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## AMIS0356

### *Certified Reference Material*

**Rare Earth Elements  
Wigu Carbonatite Complex, Tanzania**

### *Certificate of Analysis*

**Recommended Concentrations and Limits<sup>1, 2</sup>  
(at two Standard Deviations)**

#### ***Certified Concentrations***

Ce FUS	1.116	±	0.0705	%
Dy FUS	13	±	1.5	ppm
Eu M/ICP	29	±	2.1	ppm
La FUS	8533	±	731	ppm
Nd FUS	2482	±	171	ppm
Nd M/ICP	2419	±	240	ppm
Pr FUS	942	±	73	ppm
Sm FUS	159	±	12	ppm
Sm M/ICP	159	±	10	ppm
Sr FUS	1.848	±	0.127	%
Sr M/ICP	1.803	±	0.131	%
Th FUS	84	±	7	ppm
Th M/ICP	84	±	10	ppm
Tm M/ICP	0.31	±	0.04	ppm
U FUS	4.3	±	0.5	ppm
U M/ICP	4.2	±	0.5	ppm
Y FUS	35	±	4	ppm
Specific Gravity	2.99	±	0.20	

#### ***Provisional Concentrations***

Dy M/ICP	12.8	±	2.9	ppm
Eu FUS	29.7	±	3.6	ppm
Ho FUS	1.7	±	0.4	ppm
Ho M/ICP	1.6	±	0.3	ppm
La M/ICP	8226	±	1066	ppm
Nb FUS	214	±	42	ppm
Pr M/ICP	894	±	169	ppm
Sc M/ICP	28	±	6	ppm
Y M/ICP	35	±	5	ppm

## ***Indicated Means***

Er FUS	2.9	ppm
Er M/ICP	3.2	ppm
Gd FUS	72.5	ppm
Gd M/ICP	58	ppm
Lu FUS	0.24	ppm
Lu M/ICP	0.28	ppm
Nb XRF	166	ppm
Nb M/ICP	173	ppm
Tb FUS	5	ppm
Tb M/ICP	4	ppm
Tm FUS	0.32	ppm
Y XRF	27	ppm
Yb FUS	1.9	ppm
Yb M/ICP	1.9	ppm

1. *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.*
2. *There is additional certified major element data presented on p2 and uncertified trace element data presented as an appendix.*
3. *CREO = (Nd+Eu+Tb+Dy+Y)<sub>2</sub>O<sub>3</sub> = 0.314% (see Appendix 2)*

## **Major Element Recommended Concentrations and Limits (at two Standard Deviations)**

### ***Certified Concentrations***

Al <sub>2</sub> O <sub>3</sub>	5.84	±	0.10	%
CaO	15.69	±	0.42	%
Fe <sub>2</sub> O <sub>3</sub>	8.02	±	0.40	%
K <sub>2</sub> O	0.51	±	0.04	%
MgO	6.00	±	0.14	%
MnO	0.92	±	0.04	%
Na <sub>2</sub> O	2.75	±	0.10	%
P <sub>2</sub> O <sub>5</sub>	2.58	±	0.12	%
SiO <sub>2</sub>	28.86	±	0.60	%
TiO <sub>2</sub>	0.33	±	0.02	%
LOI	20.22	±	0.52	%

### ***Indicated Mean***

Cr <sub>2</sub> O <sub>3</sub>	0.02	%
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1. **Intended Use:** AMIS0356 can be used to check analysis of samples of rare earth element bearing rocks with a similar grade and matrix.

It is a matrix matched Certified Reference Material, fit for use as control samples in routine assay laboratory quality control when inserted within runs of samples and measured in parallel to the unknown. Its purpose is to monitor inter-laboratory or instrument bias and within lab precision. It can be used, indirectly, to establish the traceability of results to an SI system of units.

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

Slight variations in analytical procedures between laboratories will reflect as slight biases to the recommended concentrations (see 19). Good laboratories will report results within the two standard deviation levels with a failure rate of <10 %.

The material can also be used for method development and for the calibration of equipment.

**2. Origin of Material:** AMIS0356 is a commissioned CRM made up of material supplied by Montero Resources Ltd. from the Wigu Carbonatite Complex located 200km WSW of Dar es Salaam. Wigu Hill is underlain by Paleoproterozoic metasediments consisting of well foliated high grade gneisses and amphibolites. These rocks have been intruded by a swarm of carbonatite dykes on the southern edge of the Uluguru Mountains where the Uluguru massif is truncated by a major Karoo aged rift. The intrusions have resulted in strong carbonate alteration of the gneisses and amphibolites adjacent to the dykes and a more pervasive fenitisation and weaker carbonate alteration halo away from the dykes.

**3. Mineral and Chemical Composition:** The carbonatite material selected for this sample is fresh, compact and tightly and finely crystalline. It is bastnasite-rich with minor amounts of synchisite, parasite and monazite, with traces of apatite. The carbonatite is dolomitic with a significant proportion of Rare Earth Oxide minerals (REO's) and lesser associated quartz, barite, strontianite, iron oxides and minor manganese.

Regional sampling to date has identified that the main rare earth minerals present in the Wigu carbonatites are the light rare earths, namely Cerium, Lanthanum, Neodymium, Praseodymium, and Samarium. Minor amounts of Europium and Gadolinium are present, but the other heavy rare earth elements are present in trace amounts only.

**4. Appearance:** The material is a very fine Pale Yellowish Brown powder (Corstor colour chart – 10YR 6/4).

**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. 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 randomly selected for homogeneity testing and third party analysis. Statistical analysis of both homogeneity and consensus test results were carried out by an independent statistician.

**7. Methods of Analysis requested:**

1. Multi-acid digest, including HF, ICP- OES or ICP-MS. Multi element scan.
2. Fusion, ICP- OES or ICP-MS. Multi element scan to include REE's, Nb, Y, Sr, U and Th.
3. XRF. Multi element scan to include REE's, Nb, Y, Sr, U and Th.
4. XRF fusion. Majors ( 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, P<sub>2</sub>O<sub>5</sub>, SiO<sub>2</sub>, TiO<sub>2</sub>. LOI. )
5. SG ( gas pycnometer ).

**8. 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 ( not averages )
4. All results for Rare Earth Elements to be reported in ppm ( not as oxides).
5. All results for multi-element scans to be reported in ppm.
6. All results for major elements to be reported in %, as oxides.
7. Report all QC data, to include replicates, blanks and certified reference materials used.

**9. Method of Certification:** Twenty three laboratories were each given eight randomly selected packages of sample. Twenty one of the laboratories submitted results in time for certification.

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 21 out of 23 laboratories that provided results timeously were (not in same order as in the table of assays):

1. ACME Analytical Laboratories Ltd CA
2. Activation Laboratories Pty Ltd (ActLabs) CA
3. ALS Ammtec (Australia)
4. ALS Chemex Laboratory Group Perth WA
5. ALS Chemex Laboratory Group Vancouver CA
6. ALS OMAC (Ireland)
7. ANSTO Minerals Laboratory (Australia)
8. Bureau Veritas (Namibia)
9. Bureau Veritas (USA)
10. BV Amdel (Australia)
11. Genalysis Laboratory Services (W Australia P)
12. Intertek Utama Services (Indonesia)
13. Labtium Inc Finland
14. Set Point Laboratories (Isando) SA
15. SGS Australia Pty Ltd (Newburn) WA
16. SGS Geosol Laboratories Ltda (Brazil)
17. SGS Mineral Services Lakefield (Canada)
18. SGS South Africa (Pty) Ltd - Booysens JHB
19. SGS Toronto (Canada)
20. SGS Townsville (Australia)
21. Ultra Trace (Pty) Ltd WA

11. Assay Data: Data as received from the laboratories for the important certified elements listed on p1 is set out below.

Assay data - Economic Elements

Lab Code	Ce Fusion ppm	Dy Fusion ppm	Dy M/ICP ppm	Er Fusion ppm	Er M/ICP ppm	Eu Fusion ppm	Eu M/ICP ppm	Gd Fusion ppm	Gd M/ICP ppm	Ho Fusion ppm	Ho M/ICP ppm	La Fusion ppm	La M/ICP ppm	Lu Fusion ppm	Lu M/ICP ppm	Nb XRF ppm	Nb Fusion ppm	Nb M/ICP ppm	Nd Fusion ppm	Nd M/ICP ppm	
A													8900						175		
A													8830						182		
A													8820						172		
A													8910						179		
A													8930						180		
A													8800						176		
A													8880						178		
A													8920						172		
B		13.4		3.58		31.4		70.8			1.53	8718	8174	0.18	0.37		242	148	2550		
B		12.4		3.91		31.4		69.7			1.58	9013	8500	0.22	0.33		249	151	2632		
B		14.3		2.70		30.9		69.3			1.58	8628	7558	0.22	0.33		243	142	2558		
B		12.7		3.45		30.1		70.0			1.94	8802	8423	0.24	0.36		238	119	2576		
B		13.8		2.89		32.2		70.7			1.77	8856	8234	0.24	0.36		245	142	2592		
B		14.7		3.07		30.7		71.8			1.71	8858	8463	0.22	0.34		243	108	2622		
B		13.0		3.50		30.1		67.0			1.60	8885	7929	0.22	0.45		248	110	2620		
B		13.1		2.93		32.6		74.1			1.59	9047	8213	0.19	0.45		242	134	2646		
D		13.4		3.03		32.3		54.0		1.75		8880		0.28			233		2490		
D		13.2		3.01		31.7		56.1		1.72		8640		0.28			227		2390		
D		13.2		2.99		31.6		53.3		1.71		8600		0.29			232		2440		
D		13.1		2.95		31.5		54.9		1.70		8400		0.27			221		2350		
D		12.4		2.96		28.5		49.4		1.62		8680		0.29			255		2420		
D		12.5		3.02		29.3		50.5		1.66		8570		0.29			241		2420		
D		12.9		3.03		29.9		51.9		1.68		8710		0.29			251		2430		
D		12.6		3.00		28.8		52.3		1.64		8210		0.29			238		2310		
E	11100	12.0	13.6	2.50	3.25	29.5	29.8	52.0	55.2	1.60	1.62	8490	8520	0.20	0.36		185		2460	2410	
E	11200	13.5	13.4	3.00	3.30	30.0	29.4	56.0	58.2	1.60	1.66	8650	8370	0.40	0.36		180		2470	2330	
E	11400	13.0	13.5	2.50	3.35	30.5	29.6	52.0	54.0	1.60	1.60	8660	8560	0.20	0.40		175		2540	2410	
E	11300	13.5	13.4	2.50	3.20	30.0	28.8	56.0	55.4	1.60	1.64	8680	8430	0.40	0.40		180		2470	2330	
E	11100	14.0	13.2	3.00	3.15	29.5	29.8	56.0	53.4	1.60	1.64	8540	8620	0.20	0.38		165		2470	2400	
E	11500	13.0	13.2	3.50	3.25	30.0	29.2	60.0	54.0	1.60	1.60	8680	8480	0.20	0.36		185		2440	2370	
E	11700	14.0	13.2	3.00	3.25	31.5	29.2	58.0	55.6	1.60	1.66	8760	8510	0.20	0.36		195		2580	2370	
E	11300	13.5	13.3	3.00	3.25	29.0	29.0	56.0	55.0	1.60	1.64	8570	8530	0.20	0.40		185		2440	2440	
F	10700	13.3			2.93	32.7	27.9	88.9	14.3		1.31	9637	7948			200	100	216			
F	11160	13.2			2.47	32.9	27.8	86.1	6.53		1.34	9122	7888			210		106			
F	11180	12.2			2.31	37.5	26.2	112	15.1		1.29	9229	7657			200	120	99			
F	11080	12.8			1.68	32.3	27.2	99.3			1.32	9069	8110			220	130	136			
F	11080	11.1			1.47	30.3	26.9	102			1.36	8960	8084			200	120	115			
F	11240	12.2			2.41	29.8	28.1	97.5	15.8		1.38	9692	7987			200	110	115			
F	11060	11.6			1.96	28.9	27.7	117	1.91		1.37	9223	7993			200		133			
F	10700	11.5			2.93	30.0	29.4	83.3	23.7		1.39	9737	7921			200	100	95			
G													8000						180		
G		13.0		9.00		30.5		115			1.50		8400					150		2440	
G		12.0		9.00		28.5		105			1.50		8400					150		2305	
G		13.0		9.00		30.0		100			1.50		8500					110		2505	
G		13.0		9.00		30.5		110			1.50		8600					140		2510	
G		12.5		9.00		29.5		100			1.50		8400					195		2360	
G		13.0		9.00		29.5		105			1.50		8500					250		2420	
G		12.0		9.00		29.5		100			1.50		8500					285		2295	
H		14.0		9.83		33.1		232		1.71		8960		0.33	100					2730	
H		13.7		10.00		32.8		235		1.68		8870		0.31	94.0					2620	
H		16.0		12.10		38.4		275		1.91		10400		0.39	98.0					3040	
H		15.1		10.50		32.8		228		1.81		9390		0.37	100					2770	
H		13.4		10.30		31.0		218		1.64		8540		0.33	90.0					2390	
H		12.3		9.06		28.3		198		1.50		7890		0.29	96.0					2300	
H		11.0		8.28		25.4		175		1.37		7100		0.28	94.0					2020	
H		14.9		10.70		33.3		226		1.78		9530		0.35	108					2630	
I	10479	13.1	18.2	2.43	4.30	27.8	28.8	90.6		0.90	1.00	7646		0.23	0.30	200	220	217	2326		
I	10621	12.7	17.8	2.15	4.50	28.1	30.1	84.3	0.90	0.90	1.10	7744		0.28	0.30	200	231	223	2386		
I	10605	12.3	16.4	2.35	2.50	27.6	29.9	84.0		0.89	1.00	7809		0.25	0.30	200	227	222	2374		
I	10679	13.5	15.4	2.65	4.70	27.5	30.4	82.2	11.4	0.84	0.90	7807		0.25	0.30	200	230	216	2310		
I	11018	13.9	15.0	1.77	3.80	28.1	29.8	81.6	5.70	0.83	1.10	8019		0.23	0.30	200	229	212	2348		
I	10752	13.5	16.1	2.88	3.80	28.2	29.7	82.4	11.2	0.89	0.90	8022		0.26	0.30	200	228	212	2438		
I	10688	14.2	17.5	1.79	4.10	28.1	30.3	70.8	1.80	0.86	1.20	7802		0.26	0.30	200	240	208	2358		
I	10950	13.2	15.7	2.04	4.00	28.0	29.7	81.5	21.2	0.97	0.90	8080		0.25	0.30	200	237	210	2459		
J	11700	36.0		12.00		35.0		2.40				8787		0.80			210		2453		
J	11700	37.0		12.00		35.0		2.00				8894		0.80			210		2486		
J	11600	37.0		12.00		35.0		2.40				8818		0.80			200		2427		
J	11800	37.0		12.00		35.0		2.00				8912		0.80			200		2496		
J	11800	36.0		12.00		37.0		2.00				8937		0.80			210		2506		
J	11900	35.0		11.00		36.0		2.00				8927		0.40			200		2478		
J	11700	35.0		11.00		35.0		2.00				8800		0.80			200		2456		
J	11700	36.0		11.00		35.0		2.00				8922		0.80			190		2452		
K	10900	13.3	13.0	3.18	3.20	28.3	29.0	55.5	52.0	1.60	1.70	8670	7690	0.19	0.43		221	161	2290	2480	
K	11000	13.0	12.0	3.05	3.20	27.0	29.0	54.3	52.0	1.55	1.70	8720	7710	0.19	0.46		215	155	2170	2480	
K	10800	13.0	12.0	2.99	3.30	26.9	29.0	53.1	51.0	1.51	1.60	8620	7740	0.18	0.49		217	144	2210	2460	
K	10800	13.3	12.0	3.12	3.10	27.8	29.0	54.1	50.0	1.57	1.70	8650	7850	0.18	0.52		222	149	2290	2470	
K	10800	13.4	12.0	3.21	3.20	27.7	29.0	54.2	50.0	1.53	1.70	8660	7580	0.19	0.52		220	147	2260	2470	
K	10800	13.3	12.0	3.17	3.30	27.3	29.0	53.0	50.0	1.62	1.70	8630	7530	0.19	0.48		217	152	2230	2480	
K	10600	13.5	12.0	3.28	3.20	28.1	28.0	52.5	48.0	1.58	1.60	8460	7390	0.19	0.47		223	147	2340	2440	
K	10700	13.4	12.0	3.20	3.30	28.1	28.0	53.9	50.0	1.59	1.70	8480	7450	0.19	0.51		222	155	2310	2470	
L	11574	12.4		2.90		28.8		50.1		1.70		8616		0.27			201	208	2522		
L	11126	12.0																			

## Assay data - Economic Elements (cont)

Lab Code	Ce Fusion ppm	Dy Fusion ppm	Dy M/ICP ppm	Er Fusion ppm	Er M/ICP ppm	Eu Fusion ppm	Eu M/ICP ppm	Gd Fusion ppm	Gd M/ICP ppm	Ho Fusion ppm	Ho M/ICP ppm	La Fusion ppm	La M/ICP ppm	Lu Fusion ppm	Lu M/ICP ppm	Nb XRF ppm	Nb Fusion ppm	Nb M/ICP ppm	Nd Fusion ppm	Nd M/ICP ppm
N	14.8		3.21			31.5		92.4		2.03		8444		0.30				170	2535	
N	15.7		3.42			31.9		92.9		1.99		8311		0.29				171	2533	
N	15.2		3.05			32.2		91.9		1.98		8693		0.32				173	2631	
N	15.2		3.27			31.3		92.2		1.87		8347		0.31				169	2559	
N	14.7		2.85			30.0		93.1		1.70		8546		0.28				171	2551	
N	15.0		3.23			33.8		92.4		2.01		8609		0.28				173	2572	
N	15.7		3.26			32.3		93.4		1.97		8617		0.30				172	2623	
N	13.3		3.17			30.5		92.9		2.01		8475		0.31				173	2424	
P	11450	12.0		4.30		28.9		78.3		1.70		7800	7390	0.40			194	210	2480	
P	11150	12.0		3.80		28.1		79.2		1.50		7870	7430	0.30			186	207	2490	
P	11000	12.4		4.30		30.0		78.4		1.60		7790	7400	0.20			190	214	2490	
P	11400	12.4		4.00		29.6		79.5		1.50		7800	7540	0.30			181	208	2480	
P	10950	12.7		4.10		29.4		80.5		1.50		7730	7420	0.30			184	208	2520	
P	11050	12.3		4.00		29.8		78.8		1.40		7840	7530	0.20			182	210	2530	
P	11100	12.3		4.00		29.6		80.1		1.50		7900	7270	0.30			185	208	2520	
P	11050	12.2		4.00		29.0		78.2		1.40		7930	7240	0.20			190	202	2440	
Q	11598					23.8		19.7				8965				86.0	210	209	2538	
Q	11518					24.9		21.6				8806				86.0	219	200	2486	
Q	11616					23.7		20.1				8816				86.0	215	206	2512	
Q	11318					24.0		19.8				8853				83.0	205	205	2473	
Q	11469					25.5		20.0				8722				78.0	220	207	2523	
Q	11721					25.0		20.9				8754				78.0	217	207	2564	
Q	11363					23.2		19.2				8796				87.0	209	207	2464	
Q	11742					24.1		20.9				8720				82.0	206	211	2558	
R		14.2	13.0	5.40	5.10	31.6	29.3	75.5	69.5	1.90	1.69			0.26	200	250			2700	
R		14.4	13.2	6.10	5.20	33.9	30.3	75.6	69.4	1.90	1.75			0.26	300	260			2740	
R		13.7	12.7	6.00	5.20	32.7	29.3	74.0	66.7	1.90	1.69			0.23	200	260			2620	
R		14.2	13.3	6.10	5.30	33.1	29.9	78.4	68.6	2.00	1.71			0.25	200	245			2630	
R		13.1	13.1	5.30	5.00	31.8	30.0	77.0	69.6	1.70	1.74			0.26	200	235			2500	
R		13.4	13.0	5.30	5.40	31.7	29.1	76.1	68.9	1.80	1.73			0.24	200	230			2650	
R		13.4	13.1	5.80	5.40	32.0	30.0	72.8	68.8	1.90	1.74			0.27	200	255			2990	
R		13.1	13.2	5.10	5.30	32.8	29.5	77.7	68.5	1.80	1.74			0.27	300	235			2700	
T			11.9		1.50		26.0		40.6		1.82				0.22					2470
T			11.9		1.55		27.6		40.0		1.86				0.24					2510
T			11.7		1.50		26.8		39.4		1.88				0.24					2530
T			11.9		1.60		26.4		40.2		1.82				0.24					2480
T			11.9		1.50		27.6		40.0		1.88				0.24					2480
T			11.9		1.60		27.2		40.4		1.84				0.22					2470
T			11.9		1.55		26.8		41.0		1.80				0.24					2440
T			11.6		1.60		27.1		41.2		1.86				0.22					2470
U	10800	10.9	13.2	2.40	3.10	28.2	28.2	97.1	102	1.20	1.60	8270	8150	0.21	0.20	217	193		2360	2050
U	10600	10.4	13.4	2.00	3.20	26.6	31.8	95.5	113	1.10	1.60	7970	8010	0.16	0.20	224	201		2270	2240
U	11000	10.7	14.0	2.10	3.10	27.7	30.8	97.4	120	1.10	1.60	8310	8140	0.19	0.20	217	201		2360	2130
U	10900	10.1	12.2	2.10	3.10	27.1	29.9	97.5	106	1.10	1.50	8240	7690	0.18	0.20	210	205		2320	2160
U	10800	10.6	13.3	2.40	3.20	27.9	28.7	98.8	100	1.20	1.60	8300	8330	0.22	0.20	210	191		2350	2160
U	11000	10.8	13.3	2.00	3.10	28.0	28.4	99.7	105	1.10	1.60	8260	8220	0.19	0.20	224	201		2350	2070
U	11200	10.8	13.2	2.20	3.20	28.4	29.0	97.1	109	1.20	1.60	8420	8050	0.18	0.20	217	205		2390	2120
U	11400	10.9	13.0	2.20	3.20	28.7	31.1	103	110	1.20	1.60	8550	8120	0.18	0.20	224	206		2420	2270
V			10.4		7.80		20.6		16.6		1.01		8920		0.19			118		2550
V			10.5		7.80		20.8		16.1		1.00		8880		0.17			135		2570
V			10.0		7.50		19.9		16.3		0.98		8790		0.18			137		2470
V			9.9		7.10		18.8		16.0		0.94		8880		0.16			121		2330
V			10.2		7.60		20.8		17.4		0.99		8540		0.19			123		2550
V			10.2		7.60		20.5		17.3		0.99		8880		0.19			138		2540
V			10.2		7.50		20.2		15.5		0.97		8730		0.17			124		2500
V			10.5		7.60		20.3		15.9		0.98		9000		0.19			112		2530
W																				2740
W												9680								2770
W												9430								2630
W												9180								2720
W												9590								2700
W												9670								2800
W												9530								2740
W												9680								2830

## Assay data – Economic Elements (cont)

Lab Code	Pr Fusion ppm	Pr M/ICP ppm	Sc M/ICP ppm	Sm Fusion ppm	Sm M/ICP ppm	Sr Fusion ppm	Sr M/ICP ppm	Tb Fusion ppm	Tb M/ICP ppm	Th Fusion ppm	Th M/ICP ppm	Tm Fusion ppm	Tm M/ICP ppm	U Fusion ppm	U M/ICP ppm	Y XRF ppm	Y Fusion ppm	Y M/ICP ppm	Yb Fusion ppm	Yb M/ICP ppm	
A			31.0				14900														
A			31.0				14800													37.0	
A			31.0				14600													36.0	
A			32.0				14600													37.0	
A			31.0				14500													38.0	
A			32.0				14600													37.0	
A			34.0				14700													39.0	
A			31.0				14800													36.0	
B	947		30.1	161		17881		7.75	1.82	75.7	95.2	0.29		3.82	4.46				36.3	2.00	1.98
B	981		29.3	167		17993		7.86	1.85	80.7	95.2	0.28		3.93	4.49				35.2	2.40	1.96
B	942		29.2	168		16454		7.70	1.84	79.1	99.0	0.35		4.46	4.74				33.6	1.80	2.01
B	970		29.4	167		17389		7.48	1.56	78.6	99.0	0.26		4.65	4.81				33.3	1.80	2.01
B	969		30.8	164		17689		7.79	1.90	82.1	99.4	0.26		3.98	4.63				35.7	1.50	2.05
B	972		29.0	175		17562		7.56	1.85	81.2	95.5	0.44		4.15	4.49				33.8	1.80	2.02
B	974		29.4	169		18470		7.81	2.40	83.0	99.3	0.36		4.14	4.70				36.6	1.90	2.12
B	984		28.1	174		18940		7.60	1.82	83.8	95.6	0.27		4.35	4.40				34.8	2.20	2.13
D	984			166				4.11		78.7		0.35		3.80				37.0		1.96	
D	960			161				4.33		79.3		0.36		3.96				37.0		1.91	
D	958			161				4.02		78.3		0.35		3.88				37.7		1.85	
D	938			158				4.41		77.3		0.35		3.79				36.0		1.80	
D	911			156				4.07		86.2		0.36		4.35				40.0		2.06	
D	885			155				4.31		85.1		0.37		4.24				37.4		1.98	
D	907			158																	

### Assay data – Economic Elements (cont)

Lab Code	Pr Fusion ppm	Pr M/ICP ppm	Sc M/ICP ppm	Sm Fusion ppm	Sm M/ICP ppm	Sr Fusion ppm	Sr M/ICP ppm	Tb Fusion ppm	Tb M/ICP ppm	Th Fusion ppm	Th M/ICP ppm	Tm Fusion ppm	Tm M/ICP ppm	U Fusion ppm	U M/ICP ppm	Y XRF ppm	Y Fusion ppm	Y M/ICP ppm	Yb Fusion ppm	Yb M/ICP ppm
E	925	935	31.0	157	163	17800	17400	3.80	4.24	85.0	83.7	0.40	0.32	4.00	4.20		35.0	35.6	1.50	1.35
E	943	918	31.0	162	159	18200	17000	3.80	4.32	87.5	83.8	0.40	0.32	4.00	4.10		36.0	35.1	2.00	1.35
E	950	939	31.0	157	163	18100	17400	3.60	4.20	87.5	87.2	0.40	0.32	4.00	4.30		35.0	34.7	1.50	1.45
E	944	917	31.0	161	160	17900	17100	3.60	4.16	86.5	83.9	0.40	0.30	4.00	4.10		36.0	34.7	1.50	1.40
E	931	952	32.0	163	162	17400	18100	3.80	4.20	88.0	87.1	0.40	0.32	4.00	4.30		35.0	37.0	1.50	1.40
E	954	921	31.0	165	160	18100	17100	3.80	4.20	90.5	86.4	0.40	0.32	4.50	4.20		36.0	35.9	1.50	1.35
E	956	944	31.0	164	162	18600	17500	3.60	4.18	89.0	84.9	0.40	0.32	4.00	4.20		36.0	36.1	1.50	1.35
E	935	947	31.0	161	161	17800	17500	3.80	4.14	86.5	86.7	0.40	0.32	4.00	4.40		36.0	34.9	2.00	1.35
F	936	766		138	117	19530	17933			88.4	88.7			4.50	4.39	30.0	32.9			
F	860	791		147	121	19116	18609			91.0	89.4			4.73	4.26	30.0	33.7			
F	870	743		149	116	20293	17096			89.7	85.1			4.36	4.22	30.0	31.9			
F	852	765		146	121	19531	18268			85.6	90.6			4.47	4.51	40.0	33.2			
F	864	760		148	117	18610	18111			86.0	89.8			4.45	4.57	40.0	32.8			
F	898	789		152	126	19867	18535			87.4	90.5			4.54	4.58	30.0	34.2			
F	879	771		160	121	19103	18038			87.0	88.4			4.56	4.57	30.0	34.3			
F	912	774		154	126	19152	18121			86.2	91.9			4.41	4.65	40.0	34.4			
G						17900									4.50			38.0		
G		935			160		18900		6.50						4.50			34.0		
G		920			155		18800		7.00						4.00			31.0		
G		985			165		19200		7.00						4.00			34.0		
G		975			160		19300		7.00						4.00			32.0		
G		980			160		18500		6.50						4.50			37.0		
G		945			160		19000		7.00						4.00			32.0		
G		925			160		19100		7.00						4.00			33.0		
H		982			173		18700		10.4		103		0.36		6.08	13.0		36.1		2.41
H		963			169		18100		10.7		102		0.33		5.85	18.0		34.5		2.29
H		1110			196		19100		12.4		119		0.41		7.03	7.00		41.4		2.64
H		991			186		17800		10.6		114		0.33		6.83	20.0		39.2		2.37
H		874			163		18200		9.35		98.7		0.32		5.81			35.0		2.20
H		832			154		18200		9.13		93.0		0.29		5.36	12.0		32.5		1.98
H		730			136		16800		8.06		81.5		0.26		4.70	22.0		28.8		1.76
H		965			190		17600		10.1		111		0.34		6.53	15.0		38.1		2.32
I		883	1255	28.3	149	162	17852	4.60	6.50	82.5	90.1	0.32	0.40	3.80	4.50		36.0	33.7	2.03	2.40
I		899	1261	28.8	153	163	18251	4.49	5.90	86.8	88.3	0.32	0.30	4.30	4.20		37.2	32.4	2.06	2.90
I		890	1237	29.0	151	164	18005	4.29	6.90	86.0	90.0	0.32	0.40	4.50	4.40		34.2	33.0	2.16	2.70
I		895	1223	28.1	150	161	18056	4.42	6.20	83.8	88.2	0.31	0.40	3.80	4.30		34.4	32.6	2.30	2.20
I		907	1208	27.3	150	158	18465	4.53	6.90	83.9	87.4	0.33	0.40	4.40	5.20		35.6	32.2	2.14	2.60
I		908	1198	27.9	155	163	18567	4.26	6.10	85.6	89.2	0.33	0.40	4.20	4.20		36.8	32.6	2.20	2.50
I		895	1202	28.5	150	162	18238	4.15	6.20	84.5	85.3	0.30	0.30	4.10	4.20		34.1	31.0	1.94	2.70
I		908	1203	27.0	156	155	18805	4.35	7.50	89.5	85.0	0.31	0.30	4.60	4.10		35.2	31.0	2.29	2.40
J		934			168			11.2		80.0					3.90		36.0		5.00	
J		941			167			10.4		80.0					4.20		34.0		4.00	
J		930			165			10.4		78.0					4.20		36.0		6.00	
J		947			169			10.4		82.0					4.20		36.0		5.00	
J		947			167			10.4		82.0					4.20		38.0		5.00	
J		939			173			10.4		80.0					4.20		36.0		4.00	
J		937			164			10.8		80.0					4.20		34.0		5.00	
J		937			164			10.8		78.0					4.50		36.0		5.00	
K		937	920	23.8	155	150	19600	4.49	2.75	82.5	83.2	0.31	0.30	4.55	3.98		31.7	29.5	1.80	2.40
K		894	920	26.3	149	150	18900	4.58	2.56	79.2	84.9	0.29	0.30	4.26	4.14		30.6	32.0	1.70	2.50
K		915	910	26.5	151	150	19000	4.13	2.67	78.7	84.9	0.30	0.30	4.15	4.00		30.9	32.7	1.70	2.50
K		939	910	25.2	154	150	19900	4.42	2.64	81.2	87.0	0.30	0.30	4.45	4.28		31.8	30.6	1.70	2.60
K		936	910	24.7	155	150	20400	4.44	2.63	80.6	84.3	0.30	0.30	4.51	4.10		31.5	30.2	1.70	2.50
K		927	910	24.8	151	150	18600	4.35	2.56	80.6	84.2	0.32	0.30	4.37	4.03		31.4	30.3	1.80	2.50
K		963	890	27.8	158	150	20000	4.19	2.45	82.7	83.7	0.30	0.30	4.32	4.07		32.0	34.5	1.90	2.50
K		961	900	25.4	154	150	19500	4.24	2.42	81.9	84.5	0.30	0.30	4.37	4.06		31.7	31.4	1.80	2.60
L		970		26.0	161		18699	3.52		83.5	81.6		0.30	4.50	4.17		35.3	32.8	1.30	
L		942		26.0	157		18588	3.68		82.4	78.5		0.32	4.30	4.08		33.4	33.6	1.50	
L		960		26.0	158		18505	3.41		83.2	79.7		0.32	4.30	4.18		34.6	33.4	1.50	
L		946		26.0	157		18147	3.66		82.0	82.5		0.33	4.10	4.10		33.6	33.5	1.40	
L		947		25.0	158		18104	3.60		82.4	79.8		0.33	4.40	4.21		34.6	34.0	1.50	
L		946		25.0	156		18293	3.42		82.1	80.8		0.31	4.20	4.08		34.6	33.6	1.40	
L		951		25.0	157		18258	3.49		82.6	78.7		0.31	4.20	4.01		33.6	34.1	1.50	
L		955		26.0	159		17975	3.72		83.6	78.0		0.29	4.20	4.00		34.2	33.4	1.40	
N		948		21.9	159			6.95		71.6			0.29		4.84		36.8		2.00	
N		951		21.5	159			6.69		72.2			0.26		4.15		37.6		1.70	
N		962		21.2	163			6.88		72.5			0.33		4.73		37.7		2.10	
N		965		22.7	159			7.11		73.0			0.29		4.89		37.9		1.80	
N		934		22.5	157			7.01		70.1			0.31		4.69		36.1		1.90	
N		962		21.8	165			7.08		72.7			0.33		4.85		36.9		2.10	
N		958		21.8	165			7.04		73.3			0.27		4.54		37.8		1.80	
N		944		22.0	158			7.05		71.2			0.30		4.74		36.1		1.80	
P		978		29.5	158			4.80		87.6	76.3		0.40	4.00	4.00		34.7	36.2	1.80	
P		977		28.9	155			4.60		86.3	78.3		0.40	4.30	4.20		34.4	34.6	2.00	
P		950		28.9	160			4.70		87.4	78.9		0.30	4.10	4.40		34.5	36.5	1.50	
P		983		28.7	158			4.70		88.7	81.2		0.30	4.50	4.20		33.8	35.9	1.70	
P		993		29.8	157			4.70		88.5	79.3		0.30	4.30	4.00		32.8	36.1	1.70	
P		954		28.6	154			4.50		87.0	88.3		0.30	4.00	4.30		33.5	35.2	1.50	
P		977		29.2	158			4.50		89.2	79.6		0.30	4.10	4.10		33.8	35.6	1.80	
P		959		28.2	152			4.40		86.7	79.9		0.30	4.10	4.00		33.8	34.0	1.60	
Q		965			157		18200	11700		64										

## Assay data – Economic Elements (cont)

Lab Code	Pr Fusion ppm	Pr M/ICP ppm	Sc M/ICP ppm	Sm Fusion ppm	Sm M/ICP ppm	Sr Fusion ppm	Sr M/ICP ppm	Tb Fusion ppm	Tb M/ICP ppm	Th Fusion ppm	Th M/ICP ppm	Tm Fusion ppm	Tm M/ICP ppm	U Fusion ppm	U M/ICP ppm	Y XRF ppm	Y Fusion ppm	Y M/ICP ppm	Yb Fusion ppm	Yb M/ICP ppm
R	1020	986	24.7	167	160			7.00	6.80	86.5	80.7	0.30	0.33	4.60	4.11		36.1	32.8	2.30	2.10
R	1050	993	25.5	169	163			6.40	6.77	87.7	82.4	0.30	0.34	4.70	4.32		36.6	33.5	2.30	2.10
R	1010	969	23.6	167	158			6.80	6.43	87.8	79.5	0.30	0.33	4.80	4.22		37.6	31.6	2.30	2.10
R	1020	982	24.6	172	159			7.10	6.67	83.9	79.7	0.40	0.34	4.50	4.23		36.4	32.2	2.40	2.10
R	998	988	25.2	162	165			7.10	6.67	83.4	80.9	0.30	0.33	4.70	4.31		34.0	32.8	2.20	2.10
R	1010	958	24.1	168	159			6.70	6.51	85.8	78.5	0.30	0.33	4.30	4.15		35.7	33.7	2.30	2.00
R	1000	999	24.8	166	160			6.40	6.53	87.8	81.6	0.40	0.33	4.70	4.33		37.2	32.8	2.30	2.10
R	1050	992	24.3	182	165			6.50	6.43	80.7	80.6	0.40	0.33	4.90	4.20		36.9	32.0	2.10	2.20
T		964	31.0		159		17700		1.62		75.0		0.25		3.80			39.6		1.65
T		980	30.0		162		17800		1.66		76.5		0.30		4.00			39.7		1.70
T		980	31.0		162		18200		1.64		76.5		0.25		3.90			39.7		1.60
T		978	30.0		156		17700		1.62		78.0		0.30		3.90			38.5		1.70
T		980	30.0		166		17900		1.62		78.5		0.30		4.10			39.6		1.60
T		966	31.0		159		17500		1.66		78.5		0.25		3.80			38.6		1.65
T		968	31.0		161		17400		1.66		78.5		0.30		3.80			39.6		1.60
T		966	31.0		158		18100		1.66		78.5		0.30		3.90			39.4		1.60
U	921	836		157		17010		3.50	5.20	85.5	82.2	0.27	0.30	4.50	4.00	31.5	29.0	33.6	1.30	1.00
U	832	868		150		16260		3.50	5.30	84.6	91.4	0.20	0.30	4.10	4.20	39.4	31.0	34.8	1.00	1.20
U	873	846		157		16420		3.50	5.70	87.7	87.9	0.22	0.30	4.40	4.20	31.5	31.0	34.0	1.20	1.00
U	856	860		154		16480		3.50	4.90	85.5	81.9	0.23	0.30	4.00	3.80	39.4	31.0	34.0	1.10	1.10
U	920	889		157		17350		3.80	5.10	86.8	80.9	0.26	0.30	4.40	4.00	31.5	30.0	35.8	1.40	1.10
U	865	831		157		16290		3.70	5.60	86.8	91.2	0.21	0.30	4.20	4.00	39.4	31.0	34.1	1.10	1.00
U	891	850		161		16160		3.80	5.60	88.4	83.8	0.22	0.30	4.40	4.10	31.5	31.0	34.1	1.10	1.10
U	897	897		163		16130		3.90	4.80	89.5	87.2	0.22	0.30	4.30	4.10	31.5	31.0	35.2	1.20	1.30
V		751	18.6		131				0.53		49.7		0.18		2.86			20.9		1.10
V		771	22.8		133				0.45		50.9		0.18		2.85			24.0		1.20
V		746	27.3		127				0.45		48.2		0.17		2.70			26.8		1.10
V		710	21.9		120				0.48		43.9		0.17		2.69			23.0		1.10
V		762	18.5		133				0.52		51.4		0.16		2.75			20.4		1.10
V		756	22.4		133				0.60		50.0		0.16		2.72			23.8		1.10
V		747	18.4		129				0.44		49.0		0.16		2.82			20.5		1.10
V		761	17.8		130				0.47		48.9		0.18		2.76			19.9		1.10
W	1025			184						101.5				5.20			44.0			
W	1040			184						101.5				5.20			42.0			
W	960			175						104.5				5.00			42.0			
W	1015			183						104.5				5.00			43.0			
W	1030			181						108.0				5.20			45.0			
W	1050			186						102.5				5.20			42.0			
W	1025			184						110.0				5.40			44.0			
W	1055			190						113.5				5.60			45.0			

## Assay data 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 %	SG pyc
A	5.84	15.7	0.02	8.10	0.52	5.97	0.93	2.83	2.60	28.9	0.34	20.0	
A	5.85	15.7	0.03	8.16	0.52	5.99	0.94	2.86	2.60	29.0	0.35	20.1	
A	5.83	15.7	0.03	8.11	0.53	5.97	0.93	2.84	2.58	29.0	0.34	20.0	
A	5.83	15.7	0.01	8.10	0.53	5.96	0.93	2.79	2.60	29.0	0.33	20.0	
A	5.83	15.7	0.02	8.10	0.53	5.98	0.93	2.81	2.58	29.0	0.34	20.0	
A	5.83	15.7	0.03	8.10	0.52	5.95	0.93	2.83	2.59	28.9	0.33	20.0	
A	5.85	15.7	0.02	8.11	0.52	5.97	0.91	2.82	2.58	29.0	0.34	20.0	
A	5.84	15.7	0.03	8.12	0.53	5.99	0.91	2.80	2.58	28.9	0.34	19.9	
B	5.83	15.4		7.90	0.50	6.00	0.90	2.76	2.58	28.9	0.34	20.0	2.83
B	5.86	15.3		7.90	0.50	6.01	0.90	2.80	2.59	28.8	0.34	20.0	2.88
B	5.82	15.5		7.93	0.49	5.99	0.90	2.71	2.60	28.9	0.35	20.1	2.87
B	5.77	15.4		7.94	0.50	6.07	0.91	2.77	2.59	28.9	0.35	20.2	2.79
B	5.81	15.4		7.96	0.50	6.11	0.90	2.81	2.59	28.9	0.34	20.1	2.84
B	5.87	15.6		7.94	0.51	6.04	0.90	2.77	2.59	28.9	0.34	20.1	2.86
B	5.81	15.5		7.98	0.51	6.05	0.91	2.77	2.60	29.2	0.34	20.1	2.83
B	5.85	15.5		7.90	0.52	5.99	0.90	2.74	2.58	28.9	0.35	20.1	2.85
C	5.86	16.0		8.15	0.51	6.02	0.93	2.72	2.57	28.8	0.32	20.8	
C	5.87	16.0		8.13	0.52	6.00	0.93	2.70	2.56	28.9	0.33	20.6	
C	5.83	16.0		8.12	0.51	5.99	0.93	2.75	2.59	28.9	0.33	20.2	
C	5.80	16.0		8.10	0.51	6.00	0.93	2.74	2.57	28.8	0.33	20.6	
C	5.81	16.0		8.12	0.52	6.02	0.92	2.74	2.58	28.9	0.33	20.5	
C	5.88	15.9		8.14	0.53	5.98	0.93	2.74	2.56	28.9	0.32	20.3	
C	5.85	16.0		8.13	0.52	6.01	0.93	2.75	2.56	28.9	0.33	20.6	
C	5.82	16.0		8.11	0.51	6.01	0.93	2.70	2.56	28.8	0.33	20.5	
D	5.86	15.7	0.02	7.98	0.54	5.86	0.94	2.95	2.64	28.9	0.33	20.8	3.11
D	5.94	15.9	0.02	8.08	0.55	5.94	0.95	3.00	2.66	29.3	0.34	20.9	3.09
D	5.91	15.9	0.02	8.06	0.55	5.94	0.95	2.98	2.65	29.3	0.34	20.9	2.99
D	5.90	15.8	0.02	8.02	0.55	5.92	0.95	2.99	2.61	29.2	0.34	20.8	3.02
D	5.92	15.9	0.02	8.07	0.55	5.93	0.95	2.97	2.63	29.2	0.34	20.9	3.01
D	5.89	15.9	0.02	8.09	0.55	5.93	0.95	2.95	2.65	29.1	0.34	20.8	3.09
D	5.96	16.0	0.02	8.11	0.56	5.96	0.96	3.01	2.66	29.5	0.34	20.7	2.88
D	5.91	15.9	0.02	8.04	0.55	5.91	0.95	2.96	2.60	29.2	0.34	20.6	2.89



Assay data Major Oxides (cont)

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 %	SG pyc
E	5.83	15.7	0.02	8.12	0.52	5.98	0.91	2.76	2.59	28.9	0.33	20.0	3.07
E	5.85	15.8	0.02	8.14	0.52	5.98	0.92	2.76	2.60	28.9	0.34	19.9	3.08
E	5.82	15.7	0.02	8.14	0.52	5.98	0.92	2.76	2.60	29.0	0.34	20.0	3.07
E	5.85	15.8	0.02	8.15	0.52	5.98	0.92	2.77	2.61	29.0	0.33	19.9	3.08
E	5.83	15.7	0.02	8.14	0.52	6.01	0.92	2.75	2.60	28.9	0.34	20.0	3.08
E	5.83	15.8	0.02	8.16	0.52	6.00	0.92	2.77	2.61	28.9	0.34	19.9	3.08
E	5.83	15.8	0.02	8.16	0.52	5.99	0.93	2.76	2.60	28.9	0.34	19.9	3.09
E	5.83	15.8	0.02	8.14	0.52	5.98	0.92	2.77	2.61	28.9	0.34	19.9	3.07
F	5.84	15.8	0.01	8.21	0.53	6.04	0.95	2.70	2.53	29.3	0.32		
F	5.89	15.9	0.01	8.25	0.54	6.03	0.95	2.69	2.52	29.3	0.33		
F	5.93	15.9	0.01	8.25	0.53	6.05	0.95	2.72	2.53	29.5	0.32		
F	5.86	15.8	0.01	8.20	0.53	6.07	0.95	2.69	2.54	29.3	0.33		
F	5.88	15.9	0.01	8.23	0.53	6.10	0.95	2.77	2.53	29.3	0.32		
F	5.89	15.9	0.01	8.24	0.54	6.13	0.95	2.73	2.52	29.3	0.32		
F	5.87	15.9	0.01	8.27	0.53	6.19	0.95	2.79	2.52	29.5	0.33		
F	5.92	15.9	0.01	8.26	0.54	6.21	0.95	2.78	2.53	29.4	0.32		
G	5.94	16.0	0.03	7.90	0.51	6.01	0.92	2.78	2.65	29.0	0.32		2.93
G	5.84	15.9	0.03	7.83	0.50	5.91	0.91	2.75	2.62	28.6	0.31	20.0	2.93
G	5.96	16.1	0.03	7.94	0.51	6.07	0.92	2.81	2.69	29.1	0.32	20.0	2.93
G	5.97	16.1	0.03	7.90	0.51	6.06	0.92	2.81	2.67	29.1	0.32	20.0	2.93
G	5.92	16.0	0.03	7.85	0.50	6.04	0.91	2.76	2.67	29.0	0.31	20.0	2.93
G	5.78	15.7	0.03	7.79	0.50	5.90	0.90	2.72	2.59	28.3	0.31	19.9	2.93
G	5.91	15.9	0.03	7.89	0.51	6.02	0.91	2.77	2.67	28.8	0.32	20.0	2.94
G	6.02	16.2	0.03	8.00	0.51	6.15	0.93	2.84	2.71	29.4	0.32	19.8	2.92
H													3.05
H													3.07
H													3.08
H													3.04
H													3.09
H													3.09
H													3.11
H													3.06
I	5.78	15.6		7.83	0.49	6.06	0.85	2.69	2.52	28.7	0.30	20.5	2.82
I	5.76	15.5		7.74	0.49	6.00	0.85	2.72	2.48	28.5	0.29	20.5	2.84
I	5.78	15.6		7.79	0.49	6.04	0.84	2.71	2.51	28.7	0.29	20.5	2.83
I	5.75	15.5		7.73	0.49	6.02	0.85	2.72	2.49	28.5	0.29	20.5	2.84
I	5.76	15.4		7.72	0.50	5.99	0.84	2.72	2.50	28.5	0.31	20.4	2.81
I	5.75	15.5		7.72	0.49	6.02	0.84	2.72	2.50	28.5	0.30	20.5	2.83
I	5.77	15.5		7.80	0.49	6.03	0.85	2.73	2.50	28.6	0.29	20.4	2.84
I	5.76	15.5		7.74	0.49	6.02	0.84	2.71	2.51	28.5	0.30	20.5	2.81
K													3.13
K													3.11
K													3.18
K													3.08
K													3.13
K													3.06
K													3.17
K													3.02
L													3.07
L													3.00
L													3.01
L													3.08
L													2.98
L													3.04
L													3.01
L													3.04
N	5.83	15.3	0.03	7.73	0.49	5.98	0.86	2.94		28.3	0.32	20.4	3.01
N	5.79	15.3	0.02	7.68	0.49	5.97	0.86	2.92		28.7	0.32	20.4	2.98
N	5.85	15.5	0.01	7.78	0.49	5.93	0.88	2.96		28.7	0.32	20.4	3.00
N	5.82	15.5	0.02	7.71	0.49	5.98	0.86	2.91		28.3	0.32	20.4	3.02
N	5.82	15.5	0.02	8.18	0.49	5.93	0.87	2.93		28.6	0.32	20.4	3.02
N	5.83	15.5	0.02	7.74	0.50	5.94	0.87	2.92		28.6	0.32	20.4	2.98
N	5.86	15.5	0.02	7.73	0.49	5.95	0.86	2.93		28.6	0.32	20.3	3.00
N	5.84	15.4	0.02	7.73	0.49	5.98	0.87	2.91		28.5	0.33	20.4	3.01
P	5.64	15.0	0.01	7.59	0.49	5.95	0.88	2.72	2.82	27.3	0.30	21.0	3.00
P	5.53	14.9	0.02	7.86	0.48	6.09	0.88	2.64	2.65	27.6	0.31	21.1	2.97
P	5.65	14.7	0.02	7.85	0.47	6.13	0.88	2.66	2.62	27.7	0.31	20.9	3.02
P	5.36	15.2	0.02	7.86	0.48	5.95	0.88	2.66	2.72	28.8	0.30	21.0	2.99
P	5.60	15.0	0.02	7.83	0.47	6.15	0.88	2.65	2.64	27.8	0.31	21.0	2.94
P	5.69	14.9	0.02	7.87	0.48	6.11	0.88	2.66	2.68	27.6	0.31	20.9	2.97
P	5.68	15.0	0.02	7.81	0.47	6.27	0.88	2.59	2.65	27.2	0.31	21.1	3.03
P	5.55	15.1	0.02	7.90	0.48	6.12	0.89	2.67	2.63	27.6	0.31	21.1	2.98

## Assay data Major Oxides (cont)

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 %	SG pyc
Q	5.83	15.5	0.03	8.34	0.52	5.86	0.95		2.52	28.7	0.34	20.5	2.96
Q	5.82	15.5	0.03	8.37	0.53	5.90	0.95		2.53	28.7	0.34	20.4	2.97
Q	5.80	15.5	0.02	8.35	0.50	5.88	0.96		2.52	28.6	0.34	20.4	2.97
Q	5.77	15.5	0.03	8.39	0.50	5.79	0.94		2.49	28.3	0.33	20.5	2.98
Q	5.80	15.5	0.03	8.37	0.50	5.85	0.95		2.51	28.5	0.34	20.5	2.96
Q	5.79	15.6	0.03	8.35	0.50	5.90	0.96		2.52	28.6	0.34	20.4	2.97
Q	5.81	15.5	0.03	8.37	0.51	5.84	0.95		2.51	28.4	0.34	20.5	2.98
Q	5.83	15.6	0.04	8.38	0.50	5.91	0.95		2.52	28.8	0.34	20.4	2.97
R	5.77	15.8	0.02	8.13	0.52	6.10	0.94	2.78	2.68	29.0	0.33	20.0	
R	5.78	15.8	0.02	8.13	0.51	6.08	0.95	2.78	2.66	29.0	0.34	20.0	
R	5.75	15.8	0.02	8.15	0.52	6.05	0.94	2.79	2.59	29.0	0.34	20.0	
R	5.75	15.7	0.02	8.16	0.52	6.06	0.94	2.79	2.52	29.1	0.34	20.0	
R	5.76	15.8	0.02	8.16	0.52	6.10	0.94	2.75	2.66	28.9	0.34	20.0	
R	5.76	15.7	0.01	8.14	0.51	6.04	0.94	2.80	2.66	29.0	0.33	20.0	
R	5.77	15.8	0.02	8.13	0.51	6.07	0.94	2.78	2.68	29.0	0.33	20.0	
R	5.77	15.7	0.02	8.14	0.52	6.05	0.94	2.79	2.61	29.0	0.34	20.0	
T													3.13
T													3.16
T													3.13
T													3.13
T													3.14
T													3.12
T													3.11
T													3.13
U	5.66	15.4	0.03	7.65	0.49	5.90	0.89	2.55	2.53	28.3	0.38	20.7	2.88
U	5.63	15.3	0.02	7.58	0.49	5.85	0.88	2.49	2.50	28.0	0.37	20.6	2.94
U	5.61	15.4	0.03	7.64	0.49	5.87	0.89	2.55	2.55	28.4	0.38	20.6	2.89
U	5.65	15.4	0.02	7.68	0.49	5.95	0.90	2.54	2.52	28.4	0.39	20.6	2.92
U	5.61	15.4	0.03	7.66	0.49	5.91	0.89	2.54	2.54	28.4	0.38	20.6	2.92
U	5.70	15.4	0.03	7.67	0.50	5.89	0.89	2.53	2.54	28.3	0.38	20.6	2.87
U	5.64	15.4	0.03	7.68	0.50	5.91	0.89	2.57	2.53	28.3	0.39	20.7	2.88
U	5.62	15.2	0.03	7.56	0.50	5.85	0.87	2.55	2.49	28.1	0.38	20.7	2.87
V													3.06
V													3.06
V													3.06
V													3.07
V													3.07
V													3.06
V													3.07
V													3.05
W	5.82	15.4	0.02	7.93	0.57	5.89	0.90		2.54	28.4	0.34	20.0	2.87
W	6.03	16.2	0.02	8.28	0.60	6.16	0.94		2.68	29.4	0.36	19.9	2.88
W	5.93	15.7	0.02	8.08	0.58	6.00	0.92		2.58	28.9	0.35	20.1	2.88
W	5.90	15.9	0.02	8.14	0.56	6.05	0.92		2.58	28.9	0.35	20.1	2.87
W	5.91	15.8	0.02	8.13	0.57	6.03	0.92		2.61	29.0	0.34	20.0	2.89
W	6.02	15.9	0.02	8.24	0.60	6.08	0.93		2.61	29.3	0.34	20.0	2.88
W	5.87	15.8	0.02	8.14	0.59	6.01	0.92		2.58	28.9	0.33	20.0	2.88
W	6.07	16.1	0.02	8.29	0.62	6.14	0.93		2.67	29.6	0.34	20.1	2.81

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

The samples used in the certification process were 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>	S <sub>w</sub> <sup>3</sup>	CSU <sup>4</sup>
Ce	Fusion	ppm	352	300	177	102
Dy	Fusion	ppm	0.77	0.50	0.54	0.17
Dy	M/ICP	ppm	1.46	1.27	0.64	0.43
Er	Fusion	ppm	0.54	0.46	0.24	0.16
Er	M/ICP	ppm	1.14	1.25	0.33	0.48
Eu	Fusion	ppm	1.82	1.39	0.91	0.43
Eu	M/ICP	ppm	1.06	0.87	0.64	0.32
Gd	Fusion	ppm	17.3	15.0	3.08	4.54
Gd	M/ICP	ppm	33.3	34.2	3.94	12.10
Ho	Fusion	ppm	0.18	0.18	0.07	0.06
Ho	M/ICP	ppm	0.14	0.11	0.07	0.04
La	Fusion	ppm	365	284	122	83.1
La	M/ICP	ppm	533	421	277	137
Lu	Fusion	ppm	0.05	0.04	0.02	0.01
Lu	M/ICP	ppm	0.07	0.07	0.02	0.03
Nb	XRF	ppm	56.2	68.6	4.81	28.0
Nb	Fusion	ppm	21.2	17.6	6.47	5.37
Nb	M/ICP	ppm	36.5	31.5	13.68	10.1
Nd	Fusion	ppm	85.6	63.7	44.14	19.8
Nd	M/ICP	ppm	142	127	83.3	49.3
Pr	Fusion	ppm	36.3	24.6	18.8	7.07
Pr	M/ICP	ppm	84.6	75.2	34.4	25.4
Sc	M/ICP	ppm	3.00	2.69	0.73	0.85
Sm	Fusion	ppm	5.99	4.01	3.25	1.16
Sm	M/ICP	ppm	5.22	4.48	3.23	1.75
Sr	Fusion	ppm	636	564	385	219
Sr	M/ICP	ppm	655	638	470	295
Tb	Fusion	ppm	1.48	1.37	0.17	0.44
Tb	M/ICP	ppm	2.31	2.27	0.25	0.76
Th	Fusion	ppm	3.44	2.47	2.01	0.77
Th	M/ICP	ppm	5.07	4.15	2.25	1.34
Tm	Fusion	ppm	0.050	0.039	0.030	0.014
Tm	M/ICP	ppm	0.017	0.012	0.014	0.005
U	Fusion	ppm	0.25	0.13	0.20	0.05
U	M/ICP	ppm	0.23	0.14	0.15	0.04
Y	XRF	ppm	8.46	11.45	4.17	5.77
Y	Fusion	ppm	2.06	1.58	0.83	0.46
Y	M/ICP	ppm	2.40	1.70	1.273	0.507
Yb	Fusion	ppm	0.3	0.2	0.2	0.08
Yb	M/ICP	ppm	0.55	0.53	0.13	0.18
Al <sub>2</sub> O <sub>3</sub>	XRF	%	0.054	0.038	0.030	0.011
CaO	XRF	%	0.208	0.153	0.084	0.043
Cr <sub>2</sub> O <sub>3</sub>	XRF	%	0.005	0.004	0.003	0.001
Fe <sub>2</sub> O <sub>3</sub>	XRF	%	0.205	0.150	0.067	0.041
K <sub>2</sub> O	XRF	%	0.015	0.012	0.006	0.003
LOI		%	0.260	0.220	0.070	0.067
MgO	XRF	%	0.075	0.045	0.046	0.013
MnO	XRF	%	0.023	0.019	0.007	0.005
Na <sub>2</sub> O	XRF	%	0.046	0.037	0.026	0.013
P <sub>2</sub> O <sub>5</sub>	XRF	%	0.057	0.040	0.026	0.012
SiO <sub>2</sub>	XRF	%	0.305	0.203	0.168	0.059
TiO <sub>2</sub>	XRF	%	0.011	0.008	0.005	0.002
SG	pyc		0.098	0.069	0.033	0.018

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. S<sub>w</sub> - 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 Informational 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.

**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, who have maintained measurement traceability during the analytical process.

**15. Certification:** AMIS0356 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. This is the recommended minimum sample size 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 50g to 250g) of material. The Laboratory Packs are sealed bottles delivered in sealed foil pouches. The Explorer Packs contain material in standard geochem envelopes, 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 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, Set Point Technology (Pty) Ltd, Mike McWha, Dr Barry Smee and Smee and Associates Ltd; accept no liability for any decisions or actions taken following the use of the reference material.

3 August 2013

*(Appendix 2 Amended: 04 November 2014)*

**Certifying Officers:**



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

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



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

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

### Appendix 1. – Uncertified trace element statistics

Analyte	Method	Unit	Mean	2SD	RSD%	n
Ag	M/ICP	ppm	1.9	1.3	34.3	72
Al	M/ICP	%	3.1	0.39	6.3	112
As	M/ICP	ppm	53.5	166	155	88
Ba	M/ICP	ppm	8853	11923	67.3	72
Be	M/ICP	ppm	3.8	1.3	17.3	98
Bi	M/ICP	ppm	0.21	0.11	27.0	88
Ca	M/ICP	%	10.9	1.0	4.6	112
Cd	M/ICP	ppm	2.0	0.36	9.0	75
Ce	XRF	ppm	11547	563	2.4	24
Ce	M/ICP	ppm	11032	559	2.5	39
Co	M/ICP	ppm	11.0	3.9	17.6	110
Cr	M/ICP	ppm	79.0	37.9	24.0	118
Cs	M/ICP	ppm	0.24	0.20	42.5	73
Cu	M/ICP	ppm	42.2	18.8	22.3	118
Eu	XRF	ppm	127	55.2	21.7	14
Fe	M/ICP	%	5.6	0.59	5.3	112
Ga	M/ICP	ppm	43.6	44.2	50.6	64
Ge	M/ICP	ppm	4.1	1.5	18.7	24
Hf	M/ICP	ppm	2.1	0.87	20.8	77
In	M/ICP	ppm	0.25	0.07	13.9	79
K	M/ICP	%	0.43	0.03	3.5	106
La	XRF	ppm	8509	102	0.60	24
La	M/ICP	ppm	8307	963	5.8	96
Li	M/ICP	ppm	13.2	7.4	28.0	91
Mg	M/ICP	%	3.5	0.32	4.5	112
Mn	M/ICP	ppm	7020	807	5.7	112
Mo	M/ICP	ppm	52.7	11.9	11.3	108
Na	M/ICP	%	2.0	0.32	7.9	112
Nd	XRF	ppm	2606	318	6.1	16
Ni	M/ICP	ppm	19.3	6.8	17.6	112
P	M/ICP	ppm	10952	1462	6.7	83
Pb	M/ICP	ppm	39.3	6.8	8.6	89
Pr	XRF	ppm	908	77.7	4.3	22
Rb	M/ICP	ppm	11.6	4.3	18.4	77
S	Comb/LECO	%	0.48	0.10	10.3	24
S	M/ICP	%	0.29	0.28	48.8	88
Sb	M/ICP	ppm	0.50	0.24	24.1	91
Sc	Fusion	ppm	28.4	8.5	15.0	16
Se	M/ICP	ppm	2.3	1.4	31.3	29
Si	M/ICP	%	13.4	0.52	1.9	16
Sm	XRF	ppm	129	56.0	21.8	15
Sn	M/ICP	ppm	3.9	1.5	19.0	87
Sr	XRF	ppm	18796	1712	4.6	38
Ta	M/ICP	ppm	3.1	1.7	27.1	74
Te	M/ICP	ppm	0.88	1.6	90.8	80
Th	XRF	ppm	344	880	128	32
Th	M/ICP	ppm	83.4	13.1	7.9	96
Ti	M/ICP	%	0.18	0.04	10.2	96
Tl	M/ICP	ppm	0.22	0.09	20.9	74
U	XRF	ppm	54.2	33.3	30.7	16
U	M/ICP	ppm	4.2	0.51	6.0	103
V	M/ICP	ppm	132	22.7	8.6	111
W	M/ICP	ppm	1.1	0.42	19.7	78
Zn	M/ICP	ppm	251	39.7	7.9	100
Zr	M/ICP	ppm	62.2	43.9	35.3	87

## Appendix 2. – Rare Earth and Rare Earth Oxide content

AMIS0356 Rare Earth Element content by different reporting conventions (Total, Critical, Light, Medium, Heavy).

TREE	2.35	%	La+Ce+Pr+Nd+Sm+Eu+Gd+Tb+Dy+Ho+Er+Tm+Yb+Lu+Y
CREE	0.27	%	Nd+Eu+Tb+Dy+Y
LREE	2.32	%	La+Ce+Pr+Nd
MREE	246	ppm	Sm+Eu+Gd
HREE	25	ppm	Tb+Dy+Ho+Er+Tm+Yb+Lu+Y

AMIS0356 Rare Earth Oxide content by different reporting conventions.

TREO <sup>1</sup>	2.76	%	(La+Ce+Pr+Nd+Sm+Eu+Gd+Tb+Dy+Ho+Er+Tm+Yb+Lu+Y) <sub>2</sub> O <sub>3</sub>
CREO	0.31	%	(Nd+Eu+Tb+Dy+Y) <sub>2</sub> O <sub>3</sub>
LREO <sup>2</sup>	2.72	%	(La+Ce+Pr+Nd) <sub>2</sub> O <sub>3</sub>
MREO	285	ppm	(Sm+Eu+Gd) <sub>2</sub> O <sub>3</sub>
HREO	29	ppm	(Tb+Dy+Ho+Er+Tm+Yb+Lu+Y) <sub>2</sub> O <sub>3</sub>

*1&2. These values corrected to the Ce<sub>2</sub>O<sub>3</sub> conversion factor on 5 November 2014. Previously the factor for CeO<sub>2</sub> had been used.*

*Ref: Rare-Earth Terminology - A Quick Refresher On The Basics, by Gareth Hatch, December 11, 2012; <http://www.techmetalsresearch.com/2012/12/rare-earth-terminology-a-quick-refresher-on-the-basics/>*