1,621	1,613	1,613	-	8	-	-	17		
Kawasan selebih M.D.	36,532	34,177	34,065	34,059	6	32	71	9	2,355		
Remainder of M.D.											

Note : Angka di atas tidak disesuaikan kepada kadar kurang penghitungan.
Note : The above figures have not been adjusted for under-enumeration.

Figure 4.4: The population distribution of ethnic according to the local authority area, 2010. (Department of Statistic, Malaysia, 2010)

The population of Gua Ikan Complex was link to Dabong population due to location of Gua Ikan Complex was situated in Dabong district. Based on the statistic information provided on the website of (District Council) Majlis Daerah Dabong, the total population of Dabong district is 40,659 people in year 2010. The total of every ethnic was Malay people recorded 38,155 and others Bumiputera was 6 people. The Chinese record 42 people, Indian was 71 and other ethnics was 9 people. Meanwhile, non-Malaysian citizens was 2,376 people. In addition, statistic information provided on website for Dabong District, the total population is 1,356 people. The Malay ethnics is 1,353 and non- Malaysian citizens was 3 people. (Department of Statistic, Malaysia, 2010).

4.1.4 Forestry (or vegetation)

The study area that is Gua Ikan Complex and surrounding area still have many forestry area and vegetation. From the observation of the study area, the area of vegetation is mixing planation, rubber estate and palm oil plantation. This area has a green and calm view because there is still has thick forest around it. Following that some types of flora and fauna are still preserved in this area. The example of fauna is elephant, bird and monkey while the fauna can see many vegetation areas.

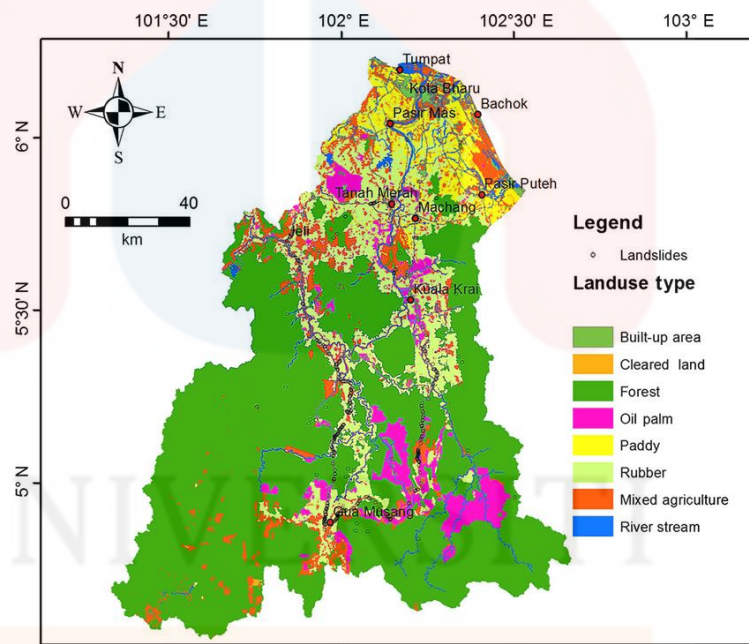


Figure 4.5: Land use/cover map of the Kelantan state (Hashim, 2016))

MALAYSIA
KELANTAN

4.1.5 Traverse and Observation

Traverses is the method that used to surveying and cover area of study to collect the latest geological information about the study area. Every geology student of final year project (FYP) in University Malaysia Kelantan (UMK) have been do research in the study area that choose with 25 km² size of places. During conduct the research it takes approximately more than one week (7 days) to finish traverse the whole study area. Besides that, the observation from research area is there are many geological features that occurred there such as in terms of structural geology, geomorphology, and lithostratigraphy.

Table 4.1: Types of rock found in study area.

Types of rock	Names of rocks
Metamorphic rocks	Marble
Metamorphic rocks	Phyllite
Metamorphic rocks	Quartzite
Weathered rocks	Weathered slate
Weathered rocks	Weathered quartzite

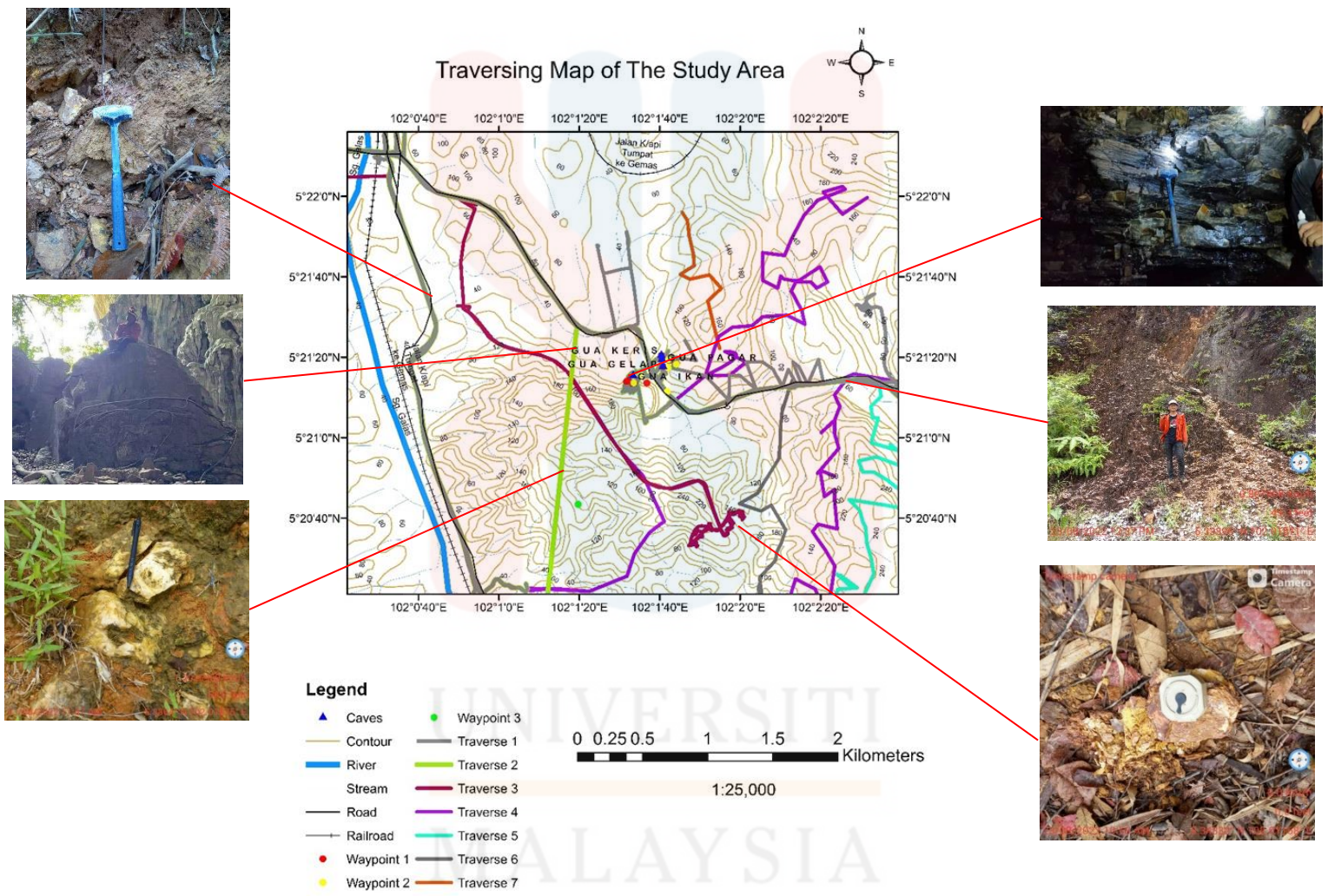


Figure 4.6: Traverse and observation map of the Gua Ikan Complex

4.2 Geomorphology

Geomorphology is the processes which shaped and developed the landform through the exogenic and endogenic processes that linkages with climate changes due to tectonic settings. The geomorphology of a certain area can clearly be seen from high elevation view. The topic was discussed on the geomorphological elements of study area including topography, drainage pattern and weathering processes that occurred in the research area.

4.2.1 Topography/Morphography

The geomorphologic unit is the landform scale features that reflect to formative processes which can determine structure and function of the rivers. It can be classified as hill/ridges, mountains, ridge, and plains. According to (Zuidam, 1996) topographic unit classification was divided into 4 classify by considering to the elevation (m). The classified can be seen in table:

Table 4.2: Classification of Topographic Unit based on elevation.

No.	Topographic Unit	Morphography	Elevation (m)
1	Plain	Plain	<50
2	Slightly sloping plain	Low land	50-100
3	Sloping hills	Low hills	100-200
4	Steep hills	Hills	200-500

(Source: (Zuidam, 1996))

The highest peak that has been recorded 300 m in the study area which was located at the north-east and south-east part that has been covered by the mountainous region. The average elevation of the study area was in an average of 200m-500m. This geomorphological unit is steep hills and landform can be considered as a hilly area. The areas are mostly high elevation but the lowest than mountainous areas and have formation of karst.

The elevation ranged from 100m to 200m can be found distributed at north and south part of study areas. It classifies as low hills landform. Its geomorphological unit is sloping hills. It is the areas that have mountain or caves in lower elevation. This suitable for tourism that have any ranged of ages to explore for example cave or Gua Ikan Complex in lower elevation.

Based on the map, the contour has ranged around 50m until 100m is low land of landform. The geomorphological unit is slightly sloping plain. Basically, this study area is the agricultural areas like rubber plantations and oil palm plantations. Meanwhile the less than 50 m elevation, the geomorphological unit described as plain. The landform is low plain. It mostly area of residential area, recreational and others.

The hilly landforms range in height from 50 to 500 metres above sea level and has a slope between 7% up to 20%, while mountainous landforms have height of more than 500 meters and slope of more than 20 %. The mountainous landforms are height of more than 500 meters and slope of more than 20 %. Hills are used for against intrusion dome landforms. The term mountains are used for a series of shapes that have an altitude of more than 500 meters and a slope of more than 20 %, usually is a network with the shape of volcano or because of activities quite strong tectonics (Zuidam, 1996).

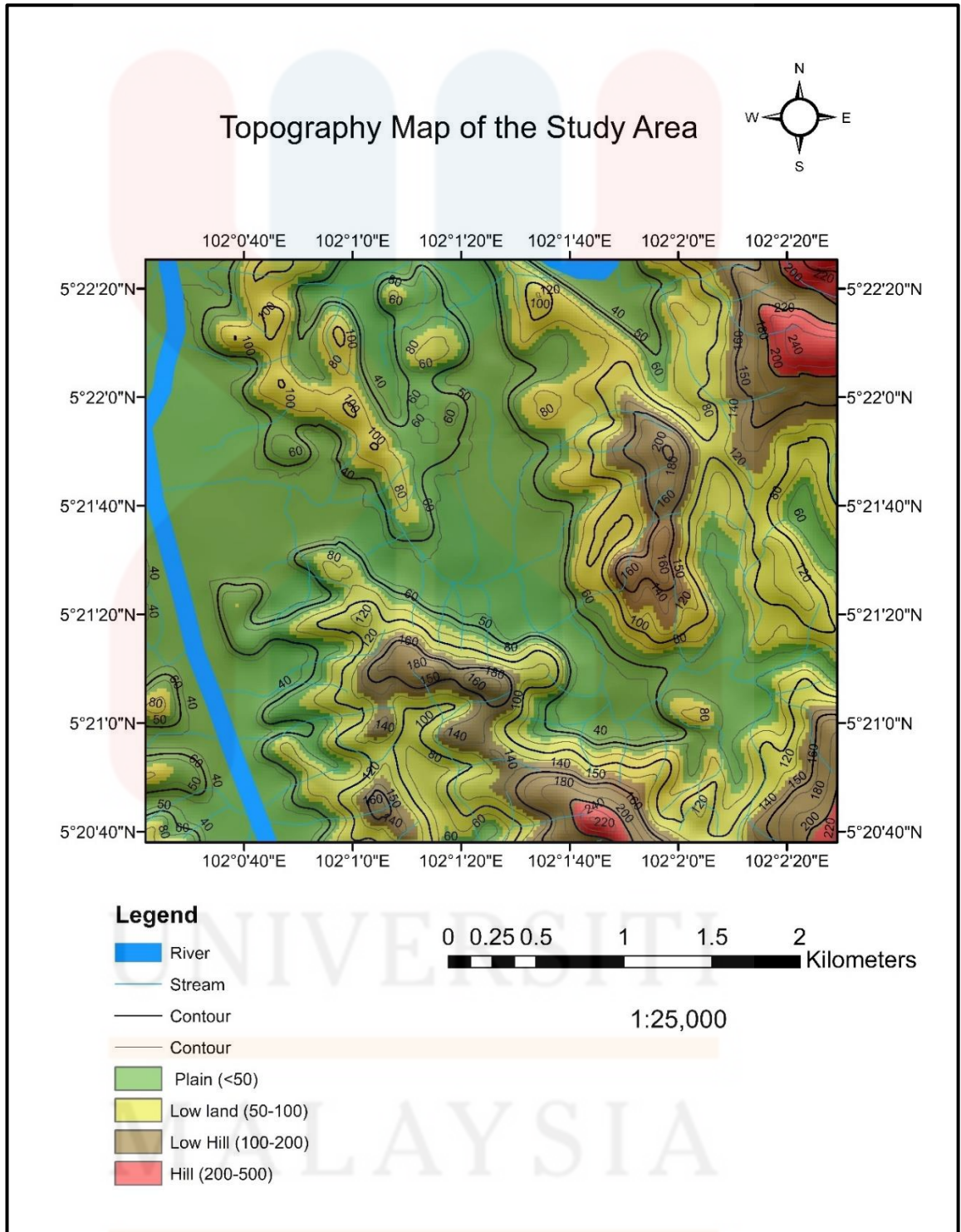
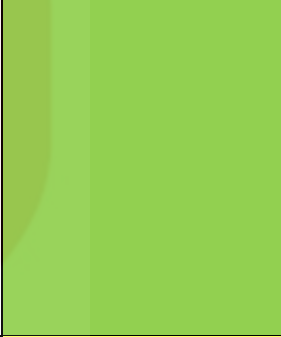

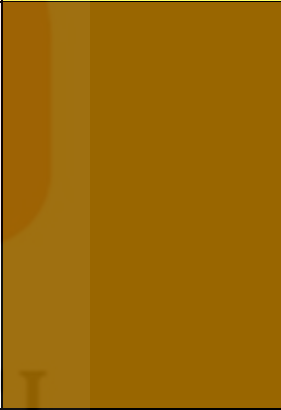
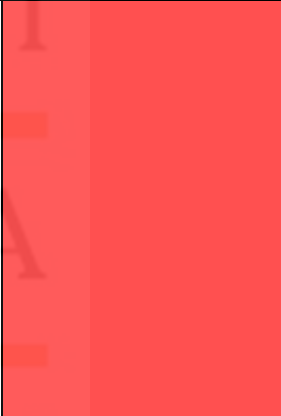


Figure 4.7: Topography map of the Gua Ikan Complex

Table 4.3: Classification of topography

Morphography	Description		Legend
Plain	Plains can occur along the bottoms of the valleys, along the coastlines, along the sides of the rivers.	Coastal plain, grasslands	
Low land	Land is at, near, or below the level of the sea.	Valleys, coastal and plains.	
Low hill	Conspicuous and often rounded natural elevation of the earth's surface, less high or craggy than a hill/mountain	Lower hills	
Hill	Piece of land that rises higher than everything surrounding it but lower than mountain.	Rounded on top hill/ mountains and movement and deposition of sediment by glaciers.	

(Zuidam, Geological, 1996)

4.2.2 Weathering

Weathering refers to the breakdown or dissolution of rocks and minerals on the Earth's surface. Weathering agents include water, ice, acids, salts, plants, animals, and temperature changes. Basically, there are three types of weathering which are physical, biological, and chemical. The factor that influences weathering is topography, physical characteristics of the rocks, climatic conditions like temperature and humidity and others.

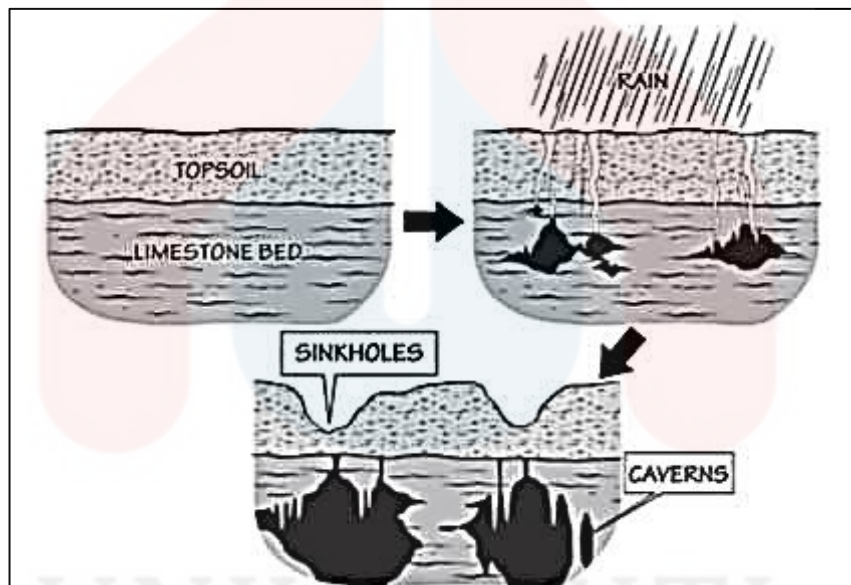


Figure 4.8: The process of Chemical Weathering (Home@Earth, 2021)



Chemical weathering changes the colour of outcrops

Figure 4.9: The Chemical Weathering occurs change colour of outcrops.

The observation on the study areas, there have one of the main formations is karst topography. It is natural landscapes that produced of chemical weathering by the water or rainwater that formed the caves. The process occurred when water absorbed carbon dioxide from the atmosphere and ground to generate carbonic acid. The acidic water diffused through the cracks and seeped into the fractures, dissolving the limestone, and spreading them. In long term the fractures become more widened.

The equation for this weathering:

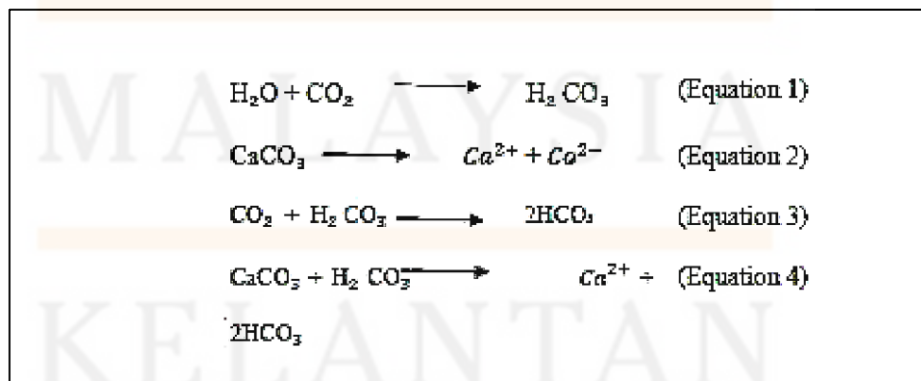


Figure 4.10: Equation of weathering rock (Source: (Jasni, 2022))

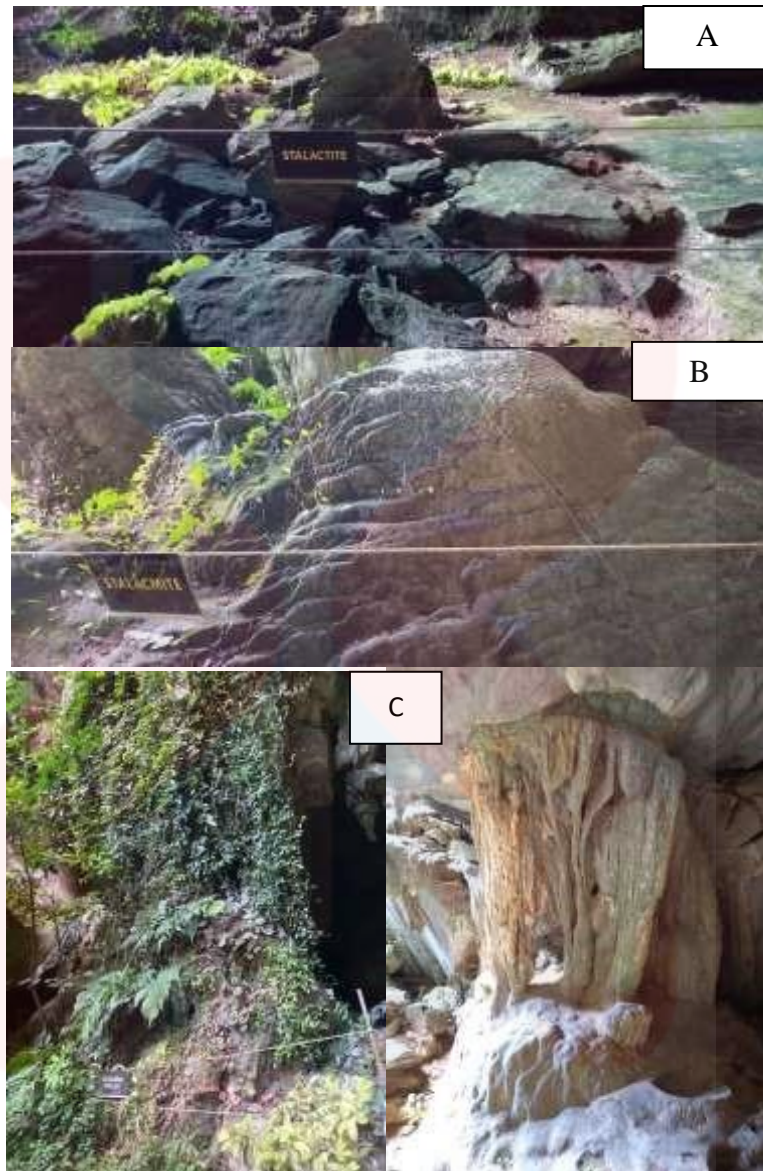


Figure 4.11: A) The stalactites feature in the Gua Ikan Complex, B) The stalagmites feature in the Gua Ikan Complex, C) The columns feature in the Gua Ikan Complex.

Then, it occurred the drainage system underground of the earth surfaces. The pace of the karst arrangement will increase when the subsurface drainage system occurred. It happened when more water was able to flow in this area. The features were created by chemical weathering inside the karst topography of Gua Ikan Complex. for instance, the cave's recent have occurs stalactites, columns, and stalagmites.

Physical weathering is a type of process that produces rock disintegration without causing chemical change. Abrasion which is the process by which clasts and other particles are reduced in size. So, it classified as the primary process in physical weathering. Temperature, pressure, frost, and other factors can cause physical weathering. Physical weathering, for example, may increase the surface area exposed to chemical action by exploiting cracks. Additionally, the chemical action of minerals in cracks can contribute to the breakdown process. Thus, study area was composed of metamorphosed limestone. Some of the rocks there have physically weathered due to the mechanical weathering.

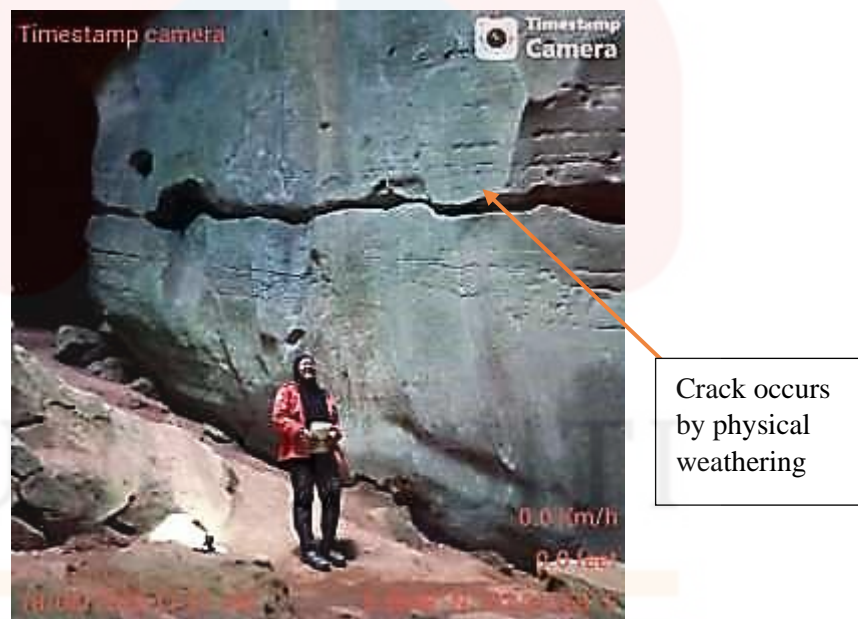


Figure 4.12: The Physical weathering

The weathered outcrops of Gua Ikan Complex due to physical weathering. When a force or pressure is applied to break rocks apart or degrade the minerals in them, this form of biological weathering. Another meaning of the biological weathering is occurred where plants break up rocks with roots or roots exudates and

by animal and microbes (lichens is organisms comprised of fungi and algae), bacteria. The process is slow, but it has the possibility of significantly influencing landscape formation. For example, the biological weathering is the root of plants were finding the source of water by the cracks, joints, or fractures. The size of the roots become bigger, and it were caused the size of the crack also becomes bigger.

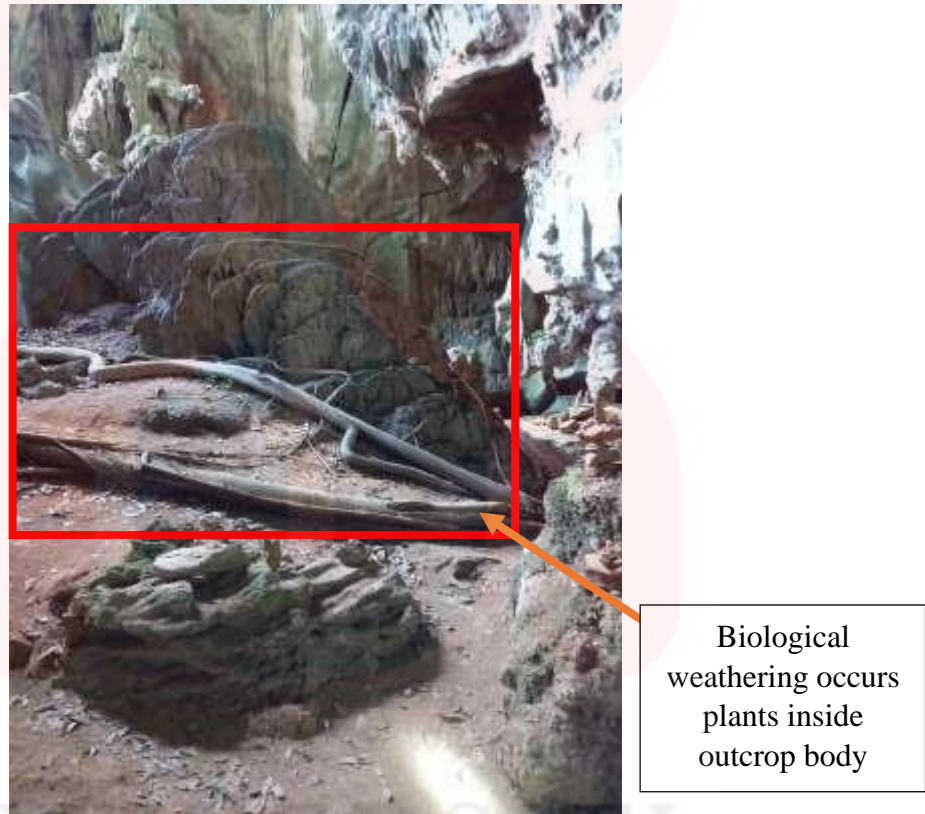


Figure 4.13: The wedging by roots of Gua Ikan due to biological weathering

4.2.3 Drainage System

The drainage system may be characterized as the pattern generated by the streams, rivers, and lakes within a certain drainage basin by further analysing the geomorphology. They are impacted by the land's topography, whether a specific location is dominated by hard or soft rocks, and the land's gradient. The geographic region from which a stream gets runoff, through flow, and groundwater flow is referred

to as a drainage basin. There are many drainages system that occurred. It can be seen in Figure 4.14.

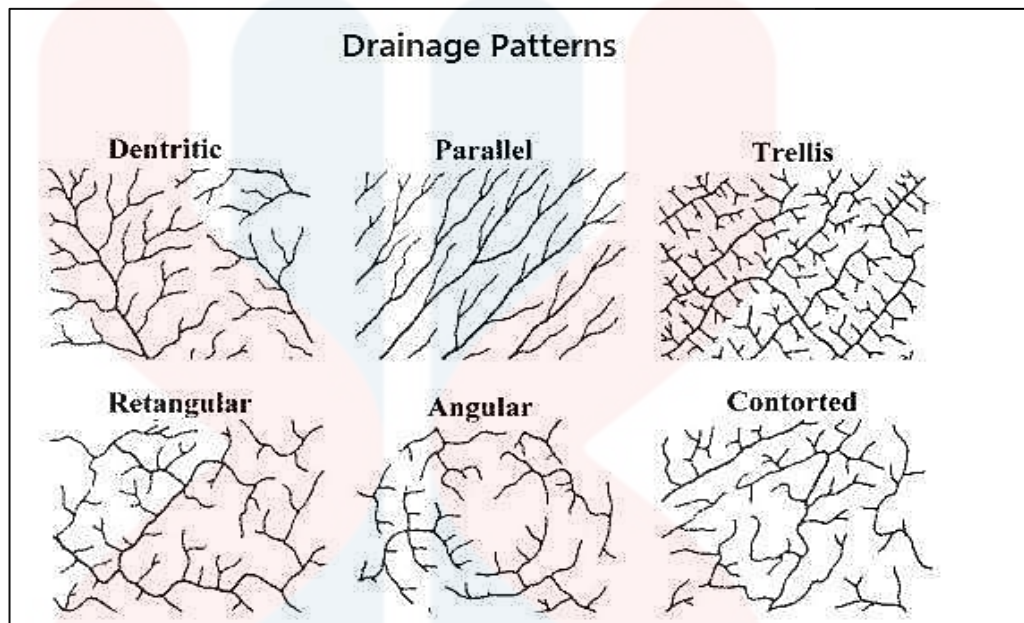





Figure 4.14: The types of drainages patterns

The study area consists of the main river which is Sungai Galas. Since the area of Gua Ikan Complex, Dabong is dominated by hilly topography, the drainage system flows from the high elevation areas to the lower elevation areas. It also near the Jelawang Waterfalls.

There are main drainage patterns that can be observed based on which is the dendritic. The dendritic shows the purple colour of legend. It is the drainage pattern that easier to identified because it patterns look like tree branches. Dendritic is the common drainage pattern that occurs in Malaysia and others country. There are many contributing streams in a dendritic system, which are ultimately connected to form tributaries of the main river. It forms as the river channel follow the terrain slope. Dendritic systems form in V-shaped valleys, requiring impermeable and types of non-porous rocks are phyllite and marble.

Besides that, types of drainages the stream that shows the blue colour near the river that is Sungai Galas. The river was formed from a main river in legend blue with big shape found in the study area that flows in certain areas such as near rubber plantations, oil palm plantations and others.

Table 4.4: Types of drainages

Types of drainage system	Descriptions	Images
Dendritic	Layers of relatively flat sedimentary rocks or packets crystalline rocks that are not uniform and have resistance to weathering. Regionally flow has a sloping slope, a type of flow pattern forming branches that spread like a tree.	 <p>(Foundation, 2018)</p>
Stream	Streams create channels by weathering down rock and carrying it and other sediment downstream. This process is called erosion.	
River	The main river at study area is Sungai Galas.	 <p>(Online, 2023)</p>

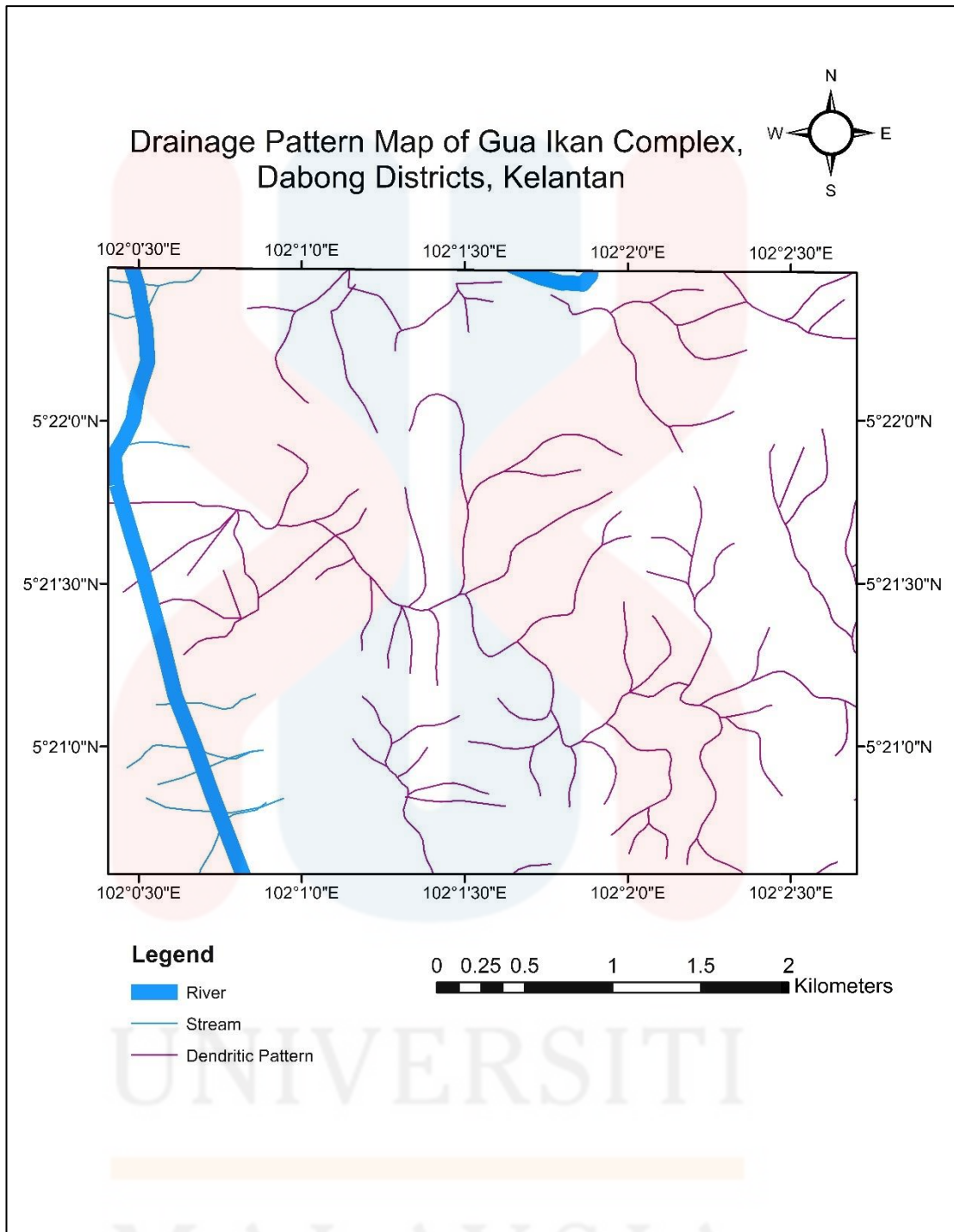


Figure 4.15: Drainage Maps of study area

4.3 Stratigraphy

The geological science that studies strata or rock layers. Stratigraphy is also the most fundamental kind of stratigraphic study, which is the recognition, subdivision, and correlation (establishing equivalency) of sedimentary rocks based on their lithology. According to geological mapping in the study areas, the Gua Ikan Complex, Gua Pagar, Gua Keris and Gua Gelap is mostly limestone caves that metamorphosed to metasediments.

In geology, stratigraphy is the study of rock layers, or strata. Stratigraphy refers to strata and graphia. It literally means the study of stratified rocks. Stratigraphy is important because it may help trace the sequence of events that took place in a sedimentary basin. The principle of stratigraphy holds that younger sediments are deposited on top of older layers. Thus, stratigraphic sequences can provide a set of relative ages depending on the geological time scale.

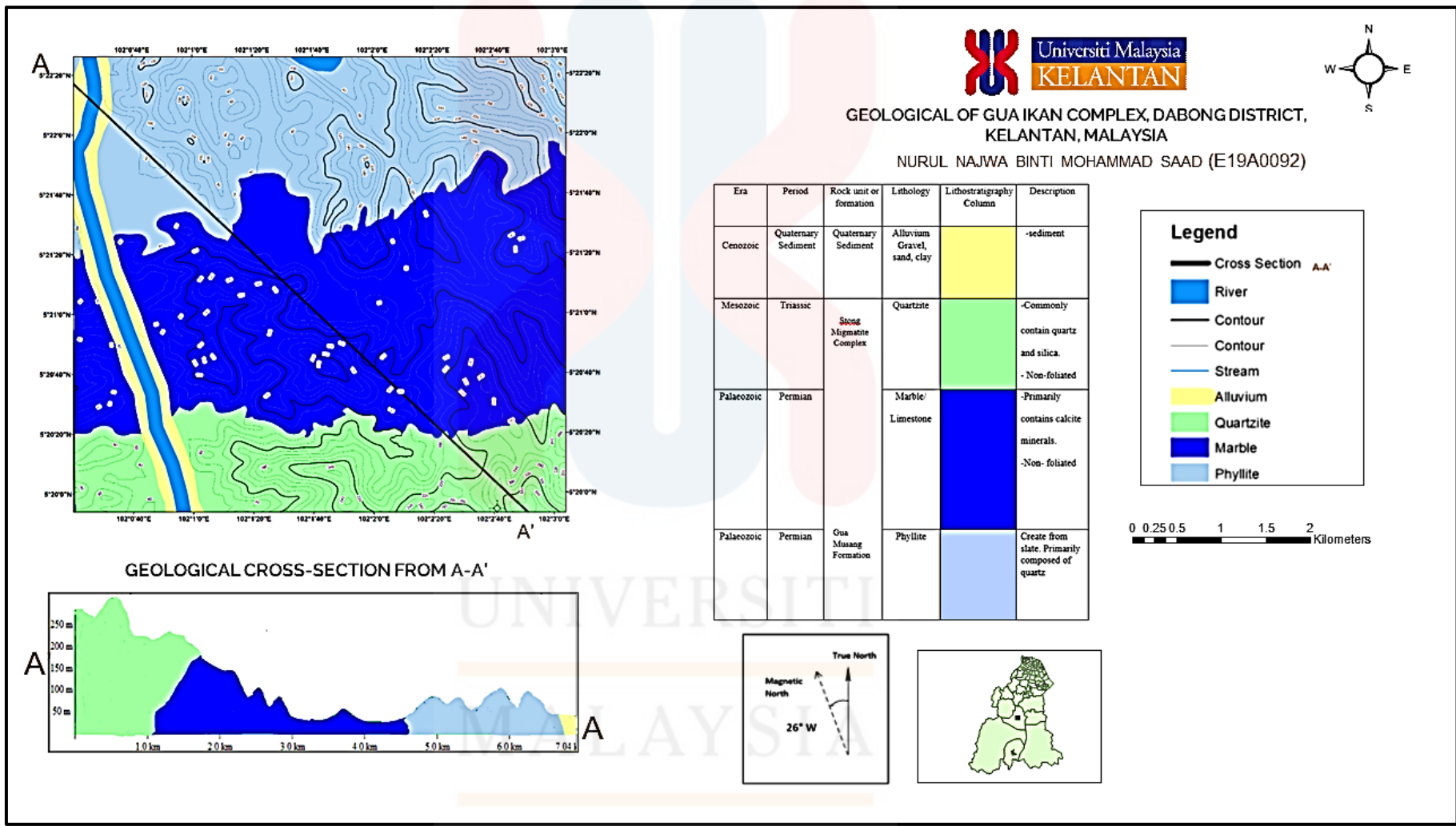
The Gua Musang Formation formed the oldest rock formation in the study area during the Permian Period. The distribution of rocks that have been found in the study area is shown by the geological map in Figure. Phyllite is the oldest rock found in study areas. Phyllite is the foliated rock, which is a metamorphic rock created from slate. Metamorphic rocks are marble. Marble is classified as a non-foliated rock. It primarily contains calcite minerals. from limestone metamorphosed into marble. It found an area of karst formation that is a cave. It is the late Permian period. The formation of marble usually occurs during regional or contacts metamorphism. The Triassic period is the youngest formation in the study area. It is the quartzite rocks, and the formation of these rocks is contact metamorphism. These are the non-foliated

types of rocks. The overall stratigraphy within the study area was classified into Permian and Triassic rock unit. It from Stong Migmatite Complex (Hutchison, 2014).

Table 4.5: Lithostratigraphy column of Gua Ikan Karst Complex

Era	Period	Rock unit or formation	Lithology	Lithostratigraphy Column	Description
Cenozoic	Quaternary Sediment	Quaternary Sediment	Alluvium Gravel, sand, clay		-Sediment
Mesozoic	Triassic	Stong Migmatite Complex	Quartzite		-Commonly contain quartz and silica. - Non-foliated
Palaeozoic	Permian		Marble/ Limestone		-Primarily contains calcite minerals. -Non- foliated
Palaeozoic	Permian	Gua Musang Formation	Phyllite		Create from slate. Primarily composed of quartz

(Hutchison, 2014)



GEOLOGICAL CROSS-SECTION FROM A-A'



A





Figure 4.16: Geological Maps of study area

4.3.1 Lithostratigraphic unit

The lithostratigraphic unit is based on rock types; it may consist of igneous, sedimentary, or metamorphic rocks, or it may be a combination of two or more of these. Based on the study areas it consists of Phyllite unit, Marble unit, and Quartzite unit.

4.3.1.1 Phyllite unit

The rocks are situated near karst formations in the study area. Phyllite is generally defined as low grade regional metamorphism along a convergent plate boundary. It is often formed because of the regional metamorphism process. Figure represents the phyllite bodies discovered parallel arrangement of certain mineral grains that gives the rock a stripe look. It is categorised as foliation of metamorphic rocks. The minerals composition of Phyllite under thin section can be referred based on the Table 4.6. Meanwhile, Figure 4.17 shows the plane and cross polarization of phyllite under thin section.



Figure 4.17: Phyllite rock bodies in the study area

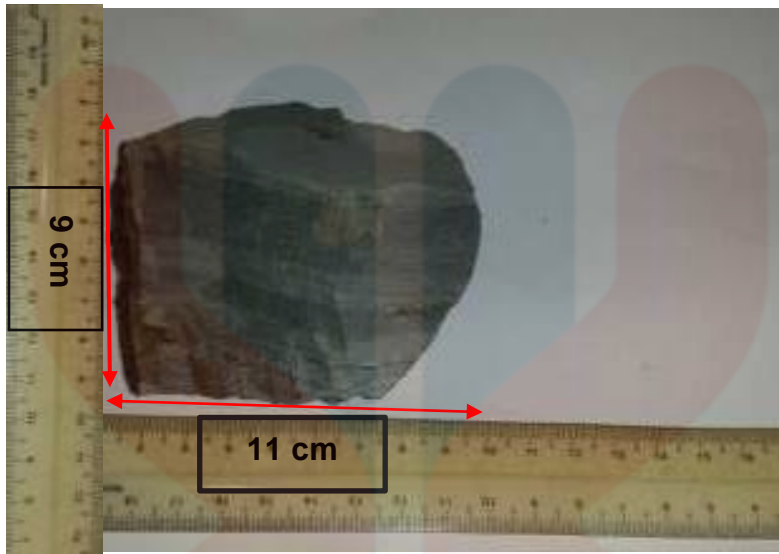


Figure 4.18: Hand specimen of Phyllite

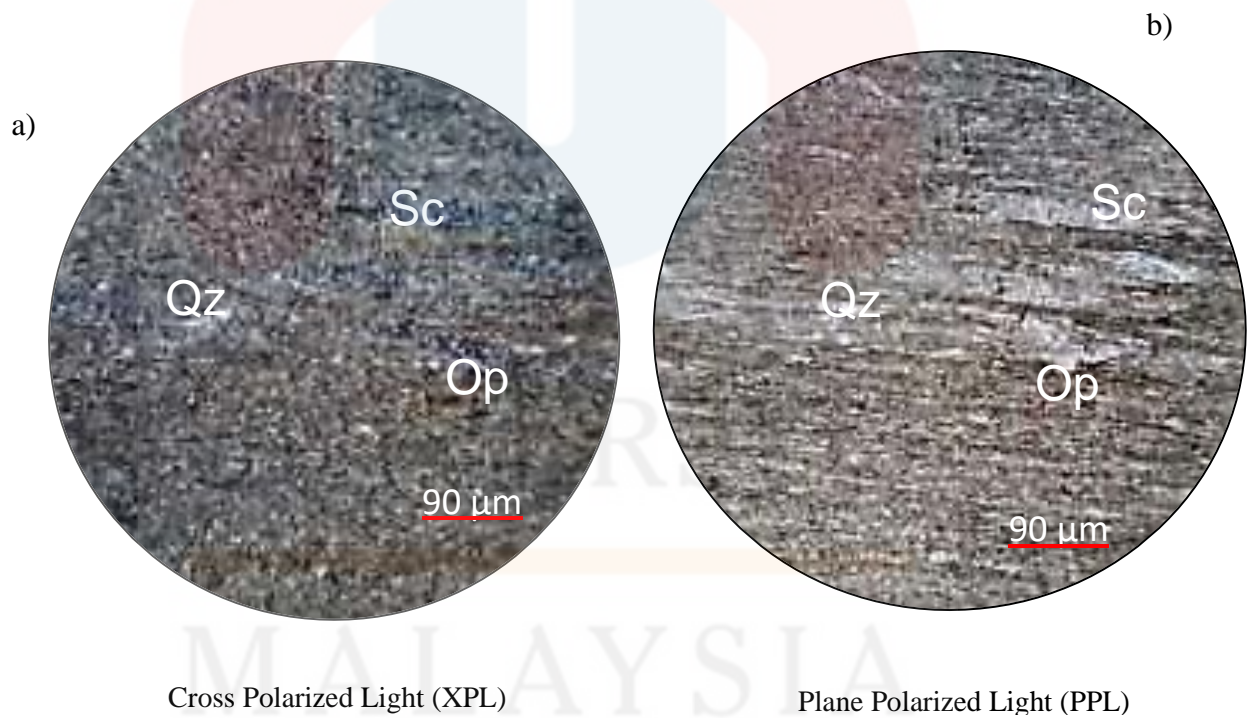


Figure 4.19: The thin section photo-micro of phyllite sample on (a) XPL (b) PPL.

Quartz= Qz, Silicate Clay= Sc, Opaque= Op (a, b) ; Magnification of 60×0.80P

Table 4.6: Mineral Properties of Phyllite

Grain size	Medium to coarse grained	
Foliation	Foliated	
Mineral present	Quartz, Silica Clay, Opaque	
Quartz	Cleavage	None
	Relief	Relief
	XPL	Grey and white
	PPL	Colourless
Silica Clay	Cleavage	None
	Relief	Low Relief
	XPL	Dark grey
	PPL	Colourless brown
Opaque	Cleavage	None
	Relief	Low relief
	XPL	Dark grey
	PPL	Colourless brown

4.3.1.2 Marble unit

Based on the study area, mostly found the marble rock, it is metamorphism of limestone. Marble is a metamorphic rock formed when limestone is exposed to metamorphic heat and pressure. It is mostly made up of the mineral calcite (CaCO_3) and others minerals. Marble was formed during the Permian period as part of the Gua Musang formation. The Figure 4.20 shows a marble outcrop with a crystalline texture in the study area.

The marble rocks usually taken in the study area. Marble is non-foliated of metamorphic rock. In the study area was doing the acid test, the marble reacts with saturated HCL. The Figure 4.21 show the plane and cross polarized view of marble under thin section. Based on the thin section, The mineral composition of marble can be referred to table 4.7.



Figure 4.20: Marble rock bodies in the study area



Figure 4.21: Hand specimen of marble in the study area

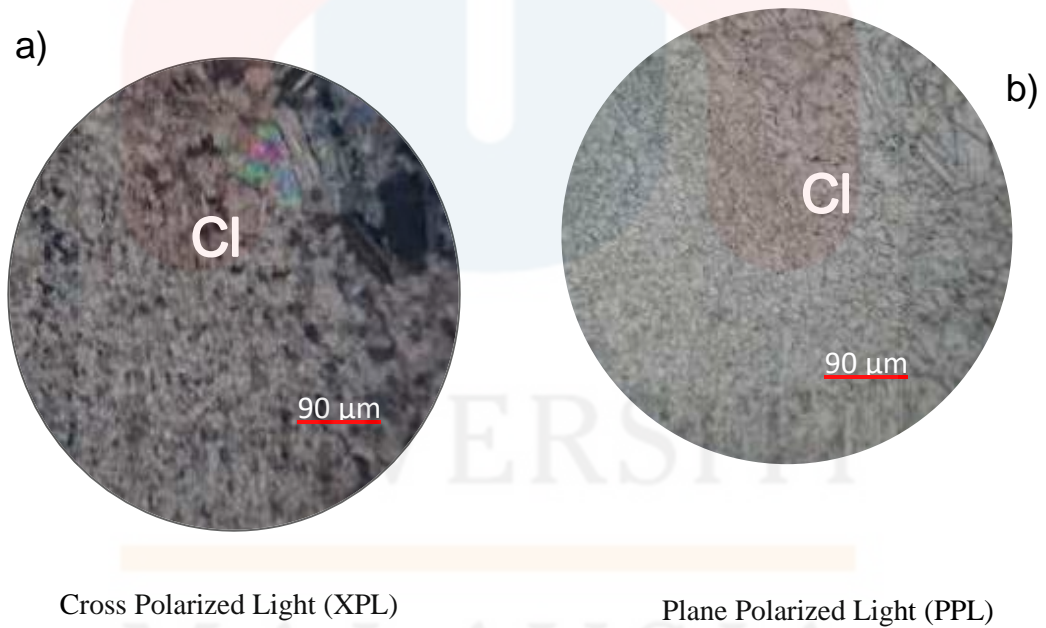


Figure 4.22: The thin section photo-micro of marble sample on (a) XPL (b) PPL. Calcite = Cl, (a , b) ; Magnification of 60×0.80P

Table 4.7: Mineral Properties of Marble

Grain size	Medium to coarse grained	
Foliation	Non-Foliated	
Mineral present	Calcite minerals	
Calcite	Cleavage	None
	Relief	Low Relief
	XPL	Pink, green
	PPL	Colourless

4.3.1.3 Quartzite unit

Sample of quartzite was collected at the oil plantations. It mostly found at the bottom or south of the study area. The quartzite discovered in the study area was formed during the Triassic period as part of the Stong migmatite Complex. It forms when sedimentary sandstone is heated and pressurised during the building of mountains. The figure 4.22 shows the quartzite that has been found in the study area.

The quartzite was test with geological hammer it has very hard structure to break. The figure shows the plane and cross polarised view of quartzite under thin section. Table 4.8 explained about the composition of quartzite based on thin section analysis.



Figure 4.23: Quartzite rock bodies in the study area



Figure 4.24: Quartzite hand specimen in the study area

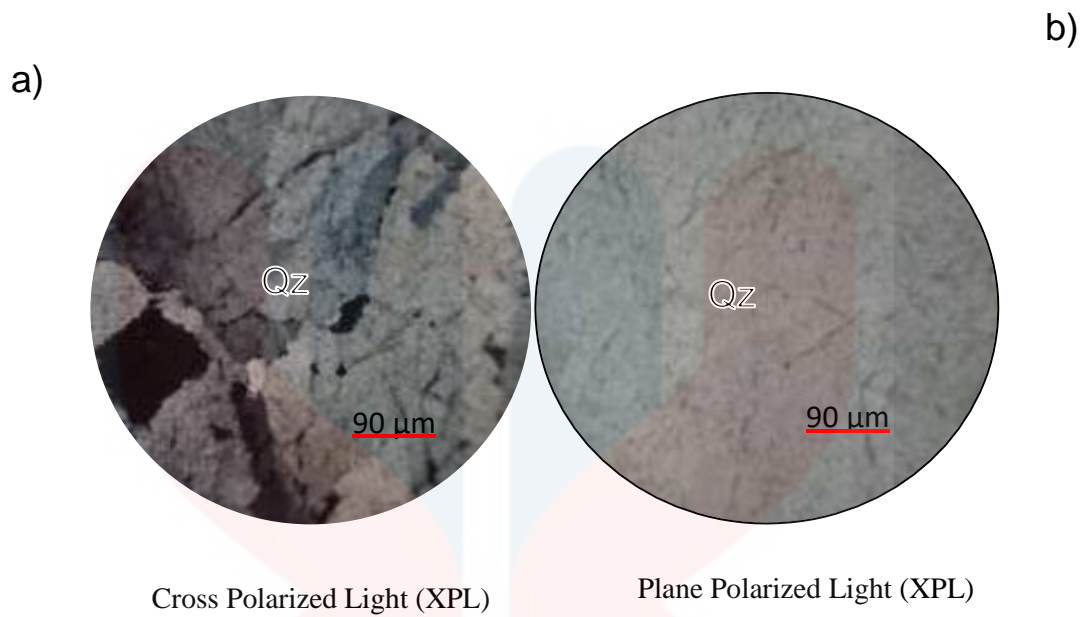


Figure 4.25: The thin section photo-micro of quartzite sample on (a) XPL (b) PPL.
 Quartz = Qz (a , b) ; Magnification of 60×0.80P

Table 4.8: Mineral Properties of Quartzite

Grain size	Coarse grained	
Foliation	Non-Foliated	
Mineral present	Quartz minerals	
Quartz	Cleavage	None
	Relief	Low relief
	XPL	Grey and white
	PPL	Colourless

4.4 Structural Geology

In term of structural geology, it is the study of the three-dimensional distribution of rock units with respect to their deformational histories. Another definition is study of geological structures, learning how, when, and why they formed, and it also is study of the architecture of the Earth's crust, resulted from deformation. For example, the three fundamental structures are contacts such as fault contacts and shear zones contacts. The structural geology deals with the geometric relationships of rocks and geologic features in general. The structural geology is important in measurements of presents-day rock geometries to uncover information about the history of deformation (strain) in the rocks.

The structural geology can be classified into two categorized. Another example is primary structures is the process that happened during the rock formation. The example, cross bedding and ripples. Meanwhile, secondary structures in nature that occurred after the rock formation. It includes joints, shear fractures, faults, folds, cleavage, and foliation.

Based on the study area, the analysis about the structure in term of primary and secondary structure. The primary structure occurred in the study area is bedding, besides that, the secondary structure is joints and fractures.

4.4.1 Lineaments Analysis.

A lineament is a landscape feature that indicates an underlying geological structure, such as a fault, fracture, or joint. In general, lineaments are referred to in the remote sensing study of fractures or structures. Frequent correlations exist between lineaments and discrete structures like as faults or fold axes, as well as structurally regulated facies boundaries. In addition, regional structural tendencies are typically associated with lineament or interruptions in the dominating lineament pattern. In this study, the lineament analysis was performed by studying the linear pattern on satellite data. The map of lineament consisting of positive and negative lineaments was created based on the comparison of the linear characteristics of the two software.

Positive lineament indicates the presence of ridges or mountain ranges in the research area. It is the geographical features consisting chain of mountain or hills. Negative lineaments are the result of a fault or joint, which can be detected by valleys or rivers. The map of lineament consisting of positive and negative lineaments was generated based on the linear feature's observation.

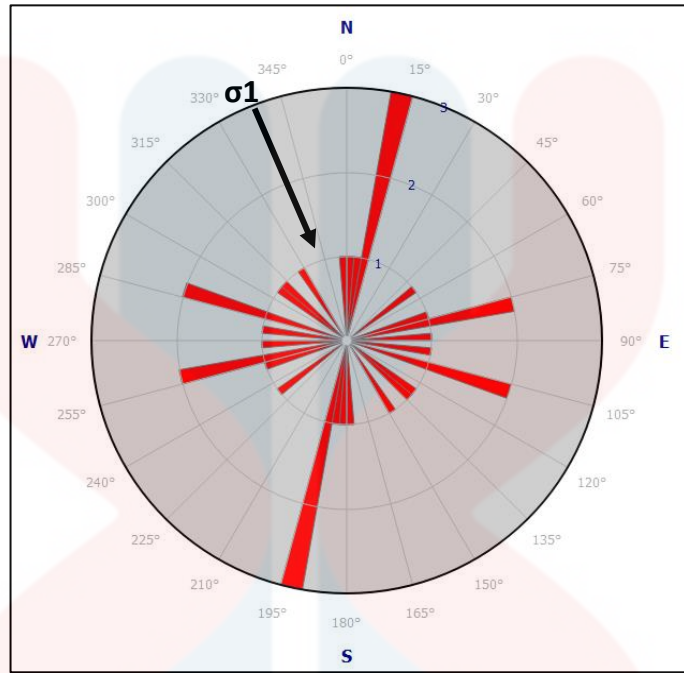


Figure 4.26: Positive Lineament

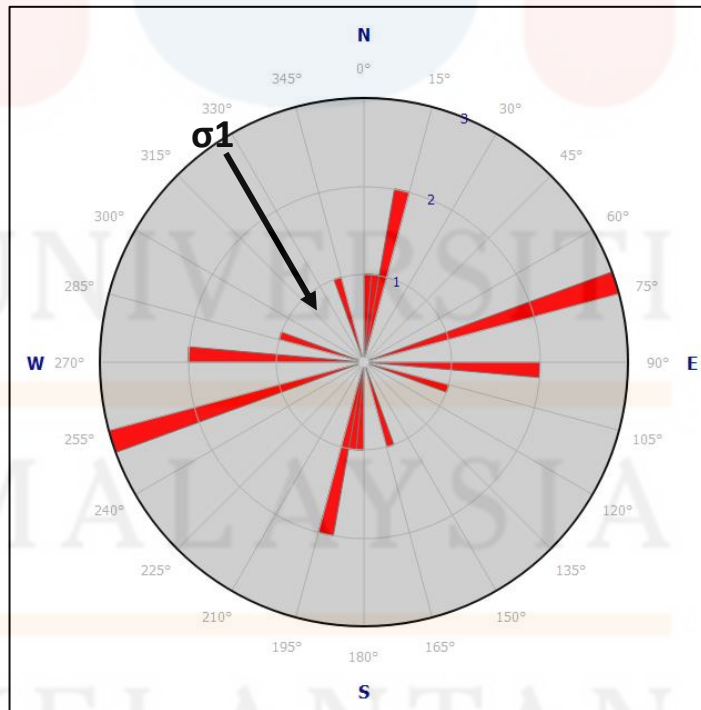


Figure 4.27: Negative lineament

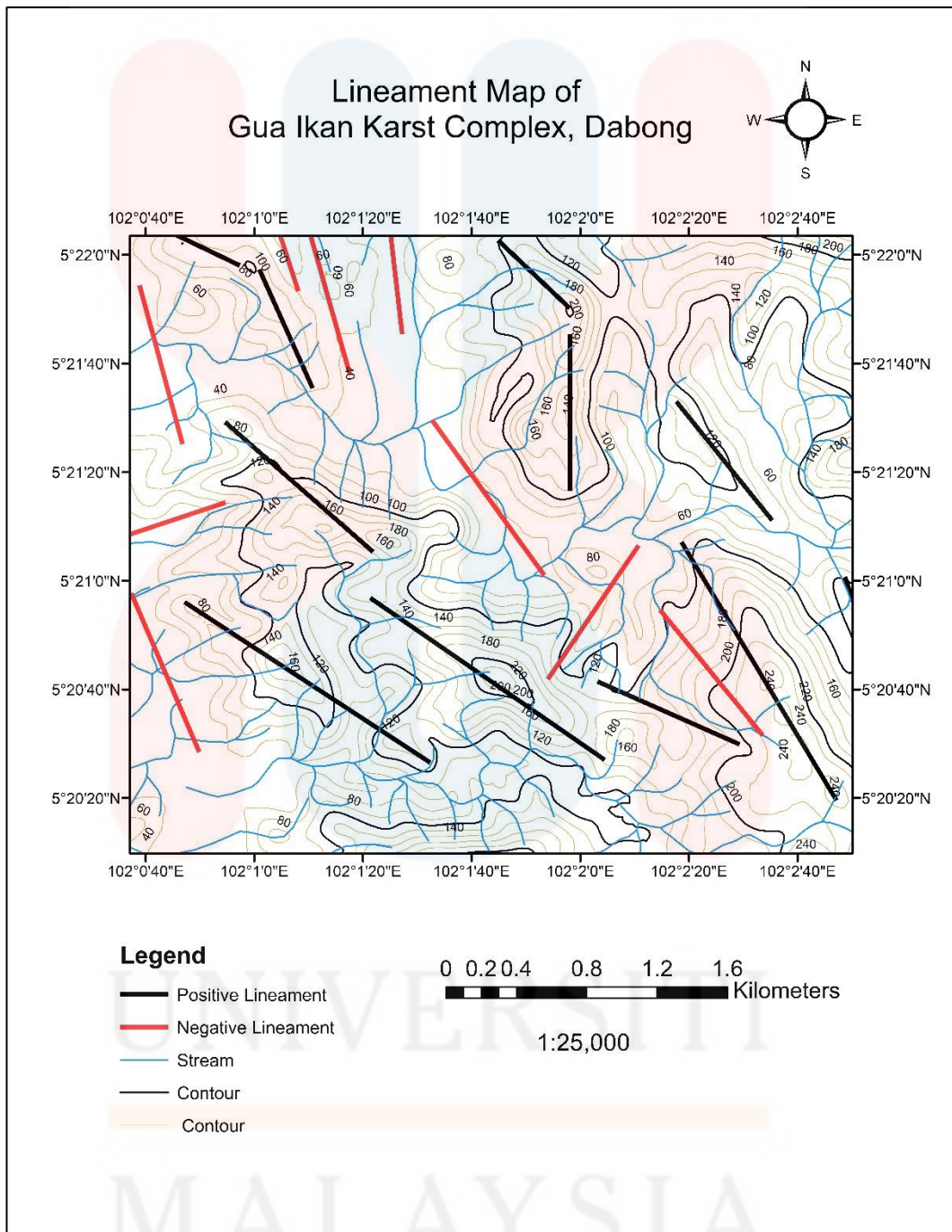


Figure 4.28: Positive and negative lineaments of Gua Ikan Complex

MALAYSIA
KELANTAN

4.4.2 Bedding

Gua Ikan Complex bedding structure has been identified. Bedding is generated as a result of sedimentary rock layering, which occurs when one sedimentary layer is deposited on top of an older layer and a sedimentary layer of rock is deposited with a new layer of sediments. This sedimentary layer's nature generates a prominent boundary between beds known as the bedding plane.



Figure 4.29: Bedding structure in study area

4.4.3 Joints

Joint may define as the fracture that divided the rocks into parts or blocks which have not been suffered any relative motion along the fracture. Generally, a joint is a crack that has no displacement within the rock body because of tensional force pulling the brittle rock apart. Joints are typically found in brittle rock under conditions of low temperature and pressure.

Joint and vein share the same method of fracture, however, what distinguishes the joint from the vein is that the joint does not have observable shear displacement and does not include mineralized minerals. The joint was forms as cracks and fractures on body of rock, it identified as systematic joint because can be measured and occurred in parallel or sub parallel joints.



Figure 4.30: Joint structure in the study area

Table 4.9: The data joint taken in the study area:

Strike (°)	Dip (°)
141	81
122	61
274	73
229	82
315	76
112	62
145	86
320	81
100	45
252	75
132	74
245	70
325	90
235	61
169	55
140	75
254	75
280	75
285	40
265	81
324	52
315	11
279	15
325	13
322	11
330	50
318	17
235	9
140	15

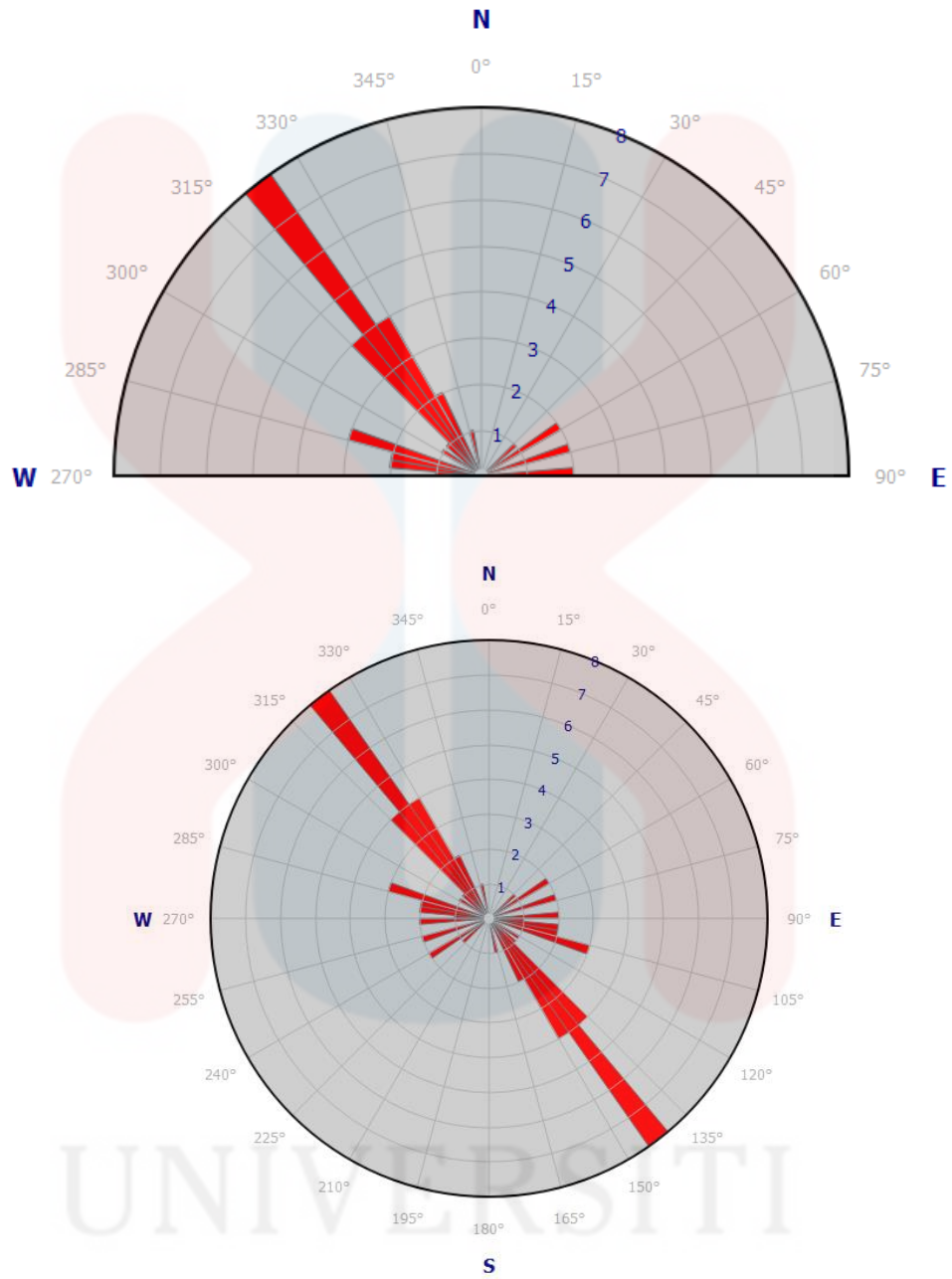


Figure 4.31: Data Joint Interpret using the rose diagram.

UNIVERSITI
MALAYSIA
KELANTAN

4.5 Historical Geology

Historical geology is a field of geology that uses geological principles and methods to study and analyse the Earth's geological history. Historical geology aids in the study of geologic processes that alter the Earth's surface and subsurface. It also about illustrate the chronology of events based on geological evidence time scale, knowledge on stratigraphy and structural geology is required.

The oldest rock bodies that have been found in the study area is foliated metamorphic rock which is phyllite in the period Permian. Phyllite is formed due to the Phyllite is associated with regional metamorphism due to mountain building. Most of the rock unit in the study area is under the Gua Musang formation. Gua Musang formation is represented by a low-grade is metamorphic sequence of Phyllite and Marble. The existence of metamorphic rock units in the study area is influenced by the tectonic activities in Peninsular Malaysia during the Palaeozoic and Mesozoic eras affect the land mass principally on the formation of fractures and joints. In addition, the range of lithology that found in the study area is stong migmatite complex because have types of quartzite from Triassic. The types of metamorphism can be divided into regional, contact, and dynamic. In this study area, the rock metamorphism is happened due to the contact and regional metamorphism. The formation of rock unit in the study area is named as Gua Musang Formation. Gua Musang Formation is establishing since Palaeozoic to Mesozoic.

CHAPTER 5

EVALUATION OF GEOSITE POTENTIAL OF GUA IKAN KARST COMPLEX, GUA KERIS, GUA GELAP, GUA PAGAR, DABONG DISTRICT, KELANTAN

5.1 Introduction

The chapter 5 were discussed about the specification, which is evaluation of Gua Ikan Complex that Gua Gelap, Gua Keris, and Gua Pagar. Dabong, Kelantan as potential of Geosite. The geosite and geological mapping method applied in this to find the geodiversity potential of study areas. The geosite usually the geological of formations occurred past ago and it have unique historical which can commercialize as tourist places.

The geosites have related the geological feature occurred that interesting for commercialization or have uniqueness for tourism in geology. For example, it has minerals, rocks and fossil, landforms, and geomorphological characteristic that occurred due to past geological event.

Thus, the evaluation conduct for survey the potential of Gua Ikan Karst Complex, Gua Pagar, Gua Keris and Gua Gelap to be as geosite places. The purpose of the research for identify the view of the geosite potential. The first part is the information about the respondent which is gender, ages and level of education shown in the figure below with 3 caves including Gua Ikan Karst Complex:

Table 5.1: The pie chart of 4 caves based on gender, age (year), level of education

Caves Name	Gender	Ages (Years)	Level of Education
GUA IKAN	<p>Male Female</p>	<p>17-21 22-25 26-29 30 above</p>	<p>School Diploma Degree Employee Others</p>
GUA PAGAR	<p>Female Male</p>	<p>17-21 22-25 26-29 30 above</p>	<p>School Diploma Degree Employee Others</p>
GUA KERIS	<p>Male Female</p>	<p>17-21 22-25 26-29 30 above</p>	<p>School Diploma Degree Employee Others</p>
GUA GELAP	<p>Male Female</p>	<p>17-21 22-25 26-29 30 above</p>	<p>School Diploma Degree Employee Others</p>

5.2 M-GAM analysis of Gua Ikan Karst Complex.

The survey data is being analysed to justify Gua Ikan Complex, Gua Keris, Gua Gelap and Gua Pagar as potential geosite. The total of respondent is 30 peoples were asked to rate the importance (Im) of subindicators from 0.00 to 1.00. First part of questionnaire is measured the socio-demographic variables (gender, age, and level education). The second part of Questionnaire was related to the assessment of the importance of indicators is Main Value (MV) which is have 12 sub-indicators. Meanwhile, Additional Value (AV) have 15 sub-indicators, the total of (MV) and (AV) have 27 sub indicators based on M-GAM analysis. The chart is the simplified result of the respondent through the survey in percentage (%).

Figure 5.1: M-GAM Analysis

M-GAM				
Main Values			Additional Values	
Scientific and educational values (VSE)	Scenic and aesthetic values (VSA)	Protection values (VPr)	Functional values (VFns)	Touristic values (VTr)

MALAYSIA

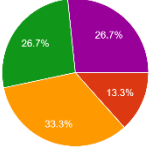
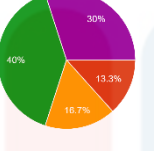
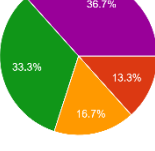
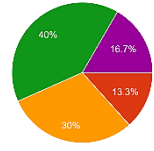
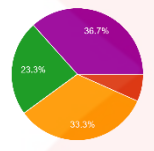
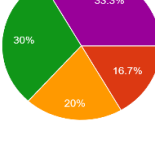
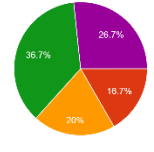
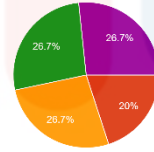
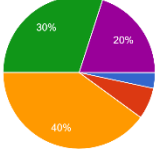
KELANTAN

5.2.1. Gua Ikan

Table 5.2: Sub-indicator of M-GAM analysis in Gua Ikan Complex.

	1.Rarity		2.Repre ntativeness		3.Knowledg es of geosite issues
	4. Level of interpretatio n		5.Viewpoi nts		6.Surface Whole surface of the site.
	7.Surroundi ng landscape and nature		8. Environment of site related		9. Current condition

UNIVERSITY
MALAYSIA
KELANTAN

 <ul style="list-style-type: none"> ● 0.00 ● 0.25 ● 0.50 ● 0.75 ● 1 	<p>10. Protection level- Eg: from local, government and international organizations</p>	 <ul style="list-style-type: none"> ● 0.00 ● 0.25 ● 0.50 ● 0.75 ● 1 	<p>11. Vulnerability-level of geosite.</p>	 <ul style="list-style-type: none"> ● 0.00 ● 0.25 ● 0.50 ● 0.75 ● 1 	<p>12. Suitable number visitors.</p>
 <ul style="list-style-type: none"> ● 0.00 ● 0.25 ● 0.50 ● 0.75 ● 1 	<p>13. Accessibility -Possibilities of approaching to the site.</p>	 <ul style="list-style-type: none"> ● 0.00 ● 0.25 ● 0.50 ● 0.75 ● 1 	<p>14. Additional natural values -Number of additional natural values in the radius of 5 km (geosites also included).</p>	 <ul style="list-style-type: none"> ● 0.00 ● 0.25 ● 0.50 ● 0.75 ● 1 	<p>15. Additional anthropogenic values</p>
 <ul style="list-style-type: none"> ● 0.00 ● 0.25 ● 0.50 ● 0.75 ● 1 	<p>16. Vicinity of emissive centres.</p>	 <ul style="list-style-type: none"> ● 0.00 ● 0.25 ● 0.50 ● 0.75 ● 1 	<p>17. Vicinity of important road network-important road network</p>	 <ul style="list-style-type: none"> ● 0.00 ● 0.25 ● 0.50 ● 0.75 ● 1 	<p>18. Additional functional values</p>



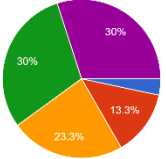
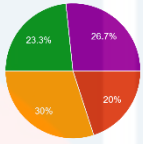
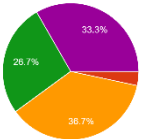
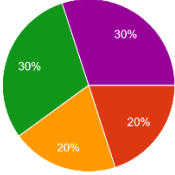
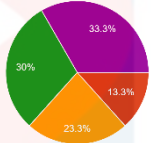
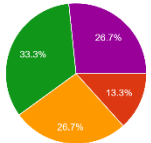
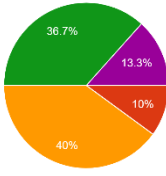
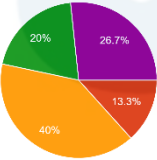
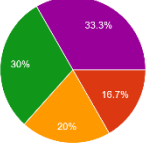
 <p>0.00 0.25 0.50 0.75 1</p>	<p>19. Promotion</p>	 <p>0.00 0.25 0.50 0.75 1</p>	<p>20. Organized visits - Annual number of organized visits to the geosite.</p>	 <p>0.00 0.25 0.50 0.75 1</p>	<p>21. Vicinity of visitor's</p>
 <p>0.00 0.25 0.50 0.75 1</p>	<p>22. Interpretative panels</p>	 <p>0.00 0.25 0.50 0.75 1</p>	<p>23. Number of visitors</p>	 <p>0.00 0.25 0.50 0.75 1</p>	<p>24. Tourism infrastructure</p>
 <p>0.00 0.25 0.50 0.75 1</p>	<p>25. Tour guide service</p>	 <p>0.00 0.25 0.50 0.75 1</p>	<p>26. Hostelry service</p>	 <p>0.00 0.25 0.50 0.75 1</p>	<p>27. Restaurant service</p>

Table 5.3: Values assigned to each sub indicator in the M-GAM model by experts and visitors.

	Values given by experts (0–1)	Im (Visitor Opinion)
Main values (MV)		
Scientific/educational value (VSE)		
Rarity	0.79	0.48
Representativeness	0.79	0.55
Knowledge on geoscientific issues	0.73	0.53
Level of interpretation	0.84	0.55
Total	3.15	2.11
Total Percentage (%)	79%	53%
Scenic/aesthetic (VSA)		
Viewpoints	0.68	0.50
Surface	0.74	0.68
Surrounding landscape and nature	0.78	0.45
Environmental fitting of sites	0.83	0.53
Total	3.03	2.16
Total Percentage (%)	76%	54%
Protection (VPr)		
Current condition	0.83	0.58
Protection level	0.74	0.50
Vulnerability	0.79	0.50
Suitable number of visitors	0.85	0.55
Total	3.21	2.13
Total Percentage (%)	80%	53%

	Values given by experts Im (0–1)	Im (Visitor Opinion)
Additional values (AVs)		
Functional values (VFns)		
Accessibility	0.73	0.5
Additional natural values	0.81	0.55
Additional anthropogenic values	0.78	0.55
Vicinity of emissive centers	0.76	0.52
Vicinity of important road network	0.70	0.55
Additional functional values	0.68	0.57
Total	4.46	3.24
Total Percentage (%)	74%	62%
Touristic values (VTr)		
Promotion	0.69	0.65
Organized visits	0.75	0.43
Vicinity of visitors’ centres	0.81	0.55
Interpretative panels	0.75	0.52
Number of visitors	0.81	0.50
Tourism infrastructure	0.76	0.52
Tour guide service	0.70	0.50
Hostelry services	0.69	0.57
Restaurant service	0.80	0.50
Total	6.79	3.72
Total Percentage (%)	75%	41%

KELANTAN

Table 5.4: Overall geosites by M-GAM (Assessment done by Expertise)

Main values (MV)				
Geosites	Scientific/educational value (VSE)	Scenic/aesthetic (VSA)	Protection (VPR)	Total Main Value (Σ)
Gua Ikan	3.15	3.03	3.21	9.39
Additional Values (AV)				
Gua Ikan	Functional values (VFns)		Touristic values (VTr)	Total Additional Value (Σ)
	4.46		6.79	11.25

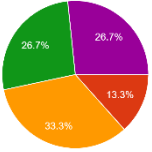
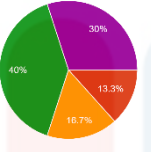
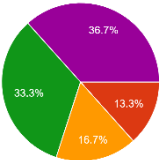
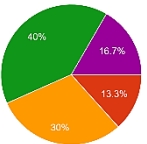
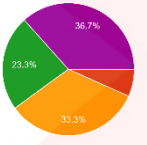
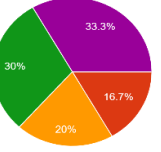
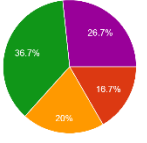
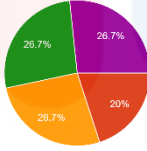
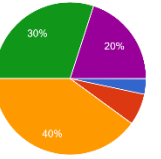
Table 5.5: Overall geosites by M-GAM (Assessment done by Tourists)

Main values (MV)				
Geosites	Scientific/educational value (VSE)	Scenic/aesthetic (VSA)	Protection (VPR)	Total Main Value (Σ)
Gua Ikan	2.11	2.16	2.13	6.4
Additional Values (AV)				
Gua Ikan	Functional values (VFns)		Touristic values (VTr)	Total Additional Value (Σ)
	3.24		3.72	6.96

5.2.2 Gua Pagar

Table 5.6: Sub-indicator of M-GAM analysis in Gua Pagar

	1.Rarity		2.Repre ntativeness		3.Knowledg es of geosite issues
	4. Level of interpretatio n		5.Viewpoi nts		6.Surface Whole surface of the site.
	7.Surroundi ng landscape and nature		8. Environment of site related		9. Current condition

 <ul style="list-style-type: none"> ● 0.00 ● 0.25 ● 0.50 ● 0.75 ● 1 	<p>10. Protection level- Eg: from local, government and international organizations</p>	 <ul style="list-style-type: none"> ● 0.00 ● 0.25 ● 0.50 ● 0.75 ● 1 	<p>11. Vulnerability-level of geosite.</p>	 <ul style="list-style-type: none"> ● 0.00 ● 0.25 ● 0.50 ● 0.75 ● 1 	<p>12. Suitable number visitors.</p>
 <ul style="list-style-type: none"> ● 0.00 ● 0.25 ● 0.50 ● 0.75 ● 1 	<p>13. Accessibility -Possibilities of approaching to the site.</p>	 <ul style="list-style-type: none"> ● 0.00 ● 0.25 ● 0.50 ● 0.75 ● 1 	<p>14. Additional natural values -Number of additional natural values in the radius of 5 km (geosites also included).</p>	 <ul style="list-style-type: none"> ● 0.00 ● 0.25 ● 0.50 ● 0.75 ● 1 	<p>15. Additional anthropogenic values</p>
 <ul style="list-style-type: none"> ● 0.00 ● 0.25 ● 0.50 ● 0.75 ● 1 	<p>16. Vicinity of emissive centres.</p>	 <ul style="list-style-type: none"> ● 0.00 ● 0.25 ● 0.50 ● 0.75 ● 1 	<p>17. Vicinity of important road network-important road network</p>	 <ul style="list-style-type: none"> ● 0.00 ● 0.25 ● 0.50 ● 0.75 ● 1 	<p>18. Additional functional values</p>

	<p>19. Promotion</p>		<p>20. Organized visits - Annual number of organized visits to the geosite.</p>		<p>21. Vicinity of visitor's</p>
	<p>22. Interpretative panels</p>		<p>23. Number of visitors</p>		<p>24. Tourism infrastructure</p>
	<p>25. Tour guide service</p>		<p>26. Hostelry service</p>		<p>27. Restaurant service</p>

Table 5.7: Values assigned to each sub-indicator in the GAM model by experts and visitors

	Values given by experts (0–1)	Im (Visitor Opinion)
Main values (MV)		
Scientific/educational value (VSE)		
Rarity	0.79	0.32
Representativeness	0.83	0.62
Knowledge on geoscientific issues	0.73	0.7
Level of interpretation	0.74	0.65
Total	3.09	2.29
Total Percentage (%)	77%	57%
Scenic/aesthetic (VSA)		
Viewpoints	0.76	0.68
Surface	0.68	0.72
Surrounding landscape and nature	0.80	0.73
Environmental fitting of sites	0.80	0.68
Total	3.04	2.81
Total Percentage (%)	76%	70%
Protection (VPr)		
Current condition	0.78	0.73
Protection level	0.74	0.73
Vulnerability	0.86	0.68
Suitable number of visitors	0.79	0.65
Total	3.17	2.79
Total Percentage (%)	79%	70%

	Values given by experts (0–1)	Im (Visitor Opinion)
Additional values (AVs)		
Functional values (VFns)		
Accessibility	0.79	0.63
Additional natural values	0.75	0.70
Additional anthropogenic values	0.70	0.65
Vicinity of emissive centers	0.71	0.68
Vicinity of important road network	0.79	0.72
Additional functional values	0.68	0.73
Total	4.48	4.11
Total Percentage (%)	74%	69%
Touristic values (VTr)		
Promotion	0.80	0.68
Organized visits	0.79	0.65
Vicinity of visitors centres	0.84	0.72
Interpretative panels	0.81	0.72
Number of visitors	0.79	0.68
Tourism infrastructure	0.80	0.68
Tour guide service	0.76	0.65
Hostelry services	0.71	0.68
Restaurant service	0.78	0.70
Total	7.08	5.44
Total Percentage (%)	78%	60%

KELANTAN

Table 5.8: Overall geosites by M-GAM (Assessment done by Expertise)

Main values (MV)				
Geosites	Scientific/educational value (VSE)	Scenic/aesthetic (VSA)	Protection (VPR)	Total Main Value (Σ)
Gua Pagar	3.09	3.04	3.14	9.27
Additional Values (AV)				
Gua Pagar	Functional values (VFns)		Touristic values (VTr)	Total Additional Value (Σ)
	4.48		7.08	11.56

Table 5.9: Overall geosites by M-GAM (Assessment done by Tourists)

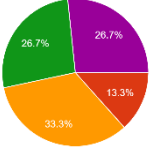
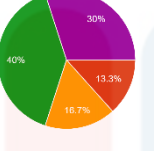
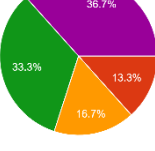
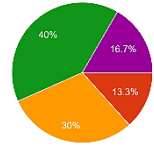
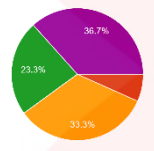
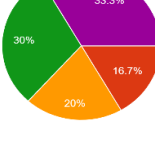
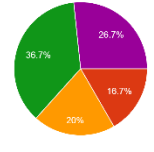
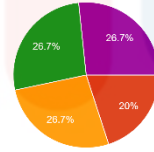
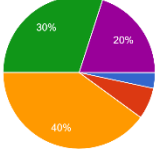
Main values (MV)				
Geosites	Scientific/educational value (VSE)	Scenic/aesthetic (VSA)	Protection (VPR)	Total Main Value (Σ)
Gua Pagar	2.29	2.81	2.79	7.89
Additional Values (AV)				
Gua Pagar	Functional values (VFns)		Touristic values (VTr)	Total Additional Value (Σ)
	4.11		5.44	9.55

5.2.3 Gua Keris

Table 5.10: The sub-indicator of M-GAM analysis in Gua Keris

	<p>1.Rarity</p>		<p>2.Repre ntativeness</p>		<p>3.Knowledg es of geosite issues</p>
	<p>4. Level of interpretatio n</p>		<p>5.Viewpoi nts</p>		<p>6.Surface Whole surface of the site.</p>
	<p>7.Surroundi ng landscape and nature</p>		<p>8. Environment of site related</p>		<p>9. Current condition</p>

UNIVERSITI
MALAYSIA
KELANTAN

 <ul style="list-style-type: none"> ● 0.00 ● 0.25 ● 0.50 ● 0.75 ● 1 	<p>10. Protection level- Eg: from local, government and international organizations</p>	 <ul style="list-style-type: none"> ● 0.00 ● 0.25 ● 0.50 ● 0.75 ● 1 	<p>11. Vulnerability-level of geosite.</p>	 <ul style="list-style-type: none"> ● 0.00 ● 0.25 ● 0.50 ● 0.75 ● 1 	<p>12. Suitable number visitors.</p>
 <ul style="list-style-type: none"> ● 0.00 ● 0.25 ● 0.50 ● 0.75 ● 1 	<p>13. Accessibility -Possibilities of approaching to the site.</p>	 <ul style="list-style-type: none"> ● 0.00 ● 0.25 ● 0.50 ● 0.75 ● 1 	<p>14. Additional natural values -Number of additional natural values in the radius of 5 km (geosites also included).</p>	 <ul style="list-style-type: none"> ● 0.00 ● 0.25 ● 0.50 ● 0.75 ● 1 	<p>15. Additional anthropogenic values</p>
 <ul style="list-style-type: none"> ● 0.00 ● 0.25 ● 0.50 ● 0.75 ● 1 	<p>16. Vicinity of emissive centres.</p>	 <ul style="list-style-type: none"> ● 0.00 ● 0.25 ● 0.50 ● 0.75 ● 1 	<p>17. Vicinity of important road network-important road network</p>	 <ul style="list-style-type: none"> ● 0.00 ● 0.25 ● 0.50 ● 0.75 ● 1 	<p>18. Additional functional values</p>



	<p>19. Promotion</p>		<p>20. Organized visits - Annual number of organized visits to the geosite.</p>		<p>21. Vicinity of visitor's</p>
	<p>22. Interpretative panels</p>		<p>23. Number of visitors</p>		<p>24. Tourism infrastructure</p>
	<p>25. Tour guide service</p>		<p>26. Hostelry service</p>		<p>27. Restaurant service</p>

Table 5.11: Values assigned to each sub indicator in the GAM model by experts and visitors.

	Values given by experts (0–1)	Im (Visitor Opinion)
Main values (MV)		
Scientific/educational value (VSE)		
Rarity	0.69	0.6
Representativeness	0.79	0.6
Knowledge on geoscientific issues	0.69	0.53
Level of interpretation	0.69	0.63
Total	3.62	2.36
Total Percentage (%)	90%	26%
Scenic/aesthetic (VSA)		
Viewpoints	0.7	0.5
Surface	0.8	0.55
Surrounding landscape and nature	0.79	0.63
Environmental fitting of sites	0.8	0.6
Total	3.09	2.28
Total Percentage (%)	77%	57%
Protection (VPr)		
Current condition	0.75	0.55
Protection level	0.78	0.5
Vulnerability	0.75	0.5
Suitable number of visitors	0.74	0.55
Total	3.02	2.10
Total Percentage (%)	76%	53%

	Values given by experts (0–1)	Im (Visitor Opinion)
Additional values (AVs)		
Functional values (VFns)		
Accessibility	0.70	0.53
Additional natural values	0.81	0.63
Additional anthropogenic values	0.78	0.5
Vicinity of emissive centers	0.76	0.55
Vicinity of important road network	0.69	0.63
Additional functional values	0.71	0.6
Total	4.45	3.44
Total Percentage (%)	74%	57%
Touristic values (VTr)		
Promotion	0.74	0.55
Organized visits	0.75	0.5
Vicinity of visitors centres	0.75	0.55
Interpretative panels	0.71	0.55
Number of visitors	0.7	0.58
Tourism infrastructure	0.76	0.58
Tour guide service	0.74	0.63
Hostelry services	0.74	0.53
Restaurant service	0.69	0.55
Total	6.59	5.02
Total Percentage (%)	73%	56%

KELANTAN

Table 5.12: Overall geosites by M-GAM (Assessment done by Expertise)

Main values (MV)				
Geosites	Scientific/educational value (VSE)	Scenic/aesthetic (VSA)	Protection (VPR)	Total Main Value (Σ)
Gua Keris	3.62	3.09	3.02	9.73
Additional Values (AV)				
Gua Keris	Functional values (VFns)		Touristic values (VTr)	Total Additional Value (Σ)
	4.45		6.59	11.04

Table 5.13: Overall geosites by M-GAM (Assessment done by Tourists)

Main values (MV)				
Geosites	Scientific/educational value (VSE)	Scenic/aesthetic (VSA)	Protection (VPR)	Total Main Value (Σ)
Gua Keris	2.36	2.28	2.10	6.74
Additional Values (AV)				
Gua Keris	Functional values (VFns)		Touristic values (VTr)	Total Additional Value (Σ)
	3.44		5.02	8.46

5.3 The description of M-GAM Analysis based on Gua Ikan Karst Complex, Gua Pagar, Gua Keris and Gua Gelap.

M-GAM analysis is the main method used in specification of study based on evaluation of geosite characteristics which have scientific and landscape value that can be conserved was conducted to determine the Geosite potential of Gua Ikan Karst Complex and 3 caves, Gua Pagar, Gua Keris and Gua Gelap. M-GAM is derived from the Geosite Assessment Model (GAM) invented by Vujičić et al. Both of methods have same indicator and sub-indicator that is Main Value (MV) and Additional Value (AV).

The main values are produced by the natural geosite properties, whereas additional values are mostly induced by humans and can change depend on expectations of visitors. Primarily, the main values (MV) indicators are divided into three categories which is scientific/educational (VSE), scenic/aesthetical (VSA), and protection values (VPr). While Additional Values (AV) are classified into two types of indicators which is functional (VFn) and touristic (VTr).

5.3.1 Main Value (MV)

The principal values are divided into three categories of the scientific/educational (VSE), scenic/aesthetical (VSA), and protective values (VPr). There are four elements that have been evaluated for scientific values: rarity, representation, expertise on geo-science concerns, and quality of interpretation. For the scenic/aesthetic values (VSA), four characteristics that is viewpoints, surface, surrounding landscape, and nature as well as the environmental suitability of sites that

need to be assessed. Meanwhile, the element that needs to be evaluate is the current condition, protection level, vulnerability, and suitability number of visitors.

5.3.1.1 Scientific/Educational Values (VSE)

There is an aspect that has to be considered in scientific/educational values, which is rarity, representativeness, information on geo-scientific concerns, and quality of interpretation. Each element was given a value ranging from 0 to 1. Based on table 4 caves in study area. For scientific value, the value that give by the expert is higher than tourist for all the caves areas which example of Gua Ikan and Gua Pagar is 3.15, 3.09 higher from visitors is, 2.11 and 2.29.

5.3.1.2 Scenic/aesthetic (VSA)

There are several sub-indicators for the Scenic/Aesthetic attributes, including the viewpoint, the surface, the surrounding landscape and nature, and the site's environmental compatibility. The surrounding environment and nature are the most important sub-indicators of aesthetic value (Đura Miljkovi et al., 2018). The experts estimate overall value score of 3.09 marked for respondents at Gua Gelap to the surrounding scenery and nature, whereas visitors assign a value of roughly Besides that, the environmental suitability of places is given value 1 by specialists and a value of by 2.28 marked overall of the geosites among the tourists.

5.3.1.3 Protection (VPr)

The protection values (VPr) for all three geosites seem to be on an enviable level, since all subindicators were higher for experts than for tourists. The observation based on study area, the protective aspect of the services is very good in terms of safeguarding the area all around Gua Ikan Complex, Gua Pagar, and Gua Gelap. The safety guards are there. Additionally, the study area provides the services of a tour guide who leads us on a trekking trail through the caves and provides instruction and explanation of the history or uniqueness that happened at the Gua Ikan Karst Complex, Dabong.

5.3.2 Additional Values

Mainly, Additional values comprised of two indicators which is Functional value (VFn) and Touristic values (VTr). For functional values, there is six elements that requires the evaluation which are accessibility, additional natural values, additional anthropogenic values, vicinity of emissive centres, vicinity of important road network and additional functional values. For the touristic values (VTr) there are nine elements which needs to be evaluate which is promotion, annual number of organised visits, vicinity of visitor's centre, interpretive panels, number of visitors, tourism infrastructure.

5.3.2.1 Functional Values (VFn)

Functional values include accessibility, extra natural values, additional anthropogenic values, closeness to emissive centres, proximity to a major road

network, and more functional values. Except for accessibility factors, which are equally essential to both groups, functional values are more significant to visitors than to specialists.

5.3.2.2 Touristic Value (VTr)

Touristic which consists sub-indicators of promotion, organized visits, vicinity of visitor centres, interpretative panels, number of visitors, tourism infrastructure. The values given by experts from overall in Gua Ikan is 7.08 and tourist is 5.44 score. Meanwhile, the expert respondents in Gua Pagar is given score 7.08 and tourist is 2.79 which much lower than experts. For sub-indicator from Gua Keris was given scores is 6.59 while tourists are 5.02. Besides that, in Gua Gelap the expert was given 6.86 while 6.81 score. Thus, the score in touristic is very good result due to the study area prepared the comfortable facilities.

Table 5.14: Values assigned to each sub indicator in the GAM model by experts and visitors.

	Values given by experts (0–1)	Im (Visitor Opinion)
Main values (MV)		
Scientific/educational value (VSE)		
Rarity	0.72	0.71
Representativeness	0.7	0.69
Knowledge on geoscientific issues	0.68	0.7
Level of interpretation	0.81	0.76
Total	2.91	2.86

Total Percentage (%)	73%	72%
Scenic/aesthetic (VSA)		
Viewpoints	0.78	0.74
Surface	0.7	0.66
Surrounding landscape and nature	0.73	0.76
Environmental fitting of sites	0.76	0.75
Total	2.97	2.91
Total Percentage (%)	74%	72%
Protection (VPr)		
Current condition	0.74	0.76
Protection level	0.71	0.63
Vulnerability	0.66	0.79
Suitable number of visitors	0.67	0.79
TotalA	2.78	2.97
Total Percentage (%)	70%	74%

	Values given by experts (0–1)	Im (Visitor Opinion)
Additional values (AVs)		
Functional values (VFns)		
Accessibility	0.75	0.73
Additional natural values	0.58	0.75
Additional anthropogenic values	0.71	0.78
Vicinity of emissive centers	0.66	0.55
Vicinity of important road network	0.67	0.75
Additional functional values	0.75	0.65
Total	4.12	4.21
Total Percentage (%)	69%	70%
Touristic values (VTr)		

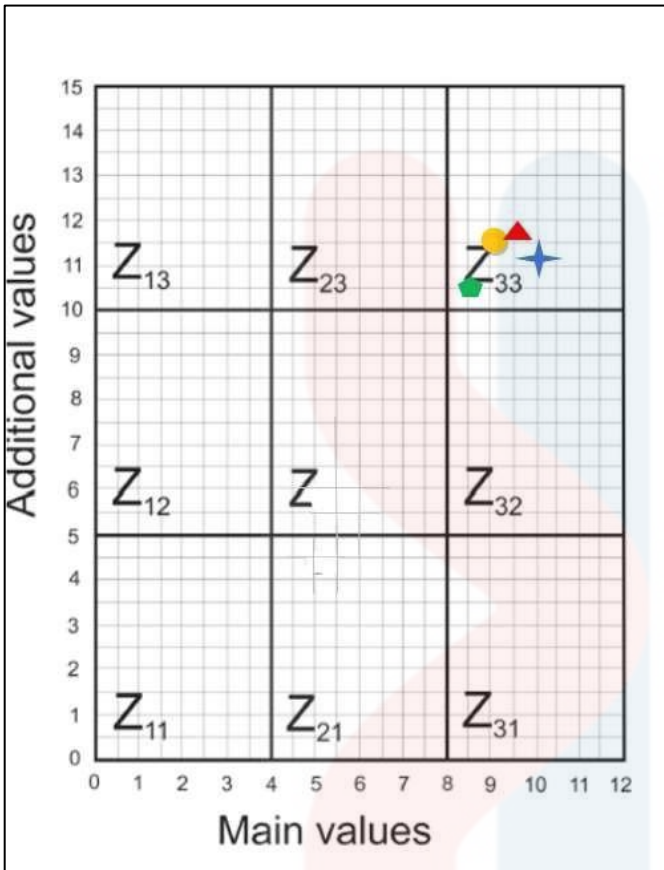
Promotion	0.58	0.74
Organized visits	0.71	0.65
Vicinity of visitor's centres	0.76	0.74
Interpretative panels	0.79	0.75
Number of visitors	0.88	0.95
Tourism infrastructure	0.83	0.73
Tour guide service	0.69	0.8
Hostelry services	0.82	0.63
Restaurant service	0.8	0.82
Total	6.86	6.81
Total Percentage (%)	76%	75%

Table 5.15: Overall geosites by M-GAM (Assessment done by Expertise)

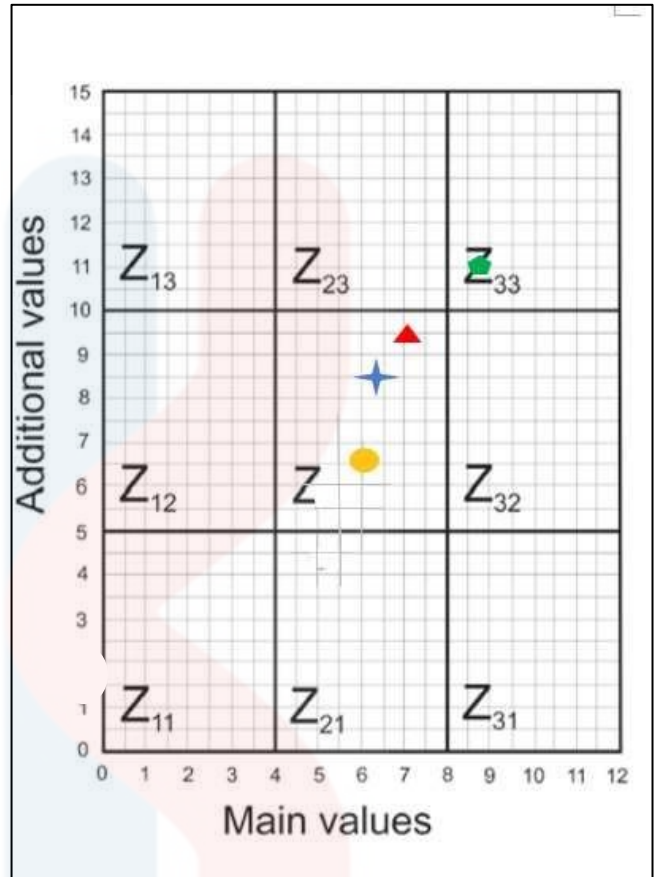
Main values (MV)				
Geosites	Scientific/educational value (VSE)	Scenic/aesthetic (VSA)	Protection (VPR)	Total Main Value (Σ)
Gua Gelap	2.91	2.97	2.78	8.66
Additional Values (AV)				
Gua Gelap	Functional values (VFns)		Touristic values (VTr)	Total Additional Value (Σ)
	4.12		6.86	10.98

Table 5.16: Overall geosites by M-GAM (Assessment done by Tourists)

Main values (MV)				
Geosites	Scientific/educational value (VSE)	Scenic/aesthetic (VSA)	Protection (VPR)	Total Main Value (Σ)
Gua Gelap	2.86	2.91	2.97	8.74
Additional Values (AV)				
Gua Gelap	Functional values (VFns)		Touristic values (VTr)	Total Additional Value (Σ)
	4.21		6.81	11.02



A) Scatter Plot of Expert



B) Scatter Plot of Tourist



Figure 5.3: The scatter plot diagram of 4 caves

5.4 Comparison of Geosites Potential of Gua Ikan Complex, Dabong, Districts based on M-GAM model and systematic studies.

5.4.1 Geosite Potential of Gua Ikan Karst Complex based on M-GAM

M-GAM analysis is evaluation method that influenced by experts and tourists' respondents. M-GAM is analysed two evaluation which is Main Value (MV) and Additional Value (AV). It has differing perspectives on the importance of sub-indicators can affect the suitability of geosites. The result shows Gua Ikan has high percentage of Scenic/aesthetic and functional value, that indicate the suitability for geosite.

Based on scientific and educational value. The level of interpretation has the highest value for experts and tourists in terms of scientific and educational value. It shown that both groups were in agreement that Gua Ikan Karst Complex had highly developed the geological and geomorphological processes, phenomena, and morphologies. Thus, the study area can be potential as geosite.

Tourist also agreed that scenic and aesthetic is the main attraction the study area with the highest value of surrounding landscape and nature touristic value, both expert and tourist agreed that highest value of sub indicator is restaurant. There is stall that serves water and food that shows in the figure 5.4. In addition, in this study area were prepared the tour guide services and hostelry. Thus, the Gua Ikan Karst Complex, Gua Pagar, Gua Keris and Gua Gelap is safe place for visitors to visit and bring their child since it has recreational place such as playground Figure 5.5.



Figure 5.4: The stall in study area



Figure 5.5: Playground at study area

UNIVERSITI
MALAYSIA
KELANTAN



Figure 5.6: The stall and tour guide services



Figure 5.7: Signboard of Gua Ikan Karst Complex

5.4.2 Systematic studies of Gua Ikan Karst Dabong, Districts.

The researcher assessed the geosite potential using a procedure of inventory, characterization, categorization, and assessment based on these systematic studies. The final overall outcome is primarily based on the opinions of experts, as opposed to the M-GAM approach, which included both expert and visitor opinions to avoid bias. The geoheritage values of science, education, aesthetics, recreation, culture, economy, and functionality were typically applied in this research.

The researcher agreed that Gua Ikan Complex had a high chance of becoming a geosite because of its high potential and uniqueness of arts, sciences, and recreation. The study area displays the highest overall scores of the geological locations in Dabong that potential geoheritage and geosite resources. The existence of the karst landform, which is made up cave formation, has the highest value in terms of science and education.

Table 5.4.2.1: Evaluation of systematic study

No	Geological site	Geodiversity	Scope	Scale
1	Pagar Cave	Rock, landform/landscape, process	Petrological site, geomorphological site, speleological site, paleontological site	Small
2	Gelap Cave	Rock, landform/landscape, process	Petrological site, geomorphological site, speleological site	Small
3	Keris Cave	Rock, landform/landscape, process	Petrological site, geomorphological site, speleological site	Small

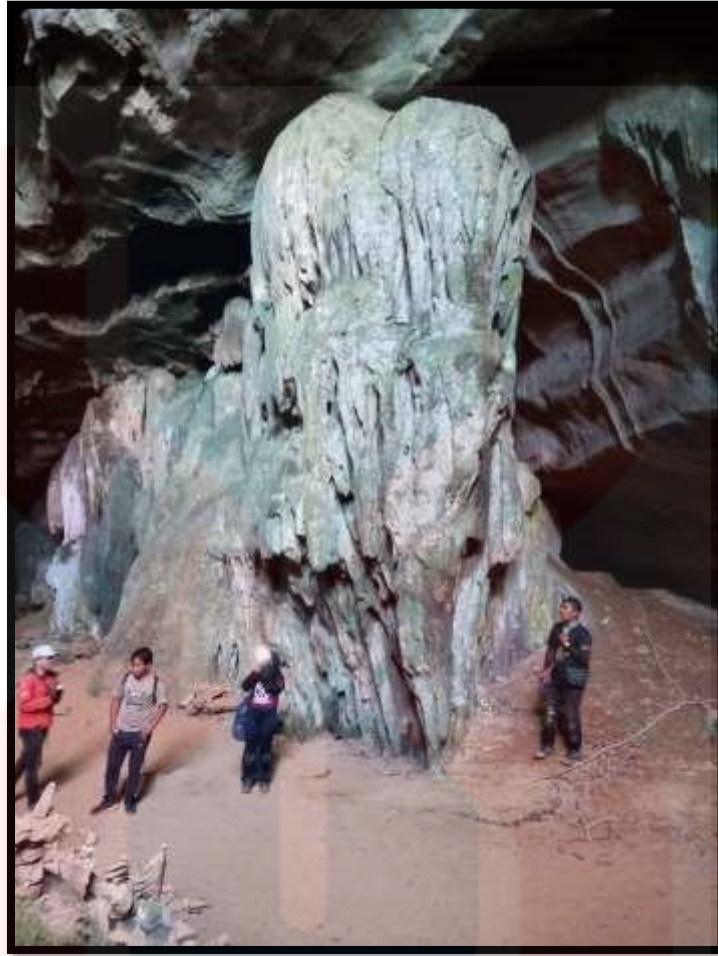


Figure 5.9: Column Formation

5.5 The special geological formation in Gua Ikan Karst Complex, Gua Pagar, Gua Keris and Gua Gelap

There are a few of geological formations that occurred in Gua Ikan Karst Complex, Gua Pagar, Gua Keris and Gua Gelap. The uniqueness of the study area was attract many tourism for traveling to the Gua Ikan Complex. There are many special formations that happened on the earth surface, which is karst, cave, limestone cave.

1.5.1 Gua Ikan



Figure 5.10: Stalactite and stalagmite

1.5.2 Gua Pagar



Figure 5.11: Seaweed Fossil



Figure 5.12: Monkey head stone

1.5.3 Gua Keris



Figure 5.13: Formation of dagger at Gua Keris

CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

As a conclusion, the geological map of the study areas, which are the Gua Ikan Complex, Dabong Districts, can be produced at a scale of 1:25,000. An updated geological map is extremely important and advantageous for geologists to use as a reference while doing research and geological field or survey work. Instead, an updated geological map can help future researchers collect data and geological information about an area more easily.

The geomorphology and landscape of Gua Ikan Complex, Gua Pagar, Gua Keris, and Gua Gelap are particularly suited for geosite potential due to their high scientific, cultural, artistic, and social economic value due to human exploitation. The survey was done among experts and tourists to evaluate the geosite potential of

Gua Ikan Complex, Gua Pagar, Gua Keris, and Gua Gelap in study areas using the M-GAM model methodology. The main value and additional value are determined by the value that has been evaluated by both groups. Due to their unique geomorphological landforms, it is possible to conclude that the Gua Ikan Complex, Gua Pagar, Gua Keris, and Gua Gelap have beautiful scenery.

Furthermore, the score given by experts and tourists for the study area received good responses from the indicators as these areas developed. This is due to the fact that the locations are extremely scenic and have many facilities and tour guides for tourists to hike and explore because they are supplied by the organisations that run the places and have many facilities that comfort tourists when they visit with family. The examples are a prayer hall, a toilet, a playground, and a stall. Because it is suitable for all ages, this study area is suitable for recreation, family gatherings, and hiking: children have playgrounds; senior citizens can recreation around the Gua Ikan Complex; adventurers can hike the Gua Ikan, Gua Pagar, Gua Keris, and Gua Gelap; and adults can hike and explore the area of the Gua Ikan Complex.

Thus, the study area that is Gua Ikan Complex, Gua Pagar, Gua Keris, and Gua Gelap has a high potential to be a geosite and a geotourism destination in Dabong districts because it has highly unique geological formations that can be commercialised as natural places for tourism.

6.2 Recommendation

Based on the findings of this research, several areas demand modification and adjustment. This study applied primary and secondary sources to create a geological map; hence, the data may be less reliable. So, from there, it is recommended to do research in the field to take the primary data and analyse it on site rather than rely more on the secondary data. It was due to the primary, more accurate data and the most recent information that occurred in the study area. In addition, it is important to do petrographic analysis to understand the types of origin rock and the lithology that occurred in the study areas.

Besides that, touristic values have a high overall score for experts and tourists, and the study area is visited by many tourists, especially on public holidays, but the facilities for car parking are quite inadequate because there is not enough capacity to park many cars. To reduce overcrowding, it is suggested that a safety guard monitor the entrances and exits of study areas.

Finally, some of the caves in the Gua Ikan Complex, like Gua Pagar, need a new safety road and a larger, more secure iron ladder to make it easier for tourists to climb up. It will improve the safety aspects of the Gua Ikan Complex and increase the number of tourists.

REFERENCES

- Agency, U. S. (2021). *Land Use*. Retrieved from <https://www.epa.gov/reportenvironment/land-use>
- Aleksandar Antić, N. T. (2017). Geoheritage and Geotourism potential of the Homolje area (eastern Serbia). *Acta Geoturistica*, 5.
- Amin Beiranvand Pour, Mazlam Hashim (2015). Structural mapping using PALSAR data in the Central Gold Belt, Peninsular Malaysia. *Ore Geology Review*, 64(January), 13–22. Retrieved from <https://www.sciencedirect.com/science/article/pii/S0169136814001449>
- Azhar, F. Z. (2016). *Geology and structural analysis at Dabong, Kuala krai*, Retrieved from Undergraduate Final Year Project Report: <http://umkeprints.umk.edu.my/7831/>.
- Brilha, J. (2016). Inventory and Quantitative Assessment of Geosites and Geodiversity Sites: a review. *Geoheritage* 8: 119–134. DOI: 10.1007/s12371-014-0139-3., 2.
- Bruno, D. (2015). Concept of Geosite., *Encyclopedia of Mineral and Energy Policy*, 1.
- Cityfacts. (2019). *Dabong, Malaysia*. Retrieved from <https://www.cityfacts.com/dabong-kelantan>.

- Dowling, R. (2005). Global Geotourism – An Emerging Form of Sustainable Tourism. *Czech Journal of Tourism*, 2(2): 59–79. DOI: 10.2478/cjot-20130004.
- daily, H. (2022). *Aspiring Stong berpotensi sebagai geopark Kelantan*. Kuala Krai.
- David. (2011). *Gua Ikan Dabong, Kelantan*. Retrieved from Malaysia-Traveller: <https://www.malaysia-traveller.com/gua-ikan.html>
- Foundation, D. T. (2018). *Drainage Patterns and Drainage Systems of India*. Retrieved from <https://www.drishtiiias.com/to-the-points/paper1/drainage-patterns-and-drainage-systems-of-india>
- foursquare. (2023). *Dabong* . Retrieved from <https://foursquare.com/v/dabong/4cdcbb73930af04d46539297>
- Geographic,N. (2022). *Location*. Retrieved from <https://education.nationalgeographic.org/resource/location>.
- GSA, G. S. (2012). Geoheritage, GSA Position Statement, pp. 56-58.
- Habib Nur, H. S. (2017). Analisis Geosite Dan Geomorphositekawasan Karsbiduk-Biduk. *Departemen Teknik Geologi, Fakultas Teknik, Universitas Gadjah Mada, Yogyakarta*, 2.
- Hashim, A. B. (2016). Application of Landsat-8 and ALOS-2 data for structural. *Nat. Hazards Earth Syst. Sci.*, 6.
- Henriques M.H., P. d., & et al, H. (2011). Geoconservation as an Emerging Geoscience. *Geoheritage*, 3(2): 117–128. DOI: 10.1007/s12371-011-0039-8.
- Henriques, M. (2017). UNESCO Global Geoparks: a Strategy towards Global Understanding and Sustainability. *Episodes*, 40(4): 349–355.
- Hutchison, C. S. (2014). *Geology of Peninsular Malaysia*. Malaysia: The University of Malaya and Geological Society of Malaysia.
- Insider, L. (2022, May 26). *Laboratory analysis definition*. Retrieved from <https://www.lawinsider.com/dictionary/laboratory-analysis>.
- Jasni, S. N. (2022). General Geology and Evaluation of Gunung Reng, Kelantan as a Potential Geomorphosite.
- Kamal Roslan Mohamed, C. A. (2016). The Gua Musang Group: A newly proposed stratigraphic unit for the Permo-Triassic sequence of Northern Central Belt, Peninsular Malaysia. *Bulletin of the Geological Society of Malaysia*, 3.
- Kamal Roslan Mohamed, N. A. (2016). The Gua Musang Group: A newly proposed stratigraphic unit for the Permo-Triassic sequence of Northern Central Belt, Peninsular Malaysia. *Bulletin of the Geological Society of Malaysia*, 4, 5.

- Kelantan, L. K. (2021, Ogos 10). *Gua Ikan*. Retrieved from Gua Ikan – Kuala Krai: <http://www.kesedar.gov.my/gua-ikan/>.
- Komoo, I. (2000). Conservation Geology: A Multidisciplinary Approach in Utilization of. *Geological Society of Malaysia Annual Geological Conference 2000*, 2.
- Krishnasamy, M. R. (2013). General geology, microfaces analysis and diagenesis of limestone in Gua Ikan, Dabong, Kelantan. . *Undergraduate Final Year Project Report*, 1.
- Lario, C. d. (2021). *What is a geosite?* Retrieved from The Geosite of the Civagno River. Lake Como (Italy): <https://en.geositocivagno.com/cos-e-un-geosito>
- Latif, N. J. (2017). General geology and Characterization of clay properties in Jeli, Kelantan. 26.
- Maps, G. (2023). *Peta ke Gua Ikan Dabong* . Retrieved from https://www.google.com/search?tbs=lf:1,lf_ui:4&tbm=lcl&q=google+maps+ke+gua+ikan++dabong&rflfq=1&num=10&ved=2ahUKEwiJif-3hJn9AhUT7jgGHclqAeEQtgN6BAgPEAc
- Marija Bratić, M. M. (2020). *M-GAM method in function of tourism potential assessment: Case study of the Sokobanja basin in eastern Serbia*. Retrieved from Open Geoscience: <https://www.degruyter.com/document/doi/10.1515/geo-2020-0116/html?lang=en#:~:text=This%20model%20combines%20the%20opinion,marked%20from%200%20to%201.>
- Metcalf I. (1989). Triassic Sedimentation in the Central Basin of Peninsular Malaysia. *International Symposium on Intermontane Basins: Geology & Resources*, 1, 173–185. Retrieved from https://www.researchgate.net/publication/278159006_Triassic_Sedimentation_in_the_Central_Basin_of_Peninsular_Malaysia
- Metcalf, I. (2013). Tectonic evolution of the Malay Peninsula. *Journal of Asian Earth Sciences*, 76, 195–213. <https://doi.org/10.1016/j.jseaes.2012.12.011>
- Mitchell. A.H.G. (1977). Tectonic setting for emplacement of southeast Asian tin granites.pdf. *Bulletin of the Geological Society of Malaysia*, 9(Nov), 123–140. Retrieved from <http://www.gsm.org.my/products/702001-101295-PDF.pdf>
- MFA Patah, N. S. (2021). Distribution of light (LHREE) and heavy rare earth elements (HREE) in Kelantan granitoids rock. . *3rd International Conference on Tropical Resources and Sustainable Sciences*, 2.
- Mohsen Kalantari, F. B. (2011). Feasibility Analysis of Sustainable Development Emphasizing. *International Conference on Biology, Environment and Chemistry*, 2-4.
- Online, U. B. (2023). *Jambatan besi merintang Sungai Galas siap menjelang Aidilfitri*:. Retrieved from

<https://www.utusanborneo.com.my/2021/04/01/jambatan-besi-merintang-sungai-galas-siap-menjelang-aidilfitri-adun-nenggi>

- Panizza, M. (2001). Geomorphosites : concepts, methods and example of geomorphological survey. *Chinese Science Bulletin*, 46, Suppl. Bd, 4-6.
- Patah, M. F. (2021). Distribution of light (LHREE) and heavy rare earth elements (HREE) in Kelantan granitoids rock. . In *IOP Conference Series: Earth and Environmental Science* , 2.
- Richardson, J. (1950). Facies Changes and Lithological Variation in the PermoCarboniferous Formation of Northwest Pahang and Southeast Kelantan, Malaya. *Geological Magazine*,, 3.
- Sulaiman, N. S. (2020). Assessment of Limestone Caves in Dabong, Kelantan using Systematic Studies for Potential, Geoheritage Sites. *IOP Conference Series: Earth and Environmental Science*, 6.
- Sulaiman, N. S. (2021). Assessment of Limestone Caves in Dabong, Kelantan using Systematic Studies for Potential Geoheritage Sites. *2nd International Conference on Tropical Resources and Sustainable Sciences*, 1,2,3.
- Vujičić MD, V. D. (2011). Preliminary geosite assessment model (GAM) and its application on Fruška gora mountain, potential geotourism destination of Serbia. *Acta Geogr Sloven*. 2.
- Vujičić, M. V. (2011). Preliminary geosite assessment model (GAM) and its application on Fruška Gora Mountain, potential geotourism destination of Serbia. *Acta Geographica Slovenica*, 51(2), pp. 361-377.
- Zuidam. (1996). *Geologi*. 25,26,27.

APPENDIX A

Title: Evaluation of Potential Gua Ikan Karst Complex, Gua Pagar, Gua Keris and Gua Gelap Dabong Districts, Kelantan.



Questionnaire survey for a final year project conducted by Geoscience Programme, Faculty of Earth Sciences, Universiti Malaysia Kelantan.

Objective: evaluate the Geosite Potential of Karts in Gua Ikan Complex, Dabong District, Kelantan

Questionnaires for 4 caves.

Section 1 to 3

1. Gender:

Male Female

2. Ages (Years):

17-21 22-25 26-29 30 above

3. Level of education:

School Diploma

Degree

Employee Others

Section A (Main Value/MV)

1. Rarity-Gua Ikan Complex have special features which is related to geology?
 Example: caves, valley, river, and channels.

0 1

2. Representativeness-Didactic and exemplary characteristics of the site due to its own quality and general configuration.

0 1

3. Knowledges of geosite issues- the geological features occur on the study area.

0 1

4. Level of interpretation-Level of interpretive possibilities on geological and geomorphologic processes, and level of scientific knowledges.

0 1

Scenic/aesthetic (VSA)

5. Viewpoints- Viewpoints -Number of viewpoints accessible by pathway. Eg:has a walkway for walking.

0 1

6. Surface - Whole surface of the site. Each site is considered in quantitative relation to other sites.

0 1

7. Surrounding landscape and nature - Panoramic view quality, presence of water and vegetation.

0 1

8. Environment of site related - level of geosite is related to nature such as, color, shape of the earth.

0 1

Protection (VPr)

9. Current condition - Current state of geosite in Gua Ikan, Dabong.

0 1

10. Protection level- Eg: from local, government and international organizations.

0 1

11. Vulnerability - Vulnerability level of geosite. Eg: Difficulty to access, the presence of access controls or restrictions, protected areas.

0 1

12. Suitable number visitors.

0 1

Section B-Additional Values (AVs)

Functional (VFn)

13. Accessibility-Possibilities of approaching to the site.

0 1

14. Additional natural values -Number of additional natural values in the radius of 5 km (geosites also included).

0 ○○○○○ 1

15. Additional anthropogenic values - Number of additional anthropogenic values in the radius (Anthropogenic: something that is made by humans, e.g: excessive greenhouse gasses).

0 ○○○○○ 1

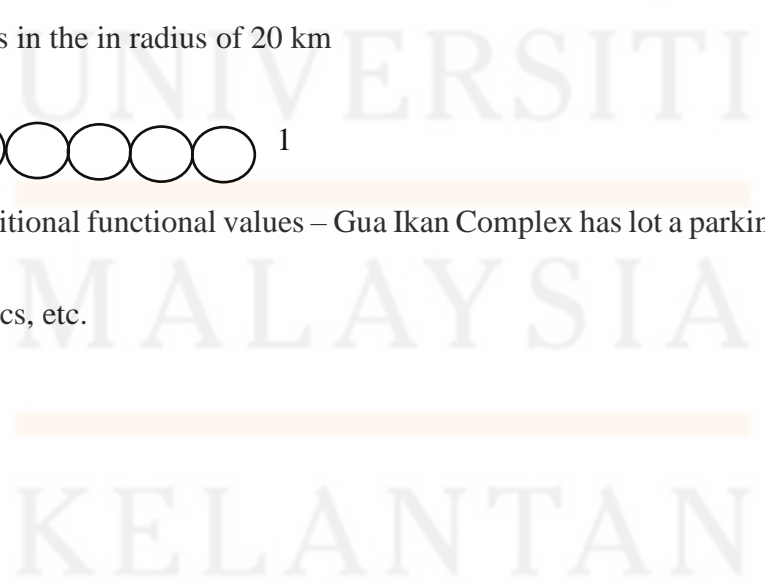
16. Vicinity of emissive centres - Gua Ikan Complex has an updated facilities management.

0 ○○○○○ 1

17. Vicinity of important road network - Gua Ikan Complex near to the important road networks in the in radius of 20 km

0 ○○○○○ 1

18. Additional functional values – Gua Ikan Complex has lot a parking lot, gas stations, mechanics, etc.



Touristic values (VTr)

19. Promotion - Gua Ikan Complex has high level and number of promotional resources.

0 1

20. Organized visits -Annual number of organized visits to the geosite.

0 1

21. Vicinity of visitor’s centres – Gua Ikan Complex has tourist information centre. It provided the visitors to a location with information such as maps.

0 1

22. Interpretative panels - Interpretative characteristics of text and graphics, material quality, size, fitting to surroundings, etc.

0 1

23. Number of visitors - Gua Ikan Complex has a lot number of visitors especially in public holidays.

0 1

24. Tourism infrastructure – Gua Ikan Complex has provided infrastructure for tourist (pedestrian pathways, resting places, garbage cans, toilets, etc.).

0 1

25. Tour guide service - If exists, expertise level, knowledge of foreign language interpretative skills, etc.

0 1

26. Hostelry service - Hostelry service close to geosite.

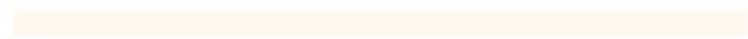
0 1

27. Restaurant service

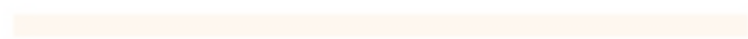
0 ○○○○○ 1



UNIVERSITI



MALAYSIA



KELANTAN