African Mineral Standards
MATRIX MATCHED REFERENCE MATERIALS

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AMIS0304

Certified Reference Material

Rare Earth Elements
Glenover Carbonatite Complex, South Africa

Certificate of Analysis

Recommended Concentrations and Limits[1. 2.]
(at two Standard Deviations)

Certified Concentrations

Ce M/ICP	8090	±	692	ppm
La M/ICP	3610	±	311	ppm
Nd M/ICP	3875	±	442	ppm
Pr M/ICP	1007	±	89	ppm
U M/ICP	24	±	1.7	ppm
Y M/ICP	410	±	39	ppm
Al M/ ICP	8070	±	676	ppm
Ca M/ICP	20.11	±	1.34	%
Fe M/ICP	14.73	±	0.93	%
Mg M/ICP	1.67	±	0.18	%
P M/ICP	7.88	±	0.35	%
P XRF	7.99	±	0.32	%
Si M/ICP	5.81	±	0.34	%
Specific gravity	3.37	±	0.10	

Provisional Concentrations

Sm M/ICP	575	±	70	ppm
Th M/ICP	437	±	67	ppm
Th XRF	450	±	71	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 = $(Nd+Eu+Tb+Dy+Y)_2O_3$ = 0.54% (see Appendix 2)*

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

Certified Concentrations

Al_2O_3	1.52	±	0.08	%
CaO	28.50	±	0.72	%
Fe_2O_3	20.93	±	1.00	%
K_2O	0.28	±	0.02	%
MgO	2.87	±	0.12	%
MnO	0.46	±	0.03	%
P_2O_5	18.35	±	0.74	%
SiO_2	12.31	±	0.40	%
TiO_2	1.80	±	0.08	%
LOI	7.45	±	0.66	%

Indicated Means

Cr_2O_3	0.01	%
Na_2O	0.09	%

1. Intended Use: AMIS0304 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 CRM can also be used for method development and for the calibration of equipment.

2. Origin of Material: AMIS0304 is a commissioned CRM made up of material supplied by Fer-Min-Ore (Pty) Ltd from the Glenover Phosphate Mine on the Glenover Carbonatite Complex. This deposit is located 88km north of Thabazimbi, Limpopo Province, South Africa. The Glenover complex is an irregular pipe like carbonatite body approximately at the centre of a large biotite pyroxenite plug with cone sheets and irregular intrusions of carbonatite emanating from the pipe. Rare Earth Elements are associated with this Carbonatite.

An apatite bearing hematite breccia body, which has been exploited for its phosphate content, is situated at the centre of the biotite pyroxenite, immediately north of the central carbonatite pipe.

3. Mineral and Chemical Composition: The central body of the carbonatite is composed of beforsite, an ankerite rich rock with crystallographic and physical characters resembling dolomite and siderite. The pyroxenite was an earlier event and comprises mainly decomposed biotite-phlogopite. The pyroxenite has been intruded by carbonatite dykes, sills and cone sheets and, where cut by the carbonatite, it has undergone carbonatisation and is veined with beforsite and sovite.

4. Appearance: The material is a very fine powder. It is colored a Moderate Red (Corstor 5R 4/8).

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 ore is crushed, then dry-milled and air classified to 100% <54µ. This fine powder is mixed in a blender for 14 hours and then split down into numbered 1 kg tubs. These lots are sampled for quality control and for round robin analysis. Quality control will typically comprise sampling 30 tubs selected from the whole stream. Round robin samples are selected the same way, so that one laboratory will receive samples from the beginning, end, and from throughout the batch.

7. Methods of Analysis requested:

1. Multi-acid digests, 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, Al, Mg, Si, P, Fe, Ca, U and Th.
3. XRF. Multi element scan to include REE's, Nb, Y, Al, Mg, Si, P, Fe, Ca, U and Th.
4. XRF fusion. Majors (Al_2O_3, CaO, Cr_2O_3, Fe_2O_3, K_2O, MgO, MnO, Na_2O, P_2O_5, SiO_2, TiO_2. 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 one laboratories were each given eight packages, comprising eight samples scientifically selected from throughout the batch. Sixteen laboratories reported results in time for certification of the economic elements.Fourteen 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: The 16 out of 21 laboratories that provided results timeously were (not in same order as in the table of assays):

1 ACME Analytical Laboratories Ltd CA
2 ALS Chemex Laboratory Group Brisbane Australia
3 Amdel Limited Adelaide (South Australia)
4 Ammtec Limited WA
5 ANSTO Minerals Laboratory (Australia)
6 Genalysis Laboratory Services (S Australia A)
7 Genalysis Laboratory Services (W Australia P)
8 Labtium Inc Finland
9 OMAC Laboratories Limited (Ireland)
10 Set Point Laboratories (Isando) SA
11 SGS Australia Pty Ltd (Newburn) WA
12 SGS Geosol Laboratories Ltda (Brazil)
13 SGS Mineral Services Lakefield (Canada)
14 SGS South Africa (Pty) Ltd - Booysens JHB
15 SGS Toronto (Canada)
16 Ultra Trace (Pty) Ltd WA

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

Assay data - Economic and important elements, Ce to U

Lab Code	Ce M/ICP ppm	Ce XRF ppm	La M/ICP ppm	La XRF ppm	Nb M/ICP ppm	Nb XRF ppm	Nd M/ICP ppm	Nd XRF ppm	Pr M/ICP ppm	Pr XRF ppm	Sm M/ICP ppm	Sm XRF ppm	Th M/ICP ppm	Th XRF ppm	U M/ICP ppm	U XRF ppm
A	7990		3500		1670		3420		954		544		423			27.50
A	8120		3650		1800		3490		972		532		464			28.00
A	7840		3510		1960		3380		945		541		423			27.50
A	8380		3680		1990		3600		1010		547		441			27.50
A	7930		3590		1690		3530		990		557		430			25.00
A	7980		3560		1540		3530		990		549		428			27.50
A	8460		3700		1960		3710		1030		560		462			29.00
A	8350		3650		1810		3590		999		573		439			26.50
B	8763		3675		3692	4995	3880		1010		579		434	445	23.39	24.90
B	8746		3617		3717	5061	3770		984		560		441	449	23.21	25.10
B	8687		3532		3671	5075	3827		993		558		422	384	23.33	22.90
B	8721		3677		3591	5110	3828		981		567		432	456	23.37	27.90
B	8664		3650		3654	5148	3882		1007		579		429	395	23.28	20.80
B	8736		3798		3611	5082	3739		981		550		433	451	23.55	26.20
B	8714		3761		3689	5084	3842		999		570		433	454	23.48	26.00
B	8713		3709		3741	5192	3723		963		546		432	467	23.41	27.60
C	7447	7950	3480	3440	5140	5160	4008	3950	944	780.00	566		492	500		60.00
C	7168	7930	3760	3500	4900	5150	3878	4000	897	810.00	565		461	490		50.00
C	7539	7980	3660	3490	5280	5140	3847	3950	943	780.00	534		491	500		30.00
C	7595	8010	3920	3540	5010	5170	3824	4000	959	790.00	532		474	490		40.00
C	7985	7900	3600	3520	4370	5120	3860	3980	998	780.00	547		487	490		50.00
C	8216	8000	3820	3460	4690	5150	3872	4030	1025	790.00	582		503	490		40.00
C	7804	7970	4040	3500	5000	5150	3639	3990	974	800.00	550		482	480		60.00
C	7955	7940	3780	3500	5270	5140	3771	3940	996	790.00	549		493	470		40.00
D						5288								370		35.00
D						5303								387		33.00
D						5192								377		31.00
D						5347								376		30.00
D						5357								386		34.00
D						5317								369		34.00
D						5368								382		32.00
D						5287								374		30.00
E	8340	8303	3520	3581	5000		3760	4004	987	1059	581	647	484	430	25.20	
E	8220	8303	3480	3581	4920		3750	3944	985	1101	584	655	493	430	25.50	
E	8280	8384	3500	3581			3720	4013	978	1101	587	655	497	420	26.00	
E	8200	8221	3490	3496	4860		3710	3995	976	1051	584	647	494	430	25.60	
E	8240	8303	3470	3496	4850		3740	3978	965	1117	593	638	496	410	25.80	
E	8140	8303	3440	3496	4740		3680	3970	965	1092	576	604	480	420	24.20	
E	7970	8384	3360	3496	4900		3580	3970	946	1076	562	664	478	420	24.80	
E	7890	8221	3350	3496	4690		3530	3978	936	1068	560	647	479	430	24.60	
F		8500		3500		5000	4460	4000	1090	1200	585		405	470	25.30	30.00
F		8500		3400		5100	3970	4000	1020	1200	571		399	440	24.60	30.00
F		8500		3500		5200	3680	4000	1040	1100	547		390	460	22.70	60.00
F		8500		3500		5100	4110	4000	1060	1200	556		396	450	24.10	
F		8600		3500		5000	4200	4000	1090	1100	551		394	450	24.40	20.00
F		8500		3600		5200	4200	4000	1070	1200	545		430	490	25.20	50.00
F		8500		3500		5200	4020	4000	1180	1100	533		394	490	25.60	50.00
F		8500		3500		5100	3990	4000	996	1100	557		388	470	24.30	30.00
H	7740		3550		3141		4111		1054		622		326		23.46	
H	7847		3974		4079		4051		1072		605		366		23.01	
H	5418		3706		2400		3571		1021		430		260			
H	6208		3724		3248		3339		1044		488		308			
H	7304		3813		3626		3835		1024		578		355		22.15	
H	7762		3923		4101		4007		1071		614		364		23.29	
H	7665		3821		3350		3957		1059		595		370		23.02	
H	8047		3896		3620		4326		1119		644		388		24.30	
K	9146		3640		7120		4222		1100		632		406		22.00	
K	9251		3688		7160		4284		1108		636		422		24.00	
K	9348		3647		7210		4264		1095		633		404		24.00	
K	9329		3722		6670		4297		1117		636		402		24.00	
K	9194		3648		7020		4173		1090		623		376		24.00	
K	9327		3646		7080		4241		1100		624		406		24.00	
K	9195		3591		6730		4171		1089		612		470		24.00	
K	9201		3657		6650		4153		1084		611		448		22.00	
L	7807		3811		387		3930		961		533		439		23.40	
L	8128		3856		380		4005		974		557		465		24.00	
L	7764		3837		457		3892		957		523		470		23.40	
L	8070		3748		525		4010		978		542		452		23.40	
L	7896		3681		1006		3940		980		543		446		23.20	
L	7827		3815		732		3951		974		538		454		22.50	
L	7800		3676		653		3935		962		530		432		22.70	
L	7943		3667		1020		4020		984		541		442		23.20	

Assay data (cont) – Economic and important elements, Ce to U

Lab Code	Ce M/ICP ppm	Ce XRF ppm	La M/ICP ppm	La XRF ppm	Nb M/ICP ppm	Nb XRF ppm	Nd M/ICP ppm	Nd XRF ppm	Pr M/ICP ppm	Pr XRF ppm	Sm M/ICP ppm	Sm XRF ppm	Th M/ICP ppm	Th XRF ppm	U M/ICP ppm	U XRF ppm
M						5170								440		
M						5420								410		
M						5290								350		
M						5220								330		
M						5250								320		
M						5250								430		
M						5190								430		
M						5090								400		
O						7365								462		22.05
O						7372								463		22.90
O						7379								460		21.20
O						7382								459		22.05
O						7394								462		22.05
O						7378								458		22.05
O						7377								455		22.05
O						7353								459		21.20
P	7705	8100	3311	3600	4742		3717	4500	998		572		433	474.00	25.60	25.20
P	8116	8100	3462	3500	5070		3931	4600	1006		586		441	476.00	24.30	23.90
P	8008	8100	3231	3700	4510		3607	4600	950		544		410	477.00	23.90	23.80
P	7916	8200	3343	3600	4797		3733	4500	967		561		418	484.00	23.80	23.60
P	7737	8200	3314	3600	4823		3697	4600	978		562		432	486.00	23.20	24.10
P	7826	8200	3171	3500	3771		3446	4600	888		521		399	482.00	23.00	22.80
P	7648	8100	3180	3500	4382		3576	4500	926		533		404	460.00	23.60	23.50
P	7672	8300	3183	3500	4075		3424	4600	900		534		406	475.00	24.80	24.50
Q	7950		3601		452		3754		1018		530		449		23.91	
Q	7847		3735		390		3718		1011		517		452		23.93	
Q	7702		3814		445		3643		991		509		456		24.45	
Q	8235		3845		418		3868		1049		546		452		24.50	
Q	8250		3694		506		3866		1037		542		445		23.77	
Q	7905		3582		731		3682		985		520		443		23.34	
Q	8165		3606		679		3831		1029		535		439		23.52	
Q	8433		3728		532		3885		1044		547		447		24.44	
R	8380		3570		5610		4010				623		452		26.00	
R	8450		3600		5680		4010				620		449		25.70	
R	7960		3350		5480		3820		982		595		418		24.40	
R	8030		3440		5660		3880		997		596		430		24.50	
R	8680		3670		5760		4120				634		452		25.90	
R	8290		3510		5590		3970				611		425		24.50	
R	7720		3310		5220		3720		952		569		406		23.60	
R	7890		3390		5350		3850		977		591		412		23.90	
T	8430		3560				4180		1040		608		380		24.20	
T	8420		3560				4190		1040		606		382		24.10	
T	8390		3550				4180		1040		605		378		24.00	
T	8410		3560				4180		1040		607		380		24.00	
T	8420		3560				4180		1040		608		380		24.00	
T	8430		3570				4190		1050		609		382		24.10	
T	8450		3570				4190		1050		608		383		24.10	
T	8440		3570				4190		1050		609		384		24.10	
U	8152		3330		1433		3830		964		606		449		24.12	
U	7837		3301		1439		3706		971		629		452		21.24	
U	8024		3325		1455		3754		978		618		455		23.30	
U	8171		3383		1176		3803		1011		633		466		23.70	
U	8134		3339		1680		3783		982		626		458		23.12	
U	7899		3325		1237		3677		978		614		453		21.82	
U	8137		3457		1740		3831		1032		663		492		22.69	
U	8111		3379		1618		3749		995		636		453		23.24	

Assay data (cont) - Economic elements and important elements, Al to Y

Lab Code	Al M/ICP ppm	Al XRF ppm	Ca M/ICP ppm	Ca XRF ppm	Fe M/ICP ppm	Fe XRF ppm	Mg M/ICP ppm	Mg XRF ppm	P M/ICP ppm	P XRF ppm	S CombLECO %	Si M/ICP ppm	Si XRF ppm	Y M/ICP ppm	Y XRF ppm
A	8300		207000		150000				80000			60100			
A	8500		211000		152000				75600			60400			
A	8300		208000		151000				79600			59800			
A	8500		212000		152000				78000			60300			
A	8300		209000		151000				81200			59800			
A	8400		212000		153000				82600			61000			
A	8300		209000		151000				82200			66100			
A	8500		213000		148000				75400			58600			
B	8018		181839		139264		14917		45409	79260	0.08	59553		400	
B	8217		184084		140365		15096		45113	78916	0.08	59633		414	
B	7916		179521		139862		14882		45604	79117	0.08	59882		399	
B	7852		176508		138590		14644		47530	78920	0.08	60025		395	
B	7977		175510		139189		14181		42699	79130	0.08	56867		401	
B	8282		180255		140583		14929		45400	79012	0.08	59171		400	
B	7872		176341		139473		14811		44537	79069	0.08	58552		404	
B	8106		180621		143562		15237		46591	78681	0.08	59707		398	
C	7644		202994		152169		16840		77592	79358		60426		430	
C	7644		201081		150571		16600		77492	79607		60164		510	
C	7464		197176		147334		16330		79218	79348		59882		440	
C	7594		198007		149532		16460		78719	79208		59782		470	
C	7474		200080		149212		16410		79428	79278		55595		450	
C	7664		201993		151140		16750		78261	79388		61493		470	
C	7444		196865		147463		16240		77961	79368		61170		450	
C	7324		191528		142977		15810		77792	79458		61734		440	
D										83710					368
D										82841					385
D										81533					362
D										81972					362
D										82841					358
D										82841					385
D										82841					378
D										82402					372
E														421	370
E														423	370
E														428	370
E														422	350
E														435	370
E														419	360
E														415	370
E														414	350
F	7700	7700	202000	205000	152000	150000	16700	17000		79300		58000	57600	382	400
F	7900	7900	196000	205000	148000	150000	15600	17200		79600		57000	57500	390	400
F	7200	7800	199000	205000	153000	150000	16300	17000		79600		57000	57300	376	400
F	7800	7800	196000	206000	153000	151000	15600	17000		79800		55000	57600	394	400
F	8000	7800	196000	206000	153000	150000	15700	17100		79600		56000	57900	388	400
F	7800	7800	200000	206000	146000	151000	15800	17100		79500		53000	57600	354	400
F	7900	7900	201000	205000	159000	149000	16300	17000		79500		56000	57500	374	300
F	8200	7900	198000	205000	147000	150000	15700	17200		79500		56000	57700	377	400
H	8365		205053				16237		42246						
H	8500		225250				17574		34420						
H	8601		205791				15983		33465						
H	8459		207543				16126		39639						
H	8643		211871				16545		42138						
H	8814		214326				16581		38579						
H	8422		208734				16331		46306						
H	8710		214750				16788		47510						

Assay data (cont) - Economic and important elements, Al to Y

Lab Code	Al M/ICP ppm	Al XRF ppm	Ca M/ICP ppm	Ca XRF ppm	Fe M/ICP ppm	Fe XRF ppm	Mg M/ICP ppm	Mg XRF ppm	P M/ICP ppm	P XRF ppm	S CombLECO %	Si M/ICP ppm	Si XRF ppm	Y M/ICP ppm	Y XRF ppm
K	7600		194000		144000		16800		78916	78916		55000		418	
K	7600		197000		147000		16800		78916	78916		56000		424	
K	8000		201000		150000		17200		78480	78480		57000		422	
K	8400		202000		149000		17200		78916	78916		57000		426	
K	7600		202000		147000		17200		78480	78480		56000		416	
K	8400		205000		149000		17600		79352	79352		57000		416	
K	7600		194000		144000		16800		78916	78916		55000		404	
K	8400		201000		147000		17200		78916	78916		57000		406	
L	8300		198106		153000		16684		76400			59000		439	
L	8600		197501		154900		17112		76500			61000		435	
L	8300		191874		154700		16592		79000			59000		434	
L	8600		187883		154300		16260		81200			60000		421	
L	8500		192627		153900		16715		80900			58000		421	
L	8400		187506		151700		16310		79000			59000		427	
L	8500		193473		152800		16323		78700			59000		428	
L	8600		188525		155400		16668		81200			60000		437	
M										82840	0.08				
M										81968	0.08				
M										81968	0.08				
M										81532	0.07				
M										81532	0.07				
M										81532	0.07				
M										81532	0.07				
M										81968	0.07				
O										80660	0.08				404.00
O										80224	0.09				398.00
O										80660	0.09				402.00
O										80660	0.09				399.00
O										80660	0.09				398.00
O										80660	0.09				394.00
O										81096	0.09				401.00
O										81096	0.09				403.00
P	8056	8200	207851	193800	149392	132700	17160	15500	80834	78393		57340		397	386.50
P	8003	8500	206635	198200	150651	134200	17280	15800	81052	78567		57011		401	372.20
P	8003	8600	205920	201000	149182	135400	17880	15900	79526	78829		58985		391	381.40
P	8056	8500	205062	199300	150301	136300	17520	15900	82230	78611		57340		386	375.30
P	8109	8600	208423	200700	150301	136300	17340	16000	80268	78262		57387		378	387.60
P	7897	8300	205277	195000	149042	129500	17880	15600	80137	78000		59220		361	368.80
P	7897	8400	204776	200500	148832	136600	17760	15800	80529	78654		59079		373	377.40
P	8003	8600	207493	201000	148273	137300	18000	16000	79701	78480		59220		353	388.70
Q	8300		194525		143500		16803		80800			57000		422	
Q	8100		193602		141100		16561		80900			57000		424	
Q	7800		195597		146600		17022		80400			55000		424	
Q	8500		195616		146800		16752		83000			59000		427	
Q	8300		196718		146200		16895		84300			59000		432	
Q	8100		189528		139000		16205		79300			56000		417	
Q	8100		188920		140800		16364		81800			57000		424	
Q	8700		190865		142100		16666		79300			57000		436	
R	7900		200000		143000		16200		89000		0.08			397	
R	7700		199000		144000		16100		88300		0.07			406	
R	7600		199000		143000		16100		88000		0.07			390	
R	7700		196000		143000		16200		85800		0.07			391	
R	7800		198000		143000		16000		87100		0.07			391	
R	7600		197000		142000		15900		88200		0.07			396	
R	7800		200000		144000		16100		88000		0.07			394	
R	7700		196000		143000		16100		88000		0.07			392	
T			207000		150000		18300		78800	75864		57100			
T			206000		153000		18600		78600	78044		56900			
T			205000		149000		18600		77100	76736		56800			
T			207000		152000		18600		77500	78044		57300			
T			207000		150000		18800		77200	77172		57500			
T			206000		151000		18700		77100	76736		56000			
T			206000		152000		18500		77300	76736		56800			
T			204000		150000		18500		76700	76736		56200			
U	7919		182570		140914	147170	17381		77167	81384		57916		398	
U	7813		178679		137361	147600	17117		75675	81903		56583		394	
U	7997		184227		142264	145560	17470		77986	81406		58669		404	
U	7921		183616		141055	145840	17309		77769	80760		57479		403	
U	7991		182604		142119	146610	17365		76672	81227		57733		403	
U	7776		179588		140301	145520	17030		75774	81462		57001		398	
U	8137		186865		148209	145530	17864		77868	81327		59224		413	
U	7977		181849		142863	147550	17318		76708	81693		57707		407	

Assay data- Major Oxides and Specific Gravity

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 %	SG pyc %
A	1.51	28.85		21.58	0.29	2.91	0.47	0.12	18.45	12.32	1.85	7.12	3.42
A	1.52	28.84		21.65	0.28	2.93	0.47	0.12	18.45	12.36	1.85	7.10	3.45
A	1.52	28.79		21.61	0.29	2.91	0.47	0.12	18.49	12.34	1.84	7.09	3.40
A	1.52	28.86		21.62	0.28	2.93	0.47	0.13	18.51	12.33	1.84	7.08	3.44
A	1.50	28.83		21.57	0.28	2.93	0.47	0.12	18.46	12.31	1.84	7.10	3.48
A	1.51	28.83		21.67	0.28	2.92	0.47	0.12	18.51	12.32	1.83	7.10	3.47
A	1.51	28.92		21.66	0.29	2.93	0.47	0.12	18.52	12.34	1.84	7.09	3.41
A	1.50	28.82		21.64	0.29	2.92	0.47	0.13	18.51	12.33	1.84	7.09	3.42
B	1.48	28.45	0.01	20.48	0.28	2.82	0.29	0.10	18.18	12.60	1.80	7.17	
B	1.48	28.32	0.01	20.35	0.27	2.81	0.29	0.08	18.10	12.55	1.77	7.38	
B	1.48	28.38	0.01	20.43	0.28	2.83	0.29	0.09	18.15	12.55	1.78	7.23	
B	1.48	28.39	0.01	20.41	0.27	2.81	0.29	0.09	18.10	12.54	1.78	7.23	
B	1.48	28.43	0.01	20.42	0.27	2.82	0.29	0.09	18.15	12.51	1.79	7.41	
B	1.48	28.43	0.01	20.50	0.28	2.81	0.29	0.09	18.12	12.58	1.79	7.02	
B	1.47	28.40	0.01	20.36	0.27	2.81	0.29	0.09	18.14	12.50	1.78	7.29	
B	1.48	28.28	0.01	20.50	0.27	2.82	0.29	0.08	18.05	12.50	1.78	7.36	
C	1.54	29.24		21.32	0.27	2.89	0.47		18.20	12.06	1.80		
C	1.54	29.32	0.01	21.42	0.27	2.91	0.47		18.26	12.02	1.84		
C	1.56	29.28	0.01	21.43	0.27	2.91	0.47		18.20	12.00	1.83		
C	1.53	29.21	0.01	21.46	0.27	2.92	0.48		18.17	12.09	1.86		
C	1.52	29.22	0.02	21.37	0.27	2.89	0.47		18.18	12.09	1.84		
C	1.54	29.15		21.35	0.27	2.89	0.47		18.21	12.03	1.84		
C	1.53	29.16		21.44	0.27	2.89	0.47		18.20	12.00	1.84		
C	1.53	29.21		21.41	0.27	2.90	0.47		18.22	12.08	1.84		

Assay data (cont) - Major Oxides and Specific Gravity

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 %	SG pyc %
D	1.63	28.61		21.40		3.07			19.20	13.44		7.71	3.33
D	1.57	28.47		21.30		3.02			19.00	13.26		7.78	3.35
D	1.54	28.14		21.00		2.95			18.70	13.14		7.76	3.34
D	1.56	28.45		21.40		2.97			18.80	13.22		7.78	3.33
D	1.56	28.59		21.30		2.97			19.00	13.35		7.82	3.33
D	1.58	28.57		21.40		2.98			19.00	13.31		7.78	3.36
D	1.54	28.66		21.50		2.97			19.00	13.31		7.79	3.32
D	1.56	28.49		21.30		2.97			18.90	13.26		7.74	3.35
E	1.55	28.10	0.01	20.90	0.28	2.91	0.45	0.10	16.90	12.60	1.72	7.11	
E	1.59	28.20	0.01	21.10	0.30	2.94	0.46	0.09	16.95	12.65	1.74	7.39	
E	1.62	28.70	0.01	21.30	0.28	2.99	0.47	0.09	17.25	12.90	1.76	7.23	
E	1.56	28.20	0.01	20.90	0.29	2.93	0.46	0.09	16.90	12.50	1.74	7.19	
E	1.60	28.30	0.01	21.10	0.26	2.94	0.46	0.09	16.90	12.65	1.74	7.19	
E	1.60	28.50	0.01	21.30	0.30	2.96	0.46	0.09	17.05	12.80	1.75	7.19	
E	1.52	27.50	0.01	20.40	0.26	2.83	0.44	0.09	16.55	12.20	1.70	7.28	
E	1.54	27.50	0.01	20.50	0.28	2.88	0.45	0.09	16.55	12.35	1.70	7.21	
F	1.45	28.70	0.01	21.50	0.28	2.83	0.46	0.11		12.30	1.81	7.27	
F	1.49	28.70	0.02	21.40	0.27	2.86	0.46	0.11		12.30	1.82	7.27	
F	1.48	28.70	0.02	21.40	0.28	2.82	0.47	0.11		12.30	1.82	7.23	
F	1.48	28.80	0.01	21.60	0.28	2.81	0.46	0.10		12.30	1.83	7.17	
F	1.48	28.80	0.01	21.50	0.28	2.84	0.47	0.12		12.40	1.83	7.24	
F	1.47	28.80	0.02	21.60	0.28	2.83	0.47	0.11		12.30	1.83	7.23	
F	1.49	28.60	0.02	21.40	0.28	2.82	0.46	0.11		12.30	1.82	7.24	
F	1.49	28.60	0.02	21.50	0.29	2.85	0.47	0.11		12.30	1.82	7.27	
K	1.47	27.90		20.30	0.27	2.81	0.45	0.08	18.10	12.10	1.80	7.07	
K	1.47	28.10		20.30	0.27	2.81	0.45	0.07	18.10	12.10	1.80	7.04	
K	1.46	27.90		20.30	0.28	2.81	0.45	0.08	18.00	12.00	1.78	7.05	
K	1.47	28.10		20.30	0.28	2.80	0.45	0.07	18.10	12.10	1.80	7.03	
K	1.48	27.90		20.20	0.27	2.82	0.45	0.07	18.00	12.00	1.78	7.02	
K	1.47	28.10		20.30	0.28	2.81	0.45	0.08	18.20	12.10	1.80	7.01	
K	1.47	28.10		20.30	0.28	2.82	0.45	0.08	18.10	12.10	1.79	7.04	
K	1.47	28.20		20.40	0.28	2.82	0.45	0.07	18.10	12.10	1.81	7.01	
L													3.31
L													3.38
L													3.41
L													3.50
L													3.44
L													3.39
L													3.34
L													3.34
M	1.55	29.90	0.01	21.60	0.29	2.89	0.47	0.11	19.00	12.50	1.88	7.15	
M	1.57	29.60	0.01	21.60	0.28	2.86	0.48	0.11	18.80	12.30	1.85	7.10	
M	1.55	29.50	0.01	21.40	0.29	2.88	0.47	0.16	18.80	12.40	1.88	7.13	
M	1.56	29.50	0.02	21.20	0.27	2.86	0.46	0.09	18.70	12.50	1.85	7.20	
M	1.55	29.60	0.01	21.50	0.27	2.92	0.47	0.08	18.70	12.40	1.84	7.23	
M	1.53	29.60	0.01	21.50	0.29	2.90	0.46	0.12	18.70	12.40	1.87	7.26	
M	1.53	29.30	0.00	21.30	0.29	2.89	0.46	0.15	18.70	12.30	1.85	7.16	
M	1.56	29.40	0.01	21.40	0.28	2.86	0.47		18.80	12.40	1.86	7.18	
O	1.20	28.40	0.01	20.70	0.26	2.92	0.47		18.50	12.30	1.99	7.70	3.35
O	1.20	28.70	0.01	20.60	0.26	2.86	0.46		18.40	12.00	2.00	7.68	3.38
O	1.20	28.20	0.01	20.70	0.26	2.90	0.47		18.50	12.40	2.00	7.65	3.37
O	1.20	28.40	0.01	20.70	0.26	2.89	0.47		18.50	12.30	2.00	7.68	3.37
O	1.20	28.10	0.01	20.60	0.26	2.87	0.46		18.50	12.10	1.99	7.64	3.39
O	1.20	28.20	0.01	20.60	0.26	2.87	0.47		18.50	12.30	1.99	7.68	3.35
O	1.20	28.70	0.01	20.50	0.27	2.90	0.47		18.60	12.50	1.99	7.67	3.37
O	1.20	28.50	0.01	20.50	0.27	2.89	0.47		18.60	12.40	1.99	7.69	3.38
P	1.54	28.48	0.01	20.86	0.24	2.93	0.41	0.08	17.98	12.40	1.77	8.10	3.14
P	1.52	28.40	0.01	20.71	0.22	2.92	0.40	0.12	18.02	12.40	1.78	7.90	3.21
P	1.56	28.55		20.96	0.23	2.95	0.41	0.10	18.08	12.40	1.79	7.80	3.22
P	1.56	28.47		20.86	0.23	2.92	0.41	0.11	18.03	12.40	1.75	7.90	3.18
P	1.53	28.31		20.84	0.23	2.92	0.40	0.10	17.95	12.30	1.75	7.90	3.12
P	1.51	28.21	0.01	20.73	0.25	2.91	0.40	0.12	17.89	12.30	1.75	8.00	3.21
P	1.50	28.42		20.79	0.22	2.94	0.40	0.07	18.04	12.30	1.76	7.90	3.14
P	1.53	28.42		20.89	0.22	2.93	0.41	0.09	18.00	12.30	1.75	7.80	3.10
Q													3.36
Q													3.39
Q													3.41
Q													3.46
Q													3.39
Q													3.43
Q													3.44
Q													3.43
T	1.60	27.80		20.50	0.33	2.78	0.44	0.12	17.40	11.90	1.73	7.62	3.39
T	1.71	28.10		20.80	0.33	2.89	0.45	0.40	17.90	12.30	1.76	7.66	3.35
T	1.62	28.00		20.80	0.33	2.82	0.44	0.21	17.60	12.00	1.75	7.69	3.39
T	1.63	27.90		20.70	0.33	2.86	0.44	0.11	17.90	12.10	1.76	7.65	3.39
T	1.58	27.70		20.20	0.32	2.76	0.45	0.24	17.70	12.00	1.72	7.69	3.35
T	1.71	27.60		20.50	0.32	2.84	0.44	0.13	17.60	12.00	1.72	7.74	3.38
T	1.74	27.60		20.50	0.32	2.87	0.44	0.23	17.60	12.10	1.71	7.67	3.40
T	1.72	27.60		20.50	0.33	2.88	0.43	0.21	17.60	12.10	1.72	7.67	3.35

Assay data (cont) - Major Oxides and Specific Gravity

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 %	SG pyc %
U	1.52	28.73		20.36	0.28	2.77	0.44	0.07	18.67	12.67	1.83	7.88	3.30
U	1.51	28.82		20.42	0.28	2.81	0.44		18.79	12.67	1.82	7.95	3.29
U	1.52	28.45		20.14	0.29	2.76	0.43	0.05	18.67	12.51	1.81	7.90	3.32
U	1.51	28.43		20.18	0.28	2.76	0.43	0.06	18.52	12.46	1.80	7.82	3.29
U	1.54	28.69		20.29	0.29	2.79	0.43	0.09	18.63	12.67	1.83	8.04	3.33
U	1.46	28.51		20.13	0.28	2.77	0.43	0.06	18.68	12.62	1.81	7.94	3.30
U	1.53	28.57		20.14	0.28	2.78	0.43	0.06	18.65	12.52	1.80	7.86	3.31
U	1.54	28.87		20.42	0.29	2.79	0.44	0.07	18.74	12.64	1.83	7.83	3.30

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:

Combined standard uncertainty=sqrt((between lab.var/no of labs) + (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	346.3	242.7	209.1	76.57
La	M/ICP	ppm	155.3	111.6	89.50	35.01
Nd	M/ICP	ppm	220.9	151.2	114.5	43.47
Pr	M/ICP	ppm	44.31	29.63	22.16	8.529
Sm	M/ICP	ppm	35.05	25.38	14.96	7.195
Th	M/ICP	ppm	33.50	25.57	14.63	7.530
Th	XRF	ppm	35.50	36.13	15.03	13.81
U	M/ICP	ppm	0.832	0.458	0.635	0.155
Y	M/ICP	ppm	19.66	16.40	7.708	5.261
Al	M/ICP	ppm	337.9	247.5	184.4	77.25
Ca	M/ICP	ppm	6716	5620	2943	1808
Fe	M/ICP	ppm	4649	3659	2071	1125
Mg	M/ICP	ppm	877.2	714.9	303.6	218.1
P	M/ICP	ppm	1761	1127	1391	436
P	XRF	ppm	1590	1435	347.0	455.5
Si	M/ICP	ppm	1716	1225	1091	406.5
Al2O3	XRF	%	0.037	0.030	0.017	0.010
CaO	XRF	%	0.356	0.281	0.139	0.086
Cr2O3	XRF	%	0.002	0.001	0.001	0.001
Fe2O3	XRF	%	0.501	0.408	0.142	0.119
K2O	XRF	%	0.009	0.007	0.006	0.002
LOI		%	0.327	0.285	0.064	0.086
MgO	XRF	%	0.059	0.045	0.024	0.013
MnO	XRF	%	0.013	0.012	0.005	0.004
Na2O	XRF	%	0.020	0.017	0.010	0.006
P2O5	XRF	%	0.367	0.331	0.079	0.105
SiO2	XRF	%	0.202	0.159	0.090	0.049
TiO2	XRF	%	0.043	0.037	0.013	0.012
SG	pyc	%	0.046	0.044	0.025	0.017

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 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 of each certificate fulfill the AMIS statistical criteria regarding agreement for certification and have been independently validated by Dr Barry Smee, BSc, PhD, P.Geo, (B.C.).

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: AMIS0304 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.

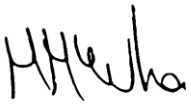
18. Availability: This product is available in Laboratory Packs containing 1kg of material and Explorer Packs containing custom weights (from 50g to 250g) of material. The Laboratory Packs are sealed bottles delivered in sealed foil pouches. The Explorer Packs contain material in standard geochem envelopes,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

10 May 2012 *(Appendix 2 Added: 05 November 2013)*

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	2.2	0.37	8.6	14
As	M/ICP	ppm	54.3	28.3	26.0	41
Au	M/ICP	ppm	105	5.8	2.8	8
Ba	M/ICP	ppm	2525	298	5.9	48
Be	M/ICP	ppm	35.8	9.9	13.8	48
Bi	M/ICP	ppm	3.1	2.9	47.4	38
Cd	M/ICP	ppm	0.52	0.09	8.5	40
Co	M/ICP	ppm	98.7	8.6	4.4	54
Cr	M/ICP	ppm	86.2	40.0	23.2	46
Cs	M/ICP	ppm	0.43	0.11	13.4	38
Cu	M/ICP	ppm	254	80.6	15.9	48
Ga	M/ICP	ppm	35.1	64.7	92.3	31
Ge	M/ICP	ppm	11.1	5.3	23.8	16
Hf	M/ICP	ppm	16.9	22.6	66.9	64
In	M/ICP	ppm	1.04	0.14	6.9	38
K	M/ICP	%	0.27	0.05	9.6	55
Li	M/ICP	ppm	19.5	11.9	30.4	45
Mn	M/ICP	ppm	3347	405	6.1	52
Mo	M/ICP	ppm	7.2	2.0	13.7	47
Na	M/ICP	%	0.08	0.01	7.0	32
Ni	M/ICP	ppm	53.5	17.4	16.2	45
Pb	M/ICP	ppm	81.9	65.0	39.7	31
Rb	M/ICP	ppm	10.9	1.6	7.5	54
Re	M/ICP	ppm	0.01	0.00	16.5	8
S	M/ICP	%	0.05	0.04	42.2	32
Sb	M/ICP	ppm	203	712	175	32
Se	M/ICP	ppm	19.3	1.1	2.9	8
Sn	M/ICP	ppm	16.2	15.6	48.2	63
Sr	M/ICP	ppm	3515	324	4.6	46
Ta	M/ICP	ppm	5.4	10.7	98.2	64
Te	M/ICP	ppm	0.69	0.12	8.9	22
Ti	M/ICP	%	0.56	0.83	73.6	24
Tl	M/ICP	ppm	304	1797	295	34
V	M/ICP	ppm	332	67.9	10.2	40
W	M/ICP	ppm	3.7	4.3	57.6	40
Zn	M/ICP	ppm	79.4	10.9	6.9	46
Zr	M/ICP	ppm	1002	396	19.8	45

Appendix 2. – Rare Earth Oxide content

AMIS0304 Rare Earth Element content by different reporting conventions (Total, Critical, Light, Medium, Heavy).

TREE	1.8	%	(La+Ce+Pr+Nd+Sm+Eu+Tb+Dy+Yb+Y)
CREE	0.463	%	(Nd+Eu+Tb+Dy+Y)
LREE	1.658	%	La+Ce+Pr+Nd
MREE	739	ppm	(Sm+Eu)
HREE	763	ppm	(Tb+Dy+Yb+Y)

AMIS0304 Rare Earth Oxide content by different reporting conventions.

TREO	2.149	%	(La+Ce+Pr+Nd+Sm+Eu+Tb+Dy+Yb+Y)2O3
CREO	0.54	%	(Nd+Eu+Tb+Dy+Y)2O3
LREO	1.99	%	(La+Ce+Pr+Nd)2O3
MREO	0.086	%	(Sm+Eu)2O3
HREO	0.076		(Tb+Dy+Yb+Y)2O3

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/