CERTIFICATION OF APPROVAL

ROCK GEOMETRY WITH COMPARISON TO POROSITY MEASUREMENT

By

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in partial fulfillment of
the requirements for the
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(Petroleum Engineering)

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Approved by,

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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.

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(MUHAMMAD HARIS B. HAMZAH)

ABSTRACT

The oil and gas industry has been around for almost 150 years. It covers from the finding of hydrocarbon in remote locations all the way to producing and selling these rare and due to recent events in the world very expansive non-renewable energy source. The understanding of the relationship between pore geometry and porosity measurement is necessary in enabling us to further locate and predict new locations whereby oil and gas can accumulate. My project will be to see this relationship base on images obtained through thin sectioning and the Scanning Electron Microscope and compared to data obtained via the Mecury Porosimeter. Samples taken from the Semanggol Formation will consist of different types to obtain a number of readings. The results will enable us to better understand the relationship between pore geometry and porosity measurement

ACKNOWLEDGEMENT

I owe a debt of gratitude to a number of people who have enabled me to be able to complete my given Final Year Project. My first and foremost appreciation goes to my Final Year Project supervisor A.P Askury Abd Kadir for without him I would have never been able to complete this project.

I would also like to show my appreciation to the men who have helped me execute my numerous test in the labs, the lab technicians in Universiti Teknologi PETRONAS. Next, I would like to thank my parents who have supported me throughout my years studying in the university as well as during the time I’ve been executing my project.

Lastly, I would like to thank the Al-Mighty, Allah S.W.T for without his guidance I would never have truly found my way to the end.

CHAPTER 1: INTRODUCTION

1. 1 Project Background

Porosity according to Chernicoff and Whitney is the volume of pore space compared to the volume of a soil, rock, or sediment. Porosity actually determines how much water or in our case oil the rock formation can hold. Porosity may be measured through a variety of methods, including

·borehole gravimetrics

·sonic, gamma-gamma density, or neutron logging

·core analysis

Each method investigates a different volume of the formation. The borehole gravimeter samples very large volumes in the order of 10^3 to 10^6 cubic feet. Wireline logging tools investigate a much smaller volume, on the order of 1 to 10 cubic feet, depending on the specific porosity device used. Core analysis investigates much smaller volumes, ranging from $10^{-3}$to 10^{-1}cubic feet. From one extreme to the other are nine orders of magnitude, so we should not be surprised to learn that porosity estimates using different tools and techniques do not always agree

Rock geometry on the other hand can be said to be the study of the formation of pores in a certain rock formation. The study of pore geometry as well as an understanding of the proper porosity measurement is vital for a future Petroleum Engineer in understanding the development of the well.

1.2 Objective

The primary objective of this project is to correlate between pore geometry via petrography with total porosity measurement of a sample taken from the Semanggol Formation in the northwest region of the Peninsula Malaysia.

1.3 Problem Statement

The main problem of my project will be what is the relationship between pore geometry of a rock formation and its porosity measurement? The major significance of the project is that it will enable us to better understand the porosity of the rocks found at the Semanggol formation as well as enable us to predict reservoir sites.

1.4 Scope of Study

The scope of study has been divided into two components which are research and experiment. On the research, I will be studying some in depth digging with the topics regarding pore geometry as well as some reading materials on porosity measurement. I will also be looking into the researches that have been done on the Semanggol formation previously.

Besides that, I will also be doing some experiments in the process. I will be making plans with regards of the type of experimentation that I would like to carry out as well as execute them. The experiments will be with regards to understanding and analyzing the pore geometry of the samples that has been taken as well as the porosity measurement of them.

1.5 Feasibility and Relevancy

It can clearly be seen that this project is feasible within the allocated time given for Final Year Project. Project activities have been planned according to their specific stages to ensure the efficiency of this project. The crucial stage of ‘Project Research’ is planned to be done from Week 3 until Week 13 to make sure sufficient literatures and data are collected and analyzed to further the students understanding of the subject matter. This study is proven to be relevant due to the reason of the related topic in Petroleum Engineering Course which is because understanding the relationship between pore morphology and porosity measurements enable us to better choose our drill site and locate possible reservoirs.

CHAPTER 2: LITERATURE REVIEW

Firstly, I would like to talk about the location where my samples will be taken. There has been little research done on the Semanggol formation in the past decade. Geological interests in Malaysia have always been focused or pin pointed to regions that rich with details that mainly includes Sabah, Sarawak and Langkawi. The Semanggol Formation as stated by Basir Jasin (1997) was introduced by J. B. Alexander in his 1959 paper for the sedimentary rocks exposed in the Semanggol range in north Perak. This formation is said to have a high possibility of being in the same basin which was later divided into three areas of wrench faults which is a type of strike-slip fault in which the fault surface is vertical, and the fault blocks move sideways past each other as stated by C. K. Burton in his 1973 paper.

As stated in Basir and Zaiton (1996) the formation on formally overlies the Kubang Pasu Formation. In the Kulim-Baling area the formation is represented by two units; the chert and the rhythmite units. The rocks in this area comprise the Ordovician-Early Devonian Mahang Formation and the Permo-Triassic Semanggol Formation. The Carboniferous rocks are not exposed. Courtier (1974) proposed the Tawar Formation as a probable Carboniferous lithostratigraphic unit but no Carboniferous fossils were discovered. Burton (1988) considered that the Tawar chert was a part of the Semanggol Formation. The existence of Carboniferous rocks in the area is yet to be discovered because the Paleozoic and early Mesozoic rocks in the area were continuously deposited in a deep marine environment and there is no trace of any unconformity or tectonic uplifting during this time. In Gunung Semanggol area only two units were exposed *i.e.* the conglomerate and the rhythmite units. The formation was uplifted by the Late Triassic granite intrusion. The chert unit is well exposed only in the Padang Terap and Kulim-Baling areas. The chert unit in the Padang Terap area forms prominent north-south strike ridges located in the vicinity of the Pokok Sena area. The chert sequence is well exposed at Bukit Larek and Kampung Lanjut Malau.

The Bukit Larek section exhibits six facies which is listed in ascending order:

1. Black laminated mudstone
2. Interbedded sandstone and mudstone
3. Siliceous shale and mudstone
4. Interbedded siliceous shale and chert
5. Tuffaceous mudstone
6. Interbedded chert and siliceous shale.

The Semanggol chert in the Kulim-Baling area is faulted and strongly folded and it was very difficult to measure the actual thickness of the chert. Burton (1988) reported that the thickness of the chert in the Kulim-Baling area was approximately 700 m based on the outcrop where the rocks were not folded. Burton (1988) described a 1.12 m typical chert sequence at Lubuk Anak Batu Estate comprising mainly thinly bedded chert intercalating with siliceous shale of varying thicknesses. Most of the previous studies (Burton, 1973, 1988; Courtier, 1974; Teoh, 1992) considered the chert unit to consist of mainly interbedded chert and siliceous shale. Extensive earth excavation at Padang Terap and Kulim-Baling areas exposed many outcrops with a complete stratigraphic section of the chert unit especially at Bukit Larek and Kampung Lanjut Malau (Padang Terap) and at Bukit Kukus near Kuala Ketil (Kulim-Baling). The section at Bukit Kukus is chosen to represent the chert unit because it provides a more complete rock sequence with a good radiolarian biostratigraphic control.

Besides the understanding of the site of our sample we must also further understand about the rock geometry. As stated by (Tarafdar, 2002) Microstructure of rocks is a subject of practical importance and scientific interest from the petrologic point of view. There has been a huge amount of interest in recent years with regards to the study of the geometry of the rock-pore interface and a lot of the works which are both computer simulations and experimental are focus primarily on the nature of the rock-pore interface and the growth if correlated pore-scale structure. A number of small events occur in a rock formation process closely to one another in time and space with few large events occuring which results in physical mechanisms that favours the power law scaling in the system and int turn favors the interface to fluctuate rather than stay flat.

Beside's doing research on the Semanggol formation which will be where my samples be taken, I also read up on a few articles with regards to porosity management. As stated in the Schlumberger website porosity is the percentage of pore volume or void space, or that volume within rock that can contain fluids. Porosity can be a relic of deposition or can develop through alteration of the rock. Simply put porosity can either be primary porosity, such as space between grains that were not compacted together completely or secondary porosity, such as when feldspar grains or fossils are preferentially dissolved from sandstones. Porosity can be generated by the development of fractures, in which case it is called fracture porosity. Effective porosity is the interconnected pore volume in a rock that contributes to fluid flow in a reservoir. It excludes isolated pores. Total porosity is the total void space in the rock whether or not it contributes to fluid flow. Thus, effective porosity is typically less than total porosity.

CHAPTER 3: METHODOLOGY

3.1 Research Methodology

There are a number of types of different research that can be conducted. I will be doing a empirical research. Empirical research relies on experience or observation alone, often without due regard for system and theory. It is data-based research, coming up with conclusions which are capable of being verified by observation or experiment. We can also call it as experimental type of research. In such a research it is necessary to get at facts firsthand, at their source, and actively to go about doing certain things to stimulate the production of desired information. In such a research, the researcher must first provide himself with a working hypothesis or guess as to the probable results. He then works to get enough facts to prove or disprove his hypothesis. He then sets up experimental designs which he thinks will manipulate the persons or the materials concerned so as to bring forth the desired information.

3.2 Project activities

- **Obtaining Sample from Semanggol Formation**

  The first part of the project is to obtain or abstract of a sample of the rock from the Semanggol Formation in the northwest region of the Peninsula Malaysia which was previously discussed in Chapter 3. I will be extracting three main samples which include sandstone, conglomerate and clastic sediments using the percussion drilling set as shown in part 3 of this chapter.

- **Understand the pore geometry of rock sample obtained**

In this part of the project, I am required to understand the soil samples obtain from the Semanggol Formation from a geological point of view. Here I will be researching each of the samples under a microscope as well as in the lab to further understand the geometry of the pore spaces. If I have enough time I will be using a CT scanner to assist my analysis of the rock geometry of the samples taken from the site.

- **Calculating porosity of soil sample**

The next part of my project is to be able to calculate the porosity of the samples which is a balance of simple calculations as well as some lab equipment usage. I will be using the Boyle's Porosimeter to estimate the porosity in the samples that I obtained. How do we calculate the porosity in the samples with using a Boyle's Porosimeter? A porous rock system has two components: the grain volume and the pore volume. The sum of the two gives the bulk volume:

$$V_b = V_{gr} + V_p$$

The porosity is defined as the ratio of the pore volume to the bulk volume, for example,

$$\phi = \frac{V_P}{V_B}$$

Thus porosity can be measured in a number of ways, such as

$$\phi = \frac{V_B - V_G}{V_B}$$

or

$$\phi = \frac{V_P}{V_G + V_P}$$

Provided any two of the three variables are measured, porosity can be deduced. Among the commonly employed methods of deduction are:

- Summation of Fluids
- Boyle's Law Porosimeter
- Washburn-Bunting
- Wet and Dry Weights
- Total Porosity

A cleaned and dried sample is placed in a sample chamber that has an air pressure P_1 .

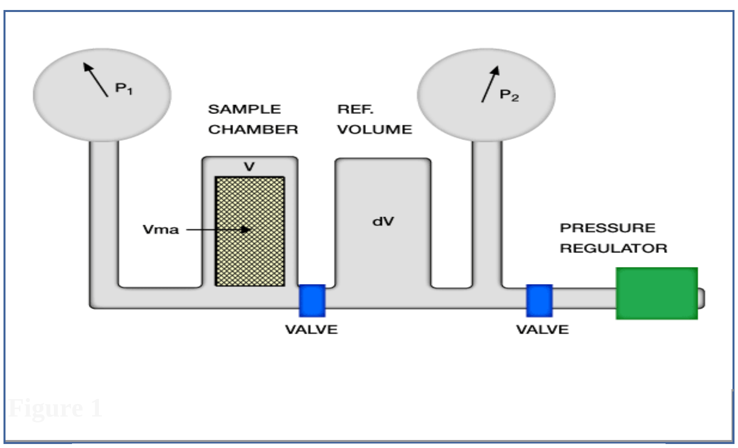


Figure 1: A graphic image of Boyle's law

When the valve that connects the sample chamber with the reference volume chamber is opened, the air will expand isothermally and equilibrate on pressure P_2. We further assume that the volume of the sample chamber is V, and that the core sample has a grain volume V_{gr}. The sample chamber will therefore contain a volume V-V_{gr} of gas. If this gas is brought isothermally from pressure P_1 to P_2 by adding reference volume dV, we can then apply the Law of Boyle and deduce:

$$(V - V_{ma}) * P_1 = (V - V_{ma} + dV) * P_2$$

From this formula the grain volume, V_{gr} and the resulting pore volume can be calculated. Application of this technique results in a measurement of the porosity of interconnected pores only. This means that isolated pores, which are common in carbonate rocks, will not be accounted for. Additionally, by drying the samples, any clay present will have lost its water content also leading to an inaccurate porosity measurement.

- **Understand the relationship of the pore geometry with porosity measurement**

  The final step of my project is to discuss my findings on the relationship between the pore geometry of each sample to the porosity obtained. This will in turn be in my final report. At the end of my project I hope to find that the rocks at the Semanggol Formation is a potential area to be a reservoir rock

3.3 Tool and Equipment

Throughout the my Final Year Project I will be using a number of tools assist in my goal to better understand the pore geometry of the rock and its relations towards porosity of it. In this part of my report I will state the equipment that shall be used in project and it purpose

1) Percussion Drilling Set

Figure 2: A Percussion Drilling Set

If drilling has to be executed in hard soils, possible containing layers of rubble and/or stones usually percussion drilling is applied. Because of the mobility of the percussion drilling equipment and its ready capacity to solve problems. A percussion drilling set is an important piece of equipment due to the fact that it is necessary to obtain rock samples from the site. With this equipment I will also used a rock hammer to assist in choosing the proper samples for this project.

2) Coring machine

Figure 3: A Coring Machine

Some of the samples I obtained from the sight had already broken off from the formation itself. This imposes a slight difficulty in analyzing the samples. Thus, I will be using the coring machine to create sample size cores to be used in my analysis. The coring machine is also used in creating smaller size samples from those obtained using the percussion drilling set.

3) Mercury Porosimeter

Figure 4: A Mercury Porosimeter

Mercury porosimeter can be used to measure the percolation characteristics of the samples obtained from the Semanggol Formation. It is able to measure the porosity and void size distribution from calculating a two dimensional approximation assuming a series of aligned cylinders, with sizes based on the Laplace equation. The maximum applied pressure of mercury for the porosimeter is 414 MPa or 60 000 psia, equivalent to a Laplace throat diameter of 0.004 µm.

4) Microscope

Figure 5: A Microscope

In my study to better to understand the relationship between rock geometry and porosity I will need to understand the geometry of the rock itself. For this I will need the assistance of the humble to microscope to assist me and taking a deeper look of the rock geometry

5) Scanning Electron Microscope (SEM)

Figure 6: A Scanning Electron Microscope

A scanning electron microscope is a type of electron microscope that images a sample by scanning it with a beam of electrons in a raster scan pattern. The electrons interact with the atoms that make up the sample producing signals that contain information about the sample's surface topography, composition, and other properties such as electrical conductivity.

CHAPTER 4: RESULTS AND DISCUSSION

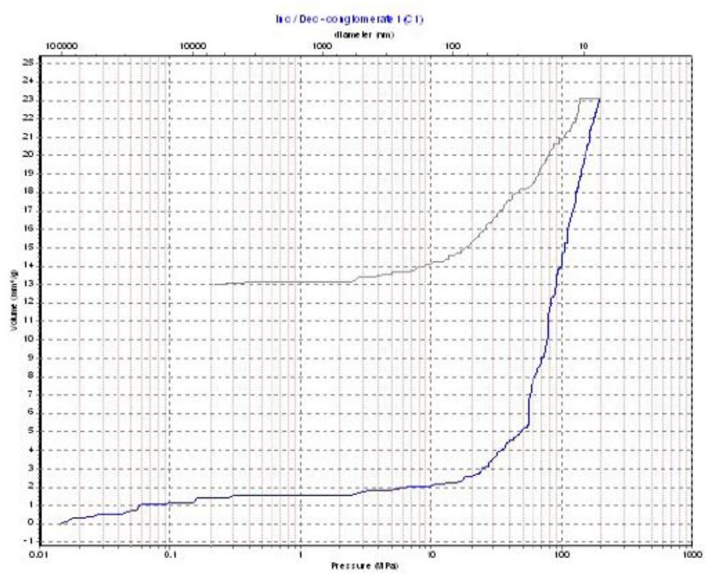
4.1 Results

Throughout the past month, a number of activities have been carried out in order to obtain the data to better understand the relationship between the rock geometry and the porosity of the samples obtained from the Semanggol Formation.

1) Mercury Porisimeter

The first equipment used in my Final Year Project was the Mercury Porisimeter. As stated previously in Chapter 3, it has a number of capabilities that include estimating the Pore size, permeability as well as fractional dimension. For the experiment, 6 samples were prepared. Two samples from conglomerate, two samples from sandstone and two samples of coarse sandstone. The results of the experiment are as stated below:-

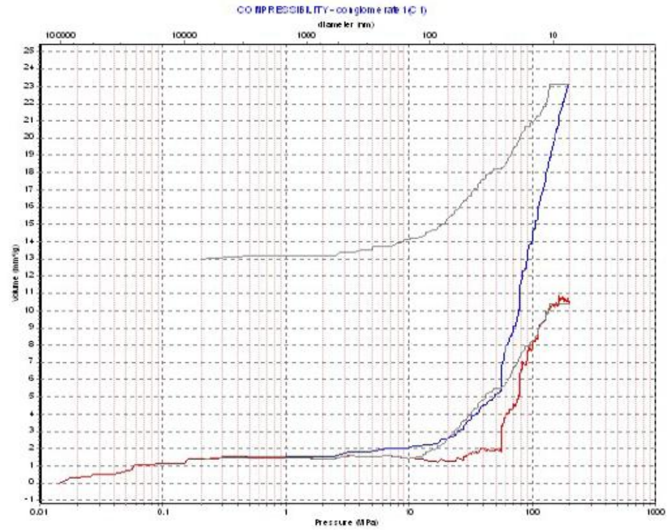
i) Conglomerate



RESULTS WITHOUT COMPRESSIBILITY CORRECTION

Total intruded volume (mm^3/g):	23.13 at pressure of (MPa):	200.6119	
Intrud. Vol. (mm^3):	2.23		
Envelope density (g/cm^3):	2.4694		
Bulk density @ pressure (g/cm^3):	2.4781	at pressure of (MPa):	0.174
Apparent density (g/cm^3):	2.6189	at pressure of (MPa):	200.6119
Void volume by real density (mm^3/g):	30.43		
Accessible porosity (%):	5.71		
Inaccessible porosity (%):	1.80		

Figure 7: Conglomerate Porosity results without compressibility correction

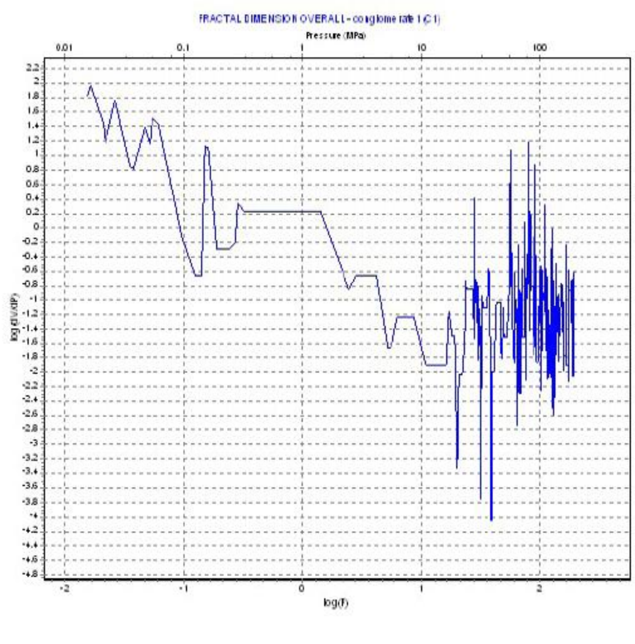


RESULTS WITH COMPRESSIBILITY CORRECTION

Correction enabled (Y/N):	Yes
Linearity range:	From (MPa): 160.4895 To (MPa): 200.6119
Correction factor ($mm^3/g.MPa$)	0.063403
Compressibility factor ($MPa.g/mm^3$)	15.7721
Compressed volume (mm^3/g):	12.72
Sample compressibility (1/MPa):	2.741E-3
Bulk modulus (MPa):	3.648E+2

Total intruded volume (mm^3/g):	10.41 at pressure (MPa):		200.6119
Intruded vol. (mm^3):	2.22		
Envelope density (g/cm^3):	2.4694		
Bulk density @ pressure (g/cm^3):	2.4780	at pressure (MPa):	0.1735
Apparent density (g/cm^3):	2.5345	at pressure (MPa):	200.6119
Real void volume by real dens. (mm^3/g):	30.43		
Accessible porosity (%):	2.57		
Inaccessible porosity (%):	4.94		

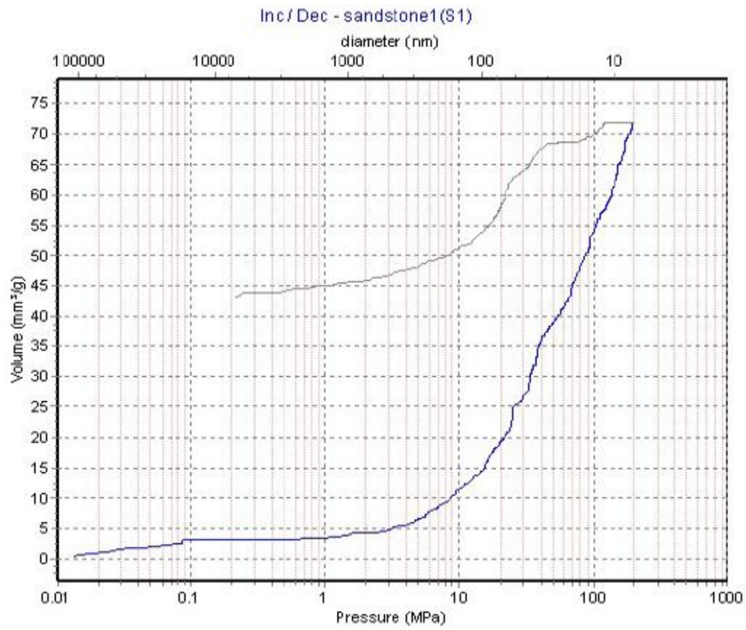
Figure 8: Conglomerate Porosity results with compressibility correction



Calc. press. range (MPa)::	0.0 to 200.6
Fractal dimension overall:	3.477

Figure 9: Fractal Dimension for Conglomerate

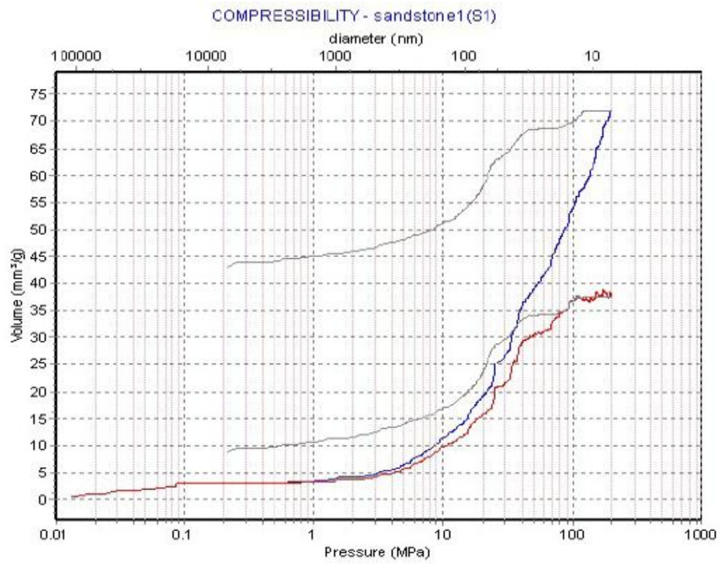
ii) Sandstone



RESULTS WITHOUT COMPRESSIBILITY CORRECTION

Total intruded volume (mm^3/g):	71.94 at pressure of (MPa):	200.3114	
Intrud. Vol. (mm^3):	2.59		
Envelope density (g/cm^3):	2.0265		
Bulk density @ pressure (g/cm^3):	2.0395	at pressure of (MPa):	0.174
Apparent density (g/cm^3):	2.3723	at pressure of (MPa):	200.3114
Void volume by real density (mm^3/g):	102.85		
Accessible porosity (%):	14.58		
Inaccessible porosity (%):	6.26		

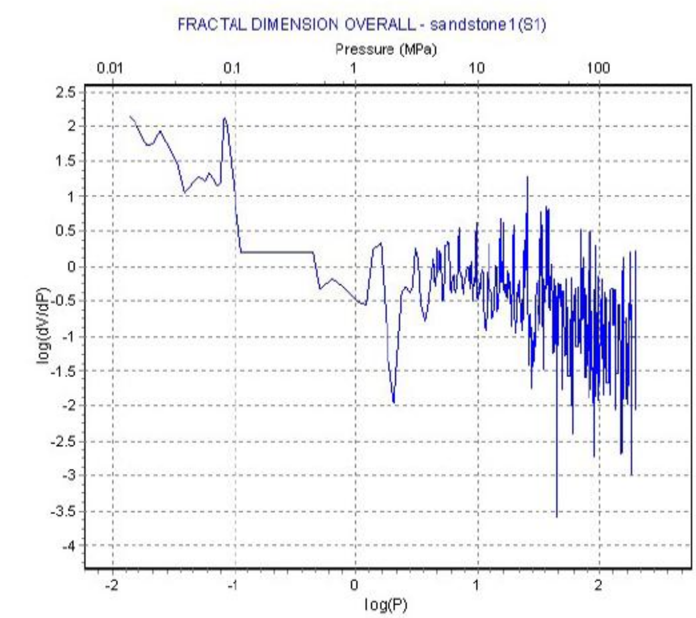
Figure 10: Sandstone Porosity results without compressibility correction



RESULTS WITH COMPRESSIBILITY CORRECTION

Correction enabled (Y/N):	Yes			
Linearity range:	From (MPa):	160.2491	To (MPa):	200.3114
Correction factor (mm³/g.MPa)	0.171175			
Compressibility factor (MPa.g/mm³)	5.8420			
Compressed volume (mm³/g):	34.29			
Sample compressibility (1/MPa):	2.379E-3			
Bulk modulus (MPa):	4.203E+2			
Total intruded volume (mm³/g):	37.65 at pressure (MPa):		200.3114	
Intruded vol. (mm³):	2.57			
Envelope density (g/cm³):	2.0265			
Bulk density @ pressure (g/cm³):	2.0394	at pressure (MPa):		0.1735
Apparent density (g/cm³):	2.1938	at pressure (MPa):		200.3114
Real void volume by real dens. (mm³/g):	102.85			
Accessible porosity (%):	7.63			
Inaccessible porosity (%):	13.21			

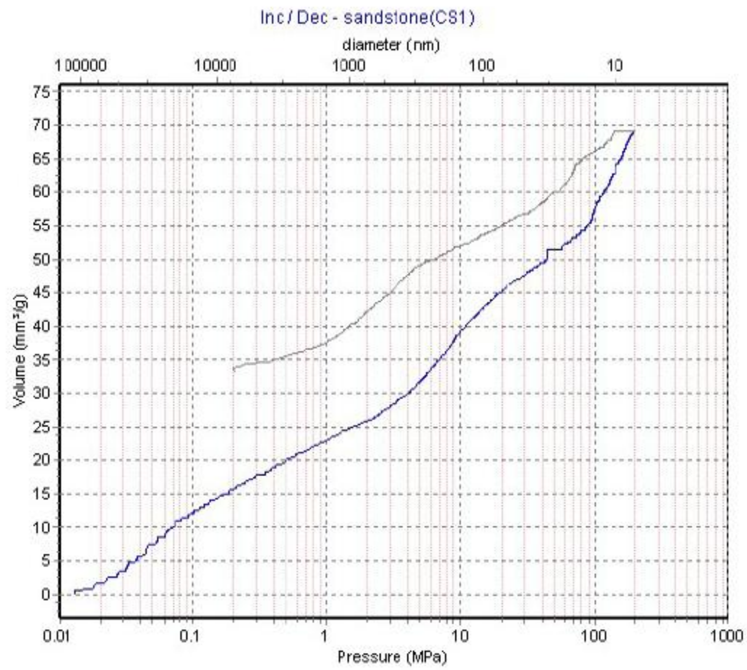
Figure 11: Sandstone Porosity results with compressibility correction



Calc. press. range (MPa)::	0.0 to 200.3
Fractal dimension overall:	3.363

Figure 12: Fractal Dimension for Sandstone

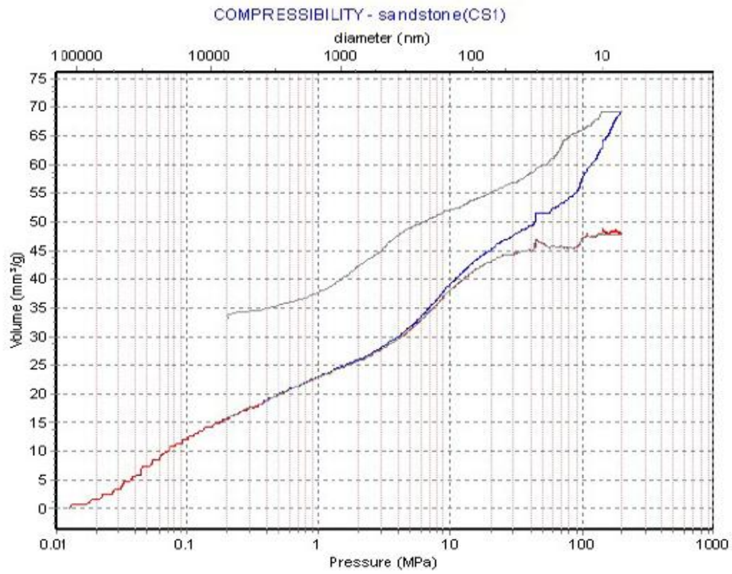
iii) Coarse Sandstone



RESULTS WITHOUT COMPRESSIBILITY CORRECTION

Total intruded volume (mm³/g):	69.08 at pressure of (MPa):	200.3111	
Intrud. Vol. (mm³):	19.03		
Envelope density (g/cm³):	3.0359		
Bulk density @ pressure (g/cm³):	3.1805	at pressure of (MPa):	0.174
Apparent density (g/cm³):	3.8415	at pressure of (MPa):	200.3111
Void volume by real density (mm³/g):	-89.01		
Accessible porosity (%):	20.97		
Inaccessible porosity (%):	-48.00		

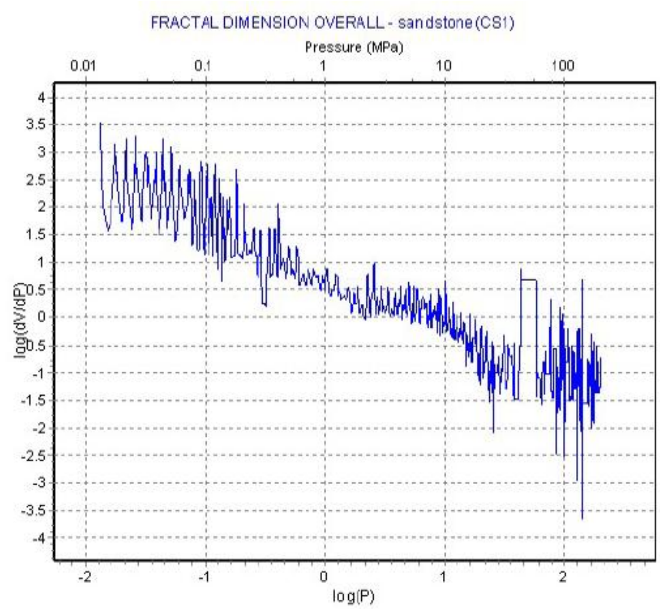
Figure 13: Coarse Sandstone Porosity results without compressibility correction



RESULTS WITH COMPRESSIBILITY CORRECTION

Correction enabled (Y/N):	Yes			
Linearity range:	From (MPa):	160.2489	To (MPa):	200.3111
Correction factor (mm³/g.MPa)	0.106036			
Compressibility factor (MPa.g/mm³)	9.4308			
Compressed volume (mm³/g):	21.24			
Sample compressibility (1/MPa):	1.535E-3			
Bulk modulus (MPa):	6.515E+2			
Total intruded volume (mm³/g):	47.84 at pressure (MPa):		200.3111	
Intruded vol. (mm³):	19.01			
Envelope density (g/cm³):	3.0359			
Bulk density @ pressure (g/cm³):	3.1804	at pressure (MPa):		0.1735
Apparent density (g/cm³):	3.5517	at pressure (MPa):		200.3111
Real void volume by real dens. (mm³/g):	-89.01			
Accessible porosity (%):	14.52			
Inaccessible porosity (%):	-41.55			

Figure 14: Coarse Sandstone Porosity results with compressibility correction



Calc. press. range (MPa):: 0.0 to 200.3
Fractal dimension overall: 3.0545

Figure 15: Fractal Dimension for Coarse Sandstone

2) Scanning Electron Microscope

The other piece of equipment used is the scanning electron microscope. As stated in Chapter 3 the scanning electron microscope is a type of electron microscope that images a sample by scanning it with a beam of electrons in a raster scan pattern. The electrons interact with the atoms that make up the sample producing signals that contain information about the sample's surface topography which will be our focus in this study. The pictures that were able to be taken are as follow:-

i) Conglomerate

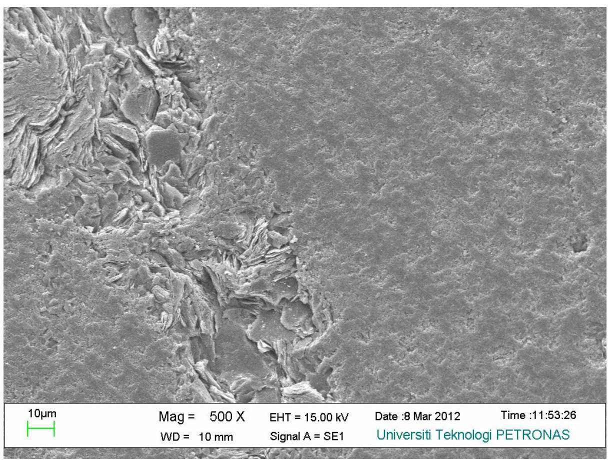


Figure 16a: Conglomerate at 500X

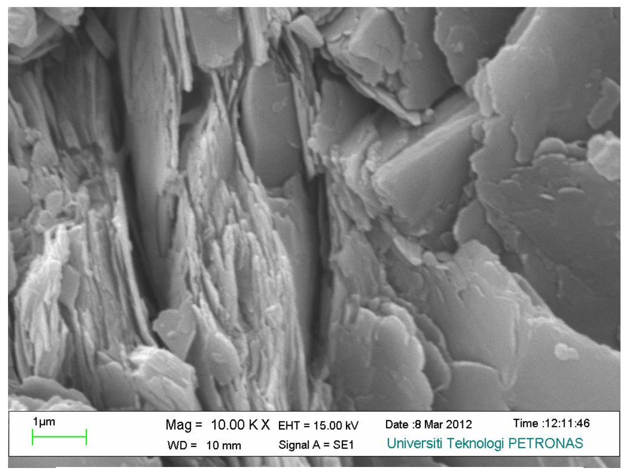


Figure 16b: Conglomerate at 10 000X

As we can see through the Scanning Electron Microscope the conglomerate sample has layered or flaky surface. It can be said that there are micro pores in the rock sample indicating possibility of porosity within the conglomerate sample.

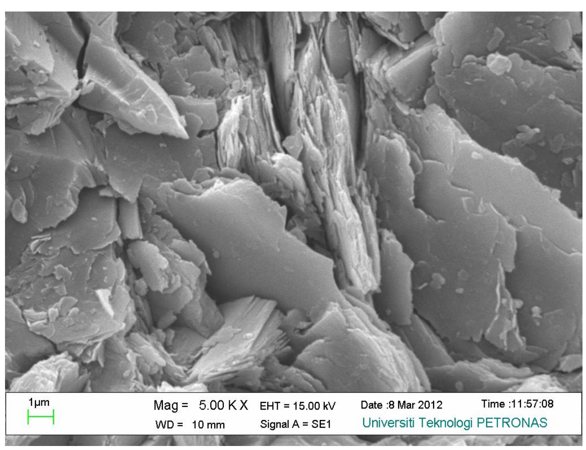
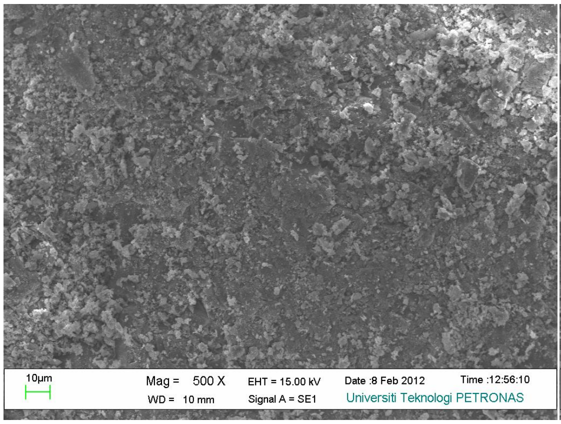


Figure 16c: Conglomerate at 5000X

ii) Sandstone



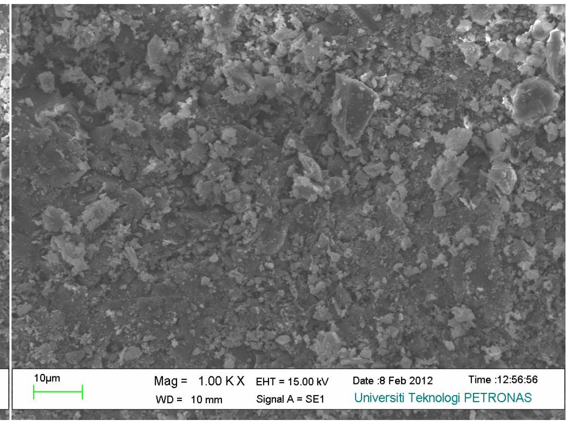


Figure 17a: Sandstone at 500X

Figure 17b: Sandstone at 1000X

Unlike the conglomerate sample, as it can clearly be seen from the Scanning Electron Microscope, the sandstone sample does not have a flaky surface. The sandstone has more rounded rock geometry and thus it creates for a better possibility of existence of pore spaces and in turn the enable a reading in our Porosimeter test. There are numerous places of micro pores to exist in sandstone.

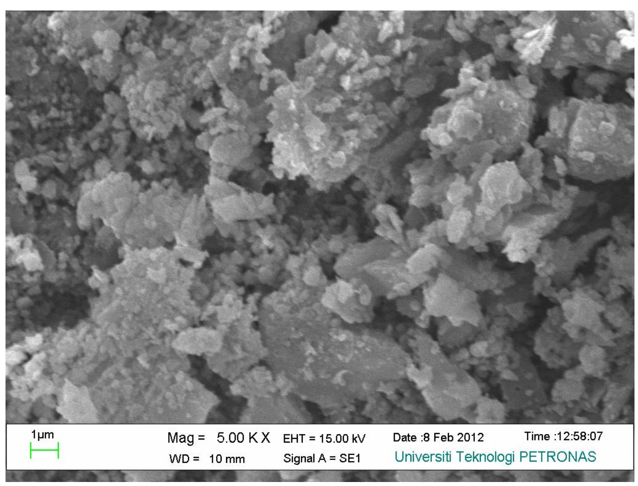
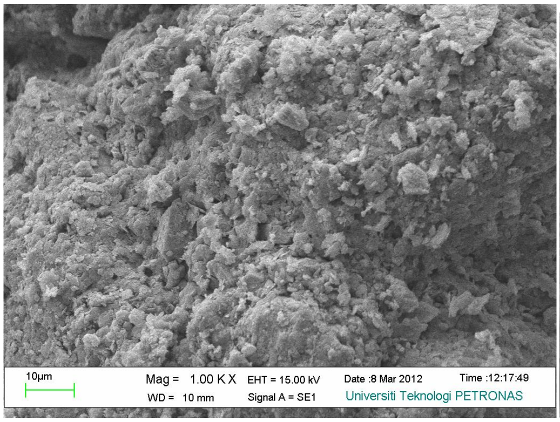


Figure 17c: Sandstone at 5000X

iii) Coarse Sandstone



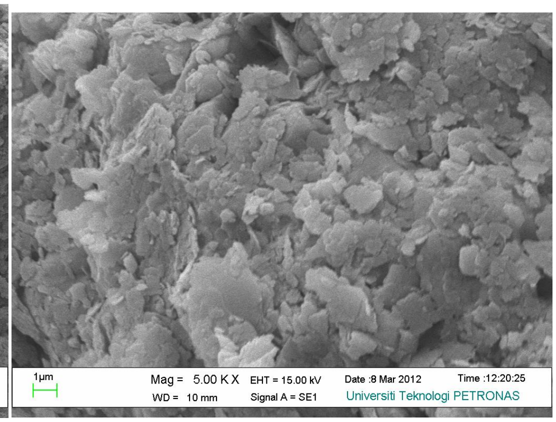


Figure 18a: Coarse Sandstone at 1000X Figure 18b: Coarse Sandstone at 5000X

The coarse sandstone by the looks of it has the similarity of the sandstone sample. The only difference that it has is that has a lot more pore spaces and micro pores compared to the normal sandstone sample. The rock geometry as shown is exactly the same as the sandstone sample from Semanggol Formation.

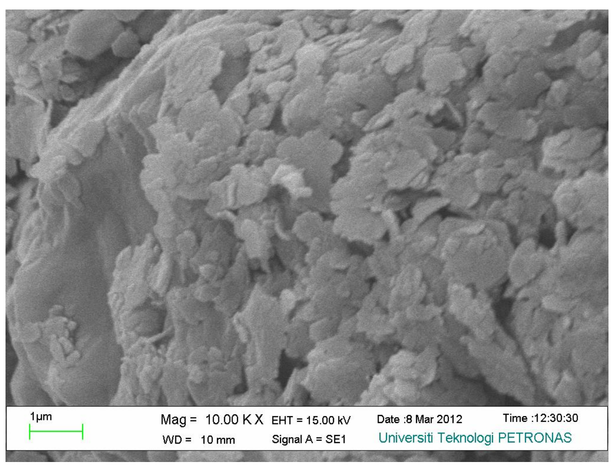


Figure 18c: Coarse Sandstone at 10000X

1) Thin Section

Thin sections are made from small slabs of a rock sample glued to a glass slide and then ground to a thickness of roughly 0.03mm which is 30 microns. At this thickness most minerals become more or less transparent and can then be studied by a microscope using transmitted light. Thin sections are time consuming to prepare. In order to further understand the thin section, JMicroVision v1.27 was used to create a rough analysis on the samples taken from Semanggol. Using the analysis capability of the image analyzing software, a rough idea of how the geometry of the rocks is obtained.

i) Conglomerate

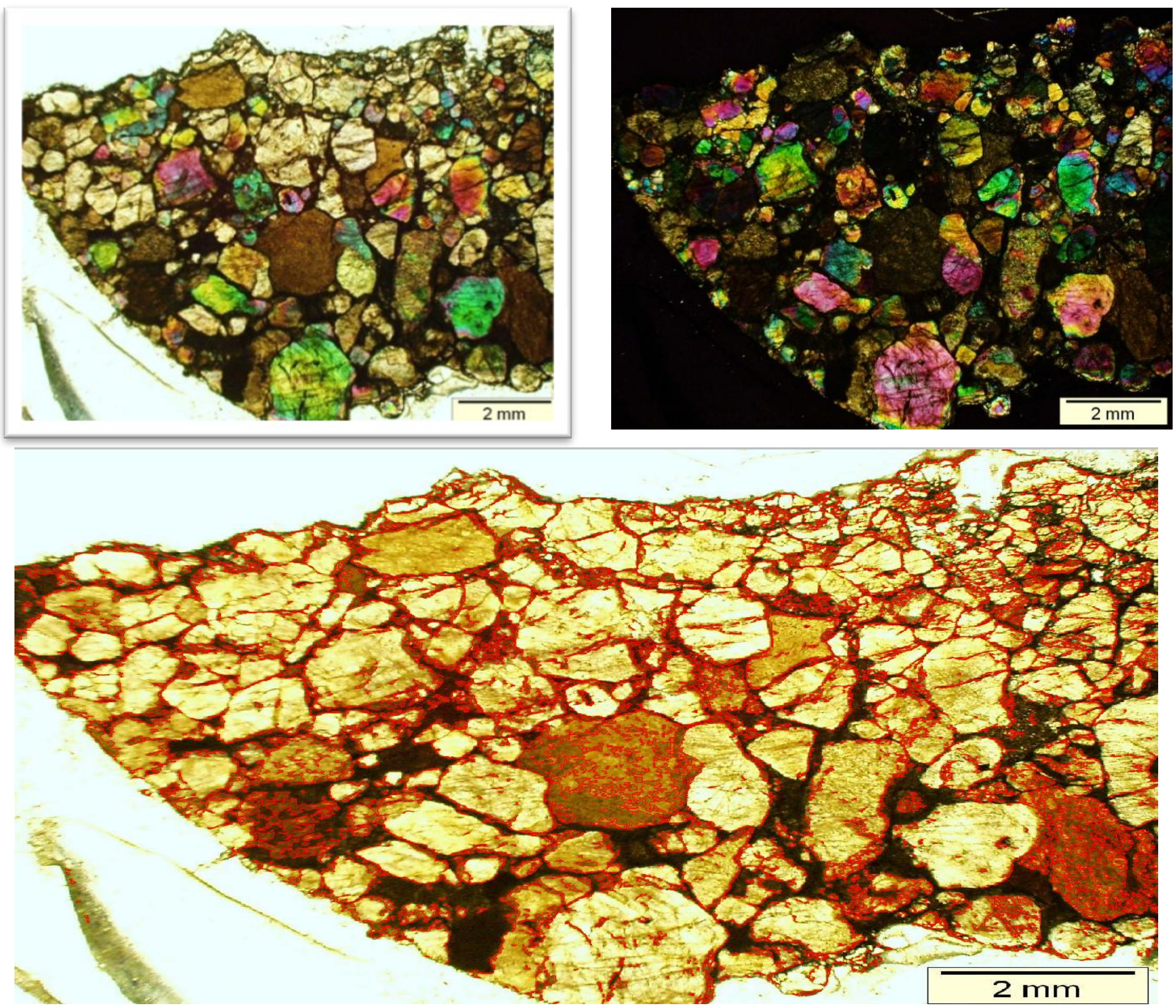


Figure 19: Microscope images of Conglomerate both Polaroid and non-Polaroid.

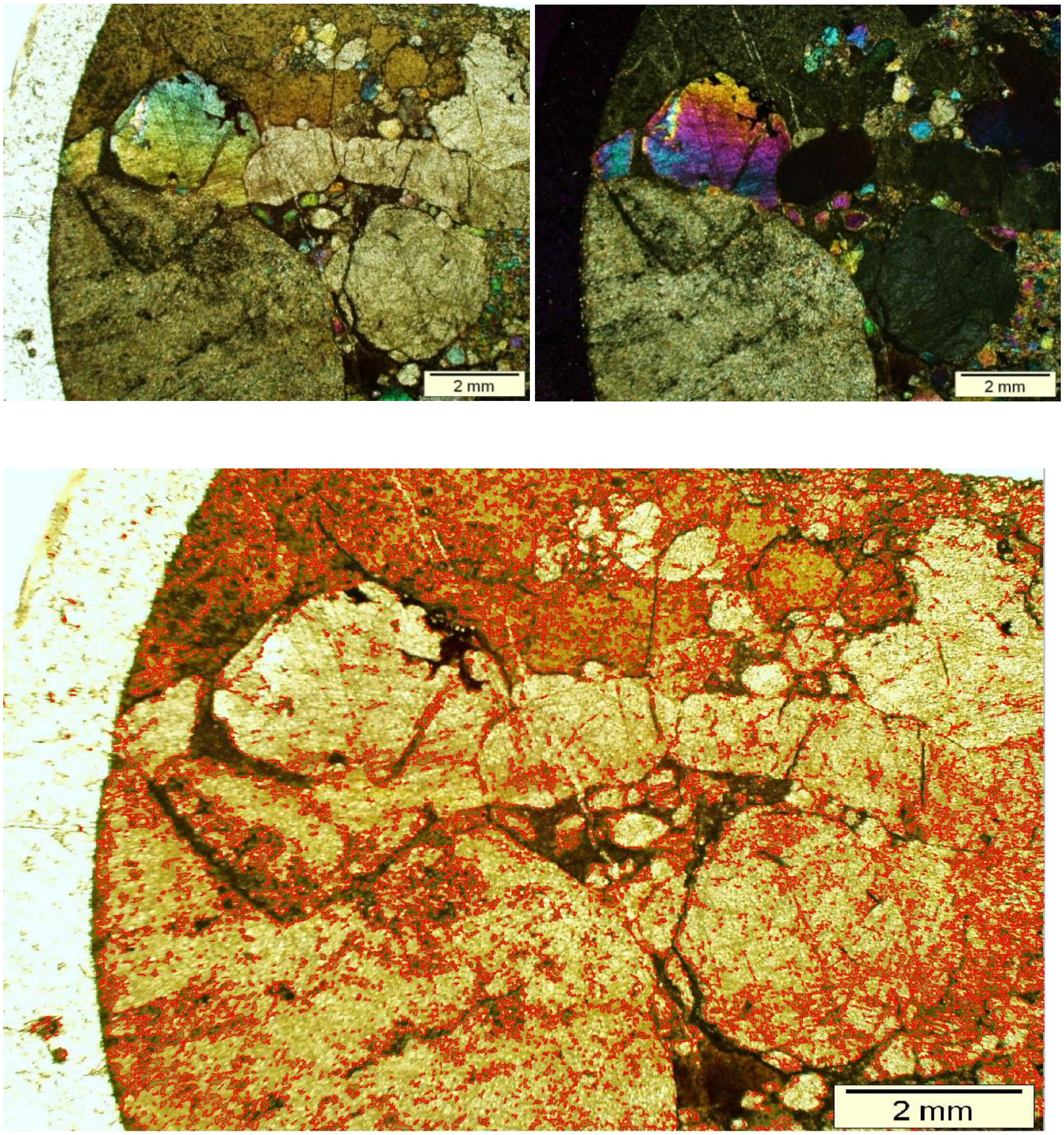


Figure 20a: Microscope images of Sandstone both Polaroid and non-Polaroid.

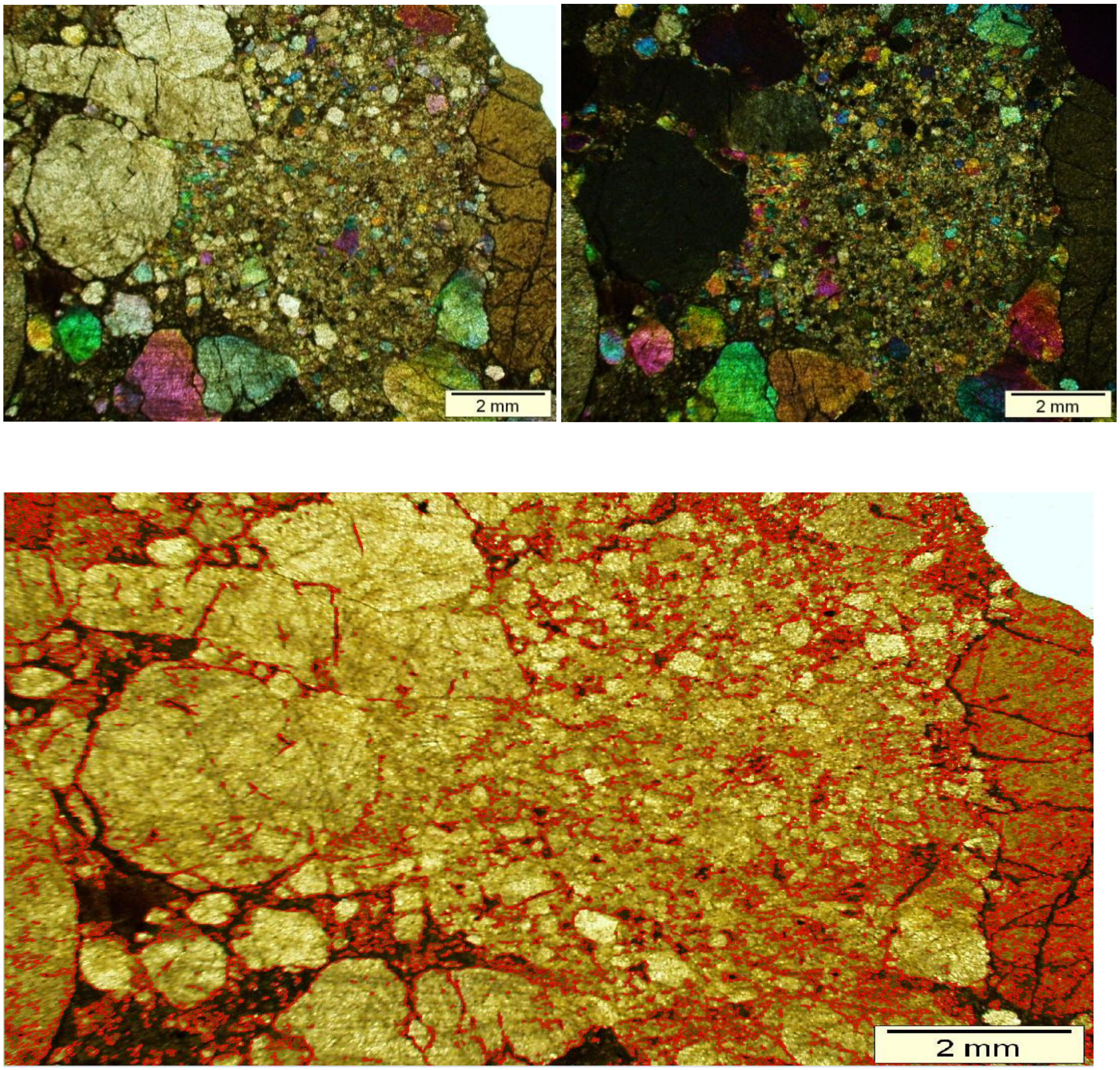


Figure 20b: Microscope images of Conglomerate both Polaroid and non-Polaroid.

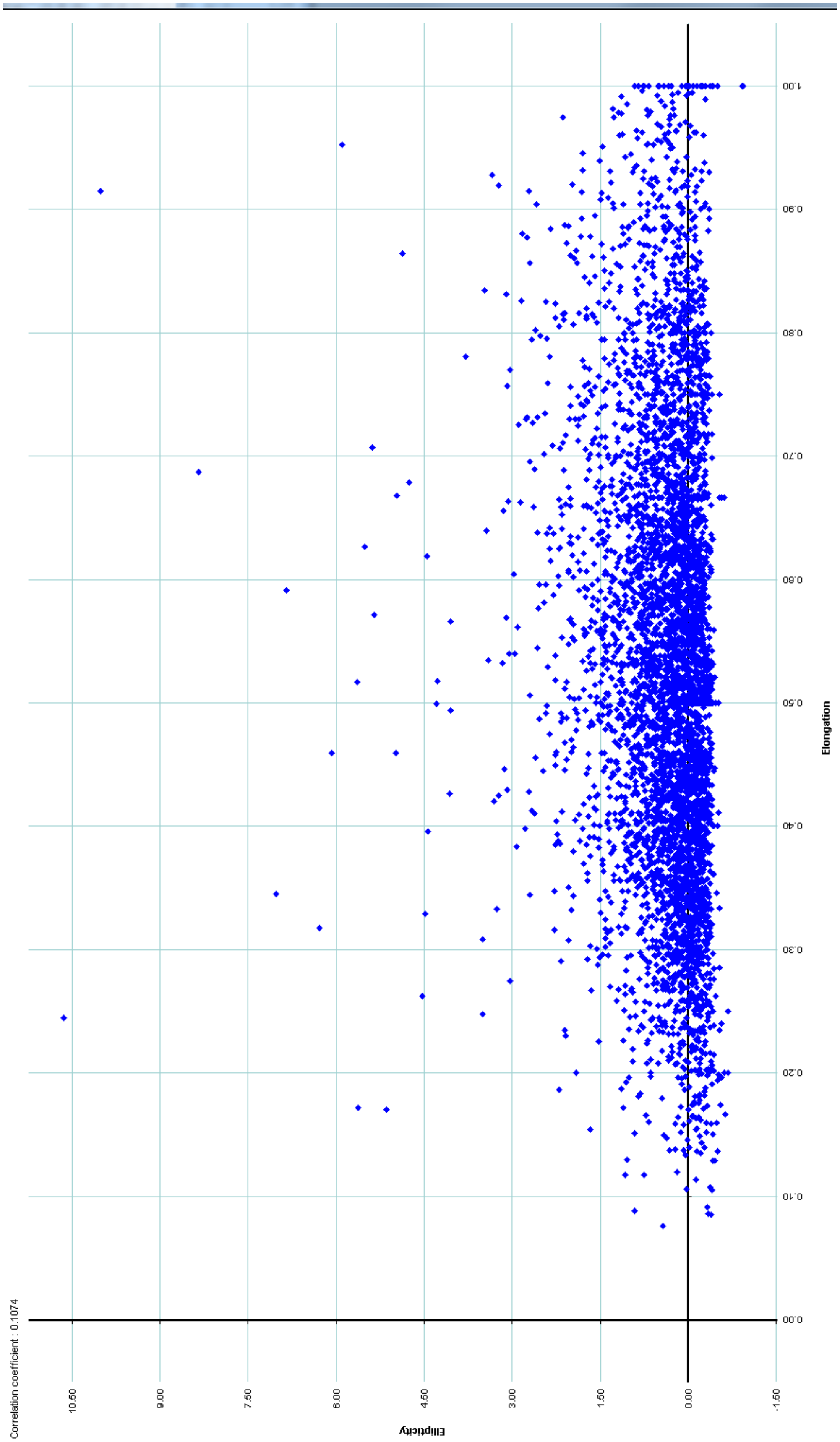


Figure 21: Scatter Plot of Elongation vs Elliplicity for Conglomerate

ii) Sandstone

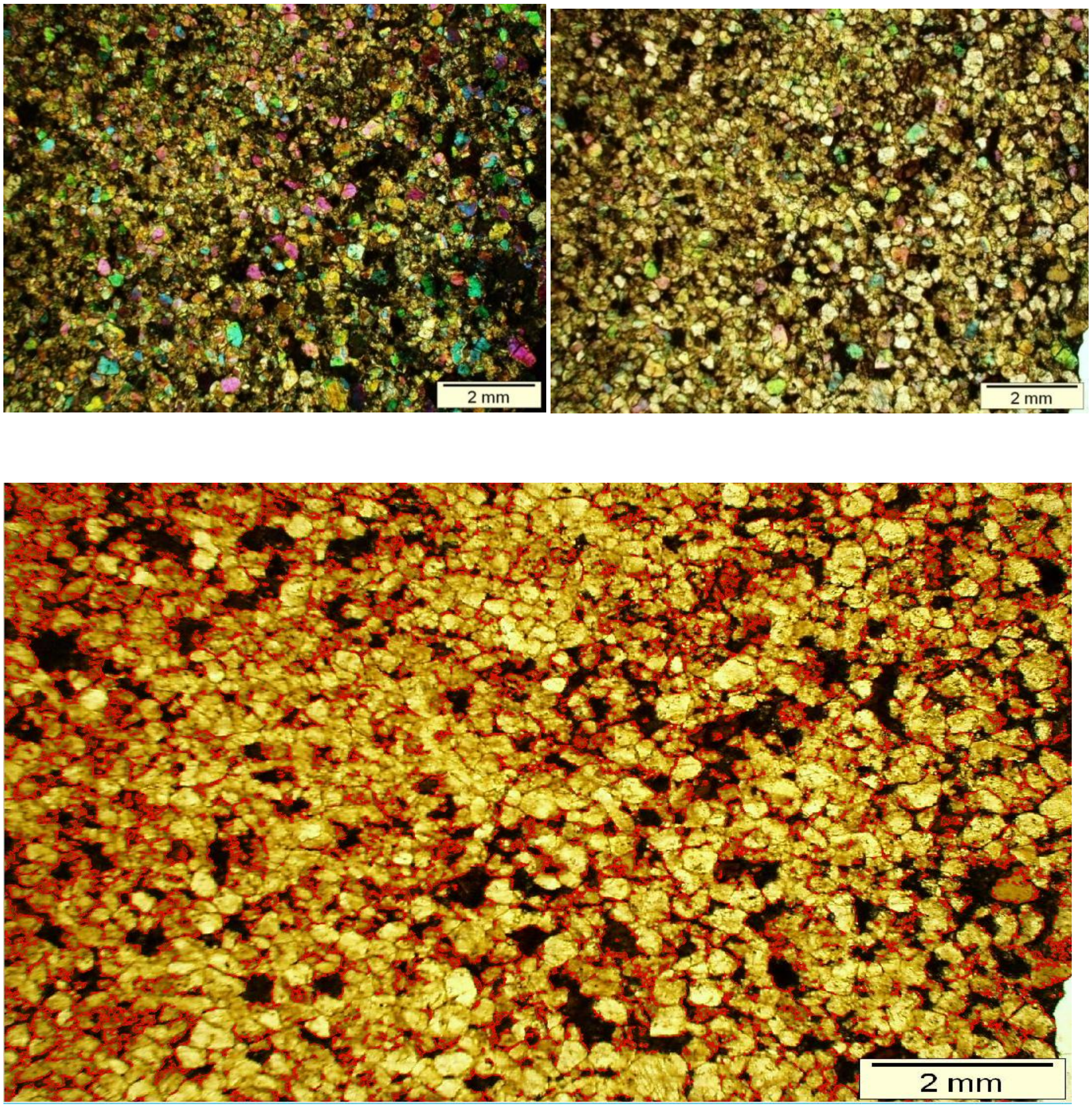


Figure 22a: Microscope images of Sandstone both Polaroid and non-Polaroid.

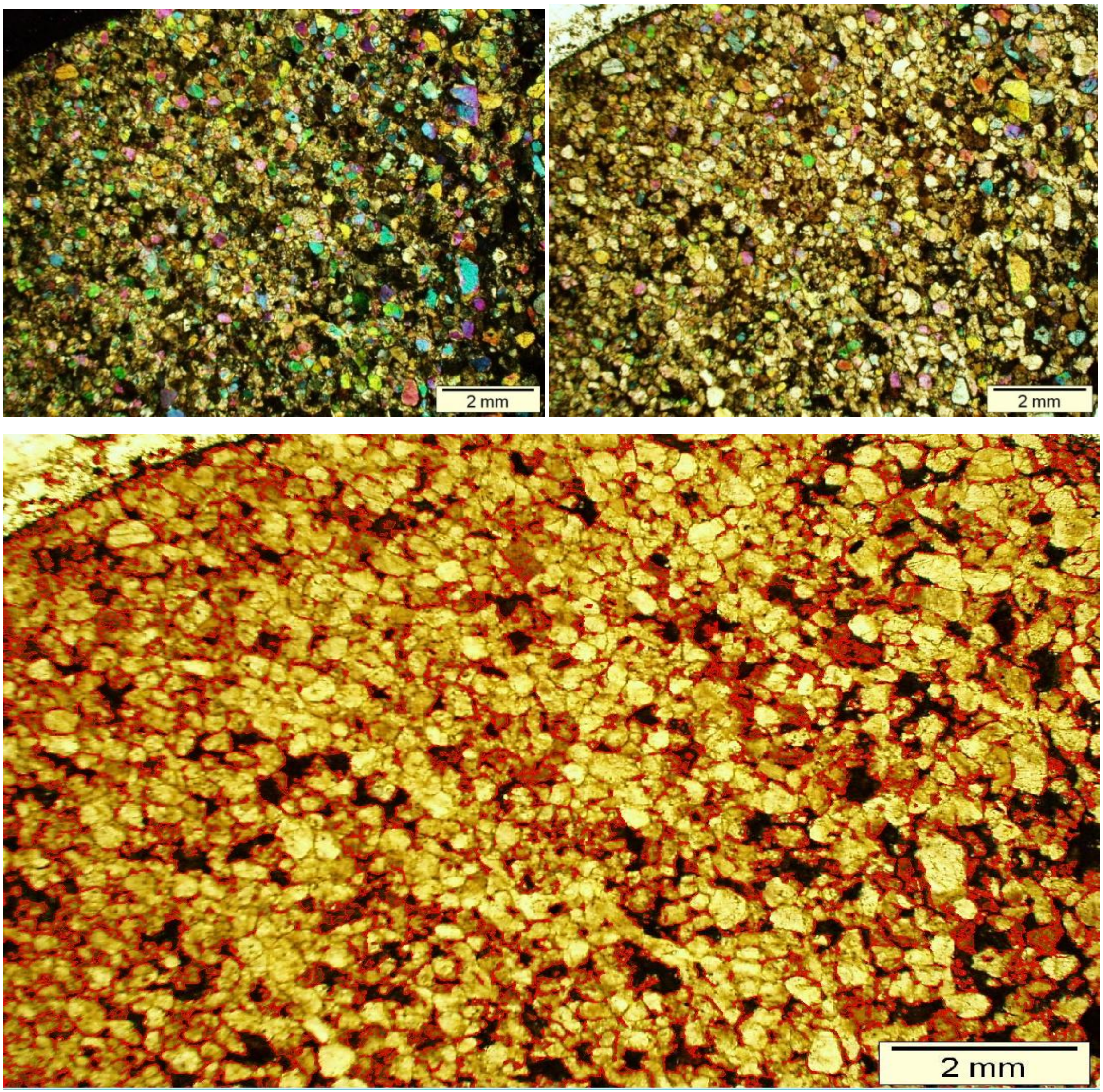


Figure 22b: Microscope images of Sandstone both Polaroid and non-Polaroid.

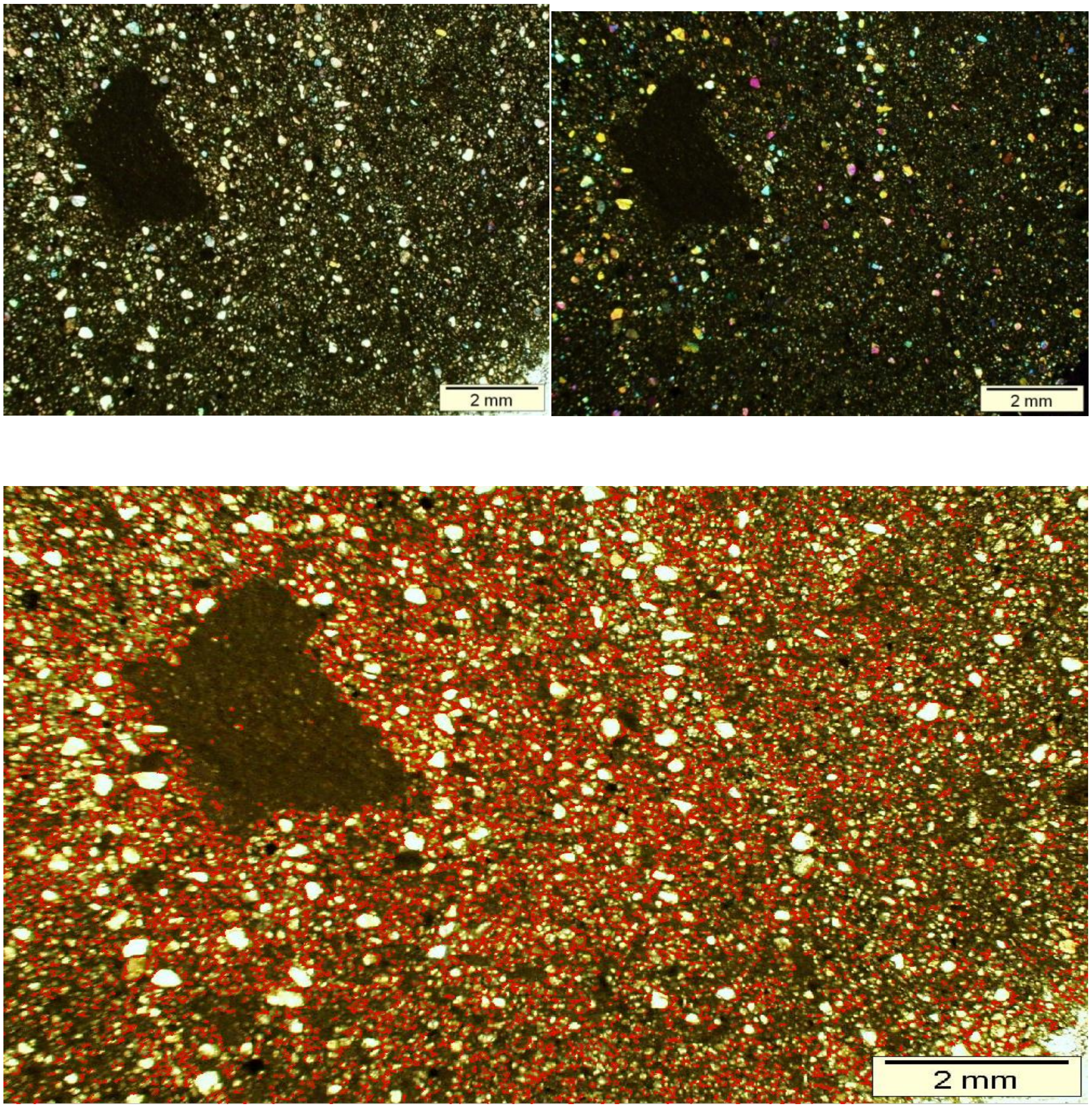


Figure 22c: Microscope images of Sandstone both Polaroid and non-Polaroid.

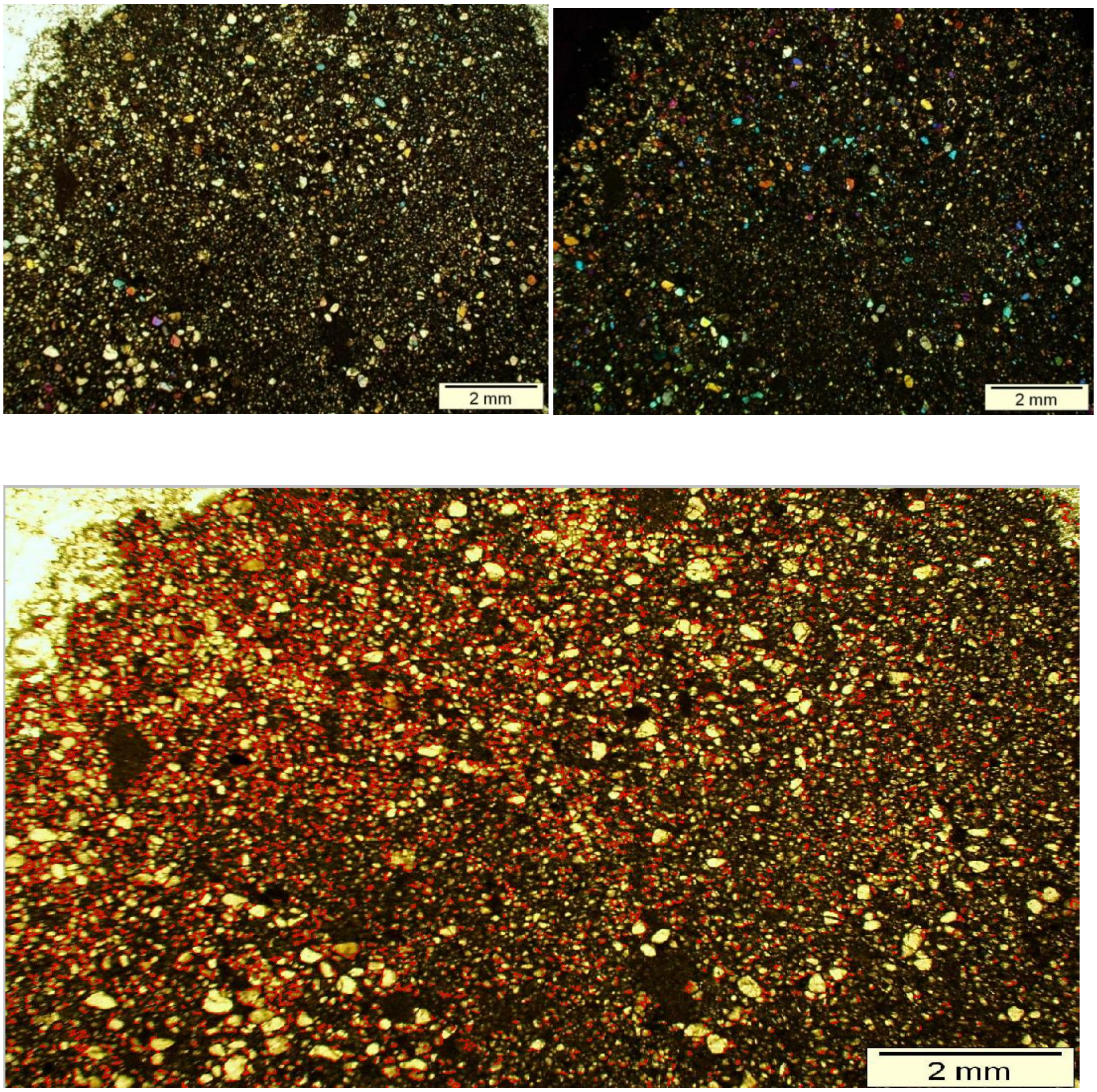


Figure 22d: Microscope images of Sandstone both Polaroid and non-Polaroid.

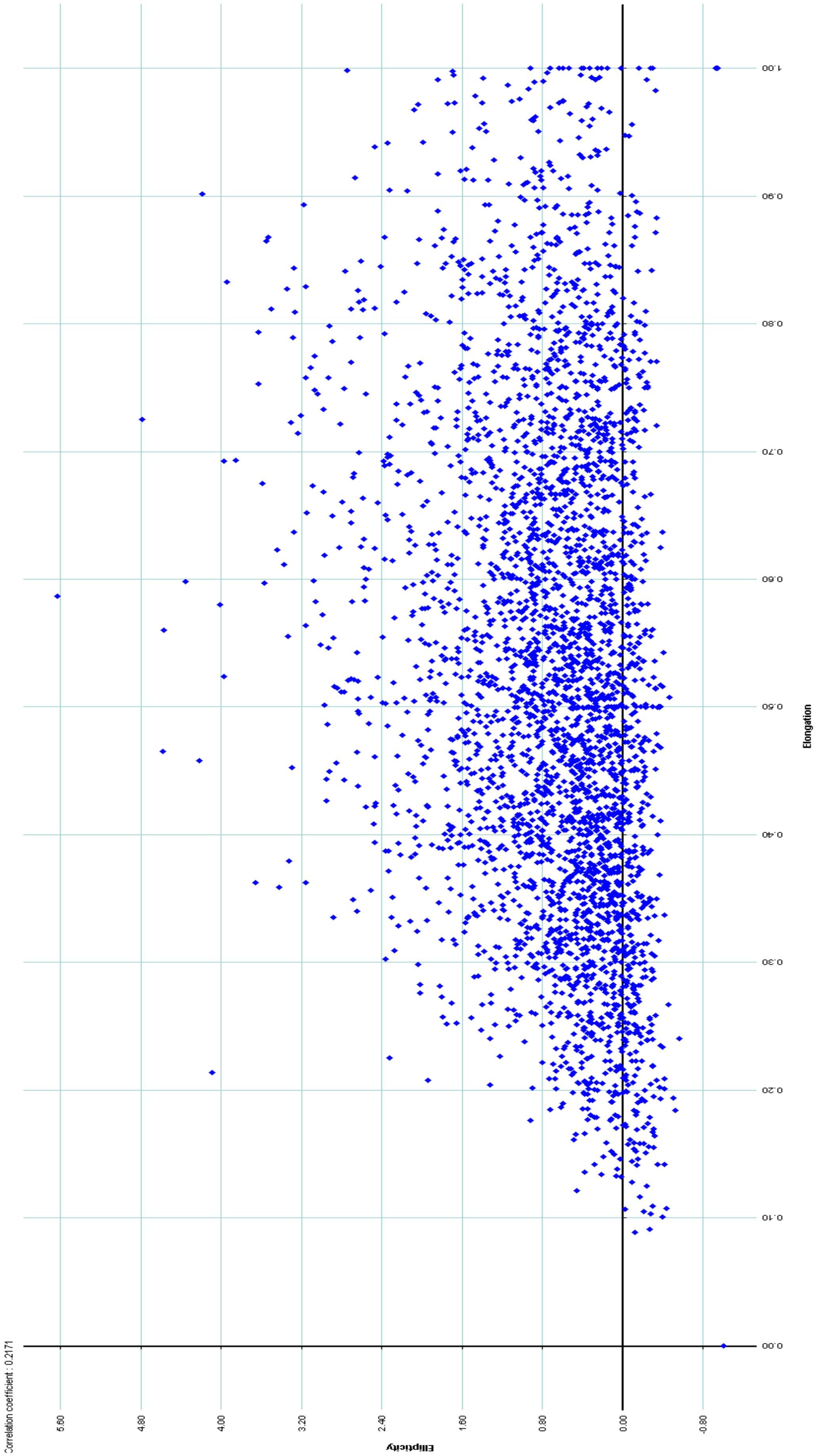


Figure 23: Scatter Plot of Elongation vs Elliplicity for Sandstone

ii) Coarse Sandstone

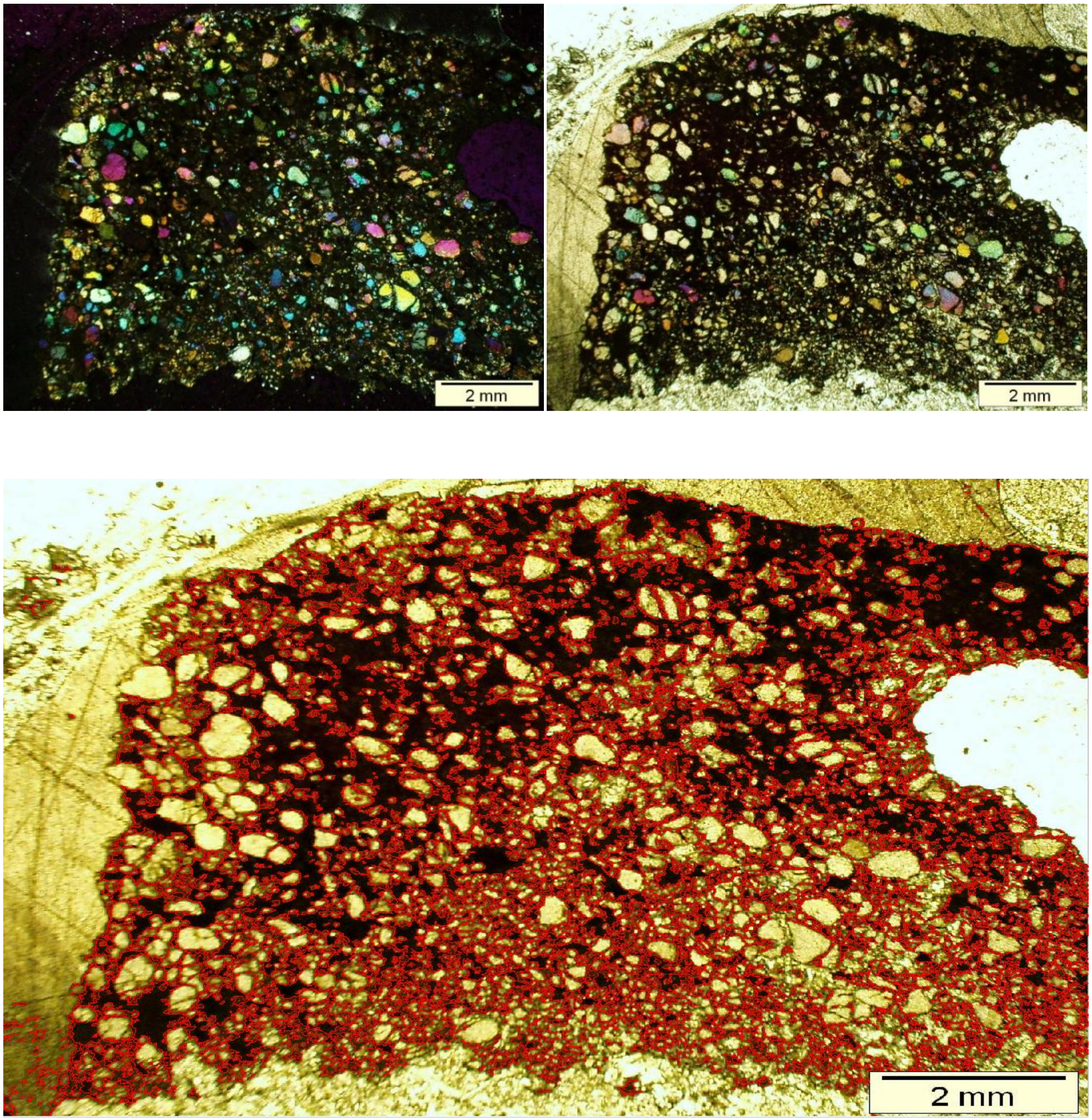


Figure 24a: Microscope images of Coarse Sandstone both Polaroid and non-Polaroid.

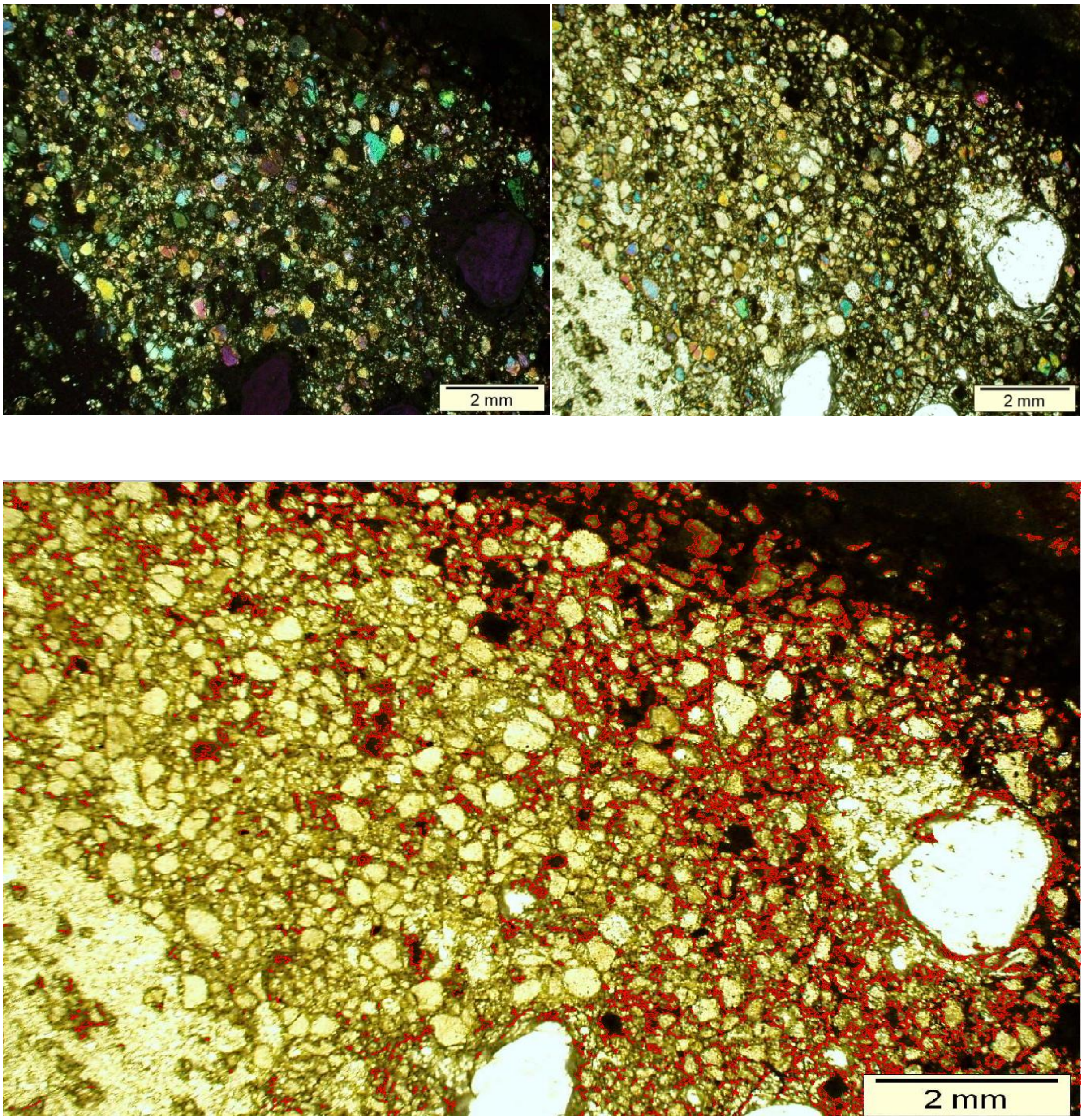


Figure 24b: Microscope images of Coarse Sandstone both Polaroid and non-Polaroid.

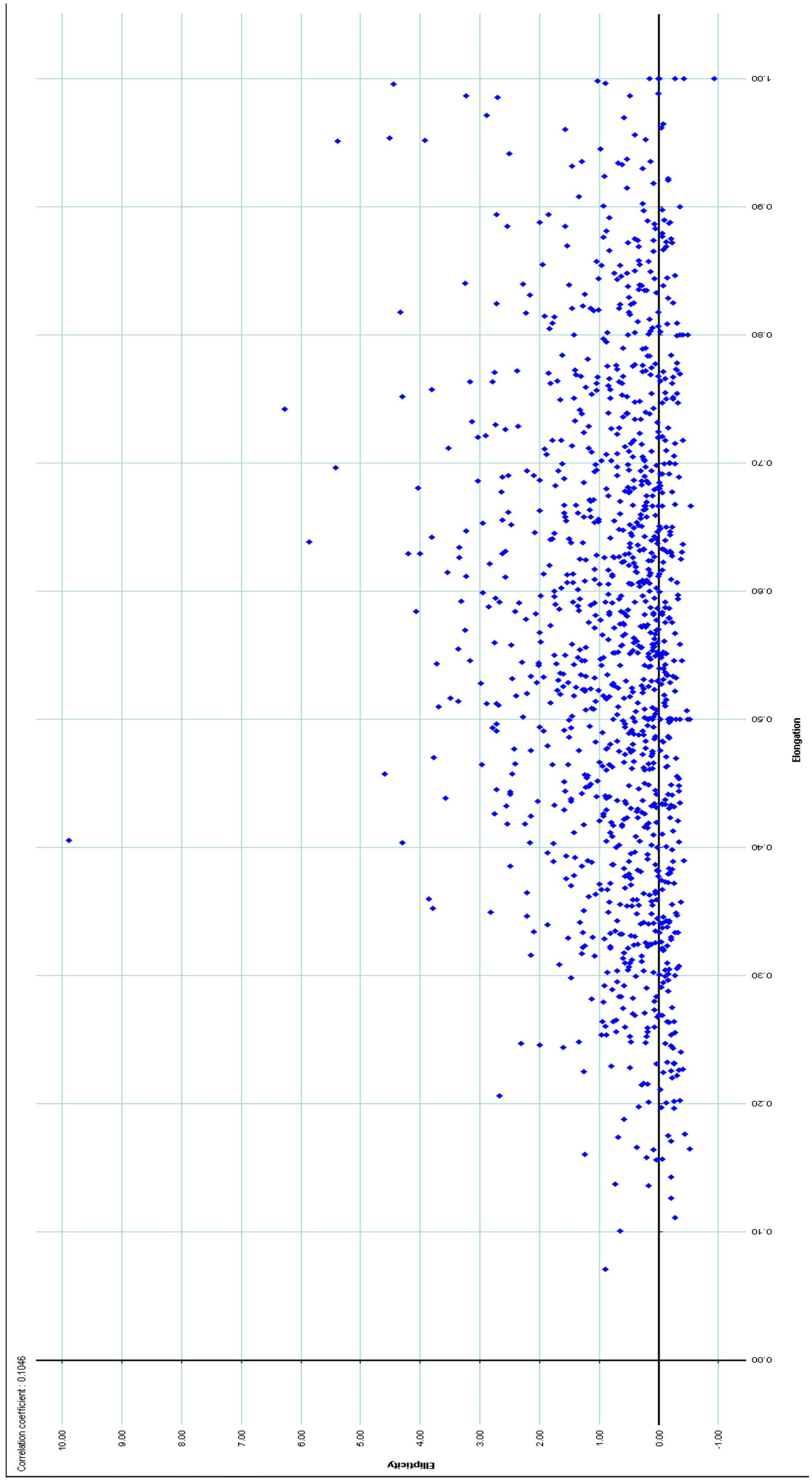


Figure 25: Scatter plot of Elongation vs Elliplicity for Coarse Sandstone

4.2 Discussion

As we can see from test we have conducted, it can be seen that the highest porosity is found on the coarse sandstone with 14.52% of accessible porosity. This in turn is followed by sandstone with 7.62% of accessible porosity and conglomerate with 2.57% of accessible porosity. The graphs that have been obtained from the Mercury Porosimeter also show the fractural dimension of each of the samples used. A fractal dimension according to Kenneth Falconer (2003) is a ratio providing a statistical index of complexity comparing how detail in a pattern in other words a fractal pattern which changes with the scale at which it is measured. He also states that it has also been characterized as a measure of the space-filling capacity of a pattern that tells how a fractal scales differently than the space it is embedded in; a fractal dimension is greater than the dimension of the space containing it and does not have to be an integer.

Continuing on, with the data obtained from the Mercury Porosimeter we must then obtained an understanding of the rock geometry of the samples. For this, as stated earlier in the report we have used the Scanning Electron Microscope and a normal microscope. Firstly, using the Scanning Electron Microscope, we can easily deduce that the more rounded grains of both the sandstone and coarse sandstone made it easier for micro pores to exist in these types of clastic sedimentary rocks. When compared to the conglomerate, the flaky surface does enable a pore spaces for porosity to be hugely available. Even though this is being said, is does not mean that that is not pore spaces at all for the conglomerate sample for it has a minute amount of it according to our Mercury Porosimeter test.

Next, we compare the results of the porosity of the samples to the analysis of the thin section that we have created. Using the JMicro Vision software we can make an estimation of the rock geometry of the samples. The image analyzing software is able to actually list down an estimation of the length and width of each of the samples but for this analysis we use a scatter plot whereby Elongation versus ellipticity . We use this comparison to see for the fact that indirectly the ellipticity represents the rock geometry of the samples and the elongation is the length of it. It is clearly seen that there is a lot of similarities between the coarse sandstone and sandstone. The major difference is seen with conglomerate whereby it has a lot less elongation and less ellipticity. This will have effect on the amount the porosity the rock sample has.

CHAPTER 5: CONCLUSION

It can be concluded in my report that my project has been able to produce an insight of the rock geometry of samples from the Semanggol Formation. As stated earlier in my report the primary objective of this project is to correlate between pore geometry via petrography with total porosity measurement of a sample taken from the Semanggol Formation in the northwest region of the Peninsula Malaysia and with that objective I believe I have the answer to what is the relationship between rock geometry of a rock formation and its porosity measurement?

In my earlier planning of this project, I was hopeful for the use of the CT Scan to enable a more conclusive result for my project. Sadly due to unforeseen circumstances this was not carried out. Using the JMicroVision software as well as the Scanning Electron Microscope, we are able to gain information to further understand the relationship between rock geometry and porosity measurement.

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APPENDIX

No.	Details/Week	1	2	3	4	5	6	7	8	9	10	11	12	13
1	Topic Selection/Proposal													
2	Preliminary Research Work													
3	Project Flow Planning													
4	Submission of Proposal Defense Report													
5	Project research (Literature Review, Data Gathering)													
6	Proposal Defence													
7	Submission of Interim Draft Report													
8	Submission of Interim Report													

Figure 26: Gantt chart FYP 1

No.	Details/Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
1	Project Work Continues															
2	Submission of Progress Report															
3	Project Work Continues															
4	Pre-EDX															
5	Submission of Draft Report															
6	Submission of Dissertation (soft Bound)															
7	Submission of Technical Paper															
8	Oral Presentation															
9	Submission of Project Dissertation (Hard Bound															

Figure 27: Gantt chart FYP 2

No.	Details / Month	Sept	Oct	Nov	Dec	Jan
1	Literature Review					
2	Identifying equipment to used - Soil Sampling - Pore geometry - Porosity Measurement					
3	Execute analysis on Pore geometry as well as execute on porosity measurement of the sample					

Figure 28: Key Milestones for FYP 1

No.	Details / Month	January	February	March	April	May
1	Continue researching on the samples obtained					
2	Analyze the data obtained					
3	Prepare Final report and Poster Presentation					

Figure 29: Key Milestones for FYP 2