CERTIFICATION OF APPROVAL

FYP2 DISSERTATION REPORT

UTILIZATION OF HIGH CALCIUM CARBONATE LIMESTONE AROUND LENGGONG, PERAK AS LOST CIRCULATION MATERIAL

By

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CERTIFICATION OF ORIGINALITY

This is to certify that I am held responsibility for the work I submitted for this project, that the original work from my own except for the work that I have cited from references and acknowledgements and that the original work contained herein have not been undertaken or taken by unspecified person or sources.

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HUZAIFAH BIN ABDUL RAHMAN

ABSTRACT

The process of drilling a well is usually assisted by drilling fluid which is used for many purposes such as lifting up the drill cutting, lubricate the drillstring and also as coolant for the drillistring. Additives such as Lost Circulation Material (LCM) is added to prevent the circulation from entering void or fracture (Loss of Circulation) created from differential pressure of the drilling mud used. The three types of LCM used is mainly categorized as granular, flakes and fibrous or combination of of either two or three type of these LCM mixed in the right and correct proportion. LCM is also preferred in smallest amount and size possible since it is easier to handle because larger amount and sizes of LCM can lead to damage in mud pump. Since Loss Circulation Material can come in different shapes and material , there is a potential to find LCM candidate which is easy to be obtained and produced at economical cost, therefore it is in the best interest to study the effectiveness of limestone obtained locally as one of LCM. Therefore a limestone karst has been chosen as a subject of study around the area of Lenggong, north of Perak which is high in calcite. This report will explore the capability limestone from lenggong as LCM and will be tested in terms of its rheological behavior, fluid loss, weight, density and solids content. Consequently, identifying the constituent minerals and elements exist in basaltic soil using X-Ray Fluorescence (XRF) and X-Ray Diffraction (XRD) scans will enable us to determine best possible usage in utilizing limestone in drilling fluids.

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Huzaifah Bin Abdul Rahman

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CHAPTER 1: INTRODUCTION

1.1 Project Background

Drilling fluid used in drilling process has several important role such as creating hydrostatic pressure in the wellbore, removing drilling cuttings in the formation, act as lubricant for the drill string and also as the coolant the constantly rotating drillstring [6]. However, during the drilling process of a well, the drilling fluid pressure can cause a void or opening in the well formation and this can lead to lost of circulation. This can usually happens when drilling during in progress or during trips, when pressure surges occur due to the lowering of drill pipe or casing into the hole. The type of void or opening in the formation may be categorized as fractured, vuggy, cavernous have highly porous and permeable capability allow drilling fluid to flow through them[9]. If fractures and void are large, they cannot be plugged by the solids present in drilling fluids such as clays, formation cuttings and others [7]. The damage from the loss of fluid can be greater if the drilling fluid used is expensive such as oil based mud.

However, these problems of lost circulation of fluid through the wellbore can be reduced by the usage of loss circulation material. Among the type of lost circulation materials used can be in flakes, granular and fibrous [6]. In this study, the type of lost circulation material to be focused is granular type which limestone high in calcium carbonate content. It will focuses on the ability of the Limestone mined from the Lenggong area to act as effective lost circulation material. In this research, the limestone form lenggong will be tested in terms of its rheological behavior, fluid loss, weight, density and solids content. Consequently, identifying the constituent minerals and elements exist in basaltic soil using XRF and XRD scans will enable us to determine best possible usage in utilizing limestone in drilling fluids.

1.2 Problem Statement

It is noted that there are many number of material that can act as lost circulation material either flakes, granular and fibrous. Although, among the LCM functions is to reduce the amount of loss circulation to the downhole formation, most of the time it is not preferable since great care is needed Larger LCM requires special care in mud handling, pumping is more difficult, and shut-downs are often needed for solids control. Approaching the problem with smaller materials first allows better definition of the downhole problem and provides useful information. It is also noted that Perak, Malaysia is a rich source of limestone hills mainly used as quarry for construction material. Compared to others source of Lost circulation material, it is the cheapest and It is therefore in great interest to utilize this abundant material as another method to reduce the lost circulation problem. This project will explain in detail investigating limestone properties, its mineral composition and relation to be used in drilling fluid.

1.3 Objective

1. To study on the possibility of using Lenggong limestone as Loss Circulation Material
2. To study the rheological behavior and suitability of Lenggong limestone as Loss Circulation Material
3. To determine the correct and best composition of the Lenggong limestone as LCM

1.4 Scope Of Study

This project focuses on the literature review on the properties of limestone – a product sedimentation of carbonaceous material. This will cover the important parameters such as, mineralogy, composition, solids content, rheology, filtrate and its mineral compositions. Then, the scope will be narrowed down and specifically into experimenting directly with obtained limestone on its composition in order to produce the desired mud properties as well as using it as Lost Circulation Material.

CHAPTER 2: LITERATURE REVIEW

2.1 Limestone (calcium carbonate)

Limestone is a sedimentary rock and mainly consist of mineral calcite which is a form of calcium carbonate (CaCO3).The formation of limestone can usually be spotted in shallow, clear warm marine waters and most of organic sedimentary rock formed from build-up of coral, shell algal and fecal debris. Precipitated calcium carbonate from ocean or lake water can also form limestone but inorganically and is called chemical sedimentary rock. These limestone however is less compared to limestone formed organically [1].

At least 50% from Limestone constituent must be of calcium carbonate in the form of mineral calcite by weight. The rest constituent can be formed from other materials such as small particles of feldspar, quartz, clay mineral and other minerals including large bud of pyrites or siderites [1]. The limestone can divided into variety of types such as:

Chalk :

Limestone with soft and fine texture. Its color can vary from white to light grayand mainly its formation is associated with calcerous shell remains of macroscopic marine organis, suh as foraminifers. [10]

Fossiliferous limestone

Its content can be from abundant and evident fossils of shells and skeletal fossils of organism that produced the limestone during its formation [10]

Oolitic limestone

It is formed by small spheres of calcium carbonate called oolites by precipitation of calcium carbonate on a sand grain or shell fragment. [10]

Tufa

It is formed by calcium laden waters precipitated during hotspring, lake shore or other location [10].

Lithographic limestone

Limestone which has dense texture and has grain size which is uniform and very fine. It has very smooth surface due to occurrence uniform grain size that occur on thin beds to separate easily. [10]

2.2 Limestone in Lenggong hill

Figure 1: Limestone hill in Lenggong shows typical characateristics of vertical cliffs and rock pinnacles

Figure 2: Limestone color from light to dark grey with dark associated with shale and light with aronaceous rock

The proposed area to take the limestone is in Lenggong limestone hill which is located in Kampung Batu Pecah. The village is located just 80km north of Ipoh and 50km south of Grik. Geological study shows The largely banded fine to medium-grained marble of the Lenggong Limestone is Lower Paleozoic in age and is intruded by the Bintang Granite of Triassic age. Lenggong Limestone occurs as several low, densely forested mogote hills with conical tops.

Crystalline limestone occurs as thin lenticular intercalations in the sedimentary-pyroclastic sequence of Grik Area. The karst topography is a typically developed from the weathering of the limestone hill. The height of the limestone hill reaches approximately 120ft and have the characteristics of pinnacled surfaces and in some places vertical cliffs. Other feature of the limestone hill include rock pinnacles, swallow holes, and grikes[2].

The limestone has different amount of impurities and its colour is identified light to dark grey and it is bedded with massive to thick crystalline rock. The dark grey colored can be associated with carbonaceous shale or phylite and the light colored bedding can associated with arenaceous rocks where it may have experience thermal metamorphism [2].

Among the impurities in the limestone are clastic argillaceous, carbonaceous and arenaceous matter and other scattered grains of quartz and feldspar originated from volcano.

2.3 Lost Circulation

Losses of whole mud to subsurface formations during drilling operations is called lost circulation or lost returns. In has been historically recorded that lost circulation has been one of the primary contributors to high mud costs. Other hole problems such as wellbore instability, stuck pipe and even blowouts have been the result of lost circulation). Besides the benefits of maintaining circulation, preventing or curing mud losses is important to other drilling objectives such as obtaining good quality formation evaluation and to achieve effective cement bond on casing. In common, lost circulation occurs in two ways:

1. Naturally occurring losses - Invasion or mud loss to formations that is porous, permeable, cavernous, vugular, fractured or unconsolidated.

2. Mechanically induced losses - Fracturing which is mud loss due to hydraulic fracturing from excessive induced pressures. This includes high hydrostatic pressure due to high mud weight, and high pressure resulting from excessive ECD.

2.4 Lost Circulation Countermeasures

Lost circulation and costs the industry hundreds of millions of dollars each year in lost or delayed production and in spending to deal with drilling problems, repair faulty primary cement jobs and replace wells irreparably damaged by lost circulation [9]

Good planning and proper drilling practices can help in preventing lost circulation and differential sticking by minimizing excessive pressures on the formation. Below are several measures that can be done in order to prevent or minimize lost circulation.

1. Set the casing in the appropriate zone so the fracture gradient of the formation at the casing shoe will be sufficient to support the hydrostatic head of heavier muds required to balance pressures in the formations below. This commonly applies to lost circulation only.

2. Minimize downhole pressures. These steps apply to both in preventing lost circulation as well as differential sticking:

a. Pipe movement should not exceed critical speeds when tripping.
b. Reduce rapid/sudden movement of pipe while circulating and ROP
c. Use enough drill collars to keep the neutral point in the Bottom-Hole Assembly (BHA) to minimize drillstring whipping
d. Control mud properties:
    i. Drill with minimum mud density
    ii. High viscosity and gel strengths increase surge pressures each time circulation is interrupted and restored
    iii. Usage of Lost Circulation Materials (LCM) - A good selection of the proper size of bridging materials helps reduce and eliminate whole mud losses into porous formations. The choice of such bridging agents will depend on the formation characteristics.

2.7 Lost Circulation Materials

Lost circulation materials are terms for substances used when drilling fluids are lost into the formation downhole while drilling. Lost circulation materials act as bridging agents that bridge the pore and vacant between the formation rocks. Compilation of layers of bridging agents (LCM) can effectively stop filtrate fluid from moving into the formation. The selection of LCM is critical

Commercially available LCM products encompass a wide array of materials. Moreover, if it can be pumped down a well, it probably has been at one time or another. Particle shapes are granular, flake or fibrous at sizes denoted as fine, medium or coarse.

(a) Granular LCM - nutshells, calcium carbonate, sized salt, hard rubber, asphalt, gilsonite, plastic.

(b) Flake-shaped LCM - mica, cellulose, cottonseed hulls, wood chips, laminated plastic, graphite, calcium carbonate.

(c) Fibre-shaped LCM - cellulose fibres', saw dust, shredded paper, hay, rice husks.

(d) Commercial Blends - Blends of two or three different materials, meant to cover a range of sizes and shapes, e.g. combining granular, fibrous and flaked in one sack.

Treatments in an active system should typically be at 5 - 20 lb/bbl (14.3 – 57.1 kg/m3), with the choice of using a single size and shape, combination of shapes and sizes or commercial blends. Pill treatments are typically at 25 – 50 lb/bbl (71.3 – 142.7 kg/m3) of LCM in slugs of 50 – 100 bbl (7.95 – 15.9 m3).Two rules are used for selecting the size and concentration of bridging materials

1. The median particle size of the bridging additive should be equal to or slightly greater than one third the median pore size of the formation

2. The concentration of the bridging size solids must be at least 5 percent by volume of the solids in the final mud mix (mud design minimize)

CHAPTER 3: PROJECT METHODOLOGY

3.1 Project Activities Flow

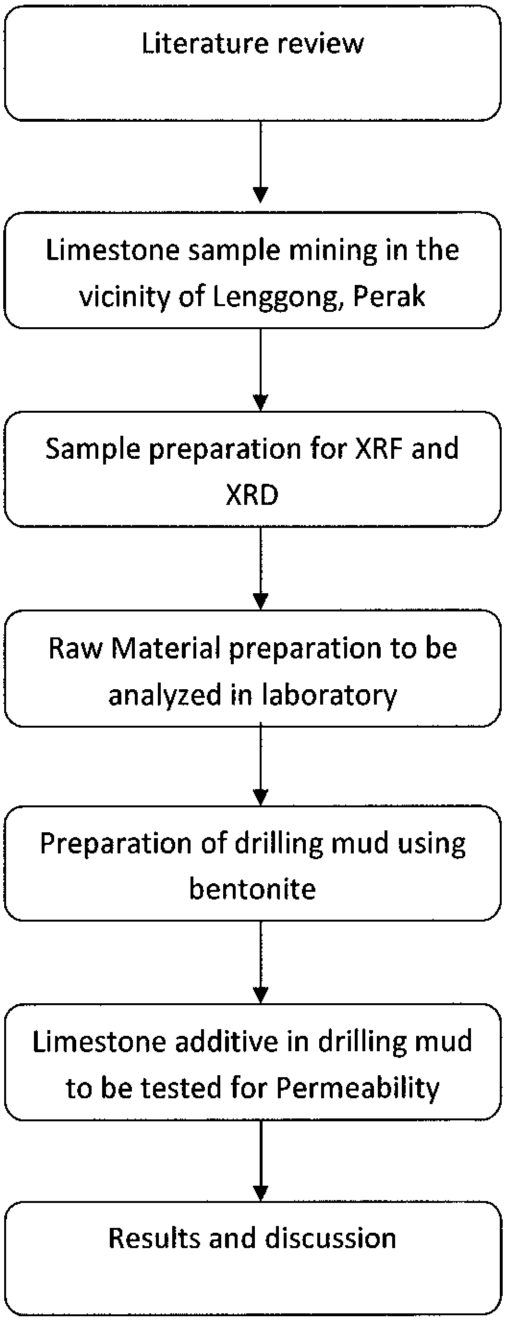

Figure 3: Project Activities Flow

3.2 Project Gantt chart:

No.	Detail/ Week	1	2	3	4	5	6	7		8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	FYP 2 Briefing	■	■						Mid-semester break														
2	Project Work & Laboratories		■	■	■	■	■	■		■	■	■	■	■									
3	Submission of Progress Report 1					●																	
4	Submission of Progress Report 2												●										
5	Pre-EDx / Poster Exhibition / Progress Reporting												●										
6	EDX													●									
7	Submission of Final Report																●						
8	Final Oral Presentation																				■	■	
9	Submission of hardbound copies																						○

● Suggested milestone

■ Progress

Table 1 : Project Gantt Chart for FYP

3.3 On-site procedure: Collecting Limestone Samples

i. Survey the limestone hill in the area around Lenggong Hill, Perak

ii. Use Global Positioning System device to record coordinate of the limestone location.

iii. Use geology hammer to extract the limestone sample in boulders with weight ranging from 2-3 kilograms.

iv. Take photographs of limestone sample with a coin as a size comparison.

v. Keep the obtained sample in tightly sealed container from any contaminant.

3.4 Lab Experiment: Apparatus & Chemicals

Apparatus	Quantity
Sieve Shaker	2
Sieves (2mm,1.18mm,600μ,325μ and 200μ) & Pan	2 sets
50 ml beaker	1
Los Angeles Abrasion Machine	1
500 ml beaker	1
Digital weight scale	1
Steel brush & spoon	2
Multimixer	1
Mud Balance	1
Chemicals	**Quantity**
Distilled water	350ml
Barite	As required
Calcium carbonate	As required

Table 2: Apparatus & Chemicals for Lab Experiment

3.5 LAB ACTIVITIES & EXPERIMENTS

3.5.1 Procedure: Grinding and Sieving Samples to Be Used In Building Mud

i. Limestone boulder are smashed into smaller pieces using a sledgehammer to be feed into the los angeles abrasion machine
ii. The hammered limestone is then fed into the Los Angeles Machine to grind them into finer particles ranging from 2.00mm to 60um.
iii. Place the grinded and pulverized samples into the sieve stack with the following mesh configuration.
iv. Turn on the sieve shaker for 1 hours for sieving each sample respectively
v. Separate the sieved samples according to the respective particle sizes
vi. Record any other relevant observations

3.5.2 Procedure: Mixing Bentonite mud

i. This experimental bentonite drilling fluid design with the following specifications:
   - Mud Weight = 8.5-9.5ppg
   - pH = 8.5-9
   - API filtrate = 15 ml/30 minutes
ii. Pour 350 ml of distilled water in the mixing cup
iii. Insert the mixing cup hold by the multimixer and turn on the agitator for 1 hours
iv. During this period, slowly add 22.5 grams of <63μ bentonite soil
v. Record any changes in fluid appearance, apparent viscosity and any other relevant observations

3.5.3 Procedure: Bentonite Mud Weight Test

i. Set the mud weight on a flat level surface.
ii. Fill the mud cup with the mud to be tested.
iii. Replace cap and rotate until it is firmly seated, ensuring some of the mud is expelled through the hole on top, to free any trapped gas.
iv. Place the beam on the base support and balance it by using the rider along the graduated scale. Balance is achieved when the bubble is directly under the centre line.
v. Take the mud weight reading
vi. Repeat step (iii) to (v) two three times and take the average reading to obtain more precise measurement.

3.5.4 Procedure: Rheology Tests

In mud rheology testing, rheometer is used. It is important to frequently monitor the mud rheology as to make sure that the mud is always within the specification as stated in the mud program:

i. Place the sample in the rheometer thermo cup and adjust the cup until the mud surface level is equal height to the scribed line on the rotor surface.

ii. Turn on the rheometer, first taking dial measurements at the top most speed (600rpm), then gradually switch to lower gear and to obtain all readings (600,300,200,100,6,3rpms).

iii. **Determining PV** – indicate the amount of solids (sands, silts) in mud. High PV means that the mud is not clean and there is a problem with the solids control equipment.

$$PV = 600\ rpm - 300\ rpm$$

iv. **Determining YP** – indicate the carrying capacity of cuttings (usually the case is that the higher the viscosity is, the higher the YP is)

$$YP = 300\ rpm - PV$$

v. **Determining Gel Value**

1. Stir the sample in 600rpm speed for 15 seconds. Just before the motor stops, slowly shift the moving gear to the lowest speed.
2. Wait for 10 seconds. After 10 seconds has finished, turn on the 3rpm speed and record the maximum deflection of the dial. This is the 10 seconds gel reading.
3. Repeat step one and step two, but this time, wait for 10 minutes before turning on the 3rpm speed. The maximum deflection of this reading shall give us the 10-minute gel reading.
4. Rewrite the gel value as (dial = 10 secs) / (dial = 10 mins)

3.5.5 Procedure: Low Pressure LowTemperature Test

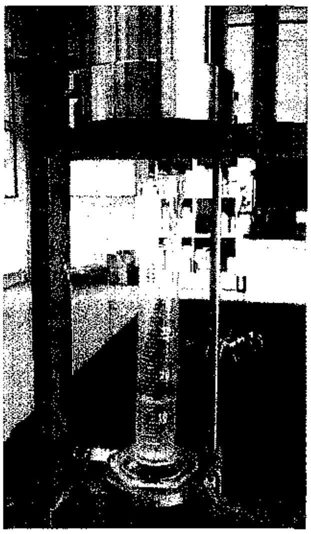

Figure 4: Filtrate loss is measured for 30 minute

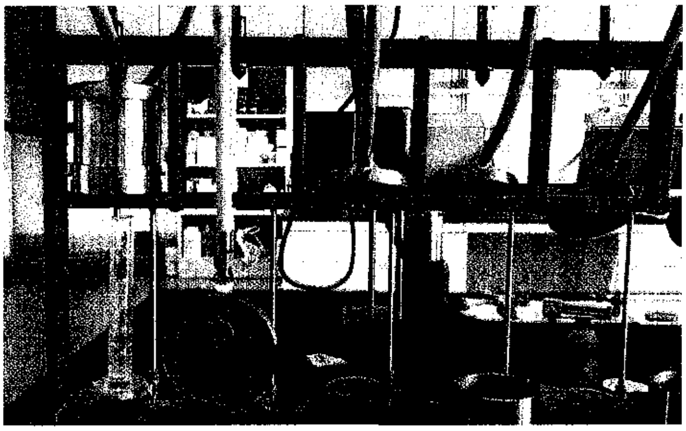

Figure 5: The assembly for Low Pressure Low Temperature apparatus

The Permeability Plugging Tester (PPT) is a modification of the standard 500-mL LPLT Filter press test (API filtrate test). It may be used in the field or in a laboratory environment for performing filtration tests on plugging materials without the interference of particles settling on the filter medium during the heat up process.

The PPT is very useful in predicting how a drilling fluid can form a low permeable filter cake to seal off depleted, under pressured intervals and help prevent differential sticking. PPT also enables engineers to identify performance and effectivity of a lost circulation material (LCM):

i. Place the sample in the rheometer thermo cup and adjust the cup until the mud surface level is equal height to the scribed line.
ii. Operate the pump to increase the pressure in the cell to the desired test pressure to initiate filtration
iii. Using the pump, maintain the desired differential pressure in the cell. The differential pressure is the cell pressure minus the amount of back pressure. Do not exceed 100 psi as the primary or inlet pressure
iv. Collect filtrate every 5 minutes interval.

v. If the back pressure rises during the test, cautiously reduce the pressure by opening the drain valve on the receiver and drawing off some of the filtrate into the graduated cylinder

CHAPTER 4: RESULTS AND DISCUSSION

4.1 Grinding and Sieving Samples to Be Used In Building Mud

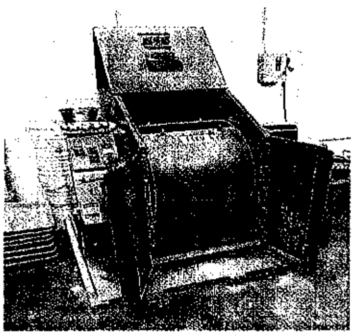
Figure 6: :Los Angeles Abrasion Machine

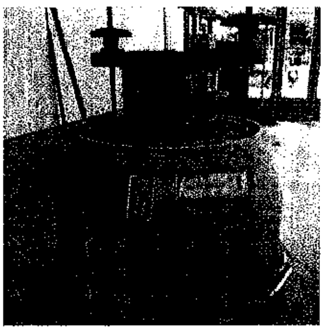
Figure 7: Sieve Shaker

Since, the limestone sample were initially in large boulder size. A grinding machine and sieve was necessary to crush the sample into smaller pieces and in smaller particle sizes. After being crushed by the Los Angeles Abrasion Machine, there was no need to heat in the oven for moisture removal since the sample crushed was already in dried condition. After the grinding of the sample. The sample was prepared in different sizes from 2.00mm>1.18mm>600 μm>325 μ>212 μm>pan. The reason for different particle sizes form limestone was to see how the crushed limestone will perform in the Permeability plugging test. The amount of fluid loss from the permeability plugging test will determine what is the optimum limestone size to be used in designing the drilling mud additives.

4.2 Limestone Composition

Limestone sample is prepared in two samples both weighing 0.6grams and was grounded to below 200um. Then it is prepared for X-Ray Fluorescence test to identify the element and substance present in the sample. The result presented below is in analyte in its weight percentage.

Analyte	Percent (wt%)
Mg	0.645
Al	1.91
Si	2.24
P	0.219
K	0.198
Ca	63.56
Ti	0.059
Fe	0.509
Cu	0.0015
Sr	0.0176
P205	1.322
K20	0.238

Table 3: :Analyte content in weight percentage

Compound	Percent (wt%)
Al2O3	0.53
CaCO3	94.33
MgCO3	0.63
SiO2	4.4

Table 4: :Compound content in limestone in weight percentage

Table above represent the percentage of compound found in limestone sample which shows high calcium carbonate content along with other trace compound..

4.3 Enlarged Images of Samples

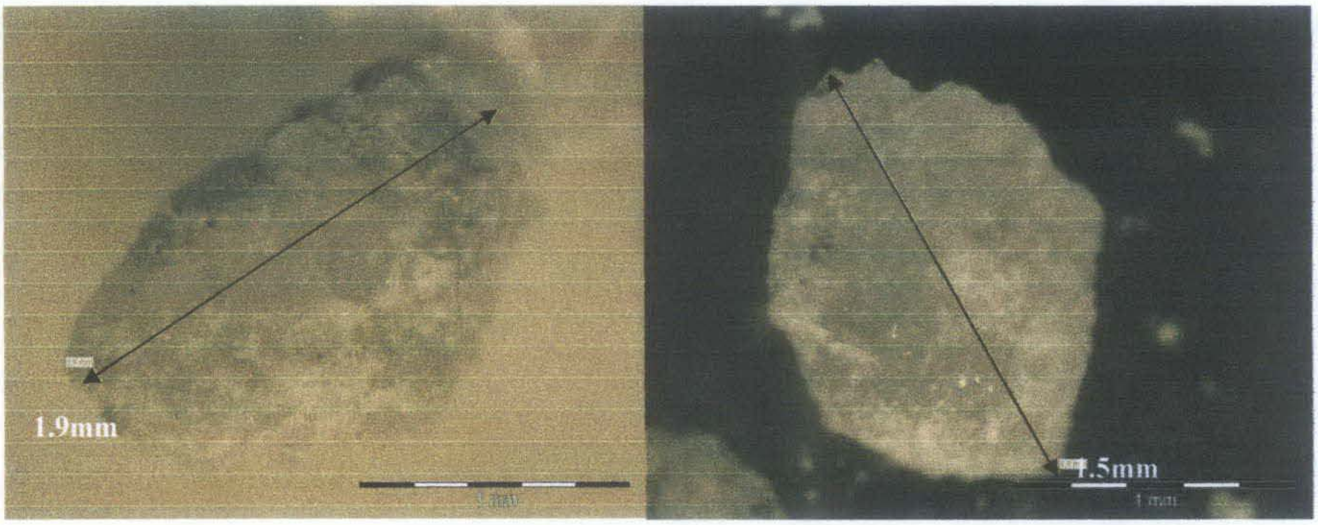

Figure 8: Enhanced images of limestone with range 1.18mm<2.00mm
shows sub angular features.

The sieved limestone is then viewed under binocular which uses diffracted light and microscope courtesy of Jabatan Mineral dan Geosains Perak which uses reflected light from the sieved sample. The purpose is to get a better understanding in how the shape and texture of the sample will relate to its performance in plugging fluid flow in the Permeability Plugging test. From figure 6 it is noted that the shape of the sieved limestone is sub angular is mainly because it has been crushed mechanically into its current shape. Both figures shows different sample with elongated length of 1.9mm and 1.5mm which is within the targeted range of sieved sample from 1.18mm to 2.00mm. The reason the length of the sample is taken from the longest part is because we want to see the longest section possible to go through the metal meshes during the sieving preparation.

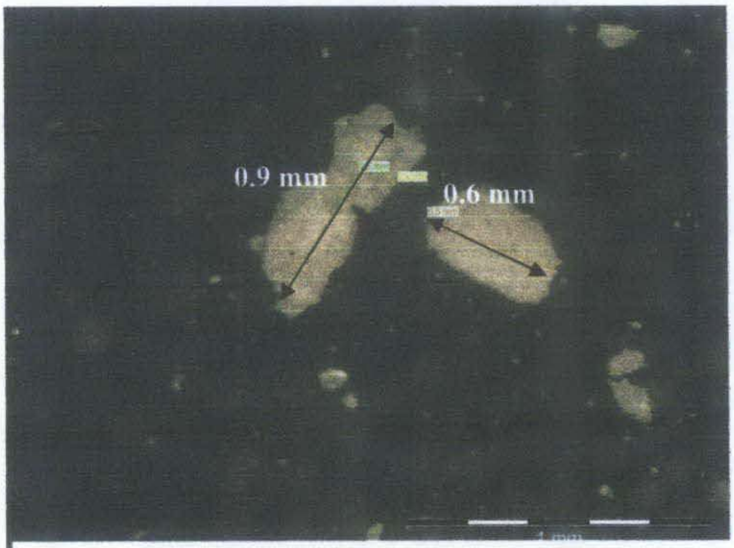

Figure 9: Enhanced images of limestone with range 600um<1.18mm
shows sub angular features.

Image from figure 7 is taken from sieved limestone from range 600um to 1.18mm also showing sub angular features due to crushed mechanically and is poorly sorted. This will affect the plugging test since poorly sorted particles can plug the fluid flow as opposed to the well sorted ones. Images above also confirm that the sieved limestone is within targeted size range which is 0.9mm and 0.6mm.

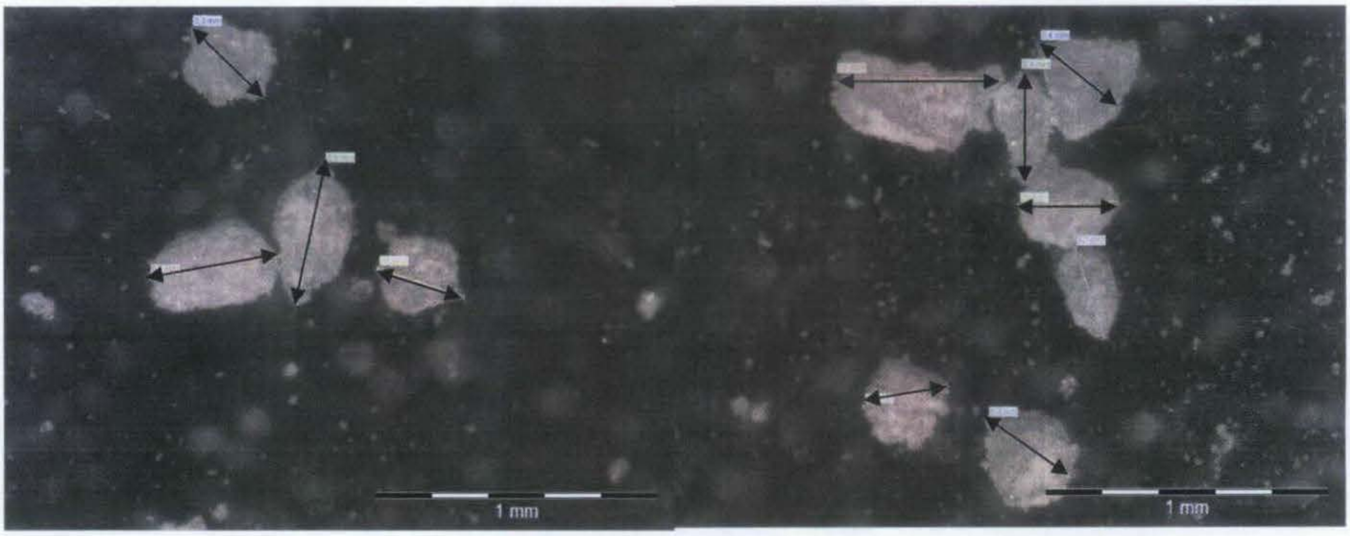

Figure 10: Enhanced images of limestone with range 200um<300um shows sub angular features.

Image from figure 8 is taken from sieved limestone from range 300um to 200mm also showing sub angular features due to crushed mechanically and is poorly sorted. Images above also confirm that the sieved limestone is within targeted size range which is 0.2um and 0.3um

4.4 Bentonite mud weight test

To produce a barrel of on-site mud, 350ml of distilled water is the equivalent amount of water needed. To produce a mud weight ranging from 8.5ppg-8.6ppg, 22.5 grams of bentonite is needed having a yield point ranging from 22-25.

Using multimixer to mix the bentonite with water for 1 hour is needed to have the sweeling effect of the bentonite clay. As expected, the bentonite clay swelled fine producing a consistently formed drilling mud. Below is the data from the rheology test performed on the mud

The Abbreviation used in the test:

2) PV = Plastic Viscosity (Higher PV values means higher solids content in mud)

3) YP = Yield Point (Cutting carrying capacity of mud)

RPM	ϴ
600	23
300	20
200	17
100	16
6	12
3	12

Table 5: RPM and viscometer reading accordingly arranged in the table

From this it is concluded that PV= 3 and and YP=17. This proves that the bentonite mud is ready to tested with the limestone as additive.

4.5 Mud test- bentonite with limestone as LCM in different concentration

Using PPT Permeability Plugging Testing which is alternative to Low Pressure Low Temperature, 4 different limestone particle size in 3 different concentration is used. One mixture of bentonite mud will also be tested in the PPT test as a control sample. Every mud is mixed with the same formula and amount of bentonite except for the amount of limestone powder and the size of it.

The objective is to compare the differencesof mud weight and other rheological properties for the limestone as LCM. The amount of limestone powder to be used is 20g, 40g and 60g. For the Low Pressure Low Temperature Test, the result were as follow

For Control Mud no additive

Limestone powder concentration	Reading
Mud Weight	8.7
Plastic Viscosity	3.5
Yield Point	15
Filtrate Loss	6

Table 6 : Rheology data for control drilling mud with no additives

For 1.18mm<2.00mm

Limestone powder concentration	20g	40g
Mud Weight	8.9	9.2
Plastic Viscosity	6	4
Yield Point	22	28
Filtrate Loss	5.6	5.4

Table 7: Rheology data for drilling mud with additive for particle size from 1.18mm<2.00m

For 600um<1.18um

Limestone powder concentration	20g	40g
Mud Weight	8.9	9.2
Plastic Viscosity	6	4
Yield Point	22	28
Filtrate Loss	5	4.8

Table 8: Rheology data for drilling mud with additive for particle size from 600um<1.18um

For 200<300um

Limestone powder concentration	20g	40g
Mud Weight	8.9	9.2
Plastic Viscosity	6	4
Yield Point	24	27
Filtrare Loss	5.5	5.5

Table 9: Rheology data for drilling mud with additive for particle size from 200um<300um

Below is the data for AFI test. The reading in the measuring cylinder is taken every 5 minutes for a total of 30 minutes.

Time Interval (min)	Control Mud (ml)	1.18-2.00mm (ml)	600um-1.18 (ml)	200um-300um (ml)
5	2.3	2.3	2.1	2.3
10	3.5	3.3	2.5	3.5
15	4.3	4.1	3.2	4
20	5	4.7	4	4.5
25	5.5	5.2	4.5	5.3
30	6	5.6	5	5.5

Table 10: Filtrate Loss data for every mud with different size of additive with different time interval

The tabulated data is then plotted using filtrate loss (ml) versus time (min) to get a better visual understanding and comparison of the three of the drilling mud with different concentration and size of additives.

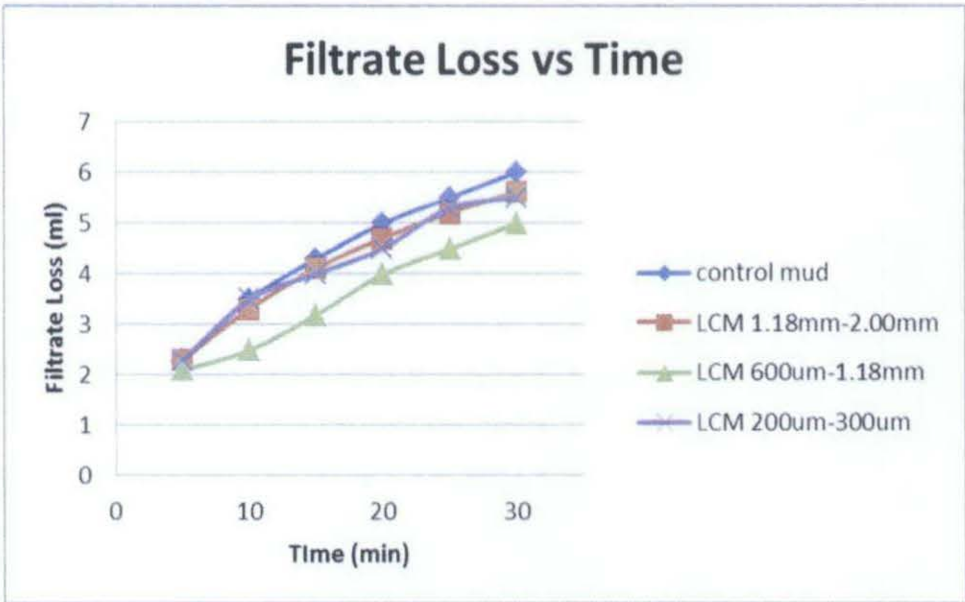

Figure 11: Plotted Filtrate Loss versus time interval in 5 minutes

By referring to the plotted data, the high calcite limestone can reduce the fluid loss but by only 20%. The optimum amount of limestone that can be added as LCM is at 20lb/bbl, because adding more LCM will not reduce the fluid loss but also can be damaging to the mud pump. It also shows that the most optimum size of limestone to be used is in the range of 600um to 1.18mm which is suitable size for LCM as larger LCM is not preferred due to its difficulty to handle and damaging to mud pump.

4.6 Mud test- Comparison of Limestone to other material as LCM

ure 12: Mud scale used to measure mud weight in pound per gallon

Figure 13: The Low Pressure Low Temperature (LPLT) alternati the Permeability Plugging Test to measure Filtrate Loss

To get a better understanding on how efficient the limestone act as Lost Circulation Material, it is imperative that the result obtained from the rheology test is compared to the other materials that is already used as Lost Circulation Material in the market. The lost circulation material to be compared to are Mica flakes, Nut Plug (Ground Walnut Shells) and basaltic rocks. The Lost circulation material will be added in the drilling mud by 20grams and 40 grams and tested for mud weight, plastic viscosity, yield point and filtrate loss . This is done to simulate the drilling scenario when using LCM at concentration of 20 pound per barrel and 40 pound per barrel [3]. The result is tabulated as below.

For Mica Flakes,

Concentration	20g	40g
MW	8.8	8.9
PV	8	4.2
YP	20	22
FL	5	3
Visual Observation	Mica flakes settle at the bottom	

Table 11: Rheology data for mica flakes

For Nut Plug,

Concentration	20g	40g
MW	8.8	8.9
PV	5	9
YP	20	15
FL	3.5	2.5
Visual Observation	Generation of foamy bubbles after period of time	

Table 12: Rheology data for nut plug (ground walnut shells)

For Basaltic Rock,

Concentration	20g	40g
MW	8.9	9.1
PV	1	3
YP	24	36
FL	6.5	6
Visual Observation	Highly Viscous	

Table 13: Rheology data for basaltic rock

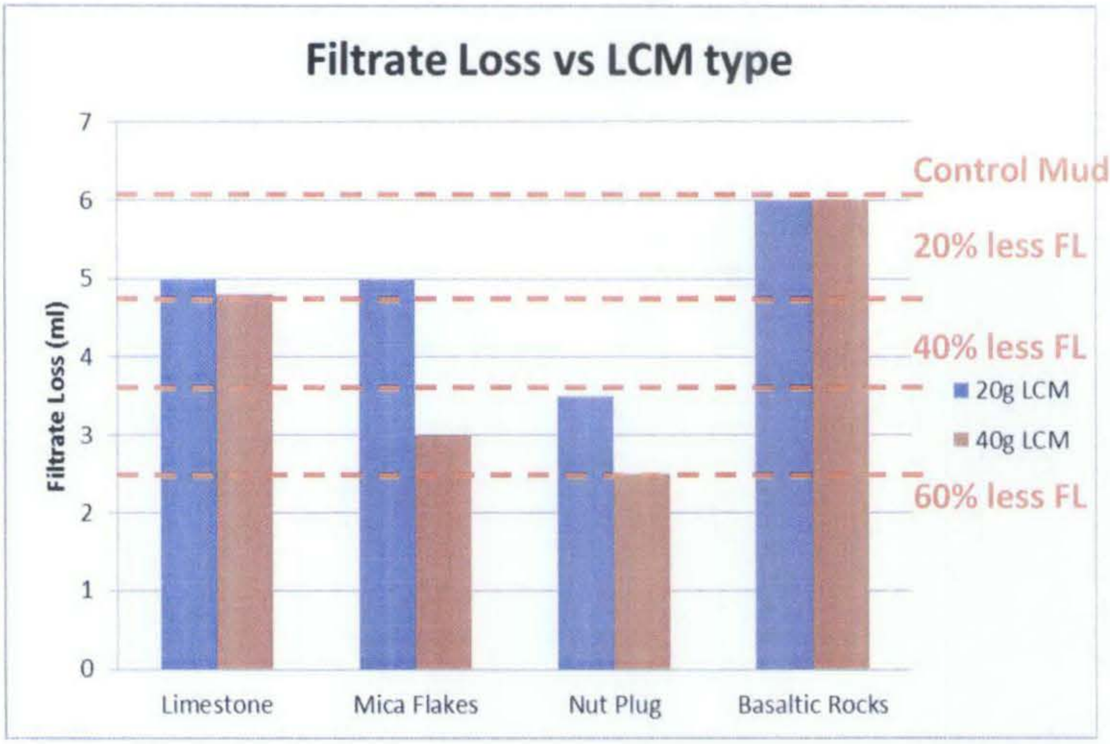

Figure 14: Bar chart showing comparison between 4 different LCM and its performance in terms of filtrate loss (ml)

The comparison is then discussed in terms of its performance tabulated below according to the respective Lost Circulation Material tested. It also listed other observation that may affect its advantage and disadvantage depending on how it is used.

LCM Type	Advantage	Disadvantage
Limestone	• Average performance in reducing filtrate loss by 20% (5ml/30min) compared to the control mud • High increment in mud weight in high concentration is good indicator as weighting agent. • Relatively cheap compared to other LCM	• High increment in mud weight with higher concentration may cause overbalance in deep water wells.

Mica flakes	• Good performance in reducing filtrate loss by as much as 20% in 20g and 45% in 40g concentration.	• If mica waste is not handled properly may lead to HSE issues as it is hazardous to human respiratory system
Nut plug (Ground walnut shells)	• Good performance in reducing filtrate loss by 40% in 20g and 60% in 40g concentration	• Low Yield point at 40g concentration value is not preferred in borehole cleaning. • Foamy bubble generated may reduce mud weight
Basalt Rock	• N/A	• Filtrate loss does not show convincing result as it is the same as control mud. (6ml/30min)

Considering the tabulated comparison above, every Lost Circulation Material has its own advantage and disadvantage. In comparison, the high calcite limestone is not a good competitor to other LCM in terms of filtrate loss performance and mud weight. The only reason limestone outshine other material is because the cheap cost of the material but then again, it is very time and energy consuming to crush the limestone into workable LCM size. But other than that, limestone may provide a good LCM since it does not cause lead to health issues and does not create foamy bubble.

CHAPTER 5: CONCLUSION & RECOMMENDATION

5.1 Conclusion

Lost circulation can be very expensive to take care of. There are many type of lost circulation materials available in the market as a solution. Among them are the Calcite in the limestone shows promising candidate as a lost circulation material. Based on the literature review, it is possible that limestone can be used a calcite provider in the drilling fluid. In the intial lab test, using 20g in 1.18mm<2.00mm amount of limestone powder as LCM in drilling mud, results shows that filtrate loss is reduced showing that it can reduce the permeability of the filter cake and therefore plug the fluid from flowing through it more freely. Although this data shows promising results for the limestone from lenggong to be used as LCM, more study needed to be conducted for different particle size of limestone so it can be determined which is the optimum size to be used as the LCM additive. The preferred one are smaller in particle size as it will reduce the damage when pumping the mud to the downhole. And also , it is noted that more concentration of limestone powder can result in increase in mud weight which will lead in overbalance in mud pressure, so more study needed to be conducted on reducing this problem

Reccomendations

Initial data from experiment show promising results for limestone from Lenggong, but it is recommended that to make the lost circulation reduced more, blended LCM is much more preferred. The usage of blended LCM is popularly used for drilling purpose because of its ease of handling and effectiveness. Since adding more concentration of fine limestone powder can result in increase of mud weight, perhaps fibrous material can be blended together with the granular limestone to provide better effectiveness in countering the fluid loss and hopefully reduce the mud weight produced. So , Permeability plugging test and formation damage test should also be done to really determine the suitability and effectiveness of blended limestone with fibrous to be used as loss circulation materials.

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