An Investigation into

THE METALLURGICAL TESTWORK TO REMOVE IMPURITIES FROM THREE SILICA SAND SAMPLES

prepared for

MINISTRY OF ENERGY AND MINERAL RESOURCES, JORDAN

Project 19097-03 – Final Report
January 31, 2022

NOTES

WARNING: The sample(s) to which the findings recorded herein (the "Findings") relate was(were) drawn and / or provided by the Client or by a third party acting at the Client's direction. The Findings constitute no warranty of the sample's representativeness of any goods and strictly relate to the sample(s). The Company accepts no liability with regard to the origin or source from which the sample(s) is/are said to be extracted.

ACCREDITATION: SGS Minerals Lakefield is accredited to the requirements of ISO/IEC 17025 for specific tests as listed on our scope of accreditation, including geochemical, mineralogical, and trade mineral tests. To view a list of the accredited methods, please visit the following website and search SGS Lakefield: *http://palcan.scc.ca/SpecsSearch/GLSearchForm.do*.

SGS Canada Inc. | P.O. Box 4300, 185 Concession Street, Lakefield, Ontario, Canada K0L 2H0
Tel: (705) 652-2000 Fax: (705) 652-6365 www.met.sgs.com www.ca.sgs.com

Member of the SGS Group (SGS SA)

Table of Contents

List of Tables

List of Figures

Executive Summary

A total of five silica sands samples from the Jordan Ministry of Energy and Mineral Resources were received at SGS Lakefield for a metallurgical testwork program. The test scope included sample preparation, head assays, particle size analysis, attrition scrubbing, dry-belt magnetic separation, wet high-intensity magnetic separation (WHIMS) and acid leaching tests. The objectives of the program were to remove any impurity elements and produce a silica sand concentrate grading at least 99.9% SiO_2.

The chemical assays of the five silica samples are presented in Table I. The SiO_2 grades of the samples were high, at 95~98% by the XRF method. The silica sand assays of samples GSB-03, GSB-04 and GSB-06 were confirmed by gravimetric method, which yielded results of 98.50, 98.67, and 98.05% SiO_2, respectively. The major trace impurity elements were alumina (0.5-1.8% Al_2O_3), iron (0.02-0.08% Fe_2O_3), calcium (0.02-0.27% CaO), titanium (0.07-0.25% TiO_2) and cobalt (710-806 g/t Co). A previous mineralogy study (SGS project# 19097-01) on a similar silica sand sample indicated kaolinite was the major impurity mineral, with trace amount of other minerals including chlorite, Fe-oxides, carbonates (calcite and dolomite), rutile/anatase, etc.

Table I: Head Assays of Silica Sand Samples

Head Assays on Silica Sand Samples											
WRA, %	GSB-01	GSB-02	GSB-03	GSB-04	GSB-06	ICP, g/t	GSB-01	GSB-02	GSB-03	GSB-04	GSB-06
SiO_2	95.9	97.2	98.3	98.4	98.1	Ag	< 200	< 200	< 200	< 200	< 200
Al_2O_3	1.80	1.20	0.64	0.47	1.01	As	< 1200	< 1200	< 1200	< 1200	< 1200
Fe_2O_3	0.08	0.03	0.02	0.05	0.03	Ba	< 30	< 30	< 30	< 30	< 30
MgO	0.03	< 0.01	< 0.01	< 0.01	< 0.01	Be	< 3	< 3	< 3	< 3	< 3
CaO	0.27	0.14	0.02	0.11	0.01	Bi	< 400	< 400	< 400	< 400	< 400
Na_2O	0.06	0.03	0.03	0.03	0.03	Cd	< 40	< 40	< 40	< 40	< 40
K_2O	0.02	< 0.01	< 0.01	< 0.01	< 0.01	Co	776	722	806	816	710
TiO_2	0.25	0.10	0.07	0.07	0.08	Cu	< 40	< 40	< 40	< 40	< 40
P_2O_5	0.02	0.01	0.01	0.02	0.02	Li	< 800	< 800	< 800	< 800	< 800
MnO	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	Mo	< 300	< 300	< 300	< 300	< 300
Cr_2O_3	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	Ni	< 300	< 300	< 300	< 300	< 300
V2O5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	Pb	< 800	< 800	< 800	< 800	< 800
LOI	1.21	0.74	0.45	0.46	0.63	Sb	< 400	< 400	< 400	< 400	< 400
Sum	99.6	99.5	99.6	99.6	99.9	Se	< 2000	< 2000	< 2000	< 2000	< 2000
Gravimetric SiO_2, %			98.50	98.67	98.05	Sn	< 800	< 800	< 800	< 800	< 800
						Sr	93	69	40	56	65
						Tl	< 2000	< 2000	< 2000	< 2000	< 2000
						U	< 400	< 400	< 400	< 400	< 400
						Y	< 8	< 8	< 8	< 8	< 8
						Zn	< 300	< 300	< 300	< 300	< 300

The particle size distributions were similar, with K_{80} sizes ranging from 477 to 601 µm, for the five silica sand samples at a crush size of -3.35 mm. Size by size analyses indicated that the impurity elements, such as alumina, calcium, and titanium, were mainly distributed in the -38 micron fraction, which can likely be removed by desliming.

Silica sand samples GSB-03, GSB-04, and GSB-06 were selected for the subsequent metallurgical testwork to remove impurity elements and improve SiO_2 grade, as per confirmation from the Jordan Ministry. The three samples were dry screened at 16 mesh (1.18 mm) to remove the oversized material. The -1.18 mm fraction of each sample was submitted for chemical assays and testwork. The WRA assays of the -1.18 mm fraction of each sample are shown in Table II.

Table II: WRA Assays on the -1.18 mm Fraction of GSB-03, GSB-04, and GSB-06

-1.18 mm Fractional Assays			
WRA, %	GSB-03	GSB-04	GSB-06
SiO_2	98.4	98.6	97.7
Al_2O_3	0.56	0.45	1.01
Fe_2O_3	0.03	0.03	0.02
MgO	< 0.01	< 0.01	< 0.01
CaO	0.01	0.09	< 0.01
Na_2O	0.02	< 0.01	< 0.01
K_2O	< 0.01	< 0.01	< 0.01
TiO_2	0.06	0.06	0.07
P_2O_5	0.01	0.01	0.02
MnO	< 0.01	< 0.01	< 0.01
Cr_2O_3	< 0.01	< 0.01	< 0.01
V2O5	< 0.01	< 0.01	< 0.01
LOI	0.56	0.42	0.78
Sum	99.6	99.7	99.6

Attrition scrubbing tests were carried out on the three samples at moderate or intensive conditions. This was followed by magnetic separation on the scrubbed material (after removal of the -38 µm fraction), using either a dry-belt magnetic separator or an Eriez WHIMS unit. Three-stage attrition scrubbing, desliming, and magnetic separation was also compared to one-stage attrition scrubbing and desliming processing.

The test results indicated that three-stage intensive attrition scrubbing at 900 rpm for 10 minutes with 60% pulp density was very effective in breaking down the gangue minerals and having them deport to the -38 micron fraction. About 88-94% of the aluminum, 69-74% of the iron, 53-81% of the calcium and 67-84% of the titanium could be removed by screening out the -38 micron fraction from the scrubbed silica sands.

WHIMS yielded better results than dry-belt magnetic separation in generating a cleaner non-magnetic silica sand. The non-magnetics generated by attrition scrubbing, desliming, and WHIMS assayed 98.8-99.0% SiO_2, 0.04-0.05% Al_2O_3, and ≤0.01% Fe_2O_3.

Acid leaching tests were performed on the non-magnetic WHIMS products. Tests L1 to L3 were carried out on silica sand GSB-03 to investigate HCl and H_2SO_4 as the lixiviant and the effect of feed size. Under the best conditions established (20% HCl, 10% solid (w/w), 80°C, and 6 hour reaction time), impurity elements such as Al, Fe, and Co were effectively removed from stage-pulverized (K_{80} of 53-58 µm) silica sands. The final leach residue of GSB-03, GSB-04, and GSB-06 contained 99.66, 99.80, and 99.58% SiO_2, respectively, by gravimetric method (ASTM-C146), slightly below the 99.9% SiO_2 target. Impurity elements were assayed by neutron activiation analysis and a borate fusion XRF method, and presented in Table III based on lower detection limit of analytical method. Assay certificates are attached in Appendix D.

Table III: Gravimetric SiO_2 Assay and Impurity Elements by Neutron Activation Analysis and Borate Fusion XRF on Final Silica Sand Products

Product	SiO_2, % ASTM C-146	Neutron Activation Analysis, ppm								Borate Fusion XRF, %					
		Al	Ca	Cr	Mg	Mn	K	Na	Ti	Fe_2O_3	P_2O_5	Cr_2O_3	V_2O_5	LOI	SUM
L3 residue, GSB-03	99.66	412	31	<10	<30	0.830	<110	22.0	74.0	0.01	<0.01	<0.01	<0.01	0.26	99.6
L4 residue, GSB-04	99.80	450	27	<10	<30	0.830	<110	74.0	99.0	<0.01	<0.01	<0.01	<0.01	0.39	99.6
L5 residue, GSB-06	99.58	407	20	<10	<30	0.650	<110	19.0	89.0	0.01	<0.01	<0.01	<0.01	0.39	100.3

The grain size distribution and the geochemical analyses of the final products indicate that several grades of silica sand may be produced from a single operation by varying the degrees of mineral processing. The very highest grades are often only achievable if produced alongside more standard grades to achieve sufficient economy of scale and to avoid having large quantities of off-specification material or waste. The geochemical analyses indicated that primary grade (>99.5%) SiO_2 can be produced from the current deposit. Elemental impurities such as Ca, Ti, and Al were generally very low indicating that there might be a wide range of applications for the final silica products.

The current processed silica sand should be readily capable of meeting the quality requirements of all but the most demanding applications (99.9% SiO_2). However, note that the metallurgical process has not been optimized. Therefore, the potential to achieve 99.9% SiO_2 is significant. It is critical to emphasize that the current results reflect the samples tested.

Based on the assumption that samples have similar particle size distributions and mineralogy, the beneficiation flowsheet for the silica sand is proposed in Figure I for industrial application.

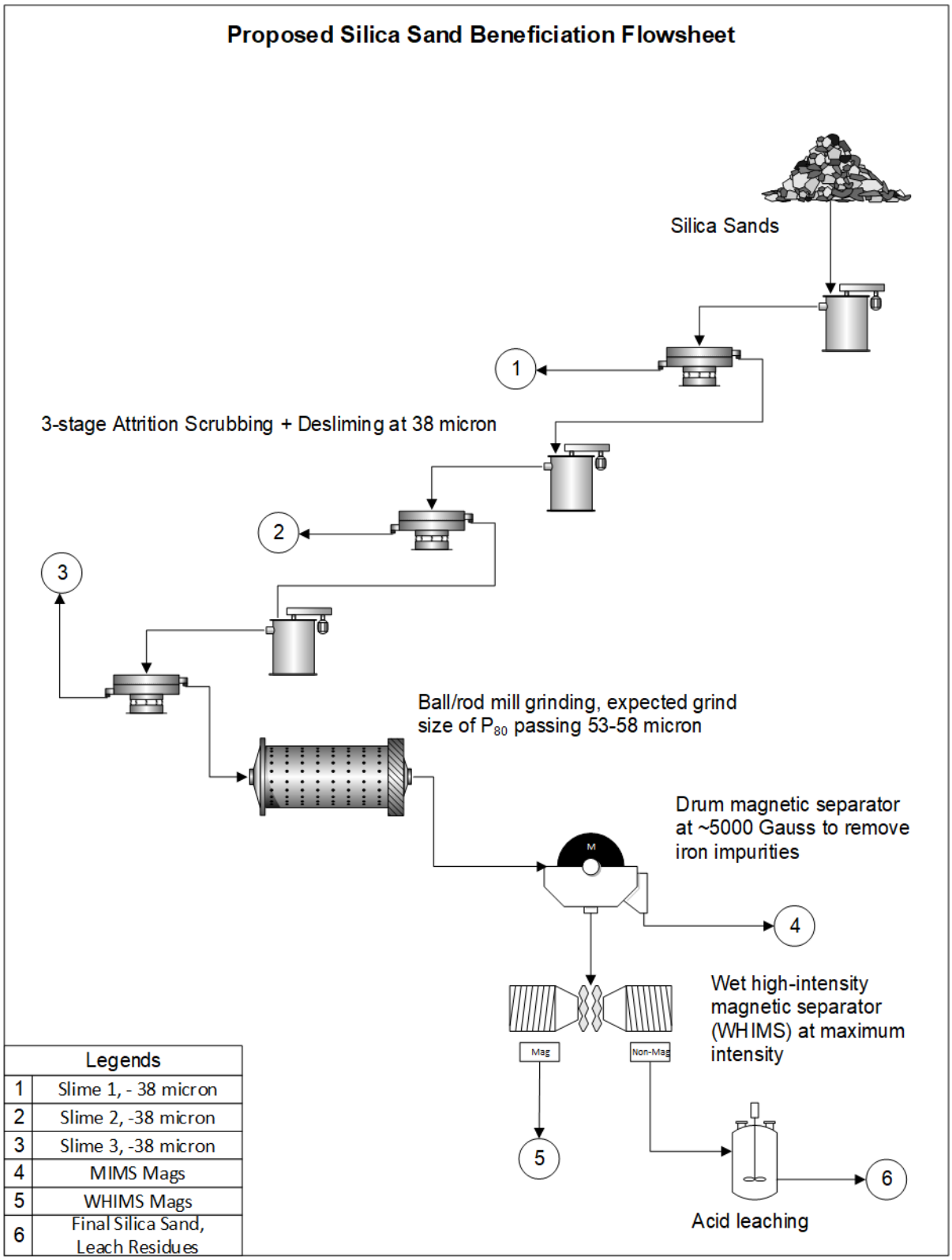


Figure I: Proposed Silica Sand Beneficiation Flowsheet

Introduction

Mr. Yahya Alhazaimeh of SGS Jordan on behalf of the Ministry of Energy and Mineral Resources of Jordan, contacted SGS Lakefield in July 2022, with a request for metallurgical testwork to remove impurities from three silica sand samples.

The scope of the testwork included sample preparation, head assays, size by size analysis, attrition test, magnetic separation, and acid leaching. The technical objective of this testwork program was to remove any impurity elements and produce a silica sand concentrate grading 99.9% SiO_2.

During the development of the testwork, progress was discussed with Mr. Yahya Alhazaimeh, Mr. Hisham Alzyood, Mr. Saleem Saleem, Mr. Saleh Al-Kharabsheh, Mr. Asmaa Alqurneh, Mr. Mohamad Abweny, and Mr. Ali Alsmadi through emails, and all results were provided to them as they became available.

Hao Li, Ph.D.
Metallurgist, Mineral Processing

Dan Imeson, M.Sc.
Manager, Mineral Processing

Experimental work by: Yanling Sheng, Rachel Brunsch
Report preparation by: Hao Li, Tassos Grammatikopoulos
Reviewed by: Cheryl Mina, Chris Fleming, Tassos Grammatikopoulos, Dan Imeson

Testwork Summary

1. Sample Receipt and Preparation

1.1. Sample Receipt

Two shipments containing a total of five boxes of samples were received at the SGS Lakefield site on August 11 and 15, 2022. Each box contained a high-grade silica sand sample in a rice bag. The sample deposit information was not known/received. The internal receipt numbers of 0159-AUG22 and 0191-AUG22 were assigned to the five samples, which were designated as GSB-01, GSB-02, GSB-03, GSB-04, and GSB-06.

All the samples were received, inventoried, and weights recorded. The sample list is shown in Table 1.

Table 1: Sample Inventory List As-received

Sample #	GSB-01	GSB-02	GSB-03	GSB-04	GSB-05
Net Weight, kg	19.9	18.7	18.5	18.9	17.3

1.2. Sample Preparation

Each of the five as-received silica sand samples was screened at 3.35 mm to remove coarse particles and/or aggregates. The oversize material was further crushed to -3.35 mm and blended with undersize material to ensure 100% passing -3.35 mm. Each of the samples was fully homogenized before being rotary split into 1-kg test charges.

Later, the 1-kg test charges of GSB-03, GSB-04 and GSB-06 were recombined into bulk samples and dry screened to remove the +1.18 mm fraction as per instructions from the Jordan Ministry. The -1.18 mm fraction of each silica sand sample was further homogenized and re-split into 1 kg charges for subsequent metallurgical testwork.

2. Sample Characterization

2.1. Head Assays

Table 2 shows the head chemical assays of five silica sands. The SiO_2 grade of the silica sands was high, at 95~98% by the borate fusion XRF method. The major trace impurity elements were alumina (0.5-1.8% Al_2O_3), iron (0.02-0.08% Fe_2O_3), calcium (0.02-0.27% CaO), titanium (0.07-0.25% TiO_2), and cobalt (710-806 g/t Co).

The silica sand GSB-03, GSB-04, and GSB-06 samples were further analyzed by the gravimetric method, which yielded grades of 98.50, 98.67, and 98.05% SiO_2, respectively

Table 2: Head Assays of Five Silica Sand Samples

Head Assays on Silica Sand Samples											
WRA, %	GSB-01	GSB-02	GSB-03	GSB-04	GSB-06	ICP, g/t	GSB-01	GSB-02	GSB-03	GSB-04	GSB-06
SiO_2	95.9	97.2	98.3	98.4	98.1	Ag	< 200	< 200	< 200	< 200	< 200
Al_2O_3	1.80	1.20	0.64	0.47	1.01	As	< 1200	< 1200	< 1200	< 1200	< 1200
Fe_2O_3	0.08	0.03	0.02	0.05	0.03	Ba	< 30	< 30	< 30	< 30	< 30
MgO	0.03	< 0.01	< 0.01	< 0.01	< 0.01	Be	< 3	< 3	< 3	< 3	< 3
CaO	0.27	0.14	0.02	0.11	0.01	Bi	< 400	< 400	< 400	< 400	< 400
Na_2O	0.06	0.03	0.03	0.03	0.03	Cd	< 40	< 40	< 40	< 40	< 40
K_2O	0.02	< 0.01	< 0.01	< 0.01	< 0.01	Co	776	722	806	816	710
TiO_2	0.25	0.10	0.07	0.07	0.08	Cu	< 40	< 40	< 40	< 40	< 40
P_2O_5	0.02	0.01	0.01	0.02	0.02	Li	< 800	< 800	< 800	< 800	< 800
MnO	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	Mo	< 300	< 300	< 300	< 300	< 300
Cr_2O_3	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	Ni	< 300	< 300	< 300	< 300	< 300
V2O5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	Pb	< 800	< 800	< 800	< 800	< 800
LOI	1.21	0.74	0.45	0.46	0.63	Sb	< 400	< 400	< 400	< 400	< 400
Sum	99.6	99.5	99.6	99.6	99.9	Se	< 2000	< 2000	< 2000	< 2000	< 2000
Gravimetric SiO_2, %			98.50	98.67	98.05	Sn	< 800	< 800	< 800	< 800	< 800
						Sr	93	69	40	56	65
						Tl	< 2000	< 2000	< 2000	< 2000	< 2000
						U	< 400	< 400	< 400	< 400	< 400
						Y	< 8	< 8	< 8	< 8	< 8
						Zn	< 300	< 300	< 300	< 300	< 300

A previous mineralogical test program (SGS project number 19097-01) on a similar silica sand sample indicated that kaolinite was the major impurity mineral, with trace amount of other minerals including chlorites, Fe-oxides, carbonates (calcite and dolomite), rutile/anatase, etc.

It should be noted that the SiO_2 assay by GC_XRF76V borate fusion XRF has a relative +/- 2% uncertainty at the concentration levels reported here. The ASTM_C146 is a wet chemistry gravimetric method that is more suitable for SiO_2 analysis on samples over 90% SiO_2, with an absolute uncertainty of +/- 0.25%. In consultation with the Jordan Ministry and SGS Jordan, it was decided to use the borate fusion XRF SiO_2 assay as a qualitative indicator for metallurgical mass balance evaluation given that it is quicker and less expensive. The gravimetric method was only used to determine the head and final product (leach residues) of GSB-03, GSB-04, and GSB-06 samples.

A comparison of the major element chemistry between the sample tested for mineralogy (Table 3) and the GSB-01, 02, 03, 04 and 06 samples, shows that:

- SiO_2 is lower (95.1%) than the GSB samples (95.9-98.4%),
- Al_2O_3 is higher (2.67%) than GSB samples (0.47-1.8%)
- Fe_2O_3 is higher (0.18%) than GSB samples (0.02-0.08%)
- TiO_2 is 0.12% and comparable to the GSB samples (0.07-0.25%)
- CaO is lower (0.01%) than in the GSB (0.01%-0.27%)
- LOI higher (1.26%) than GSB samples (0.45-1.21%).
- Note the very low amounts of K_2O in all samples.

Therefore, it was assumed that Al_2O_3 is derived mainly from kaolinite as shown in the mineralogy report. Titanium is reflected by the presence of rutile, calcium by the presence of Ca-silicates and / or carbonates. LOI reflects the presence of mainly kaolinite and possibly any debris of organic material possibly present in the samples.

Table 3: Head Assays of Sand Glass (Mineralogy Sample)

Sample ID	Sand Glass
SiO2 %	95.1
Al2O3 %	2.67
Fe2O3 %	0.18
MgO %	< 0.01
CaO %	0.01
Na2O %	0.03
K2O %	0.01
TiO2 %	0.12
P2O5 %	0.02
MnO %	< 0.01
Cr2O3 %	0.02
V2O5 %	< 0.01
LOI %	1.26
Total %	99.4

Sample ID	SiO2_Grav SiO2 %
Sand Glass	95.76

2.2. Particle Size Analysis and Size x Size Analysis

The particle size distribution plots of the five silica sands at a crush size of 100% passing -3.35 mm are presented in Figure 1. Detailed PSA results of each sample are listed in Appendix A.

The particle size distributions were similar for all samples, with K_{80} sizes ranging from 477 to 601 µm.

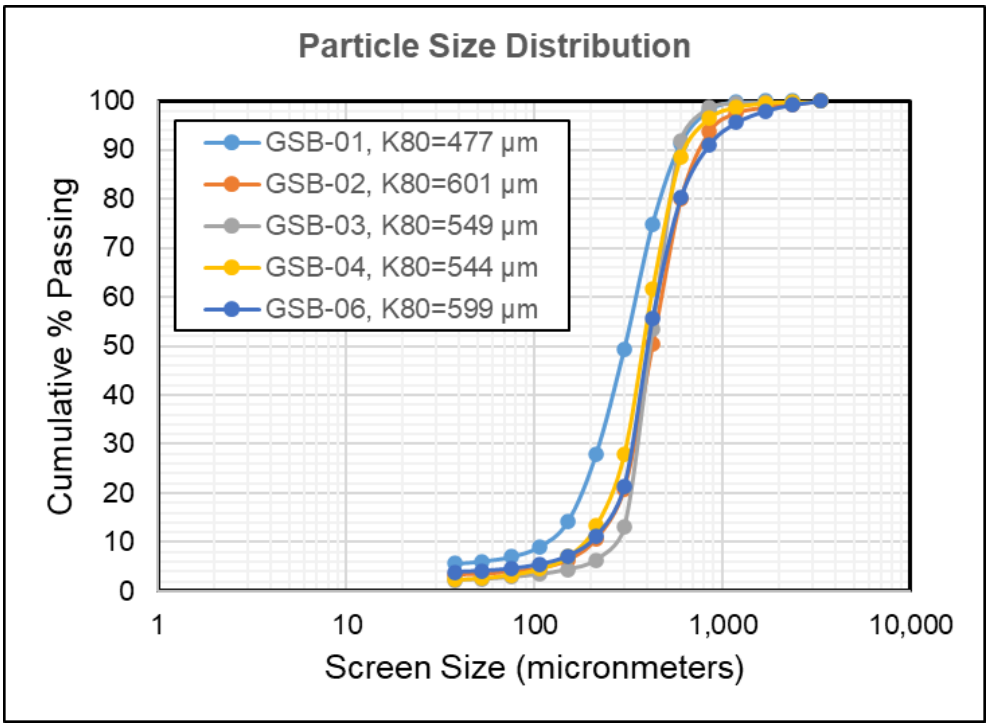


Figure 1: Particle Size Distribution of Five Silica Sand Samples

2.3. Size by Size Analysis

The trends of key element assays in each size fraction of the five silica sands are presented in Figure 2 with assay details in Appendix B. The mass balance of the -38 µm and cumulative +38 µm fractions is summarized in Table 4.

The SiO_2 grades of -850/+150 µm fractions were consistently high across all five samples, at 98-99% SiO_2. Lower SiO_2 grades were observed at finer size fractions (i.e., -150 µm), which was due to higher content of Al, Ca, and Ti gangue minerals in the slimes. As illustrated in Table 4, the Al_2O_3, CaO and TiO_2 assays and their corresponding distributions reporting to the -38 µm fraction were exceptionally high. As a result, the silica grade was only 55-77% SiO_2 in this fraction, which accounted for only 2-3% of the total silica distribution. Therefore, removing the -38 µm fraction will reject significant impurities and improve SiO_2 grades.

The silica content in the +850 µm fraction of the GSB-01, GSB-02, and GSB-03 samples were slightly lower, in the range of 95-97% SiO_2, mainly due to Fe and Ca-bearing gangue minerals.

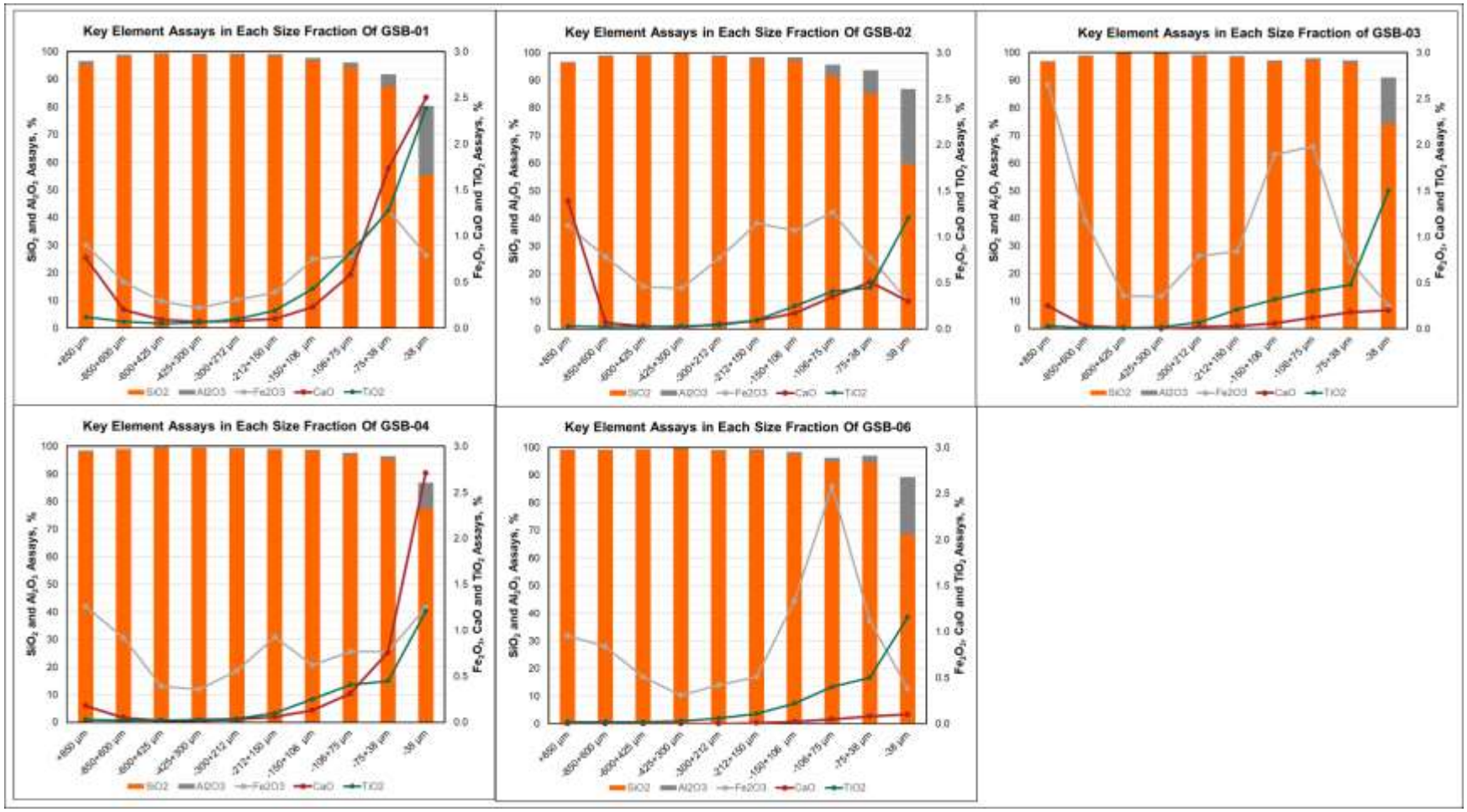


Figure 2: Trend of Key Element Assays in Each Size Fractions of Five Silica Sand Samples

Table 4: The Mass Pull, Assays, and Distributions of Five Silica Sand Samples in +38 µm and -38 µm Fractions

Sample ID	Size Fraction	Weight %	Assays, %						Distribution, %					
			SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	TiO_2	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	TiO_2
GSB-01	+38 µm frac.	94.4	98.3	0.58	0.37	0.15	0.04	0.14	96.8	28.1	88.7	50.0	90.4	50.1
	-38 µm frac.	5.6	55.3	25.1	0.79	2.50	0.08	2.39	3.2	71.9	11.3	50.0	9.6	49.9
	Feed (calc.)	100	95.9	1.96	0.39	0.28	0.05	0.27	100	100	100	100	100	100
GSB-02	+38 µm frac.	96.7	98.7	0.41	0.62	0.13	0.03	0.05	98.0	30.5	98.4	92.8	97.1	54.4
	-38 µm frac.	3.3	59.7	27.2	0.30	0.30	0.03	1.34	2.0	69.5	1.6	7.2	2.9	45.6
	Feed (calc.)	100	97.4	1.30	0.61	0.14	0.03	0.10	100	100	100	100	100	100
GSB-03	+38 µm frac.	97.8	99.3	0.24	0.51	0.02	0.03	0.03	98.3	38.6	98.9	79.9	98.7	47.5
	-38 µm frac.	2.2	74.2	16.8	0.25	0.20	0.02	1.5	1.7	61.4	1.1	20.1	1.3	52.5
	Feed (calc.)	100	98.8	0.61	0.50	0.02	0.03	0.06	100	100	100	100	100	100
GSB-04	+38 µm frac.	97.6	99.2	0.23	0.53	0.05	0.03	0.05	98.1	49.1	94.5	40.9	91.9	61.2
	-38 µm frac.	2.4	77.4	9.47	1.25	2.71	0.10	1.21	1.9	50.9	5.5	59.1	8.1	38.8
	Feed (calc.)	100	98.6	0.45	0.55	0.11	0.03	0.07	100	100	100	100	100	100
GSB-06	+38 µm frac.	96.2	99.1	0.29	0.55	0.01	0.04	0.04	97.3	25.9	97.3	73.6	92.9	47.7
	-38 µm frac.	3.8	68.5	20.8	0.38	0.10	0.07	1.16	2.7	74.1	2.7	26.4	7.1	52.3
	Feed (calc.)	100	97.9	1.07	0.54	0.01	0.04	0.08	100	100	100	100	100	100

3. Metallurgical Testwork on GSB-03, GSB-04, and GSB-06

After reviewing the head assays and discussing with the Jordan Ministry, samples GSB-03, GSB-04, and GSB-06 were selected for metallurgical testwork to remove impurities and upgrade the SiO_2 grade, with a technical objective of 99.9+% SiO_2 purity.

3.1. WRA Assays of the -1.18 mm fraction of GSB-03, GSB-04, and GSB-06

Samples GSB-03, GSB-04, and GSB-06 were dry screened at 16 mesh (1.18 mm) to remove the oversize material. The WRA assays of the -1.18 mm fractions are presented in Table 5. The mass balances of the +1.18 and -1.18 mm fractions of three silica sands are summarized in Table 6.

Owing to the low mass in the +1.18 mm fractions, the SiO_2 upgrading by rejecting this fraction was negligible, but impurity rejection was apparent: since about 28% of the calcium was discarded from GSB-03 in the +1.18 mm fraction, along with 9.4% calcium and 4.9% iron rejection from GSB-04 and 5.4% iron rejection from GSB-06.

Table 5: -1.18 mm Fractional Assays of GSB-03, GSB-04, and GSB-06

-1.18 mm Fractional Assays			
WRA, %	GSB-03	GSB-04	GSB-06
SiO_2	98.4	98.6	97.7
Al_2O_3	0.56	0.45	1.01
Fe_2O_3	0.03	0.03	0.02
MgO	< 0.01	< 0.01	< 0.01
CaO	0.01	0.09	< 0.01
Na_2O	0.02	< 0.01	< 0.01
K_2O	< 0.01	< 0.01	< 0.01
TiO_2	0.06	0.06	0.07
P_2O_5	0.01	0.01	0.02
MnO	< 0.01	< 0.01	< 0.01
Cr_2O_3	< 0.01	< 0.01	< 0.01
V2O5	< 0.01	< 0.01	< 0.01
LOI	0.56	0.42	0.78
Sum	99.6	99.7	99.6

Table 6: The Mass Pull, Assays, and Distributions of GSB-03, GSB-04 and GSB-06 in +1.18 and -1.18 mm Fractions

Sample ID	Size Fraction	Weight	Assays, %						Distribution, %					
		%	SiO_2	Al_2O_3	Fe_2O_3	CaO*	Na_2O*	TiO_2	SiO_2	Al_2O_3	Fe_2O_3	CaO*	Na_2O*	TiO_2
GSB-03	+1.18 mm frac.	0.4	96.8	0.37	0.03	0.99	0.01	0.09	0.4	0.3	0.4	27.5	0.2	0.6
	-1.18 mm frac.	99.6	98.4	0.56	0.03	0.01	0.02	0.06	99.6	99.7	99.6	72.5	99.8	99.4
	Head (calc.)	100	98.4	0.56	0.03	0.01	0.02	0.06	100	100	100	100	100	100
	Head (dir.)		98.3	0.64	0.02	0.02	0.03	0.07						
GSB-04	+1.18 mm frac.	1.0	96.4	0.89	0.15	0.90	0.02	0.07	1.0	2.0	4.9	9.4	2.0	1.2
	-1.18 mm frac.	99.0	98.6	0.45	0.03	0.09	< 0.01	0.06	99.0	98.0	95.1	90.6	98.0	98.8
	Head (calc.)	100	98.6	0.45	0.03	0.10	0.01	0.06	100	100	100	100	100	100
	Head (dir.)		98.4	0.47	0.05	0.11	0.03	0.07						
GSB-06	+1.18 mm frac.	3.7	98.5	0.29	0.03	< 0.01	0.02	0.02	3.7	1.1	5.4	3.7	7.1	1.1
	-1.18 mm frac.	96.3	97.7	1.01	0.02	< 0.01	< 0.01	0.07	96.3	98.9	94.6	96.3	92.9	98.9
	Head (calc.)	100	97.7	0.98	0.02	0.01	0.01	0.07	100	100	100	100	100	100
	Head (dir.)		98.1	1.01	0.03	0.01	0.03	0.08						

* Element Distribution was calculated assuming assay is 0.01% when below detection limit

3.2. Attrition Scrubbing Testwork

Attrition scrubbing, which utilizes strong friction forces between particles under controlled machine turbulence, can effectively break down clay particles from silica sands and assist in scouring of loosely adhering iron oxide particles to produce a higher-purity silica sand product.

Four attrition scrubbing tests were carried out on full size (without removing +1.18 mm fraction) silica sand samples GSB-03, GSB-04, and GSB-06. An image of the scrubbing unit used in the test is shown in Figure 3. Attrition tests A1 and A2 were completed on GSB-06 at scrubbing intensities of 400 and 900 rpm, each for 10 minutes. Attrition test A3 and A4 were carried out on GSB-04 and GSB-03, using the most effective attrition condition established in test A1 or A2. Each sample was scrubbed at 60% solid density in 1 kg batches in a baffled stainless steel container. A ~200 g subsample from each batch of scrubbed material was screened from its top size down to 38 µm, followed by WRA assay of ten (10) selected size fractions. The effect of attrition scrubbing and scrubbing intensity on upgrading of silica sand sample GSB-06 is presented in Figure 4. The size by size assays and distributions of three scrubbed silica sands are listed in Table 7. More detailed particle size distributions and size by size mass balances are included in Appendix A and Appendix B.

Figure 3: An Image of Multi-blade High Intensity Scrubbing Unit

As can be seen from Figure 4 and Table 7, high-intensive attrition scrubbing can effectively remove impurity elements without compromising the SiO_2 grade of the combined +38 micron fraction of silica sand GSB-06. The major impurity element, Al-bearing minerals (most likely kaolinite clay), can be easily released and washed from the silica sand by intensive attrition conditioning. The alumina reported to -38 micron fraction increased from 74.1% without scrubbing, to 84.5% with moderate scrubbing at 400 rpm, and further enhanced to 88.1% with intensive conditioning at 900 rpm. Therefore, more intensive attritioning was desired for a better impurity removal efficiency for these silica sand samples.

Attrition scrubbing tests on silica sands GSB-03 and GSB-04 were completed using the test A2 conditions (i.e., 900 rpm, 10 min, 60% solid). Similarly, most of the alumina reported to the -38 micron fraction of GSB-03 and GSB-04, which increased by 17.2% and 20.5%, respectively, as a result of attritioning and scrubbing.

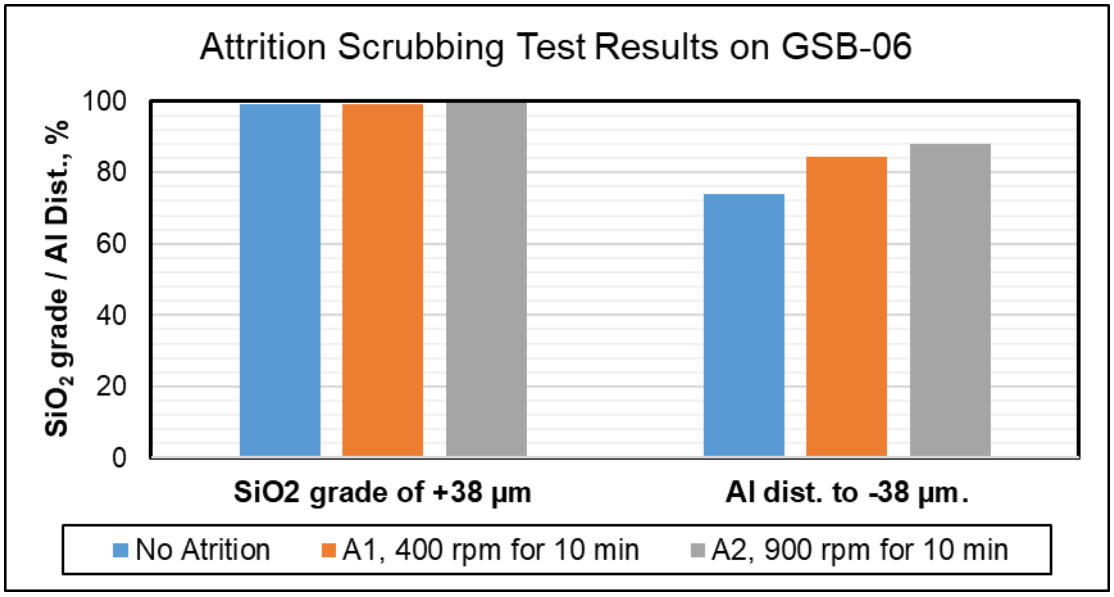


Figure 4: Attrition Scrubbing Test Result Summary on Silica Sand GSB-06 Sample

Table 7: Size by Size Assays and Distributions of Scrubbed Silica Sands

Test# condition	Size Fraction	Weight	Assays, %						Distribution, %					
		%	SiO_2	Al_2O_3	Fe_2O_3	CaO*	Na_2O*	TiO_2*	SiO_2	Al_2O_3	Fe_2O_3	CaO*	Na_2O*	TiO_2*
A1 GSB-06 400 rpm 10 min	+850 µm	8.3	99.1	0.19	0.78	0.02	0.05	0.01	8.4	1.3	12.2	10.4	13.4	1.0
	-850+600 µm	10.5	99.4	0.13	0.63	0.01	0.03	0.01	10.7	1.2	12.5	6.6	10.2	1.2
	-600+425 µm	25.4	99.7	0.14	0.37	< 0.01	0.02	0.02	25.9	3.0	17.7	15.9	16.3	5.9
	-425+300 µm	33.3	99.3	0.16	0.28	< 0.01	0.03	0.02	33.9	4.6	17.6	20.9	32.2	7.7
	-300+212 µm	10.2	98.8	0.22	0.65	< 0.01	0.03	0.04	10.3	1.9	12.5	6.4	9.9	4.7
	-212+150 µm	4.1	98.5	0.33	1.12	< 0.01	0.04	0.09	4.1	1.1	8.6	2.6	5.2	4.2
	-150+106 µm	1.8	97.3	0.50	1.83	0.02	0.04	0.17	1.8	0.8	6.2	2.2	2.3	3.5
	-106+75 µm	0.9	95.4	0.78	2.94	0.04	0.06	0.31	0.9	0.6	5.0	2.2	1.7	3.2
	-75+38 µm	0.9	95.3	1.21	2.61	0.07	0.05	0.41	0.9	1.0	4.6	4.1	1.5	4.5
	-38 µm	4.6	67.2	21.7	0.39	0.10	0.05	1.21	3.1	84.5	3.3	28.6	7.3	64.0
	Head	100	97.7	1.17	0.53	0.02	0.03	0.09	100	100	100	100	100	100
A2 GSB-06 900 rpm 10 min	+850 µm	8.6	99.1	0.09	0.91	< 0.01	0.04	0.01	8.7	0.7	14.7	5.7	11.2	1.0
	-850+600 µm	10.3	99.3	0.07	0.80	< 0.01	0.03	0.02	10.5	0.6	15.5	6.9	10.1	2.3
	-600+425 µm	24.5	99.4	0.09	0.38	< 0.01	0.04	0.02	24.9	2.0	17.5	16.3	32.0	5.5
	-425+300 µm	32.6	99.6	0.11	0.28	< 0.01	0.02	0.02	33.2	3.2	17.1	21.6	21.3	7.2
	-300+212 µm	10.6	99.7	0.14	0.54	< 0.01	0.03	0.03	10.8	1.3	10.7	7.0	10.4	3.5
	-212+150 µm	4.3	99.7	0.21	0.99	< 0.01	0.04	0.08	4.3	0.8	7.9	2.8	5.6	3.8
	-150+106 µm	2.0	98.0	0.34	1.43	0.02	0.03	0.13	2.0	0.6	5.3	2.6	1.9	2.8
	-106+75 µm	1.0	96.7	0.73	2.09	0.04	0.04	0.23	1.0	0.6	3.8	2.6	1.3	2.5
	-75+38 µm	1.0	94.0	2.42	1.51	0.06	0.04	0.33	0.9	2.1	2.8	3.9	1.3	3.6
	-38 µm	5.1	70.6	19.4	0.48	0.09	0.03	1.19	3.7	88.1	4.6	30.6	5.0	67.8
	Head	100	97.9	1.13	0.53	0.02	0.03	0.09	100	100	100	100	100	100
A3 GSB-04 900 rpm 10 min	+850 µm	3.1	97.9	0.32	0.05	0.12	0.05	0.02	3.0	2.1	2.3	3.6	8.5	0.9
	-850+600 µm	7.6	99.0	0.10	0.03	0.04	< 0.01	0.01	7.6	1.7	3.4	3.0	4.2	1.2
	-600+425 µm	26.6	99.6	0.13	0.02	0.02	< 0.01	0.01	26.9	7.6	7.9	5.2	14.8	4.1
	-425+300 µm	33.2	99.5	0.09	0.02	0.02	< 0.01	0.01	33.5	6.5	9.9	6.5	18.5	5.1
	-300+212 µm	14.8	99.1	0.12	0.03	0.02	0.02	0.02	14.9	3.9	6.6	2.9	16.5	4.5
	-212+150 µm	6.4	98.6	0.19	0.04	0.04	0.02	0.06	6.4	2.6	3.8	2.5	7.1	5.9
	-150+106 µm	2.6	98.3	0.26	0.06	0.08	0.03	0.14	2.6	1.5	2.4	2.1	4.4	5.7
	-106+75 µm	1.5	97.1	0.37	0.10	0.15	0.06	0.25	1.5	1.2	2.2	2.2	5.0	5.7
	-75+38 µm	1.2	97.0	0.54	0.22	0.29	0.06	0.24	1.2	1.5	4.1	3.5	4.1	4.6
	-38 µm	3.0	76.3	10.8	1.28	2.33	0.10	1.35	2.3	71.4	57.5	68.7	16.8	62.4
	Head	100	98.5	0.46	0.07	0.10	0.02	0.07	100	100	100	100	100	100
A4 GSB-03 900 rpm 10 min	+850 µm	1.3	95.6	0.41	0.06	0.38	0.11	0.02	1.2	1.0	1.7	18.1	7.9	0.4
	-850+600 µm	7.2	99.0	0.11	0.02	0.02	0.01	< 0.01	7.3	1.5	3.2	5.4	4.0	1.1
	-600+425 µm	38.7	99.2	0.09	0.02	< 0.01	0.02	0.02	39.0	6.5	17.0	14.4	43.3	11.9
	-425+300 µm	38.5	99.5	0.10	0.02	< 0.01	0.01	0.02	38.9	7.2	16.9	14.4	21.5	11.8
	-300+212 µm	6.8	98.7	0.19	0.03	0.02	0.02	0.04	6.8	2.4	4.5	5.1	7.6	4.2
	-212+150 µm	2.1	98.0	0.27	0.06	0.03	0.03	0.10	2.1	1.1	2.8	2.3	3.5	3.2
	-150+106 µm	1.0	97.5	0.38	0.09	0.05	0.06	0.15	1.0	0.7	2.0	1.9	3.4	2.4
	-106+75 µm	0.7	96.9	0.37	0.12	0.08	0.05	0.17	0.7	0.5	1.8	2.0	1.9	1.8
	-75+38 µm	0.6	95.3	0.42	0.18	0.14	0.05	0.20	0.6	0.5	2.4	3.1	1.7	1.8
	-38 µm	3.1	77.7	13.6	0.71	0.29	0.03	1.30	2.4	78.6	47.9	33.2	5.2	61.4
	Head	100	98.5	0.53	0.05	0.03	0.02	0.07	100	100	100	100	100	100

* mass balance was calculated assuming assays were 0.01% when below detection limits

3.3. One-Stage Attrition Scrubbing, Desliming, and Magnetic Separation Testwork

Four magnetic separation tests were carried out on silica sand samples GSB-03, GSB-04, and GSB-06 to reject any magnetic-susceptible particles (such as iron oxides and/or iron silicates) and improve the SiO_2 grade. These samples were attrition scrubbed at 900 rpm for 10 min at 60% solid density, and wet screened to remove the -38 micron fraction, which was considered as an effective cut-off particle size for removing gangue minerals without significant silica losses. The resulting +38 micron fractions were submitted for magnetic separation testwork.

3.3.1. Dry-Belt Magnetic Separation *vs.* Wet High-Intensity Magnetic Separation (WHIMS)

Due to the relatively coarse particle sizes, magnetic separation on a deslimed silica sand GSB-06 was assessed using a High-Force® dry belt magnetic separator and an Eriez wet high-intensity magnetic separator. The images of the lab testing equipment are shown in Figure 5.

The dry belt magnetic separator was equipped with a magnetic roller, with an expected magnetic intensity of 20,000 Gauss. Testing was completed by adjusting the belt speed, roll speed, and splitter for visual differences of the optimal trajectory of magnetic and non-magnetic streams. WHIMS testing was completed by passing the material through a coarse-expanded metal matrix at a pulp density of 20-30% solids, at 5,000 Gauss intensity. The non-magnetic fraction was repassed at 20,000 Gauss intensity for maximum magnetics rejection.

Figure 5: Exhibition of Dry Magnetic Separator (left) and Eriez WHIMS Lab Unit (right)

The results of the dry and wet magnetic separation with the GSB-06 sample are presented in Table 8. Both units removed iron effectively from the GSB-06 sample. The iron content in the two non-magnetics was

very low, at or below the lower XRF detection limit of 0.01% Fe_2O_3. However, the WHIMS non-magnetic product assayed 99.6% SiO_2 and 0.06% Al_2O_3, better than the non-magnetics from dry belt magnetic separation, which was assayed 98.8% SiO_2 and 0.08% Al_2O_3. Therefore, WHIMS is preferred over a dry-belt magnetic separator for the application of silica sand upgrading and impurity removal in this project.

Table 8: Dry and Wet Magnetic Separation Test Results on Silica Sand GSB-06

Test#	Mag Sep Product	Weight	Assays, %						Distribution, %					
	GSB-06, full size	%	SiO_2	Al_2O_3	Fe_2O_3*	CaO*	Na_2O*	TiO_2	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	TiO_2
M1	Dry Mag Sep, Non-mag	91.6	98.8	0.08	< 0.01	< 0.01	< 0.01	0.02	92.9	7.0	22.1	71.0	79.4	22.0
	Dry Mag Sep, Mag	3.5	98.9	0.51	0.16	0.01	0.04	0.20	3.6	1.7	13.7	2.7	12.2	8.5
Dry Mag Sep	-38 micron fraction	4.8	70.1	19.7	0.55	0.07	0.02	1.20	3.5	91.2	64.2	26.2	8.4	69.5
	Head Sample(calc.)	100	97.4	1.04	0.04	0.01	0.01	0.08	100	100	100	100	100	100
	Head Sample (dir.)		98.1	1.01	0.03	0.01	0.03	0.08						
M2	WHIMS, 20K Gauss, Non-mag	90.7	99.6	0.06	0.01	< 0.01	0.01	0.01	92.1	5.3	21.0	69.8	83.5	12.6
	WHIMS, 20K Gauss, Mag	3.5	98.8	0.17	0.13	0.01	0.01	0.09	3.6	0.6	10.6	2.7	3.3	4.4
	WHIMS, 5K Gauss, Mag	0.9	97.0	0.69	0.31	0.02	0.05	0.16	0.9	0.6	6.8	1.5	4.4	2.1
WHIMS	-38 micron fraction	4.8	70.1	19.7	0.55	0.07	0.02	1.20	3.5	93.4	61.5	26.0	8.9	80.8
	Head Sample(calc.)	100	98.1	1.02	0.04	0.01	0.01	0.07	100	100	100	100	100	100
	Head Sample (dir.)		98.1	1.01	0.03	0.01	0.03	0.08						

* Element Distribution was calculated assuming assay is 0.01% when below detection limit

3.3.2. WHIMS Testing on Silica Sands GSB-03 and GSB-04

WHIMS testing was completed on the -1.18 mm fraction of samples GSB-03 and GSB-04, after attrition scrubbing and desliming. The mass balances are listed in Table 9.

WHIMS was shown to be very effective for removal of both alumina and iron from silica sands. Only 0.08% Al_2O_3 and 0.02% Fe_2O_3 remained in the non-magnetic portion of sample GSB-03 and 0.06% Al_2O_3 and <0.01% Fe_2O_3 in the non-magnetic product of sample GSB-04.

Table 9: WHIMS Testwork Results on Silica Sand GSB-03 and GSB-04, -1.18 mm Fraction

Test#	Mag Sep Product	Weight	Assays, %						Distribution, %					
		%	SiO_2	Al_2O_3	Fe_2O_3*	CaO	Na_2O*	TiO_2	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	TiO_2
M3	WHIMS, 20K Gauss, Non-mag	95.2	98.8	0.08	0.02	0.02	< 0.01	0.01	96.0	12.4	44.4	65.7	90.2	16.3
	WHIMS, 20K Gauss, Mag	0.7	97.1	0.40	0.25	0.12	0.03	0.30	0.7	0.4	3.8	2.7	1.9	3.4
GSB-03,	WHIMS, 5K Gauss, Mag	1.0	96.2	0.88	0.36	0.11	0.05	0.28	1.0	1.5	8.8	4.0	5.0	5.0
-1.18 mm	-38 micron fraction	3.1	72.8	17.1	0.60	0.26	0.01	1.43	2.3	85.7	43.0	27.6	2.9	75.3
Frac.	Head Sample (calc.)	100	98.0	0.61	0.04	0.03	0.01	0.06	100	100	100	100	100	100
	Head Sample (dir.)		98.4	0.56	0.03	0.01	0.02	0.06						
M4	WHIMS, 20K Gauss, Non-mag	95.9	98.4	0.06	< 0.01	0.01	< 0.01	0.01	96.7	13.7	19.2	11.2	80.8	17.2
	WHIMS, 20K Gauss, Mag	0.6	97.1	0.51	0.15	0.04	0.02	0.24	0.6	0.7	1.8	0.3	1.0	2.5
GSB-04,	WHIMS, 5K Gauss, Mag	0.8	96.1	1.32	0.53	0.04	0.07	0.30	0.8	2.4	8.1	0.4	4.5	4.1
-1.18 mm	-38 micron fraction	2.7	71.7	12.9	1.31	2.77	0.06	1.57	2.0	83.2	71.0	88.1	13.7	76.2
Frac.	Head Sample (calc.)	100	97.6	0.42	0.05	0.09	0.01	0.06	100	100	100	100	100	100
	Head Sample (dir.)		98.6	0.45	0.03	0.09	< 0.01	0.06						

* Element Distribution was calculated assuming assay is 0.01% when below detection limit

3.4. Three-stage Attrition Scrubbing, Desliming, and WHIMS Testwork

To maximize the alumina and iron rejection and improve SiO_2 grade, a three-stage attrition scrubbing, desliming, followed by WHIMS magnetic separation was tested on the -1.18 mm fraction of samples GSB-03, GSB-04, and GSB-06. The pulp pH was adjusted to 12 with caustic soda to aid in the dispersion of fine clay particles that were broken down from coarse silica sand particles. This was different from the attrition scrubbing procedure described in Section 3.2 and Section 3.3. WHIMS testing was also completed on samples that had been separated into three size fractions (+600 micron, -600/+300 micron, and -300 micron), which was believed to improve the magnetic separation efficiency, compared with passing the material in one size. The block flowsheet diagram is presented in Figure 6 and the results are summarized in Table 10. .

The three-stage process removed >80% of the iron and >90% of the alumina from all three silica sands samples and recovered 95-96% of the silica in a final non-magnetic product that assayed ~99% SiO_2. The major impurities in the non-magnetics fraction of GSB-03, GSB-04, and GSB-06 were 0.04-0.05% Al_2O_3 and ≤0.01% Fe_2O_3, lower than the trace impurity levels achieved in the one-stage process. The SiO_2 of the non-magnetics (99.0%, 98.8%, and 98.9%) were performed by borate fusion XRF, which, as stated previously has a relative error of +/-2% when above 90%.

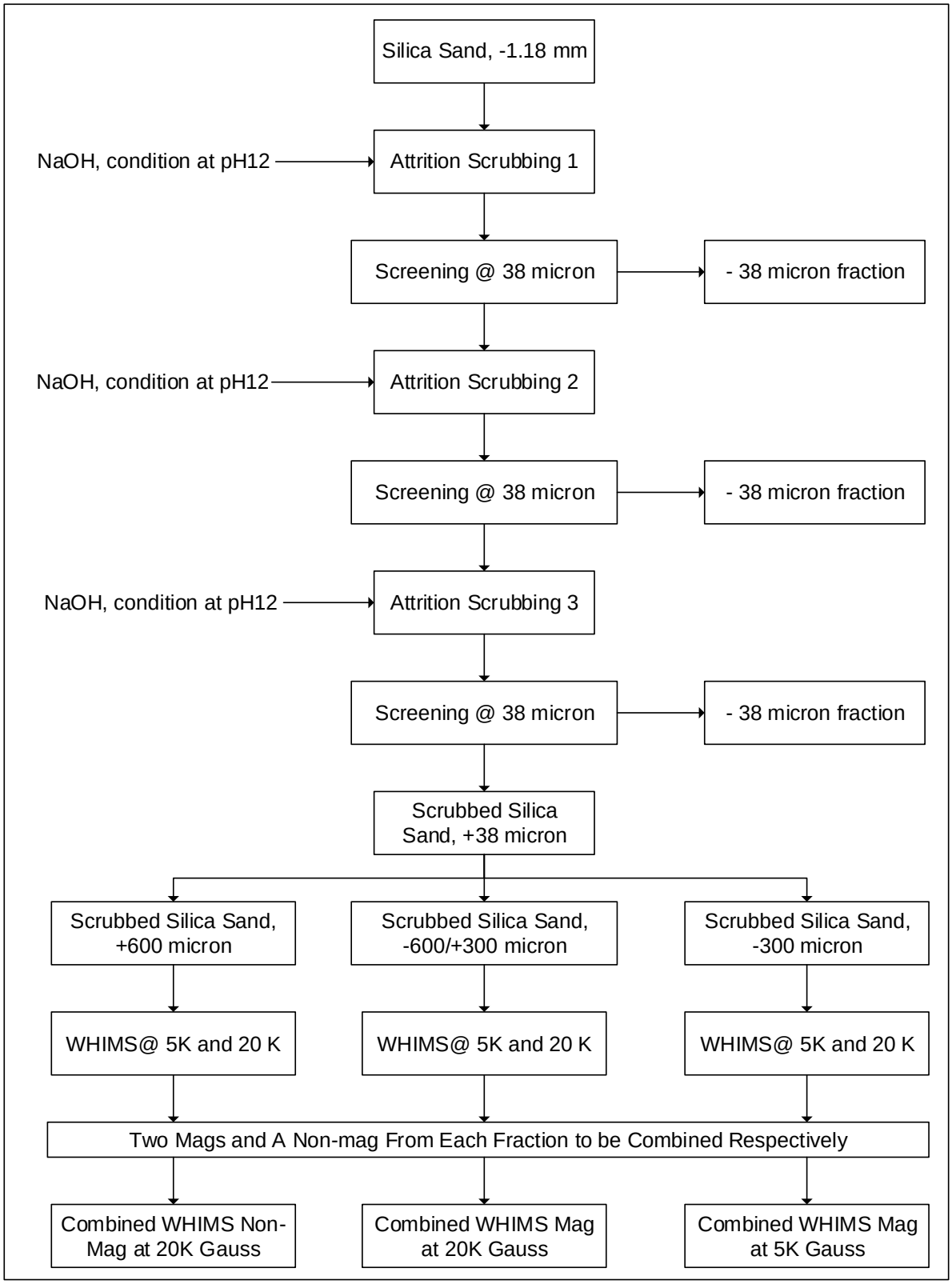


Figure 6: Block Flow Diagram of Three-Stage Attrition Scrubbing and WHIMS Testing

Table 10: Test Summary of Three-stage Attrition Scrubbing and WHIMS on the -1.18 mm Fraction of Silica Sand GSB-03, GSB-04, and GSB-06 Samples

Sample ID	Product	Weight	Assays, %						Distribution, %					
		%	SiO_2	Al_2O_3	Fe_2O_3*	CaO*	Na_2O*	TiO_2	SiO_2	Al_2O_3	Fe_2O_3*	CaO*	Na_2O*	TiO_2*
GSB-03	WHIMS, 20K Gauss, Non-mag	95.3	99.0	0.05	0.01	< 0.01	< 0.01	< 0.01	96.2	7.8	18.7	42.0	86.0	15.7
	WHIMS, 20K Gauss, Mag	0.5	96.7	0.63	0.47	0.03	0.06	0.21	0.4	0.5	4.2	0.6	2.5	1.6
	WHIMS, 5K Gauss, Mag	0.5	93.6	2.18	0.83	0.10	0.11	0.34	0.5	1.8	8.2	2.2	5.0	2.8
	-38 micron fraction, 3rd Scrub	0.2	94.0	1.18	2.52	0.16	0.01	0.4	0.2	0.5	12.0	1.7	0.2	1.6
	-38 micron fraction, 2nd Scrub	0.3	91.7	2.44	2.57	0.20	0.02	0.57	0.3	1.3	16.3	2.8	0.6	3.0
	-38 micron fraction, 1st Scrub	3.2	72.9	17.0	0.65	0.36	0.02	1.43	2.4	88.2	40.7	50.6	5.8	75.2
	Head Sample (calc.)	100	98.1	0.61	0.05	0.02	0.01	0.06	100	100	100	100	100	100
	Head Sample (dir.)		98.1	1.01	0.03	0.01	0.03	0.08						
GSB-04	WHIMS, 20K Gauss, Non-mag	95.8	98.8	0.04	< 0.01	0.02	< 0.01	0.02	96.6	9.3	16.6	17.6	77.2	28.3
	WHIMS, 20K Gauss, Mag	0.7	97.3	0.56	0.33	0.09	0.04	0.25	0.6	0.9	3.7	0.5	2.1	2.4
	WHIMS, 5K Gauss, Mag	0.5	94.7	1.65	0.67	0.11	0.1	0.34	0.5	1.9	5.5	0.5	3.8	2.4
	-38 micron fraction, 3rd Scrub	0.2	93.5	1.03	1.72	0.76	0.08	0.54	0.2	0.5	6.0	1.4	1.3	1.6
	-38 micron fraction, 2nd Scrub	0.4	89.0	3.14	2.08	1.23	0.05	0.89	0.4	3.4	15.9	5.0	1.8	5.8
	-38 micron fraction, 1st Scrub	2.5	68.8	14.2	1.23	3.34	0.07	1.64	1.7	84.1	52.3	75.0	13.8	59.5
	Head Sample (calc.)	100	98.0	0.41	0.06	0.11	0.01	0.07	100	100	100	100	100	100
	Head Sample (dir.)		98.6	0.45	0.03	0.09	< 0.01	0.06						
GSB-06	WHIMS, 20K Gauss, Non-mag	93.2	98.9	0.05	< 0.01	< 0.01	< 0.01	0.01	94.7	4.5	18.2	44.4	86.9	12.8
	WHIMS, 20K Gauss, Mag	0.8	98.4	0.29	0.16	0.02	0.03	0.13	0.8	0.2	2.4	0.7	2.2	1.4
	WHIMS, 5K Gauss, Mag	0.5	94.2	1.87	0.65	0.06	0.09	0.27	0.5	0.9	6.6	1.5	4.4	1.9
	-38 micron fraction, 3rd Scrub	0.3	95.0	1.31	1.94	0.06	0.06	0.4	0.3	0.4	12.2	0.9	1.8	1.8
	-38 micron fraction, 2nd Scrub	0.5	91.2	3.37	2.08	0.08	< 0.01	0.58	0.5	1.7	21.2	2.0	0.5	4.1
	-38 micron fraction, 1st Scrub	4.6	68.7	20.7	0.44	0.23	< 0.01	1.24	3.2	92.2	39.4	50.4	4.3	78.0
	Head Sample (calc.)	100	97.4	1.03	0.05	0.02	0.01	0.07	100	100	100	100	100	100
	Head Sample (dir.)		97.7	1.01	0.02	< 0.01	< 0.01	0.07						

* Element Distribution was calculated assuming assay is 0.01% when below detection limit

SiO_2 assay by borate fusion XRF method has a relative error of 2%

3.5. Acid Leaching Testwork

Five acid leaching tests were completed on the non-magnetic products generated in the three-stage attrition scrubbing, desliming and WHIMS flowsheet. Extreme leaching conditions were used in these scoping leach tests, with no attempt at process optimization. The purpose was to extract any remaining impurity elements while leaving silica behind in the leach residue, at a target grade of 99.9% SiO_2.

The standard procedure involved placing 200 g of the leach feed, either as-is or stage-pulverized to 100% passing 75 µm, in a glass reactor followed by DI water and acid addition to the desired solid content and acidity, with temperature maintained at approximately 80°C under atmospheric condition. The leaching time was either four or six hours. At the end of the test, the pulp was filtered and washed. The leach residue was dried and submitted for WRA or gravimetric SiO_2. Selected leach residues were submitted for trace impurity assays by neutron activation analysis and the wash solution was also submitted for ICP analysis. The acid consumption was based on the difference between acid added and acid remaining in solution at the end of the test.

Tests L1 to L3 were carried out on WHIMS non-magnetic product of silica sand GSB-03. Tests L1 and L2 compared the extraction performance of HCl and H_2SO_4 as the lixiviant, while test L3 investigated the effect of feed particle size. Test L4 and L5 were carried out on silica sand GSB-04 and GSB-06, respectively,

using the pre-optimized test conditions. A summary of each test condition is presented in Table 11 and full test details are in Appendix C.

Table 11: Conditions for Acid Leaching Tests L1-L5

Test ID	L1	L2	L3	L4	L5
Feed	GSB-03, WHIMS Non-mag	GSB-03, WHIMS Non-mag	GSB-03, WHIMS Non-mag	GSB-04, WHIMS Non-mag	GSB-06, WHIMS Non-mag
%solids	10	10	10	10	10
Feed Size (K_{80}, µm)	As is	As is	53.1	57.9	54.9
Temp, °C	80	80	80	80	80
Leach Time, hr	4	4	6	6	6
Reagent	HCl	H_2SO_4	HCl	HCl	HCl
Target Acidity, w/w %	20	20	20	20	20
Acid added, tonne/tonne	1.81	1.81	1.79	1.80	1.81
Acid Cons, kg/tonne	3	18	595	615	663

The extraction of impurities in leach tests L1-L5 is shown in Table 12. Photographs of PLS solutions and acid leach residues are presented in Figure 7 and Figure 8.

It should be noted that most of the impurity elements in the feed solids were already below or around the analytical detection limits of the borate fusion XRF and ICP-MS techniques and were expected to be even lower in the leach residues, which led to an incomplete mass balance. Therefore, the amount of extracted metal units in the leach solution (in milligrams per 200 g of leach feed) was used to estimate the purity of the SiO_2 in the leach residue to provide an indication of the leach performances.

Table 12: Result Summary of Acid Leaching Tests L1-L5

Test ID	Leach Feed	Residue, %	SiO_2 % in Feed XRF_76V	SiO_2 % in Residue		Extracted Metals, mg		
				XRF_76V	ASTM-C146	Al	Fe	Co
L1	GSB-03, WHIMS Non-mag	100	99.0	99.5	-	3	6	-
L2	GSB-03, WHIMS Non-mag	99.3	99.0	99.3	-	1	3	-
L3	GSB-03, WHIMS Non-mag	96.7	99.0	-	99.66	n/a	n/a	n/a
L4	GSB-04, WHIMS Non-mag	94.5	98.8	-	99.80	15	27	99
L5	GSB-06, WHIMS Non-mag	97.5	98.9	-	99.58	12	15	110

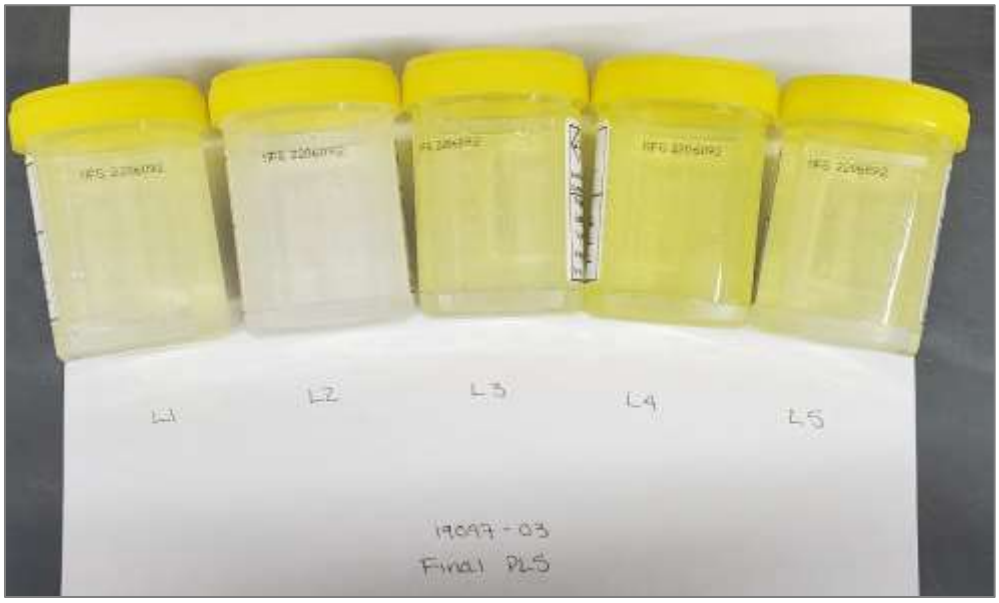


Figure 7: Images of PLS solutions of Acid Leaching Tests L1-L5

Figure 8: Images of Residues of Acid Leaching Tests L3-L5

Based on the test results and observations, the following conclusions can be made:

- Negligible impurity metals were extracted from as-received silica sand samples by HCl or H_2SO_4. HCl showed slightly better leaching performance than H_2SO_4 at same acidity strength.
- Fine grinding to K_{80} of 53-58 µm significantly improved Al, Fe, and Co impurity removal efficiency.
- Finer grinding as well as stronger HCl or longer leach time should all be investigated to see whether the target purity of 99.9% SiO_2 can be achieved.

It should be mentioned that test L3 only reported residue assays without quantifying the extracted metals from PLS and wash solution, which were discarded accidently before subsampling was to occur. The extractive performance in test L3, however, should be similar to test L4 or L5, judging from the purity of leach residues and colour of PLS solutions as presented in Figure 7 and Figure 8.

3.4. Final Silica Sand Products Assays

The gravimetric SiO_2 and impurity element assays of the leached residues from the -1.18 mm fraction of silica sand GSB-03, GSB-04, and GSB-06 samples after acid washing are presented in Table 13. The assay certificates are attached in Appendix D.

The final leach residue of GSB-03, GSB-04, and GSB-06 graded 99.66, 99.80, and 99.58% SiO_2 by a gravimetric method (ASTM-C146), slightly lower than the 99.9% SiO_2 target.

The alumina remained as the major impurity element in the leach residue of GSB-03, GSB-04, and GSB-06, followed by titanium and calcium, which assayed 407-450, 74-99, and 20-31 ppm, respectively,

Table 13: Gravimetric SiO_2 Assay and Impurity Elements by Neutron Activation Analysis and Borate Fusion XRF on Final Silica Sand Products

Product	SiO_2, % ASTM C-146	Neutron Activation Analysis, ppm								Borate Fusion XRF, %					
		Al	Ca	Cr	Mg	Mn	K	Na	Ti	Fe_2O_3	P_2O_5	Cr_2O_3	V_2O_5	LOI	SUM
L3 residue, GSB-03	99.66	412	31	<10	<30	0.830	<110	22.0	74.0	0.01	<0.01	<0.01	<0.01	0.26	99.6
L4 residue, GSB-04	99.80	450	27	<10	<30	0.830	<110	74.0	99.0	<0.01	<0.01	<0.01	<0.01	0.39	99.6
L5 residue, GSB-06	99.58	407	20	<10	<30	0.650	<110	19.0	89.0	0.01	<0.01	<0.01	<0.01	0.39	100.3

3.5. Marketing Evaluation on Final Silica Sand Products

The grain size distribution and the geochemical analyses of the final products (Table 13) indicate that several grades of silica sand may be produced from a single operation by varying the degrees of mineral processing. The very highest grades are often only achievable if produced alongside more standard grades to achieve sufficient economy of scale and to avoid having large quantities of off-specification material or waste. The geochemical analyses indicated that primary grade (>99.5%) SiO_2 can be produced from the current deposit. Elemental impurities such as Ca, Ti, and Al were generally very low indicating that there might be a wide range of applications for the final silica products. Note that Fe_2O_3 was 0.02-0.08% in the head samples, and below 0.03% in the -1.18 mm fractions (GSB-03, 04, 06) which may meet the specifications for most applications. For example, iron (see Table 16 in the Mineralogy report) has to be <0.035% for ceramics application, 0.013% for colour TV glass etc.

The current processed silica sand should be readily capable of meeting the quality requirements of all but the most demanding applications (99.9% SiO_2). Table 14 summarizes potential applications for 99.5% and 99.9% silica sand. However, note that the metallurgical process has not been optimized. Therefore, the potential to achieve 99.9% SiO_2 is significant.

It is critical to emphasize that the current results reflect the samples tested.

Table 14: Potential Markets for 99.5% and 99.9% SiO_2 Silica Sand from Jordan

Market Application	99.5% SiO_2	Comments	99.9% SiO_2	Comments
Insulation Glass fibre	Yes	-200 mesh	Yes	-200 mesh
Reinforcing Glass Fibre	Yes	-200 mesh	Yes	-200 mesh
Coloured Glass	Yes	40 x 80 mesh		Can be used but not required
Clear float glass			Yes	40 x 80 mesh
Container Glass (clear)			Yes	40 x 80 mesh
Container Glass (coloured)	Yes	40 x 80 mesh		Can be used but not required
Ceramics			Yes	-200 mesh
Sodium Silicate	Yes	<0.03% Al_2O_3, -60 µm	Yes	<0.03% Al_2O_3, -60 µm
Pharmaceutical glass			Yes	Within limits based on total Fe_2O_3 in silica batch
Optical/opthalmic glass			Possible	Depends on total Fe, Al_2O_3, K in silica batch
Crystal Glass			Possible	Depends on total Fe, Al_2O_3, K in silica batch
SiC – green			Yes	
SiC- black	Yes			
Filtration	Yes	Water filtration, garins size important	Yes	Water filtration, grain size important
Whole grain fillers/builders products	Yes			May be too expensive
Golf course sand	Yes	Grain size and morphology important, high brightness required	Yes	Grain size and morphology important, high brightness required

3.6. Proposed Silica Sand Beneficiation Flowsheet

The beneficiation flowsheet for the Silica sand (Figure 9) was proposed for industrial application based on the assumption that samples have similar particle size distributions and mineralogy. It should be noted that additional testing and process optimization are still required before implementing the flowsheet across the silica sand deposit or other deposits which may have different metallurgical response.

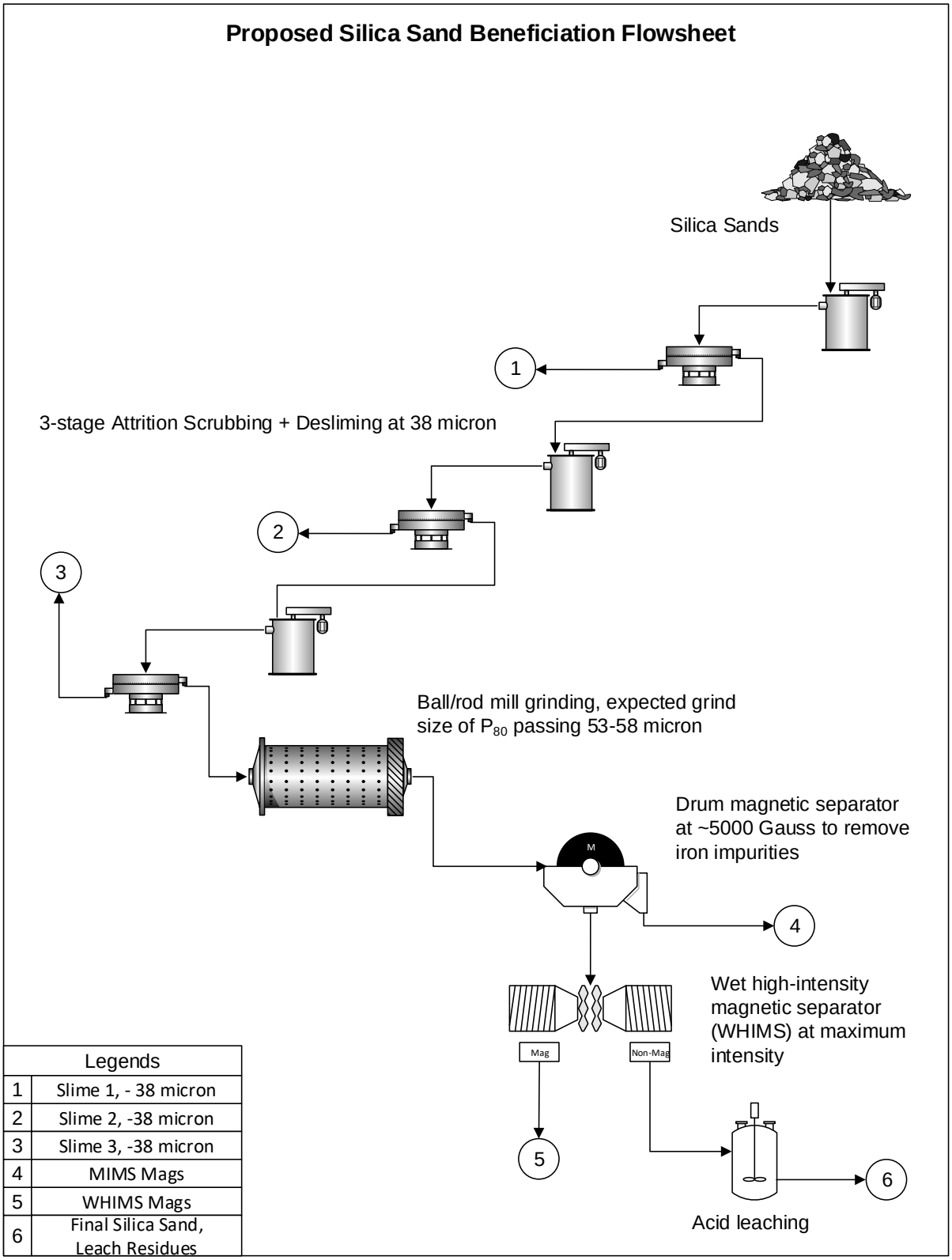


Figure 9: Proposed Silica Sand Beneficiation Flowsheet (test validation required)

Conclusions and Recommendations

The following conclusions can be drawn based on the testwork results:

- The five silica sand samples assayed 95~98% SiO_2 by borate fusion XRF. The major impurity elements were alumina (0.5-1.8% Al_2O_3), iron (0.02-0.08% Fe_2O_3), calcium (0.02-0.27% CaO), titanium (0.07-0.25% TiO_2), and cobalt (710-806 g/t Co). Al_2O_3 reflects mainly the presence of kaolinite as was shown in the mineralogy report (19097-01).

- The particle size distributions were similar; K_{80} sizes ranged from 477 to 601 µm, for the five silica sand samples at a crush size of -3.35 mm. Size by size analyses indicated that the impurity elements, such as alumina, calcium, and titanium, were mainly distributed in the -38 micron fraction, which can likely be removed by desliming.

- Samples GSB-03, GSB-04, and GSB-06 were selected for the metallurgical testwork as a proof-of-concept purpose, with technical objectives of removing impurity elements and improve SiO_2 grade to 99.9+% purity.

- Intensive attrition scrubbing and desliming/washing out the -38 µm fine particles was a cost-effective beneficiation method capable of scrubbing out most of the gangue mineral impurities. Three-stage intensive attrition scrubbing and desliming also produced cleaner silica sands than one-stage intensive attrition scrubbing and desliming.

- Magnetic separation was capable of removing >80% of the residual iron and >90% of the residual alumina remaining in the silica sand after intensive scrubbing and desliming ,and thus increased the purity of the silica sand to ~99.0%. Eriez wet high-intensity magnetic separation (WHIMS) was more effective than a dry-belt magnetic separator in this aspect. The non-magnetic fractions of WHIMS test graded 98.8-99.0% SiO_2 by borate fusion XRF, while some of the impurities assayed 0.04-0.05% Al_2O_3 and $\leqslant$0.01% Fe_2O_3.

- Leaching with hydrochloric acid under best established test conditions (20% HCl, 10% solid (w/w), 80°C, and 6 hour reaction time) further improved the silica grade of GSB-03, GSB-04 and GSB-06 to 99.66, 99.80, and 99.58% SiO_2, with +/-0.25% absolute uncertainty. This was still slightly below the 99.9%SiO_2 target, which was not achieved in this testwork.

- The geochemical analyses of the current silica sand should meet the quality requirements of all but the most demanding applications (99.9% SiO_2), but this should be verified.

The following recommendations are made for the future testing:

- Further optimize the attrition scrubbing conditions, such as higher solid density, longer scrubbing time, with/without dispersant addition.
- Further optimize the WHIMS test conditions on stage-ground scrubbed silica sands to maximize iron and alumina rejection.
- Investigate the effect of temperature, acidity, solids density, and feed particle size to optimize the acid leaching condition.
- Perform bench leaching tests using newly established test conditions to determine the impact of recycled leaching solution on silica sand samples.
- Carry out variability testwork to evaluate the silica sand upgrading potentials using the proposed flowsheet. This should also include geochemical analyses, and mineralogical (10% of the samples) analyses of representative samples across the deposit to ensure that the elemental and mineral impurities are similar.
- Carry out bench-scale testing to validate the proposed silica sand beneficiation flowsheet presented in Figure 9.
- Test a large composite and representative sample from the deposit to ensure that bulk mining can be implemented.
- Perform a fully integrated pilot plant on silica sand composite ore to demonstrate and confirm the flowsheet developed at the bench scale.
- Perform environmental testing on the tailings sample generated.
- Develop analytical methods to to lower detection limits of trace impurity elements and improve precision of SiO2 assay.

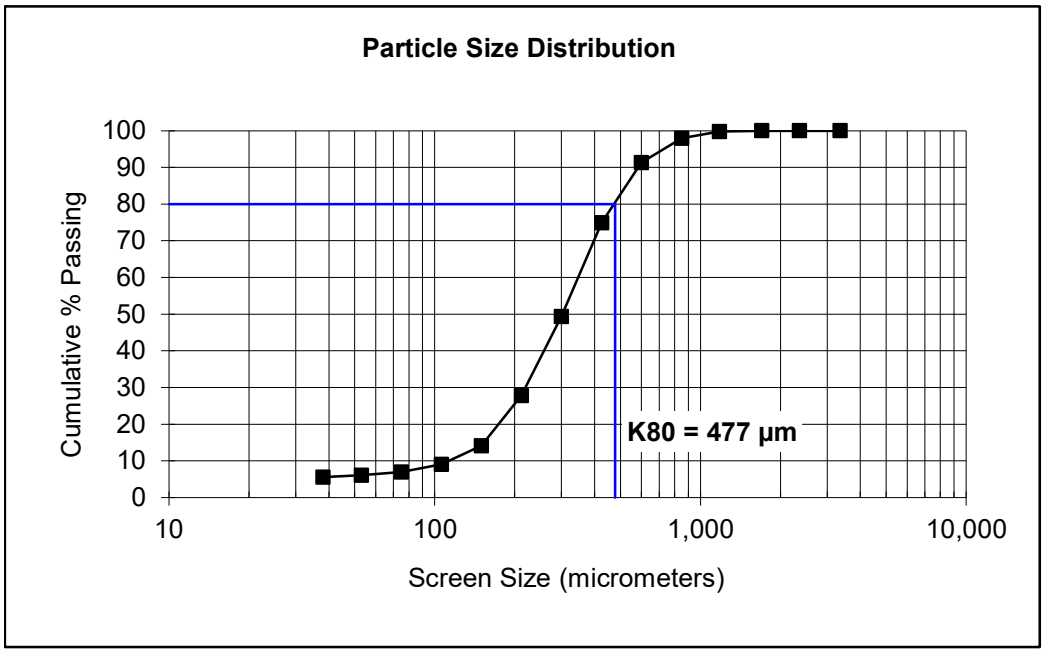
Appendix A – Particle Size Distributions

SGS Minerals Services
Size Distribution Analysis

Project No. **19097-03**

Sample: **GSB-01** Test No.: **SFA**

Size		Weight	% Retained		% Passing
Mesh	µm	grams	Individual	Cumulative	Cumulative
6	3,350	0.0	0.0	0.0	100.0
8	2,360	0.0	0.0	0.0	100.0
10	1,700	0.0	0.0	0.0	100.0
14	1,180	0.6	0.2	0.2	99.8
20	850	4.8	1.8	2.0	98.0
28	600	17.7	6.7	8.7	91.3
35	425	43.6	16.4	25.1	74.9
48	300	67.8	25.5	50.6	49.4
65	212	57.2	21.5	72.1	27.9
100	150	36.4	13.7	85.8	14.2
150	106	13.6	5.1	91.0	9.0
200	75	5.4	2.0	93.0	7.0
270	53	2.4	0.9	93.9	6.1
400	38	1.3	0.5	94.4	5.6
Pan	-38	14.9	5.6	100.0	0.0
Total	**-**	**265.7**	100.0	**-**	**-**
K80	**477**				

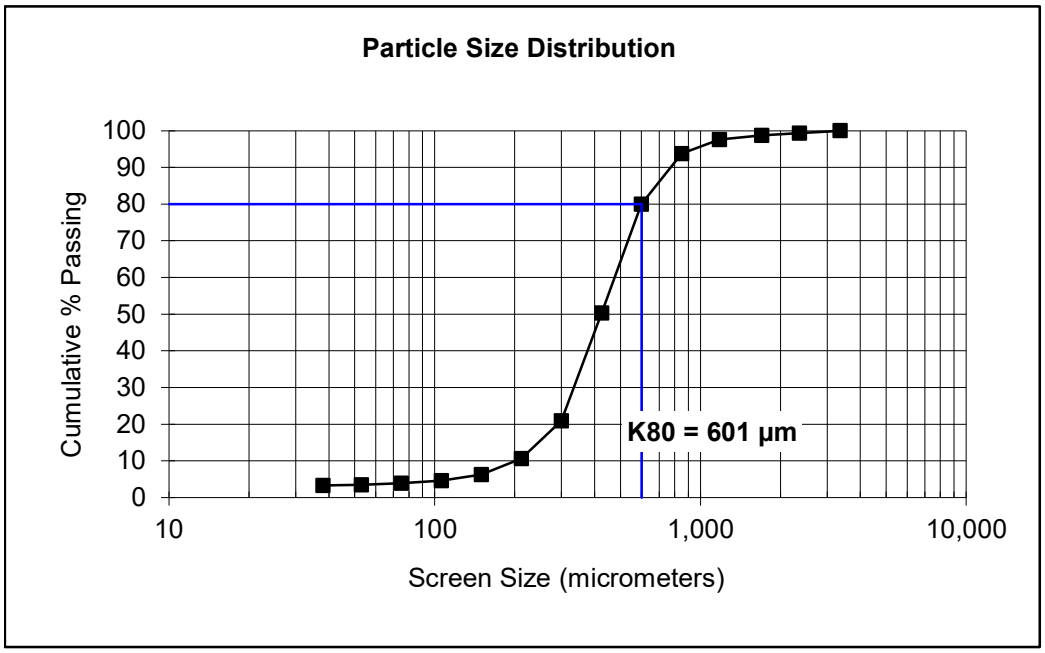


SGS Minerals Services
Size Distribution Analysis

Project No. **19097-03**

Sample: **GSB-02** Test No.: **SFA**

Size		Weight	% Retained		% Passing
Mesh	µm	grams	Individual	Cumulative	Cumulative
6	3,350	0.0	0.0	0.0	100.0
8	2,360	1.6	0.6	0.6	99.4
10	1,700	1.6	0.6	1.3	98.7
14	1,180	2.9	1.2	2.4	97.6
20	850	9.6	3.8	6.3	93.7
28	600	34.6	13.8	20.1	79.9
35	425	74.2	29.6	49.7	50.3
48	300	73.7	29.4	79.1	20.9
65	212	25.9	10.3	89.4	10.6
100	150	10.8	4.3	93.7	6.3
150	106	4.2	1.7	95.4	4.6
200	75	1.8	0.7	96.1	3.9
270	53	1.0	0.4	96.5	3.5
400	38	0.5	0.2	96.7	3.3
Pan	-38	8.3	3.3	100.0	0.0
Total	**-**	**250.7**	100.0	**-**	**-**
K80	**601**				

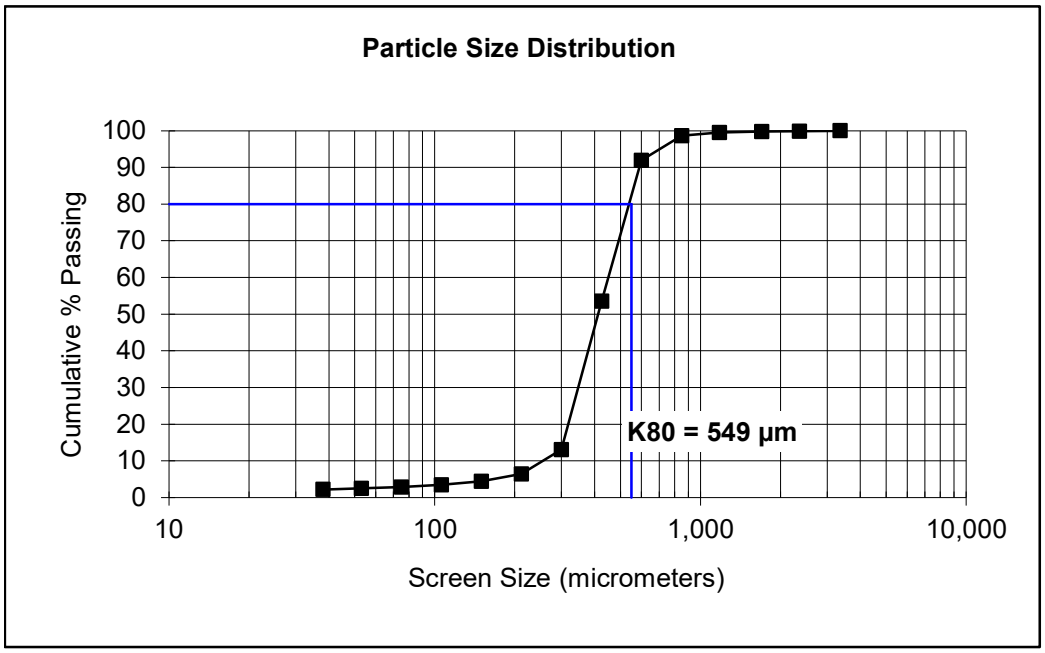


SGS Minerals Services
Size Distribution Analysis

Project No. **19097-03**

Sample: **GSB-03** Test No.: **SFA**

Size		Weight	% Retained		% Passing
Mesh	µm	grams	Individual	Cumulative	Cumulative
6	3,350	0.0	0.0	0.0	100.0
8	2,360	0.4	0.2	0.2	99.8
10	1,700	0.3	0.1	0.3	99.7
14	1,180	0.6	0.2	0.5	99.5
20	850	2.3	0.9	1.4	98.6
28	600	16.9	6.6	8.1	91.9
35	425	97.8	38.4	46.5	53.5
48	300	103.1	40.5	87.0	13.0
65	212	16.9	6.6	93.6	6.4
100	150	5.0	2.0	95.6	4.4
150	106	2.5	1.0	96.5	3.5
200	75	1.5	0.6	97.1	2.9
270	53	1.0	0.4	97.5	2.5
400	38	0.6	0.2	97.8	2.2
Pan	-38	5.7	2.2	100.0	0.0
Total	**-**	**254.6**	100.0	**-**	**-**
K80	**549**				

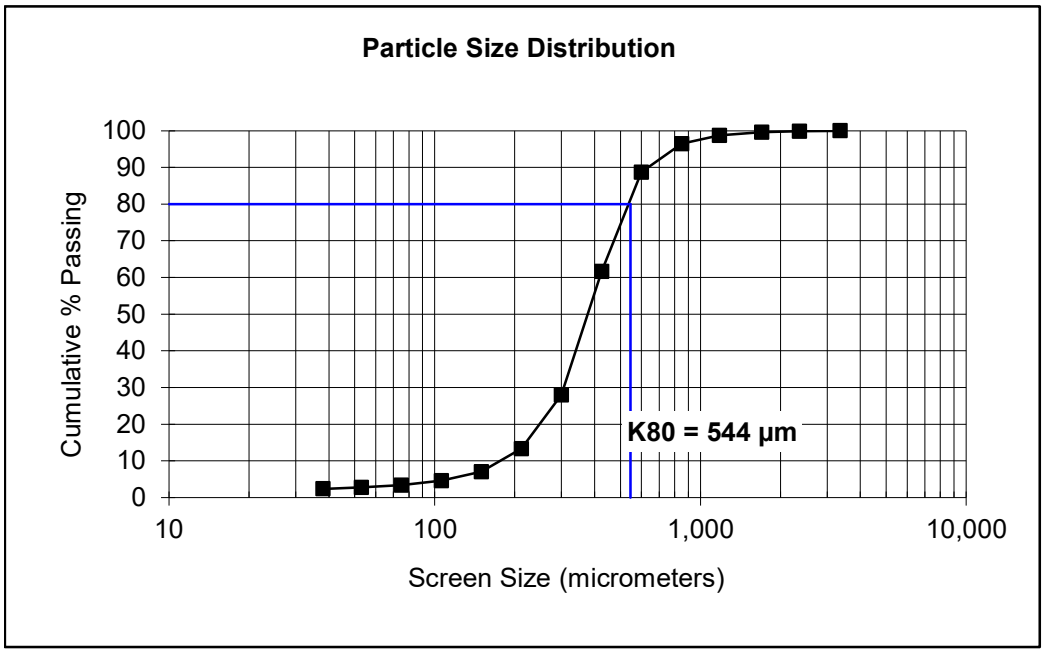


SGS Minerals Services
Size Distribution Analysis

Project No. **19097-03**

Sample: **GSB-04** Test No.: **SFA**

Size		Weight	% Retained		% Passing
Mesh	µm	grams	Individual	Cumulative	Cumulative
6	3,350	0.0	0.0	0.0	100.0
8	2,360	0.3	0.1	0.1	99.9
10	1,700	0.7	0.3	0.4	99.6
14	1,180	2.0	0.8	1.2	98.8
20	850	5.5	2.3	3.5	96.5
28	600	18.9	7.8	11.4	88.6
35	425	65.1	27.0	38.3	61.7
48	300	81.4	33.7	72.0	28.0
65	212	35.4	14.7	86.7	13.3
100	150	15.1	6.3	93.0	7.0
150	106	5.9	2.4	95.4	4.6
200	75	2.9	1.2	96.6	3.4
270	53	1.5	0.6	97.2	2.8
400	38	0.9	0.4	97.6	2.4
Pan	-38	5.8	2.4	100.0	0.0
Total	**-**	**241.4**	100.0	**-**	**-**
K80	**544**				

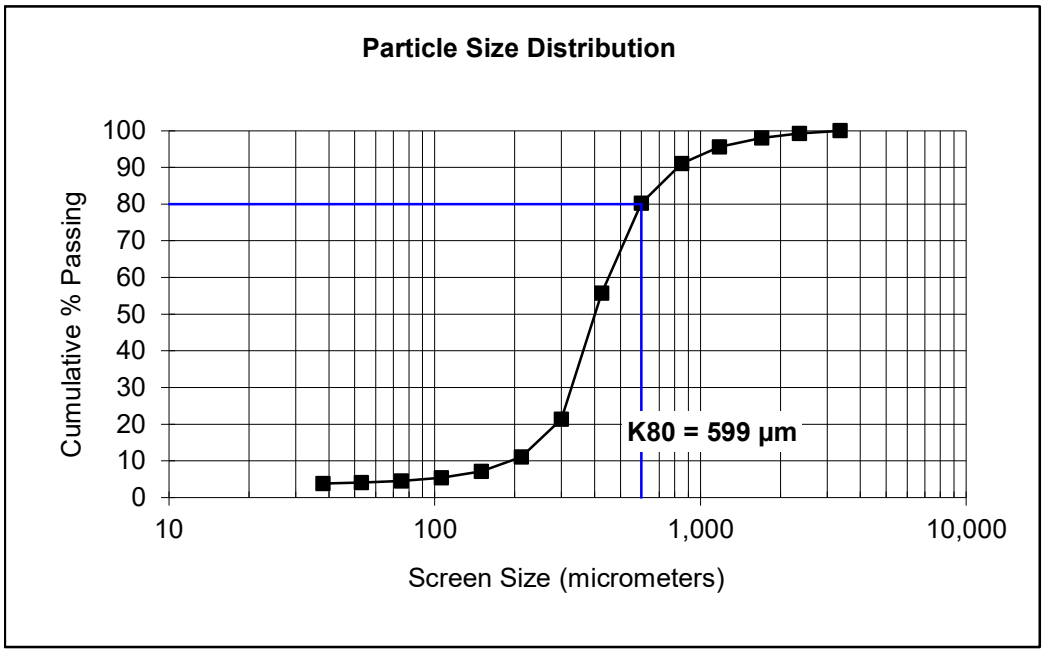


SGS Minerals Services
Size Distribution Analysis

Project No. **19097-03**

Sample: **GSB-06** Test No.: **SFA**

Size		Weight	% Retained		% Passing
Mesh	µm	grams	Individual	Cumulative	Cumulative
6	3,350	0.0	0.0	0.0	100.0
8	2,360	2.0	0.8	0.8	99.2
10	1,700	3.3	1.3	2.0	98.0
14	1,180	6.4	2.4	4.4	95.6
20	850	12.0	4.5	9.0	91.0
28	600	28.6	10.8	19.8	80.2
35	425	64.5	24.4	44.2	55.8
48	300	90.9	34.4	78.7	21.3
65	212	27.0	10.2	88.9	11.1
100	150	10.5	4.0	92.9	7.1
150	106	4.5	1.7	94.6	5.4
200	75	2.3	0.9	95.5	4.5
270	53	1.2	0.5	95.9	4.1
400	38	0.7	0.3	96.2	3.8
Pan	-38	10.1	3.8	100.0	0.0
Total	**-**	**264.0**	100.0	**-**	**-**
K80	**599**				

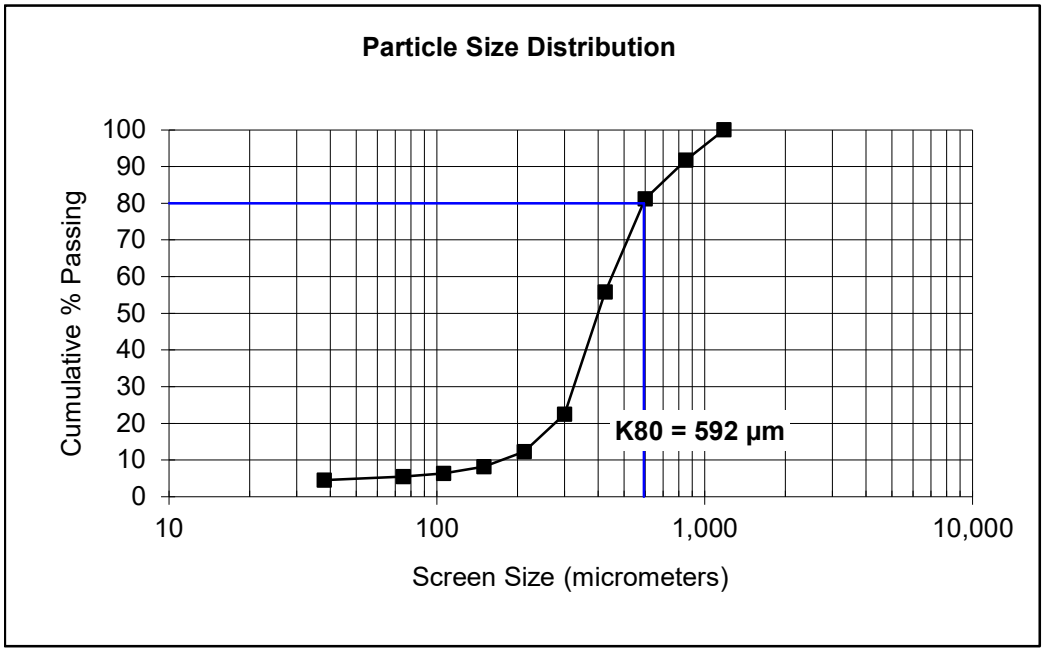


SGS Minerals Services
Size Distribution Analysis

Project No. **19097-03**

Sample: **400 RPM 10min** Test No.: **GSB-06 Attrition**

Size		Weight	% Retained		% Passing
Mesh	µm	grams	Individual	Cumulative	Cumulative
14	1,180	0.0	0.0	0.0	100.0
20	850	20.4	8.3	8.3	91.7
28	600	25.9	10.5	18.8	81.2
35	425	62.4	25.4	44.2	55.8
48	300	81.9	33.3	77.5	22.5
65	212	25.1	10.2	87.8	12.2
100	150	10.0	4.1	91.8	8.2
150	106	4.4	1.8	93.6	6.4
200	75	2.2	0.9	94.5	5.5
400	38	2.3	0.9	95.4	4.6
Pan	-38	11.2	4.6	100.0	0.0
Total	**-**	**245.8**	100.0	**-**	**-**
K80	**592**				

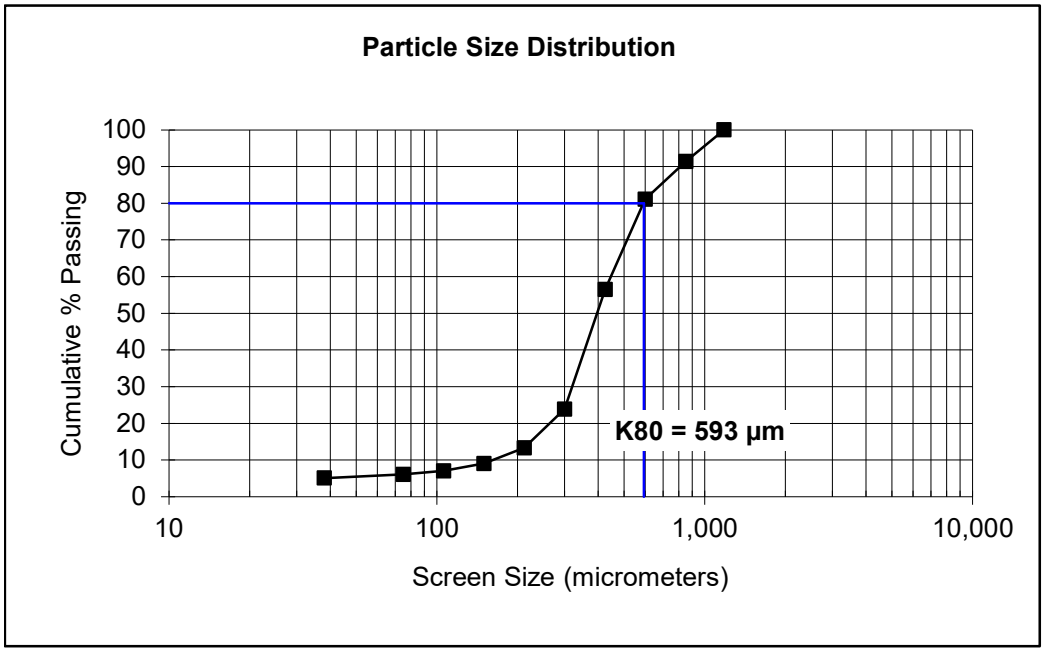


SGS Minerals Services
Size Distribution Analysis

Project No. **19097-03**

Sample: **900 RPM 10min** Test No.: **GSB-06 Attrition**

Size		Weight	% Retained		% Passing
Mesh	µm	grams	Individual	Cumulative	Cumulative
14	1,180	0.0	0.0	0.0	100.0
20	850	22.0	8.6	8.6	91.4
28	600	26.4	10.3	18.9	81.1
35	425	62.7	24.5	43.5	56.5
48	300	83.3	32.6	76.1	23.9
65	212	27.1	10.6	86.7	13.3
100	150	10.9	4.3	91.0	9.0
150	106	5.0	2.0	92.9	7.1
200	75	2.5	1.0	93.9	6.1
400	38	2.5	1.0	94.9	5.1
Pan	-38	13.1	5.1	100.0	0.0
Total	**-**	**255.5**	100.0	**-**	**-**
K80	**593**				

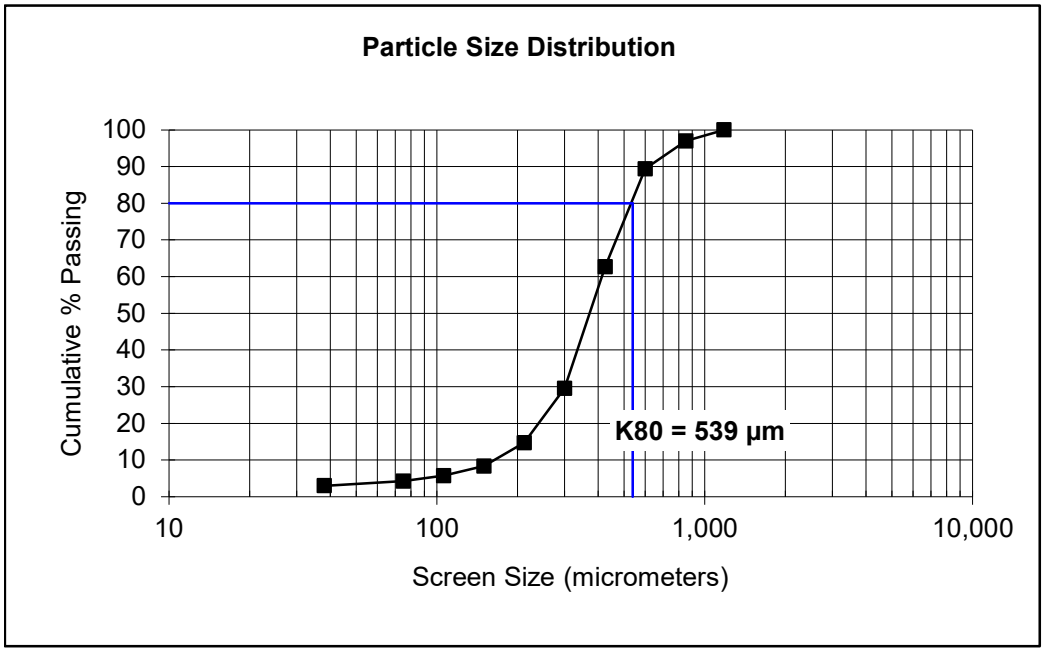


SGS Minerals Services
Size Distribution Analysis

Project No. **19097-03**

Sample: **Attrition 900 RPM 10min** Test No.: **GSB-04**

Size		Weight	% Retained		% Passing
Mesh	µm	grams	Individual	Cumulative	Cumulative
14	1,180	0.0	0.0	0.0	100.0
20	850	7.4	3.1	3.1	96.9
28	600	18.3	7.6	10.6	89.4
35	425	64.4	26.6	37.3	62.7
48	300	80.3	33.2	70.5	29.5
65	212	35.7	14.8	85.2	14.8
100	150	15.4	6.4	91.6	8.4
150	106	6.4	2.6	94.3	5.7
200	75	3.6	1.5	95.7	4.3
400	38	3.0	1.2	97.0	3.0
Pan	-38	7.3	3.0	100.0	0.0
Total	**-**	**241.8**	100.0	**-**	**-**
K80	**539**				

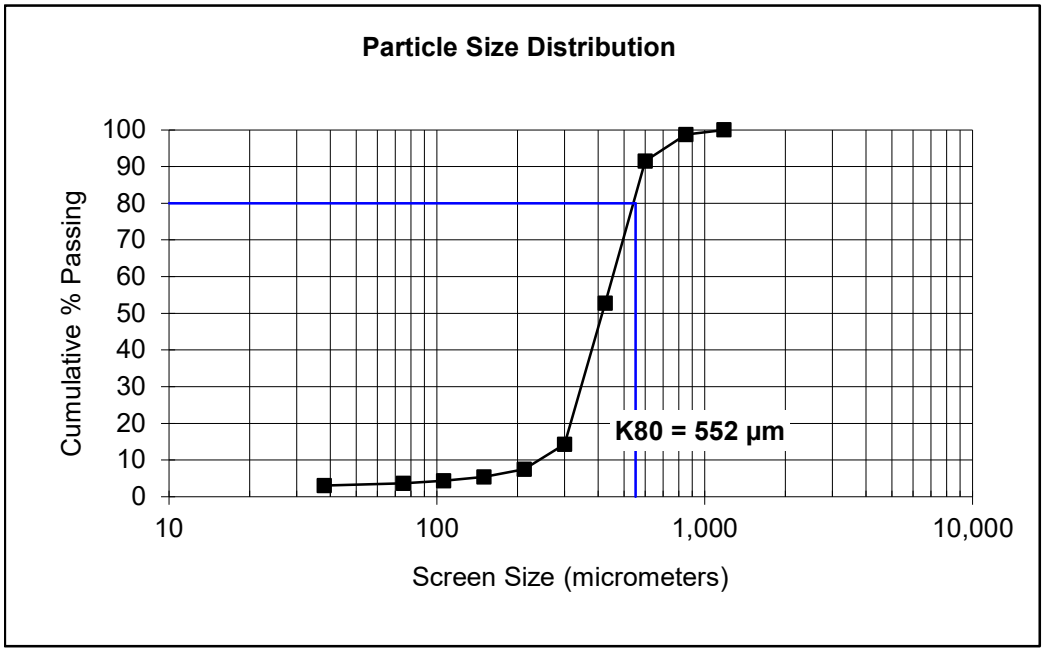


SGS Minerals Services
Size Distribution Analysis

Project No. **19097-03**

Sample: **Attrition 900 RPM 10min** Test No.: **GSB-03**

Size		Weight	% Retained		% Passing
Mesh	µm	grams	Individual	Cumulative	Cumulative
14	1,180	0.0	0.0	0.0	100.0
20	850	3.0	1.3	1.3	98.7
28	600	16.9	7.2	8.5	91.5
35	425	90.7	38.7	47.2	52.8
48	300	90.3	38.5	85.7	14.3
65	212	15.9	6.8	92.5	7.5
100	150	4.9	2.1	94.6	5.4
150	106	2.4	1.0	95.6	4.4
200	75	1.6	0.7	96.3	3.7
400	38	1.4	0.6	96.9	3.1
Pan	-38	7.2	3.1	100.0	0.0
Total	**-**	**234.3**	100.0	**-**	**-**
K80	**552**				



Appendix B – Size x Size Analysis Results

Project Number : 19097-03
Client: SGS Jordan
Testwork: Size x Size Analysis
Sample : GSB-01

Size Fracion	Weight		Assays, %						Distribution, %					
GSB-01	g	%	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	TiO_2	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	TiO_2
+850 µm	5.4	2.0	95.3	1.22	0.90	0.76	0.18	0.12	2.0	1.3	4.7	5.5	7.8	0.9
-850+600 µm	17.7	6.7	98.3	0.57	0.50	0.20	0.06	0.07	6.8	1.9	8.5	4.8	8.6	1.7
-600+425 µm	43.6	16.4	99.1	0.34	0.29	0.09	0.04	0.05	17.0	2.8	12.1	5.3	14.1	3.1
-425+300 µm	67.8	25.5	98.8	0.36	0.22	0.07	0.04	0.06	26.3	4.7	14.3	6.4	21.9	5.7
-300+212 µm	57.2	21.5	98.8	0.47	0.31	0.08	0.03	0.10	22.2	5.2	17.0	6.1	13.8	8.0
-212+150 µm	36.4	13.7	98.4	0.64	0.39	0.10	0.04	0.19	14.1	4.5	13.6	4.9	11.7	9.7
-150+106 µm	13.6	5.1	96.7	1.02	0.75	0.23	0.05	0.43	5.2	2.7	9.8	4.2	5.5	8.2
-106+75 µm	5.4	2.0	94.2	1.85	0.79	0.58	0.07	0.82	2.0	1.9	4.1	4.2	3.1	6.2
-75+38 µm	3.7	1.4	87.3	4.42	1.28	1.73	0.13	1.28	1.3	3.1	4.5	8.6	3.9	6.6
-38 µm	14.9	5.6	55.3	25.1	0.79	2.50	0.08	2.39	3.2	71.9	11.3	50.0	9.6	49.9
Head Sample (calc.)	266	100	95.9	1.96	0.39	0.28	0.05	0.27	100	100	100	100	100	100
Head Sample (dir.)			95.9	1.80	0.08	0.27	0.06	0.25						

Combined Size Fraction	Weight		Assays, %						Distribution, %					
GSB-01	g	%	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	TiO_2	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	TiO_2
+850 µm	5.4	2.0	95.3	1.22	0.90	0.76	0.18	0.12	2.0	1.3	4.7	5.5	7.8	0.9
+600 µm	23.1	8.7	97.6	0.72	0.59	0.33	0.09	0.08	8.8	3.2	13.2	10.3	16.4	2.6
+425 µm	66.7	25.1	98.6	0.47	0.40	0.17	0.06	0.06	25.8	6.1	25.3	15.5	30.5	5.7
+300 µm	135	50.6	98.7	0.42	0.31	0.12	0.05	0.06	52.1	10.7	39.6	21.9	52.4	11.4
+212 µm	192	72.1	98.7	0.43	0.31	0.11	0.04	0.07	74.3	15.9	56.6	28.1	66.2	19.4
+150 µm	228	85.8	98.7	0.47	0.32	0.11	0.04	0.09	88.3	20.4	70.3	33.0	78.0	29.1
+106 µm	242	91.0	98.6	0.50	0.35	0.11	0.04	0.11	93.5	23.1	80.1	37.2	83.5	37.3
+75 µm	247	93.0	98.5	0.53	0.35	0.12	0.04	0.13	95.5	25.0	84.2	41.4	86.5	43.5
+38 µm	251	94.4	98.3	0.58	0.37	0.15	0.04	0.14	96.8	28.1	88.7	50.0	90.4	50.1
-38 µm	14.9	5.6	55.3	25.1	0.79	2.50	0.08	2.39	3.2	71.9	11.3	50.0	9.6	49.9
Head Sample (calc.)	266	100	95.9	1.96	0.39	0.28	0.05	0.27	100	100	100	100	100	100

Combined Size Fraction	Weight		Assays, %						Distribution, %					
GSB-01	g	%	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	TiO_2	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	TiO_2
+850 µm	5.4	2.0	95.3	1.22	0.90	0.76	0.18	0.12	2.0	1.3	4.7	5.5	7.8	0.9
-850 µm	260	98.0	95.9	1.97	0.38	0.27	0.04	0.27	98.0	98.7	95.3	94.5	92.2	99.1
-600 µm	243	91.3	95.7	2.08	0.37	0.28	0.04	0.29	91.2	96.8	86.8	89.7	83.6	97.4
-425 µm	199	74.9	95.0	2.46	0.39	0.32	0.04	0.34	74.2	93.9	74.7	84.5	69.5	94.3
-300 µm	131	49.4	93.0	3.54	0.48	0.44	0.04	0.48	47.9	89.3	60.4	78.1	47.6	88.6
-212 µm	74.0	27.9	88.5	5.91	0.61	0.72	0.06	0.78	25.7	84.1	43.4	71.9	33.8	80.6
-150 µm	37.6	14.2	79.0	11.0	0.82	1.33	0.07	1.35	11.7	79.6	29.7	67.0	22.0	70.9
-106 µm	24.0	9.0	69.0	16.7	0.87	1.95	0.09	1.87	6.5	76.9	19.9	62.8	16.5	62.7
-75 µm	18.6	7.0	61.7	21.0	0.89	2.35	0.09	2.17	4.5	75.0	15.8	58.6	13.5	56.5
-38 µm	14.9	5.6	55.3	25.1	0.79	2.50	0.08	2.39	3.2	71.9	11.3	50.0	9.6	49.9
Head Sample (calc.)	266	100	95.9	1.96	0.39	0.28	0.05	0.27	100	100	100	100	100	100

Project Number : 19097-03
Client: SGS Jordan
Testwork: Size x Size Analysis
Sample : GSB-02

Size Fracion	Weight		Assays, %						Distribution, %					
GSB-02	g	%	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	TiO_2	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	TiO_2
+850 µm	15.7	6.3	96.4	0.29	1.12	1.39	0.03	0.02	6.2	1.4	11.4	62.7	5.4	1.3
-850+600 µm	34.6	13.8	98.7	0.30	0.78	0.07	0.03	0.02	14.0	3.2	17.5	7.0	11.9	2.8
-600+425 µm	74.2	29.6	99.0	0.25	0.46	0.03	0.03	0.03	30.1	5.7	22.2	6.4	25.5	9.1
-425+300 µm	73.7	29.4	99.6	0.29	0.44	0.02	0.04	0.03	30.1	6.6	21.1	4.2	33.8	9.1
-300+212 µm	25.9	10.3	98.6	0.43	0.77	0.05	0.03	0.07	10.5	3.4	13.0	3.7	8.9	7.4
-212+150 µm	10.8	4.3	97.7	0.68	1.15	0.09	0.04	0.16	4.3	2.3	8.1	2.8	4.9	7.1
-150+106 µm	4.2	1.7	97.0	1.21	1.07	0.17	0.04	0.38	1.7	1.6	2.9	2.1	1.9	6.5
-106+75 µm	1.8	0.7	91.4	4.18	1.27	0.35	0.10	0.76	0.7	2.3	1.5	1.8	2.1	5.6
-75+38 µm	1.5	0.6	85.0	8.73	0.77	0.51	0.16	0.87	0.5	4.0	0.8	2.2	2.7	5.4
-38 µm	8.3	3.3	59.7	27.2	0.30	0.30	0.03	1.34	2.0	69.5	1.6	7.2	2.9	45.6
Head Sample (calc.)	251	100	97.4	1.30	0.61	0.14	0.03	0.10	100	100	100	100	100	100
Head Sample (dir.)			97.2	1.20	0.03	0.14	0.03	0.1						

Combined Size Fraction	Weight		Assays, %						Distribution, %					
GSB-02	g	%	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	TiO_2	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	TiO_2
+850 µm	15.7	6.3	96.4	0.29	1.12	1.39	0.03	0.02	6.2	1.4	11.4	62.7	5.4	1.3
+600 µm	50.3	20.1	98.0	0.30	0.89	0.48	0.03	0.02	20.2	4.6	29.0	69.6	17.3	4.1
+425 µm	125	49.7	98.6	0.27	0.63	0.21	0.03	0.03	50.3	10.3	51.1	76.0	42.8	13.3
+300 µm	198	79.1	99.0	0.28	0.56	0.14	0.03	0.03	80.3	16.9	72.2	80.3	76.6	22.3
+212 µm	224	89.4	98.9	0.29	0.58	0.13	0.03	0.03	90.8	20.3	85.2	84.0	85.5	29.8
+150 µm	235	93.7	98.9	0.31	0.61	0.13	0.03	0.04	95.1	22.6	93.2	86.8	90.4	36.9
+106 µm	239	95.4	98.8	0.33	0.62	0.13	0.03	0.04	96.8	24.1	96.1	88.8	92.3	43.4
+75 µm	241	96.1	98.8	0.36	0.62	0.13	0.03	0.05	97.4	26.5	97.6	90.6	94.4	49.0
+38 µm	242	96.7	98.7	0.41	0.62	0.13	0.03	0.05	98.0	30.5	98.4	92.8	97.1	54.4
-38 µm	8.3	3.3	59.7	27.20	0.30	0.30	0.03	1.34	2.0	69.5	1.6	7.2	2.9	45.6
Head Sample (calc.)	251	100	97.4	1.30	0.61	0.14	0.03	0.10	100	100	100	100	100	100

Combined Size Fraction	Weight		Assays, %						Distribution, %					
GSB-02	g	%	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	TiO_2	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	TiO_2
+850 µm	15.7	6.3	96.4	0.29	1.12	1.39	0.03	0.02	6.2	1.4	11.4	62.7	5.4	1.3
-850 µm	235	93.7	97.5	1.36	0.58	0.06	0.04	0.10	93.8	98.6	88.6	37.3	94.6	98.7
-600 µm	200	79.9	97.3	1.55	0.55	0.05	0.04	0.12	79.8	95.4	71.0	30.4	82.7	95.9
-425 µm	126	50.3	96.2	2.31	0.60	0.07	0.04	0.17	49.7	89.7	48.9	24.0	57.2	86.7
-300 µm	53	20.9	91.5	5.14	0.82	0.13	0.04	0.36	19.7	83.1	27.8	19.7	23.4	77.7
-212 µm	26.6	10.6	84.6	9.73	0.86	0.21	0.05	0.64	9.2	79.7	14.8	16.0	14.5	70.2
-150 µm	15.8	6.3	75.6	15.9	0.66	0.29	0.05	0.97	4.9	77.4	6.8	13.2	9.6	63.1
-106 µm	11.6	4.6	67.9	21.2	0.51	0.33	0.06	1.19	3.2	75.9	3.9	11.2	7.7	56.6
-75 µm	9.8	3.9	63.6	24.4	0.37	0.33	0.05	1.27	2.6	73.5	2.4	9.4	5.6	51.0
-38 µm	8.3	3.3	59.7	27.2	0.30	0.30	0.03	1.34	2.0	69.5	1.6	7.2	2.9	45.6
Head Sample (calc.)	251	100	97.4	1.30	0.61	0.14	0.03	0.10	100	100	100	100	100	100

Project Number : 19097-03
Client: SGS Jordan
Testwork: Size x Size Analysis
Sample : GSB-03

Size Fracion	Weight		Assays, %						Distribution, %					
GSB-03	g	%	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	TiO_2	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	TiO_2
+850 µm	3.6	1.4	96.6	0.31	2.65	0.25	0.03	0.03	1.4	0.7	7.4	15.9	1.2	0.7
-850+600 µm	16.9	6.6	98.8	0.16	1.17	0.03	0.03	0.01	6.6	1.7	15.4	9.0	5.8	1.0
-600+425 µm	97.8	38.4	99.6	0.19	0.36	0.01	0.04	0.01	38.7	11.9	27.4	17.3	45.1	6.0
-425+300 µm	103	40.5	99.5	0.25	0.35	< 0.01	0.03	0.02	40.8	16.5	28.1	18.2	35.6	12.7
-300+212 µm	16.9	6.6	98.8	0.35	0.79	0.02	0.03	0.07	6.6	3.8	10.4	6.0	5.8	7.3
-212+150 µm	5.0	2.0	98.4	0.45	0.84	0.03	0.04	0.21	2.0	1.4	3.3	2.6	2.3	6.4
-150+106 µm	2.5	1.0	96.6	0.57	1.89	0.06	0.04	0.32	1.0	0.9	3.7	2.6	1.2	4.9
-106+75 µm	1.5	0.6	97.2	0.73	1.98	0.12	0.06	0.41	0.6	0.7	2.3	3.2	1.0	3.8
-75+38 µm	1.6	0.6	96.3	0.83	0.73	0.18	0.03	0.48	0.6	0.9	0.9	5.1	0.6	4.7
-38 µm	5.7	2.2	74.2	16.8	0.25	0.20	0.02	1.50	1.7	61.4	1.1	20.1	1.3	52.5
Head Sample (calc.)	255	100	98.8	0.61	0.50	0.02	0.03	0.06	100	100	100	100	100	100
Head Sample (dir.)			98.3	0.64	0.02	0.02	0.03	0.07						

* CaO Distribution was calculated assuming 0.01% CaO when assay was below detection limit (<0.01% CaO)

Combined Size Fraction	Weight		Assays, %						Distribution, %					
GSB-03	g	%	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	TiO_2	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	TiO_2
+850 µm	3.6	1.4	96.6	0.31	2.65	0.25	0.03	0.03	1.4	0.7	7.4	15.9	1.2	0.7
+600 µm	20.5	8.1	98.4	0.19	1.43	0.07	0.03	0.01	8.0	2.4	22.8	24.8	7.1	1.7
+425 µm	118	46.5	99.4	0.19	0.55	0.02	0.04	0.01	46.8	14.4	50.2	42.1	52.2	7.7
+300 µm	221	87.0	99.4	0.22	0.45	0.02	0.03	0.01	87.6	30.9	78.3	60.3	87.8	20.4
+212 µm	238	93.6	99.4	0.23	0.48	0.02	0.03	0.02	94.2	34.7	88.7	66.3	93.6	27.6
+150 µm	243	95.6	99.4	0.23	0.49	0.02	0.03	0.02	96.2	36.1	92.0	69.0	95.9	34.1
+106 µm	246	96.5	99.3	0.24	0.50	0.02	0.03	0.03	97.1	37.0	95.7	71.6	97.1	39.0
+75 µm	247	97.1	99.3	0.24	0.51	0.02	0.03	0.03	97.7	37.7	98.0	74.8	98.1	42.8
+38 µm	249	97.8	99.3	0.24	0.51	0.02	0.03	0.03	98.3	38.6	98.9	79.9	98.7	47.5
-38 µm	5.7	2.2	74.2	16.80	0.25	0.20	0.02	1.50	1.7	61.4	1.1	20.1	1.3	52.5
Head Sample (calc.)	255	100	98.8	0.61	0.50	0.02	0.03	0.06	100	100	100	100	100	100

* CaO Distribution was calculated assuming 0.01% CaO when assay was below detection limit (<0.01% CaO)

Combined Size Fraction	Weight		Assays, %						Distribution, %					
GSB-03	g	%	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	TiO_2	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	TiO_2
+850 µm	3.6	1.4	96.6	0.31	2.65	0.25	0.03	0.03	1.4	0.7	7.4	15.9	1.2	0.7
-850 µm	251	98.6	98.8	0.62	0.47	0.02	0.03	0.06	98.6	99.3	92.6	84.1	98.8	99.3
-600 µm	234	91.9	98.8	0.65	0.42	0.02	0.03	0.07	92.0	97.6	77.2	75.2	92.9	98.3
-425 µm	136	53.5	98.2	0.98	0.47	0.02	0.03	0.11	53.2	85.6	49.8	57.9	47.8	92.3
-300 µm	33	13.0	94.2	3.25	0.84	0.07	0.03	0.39	12.4	69.1	21.7	39.7	12.2	79.6
-212 µm	16.3	6.4	89.3	6.25	0.89	0.12	0.03	0.72	5.8	65.3	11.3	33.7	6.4	72.4
-150 µm	11.3	4.4	85.3	8.8	0.91	0.16	0.03	0.95	3.8	63.9	8.0	31.0	4.1	65.9
-106 µm	8.8	3.5	82.1	11.2	0.63	0.18	0.03	1.13	2.9	63.0	4.3	28.4	2.9	61.0
-75 µm	7.3	2.9	79.0	13.3	0.36	0.20	0.02	1.28	2.3	62.3	2.0	25.2	1.9	57.2
-38 µm	5.7	2.2	74.2	16.8	0.25	0.20	0.02	1.50	1.7	61.4	1.1	20.1	1.3	52.5
Head Sample (calc.)	255	100	98.8	0.61	0.50	0.02	0.03	0.06	100	100	100	100	100	100

* CaO Distribution was calculated assuming 0.01% CaO when assay was below detection limit (<0.01% CaO)

Project Number : 19097-03
Client: SGS Jordan
Testwork: Size x Size Analysis
Sample : GSB-04

Size Fracion	Weight		Assays, %						Distribution, %					
GSB-04	g	%	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	TiO_2	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	TiO_2
+850 µm	8.5	3.5	98.1	0.36	1.26	0.18	0.03	0.03	3.5	2.8	8.1	5.8	3.6	1.4
-850+600 µm	18.9	7.8	99.0	0.13	0.92	0.05	0.02	0.02	7.9	2.3	13.2	3.6	5.3	2.1
-600+425 µm	65.1	27.0	99.5	0.15	0.39	0.02	0.03	0.02	27.2	9.0	19.3	4.9	27.2	7.2
-425+300 µm	81.4	33.7	99.4	0.19	0.36	0.02	0.02	0.03	34.0	14.3	22.3	6.1	22.7	13.5
-300+212 µm	35.4	14.7	99.1	0.27	0.56	0.03	0.04	0.04	14.7	8.9	15.1	4.0	19.7	7.8
-212+150 µm	15.1	6.3	98.8	0.34	0.93	0.06	0.03	0.10	6.3	4.8	10.7	3.4	6.3	8.4
-150+106 µm	5.9	2.4	98.3	0.47	0.62	0.13	0.03	0.25	2.4	2.6	2.8	2.9	2.5	8.2
-106+75 µm	2.9	1.2	96.9	0.67	0.77	0.31	0.05	0.41	1.2	1.8	1.7	3.4	2.0	6.6
-75+38 µm	2.4	1.0	95.3	1.20	0.77	0.76	0.08	0.45	1.0	2.7	1.4	6.9	2.7	6.0
-38 µm	5.8	2.4	77.4	9.5	1.25	2.71	0.10	1.21	1.9	50.9	5.5	59.1	8.1	38.8
Head Sample (calc.)	241	100	98.6	0.45	0.55	0.11	0.03	0.07	100	100	100	100	100	100
Head Sample (dir.)			98.4	0.47	0.05	0.11	0.03	0.07						

Combined Size Fraction	Weight		Assays, %						Distribution, %					
GSB-04	g	%	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	TiO_2	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	TiO_2
+850 µm	8.5	3.5	98.1	0.36	1.26	0.18	0.03	0.03	3.5	2.8	8.1	5.8	3.6	1.4
+600 µm	27.4	11.4	98.7	0.20	1.03	0.09	0.02	0.02	11.4	5.1	21.3	9.3	8.8	3.5
+425 µm	92.5	38.3	99.3	0.17	0.58	0.04	0.03	0.02	38.6	14.2	40.6	14.2	36.0	10.7
+300 µm	174	72.0	99.3	0.18	0.48	0.03	0.02	0.03	72.5	28.5	62.9	20.3	58.7	24.2
+212 µm	209	86.7	99.3	0.19	0.49	0.03	0.03	0.03	87.3	37.3	77.9	24.3	78.4	32.1
+150 µm	224	93.0	99.3	0.20	0.52	0.03	0.03	0.03	93.5	42.1	88.6	27.7	84.8	40.4
+106 µm	230	95.4	99.2	0.21	0.52	0.04	0.03	0.04	96.0	44.7	91.4	30.6	87.2	48.6
+75 µm	233	96.6	99.2	0.22	0.53	0.04	0.03	0.04	97.2	46.5	93.1	34.0	89.2	55.2
+38 µm	236	97.6	99.2	0.23	0.53	0.05	0.03	0.05	98.1	49.1	94.5	40.9	91.9	61.2
-38 µm	5.8	2.4	77.4	9.47	1.25	2.71	0.10	1.21	1.9	50.9	5.5	59.1	8.1	38.8
Head Sample (calc.)	241	100	98.6	0.45	0.55	0.11	0.03	0.07	100	100	100	100	100	100

Combined Size Fraction	Weight		Assays, %						Distribution, %					
GSB-04	g	%	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	TiO_2	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	TiO_2
+850 µm	8.5	3.5	98.1	0.36	1.26	0.18	0.03	0.03	3.5	2.8	8.1	5.8	3.6	1.4
-850 µm	233	96.5	98.7	0.45	0.52	0.11	0.03	0.08	96.5	97.2	91.9	94.2	96.4	98.6
-600 µm	214	88.6	98.6	0.48	0.48	0.11	0.03	0.08	88.6	94.9	78.7	90.7	91.2	96.5
-425 µm	149	61.7	98.3	0.62	0.52	0.15	0.03	0.11	61.4	85.8	59.4	85.8	64.0	89.3
-300 µm	68	28.0	96.9	1.14	0.72	0.31	0.04	0.20	27.5	71.5	37.1	79.7	41.3	75.8
-212 µm	32.1	13.3	94.4	2.11	0.90	0.63	0.05	0.38	12.7	62.7	22.1	75.7	21.6	67.9
-150 µm	17.0	7.0	90.5	3.7	0.88	1.13	0.06	0.63	6.5	57.9	11.4	72.3	15.2	59.6
-106 µm	11.1	4.6	86.4	5.4	1.02	1.66	0.08	0.84	4.0	55.3	8.6	69.4	12.8	51.4
-75 µm	8.2	3.4	82.6	7.0	1.11	2.14	0.09	0.99	2.8	53.5	6.9	66.0	10.8	44.8
-38 µm	5.8	2.4	77.4	9.5	1.25	2.71	0.10	1.21	1.9	50.9	5.5	59.1	8.1	38.8
Head Sample (calc.)	241	100	98.6	0.45	0.55	0.11	0.03	0.07	100	100	100	100	100	100

Project Number : 19097-03
Client: SGS Jordan
Testwork: Size x Size Analysis
Sample : GSB-06

Size Fracion	Weight		Assays, %						Distribution, %					
GSB-06	g	%	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	TiO_2	SiO_2	Al_2O_3	Fe_2O_3	CaO*	Na_2O	TiO_2
+850 µm	23.7	9.0	99.1	0.16	0.96	< 0.01	0.03	0.02	9.1	1.3	16.0	6.2	7.1	2.1
-850+600 µm	28.6	10.8	99.1	0.18	0.84	< 0.01	0.02	0.02	11.0	1.8	16.9	7.5	5.7	2.6
-600+425 µm	64.5	24.4	99.2	0.21	0.51	< 0.01	0.03	0.02	24.7	4.8	23.1	16.9	19.4	5.8
-425+300 µm	90.9	34.4	99.5	0.27	0.31	< 0.01	0.04	0.03	35.0	8.7	19.8	23.8	36.4	12.2
-300+212 µm	27.0	10.2	98.7	0.36	0.42	< 0.01	0.04	0.06	10.3	3.4	8.0	7.1	10.8	7.2
-212+150 µm	10.5	4.0	98.9	0.53	0.51	0.01	0.04	0.11	4.0	2.0	3.8	2.7	4.2	5.2
-150+106 µm	4.5	1.7	97.5	0.80	1.33	0.02	0.05	0.22	1.7	1.3	4.2	2.4	2.3	4.4
-106+75 µm	2.3	0.9	94.9	1.28	2.58	0.05	0.11	0.40	0.8	1.0	4.2	3.0	2.5	4.1
-75+38 µm	1.9	0.7	94.5	2.43	1.12	0.08	0.23	0.50	0.7	1.6	1.5	4.0	4.4	4.2
-38 µm	10.1	3.8	68.5	20.8	0.38	0.10	0.07	1.16	2.7	74.1	2.7	26.4	7.1	52.3
Head Sample (calc.)	264	100	97.9	1.07	0.54	0.01	0.04	0.08	100	100	100	100	100	100
Head Sample (dir.)			98.1	1.01	0.03	0.01	0.03	0.08						

* CaO Distribution was calculated assuming 0.01% CaO when assay was below detection limit (<0.01% CaO)

Combined Size Fraction	Weight		Assays, %						Distribution, %					
GSB-06	g	%	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	TiO_2	SiO_2	Al_2O_3	Fe_2O_3	CaO*	Na_2O	TiO_2
+850 µm	23.7	9.0	99.1	0.16	0.96	0.01	0.03	0.02	9.1	1.3	16.0	6.2	7.1	2.1
+600 µm	52.3	19.8	99.1	0.17	0.89	0.01	0.02	0.02	20.0	3.2	32.8	13.7	12.9	4.7
+425 µm	117	44.2	99.2	0.19	0.68	0.01	0.03	0.02	44.8	7.9	55.9	30.6	32.3	10.4
+300 µm	208	78.7	99.3	0.23	0.52	0.01	0.03	0.02	79.8	16.6	75.7	54.4	68.7	22.6
+212 µm	235	88.9	99.2	0.24	0.51	0.01	0.03	0.03	90.1	20.0	83.7	61.5	79.5	29.8
+150 µm	245	92.9	99.2	0.25	0.51	0.01	0.03	0.03	94.1	22.0	87.4	64.2	83.7	35.0
+106 µm	250	94.6	99.2	0.26	0.52	0.01	0.03	0.04	95.8	23.2	91.6	66.6	86.0	39.4
+75 µm	252	95.5	99.2	0.27	0.54	0.01	0.04	0.04	96.6	24.3	95.8	69.6	88.5	43.5
+38 µm	254	96.2	99.1	0.29	0.55	0.01	0.04	0.04	97.3	25.9	97.3	73.6	92.9	47.7
-38 µm	10.1	3.8	68.5	20.80	0.38	0.10	0.07	1.16	2.7	74.1	2.7	26.4	7.1	52.3
Head Sample (calc.)	264	100	97.9	1.07	0.54	0.01	0.04	0.08	100	100	100	100	100	100

* CaO Distribution was calculated assuming 0.01% CaO when assay was below detection limit (<0.01% CaO)

Combined Size Fraction	Weight		Assays, %						Distribution, %					
GSB-06	g	%	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	TiO_2	SiO_2	Al_2O_3	Fe_2O_3	CaO*	Na_2O	TiO_2
+850 µm	23.7	9.0	99.1	0.16	0.96	0.01	0.03	0.02	9.1	1.3	16.0	6.2	7.1	2.1
-850 µm	240	91.0	97.8	1.16	0.50	0.01	0.04	0.09	90.9	98.7	84.0	93.8	92.9	97.9
-600 µm	212	80.2	97.7	1.30	0.45	0.02	0.04	0.10	80.0	96.8	67.2	86.3	87.1	95.3
-425 µm	147	55.8	97.0	1.77	0.43	0.02	0.05	0.14	55.2	92.1	44.1	69.4	67.7	89.6
-300 µm	56	21.3	92.9	4.20	0.61	0.03	0.06	0.31	20.2	83.4	24.3	45.6	31.3	77.4
-212 µm	29.3	11.1	87.6	7.74	0.79	0.05	0.07	0.54	9.9	80.0	16.3	38.5	20.5	70.2
-150 µm	18.8	7.1	81.3	11.8	0.95	0.07	0.09	0.78	5.9	78.0	12.6	35.8	16.3	65.0
-106 µm	14.3	5.4	76.2	15.2	0.83	0.09	0.10	0.95	4.2	76.8	8.4	33.4	14.0	60.6
-75 µm	12.0	4.5	72.6	17.9	0.50	0.10	0.10	1.06	3.4	75.7	4.2	30.4	11.5	56.5
-38 µm	10.1	3.8	68.5	20.8	0.38	0.10	0.07	1.16	2.7	74.1	2.7	26.4	7.1	52.3
Head Sample (calc.)	264	100	97.9	1.07	0.54	0.01	0.04	0.08	100	100	100	100	100	100

* CaO Distribution was calculated assuming 0.01% CaO when assay was below detection limit (<0.01% CaO)

Project Number : 19097-03
Client: SGS Jordan
Testwork: Attrition Test using a multi-blade high intensity scrubber
Test# A1
Sample : GSB-06
Sample Weight: 1 Kg
Pulp density: 60%
Attrition RPM 400 rpm
Attrition Time: 10 min

Size Fracion	Weight		Assays, %						Distribution, %					
GSB-06	g	%	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	TiO_2	SiO_2	Al_2O_3	Fe_2O_3	CaO*	Na_2O	TiO_2
+850 µm	20.4	8.3	99.1	0.19	0.78	0.02	0.05	0.01	8.4	1.3	12.2	10.4	13.4	1.0
-850+600 µm	25.9	10.5	99.4	0.13	0.63	0.01	0.03	0.01	10.7	1.2	12.5	6.6	10.2	1.2
-600+425 µm	62.4	25.4	99.7	0.14	0.37	< 0.01	0.02	0.02	25.9	3.0	17.7	15.9	16.3	5.9
-425+300 µm	81.9	33.3	99.3	0.16	0.28	< 0.01	0.03	0.02	33.9	4.6	17.6	20.9	32.2	7.7
-300+212 µm	25.1	10.2	98.8	0.22	0.65	< 0.01	0.03	0.04	10.3	1.9	12.5	6.4	9.9	4.7
-212+150 µm	10.0	4.1	98.5	0.33	1.12	< 0.01	0.04	0.09	4.1	1.1	8.6	2.6	5.2	4.2
-150+106 µm	4.4	1.8	97.3	0.50	1.83	0.02	0.04	0.17	1.8	0.8	6.2	2.2	2.3	3.5
-106+75 µm	2.2	0.9	95.4	0.78	2.94	0.04	0.06	0.31	0.9	0.6	5.0	2.2	1.7	3.2
-75+38 µm	2.3	0.9	95.3	1.21	2.61	0.07	0.05	0.41	0.9	1.0	4.6	4.1	1.5	4.5
-38 µm	11.2	4.6	67.2	21.7	0.39	0.10	0.05	1.21	3.1	84.5	3.3	28.6	7.3	64.0
Head Sample (calc.)	246	100	97.7	1.17	0.53	0.02	0.03	0.09	100	100	100	100	100	100
Head Sample (dir.)			98.1	1.01	0.03	0.01	0.03	0.08						

* CaO Distribution was calculated assuming assay is 0.01% when below detection limit

Combined Size Fraction	Weight		Assays, %						Distribution, %					
GSB-06	g	%	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	TiO_2	SiO_2	Al_2O_3	Fe_2O_3	CaO*	Na_2O	TiO_2
+850 µm	20.4	8.3	99.1	0.19	0.78	0.02	0.05	0.01	8.4	1.3	12.2	10.4	13.4	1.0
+600 µm	46.3	18.8	99.3	0.16	0.70	0.01	0.04	0.01	19.1	2.5	24.7	17.0	23.5	2.2
+425 µm	108.7	44.2	99.5	0.15	0.51	0.01	0.03	0.02	45.0	5.6	42.3	33.0	39.9	8.1
+300 µm	190.6	77.5	99.4	0.15	0.41	0.01	0.03	0.02	78.9	10.1	59.9	53.9	72.0	15.8
+212 µm	215.7	87.8	99.4	0.16	0.44	0.01	0.03	0.02	89.2	12.0	72.4	60.3	81.9	20.6
+150 µm	225.7	91.8	99.3	0.17	0.47	0.01	0.03	0.02	93.3	13.2	80.9	62.8	87.1	24.8
+106 µm	230.1	93.6	99.3	0.17	0.49	0.01	0.03	0.03	95.1	13.9	87.1	65.1	89.4	28.3
+75 µm	232.3	94.5	99.2	0.18	0.52	0.01	0.03	0.03	96.0	14.5	92.1	67.3	91.2	31.6
+38 µm	234.6	95.4	99.2	0.19	0.54	0.01	0.03	0.03	96.9	15.5	96.7	71.4	92.7	36.0
-38 µm	11.2	4.6	67.2	21.7	0.39	0.10	0.05	1.21	3.1	84.5	3.3	28.6	7.3	64.0
Head Sample (calc.)	246	100	97.7	1.17	0.53	0.02	0.03	0.09	100	100	100	100	100	100

* CaO Distribution was calculated assuming assay is 0.01% when below detection limit

Combined Size Fraction	Weight		Assays, %						Distribution, %					
GSB-06	g	%	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	TiO_2	SiO_2	Al_2O_3	Fe_2O_3	CaO*	Na_2O	TiO_2
+850 µm	20.4	8.3	99.1	0.19	0.78	0.02	0.05	0.01	8.4	1.3	12.2	10.4	13.4	1.0
-850 µm	225	91.7	97.6	1.26	0.51	0.02	0.03	0.09	91.6	98.7	87.8	89.6	86.6	99.0
-600 µm	200	81.2	97.4	1.41	0.49	0.02	0.03	0.10	80.9	97.5	75.3	83.0	76.5	97.8
-425 µm	137	55.8	96.3	1.98	0.55	0.02	0.03	0.14	55.0	94.4	57.7	67.0	60.1	91.9
-300 µm	55	22.5	91.9	4.68	0.95	0.03	0.04	0.32	21.1	89.9	40.1	46.1	28.0	84.2
-212 µm	30.1	12.2	86.2	8.41	1.20	0.05	0.05	0.56	10.8	88.0	27.6	39.7	18.1	79.4
-150 µm	20.1	8.2	80.1	12.4	1.24	0.07	0.05	0.79	6.7	86.8	19.1	37.2	12.9	75.2
-106 µm	15.7	6.4	75.3	15.8	1.07	0.09	0.05	0.97	4.9	86.1	12.9	34.9	10.6	71.7
-75 µm	13.5	5.5	72.0	18.2	0.77	0.09	0.05	1.07	4.0	85.5	7.9	32.7	8.8	68.4
-38 µm	11.2	4.6	67.2	21.7	0.39	0.10	0.05	1.21	3.1	84.5	3.3	28.6	7.3	64.0
Head Sample (calc.)	246	100	97.7	1.17	0.53	0.02	0.03	0.09	100	100	100	100	100	100

* CaO Distribution was calculated assuming assay is 0.01% when below detection limit

Project Number : 19097-03
Client: SGS Jordan
Testwork: Attrition Test using a multi-blade high intensity scrubber
Test # A2
Sample : GSB-06
Sample Weight: 1 kg
Pulp density: 60%
Attrition RPM 900 rpm
Attrition Time: 10 min

Size Fracion	Weight		Assays, %						Distribution, %					
GSB-06	g	%	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	TiO_2	SiO_2	Al_2O_3	Fe_2O_3	CaO*	Na_2O	TiO_2
+850 µm	22.0	8.6	99.1	0.09	0.91	< 0.01	0.04	0.01	8.7	0.7	14.7	5.7	11.2	1.0
-850+600 µm	26.4	10.3	99.3	0.07	0.80	< 0.01	0.03	0.02	10.5	0.6	15.5	6.9	10.1	2.3
-600+425 µm	62.7	24.5	99.4	0.09	0.38	< 0.01	0.04	0.02	24.9	2.0	17.5	16.3	32.0	5.5
-425+300 µm	83.3	32.6	99.6	0.11	0.28	< 0.01	0.02	0.02	33.2	3.2	17.1	21.6	21.3	7.2
-300+212 µm	27.1	10.6	99.7	0.14	0.54	< 0.01	0.03	0.03	10.8	1.3	10.7	7.0	10.4	3.5
-212+150 µm	10.9	4.3	99.7	0.21	0.99	< 0.01	0.04	0.08	4.3	0.8	7.9	2.8	5.6	3.8
-150+106 µm	5.0	2.0	98.0	0.34	1.43	0.02	0.03	0.13	2.0	0.6	5.3	2.6	1.9	2.8
-106+75 µm	2.5	1.0	96.7	0.73	2.09	0.04	0.04	0.23	1.0	0.6	3.8	2.6	1.3	2.5
-75+38 µm	2.5	1.0	94.0	2.42	1.51	0.06	0.04	0.33	0.9	2.1	2.8	3.9	1.3	3.6
-38 µm	13.1	5.1	70.6	19.4	0.48	0.09	0.03	1.19	3.7	88.1	4.6	30.6	5.0	67.8
Head Sample (calc.)	256	100	97.9	1.13	0.53	0.02	0.03	0.09	100	100	100	100	100	100
Head Sample (dir.)			98.1	1.01	0.03	0.01	0.03	0.08						

* CaO Distribution was calculated assuming assay is 0.01% when below detection limit

Combined Size Fraction	Weight		Assays, %						Distribution, %					
GSB-06	g	%	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	TiO_2	SiO_2	Al_2O_3	Fe_2O_3	CaO*	Na_2O	TiO_2
+850 µm	22.0	8.6	99.1	0.09	0.91	0.01	0.04	0.01	8.7	0.7	14.7	5.7	11.2	1.0
+600 µm	48.4	18.9	99.2	0.08	0.85	0.01	0.03	0.02	19.2	1.3	30.2	12.6	21.3	3.3
+425 µm	111.1	43.5	99.3	0.09	0.58	0.01	0.04	0.02	44.1	3.3	47.7	28.8	53.3	8.7
+300 µm	194.4	76.1	99.4	0.10	0.45	0.01	0.03	0.02	77.3	6.5	64.8	50.5	74.6	16.0
+212 µm	221.5	86.7	99.5	0.10	0.46	0.01	0.03	0.02	88.1	7.8	75.6	57.5	85.0	19.5
+150 µm	232.4	91.0	99.5	0.11	0.49	0.01	0.03	0.02	92.4	8.6	83.5	60.3	90.5	23.3
+106 µm	237.4	92.9	99.4	0.11	0.51	0.01	0.03	0.03	94.4	9.2	88.8	62.9	92.4	26.1
+75 µm	239.9	93.9	99.4	0.12	0.53	0.01	0.03	0.03	95.4	9.8	92.6	65.5	93.7	28.6
+38 µm	242.4	94.9	99.4	0.14	0.54	0.01	0.03	0.03	96.3	11.9	95.4	69.4	95.0	32.2
-38 µm	13.1	5.1	70.6	19.4	0.48	0.09	0.03	1.19	3.7	88.1	4.6	30.6	5.0	67.8
Head Sample (calc.)	256	100	97.9	1.13	0.53	0.02	0.03	0.09	100	100	100	100	100	100

* CaO Distribution was calculated assuming assay is 0.01% when below detection limit

Combined Size Fraction	Weight		Assays, %						Distribution, %					
GSB-06	g	%	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	TiO_2	SiO_2	Al_2O_3	Fe_2O_3	CaO*	Na_2O	TiO_2
+850 µm	22.0	8.6	99.1	0.09	0.91	0.01	0.04	0.01	8.7	0.7	14.7	5.7	11.2	1.0
-850 µm	234	91.4	97.8	1.23	0.50	0.02	0.03	0.10	91.3	99.3	85.3	94.3	88.8	99.0
-600 µm	207	81.1	97.6	1.37	0.46	0.02	0.03	0.11	80.8	98.7	69.8	87.4	78.7	96.7
-425 µm	144	56.5	96.8	1.93	0.49	0.02	0.03	0.15	55.9	96.7	52.3	71.2	46.7	91.3
-300 µm	61	23.9	93.0	4.42	0.78	0.03	0.03	0.32	22.7	93.5	35.2	49.5	25.4	84.0
-212 µm	34.0	13.3	87.6	7.82	0.98	0.05	0.03	0.54	11.9	92.2	24.4	42.5	15.0	80.5
-150 µm	23.1	9.0	81.9	11.4	0.97	0.07	0.03	0.76	7.6	91.4	16.5	39.7	9.5	76.7
-106 µm	18.1	7.1	77.4	14.5	0.84	0.08	0.03	0.94	5.6	90.8	11.2	37.1	7.6	73.9
-75 µm	15.6	6.1	74.4	16.7	0.65	0.09	0.03	1.05	4.6	90.2	7.4	34.5	6.3	71.4
-38 µm	13.1	5.1	70.6	19.4	0.48	0.09	0.03	1.19	3.7	88.1	4.6	30.6	5.0	67.8
Head Sample (calc.)	256	100	97.9	1.13	0.53	0.02	0.03	0.09	100	100	100	100	100	100

* CaO Distribution was calculated assuming assay is 0.01% when below detection limit

Project Number : 19097-03
Client: SGS Jordan
Testwork: Size x Size Analysis
Sample : GSB-04
Sample Weight: 1 kg
Pulp density: 60%
Attrition RPM 900 rpm
Attrition Time: 10 min

Size Fracion	Weight		Assays, %						Distribution, %					
GSB-04	g	%	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	TiO_2	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	TiO_2
+850 µm	7.4	3.1	97.9	0.32	0.05	0.12	0.05	0.02	3.0	2.1	2.3	3.6	8.5	0.9
-850+600 µm	18.3	7.6	99.0	0.10	0.03	0.04	< 0.01	0.01	7.6	1.7	3.4	3.0	4.2	1.2
-600+425 µm	64.4	26.6	99.6	0.13	0.02	0.02	< 0.01	0.01	26.9	7.6	7.9	5.2	14.8	4.1
-425+300 µm	80.3	33.2	99.5	0.09	0.02	0.02	< 0.01	0.01	33.5	6.5	9.9	6.5	18.5	5.1
-300+212 µm	35.7	14.8	99.1	0.12	0.03	0.02	0.02	0.02	14.9	3.9	6.6	2.9	16.5	4.5
-212+150 µm	15.4	6.4	98.6	0.19	0.04	0.04	0.02	0.06	6.4	2.6	3.8	2.5	7.1	5.9
-150+106 µm	6.4	2.6	98.3	0.26	0.06	0.08	0.03	0.14	2.6	1.5	2.4	2.1	4.4	5.7
-106+75 µm	3.6	1.5	97.1	0.37	0.10	0.15	0.06	0.25	1.5	1.2	2.2	2.2	5.0	5.7
-75+38 µm	3.0	1.2	97.0	0.54	0.22	0.29	0.06	0.24	1.2	1.5	4.1	3.5	4.1	4.6
-38 µm	7.3	3.0	76.3	10.8	1.28	2.33	0.10	1.35	2.3	71.4	57.5	68.7	16.8	62.4
Head Sample (calc.)	242	100	98.5	0.46	0.07	0.10	0.02	0.07	100	100	100	100	100	100
Head Sample (dir.)			98.4	0.47	0.05	0.11	0.03	0.07						

*Na_2O Distribution was calculated assuming assay is 0.01% when below detection limit

Combined Size Fraction	Weight		Assays, %						Distribution, %					
GSB-04	g	%	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	TiO_2	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	TiO_2
+850 µm	7.4	3.1	97.9	0.32	0.05	0.12	0.05	0.02	3.0	2.1	2.3	3.6	8.5	0.9
+600 µm	25.7	10.6	98.7	0.16	0.04	0.06	0.02	0.01	10.6	3.8	5.7	6.5	12.7	2.1
+425 µm	90.1	37.3	99.3	0.14	0.02	0.03	0.01	0.01	37.6	11.4	13.6	11.7	27.6	6.2
+300 µm	170.4	70.5	99.4	0.12	0.02	0.03	0.01	0.01	71.1	17.9	23.5	18.2	46.1	11.3
+212 µm	206.1	85.2	99.4	0.12	0.02	0.03	0.01	0.01	86.0	21.8	30.1	21.1	62.5	15.8
+150 µm	221.5	91.6	99.3	0.12	0.02	0.03	0.01	0.02	92.3	24.4	33.9	23.6	69.6	21.6
+106 µm	227.9	94.3	99.3	0.13	0.03	0.03	0.01	0.02	95.0	26.0	36.2	25.7	74.1	27.3
+75 µm	231.5	95.7	99.2	0.13	0.03	0.03	0.01	0.02	96.4	27.2	38.4	27.8	79.0	33.0
+38 µm	234.5	97.0	99.2	0.13	0.03	0.03	0.02	0.03	97.7	28.6	42.5	31.3	83.2	37.6
-38 µm	7.3	3.0	76.3	10.8	1.28	2.33	0.10	1.35	2.3	71.4	57.5	68.7	16.8	62.4
Head Sample (calc.)	242	100	98.5	0.46	0.07	0.10	0.02	0.07	100	100	100	100	100	100

*Na_2O Distribution was calculated assuming assay is 0.01% when below detection limit

Combined Size Fraction	Weight		Assays, %						Distribution, %					
GSB-04	g	%	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	TiO_2	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	TiO_2
+850 µm	7.4	3.1	97.9	0.32	0.05	0.12	0.05	0.02	3.0	2.1	2.3	3.6	8.5	0.9
-850 µm	234	96.9	98.5	0.46	0.07	0.10	0.02	0.07	97.0	97.9	97.7	96.4	91.5	99.1
-600 µm	216	89.4	98.5	0.49	0.07	0.11	0.02	0.07	89.4	96.2	94.3	93.5	87.3	97.9
-425 µm	152	62.7	98.0	0.65	0.09	0.14	0.02	0.10	62.4	88.6	86.4	88.3	72.4	93.8
-300 µm	71	29.5	96.4	1.27	0.17	0.28	0.03	0.20	28.9	82.1	76.5	81.8	53.9	88.7
-212 µm	35.7	14.8	93.7	2.42	0.32	0.55	0.05	0.37	14.0	78.2	69.9	78.9	37.5	84.2
-150 µm	20.3	8.4	90.0	4.1	0.53	0.93	0.06	0.61	7.7	75.6	66.1	76.4	30.4	78.4
-106 µm	13.9	5.7	86.2	5.9	0.75	1.33	0.08	0.83	5.0	74.0	63.8	74.3	25.9	72.7
-75 µm	10.3	4.3	82.3	7.8	0.97	1.74	0.09	1.03	3.6	72.8	61.6	72.2	21.0	67.0
-38 µm	7.3	3.0	76.3	10.8	1.28	2.33	0.10	1.35	2.3	71.4	57.5	68.7	16.8	62.4
Head Sample (calc.)	242	100	98.5	0.46	0.07	0.10	0.02	0.07	100	100	100	100	100	100

*Na_2O Distribution was calculated assuming assay is 0.01% when below detection limit

Project Number : 19097-03
Client: SGS Jordan
Testwork: Size x Size Analysis
Sample : GSB-03
Sample Weight: 1 kg
Pulp density: 60%
Attrition RPM 900 rpm
Attrition Time: 10 min

Size Fracion	Weight		Assays, %						Distribution, %					
GSB-03	g	%	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	TiO_2	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	TiO_2
+850 µm	3.0	1.3	95.6	0.41	0.06	0.38	0.11	0.02	1.2	1.0	1.7	18.1	7.9	0.4
-850+600 µm	16.9	7.2	99.0	0.11	0.02	0.02	0.01	< 0.01	7.3	1.5	3.2	5.4	4.0	1.1
-600+425 µm	90.7	38.7	99.2	0.09	0.02	< 0.01	0.02	0.02	39.0	6.5	17.0	14.4	43.3	11.9
-425+300 µm	90.3	38.5	99.5	0.10	0.02	< 0.01	0.01	0.02	38.9	7.2	16.9	14.4	21.5	11.8
-300+212 µm	15.9	6.8	98.7	0.19	0.03	0.02	0.02	0.04	6.8	2.4	4.5	5.1	7.6	4.2
-212+150 µm	4.9	2.1	98.0	0.27	0.06	0.03	0.03	0.10	2.1	1.1	2.8	2.3	3.5	3.2
-150+106 µm	2.4	1.0	97.5	0.38	0.09	0.05	0.06	0.15	1.0	0.7	2.0	1.9	3.4	2.4
-106+75 µm	1.6	0.7	96.9	0.37	0.12	0.08	0.05	0.17	0.7	0.5	1.8	2.0	1.9	1.8
-75+38 µm	1.4	0.6	95.3	0.42	0.18	0.14	0.05	0.20	0.6	0.5	2.4	3.1	1.7	1.8
-38 µm	7.2	3.1	77.7	13.6	0.71	0.29	0.03	1.30	2.4	78.6	47.9	33.2	5.2	61.4
Head Sample (calc.)	234	100	98.5	0.53	0.05	0.03	0.02	0.07	100	100	100	100	100	100
Head Sample (dir.)			98.3	0.64	0.02	0.02	0.03	0.07						

*CaO and TiO_2 Distribution were calculated assuming assay is 0.01% when below detection limit

Combined Size Fraction	Weight		Assays, %						Distribution, %					
GSB-03	g	%	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	TiO_2	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	TiO_2
+850 µm	3.0	1.3	95.6	0.41	0.06	0.38	0.11	0.02	1.2	1.0	1.7	18.1	7.9	0.4
+600 µm	19.9	8.5	98.5	0.16	0.03	0.07	0.03	0.01	8.5	2.5	4.8	23.5	11.9	1.5
+425 µm	110.6	47.2	99.1	0.10	0.02	0.02	0.02	0.02	47.5	9.0	21.8	37.9	55.2	13.4
+300 µm	200.9	85.7	99.3	0.10	0.02	0.02	0.02	0.02	86.4	16.3	38.7	52.3	76.7	25.2
+212 µm	216.8	92.5	99.2	0.11	0.02	0.02	0.02	0.02	93.2	18.7	43.2	57.4	84.3	29.4
+150 µm	221.7	94.6	99.2	0.11	0.02	0.02	0.02	0.02	95.3	19.8	46.0	59.7	87.8	32.6
+106 µm	224.1	95.6	99.2	0.11	0.02	0.02	0.02	0.02	96.3	20.5	48.0	61.6	91.3	35.0
+75 µm	225.7	96.3	99.2	0.12	0.02	0.02	0.02	0.02	97.0	21.0	49.8	63.7	93.2	36.8
+38 µm	227.1	96.9	99.1	0.12	0.02	0.02	0.02	0.03	97.6	21.4	52.1	66.8	94.8	38.6
-38 µm	7.2	3.1	77.7	13.6	0.71	0.29	0.03	1.30	2.4	78.6	47.9	33.2	5.2	61.4
Head Sample (calc.)	234	100	98.5	0.53	0.05	0.03	0.02	0.07	100	100	100	100	100	100

*CaO and TiO_2 Distribution were calculated assuming assay is 0.01% when below detection limit

Combined Size Fraction	Weight		Assays, %						Distribution, %					
GSB-03	g	%	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	TiO_2	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	TiO_2
+850 µm	3.0	1.3	95.6	0.41	0.06	0.38	0.11	0.02	1.2	1.0	1.7	18.1	7.9	0.4
-850 µm	231	98.7	98.5	0.53	0.05	0.02	0.02	0.07	98.8	99.0	98.3	81.9	92.1	99.6
-600 µm	214	91.5	98.5	0.57	0.05	0.02	0.02	0.07	91.5	97.5	95.2	76.5	88.1	98.5
-425 µm	124	52.8	97.9	0.92	0.07	0.03	0.02	0.11	52.5	91.0	78.2	62.1	44.8	86.6
-300 µm	33	14.3	93.8	3.12	0.20	0.09	0.03	0.34	13.6	83.7	61.3	47.7	23.3	74.8
-212 µm	17.5	7.5	89.3	5.79	0.35	0.15	0.04	0.61	6.8	81.3	56.8	42.6	15.7	70.6
-150 µm	12.6	5.4	85.9	7.9	0.46	0.20	0.04	0.82	4.7	80.2	54.0	40.3	12.2	67.4
-106 µm	10.2	4.4	83.1	9.7	0.54	0.24	0.04	0.97	3.7	79.5	52.0	38.4	8.7	65.0
-75 µm	8.6	3.7	80.6	11.5	0.62	0.27	0.03	1.12	3.0	79.0	50.2	36.3	6.8	63.2
-38 µm	7.2	3.1	77.7	13.6	0.71	0.29	0.03	1.30	2.4	78.6	47.9	33.2	5.2	61.4
Head Sample (calc.)	234	100	98.5	0.53	0.05	0.03	0.02	0.07	100	100	100	100	100	100

*CaO and TiO_2 Distribution were calculated assuming assay is 0.01% when below detection limit

Appendix C – Acid Leaching Results

Project: 19097-03 **Date:** 03-11-22

Client: SGS Jordan **Technologist:** R. Brunsch

Test: L1

Purpose: Scoping HCl leach test on GSB-03 WHIMS Non-mag (as is) at 219 g/L acid

Sample: **GSB-03 WHIMS Non-mag (as is)**

H&S: - Review SDS for HCl, Silica, etc. - conduct testing in fumehood
- Wear face shield (or work behind fumehood sash), lab coat and gloves when interacting with all acidic process solutions and containers until they are washed and chemical hazards have been removed

Procedure:

1. Add the calculated amount of DI water to a suitably sized glass reactor and begin mixing in the feed. Once all feed has been added, equip with a lid (including condenser) and agitate and begin heating to target temperature. Ensure that mixing is vigorous to suspend the solids. No exposed metal in inside the reactor.
2. At ~25°C below target temperature, begin adding initial acid dose.
3. Time zero occurs once all acid has been added and target temperature is achieved (note any overshoot). Determine the acidity of the PLS, add more acid if required to achieve the FA target. Check acidity again frequently until stable.
4. Collect kinetic samples as per Sampling Info table. Check FA and add acid if required.
5. After the required time, stop the test and weigh the pulp before filtering. Collect the filtrate and submit a sample for assay. Measure the pH, ORP, and density of the filtrate.
6. Repulp wash the filter cake in a volume of water similar to the amount initially used in the test (at room temperature).
7. Filter again, and displacement wash three times. Combine all washes, weigh, and submit a sample for assay. Measure the pH, ORP, and density of the combined wash.
8. Record the wet weight of the solids and then dry solids. Record the dry weight and submit sample for assay.

Assays:

Liquors				Solids			
#	Streams	Analysis	Code	#	Streams	Analysis	Code
2	Kinetic Liquors	No kinetics samples collected		2	Kinetic Solids	No kinetics samples collected	
1	Final Liquor	ICP	Met16-GC_SOL91T	1	Final Solids		WRA
					Use W pot to puverize the residue, max 50 g for pulverization		
1	Final Wash	ICP	Met16-GC_SOL91T				

Conditions:

Feed Weight (dry):	**200**	**g, as received:**
Reagent:	HCl	
Reagent Strength:	37	%
Acidity Target:	219	g/L HCl
37% HCl to Add:	**973**	**g**
Acidity Target:	**20**	(w/w)% HCl
Target % Solids (vs. Leach Feed):	10.0%	after all initial acid has been added
Calc. Pulp Weight:	2000	g
DI Water to add:	**827**	**g**
Test Time:	4	h
Temperature:	80	°C

Project: 19097-03
Client: SGS Jordan

Date: 03-11-22
Technologist: R. Brunsch

Test: L1

Test Data:

Time		Reactor			Reagents / Feed			Comments:	
(24 h)	(h) elapsed	Temp °C	pH	ORP mV	Feed g	H_2O g	HCl 37% g		
13:20		50.0			200.00	830.00	979.0	All acid in	
13:30	0	84.2						Conditions met, T=0, FAT 1	222 g/L
14:30	1	82.7						FAT 2	229 g/L
15:30	2	81.5							
16:30	3	82.4						FAT 3	259 g/L
17:30	4	82.6						Test OFF	
Totals/Avg.		82.3	-	-	200.0	830.0	979.0		

Project: 19097-03
Client: SGS Jordan

Date: 03-11-22
Technologist: R. Brunsch

Test: L1

Sampling Info:

Sample	Elapsed Time (h)	Weight (g) Pulp	Weight (g) Filtrate	Filt. Dens. g/mL	PLS Vol mL	At Ambient Temp ORP	At Ambient Temp pH	Wet Res. g	Dry Res. g	Filtration fast/slow	Pulp % Solids	Calc PLS Vol, mL
Kinetic 1	1				-					fast	#DIV/0!	-
Kinetic 2	2				-					fast	#DIV/0!	-
Final	4	1910.3	1687.7	1.097	1538	465	-0.86			fast	10.5%	1558
Final Wash			2100.0	1.001	2098	582	0.22	232.60	200.90	fast		

Free Acid Data:

Sample #	Aliquot mL	Titrant N	Titrant mL	Which Acid	Stoich mol/mol	MW g/mole	g/L acid	g acid
Kinetic 1	0.5	0.2		HCl	1	36.5	0	#VALUE!
Kinetic 2	0.5	0.2		HCl	1	36.5	0	#VALUE!
Final	0.5	0.2	15.69	HCl	1	36.5	229	351.9
Final Wash	5	0.2	3.14	HCl	1	36.5	4.6	9.6

Final Filtration/Washing:

Diameter of filtration paper:	150	mm
Type of Paper (Whatman #):	185	
Filtration Time:	10	minutes
Washing Time:	20	minutes
Cake Moisture:	14%	
Weight Loss:	0%	

Colour and Clarity:

Clarity of Filtrate:	clear
Colour of Filtrate:	yellow
Clarity of Wash:	clear
Colour of Wash:	ww
Colour of Residue:	white/pink granules

Residue: Total

Tare:	
Tare + Wet:	232.6 g
Tare + Dry:	200.9 g

Acid Addition	*1811*	*kg/t*
Acid Remaining	*1808*	*kg/t*
Acid Consumed	*3*	*kg/t*

Leach Feed Basis

Comments:

DI water contaminated by hard water. Ca, Mg and Na assays in leached solution were not accurate

Project: 19097-03 **Date:** 03-11-22

Client: SGS Jordan **Technologist:** R. Brunsch

Test: L1

Metallurgical Balance

Sample & Quant.	Assay Units	Feed GSB-03 WHIMS Non-mag (as is)	1h Filtrate	2h Filtrate	4h (final) Filtrate	Final Wash	1h Residue	2h Residue	4h (final) Residue	Extract. Final	Account. out/in	Calc Head
(mL or g)		200	-	-	1538	2098	0	0	201	%	%	
Al	mg/L, %	0.03			1.8	< 0.2			0.03	5	106	0.03
Fe	mg/L, %	0.01			3.6	0.2			< 0.01	-	-	-
Co	mg/L, %				< 0.3	< 0.3				-	-	-
	mg/L, %									-	-	-
	mg/L, %									-	-	-
	mg/L, %										-	-
	mg/L, %											-
	mg/L, %										-	-
	mg/L, %											
	mg/L, %										-	-
	mg/L, %										-	
	mg/L, %									-	-	-
	mg/L, %									-	-	-
	mg/L, %										-	

Project: 19097-03
Client: SGS Jordan

Date:	09-11-22
Technologist:	R. Brunsch

Test: L2

Purpose: Scoping H2SO4 leach test on GSB-03 WHIMS Non-mag (as is) at 220.3 g/L acid

Sample: **GSB-03 WHIMS Non-mag (as is)**
H&S: - Review SDS for H2SO4, Silica, etc. - conduct testing in fumehood
- Wear face shield (or work behind fumehood sash), lab coat and gloves when interacting with all acidic process solutions and containers until they are washed and chemical hazards have been removed

Procedure:

1. Add the calculated amount of DI water to a suitably sized glass reactor and begin mixing in the feed. Once all feed has been added, equip with a lid (including condenser) and agitate and begin heating to target temperature. Ensure that mixing is vigorous to suspend the solids. No exposed metal in inside the reactor.
2. At ~25°C below target temperature, begin adding initial acid dose.
3. Time zero occurs once all acid has been added and target temperature is achieved (note any overshoot). Determine the acidity of the PLS, add more acid if required to achieve the FA target. Check acidity again frequently until stable.
4. Collect kinetic samples as per Sampling Info table. Check FA and add acid if required.
5. After the required time, stop the test and weigh the pulp before filtering. Collect the filtrate and submit a sample for assay. Measure the pH, ORP, and density of the filtrate.
6. Repulp wash the filter cake in a volume of water similar to the amount initially used in the test (at room temperature).
7. Filter again, and displacement wash three times. Combine all washes, weigh, and submit a sample for assay. Measure the pH, ORP, and density of the combined wash.
8. Record the wet weight of the solids and then dry solids. Record the dry weight and submit sample for assay.

Assays:

Liquors				Solids			
#	Streams	Analysis	Code	#	Streams	Analysis	Code
2	Kinetic Liquors	No kinetics samples collected		2	Kinetic Solids	No kinetics samples collected	
1	Final Liquor	ICP	Met16-GC_SOL91T	1	Final Solids		TBD
					Use W pot to puverize the residue, max 50 g for pulverization		
1	Final Wash	ICP	Met16-GC_SOL91T				

Conditions:

Feed Weight (dry):	**200**	**g, as received:**
Reagent:	H_2SO_4	
Reagent Strength:	98	%
Acidity Target:	220	g/L H_2SO_4
98% H2SO4 to Add:	**367**	**g**
Acidity Target:	**20**	% H_2SO_4
Target % Solids (vs. Leach Feed):	10.0%	after all initial acid has been added
Calc. Pulp Weight:	2000	g
DI Water to add:	**1433**	**g**
Test Time:	4	h
Temperature:	80	°C

Project: 19097-03
Client: SGS Jordan

Date:	09-11-22
Technologist:	R. Brunsch

Test: L2

Test Data:

Time		Reactor			Reagents / Feed			Comments:	
(24 h)	(h) elapsed	Temp °C	pH	ORP mV	Feed g	H_2O g	H2SO4 98% g		
8:15		44.6			200	1433	369	All acid in	
8:25	T = 0	79.9						Conditions met, T=0, FAT 1	255.74
9:25	1	86.4						FAT 2	262 g/L
11:25	3	86.8						FAT 3	277 g/L
12:25	4	85.9						End of Test	235 g/L
Totals/Avg.		86.4	-	-	200.0	1433.0	369.0		

Project: 19097-03
Client: SGS Jordan

Date: 09-11-22
Technologist: R. Brunsch

Test: L2

Sampling Info:

Sample	Elapsed Time (h)	Weight (g) Pulp	Weight (g) Filtrate	Filt. Dens. g/mL	PLS Vol mL	At Ambient Temp ORP	At Ambient Temp pH	Wet Res. g	Dry Res. g	Filtration fast/slow	Pulp % Solids	Calc PLS Vol, mL
Kinetic 1	1				-				200	fast	#DIV/0!	-
Kinetic 2	2				-					fast	#DIV/0!	-
Final	4	1990.1	1676.7	1.140	1471	475	0.82			fast	10.0%	1572
Final Wash			2061.7	1.003	2056	568	1.20	239.97	198.50	fast		

Free Acid Data:

Sample #	Aliquot mL	Titrant N	Titrant mL	Which Acid	Stoich mol/mol	MW g/mole	g/L acid	g acid
Kinetic 1	0.5	0.2		H2SO4	2	98.1	0	#VALUE!
Kinetic 2	0.5	0.2		H2SO4	2	98.1	0	#VALUE!
Final	0.5	0.2	11.96	H2SO4	2	98.1	235	345.2
Final Wash	5	0.2	3.17	H2SO4	2	98.1	6.2	12.8

Final Filtration/Washing:

Diameter of filtration paper:	150	mm
Type of Paper (Whatman #):	185	
Filtration Time:	10	minutes
Washing Time:	20	minutes
Cake Moisture:	17%	
Weight Loss:	1%	

Colour and Clarity:

Clarity of Filtrate:	clear
Colour of Filtrate:	clear
Clarity of Wash:	clear
Colour of Wash:	ww
Colour of Residue:	white/pink granules

Residue: Total

Tare:	.0 g
Tare + Wet:	240.0 g
Tare + Dry:	198.5 g

Acid Addition	*1808*	*kg/t*
Acid Remaining	*1790*	*kg/t*
Acid Consumed	*18*	*kg/t*

Leach Feed Basis

Comments:

DI water contaminated by hard water. Ca, Mg and Na assays in leached solution were not accurate

Project: 19097-03 **Date:** 09-11-22

Client: SGS Jordan **Technologist:** R. Brunsch

Test: L2

Metallurgical Balance

Sample & Quant.	Assay Units	Feed GSB-03 WHIMS Non-mag (as is)	1h Filtrate	2h Filtrate	4h (final) Filtrate	Final Wash	1h Residue	2h Residue	4h (final) Residue	Extract. Final	Account. out/in	Calc Head
(mL or g)		200	-	-	1471	2056	200	0	199	%	%	
Al	mg/L, %	0.03			1	< 0.2			0.03	2	122	0.03
Fe	mg/L, %	0.01			2	< 0.2			< 0.01	-	-	-
Co	mg/L, %				< 0.3	< 0.3				-	-	-
	mg/L, %									-	-	-
	mg/L, %									-	-	-
	mg/L, %										-	-
	mg/L, %											-
	mg/L, %										-	-
	mg/L, %											
	mg/L, %										-	-
	mg/L, %										-	
	mg/L, %									-	-	-
	mg/L, %									-	-	-
	mg/L, %										-	

Project: 19097-03 **Date:** 11-11-22

Client: SGS Jordan **Technologist:** R. Brunsch

Test: L3

Purpose: Scoping HCl leach test on GSB-03 WHIMS Non-mag (pulverized to 100% passing 75 micron) at 219 g/L acid

Sample: **GSB-03 WHIMS Non-mag (pulverized to 100% passing 75 micron)**

H&S: - Review SDS for HCl, Silica, etc. - conduct testing in fumehood
- Wear face shield (or work behind fumehood sash), lab coat and gloves when interacting with all acidic process solutions and containers until they are washed and chemical hazards have been removed

Procedure:

1. Add the calculated amount of DI water to a suitably sized glass reactor and begin mixing in the feed. Once all feed has been added, equip with a lid (including condenser) and agitate and begin heating to target temperature. Ensure that mixing is vigorous to suspend the solids. No exposed metal in inside the reactor.
2. At ~25°C below target temperature, begin adding initial acid dose.
3. Time zero occurs once all acid has been added and target temperature is achieved (note any overshoot). Determine the acidity of the PLS, add more acid if required to achieve the FA target. Check acidity again frequently until stable.
4. Collect kinetic samples as per Sampling Info table. Check FA and add acid if required.
5. After the required time, stop the test and weigh the pulp before filtering. Collect the filtrate and submit a sample for assay. Measure the pH, ORP, and density of the filtrate.
6. Repulp wash the filter cake in a volume of water similar to the amount initially used in the test (at room temperature).
7. Filter again, and displacement wash three times. Combine all washes, weigh, and submit a sample for assay. Measure the pH, ORP, and density of the combined wash.
8. Record the wet weight of the solids and then dry solids. Record the dry weight and submit sample for assay.

Assays:

Liquors				Solids			
#	Streams	Analysis	Code	#	Streams	Analysis	Code
2	Kinetic Liquors	No kinetics samples collected		2	Kinetic Solids	No kinetics samples collected	
1	Final Liquor	ICP	GC_SOL91T 3 day TAT	1	Final Solids		Pulverize all ASTM-C146
					Use W pot to puverize the residue, max 50 g for pulverization		
1	Final Wash	ICP	GC_SOL91T 3 day TAT	Please run wet Malvern PSA on L4 feed rejects Photograph the feed, residue and PLS			

Conditions:

Feed Weight (dry):	**200**	**g, Stage-pulverized to 100% passing 75 micron**
Reagent:	HCl	
Reagent Strength:	37	%
Acidity Target:	219	g/L HCl
37% HCl to Add:	**973**	**g**
Acidity Target:	**20**	(w/w)% HCl
Target % Solids (vs. Leach Feed):	10.0%	after all initial acid has been added
Calc. Pulp Weight:	2000	g
DI Water to add:	**827**	**g**
Test Time:	6	h
Temperature:	80	°C

Project: 19097-03
Client: SGS Jordan

Date: 11-11-22
Technologist: R. Brunsch

Test: L3

Test Data:

Time		Reactor			Reagents / Feed			Comments:	
(24 h)	(h) elapsed	Temp °C	pH	ORP mV	Feed g	H_2O g	HCl 37% g		
7:05		22.5			202	832		Controls on	
7:10		43.6					975.0	All acid in	
7:25	T=0	89.2						Conditions met, T=0, FAT 1	256.7 g/L
8:45	1h	79.4						FAT 2	240.6 g/L
10:25	3h	84.6						FAT 3	253.18 g/L
13:25	6h	84.2						End of Test	
Totals/Avg.		82.7	-	-	202.0	832.0	975.0		

Project: 19097-03
Client: SGS Jordan

Date: 11-11-22
Technologist: R. Brunsch

Test: L3

Sampling Info:

Sample	Elapsed Time (h)	Weight (g)		Filt. Dens.	PLS Vol	At Ambient Temp		Wet Res.	Dry Res.	Filtration	Pulp	Calc PLS
		Pulp	Filtrate	g/mL	mL	ORP	pH	g	g	fast/slow	% Solids	Vol, mL
Kinetic 1	1				-					fast	#DIV/0!	-
Kinetic 2	2				-					fast	#DIV/0!	-
Final	6	1982.0	1682.3	1.099	1531	503	-0.26			fast	9.9%	1626
Final Wash			1684.3	1.002	1681	543	1.41	223.20	195.40	fast		

Free Acid Data:

Sample #	Aliquot mL	Titrant N	Titrant mL	Which Acid	Stoich mol/mol	MW g/mole	g/L acid	g acid
Kinetic 1	0.5	0.2		HCl	1	36.5	0	#VALUE!
Kinetic 2	0.5	0.2		HCl	1	36.5	0	#VALUE!
Final	0.5	0.2	16.10	HCl	1	36.5	235	234.8
Final Wash	5	0.2	4.00	HCl	1	36.5	5.8	5.8

Final Filtration/Washing:

Diameter of filtration paper:	150	mm
Type of Paper (Whatman #):	185	
Filtration Time:	15	minutes
Washing Time:	30	minutes
Cake Moisture:	12%	
Weight Loss:	3%	

Colour and Clarity:

Clarity of Filtrate:	clear
Colour of Filtrate:	yellowish green
Clarity of Wash:	clear
Colour of Wash:	ww
Colour of Residue:	white, slight grey tinge

Residue: Total

Tare:	12.8 g
Tare + Wet:	236.0 g
Tare + Dry:	208.2 g

Acid Addition	*1786*	*kg/t*
Acid Remaining	*1191*	*kg/t*
Acid Consumed	*595*	*kg/t*

Leach Feed Basis

Comments:

Small amount of off-gassing with acid addition, paired with a temperature increase of approximately 30 degrees.

Within 20 minutes of test start, filtrate and feed appeared to have a lighter color than was present at the beginning

DI water contaminated by hard water. Ca, Mg and Na assays in leached solution were not accurate

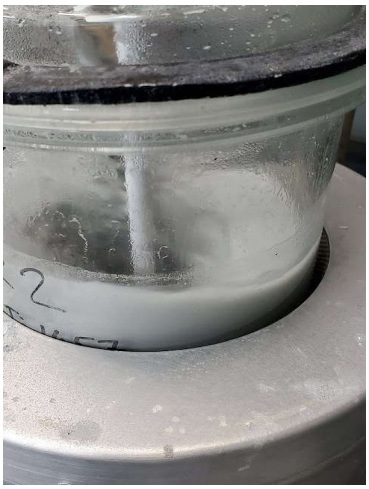
Project: 19097-03 **Date:** 11-11-22

Client: SGS Jordan **Technologist:** R. Brunsch

Test: L3

Metallurgical Balance

Sample & Quant.	Assay Units	Feed GSB-03 WHIMS Non-mag (pulverize	1h Filtrate	2h Filtrate	6h (final) Filtrate	Final Wash	1h Residue	2h Residue	6h (final) Residue	Extract. Final	Account. out/in	Calc Head
(mL or g)		202	-	-	1531	1681	0	0	195	%	%	
Al	mg/L, %	0.03			331	27.90				-	-	-
Fe	mg/L, %				757	63.8				-	-	-
Co	mg/L, %				6.60	0.60				-	-	-
	mg/L, %									-	-	-
	mg/L, %									-	-	-
	mg/L, %										-	-
	mg/L, %											-
	mg/L, %										-	-
	mg/L, %											
	mg/L, %										-	-
	mg/L, %										-	
	mg/L, %									-	-	-
	mg/L, %									-	-	-
	mg/L, %										-	




AR2

Project: 19097-03 **Date:** 15-11-22

Client: SGS Jordan **Technologist:** R. Brunsch

Test: L4

Purpose: Scoping HCl leach test on GSB-04 WHIMS Non-mag (pulverized to 100% passing 75 micron) at 219 g/L acid

Sample: **GSB-04 WHIMS Non-mag (pulverized to 100% passing 75 micron)**

H&S: - Review SDS for HCl, Silica, etc. - conduct testing in fumehood
- Wear face shield (or work behind fumehood sash), lab coat and gloves when interacting with all acidic process solutions and containers until they are washed and chemical hazards have been removed

Procedure:

1. Add the calculated amount of DI water to a suitably sized glass reactor and begin mixing in the feed. Once all feed has been added, equip with a lid (including condenser) and agitate and begin heating to target temperature. Ensure that mixing is vigorous to suspend the solids. No exposed metal in inside the reactor.
2. At ~25°C below target temperature, begin adding initial acid dose.
3. Time zero occurs once all acid has been added and target temperature is achieved (note any overshoot). Determine the acidity of the PLS, add more acid if required to achieve the FA target. Check acidity again frequently until stable.
4. Collect kinetic samples as per Sampling Info table. Check FA and add acid if required.
5. After the required time, stop the test and weigh the pulp before filtering. Collect the filtrate and submit a sample for assay. Measure the pH, ORP, and density of the filtrate.
6. Repulp wash the filter cake in a volume of water similar to the amount initially used in the test (at room temperature).
7. Filter again, and displacement wash three times. Combine all washes, weigh, and submit a sample for assay. Measure the pH, ORP, and density of the combined wash.
8. Record the wet weight of the solids and then dry solids. Record the dry weight and submit sample for assay.

Assays:

Liquors				Solids			
#	Streams	Analysis	Code	#	Streams	Analysis	Code
2	Kinetic Liquors	No kinetics samples collected		2	Kinetic Solids	No kinetics samples collected	
1	Final Liquor	ICP	GC_SOL91T 3 day TAT	1	Final Solids		Pulverize all ASTM-C146
					Use W pot to puverize the residue, max 50 g for pulverization		
1	Final Wash	ICP	GC_SOL91T 3 day TAT	Please run wet Malvern PSA on L4 feed rejects Photograph the feed, residue and PLS			

Conditions:

Feed Weight (dry):	**200**	**g, Stage-pulverized to 100% passing 75 micron**
Reagent:	HCl	
Reagent Strength:	37	%
Acidity Target:	219	g/L HCl
37% HCl to Add:	**973**	**g**
Acidity Target:	**20**	(w/w)% HCl
Target % Solids (vs. Leach Feed):	10.0%	after all initial acid has been added
Calc. Pulp Weight:	2000	g
DI Water to add:	**827**	**g**
Test Time:	6	h
Temperature:	80	°C

Project: 19097-03
Client: SGS Jordan

Date: 15-11-22
Technologist: R. Brunsch

Test: L4

Test Data:

Time		Reactor			Reagents / Feed			Comments:	
(24 h)	(h) elapsed	Temp °C	pH	ORP mV	Feed g	H_2O g	HCl 37% g		
7:30		30.0			200	830	974	Acid in	
7:50	T=0	79.5						All conditions met, T=0, FAT 1	256 g/L
9:30	1.5	81.6						FAT 2	257.9 g/L
11:20	3.5	84.8						FAT 3	266 g/L
13:50	6	83.0						Test End	
Totals/Avg.		83.9	-	-	200.0	830.0	974.0		

Project: 19097-03
Client: SGS Jordan

Date: 15-11-22
Technologist: R. Brunsch

Test: L4

Sampling Info:

Sample	Elapsed Time (h)	Weight (g) Pulp	Weight (g) Filtrate	Filt. Dens. g/mL	PLS Vol mL	At Ambient Temp ORP	At Ambient Temp pH	Wet Res. g	Dry Res. g	Filtration fast/slow	Pulp % Solids	Calc PLS Vol, mL
Kinetic 1	1				-					fast	#DIV/0!	-
Kinetic 2	2				-					fast	#DIV/0!	-
Final	6	1970.0	1686.3	1.099	1535	888	-0.13			fast	9.6%	1621
Final Wash			2088.3	0.999	2090	613	0.88	241.00	189.00	fast		

Free Acid Data:

Sample #	Aliquot mL	Titrant N	Titrant mL	Which Acid	Stoich mol/mol	MW g/mole	g/L acid	g acid
Kinetic 1	0.5	0.2		HCl	1	36.5	0	#VALUE!
Kinetic 2	0.5	0.2		HCl	1	36.5	0	#VALUE!
Final	0.5	0.2	16.16	HCl	1	36.5	236	236.0
Final Wash	5	0.2	1.01	HCl	1	36.5	1.5	1.5

Final Filtration/Washing:

Diameter of filtration paper:	150	mm
Type of Paper (Whatman #):	185	
Filtration Time:	25	minutes
Washing Time:	45	minutes
Cake Moisture:	22%	
Weight Loss:	6%	

Colour and Clarity:

Clarity of Filtrate:	clear
Colour of Filtrate:	green
Clarity of Wash:	clear
Colour of Wash:	ww
Colour of Residue:	white

Residue: Total

Tare:	
Wet:	241.0 g
Dry:	189.0 g

Acid Addition	*1802*	*kg/t*
Acid Remaining	*1187*	*kg/t*
Acid Consumed	*615*	*kg/t*

Leach Feed Basis

Comments:

DI water contaminated by hard water. Ca, Mg and Na assays in leached solution were not accurate

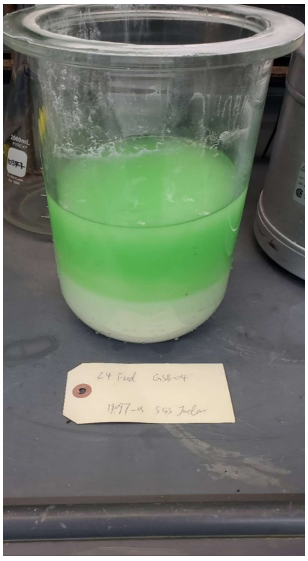
Project: 19097-03
Client: SGS Jordan

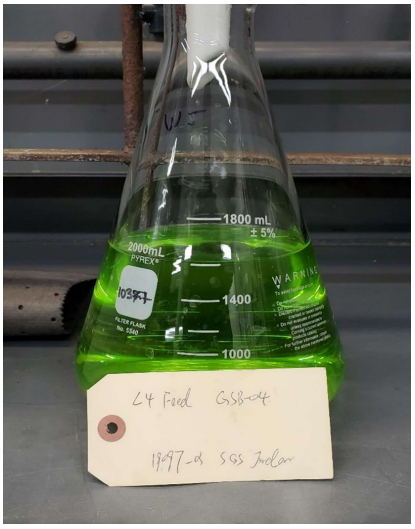
Date: 15-11-22
Technologist: R. Brunsch

Test: L4

Metallurgical Balance

Sample & Quant.	Assay Units	Feed GSB-04 WHIMS Non-mag (pulverize	1h Filtrate	2h Filtrate	6h (final) Filtrate	Final Wash	1h Residue	2h Residue	6h (final) Residue	Extract. Final	Account. out/in	Calc Head
(mL or g)		200	-	-	1535	2090	0	0	189	%	%	
Al	mg/L, %	0.02			9.7	< 0.2				-	-	-
Fe	mg/L, %	< 0.01			17.4	< 0.2				-	-	-
Co	mg/L, %				64.3	< 0.3				-	-	-
	mg/L, %									-	-	-
	mg/L, %									-	-	-
	mg/L, %										-	-
	mg/L, %											-
	mg/L, %										-	-
	mg/L, %											
	mg/L, %										-	-
	mg/L, %											
	mg/L, %									-	-	-
	mg/L, %									-	-	-
	mg/L, %										-	


L4 Feed GSB-04
1997-08 SGS Jacksonville


1800 mL
± 5%
2000mL
PYREX
1400
1000
L4 Feed GSB-04
1997-08 SGS Jacksonville

Project: 19097-03 **Date:** 15-11-22

Client: SGS Jordan **Technologist:** R. Brunsch

Test: L5

Purpose: Scoping HCl leach test on GSB-06 WHIMS Non-mag (pulverized to 100% passing 75 micron) at 219 g/L acid

Sample: **GSB-06 WHIMS Non-mag (pulverized to 100% passing 75 micron)**

H&S: - Review SDS for HCl, Silica, etc. - conduct testing in fumehood
- Wear face shield (or work behind fumehood sash), lab coat and gloves when interacting with all acidic process solutions and containers until they are washed and chemical hazards have been removed

Procedure:

1. Add the calculated amount of DI water to a suitably sized glass reactor and begin mixing in the feed. Once all feed has been added, equip with a lid (including condenser) and agitate and begin heating to target temperature. Ensure that mixing is vigorous to suspend the solids. No exposed metal in inside the reactor.
2. At ~25°C below target temperature, begin adding initial acid dose.
3. Time zero occurs once all acid has been added and target temperature is achieved (note any overshoot). Determine the acidity of the PLS, add more acid if required to achieve the FA target. Check acidity again frequently until stable.
4. Collect kinetic samples as per Sampling Info table. Check FA and add acid if required.
5. After the required time, stop the test and weigh the pulp before filtering. Collect the filtrate and submit a sample for assay. Measure the pH, ORP, and density of the filtrate.
6. Repulp wash the filter cake in a volume of water similar to the amount initially used in the test (at room temperature).
7. Filter again, and displacement wash three times. Combine all washes, weigh, and submit a sample for assay. Measure the pH, ORP, and density of the combined wash.
8. Record the wet weight of the solids and then dry solids. Record the dry weight and submit sample for assay.

Assays:

Liquors				Solids			
#	Streams	Analysis	Code	#	Streams	Analysis	Code
2	Kinetic Liquors	No kinetics samples collected		2	Kinetic Solids	No kinetics samples collected	
1	Final Liquor	ICP	GC_SOL91T 3 day TAT	1	Final Solids		Pulverize all ASTM-C146 Use W pot to puverize the residue, max 50 g for pulverization Require to thoroughly clean the pulverizer, 99+ % SiO2 expected
1	Final Wash	ICP	GC_SOL91T 3 day TAT	Please run wet Malvern PSA on L4 feed rejects Photograph the feed, residue and PLS			

Conditions:

Feed Weight (dry):	**200**	**g, Stage-pulverized to 100% passing 75 micron**
Reagent:	HCl	
Reagent Strength:	37	%
Acidity Target:	219	g/L HCl
37% HCl to Add:	**973**	**g**
Acidity Target:	**20**	(w/w)% HCl
Target % Solids (vs. Leach Feed):	10.0%	after all initial acid has been added
Calc. Pulp Weight:	2000	g
DI Water to add:	**827**	**g**
Test Time:	6	h
Temperature:	80	°C

Project: 19097-03
Client: SGS Jordan

Date: 15-11-22
Technologist: R. Brunsch

Test: L5

Test Data:

Time		Reactor			Reagents / Feed			Comments:	
(24 h)	(h) elapsed	Temp °C	pH	ORP mV	Feed g	H_2O g	HCl 37% g		
7:30		29.0			200	828		Acid in	
7:50	T=0	76.9					981.0	All conditions met, T=0, FAT 1	261.4 g/L
9:30	1.5	81.9						FAT 2	253.5 g/L
11:20	3.5	80.1						FAT 3	251.4 g/L
13:50	6	80.6						Test End	
Totals/Avg.		80.4	-	-	200.0	828.0	981.0		

Project: 19097-03 | **Date:** 15-11-22

Client: SGS Jordan | **Technologist:** R. Brunsch

Test: L5

Sampling Info:

Sample	Elapsed Time (h)	Weight (g) Pulp	Weight (g) Filtrate	Filt. Dens. g/mL	PLS Vol mL	At Ambient Temp ORP	At Ambient Temp pH	Wet Res. g	Dry Res. g	Filtration fast/slow	Pulp % Solids	Calc PLS Vol, mL
Kinetic 1	1				-					fast	#DIV/0!	-
Kinetic 2	2				-					fast	#DIV/0!	-
Final	6	1972.0	1677.0	1.099	1526	466	-0.36			fast	9.9%	1618
Final Wash			1926.0	1.000	1926	579	0.85	249.00	195.00	fast		

Free Acid Data:

Sample #	Aliquot mL	Titrant N	Titrant mL	Which Acid	Stoich mol/mol	MW g/mole	g/L acid	g acid
Kinetic 1	0.5	0.2		HCl	1	36.5	0	#VALUE!
Kinetic 2	0.5	0.2		HCl	1	36.5	0	#VALUE!
Final	0.5	0.2	15.60	HCl	1	36.5	228	227.5
Final Wash	5	0.2	1.98	HCl	1	36.5	2.9	2.9

Final Filtration/Washing:

Diameter of filtration paper:	150	mm
Type of Paper (Whatman #):	185	
Filtration Time:	25	minutes
Washing Time:	45	minutes
Cake Moisture:	22%	
Weight Loss:	3%	

Colour and Clarity:

Clarity of Filtrate:	clear
Colour of Filtrate:	green
Clarity of Wash:	clear
Colour of Wash:	ww
Colour of Residue:	white

Residue: Total

Tare:	.0 g
Wet:	249.0 g
Dry:	195.0 g

Acid Addition	*1815*	*kg/t*
Acid Remaining	*1152*	*kg/t*
Acid Consumed	*663*	*kg/t*

Leach Feed Basis

Comments:

DI water contaminated by hard water. Ca, Mg and Na assays in leached solution were not accurate

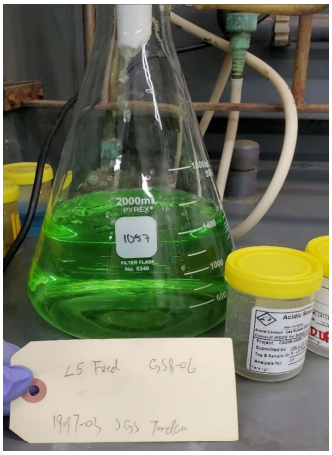
Project: 19097-03 **Date:** 15-11-22

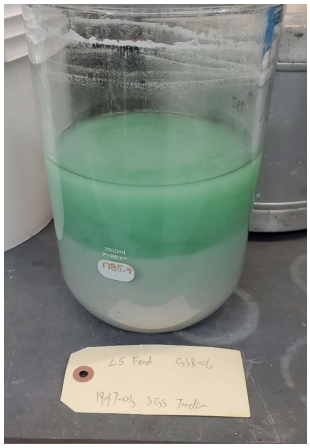
Client: SGS Jordan **Technologist:** R. Brunsch

Test: L5

Metallurgical Balance

Sample & Quant.	Assay Units	Feed GSB-06 WHIMS Non-mag (pulverize	1h Filtrate	2h Filtrate	6h (final) Filtrate	Final Wash	1h Residue	2h Residue	6h (final) Residue	Extract. Final	Account. out/in	Calc Head
(mL or g)		200	-	-	1526	1926	0	0	195	%	%	
Al	mg/L, %	0.03			7.6	< 0.2				-	-	-
Fe	mg/L, %	< 0.01			9.6	< 0.2				-	-	-
Co	mg/L, %				72.0	0.70				-	-	-
	mg/L, %									-	-	-
	mg/L, %									-	-	-
	mg/L, %										-	-
	mg/L, %											-
	mg/L, %										-	-
	mg/L, %											
	mg/L, %										-	-
	mg/L, %										-	
	mg/L, %									-	-	-
	mg/L, %									-	-	-
	mg/L, %										-	


2000ml
PYREX
1057
L5 Feed GSS-06
1997-03 SGS Jordan


L5 Feed GSS-06
1997-03 SGS Jordan

Appendix D – Assay Certificate of Acid Leach Residues of Silica Sands

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

LR Internal Dept 14
Attn : H. Li / R. Brunsch

---, ---

Phone: ---
Fax:---

22-December-2022

Date Rec. : 14 November 2022
LR Report : **CA02214-NOV22**
Project : CA20M-00000-110-19097-03

CERTIFICATE OF ANALYSIS

Final Report

Sample ID	SiO2 %	Net Wt g
1: L3 Residue	99.66	195.4

Assayed Via ASTM C 146
precision +/- 0.25

Sarah Thyret-Arbour
Technologist, Mineral Services, Analytical

OnLine LIMS

00031707 15

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

LR Internal Dept 14
Attn : Hao / Rachel

22-December-2022

Date Rec. : 16 November 2022
LR Report : **CA02248-NOV22**
Project : CA20M-00000-110-19097-03

CERTIFICATE OF ANALYSIS

Final Report

Sample ID	SiO2 %	Net Wt g
1: L4 Residue	99.80	189.1
2: L5 Residue	99.58	195

Assayed Via ASTM C 146
precision +/- 0.25

Sarah Thyret-Arbour
Technologist, Mineral Services, Analytical

OnLine LIMS

00003170730

Your P.O. #: 309047
Your C.O.C. #: N/a

Attention: Hao Li

SGS Canada Inc
Postal Bag 4300
185 Concession St
Lakefield, ON
Canada K0L 2H0

Report Date: 2022/12/13
Report #: R7428409
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BUREAU VERITAS JOB #: C2X8951
Received: 2022/11/18, 08:50

Sample Matrix: Solid
Samples Received: 3

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Multielement Neutron Activation Analysis	3	N/A	2022/11/30	BQL SOP-00004	Neutron Activation

Remarks:

Bureau Veritas is accredited to ISO/IEC 17025 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Bureau Veritas are based upon recognized Provincial, Federal or US method compendia such as CCME, MELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Bureau Veritas' profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Bureau Veritas in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

Bureau Veritas liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Bureau Veritas has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Bureau Veritas, unless otherwise agreed in writing. Bureau Veritas is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested. When sampling is not conducted by Bureau Veritas, results relate to the supplied samples tested.

Reference Method suffix "m" indicates test methods incorporate validated modifications from specific reference methods to improve performance.

Bureau Veritas 6790 Kitimat Rd, Unit 4, Mississauga, ON L5N 5L9 Phone: (905) 826-3080 Fax: (905) 826-4151 Toll Free: 1 877-726-3080 www.bvna.com

Your P.O. #: 309047
Your C.O.C. #: N/a

Attention: Hao Li

SGS Canada Inc
Postal Bag 4300
185 Concession St
Lakefield, ON
Canada K0L 2H0

Report Date: 2022/12/13
Report #: R7428409
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BUREAU VERITAS JOB #: C2X8951
Received: 2022/11/18, 08:50

Encryption Key

Mayank Nigam
Project Manager
13 Dec 2022 12:11:42

Please direct all questions regarding this Certificate of Analysis to:
Mayank Nigam, Project Manager
Email: Mayank.Nigam@bureauveritas.com
Phone# (905) 826-3080

==========

Bureau Veritas has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports. For Service Group specific validation, please refer to the Validation Signatures page if included, otherwise available by request. For Department specific Analyst/Supervisor validation names, please refer to the Test Summary section if included, otherwise available by request. This report is authorized by Rodney Major, General Manager responsible for Ontario Environmental laboratory operations.

Bureau Veritas 6790 Kitimat Rd, Unit 4, Mississauga, ON L5N 5L9 Phone: (905) 826-3080 Fax: (905) 826-4151 Toll Free: 1 877-726-3080 www.bvna.com

Bureau Veritas Job #: C2X8951
Report Date: 2022/12/13

SGS Canada Inc
Your P.O. #: 309047

RESULTS OF ANALYSES OF SOLID

Bureau Veritas ID		UIN976	UIN977		UIN978		
Sampling Date		2022/11/17	2022/11/17		2022/11/17		
COC Number		N/a	N/a		N/a		
	UNITS	L3 RESIDUE, GSB-03	L4 RESIDUE, GSB-04	RDL	L5 RESIDUE, GSB-06	RDL	QC Batch
Aluminum (Al)	ppm	412	450	0.50	407	0.50	8362589
Calcium (Ca)	ppm	31	27	10	20	10	8362589
Chromium (Cr)	ppm	<10	<10	10	<10	10	8362589
Iron (Fe)	ppm	<1000	<1000	1000	<1000	1000	8362589
Magnesium (Mg)	ppm	<30	<30	30	<45	45	8362589
Manganese (Mn)	ppm	0.830	0.830	0.050	0.650	0.050	8362589
Potassium (K)	ppm	<110	<110	110	<110	110	8362589
Sodium (Na)	ppm	22.0	74.0	0.10	19.0	0.10	8362589
Titanium (Ti)	ppm	74.0	99.0	0.50	89.0	0.50	8362589

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Bureau Veritas 6790 Kitimat Rd, Unit 4, Mississauga, ON L5N 5L9 Phone: (905) 826-3080 Fax: (905) 826-4151 Toll Free: 1 877-726-3080 www.bvna.com

Bureau Veritas Job #: C2X8951
Report Date: 2022/12/13

SGS Canada Inc
Your P.O. #: 309047

GENERAL COMMENTS

Results relate only to the items tested.

Bureau Veritas 6790 Kitimat Rd, Unit 4, Mississauga, ON L5N 5L9 Phone: (905) 826-3080 Fax: (905) 826-4151 Toll Free: 1 877-726-3080 www.bvna.com

Bureau Veritas Job #: C2X8951
Report Date: 2022/12/13

SGS Canada Inc
Your P.O. #: 309047

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by:

Steven Simpson, Lab Director

Bureau Veritas has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports. For Service Group specific validation, please refer to the Validation Signatures page if included, otherwise available by request. For Department specific Analyst/Supervisor validation names, please refer to the Test Summary section if included, otherwise available by request. This report is authorized by {0}, {1} responsible for {2} {3} laboratory operations.

Bureau Veritas 6790 Kitimat Rd, Unit 4, Mississauga, ON L5N 5L9 Phone: (905) 826-3080 Fax: (905) 826-4151 Toll Free: 1 877-726-3080 www.bvna.com

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

LR Internal Priority
Attn : H. Li

16-January-2023

Date Rec. : 11 January 2023
LR Report : **CA07155-JAN23**
Project : CA20M-00000-110-19097-03
Client Ref : SGS Jordan

CERTIFICATE OF ANALYSIS

Final Report

Sample ID	Al2O3 %	Fe2O3 %	MgO %	CaO %	Na2O %	K2O %
1: L3 Residue	0.04	0.01	< 0.01	< 0.01	< 0.01	< 0.01
2: L4 Residue	0.04	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
3: L5 Residue	0.04	0.01	< 0.01	< 0.01	< 0.01	< 0.01

Sample ID	TiO2 %	P2O5 %	MnO %	Cr2O3 %	V2O5 %	LOI %	Sum %
1: L3 Residue	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.26	99.6
2: L4 Residue	0.02	< 0.01	< 0.01	< 0.01	< 0.01	0.39	99.6
3: L5 Residue	0.02	< 0.01	< 0.01	< 0.01	< 0.01	0.39	100.3

Control Quality Assay
Not Suitable for Commercial Exchange

Method Descriptions

Parameter	Units	Low Limit	Description	SGS Method Code
Al2O3	%	0.01	Aluminum by by borate fusion XRF	GO/GC/GT_XRF76V/R
CaO	%	0.01	Calcium by borate fusion XRF	GO/GC/GT_XRF76V/R
Cr2O3	%	0.01	Chromium by borate fusion XRF	GO/GC/GT_XRF76V/R
Fe2O3	%	0.01	Iron by borate fusion XRF	GO/GC/GT_XRF76V/R
K2O	%	0.01	Potassium by borate fusion XRF	GO/GC/GT_XRF76V/R
LOI	%	no	Loss at 1000C XRF	GO/GC/GT_XRF76V/R
MgO	%	0.01	Magnesium by borate fusion XRF	GO/GC/GT_XRF76V/R
MnO	%	0.01	Manganese by borate fusion XRF	GO/GC/GT_XRF76V/R

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

LR Report : **CA07155-JAN23**

Parameter	Units	Low Limit	Description	SGS Method Code
Na2O	%	0.01	Sodium by borate fusion XRF	GO/GC/GT_XRF76V/R
P2O5	%	0.01	Phosphorus by borate fusion XRF	GO/GC/GT_XRF76V/R
Sum	%	98.5	Sum	
TiO2	%	0.01	Titanium by borate fusion XRF	GO/GC/GT_XRF76V/R
V2O5	%	0.01	Vanadium by borate fusion XRF	GO/GC/GT_XRF76V/R

Sarah Thyret-Arbour
Technologist, Mineral Services, Analytical

SGS	**Geochemistry** **Lakefield Laboratory**	Doc Type: **Method Summary** Method Code: **GC_XRF76V** Service: **Testing** Issued Date: **December 2021**
Natural Resources	**Preparation and Determination of Major Element Oxides, LOI and Rare Earth Oxides by Borate Fusion and Xray Fluorescence Spectrometry** [SiO_2, Al_2O_3, Fe_2O_3, MgO, CaO, Na_2O, K_2O, P_2O_5, MnO, TiO_2, Cr_2O_3; V_2O_5; LOI; additions BaO; Ce_2O_3; Nd_2O_3, La_2O_3; Pr_2O_3, Sm_2O_3; Nb_2O_5,ThO_2, Ta_2O_5; SnO_2; SrO; ZrO_2; HfO_2; Y_2O_3; WO_3; U_3O_8; Co; Ni ; XRF]	Approved by: **K. Loftus**

1. **Parameter(s) measured, unit(s):**
   Silicon Dioxide (SiO_2), Aluminum Oxide (Al_2O_3), Iron(III) Oxide (Fe_2O_3), Magnesium Oxide (MgO), Calcium Oxide (CaO), Sodium Oxide (Na_2O), Potassium Oxide (K_2O), Phosphorus Pentoxide (P_2O_5), Manganese Oxide (MnO), Titanium Dioxide (TiO_2), Chromium (III) Oxide (Cr_2O_3), Vanadium Oxide (V_2O_5), LOI, in %
   Barium Oxide (BaO), Cerium (III) Oxide(Ce_2O_3), Neodymium Oxide (Nd_2O_3), Lanthanum Oxide (La_2O_3), Praseodymium Oxide (Pr_2O_3), Samarium Oxide (Sm_2O_3), Niobium Pentoxide (Nb_2O_5), Thorium Dioxide (ThO_2), Tantalum Pentoxide (Ta_2O_5), Tin Dioxide (SnO_2) Uranium Oxide (U_3O_8), Cobalt (Co), Nickel (Ni), Strontium Oxide (SrO), Zirconium Dioxide (ZrO_2), Hafnium Oxide (HfO_2), Yttrium Oxide (Y_2O_3), Tungsten Trioxide (WO_3) in % can be added as additions

2. **Typical sample size:**
   0.2 to 0.5g

3. **Type of sample applicable (media):**
   Rocks, oxide ores, concentrates and catalysts

4. **Sample preparation technique used:**
   Samples are crushed and pulverized according to client specified instructions or default preparation procedures. Sample preparation entails the formation of a homogenous glass disk by the fusion of the sample and a lithium tetraborate/lithium metaborate mixture. The LOI is determined separately and gravimetrically at 1000°C.

5. **Method of analysis used:**
   The prepared disks are analyzed by wavelength dispersion X-ray fluorescence (WD-XRF). The LOI is included in the matrix correction calculations, which are performed by the XRF software.

6. **Data reduction by:**
   Computer, on line, data fed to Laboratory Information Management System with secure audit trail.

7. Figures of Merit:

This method has been fully validated for the range of samples typically analyzed. Method validation includes the use of reference materials, replicates, duplicates and blanks to calculate accuracy, precision, linearity, range, limit of detection, reporting limit, specificity and measurement uncertainty.

The estimated Measurement Uncertainty (MU) has been established for the following parameters at various concentration ranges. The estimated MU is assessed using reference materials, and replicate samples or duplicate samples (comprising of different samples, analysts, laboratory conditions, equipment, etc.,) over a period of greater than 3 months.

Where insufficient live sample data is available to calculate the estimated MU, a theoretical estimate is provided in blue.

	Estimated Measurement Uncertainty in given concentration ranges (MU) +/- *(relative percent)*													
Element	SiO2	Al2O3	MgO	Na2O	K2O	CaO	P2O5	TiO2	Cr2O3	V2O5	Fe2O3	MnO		LOI
Report limit,%	0.01													-10
0.01-<0.05%	**111**	**85**	**86**	**85**	**85**	**85**	**85**	**85**	**85**	**85**	**98**	**85**		TBD
0.05-<0.1%	**39**	**37**	**64**	**70**	**35**	**50**	**38**	**35**	**54**	**59.4**	**35**	**35**		TBD
0.1-<0.5%	**14**	**12**	**18**	**31**	**10**	**12**	**11**	**10**	**10**	**10**	**13**	**10**		TBD
0.5-< 1%	**12**	**10**	**6.7**	**28**	**5.4**	**7.2**	**9.4**	**8.9**	**7.1**	**6.4**	**7.6**	**5.6**		TBD
1-<5 %	**3.7**	**4.2**	**4.6**	**4.3**	**4**	**5.3**	**3.5**	**3.5**	**3.8**	TBD	**4.3**	**4.3**		**10.6**
5-<10 %	**2.6**	**4.2**	**4.3**	**3.3**	**3.7**	**4.7**	**3**	**3.1**	**3.7**	TBD	**3.4**	**2.3**		**9.5**
10-<50 %	**2.1**	**4.0**	**2.4**	**2.1**	**2.4**	**2.1**	**3.1**	**3**	**3.5**	TBD	**2.1**	**2.1**		**2.5**
50-<100%	**2.1**	**4.0**	**2.4**	**2.0**	**2**	**2**	**2**	**2.7**	**2.7**	TBD	**2**	**2**		**2.0**
Upper limit (%)	100													

Note: Measurement Uncertainty estimates may vary from location to location due to dependency on instrumentation
The reported uncertainty is expanded using a coverage factor k=2 for a level of confidence of approximately 95%, assuming a normal distribution.

8. Quality control:

Quality control materials include method blanks, replicates and reference materials and are randomly inserted with the frequency set according to method protocols at ~18% for process control analysis. Quality control materials will also include BRM (Barren reference materials, or preparations blanks) and duplicates if samples have been taken through the sample reduction process. Calibration materials that cover the range upon method set-up; calibration check performed weekly.

9. Accreditation:

SGS Natural Resources conforms to the requirements of ISO/IEC 17025. Scopes of Accredited tests are site specific, please visit https://www.scc.ca/en/search/laboratories