



AMIS\_Documents

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Certificate

# AMIS0433

## Certified Reference Material

Ferralsol tropical soil, Kansanshi mine area  
Zambia<sup>1</sup>.

## *Certificate of Analysis*

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### AMIS

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## Recommended Concentrations and two “Between Laboratory” Standard Deviations<sup>2</sup>

### ***Certified Concentrations***

Co M/ICP	20.1	±	2.4	ppm
Cu M/ICP	158	±	9	ppm
Cu P	128	±	21	ppm
Cu XRF	150	±	23	ppm
Ni M/ICP	43	±	4	ppm
Fe XRF	8.3	±	0.2	%
K XRF	0.33	±	0.01	%
Mn XRF	0.055	±	0.01	%
Specific Gravity	2.71	±	0.12	Dimensionless

### ***Provisional Concentrations***

As M/ICP	3.5	±	0.9	ppm
As P	2.2	±	0.6	ppm
Co P	17.0	±	2.2	ppm
Ni P	26	±	3	ppm
Pb M/ICP	13	±	3	ppm
Pb P	9.8	±	1.2	ppm
Zn M/ICP	32.5	±	6.9	ppm

### ***Informational Means<sup>3</sup>***

Au Pb Collection	14.5	ppb
Pt Pb Collection	1.6	ppb
Pd Pb Collection	2.0	ppb
Au P	11.8	ppb
Ag M/ICP	0.08	ppm
Ag P	0.05	ppm
Ni XRF	61	ppm
Zn P	21.1	ppm

1. N.B. This location was incorrectly stated on early certificates, corrected 8 May 2014.

2. Manufacturers recommended limits for use of the material as control samples, based on two standard deviations, calculated using “Between Laboratory” statistics for treatment of the data for trivial, non-trivial and technically invalid results. See sections 1, 9 and 12.

3. There is additional certified major element data presented on p2. Statistics for this Informational data plus statistics for uncertified trace element data is presented as an appendix.

# Major Element Recommended Concentrations and two “Between Laboratory” Standard Deviations

## ***Certified Concentrations***

Al <sub>2</sub> O <sub>3</sub>	13.60	±	0.32	%
C	0.91	±	0.04	%
Fe <sub>2</sub> O <sub>3</sub>	11.82	±	0.24	%
K <sub>2</sub> O	0.40	±	0.01	%
MnO	0.07	±	0.001	%
P <sub>2</sub> O <sub>5</sub>	0.11	±	0.006	%
SiO <sub>2</sub>	63.74	±	1.16	%
TiO <sub>2</sub>	2.42	±	0.05	%
LOI	7.17	±	0.26	%

## ***Provisional Concentrations***

CaO	0.05	±	0.01	%
Cr <sub>2</sub> O <sub>3</sub>	0.03	±	0.004	%
MgO	0.17	±	0.02	%
S Comb/LECO	0.02	±	0.004	%

## ***Informational Mean***

Na <sub>2</sub> O	0.04	%
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1. **Intended Use:** AMIS0433 is a matrix matched certified reference material (CRM) specifically made for use as control samples to monitor analyses of soil samples, if used in parallel to samples with the unknown chemical characteristics, and which should demonstrate the validity of the measurement results. Good laboratories will report results for this CRM within the two standard deviation levels with a failure rate of <10 %.

The CRM's purpose is primarily to monitor inter-laboratory or instrument bias and within-lab precision. It can be used, indirectly, also to establish the traceability of results to an SI system of units. The material can also be used for method development and for the calibration of equipment.

The recommended concentrations and limits for this material are property values based on a measurement campaign (round robin) and which reflect consensus results from the participating laboratories.

Slight variations in analytical procedures between laboratories will reflect in use of this CRM as slight biases to the recommended concentrations (see 19).

2. **Origin of Material:** This standard was made using soil material collected from the Kansanshi Mine, located in the North Western Province of Zambia<sup>1</sup>. The mine is located approximately 10 kilometres north of the town of Solwezi, 180 kilometres to the northwest of the Copperbelt town of Chingola and 16 kilometres south of the Democratic Republic of Congo border.

3. **Mineral and Chemical Composition.** This CRM is made from a tropical ferralsol soil. These are the classical deeply weathered red or yellow soils of the humid tropics. They are dominated by low activity clays, mainly kaolinite and sesquioxides. Globally large contiguous areas

*N.B. This location was incorrectly stated on early certificates, corrected 8 May 2014.*

of Ferralsols are found on old geomorphic surfaces, such as the Congo Basin and the Amazon Shield, on peneplained surfaces that typically comprise mid to end-Tertiary deposits. This particular ferralsol has an elevated metals content, particularly copper, reflecting its origin in a copper rich environment.

**4. Appearance:** The material is a very fine powder. It is colored Strong Brown (Corstor 5YR 4/6).

**5. Handling instructions:** The material is packaged in Laboratory Packs and Explorer Packs that must be shaken or otherwise agitated before use. Normal safety precautions for handling fine particulate matter are suggested, such as the use of safety glasses, breathing protection, gloves and a laboratory coat.

**6. Storage information:** The material should be stored in a cool dry place, in such a way that it does not compromise the integrity of the CRM. The material should be stored in conditions which will ensure it does not absorb moisture.

**7. Method of Preparation:** The material was crushed, dry-milled and air-classified to <54um. Wet sieve particle size analysis of random samples confirmed the material was 98.5% <54um. It was then blended in a bi-conical mixer, systematically divided and then sealed into 1kg Laboratory Packs. Explorer Packs are subdivided from the Laboratory packs as required. Samples were scientifically selected for homogeneity testing and third party analysis. Statistical analysis of both homogeneity and the consensus test results were carried out by independent statisticians.

**8. Methods of Analysis requested:**

1. Multi-acid digest, multi element scan, to include Ag, As, Co, Cu, Pb, Ni, Zn; ICP-OES or ICP-MS (M/ICP).
2. 1 gram aliquot - Aqua regia digest, multi element scan to include Ag, As, Co, Cu, Pb, Ni, Zn; ICP-OES or ICP-MS (P).
3. 25 or 30 gram aliquot - Aqua regia digest multi element, scan to include Ag, As, Au, Co, Cu, Pb, Ni, Zn; ICP-OES or ICP-MS (P1).
4. Au, Pt, Pd, 50g aliquot, Pb collection, 1 ppb detection limit (trace levels) ICP-OES/ICP-MS.
5. Major elements by XRF fusion (Al<sub>2</sub>O<sub>3</sub>, CaO, Cr<sub>2</sub>O<sub>3</sub>, Fe<sub>2</sub>O<sub>3</sub>, K<sub>2</sub>O, MgO, MnO, Na<sub>2</sub>O, SiO<sub>2</sub>, TiO<sub>2</sub>. LOI.).
6. C and S – LECO/Comb.
7. SG – Gas Pycnometer
8. XRF (Cu/ Ni/ Fe/ Mn/ K)

**9. Information requested:**

1. State and provide brief description of analytical techniques used
2. State aliquots used for all determinations
3. Results for individual analyses to be reported, with units of measure clearly marked
4. Report all QC data, to include replicates, blanks and certified reference materials used

**9. Method of Certification:** Twenty six laboratories were each given eight scientifically selected packages of sample. Twenty two of the laboratories submitted results. For certification of additional elements Five laboratories were each given eight scientifically selected packages of samples. Four of the laboratories submitted results.

Final limits were calculated after first determining if all data was compatible within a spread normally expected for similar analytical methods done by reputable laboratories. Data from any one laboratory was then removed from further calculations when the mean of all analyses from that laboratory failed a “t test” of the global means of the other laboratories. The means and standard deviations were then re-calculated using all remaining data. Any analysis that fell outside of the new two standard deviations

was removed from the ensuing data base. The mean and standard deviations were again calculated using the remaining data.

The “between-laboratory” standard deviation is used in the calculation to eliminate technically and statistically invalid data. Upper and lower limits are based on the standard deviation of the remaining data, which reflect individual analyses and can be used to monitor accuracy in routine laboratory quality control. This is different to limits based on standard deviations derived from grouped set of analyses (see 12), which provide important measures for precision and trueness, but which are less useful for routine QC.

Standards with an RSD of near or less than 5 % are termed “Certified”, RSD’s of between near 5 % and 15 % are termed “Provisional”, and RSD’s over 15 % are termed “Informational”.

**10. Participating Laboratories:** The 22 out of 26 laboratories and 4 out of 5 (for certification of additional elements) that provided results timeously were (not in same order as in the table of assays):

- 1 ACME Vancouver
- 2 ALS Chemex Laboratory Group Brisbane Australia
- 3 ALS Chemex Laboratory Group Johannesburg SA
- 4 ALS Chemex Laboratory Group Perth WA
- 5 ALS Chemex Laboratory Group Vancouver CA
- 6 ALS OMAC (Ireland)
- 7 Bureau Veritas Minerals Ultra Trace Pty Ltd
- 8 Bureau Veritas (USA)
- 9 Genalysis Laboratory Services (South Africa) Pty
- 10 Genalysis Laboratory Services (W Australia P)
- 11 Intertek Mineral Laboratory (Townsville)
- 12 Intertek Testing Services (Philippines)
- 13 Intertek Testing Services Ltd Shanghai (Beijing)
- 14 Intertek Utama Services (Indonesia)
- 15 Scrooby's Lab
- 16 Set Point Laboratories (Isando) SA
- 17 SGS Australia Pty Ltd (Newburn) WA
- 18 SGS Geosol Laboratories Ltda (Brazil)
- 19 SGS Mineral Services Callao (Peru)
- 20 SGS Mineral Services Lakefield (Canada)
- 21 SGS South Africa (Pty) Ltd - Booyens JHB
- 22 SGS Tianjin (China)
- 23 SGS Vancouver (Canada)
- 24 UIS Analytical Services (pty) Ltd
- 25 Ultra Trace (Pty) Ltd WA

11. **Assay Data:** Data as received from the laboratories for the important certified elements are set out below – Economic elements.

**Assay data – Important geochem level elements**

Lab Code	As M/ICP ppm	As P ppm	Co M/ICP ppm	Co P ppm	Cu M/ICP ppm	Cu P ppm	Ni M/ICP ppm	Ni P ppm	Pb M/ICP ppm	Pb P ppm	Zn M/ICP ppm
A			18.00	16.00	156	152	41.00	36.00	19.00	7.00	33.00
A			18.00	16.00	159	152	41.00	38.00	19.00	6.00	33.00
A			18.00	16.00	153	148	41.00	37.00	19.00	6.00	32.00
A			18.00	16.00	158	149	40.00	35.00	17.00	6.00	32.00
A			18.00	16.00	151	145	40.00	35.00	18.00	6.00	33.00
A			18.00	16.00	156	146	42.00	37.00	17.00	6.00	32.00
A			18.00	16.00	156	148	41.00	36.00	17.00	6.00	33.00
A			18.00	15.00	156	142	41.00	35.00	17.00	7.00	32.00
B	3.60	2.20	19.70	16.00	153	127	42.90	25.80	13.00	10.60	30.00
B	4.00	2.30	21.30	15.80	163	126	46.50	25.30	13.80	10.10	32.00
B	3.70	2.10	20.00	15.60	154	123	43.50	24.70	13.00	9.90	31.00
B	3.70	2.10	20.00	15.40	156	123	43.10	24.80	12.80	9.80	30.00
B	3.60	2.10	19.70	15.70	152	124	42.80	25.00	12.40	9.70	30.00
B	3.50	2.10	19.40	15.70	150	125	43.80	25.00	15.30	9.90	29.00
B	3.70	2.30	20.30	15.80	158	126	44.60	25.10	14.00	10.10	31.00
B	3.60	2.20	19.70	15.70	153	125	43.00	25.10	13.00	9.80	30.00
C	5.00	2.50	25.00	17.00	165	130	50.00	26.00	13.00		40.00
C	5.00	2.30	20.00	18.00	160	132	50.00	28.00	13.00		40.00
C	5.00	2.50	20.00	18.00	165	128	55.00	26.00	14.00		35.00
C	5.00	2.30	25.00	17.00	165	130	50.00	28.00	13.00		40.00
C	5.00	2.50	20.00	19.00	165	134	60.00	27.00	12.00		40.00
C	5.00	2.30	25.00	17.00	165	129	50.00	27.00	13.00		30.00
C	5.00	2.40	25.00	17.00	160	127	50.00	29.00	13.00		35.00
C	4.00	2.30	20.00	19.00	160	127	50.00	28.00	12.00		35.00
D			19.94		147		43.11		12.99		27.03
D			20.26		153		44.64		13.09		30.71
D			18.85		143		41.55		12.38		27.58
D			19.47		140		41.68		12.41		27.19
D			19.61		144		41.59		12.71		26.75
D			19.94		142		43.01		12.67		27.14
D			19.35		145		41.70		12.42		28.60
D			21.08		143		45.67		12.22		28.02

**Assay data (cont) – Important geochem level elements**

Lab Code	As M/ICP ppm	As P ppm	Co M/ICP ppm	Co P ppm	Cu M/ICP ppm	Cu P ppm	Ni M/ICP ppm	Ni P ppm	Pb M/ICP ppm	Pb P ppm	Zn M/ICP ppm
E			21.00		192				12.00	9.00	33.00
E			20.00		195				12.00	10.00	34.00
E				16.00				23.00	13.00	10.00	
E			21.00					24.00		10.00	32.00
E			19.00	15.00	180			24.00	13.00	10.00	33.00
E			21.00	15.00	182			24.00	11.00	9.00	32.00
E			19.00	16.00	193			22.00	11.00		34.00
E			19.00	15.00				22.00	12.00		31.00
F	7.00	3.00	21.00	16.00	173	129	48.00	25.00	20.00	10.00	36.00
F	7.00	2.00	21.00	17.00	175	138	48.00	26.00	19.00	10.00	36.00
F	7.00	3.00	21.00	16.00	183	125	49.00	26.00	20.00	10.00	37.00
F	5.00	3.00	21.00	17.00	183	132	49.00	26.00	21.00	9.00	38.00
F	6.00	4.00	21.00	16.00	183	131	49.00	27.00	20.00	10.00	37.00
F	6.00	3.00	21.00	16.00	187	131	49.00	25.00	22.00	10.00	37.00
F	6.00	2.00	21.00	16.00	181	126	48.00	26.00	19.00	10.00	37.00
F	6.00	2.00	21.00	16.00	177	124	49.00	25.00	20.00	10.00	37.00
G	4.00	2.00	20.00	18.10	161	121	42.00	27.30	13.50	10.00	35.00
G	3.60	1.90	18.20	18.30	154	122	43.30	27.10	12.20	10.30	30.00
G	3.10	1.90	17.80	17.60	157	120	41.00	26.30	16.70	10.10	41.00
G	3.80	1.90	18.60	18.10	160	120	41.40	27.70	17.20	9.90	44.00
G	3.70	1.80	20.40	16.50	161	114	42.60	23.00	14.80	9.10	37.00
G	3.40	1.80	19.20	17.60	163	118	41.30	25.00	11.80	10.30	29.00
G	3.50	1.60	19.70	17.30	162	115	42.20	26.60	11.60	9.70	28.00
G	3.40	1.80	16.80	17.90	155	119	39.20	27.20	11.20	10.20	27.00
H			20.00		165		43.00		9.00		28.00
H			20.00		150		42.00		10.00		28.00
H			20.00		162		42.00		8.00		28.00
H			20.00		152		43.00		9.00		28.00
H			20.00		163		43.00		10.00		26.00
H			20.00		164		43.00		8.00		27.00
H			19.00		170		43.00		9.00		27.00
H			20.00		152		43.00		9.00		27.00
I			20.00	17.00	141	116	36.00	25.00			
I			22.00	19.00	144	117	34.00	22.00			
I			22.00	16.00	144	113	38.00	25.00			
I			20.00	16.00	143	114	38.00	21.00			
I			22.00	19.00	141	114	36.00	23.00			
I			21.00	17.00	137	112	39.00	25.00			
I			21.00	20.00	136	116	36.00	25.00			
I			21.00	17.00	136	112	35.00	24.00			
J	8.00		18.00	16.00	165	104	44.00	22.00	20.00	14.00	
J	7.00		18.00	16.00	163	103	45.00	23.00	11.00	12.00	41.00
J			17.00	16.00	143	105	40.00	23.00	12.00	11.00	35.00
J			18.00	17.00	160	107	44.00	23.00	14.00	12.00	36.00
J			18.00	17.00	161	107	44.00	23.00	11.00	12.00	36.00
J			16.00	17.00	146	108	40.00	23.00	11.00	11.00	34.00
J	6.00		18.00	17.00	162	106	46.00	23.00	15.00	12.00	36.00
J	9.00		18.00	17.00	163	111	45.00	23.00	12.00	12.00	39.00
L	4.00	4.00	18.20	17.70	159	140	40.60	28.90		17.70	36.00
L	4.00	3.00	18.60	17.90	156	139	42.20	27.30		16.50	41.00
L	4.00	3.00	18.60	17.30	159	140	41.50	28.50		17.10	39.00
L	3.00	2.00	19.30	17.90	156	137	42.70	28.00		15.70	36.00
L	3.00	2.00	18.30	17.20	161	141	42.90	27.70		16.40	40.00
L	4.00	3.00	19.40	17.10	159	137	41.80	27.80		17.30	37.00
L	4.00	3.00	18.60	17.50	156	141	40.70	28.60		17.30	37.00
L	3.00	2.00	19.20	17.30	157	136	41.50	28.10		15.60	42.00
M	3.70	2.20	20.10	17.10	159	127	43.20	26.30	12.80	9.40	29.00
M	4.20	2.10	20.90	16.80	162	122	43.30	25.90	12.60	9.50	29.00
M	3.90	2.20	20.10	16.70	159	124	43.50	25.60	12.60	9.20	29.00
M	3.40	2.10	20.20	17.40	157	126	42.50	26.70	12.60	9.60	29.00
M	3.30	2.10	20.00	17.10	156	124	42.70	26.40	12.70	9.30	28.00
M	3.70	2.00	20.20	17.30	160	127	43.50	27.00	13.20	9.50	28.00
M	2.90	2.30	20.00	18.60	157	129	42.70	28.70	12.60	10.10	28.00
M	3.50	2.00	20.20	17.10	156	124	42.70	26.40	13.10	9.20	28.00
O	3.30	2.20	19.00	17.40	165	133	45.90	29.40	20.30	15.80	32.00
O	3.50	2.10	19.10	17.30	159	124	44.10	27.00	16.10	11.40	31.00
O	3.40	2.00	18.70	17.50	157	126	42.20	27.00	14.70	11.00	29.00
O	4.10	2.10	18.80	17.70	158	128	42.70	27.20	14.50	10.80	30.00
O	3.40	2.20	18.80	16.80	158	124	43.70	25.90	14.00	10.50	29.00
O	3.60	2.00	18.70	16.80	160	123	44.00	25.40	13.50	10.20	33.00
O	4.10	2.00	19.30	16.70	160	121	44.30	25.30	14.00	10.10	32.00
O	3.70	2.10	19.40	17.40	164	124	44.20	26.40	14.80	10.50	31.00
Q	4.00	2.00	20.10	17.70	161	143	42.10	28.40	13.00	11.00	30.90
Q	3.00	2.00	21.40	18.80	157	137	44.30	27.00	15.00	11.00	33.80
Q	4.00	2.00	20.90	18.40	161	137	42.90	27.10	15.00	11.00	32.10
Q	3.00	2.00	21.70	18.80	155	137	43.20	27.30	14.00	11.00	33.50
Q	3.00	2.00	20.80	18.70	158	135	44.00	26.50	13.00	10.00	32.10
Q	4.00	3.00	21.30	18.10	162	142	43.60	25.90	13.00	12.00	32.40
Q	3.00	2.00	21.40	18.70	155	137	42.50	26.80	14.00	10.00	34.00
Q	3.00	2.00	20.70	19.00	158	139	43.10	27.90	13.00	10.00	32.70

## Assay data (cont) – Important geochem level elements

Lab Code	As M/ICP ppm	As P ppm	Co M/ICP ppm	Co P ppm	Cu M/ICP ppm	Cu P ppm	Ni M/ICP ppm	Ni P ppm	Pb M/ICP ppm	Pb P ppm	Zn M/ICP ppm
R	3.00		20.60		151		40.50		12.40		30.00
R	3.00		20.20		151		42.20		13.50		30.00
R	3.00		20.20		142		39.50		12.40		29.00
R	3.00		21.20		152		40.90		13.20		28.00
R	4.00		20.90		157		43.90		12.50		31.00
R	3.00		21.20		148		43.20		12.40		29.00
R	3.00		20.80		154		41.90		13.00		30.00
R	2.00		20.90		148		42.40		12.80		30.00
S	2.00	9.30	21.90	17.60	170	128	47.20	25.30	14.70	8.30	37.00
S	3.00	2.40	22.10	16.00	164	122	45.10	26.50	14.20	8.20	35.00
S	3.00	2.10	22.00	16.60	171	121	47.30	23.80	14.90	8.00	35.00
S	2.00	2.20	23.30	16.90	183	131	49.00	24.40	14.80	8.90	35.00
S	3.00	2.10	22.70	16.20	173	123	47.00	23.30	15.20	8.00	36.00
S	3.00	2.30	21.50	16.50	175	124	46.60	26.60	14.20	8.40	36.00
S	3.00	2.10	21.90	16.20	167	121	43.30	25.10	14.40	8.20	35.00
S	3.00	2.00	20.60	17.50	159	129	43.60	24.60	14.20	8.50	32.00
T	2.50		20.10		155		45.80		20.80		35.60
T	2.60		20.40		155		45.60		19.80		35.50
T	2.70		21.10		154		46.90		20.10		37.60
T	2.80		20.30		155		44.80		20.50		34.80
T	2.60		21.50		155		47.80		21.10		37.50
T	2.90		21.50		160		47.90		20.50		37.30
T	2.70		22.10		163		49.00		20.50		38.40
T	2.80		21.10		160		46.60		22.10		36.80
V			25.00	19.00	159	128	46.00	26.00	4.00	3.00	41.00
V			26.00	19.00	158	128	45.00	26.00	6.00	4.00	42.00
V			25.00	19.00	159	125	44.00	26.00	4.00	2.00	41.00
V			25.00	19.00	159	130	45.00	26.00	4.00	5.00	42.00
V			25.00	19.00	155	130	42.00	27.00	4.00	3.00	42.00
V			25.00	18.00	154	127	43.00	26.00	4.00	4.00	41.00
V			23.00	19.00	159	128	46.00	27.00	4.00	2.00	43.00
V			25.00	19.00	159	126	45.00	27.00	6.00	4.00	42.00
W	3.63	1.94	19.63	17.00	159	133	39.32	26.87	12.41	9.93	32.77
W	3.61	2.05	19.02	17.51	162	134	40.73	27.98	12.70	10.14	31.81
W	3.59	2.21	19.75	17.37	161	134	40.33	27.14	12.54	9.79	33.26
W	3.94	2.06	19.53	17.37	163	133	40.08	27.68	12.53	9.84	31.37
W	3.91	2.06	19.61	16.93	163	132	39.68	25.75	12.29	8.97	30.84
W	3.65	2.23	19.81	17.59	160	134	39.22	27.12	12.37	9.65	30.62
W	4.23	2.07	19.65	18.22	164	132	39.71	28.68	12.81	10.37	31.66
W	4.03	1.89	20.30	17.43	167	133	39.61	26.83	12.50	9.28	32.88
X	3.60	2.20	19.70	16.00	153	127	42.90	25.80	13.00	10.60	30.00
X	4.00	2.30	21.30	15.80	163	126	46.50	25.30	13.80	10.10	32.00
X	3.70	2.10	20.00	15.60	154	123	43.50	24.70	13.00	9.90	31.00
X	3.70	2.10	20.00	15.40	156	123	43.10	24.80	12.80	9.80	30.00
X	3.60	2.10	19.70	15.70	152	124	42.80	25.00	12.40	9.70	30.00
X	3.50	2.10	19.40	15.70	150	125	43.80	25.00	15.30	9.90	29.00
X	3.70	2.30	20.30	15.80	158	126	44.60	25.10	14.00	10.10	31.00
X	3.60	2.20	19.70	15.70	153	125	43.00	25.10	13.00	9.80	30.00
Y	5.00	2.00	22.20	17.40	166	130	46.00	29.00	13.00	9.70	32.00
Y	4.00	2.00	22.20	17.60	160	129	46.00	28.00	14.00	9.70	32.00
Y	5.00	2.00	22.40	17.30	168	130	47.00	29.00	14.00	9.40	34.00
Y	5.00	2.00	21.70	17.50	162	128	46.00	28.00	14.00	9.70	37.00
Y	4.00	2.00	22.60	17.50	165	130	48.00	28.00	14.00	9.50	31.00
Y	4.00	2.00	22.30	17.10	162	129	45.00	28.00	14.00	9.60	33.00
Y	4.00	2.00	22.00	17.00	164	124	45.00	28.00	14.00	9.30	32.00
Y	4.00	2.00	22.40	17.20	163	126	46.00	27.00	14.00	9.50	31.00
Z	7.00	9.00	19.00	13.00	150	129	44.00	30.00	11.00	8.00	35.00
Z	7.00	6.00	17.00	17.00	152	128	42.00	27.00	8.00	7.00	35.00
Z	8.00	9.00	17.00	15.00	154	132	43.00	27.00	8.00	10.00	33.00
Z	9.00	8.00	18.00	14.00	153	131	42.00	28.00	9.00	10.00	37.00
Z	8.00	7.00	18.00	17.00	151	129	42.00	29.00	9.00	9.00	33.00
Z	8.00	8.00	17.00	15.00	154	130	41.00	29.00	8.00	11.00	34.00
Z	7.00	7.00	17.00	15.00	150	139	41.00	28.00	11.00	10.00	32.00
Z	6.00	6.00	17.00	16.00	154	135	42.00	29.00	11.00	9.00	35.00

## Assay data – Major Oxides

Lab code	Al2O3 XRF %	CaO XRF %	Cr2O3 XRF %	Fe2O3 XRF %	K2O XRF %	MgO XRF %	MnO XRF %	Na2O XRF %	P2O5 XRF %	SiO2 XRF %	TiO2 XRF %	LOI %	C Comb/LECO %	S Comb/LECO %	SG pyc
B	13.55	0.05	0.03	11.83	0.40	0.16	0.07	0.04	0.11	63.40	2.40	7.44		0.02	2.67
B	13.55	0.05	0.03	11.77	0.40	0.16	0.07	0.04	0.11	63.30	2.40	7.33		0.02	2.72
B	13.65	0.05	0.03	11.87	0.40	0.16	0.07	0.04	0.11	63.30	2.40	7.34		0.02	2.69
B	13.45	0.05	0.03	11.71	0.40	0.15	0.07	0.04	0.11	63.40	2.40	7.40		0.02	2.71
B	13.45	0.05	0.03	11.71	0.40	0.16	0.07	0.04	0.11	64.00	2.41	7.19		0.02	2.69
B	13.40	0.05	0.03	11.68	0.40	0.15	0.07	0.03	0.10	63.90	2.39	7.19		0.02	2.66
B	13.45	0.05	0.03	11.71	0.40	0.16	0.07	0.04	0.11	63.90	2.40	7.21		0.02	2.69
B	13.45	0.05	0.03	11.78	0.40	0.16	0.07	0.04	0.11	64.00	2.43	7.27		0.02	2.68



## Assay data (cont) – Major Oxides

Lab code	Al <sub>2</sub> O <sub>3</sub> XRF %	CaO XRF %	Cr <sub>2</sub> O <sub>3</sub> XRF %	Fe <sub>2</sub> O <sub>3</sub> XRF %	K <sub>2</sub> O XRF %	MgO XRF %	MnO XRF %	Na <sub>2</sub> O XRF %	P <sub>2</sub> O <sub>5</sub> XRF %	SiO <sub>2</sub> XRF %	TiO <sub>2</sub> XRF %	LOI %	C Comb/LECO %	S Comb/LECO %	SG pyc
C	13.67	0.06	0.03	11.75	0.40	0.16	0.07			64.12	2.41	7.04	0.92	0.02	2.88
C	13.69	0.06	0.03	11.72	0.40	0.16	0.07			63.99	2.39	7.13	0.92	0.03	2.90
C	13.69	0.06	0.03	11.73	0.40	0.17	0.07			63.96	2.40	7.13	0.93	0.03	2.89
C	13.66	0.06	0.03	11.76	0.40	0.17	0.07			63.96	2.41	7.14	0.92	0.02	2.88
C	13.74	0.06	0.03	11.78	0.40	0.17	0.07			63.71	2.41	7.12	0.92	0.02	2.90
C	13.76	0.06	0.03	11.78	0.40	0.18	0.07			63.75	2.40	7.17	0.92	0.02	2.88
C	13.82	0.06	0.03	11.83	0.40	0.17	0.07			63.71	2.40	7.16	0.92	0.02	2.90
C	13.78	0.06	0.03	11.83	0.40	0.16	0.07			63.74	2.41	7.13	0.92	0.02	2.89
D	13.85	0.06	0.03	11.99	0.39	0.13	0.08			64.81	2.41	7.10	0.90	0.02	2.65
D	13.77	0.06	0.02	11.97	0.40	0.12	0.08			64.05	2.44	7.13	0.87	0.01	2.60
D	13.75	0.06	0.03	11.87	0.39	0.11	0.08			64.27	2.41	7.10	0.89	0.01	2.63
D	13.95	0.06	0.02	11.91	0.39	0.12	0.08			64.26	2.43	7.22	0.89	0.01	2.69
D	13.82	0.06	0.03	11.96	0.41	0.13	0.08			64.80	2.42	7.17	0.88	0.01	2.64
D	13.70	0.05	0.02	11.95	0.39	0.13	0.08			64.54	2.42	7.17	0.91	0.01	2.63
D	13.79	0.05	0.03	11.92	0.40	0.13	0.08			64.45	2.43	7.24	0.92	0.01	2.60
D	13.79	0.06	0.03	12.00	0.39	0.12	0.08			64.18	2.41	7.27	0.91	0.01	2.62
E	13.41	0.03		11.94	0.39	0.17	0.05	0.03	0.10	63.06	2.41	7.29			2.75
E	13.48	0.03		12.11	0.39	0.18	0.05	0.02	0.11	63.04	2.44	7.13			2.87
E	13.45	0.04		12.10	0.39		0.05	0.03	0.11	63.30	2.44	7.26			2.85
E	13.29	0.03		12.00	0.39	0.17	0.05		0.11	62.87	2.43	7.09			2.91
E	13.49	0.03		12.01	0.39		0.05	0.04	0.10	62.94	2.41	7.18			2.74
E	13.40	0.04		12.01	0.39	0.17	0.05	0.03	0.10	63.00	2.43	7.08			2.78
E	13.52	0.03		12.10	0.40	0.18	0.05	0.02	0.11	63.24	2.43	7.12			
E	13.45	0.03		12.08	0.39	0.17	0.05	0.02	0.11	63.00	2.43	7.15			2.86
F	13.70	0.06	0.03	11.90	0.40	0.16	0.08	0.06		63.70	2.44	7.19			
F	13.70	0.06	0.03	11.90	0.40	0.16	0.08	0.06		63.70	2.45	7.19			
F	13.80	0.06	0.03	11.90	0.40	0.15	0.08	0.06		63.70	2.45	7.16			
F	13.70	0.06	0.03	11.90	0.40	0.16	0.07	0.05		63.80	2.44	7.19			
F	13.70	0.06	0.03	12.00	0.40	0.15	0.08	0.06		63.70	2.44	7.15			
F	13.60	0.06	0.03	11.80	0.40	0.16	0.08	0.05		64.00	2.44	7.22			
F	13.80	0.06	0.03	12.00	0.40	0.16	0.08	0.06		63.70	2.45	7.15			
F	13.70	0.06	0.03	11.90	0.40	0.16	0.08	0.06		63.70	2.44	7.17			
G	13.65	0.05	0.03	11.86	0.41	0.16	0.07	0.02		63.50	2.40	7.08			
G	13.60	0.05	0.03	11.78	0.40	0.16	0.07	0.02		63.90	2.40	7.10			
G	13.60	0.05	0.03	11.78	0.40	0.16	0.07	0.02		63.90	2.41	7.06			
G	13.55	0.05	0.03	11.74	0.40	0.16	0.07	0.02		63.80	2.40	7.05			
G	13.60	0.05	0.03	11.80	0.40	0.16	0.07	0.01		63.80	2.41	7.06			
G	13.65	0.05	0.03	11.79	0.40	0.17	0.07	0.02		63.80	2.40	7.05			
G	13.60	0.05	0.03	11.78	0.40	0.16	0.07	0.02		63.30	2.38	7.09			
G	13.65	0.05	0.03	11.81	0.40	0.16	0.07	0.02		63.60	2.39	7.00			
H	13.70	0.04	0.03	12.00	0.40	0.17	0.07	0.07	0.11	64.10	2.50	6.98	0.92	0.04	2.61
H	13.60	0.05	0.02	11.90	0.40	0.19	0.07	0.06	0.11	64.40	2.50	7.09	0.92	0.03	2.70
H	13.60	0.05	0.03	11.90	0.42	0.16	0.07	0.04	0.11	64.40	2.52	7.22	0.93	0.04	2.73
H	13.60	0.06	0.03	11.90	0.40	0.17	0.07	0.05	0.12	64.30	2.50	7.33	0.92	0.04	2.66
H	13.60	0.05	0.03	11.90	0.40	0.19	0.07	0.08	0.11	64.40	2.50	7.03	0.92	0.04	2.73
H	13.60	0.05	0.03	11.90	0.39	0.14	0.07	0.00	0.11	64.20	2.46	7.06	0.92	0.04	2.67
H	13.60	0.05	0.03	11.90	0.41	0.15	0.07	0.08	0.11	64.00	2.49	7.18	0.92	0.04	2.74
H	13.70	0.05	0.03	12.00	0.40	0.17	0.07	0.10	0.10	64.20	2.50	6.92	0.92	0.05	2.71
I	13.50	0.04	0.04	12.07	0.38	0.11	0.07		0.15	63.60	2.29	7.35	0.92	0.02	2.77
I	13.40	0.04	0.04	11.95	0.37	0.14	0.07		0.15	62.50	2.36	7.38	0.92	0.02	2.78
I	13.30	0.03	0.04	11.84	0.37	0.13	0.07		0.15	62.30	2.35	7.35	0.93	0.02	2.77
I	13.40	0.04	0.04	11.98	0.37	0.12	0.07		0.15	63.40	2.37	7.34	0.92	0.02	2.77
I	13.40	0.04	0.04	11.96	0.38	0.14	0.07		0.15	62.70	2.35	7.32	0.93	0.02	2.76
I	13.40	0.04	0.04	11.95	0.38	0.12	0.07		0.15	62.60	2.37	7.32	0.93	0.02	2.77
I	13.70	0.07	0.04	12.03	0.38	0.12	0.07		0.15	63.40	2.36	7.29	0.93	0.02	2.77
I	13.60	0.04	0.04	12.06	0.38	0.11	0.07		0.15	63.90	2.36	7.35	0.93	0.02	2.79
J													0.97	0.33	
J													0.96	0.27	
J													0.94	0.15	
J													0.96	0.21	
J													0.99	0.22	
J													0.96	0.19	
J													0.95	0.18	
J													0.97	0.21	
L													0.91	0.02	2.69
L													0.90	0.02	2.69
L													0.91	0.02	2.65
L													0.92	0.02	2.71
L													0.91	0.02	2.67
L													0.92	0.02	2.66
L													0.92	0.02	2.71
L													0.92	0.02	2.64
M	13.65	0.05	0.03	11.64	0.40	0.17	0.07	0.04	0.11	63.10	2.40	7.27		0.02	2.73
M	13.65	0.06	0.03	11.76	0.41	0.18	0.07	0.06	0.11	64.20	2.53	7.42		0.02	2.72
M	13.35	0.05	0.05	11.52	0.39	0.16	0.07	0.04	0.11	63.70	2.42	7.38		0.02	2.70
M	13.65	0.05	0.03	11.60	0.40	0.17	0.07	0.05	0.11	63.50	2.46	7.54		0.02	2.73
M	13.45	0.05	0.03	11.69	0.40	0.17	0.07	0.05	0.11	63.20	2.41	7.38		0.02	2.64
M	13.40	0.05	0.04	11.58	0.39	0.16	0.07	0.04	0.11	64.00	2.44	7.22		0.02	2.72
M	13.45	0.05	0.03	11.70	0.40	0.16	0.07	0.05	0.11	64.70	2.47	7.49		0.02	2.70
M	13.55	0.05	0.03	11.66	0.40	0.17	0.07	0.05	0.11	63.70	2.42	7.39		0.02	2.73
Q															2.68
Q															2.73
Q															2.68
Q															2.69
Q															2.68
Q															2.67
Q															2.72
Q															2.67
R	13.50	0.05	0.03	11.90	0.41	0.18	0.06	0.02	0.10	63.70	2.43		0.91	0.02	
R	13.60	0.05	0.03	11.90	0.40	0.19	0.07	0.01	0.11	63.80	2.45		0.93	0.02	
R	13.60	0.06	0.03	11.90	0.41	0.18	0.06	0.02	0.11	64.10	2.45		0.92	0.01	
R	13.60	0.05	0.03	11.90	0.41	0.19	0.07	0.02	0.11	63.50	2.45		0.91	0.01	
R	13.70	0.05	0.03	12.00	0.41	0.20	0.07	0.03	0.11	63.40	2.45		0.92	0.01	
R	13.80	0.05	0.03	11.90	0.40	0.17	0.06	0.01	0.11	63.40	2.44		0.94	0.01	
R	13.80	0.06	0.03	12.00	0.40	0.17	0.06	0.01	0.11	63.40	2.44		0.93	0.02	
R	13.80	0.05	0.02	12.00	0.41	0.19	0.07	0.03	0.11	63.50	2.44		0.93	0.01	

### Assay data (cont) – Major Oxides

Lab code	Al2O3 XRF %	CaO XRF %	Cr2O3 XRF %	Fe2O3 XRF %	K2O XRF %	MgO XRF %	MnO XRF %	Na2O XRF %	P2O5 XRF %	SiO2 XRF %	TiO2 XRF %	LOI %	C Comb/LECO %	S Comb/LECO %	SG pyc
S	13.88	0.05	0.03	11.73	0.41	0.15	0.07		0.11	64.69	2.45	6.95	0.99	0.02	2.61
S	13.99	0.04	0.03	11.80	0.41	0.16	0.07		0.11	64.86	2.45	6.96	0.99	0.02	2.60
S	13.88	0.04	0.03	11.77	0.42	0.15	0.07		0.11	64.54	2.45	6.93	0.97		2.60
S	13.90	0.05	0.03	11.76	0.41	0.15	0.07		0.11	64.80	2.45	6.96	1.00		2.61
S	13.89	0.05	0.03	11.78	0.41	0.16	0.07		0.11	64.73	2.44	6.93	0.97		2.61
S	13.86	0.04	0.03	11.80	0.41	0.14	0.07		0.11	64.51	2.44	6.97	0.99	0.02	2.61
S	13.92	0.04	0.03	11.82	0.42	0.15	0.07		0.11	64.67	2.44	6.96	1.00	0.02	2.61
S	13.85	0.05	0.03	11.74	0.41	0.15	0.07		0.11	64.46	2.43	6.96	0.93		2.61
T	13.45	0.04	0.02	11.75	0.38	0.18	0.08	0.12		62.71	2.48	7.68			
T	13.44	0.05	0.02	11.80	0.39	0.19	0.08	0.12		62.75	2.45	7.56			
T	13.48	0.05	0.02	11.75	0.39	0.18	0.08	0.12		62.73	2.47	7.57			
T	13.36	0.04	0.02	11.72	0.39	0.18	0.08	0.13		62.83	2.45	7.57			
T	13.45	0.05	0.02	11.79	0.38	0.17	0.08	0.12		62.70	2.46	7.62			
T	13.44	0.04	0.02	11.82	0.38	0.17	0.08	0.12		62.65	2.45	7.69			
T	13.50	0.05	0.02	11.81	0.39	0.19	0.08	0.12		62.62	2.45	7.58			
T	13.38	0.05	0.02	11.68	0.39	0.17	0.08	0.13		62.84	2.46	7.62			
V	13.30	0.11	0.02	11.60	0.40	0.19	0.07	0.04	0.10	64.29	2.34	6.90	0.88	0.02	2.68
V	13.25	0.11	0.02	11.59	0.40	0.18	0.07	0.03	0.10	64.40	2.34	6.80	0.88	0.02	2.69
V	13.35	0.11	0.03	11.59	0.39	0.19	0.07	0.05	0.10	64.16	2.33	7.00	0.84	0.02	2.69
V	13.24	0.11	0.02	11.58	0.39	0.18	0.07	0.04	0.10	64.40	2.35	6.90	0.87	0.02	2.66
V	13.28	0.11	0.02	11.57	0.40	0.18	0.07	0.04	0.10	64.29	2.33	6.90	0.86	0.02	2.72
V	13.24	0.11	0.02	11.53	0.39	0.18	0.07	0.03	0.10	64.59	2.34	6.80	0.88	0.02	2.74
V	13.48	0.11	0.03	11.68	0.39	0.18	0.07	0.03	0.10	64.25	2.33	7.00	0.88	0.02	2.71
V	13.58	0.11	0.03	11.69	0.40	0.18	0.07	0.03	0.11	64.04	2.32	7.00	0.88	0.02	2.71
W	13.44	0.06	0.03	11.79	0.40	0.16	0.07	0.08		63.56	2.41	7.17	0.90	0.01	2.78
W	13.56	0.06	0.03	11.83	0.40	0.16	0.07	0.08		64.25	2.42	7.15	0.89	0.02	2.78
W	13.59	0.06	0.03	11.83	0.40	0.16	0.07	0.08		64.46	2.41	7.19	0.91	0.02	2.78
W	13.59	0.06	0.04	11.76	0.40	0.16	0.07	0.07		64.27	2.41	7.11	0.88	0.02	2.78
W	13.52	0.06	0.02	11.85	0.40	0.16	0.07	0.08		63.96	2.40	7.20	0.89	0.02	2.78
W	13.58	0.06	0.03	11.82	0.40	0.16	0.07	0.08		63.94	2.40	7.28	0.90	0.02	2.78
W	13.74	0.06	0.03	11.95	0.40	0.16	0.07	0.08		64.50	2.42	7.36	0.89	0.02	2.78
W	13.77	0.06	0.03	11.91	0.40	0.16	0.07	0.08		64.56	2.41	7.26	0.90	0.02	2.78
X	13.55	0.05	0.03	11.83	0.40	0.16	0.07	0.04	0.11	63.40	2.40	7.44		0.02	2.67
X	13.55	0.05	0.03	11.77	0.40	0.16	0.07	0.04	0.11	63.30	2.40	7.33		0.02	2.72
X	13.65	0.05	0.03	11.87	0.40	0.16	0.07	0.04	0.11	63.30	2.40	7.34		0.02	2.69
X	13.45	0.05	0.03	11.71	0.40	0.15	0.07	0.04	0.11	63.40	2.40	7.40		0.02	2.71
X	13.45	0.05	0.03	11.71	0.40	0.16	0.07	0.04	0.11	64.00	2.41	7.19		0.02	2.69
X	13.40	0.05	0.03	11.68	0.40	0.15	0.07	0.03	0.10	63.90	2.39	7.19		0.02	2.66
X	13.45	0.05	0.03	11.71	0.40	0.16	0.07	0.04	0.11	63.90	2.40	7.21		0.02	2.69
X	13.45	0.05	0.03	11.78	0.40	0.16	0.07	0.04	0.11	64.00	2.43	7.27		0.02	2.68
Y	13.60	0.05	0.03	11.81	0.39	0.16	0.07	0.04	0.11	64.08	2.43	7.02	0.93	0.02	
Y	13.76	0.05	0.03	11.88	0.40	0.17	0.07	0.04	0.12	63.85	2.43	7.11	0.91	0.03	2.80
Y	13.85	0.05	0.03	11.86	0.40	0.17	0.07	0.04	0.11	63.80	2.43	7.09	0.89	0.02	2.76
Y	13.83	0.05	0.03	11.87	0.39	0.17	0.07	0.04	0.11	63.80	2.42	7.05	0.90	0.03	2.80
Y	13.78	0.05	0.03	11.94	0.39	0.17	0.07	0.04	0.11	63.90	2.45	7.09	0.90	0.02	2.79
Y	13.73	0.05	0.03	11.87	0.40	0.17	0.07	0.03	0.12	63.83	2.45	7.16	0.92	0.02	2.83
Y	13.82	0.05	0.03	11.89	0.40	0.17	0.07	0.04	0.11	63.77	2.44	7.08	0.92	0.02	2.87
Y	13.79	0.05	0.03	11.87	0.40	0.17	0.07	0.04	0.11	63.68	2.44	7.13	0.93	0.02	2.84
Z	13.40	0.08	0.03	11.60	0.41	0.26	0.07	0.11		62.90	2.40	7.20	0.93	0.02	2.79
Z	13.40	0.10	0.08	11.70	0.42	0.23	0.07	0.12		63.30	2.43	7.20	0.92	0.02	2.78
Z	13.40	0.07	0.03	11.60	0.41	0.25	0.07	0.11		62.90	2.39	7.22	0.92	0.02	2.80
Z	13.40	0.07	0.03	11.00	0.40	0.25	0.07	0.12		62.60	2.40	7.21	0.94	0.02	2.76
Z	13.50	0.07	0.03	11.50	0.40	0.25	0.07	0.12		62.60	2.39	7.20	0.91	0.02	2.78
Z	13.40	0.07	0.03	11.80	0.41	0.24	0.07	0.10		62.90	2.39	7.19	0.92	0.02	2.80
Z	13.40	0.08	0.03	11.60	0.41	0.25	0.07	0.11		62.60	2.40	7.16	0.94	0.02	2.78
Z	13.50	0.07	0.03	11.60	0.41	0.25	0.07	0.13		62.90	2.41	7.15	0.91	0.02	2.78

## Assay data (cont)

XRF Cu ppm	XRF Fe ppm	XRF K ppm	XRF K ppm	XRF K ppm	XRF Mn ppm	XRF Mn ppm	XRF Mn ppm
149	8.41	0.33	0.33	0.32	0.05	0.05	0.06
168	8.38	0.33	0.33	0.32	0.05	0.05	0.06
167	8.31	0.33	0.33	0.32	0.05	0.05	0.05
134	8.35	0.33	0.33	0.33	0.05	0.05	0.05
139	8.35	0.33	0.33	0.33	0.05	0.05	0.05
149	8.41	0.33	0.33	0.32	0.05	0.05	0.05
136	8.37	0.33	0.33	0.32	0.05	0.05	0.05
142	8.34	0.33	0.33	0.33	0.05	0.05	0.05
160	8.26	0.33	0.33	0.32	0.06	0.05	0.05
160	8.24	0.33	0.32	0.32	0.06	0.05	0.05
160	8.22	0.33	0.34	0.33	0.05	0.05	0.06
160	8.27	0.33	0.33	0.33	0.06	0.05	0.05
160	8.23	0.33	0.32	0.33	0.06	0.05	0.06
160	8.27	0.33	0.32	0.33	0.05	0.05	0.06
160	8.25	0.33	0.32	0.33	0.06	0.05	0.06
160	8.23	0.33	0.32	0.33	0.06	0.05	0.06
193	8.08	0.32	0.32	0.33	0.06	0.05	0.06
231	8.05	0.33	0.33	0.33	0.06	0.05	0.06
202	7.95	0.32	0.34	0.34	0.06	0.05	0.05
217	7.98	0.32	0.32	0.33	0.06	0.05	0.05
169	7.92	0.34	0.33	0.33	0.06	0.05	0.05
148	7.72	0.32	0.33	0.33	0.06	0.05	0.05
166	8.07	0.34	0.32	0.33	0.06	0.05	0.05
201	8.02	0.32	0.33	0.33	0.06	0.05	0.05
140		0.32	0.33	0.33	0.06	0.05	0.05
140		0.32	0.34	0.33	0.06	0.05	0.05
150		0.32	0.33	0.33	0.06	0.05	0.05
140		0.32	0.34	0.32	0.05	0.05	0.05
150		0.32	0.34	0.33	0.06	0.05	0.05
140		0.32	0.34	0.33	0.06	0.05	0.05
140		0.33	0.33	0.32	0.06	0.05	0.05
140		0.32	0.33	0.32	0.06	0.05	0.05
		0.33	0.34	0.33	0.05	0.05	0.05
		0.33	0.34	0.33	0.05	0.05	0.05
		0.33	0.34	0.34	0.05	0.05	0.05
		0.33	0.34	0.34	0.05	0.05	0.05
		0.33	0.34	0.33	0.05	0.06	0.05
		0.33	0.34	0.33	0.05	0.06	0.05
		0.33	0.32	0.34	0.05	0.06	0.05
		0.34	0.33	0.34	0.05	0.06	0.05
		0.33	0.32	0.34	0.05	0.06	0.05
		0.33	0.33		0.05	0.06	

## 12. Measurement of Uncertainty : (ref Dr Hugh Bartlett, Hugh Bartlett Consulting CC.)

The samples used in this certification process have been selected in such a way as to represent the entire batch of material and were taken from the final packaged units; therefore all possible sources of uncertainty (sample uncertainty and measurement uncertainty) are included in the final combined standard uncertainty determination.

The uncertainty measurement takes into consideration the between lab and the within lab variances and is calculated from the square roots of the variances of these components using the formula:

$$\text{Combined standard uncertainty} = \sqrt{(\text{between lab.var/no of labs}) + (\text{mean square within lab.var /no of assays})}$$

These uncertainty measurements may be used, by laboratories, as a component for calculating the total uncertainty for method validation according to the relevant ISO guidelines.

Analyte	Method	unit	S <sup>1</sup>	$\sigma L$ <sup>2</sup>	SW <sup>3</sup>	CSU <sup>4</sup>
As	M/ICP	ppm	1.466	0.267	0.315	0.084
As	P	ppm	1.634	0.164	0.225	0.053
Co	M/ICP	ppm	1.867	0.711	0.541	0.169
Co	P	ppm	1.185	0.624	0.564	0.155
Cu	M/ICP	ppm	10.21	2.20	3.11	0.60
Cu	P	ppm	9.63	3.54	2.64	0.98
Ni	M/ICP	ppm	3.462	1.063	1.145	0.277
Cu	XRF	ppm	11.704	13.865	8.056	8.172
Fe	XRF	%	0.087	0.164	0.028	0.116
K	XRF	%	0.006	0.003	0.004	0.001
Mn	XRF	%	0.003	0.002	0.001	0.001
Ni	P	ppm	2.946	0.959	0.868	0.245
Pb	M/ICP	ppm	3.669	1.014	0.869	0.258
Pb	P	ppm	2.379	0.382	0.402	0.118
Zn	M/ICP	ppm	4.140	1.909	1.631	0.447
Al <sub>2</sub> O <sub>3</sub>	XRF	%	0.171	0.097	0.080	0.025
CaO	XRF	%	0.017	0.004	0.003	0.001
Cr <sub>2</sub> O <sub>3</sub>	XRF	%	0.007	0.001	0.001	0.000
Fe <sub>2</sub> O <sub>3</sub>	XRF	%	0.151	0.083	0.057	0.021
K <sub>2</sub> O	XRF	%	0.009	0.004	0.004	0.001
MgO	XRF	%	0.027	0.007	0.006	0.002
MnO	XRF	%	0.007	0.000	0.000	0.000
Na <sub>2</sub> O	XRF	%	0.034	0.015	0.007	0.004
P <sub>2</sub> O <sub>5</sub>	XRF	%	0.013	0.003	0.001	0.001
SiO <sub>2</sub>	XRF	%	0.601	0.363	0.267	0.091
TiO <sub>2</sub>	XRF	%	0.040	0.016	0.011	0.004
LOI		%	0.178	0.084	0.068	0.023
C	Comb/LECO	%	0.030	0.015	0.010	0.005
S	Comb/LECO	%	0.053	0.002	0.001	0.001
SG	pyc	Dimensionless	0.079	0.043	0.025	0.012

1. S - Std Dev for use on control charts.
2.  $\sigma L$  - Betw Lab Std Dev, for use to calculate a measure of accuracy.
3. SW - Within Lab Stc Dev, for use to calculate a measure of precision.
4. CSU - Combined Standard Uncertainty, a component for use to calculate the total uncertainty in method validation.

**13. Certified values:** The Certified, Provisional and Indicated values listed on p1 and p2 of this certificate fulfill the AMIS statistical criteria regarding agreement for certification and have been independently validated by Dr Barry Smee. The Certified values listed on p1 XRF (Cu, Fe) of this certificate fulfill the AMIS statistical criteria regarding agreement for certification and have been independently validated by Allan Fraser

**14. Metrological Traceability:** The values quoted herein are based on the consensus values derived from statistical analysis of the data from an inter laboratory measurement program. Traceability to SI units is via the standards used by the individual laboratories the majority of which are accredited and who have maintained measurement traceability during the analytical process.

**15. Certification:** AMIS0433 is a new material.

**16. Period of validity:** The certified values are valid for this product, while still sealed in its original packaging, until notification to the contrary. The stability of the material will be subject to continuous testing for the duration of the inventory. Should product stability become an issue, all customers will be notified and notification to that effect will be placed on the [www.amis.co.za](http://www.amis.co.za) website.

**17. Minimum sample size:** The majority of laboratories reporting used a 0.5g sample size for the ICP and a 30g sample size for the fire assay. These are the recommended minimum sample sizes for the use of this material.

**18. Availability:** This product is available in Laboratory Packs containing 1kg of material and Explorer Packs containing custom weights (from 50 to 250g) of material. The Laboratory Packs are sealed bottles delivered in sealed foil pouches. The Explorer Packs contain material in standard geochem envelopes, nitrogen flushed and vacuum sealed in foil pouches.

**19. Recommended use:** The data used to characterize this CRM has been scrutinized using outlier treatment techniques. This, together with the number of participating laboratories, should overcome any "inter-laboratory issues" and should lead to a very accurate measure for the given methods; notwithstanding the underlying assumption that what the good inter-laboratory labs reported was accurate. However an amount of bad data might have had an effect, resulting in limits which in some situations might be too broad for the effective monitoring of a single analytical method, laboratory or production process. Users should therefore set their own limits based on their own data quality objectives and control measurements, after determining the performance characteristics of their own particular method, using a minimum of 20 analyses using this CRM. User set limits should normally be within the limits recommended on p1 and 2 of this certificate.

**20. Legal Notice:** This certificate and the reference material described in it have been prepared with due care and attention. However AMIS, a division of Torre Analytical Services (Pty) Ltd, Mike McWha, Dr Barry Smee, Smee and Associates Ltd, Thivhafuni Matodzi and Allan Fraser; accept no liability for any decisions or actions taken following the use of the reference material.

14 April 2014

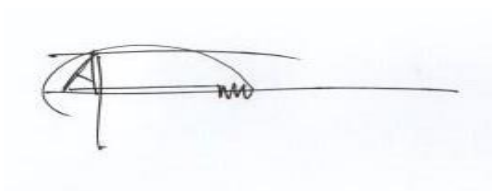
**Revision:001**

**Amended-09 January 2017-Certifying officers: Thivhafuni Matodzi and Allan Fraser Cu (XRF), Fe (XRF), K (XRF), Mn (XRF)**

**Certifying Officers:**

**African Mineral Standards:** \_\_\_\_\_

**Thivhafuni Matodzi (Quality specialist)**



**Geochemist:** \_\_\_\_\_

**Allan Fraser**  
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**African Mineral Standards:** \_\_\_\_\_

**Mike McWha**  
**BSc (Hons), FGSSA, MAusIMM, Pr.Sci.Nat**



**Geochemist:** \_\_\_\_\_

**Barry W. Smee**  
**BSc, PhD, P.Geo, (B.C.)**

### Appendix – uncertified trace element statistics

Analyte	Method	Unit	Mean	2SD	RSD%	n
Ag	M/ICP	ppm	0.08	0.07	44.8	69
Ag	P	ppm	0.05	0.02	21.3	66
Ag	P1	ppm	0.05	0.02	16.6	17
Al	M/ICP	%	7.0	0.40	2.9	98
As	P1	ppm	1.8	0.97	27.6	38
Au	Pb Coll	ppb	14.5	4.1	14.1	123
Au	P	ppb	11.8	3.6	15.3	61
Ba	M/ICP	ppm	133	13.2	5.0	106
Be	M/ICP	ppm	0.87	0.22	13.0	79
Bi	M/ICP	ppm	0.38	0.11	14.7	79
Ca	M/ICP	%	0.04	0.00	4.3	98
Cd	M/ICP	ppm	0.04	0.03	35.7	52
Ce	M/ICP	ppm	85.5	10.0	5.8	70
Co	P1	ppm	17.2	1.6	4.7	39
Cs	M/ICP	ppm	2.9	0.24	4.1	67
Cu	P1	ppm	129	11.2	4.3	38
Dy	M/ICP	ppm	4.6	0.25	2.7	7
Er	M/ICP	ppm	2.5	0.08	1.5	7
Eu	M/ICP	ppm	1.4	0.11	3.8	8
Fe	M/ICP	%	7.8	0.58	3.7	115
Ga	M/ICP	ppm	21.0	2.6	6.1	79
Gd	M/ICP	ppm	5.4	0.37	3.4	8
Ge	M/ICP	ppm	0.24	0.16	32.9	45
Hf	M/ICP	ppm	2.5	0.52	10.4	79
Ho	M/ICP	ppm	0.86	0.06	3.5	8
In	M/ICP	ppm	0.11	0.02	8.2	82
K	M/ICP	%	0.33	0.03	4.6	110
La	M/ICP	ppm	41.2	6.9	8.4	83
Li	M/ICP	ppm	14.5	1.6	5.4	96
Lu	M/ICP	ppm	0.33	0.04	5.9	31
Mg	M/ICP	%	0.08	0.01	7.6	93
Mn	M/ICP	ppm	532	45.7	4.3	116
Mo	M/ICP	ppm	2.7	0.34	6.4	78
Na	M/ICP	%	0.03	0.01	19.9	102
Nb	M/ICP	ppm	37.4	8.4	11.3	79
Nd	M/ICP	ppm	32.3	1.1	1.8	8
Ni	P1	ppm	27.2	2.4	4.5	38
P	M/ICP	ppm	449	64.7	7.2	108
Pb	P1	ppm	9.5	1.9	9.9	32
Pd	Pb Coll	ppb	2.0	1.3	32.0	68
Pr	M/ICP	ppm	10.9	3.9	17.8	16
Pt	Pb Coll	ppb	1.6	0.78	24.6	41
Rb	M/ICP	ppm	23.7	2.5	5.4	83
S	M/ICP	%	0.02	0.0	4.1	100
Sb	M/ICP	ppm	0.29	0.16	26.6	69
Sc	M/ICP	ppm	16.3	2.0	6.0	101
Se	M/ICP	ppm	1.9	1.2	32.4	40
Si	M/ICP	%	29.5	0.42	0.71	8
Sm	M/ICP	ppm	6.5	0.35	2.7	8
Sn	M/ICP	ppm	3.1	0.27	4.4	58
Sr	M/ICP	ppm	23.2	2.8	6.1	118
Ta	M/ICP	ppm	2.4	0.67	13.8	63
Tb	M/ICP	ppm	0.74	0.10	6.7	24
Te	M/ICP	ppm	0.3	0.06	10.3	54
Th	M/ICP	ppm	13.8	1.6	5.7	79
Ti	M/ICP	%	1.1	0.09	4.5	93
Tl	M/ICP	ppm	0.26	0.04	8.8	79
Tm	M/ICP	ppm	0.37	0.04	5.7	8
U	M/ICP	ppm	2.8	0.25	4.6	69
V	M/ICP	ppm	147	14.0	4.8	108
W	M/ICP	ppm	1.2	0.38	16.4	62
Y	M/ICP	ppm	20.3	2.1	5.1	84
Yb	M/ICP	ppm	2.3	0.30	6.5	32
Zn	P	ppm	21.0	6.1	14.6	124
Zn	P1	ppm	20.8	2.8	6.7	39
Zr	M/ICP	ppm	88.0	22.8	13.0	96

<b>Element</b>	<b>Method</b>	<b>Unit</b>	<b>Mean</b>	<b>2SD</b>	<b>RSD_%</b>	<b>n</b>
Ni	XRF	ppm	61.10	27.82	22.77	24