



AMIS0185

Certified Reference Material

Rare Earth Elements
Wigu Carbonatite Complex, Tanzania

Certificate of Analysis

Recommended Concentrations and Limits^{1, 2.}
(at two Standard Deviations)

Certified Concentrations^{3.}

Ce M/ICP	4.075	±	0.461	%
La XRF	3.003	±	0.171	%
La M/ICP	2.976	±	0.272	%
Nd M/ICP	9238	±	1033	ppm
Pr M/ICP	3471	±	343	ppm
Sm M/ICP	556	±	48	ppm
Specific Gravity	3.28	±	0.08	

Provisional Concentrations^{3.}

Ce XRF	4.154	±	0.618	%
Dy M/ICP	27.1	±	5.1	ppm
Eu M/ICP	94.2	±	12.1	ppm
Ho M/ICP	3.2	±	0.5	ppm
Tm M/ICP	0.43	±	0.08	ppm
Y M/ICP	62.0	±	7.7	ppm
Y XRF	56.9	±	14.2	ppm

Informational Means

Er M/ICP	4.24	ppm
Gd M/ICP	244	ppm
Lu M/ICP	0.56	ppm
Sc M/ICP	15.4	ppm
Tb M/ICP	15.3	ppm
Yb M/ICP	2.75	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. See Appendix 2 for the oxide conversions.
3. There is additional certified major element data presented on p2 and uncertified trace element data presented as an appendix.
4. TREO = 9.963% (see Appendix 2)

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

Certified Concentrations

Al ₂ O ₃	2.22	±	0.12	%
CaO	11.48	±	0.36	%
Fe ₂ O ₃	5.29	±	0.28	%
LOI	20.69	±	0.64	%
MgO	4.65	±	0.20	%
P ₂ O ₅	1.74	±	0.10	%
S Comb/LECO	1.93	±	0.14	%
SiO ₂	21.53	±	0.82	%

Provisional Concentrations

K ₂ O	0.10	±	0.02	%
MnO	1.09	±	0.16	%
TiO ₂	0.081	±	0.024	%

Informational Means

Cr ₂ O ₃	0.026	%
Na ₂ O	0.17	%

1. **Intended Use:** AMIS0185 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:** AMIS0185 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 Red powder (Corstor colour chart – 10R 6/2).

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 to include REE, Y & Sc.
2. Fusion, ICP- OES or ICP-MS. Multi element scan to include REE, Y & Sc.
3. XRF. Light & Heavy Rare Earth Elements, Y & Sc.
4. XRF fusion. Majors (Al₂O₃, CaO, Cr₂O₃, Fe₂O₃, K₂O, MgO, MnO, Na₂O, P₂O₅, SiO₂, TiO₂. LOI.)
5. S. Combustion analysis.
6. 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: Nineteen laboratories were each given eight packages, comprising eight samples scientifically selected from throughout the batch. Eighteen laboratories reported results in time for certification of the economic elements. Eight of these laboratories reported results for the major elements.

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: (Not in same order as in the table of assays):

1. Alex Stewart International Corporation Zambia
2. ALS Chemex Laboratory Group Brisbane Australia
3. ALS Chemex Laboratory Group Johannesburg SA
4. ALS Chemex Laboratory Group Lima (Peru)
5. ALS Chemex Laboratory Group Perth WA
6. ALS Chemex Laboratory Group Vancouver CA
7. Anglo Research (Crown Campus)
8. Genalysis Laboratory Services (South Africa) Pty
9. Genalysis Laboratory Services WA
10. Intertek Utama Services (Indonesia)
11. OMAC Laboratories Limited (Ireland)
12. Set Point Laboratories (Isando) SA
13. SGS Australia Pty Ltd (Newburn) WA
14. SGS Mineral Services Callao (Peru)
15. SGS Mineral Services Lakefield (Canada)
16. SGS South Africa (Pty) Ltd - Booyens
17. SGS Toronto (Canada)
18. 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. A proficiency report has been sent to the managers of the participating laboratories. Additional digital data from this round robin is available on request.

Lab Code	Ce XRF ppm	Ce M/ICP ppm	Dy M/ICP ppm	Er M/ICP ppm	Eu M/ICP ppm	Gd M/ICP ppm	Ho M/ICP ppm	La XRF ppm	La M/ICP ppm	Lu M/ICP ppm	Nd M/ICP ppm	Pr M/ICP ppm	Sc M/ICP ppm	Sm M/ICP ppm	Tb M/ICP ppm	Tm M/ICP ppm	Y XRF ppm	Y M/ICP ppm	Yb M/ICP ppm
A	40900		29.00	1.50	101.00	144	3.50	30000		0.60	9340	3690	10.00	575	8.00	0.40	64.00	65.00	2.00
A	41300		29.50	1.50	101.00	150	3.50	29300		0.40	9340	3760	20.00	576	8.50	0.40	62.00	65.00	2.00
A	41400		29.50	1.50	101.00	148	3.50	29200		0.60	9510	3860	10.00	588	7.50	0.40	64.00	60.00	2.00
A	41800		29.00	1.50	100.00	144	3.00	29000		0.60	9540	3810	10.00	579	7.50	0.40	62.00	60.00	2.00
A	41600		30.50	1.50	100.00	152	3.50	30300		0.40	9460	3710	10.00	578	7.50	0.40	60.00	65.00	2.00
A	41700		29.00	1.50	100.00	144	3.00	29200		0.40	9300	3760	10.00	579	7.50	0.40	61.00	60.00	2.00
A	41300		29.00	1.50	99.00	142	3.50	29000		0.40	9370	3710	10.00	567	8.00	0.40	63.50	60.00	2.00
A	40400		29.50	1.50	99.50	148	3.00	30200		0.40	9310	3580	20.00	568	8.00	0.60	62.00	65.00	2.00
B		44000	21.10	1.90	88.90	215	1.40		30700	0.13	9670	3550	37.00	576	9.50	0.16	60.00	51.00	0.90
B		45200	21.80	1.90	90.80	227	1.60		31300	0.15	9890	3630	37.00	585	9.90	0.17	60.00	51.00	1.00
B		44700	21.40	1.90	89.00	230	1.50		31300	0.14	9740	3560	37.00	573	9.70	0.16	60.00	52.00	0.90
B		45300	21.70	2.00	91.10	230	1.50		31900	0.13	9910	3610	38.00	587	9.80	0.16	60.00	53.00	0.90
B		45100	21.90	1.90	90.20	228	1.60		31700	0.14	9770	3600	38.00	579	10.30	0.16	60.00	51.00	0.90
B		44500	21.60	1.90	89.50	227	1.50		31200	0.13	9740	3560	38.00	576	9.90	0.16	50.00	52.00	0.90
B		44400	21.50	1.90	88.00	223	1.50		31300	0.13	9680	3560	37.00	569	9.80	0.17	60.00	52.00	0.90
B		43800	21.20	1.90	88.80	231	1.50		30600	0.14	9580	3500	38.00	568	10.20	0.16	60.00	52.00	0.90
C		43234	28.20	5.50	91.80	167	3.20		31502	0.73	9806	3613	16.00	550	14.43	0.40		57.70	1.20
C		43049	27.90	5.40	90.80	163	3.30		31860	0.72	9907	3599	16.00	551	13.71	0.40		59.50	1.10
C		43631	28.40	5.30	90.70	164	3.20		32099	0.79	9900	3645	16.00	550	14.77	0.40		57.50	1.30
C		42921	28.00	5.40	91.70	160	3.20		31704	0.72	9927	3627	17.00	550	14.18	0.40		60.30	1.30
C		43629	28.40	5.40	92.50	169	3.10		32014	0.68	9964	3642	17.00	553	14.48	0.40		59.80	1.40
C		43356	28.50	5.30	91.10	164	3.10		32054	0.78	9842	3659	16.00	549	14.04	0.40		60.90	1.40
C		43616	27.50	5.30	92.40	158	3.00		32273	0.75	10078	3649	16.00	557	13.53	0.50		60.00	1.30
C		42652	28.30	5.20	91.60	161	3.20		31451	0.71	9733	3567	18.00	535	13.61	0.40		59.10	1.30
D	40256	40260	24.42	3.39	94.35		2.84	29901	29900			3123	17.00	519	10.37	0.38	64.58	64.20	
D	40295	40300	26.95	3.04	92.71		2.85	29901	29900			3167	16.00	512	10.46	0.38	63.01	63.00	
D	40036	40040	23.31	3.19	94.24		2.91	29590	29590			3176	16.00	505	9.90	0.37	63.80	63.80	
D	40276	40280	23.43	2.91	94.81		2.90	29821	29820			3202	15.00	515	9.79	0.37	62.22	62.20	
D	39936	39940	26.65	2.59	96.02		2.95	29730	29730			3295	16.00	525	10.17	0.40	65.37	65.50	
D	40256	40260	22.76	3.10	94.50		2.87	29801	29800			3232	15.00	524	10.07	0.39	64.58	64.20	
D	40186	40190	23.92	3.23	94.81		2.95	29770	29770			3278	15.00	527	10.66	0.40	63.80	63.60	
D	40236	40240	24.56	3.29	93.47		2.96	29891	29890			3319	15.00	527	10.67	0.39	62.22	62.30	
E									29400					36.00					108.00
E									28800					36.00					108.00
E									29000					34.00					104.00
E									29300					36.00					108.00
E									28900					34.00					105.00
E									29300					35.00					104.00
E									29100					35.00					105.00
E									29400					35.00					105.00

Assay data (cont)

Lab Code	Al2O3 XRF %	CaO XRF %	Cr2O3 XRF %	Fe2O3 XRF %	K2O XRF %	MgO XRF %	MnO XRF %	Na2O XRF %	P2O5 XRF %	S Comb/LECO %	SiO2 XRF %	TiO2 XRF %	LOI %	SG pycnometer
B	2.52	11.32	0.03	5.23	0.10	4.66	1.14	0.27	1.76	1.98	21.75	0.09	21.75	3.28
B	2.55	11.36	0.04	5.25	0.10	4.63	1.15	0.30	1.78	1.98	21.95	0.09	21.68	3.27
B	2.51	11.28	0.04	5.22	0.10	4.62	1.14	0.25	1.77	1.99	21.80	0.10	21.67	3.32
B	2.51	11.32	0.05	5.24	0.09	4.61	1.15	0.30	1.76	2.00	21.59	0.09	21.70	3.23
B	2.54	11.35	0.03	5.23	0.09	4.61	1.15	0.32	1.77	2.01	21.67	0.10	21.73	3.22
B	2.52	11.37	0.03	5.23	0.09	4.67	1.15	0.26	1.78	2.03	21.77	0.10	21.66	3.23
B	2.55	11.37	0.03	5.23	0.09	4.66	1.15	0.27	1.79	2.03	21.76	0.10	21.59	3.26
B	2.54	11.34	0.03	5.25	0.11	4.65	1.15	0.31	1.79	1.98	21.85	0.09	21.71	3.23
C										2.13				3.21
C										2.04				3.28
C										2.02				3.26
C										2.05				3.31
C										2.03				3.17
C										2.06				3.18
C										2.14				3.32
C										2.09				3.21
D	2.44	11.59	0.01	5.26	0.10	4.69	1.16	0.04	1.79		21.78	0.07	21.56	
D	2.45	11.45	0.01	5.26	0.09	4.70	1.16	0.05	1.78		21.73	0.07	21.02	
D	2.42	11.45	0.01	5.24	0.09	4.67	1.15	0.05	1.77		21.65	0.07	21.14	
D	2.45	11.35	0.01	5.24	0.09	4.67	1.15	0.05	1.78		21.73	0.07	20.96	
D	2.44	11.52	0.01	5.27	0.09	4.71	1.16	0.05	1.76		21.77	0.07	21.20	
D	2.44	11.44	0.01	5.32	0.10	4.68	1.15	0.05	1.81		21.72	0.07	21.15	
D	2.44	11.48	0.01	5.27	0.09	4.72	1.16	0.05	1.79		21.75	0.07	21.29	
D	2.43	11.47	0.01	5.23	0.10	4.67	1.15	0.05	1.78		21.72	0.07	21.22	
E	2.19	10.75			0.10	4.79	0.98	0.32	1.69		21.22	0.09	20.20	3.04
E	2.19	10.77			0.10	4.83	0.97	0.32	1.70		21.11	0.10	20.40	3.09
E	2.20	10.79			0.10	4.80	0.98	0.28	1.70		21.14	0.09	20.30	3.10
E	2.18	10.76			0.10	4.80	0.98	0.31	1.70		21.05	0.09	20.30	3.08
E	2.19	10.78			0.10	4.81	0.99	0.30	1.70		21.07	0.09	20.60	3.03
E	2.18	10.75			0.10	4.81	0.98	0.28	1.70		21.19	0.09	20.40	3.02
E	2.16	10.76			0.10	4.71	0.99	0.36	1.69		20.89	0.09	20.30	3.04
E	2.16	10.77			0.10	4.72	0.99	0.36	1.70		20.94	0.09	20.40	3.01
G	2.28	10.76	0.01	5.29	0.10	4.74	1.10	0.09	1.79	2.00	21.21	0.08	21.09	3.28
G	2.21	10.99	0.01	5.21	0.10	4.69	1.10	0.09	1.78	2.00	21.63	0.08	21.11	3.22
G	2.20	10.99	0.01	5.07	0.09	4.66	1.09	0.09	1.72	1.98	21.35	0.08	21.11	3.31
G	2.24	10.93	0.01	5.22	0.10	4.74	1.11	0.09	1.79	1.99	21.59	0.08	21.12	3.29
G	2.28	11.20	0.01	5.27	0.10	4.82	1.12	0.09	1.79	2.01	21.57	0.08	21.31	3.22
G	2.17	11.05	0.01	4.96	0.10	4.64	1.07	0.09	1.70	2.00	21.54	0.08	21.15	3.22
G	2.33	11.10	0.01	5.42	0.10	4.89	1.15	0.09	1.84	2.02	21.73	0.08	21.14	3.31
G	2.19	11.17	0.01	5.01	0.09	4.65	1.08	0.08	1.73	2.00	21.64	0.08	21.27	3.29
H	3.67	11.30	0.05	5.08	0.09	5.23	0.95	0.13	1.69	1.93	25.00		20.61	3.30
H	3.68	11.30	0.06	5.10	0.09	5.24	0.95	0.13	1.68	1.92	25.20		20.61	3.29
H	3.61	11.30	0.06	5.09	0.09	5.21	0.96	0.13	1.71	1.90	25.40		20.59	3.30
H	3.63	11.30	0.05	5.08	0.09	5.21	0.96	0.13	1.70	1.90	25.30		20.60	3.29
H	3.67	11.30	0.06	5.05	0.08	5.21	0.95	0.13	1.68	1.93	25.40		20.56	3.29
H	3.59	11.30	0.04	5.03	0.08	5.22	0.96	0.13	1.70	1.93	25.20		20.49	3.29
H	3.65	11.30	0.06	5.06	0.08	5.21	0.96	0.13	1.70	1.93	25.20		20.49	3.29
H	3.68	11.30	0.04	5.08	0.09	5.24	0.96	0.13	1.70	1.94	25.10		20.54	3.29
I	2.09	10.60			0.10	4.45	0.99	0.13	1.69	1.80	20.70	0.07	20.34	3.33
I	2.07	10.50			0.10	4.43	0.97	0.12	1.67	1.82	20.50	0.07	20.35	3.35
I	2.09	10.50			0.10	4.45	0.97	0.12	1.68	1.82	20.60	0.07	20.36	3.32
I	2.08	10.50			0.10	4.45	0.97	0.13	1.69	1.88	20.70	0.07	20.36	3.35
I	2.06	10.50			0.10	4.42	0.97	0.13	1.69	1.80	20.70	0.07	20.35	3.32
I	2.09	10.50			0.10	4.43	0.96	0.12	1.68	1.84	20.60	0.07	20.36	3.34
I	2.09	10.50			0.10	4.45	0.97	0.13	1.70	1.92	20.70	0.07	20.34	3.32
I	2.07	10.50			0.10	4.43	0.97	0.12	1.68	1.82	20.70	0.06	20.29	3.36
J	2.20	11.55	0.01	5.19	0.12	4.61	1.16		1.80		21.80	0.10	20.57	
J	2.21	11.55	0.01	5.21	0.12	4.59	1.15		1.80		21.70	0.09	20.78	
J	2.20	11.50	0.02	5.13	0.12	4.64	1.14		1.80		21.70	0.09	20.56	
J	2.20	11.55	0.01	5.21	0.12	4.62	1.16		1.80		21.80	0.09	20.71	
J	2.19	11.55	0.01	5.20	0.12	4.63	1.16		1.82		21.80	0.09	20.49	
J	2.21	11.55	0.01	5.20	0.12	4.65	1.16		1.80		21.90	0.09	20.54	
J	2.22	11.45	0.01	5.15	0.12	4.63	1.14		1.80		21.70	0.09	20.53	
J	2.20	11.50	0.01	5.14	0.12	4.65	1.14		1.80		21.80	0.09	20.67	
K	2.150	10.30	0.01		0.10	4.47		0.20	1.63	1.91	19.90	0.06	20.30	3.22
K	2.180	10.45	0.02		0.10	4.52		0.20	1.65	1.91	20.10	0.06	20.40	3.22
K	2.180	10.45	0.02		0.10	4.53		0.20	1.65	1.93	20.20	0.06	20.40	3.23
K	2.22	10.60	0.02		0.10	4.59		0.20	1.67	1.93	20.40	0.07	20.40	3.24
K	2.16	10.40	0.02		0.10	4.50		0.20	1.64	1.90	19.95	0.06	20.50	3.23
K	2.11	10.10	0.01		0.10	4.37		0.19	1.59	1.90	19.40	0.06	20.30	3.21
K	2.24	10.65	0.03		0.10	4.61		0.21	1.70	1.88	20.60	0.07	20.50	3.21
K	2.13	10.20	0.01		0.10	4.41		0.19	1.61	1.92	19.65	0.06	20.40	3.21
L	2.34	11.40	0.10	5.40	0.11	4.52	1.15	0.26			21.30	0.10	20.74	3.32
L	2.30	11.50	0.10	5.31	0.12	4.48	1.12	0.39			21.20	0.10	20.68	3.29
L	2.28	11.50	0.09	5.42	0.14	4.53	1.13	0.28			21.40	0.11	20.71	3.30
L	2.35	11.50	0.10	5.36	0.19	4.54	1.14	0.28			21.10	0.10	20.81	3.31
L	2.28	11.50	0.12	5.39	0.12	4.54	1.12	0.27			21.00	0.11	20.56	3.29
L	2.36	11.90	0.18	5.50	0.13	4.74	1.16	0.33			21.90	0.12	20.94	3.32
L	2.31	11.50	0.10	5.36	0.12	4.52	1.13	0.28			21.40	0.11	20.20	3.31
L	2.31	11.60	0.10	5.45	0.20	4.51	1.14	0.33			21.30	0.11	20.79	3.31

Assay data (cont)

Lab Code	Al ₂ O ₃ XRF %	CaO XRF %	Cr ₂ O ₃ XRF %	Fe ₂ O ₃ XRF %	K ₂ O XRF %	MgO XRF %	MnO XRF %	Na ₂ O XRF %	P ₂ O ₅ XRF %	S Comb/LECO %	SiO ₂ XRF %	TiO ₂ XRF %	LOI %	SG pycnometer
M	2.21	11.35	0.05		0.10	4.69	1.03	0.19	1.73	1.89	21.10	0.08	21.00	3.06
M	2.23	11.40	0.05		0.10	4.70	1.03	0.19	1.73	1.88	21.10	0.07	20.90	3.06
M	2.20	11.20	0.05		0.10	4.62	1.02	0.19	1.71	1.88	20.80	0.08	21.00	3.08
M	2.22	11.40	0.06		0.10	4.71	1.04	0.20	1.74	1.90	21.10	0.08	20.90	3.03
M	2.24	11.55	0.05		0.10	4.74	1.05	0.20	1.76	1.90	21.30	0.07	20.90	3.05
M	2.25	11.55	0.05		0.10	4.74	1.04	0.20	1.75	1.89	21.30	0.07	20.90	3.06
M	2.25	11.45	0.05		0.10	4.72	1.04	0.19	1.74	1.86	21.20	0.07	20.90	3.12
M	2.22	11.50	0.05		0.10	4.71	1.04	0.20	1.74	1.89	21.20	0.07	20.90	3.07
N	2.22	11.70		5.47	0.12	4.75	1.16	0.04			21.90	0.08	20.50	
N	2.22	11.80		5.53	0.12	4.79	1.17	0.03			22.00	0.09	20.50	
N	2.21	11.70		5.49	0.12	4.77	1.16	0.04			21.90	0.09	20.50	
N	2.23	11.80		5.48	0.12	4.79	1.16	0.04			22.00	0.09	20.50	
N	2.23	11.70		5.47	0.12	4.78	1.15	0.05			22.00	0.09	20.50	
N	2.24	11.70		5.49	0.12	4.77	1.16	0.04			21.90	0.09	20.50	
N	2.22	11.70		5.50	0.12	4.77	1.16	0.05			21.90	0.09	20.60	
N	2.24	11.70		5.47	0.12	4.77	1.15	0.04			21.90	0.09	20.60	
O	2.24	11.70		5.33	0.11	4.62	1.20	0.21	1.81		22.20	0.07	21.20	3.31
O	2.24	11.70		5.39	0.11	4.67	1.17	0.23	1.82		21.90	0.08	21.20	3.29
O	2.21	11.60		5.39	0.11	4.65	1.18	0.26	1.80		22.10	0.08	21.20	3.33
O	2.20	11.60		5.44	0.10	4.62	1.19	0.20	1.82		22.00	0.09	21.20	3.29
O	2.24	11.70		5.47	0.11	4.65	1.16	0.23	1.83		22.10	0.08	21.10	3.36
O	2.27	11.70		5.43	0.11	4.68	1.18	0.27	1.82		22.00	0.09	21.10	3.40
O	2.21	11.70		5.48	0.11	4.66	1.18	0.22	1.80		22.00	0.08	21.20	3.33
O	2.25	11.70		5.47	0.11	4.62	1.19	0.15	1.83		22.00	0.09	21.20	3.34
P	2.37	11.70	0.01	5.40	0.12	4.83	1.16	0.10	1.87	1.85	23.90	0.09	20.40	
P	2.41	11.50	0.01	5.35	0.13	4.71	1.02	0.20	1.58	1.85	23.90	0.08	20.50	
P	2.26	11.10		5.29	0.11	4.59	1.07		1.70	1.91	23.20	0.08	20.40	
P	2.28	11.30		5.18	0.10	4.64	1.10		1.77	1.84	23.70	0.08	20.50	
P	2.32	11.30		5.17	0.10	4.66	1.10	0.10	1.79	1.83	23.80	0.08	20.50	
P	2.34	11.60		5.31	0.10	4.72	1.12		1.73	1.86	24.10	0.08	20.50	
P	2.31	11.60		5.28	0.11	4.73	1.12	0.10	1.76	1.85	24.20	0.09	20.50	
P	2.40	11.90		5.44	0.12	4.77	1.15	0.10	1.81	1.85	24.60	0.09	20.50	

12. Measurement of Uncertainty: 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 ¹	σ _L ²	SW ³	CSU ⁴
Ce	M/ICP	ppm	2304	2169	687	727
La	XRF	ppm	856	889	285	338
La	M/ICP	ppm	1361	1252	515	422
Nd	M/ICP	ppm	516	464	145	148
Pr	M/ICP	ppm	171	130	73	38
Sm	M/ICP	ppm	23.9	17.9	11.0	5.3
SG	pyc		0.048	0.038	0.031	0.014
Al ₂ O ₃	XRF	%	0.064	0.052	0.030	0.017
CaO	XRF	%	0.181	0.136	0.101	0.044
Cr ₂ O ₃	XRF	%	0.019	0.018	0.005	0.006
Fe ₂ O ₃	XRF	%	0.139	0.122	0.062	0.041
K ₂ O	XRF	%	0.011	0.008	0.005	0.002
LOI		%	0.319	0.256	0.096	0.075
MgO	XRF	%	0.104	0.077	0.045	0.023
MnO	XRF	%	0.080	0.066	0.017	0.019
Na ₂ O	XRF	%	0.093	0.075	0.021	0.022
P ₂ O ₅	XRF	%	0.054	0.043	0.021	0.013
S	Comb/LECO	%	0.068	0.061	0.026	0.020
SiO ₂	XRF	%	0.406	0.352	0.134	0.112
TiO ₂	XRF	%	0.012	0.009	0.004	0.003
Ce	XRF	ppm	3088	3496	450	1323
Dy	M/ICP	ppm	2.75	2.34	0.78	0.71
Eu	M/ICP	ppm	7.08	5.97	2.26	1.82
Ho	M/ICP	ppm	0.251	0.199	0.107	0.061
Tm	M/ICP	ppm	0.044	0.028	0.030	0.009
Y	M/ICP	ppm	3.86	2.89	1.31	0.81
Y	XRF	ppm	7.10	9.34	2.10	4.19
Er	M/ICP	ppm	1.72	1.81	0.25	0.64
Gd	M/ICP	ppm	90.1	79.9	7.8	24.1
Lu	M/ICP	ppm	0.339	0.293	0.072	0.089
Sc	M/ICP	ppm	3.45	2.99	1.69	1.02
Tb	M/ICP	ppm	5.24	4.40	0.53	1.27
Yb	M/ICP	ppm	1.33	1.13	0.12	0.33

1. S - Std Dev for use on control charts.
2. σ_L - Betw Lab Std Dev, for use to calculate a measure of accuracy.
3. SW - Within Lab Std 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: AMIS0185 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 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.

14 December 2010

(Appendix 2 added; and minor corrections made to Sections 8 & 9, 3: 8 March 2011)
(Appendix 2 Amended: 05 November 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

Eight of the laboratories submitted significant total digestion / multi element scan trace element data. This data has been compiled and iterated; some of the elements could be certified (if requested). It is presented below for informational use.

Analyte	Method	Unit	Mean	2SD	RSD%	n
Ag	M/ICP	ppm	0.79	0.29	18.42	40
Al	M/ICP	%	1.19	0.21	8.98	63
As	M/ICP	ppm	31.01	37.87	61.07	63
Ba	M/ICP	ppm	59760	76725	64.19	88
Be	M/ICP	ppm	3.59	2.02	28.12	59
Bi	M/ICP	ppm	0.19	0.02	5.07	39
Ca	M/ICP	%	7.66	1.49	9.74	60
Cd	M/ICP	ppm	0.91	0.13	7.24	39
Co	M/ICP	ppm	6.06	2.88	23.77	57
Cr	M/ICP	ppm	48.17	22.12	22.96	64
Cs	M/ICP	ppm	0.21	0.18	44.23	24
Cu	M/ICP	ppm	15.35	9.83	32.00	63
Dy	XRF	ppm	24.50	3.10	6.20	8
Eu	XRF	ppm	120	8.00	3.20	7
Fe	M/ICP	%	3.59	0.39	5.38	56
Ga	M/ICP	ppm	183	155	42.37	40
Ge	M/ICP	ppm	23.38	14.92	31.91	32
Hf	M/ICP	ppm	1.35	1.11	41.06	54
In	M/ICP	ppm	0.31	0.06	9.50	25
K	M/ICP	%	0.08	0.03	20.35	60
Li	M/ICP	ppm	18.50	11.11	30.02	56
Mg	M/ICP	%	2.84	0.21	3.71	56
Mn	M/ICP	ppm	8050	1396	8.67	59
Mo	M/ICP	ppm	22.33	2.52	5.64	65
Na	M/ICP	%	0.07	0.04	28.03	56
Nb	M/ICP	ppm	72.63	88.26	60.76	80
Nd	XRF	ppm	9141	1230	6.70	24
Ni	M/ICP	ppm	12.57	4.14	16.47	56
P	M/ICP	ppm	7535	890	5.90	50
Pb	M/ICP	ppm	145	28.54	9.84	68
Pr	XRF	ppm	3469	564	8.10	16
Rb	M/ICP	ppm	4.70	0.78	8.33	51
Re	M/ICP	ppm	0.02	0.01	26.02	24
S	M/ICP	%	0.17	0.14	40.49	32
Sb	M/ICP	ppm	0.46	0.40	43.22	48
Sc	XRF	ppm	14.90	1.30	4.30	8
Se	M/ICP	ppm	6.12	5.00	40.89	28
Si	M/ICP	%	10.18	0.30	1.47	22
Sm	XRF	ppm	572	115	10.10	20
Sn	M/ICP	ppm	1.13	0.20	8.72	39
Sr	M/ICP	ppm	53344	3848	3.61	64
Ta	M/ICP	ppm	0.16	0.14	43.86	48
Te	M/ICP	ppm	3.46	11.28	163	40
Th	M/ICP	ppm	237	42.29	8.94	88
Ti	M/ICP	%	0.04	0.02	27.66	52
Tl	M/ICP	ppm	0.06	0.08	61.97	29
U	M/ICP	ppm	46.30	9.30	10.04	68
V	M/ICP	ppm	54.15	21.98	20.30	60
W	M/ICP	ppm	1.31	2.11	80.32	43
Y	XRF	ppm	57.00	14.00	12.50	39
Zn	M/ICP	ppm	622	70.32	5.66	72
Zr	M/ICP	ppm	57.49	45.20	39.31	64

Appendix 2. – Rare Earth Oxide content

AMIS0185 Rare Earth Element content by different reporting conventions (Total, Critical, Light, Medium, Heavy).

TREE	8.5	%	(La+Ce+Pr+Nd+Sm+Eu+Gd+Tb+Dy+Er+Tm+Yb+Lu+Y)
CREE	0.9	%	(Nd+Eu+Tb+Dy+Y)
LREE	8.4	%	(La+Ce+Pr+Nd)
MREE	913	ppm	(Sm+Eu+Gd)
HREE	116	ppm	(Tb+Dy+Er+Tm+Yb+Lu+Y)

AMIS0185 Rare Earth Oxide content by different reporting conventions.

TREO	9.963	%	(La+Ce+Pr+Nd+Sm+Eu+Gd+Tb+Dy+Er+Tm+Yb+Lu+Y) ₂ O ₃
CREO	1.099	%	(Nd+Eu+Tb+Dy+Y) ₂ O ₃
LREO	9.844	%	(La+Ce+Pr+Nd) ₂ O ₃
MREO	0.106	%	(Sm+Eu+Gd) ₂ O ₃
HREO	141.079	ppm	(Tb+Dy+Er+Tm+Yb+Lu+Y) ₂ O ₃

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/>