Sedimentology of Anak Datai of Machinchang Formation, Langkawi, Kedah

By

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13821

Dissertation submitted in partial fulfillment of the requirements for the

Bachelor of Technology (Hons) (Petroleum Geoscience Programme)

MAY 2014

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CERTIFICATION OF APPROVAL

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Approved by,

____

(AP. DR. Abdul Hadi bin Abd Rahman)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

May 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 the original work contained herein have not been undertaken or done by unspecified sources or persons.

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(SITI NUR AMIRAH BINTI ISMAIL)

ABSTRACT

Anak Datai beach is composed of rocks dated Cambrian age making it the oldest rock found in Peninsular Malaysia. It is located in the Northwest of Langkawi Island. Anak Datai beach area covers several beds such as Anak Datai Bed, Temurun Bed and Tengkorak Bed of the Chinchin Member under Machinchang Formation.The objective of the project is to perform sedimentology study by describing the sedimentary facies along with the facies succession and its association to understand the sedimentary processes and environment.

For this project, sedimentary logs are created and used as the main data. There are six sedimentary logs constructed along the transect route which are mainly composed of sandstone with minor intercalations of silty and muddy layers. Based on the research done, generally it is coarsening upward succession of sandstone with thin intercalation of muddy and silty layers. The sandstone is classified as metaquartzite sandstone as it has undergone low metamorphism. From facies analysis, the study area is mainly made up of four facies such as trough cross-bedding sandstone, planar cross-bedding sandstone, parallel lamination sandstone and massive sandstone. All of the facies type identified suggesting upper shoreface as the paleo-environment of deposition for the study area with wave dominated environment. Petrographic analysis is also carried out in order to understand further about the rock in the area in terms of mineralogy properties. 12 samples were prepared and the samples were categorized according to the grain sizes of the quartz minerals. The main mineral observed in the samples is predominantly quartz with matrix composed of smaller crystals of quartz, clay and carbonaceous matter.

ACKNOWLEDGEMENT

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

1.1.1 Location

The area surveyed is bounded approximately by latitudes of N 06°25' till N 06°27' and longitudes of E 99°41' till E 99°44' covers the Northwestern part of Langkawi Island. The transect route is along Jalan Datai which is approximately three kilometers.

1.1.2 Topography and drainage

The topography of Gunung Machinchang composed of a very rugged forest covered terrain. The hills are steep and sometimes have vertical cliffs rising up to 760 meters. Waterfalls are common in the area of Gunung Machinchang such as Temurun Waterfall, Telaga Tujuh and many more.

Drainage system is well developed due to the formation of joints and faults. The dominant pattern of Machinchang terrain is radial drainage system. The shallow streams indicates dendritic drainage pattern. During the dry season, the shallow streams usually dry out.

1.1.3 Climate and vegetation

Langkawi Island has a hot and humid climate. It has high rainfall between 80 to 100 inches. Generally, it has the most rainfall in the month of September till October due to monsoon winds. The temperature is constant along the year. The average temperature during the day is approximately 30 to 35^{0}C while in night the temperature ranges from 28 to 29^{0}C.

Tropical vegetation mostly covers the Langkawi Island. Previously, the island is made up of thick vegetation but nowadays, the thick forests had been brought down for development plans especially at the south of the island. At the Northwestern part of Langkawi Island, the outcrops are still covered with vegetation causing some difficulties during fieldwork (Figure 1).

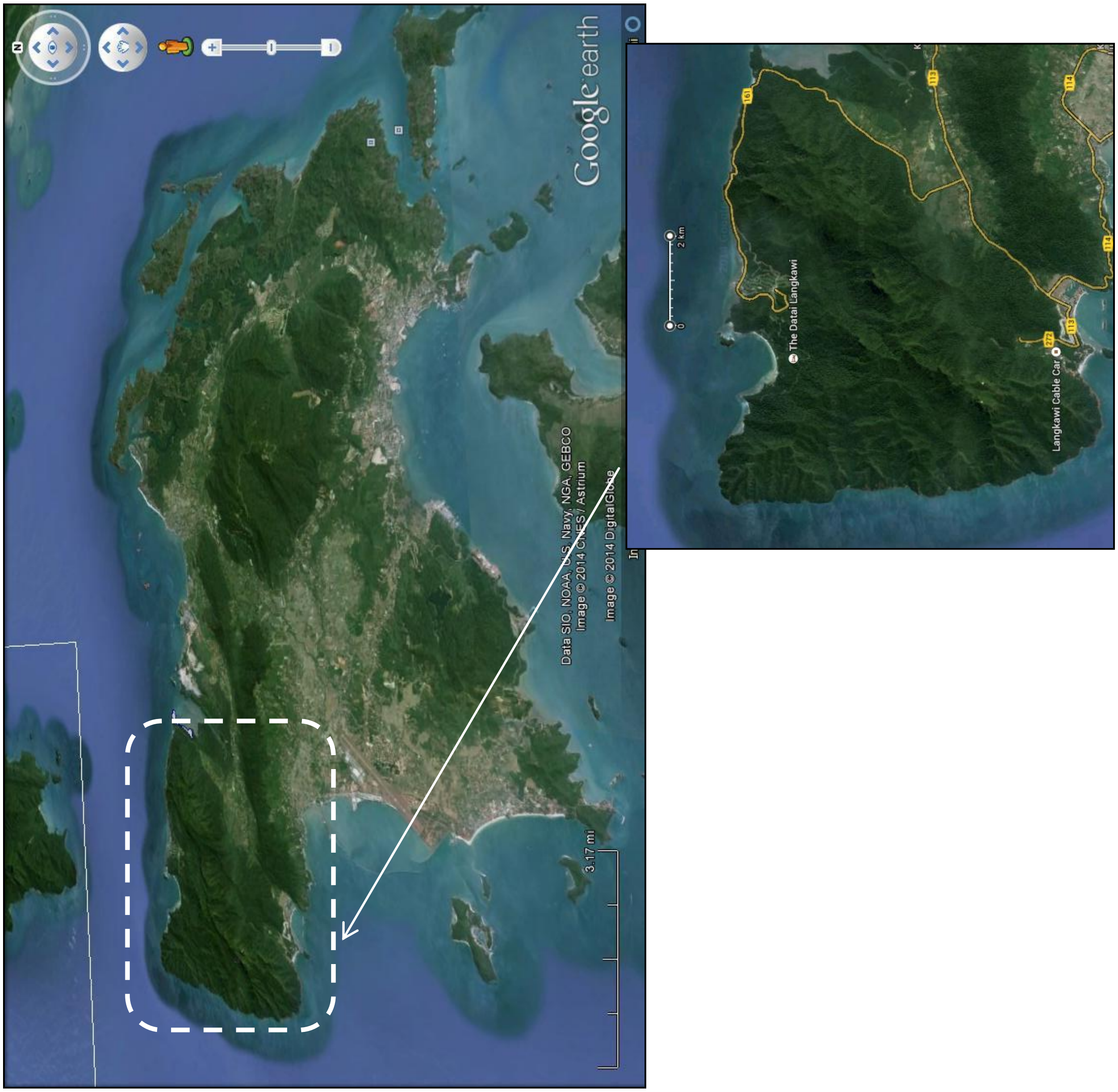

Figure 1: Google earth map view of Langkawi Island and Northwestern of Langkawi.

1.2 Problem Statement

The study area along Jalan Datai covers several beds which falls under Chinchin Member and each bed composed of several facies. It is crucial to identify the facies type and facies succession in order to determine and understand the paleo-environment of deposition of the study area. Besides, due to road construction and weathering effect, there are new exposed outcrop which can improve the information obtained from all of the previous researches.

1.3 Objectives

The main objectives are:-

i. Describe and interpret sedimentary facies of Anak Datai beach based on sedimentary log analysis.
ii. Identify facies succession in terms of sedimentary processes and environment while suggesting the depositional model for the study area.

1.4 Scope of study

The main purpose of Final Year Project (FYP) is to study about the sedimentology of the study area which is Jalan Datai of Machinchang Formation. The crucial steps taken to perform this study are by identifying lithology, lithofacies, sedimentary features and geologic structures in the area. This is because, all of them are essential to understand the sedimentary process and environment. Lee (2006) sequence stratigraphy concept is the main reference for this study in order to produce a systematic interpretation.

Samples from the area of study also will be collected to perform analysis such as petrographic analysis in order to identify the mineralogical properties of the sandstone which includes the mineral composition of the samples.

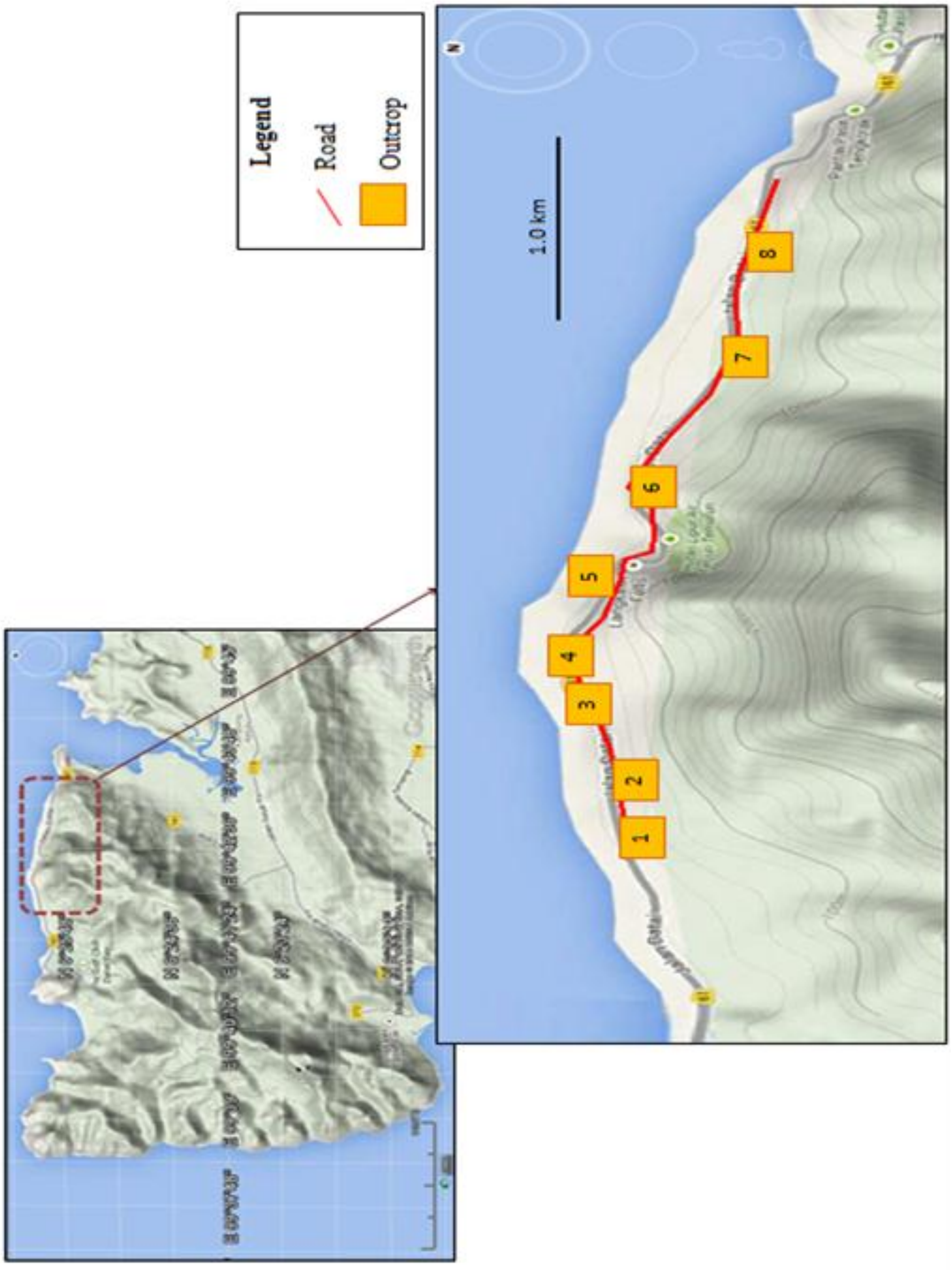

Figure 2: The study area is located at Northwest of Langkawi focussing on along Jalan Datai with eight outcrops.

1.5 Geologic Setting

The geology of Malay Peninsula is divided to three north-south longitudinal belts, which are Western, Central and Eastern belt (Metcalfe, 2013).

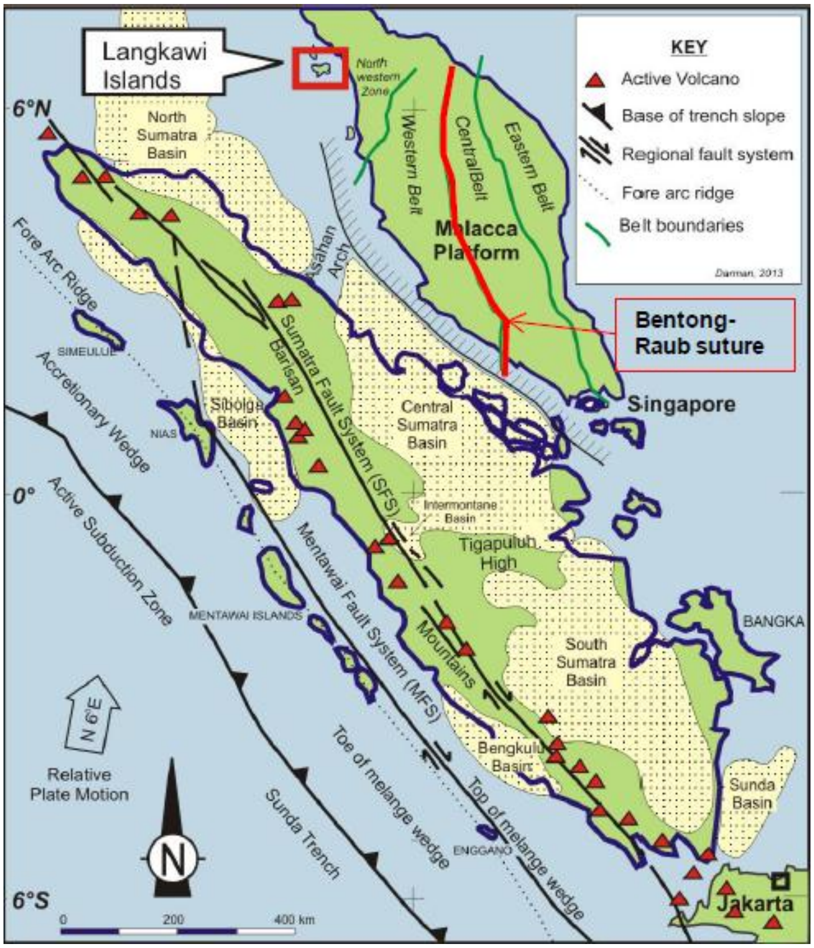

Figure 3: Langkawi map. The three belts are after Lee (2009) and Sumatra map is after Darman & Sidi (2000).

Langkawi is located within Northwestern Domain of Western Belt of Peninsular Malaysia (Lee, 2009) which is a part of Sundaland (SE Asian extension of the Eurasian Plate). To be exact, it is located in Sibumasu terrane which is bounded by Mogok Metamorphic Belt, the Andaman Sea and Medial Sumatra Tectonic zone as proposed by Metcalfe (2013).

Langkawi Island is located 30 km off coast Perlis and 112 km north of Penang which is made up of the Paleozoic sedimentary rocks, ranging from Cambrian to Permian age. These rocks are consists of clastics and carbonates which are mainly shallow-marine shelf sediments. Lee (2009) suggested that the Northwestern Domain of Western Belt of Langkawi Island is made up of Machinchang Formation, Setul Formation, Singa Formation and Chuping Formation.

The research will be focused on the Northwest of Langkawi which is along Anak Datai beach of Machinchang Formation. It is a formation which is made up of oldest rock in Malay Peninsula dated Cambrian. Machinchang Formation is correlative to Jerai Formation positioned near to the west coast of Kedah and Tarutao Formation in Thailand (Lee, 2006).

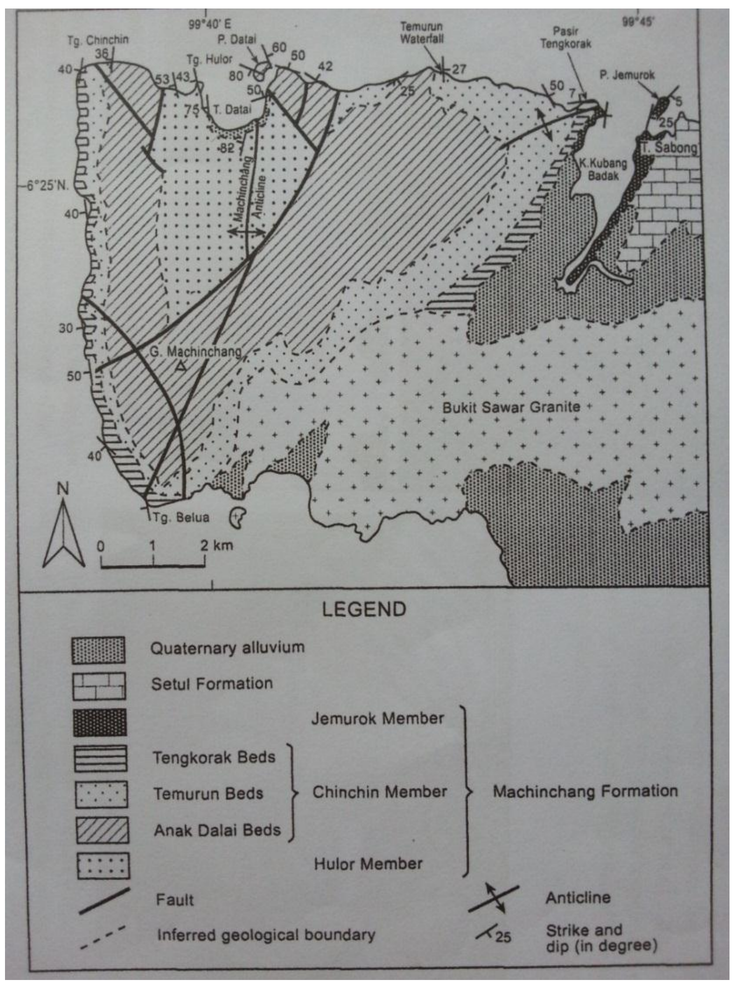

Figure 4: Northwest Langkawi map.

CHAPTER 2

LITERATURE REVIEW

2.**1 Regional Geology and Paleozoic Stratigraphy of Western Belt**

Metcalfe (1984) proposed Langkawi Island is located on Sibumasu terrane which includes Shan Plateau of Burma, Northwest Thailand, Peninsular Burma and Thailand, Western Malay Peninsula (Western Belt) and NE Sumatra and possibly extends northwards into Western China and Tibet. Sibumasu block was derived from Gondwana in late Early Permian as Meso-Tethys Ocean was opened.

Langkawi is located within Northwestern Domain of Western Belt of Peninsular Malaysia (Lee, 2009). Middle Cambrian to Early Ordovician clastic rocks are the oldest rock found in Machinchang and Jerai formations in NW Peninsular Malaysia (Lee, 2009). Tarutao formation in Southern Thailand is the equivalent formation of Cambrian rocks with Machinchang formation

The first broad geological succession of Perlis, north Kedah and Langkawi Island was done by Jones (1981). Then, Cook et al. (2005) revised the stratigraphy by enhancing Setul Formation to formations within a Setul Group. Meor and Lee (2005) further divided the Middle Palaezoic Devonioan to Lower Carboniferous transitional sequence, above the Silurian Mempelam (Upper Setul) Limestone, to the Carboniferous Singa and Kubang Pasu Formations into several formations. Figure 3 below shows the revised stratigraphy between Jones, Cooks et al. and Meor and Lee.

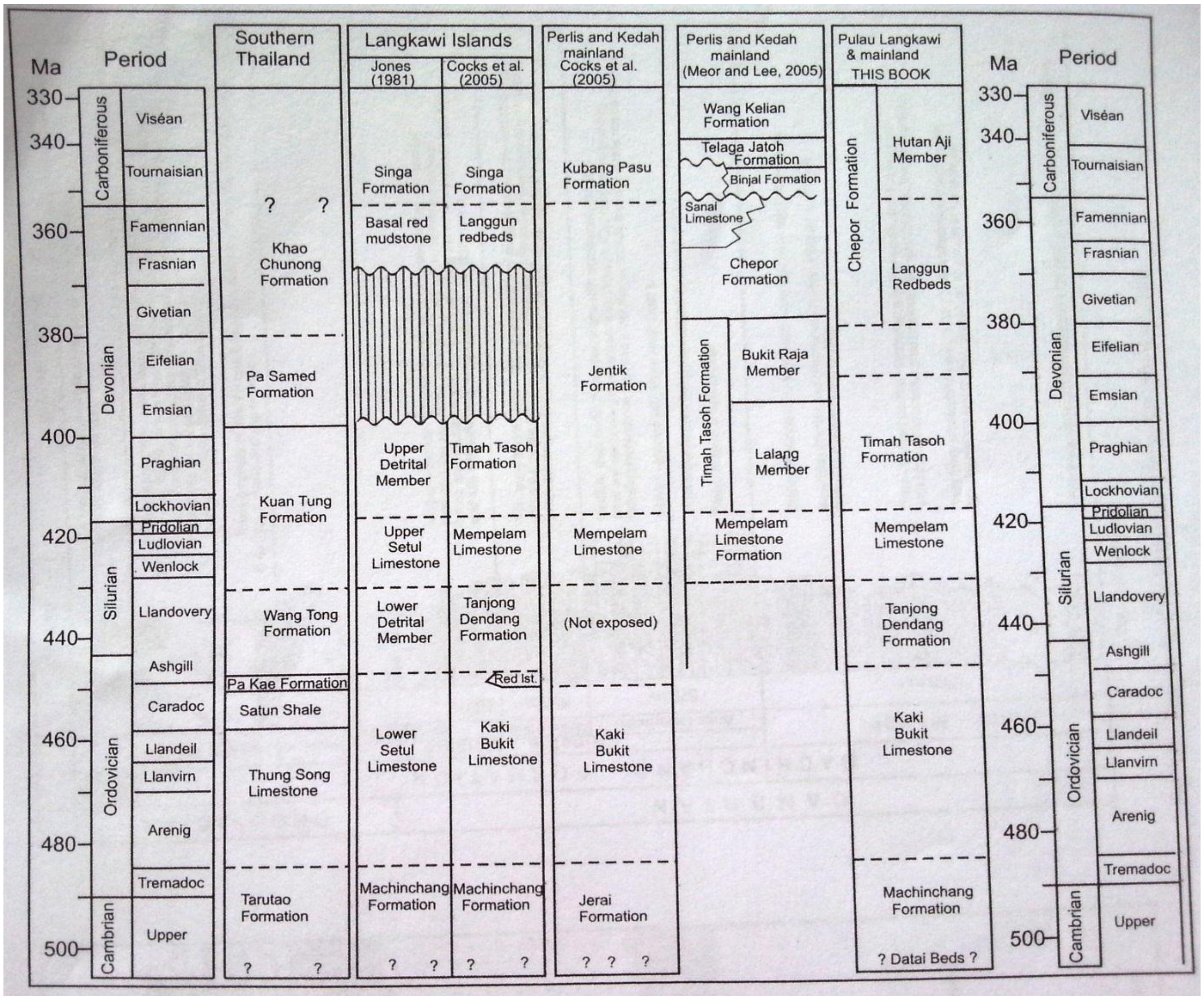

Figure 5: Revised stratigraphy of Paleozoic rocks in Northwestern Domain (Lee, 2009).

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2.2 Stratigraphy and Sequence Stratigraphy of Machinchang Formation

Machinchang Formation is named after the Machinchang Mountains in the Northwest of Langkawi Island (Jones, 1961). Machinchang Formation consists of grey, brown, purple and red, coarse to medium-grained quartzite, arkose and subgreywacke as interpreted by Jones in 1978.

There are three members visible in Machinchang formation (Lee, 2006) which covers about 20 square miles of northwest Langkawi Island with thickness of 6700 feet. The table below summarizes the stratigraphy of Machinchang Formation according to Lee (2006) research paper entitled The Cambrian of Malaysia.

Table 1: Stratigraphy of Machinchang Formation (Lee, 2006).

Member	Beds and facies
Hulor Member ▪ Thickness is more than 1260m. ▪ Coarsening upwards sequence of rhythmic interlayered graded siltstone and phyllitic mudstone interbedded with thicker bedded clayey sandstone.	Consists of four facies:- 1. Rhythmic deposits of light brown siltstones grading into dark grey mudstone. (mm to cm thick) 2. Fine argillaceous sandstones (cm to dm) cut through first facies. 3. Slumped, very thick, poorly bedded to massive fine argillaceous sandstone. 4. Black carbonaceous and pyfritifeorus silty shale.
Chinchin Member ▪ Thickness is more than 1575m. ▪ Fining upward succession of subangular quartzose anglomerate to very fine sandstone.	Consists of four beds:- 1. Anak Datai Bed (575m thick) - Coarse grained facies (graded lenticular beds of abundantly cross-bedded pebbly sandstone and conglomerate) with interbedded fine grained facies (low angle, planar cross-bedded sandstone). 2. Temurun Bed (300m thick)

	- Wavy bedded fine sandstone facies with minor graded pebbly sandstone, fine tuffaceous and thin argillaceous intercalations. 3. Tengkorak Bed (more than 200m thick) - Fine to very fine thick bedded sandstone facies with less prominent of fine rippled sandstone, acid tuff and mudstone.
Jemurok Member ▪ Thickness is more than 420m	Consists of three facies:- 1. Bedded mudstone with thin lenses and streaks of rippled siltstone or very fine sandstone. 2. Thin to thick bedded very fine sandstone and siltstone. - Dictyodora and Chondrites trace fossils found preserved 3. Thin wedging beds and lenses of impure limestone which is in the transitional zone of Ordovician-Silurian Setul Formation

Leman et al. (2007), focused on stratigraphy of Langkawi Island which consists of Machinchang, Setul, Singa and Chuping Formations (from oldest to youngest formation). Most of them are shallow marine shelf type deposits. Figure 4 simplify the stratigraphy and major geology events according to the geologic age.

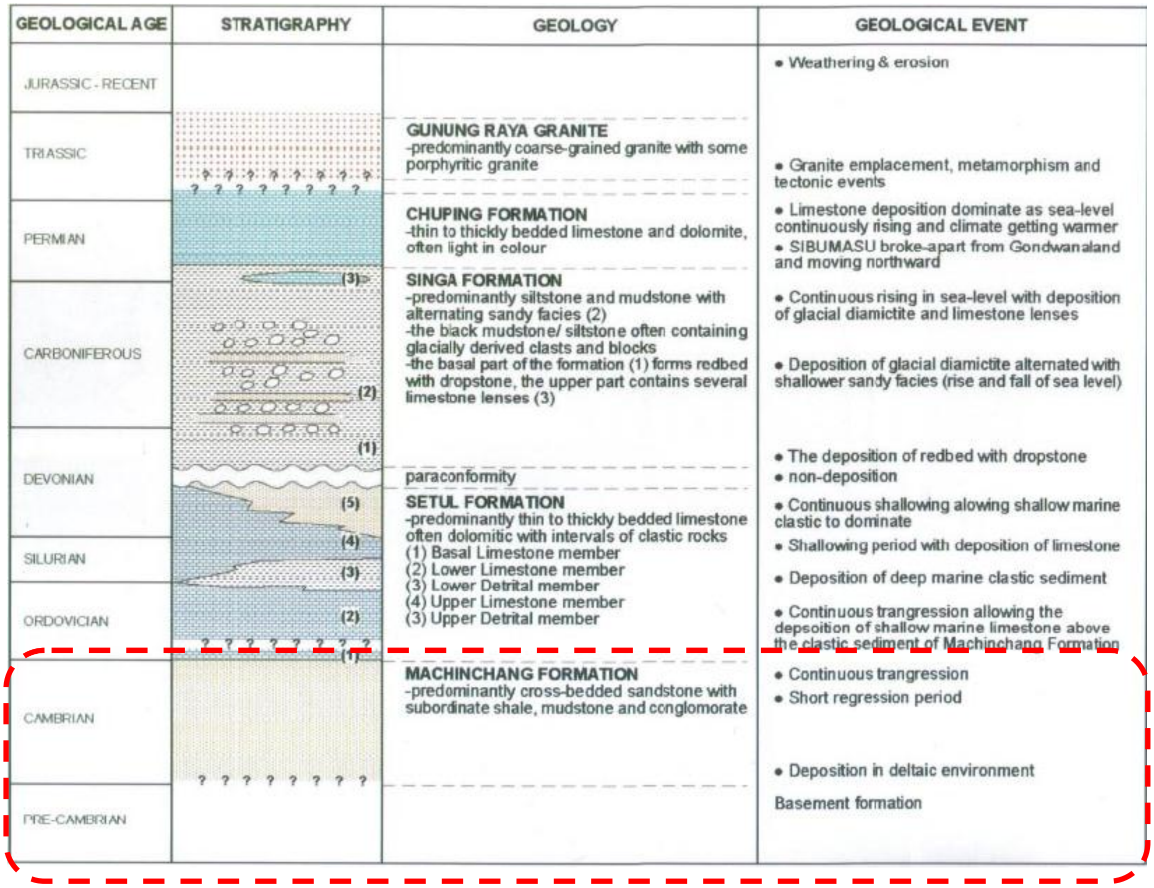


Figure 6: Stratigraphy and major events in geologic history of Langkawi islands (Leman et al., 2007).

2.3 Sedimentology and Paleoenvironmental analysis

In terms of paleoenvironment, Jones (1981) interpreted Machinchang formation as a deltaic deposit. Abdullah et al (1997) suggested it is fluvial to deltaic and open marine deposit. Then, Lee (2006) proposed that the environment of deposition is shallow marine deltaic setting within the Yunnan-Malayan region based on the overall Machinchang formation succession. Miall (1979) proposed seven features for recognising ancient deltas. Machinchang Formation fulfills five of those features which are:-

i. Large thickness of Machinchang formation.
ii. Presence of considerable volume of sandstone and/or siltstone.
iii. Sedimentary structure shows shallow water deposition by traction.
iv. Gradation into finer grained clastic deposits of offshore origin (Hulor Member).
v. Coarsening upward cycle in Hulor Member.

The other two features are not applicable for Machinchang formation as there were no faunas during Cambrian and absence of coal beds.

From all the research papers, it can be concluded that the paleoenvironment for this formation is shallow marine deltaic setting.

2.4 Paleontology

In Machinchang Formation, fossils are scarce compared to Tarutao Formation. Only fragments of trilobites and brachiopods had been found at Tanjung Buta and Pulau Jemurok which dated Machinchang as Upper Cambrian age. Lee (2006) found Kinneyan wrinkle marks and trace fossil such as Dictyodora and Chondrites in Jemurok Member especially in the second facies. Tarutao Formation contains more fossils compared to Machinchang Formation.

CHAPTER 3

METHODOLOGY

1. Reviewing previous reports, journals and books.

2. Fieldwork:-

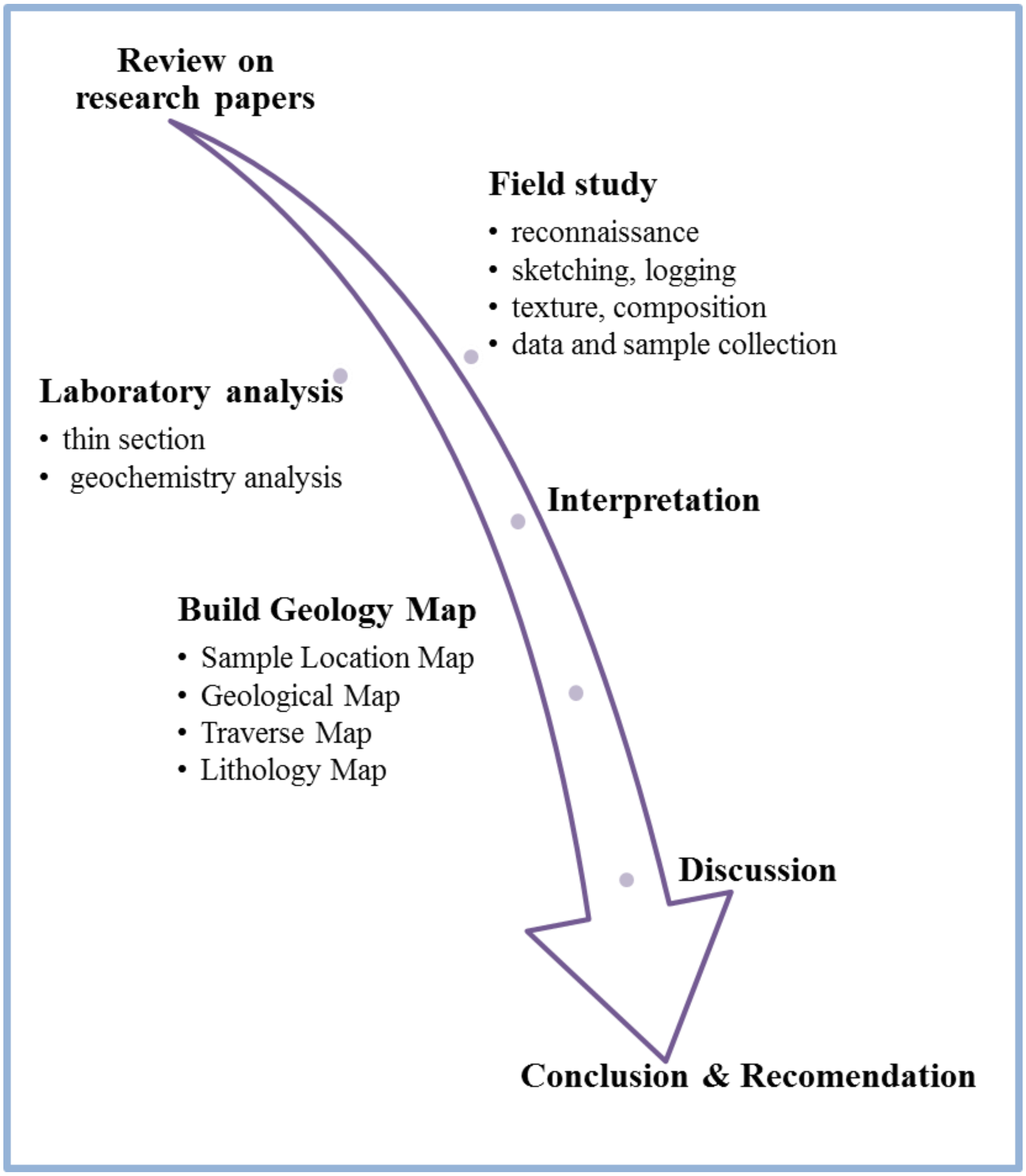
    i. Locating potential outcrop.
    ii. Analysing the outcrop as a whole rock unit for measuring the rock extension.
    iii. Identifying the type of lithology in the outcrop.
    iv. Taking GPS reading.
    v. Performing sedimentary logging and sketching on the outcrop.
    vi. Measuring strike and dip of the outcrop.
    vii. Collecting all the samples for further analysis.

3. Perform laboratory study or analysis to understand the mineralogy, identify the lithofacies of rocks and type of sandstone.
    a. Thin section

4. Using sequence stratigraphy concept to define facies successions either vertical or lateral.

5. Create location map, geological map, traverse map and lithology map. Propose environment of deposition.

3.1 Key Milestone



3.2 Project Timeline (Gantt-Chart)

- FYP I

Table 2: Projected timeline for FYP I.

Months	January		February				March				April			
Nom. of Weeks	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Literature review														
Extended proposal														
Fieldtrip														
Interpretation & Discussion														

- FYP II

Table 3: Projected timeline for FYP II.

Months	May				Jun				Julai				August			
Nom. of Weeks	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Fieldwork																
Conduct analysis																
Interpretation & Discussion																
Documentation																
VIVA																

CHAPTER 4

RESULT & DISCUSSION

4.1 Outcrop and Sedimentary log

There are eight outcrops identified along Jalan Datai which are:-

1) Outcrop 1 – N 06^{o}26.115^{o}, E 99^{o} 42.057^{o}
2) Outcrop 2 – N 06^{o} 26’ 08.30’’, E 99^{o} 42’ 06.30’’
3) Outcrop *3* – N 06^{o} 26.125^{o}, E 99^{o} 42.354^{o}
4) Outcrop 4 – N 06^{o} 26.130^{o}, E 99^{o} 42.320^{o}
5) Outcrop 5 – Temurun waterfall
6) Outcrop 6 – N 06^{o} 26.096^{o}, E 99^{o} 42.593^{o}
7) Outcrop 7 – N 06^{o} 25’57.6’’, E 99^{o} 43’05.0’’
8) Outcrop 8 – N 06^{o} 25’55.4’’, E 99^{o} 43’10.9’’

Most of the outcrops are showing northwest strike with southwest dip direction. There are total of six sedimentary logs constructed from the outcrops.

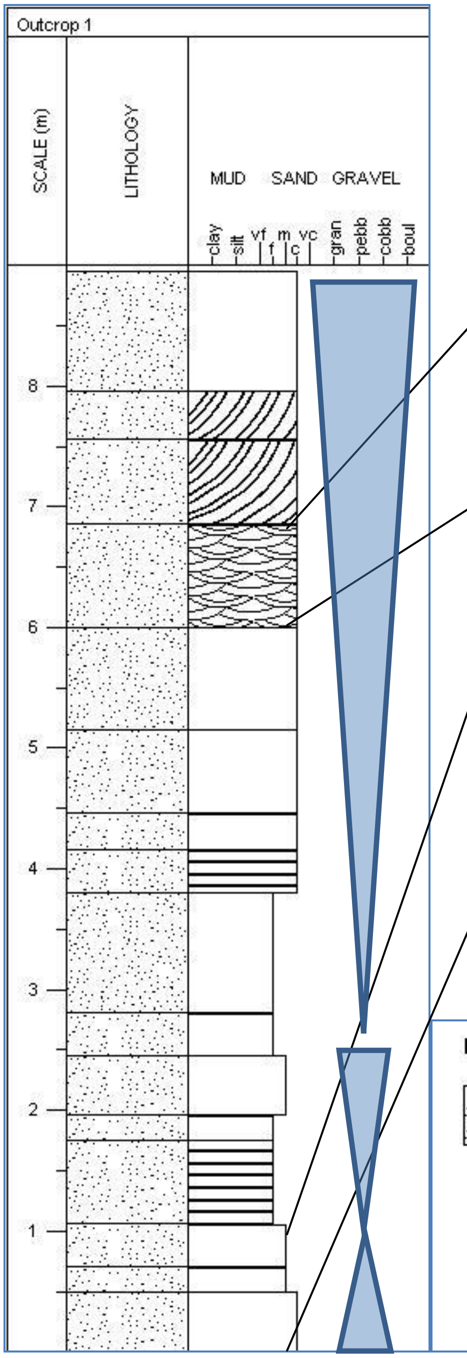
The main lithology identified is sandstone with only minor thin intercalations of muddy or silty layers. There are variations in grain size of the sandstone from very fine to coarse grained sands. All of the beds are showing sharp contact with thickness ranging from dm to cm concluding them as graded bedding. The outcrops are mostly highly fractured and weathered. The rocks are orange in colour at the surface due to iron oxide as the product of weathering.

The most common sedimentary structures found are trough cross bedding, planar cross bedding, parallel laminations and quartz veins.

Outcrop 1 – N 06^{0}26.115^0, E 99^0 42.057^0

Figure 7: Trough cross bedding sedimentary structure.

Figure 8: Massive sandstone with distinct bedding.



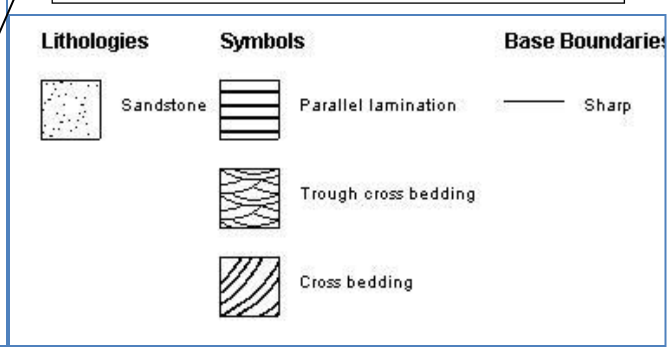


Figure 9: Sedimentary log of outcrop 1. Parallel lamination is commonly found at the bottom and middle part of the outcrop while cross-bedding structures are dominant at the top part of the outcrop.

The sandstone rock observed have different grain sizes which range from fine to coarse grained. There is sharp contact at each bed making it as graded bedding. Starting from the bottom, the coarse grained sandstone is up to the height of 70 cm, and then followed by the medium to fine grained sandstone are seen up until the height of 456 cm. Then, the coarse grained sandstone dominates up until the height of 1301 cm. The total height of the outcrop as it pinches out from the east for about one kilometer long to west is 13 meters.

One of the sedimentary structures found in this outcrop is cross bedding such as trough and planar cross bedding which dominates the higher part of the outcrop starting at 6 m height. Parallel lamination is commonly found at the bottom part of the outcrop.

Generally it is a coarsening upward sequence with change from fine to coarse grained sandstone.

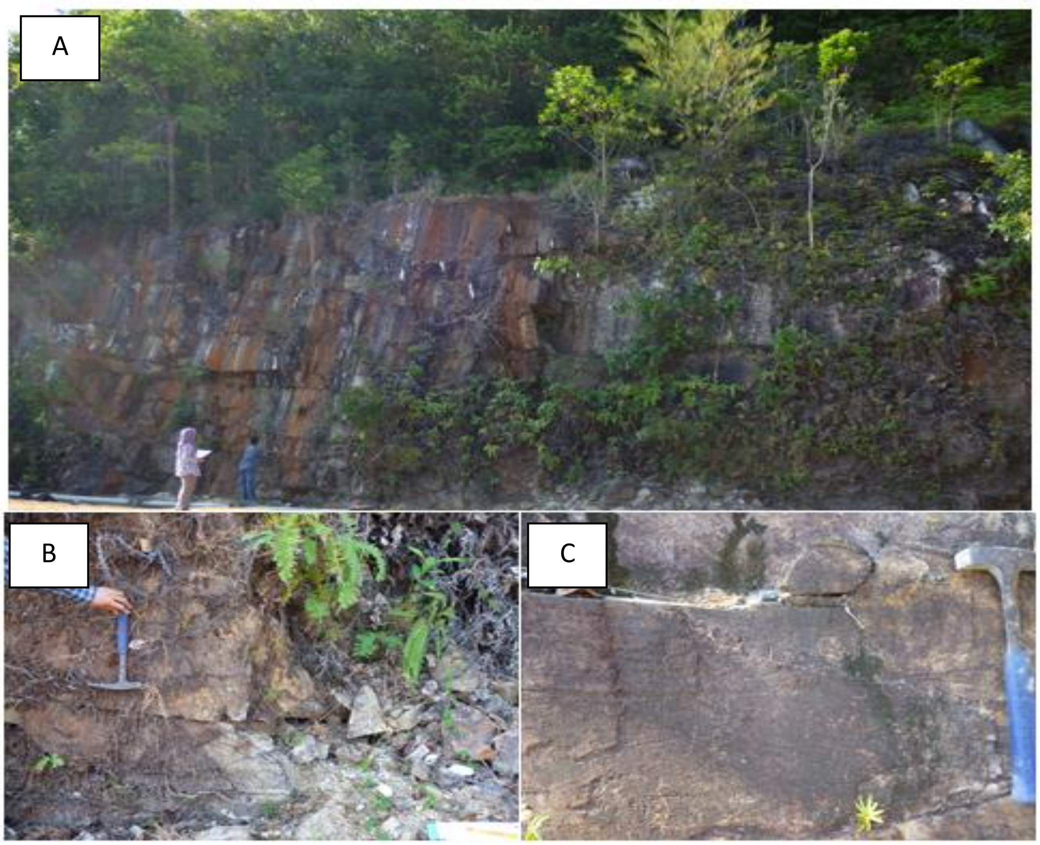


Figure 10: (A) Outcrop 1 with distinct bedding. (B) Sharp contact at each bed. (C) Trough cross bedding structure.

Outcrop 3 – **N 06⁰ 26.125⁰, E 99⁰ 42.354⁰**

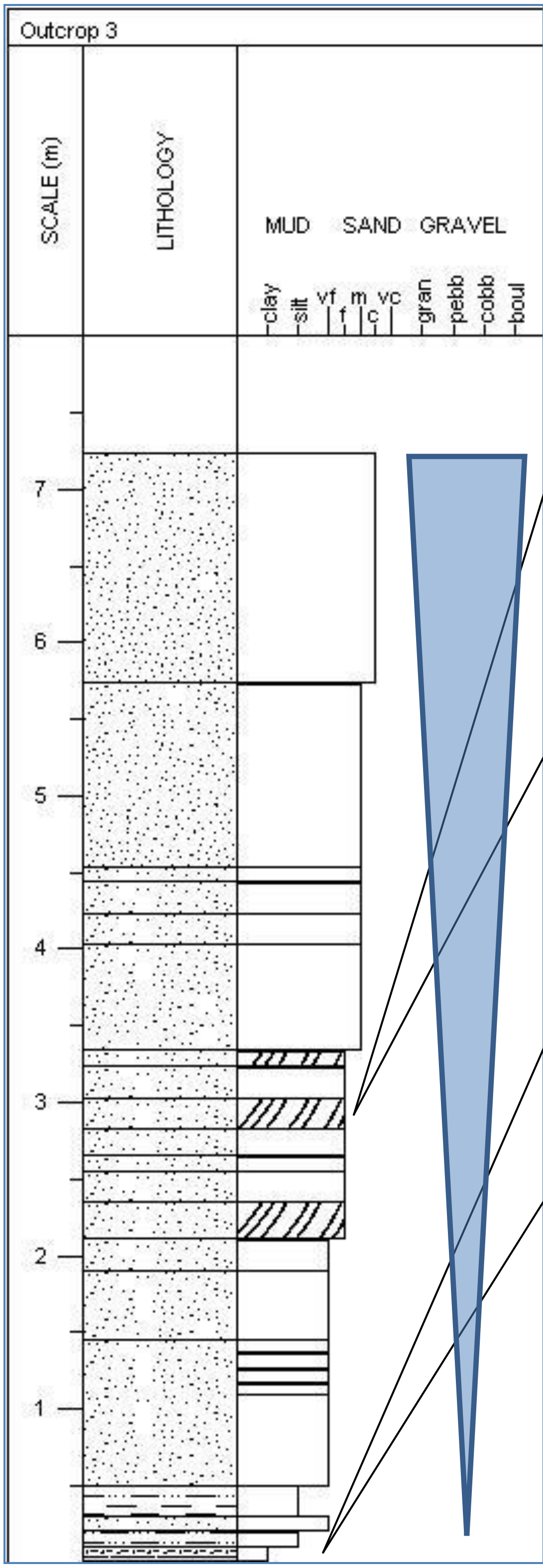


Figure 12: Planar cross bedding structure.

Figure 11: Intercalation of muddy and silty layers.

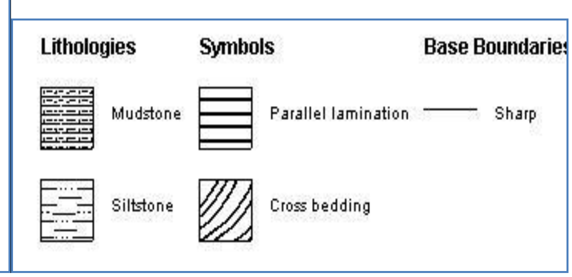


Figure 13: Sedimentary log of outcrop 3 showing coarsening upwards succession with thinner sandstone layer at the bottom and thicker layers at the top.

The sandstone in the outcrop 3 is showing distinct variation in the grain size from very fine to coarse grained. Each bed is showing sharp contact due to the fractures along the bedding. There are thin intercalations of muddy and silty layers at the bottom of the outcrop. Then it is followed by very fine sandstone up to the height of 2 metres. In this very fine sandstone, parallel laminations are commonly seen. Then, fine sandstone is identified up to 3.5 meters and it is composed of planar cross bedding. After that, medium sandstone is measured from 3.5 to 5.7 meters. Coarse grained sandstone dominates up until the top of the outcrop and there are no sedimentary structures identified at the medium and coarse grained sandstone. The total thickness of the outcrop is approximately 7.3 metres which extends horizontally to 500 m.

It is a coarsening upward sequence with change in grain size of very fine to coarse grained sandstone.

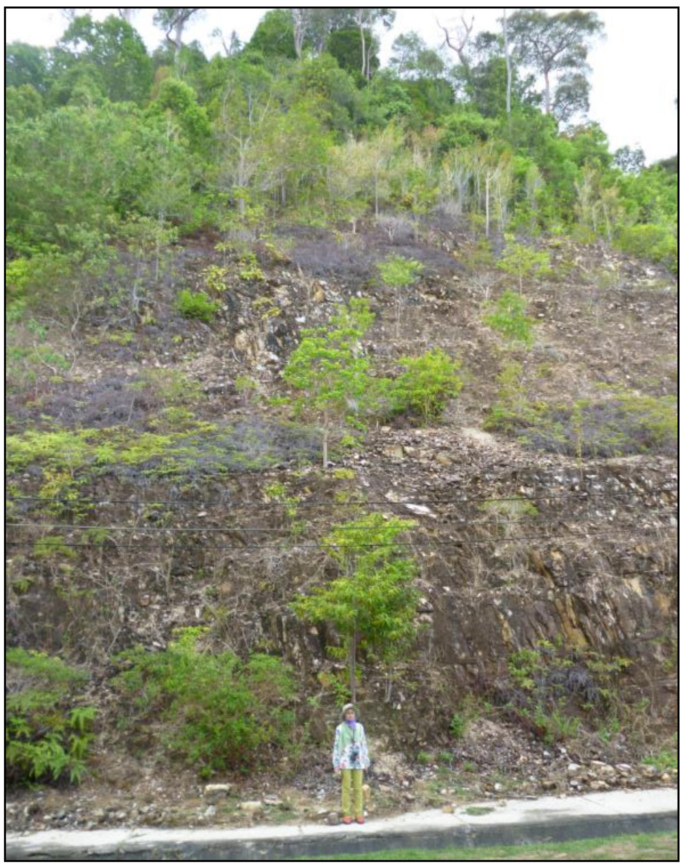


Figure 14: Outcrop 3 is weathered and fractured. The sandstone surface has been weathered by iron oxide giving brownish to orange colour. The top part of the outcrop was out of reach by the author due to HSE issue.

Outcrop 4 - N 06^0 26.130^0, E 99^0 42.320^0


Figure 15: Planar cross bedding structure in sandstone.

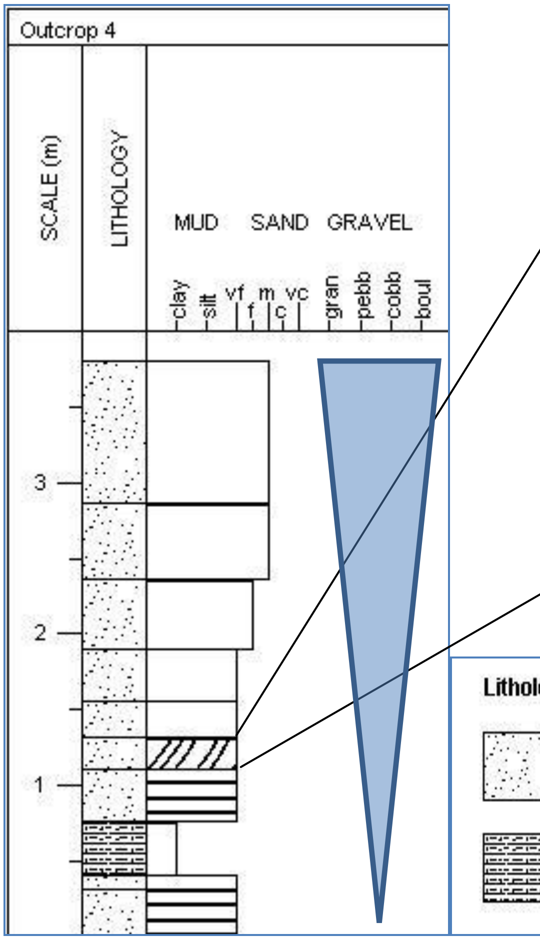


Figure 16: Sedimentary log of outcrop 4 showing coarsening upward sequence.

The grain size of this particular outcrop is ranging from very fine to medium grained sandstone with sharp contact at each bed. The very fine grained sandstone is up to 2 meters is intercalated with thin layer of mudstone. Parallel lamination and planar cross bedding is commonly found in the very fine grained sandstone. Then, it is followed by fine grained sandstone up to the height of 2.4 metres. Lastly, it is finished at approximately 3.8 metres by medium grained sandstone. There are no sedimentary structures observed at the upper part of the outcrop particularly at the fine and medium grained sandstone. Hence, the total thickness for this outcrop is approximately 4 meters which extend horizontally for 450 meters. It is highly fractured and the rocks are tainted by iron oxide due to weathering effect. Based on the sedimentary log drawn, it is a coarsening upward sequence.

Outcrop 6 – N 06^0 26.096^0, E 99^0 42.593^0

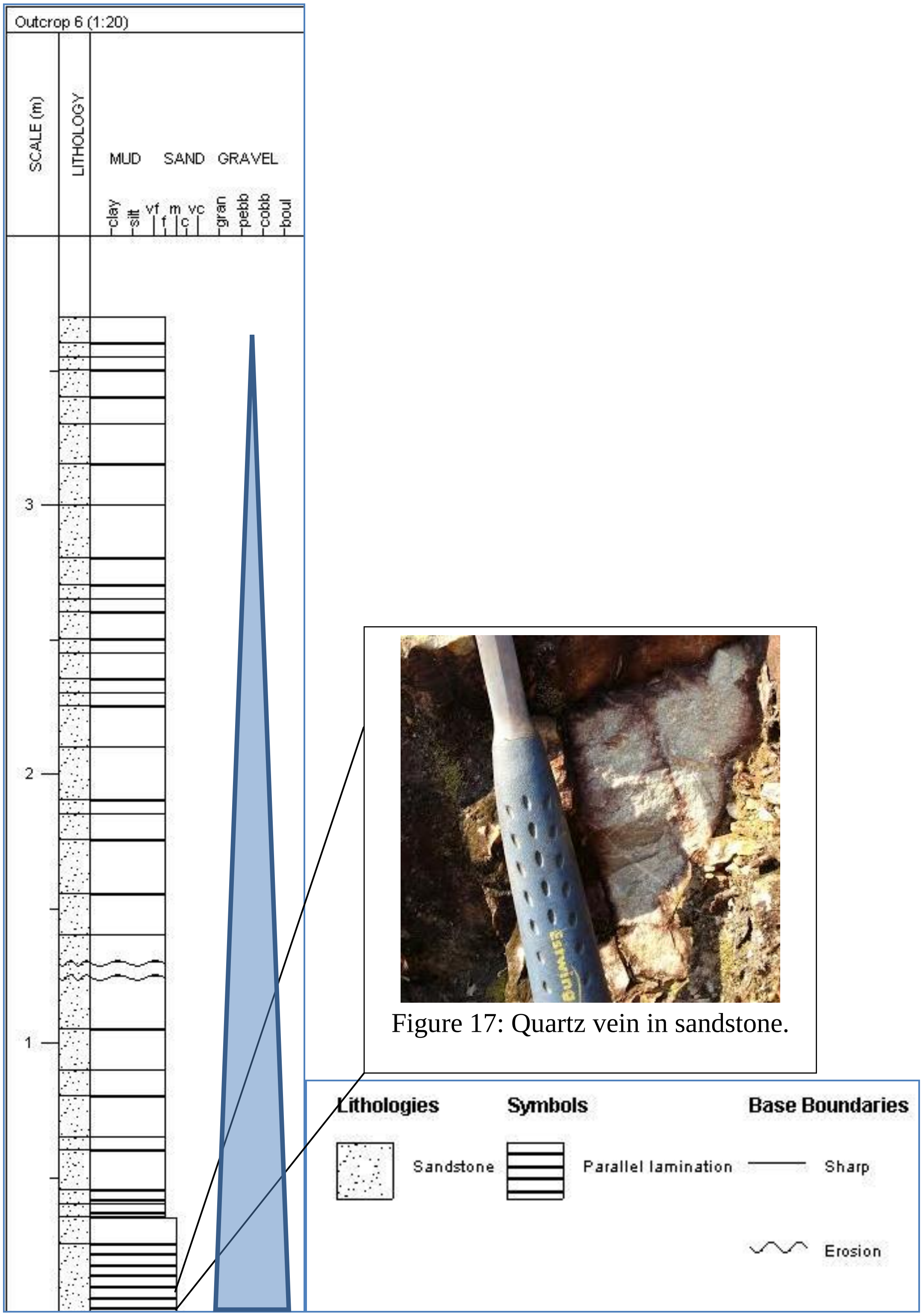


Figure 17: Quartz vein in sandstone.

Figure 18: Sedimentary log of outcrop 6 showing fining upward sequence. The top part was assumed to be fine grained due to HSE issue at the top part of the outcrop.

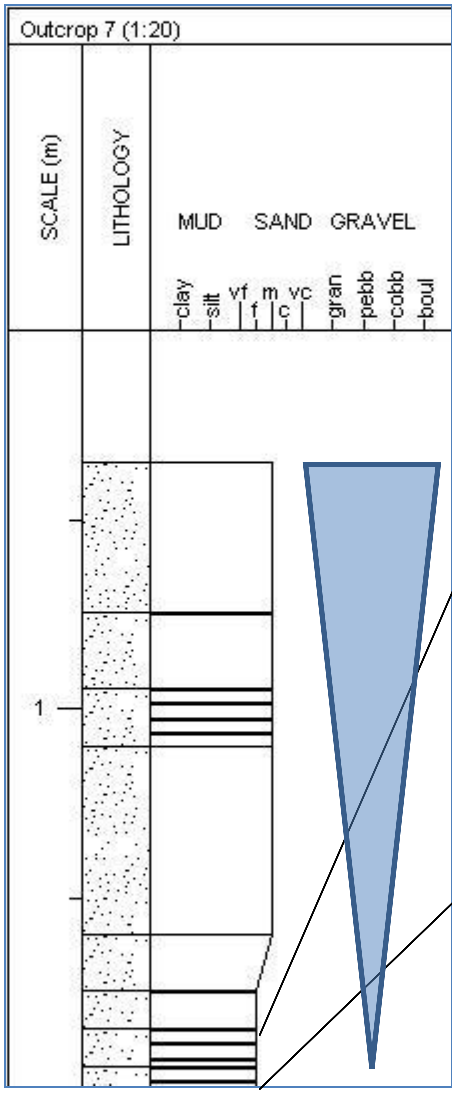
For this outcrop, it is purely composed of sandstone with two particular grain sizes observed which are mainly medium and fine grained sandstone. The total thickness of the outcrop is 3.7 meters which extends laterally up to 300 metres. The medium grained sandstone are showing parallel laminations up until the height of 0.4 metres and the followed by fine grained sandstone. Quartz veins are abundant in the medium grained sandstone due to hydrothermal fluids that flow in the fractures had deposited quartz minerals along the fractures path in the rock. For the fine grained sandstone, parallel laminations are observed and then onwards, there is no structures distinguished up until 3.7 metres.

Generally, it is a fining upward sequence.

Figure 19: Outcrop 6 is made up of purely sandstone which are well lithified and compacted.

Outcrop 7 – N 06^0 25’57.6’’, E 99^0 43’05.0’’

Figure 20: Parallel lamination in sandstone.



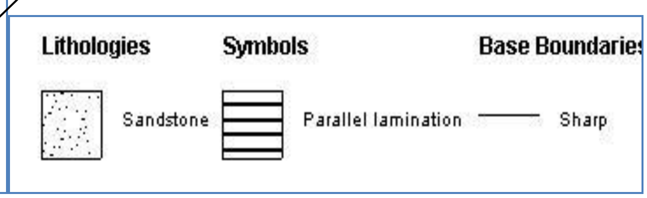


Figure 21: Sedimentary log of outcrop 7 with parallel laminations structure found in the sandstone showing coarsening upward sequence.

The main lithology for outcrop 7 is sandstone from fine to medium grained size. The total thickness is approximately 1.6 meters. The fine grained sandstone is up to 0.4 meters. Then it is followed by medium grained sandstone up until the height of 1.6 meters.

The most common sedimentary structure observed is parallel laminations. Quartz vein is also found in the rocks.

Outcrop 8 – N 06^{0} 25’55.4’’, E 99^{0} 43’10.9’’

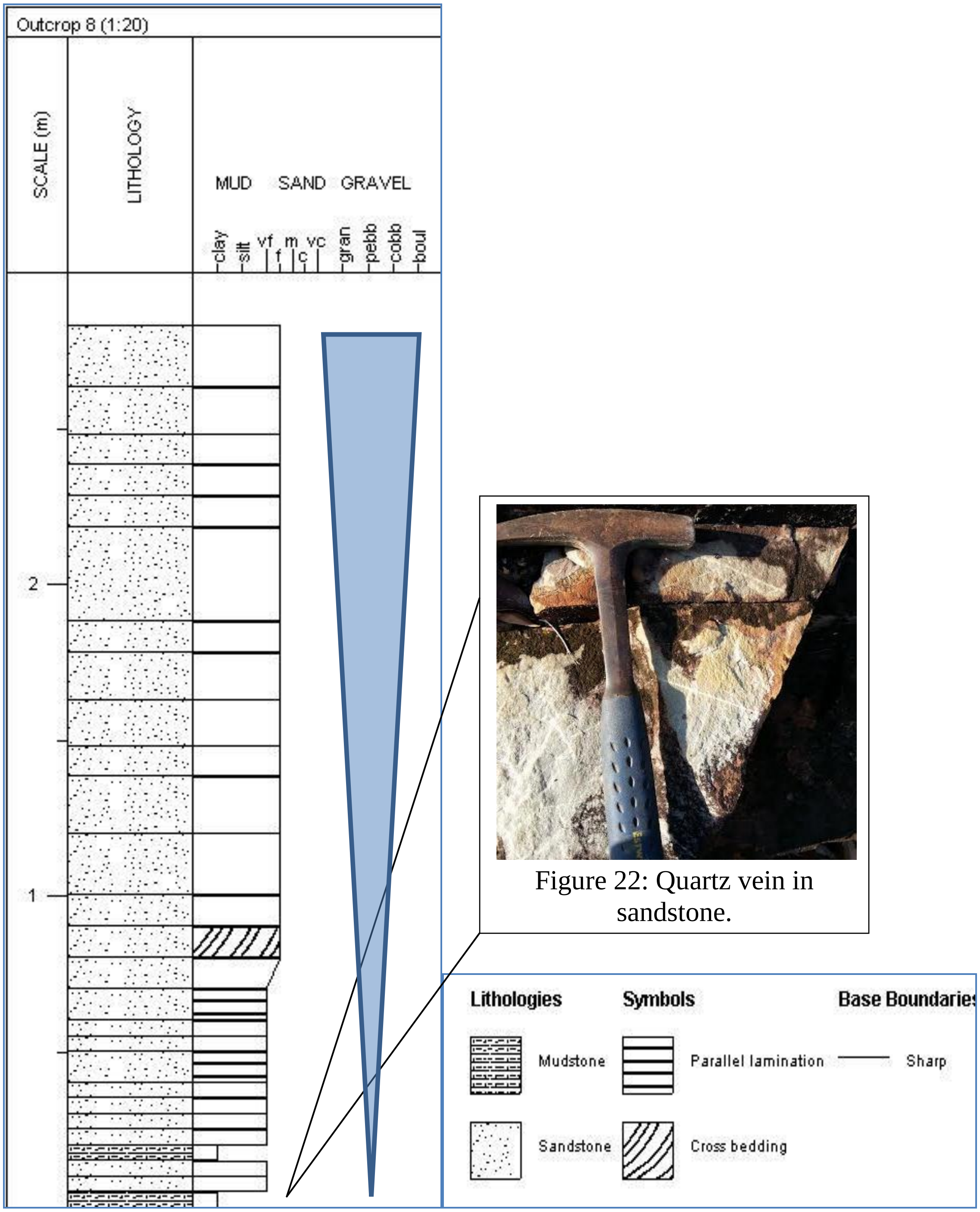


Figure 22: Quartz vein in sandstone.

Figure 23: Sedimentary log of outcrop 8 showing coarsening upwards sequence of very fine to fine sandstone.

The total thickness of the outcrop is approximately 3 meters and is highly weathered and fractured according to the bedding. It is made up of sandstone with muddy layers found in the bottom of the outcrop. There are plenty of micro quartz veins found in the fragments of the rock. The sandstone grained size change from very fine to fine. In the very fine sandstone, there are thin intercalations of muddy layers and parallel laminations are found up until the height of 0.7 meters. Then, it is followed by fine grained sandstone and there are no structures seen as it is a very steep outcrop and the author was not able to examine the outcrop thoroughly. It is a coarsening upward sequence.

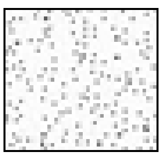
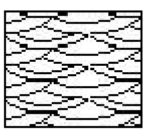
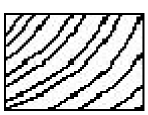
Figure 24: (A) Outcrop 8 showing distinct bedding. (B) Sharp contact at each bed and highly fractured. (C) Quartz veins found in the pieces of sandstone.

4.2 Facies

4.2.1 Facies Identification

There are four facies distinguished from the all of the outcrops found along Jalan Datai which are shown clearly in Table 1 below.

Table 4: Facies type of outcrops.

Facies	**Lithology**	**Sedimentary structures & processes**	**Interpretation**
Structureless sandstone 	Coarse- medium-fine-very fine grained sandstone	No structures observed in the sandstone facies.	Lower to middle shoreface enviroment
Trough cross-bedded sandstone 	Coarse grained sandstone	Trough cross-bedding. Represents water current flowing in a confined space.	Tidal channel fills or upper shoreface.
Planar cross-bedded sandstone 	Coarse-fine-very fine grained sandstone	Planar cross-bedded.	Channel deposits and shallow marine sediments.
Parallel lamination sandstone 	Coarse- medium-fine-very fine grained sandstone	Parallel lamination. Wave energy causes a separation between different grain sizes.	Coastal environment.

4.2.2 Facies Succsession

Generally, the sedimentary logs constructed are coarsening upward. The environment of deposition is wave dominated environment as the grain size change from very fine to coarse grain. It can be concluded that the environment of deposition for this study area is most probably upper shoreface due to:-

- Abundant thin parallel lamination found in the beds and some intercalation of finer silty or muddy layers.
- Good to moderate sorting of sands with planar cross-bedding and trough cross-bedding sandstone as the sedimentary structures.

This is based on Massachusetts Institute of Technology (MIT) OCW (2007) as upper shoreface environment is composed of trough cross-bedding, plane beds and it is shown in the Figure 25 highlighted by the red square line.

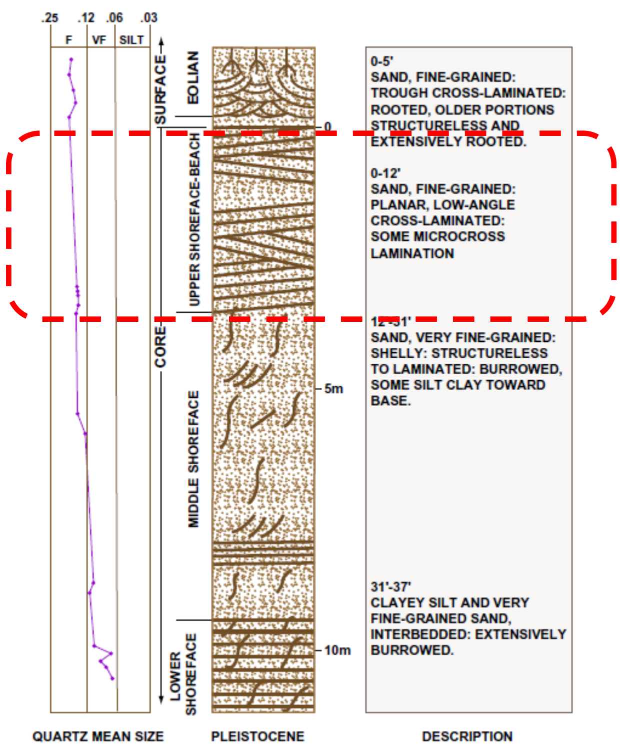


Figure 25: Vertical section of a tyical beach deposit MIT OCW (2007). The red square is highlighting the upper shoreface to beach environment which are composed of fine grained sands with planar to low angle cross bedding.

Hence, Figure 26 is showing the suggested paleo-environment of the study area which is upper shoreface with wave dominated environment.

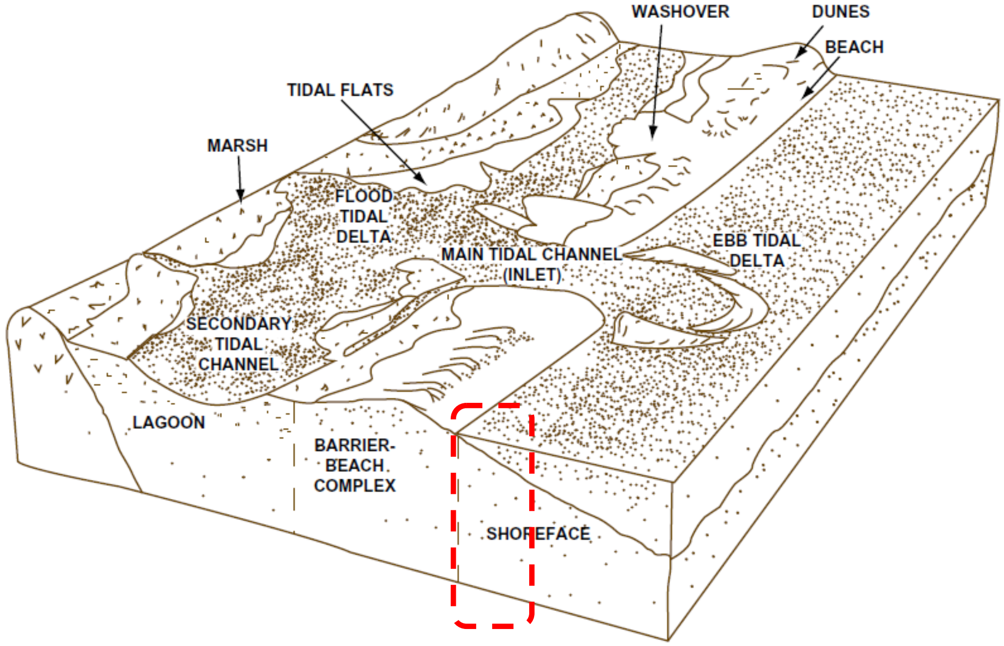


Figure 26: Model of a barrier island to shoreface environment (Gore, 2010). This is the proposed upper shoreface environment for the study area.

4.3 Petrographic Analysis

12 samples were taken to perform thin section analysis. Most of the samples collected are highly weathered and oxidized causing limitation in preparing the thin section samples.

Overall, quartz is the most predominant mineral found in all of the samples. The grains are moderate sorted with high sphericity and sub-angular to sub-rounded. The matrix is composed of clay, smaller crystals of quartz and carbonaceous matter. The carbonaceous matter originated from higher ground and due to its low density, it is transported easily by water and suspended in the water column at lower ground and lastly it is deposited along with the sands. In the thin section, the black coloured matter is representing carbonaceous matter while quartz mineral is showing colourless nature , first order white to gray interference colours and undulatory extinction. Clay is indicated by the brownish colour under the cross-polarized light. There is no feldspar observed in the samples as it has been weathered and converted into clay materials. Hence, it is considered as mature rock due to absence of feldspar.

The area also has been exposed to low metamorphism due to its old age causing the sandstone to be metamorphosed into metaquartzite. It is formed when there is clearly visible interlocking crystals as quartz rich sandstone is metamorphosed due to low heat and pressure exerted upon it.

From the petrographic analysis, there are four types of metaquartzite classified according to the grain size of the rocks:-

1. Very fine grain quartzite
2. Fine grain quartzite
3. Medium grain quartzite
4. Coarse grain quartzite

1. Very fine grain metaquartzite

(Sample: 22a)

- Macroscopic description:

Part of the rock has been oxidized by iron oxide. The sample is light grey and contains very fine grains.

Figure 27: Sample 22. Very fine metaquartzite. Location: Outcrop 8.

- Microscopic description:

The sample is fine grain with grain size in range of 0.12 to 0.06 mm. The quartzite has angular grains. The matrix is made up of carbonaceous matter, clay and very fine quartz.

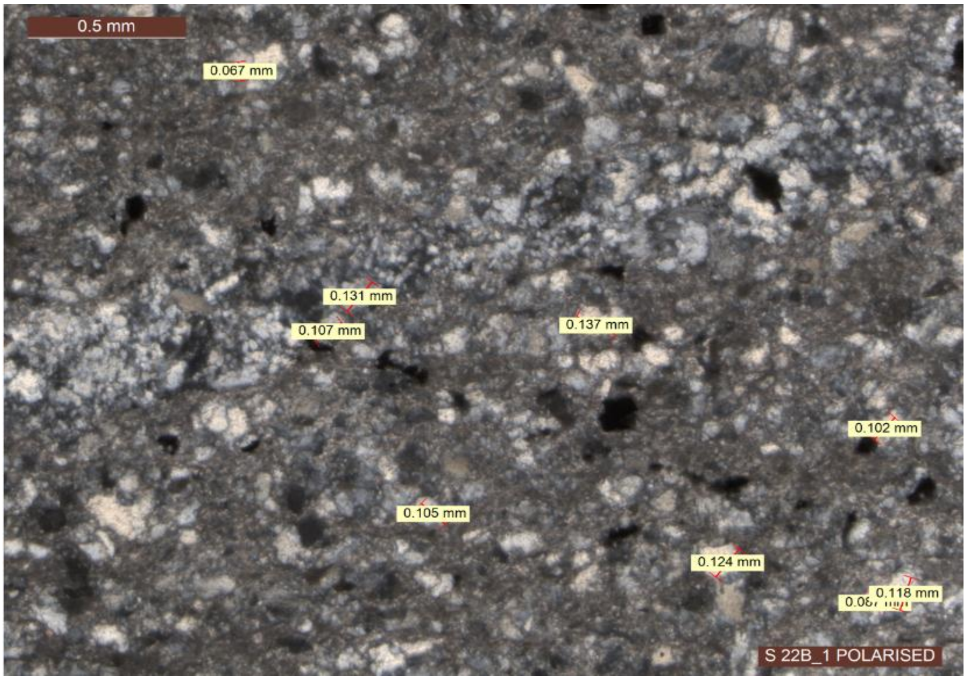


Figure 28: Photomicrograph of very fine metaquartzite. Cross polarised with x4 magnification.

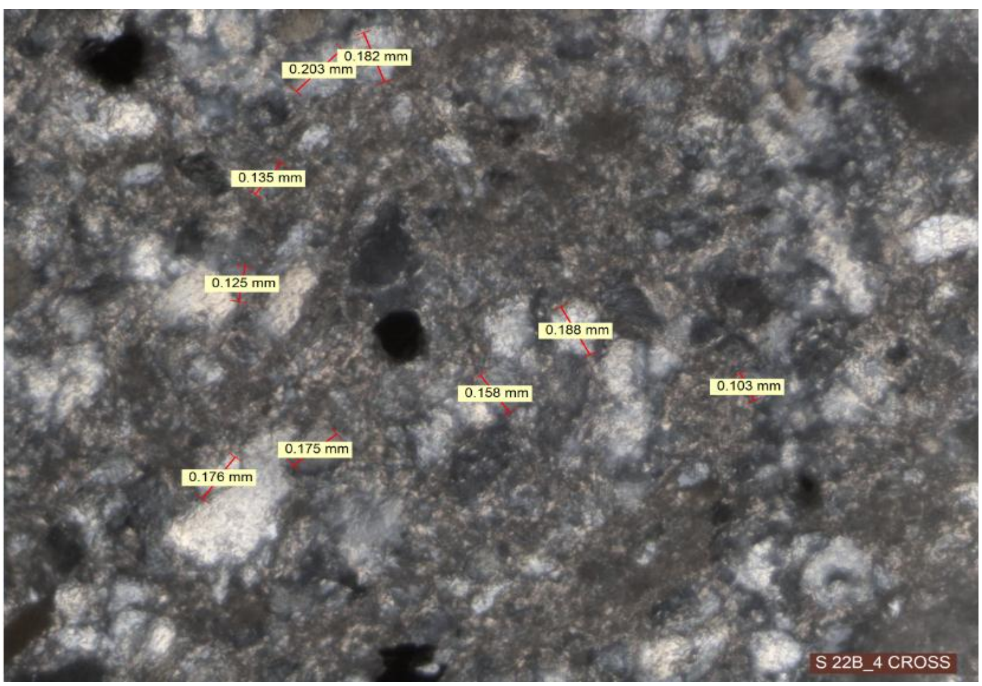


Figure 29: Photomicrograph of very fine metaquartzite. Cross polarised with x10 magnification.

2. Fine grain metaquartzite

(Sample 12, 21 and 22b)

- Macroscopic description:

Sample 12, 21 and 22b are light brown in colour due to oxidation. The inner part of sample 21 is light grey colour. All of the samples are fine grain which grain size range from 0.25 to 0.12 mm.

Figure 30: (A) Sample 12. Location: Outcrop 3. (B) Sample 21. Location: Outcrop 8. (C) Sample 22b. Location: Outcrop 8.

- Microscopic description:

The quartz minerals are angular in shape. The matrix is made up of carbonaceous matter, clay and very fine quartz.

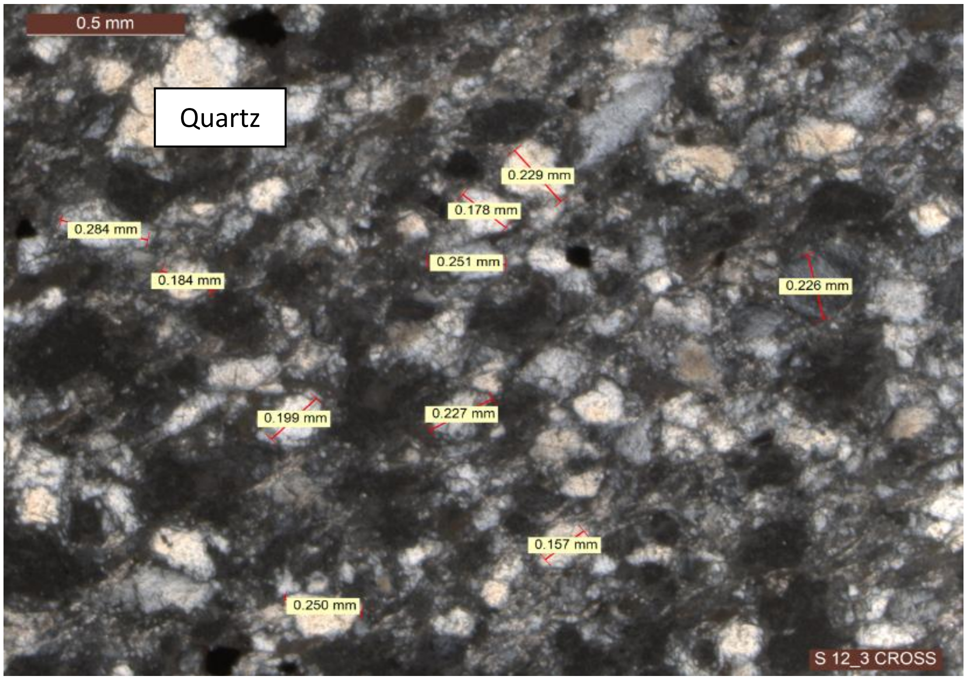


Figure 31: Photomicrograph of fine metaquartzite of Sample 12. Cross polarised with x4 magnification.

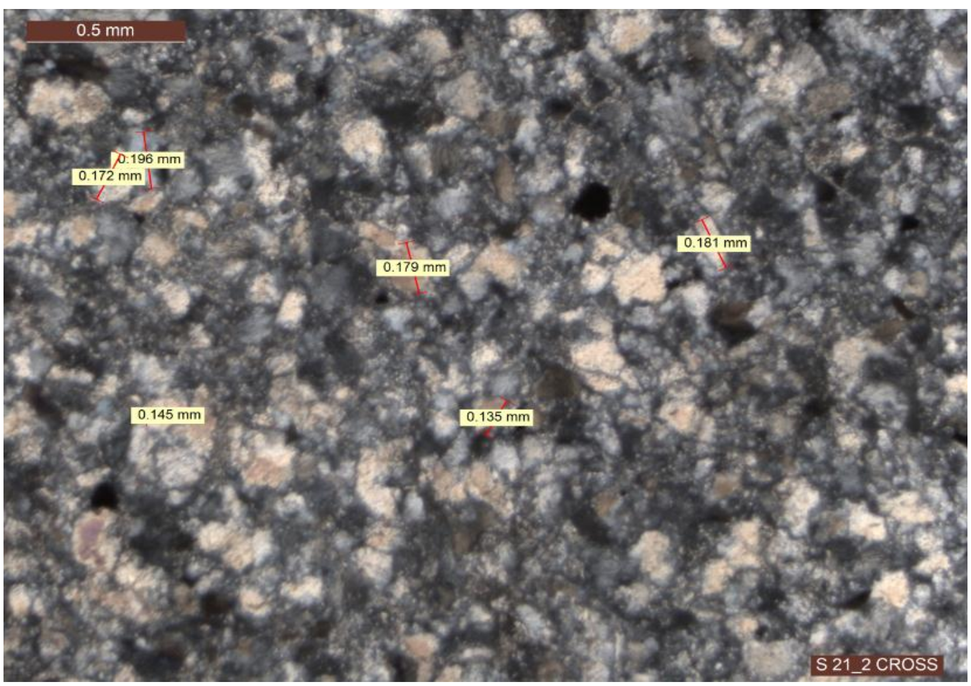


Figure 32: Photomicrograph of fine metaquartzite of Sample 21. Cross polarised with x4 magnification.

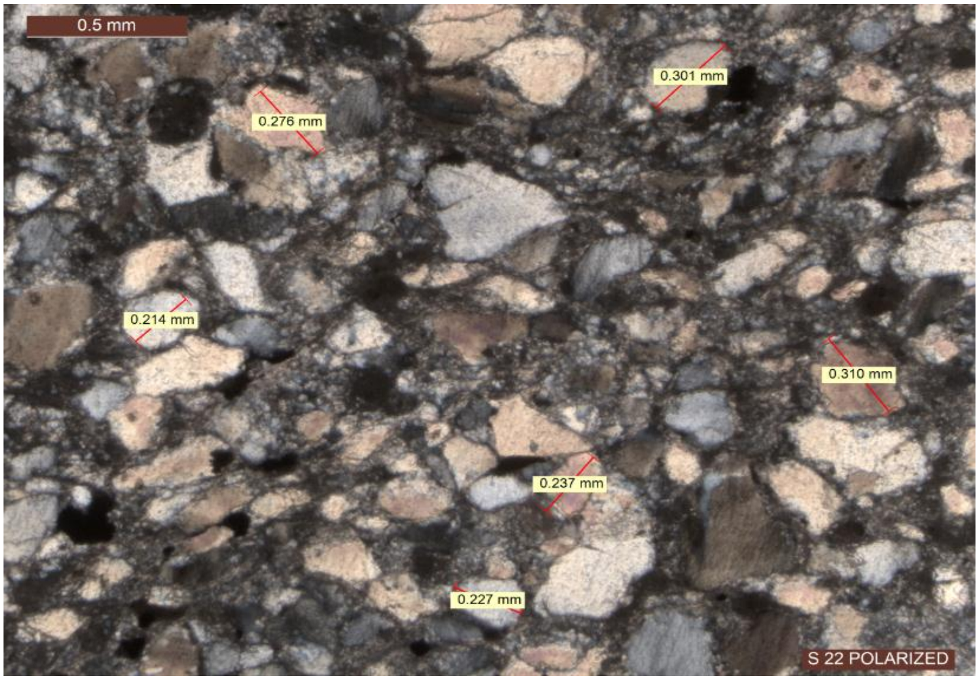


Figure 33: Photomicrograph of fine metaquartzite of Sample 22b. Cross polarised with x4 magnification.

3. Medium grain metaquartzite

(Sample 1, 2, 3 and 7)

- Macroscopic description:

All of the samples are light grey colour with medium grain size ranging from 0.50 to 0.25 mm.

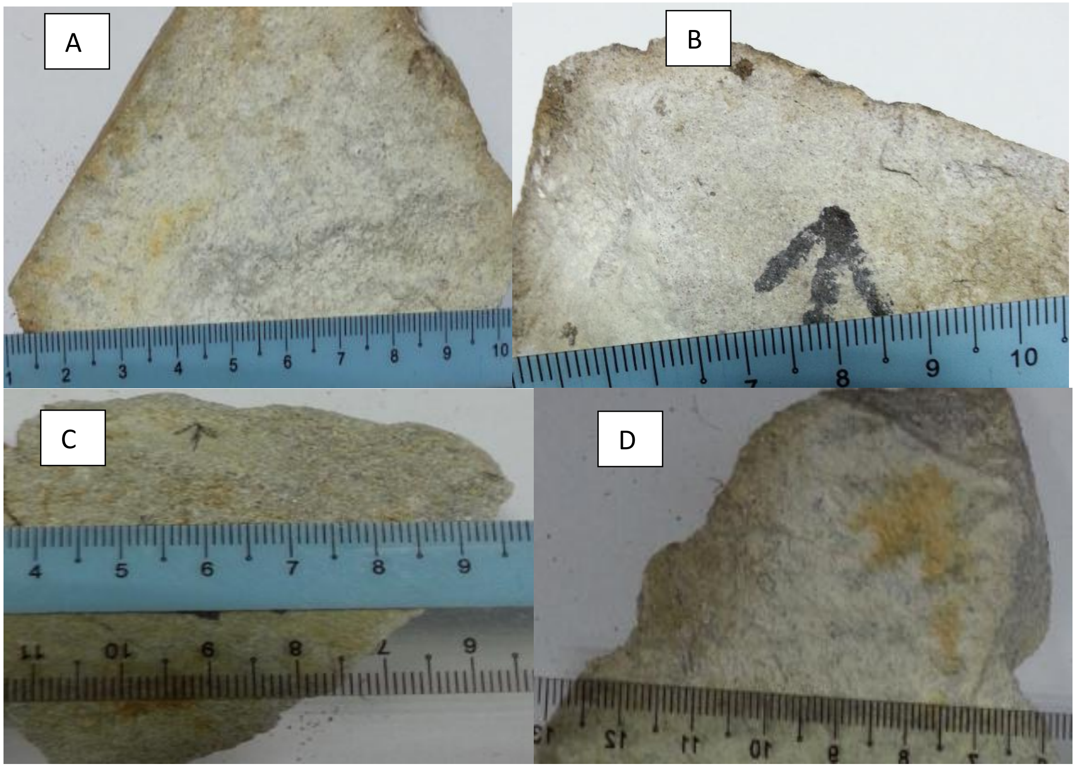


Figure 34: (A) Sample 1. (B) Sample 2. (C) Sample 3. (D) Sample 7. Location: Outcrop 1.

- Microscopic description:

The quartz minerals are angular and sub-rounded in shape. The matrix is made up of carbonaceous matter, clay and very fine quartz.

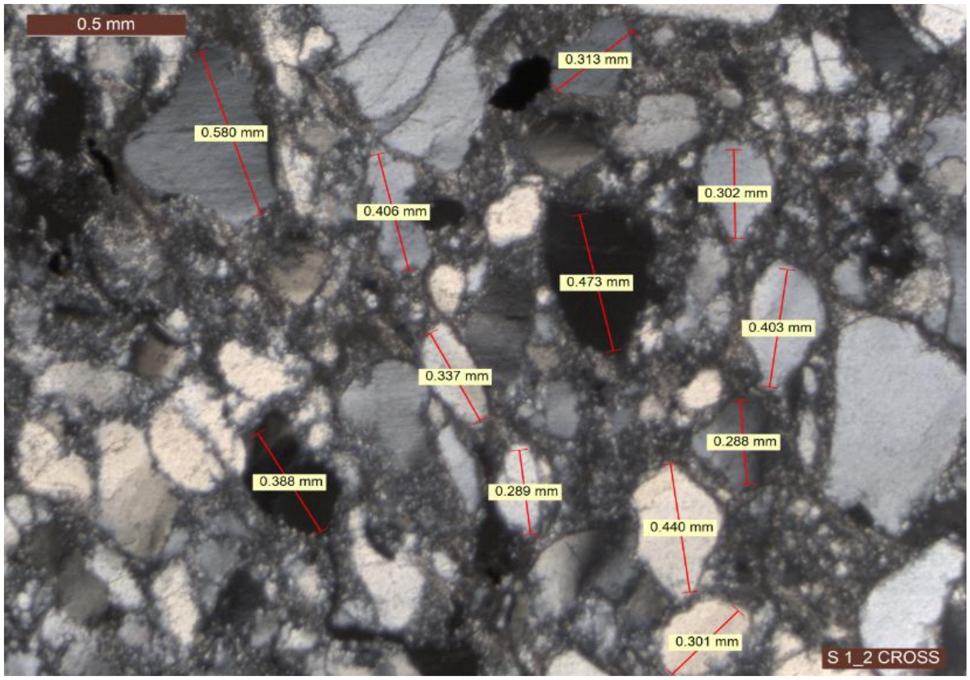


Figure 35: Photomicrograph of medium metaquartzite of Sample 1. Cross polarised with x4 magnification.

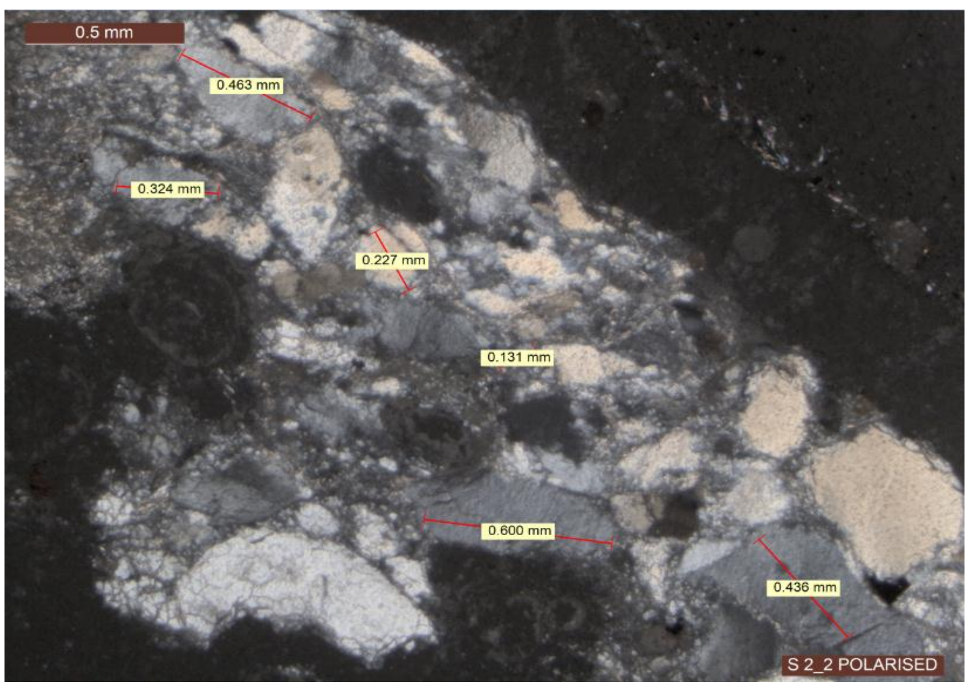


Figure 36: Photomicrograph of medium metaquartzite of Sample 2. Cross polarised with x4 magnification.

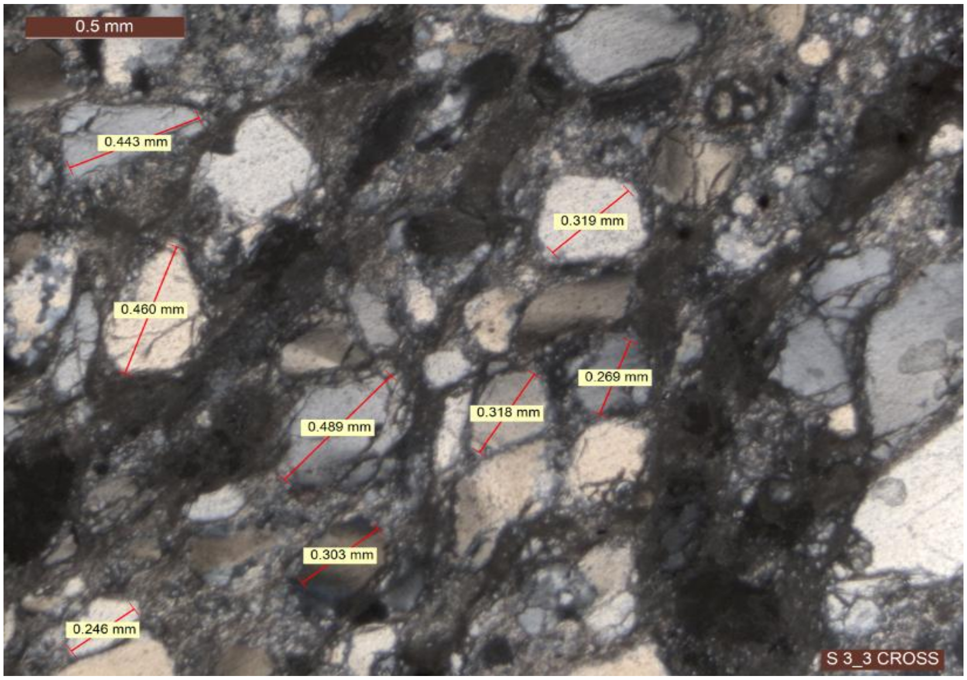


Figure 37: Photomicrograph of medium metaquartzite of Sample 3. Cross polarised with x4 magnification.

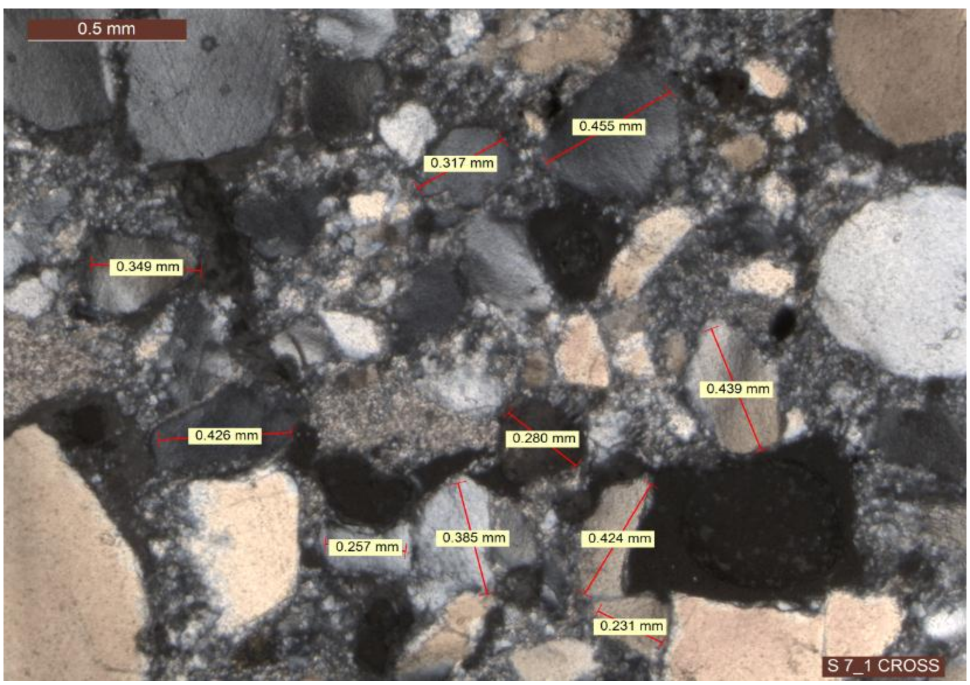


Figure 38: Photomicrograph of medium metaquartzite of Sample 7. Cross polarised with x4 magnification.

4. Coarse grain metaquartzite

(Sample 8)

Sample 8 is light grey colour with coarse grain ranging from 1.0 to 0.5 mm. Some part of the sample has been oxidized causing orange colour due to iron oxide.

- Macroscopic description:

Figure 39: Sample 8. Location: Outcrop 1.

- Microscopic description:

The quartz minerals are low sphericity and sub-rounded. The matrix is made up of carbonaceous matter, clay and very fine quartz.

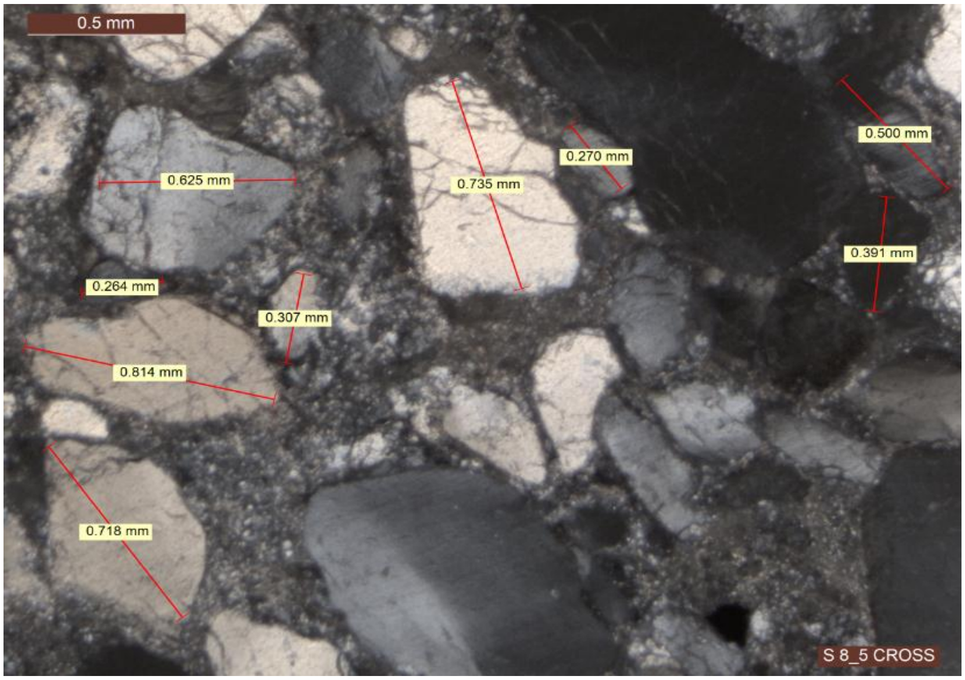


Figure 40: Photomicrograph of coarse metaquartzite of Sample 8. Cross polarised with x4 magnification.

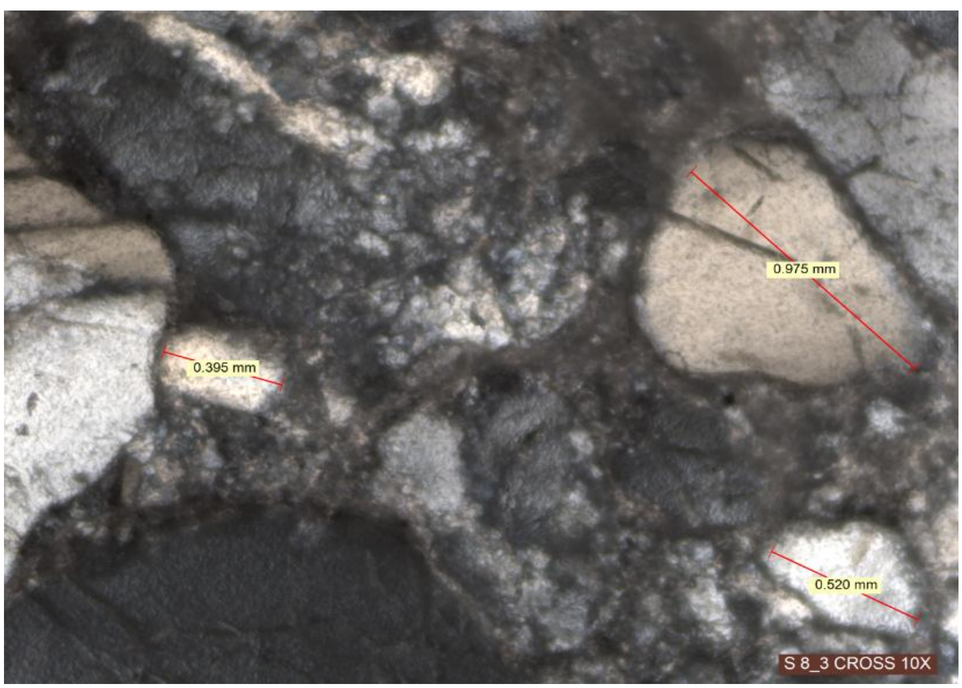


Figure 41: Photomicrograph of coarse metaquartzite of Sample 8. Cross polarised with x10 magnification.

4.3.1 Sandstone Classification

Based on the Dott (1964) classification, the sandstone is classified as sublitharenite or quartarenite. This is because the quartz content is more than 80% while the matrix is less than 15%. Below is one of the examples of point count of a coarse thin section sample for point counting method.

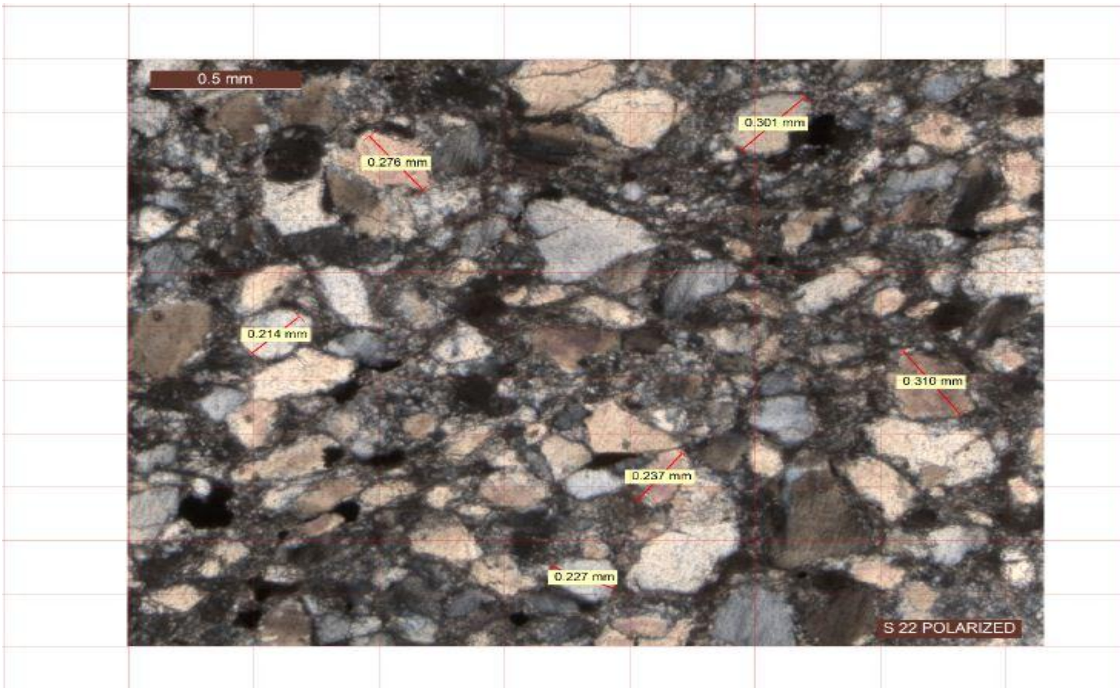


Figure 42: Coarse grained thin section sample for point count method.

Point Count Data:-

Component	Number of grains counted	Proportion (%)
Quartz	198	86
Fekdspar	-	-
Rock fragments	-	-
Matrix	32	14
Total	**230**	**100**

In the QFL Ternary Diagram, the sandstone falls under the region of quartzarenite to sublitheranite. Due to low metamorphism exerted upon the rocks in the area, the rocks become metaquartzite.

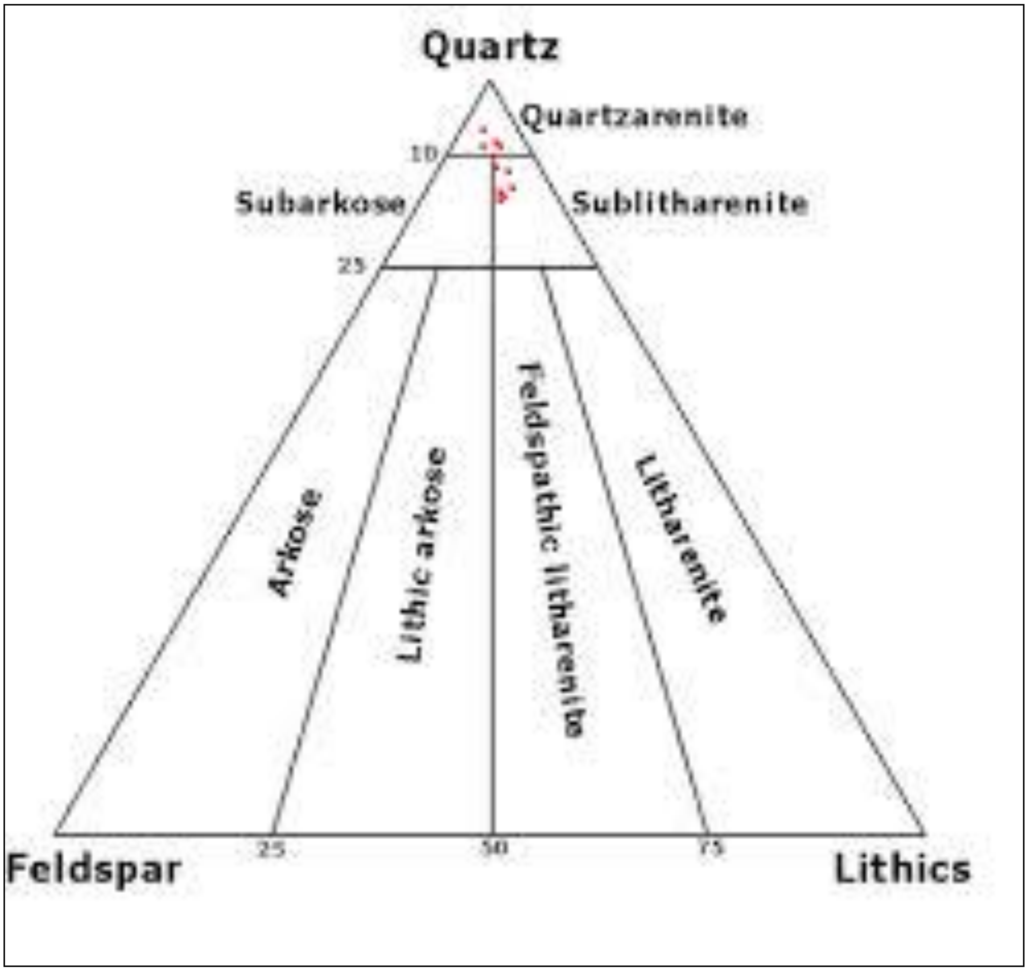


Figure 43: QFL ternary diagram. All of the samples falls under sublitharenite to quartzarenite as the composition of quartz is more than 80%.

4.4 Mapping

4.4.1 Traverse map

Figure 44: Transect route which is along Jalan Datai. Eight outcrops were identified along the transect route.

4.4.2 Lithology map

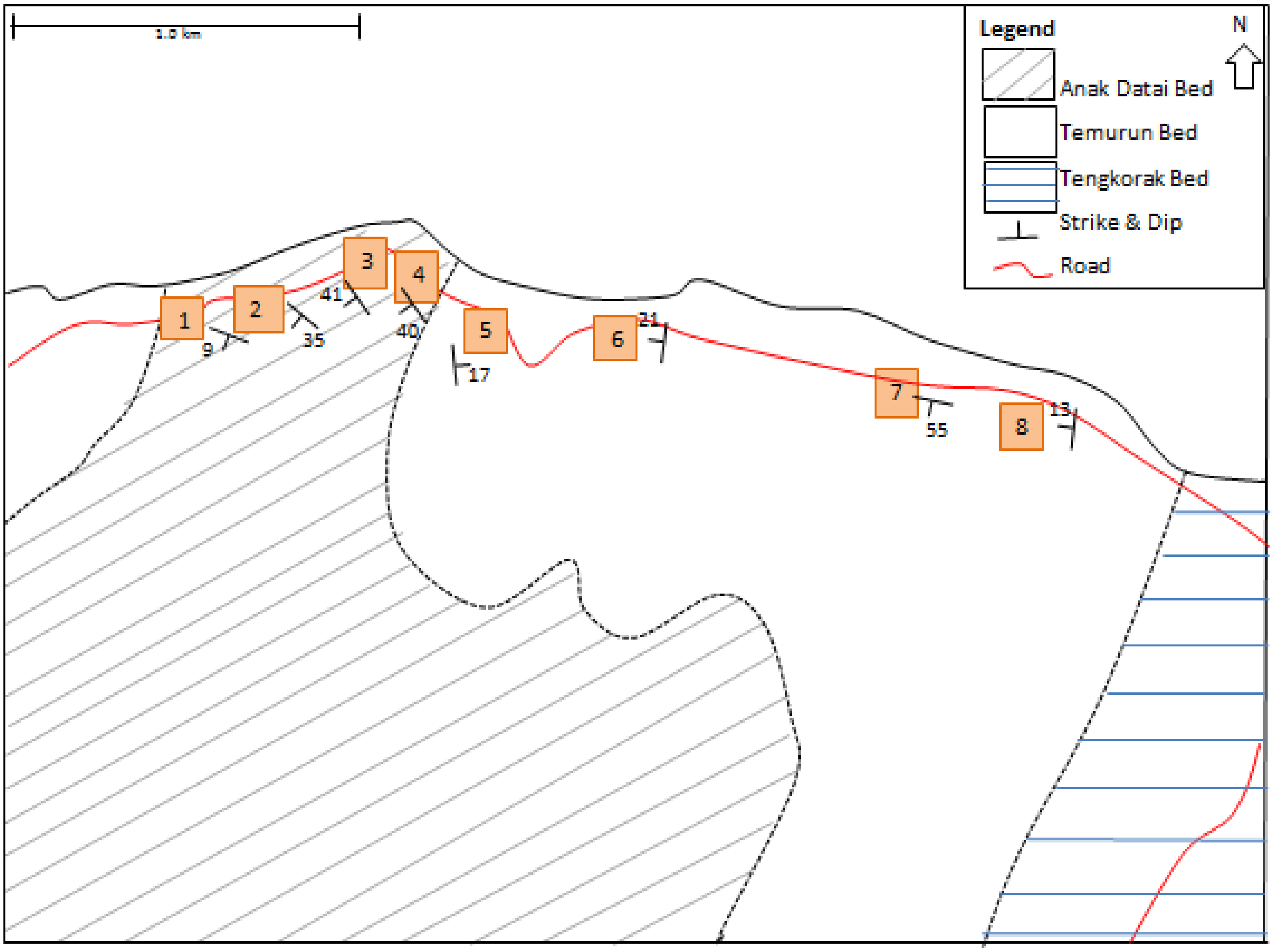
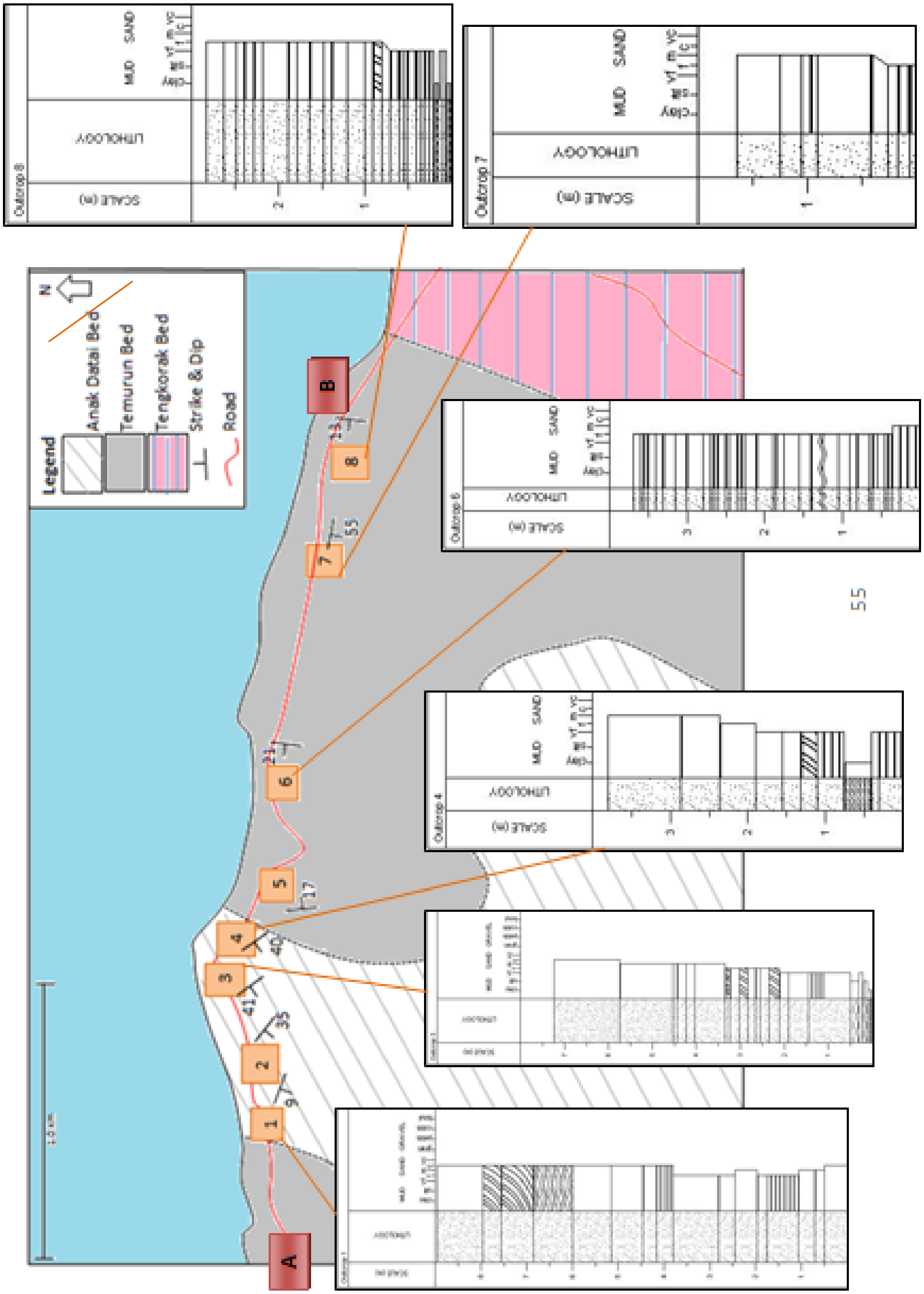


Figure 45: Lithology map of study area. The study area covers Anak Datai and Temurun Bed.

4.4.3 Lithology map with sedimentary logs



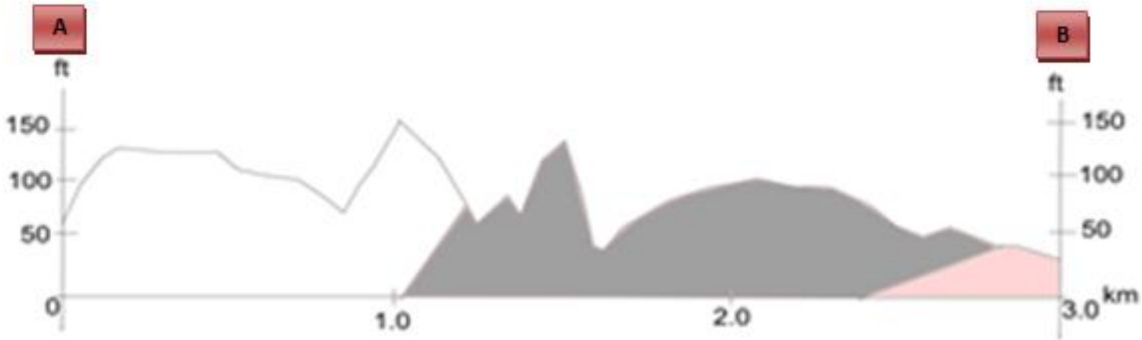


Figure 46: Lithology map along with sedimentary logs and the cross section of the transect route starting from A to B. The sedimentary logs constructed along the route mostly showing coarsening upwards sequence.

CHAPTER 5

CONCLUSION & RECOMMENDATION

5.1 Conclusion

The main lithology identified for the study area is sandstone with minor thin intercalation of muddy or silty layers. There are four main facies distinguished for the study area based on the sedimentary structures observed in the sandstone. The facies identified are trough cross-bedding sandstone, planar cross-bedding sandstone, parallel lamination sandstone and massive sandstone. All of the facies supported upper shoreface as the environment of deposition. Based on the facies succession, generally it is a coarsening upward sequence which concluded the environment of deposition as upper shoreface with wave dominated environment.

Through petrographic analysis, the main mineral identified is quartz mineral and the matrix is composed of clay, smaller crystals of quartz and carbonaceous matter. There is no feldspar in the sample which indicated the maturity of the rock. The grain sizes of the sandstone are varying from very fine, fine, medium to coarse sands. It is classified as quartzarenite to sublitheranite sandstone because quartz mineral dominated with more than 80% of the total composition and its matrix is less than 15%. The rock in the study area has been exposed to low metamorphism causing the sandstone to become metaquartzite.

5.2 Recommendation

There are limitations in performing the project due to great heights causing limited fieldwork can be conducted at the top of the outcrop. Hence, it is recommended to perform jungle or river traversing to obtain more information regarding the formation. The contact between two beds which are Anak Datai bed and Temurun bed is also hard to locate due to thick vegetation along the road. Therefore, further information regarding the contact was taken from the previous researches done.

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APPENDIXES

Outcrop 1:

Coordinate:

- N 06^{0}26.115^0
- E 99^0 42.057^0

Direction: South West

	Strike	Dip angle
1	110^0	9^0
2	100^0	8^0
3	101^0	9^0
4	103^0	7^0
5	99^0	5^0
6	100^0	10^0
7	101^0	4^0
8	102^0	6^0
9	108^0	9^0
10	106^0	8^0
11	107^0	9^0
12	102^0	5^0
13	110^0	6^0
14	108^0	8^0
15	109^0	9^0
Average	110^0	9^0

Outcrop 2:

Coordinate:

- N 06^0 26’ 08.30’’
- E 99^0 42’ 06.30’’

Direction: South West

	Strike	Dip angle
1	151^0	30^0
2	150^0	32^0
3	149^0	30^0
4	148^0	23^0
5	146^0	26^0
6	147^0	20^0
7	143^0	21^0
8	155^0	30^0
9	152^0	33^0
10	147^0	35^0
11	148^0	39^0
12	150^0	30^0
13	143^0	28^0
14	130^0	25^0
15	145^0	31^0
Average	150^0	35^0

Outcrop 3:

Coordinate:

- N 06^0 26.125^0
- E 99^0 42.354^0

Direction: South West

	Strike	Dip angle
1	160^0	40^0
2	159^0	42^0
3	160^0	40^0
4	163^0	39^0
5	154^0	37^0
6	157^0	38^0
7	160^0	41^0
8	159^0	41^0
9	155^0	39^0
10	145^0	42^0
11	153^0	38^0
12	155^0	40^0
13	161^0	36^0
14	162^0	40^0
15	164^0	39^0
Average	165^0	41^0

Outcrop 4:

Coordinate:

- N 06^0 26.130^0
- E 99^0 42.320^0

Direction: South West

	Strike	Dip angle
1	160^0	40^0
2	159^0	42^0
3	160^0	40^0
4	163^0	39^0
5	154^0	37^0
6	157^0	38^0
7	160^0	41^0
8	159^0	41^0
9	155^0	39^0
10	145^0	42^0
11	153^0	38^0
12	155^0	40^0
13	161^0	36^0
14	162^0	40^0
15	164^0	39^0
Average	160^0	40^0

Outcrop 5 – Temurun waterfall

Direction: North East

	Strike	Dip angle
1	170^0	10^0
2	179^0	12^0
3	166^0	14^0
4	178^0	15^0
5	180^0	18^0
6	177^0	13^0
7	168^0	16^0
8	161^0	11^0
9	165^0	17^0
10	175^0	15^0
11	173^0	18^0
12	185^0	17^0
13	181^0	16^0
14	172^0	20^0
15	174^0	19^0
Average	178^0	17^0

Outcrop 6:

Coordinate:

- N 06^0 26.096^0
- E 99^0 42.593^0

Direction: North West

	Strike	Dip angle
1	178^0	19^0
2	181^0	26^0
3	186^0	21^0
4	188^0	22^0
5	180^0	20^0
6	187^0	22^0
7	178^0	25^0
8	179^0	19^0
9	175^0	24^0
10	185^0	20^0
11	183^0	21^0
12	184^0	22^0
13	180^0	18^0
14	183^0	23^0
15	185^0	21^0
Average	185^0	22^0

Outcrop 7:

Coordinate:

- N 06^0 25’57.6’’
- E 99^0 43’05.0’’

Direction: South West

	Strike	Dip angle
1	98^0	48^0
2	99^0	49^0
3	96^0	41^0
4	97^0	45^0
5	94^0	59^0
6	100^0	52^0
7	101^0	53^0
8	97^0	55^0
9	96^0	54^0
10	94^0	54^0
11	93^0	55^0
12	94^0	53^0
13	90^0	48^0
14	93^0	53^0
15	85^0	51^0
Average	96^0	55^0

Outcrop 8:

Coordinate:

- N 06^0 25’55.4’’
- E 99^0 43’10.9’’

Direction: NorthWest

	Strike	Dip angle
1	180^0	13^0
2	189^0	12^0
3	196^0	13^0
4	187^0	14^0
5	194^0	11^0
6	180^0	10^0
7	181^0	13^0
8	187^0	15^0
9	186^0	24^0
10	184^0	24^0
11	188^0	5^0
12	190^0	13^0
13	190^0	18^0
14	191^0	13^0
15	185^0	11^0
Average	188^0	13^0