

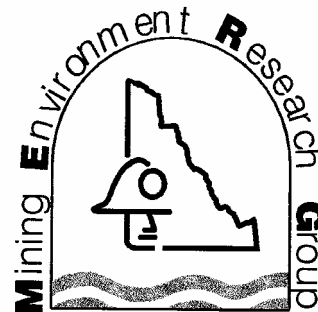
MERG Report 2003-4

Mine Sludge Stability/Densification in Cold Climates Sludge Characterization and Sludge Densification

By Jean-Francois Fiset, Janice Zinck and Giles Laflamme,
Natural Resources Canada

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EXECUTIVE SUMMARY

In 2001, a project was initiated to study the behavior of treatment sludges in northern climatic conditions. For this study, leach columns were commissioned in the laboratory to evaluate metal mobility from treatment sludges. In addition, sludge densification by the freeze-thaw mechanism was studied.

Sludge samples from effluent treatment operations at United Keno Hill (UKH) and Faro mine sites were used in this study. This project has been divided into two main tasks; a leaching study and a freeze-thaw study, both conducted in the laboratory and in the field. This final report presents the results of the sludge characterization, the freeze-thaw study and the leaching study.

The composition of the acid mine drainage sludge produced at Faro and UKH mine sites were different as compared to typical lime treatment sludge. The metal composition of the mine water was very low, in particular for iron. While the pH of the wastewater was near neutral, the addition of lime was required mainly to precipitate zinc. The metal content of the sludge was low and the neutralization potential was very high which was in accordance with the high carbonate content measured in the sludge. The United Keno Hill sludge was mainly composed of calcite. Instead of calcite, the Faro sludge had as a major constituent aragonite, a pseudomorph of calcite crystals.

The sludge characterization revealed that the lime treatment process at both sites could be optimized. The origin of the high carbonate content of the sludge was probably from the lime quality used and from a high carbonate concentration in the mine water. Mineralogical results revealed evidence that minor amounts of calcium carbonate is from primary precipitation during the lime addition. Also, larger particles of calcium carbonate were also identified in both sludges which are thought to be from the lime used to precipitate metals. The lime treatment process could probably be improved by optimizing the slaking temperature, agitation time rate and using the proper chemical reagents to precipitate metals.

The freeze-thaw mechanism evaluated in the field increased the percent solids of the sludge from 23% to 60% for the UKH and from 28% to 58% for the Faro sludge. The freeze-thaw study conducted in the laboratory showed final percent solids values in the

same order. The capability of the sludge to dewater so easily is explained by the low amount of iron hydroxide in the sludge. Because no particle repulsion force or bond water are associated to the iron hydroxide phase. The high solids content reached in this study was mainly due to natural dewatering rather than the freeze-thaw mechanism.

In terms of chemical stability, the column and the SPLP studies revealed that the metal release is minimal because of the high neutralization of both sludges. The variation of the temperature did not have any significant impact on metal mobility. Nickel and zinc were released to significant levels for both sludges when the sludges were subjected to the TCLP.

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1.0 INTRODUCTION

It is common practice in the mining industry to treat metalliferous process water and acidic drainage with lime for pH neutralization and metal precipitation. This method typically generates voluminous, low-density sludge which may re-mobilize metals after disposal.

In recent years, several studies have been undertaken to study and evaluate the degree of metal mobility from lime sludges and their long-term chemical stability (Zinck, 1999; Zinck, 2000; MEND 3.42.2, 1997 and Zinck et al., 1996). However, very little, if any, information is available in the literature on the stability of lime treatment sludge in northern environmental conditions.

As noted above, the challenges generally associated with the treatment of acid mine drainage (AMD) with lime are typically the voluminous amounts of sludge to dispose, the lower solid content and long-term stability of the sludge. Sludge volume may be reduced by progressive freezing cycles, making the sludge denser. The sludge thickening effect is attributable to the growth of ice crystals which incorporate water molecules in their structure. The sludge is compressed by the ice front. When the ice melts, the sludge solids content remains in its compressed state which promotes water drainage and sludge dewatering (Vesilind and Martel, 1990). The freeze-thaw process was extensively studied by various researchers (Hung et al., 1996; Ezekwo et al., 1980; Halde, 1980) on municipal sludge and alum sludge but not on AMD sludge.

A two-year project was initiated to study the physical behavior and environmental impact of lime treatment sludge from northern climates. This study was based mainly on two mine sites located in the Yukon; United Keno Hill (Elsa, Yukon) and the Faro mine site (Faro, Yukon). Parallel field and laboratory studies were conducted to examine both the freeze-thaw and the sludge stability.

1.1 Project Objectives

The objectives of the project were:

- to evaluate and assess metal mobility and chemical stability of lime treatment sludge in northern environmental conditions through both field trials and laboratory testing; and
- to investigate the freeze-thaw effects on sludge densification.

This report presents sludge characterization, sludge densification results and sludge leachability. In addition, this report summarizes the column set-up, methodology and analytical approach used in this study.

2.0 FIELD METHODOLOGY AND ANALYTICAL PROCEDURES

2.1 United Keno Hill

The sludge at the United Keno Hill mine site was sampled in September 2001 by a CANMET-MMSL team. Representative samples of sludge were collected from sludge ponds with a water cover near the Galkeno adit 900. An Eckman grab was used to collect the sludge from the ponds.

Specially constructed cell units were installed in the ground near the sludge ponds to study the freeze-thaw effect and the chemical stability of the sludge. Three cell units having a diameter of 30 cm and a height of 37 cm with piezometers for water sampling were installed. Three piezometers consisting of PVC tubing per cell unit were installed at different heights on a bridge. The bridge was installed on the cell walls and the bottom section of the piezometers were protected with a piece of geotextile to avoid clogging. In each cell, piezometers were placed at a distance of 10, 20 and 30 cm from the surface in order to collect porewater at three different locations. The bottom of the cell unit was covered with a 5 cm layer of polypropylene beads. Figure 1 represents the field set-up (UKH).



Figure 1: Field set-up for the freeze-thaw study and the leaching study at UKH.

During the second field campaign in June 2002, supernatant water, porewater and sludge samples were collected from each cell unit. The porewater samples were collected by sampling the piezometers using a pump. A parallel experimental set-up (Figure 1b) was also commissioned at CANMET's Ottawa laboratory in order to gather more data and compare field and laboratory results.

Three additional cell units were installed on site to evaluate the freeze-thaw effect of the sludge. Initial percent solids content of the sludge was taken in the fall of 2001 and the final solid contents of the sludge were determined during the spring of 2002. A layer of sand (5 cm) was placed at the bottom of the cells. Parallel experiments were also conducted in the laboratory.

2.2 Faro

The sludge at Faro mine (Faro, Yukon) is produced by a process similar to a high density sludge process. Fresh sludge was collected directly from the recycle line at the plant. An experimental set-up similar to the one at UKH (Figure 1) was also installed at the Faro site to study the freeze-thaw and metal leaching characteristics. Three cell units were installed for the freeze-thaw task and six units for metal leachability study. Three of the six cell units were set up with a water cover.

2.3 Laboratory Freeze-thaw

This section outlines the experimental set-up and methodology for the laboratory freeze-thaw testing.

2.3.1 Column Set-up and Methodology

The laboratory columns were made of plastic (Lexan) measuring 25 cm in internal diameter and 39 cm in height. Sand was placed between two geotextile layers at the bottom of the column in order to facilitate drainage. The sand and the geotextile were prewashed with 2% nitric acid and rinsed several times with distilled water until the pH reached a value between 6.0 and 7.0. The columns were insulated on the sides by wrapping them with fiber glass wool to a thickness of 15 cm as showed in Figure 1a. This was done to promote the freezing of the column and the ice front advance from the top and bottom of the columns. The aim of the insulation was to simulate ground conditions in permafrost regions.



Figure 1a: Laboratory set-up for the freeze-thaw study

The columns were filled with sludge to obtain a final bed height of ~30 cm after gravity dewatering. Representative sludge samples were taken at the time of column loading for mineralogical, chemical, solids content and particle size analyses. The columns were then placed in a freezer for four consecutive freeze-thaw cycles. Each freeze-thaw cycle started at 20°C and the temperature decrease to 2°C/hour until the temperature reached -20°C. At this temperature, the columns were allowed to rest for a period of one day, afterwards, the temperature started to increase at the same rate until the temperature reached the set point of 20°C. Between each cycle, sludge sampling was done at four different locations at 7 cm below the sludge surface. Particle size distribution and percent solids were measured after each freeze-thaw cycle and mineralogical analysis after completion of the fourth cycle. Particle size distribution results are given in Appendix A.

The freeze-thaw experiment was conducted in duplicate, 2 columns for the Faro sludge, 2 columns for the UKH sludge and 2 control room temperature columns, one for each sludge for a total of six columns.

2.4 Leaching Procedure

For leaching tests, the columns were loaded with the test sludge to obtain a final bed height of ~30 cm. The columns were leached once a week with 155 mL of distilled water to simulate ambient wet/dry cycle. In order to simulate the impact of cold temperature conditions on the sludge leaching, these tests were also conducted at low temperature. Temperature varied from -20°C to 20°C at a rate of around 1°C/day.

2.4.1 Batch Leaching Tests

In addition, leaching tests using the Toxicity Characteristic Leaching Procedure (TCLP), Synthetic Precipitation Leaching Procedure (SPLP) and the distilled water were conducted. The TCLP and SPLP are designed to determine the mobility of both organic and inorganic analytes in the waste. TCLP tests are conducted using acetic acid as an extraction fluid while the SPLP is water and the pH is adjusted to 4.2 using a mixture of sulfuric and nitric acid (60/40 wt).

2.5 Analytical Procedures

The pH, Eh and Ec were measured in the field and in the laboratory. The samples were analysed by the Analytical Services Group (ASG), of the CANMET Mining and Mineral Sciences Laboratories. The ASG is ISO 9002 certified and their QA/QC protocols can be found in the ASG Quality Manual (2000).

2.5.1 Chemical Composition

A complete characterization of the sludges used in this study, including chemistry and mineralogy was completed. The sludge samples and the leachates were analyzed chemically for the following components: redox potential (Eh), conductivity (Ec), pH, Al,

Ag, As, Ba, Ca, Cd, Cu, Fe, Hg, Mg, Mn Pb, Se, S, Si, SO₄ and Zn. The analyses were carried out using ICP-MS, ICM-AES and ion chromatography.

2.5.2 pH, Eh and Conductivity

The electrical conductivity measurements were completed using a epoxy/graphite Ec electrode and a Oakton CON 500 series conductivity meter. The pH measurements were done using a glass electrode with an Ag/AgCl reference, the Eh was measured using a platinum tip combination electrode and Consort meter. Paste pH and Eh on the solid samples were done according to the methodology of Lawrence and Marchant (MEND 1.16.1b,1991).

2.5.3 Solids Content

The solids content of the sludge was determined by sample weight loss after oven drying to constant weight at 60°C for at least 24 hours.

2.5.4 Particle Size Determination

Particle size determination was completed on all the samples using a Horiba LA-300 laser scattering analyzer. The particle size determination range for the analyser is 0.10 to 600 µm. As the particle size analyzer carries out measurements with the particles in a diluted state, the dispersed state of the particle is an important factor in measurement accuracy. The dispersing agent must be one that does not cause coagulation, dissolution, swelling or chemical reaction. Methanol was used as the dispersant fluid for the sludge sample to avoid the dissolution of calcite, gypsum or other soluble components in the sludge. The samples were run in duplicate using a run time of 2 minutes. Appendix A presents the particle size data for the sludge before and after the freeze-thaw tests.

2.5.5 Neutralization Potential

The neutralization potential was determined by treating a freeze-dried sample with an excess of standardised hydrochloric acid and heating to ensure complete reaction. A fizz test was employed to ensure that the amount of acid added was sufficient to react with all the acid-consuming minerals present. The unconsumed acid was back titrated

with standardized base to pH 8.3 to allow calculation of calcium carbonate equivalent of the acid consumed (MEND 1.16.1b, 1991).

2.6 Mineralogy

Polished sections were prepared from sub-samples of each sludge sample. The polished sections were prepared without the use of water during grinding and polished steps, in order to minimize the effect on water-sensitive minerals. These were first examined by optical microscopy under reflected light, followed by scanning electron microscopy (SEM) in the back-scattered electron (BEI) mode, with a JEOL 820 SEM operated at 20 kV, with a beam current of 1 nA. Identifications were done by Energy Dispersion Spectrometry (EDS), using a Link ISIS series 300 system. In addition, parts of the samples were submitted for X-ray diffraction analysis (XRD) and image analysis to identify and quantify the mineral components, as these are both complementary techniques for mineral identifications. The modal analysis by XRD was done on the samples by the Rietveld Method. The samples were scanned from 5 to 90 degrees (two theta) at a sampling interval of 0.02 degrees and at a scan rate of 1.2 degrees per minute. The data were reformatted and the background was removed. The proportions of the crystalline phases were determined by data refinement using the General Structure Analysis System (GSAS) software.

3.0 RESULTS AND DISCUSSION

3.1 Sludge Characterization

The sludge sample from the United Keno Hill and Faro mine sites were characterized for their physical properties, chemical and mineralogical compositions. The chemical characterization results are presented in Table 1 and are discussed below.

3.1.1 United Keno Hill Sludge (UKH)

The sludge was collected from the sludge ponds near the Galkeno 900 adit at United Keno Hill mine site. The sludge at the site is disposed under a water cover. The particle size distribution showed the sludge was a fine-grained material with a bimodal distribution with two peaks centered at 0.39 μm and 7.70 μm . The mean particle size of lime sludge was 4.1 μm . The sludge paste pH and Eh were respectively of 8.76 and 301 mV.

The sludge was mainly composed of calcium carbonate. The metal content of the sludge was quite low, particularly iron. The iron, zinc, calcium and carbonate represented respectively 0.19%, 0.66%, 37% and 52.5%. The paste pH of the sludge was low compared to typical sludge types (MEND 3.42.2). However, the lower pH was in accordance with the major phase detected in the sludge, which was calcium carbonate that has a pK value of 8.0.

The neutralization potential (NP) of the sludge was very high at 911 kg CaCO_3 equiv/tonnes, one of the highest reported in the literature (MEND 3.42.2, 1997). Galkeno 900 adit discharge effluent was nearly neutral having a pH around 7.0. Lime treatment was required to bring the pH to ~ 9 for precipitation of zinc. In this type of process, very low quantities of lime are generally required to raise the pH. Higher NP values suggest that more lime is used than required for zinc precipitation. Overdosing lime through poor slaking and insufficient mixing usually lead to high NP values (MEND 3.42.2, 1997). The origin of calcite remains unclear but the results suggest that a portion of unused lime may react with atmospheric CO_2 to precipitate CaCO_3 . Also some of the CaCO_3 in lime may be present from poor or insufficient lime calcination.

Modal analysis (XRD technique) showed two different phases of calcium carbonate, calcite (93.3 wt.%) with minor amounts of aragonite (6.7 wt. %). Optical microscopy revealed fine-grained agglomerated particles of well recrystallized calcite (Figure 2). Also observed in this sample and identified by EDS, was a Zn-bearing hydrated hydroxy carbonate or sulphate phase containing Ca, Mg, Mn, and Si (Figure 3). Numerous particles of pyrite were also observed, generally showing a goethite-like rim (Figures 4 and 5) and much larger particles of calcite (Figure 3), quartz (Figures 6 and 7) and other silicates i.e., muscovite, amphibole and chlorite (Figures 6-8), as well as trace amounts of rutile and Ca-Fe (Figure 9) and Mn oxide particles. Table 2 presents a summary of minerals identified by SEM-EDS and XRD for the Faro and UKH sludge.

Under certain conditions, the crystallization of calcite is discouraged and aragonite forms instead. The magnesium and salt content of the crystallization fluid, the turbidity of the fluid and the time of the crystallization are important factors in determining whether aragonite or calcite will predominate.

Table 1 - Chemical composition of the sludges

Parameters	UKH	Faro
Al, %	0.40	0.20
Ag, µg/g	< 0.6	< 0.6
As, µg/g	37	2
Ba, µg/g	16	67
Ca, %	37	32
Cd, µg/g	1.82	54.8
Cu, µg/g	7.22	31.3
C_{total}, %	10.5	10
C_{inorganic}, %	10.5	9.88
C_{organic}, %	---	0.12
CO₂, %	38.4	36.2
Fe, %	0.19	0.10
Hg, µg/g	< 3	< 3
Mg, %	0.81	1.2
Mn, %	1.8	1.1
Ni, µg/g	173	393
Pb, µg/g	2.37	43.6
Se, µg/g	< 2	< 2
Si, %	0.63	1.37
S, %	0.44	0.15
Zn, %	0.66	4.52
SO₄, %	0.63	0.48
NP, kg CaCO₃ equiv./tonne	911	849
pH	8.76	8.81
Eh, mV	301	279

Table 2 - Summary of minerals identified by SEM-EDS and XRD

Samples	SEM-EDS			XRD results
	Major	Minor	Trace	
Faro	CaCO ₃		Cal, Und1, Sph, Gn Qtz, feldspars, Chl, Fe-O	Arg (major), Cal (trace)
UKH	CaCO ₃		Py, Und2, Qtz, Ms, Amp, Chl, Goe, Ca-Fe-O, Mn-O, Rt	Cal (major), Arg (minor)

Abbreviations used: Amp=amphibole, Arg=aragonite, Cal=calcite, Sph=sphalerite Py=pyrite, Qtz=quartz, Ms=muscovite, Chl=clinochlore, Cp=chalcopyrite, Gn=galena, Rt=rutile, Brt=barite; Goe=goethite; Und1= poorly crystalline Zn-bearing hydrated hydroxy-carbonate containing Si, Mg, Ca and Mn, Und2= poorly crystalline Zn-bearing hydrated hydroxy-sulphate containing major Ca and lower contents of Mg, Mn and Si.

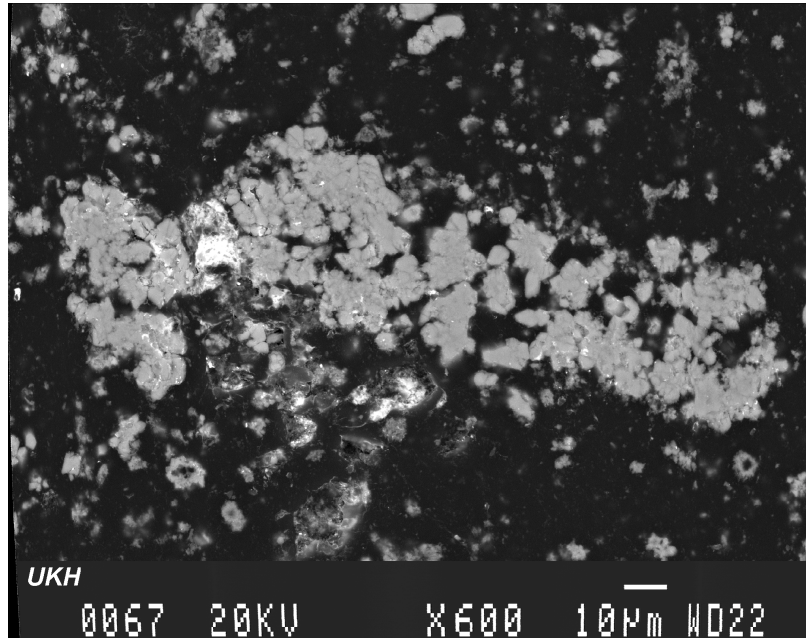


Figure 2: BEI that shows recrystallized calcite particles partly agglomerated; UKH

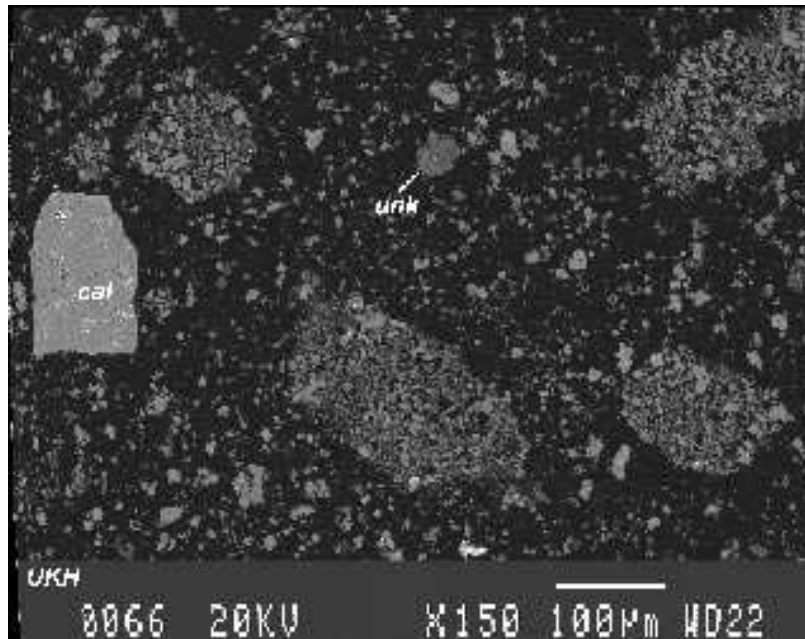


Figure 3: BEI that shows fine-grained recrystallized calcite particles (partly agglomerated), a large calcite particle and a small particle of a Zn-bearing hydrated hydroxy carbonate or sulphate (unk); UKH

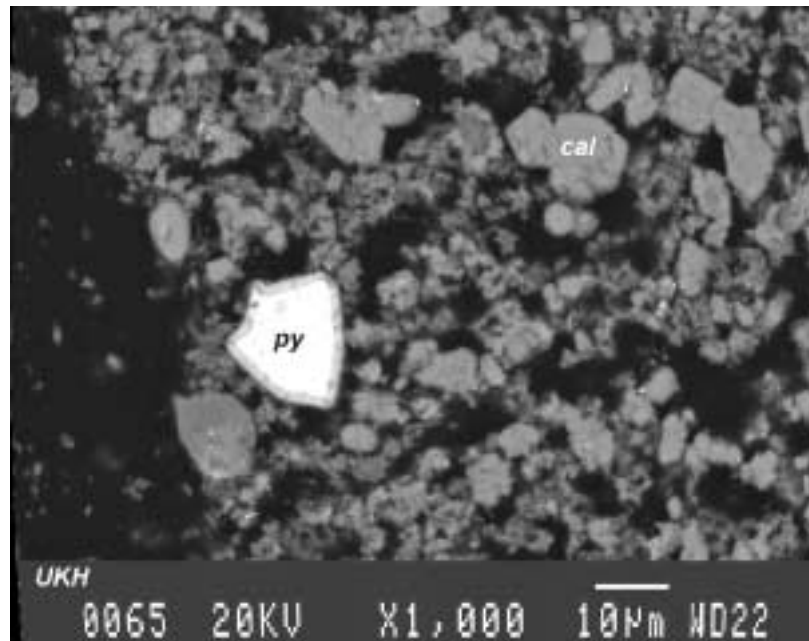


Figure 4: BEI that shows recrystallized calcite particles and a pyrite grain showing a goethite-like rim; UKH

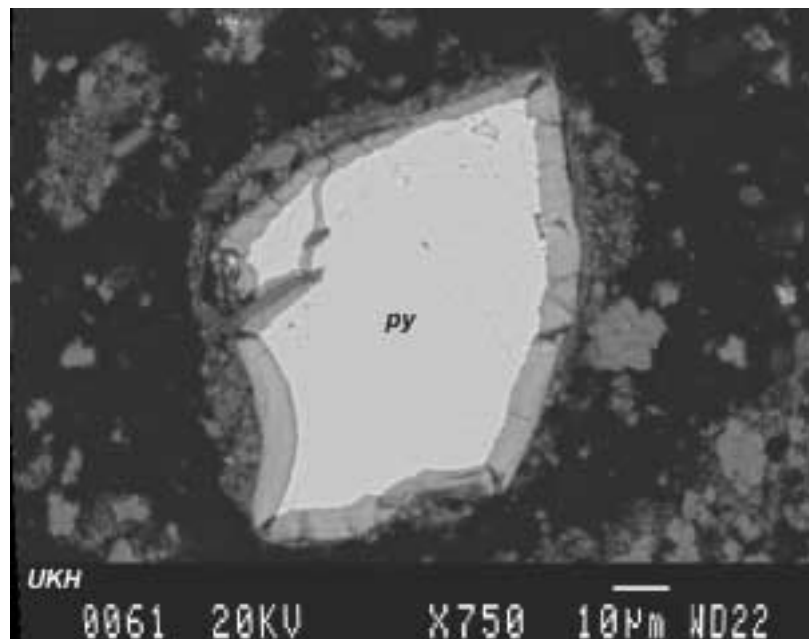


Figure 5: BEI that shows a larger pyrite particle with a goethite-like rim; UKH

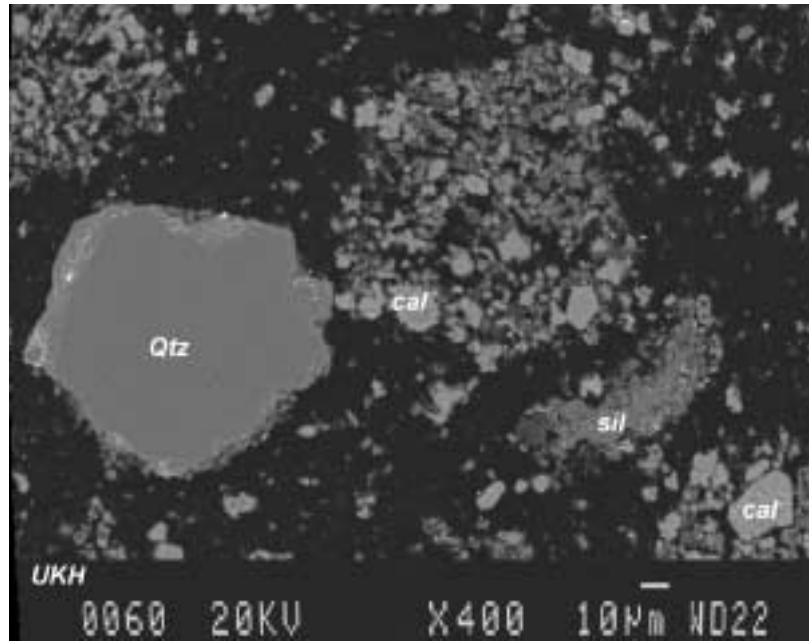


Figure 6: BEI that shows large particles of silicates (quartz, and chlorite (sil)) surrounded by partly agglomerated calcite particles; UKH

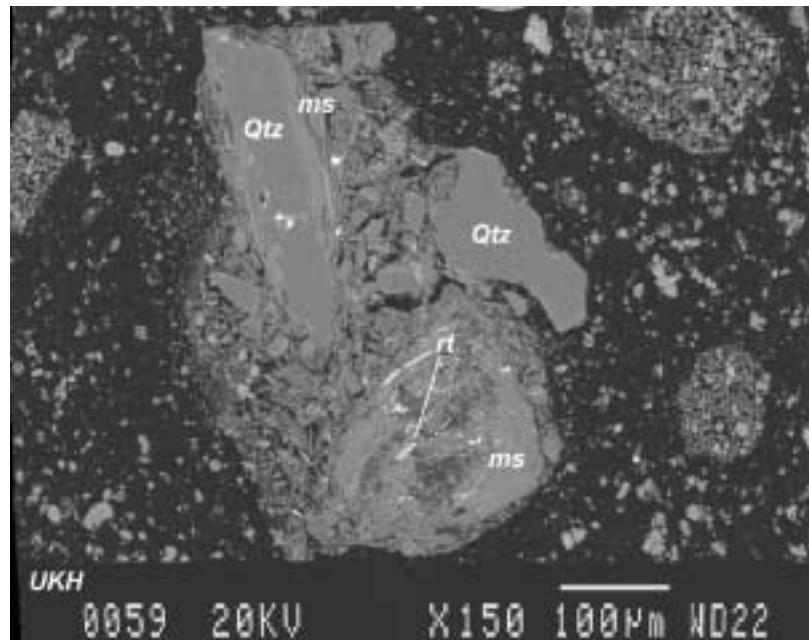


Figure 7: BEI that shows a complex multiminerale particle of quartz (qtz), muscovite (ms) and rutile (rt) surrounded by fine-grained calcite; UKH

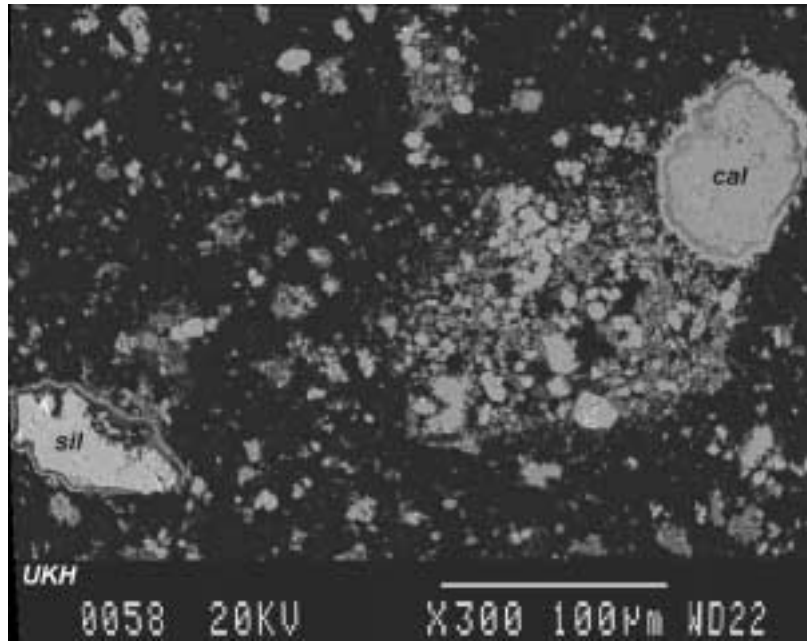


Figure 8: BEI that shows larger particles of calcite and amphibole (sil) with finer-grained calcite particles (partly agglomerated); UKH

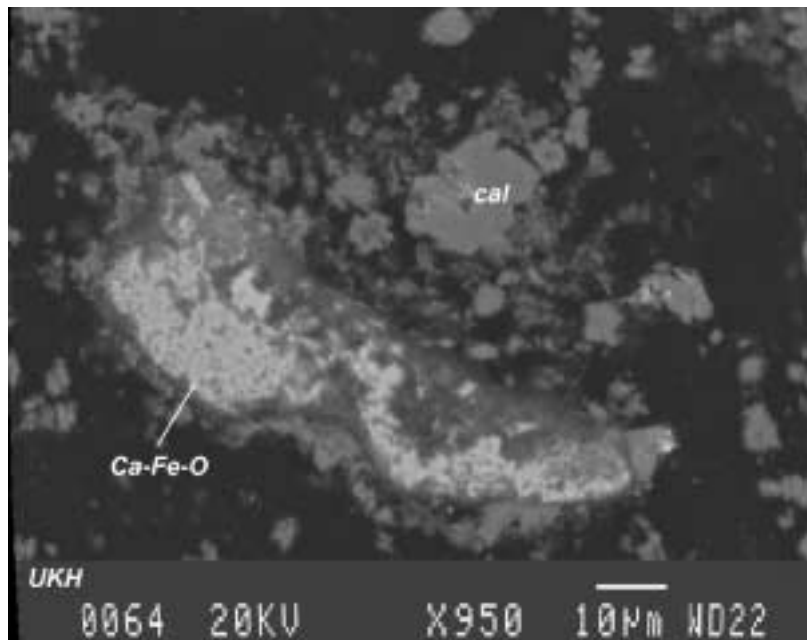


Figure 9: BEI that shows a Ca-Fe oxide particle partly rimmed and surrounded by recrystallized calcite; UKH

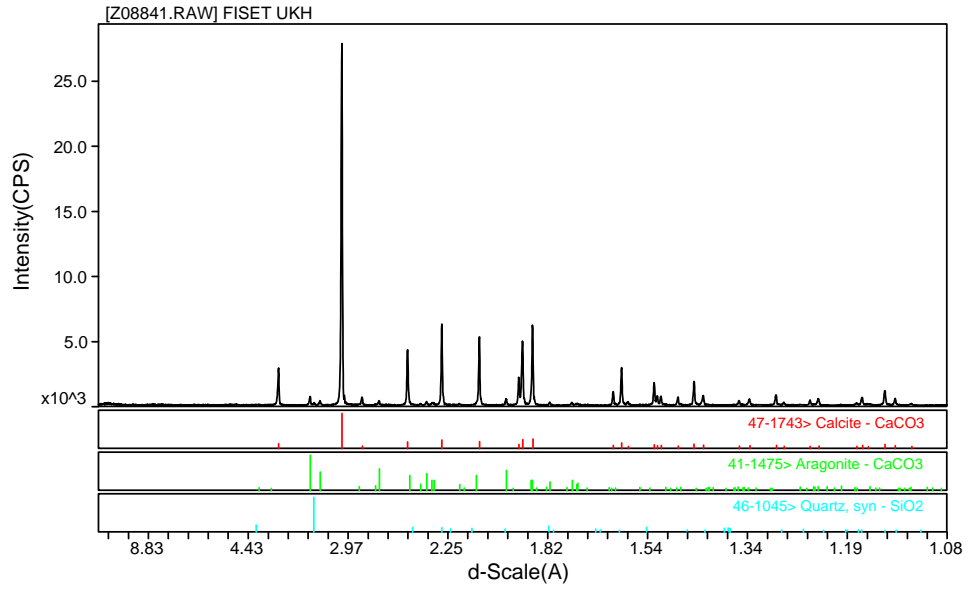


Figure 10: XRD pattern of UKH sludge

3.1.2 Faro Sludge (Faro)

The fresh sludge was collected directly at the mill. The particle size distribution showed a bimodal distribution with two peaks centered at 0.34 and 8.8 μm . The paste pH and Eh values of 8.81 and 279 mV were measured.

The chemical composition of the sludge was relatively similar to the UKH sludge with the exception of the zinc content. The sludge content was high in calcium, carbonate and low in iron with values respectively of 32%, 49% and 0.1%. The zinc content was relatively high with a value of 4.5%. Calcium carbonate in the form of aragonite was the major constituent of the sludge. The high amount of carbonate was also reflected in the neutralization potential which was very high with a value of 849 kg CaCO_3 equiv/tonne of material.

The modal analysis done by X-ray diffraction (XRD) technique using the Rievelde method revealed that the crystalline phases within the sample consisted of aragonite (99.1 wt. %), with a trace of calcite. The examination of the sample by optical microscopy in reflected light, showed that it consisted of fine-grained (< 2 to 15 μm) agglomerated particles (Figures 11,12,14 and 15) identified by SEM-EDS as mainly a calcium carbonate. Present in trace amounts, was a Zn-bearing hydrated hydroxy-carbonate phase containing Si, Mg, Ca, and Mn (Figure 13) which showed the same morphology as the major Ca carbonate (Figures 11 and 12). Numerous small particles of sphalerite were also found, often as a part of the fine-grained agglomerated particles (Figures 12 and 14), sometimes showing a rim of calcite (Figures 15 and 16). Numerous large particles of calcite (Figures 17 and 18), quartz (Figure 19), Ca-Na-Al silicates (feldspars) as well as chlorite were observed. A few small particles of Fe oxide were also present.

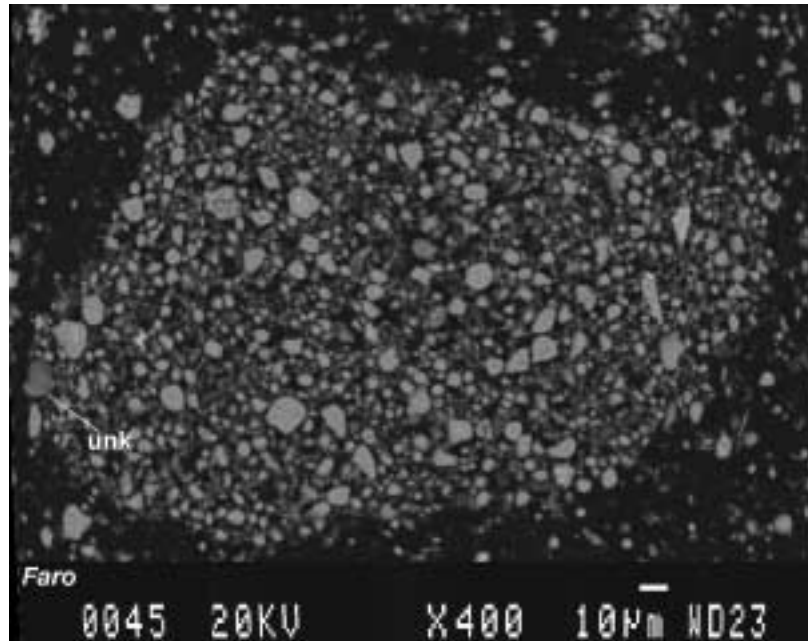


Figure 11: Backscattered electron image (BEI) that shows fine-grained agglomerated Ca carbonate with a trace amount of Zn-bearing hydrated hydroxy carbonate, slightly darker grey (unk); Faro

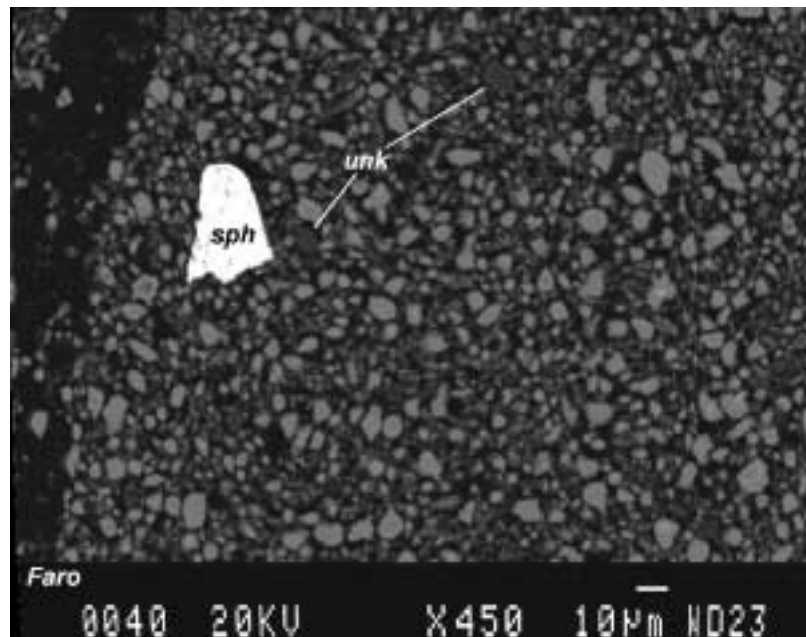


Figure 12: BEI that shows fine-grained agglomerated Ca carbonate particles with a trace amount of Zn-bearing hydrated hydroxy carbonate, darker grey (unk), and a larger sphalerite particle (sph); Faro

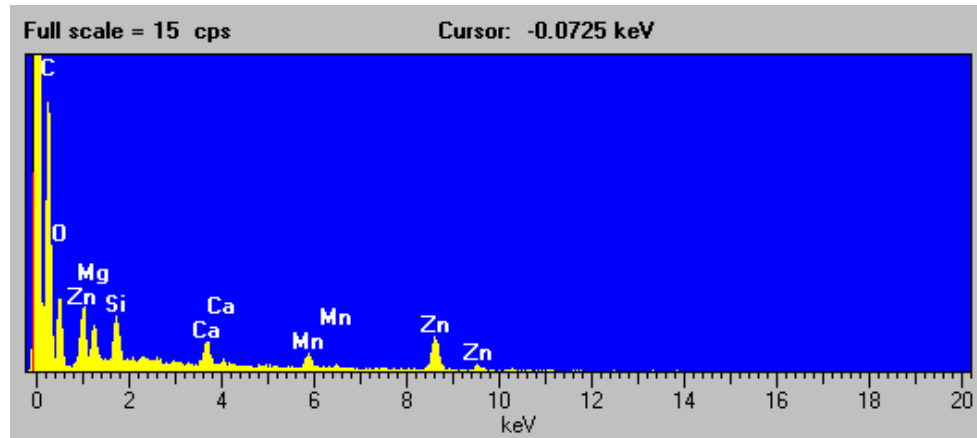


Figure 13: Energy dispersive spectrum (EDS) of the undefined Zn-bearing hydrated hydroxy carbonate phase which contains Si, Mg, Ca and Mn; Faro

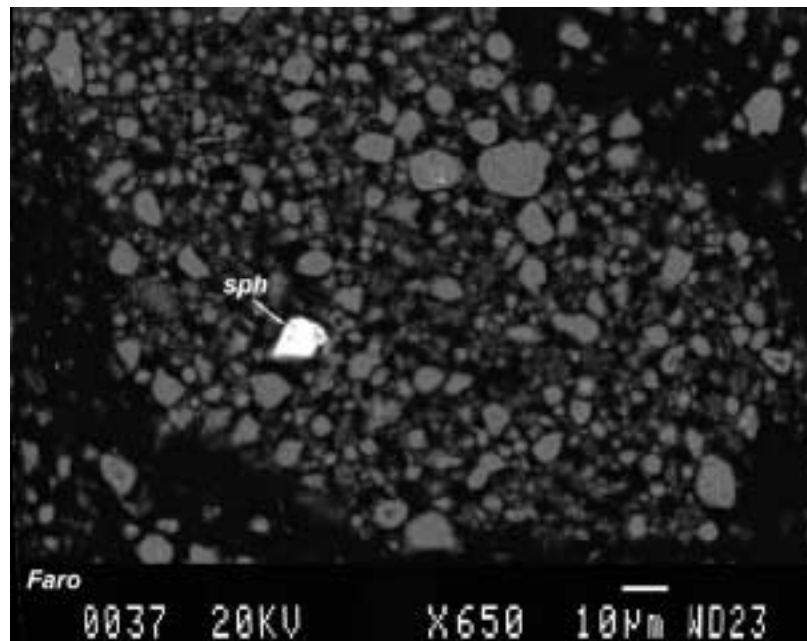


Figure 14: BEI that shows fine-grained agglomerated Ca carbonate particles together with a small sphalerite particle (sph); Faro

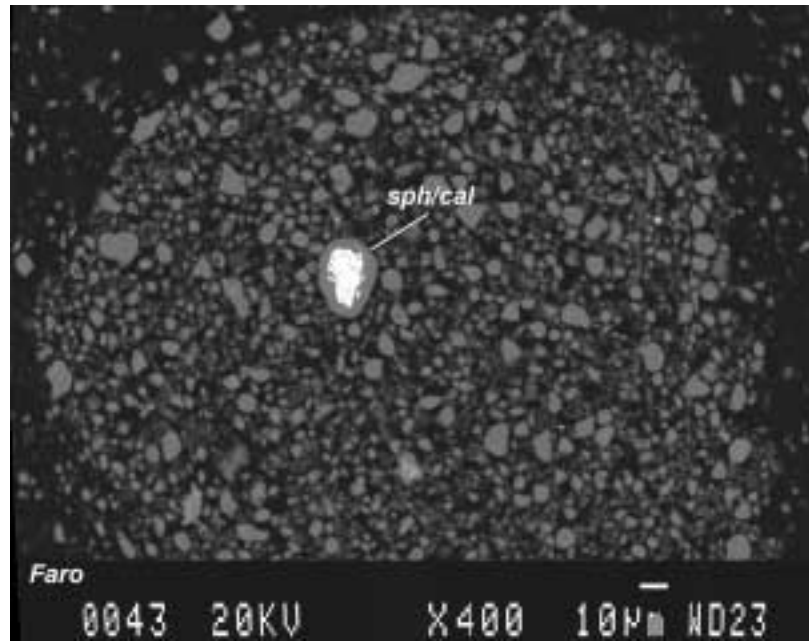


Figure 15: BEI that shows fine-grained agglomerated Ca carbonate particles with a small spherulite particle (sph) rimmed by a Ca carbonate; Faro

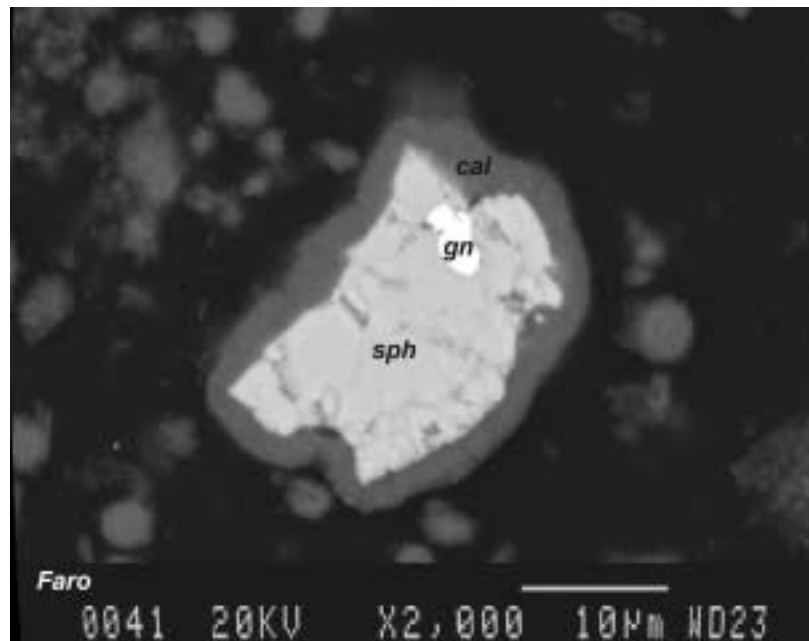


Figure 16: BEI that shows a spherulite (sph) particle with a small encapsulated grain of galena (gn) and rimmed by a Ca carbonate (possibly calcite); Faro

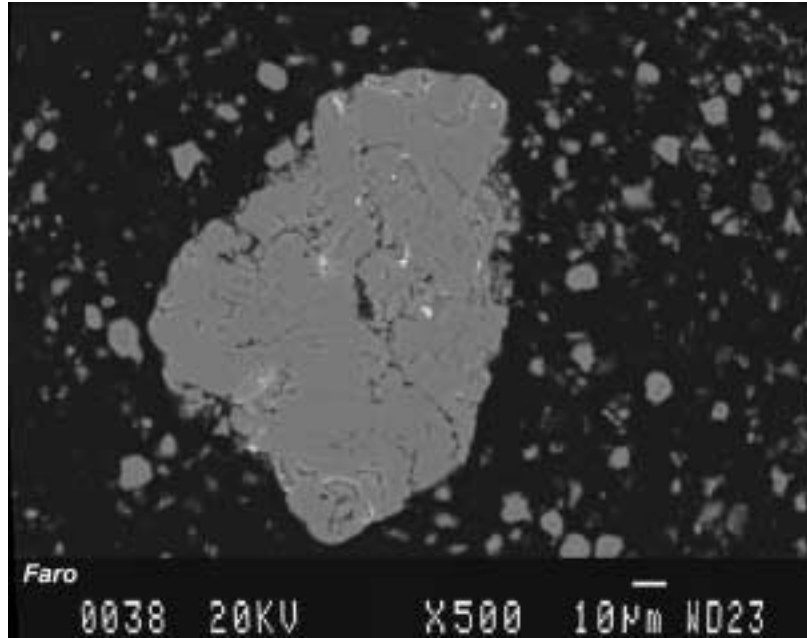


Figure 17: BEI that shows a large particle of calcite, with smaller particles of possibly aragonite; Faro

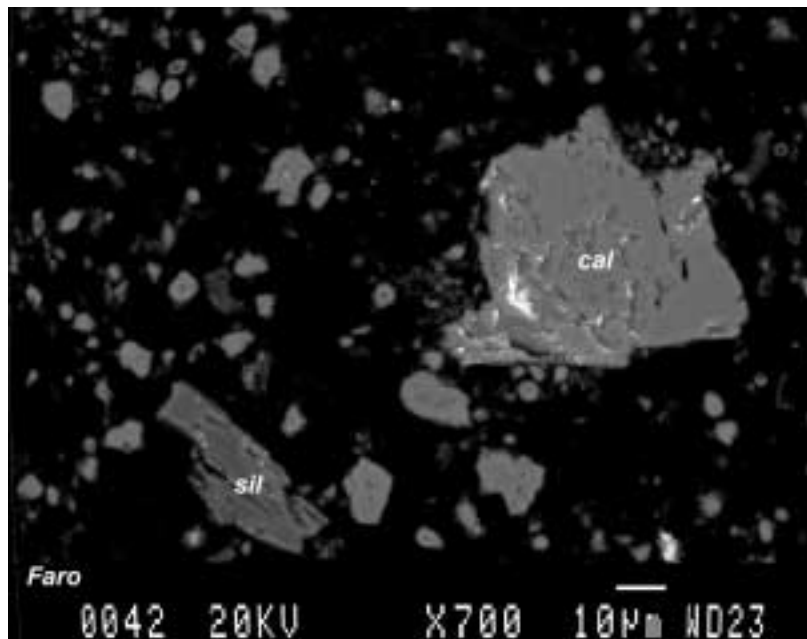


Figure 18: BEI that shows large particles of calcite (cal) and silicate (sil), with smaller particles of possibly aragonite; Faro

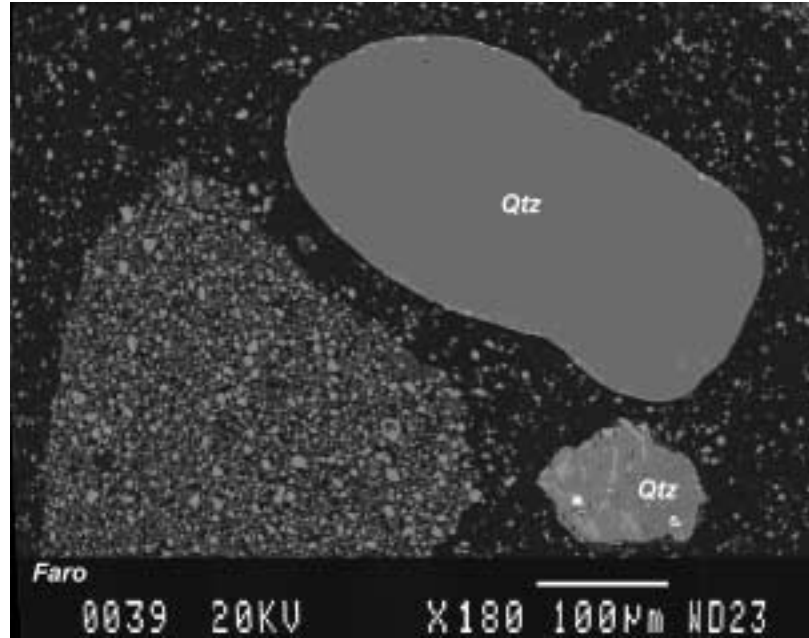


Figure 19: BEI that shows fine-grained aragonite with large particles of quartz (Qtz), the smaller quartz particle also showing minor chlorite (lighter grey) and Fe oxide (white) associated; Faro

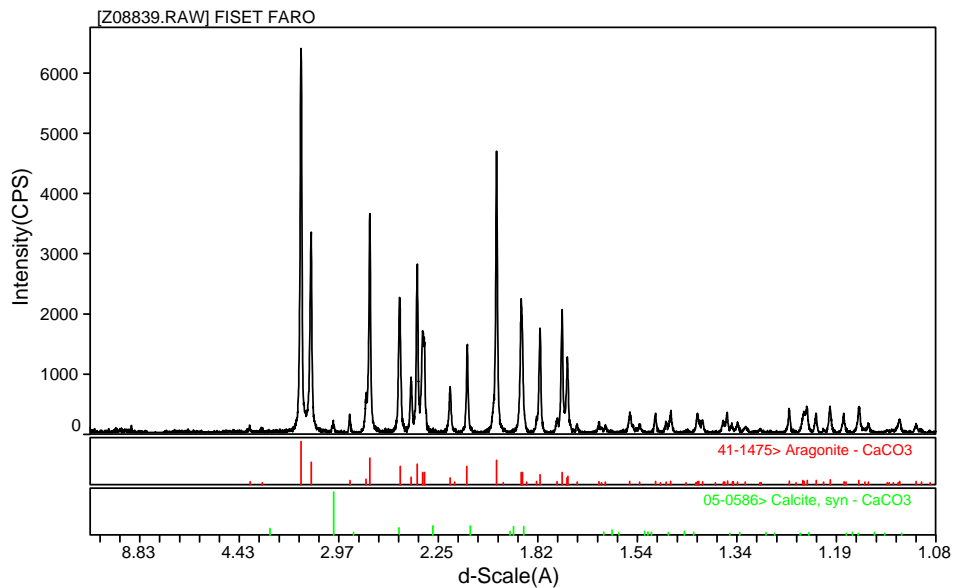


Figure 20: XRD pattern of the Faro sludge

Calcium and carbonate were the major components of the sludge. The calcium in the sludge varied from 32% (Faro) to 37% (UKH). Calcium was present mainly as calcite/aragonite, gypsum was not present at a significant level. For both sludges, the molar ratio of Ca:CO₃ approaches unity. The high neutralization potential and the sludge paste pH measured in this study correlate strongly with carbonate values in the sludge.

As mentioned previously, the origin of the calcite remained unclear. Several theories have been postulated (MEND 3.42.2, 1997) with respect to the calcite source, including: carbonation as a result of aeration (Aubé, 1997; Zinck and Aubé, 2000), the presence of unburnt lime in the quick lime (Bisceglia, 1966) or the presence of carbonate from the use of soda ash in the process stream. Based on mineralogical results, the most probable origin of the carbonate at the Faro and UKH mine sites would be from the lime quality used to precipitate out the metals and presence of carbonate in their process stream.

The mineralogical results revealed evidence that minor amounts of calcium carbonate is from primary precipitation during lime addition. A rim of calcite was observed around Ca-Fe and Mn oxide (Figures 9 and 26). Similar rims of calcium carbonate was observed from the Faro sludge samples around particles of sphalerite, galena and pyrite (Figures 15, 16, 31 and 32). The source of the carbonate is probably from the atmospheric adsorption of the CO₂ in the mine water resulting in calcium carbonate precipitate around particles and from carbonate in their process stream. Larger particles of calcium carbonate were also identified for UKH sludge sample (Figure 8) and Faro sludge (Figures 18 and 19) which appear to be from the lime used to precipitate the metals.

No lime samples were collected for characterization during the first sampling campaign in 2001. However, lime samples were collected during the second field trip in 2002. The lime used at UKH mine site to produce their sludge was composed of Ca(OH)₂ (36.1 wt.%), calcite (46 wt.%), aragonite (12.3 wt.%) and quartz (5.6 wt.%). The lime used at the Faro mine site was quite different with 85.8 wt.% of Ca(OH)₂, 2.1 wt.% of calcite and 12.1 wt.% of CaO. Details of the lime characterization are presented in Appendix B. No direct conclusion could be done from the lime and the sludge composition because they were not sampled at the same period. Between the time period, the lime composition may have changed. However, the lime characterization

showed that calcium carbonate was present in the lime and could be used as an indicator to explain the origin of some of the carbonate.

The sludge characterization showed that lime quality and addition required further investigation and the process could also be optimized. Several treatment parameters significantly impact on operating costs, effluent quality, sludge type and the required pH for precipitation (Zinck and Aubé, 2000). The lime slaking, lime slurry feeding, pH control, lime consumption, sludge settleability, leachability and the operating costs need to be evaluated and optimized for each site. The neutralization potential (NP) is very high, one of the highest reported in the literature (MEND 3.42.2, 1997). The neutralization potential measured was 911 and 849 kg CaCO₃ equiv/tonnes respectively for United Keno Hill and Faro sludges. Overdosing of lime, ineffective slaking practices, insufficient mixing and poor pH control usually lead to high NP values. High amounts of calcite/aragonite were also reported in the sludge which could lead to excessive treatment costs. Zinck and Aubé (2000) estimated that it costs \$56 for every tonne of calcite produced in the sludge.

3.2 Freeze-Thaw Study

3.2.1 Field Freeze-thaw Study

The field freeze-thaw task consisted of perforated cell units installed in the ground in triplicate for which sludge samples were placed to evaluate in the freeze-thaw mechanism on the sludge densification. After one winter, the percent solids of UKH sludge increased from approximately 23% to 60%. The percent solids of the Faro sludge also increased after one winter from 28% to 58%. Table 3 presents the initial percent solid for the UKH and for Faro sludge as well as the percent solids after one winter.

The ability of the Faro and UKH sludges to dewater was different to most AMD sludge that contain iron hydroxide and gypsum as major constituents. The iron particles are surrounded by an envelope of bond water and hydroxyl ions are absorbed by the particle creating an electric double layer (Bosman, 1974). The metal hydroxide particle is surrounded by water molecules, to which hydroxyl ions are attracted, creating an electric double layer, as illustrated in Figure 20a.

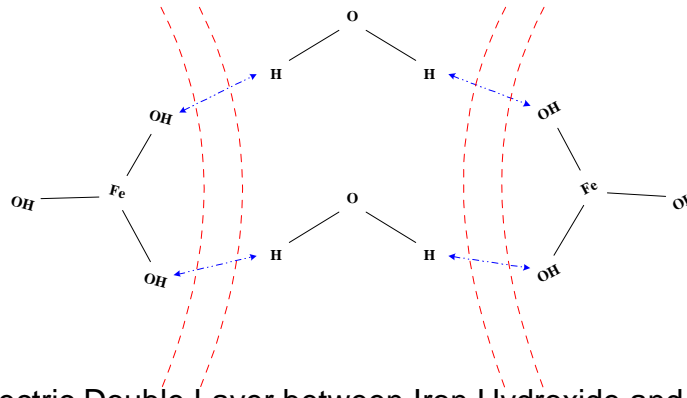


Figure 20a: Electric Double Layer between Iron Hydroxide and Water Molecules

The main reasons for which sludge are voluminous are the particle repulsion, bounded water and a rapid hydrolysis (Laitinen, 1960, Moser, 1929). The percent solids measured in this study were particularly high compared to typical AMD sludge but they could be explained by the chemical composition of the sludge; minor amounts of iron was present. Consequently, it was much more easier to dewater the sludge because of low levels of iron hydroxide in the sludge.

Table 3 - Effect of freeze-thaw on percent solids (field)

Sample	Initial percent solids %	Percent solids after one winter %	Degree of densification %
UKH-4	23.0	59.7	160
UKH-5	14.8	51.5	248
UKH-6	20.1	60.9	203
Faro-7	26.9	56.3	109
Faro-8	28.2	58.0	106
Faro-9	28.6	55.2	93

3.2.2 Laboratory Freeze-thaw Study

For the laboratory freeze-thaw study, a total of six columns were commissioned; the Faro and the UKH columns in duplicate were subjected to four freeze-thaw cycles and two room temperature controls. Overall, there was no major difference in the solid concentration of dewatered sludge used for freeze-thaw tests compared to the room temperature control. Final results showed a slight increase in the percent solids for the UKH sludge after four cycles compared to the room temperature control. No significant increase in sludge density was measured for the Faro sludge after the four freeze-thaw cycles. Compared to the room column controls, the results were similar and the densification was mainly due to gravity dewatering rather than the freeze-thaw mechanism. Sludge solids content were also comparable to the results obtained from the field. Table 4 presents the percent solids after four cycles of the freeze thaw study.

The particle size distribution of the Faro and UKH sludges remained the same between each cycle of the laboratory study. No agglomeration or particle division has been observed. From a mineralogical point of view, the UKH sludge gave similar results to the initial sample, i.e., 93.8 wt.% calcite and 6.2 wt.% aragonite. No phase changes were observed during the laboratory freeze-thaw study. Optical microscopy showed pretty much the same, with fine-grained agglomerated, often well recrystallized calcite particles (Figures 21 and 22), with trace amounts of a Zn-bearing hydrated hydroxy carbonate or sulphate phase containing Ca, Mg, Mn and Si (Figures 23 and 24).

A few pyrite particles were observed (Figure 22) as part of the fine-grained agglomerated particles of calcite. As in the previous sample, the pyrite showed a goethite-like rim. Much larger particles of calcite, quartz (Figure 25) were also found. Trace amounts of rutile, and Ca-Fe and Mn oxides were also present.

The XRD analysis of the Faro sludge after the fourth freeze-thaw cycle gave identical results as the previous sample examined, i.e., aragonite as the major constituent (99.1 wt%) and trace amount of calcite (0.9 wt%). The examination by optical microscopy also revealed that this sample was not really different mineralogically relative to the previous sample. It consisted mainly of fine-grained particles of aragonite generally agglomerated (Figure 28), with trace amounts of a Zn-bearing hydrated hydroxy-carbonate phase which showed identical morphology/texture as the major Ca carbonate present. This phase often had a slightly darker grey level in the

backscattered electron mode, as shown in Figures 29 and 30, which is related to the composition. Trace amounts of sphalerite and pyrite were present. Figure 31 showed a multiminerale particle that consisted of sphalerite associated with galena, pyrite and barite, with a rim of Ca carbonate (possibly calcite). Figure 32 showed a particle of pyrite with a rim of calcite, whereas Figure 33 showed agglomerated fine-grained aragonite particles with small particles of chalcopryrite and a Ca-Fe oxide. Numerous large particles of calcite were observed (Figure 34), but also of quartz, feldspars and chlorite (Figure 35).

Table 4 - Freeze-thaw effect vs percent solids (laboratory)

Initial percent solids*	UKH-1 (%)	UKH-2 (%)	UKH-control (%)	Faro-1 (%)	Faro-2 (%)	Faro-control (%)
	41.6	41.6	41.0	45.5	44.6	44.7
After cycle 1	53.8	54.2	49.2	49.6	49.7	49.1
After cycle 2	55.4	57.1	52.4	48.5	48.6	52.7
After cycle 3	57.0	59.2	53.4	48.5	48.8	53.2
After cycle 4	57.3	57.4	56.5	48.6	48.4	55.3

*: after gravity dewatering

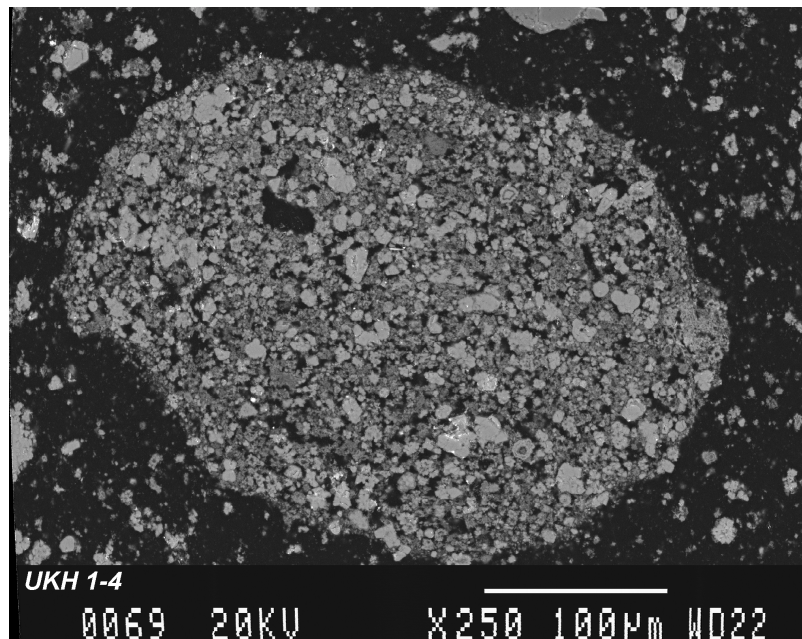


Figure 21: BEI that shows a typical agglomeration of fine-grained recrystallized calcite particles with minor to trace amounts of the undefined Zn-bearing hydrated hydroxy carbonate or sulphate (generally darker grey than calcite); UKH1-4

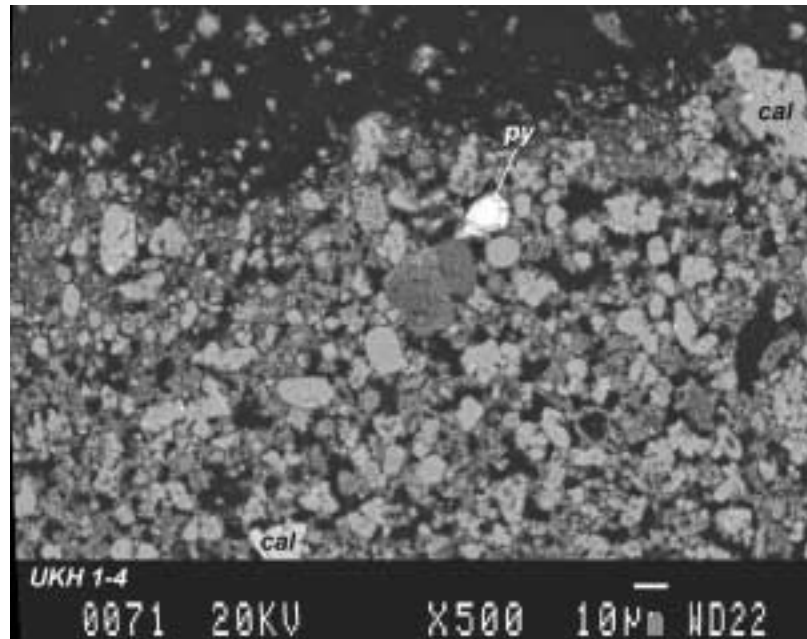


Figure 22: BEI that shows agglomerated fine-grained recrystallized calcite particles with minor to trace amounts of the Zn-bearing hydrated hydroxy carbonate or sulphate phase (generally darker grey than calcite), and a small pyrite grain showing a goethite-like rim; UKH1-4

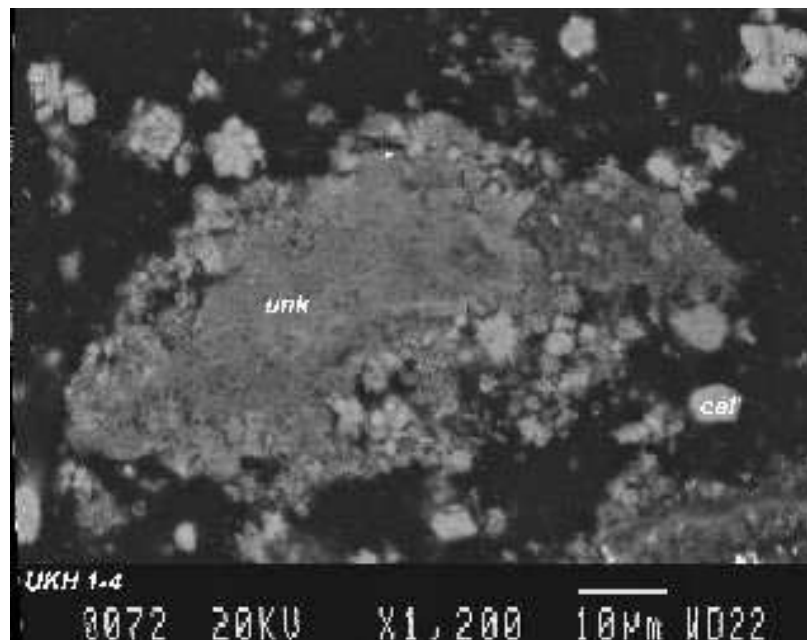


Figure 23: BEI that shows a particle of the Zn-bearing hydrated hydroxy carbonate or sulphate phase (unk, generally darker grey than calcite), surrounded by fine-grained recrystallized calcite; UKH1-4

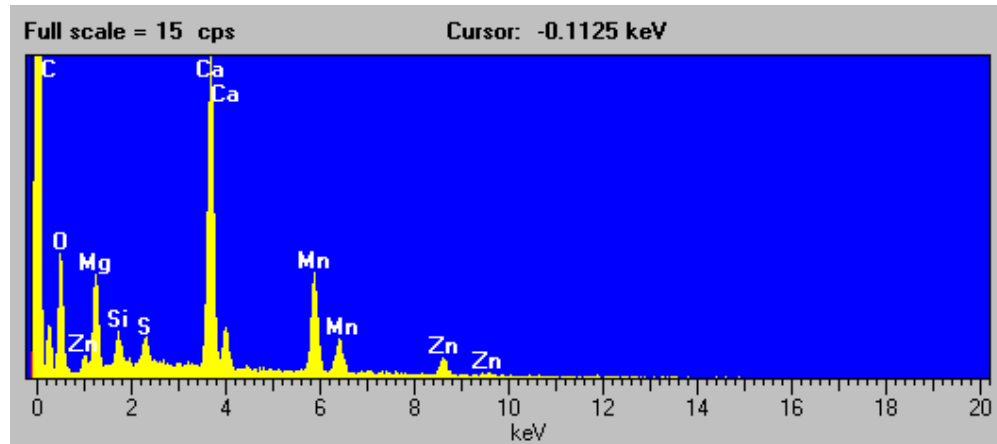


Figure 24: Energy dispersive spectrum (EDS) of the undefined Zn-bearing hydrated hydroxy carbonate or sulphate phase which contains major Ca, minor Mn and Mg and low Si, S and Zn; UKH1-4

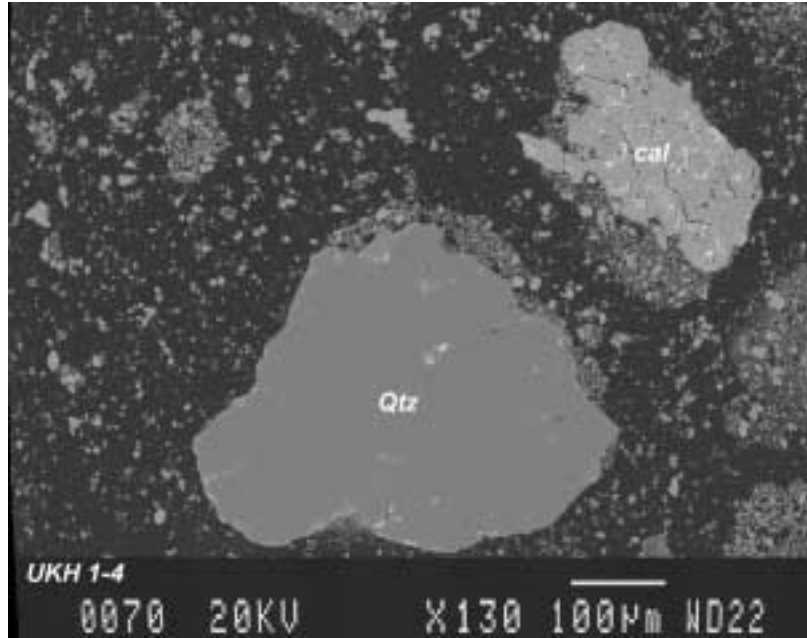


Figure 25: BEI that shows large particles of calcite and quartz surrounded by fine-grained calcite; UKH1-4

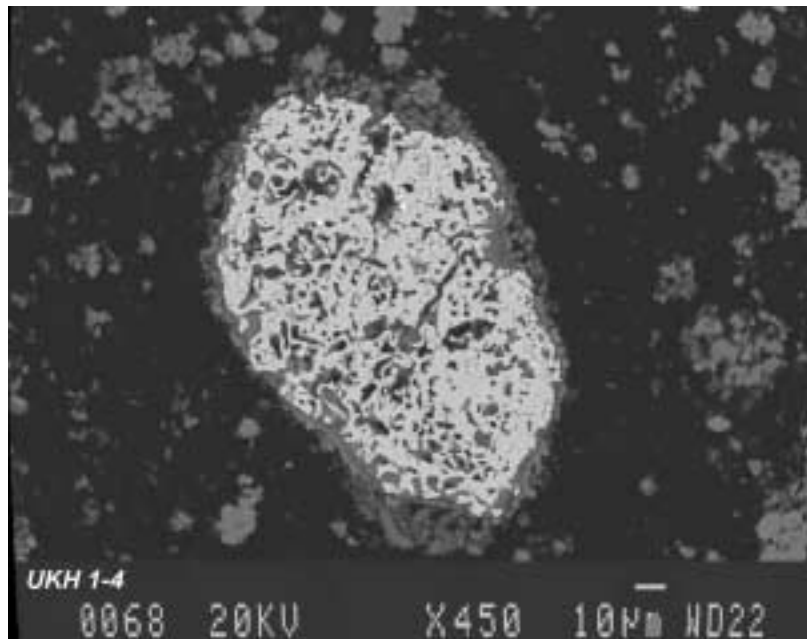


Figure 26: BEI that shows a Mn oxide particle rimmed by a Ca carbonate (possibly calcite); UKH1-4

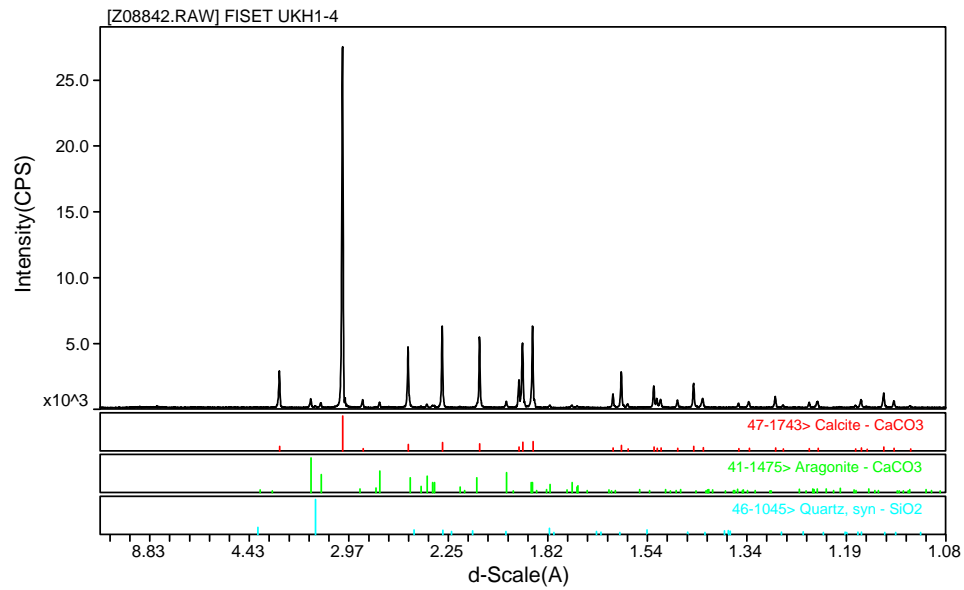


Figure 27: XRD pattern of the UKH sludge after the fourth freeze-thaw cycle

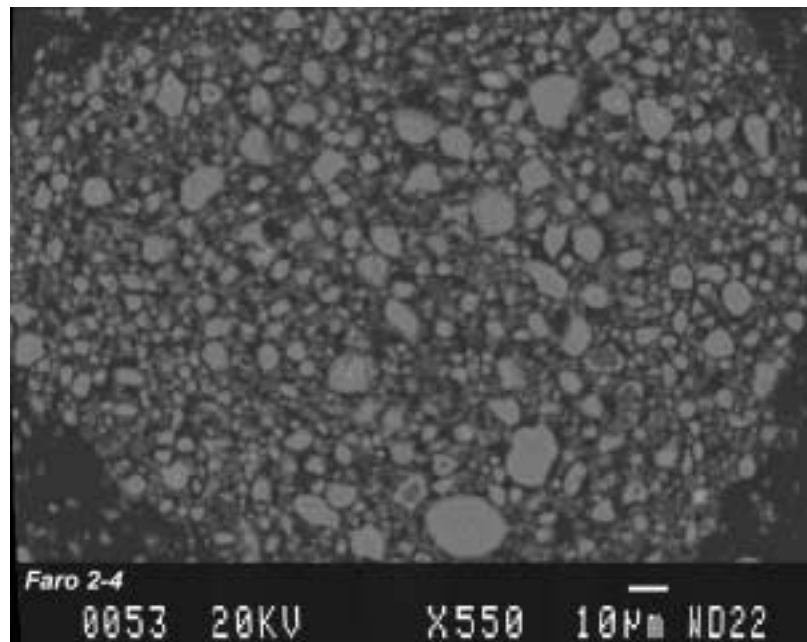


Figure 28: BEI that shows fine-grained aragonite particles agglomerated; Faro2-4

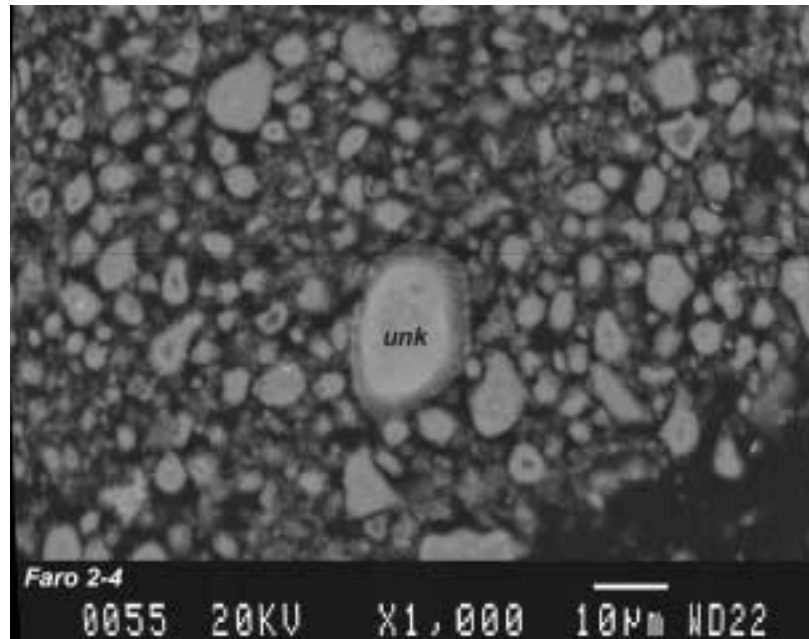


Figure 29: BEI that shows fine-grained agglomerated Ca carbonate particles with a slightly larger particle of a Zn-bearing hydrated hydroxy carbonate (unk); Faro2-4

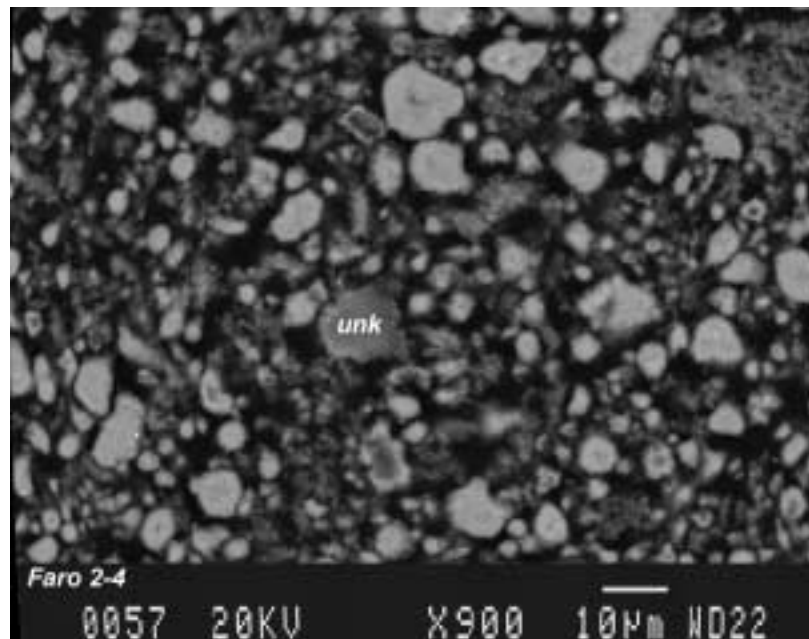


Figure 30: BEI that shows a Zn-bearing hydrated hydroxy carbonate particle (unk), within agglomerated fine-grained aragonite particles; Faro2-4

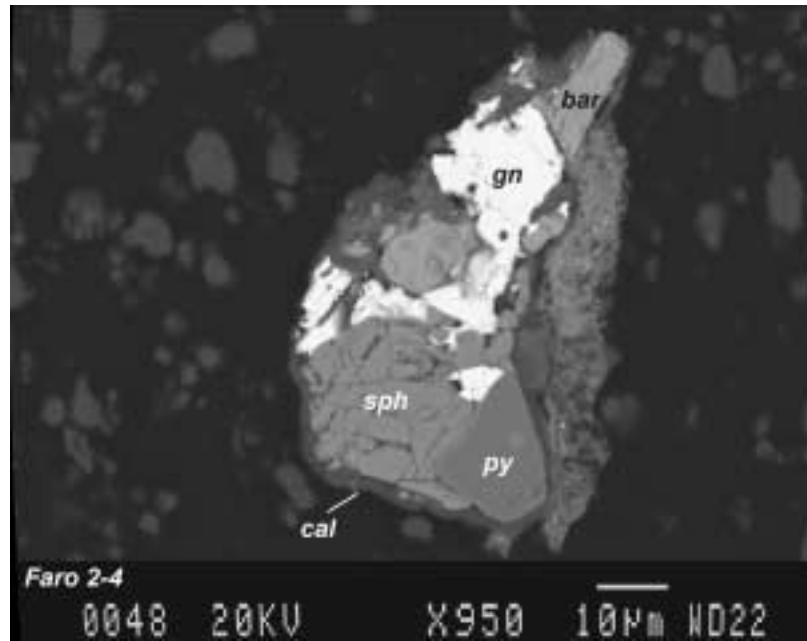


Figure 31: BEI that shows a complex multiminerale particle of sphalerite (sph)/pyrite (py)/galena (gn) and barite (bar), partly rimmed by possibly calcite, cal; Faro2-4

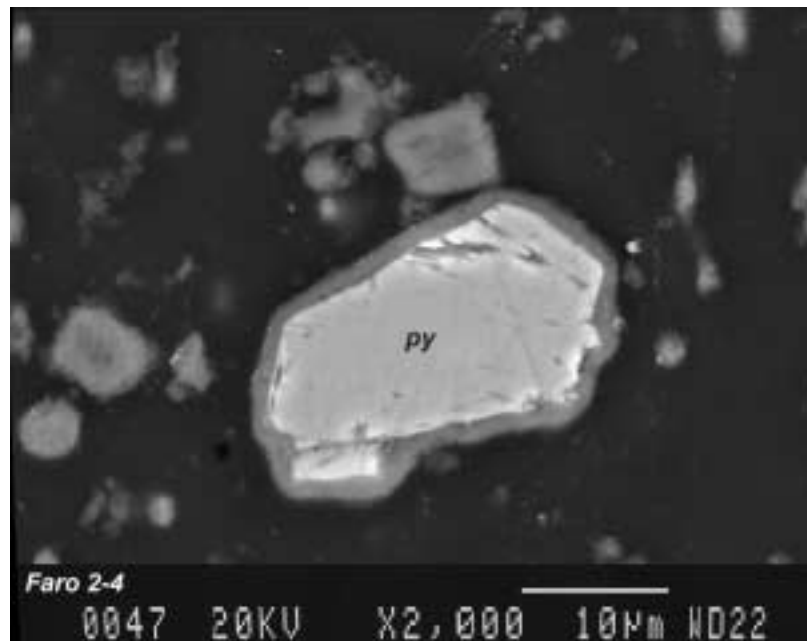


Figure 32: BEI that shows pyrite (py), rimmed by a Ca carbonate (possibly calcite); Faro2-4

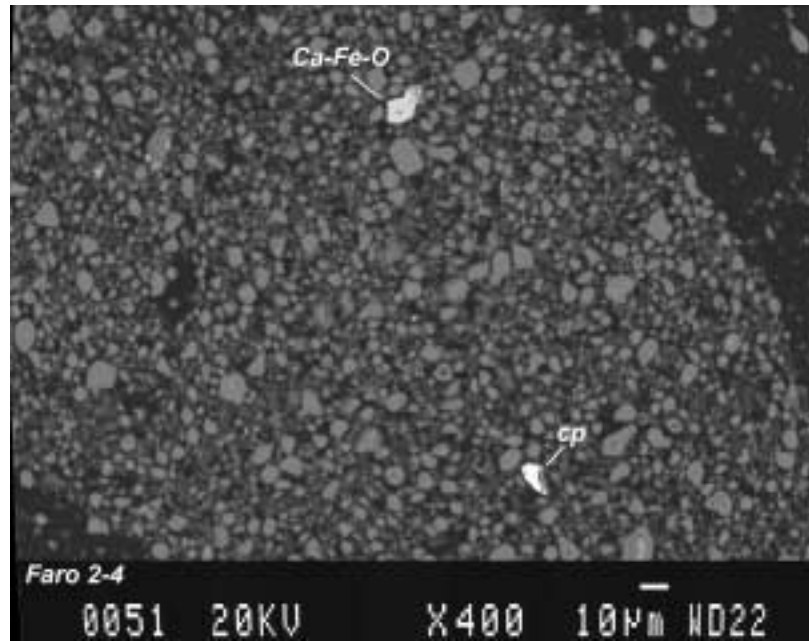


Figure 33: BEI that shows fine-grained aragonite particles, with small grains of a Ca-Fe oxide and chalcopyrite (cp); Faro2-4

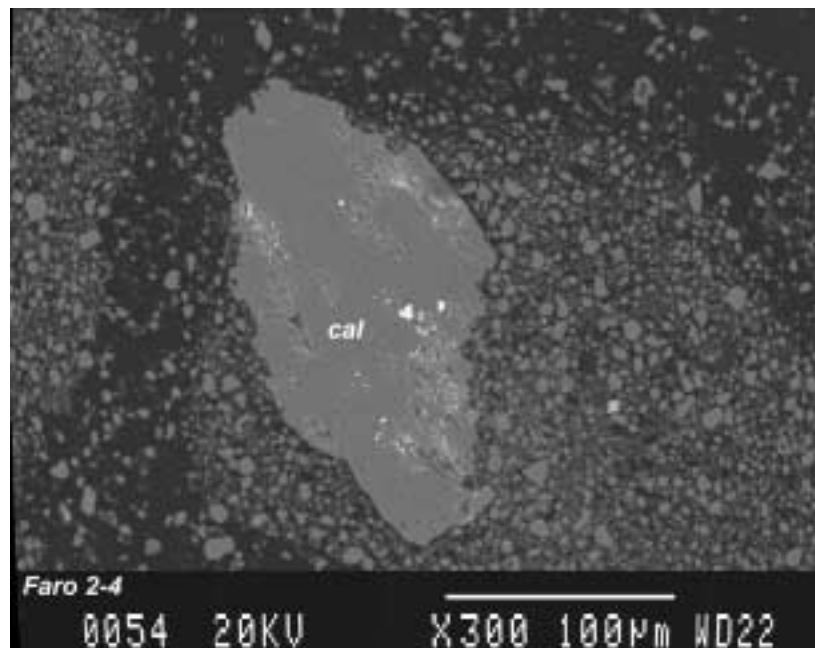


Figure 34: BEI that shows a large particle of calcite, surrounded by fine-grained aragonite particles; Faro2-4

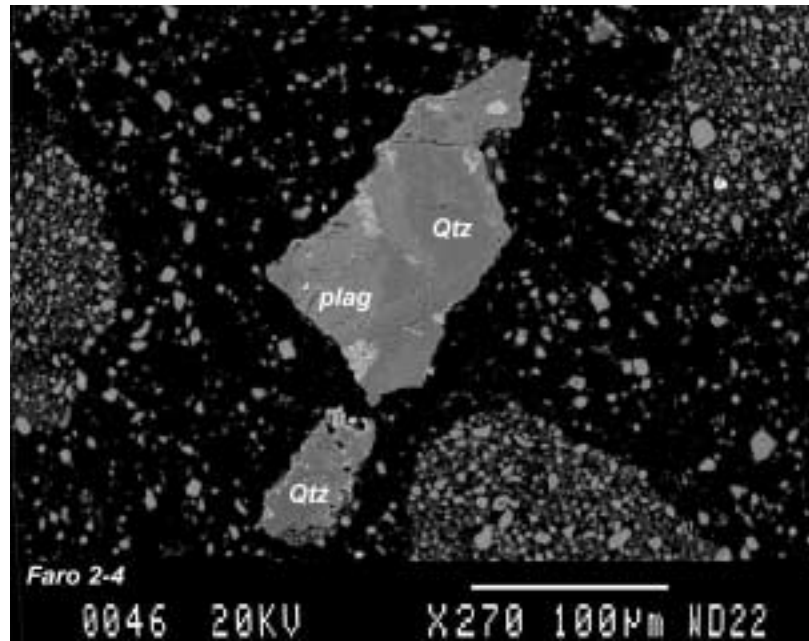


Figure 35: BEI that shows large particles of silicates (quartz, plagioclase and chlorite (lighter grey) surrounded by fine-grained aragonite particles; Faro2-4

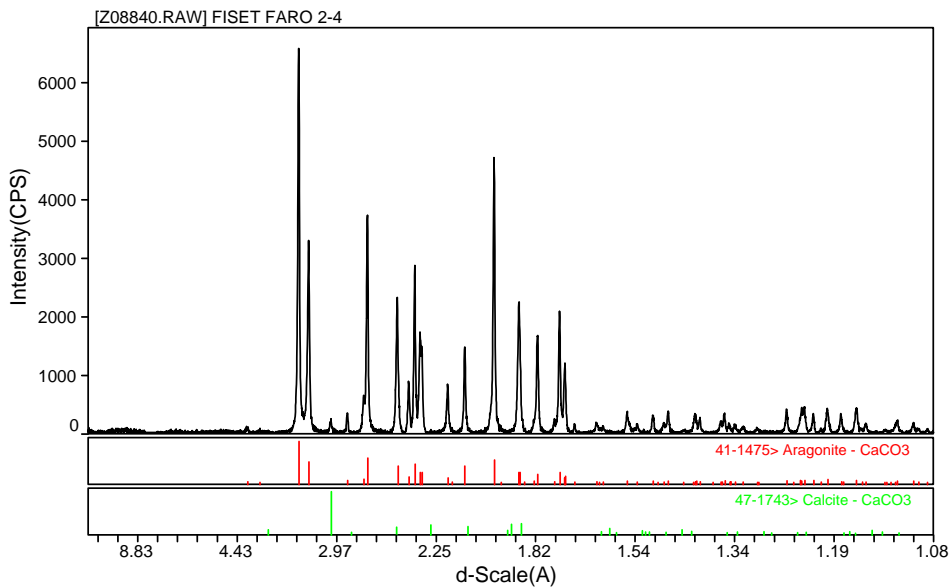


Figure 36: XRD pattern of the Faro sludge after the fourth cycle

3.3 Sludge Chemical Stability

This section presents results of the sludge column leachability conducted using column leaching and batch tests. Appendix C contains all the tables regarding the metal concentrations measured during the leaching study.

3.3.1 UKH Column Leaching Study

The pH of the leachate of the UKH sludge subjected to the freeze-thaw slightly decreased from around 11.4 to 10.6 over the leaching period. The room temperature control column showed a significant decrease of the pH from around 11.2 to 8.0. The redox potential remains relatively constant with values around 200 mV and the conductivity measurement decreased slightly over the leaching results.

The metal concentrations leached were typically close to the limit of quantification of the method for As, Cd, Cu, Mn and Zn. The aluminum concentration was higher at the beginning of the study with values around 0.3 mg/L decreasing during the leaching study to values typically below 0.001 mg/L. The sulphate and calcium concentrations decreased over time which is in accordance with the decreased of the conductivity results. Under the column leaching conditions, the UKH sludge appeared to be chemically stable at least in the short term.

3.3.2 Faro column leaching study

The pH of the leachate from the Faro column was lower compared to the UKH but it was in accordance with the sludge paste pH. The pH remained relatively constant at around 9.0 for the Faro-1,2 and the room temperature column. The redox potential fluctuated from 200 to 400 mV and the conductivity was relatively constant at 1.17 mS.

As indicated in Tables C-4 and C-5 (Appendix C), the metal concentrations measured in the leachate were particularly low for Al, As, Cd, Cu, Zn and Fe. The sulphate concentrations remained relatively constant over the column leaching period.

3.3.3 Batch Leaching Test

The TCLP leachate test uses an acetic acid solution as a leachant while the SPLP test substitutes a nitric and sulfuric acid mixture for the acetic acid to simulate acidic rain. A leaching test using mineral acid would be more representative of the kinds of acid that would accompany acidic precipitation. Table 5 presents batch leachability (TCLP, SPLP and water) results for both sludges. The amount of zinc and nickel released during the TCLP test was quite high with values respectively of 264 mg/L and 3.8 mg/L for the Faro sludge. The UKH sludge also showed high zinc and nickel mobility with values of 17 mg/L of Zn and 3.1 mg/L of Ni. The SPLP method revealed lower metal mobility for Zn and Ni which were in the mg/L range.

The batch tests (TCLP) revealed that zinc and nickel would be released to significant levels. The SPLP test uses an unbuffered acidic leachant and did not significantly increase metal mobility. The results of the SPLP were similar to the results with water alone and with the results from the leaching study. Compared to the SPLP and the column leaching study, the TCLP is a much more aggressive test such as the acetic acid has a buffering capacity and the SPLP had a slight acidity. As a result, the final pH of the acetic acid test is much lower thereby mobilizing more metal.

Table 5 - Chemical leachability of the Faro and UKH sludges

Parameter	Faro (µg/L)			UKH (µg/L)		
	TCLP	SPLP	Water	TCLP	SPLP	Water
As	3.85	< 0.48	< 0.48	0.69	< 0.48	< 0.48
Al	117	< 5	< 4.4	125	8	8
Ca	1 439 000	561 000	554 000	1 729 000	129 100	134 600
Cd	65.2	< 0.09	< 0.09	0.29	< 0.09	< 0.09
Fe	< 21	< 21	< 21	< 21	< 21	< 21
Ni	3827	1.88	2.11	3097	< 0.98	< 0.98
Pb	< 0.16	< 0.16	< 0.16	< 0.16	< 0.16	< 0.16
Zn	264 400	2.6	< 0.5	17 480	< 0.5	< 0.5
Final pH	6.50	8.85	8.90	6.03	8.90	8.95

The SPLP and water leachate results are more representative and indicate chemical stability in the short to medium term. As long as the buffering capacity of the sludge is not depleted, metal leachability should not be a concern.

4.0 CONCLUSIONS

1. The United Keno Hill as well as the Faro sludges are mainly composed of calcium carbonate.
2. The origin of the carbonate in the sludge appears to be related to high levels of carbonate in the effluent during lime treatment, resulting in calcium carbonate precipitation.
3. Heavy metals in the sludge would be stable for a long period as long as excess alkalinity is present.
4. Both mine sites have excellent potential for lime treatment optimization.
5. The percent solids during the study reached values near 60% for both sludges. The increase in solids content was mainly due to gravity dewatering rather than from the freeze-thaw effects.

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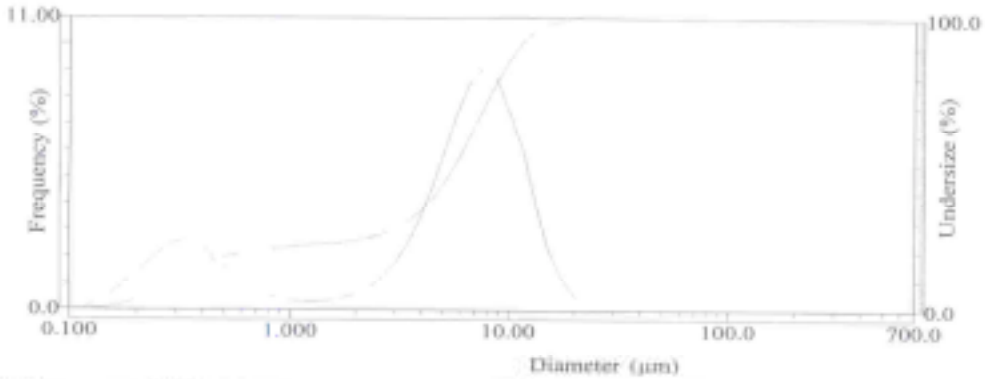
Zinck, J.M. and Aubé, B., 2000. Optimization of lime treatment processes. *CIM Bulletin*, 93 (1043), p. 98-105.

Zinck, J.M., Chen, T.T., Mikhail, S., Turcotte, A.M., Wilson, L. and Griffith, W.F. 1996, *Characterization and Stability of AMD Treatment Sludge*. MMSL Report 96-079(CR) for MEND.

APPENDIX A

Particle Size Distribution

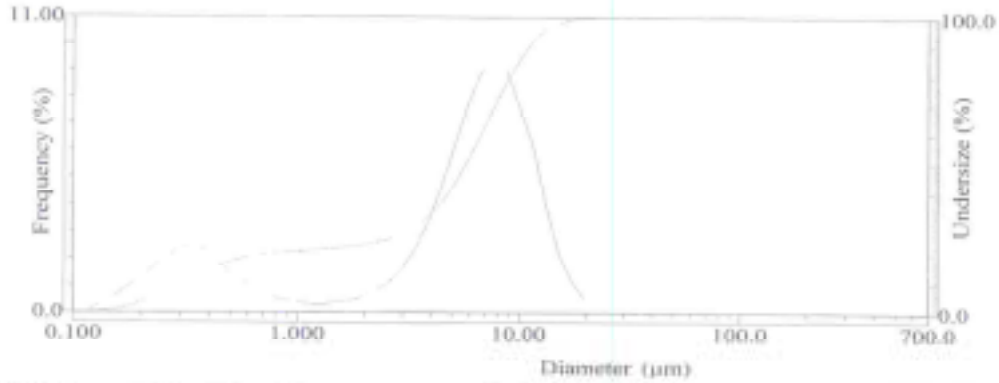
Faro RM Start



S.P. Area	: 53354(µm² /cm²)	:90.00 (%) = 11.166(µm)	:53.00 (µm) = 100.0
Median	: 5.711(µm)	:95.00 (%) = 12.961(µm)	:38.00 (µm) = 100.0
Diameter in %	:5.000 (%) = 0.226(µm)	% on Diameter	:850.0 (µm) = 100.000(%)
	:10.00 (%) = 0.299(µm)		:600.0 (µm) = 100.000(%)
	:20.00 (%) = 0.647(µm)		:425.0 (µm) = 100.000(%)
	:30.00 (%) = 3.425(µm)		:300.0 (µm) = 100.000(%)
	:40.00 (%) = 4.638(µm)		:212.0 (µm) = 100.000(%)
	:60.00 (%) = 6.703(µm)		:150.0 (µm) = 100.000(%)
	:70.00 (%) = 7.731(µm)		:106.0 (µm) = 100.000(%)
	:80.00 (%) = 9.140(µm)		:75.00 (µm) = 100.000(%)
		Mean	: 5.768(µm)
		Variance	: 17.140
		S.D.	: 4.140(µm)
		Mode	: 7.195(µm)
		Span	: 1.903

No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %
1	0.115	0.000	0.000	27	3.905	3.389	23.270	53	132.103	0.000	100.000
2	0.131	0.328	0.328	28	4.472	4.622	27.893	54	152.453	0.000	100.000
3	0.150	0.544	0.872	29	5.122	6.074	43.967	55	174.616	0.000	100.000
4	0.172	0.952	1.824	30	5.867	7.522	51.488	56	200.000	0.000	100.000
5	0.197	1.394	3.217	31	6.720	8.670	60.159	57	229.075	0.000	100.000
6	0.226	1.795	5.012	32	7.697	9.141	69.300	58	262.376	0.000	100.000
7	0.259	2.217	7.229	33	8.816	8.729	78.029	59	300.518	0.000	100.000
8	0.296	2.559	9.788	34	10.097	7.413	85.442	60	344.206	0.000	100.000
9	0.339	2.627	12.415	35	11.565	6.149	91.591	61	394.244	0.000	100.000
10	0.389	2.442	14.857	36	13.246	4.061	95.652	62	451.556	0.000	100.000
11	0.445	1.925	16.783	37	15.172	2.315	97.968	63	517.200	0.000	100.000
12	0.510	1.498	18.281	38	17.377	1.269	99.237	64	592.387	0.000	100.000
13	0.584	1.110	19.391	39	19.904	0.552	99.788				
14	0.669	0.802	20.193	40	22.797	0.212	100.000				
15	0.766	0.586	20.779	41	26.111	0.000	100.000				
16	0.877	0.432	21.231	42	29.907	0.000	100.000				
17	1.025	0.369	21.600	43	34.255	0.000	100.000				
18	1.191	0.338	21.938	44	39.234	0.000	100.000				
19	1.378	0.344	22.282	45	44.938	0.000	100.000				
20	1.570	0.384	22.666	46	51.471	0.000	100.000				
21	1.729	0.486	23.132	47	58.953	0.000	100.000				
22	1.981	0.610	23.742	48	67.523	0.000	100.000				
23	2.269	0.840	24.582	49	77.339	0.000	100.000				
24	2.599	1.188	25.769	50	88.585	0.000	100.000				
25	2.976	1.694	27.463	51	101.460	0.000	100.000				
26	3.409	2.419	29.881	52	116.210	0.000	100.000				

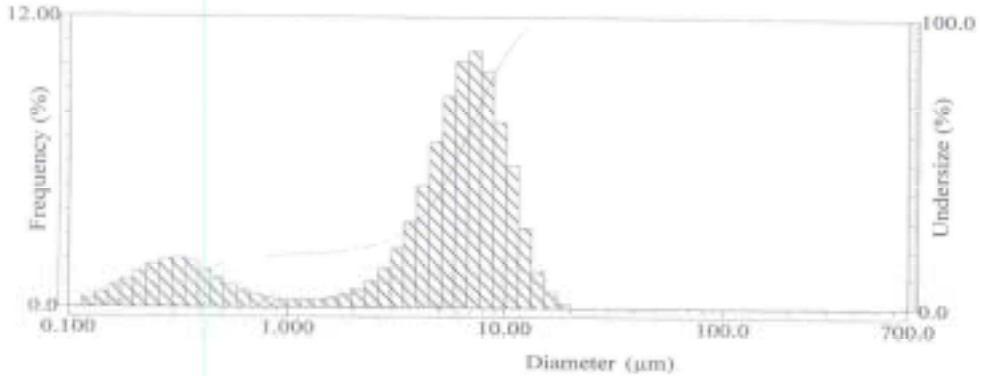
Faro RM Cycle 1



S.P. Area	: 51629(cm ² /cm ³)	:90.00 (%) = 11.082(µm)	:53.00 (µm) = 100.0
Median	: 3.782(µm)	:95.00 (%) = 12.829(µm)	:38.00 (µm) = 100.0
Diameter on %	:5.000 (%) = 0.228(µm)	% on Diameter	:850.0 (µm) = 100.000(%)
	:10.00 (%) = 0.308(µm)		:600.0 (µm) = 100.000(%)
	:20.00 (%) = 0.772(µm)		:425.0 (µm) = 100.000(%)
	:30.00 (%) = 3.557(µm)		:300.0 (µm) = 100.000(%)
	:40.00 (%) = 4.781(µm)		:212.0 (µm) = 100.000(%)
	:60.00 (%) = 6.743(µm)		:150.0 (µm) = 100.000(%)
	:70.00 (%) = 7.790(µm)		:100.0 (µm) = 100.000(%)
	:80.00 (%) = 9.107(µm)		:75.00 (µm) = 100.000(%)
		Mean	: 5.800(µm)
		Variance	: 16.562
		S.D.	: 4.070(µm)
		Mode	: 7.193(µm)
		Span	: 1.864

No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %
1	0.115	0.040	0.000	27	2.905	3.374	32.319	53	133.103	0.000	100.000
2	0.131	0.343	0.343	28	4.472	4.648	36.967	54	152.453	0.000	100.000
3	0.150	0.560	0.903	29	5.122	6.165	43.132	55	174.616	0.000	100.000
4	0.172	0.926	1.829	30	5.867	7.700	50.832	56	200.000	0.000	100.000
5	0.197	1.304	3.133	31	6.720	8.930	59.762	57	229.073	0.000	100.000
6	0.226	1.690	4.823	32	7.697	9.438	69.200	58	262.376	0.000	100.000
7	0.259	2.077	6.899	33	8.816	8.983	78.186	59	300.318	0.000	100.000
8	0.296	2.398	9.297	34	10.097	7.558	83.743	60	344.206	0.000	100.000
9	0.339	2.479	11.776	35	11.565	6.202	91.946	61	394.244	0.000	100.000
10	0.389	2.330	14.106	36	13.246	3.997	93.943	62	451.556	0.000	100.000
11	0.445	1.870	15.976	37	15.172	2.210	98.153	63	517.200	0.000	100.000
12	0.510	1.478	17.455	38	17.377	1.174	99.327	64	592.387	0.000	100.000
13	0.584	1.111	18.565	39	19.904	0.491	99.817				
14	0.669	0.811	19.376	40	22.797	0.183	100.000				
15	0.766	0.595	19.972	41	26.111	0.000	100.000				
16	0.877	0.459	20.431	42	29.907	0.000	100.000				
17	1.005	0.374	20.805	43	34.255	0.000	100.000				
18	1.151	0.340	21.145	44	39.234	0.000	100.000				
19	1.318	0.343	21.488	45	44.938	0.000	100.000				
20	1.510	0.379	21.868	46	51.471	0.000	100.000				
21	1.729	0.456	22.323	47	58.953	0.000	100.000				
22	1.981	0.595	22.918	48	67.523	0.000	100.000				
23	2.269	0.819	23.737	49	77.339	0.000	100.000				
24	2.599	1.159	24.897	50	88.580	0.000	100.000				
25	2.976	1.660	26.557	51	101.460	0.000	100.000				
26	3.409	2.388	28.945	52	116.210	0.000	100.000				

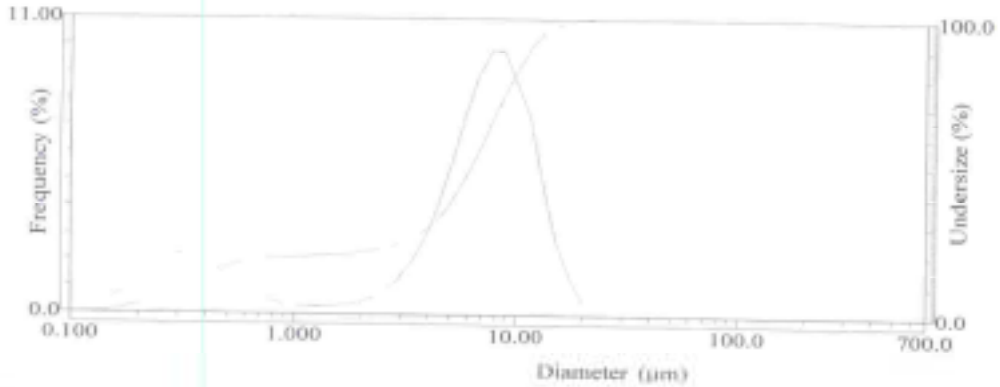
Faro RM Cycle 2



S.P. Area	: 47135(cm ² /cm ³)	-90.00 (%) = 10.491(µm)	-53.00 (µm) = 100.0
Median	: 5.856(µm)	-95.00 (%) = 11.934(µm)	-38.00 (µm) = 100.0
Diameter on %	-5.000 (%) = 0.233(µm)	% on Diameter	-850.0 (µm) = 100.000(%)
	-10.00 (%) = 0.330(µm)		-600.0 (µm) = 100.000(%)
	-20.00 (%) = 2.001(µm)		-425.0 (µm) = 100.000(%)
	-30.00 (%) = 3.960(µm)		-300.0 (µm) = 100.000(%)
	-40.00 (%) = 4.983(µm)		-212.0 (µm) = 100.000(%)
	-50.00 (%) = 6.694(µm)		-150.0 (µm) = 100.000(%)
	-70.00 (%) = 7.619(µm)		-106.0 (µm) = 100.000(%)
	-80.00 (%) = 8.737(µm)		-75.00 (µm) = 100.000(%)
		Mean	: 5.756(µm)
		Variance	: 13.559
		S.D.	: 3.682(µm)
		Mode	: 7.173(µm)
		Span	: 1.735

No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %
1	0.113	0.000	0.000	27	3.905	3.537	29.473	33	133.103	0.000	100.000
2	0.131	0.300	0.390	28	4.472	5.053	34.526	34	152.453	0.000	100.000
3	0.150	0.617	1.007	29	5.122	6.870	41.396	35	174.616	0.000	100.000
4	0.172	0.915	1.921	30	5.867	8.725	50.122	36	200.000	0.000	100.000
5	0.197	1.178	3.100	31	6.720	10.165	60.287	37	229.075	0.000	100.000
6	0.228	1.495	4.595	32	7.697	10.610	70.897	38	262.376	0.000	100.000
7	0.259	1.770	6.365	33	8.816	9.749	80.640	39	300.518	0.000	100.000
8	0.296	1.995	8.360	34	10.097	7.680	88.326	40	344.206	0.000	100.000
9	0.339	2.038	10.397	35	11.565	5.895	94.251	41	394.244	0.000	100.000
10	0.389	1.909	12.307	36	13.246	3.325	97.556	42	451.556	0.000	100.000
11	0.445	1.553	13.860	37	15.177	1.539	99.095	43	517.200	0.000	100.000
12	0.510	1.245	15.105	38	17.377	0.686	99.782	44	592.387	0.000	100.000
13	0.584	0.950	16.055	39	19.904	0.218	100.000				
14	0.669	0.704	16.759	40	22.797	0.000	100.000				
15	0.766	0.523	17.281	41	26.111	0.000	100.000				
16	0.877	0.407	17.688	42	29.907	0.000	100.000				
17	1.005	0.325	18.023	43	34.255	0.000	100.000				
18	1.151	0.266	18.329	44	39.234	0.000	100.000				
19	1.318	0.209	18.638	45	44.938	0.000	100.000				
20	1.510	0.142	18.980	46	51.471	0.000	100.000				
21	1.729	0.114	19.394	47	58.953	0.000	100.000				
22	1.981	0.049	19.943	48	67.523	0.000	100.000				
23	2.269	0.071	20.714	49	77.339	0.000	100.000				
24	2.599	0.117	21.830	50	88.583	0.000	100.000				
25	2.976	1.644	23.475	51	101.460	0.000	100.000				
26	3.409	2.441	25.916	52	116.210	0.000	100.000				

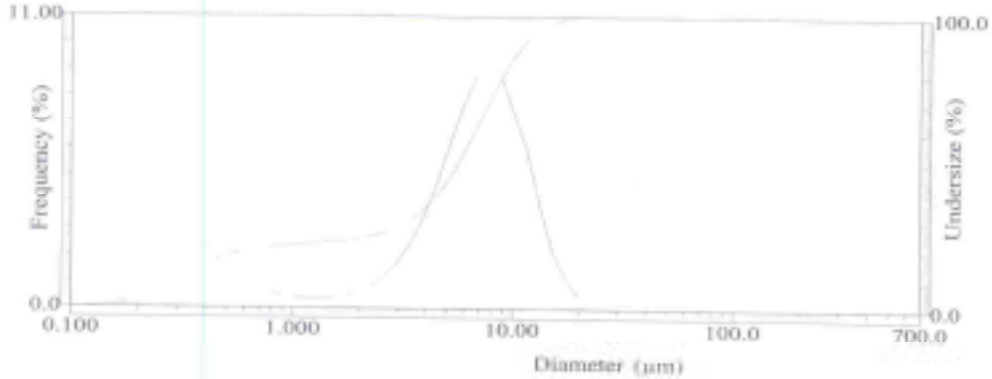
Faro RM Cycle 3



S.P. Area	: 47928(µm ² /cm ²)	:90.00 (%) = 11.503(µm)	:53.00 (µm) = 100.0
Median	: 8.257(µm)	:95.00 (%) = 13.191(µm)	:38.00 (µm) = 100.0
Diameter on %	:5.000 (%) = 0.234(µm)	% on Diameter	:850.0 (µm) = 100.000(%)
	:10.00 (%) = 0.322(µm)		:600.0 (µm) = 100.000(%)
	:20.00 (%) = 1.552(µm)		:425.0 (µm) = 100.000(%)
	:30.00 (%) = 4.079(µm)		:300.0 (µm) = 100.000(%)
	:40.00 (%) = 5.272(µm)		:212.0 (µm) = 100.000(%)
	:60.00 (%) = 7.233(µm)		:150.0 (µm) = 100.000(%)
	:70.00 (%) = 8.305(µm)		:106.0 (µm) = 100.000(%)
	:80.00 (%) = 9.642(µm)		:75.00 (µm) = 100.000(%)
		Mean	: 6.221(µm)
		Variance	: 17.231
		S.D.	: 4.151(µm)
		Mode	: 7.237(µm)
		Span	: 1.787

No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %
1	0.113	0.000	0.000	27	3.905	2.904	28.670	53	133.103	0.000	100.000
2	0.131	0.348	0.348	28	4.472	4.119	32.789	54	152.453	0.000	100.000
3	0.150	0.555	0.904	29	5.122	3.651	38.442	55	174.616	0.000	100.000
4	0.172	0.870	1.774	30	5.867	7.340	45.782	56	200.000	0.000	100.000
5	0.197	1.188	2.962	31	6.720	8.888	54.670	57	229.075	0.000	100.000
6	0.226	1.552	4.514	32	7.697	9.837	64.507	58	262.376	0.000	100.000
7	0.259	1.894	6.408	33	8.816	9.808	74.315	59	300.518	0.000	100.000
8	0.296	2.189	8.588	34	10.097	8.607	82.922	60	344.296	0.000	100.000
9	0.339	2.255	10.843	35	11.565	7.370	90.292	61	394.244	0.000	100.000
10	0.389	2.123	12.966	36	13.246	4.859	95.151	62	451.536	0.000	100.000
11	0.445	1.712	14.678	37	15.172	2.681	97.832	63	517.200	0.000	100.000
12	0.510	1.354	16.032	38	17.377	1.432	99.264	64	592.387	0.000	100.000
13	0.584	1.014	17.047	39	19.904	0.556	99.820				
14	0.669	0.734	17.781	40	22.797	0.180	100.000				
15	0.766	0.532	18.313	41	26.111	0.000	100.000				
16	0.877	0.403	18.716	42	29.907	0.000	100.000				
17	1.005	0.323	19.039	43	34.255	0.000	100.000				
18	1.151	0.288	19.327	44	39.234	0.000	100.000				
19	1.318	0.286	19.613	45	44.938	0.000	100.000				
20	1.510	0.311	19.924	46	51.471	0.000	100.000				
21	1.729	0.370	20.295	47	58.933	0.000	100.000				
22	1.981	0.481	20.776	48	67.523	0.000	100.000				
23	2.269	0.663	21.439	49	77.339	0.000	100.000				
24	2.599	0.946	22.385	50	88.583	0.000	100.000				
25	2.976	1.372	23.756	51	101.468	0.000	100.000				
26	3.409	2.010	25.766	52	116.210	0.000	100.000				

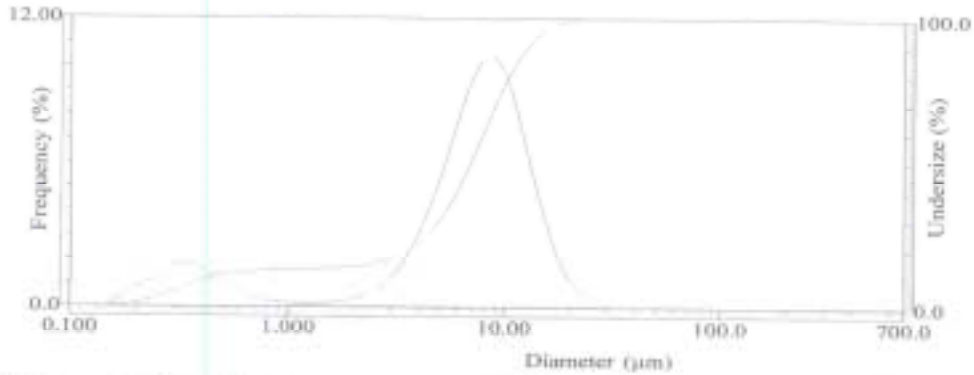
Faro RM Cycle 4



S.P. Area	: 53906(cmi /µm²)		:90.00 (%) = 11.058(µm)		:53.00 (µm) = 100.0
Median	: 5.640(µm)		:95.00 (%) = 12.833(µm)		:38.00 (µm) = 100.0
Diameter on %	:5.000 (%) = 0.225(µm)	% on Diameter	:850.0 (µm) = 100.000(%)	Mean	: 5.693(µm)
	:10.00 (%) = 0.298(µm)		:600.0 (µm) = 100.000(%)	Variance	: 16.851
	:20.00 (%) = 0.628(µm)		:425.0 (µm) = 100.000(%)	S.D.	: 4.105(µm)
	:30.00 (%) = 3.323(µm)		:300.0 (µm) = 100.000(%)	Mode	: 7.192(µm)
	:40.00 (%) = 4.618(µm)		:212.0 (µm) = 100.000(%)	Span	: 1.908
	:60.00 (%) = 6.630(µm)		:150.0 (µm) = 100.000(%)		
	:70.00 (%) = 7.699(µm)		:106.0 (µm) = 100.000(%)		
	:80.00 (%) = 9.079(µm)		:75.00 (µm) = 100.000(%)		

No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %
1	0.115	0.000	0.000	27	3.905	3.432	33.895	53	133.103	0.000	100.000
2	0.131	0.341	0.341	28	4.472	4.638	38.554	54	152.453	0.000	100.000
3	0.150	0.565	0.906	29	5.122	6.100	44.654	55	174.616	0.000	100.000
4	0.172	0.968	1.874	30	5.867	7.556	52.190	56	200.000	0.000	100.000
5	0.197	1.396	3.270	31	6.720	8.670	60.860	57	229.075	0.000	100.000
6	0.226	1.804	5.074	32	7.697	9.119	69.979	58	262.376	0.000	100.000
7	0.259	2.221	7.294	33	8.816	8.672	78.651	59	300.518	0.000	100.000
8	0.296	2.560	9.854	34	10.097	7.314	85.965	60	344.206	0.000	100.000
9	0.339	2.630	12.484	35	11.565	6.026	91.991	61	394.244	0.000	100.000
10	0.389	2.452	14.935	36	13.246	3.926	95.917	62	451.556	0.000	100.000
11	0.445	1.950	16.885	37	15.172	2.200	98.117	63	517.200	0.000	100.000
12	0.510	1.529	18.414	38	17.377	1.186	99.303	64	592.387	0.000	100.000
13	0.584	1.143	19.556	39	19.904	0.505	99.808				
14	0.669	0.814	20.390	40	22.797	0.192	100.000				
15	0.766	0.614	21.004	41	26.111	0.000	100.000				
16	0.877	0.478	21.482	42	29.907	0.000	100.000				
17	1.003	0.393	21.875	43	34.255	0.000	100.000				
18	1.151	0.360	22.235	44	39.234	0.000	100.000				
19	1.318	0.367	22.602	45	44.938	0.000	100.000				
20	1.510	0.409	23.011	46	51.471	0.000	100.000				
21	1.729	0.493	23.504	47	58.953	0.000	100.000				
22	1.981	0.642	24.147	48	67.523	0.000	100.000				
23	2.269	0.878	25.025	49	77.339	0.000	100.000				
24	2.599	1.231	26.256	50	88.583	0.000	100.000				
25	2.976	1.741	27.997	51	101.460	0.000	100.000				
26	3.409	2.467	30.463	52	116.210	0.000	100.000				

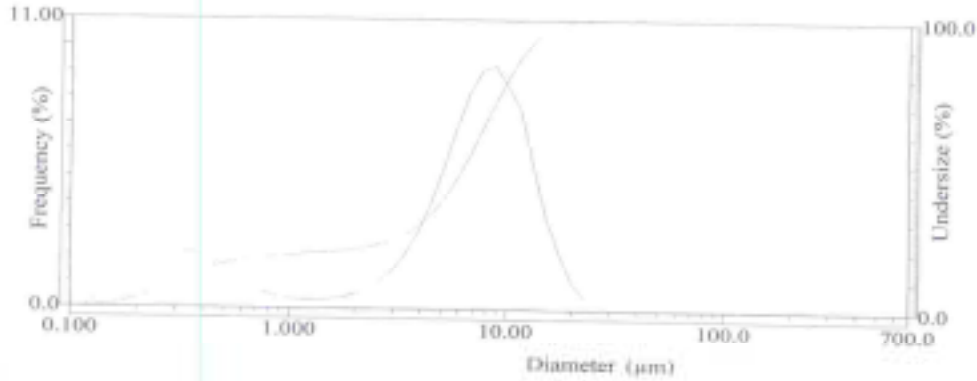
Faro 1 Start



S.P. Area	: 33962(cm ² /cm ³)	:90.00 (%) = 12.687(µm)	:53.00 (µm) = 100.0
Median	: 6.314(µm)	:95.00 (%) = 14.806(µm)	:38.00 (µm) = 100.0
Diameter on %	-5.000 (%) = 0.284(µm)	% on Diameter	:850.0 (µm) = 100.000(%)
	-10.00 (%) = 0.426(µm)		:800.0 (µm) = 100.000(%)
	-20.00 (%) = 3.631(µm)		:425.0 (µm) = 100.000(%)
	-30.00 (%) = 4.938(µm)		:300.0 (µm) = 100.000(%)
	-40.00 (%) = 5.974(µm)		:212.0 (µm) = 100.000(%)
	-60.00 (%) = 7.893(µm)		:150.0 (µm) = 100.000(%)
	-70.00 (%) = 9.000(µm)		:106.0 (µm) = 100.000(%)
	-80.00 (%) = 10.418(µm)		:75.00 (µm) = 100.000(%)
		Mean	: 7.114(µm)
		Variance	: 19.120
		S.D.	: 4.373(µm)
		Mode	: 8.208(µm)
		Span	: 1.773

No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %
1	0.115	0.080	0.080	27	3.985	2.877	21.537	53	133.303	0.000	100.000
2	0.131	0.080	0.080	28	4.472	4.156	25.693	54	152.453	0.000	100.000
3	0.150	0.080	0.080	29	5.122	5.673	31.366	55	174.616	0.000	100.000
4	0.172	0.478	0.478	30	5.867	7.422	38.788	56	200.000	0.000	100.000
5	0.197	0.767	1.245	31	6.720	9.078	47.866	57	229.078	0.000	100.000
6	0.226	1.086	2.332	32	7.697	10.188	58.055	58	262.370	0.000	100.000
7	0.259	1.441	3.773	33	8.816	10.474	68.528	59	300.518	0.000	100.000
8	0.296	1.747	5.520	34	10.097	9.650	78.179	60	344.206	0.000	100.000
9	0.339	1.852	7.372	35	11.565	7.903	86.081	61	394.244	0.000	100.000
10	0.389	1.730	9.102	36	13.246	5.745	91.826	62	451.556	0.000	100.000
11	0.445	1.311	10.413	37	15.172	3.870	95.697	63	517.200	0.000	100.000
12	0.510	0.964	11.377	38	17.377	2.233	97.930	64	592.387	0.000	100.000
13	0.584	0.659	12.036	39	19.904	1.212	99.142				
14	0.660	0.432	12.468	40	22.797	0.602	99.744				
15	0.760	0.287	12.755	41	26.111	0.256	100.000				
16	0.877	0.205	12.960	42	29.907	0.000	100.000				
17	1.005	0.161	13.121	43	34.255	0.000	100.000				
18	1.151	0.147	13.268	44	39.234	0.000	100.000				
19	1.318	0.154	13.422	45	44.938	0.000	100.000				
20	1.510	0.181	13.603	46	51.471	0.000	100.000				
21	1.729	0.234	13.837	47	58.953	0.000	100.000				
22	1.981	0.337	14.174	48	67.523	0.000	100.000				
23	2.269	0.519	14.693	49	77.339	0.000	100.000				
24	2.599	0.803	15.496	50	88.583	0.000	100.000				
25	2.976	1.237	16.733	51	101.460	0.000	100.000				
26	3.409	1.926	18.660	52	116.210	0.000	100.000				

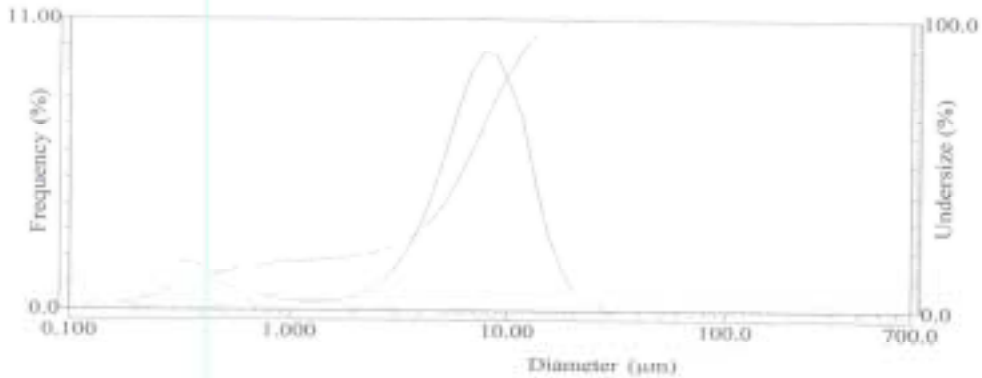
Faro 1 ~~Start~~ Cycle 1



S.P. Area	: 46184(µm²/cm²)	:90.00 (%) = 12.396(µm)	:53.00 (µm) = 100.0
Median	: 6.427(µm)	:95.00 (%) = 14.474(µm)	:38.00 (µm) = 100.0
Diameter on %	:5.000 (%) = 0.238(µm)	% on Diameter	:850.0 (µm) = 100.000(%)
	:10.00 (%) = 0.333(µm)		:600.0 (µm) = 100.000(%)
	:20.00 (%) = 1.857(µm)		:425.0 (µm) = 100.000(%)
	:30.00 (%) = 4.130(µm)		:300.0 (µm) = 100.000(%)
	:40.00 (%) = 5.364(µm)		:212.0 (µm) = 100.000(%)
	:60.00 (%) = 7.494(µm)		:150.0 (µm) = 100.000(%)
	:70.00 (%) = 8.681(µm)		:106.0 (µm) = 100.000(%)
	:80.00 (%) = 10.179(µm)		:75.00 (µm) = 100.000(%)
		Mean	: 6.535(µm)
		Variance	: 20.299
		S.D.	: 4.505(µm)
		Mode	: 8.201(µm)
		Span	: 1.877

No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %
1	0.115	0.000	0.000	27	3.701	2.883	28.349	53	133.103	0.000	100.000
2	0.131	0.236	0.136	28	4.472	3.986	32.335	54	152.453	0.000	100.000
3	0.150	0.537	0.473	29	5.122	5.344	37.679	55	174.616	0.000	100.000
4	0.172	0.845	1.718	30	5.867	6.819	44.499	56	200.000	0.000	100.000
5	0.197	1.146	2.864	31	6.720	8.189	52.687	57	229.075	0.000	100.000
6	0.226	1.468	4.332	32	7.697	9.099	61.787	58	262.376	0.000	100.000
7	0.259	1.783	6.115	33	8.816	9.267	71.053	59	300.518	0.000	100.000
8	0.296	2.047	8.162	34	10.097	8.492	79.545	60	344.206	0.000	100.000
9	0.339	2.121	10.283	35	11.563	7.619	87.164	61	394.244	0.000	100.000
10	0.389	2.009	12.292	36	13.246	5.545	92.710	62	451.356	0.000	100.000
11	0.445	1.637	13.929	37	15.172	3.507	96.217	63	517.200	0.000	100.000
12	0.510	1.315	15.245	38	17.377	2.141	98.357	64	592.387	0.000	100.000
13	0.584	1.005	16.250	39	19.904	1.037	99.395				
14	0.669	0.744	16.994	40	22.797	0.442	99.836				
15	0.766	0.553	17.546	41	26.111	0.164	100.000				
16	0.877	0.429	17.975	42	29.907	0.000	100.000				
17	1.005	0.350	18.326	43	34.255	0.000	100.000				
18	1.151	0.317	18.643	44	39.234	0.000	100.000				
19	1.318	0.318	18.961	45	44.938	0.000	100.000				
20	1.510	0.347	19.308	46	51.471	0.000	100.000				
21	1.729	0.413	19.720	47	58.953	0.000	100.000				
22	1.981	0.532	20.252	48	67.523	0.000	100.000				
23	2.269	0.723	20.975	49	77.339	0.000	100.000				
24	2.599	1.011	21.986	50	88.583	0.000	100.000				
25	2.976	1.433	23.419	51	101.460	0.000	100.000				
26	3.409	2.047	25.466	52	116.210	0.000	100.000				

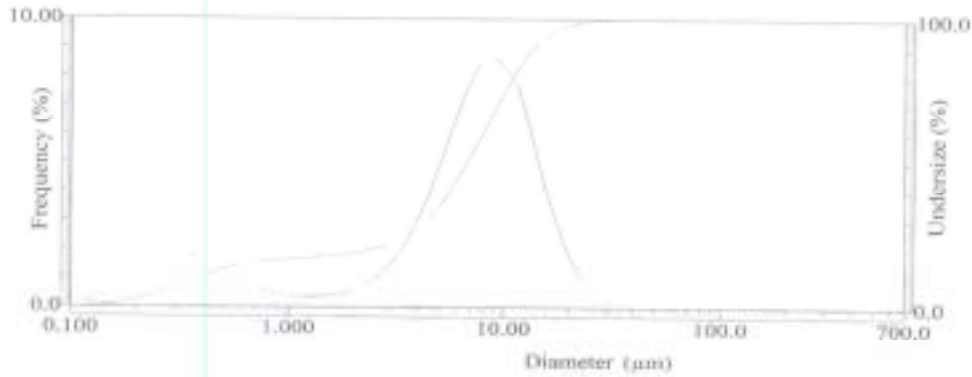
Faro 1 Cycle 2



S.P. Area	: 42638(µm² /µm²)	:90.00 (%) = 11.846(µm)	:53.00 (µm) = 100.0
Median	: 6.355(µm)	:95.00 (%) = 13.772(µm)	:38.00 (µm) = 100.0
Diameter on %	:5.000 (%) = 0.246(µm)	% on Diameter	:850.0 (µm) = 100.000(%)
	:10.00 (%) = 0.368(µm)		:600.0 (µm) = 100.000(%)
	:20.00 (%) = 2.570(µm)		:425.0 (µm) = 100.000(%)
	:30.00 (%) = 4.300(µm)		:300.0 (µm) = 100.000(%)
	:40.00 (%) = 5.390(µm)		:212.0 (µm) = 100.000(%)
	:60.00 (%) = 7.333(µm)		:150.0 (µm) = 100.000(%)
	:70.00 (%) = 8.428(µm)		:106.0 (µm) = 100.000(%)
	:80.00 (%) = 9.819(µm)		:75.00 (µm) = 100.000(%)
		Mean	: 6.459(µm)
		Variance	: 17.834
		S.D.	: 4.223(µm)
		Mode	: 7.228(µm)
		Span	: 1.806

No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %
1	0.115	0.000	0.000	27	3.905	1.120	26.889	33	133.303	0.000	100.000
2	0.131	0.376	0.376	28	4.472	4.372	31.261	34	152.453	0.000	100.000
3	0.150	0.984	0.980	29	5.122	5.904	37.165	35	174.616	0.000	100.000
4	0.172	0.822	1.782	30	5.867	7.340	44.705	36	200.000	0.000	100.000
5	0.197	1.012	2.794	31	6.720	8.987	53.692	37	229.075	0.000	100.000
6	0.226	1.266	4.060	32	7.697	9.811	63.503	38	262.376	0.000	100.000
7	0.259	1.492	5.552	33	8.816	9.709	73.212	39	300.518	0.000	100.000
8	0.296	1.689	7.241	34	10.097	8.548	81.760	40	344.206	0.000	100.000
9	0.339	1.758	8.999	35	11.565	7.349	89.109	41	394.244	0.000	100.000
10	0.389	1.692	10.691	36	13.246	5.036	94.145	42	451.526	0.000	100.000
11	0.445	1.428	12.119	37	15.172	2.980	97.125	43	517.200	0.000	100.000
12	0.510	1.190	13.309	38	17.377	1.697	98.822	44	592.387	0.000	100.000
13	0.584	0.945	14.254	39	19.904	0.765	99.587				
14	0.669	0.725	14.979	40	22.797	0.305	99.893				
15	0.766	0.553	15.532	41	26.111	0.107	100.000				
16	0.877	0.437	15.970	42	29.907	0.000	100.000				
17	1.005	0.361	16.331	43	34.255	0.000	100.000				
18	1.151	0.328	16.658	44	39.234	0.000	100.000				
19	1.318	0.326	16.985	45	44.938	0.000	100.000				
20	1.510	0.354	17.339	46	51.471	0.000	100.000				
21	1.729	0.419	17.758	47	58.953	0.000	100.000				
22	1.981	0.541	18.299	48	67.523	0.000	100.000				
23	2.269	0.741	19.040	49	77.339	0.000	100.000				
24	2.599	1.045	20.085	50	88.583	0.000	100.000				
25	2.976	1.502	21.587	51	101.460	0.000	100.000				
26	3.409	2.181	23.768	52	116.210	0.000	100.000				

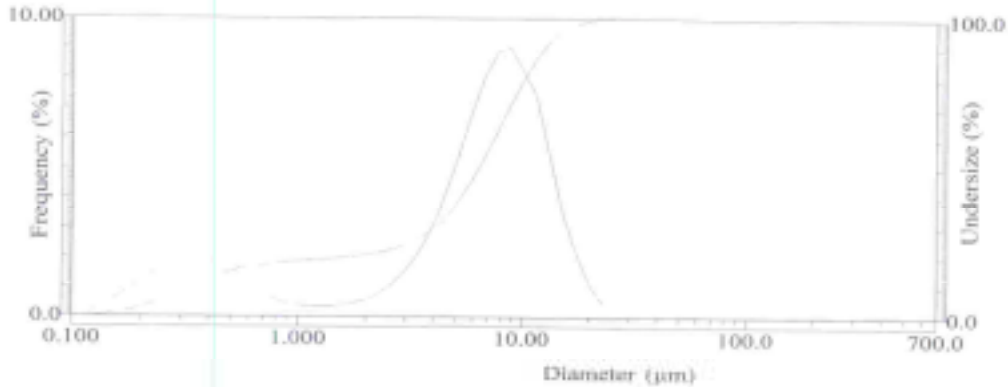
Faro 1 Cycle 3



S.P. Area	: 41769(µm ² /µm ³)	:90.00 (%) = 11.693(µm)	:53.00 (µm) = 100.0
Median	: 6.753(µm)	:95.00 (%) = 16.397(µm)	:38.00 (µm) = 100.0
Diameter on %	:5.000 (%) = 0.231(µm)	% on Diameter	:850.0 (µm) = 100.000(%)
	:10.00 (%) = 0.373(µm)		:600.0 (µm) = 100.000(%)
	:20.00 (%) = 2.495(µm)		:425.0 (µm) = 100.000(%)
	:30.00 (%) = 4.381(µm)		:300.0 (µm) = 100.000(%)
	:40.00 (%) = 5.614(µm)		:212.0 (µm) = 100.000(%)
	:60.00 (%) = 7.820(µm)		:150.0 (µm) = 100.000(%)
	:70.00 (%) = 9.277(µm)		:106.0 (µm) = 100.000(%)
	:80.00 (%) = 10.997(µm)		:75.00 (µm) = 100.000(%)
		Mean	: 7.166(µm)
		Variance	: 26.168
		S.D.	: 5.116(µm)
		Mode	: 8.223(µm)
		Span	: 1.973

No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %
1	0.112	0.000	0.000	27	3.905	2.856	26.718	53	133.103	0.000	100.000
2	0.131	0.344	0.344	28	4.472	3.872	30.590	54	152.453	0.000	100.000
3	0.150	0.535	0.879	29	5.122	5.092	35.682	55	174.616	0.000	100.000
4	0.172	0.773	1.652	30	5.857	6.399	42.081	56	200.000	0.000	100.000
5	0.197	0.977	2.629	31	6.720	7.614	49.695	57	229.075	0.000	100.000
6	0.226	1.237	3.866	32	7.697	8.462	58.156	58	262.376	0.000	100.000
7	0.259	1.479	5.345	33	8.816	8.736	66.892	59	300.518	0.000	100.000
8	0.296	1.692	7.038	34	10.097	8.272	75.164	60	344.206	0.000	100.000
9	0.339	1.773	8.813	35	11.565	7.685	82.849	61	394.244	0.000	100.000
10	0.389	1.721	10.534	36	13.246	6.086	88.935	62	451.556	0.000	100.000
11	0.443	1.459	11.993	37	15.172	4.353	93.288	63	517.200	0.000	100.000
12	0.510	1.221	13.214	38	17.377	2.591	95.280	64	592.387	0.000	100.000
13	0.584	0.975	14.189	39	19.904	1.799	96.078				
14	0.669	0.753	14.941	40	22.797	1.008	99.086				
15	0.766	0.579	15.520	41	26.111	0.522	99.608				
16	0.877	0.463	15.983	42	29.907	0.264	99.872				
17	1.005	0.385	16.368	43	34.255	0.128	100.000				
18	1.151	0.352	16.721	44	39.234	0.000	100.000				
19	1.318	0.353	17.074	45	44.838	0.000	100.000				
20	1.510	0.383	17.457	46	51.471	0.000	100.000				
21	1.729	0.452	17.909	47	58.953	0.000	100.000				
22	1.981	0.576	18.485	48	67.523	0.000	100.000				
23	2.269	0.772	19.257	49	77.339	0.000	100.000				
24	2.599	1.061	20.318	50	88.583	0.000	100.000				
25	2.976	1.476	21.794	51	101.460	0.000	100.000				
26	3.409	2.069	23.862	52	116.210	0.000	100.000				

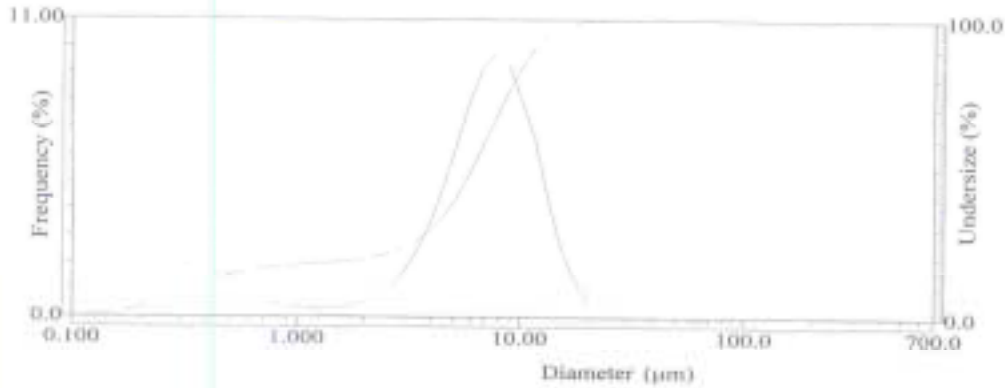
Faro 1 Cycle 4



S.P. Area : 46517(µm²/cm²)	:90.00 (%) = 12.501(µm)	:53.00 (µm) = 100.0
Median : 6.360(µm)	:95.00 (%) = 14.652(µm)	:38.00 (µm) = 100.0
Diameter on % :5.000 (%) = 0.238(µm)	% on Diameter :850.0 (µm) = 100.000(%)	Mean : 6.539(µm)
:10.00 (%) = 0.334(µm)	:600.0 (µm) = 100.000(%)	Variance : 20.972
:20.00 (%) = 1.649(µm)	:425.0 (µm) = 100.000(%)	S.D. : 4.580(µm)
:30.00 (%) = 4.019(µm)	:300.0 (µm) = 100.000(%)	Mode : 8.201(µm)
:40.00 (%) = 5.280(µm)	:212.0 (µm) = 100.000(%)	Span : 1.913
:60.00 (%) = 7.452(µm)	:150.0 (µm) = 100.000(%)	
:70.00 (%) = 8.668(µm)	:106.0 (µm) = 100.000(%)	
:80.00 (%) = 10.209(µm)	:75.00 (µm) = 100.000(%)	

No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %
1	0.113	0.000	0.000	27	3.905	2.944	29.143	53	131.103	0.000	100.000
2	0.131	0.342	0.342	28	4.472	4.021	33.164	54	152.455	0.000	100.000
3	0.150	0.945	0.887	29	5.122	5.330	38.494	55	174.616	0.000	100.000
4	0.172	0.846	1.732	30	5.867	6.734	45.228	56	200.000	0.000	100.000
5	0.197	1.133	2.865	31	6.720	8.020	53.248	57	229.075	0.000	100.000
6	0.226	1.452	4.318	32	7.697	8.863	62.111	58	262.376	0.000	100.000
7	0.259	1.765	6.082	33	8.816	9.097	71.118	59	300.518	0.000	100.000
8	0.296	2.033	8.115	34	10.097	8.275	79.393	60	344.206	0.000	100.000
9	0.339	2.121	10.236	35	11.565	7.449	86.842	61	394.244	0.000	100.000
10	0.389	2.029	12.265	36	13.246	5.506	92.347	62	451.556	0.000	100.000
11	0.445	1.677	13.942	37	15.172	3.570	95.917	63	517.200	0.000	100.000
12	0.510	1.367	15.309	38	17.377	2.230	98.147	64	592.387	0.000	100.000
13	0.584	1.061	16.370	39	19.904	1.134	99.281				
14	0.669	0.797	17.167	40	22.797	0.514	99.795				
15	0.766	0.600	17.767	41	26.111	0.205	100.000				
16	0.877	0.470	18.237	42	29.907	0.000	100.000				
17	1.008	0.386	18.624	43	34.255	0.000	100.000				
18	1.151	0.331	18.973	44	39.234	0.000	100.000				
19	1.318	0.331	19.325	45	44.938	0.000	100.000				
20	1.510	0.382	19.707	46	51.471	0.000	100.000				
21	1.729	0.451	20.158	47	58.953	0.000	100.000				
22	1.981	0.576	20.735	48	67.523	0.000	100.000				
23	2.269	0.775	21.510	49	77.339	0.000	100.000				
24	2.599	1.072	22.582	50	88.583	0.000	100.000				
25	2.976	1.501	24.082	51	101.460	0.000	100.000				
26	3.409	2.117	26.199	52	116.210	0.000	100.000				

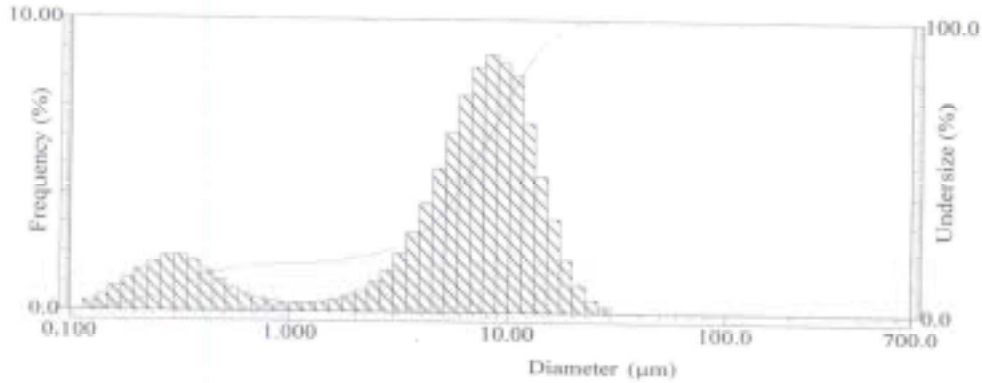
Faro 2 Start



S.P. Area : 44843(cm² /cm³)	:50.00 (%) = 11.444(µm)	:53.00 (µm) = 100.0
Median : 6.077(µm)	:95.00 (%) = 13.285(µm)	:58.00 (µm) = 100.0
Diameter on %	% on Diameter	Mean : 6.185(µm)
:5.000 (%) = 0.241(µm)	:850.0 (µm) = 100.000(%)	Variance : 17.163
:10.00 (%) = 0.348(µm)	:600.0 (µm) = 100.000(%)	S.D. : 4.143(µm)
:20.00 (%) = 2.200(µm)	:425.0 (µm) = 100.000(%)	Mode : 7.201(µm)
:30.00 (%) = 4.048(µm)	:300.0 (µm) = 100.000(%)	Span : 1.826
:40.00 (%) = 5.145(µm)	:212.0 (µm) = 100.000(%)	
:60.00 (%) = 7.027(µm)	:150.0 (µm) = 100.000(%)	
:70.00 (%) = 8.094(µm)	:106.0 (µm) = 100.000(%)	
:80.00 (%) = 9.454(µm)	:75.00 (µm) = 100.000(%)	

No.	Diameter	Freq.	% Under	No.	Diameter	Freq.	% Under	No.	Diameter	Freq.	% Under
1	0.115	0.000	0.000	27	3.905	3.398	28.747	53	133.002	0.000	100.000
2	0.131	0.364	0.364	28	4.472	4.715	33.462	54	152.453	0.000	100.000
3	0.150	0.570	0.934	29	3.122	6.282	39.744	55	174.616	0.000	100.000
4	0.172	0.837	1.771	30	5.867	7.875	47.620	56	200.000	0.000	100.000
5	0.197	1.074	2.845	31	6.720	9.171	56.791	57	229.075	0.000	100.000
6	0.226	1.367	4.213	32	7.697	9.744	66.534	58	262.376	0.000	100.000
7	0.259	1.636	5.849	33	8.816	9.354	75.889	59	300.518	0.000	100.000
8	0.296	1.865	7.714	34	10.097	7.982	83.870	60	344.206	0.000	100.000
9	0.339	1.938	9.652	35	11.565	6.645	90.515	61	394.244	0.000	100.000
10	0.389	1.850	11.502	36	13.246	4.430	94.945	62	451.556	0.000	100.000
11	0.445	1.534	13.036	37	15.172	2.576	97.521	63	517.200	0.000	100.000
12	0.510	1.254	14.291	38	17.377	1.435	98.956	64	592.387	0.000	100.000
13	0.584	0.976	15.266	39	19.904	0.659	99.615				
14	0.669	0.734	16.001	40	22.797	0.277	99.892				
15	0.766	0.532	16.533	41	26.111	0.108	100.000				
16	0.877	0.434	16.967	42	29.907	0.000	100.000				
17	1.005	0.338	17.345	43	34.255	0.000	100.000				
18	1.151	0.328	17.673	44	39.234	0.000	100.000				
19	1.318	0.331	18.003	45	44.938	0.000	100.000				
20	1.510	0.364	18.368	46	51.471	0.000	100.000				
21	1.729	0.439	18.806	47	58.953	0.000	100.000				
22	1.981	0.576	19.382	48	67.523	0.000	100.000				
23	2.269	0.799	20.181	49	77.339	0.000	100.000				
24	2.599	1.138	21.319	50	88.583	0.000	100.000				
25	2.976	1.643	22.962	51	101.460	0.000	100.000				
26	3.409	2.387	25.349	52	116.210	0.000	100.000				

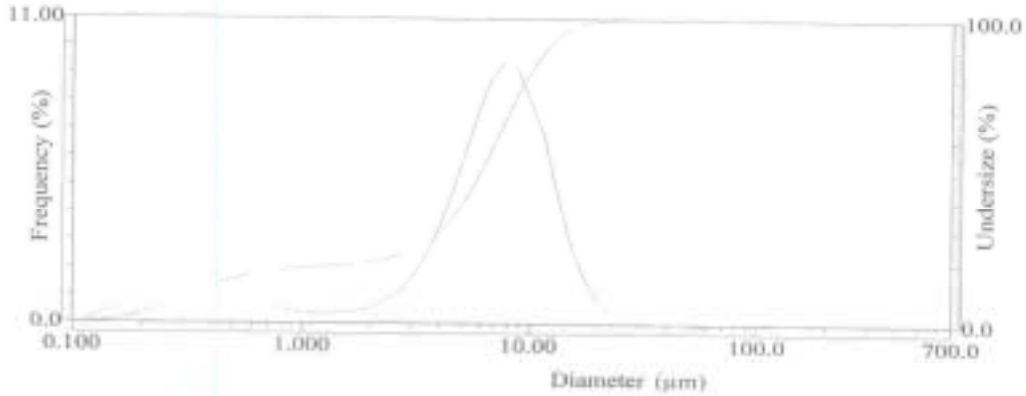
Faro 2 Cycle 1



S.P. Area : 43143(cm ² /cm ³)	:90.00 (%) = 13.728(µm)	:53.00 (µm) = 100.0
Median : 6.900(µm)	:95.00 (%) = 16.239(µm)	:38.00 (µm) = 100.0
Diameter on % :5.000 (%) = 0.239(µm)	% on Diameter :850.0 (µm) = 100.000(%)	Mean : 7.217(µm)
:10.00 (%) = 0.346(µm)	:600.0 (µm) = 100.000(%)	Variance : 25.151
:20.00 (%) = 2.569(µm)	:425.0 (µm) = 100.000(%)	S.D. : 5.015(µm)
:30.00 (%) = 4.483(µm)	:300.0 (µm) = 100.000(%)	Mode : 8.247(µm)
:40.00 (%) = 5.747(µm)	:212.0 (µm) = 100.000(%)	Span : 1.929
:60.00 (%) = 8.089(µm)	:150.0 (µm) = 100.000(%)	
:70.00 (%) = 9.452(µm)	:106.0 (µm) = 100.000(%)	
:80.00 (%) = 11.132(µm)	:75.00 (µm) = 100.000(%)	

No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %
1	0.115	0.000	0.000	27	3.905	2.780	26.227	53	153.103	0.000	100.000
2	0.131	0.325	0.325	28	4.472	3.688	29.916	54	152.453	0.000	100.000
3	0.150	0.522	0.847	29	5.122	4.864	34.780	55	174.616	0.000	100.000
4	0.172	0.841	1.688	30	5.867	6.159	40.939	56	200.000	0.000	100.000
5	0.197	1.148	2.835	31	6.720	7.422	48.360	57	229.075	0.000	100.000
6	0.226	1.434	4.270	32	7.697	8.396	56.756	58	262.376	0.000	100.000
7	0.259	1.699	5.968	33	8.816	8.851	65.606	59	300.518	0.000	100.000
8	0.296	1.897	7.865	34	10.097	8.552	74.159	60	344.206	0.000	100.000
9	0.339	1.900	9.765	35	11.565	8.125	82.284	61	394.244	0.000	100.000
10	0.389	1.736	11.500	36	13.246	6.498	88.783	62	451.556	0.000	100.000
11	0.445	1.371	12.872	37	15.172	4.625	93.408	63	517.200	0.000	100.000
12	0.510	1.071	13.943	38	17.377	3.177	96.585	64	592.387	0.000	100.000
13	0.584	0.804	14.747	39	19.904	1.825	98.411				
14	0.669	0.594	15.341	40	22.797	0.949	99.360				
15	0.766	0.446	15.788	41	26.111	0.444	99.804				
16	0.877	0.356	16.143	42	29.907	0.196	100.000				
17	1.005	0.302	16.445	43	34.255	0.000	100.000				
18	1.151	0.285	16.731	44	39.234	0.000	100.000				
19	1.318	0.298	17.029	45	44.938	0.000	100.000				
20	1.510	0.339	17.368	46	51.471	0.000	100.000				
21	1.729	0.414	17.783	47	58.953	0.000	100.000				
22	1.981	0.542	18.325	48	67.523	0.000	100.000				
23	2.269	0.738	19.062	49	77.339	0.000	100.000				
24	2.599	1.023	20.085	50	88.583	0.000	100.000				
25	2.976	1.425	21.510	51	101.460	0.000	100.000				
26	3.409	1.987	23.497	52	116.210	0.000	100.000				

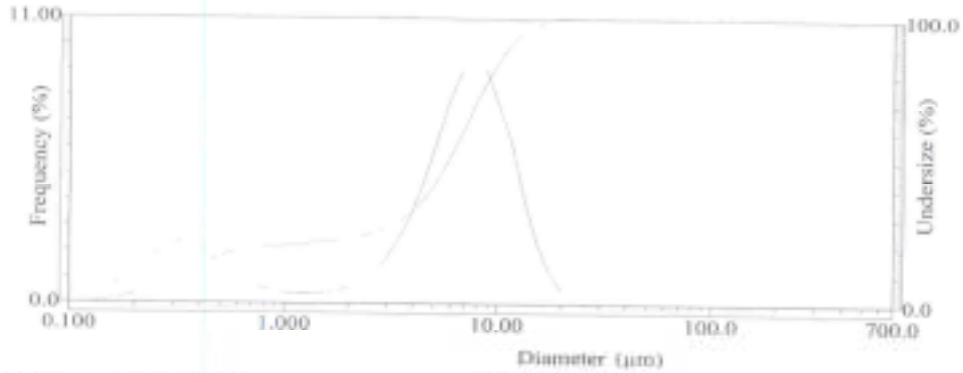
Faro 2 Cycle 2



S.P. Area	: 45818[cm ² /cm ³]	:90.00 (%) = 11.790(µm)	:53.00 (µm) = 100.0
Median	: 6.127(µm)	:95.00 (%) = 13.854(µm)	:38.00 (µm) = 100.0
Diameter on %	:5.000 (%) = 0.240(µm)	% on Diameter	:850.0 (µm) = 100.000(%)
	:10.00 (%) = 0.343(µm)		:600.0 (µm) = 100.000(%)
	:20.00 (%) = 1.880(µm)		:425.0 (µm) = 100.000(%)
	:30.00 (%) = 3.998(µm)		:300.0 (µm) = 100.000(%)
	:40.00 (%) = 5.152(µm)		:212.0 (µm) = 100.000(%)
	:60.00 (%) = 7.122(µm)		:150.0 (µm) = 100.000(%)
	:70.00 (%) = 8.241(µm)		:106.0 (µm) = 100.000(%)
	:80.00 (%) = 9.671(µm)		:75.00 (µm) = 100.000(%)
		Mean:	: 6.273(µm)
		Variance	: 18.645
		S.D.	: 4.318(µm)
		Mode:	: 7.211(µm)
		Span	: 1.868

No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %
1	0.115	0.000	0.000	27	3.905	3.242	29.217	53	133.103	0.000	100.000
2	0.131	0.365	0.365	28	4.472	4.490	33.707	54	152.453	0.000	100.000
3	0.150	0.573	0.938	29	5.122	5.979	39.685	55	174.616	0.000	100.000
4	0.172	0.819	1.757	30	5.867	7.507	47.192	56	208.090	0.000	100.000
5	0.197	1.078	2.835	31	6.720	8.781	55.973	57	229.075	0.000	100.000
6	0.226	1.382	4.217	32	7.697	9.410	65.384	58	262.376	0.000	100.000
7	0.259	1.669	5.906	33	8.816	9.163	74.547	59	300.518	0.000	100.000
8	0.296	1.922	7.828	34	10.097	7.988	82.525	60	344.206	0.000	100.000
9	0.339	2.021	9.849	35	11.565	6.797	89.332	61	394.244	0.000	100.000
10	0.389	1.956	11.804	36	13.246	4.715	94.046	62	451.256	0.000	100.000
11	0.445	1.642	13.446	37	15.172	2.885	96.932	63	517.200	0.000	100.000
12	0.510	1.358	14.804	38	17.377	1.691	98.623	64	592.387	0.000	100.000
13	0.584	1.066	15.870	39	19.904	0.836	99.459				
14	0.669	0.806	16.676	40	22.797	0.381	99.840				
15	0.766	0.606	17.282	41	26.111	0.160	100.000				
16	0.877	0.473	17.755	42	29.907	0.000	100.000				
17	1.005	0.386	18.141	43	34.255	0.000	100.000				
18	1.151	0.348	18.489	44	39.234	0.000	100.000				
19	1.318	0.345	18.833	45	44.938	0.000	100.000				
20	1.510	0.373	19.207	46	51.471	0.000	100.000				
21	1.729	0.442	19.649	47	58.953	0.000	100.000				
22	1.981	0.572	20.221	48	67.523	0.000	100.000				
23	2.269	0.783	21.005	49	77.339	0.000	100.000				
24	2.599	1.104	22.107	50	88.583	0.000	100.000				
25	2.976	1.582	23.689	51	101.460	0.000	100.000				
26	3.409	2.286	25.975	52	116.210	0.000	100.000				

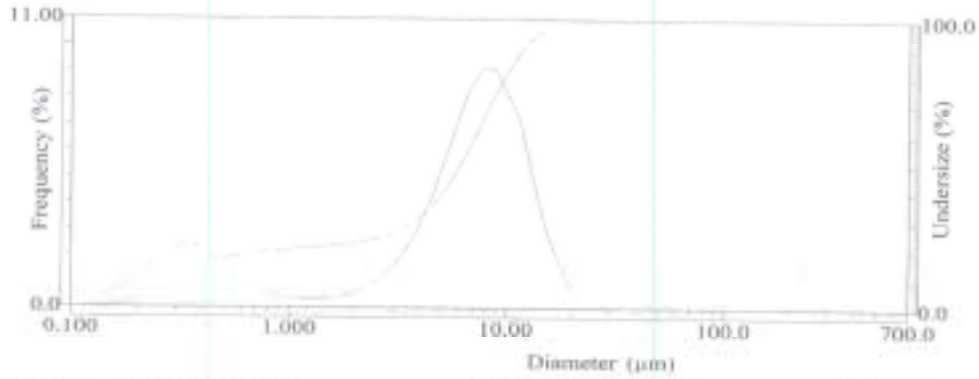
Faro 2 Cycle 3



S.P. Area	: 49423(µm²/cm²)	:90.00 (%) = 11.197(µm)	:53.00 (µm) = 100.0
Median	: 3.843(µm)	:95.00 (%) = 12.074(µm)	:38.00 (µm) = 100.0
Diameter on %	:5.000 (%) = 0.234(µm)	% on Diameter	:850.0 (µm) = 100.000(%)
	:10.00 (%) = 0.321(µm)		:600.0 (µm) = 100.000(%)
	:20.00 (%) = 1.018(µm)		:425.0 (µm) = 100.000(%)
	:30.00 (%) = 3.653(µm)		:300.0 (µm) = 100.000(%)
	:40.00 (%) = 4.845(µm)		:212.0 (µm) = 100.000(%)
	:60.00 (%) = 6.803(µm)		:150.0 (µm) = 100.000(%)
	:70.00 (%) = 7.864(µm)		:106.0 (µm) = 100.000(%)
	:80.00 (%) = 9.204(µm)		:75.00 (µm) = 100.000(%)
		Mean	: 5.388(µm)
		Variance	: 16.766
		S.D.	: 4.095(µm)
		Mode	: 7.198(µm)
		Span	: 1.861

No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %
1	0.115	0.000	0.000	27	3.905	3.401	31.680	53	133.103	0.000	100.000
2	0.131	0.342	0.342	28	4.472	4.674	36.353	54	132.453	0.000	100.000
3	0.150	0.548	0.890	29	5.122	6.181	42.534	55	174.616	0.000	100.000
4	0.172	0.869	1.759	30	5.867	7.659	50.233	56	200.000	0.000	100.000
5	0.197	1.189	2.948	31	6.720	8.917	59.150	57	229.073	0.000	100.000
6	0.226	1.544	4.492	32	7.697	9.426	68.576	58	262.376	0.000	100.000
7	0.259	1.900	6.392	33	8.816	9.000	77.576	59	300.518	0.000	100.000
8	0.296	2.209	8.600	34	10.097	7.623	85.199	60	344.206	0.000	100.000
9	0.339	2.318	10.919	35	11.565	6.301	91.500	61	394.244	0.000	100.000
10	0.389	2.223	13.142	36	13.246	4.133	95.632	62	451.556	0.000	100.000
11	0.445	1.836	14.971	37	15.172	2.338	97.970	63	517.200	0.000	100.000
12	0.510	1.483	16.454	38	17.377	1.271	99.241	64	592.387	0.000	100.000
13	0.584	1.141	17.595	39	19.904	0.549	99.790				
14	0.669	0.849	18.443	40	22.797	0.210	100.000				
15	0.766	0.631	19.075	41	26.111	0.000	100.000				
16	0.877	0.490	19.565	42	29.907	0.000	100.000				
17	1.003	0.400	19.965	43	34.255	0.000	100.000				
18	1.151	0.362	20.326	44	39.234	0.000	100.000				
19	1.318	0.362	20.688	45	44.938	0.000	100.000				
20	1.510	0.396	21.083	46	51.471	0.000	100.000				
21	1.729	0.472	21.555	47	58.953	0.000	100.000				
22	1.981	0.612	22.167	48	67.523	0.000	100.000				
23	2.269	0.837	22.904	49	77.339	0.000	100.000				
24	2.599	1.179	24.183	50	88.593	0.000	100.000				
25	2.976	1.682	25.865	51	101.460	0.000	100.000				
26	3.409	2.414	28.279	52	116.210	0.000	100.000				

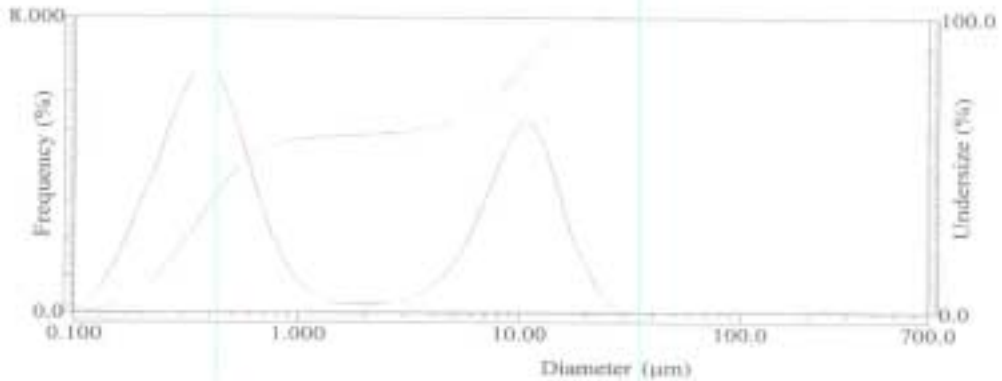
Faro 2 Cycle 4



S.P. Area : 49166(µm² /µm³)	50.00 (%) = 11.863(µm)	53.00 (µm) = 100.0
Median : 6.136(µm)	55.00 (%) = 13.833(µm)	58.00 (µm) = 100.0
Diameter on %	% on Diameter	Mean : 6.218(µm)
5.000 (%) = 0.235(µm)	350.0 (µm) = 100.000(%)	Variance : 19.139
10.00 (%) = 0.319(µm)	400.0 (µm) = 100.000(%)	S.D. : 4.375(µm)
20.00 (%) = 0.984(µm)	425.0 (µm) = 100.000(%)	Mode : 7.234(µm)
30.00 (%) = 3.808(µm)	300.0 (µm) = 100.000(%)	Span : 1.881
40.00 (%) = 5.092(µm)	212.0 (µm) = 100.000(%)	
60.00 (%) = 7.177(µm)	150.0 (µm) = 100.000(%)	
70.00 (%) = 8.328(µm)	106.0 (µm) = 100.000(%)	
80.00 (%) = 9.773(µm)	75.00 (µm) = 100.000(%)	

No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %
1	0.115	0.000	0.000	27	3.905	3.013	30.557	53	133.311	0.000	100.000
2	0.131	0.317	0.317	28	4.472	4.147	34.703	54	152.453	0.000	100.000
3	0.150	0.508	0.825	29	5.122	5.534	40.238	55	174.616	0.000	100.000
4	0.172	0.832	1.657	30	5.867	7.011	47.248	56	200.000	0.000	100.000
5	0.197	1.184	2.841	31	6.720	8.331	55.579	57	229.073	0.000	100.000
6	0.226	1.569	4.411	32	7.697	9.125	64.704	58	262.376	0.000	100.000
7	0.259	1.900	6.370	33	8.816	9.113	73.818	59	300.518	0.000	100.000
8	0.296	2.295	8.665	34	10.097	8.139	81.957	60	344.206	0.000	100.000
9	0.339	2.408	11.073	35	11.565	7.132	89.069	61	394.244	0.000	100.000
10	0.389	2.292	13.365	36	13.246	4.973	94.042	62	451.556	0.000	100.000
11	0.445	1.861	15.226	37	15.172	2.998	97.040	63	517.200	0.000	100.000
12	0.510	1.481	16.707	38	17.377	1.744	98.784	64	592.387	0.000	100.000
13	0.584	1.116	17.824	39	19.904	0.793	99.577				
14	0.669	0.814	18.638	40	22.797	0.315	99.892				
15	0.766	0.595	19.233	41	26.111	0.108	100.000				
16	0.877	0.456	19.689	42	29.907	0.000	100.000				
17	1.005	0.369	20.057	43	34.255	0.000	100.000				
18	1.151	0.332	20.389	44	39.234	0.000	100.000				
19	1.318	0.331	20.720	45	44.938	0.000	100.000				
20	1.510	0.363	21.083	46	51.471	0.000	100.000				
21	1.729	0.432	21.515	47	58.953	0.000	100.000				
22	1.981	0.587	22.072	48	67.523	0.000	100.000				
23	2.269	0.759	22.831	49	77.339	0.000	100.000				
24	2.599	1.062	23.893	50	88.383	0.000	100.000				
25	2.976	1.505	25.398	51	101.460	0.000	100.000				
26	3.409	2.146	27.544	52	116.210	0.000	100.000				

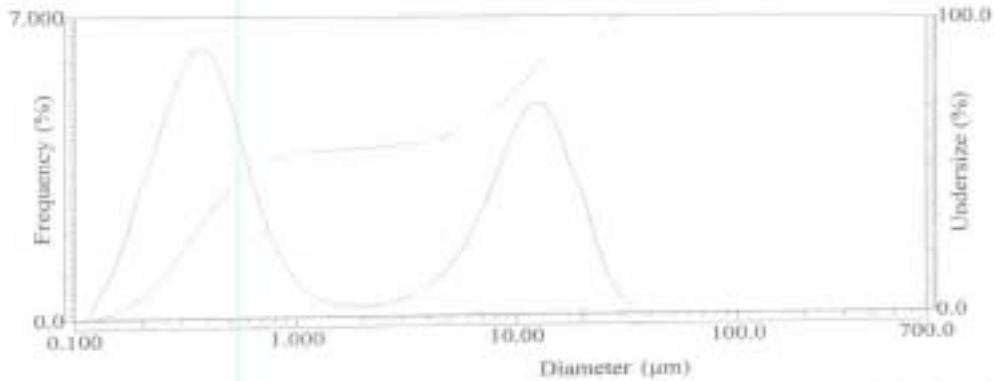
UKH RM Start



S.P. Area : 118798(µm ² /cm ²)	:50.00 (%) = 12.249(µm)	:53.00 (µm) = 100.0
Median : 0.556(µm)	:95.00 (%) = 14.671(µm)	:38.00 (µm) = 100.0
Diameter on %	% on Diameter	Mean : 4.148(µm)
:5.000 (%) = 0.176(µm)	:350.0 (µm) = 100.000(%)	Variance : 28.217
:10.00 (%) = 0.215(µm)	:600.0 (µm) = 100.000(%)	S.D. : 5.312(µm)
:20.00 (%) = 0.282(µm)	:425.0 (µm) = 100.000(%)	Mode : 0.362(µm)
:30.00 (%) = 0.349(µm)	:300.0 (µm) = 100.000(%)	Span : 21.636
:40.00 (%) = 0.429(µm)	:212.0 (µm) = 100.000(%)	
:60.00 (%) = 1.485(µm)	:150.0 (µm) = 100.000(%)	
:70.00 (%) = 6.826(µm)	:106.0 (µm) = 100.000(%)	
:80.00 (%) = 9.324(µm)	:75.00 (µm) = 100.000(%)	

No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %
1	0.115	0.339	0.339	27	3.905	0.655	62.408	53	133.103	0.000	100.000
2	0.131	0.702	1.041	28	4.472	0.957	63.366	54	152.453	0.000	100.000
3	0.150	1.325	2.365	29	5.122	1.385	64.751	55	174.616	0.000	100.000
4	0.172	2.113	4.478	30	5.867	1.999	66.750	56	200.000	0.000	100.000
5	0.197	3.044	7.521	31	6.720	2.821	69.570	57	229.075	0.000	100.000
6	0.226	3.829	11.350	32	7.697	3.709	73.280	58	262.376	0.000	100.000
7	0.259	4.919	16.269	33	8.816	4.593	77.873	59	300.518	0.000	100.000
8	0.296	5.852	22.121	34	10.097	5.149	83.022	60	344.206	0.000	100.000
9	0.339	6.525	28.646	35	11.565	5.111	88.133	61	394.244	0.000	100.000
10	0.389	6.759	35.405	36	13.246	4.412	92.545	62	451.556	0.000	100.000
11	0.445	6.367	41.772	37	15.172	3.262	95.807	63	517.200	0.000	100.000
12	0.510	5.476	47.248	38	17.377	2.054	97.861	64	592.387	0.000	100.000
13	0.584	4.286	51.534	39	19.904	1.325	99.186				
14	0.669	3.062	54.596	40	22.797	0.593	99.778				
15	0.766	2.082	56.678	41	26.111	0.222	100.000				
16	0.877	1.355	58.033	42	29.907	0.000	100.000				
17	1.005	0.838	58.871	43	34.255	0.000	100.000				
18	1.151	0.538	59.409	44	39.234	0.000	100.000				
19	1.318	0.370	59.779	45	44.938	0.000	100.000				
20	1.510	0.253	60.031	46	51.471	0.000	100.000				
21	1.729	0.231	60.263	47	58.953	0.000	100.000				
22	1.981	0.218	60.480	48	67.521	0.000	100.000				
23	2.269	0.226	60.707	49	77.339	0.000	100.000				
24	2.599	0.261	60.968	50	88.583	0.000	100.000				
25	2.976	0.332	61.300	51	101.460	0.000	100.000				
26	3.409	0.454	61.754	52	116.210	0.000	100.000				

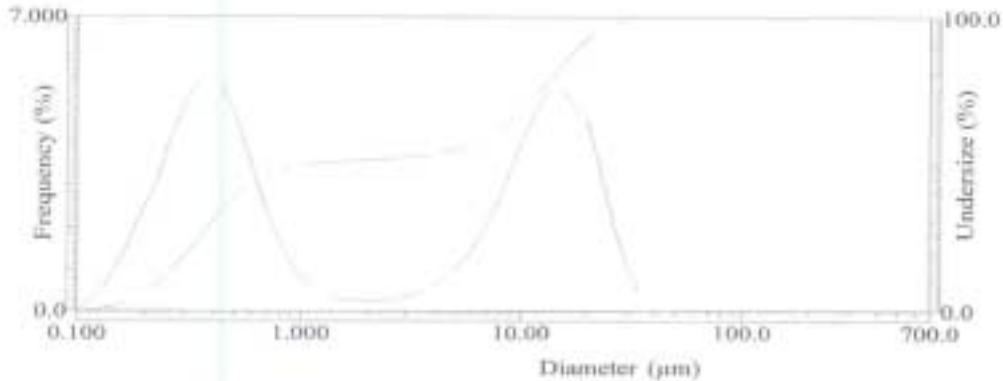
UKH RM Cycle 1



S.P. Area	: 110626(cm ² /cm ³)	:90.00 (%) = 14.947(µm)	:53.00 (µm) = 100.0
Median	: 0.644(µm)	:95.00 (%) = 18.204(µm)	:38.00 (µm) = 100.0
Diameter on %	:5.000 (%) = 0.182(µm)	% on Diameter	:850.0 (µm) = 100.000(%)
	:10.00 (%) = 0.221(µm)		:600.0 (µm) = 100.000(%)
	:20.00 (%) = 0.288(µm)		:425.0 (µm) = 100.000(%)
	:30.00 (%) = 0.359(µm)		:300.0 (µm) = 100.000(%)
	:40.00 (%) = 0.452(µm)		:212.0 (µm) = 100.000(%)
	:60.00 (%) = 4.706(µm)		:150.0 (µm) = 100.000(%)
	:70.00 (%) = 8.331(µm)		:106.0 (µm) = 100.000(%)
	:80.00 (%) = 11.234(µm)		:75.00 (µm) = 100.000(%)
		Mean	: 5.205(µm)
		Variance	: 42.281
		S.D.	: 6.502(µm)
		Mode	: 0.361(µm)
		Span	: 22.875

No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %
1	0.115	0.000	0.000	27	3.905	0.668	58.618	53	133.103	0.000	100.000
2	0.131	0.601	0.601	28	4.472	0.916	59.534	54	152.453	0.000	100.000
3	0.150	1.160	1.761	29	5.122	1.243	60.777	55	174.616	0.000	100.000
4	0.172	1.996	3.756	30	5.867	1.699	62.477	56	200.000	0.000	100.000
5	0.197	3.046	6.802	31	6.720	2.308	64.784	57	229.075	0.000	100.000
6	0.226	3.854	10.657	32	7.697	3.000	67.783	58	262.376	0.000	100.000
7	0.259	4.825	15.482	33	8.816	3.794	71.579	59	300.518	0.000	100.000
8	0.296	5.664	21.146	34	10.097	4.516	76.095	60	344.206	0.000	100.000
9	0.339	6.204	27.350	35	11.565	4.969	81.063	61	394.244	0.000	100.000
10	0.389	6.283	33.636	36	13.246	4.973	86.036	62	451.556	0.000	100.000
11	0.445	5.776	39.412	37	15.172	4.453	90.490	63	517.290	0.000	100.000
12	0.510	4.869	44.281	38	17.377	3.529	94.018	64	592.387	0.000	100.000
13	0.584	3.766	48.047	39	19.904	2.868	96.886				
14	0.669	2.714	50.761	40	22.797	1.720	98.606				
15	0.766	1.881	52.642	41	26.111	0.868	99.473				
16	0.877	1.266	53.908	42	29.907	0.378	99.852				
17	1.005	0.817	54.725	43	34.255	0.148	100.000				
18	1.151	0.552	55.277	44	39.234	0.000	100.000				
19	1.318	0.399	55.676	45	44.938	0.000	100.000				
20	1.510	0.290	55.966	46	51.471	0.000	100.000				
21	1.729	0.272	56.239	47	58.953	0.000	100.000				
22	1.981	0.261	56.500	48	67.523	0.000	100.000				
23	2.269	0.271	56.771	49	77.339	0.000	100.000				
24	2.599	0.308	57.079	50	88.583	0.000	100.000				
25	2.976	0.379	57.458	51	101.460	0.000	100.000				
26	3.409	0.492	57.950	52	116.210	0.000	100.000				

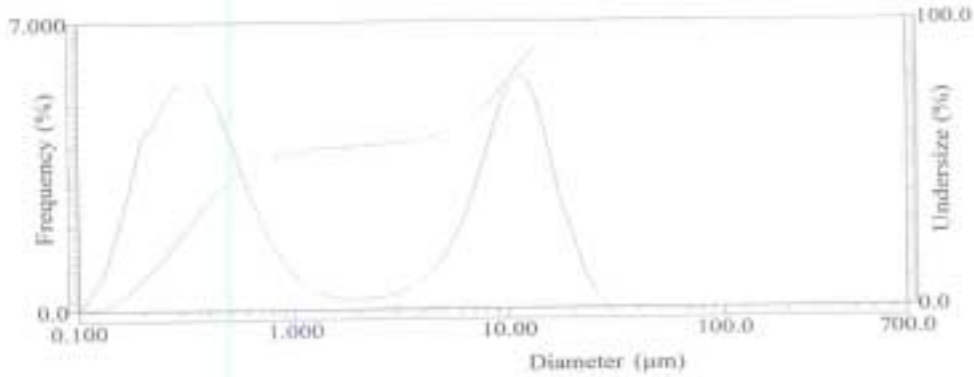
UKH RM Cycle 2



S.P. Area	: 99190(µm ² /cm ²)	:90.00 (%) = 18.367(µm)	:55.00 (µm) = 100.0
Median	: 1.147(µm)	:95.00 (%) = 21.834(µm)	:38.00 (µm) = 99.95
Diameter on %	:5.000 (%) = 0.185(µm)	% on Diameter	:850.0 (µm) = 100.000(%)
	:10.00 (%) = 0.232(µm)		:600.0 (µm) = 100.000(%)
	:20.00 (%) = 0.312(µm)		:425.0 (µm) = 100.000(%)
	:30.00 (%) = 0.399(µm)		:300.0 (µm) = 100.000(%)
	:40.00 (%) = 0.528(µm)		:212.0 (µm) = 100.000(%)
	:60.00 (%) = 0.738(µm)		:150.0 (µm) = 100.000(%)
	:70.00 (%) = 10.681(µm)		:106.0 (µm) = 100.000(%)
	:80.00 (%) = 13.944(µm)		:75.00 (µm) = 100.000(%)
		Mean	: 6.706(µm)
		Variance	: 61.295
		S.D.	: 7.829(µm)
		Mode	: 0.363(µm)
		Span	: 15.810

No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %
1	0.115	0.300	0.300	27	3.903	0.584	51.093	53	132.103	0.000	100.000
2	0.131	0.599	0.899	28	4.472	0.786	53.879	54	152.453	0.000	100.000
3	0.150	1.094	1.994	29	5.122	1.048	54.927	55	174.616	0.000	100.000
4	0.172	1.705	3.699	30	5.867	1.414	56.340	56	200.900	0.000	100.000
5	0.197	2.421	6.120	31	6.720	1.913	58.253	57	229.075	0.000	100.000
6	0.226	3.075	9.194	32	7.697	2.507	60.761	58	262.376	0.000	100.000
7	0.259	3.998	13.192	33	8.816	3.244	64.004	59	300.518	0.000	100.000
8	0.296	4.788	17.980	34	10.097	4.031	68.035	60	344.206	0.000	100.000
9	0.339	5.385	23.365	35	11.565	4.743	72.778	61	394.244	0.000	100.000
10	0.389	5.830	28.995	36	13.246	5.215	77.993	62	451.556	0.000	100.000
11	0.445	5.368	34.363	37	15.172	5.279	83.272	63	517.200	0.000	100.000
12	0.510	4.679	39.041	38	17.377	4.859	88.130	64	592.387	0.000	100.000
13	0.584	3.718	42.760	39	19.904	4.582	92.713				
14	0.669	2.718	45.477	40	22.797	3.353	96.066				
15	0.766	1.896	47.373	41	26.111	2.086	98.152				
16	0.877	1.274	48.647	42	29.907	1.114	99.267				
17	1.005	0.818	49.465	43	34.253	0.521	99.787				
18	1.151	0.548	50.014	44	39.234	0.213	100.000				
19	1.318	0.342	50.405	45	44.938	0.000	100.000				
20	1.510	0.279	50.685	46	51.471	0.000	100.000				
21	1.729	0.260	50.944	47	58.953	0.000	100.000				
22	1.981	0.246	51.190	48	67.523	0.000	100.000				
23	2.269	0.253	51.444	49	77.339	0.000	100.000				
24	2.599	0.284	51.727	50	88.583	0.000	100.000				
25	2.976	0.343	52.071	51	101.460	0.000	100.000				
26	3.409	0.439	52.509	52	116.210	0.000	100.000				

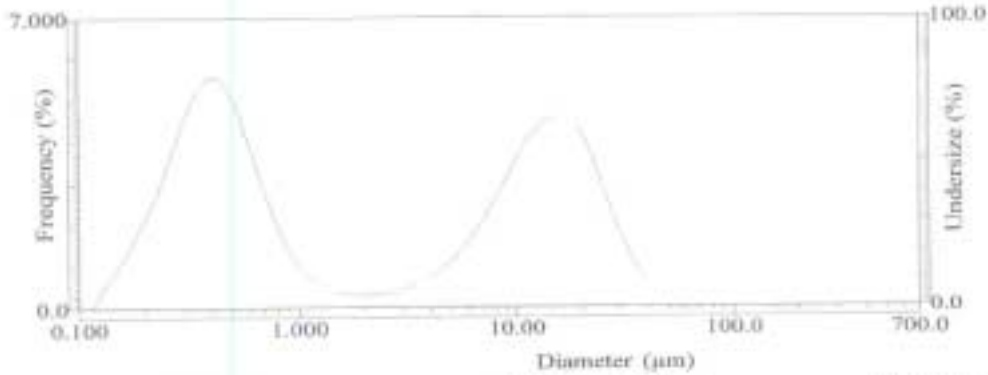
UKH RM Cycle 3



S.P. Area	: 121638($\mu\text{m}^2/\text{cm}^2$)	:90.00 (%) = 13.114(μm)	:53.00 (μm) = 100.0
Median	: 0.622(μm)	:95.00 (%) = 15.606(μm)	:38.00 (μm) = 100.0
Diameter on %	:5.000 (%) = 0.163(μm)	% on Diameter :850.0 (μm) = 100.000(%)	Mean : 4.666(μm)
	:10.00 (%) = 0.195(μm)	:600.0 (μm) = 100.000(%)	Variance : 31.973
	:20.00 (%) = 0.258(μm)	:425.0 (μm) = 100.000(%)	S.D. : 5.654(μm)
	:30.00 (%) = 0.329(μm)	:300.0 (μm) = 100.000(%)	Mode : 10.776(μm)
	:40.00 (%) = 0.425(μm)	:212.0 (μm) = 100.000(%)	Span : 20.760
	:60.00 (%) = 4.598(μm)	:150.0 (μm) = 100.000(%)	
	:70.00 (%) = 7.837(μm)	:106.0 (μm) = 100.000(%)	
	:80.00 (%) = 10.224(μm)	:75.00 (μm) = 100.000(%)	

No.	Diameter	Freq.	% Under	No.	Diameter	Freq.	% Under	No.	Diameter	Freq.	% Under
1	0.135	0.415	0.415	27	3.905	0.677	58.729	53	133.103	0.000	100.000
2	0.131	0.921	1.336	28	4.472	0.963	59.722	54	152.453	0.000	100.000
3	0.150	1.838	3.174	29	3.122	1.355	61.077	55	174.616	0.000	100.000
4	0.172	2.951	6.125	30	5.867	1.932	63.009	56	200.000	0.000	100.000
5	0.197	4.163	10.288	31	6.720	2.726	65.735	57	229.075	0.000	100.000
6	0.226	4.596	14.884	32	7.697	3.645	69.380	58	262.376	0.000	100.000
7	0.259	5.146	20.031	33	8.816	4.650	74.030	59	300.518	0.000	100.000
8	0.296	5.554	25.585	34	10.097	5.445	79.475	60	344.206	0.000	100.000
9	0.339	5.684	31.268	35	11.565	5.699	85.175	61	394.244	0.000	100.000
10	0.389	5.481	36.749	36	13.246	5.209	90.384	62	451.556	0.000	100.000
11	0.445	4.880	41.629	37	15.172	4.062	94.446	63	517.200	0.000	100.000
12	0.510	4.069	45.697	38	17.377	2.665	97.111	64	592.387	0.000	100.000
13	0.584	3.185	48.882	39	19.904	1.795	98.905				
14	0.669	2.379	51.261	40	22.797	0.804	99.710				
15	0.766	1.703	52.964	41	26.111	0.290	100.000				
16	0.877	1.182	54.147	42	29.907	0.000	100.000				
17	1.005	0.785	54.932	43	34.255	0.000	100.000				
18	1.151	0.541	55.473	44	39.234	0.000	100.000				
19	1.318	0.394	55.867	45	44.938	0.000	100.000				
20	1.510	0.287	56.154	46	51.471	0.000	100.000				
21	1.729	0.266	56.420	47	58.953	0.000	100.000				
22	1.981	0.253	56.673	48	67.523	0.000	100.000				
23	2.269	0.261	56.934	49	77.339	0.000	100.000				
24	2.599	0.296	57.230	50	88.583	0.000	100.000				
25	2.976	0.367	57.597	51	101.460	0.000	100.000				
26	3.409	0.485	58.082	52	116.210	0.000	100.000				

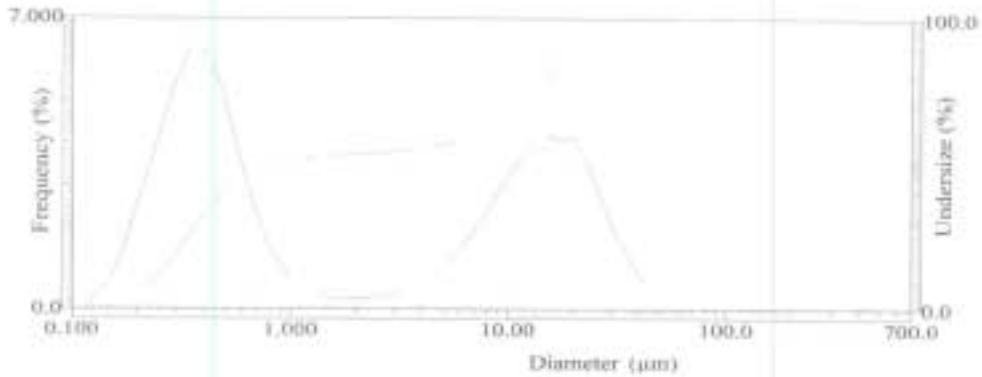
UKH RM Cycle 4



S.P. Area	: 93480(cm ² /cm ³)	:90.00 (%) = 20.261(µm)	:53.00 (µm) = 99.91
Median	: 1.362(µm)	:95.00 (%) = 25.242(µm)	:38.00 (µm) = 99.11
Diameter on %	:5.000 (%) = 0.196(µm)	% on Diameter :850.0 (µm) = 100.000(%)	Mean : 7.335(µm)
	:10.00 (%) = 0.245(µm)	:600.0 (µm) = 100.000(%)	Variance : 83.491
	:20.00 (%) = 0.330(µm)	:425.0 (µm) = 100.000(%)	S.D. : 9.137(µm)
	:30.00 (%) = 0.422(µm)	:300.0 (µm) = 100.000(%)	Mode : 0.365(µm)
	:40.00 (%) = 0.563(µm)	:212.0 (µm) = 100.000(%)	Span : 14.691
	:60.00 (%) = 7.231(µm)	:150.0 (µm) = 100.000(%)	
	:70.00 (%) = 10.855(µm)	:106.0 (µm) = 100.000(%)	
	:80.00 (%) = 14.750(µm)	:75.00 (µm) = 100.000(%)	

No.	Diameter	Freq.	% Under	No.	Diameter	Freq.	% Under	No.	Diameter	Freq.	% Under
1	0.115	0.000	0.000	27	3.905	0.682	53.145	53	133.103	0.000	100.000
2	0.131	0.538	0.538	28	4.472	0.895	54.040	54	152.453	0.000	100.000
3	0.150	0.970	1.508	29	5.122	1.162	55.202	55	174.616	0.000	100.000
4	0.172	1.489	2.997	30	5.867	1.511	56.713	56	200.000	0.000	100.000
5	0.197	2.099	5.096	31	6.720	1.961	58.673	57	229.075	0.000	100.000
6	0.226	2.713	7.809	32	7.697	2.457	61.131	58	262.376	0.000	100.000
7	0.259	3.626	11.435	33	8.816	3.041	64.171	59	300.518	0.000	100.000
8	0.296	4.462	15.897	34	10.097	3.626	67.798	60	344.206	0.000	100.000
9	0.339	5.158	21.055	35	11.565	4.131	71.929	61	394.244	0.000	100.000
10	0.389	5.563	26.619	36	13.246	4.467	76.396	62	451.556	0.000	100.000
11	0.445	5.486	32.105	37	15.172	4.549	80.945	63	517.200	0.000	100.000
12	0.510	4.945	37.050	38	17.377	4.350	85.295	64	592.387	0.000	100.000
13	0.584	4.058	41.108	39	19.904	4.246	89.541				
14	0.669	3.047	44.155	40	22.797	3.502	93.043				
15	0.766	2.176	46.330	41	26.111	2.608	95.650				
16	0.877	1.491	47.821	42	29.907	1.786	97.436				
17	1.005	0.969	48.790	43	34.255	1.150	98.586				
18	1.151	0.656	49.446	44	39.234	0.695	99.281				
19	1.318	0.472	49.918	45	44.938	0.392	99.673				
20	1.510	0.338	50.256	46	51.471	0.213	99.887				
21	1.729	0.316	50.572	47	58.951	0.113	100.000				
22	1.981	0.300	50.872	48	67.523	0.000	100.000				
23	2.269	0.309	51.181	49	77.339	0.000	100.000				
24	2.599	0.345	51.526	50	88.583	0.000	100.000				
25	2.976	0.414	51.940	51	101.440	0.000	100.000				
26	3.409	0.522	52.463	52	116.210	0.000	100.000				

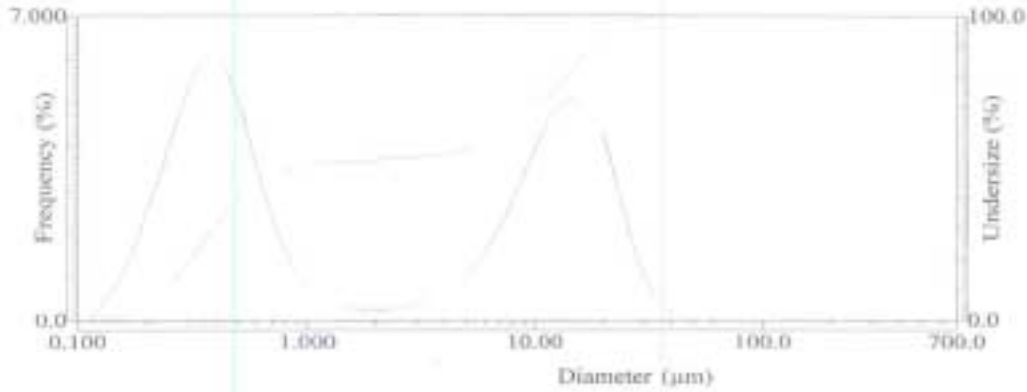
UKH 1 Start



S.P. Area	100920(cm ² /cm ³)	:90.00 (%) = 21.277(µm)	:53.00 (µm) = 99.86
Median	0.814(µm)	:95.00 (%) = 26.810(µm)	:58.00 (µm) = 98.75
Diameter on %	:5.000 (%) = 0.196(µm)	% on Diameter	:50.0 (µm) = 100.000(%)
	:10.00 (%) = 0.236(µm)		:600.0 (µm) = 100.000(%)
	:20.00 (%) = 0.305(µm)		:425.0 (µm) = 100.000(%)
	:30.00 (%) = 0.379(µm)		:300.0 (µm) = 100.000(%)
	:40.00 (%) = 0.485(µm)		:212.0 (µm) = 100.000(%)
	:60.00 (%) = 6.704(µm)		:150.0 (µm) = 100.000(%)
	:70.00 (%) = 10.793(µm)		:106.0 (µm) = 100.000(%)
	:80.00 (%) = 15.142(µm)		:75.00 (µm) = 100.000(%)
		Mean	: 7.422(µm)
		Variance	: 93.964
		S.D.	: 9.693(µm)
		Mode	: 0.361(µm)
		Span	: 25.850

No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %
1	0.115	0.000	0.000	27	3.905	0.618	55.004	53	133.103	0.000	100.000
2	0.131	0.401	0.401	28	4.472	0.814	55.818	54	152.453	0.000	100.000
3	0.150	0.761	1.162	29	5.122	1.061	56.880	55	174.616	0.000	100.000
4	0.172	1.469	2.631	30	5.867	1.377	58.257	56	200.000	0.000	100.000
5	0.197	2.489	5.119	31	6.720	1.774	60.031	57	229.075	0.000	100.000
6	0.226	3.463	8.583	32	7.697	2.208	62.239	58	262.376	0.000	100.000
7	0.259	4.528	13.111	33	8.816	2.718	64.957	59	300.518	0.000	100.000
8	0.296	5.529	18.640	34	10.097	3.232	68.189	60	344.206	0.000	100.000
9	0.339	6.203	24.843	35	11.565	3.688	71.877	61	394.244	0.000	100.000
10	0.389	6.330	31.172	36	13.246	4.020	75.897	62	451.556	0.000	100.000
11	0.445	5.770	36.942	37	15.172	4.164	80.061	63	517.200	0.000	100.000
12	0.510	4.774	41.716	38	17.377	4.091	84.153	64	592.387	0.000	100.000
13	0.584	3.586	45.303	39	19.904	4.102	88.255				
14	0.669	2.499	47.802	40	22.797	3.549	91.804				
15	0.766	1.695	49.498	41	26.113	2.799	94.603				
16	0.877	1.124	50.621	42	29.907	2.043	96.646				
17	1.005	0.723	51.344	43	34.255	1.409	98.055				
18	1.151	0.492	51.836	44	39.254	0.910	98.965				
19	1.318	0.362	52.199	45	44.938	0.548	99.512				
20	1.510	0.271	52.469	46	51.471	0.314	99.827				
21	1.729	0.260	52.729	47	58.953	0.173	100.000				
22	1.981	0.252	52.981	48	67.523	0.000	100.000				
23	2.269	0.265	53.246	49	77.339	0.000	100.000				
24	2.599	0.302	53.547	50	88.583	0.000	100.000				
25	2.978	0.369	53.916	51	101.460	0.000	100.000				
26	3.409	0.470	54.386	52	116.210	0.000	100.000				

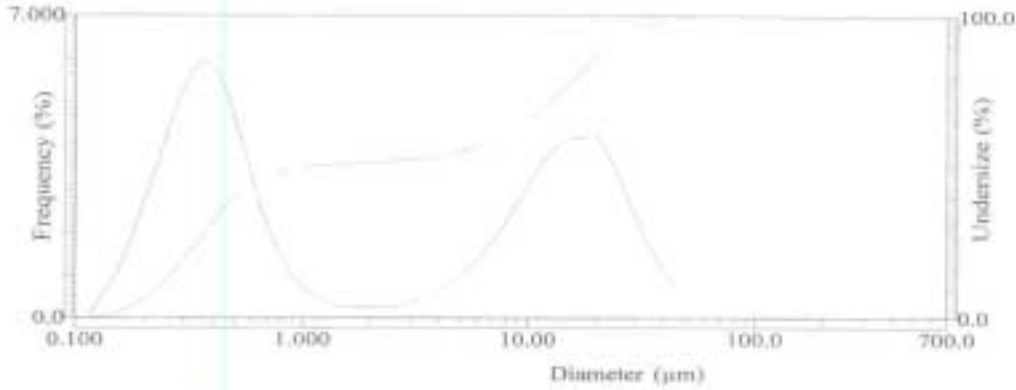
UKH 1 Cycle 1



S.P. Area	: 99413 (µm²/cm²)	:90.00 (%) = 18.066(µm)	:53.00 (µm) = 100.0
Median	: 0.342(µm)	:95.00 (%) = 21.624(µm)	:38.00 (µm) = 99.95
Diameter on %	-5.000 (%) = 0.195(µm)	% on Diameter	:850.0 (µm) = 100.000(%)
	-10.00 (%) = 0.237(µm)		:600.0 (µm) = 100.000(%)
	-20.00 (%) = 0.310(µm)		:425.0 (µm) = 100.000(%)
	-30.00 (%) = 0.389(µm)		:300.0 (µm) = 100.000(%)
	-40.00 (%) = 0.501(µm)		:212.0 (µm) = 100.000(%)
	-60.00 (%) = 6.834(µm)		:150.0 (µm) = 100.000(%)
	-70.00 (%) = 10.249(µm)		:106.0 (µm) = 100.000(%)
	-80.00 (%) = 13.557(µm)		:75.00 (µm) = 100.000(%)
		Mean	: 6.473(µm)
		Variance	: 39.854
		S.D.	: 7.737(µm)
		Mode	: 0.362(µm)
		Span	: 20.224

No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %
1	0.115	0.000	0.000	27	1.905	0.807	54.334	53	133.103	0.000	100.000
2	0.131	0.468	0.468	28	4.472	0.819	55.153	54	152.453	0.000	100.000
3	0.150	0.865	1.333	29	5.122	1.093	56.246	55	174.616	0.000	100.000
4	0.172	1.515	2.848	30	5.867	1.468	57.714	56	200.000	0.000	100.000
5	0.197	2.379	5.227	31	6.720	1.970	59.684	57	229.075	0.000	100.000
6	0.226	3.228	8.455	32	7.697	2.552	62.236	58	262.376	0.000	100.000
7	0.259	4.276	12.731	33	8.816	3.260	65.497	59	300.518	0.000	100.000
8	0.296	5.222	17.952	34	10.097	3.993	69.490	60	344.206	0.000	100.000
9	0.339	5.911	23.864	35	11.565	4.630	74.120	61	394.244	0.000	100.000
10	0.389	6.135	29.999	36	13.246	5.022	79.142	62	451.556	0.000	100.000
11	0.445	5.732	35.731	37	15.172	5.029	84.171	63	517.200	0.000	100.000
12	0.510	4.863	40.594	38	17.377	4.596	88.767	64	592.387	0.000	100.000
13	0.584	3.739	44.333	39	19.904	4.305	93.072				
14	0.669	2.644	46.976	40	22.797	3.157	96.229				
15	0.766	1.803	48.779	41	26.111	1.979	98.208				
16	0.877	1.194	49.973	42	29.907	1.071	99.279				
17	1.005	0.761	50.734	43	34.235	0.589	99.788				
18	1.151	0.511	51.245	44	39.234	0.212	100.000				
19	1.318	0.369	51.613	45	44.938	0.000	100.000				
20	1.510	0.268	51.881	46	51.471	0.000	100.000				
21	1.729	0.253	52.135	47	58.953	0.000	100.000				
22	1.981	0.243	52.378	48	67.523	0.000	100.000				
23	2.269	0.254	52.632	49	77.339	0.000	100.000				
24	2.599	0.288	52.920	50	88.583	0.000	100.000				
25	2.976	0.353	53.272	51	101.460	0.000	100.000				
26	3.409	0.454	53.726	52	116.210	0.000	100.000				

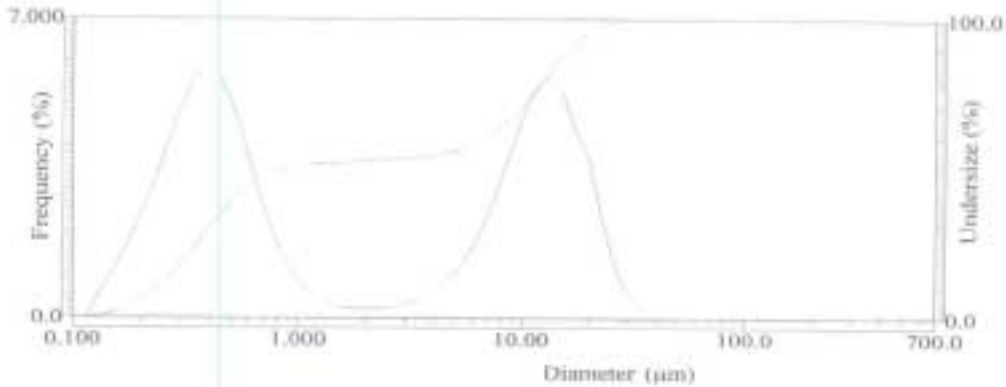
UKH 1 Cycle 2



S.P. Area	: 100598(µm² /cm²)	:90.00 (%) = 22.607(µm)	:53.00 (µm) = 99.66
Median	: 0.980(µm)	:95.00 (%) = 28.801(µm)	:38.00 (µm) = 98.18
Diameter on %	:5.000 (%) = 0.189(µm)	% on Diameter	:850.0 (µm) = 100.000(%)
	:10.00 (%) = 0.231(µm)		:600.0 (µm) = 100.000(%)
	:20.00 (%) = 0.303(µm)		:425.0 (µm) = 100.000(%)
	:30.00 (%) = 0.381(µm)		:300.0 (µm) = 100.000(%)
	:40.00 (%) = 0.497(µm)		:212.0 (µm) = 100.000(%)
	:50.00 (%) = 0.7468(µm)		:150.0 (µm) = 100.000(%)
	:70.00 (%) = 11.638(µm)		:106.0 (µm) = 100.000(%)
	:80.00 (%) = 16.197(µm)		:75.00 (µm) = 100.000(%)
		Mean:	: 8.077(µm)
		Variance:	: 109.413
		S.D.:	: 10.460(µm)
		Mode:	: 0.361(µm)
		Span:	: 22.836

No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %
1	0.115	0.000	0.000	27	1.905	0.583	33.602	53	133.103	0.000	100.000
2	0.131	0.569	0.569	28	4.472	0.769	54.371	54	152.453	0.000	100.000
3	0.150	0.965	1.474	29	5.122	1.003	55.374	55	174.616	0.000	100.000
4	0.172	1.689	3.163	30	5.867	1.303	56.676	56	200.000	0.000	100.000
5	0.197	2.634	5.797	31	6.720	1.685	58.362	57	229.075	0.000	100.000
6	0.226	3.471	9.268	32	7.697	2.108	60.469	58	262.376	0.000	100.000
7	0.259	4.468	13.737	33	8.816	2.610	63.079	59	300.518	0.000	100.000
8	0.296	5.318	19.055	34	10.097	3.129	66.208	60	344.206	0.000	100.000
9	0.339	5.876	24.931	35	11.565	3.607	69.813	61	394.244	0.000	100.000
10	0.389	5.955	30.886	36	13.246	3.980	73.796	62	451.556	0.000	100.000
11	0.445	5.439	36.325	37	15.172	4.186	77.982	63	517.209	0.000	100.000
12	0.510	4.525	40.850	38	17.377	4.188	82.170	64	592.387	0.000	100.000
13	0.584	3.429	44.279	39	19.904	4.273	86.442				
14	0.669	2.415	46.694	40	22.797	3.791	90.233				
15	0.766	1.643	48.337	41	26.111	3.082	93.315				
16	0.877	1.091	49.428	42	29.907	2.332	95.647				
17	1.005	0.702	50.130	43	34.255	1.675	97.323				
18	1.151	0.476	50.606	44	39.234	1.133	98.456				
19	1.318	0.348	50.954	45	44.938	0.717	99.173				
20	1.510	0.256	51.210	46	51.471	0.433	99.607				
21	1.729	0.245	51.455	47	58.953	0.251	99.858				
22	1.981	0.238	51.693	48	67.523	0.142	100.000				
23	2.269	0.250	51.943	49	77.339	0.000	100.000				
24	2.599	0.284	52.228	50	88.583	0.000	100.000				
25	2.976	0.347	52.575	51	101.460	0.000	100.000				
26	3.409	0.443	53.018	52	116.210	0.000	100.000				

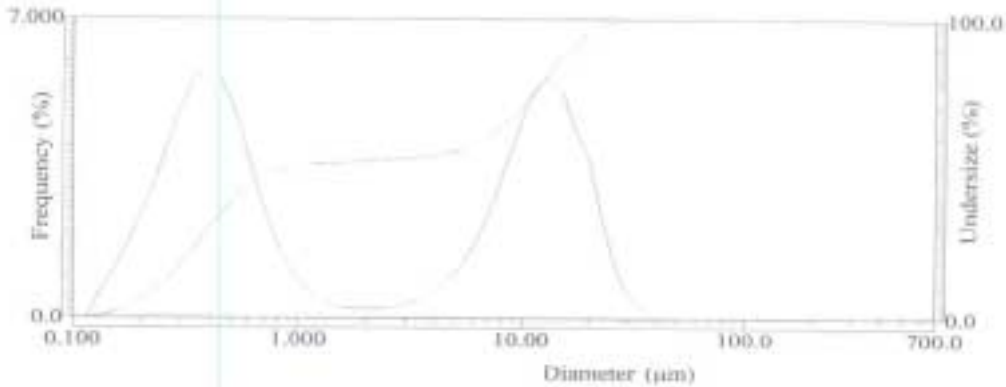
UKH 1 Cycle # 5



S.P. Area	99296(cm ² /cm ³)	:90.00 (%) = 16.438(µm)	:53.00 (µm) = 100.0
Median	0.910(µm)	:95.00 (%) = 19.501(µm)	:58.00 (µm) = 100.0
Diameter on %	-5.000 (%) = 0.189(µm)	% on Diameter	:850.0 (µm) = 100.000(%)
	:10.00 (%) = 0.235(µm)		:600.0 (µm) = 100.000(%)
	:20.00 (%) = 0.314(µm)		:425.0 (µm) = 100.000(%)
	:30.00 (%) = 0.398(µm)		:300.0 (µm) = 100.000(%)
	:40.00 (%) = 0.516(µm)		:212.0 (µm) = 100.000(%)
	:60.00 (%) = 0.848(µm)		:150.0 (µm) = 100.000(%)
	:70.00 (%) = 0.798(µm)		:106.0 (µm) = 100.000(%)
	:80.00 (%) = 12.594(µm)		:75.00 (µm) = 100.000(%)
		Mean	: 6.043(µm)
		Variance	: 49.091
		S.D.	: 7.006(µm)
		Mode	: 0.364(µm)
		Span	: 17.798

No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %
1	0.115	0.000	0.000	27	3.905	0.563	54.002	53	122.103	0.000	100.000
2	0.131	0.592	0.592	28	4.472	0.790	54.792	54	152.453	0.000	100.000
3	0.150	1.078	1.670	29	5.122	1.095	55.887	55	174.616	0.000	100.000
4	0.172	1.679	3.349	30	5.867	1.582	57.430	56	200.000	0.000	100.000
5	0.197	2.389	5.738	31	6.720	2.166	59.595	57	229.075	0.000	100.000
6	0.226	3.055	8.793	32	7.697	2.914	62.509	58	262.376	0.000	100.000
7	0.259	4.017	12.814	33	8.816	3.818	66.328	59	305.518	0.000	100.000
8	0.296	4.865	17.679	34	10.097	4.719	71.046	60	344.206	0.000	100.000
9	0.339	5.529	23.208	35	11.565	5.405	76.451	61	394.244	0.000	100.000
10	0.389	5.845	29.053	36	13.246	5.648	82.100	62	451.556	0.000	100.000
11	0.445	5.631	34.684	37	15.172	5.298	87.397	63	517.200	0.000	100.000
12	0.510	4.950	39.634	38	17.377	4.408	91.805	64	592.387	0.000	100.000
13	0.584	3.955	43.589	39	19.904	3.761	95.566				
14	0.669	2.876	46.465	40	22.797	2.376	97.943				
15	0.766	1.991	48.456	41	26.111	1.258	99.200				
16	0.877	1.319	49.774	42	29.907	0.570	99.771				
17	1.005	0.829	50.603	43	34.255	0.229	100.000				
18	1.151	0.541	51.144	44	39.234	0.000	100.000				
19	1.318	0.376	51.520	45	44.938	0.000	100.000				
20	1.510	0.260	51.780	46	51.471	0.000	100.000				
21	1.729	0.237	52.017	47	58.953	0.000	100.000				
22	1.981	0.221	52.238	48	67.523	0.000	100.000				
23	2.269	0.226	52.464	49	77.339	0.000	100.000				
24	2.599	0.254	52.718	50	88.583	0.000	100.000				
25	2.976	0.312	53.030	51	101.469	0.000	100.000				
26	3.409	0.409	53.439	52	116.210	0.000	100.000				

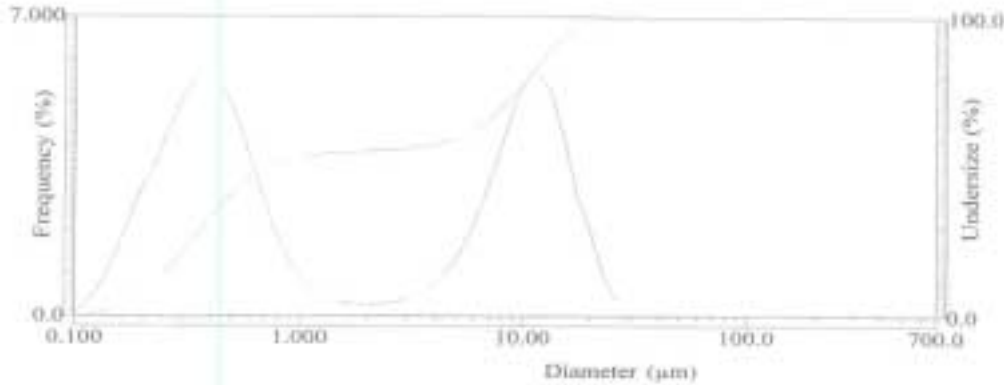
UKH 1 Cycle # 5



S.P. Area	99296(cm ² /cm ³)	:90.00 (%) = 16.438(µm)	:53.00 (µm) = 100.0
Median	0.910(µm)	:95.00 (%) = 19.501(µm)	:58.00 (µm) = 100.0
Diameter on %	-5.000 (%) = 0.189(µm)	% on Diameter	:850.0 (µm) = 100.000(%)
	:10.00 (%) = 0.235(µm)		:600.0 (µm) = 100.000(%)
	:20.00 (%) = 0.314(µm)		:425.0 (µm) = 100.000(%)
	:30.00 (%) = 0.398(µm)		:300.0 (µm) = 100.000(%)
	:40.00 (%) = 0.516(µm)		:212.0 (µm) = 100.000(%)
	:60.00 (%) = 0.848(µm)		:150.0 (µm) = 100.000(%)
	:70.00 (%) = 0.798(µm)		:106.0 (µm) = 100.000(%)
	:80.00 (%) = 12.594(µm)		:75.00 (µm) = 100.000(%)
		Mean	: 6.043(µm)
		Variance	: 49.091
		S.D.	: 7.006(µm)
		Mode	: 0.364(µm)
		Span	: 17.798

No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %
1	0.115	0.000	0.000	27	3.905	0.563	54.002	53	122.103	0.000	100.000
2	0.131	0.592	0.592	28	4.472	0.790	54.792	54	152.453	0.000	100.000
3	0.150	1.078	1.670	29	5.122	1.095	55.887	55	174.616	0.000	100.000
4	0.172	1.679	3.349	30	5.867	1.582	57.430	56	200.000	0.000	100.000
5	0.197	2.389	5.738	31	6.720	2.166	59.595	57	229.075	0.000	100.000
6	0.226	3.055	8.793	32	7.697	2.914	62.509	58	262.376	0.000	100.000
7	0.259	4.017	12.814	33	8.816	3.818	66.328	59	305.518	0.000	100.000
8	0.296	4.865	17.679	34	10.097	4.719	71.046	60	344.206	0.000	100.000
9	0.339	5.529	23.208	35	11.565	5.405	76.451	61	394.244	0.000	100.000
10	0.389	5.845	29.053	36	13.246	5.648	82.100	62	451.556	0.000	100.000
11	0.445	5.631	34.684	37	15.172	5.298	87.397	63	517.200	0.000	100.000
12	0.510	4.950	39.634	38	17.377	4.408	91.805	64	592.387	0.000	100.000
13	0.584	3.955	43.589	39	19.904	3.761	95.566				
14	0.669	2.876	46.465	40	22.797	2.376	97.943				
15	0.766	1.991	48.456	41	26.111	1.258	99.200				
16	0.877	1.319	49.774	42	29.907	0.570	99.771				
17	1.005	0.829	50.603	43	34.255	0.229	100.000				
18	1.151	0.541	51.144	44	39.234	0.000	100.000				
19	1.318	0.376	51.520	45	44.938	0.000	100.000				
20	1.510	0.260	51.780	46	51.471	0.000	100.000				
21	1.729	0.237	52.017	47	58.953	0.000	100.000				
22	1.981	0.221	52.238	48	67.523	0.000	100.000				
23	2.269	0.226	52.464	49	77.339	0.000	100.000				
24	2.599	0.254	52.718	50	88.583	0.000	100.000				
25	2.976	0.312	53.030	51	101.469	0.000	100.000				
26	3.409	0.409	53.439	52	116.210	0.000	100.000				

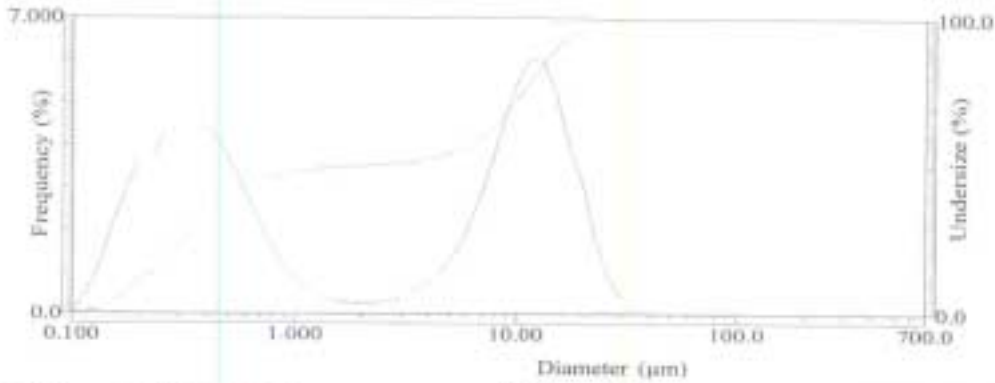
UKH 1 Cycle 4



S.P. Area	: 109570(cmf /cm²)	:90.00 (%) = 13.491(µm)	:53.00 (µm) = 100.0
Median	: 0.722(µm)	:95.00 (%) = 16.178(µm)	:38.00 (µm) = 100.0
Diameter on %	:5.000 (%) = 0.175(µm)	% on Diameter	:850.0 (µm) = 100.000(%)
	:10.00 (%) = 0.216(µm)		:600.0 (µm) = 100.000(%)
	:20.00 (%) = 0.292(µm)		:425.0 (µm) = 100.000(%)
	:30.00 (%) = 0.372(µm)		:300.0 (µm) = 100.000(%)
	:40.00 (%) = 0.481(µm)		:212.0 (µm) = 100.000(%)
	:60.00 (%) = 5.218(µm)		:150.0 (µm) = 100.000(%)
	:70.00 (%) = 8.099(µm)		:106.0 (µm) = 100.000(%)
	:80.00 (%) = 10.484(µm)		:75.00 (µm) = 100.000(%)
		Mean	: 4.905(µm)
		Variance	: 33.924
		S.D.	: 5.824(µm)
		Mode	: 10.782(µm)
		Span	: 18.382

No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %
1	0.115	0.361	0.361	27	3.905	0.704	57.323	53	133.103	0.000	100.000
2	0.131	0.753	1.114	28	4.472	1.000	58.323	54	152.453	0.000	100.000
3	0.150	1.418	2.532	29	5.122	1.406	59.729	55	174.616	0.000	100.000
4	0.172	2.161	4.693	30	5.867	1.995	61.724	56	200.000	0.000	100.000
5	0.197	2.977	7.670	31	6.720	2.798	64.522	57	229.075	0.000	100.000
6	0.226	3.530	11.200	32	7.697	3.713	68.235	58	262.378	0.000	100.000
7	0.259	4.347	15.546	33	8.816	4.702	72.937	59	300.518	0.000	100.000
8	0.296	5.040	20.586	34	10.097	5.477	78.414	60	344.208	0.000	100.000
9	0.339	5.530	26.116	35	11.565	6.373	84.147	61	394.244	0.000	100.000
10	0.389	5.709	31.825	36	13.246	7.286	89.433	62	451.556	0.000	100.000
11	0.445	5.429	37.254	37	15.172	8.211	93.644	63	517.200	0.000	100.000
12	0.510	4.776	42.030	38	17.377	8.868	96.512	64	592.387	0.000	100.000
13	0.584	3.876	45.906	39	19.904	8.203	98.514				
14	0.669	2.915	48.821	40	22.797	6.968	99.482				
15	0.766	2.082	50.903	41	26.111	5.386	99.868				
16	0.877	1.425	52.328	42	29.907	4.152	100.000				
17	1.005	0.922	53.250	43	34.255	3.000	100.000				
18	1.151	0.617	53.866	44	39.234	2.000	100.000				
19	1.318	0.436	54.302	45	44.938	1.000	100.000				
20	1.510	0.307	54.610	46	51.471	0.000	100.000				
21	1.729	0.281	54.891	47	58.953	0.000	100.000				
22	1.981	0.264	55.155	48	67.523	0.000	100.000				
23	2.269	0.272	55.427	49	77.339	0.000	100.000				
24	2.599	0.307	55.734	50	88.583	0.000	100.000				
25	2.976	0.381	56.115	51	101.460	0.000	100.000				
26	3.409	0.504	56.619	52	116.210	0.000	100.000				

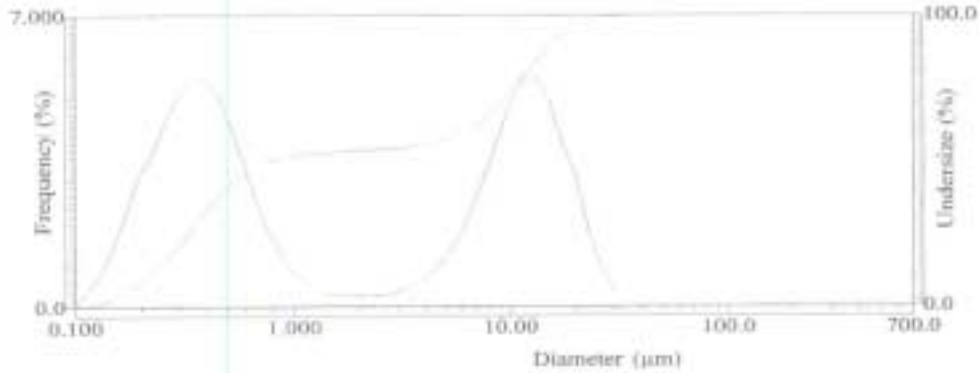
UKH 2 Start



S.P. Area	: 109420 (cm² / cm³)	:90.00 (%) = 15.331 (µm)	:53.00 (µm) = 100.0
Median	: 2.018 (µm)	:95.00 (%) = 18.413 (µm)	:38.00 (µm) = 100.0
Diameter on %	:5.000 (%) = 0.160 (µm)	% on Diameter	:850.0 (µm) = 100.000 (%)
	:10.00 (%) = 0.195 (µm)		:600.0 (µm) = 100.000 (%)
	:20.00 (%) = 0.273 (µm)		:425.0 (µm) = 100.000 (%)
	:30.00 (%) = 0.369 (µm)		:300.0 (µm) = 100.000 (%)
	:40.00 (%) = 0.525 (µm)		:212.0 (µm) = 100.000 (%)
	:60.00 (%) = 7.007 (µm)		:150.0 (µm) = 100.000 (%)
	:70.00 (%) = 9.483 (µm)		:106.0 (µm) = 100.000 (%)
	:80.00 (%) = 11.950 (µm)		:75.00 (µm) = 100.000 (%)
		Mean	: 5.885 (µm)
		Variance	: 43.366
		S.D.	: 6.583 (µm)
		Mode	: 10.861 (µm)
		Span	: 7.500

No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %
1	0.115	0.507	0.507	27	1.305	0.676	52.048	53	133.103	0.000	100.000
2	0.131	1.100	1.607	28	4.472	0.937	53.005	54	152.453	0.000	100.000
3	0.150	2.100	3.707	29	5.122	1.339	54.344	55	174.616	0.000	100.000
4	0.172	2.912	6.619	30	5.867	1.896	56.239	56	200.000	0.000	100.000
5	0.197	3.642	10.261	31	6.720	2.662	58.901	57	229.075	0.000	100.000
6	0.226	3.773	14.034	32	7.697	3.561	62.462	58	262.376	0.000	100.000
7	0.259	4.179	18.213	33	8.816	4.581	67.043	59	300.518	0.000	100.000
8	0.296	4.446	22.659	34	10.097	5.497	72.539	60	344.206	0.000	100.000
9	0.339	4.555	27.214	35	11.565	6.026	78.566	61	394.244	0.000	100.000
10	0.389	4.469	31.682	36	13.246	5.943	84.508	62	451.356	0.000	100.000
11	0.443	4.110	35.793	37	15.172	5.186	89.694	63	517.200	0.000	100.000
12	0.510	3.565	39.358	38	17.377	3.975	93.669	64	592.387	0.000	100.000
13	0.584	2.918	42.276	39	19.904	3.119	96.789				
14	0.669	2.270	44.547	40	22.797	1.799	98.588				
15	0.766	1.674	46.220	41	26.111	0.881	99.469				
16	0.877	1.187	47.407	42	29.907	0.380	99.849				
17	1.005	0.798	48.205	43	34.255	0.351	100.000				
18	1.151	0.552	48.757	44	39.234	0.000	100.000				
19	1.318	0.401	49.158	45	44.938	0.000	100.000				
20	1.510	0.288	49.446	46	51.471	0.000	100.000				
21	1.729	0.266	49.712	47	58.953	0.000	100.000				
22	1.981	0.252	49.964	48	67.523	0.000	100.000				
23	2.269	0.262	50.226	49	77.339	0.000	100.000				
24	2.599	0.296	50.522	50	88.583	0.000	100.000				
25	2.976	0.366	50.888	51	101.460	0.000	100.000				
26	3.409	0.484	51.372	52	116.210	0.000	100.000				

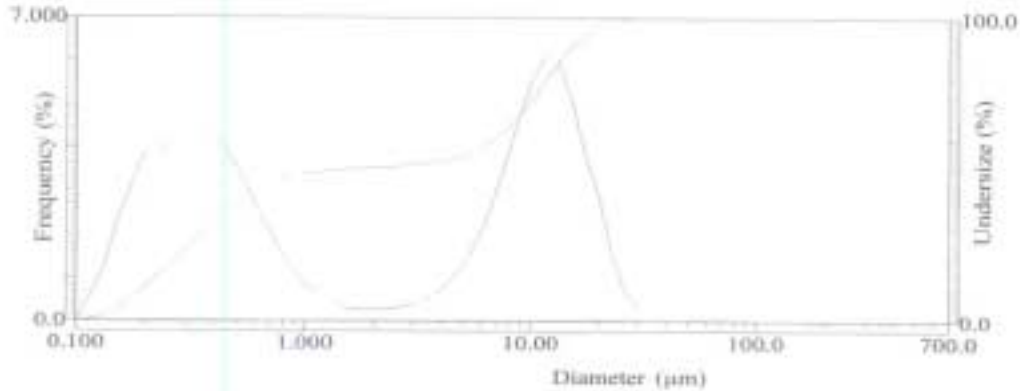
UKH 2 Cycle 1



S.P. Area	: 109054(µm² /µm³)	:90.00 (%) = 15.393(µm)	:53.00 (µm) = 100.0
Median	: 0.801(µm)	:95.00 (%) = 18.566(µm)	:38.00 (µm) = 100.0
Diameter on %	:5.000 (%) = 0.173(µm)	% on Diameter	:850.0 (µm) = 100.000(%)
	:10.00 (%) = 0.211(µm)		:600.0 (µm) = 100.000(%)
	:20.00 (%) = 0.286(µm)		:425.0 (µm) = 100.000(%)
	:30.00 (%) = 0.367(µm)		:300.0 (µm) = 100.000(%)
	:40.00 (%) = 0.483(µm)		:212.0 (µm) = 100.000(%)
	:60.00 (%) = 6.164(µm)		:150.0 (µm) = 100.000(%)
	:70.00 (%) = 9.116(µm)		:106.0 (µm) = 100.000(%)
	:80.00 (%) = 11.803(µm)		:75.00 (µm) = 100.000(%)
		Mean	: 5.623(µm)
		Variance	: 44.172
		S.D.	: 6.646(µm)
		Mode	: 0.363(µm)
		Span	: 18.951

No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %
1	0.115	0.370	0.370	27	1.905	0.635	55.290	52	133.103	0.000	100.000
2	0.131	0.780	1.149	28	4.472	8.889	56.178	54	152.453	0.000	100.000
3	0.150	1.484	2.634	29	5.122	1.230	57.409	55	174.616	0.000	100.000
4	0.172	2.285	4.919	30	5.867	1.721	59.130	56	200.080	0.000	100.000
5	0.197	3.164	8.083	31	6.720	2.393	61.522	57	229.075	0.000	100.000
6	0.226	3.705	11.789	32	7.697	3.177	64.700	58	262.376	0.000	100.000
7	0.259	4.473	16.261	33	8.816	4.085	68.785	59	300.518	0.000	100.000
8	0.296	5.079	21.340	34	10.097	4.926	73.711	60	344.206	0.000	100.000
9	0.339	5.455	26.795	35	11.365	5.466	79.177	61	394.244	0.000	100.000
10	0.389	5.408	32.204	36	13.246	5.492	84.669	62	451.556	0.000	100.000
11	0.445	5.095	37.388	37	15.172	4.917	89.586	63	517.200	0.000	100.000
12	0.510	4.368	41.756	38	17.377	3.882	93.469	64	592.387	0.000	100.000
13	0.584	3.463	45.220	39	19.904	3.143	96.611				
14	0.669	2.564	47.784	40	22.797	1.875	98.484				
15	0.766	1.909	49.593	41	26.111	0.941	99.425				
16	0.877	1.231	50.824	42	29.907	0.411	99.836				
17	1.005	0.798	51.622	43	34.255	0.164	100.000				
18	1.151	0.538	52.160	44	39.234	0.000	100.000				
19	1.318	0.385	52.545	45	44.938	0.000	100.000				
20	1.510	0.274	52.818	46	51.471	0.000	100.000				
21	1.729	0.254	53.072	47	58.953	0.000	100.000				
22	1.981	0.241	53.313	48	67.523	0.000	100.000				
23	2.269	0.250	53.563	49	77.339	0.000	100.000				
24	2.599	0.283	53.846	50	88.583	0.000	100.000				
25	2.976	0.350	54.195	51	101.460	0.000	100.000				
26	3.409	0.460	54.655	52	116.230	0.000	100.000				

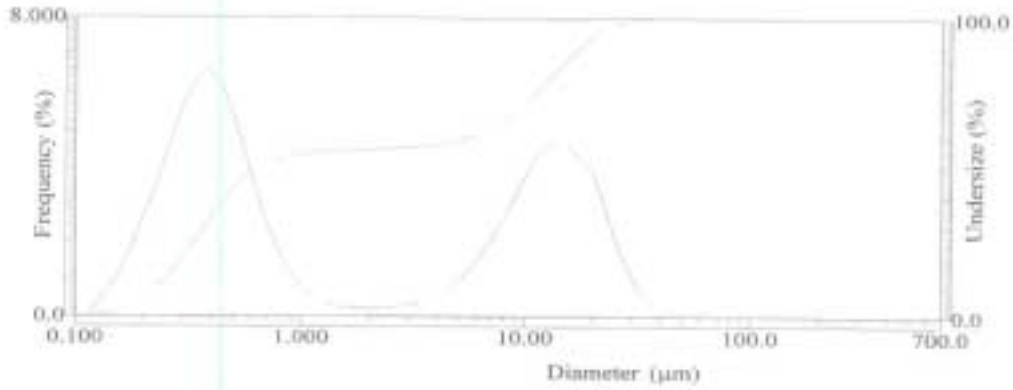
UKH 2 Cycle 2



S.P. Area : 111738(cm^3/cm^3) :90.00 (%) = 14.959(μm) :53.00 (μm) = 100.0
 Median : 1.699(μm) :95.00 (%) = 17.913(μm) :38.00 (μm) = 100.0
 Diameter on % :5.000 (%) = 0.157(μm) % on Diameter :350.0 (μm) = 100.000(%) Mean : 5.742(μm)
 :10.00 (%) = 0.190(μm) :600.0 (μm) = 100.000(%) Variance : 41.301
 :20.00 (%) = 0.267(μm) :425.0 (μm) = 100.000(%) S.D. : 6.427(μm)
 :30.00 (%) = 0.363(μm) :300.0 (μm) = 100.000(%) Mode : 10.850(μm)
 :40.00 (%) = 0.519(μm) :212.0 (μm) = 100.000(%) Span : 8.694
 :60.00 (%) = 0.874(μm) :150.0 (μm) = 100.000(%)
 :70.00 (%) = 0.9319(μm) :106.0 (μm) = 100.000(%)
 :80.00 (%) = 1.1714(μm) :75.00 (μm) = 100.000(%)

No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %
1	0.113	0.550	0.550	27	3.905	0.688	52.435	53	133.100	0.000	100.000
2	0.131	1.205	1.755	28	4.472	0.972	53.407	54	152.453	0.000	100.000
3	0.150	2.305	4.060	29	5.122	1.357	54.764	55	174.616	0.000	100.000
4	0.172	3.118	7.177	30	5.867	1.923	56.687	56	200.000	0.000	100.000
5	0.197	3.809	10.986	31	6.720	2.707	59.393	57	229.075	0.000	100.000
6	0.226	3.842	14.828	32	7.697	3.631	63.024	58	262.376	0.000	100.000
7	0.259	4.183	19.011	33	8.816	4.678	67.702	59	300.518	0.000	100.000
8	0.296	4.386	23.397	34	10.097	5.611	73.313	60	344.206	0.000	100.000
9	0.339	4.446	27.842	35	11.565	6.124	79.437	61	394.244	0.000	100.000
10	0.389	4.336	32.178	36	13.246	5.976	85.414	62	451.556	0.000	100.000
11	0.445	3.984	36.162	37	15.172	5.120	90.534	63	517.200	0.000	100.000
12	0.510	3.468	39.630	38	17.377	3.815	94.349	64	592.387	0.000	100.000
13	0.584	2.862	42.492	39	19.904	2.912	97.261				
14	0.669	2.258	44.750	40	22.797	1.998	98.859				
15	0.766	1.685	46.434	41	26.111	0.736	99.595				
16	0.877	1.209	47.643	42	29.907	0.296	99.891				
17	1.005	0.822	48.465	43	34.255	0.109	100.000				
18	1.151	0.574	49.039	44	39.234	0.000	100.000				
19	1.318	0.419	49.458	45	44.938	0.000	100.000				
20	1.510	0.301	49.759	46	51.471	0.000	100.000				
21	1.729	0.278	50.037	47	58.953	0.000	100.000				
22	1.981	0.263	50.300	48	67.523	0.000	100.000				
23	2.269	0.271	50.571	49	77.339	0.000	100.000				
24	2.599	0.306	50.877	50	88.583	0.000	100.000				
25	2.976	0.376	51.253	51	101.460	0.000	100.000				
26	3.409	0.495	51.748	52	116.210	0.000	100.000				

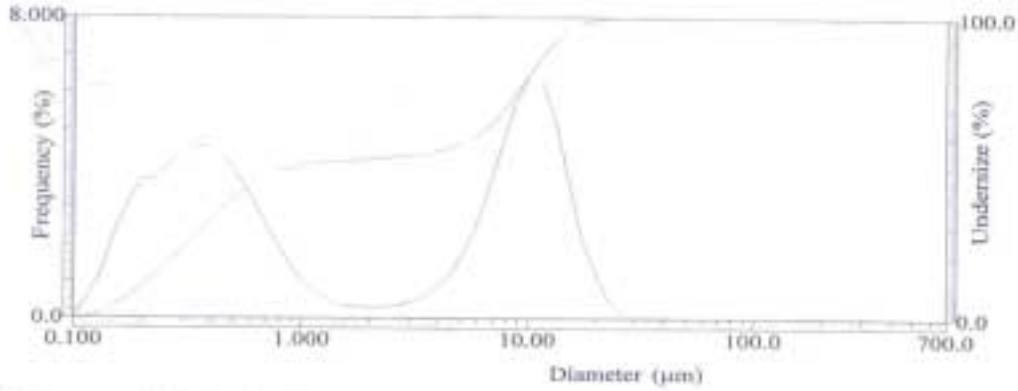
UKH 2 Cycle 3



S.P. Area	: 106484(µm² /µm)	-90.00 (%) = 17.524(µm)	-53.00 (µm) = 100.0
Median	: 0.654(µm)	-95.00 (%) = 21.238(µm)	-38.00 (µm) = 99.94
Diameter on %	:5.000 (%) = 0.189(µm)	% on Diameter	:85.0 (µm) = 100.000(%)
	:10.00 (%) = 0.251(µm)		:600.0 (µm) = 100.000(%)
	:20.00 (%) = 0.300(µm)		:425.0 (µm) = 100.000(%)
	:30.00 (%) = 0.371(µm)		:300.0 (µm) = 100.000(%)
	:40.00 (%) = 0.463(µm)		:212.0 (µm) = 100.000(%)
	:60.00 (%) = 5.527(µm)		:150.0 (µm) = 100.000(%)
	:70.00 (%) = 9.468(µm)		:106.0 (µm) = 100.000(%)
	:80.00 (%) = 12.904(µm)		:75.00 (µm) = 100.000(%)
		Mean	: 6.022(µm)
		Variance	: 57.928
		S.D.	: 7.611(µm)
		Mode	: 0.362(µm)
		Span	: 26.450

No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %
1	0.115	0.000	0.000	27	3.905	0.527	57.526	53	133.103	0.000	100.000
2	0.131	0.518	0.318	28	4.472	0.726	58.252	54	152.453	0.000	100.000
3	0.150	0.978	1.497	29	5.122	0.989	59.241	55	174.616	0.000	100.000
4	0.172	1.681	3.178	30	5.867	1.356	60.597	56	200.000	0.000	100.000
5	0.197	2.590	5.768	31	6.720	1.852	62.448	57	229.075	0.000	100.000
6	0.226	3.463	9.232	32	7.697	2.427	64.876	58	262.376	0.000	100.000
7	0.259	4.587	13.819	33	8.816	3.118	67.994	59	300.518	0.000	100.000
8	0.296	5.990	19.410	34	10.097	3.813	71.808	60	344.206	0.000	100.000
9	0.339	6.322	25.731	35	11.565	4.392	76.200	61	394.244	0.000	100.000
10	0.389	6.567	32.298	36	13.246	4.709	80.908	62	451.556	0.000	100.000
11	0.445	6.144	38.442	37	15.172	4.651	85.559	63	517.200	0.000	100.000
12	0.510	5.214	43.656	38	17.377	4.200	89.760	64	592.387	0.000	100.000
13	0.584	4.003	47.659	39	19.904	3.882	93.641				
14	0.669	2.809	50.468	40	22.797	2.841	96.482				
15	0.766	1.890	52.357	41	26.111	1.800	98.282				
16	0.877	1.226	53.584	42	29.907	1.000	99.282				
17	1.005	0.761	54.345	43	34.255	0.497	99.780				
18	1.151	0.495	54.840	44	39.234	0.220	100.000				
19	1.318	0.345	55.185	45	44.938	0.000	100.000				
20	1.510	0.242	55.427	46	51.471	0.000	100.000				
21	1.729	0.222	55.649	47	58.953	0.000	100.000				
22	1.981	0.209	55.858	48	67.523	0.000	100.000				
23	2.269	0.215	56.073	49	77.339	0.000	100.000				
24	2.599	0.242	56.315	50	88.583	0.000	100.000				
25	2.976	0.297	56.612	51	101.460	0.000	100.000				
26	3.409	0.387	56.999	52	116.210	0.000	100.000				

UKH 2 Cycle 4



S.P. Area	: 113614(cm^2/cm^2)	:90.00 (%) = 12.480(μm)	:53.00 (μm) = 100.0
Median	: 0.913(μm)	:95.00 (%) = 14.639(μm)	:38.00 (μm) = 100.0
Diameter on %	:5.000 (%) = 0.157(μm)	% on Diameter	:850.0 (μm) = 100.000(%)
	:10.00 (%) = 0.192(μm)		:600.0 (μm) = 100.000(%)
	:20.00 (%) = 0.271(μm)		:425.0 (μm) = 100.000(%)
	:30.00 (%) = 0.366(μm)		:300.0 (μm) = 100.000(%)
	:40.00 (%) = 0.506(μm)		:212.0 (μm) = 100.000(%)
	:60.00 (%) = 5.709(μm)		:150.0 (μm) = 100.000(%)
	:70.00 (%) = 7.956(μm)		:106.0 (μm) = 100.000(%)
	:80.00 (%) = 9.932(μm)		:75.00 (μm) = 100.000(%)
		Mean	: 4.750(μm)
		Variance	: 28.363
		S.D.	: 5.326(μm)
		Mode	: 9.487(μm)
		Span	: 13.457

No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %	No.	Diameter	Freq.	% Under %
1	0.113	0.350	0.350	27	3.905	0.798	55.205	53	133.103	0.000	100.000
2	0.131	1.197	1.746	28	4.472	1.164	56.370	54	152.453	0.000	100.000
3	0.150	2.272	4.018	29	5.122	1.679	58.049	55	174.616	0.000	100.000
4	0.172	3.039	7.057	30	5.867	2.442	60.490	56	200.000	0.000	100.000
5	0.197	3.683	10.740	31	6.720	3.479	63.970	57	229.075	0.000	100.000
6	0.226	3.717	14.457	32	7.697	4.627	68.597	58	262.376	0.000	100.000
7	0.259	4.091	18.548	33	8.816	5.734	74.350	59	300.518	0.000	100.000
8	0.296	4.378	22.926	34	10.097	6.430	80.780	60	344.206	0.000	100.000
9	0.339	4.538	27.464	35	11.565	6.280	87.060	61	394.244	0.000	100.000
10	0.389	4.552	32.016	36	13.246	5.243	92.303	62	451.536	0.000	100.000
11	0.445	4.318	36.333	37	15.172	3.662	95.965	63	517.200	0.000	100.000
12	0.510	3.886	40.219	38	17.377	2.123	98.088	64	592.387	0.000	100.000
13	0.584	3.315	43.534	39	19.904	1.261	99.349				
14	0.669	2.675	46.210	40	22.797	0.493	99.843				
15	0.766	2.031	48.241	41	26.111	0.157	100.000				
16	0.877	1.467	49.708	42	29.907	0.000	100.000				
17	1.005	0.991	50.699	43	34.255	0.000	100.000				
18	1.151	0.681	51.380	44	39.234	0.000	100.000				
19	1.318	0.487	51.867	45	44.938	0.000	100.000				
20	1.510	0.342	52.209	46	51.471	0.000	100.000				
21	1.729	0.309	52.518	47	58.953	0.000	100.000				
22	1.981	0.289	52.806	48	67.523	0.000	100.000				
23	2.269	0.295	53.102	49	77.339	0.000	100.000				
24	2.599	0.333	53.435	50	88.583	0.000	100.000				
25	2.976	0.415	53.849	51	101.460	0.000	100.000				
26	3.409	0.558	54.407	52	116.210	0.000	100.000				

APPENDIX B

Lime XRD Analyses

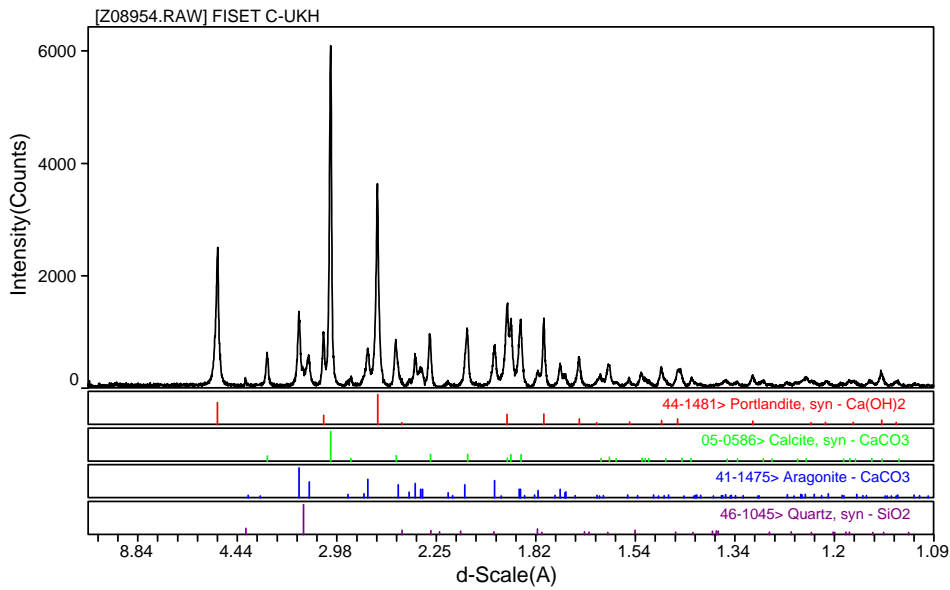


Figure B1: XRD pattern of the lime used at the UKH mine site

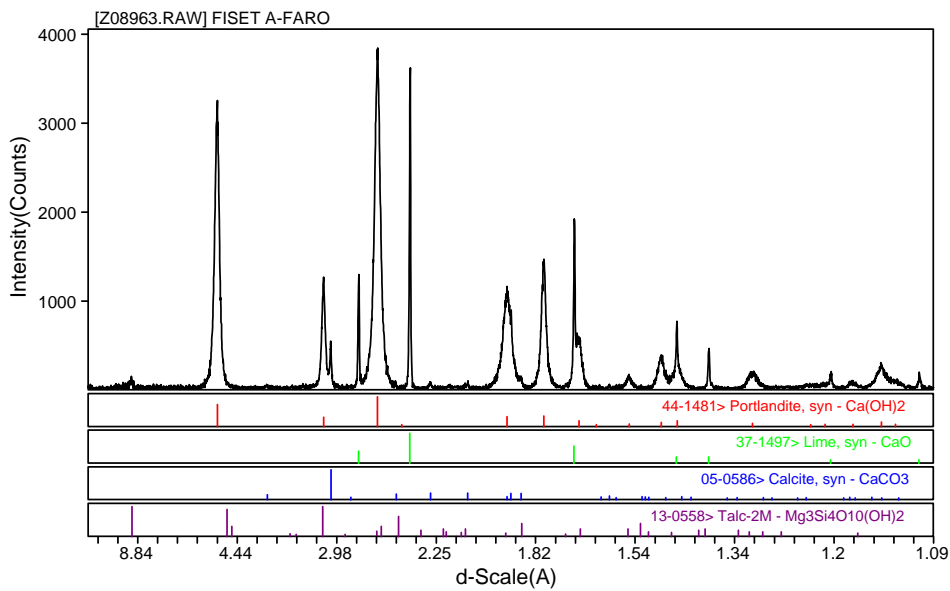


Figure B2: XRD pattern of the lime used at the Faro mine site

APPENDIX C

Metal Concentrations of the Column Leaching Study