GEOLOGY OF SUNGAI SIPUT LIMESTONE QUARRY WITH EMPHASIS ON SOME PETROPHYSICAL CHARACTERISTICS

by

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13768

Dissertation submitted in partial fulfillment of

the requirements for the

Bachelor of Technology (Hons.)

Petroleum Geoscience

JUNE 2014

Universiti Teknologi PETRONAS

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Perak

CERTIFICATION OF APPROVAL

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Approved by,

____

(A.P. DR ESWARAN PADMANABHAN)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

JANUARY 2014

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

NAZMY AMIR BIN HAMIDUN MAJID

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Acknowledgement

First of all, I would like to express my gratitude to my Final Year Project Advisor, AP. Dr. Eswaran Padmanabhan for is assistance in completing this project throughout the entire length of this project. Highest gratitude is also for the late Dr. Essam Mansour, at which to whom this project is dedicated as the title were one of his final ideas before his early passing. May he rest in peace.

I also would like to thank my parents, all lecturers and dear friends who has been very supportive in this 5 years of my study in Universiti Teknologi PETRONAS. The experience gathered during this time is priceless and is hoped to help in helping me to become a professional in the oil and gas industry.

The final year project is a great exposure especially to us, Petroleum Geoscience students, at which the project helps us to implement and to test theories learnt in classroom into practice, thus securing the knowledge to ourselves. In the project titled “Geology of Sungai Siput Quarry with Emphasis on Some Petrophysical Characteristics”, I has learnt a lot in conducting a geological fieldwork as well as conducting a number of tests to confirm the ideas and hypotheses based on the observation of the study area. And it is hoped that the project can be used and useful to the geological community today.

Here, I also would like to acknowledge all the personnel who at which has helped me in completing this project directly or indirectly. Special thanks to AP Askury Abdul Kadir, Mr. Solomon and not to forget the staff of Jabatan Mineral dan Geosains, Ipoh for their guidance given.

Finally, I would like to express my gratitude to Universiti Teknologi PETRONAS for designing a course structure as useful as this. The experience is really beneficial in preparing ourselves before becoming industry players.

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Abstract

This project is about the sedimentation and petrophysical characteristics of limestone found in Sungai Siput. The area is mostly made up of limestone hills that were remnants of massive carbonate beds covered with alluvial sediments. This research will provide geological study of the area as well as providing a geological map of the study area. The study is divided into two parts in which the first part is the geological mapping of the area followed by the relation of carbonate facies to the petrophysical properties of the area. The study also includes a number of test such as porosity and permeability, to measure reservoir quality of limestone found in the area, and thin section analysis which allows us to determine and examine the mineral composition found in the rock.

CHAPTER 1: INTRODUCTION

1.1 Background

Sungai Siput is located in the state of Perak. It is mostly made up of unique landform and terrains of limestone features. The area is covered with mountainous limestone cliffs and enormous karstic formation as well as pinnacled limestone bedrock. Kinta Valley once one of the main producer of tin ore or cassiterite around 1876 to 1950.

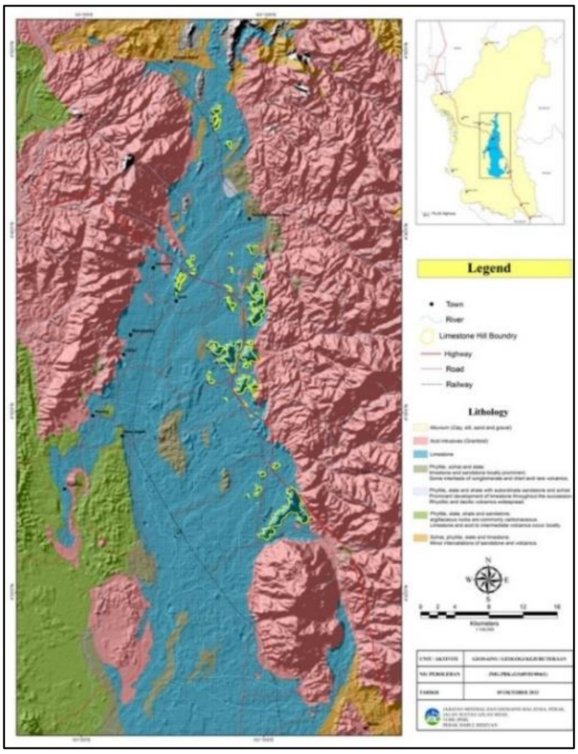


Figure 1: General Geology of Kinta Valley (JMG, 2012)

Kinta Valley carbonate hills dominates the area of about 200km^2 and are the remaining remnant of an extensive carbonate system formed during Palaeozoic and covers large parts of South East Asia. The area is mainly composed of limestone beds interbedded with sediments such as sandstone and siltstone with total of 3000m in thickness.

Generally, the geologic history of Kinta Valley is located on top of a limestone bedrock called Kinta Limestone. This very limestone is the one that rises and forms the vast and extensive coverage of steep limestone hills found throughout Kinta Valley. The limestone bedrock is covered with thick alluvial sediments. The presence of two large granitic range to the East and West of Kinta Valley gives the tin rich alluvial sediments which has been mined for centuries.

Yin (1976) and Ingham & Bradford (1960) indicated that the limestone were formed during Palaeozoic together with some basal schist followed by granitic intrusion which forms the Main Range and Kledang Range. During the formation of granite ranges, contact metamorphism occur at which the limestone were transformed into marbles and the evidence can be clearly seen at the Southern part of Kinta Valley especially in Simpang Pulai where the area is mostly made up of marble hills. Following the granitic intrusion, the some limestone were dissolved and formed the karst that can still be observed today. Finally, in Quaternary, alluvium were deposited in the valley which also carry tin ores.

Past researches focused on the economic value of the rock as well as the mineral deposition found within Kinta Valley. In this research, it is hoped that new properties of the limestone facies could be discovered and help in understanding this unique formation found within the State of Perak.

1.2 Problem Statement

There are a number of studies that has been conducted in Kinta Valley area. However, most of the studies conducted mostly covers on the mineral deposits and the economic value of the area especially in tin ore accumulation.

In this study, the main focus is to determine the reservoir quality based on the facies type found within the formations found in Kinta Valley limestone. The research conducted will give new insight on the geological setting and reservoir quality of limestone within Kinta Valley. Besides, this research will also produce a geologic map that can be used to determine the distribution of facies throughout the area.

1.3 Objective and Scope of Study

The scope of study is on the sedimentology and petrophysical properties of selected limestone in Sungai Siput.

The objectives of the study are as follows;

- To evaluate the geology of the Sungai Siput area specifically in the limestone area.
- To conduct a study on the sedimentological variation of the limestone and its impact on certain petrophysical property.
- To evaluate the reservoir quality of different facies present.

CHAPTER 2: LITERATURE REVIEW AND THEORY

Limestone is a sedimentary rock composed mainly of calcium carbonate, $CaCO_3$ and this mineral made up the majority of formation found in Kinta Valley, Perak (Tan, 2010). All the limestone mountainous hills are what remains from the limestone beds that were eroded which formed around Paleozoic (Ordovician to Permian), (Askury et. al., 2008). The hills have almost similar characteristics which includes tower-like morphology with rounded tops that is formed by the karstification or dissolution of limestone by water.

The limestone of Kinta Valley is estimated to be of about 3000m thick and is made up of succession of Carboniferous limestone, dolomite and black shale interbedded with carbonaceous shale. Structurally, the formation is highly folded and faulted and there are regions of which the limestone has been metamorphosed due to direct contact with igneous body found in the western belt of the Main Range (Chappell and White, 1974).

Studies conducted in the 1970s' in the area has speculated that there are potential hydrocarbon play based on the sedimentary facies, structural history and regional setting. However, the study concluded that the only successful play is the basement play due to fractured basement. The area is most likely to have good reservoir quality through dolomitization and dissolution of the reservoir rock.

CHAPTER 3: METHODOLOGY

The first part of the study was conducted by mapping the general area of the location based on the lithology. The geological map produced will provide the information about the type of rocks present in the study area. A field work was conducted to gather information of strike and dip of formations. The data gathered is then being used to evaluate the structural geology of the area.

For the geological fieldwork, among the required equipment are;

- Geological hammer
- Compass
- Magnifying lens
- Global Positioning System device (GPS)

Sedimentary logs of the area were produced at which indicate the differences between facies and from it allows us to identify the relationship between facies and the different reservoir quality. The sedimentary logs encompasses the composition, texture, sedimentary structure and other observable features found within the outcrop. From this, the depositional environment of the rock unit can be deduced.

Then, a number of tests will be conducted to samples gathered from site to ensure that the properties of the formation is fully understood. The tests that will be conducted includes;

1. Porosity and Permeability
2. Thin Section Analysis
3. Thermal Conductivity

3.1 Porosity and Permeability

In porosity and permeability test, the rock sample is tested its reservoir quality which is the ability to store and transmit the fluid within the reservoir body. In this test, different facies of carbonate rocks gathered was tested to determine which facies of the formation with the most porosity and permeability.

The theory in porosity measuring is by using helium expansion based on Boyle's Law which states that the product of pressure in an ideal gas and volume would always give out constant value at constant temperature (Cone, M. P. and Kersey, D. G., 1992). The void space in between the grains can be calculated by measuring the volume of gas of known pressure and temperature, in this case, helium into the rock sample. The pore volume is calculated by using the formula;

$$Porosity = \frac{V_{bulk} - V_{grain}}{V_{bulk}} \ x \ 100$$

In permeability, it is the measure of the capacity of a porous medium to transmit fluid. The test is conducted by encasing a core plug of known length and diameter into an air-tight sleeve. Fluid of known density is then injected through the core plug and the difference of pressure of one end to the other is measured. The permeability is then calculated by using the formula;

$$q_w = c \ \frac{A \ \Delta h_w}{L}$$

Where;
qw = volumetric flow rate of water
L = vertical height of the filter bed
A = cross sectional area of filter bed
c = proportionality constant
Δhw = vertical head of water above the outlet pipe

3.2 Thin Section Analysis

Thin section test is a test to determine mineral composition of a rock by analyzing the rock under a microscope. Mineral composition of the rock can be differentiated by the characteristic of the mineral under polarized or cross-polarized light. The rock sample will show the microscopic texture and structure which are critical in understanding the origin of the rock.

The test is conducted by making a thin sample of the rock and making it to be translucent that will allows us to study the petrophysical properties of the rock sample.

<u>Procedure in Thin Section Analysis</u>

1. The sample is immersed into the epoxy and vacuum impregnate to fill the pores and mechanically support the specimen material.

2. Sample obtained is first cut into smaller base size probably slightly smaller than the glass plate by using the Geocut machine.

3. Sample base is grinned so that it is smooth by using the Forcipol grinding machine. This is to avoid bubbles when the sample is glued onto the glass slide.

4. Hold the base surface against light at approximately a 45 degree angle. An evenly reflective surface indicates that the entire surface has been grinned properly. A non-uniform, dull surface may indicate the entire surface is not flat and should be grinned for a longer time.
5. Glass slide is heated on the heater. After some time, adhesive resin is applied onto the glass slide and immediately, sample is placed onto the adhesive and pressed to remove air.
6. The attached sample is left to cool down for a day.
7. The glass slide with sample is mounted onto the Micracut precision cutter and cut into a thinner layer.
8. The thin layer is further grinned by using the Forcipol grinding machine to achieve 30 µm thin section.

9. Thinned sample is observed below the microscope to see whether we can see the minerals. The grinding process is continued until minerals are visible.
10. Steps 1 to 9 is repeated for all sample.

Figure 2: Geocut Sectioning Machine

Figure 3: FORCIPOL 300-1V Grinder

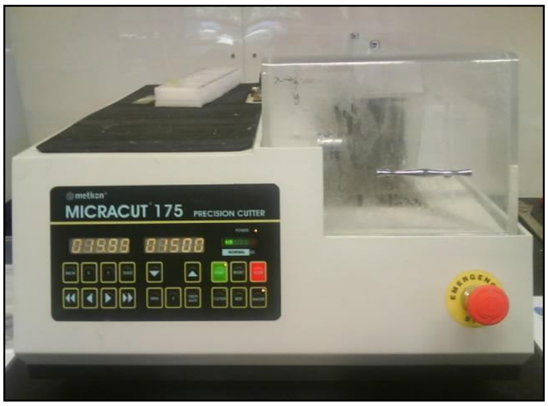


Figure 4: Micracut 175 Precision Cutter

Figure 5: Example of Completed Thin Section Sample

3.3 Thermal Conductivity Analysis

Thermal conductivity is an analysis where the relation between temperature gradient and the heat flow within a rock. Thermal conductivity plays an important role in transfer properties of fluid interactions which is a good way to understand the fluid-rock interactions between the porous and fracture network and to predict the porosity of a rock reservoir (Surma & Geraud, 2003). The thermal conductivity value is usually perpendicular to the layers and the value differs based on the direction of rock layers.

In this analysis, thermal conductivity is conducted to measure the rocks temperature gradient of the rock facies.

<u>Procedure in Thermal Conductivity Analysis</u>

1. The rock sample is identified and lines are drawn on the face of the rock. The lines are 10cm in length and 1cm apart.
2. The minerals present in the line is identified for each line at 1cm separation.
3. By using a heating pad, one side of the rock is heated perpendicular to the lines drawn for 5 minutes.
4. The temperature at both ends of the line is measured by using electronic thermometer.
5. The temperature is recorded at all lines.
6. The thermal conductivity of the rock is then calculated using the formula:

$$k = \frac{Q\Delta x}{A(T_2 - T_1)}$$

CHAPTER 4: RESULT AND DISCUSSION

4.1 Sedimentology and Geology of Study Area

<u>Field Characteristics</u>

The main lithology found in the study area is limestone. Limestone is a sedimentary rock composed mainly by calcium carbonate, $CaCO_3$ with the main mineral of calcite. Usually, carbonate rocks are formed by the formation of coral reef platforms in shallow water by organic organisms, but, calcite can also be precipitated directly from calcium carbonate from the water.

Limestone found within the area are mostly white to greyish in color with some thin iron bands in between them which indicates the precipitation of iron in the place. The carbonate rocks found does not contain any visible calcareous skeletal organisms which indicates lack of organic built-ups.

Figure 6: Limestone outcrop in study area

Structural Analysis

There are a number of structural features that can be observed during the fieldwork. The most dominant feature found within this limestone hills are joints and some faults. The deformation features exhibited by the limestone formation are mostly caused by tectonic forces. This is probably due to the presence of a granitic range within the area.

- Joints

Joints are defined as the fractures within the surface of the rock but without any displacement. It can be categorized into non-systematic joints and systematic joints which is based on its orientation and angle of jointing. In non-systematic joints, the angle between joints are irregular while systematic joints usually exhibit a dihedral angle of 30°–60° and orthogonal which its dihedral angle are 90°.

Based on the fieldwork conducted, there type of joint that is found in the area are mostly non-systematic joints due to the irregularities of the rock joints. However, there are also rock sample that exhibit almost parallel jointing that can be mistaken as faults.

Figure 7: Example of highly jointed rock outcrop (non-systematic)

Figure 8: Parallel jointing system

- Fault

In the field observation, faults also is observable from the rock outcrop. In general, faults can be divided into three types which are, dip-slip fault, strike-slip faults and oblique faults.

In the field, a major fault is observed to be at about 140° from the North (strike).

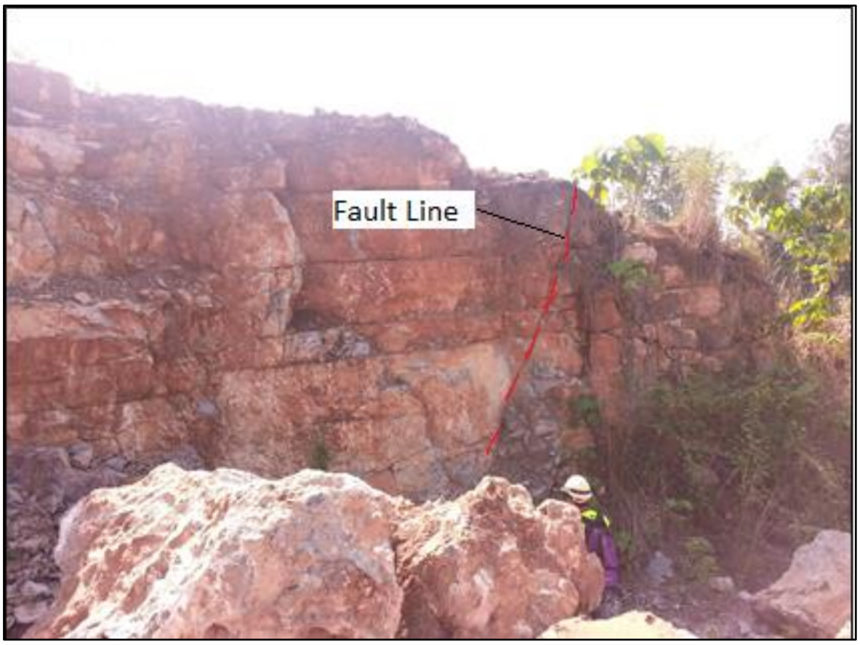


Figure 9: Major fault found in field

- Cave System

This area in Sungai Siput also exhibit features such as the re-precipitation of carbonate on the walls indicative of a cave system was once in place. This feature indicates that the carbonates were dissolved and then were deposited on the walls of the cave.

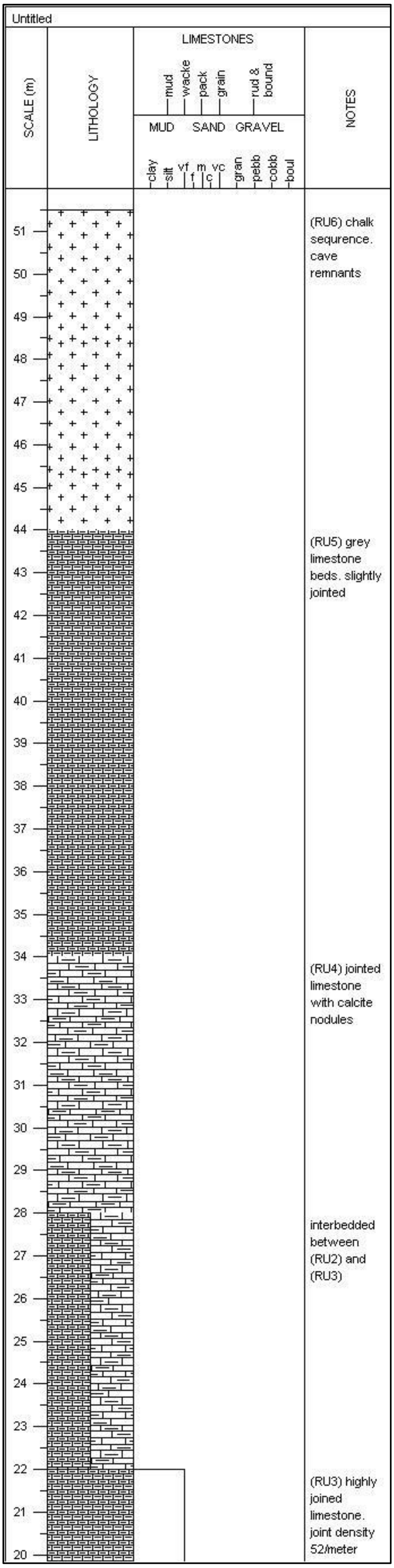
Figure 10: Lamination caused by re-precipitation of carbonate usually found in caves

Besides, there are also some stalactites exposed on the outer part of the cave which also indicates that the area was once a cave system. This is proven by the fact that stalactites can only form within a cave with enough supply of carbonate rich water to allow recrystallization of carbonates.

Stratigraphic Sequence

Based on the fieldworks conducted, there are a few data that can be used in determining the sequence of limestone in the area. The preliminary stratigraphic log which shows the different facies found within the area. The outcrop location is based on the different type of facies and significant changes in physical property of the lithology. The table at which the data collected is attached in the appendix as Table 2 in the appendices.

The sedimentary data is then used to produce stratigraphic log that is based on the thickness and properties of the different facies. In general, the sedimentary sequence of the limestone hill found in the area can be condensed into the following;


Untitled
SCALE (m)
LITHOLOGY
LIMESTONES
mud
wacke
pack
grain
rud & bound
MUD SAND GRAVEL
clay
silt
vf
f
m
c
vc
gran
pebb
cobb
boul
NOTES
51
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48
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20
(RU6) chalk sequrence. cave remnants
(RU5) grey limestone beds. slightly jointed
(RU4) jointed limestone with calcite nodules
interbedded between (RU2) and (RU3)
(RU3) highly joined limestone. joint density 52/meter

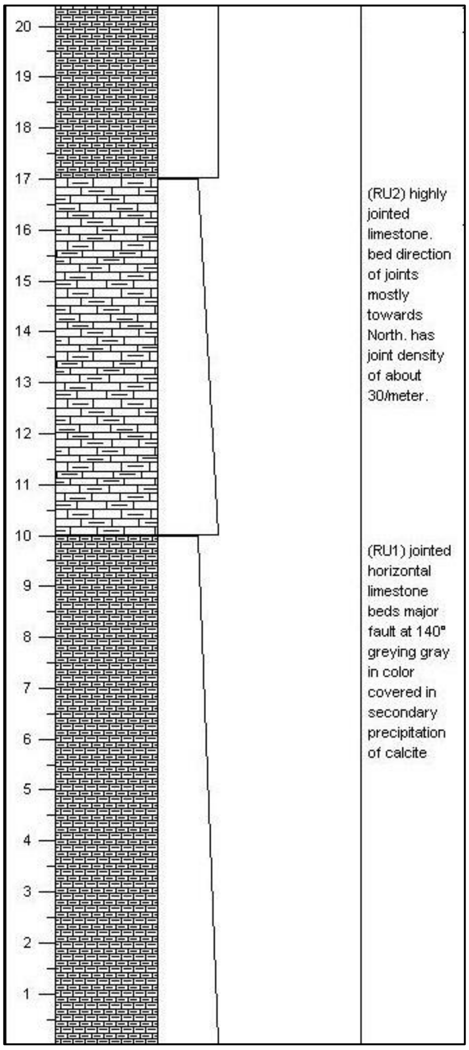


Figure 11: General stratigraphic sequence of exposed limestone

The stratigraphic sequence shows the different variation of limestone facies found in the study area. From the study, it is noted that the limestone are made up of six observable rock units. The different rock units indicates the small variation in the outcrop from the bottom to the top of the hill.

The sedimentary setting of the location starts with a greyish to grey limestone rock (RU1). The thickness is about 10m with heavily jointed limestone outcrop. The rock is covered by calcite precipitation.

The second rock unit (RU2) observed in the field is about 7m of not heavily jointed rock formation overlain by the third unit (RU3) with thickness of about 5m.

The differences between them is that the joint density of the units can be clearly seen with about 30 joints/m in RU2 and 52joints/m in RU3.

Sedimentary sequence of the area is followed by the interbedded between RU2 and RU3 with about 6m in thickness.

It is then followed by RU4, RU5 and RU6 which indicates jointed limestone with calcite nodules, grey limestone beds with slight jointing and finally chalk sequence with cave remnants.

<u>Maps</u>

Figure 12: Contour map of study area

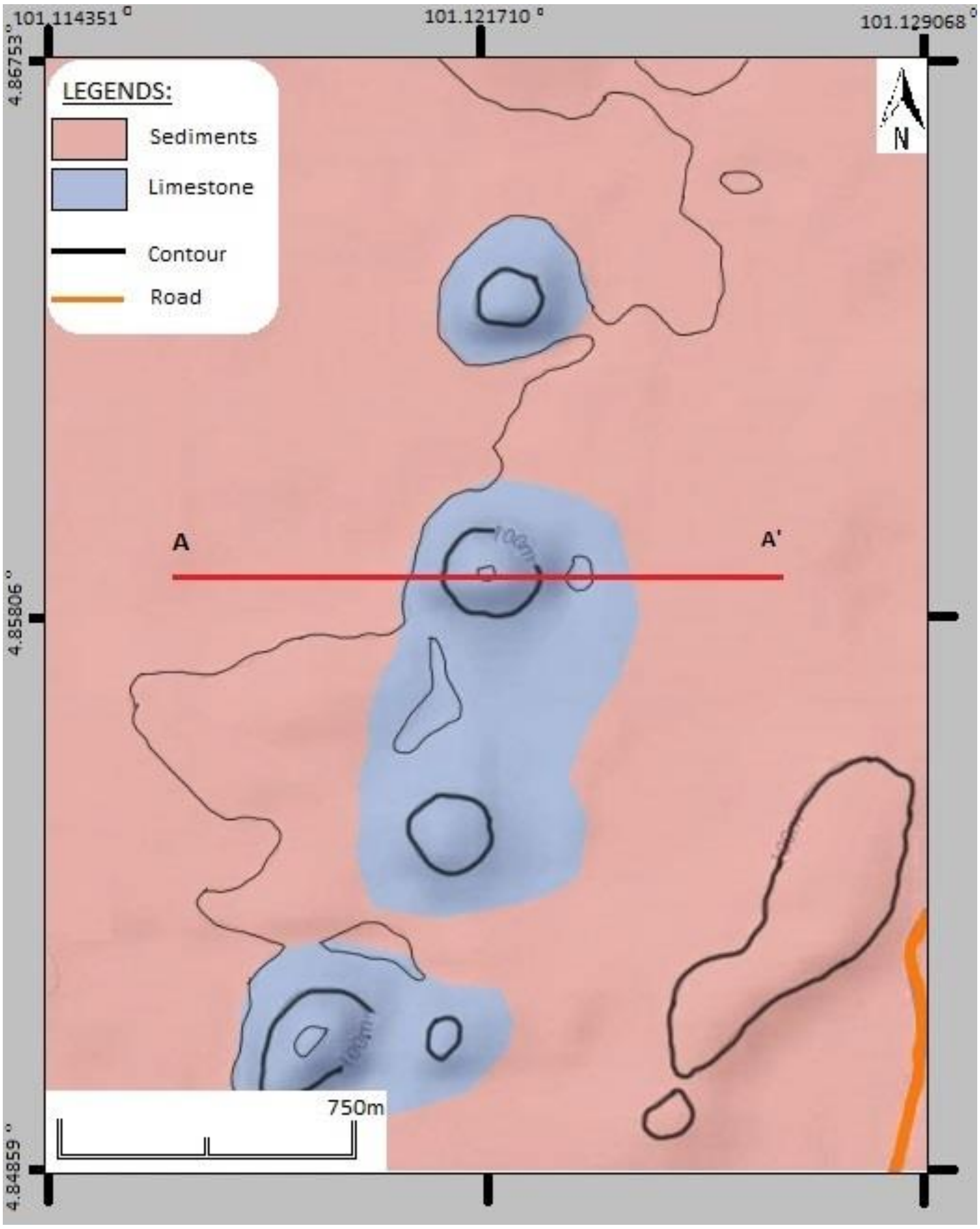


Figure 13: General geologic map of Sungai Siput area

Based on the research, the study area is the cluster of limestone hills with alluvial deposits covering area in between.

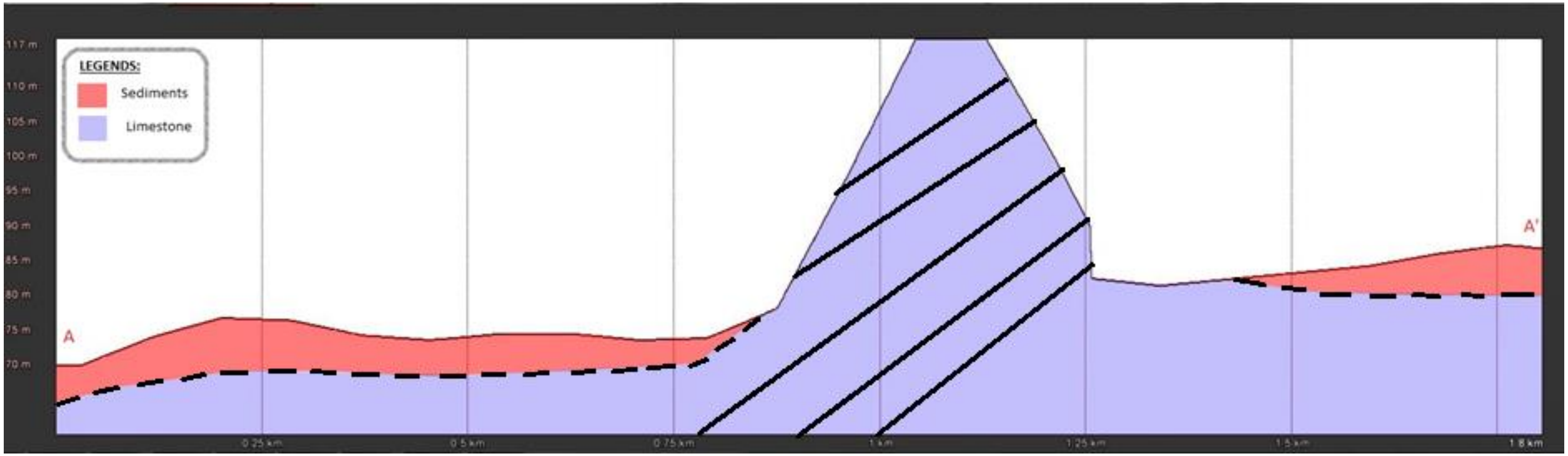


Figure 14: Cross section of the limestone hill

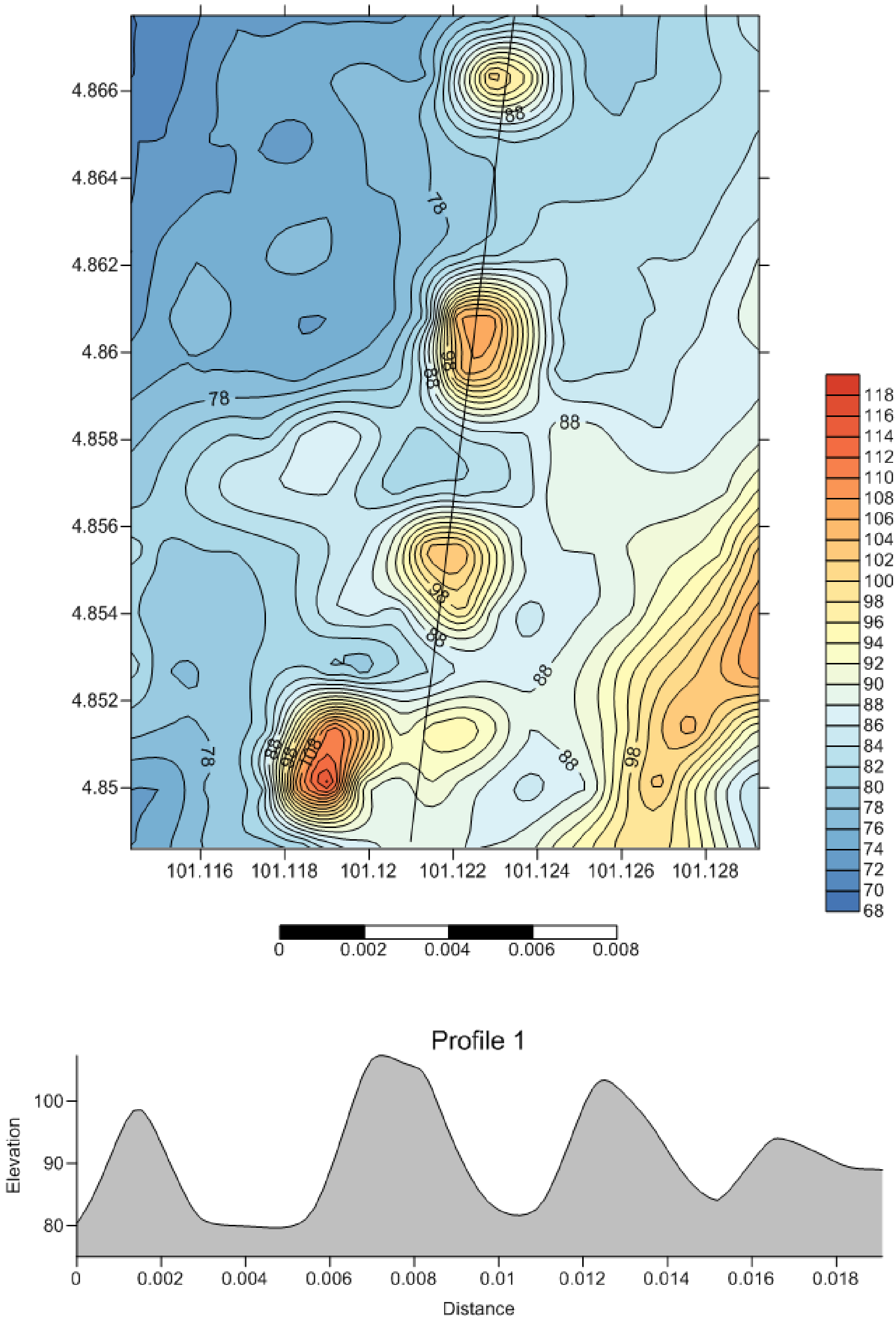


Figure 15: Elevation profile of the study area

The elevation profile is generated from the past researches conducted in the area which encompasses the elevation of the area. Contours were generated by joining the points which has similar in elevation and the result are as above. The cross section indicate the height of limestone hills in the area. This profile is used in determining the lithology boundary of the outcrop.

Rose Diagram and Stereonet

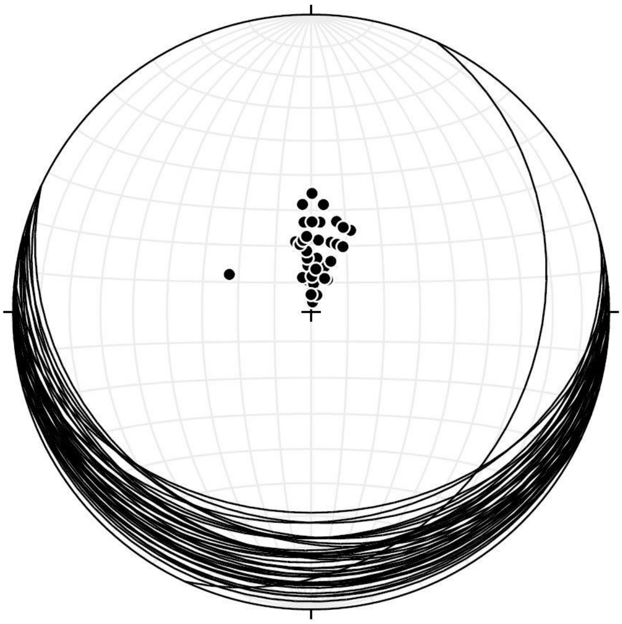


Figure 16: Stereonet of joints found in Location 1

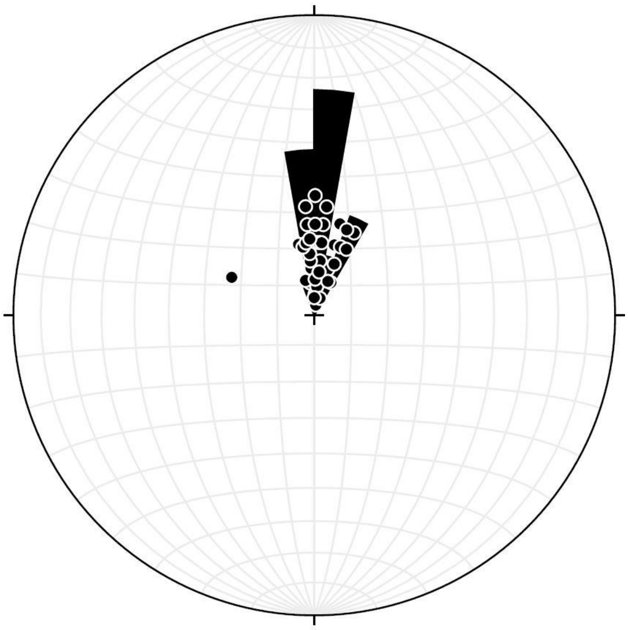


Figure 17: Rose Diagram of Location 1 joints

Based on the rose diagram, the most prominent force that causes the formation of joints are in North-South in direction. The reading of joints are consistent as the outcrop exhibit only one direction of joints.

<u>Outcrop Photos</u>

Figure 18: Limestone outcrop with parallel joints

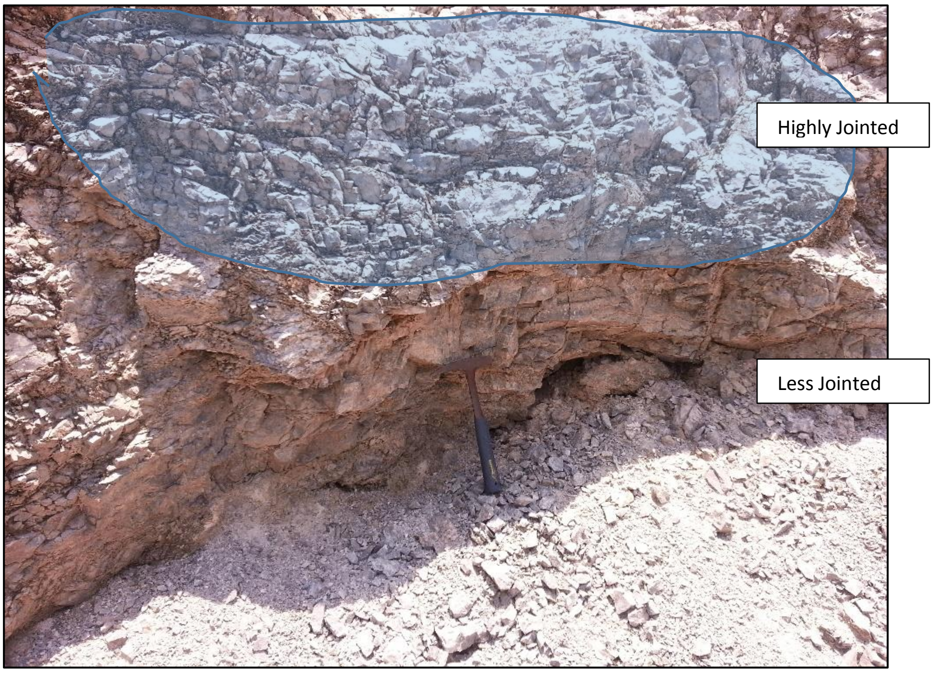


Figure 19: Contact between highly jointed with less jointed limestone facies

Figure 20: Limestone facies with 1-2cm calcite nodules

Figure 21: Remnant of a cave system

4.2 Porosity and Permeability Analysis

From the analysis conducted, the result for porosity and permeability of selected sample of limestone are as follows;

Table 1: Table of Porosity and Permeability

Key Parameters						
Sample #	1	2	3	4	9	11
Sample diameter, mm	25	25	25	25	25	25
Core length, mm	27	27	26	27	29	26
Core weight, g	41.03	40.72	37.83	39.98	41.86	36.58
Confining pressure, Psi	400	400	400	400	400	400
Bulk volume, cc	13.25	13.25	12.76	13.25	14.24	12.76
Pore volume, cc	0.133	0.266	0.192	0.33	0.285	0.383
Porosity, %	1	2	1.5	2.5	2	3
Permeability, mD	2	3	2	5	6	11

The porosity of the limestone facies found in the area shows an average of 1-3% in porosity and about 2-11mD in permeability. This is considered as very poor in terms of reservoir quality and its storage capacity to contain hydrocarbon.

The highest value in both porosity and permeability of the limestone sample is found at Sample 11 with porosity of 3% and 11 mD in permeability while the lowest value recorded is 1% in porosity and 2 mD permeability in Sample 1.

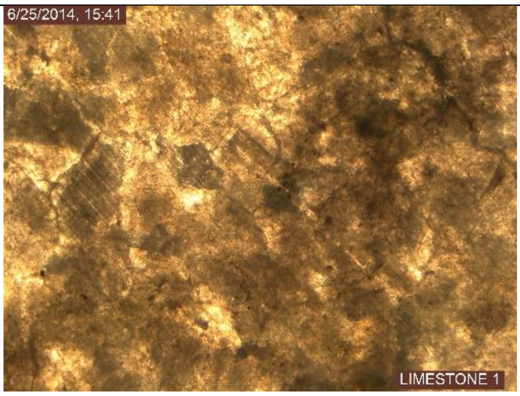
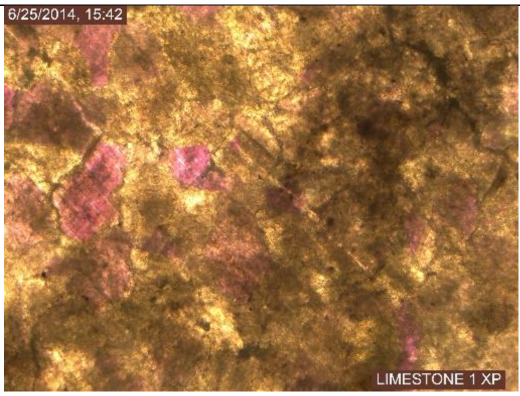
Based on the analysis, even though the limestone does have reservoir properties in porosity and permeability, the value is not significant enough for it to be a good reservoir. Hence, the rock formation is considered as very poor in this aspect.

4.3 Thin Section Analysis

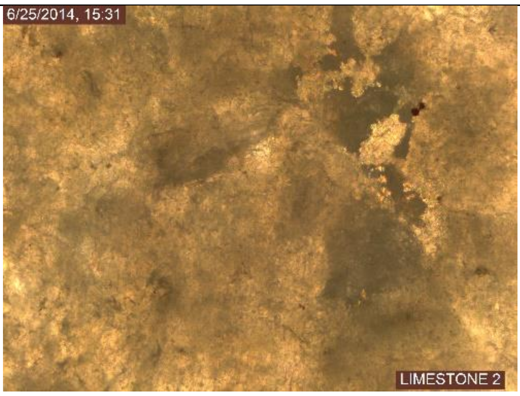
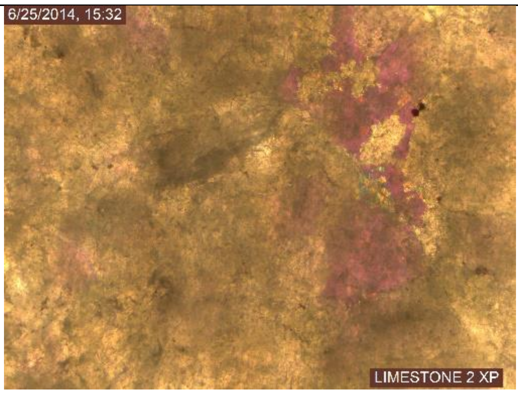
Sample Description

Sample #	Description
1	Grey limestone RU1
2	Grey limestone
3	Grey limestone
4	Highly jointed RU3
9	Interbedded between RU2 and RU3
11	Limestone with chalk RU6

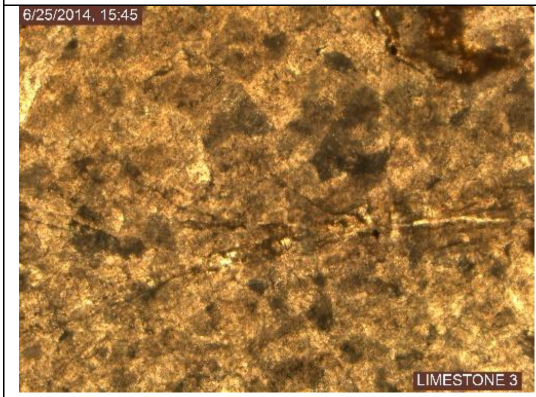
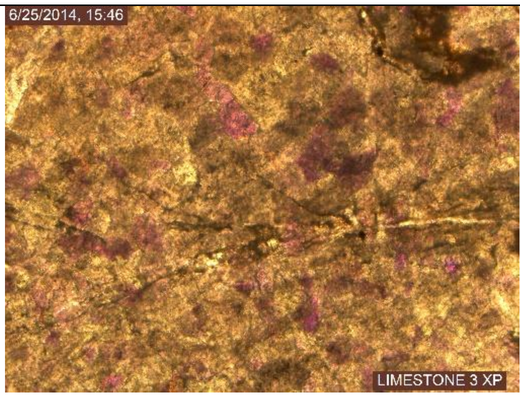
Sample Number 1 (4x)

Plain Light	Cross Polarized Light
	

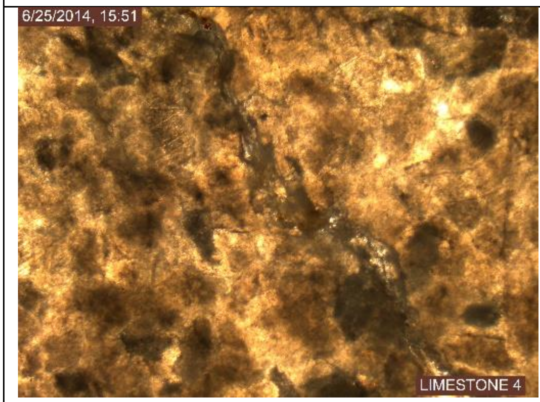
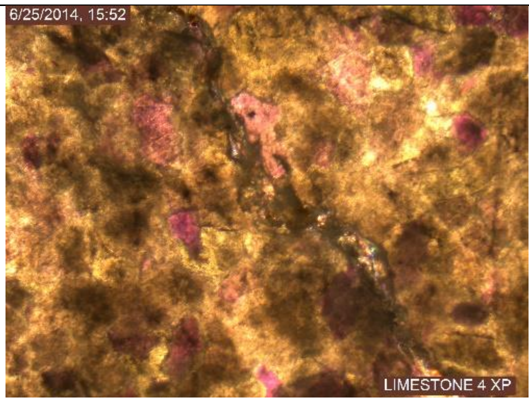
Sample Number 2 (10x)

Plain Light	Cross Polarized Light
	

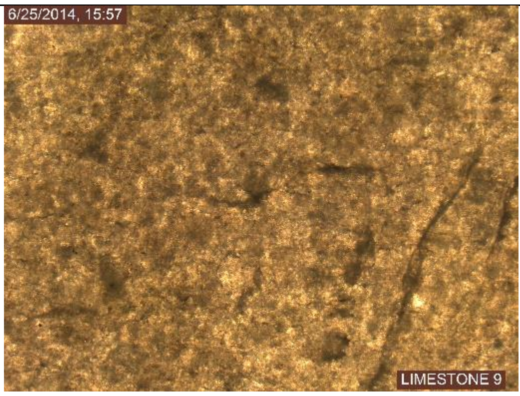
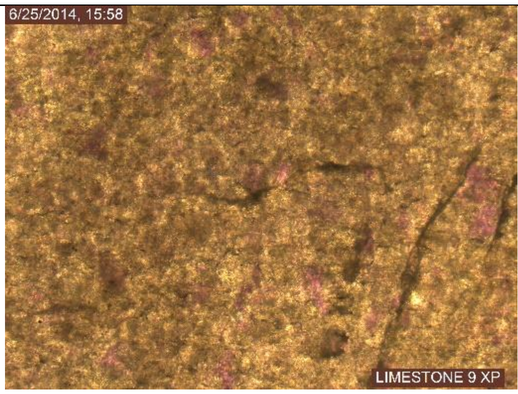
Sample Number 3 (4x)

Plain Light	Cross Polarized Light
	

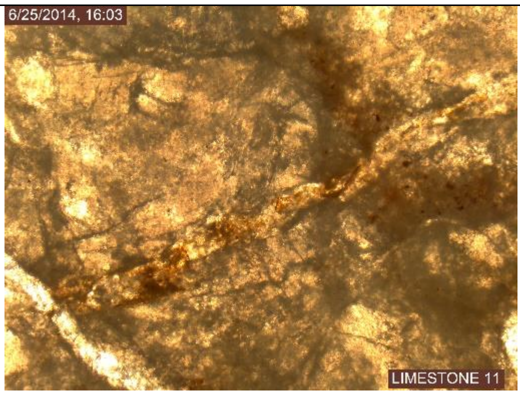
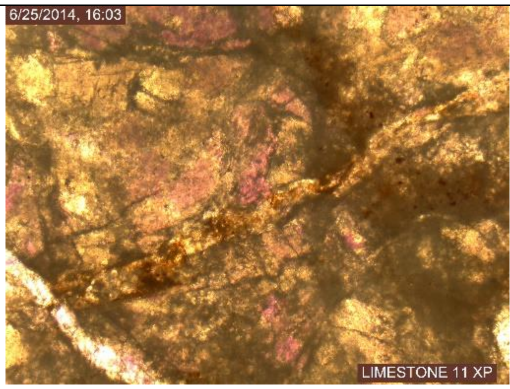
Sample Number 4 (4x)

Plain Light	Cross Polarized Light
	

Sample Number 9 (4x)

Plain Light	Cross Polarized Light
	

Sample Number 11 (4x)

Plain Light	Cross Polarized Light
	

From the thin section analysis, the main mineral of the limestone rock formation is calcite and some dolomite and the grains is not clearly distinguishable. This explains the low level of porosity and permeability of the rock samples.

4.4 Thermal Conductivity Analysis

SAMPLE 1								
	Q	Q/t	L	A	T1	T2	DT	k
line 1	40	0.011111	0.08	0.0096	22.4	23	0.6	1.54321
line 2	40	0.011111	0.08	0.0096	22.4	23.1	0.7	1.322751
line 3	40	0.011111	0.08	0.0096	22.4	23.1	0.7	1.322751
line 4	40	0.011111	0.08	0.0096	22.4	23.2	0.8	1.157407
line 5	40	0.011111	0.08	0.0096	22.4	23.1	0.7	1.322751

SAMPLE 2								
	Q	Q/t	L	A	T1	T2	DT	k
line 1	40	0.011111	0.1	0.0048	22.5	23.1	0.6	3.858025
line 2	40	0.011111	0.1	0.0048	22.5	23.2	0.7	3.306878
line 3	40	0.011111	0.1	0.0048	22.5	23.2	0.7	3.306878
line 4	40	0.011111	0.1	0.0048	22.5	23.3	0.8	2.893519
line 5	40	0.011111	0.1	0.0048	22.5	23.4	0.9	2.572016

SAMPLE 3								
	Q	Q/t	L	A	T1	T2	DT	k
line 1	40	0.011111	0.09	0.008625	22.4	22.7	0.3	3.864734
line 2	40	0.011111	0.09	0.008625	22.4	22.7	0.3	3.864734
line 3	40	0.011111	0.09	0.008625	22.4	22.8	0.4	2.898551
line 4	40	0.011111	0.09	0.008625	22.4	22.8	0.4	2.898551
line 5	40	0.011111	0.09	0.008625	22.4	22.9	0.5	2.318841

SAMPLE 4								
	Q	Q/t	L	A	T1	T2	DT	k
line 1	40	0.011111	0.09	0.005225	22.7	23.1	0.4	4.784689
line 2	40	0.011111	0.09	0.005225	22.6	23.2	0.6	3.189793
line 3	40	0.011111	0.09	0.005225	22.6	23.2	0.6	3.189793
line 4	40	0.011111	0.09	0.005225	22.6	23.2	0.6	3.189793
line 5	40	0.011111	0.09	0.005225	22.6	23.2	0.6	3.189793

SAMPLE 9								
	Q	Q/t	L	A	T1	T2	DT	k
line 1	40	0.011111	0.08	0.0077	22.6	23.1	0.5	2.308802
line 2	40	0.011111	0.08	0.0077	22.6	23.1	0.5	2.308802
line 3	40	0.011111	0.08	0.0077	22.6	23.3	0.7	1.649145
line 4	40	0.011111	0.08	0.0077	22.6	23.3	0.7	1.649145
line 5	40	0.011111	0.08	0.0077	22.6	23.1	0.5	2.308802

SAMPLE 11								
	Q	Q/t	L	A	T1	T2	DT	k
line 1	40	0.011111	0.1	0.00825	22	23.4	1.4	0.962001
line 2	40	0.011111	0.1	0.00825	22	23.5	1.5	0.897868
line 3	40	0.011111	0.1	0.00825	22.2	23.6	1.4	0.962001
line 4	40	0.011111	0.1	0.00825	22.3	23.7	1.4	0.962001
line 5	40	0.011111	0.1	0.00825	22.4	23.8	1.4	0.962001

Based on the thermal conductivity value of the limestone samples it is noted that the rocks generally show a decrease in thermal value as we go up the hill. On average, the limestone rock sample has the following thermal conductivity value;

Table 2: Table of thermal conductivity of each rock sample

Sample	Thermal Conductivity W/(m.K)
1	1.33
2	3.19
3	3.17
4	3.51
9	2.05
11	0.95

Based on the result, it is noted that the value of thermal conductivity generally decreases as we go higher on to the hill. The highest value is obtained at the Sample 4 with thermal conductivity of 3.51 W/(m.K) while the lowest is at the top most point with 0.95 W/(m.K) from Sample 11.

This result is correlatable to the porosity and permeability analysis at which the highest value of porosity and permeability is the one with the lowest thermal conductivity.

A more porous rock usually will exhibit less thermal conductivity compared to tightly packed rocks. In this case, the result is consistent with the porosity and permeability result which shows lower conductivity in the upper hill compared to lower hill samples. Therefore, it can be said that thermal conductivity is directly related to the porosity of a rock.

CHAPTER 5: CONCLUSION AND RECOMMENDATION

In conclusion, the main lithology of the area is limestone and based on the study conducted, it is found out that the carbonates in the area does not carry significant reservoir quality based on the different facies found. The study also found that the petrophysical parameter of limestone in the area varies slightly in the facies with very low aspect in porosity and permeability.

Based on the porosity and analysis conducted, it is very obvious that the porosity and permeability of the limestone found decreases as it get closer to the ground, hence this suggests us that this might be caused by the dissolution and reprecipitation of mineral from upper layer at the lower part. This diagenesis characteristic is also might be caused by dolomitization process which causes the existing pores to be blocked by the dolomite minerals.

The porosity and permeability result is further supported by the thermal conductivity analysis result which shows the decreasing trend in thermal conductivity as we go up the hills. This phenomenon is most likely due to the dissolution of carbonate mineral from above that reprecipitated onto the lower facies and causes the pores to be filled by carbonate minerals.

Finally, it is hoped that the study conducted will benefit the geological society by determining the effect of facies to the reservoir quality of limestone as well as the petrophysical properties of the rock. The tests conducted to the rock sample will also give us more understanding of reservoir characteristics.

REFERENCES

Askury. A. K.., Pierson, B., Tuan Harith, Z. Z. and Weng Sum, C. 2008. *Paleozoic limestone of the Kinta Valley: Paleogeography and implications to the regional geology of Peninsular Malaysia - UTP Institutional Repository*. [online] Available at: http://eprints.utp.edu.my/5556/ [Accessed: 19 Feb 2014].

Chappell, B. W. and Hiter, A. J. (1974), Two Contrasting Granite Types, Pacific Geology

Cone, M. P. and Kersey, D. G., (1992), Porosity, AAPG Special Journal, Vol. ME10, Development Geology Reference, pp. 204-209

Hutchinson, C.S., 2007. Geological Evolution of South-East Asia (2nd Edition), Geological Society of Malaysia (Publ).

Ingham, F. & Bradford, E. (1960). The geology and mineral resources of the Kinta Valley, Perak. 9th ed. Federation of Malaya: Memoir Geological Survey Dept.

Petrology Lab – Thin Section, Distinguishing Features of Minerals (n.d.), Retrieved from, https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=7&ved=0CDUQFjAG&url=http%3A%2F%2Fwww.uta.edu%2Ffaculty%2Fmattioli%2Fgeol_2313%2Fdistin_features_minerals.pdf&ei=gXOrU46eM9eUuASQvoGoDA&usg=AFQjCNHzP0G-wWxYo6NmPFYtLaDdELd0qA&sig2=p8WqjXovsYAYcqFplKVK4Q&bvm=bv.69837884,d.c2E&cad=rja

PETRONAS (1999). *The Petroleum Geology and Resources of Malaysia*. Kuala Lumpur: PETRONAS

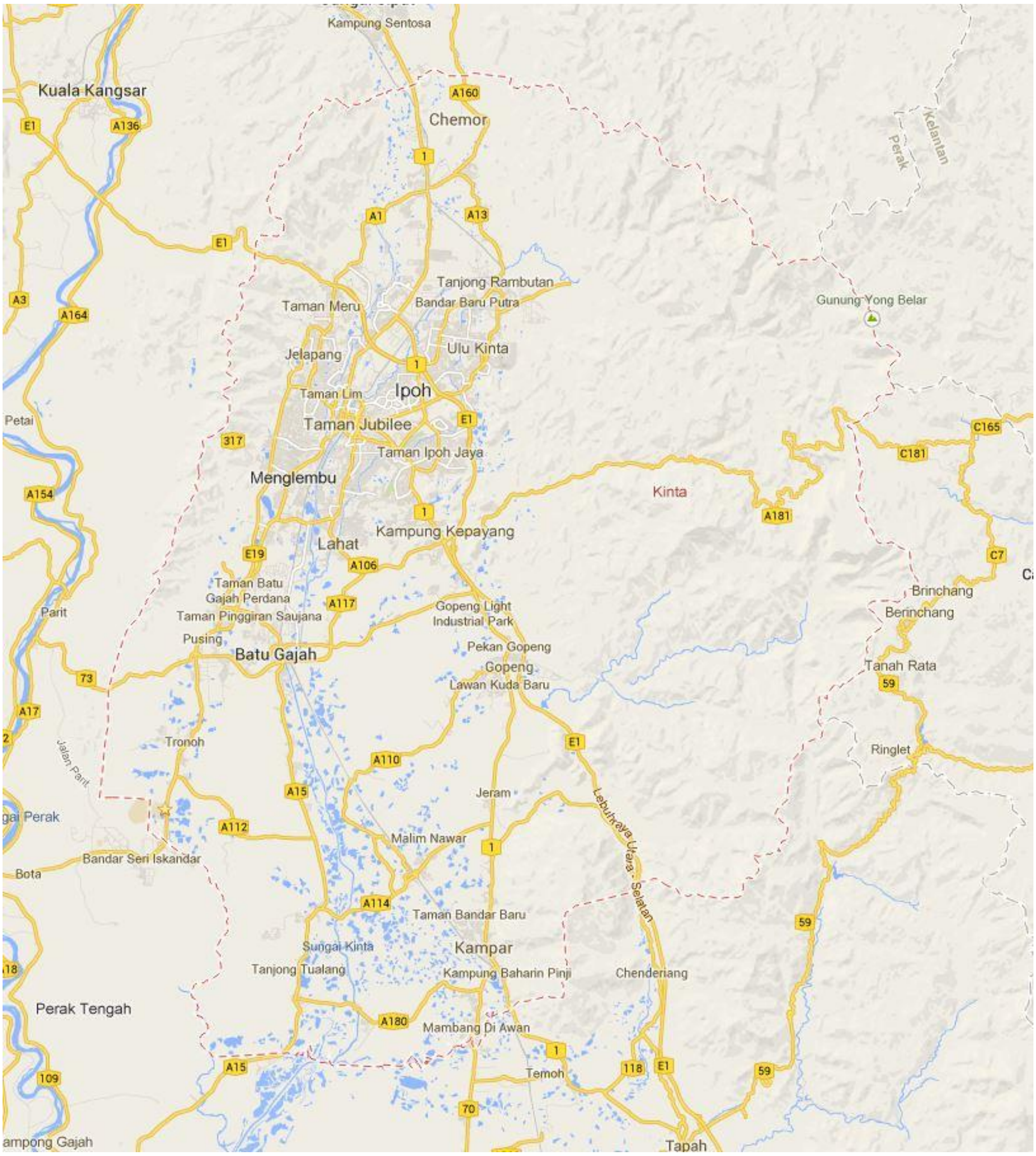
Surma, F., & Geraud, Y. (2003). Porosity and Thermal Conductivity of Soultz-sous ForÃªtz Granite. *Pure and Applied Geophsics*, *160*(-), 1125-1136

Tan, B.K. 2014. Engineering Geology of Limestone in Malaysia. *Acta Geologica Sinica - English Edition*, 75 (3), pp. 54-56. Available from: doi: 10.1111/j.1755-6724.2001.tb00538.x.

Tan, B.K. (2006). Urban geology of Kuala Lumpur and Ipoh, Malaysia. *IAEG2006*, 24 Retrieved from: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=11&ved=0CCYQFjAAOAo&url=http%3A%2F%2Fwww.iaeg.info%2Fiaeg2006%2Fpapers%2Fiaeg_024.pdf&ei=3X1KU9TOB8WMrQfNx4HABw&usg=AFQjCNE6MMvpBVvFUECkDneIAA6VtscDIw&sig2=j0uQ9TXgUhKTtNDFx2lsyg&bvm=bv.64542518,d.bmk&cad=rja [Accessed: 13 Feb 2014].

Yin, E. H. (1976). Geologic Map of Kinta Valley, Perak

APPENDICES



igure 22: The total extend of Kinta Valley area

<table>
<tr><th>Rock Unit (Sample)</th><th>Coordinates</th><th>Thickness</th><th>Elevation</th><th colspan="4">Readings</th><th>Features</th></tr>
<tr><td rowspan="11">Location 1
RU1
(Sample 1, 2, 3)</td><td rowspan="11">4° 51.437’ N
101° 7.314’ E</td><td rowspan="11">10m</td><td rowspan="11">98m</td><td colspan="4">Joint Readings:</td><td rowspan="11">Greyish to grey in color. Fine to very fine grains size

Highly jointed limestone rock.

Covered with calcite precipitation, indicates the area is part of a cave system.

Major fault at 140°N</td></tr>
<tr><td>77/20</td><td>90/20</td><td>115/10</td><td>85/17</td></tr>
<tr><td>98/10</td><td>115/25</td><td>95/15</td><td>80/19</td></tr>
<tr><td>95/25</td><td>93/8</td><td>110/20</td><td>83/20</td></tr>
<tr><td>85/12</td><td>90/25</td><td>90/10</td><td>90/33</td></tr>
<tr><td>105/13</td><td>105/26</td><td>96/30</td><td>95/12</td></tr>
<tr><td>110/15</td><td>85/30</td><td>93/3</td><td>95/20</td></tr>
<tr><td>82/9</td><td>105/20</td><td>110/10</td><td>87/5</td></tr>
<tr><td>85/13</td><td>85/25</td><td>85/15</td><td>86/21</td></tr>
<tr><td>75/10</td><td>93/20</td><td>110/25</td><td>115/20</td></tr>
<tr><td>90/6</td><td>90/25</td><td>105/5</td><td>105/25</td></tr>
<tr><td>Location 2
Southern Hill</td><td>4° 51.398’ N
101° 7.311’ E</td><td></td><td></td><td colspan="4"></td><td>Massive limestone structure.
Not heavily jointed
Joints mostly in North direction</td></tr>
<tr><td>Location 3
RU2
RU3
(Sample 4, 5, 6, 7, 8 101, 102)</td><td>4° 51.522’ N
101° 7.340’ E</td><td>RU2- 7m
RU3- 5m</td><td></td><td colspan="4"></td><td>Contact between RU2 (below) and RU3 (above)
RU2 is not heavily jointed with joint density of 30/m, RU3 heavily jointed with 52/m.</td></tr>
<tr><td>Location 4
(Sample 9)</td><td>4° 51.586’ N
101° 7.329’ E</td><td>6m</td><td></td><td colspan="4"></td><td>Interbedded between RU2 and RU3</td></tr>
</table>

Location 5 RU4 (Sample 10, 11) (12 grey limestone) (Sample 14 chalk)	4° 51.605’ N 101° 7.340’ E	6m 10m grey About 9m of chalk			Highly jointed limestone with 1-2cm diameter calcite nodules. Followed by thick chalk formation
Location 6 RU5, RU6	4° 51.625’ N 101° 7.367’ E		151m		Cave remnants. Exposed stalactites indicates that the area once is a cave system. The formation is followed by chalk
Location 7	4° 51.640’ N 101° 7.417’ E		88m		

Table 3: Data gathered from field work

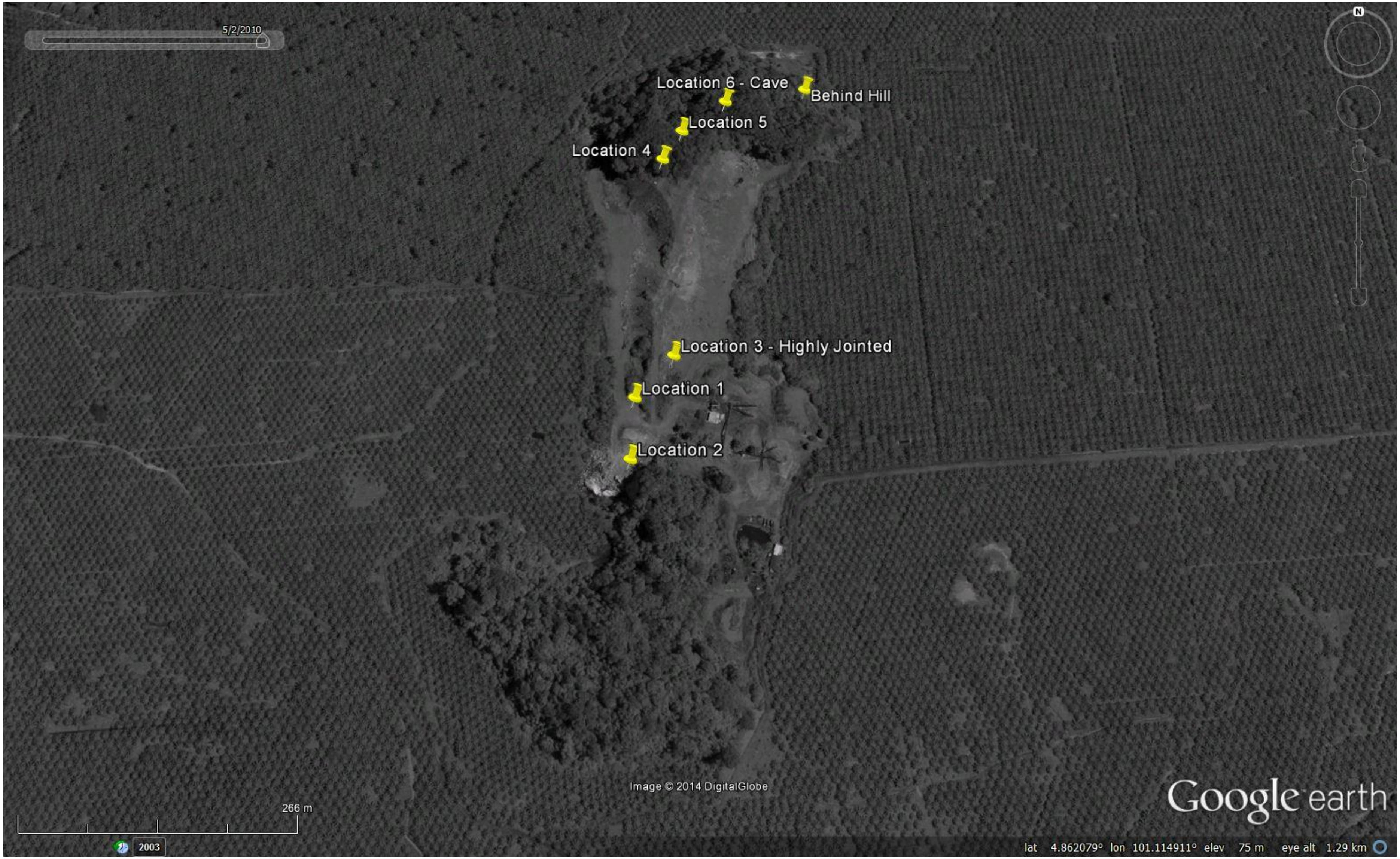


Figure 23: Location of study points