



African Mineral Standards

MATRIX REFERENCE MATERIALS

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AMIS0248

Certified Reference Material

**Copper cobalt oxide ore
Kinsevere, DRC**

Certificate of Analysis

Recommended Concentrations and Limits¹ (at two Standard Deviations)

Certified Concentrations²

Co F	4807	±	348	ppm
Co M/ICP	4653	±	471	ppm
Co P	4673	±	283	ppm
Cu F	18.599	±	0.965	%
Cu M/ICP	18.567	±	0.622	%
Cu P	18.571	±	0.892	%
Specific Gravity	3.21	±	0.12	

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.

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

Certified Concentrations

Al ₂ O ₃	5.96	±	0.30	%
Fe ₂ O ₃	9.26	±	0.60	%
K ₂ O	0.88	±	0.08	%
MgO	2.92	±	0.12	%
MnO	0.10	±	0.01	%
SiO ₂	42.98	±	0.78	%
TiO ₂	0.45	±	0.04	%
LOI	12.22	±	0.34	%

Provisional Concentrations

CaO	0.11	±	0.04	%
Cr ₂ O ₃	0.04	±	0.01	%

Indicated Means

Na ₂ O	0.07	%
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1. Intended Use: AMIS0248 can be used to check analysis of samples of copper cobalt ores with a similar grade and matrix.

It is a matrix matched Certified Reference Material (CRM) 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: AMIS0248 is a commissioned CRM made from "FM" material supplied by SGS Minerals Services from the Kinsevere Copper Mine, 27 km north on Lubumbashi, in the Katanga Province of the Democratic Republic of Congo (DRC). Kinsevere, formerly owned by Anvil Mining Limited, is now 95% owned by Minmetals Resources.

The Kinsevere Project comprises three known structurally modified stratiform copper deposits; Tshifufia, Tshifufiamashi and Kinsevere Hill. These are hosted within interbedded calcareous siltstones and silty dolomites of the Mines Group, overturned to a steep eastward dip during the Lufilian Orogeny (approximately 550 Ma). Deep weathering, extending to approximately 100 m below surface, has led to the development of a large oxide resource hosted by highly altered dolomitic and argillaceous sediments. Underlying sulphide mineralisation comprises chalcopyrite in crosscutting veins and stringers.

3. Mineral and Chemical Composition: Oxide ore mineralogy at Tshifufia, Tshifufiamashi and Kinsevere Hill is composed predominantly of malachite and pseudomalachite, with minor chrysocolla and rare intergrown heterogenite. These occur as disseminations and/or in veins and veinlets, which sometimes coalesce into prominent "clots". Underlying sulphide mineralisation comprises chalcopyrite, chalcocite, and bornite; typically occurring as finely disseminated, bedding parallel layers, stratiform veins or as replacement of pyrite nodules. Lesser cross cutting quartz-carbonate- sulphide veins are also observed. Sulphide remobilisation during faulting has also led to the development of variably mineralised breccias.

4. Appearance: The material is a very fine powder. It is colored a Pale Olive (Corstor 5Y 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 <54µm. Wet sieve particle size analysis of random samples confirmed the material was 98.5% <54µm. It was then homogenized in a double cone blender, systematically divided and 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. Co, Cu. Fusion AAS or ICP-OES (F).
2. Multi-acid digest multi-element scan - (to include Co, Cu). ICP-OES or ICP-MS (M/ICP).
3. Aqua regia digest – Co, Cu. ICP-OES or ICP-MS (P).
4. Pressed pellet multi-element scan - (to include Co, Cu) (XRF).
5. Majors (Al₂O₃, CaO, Cr₂O₃, Fe₂O₃, K₂O, MgO, MnO, Na₂O, SiO₂, TiO₂. LOI.) XRF fusion.
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.
4. All results for base metals to be reported in ppm.
5. Report all QC data, to include replicates, blanks and certified reference materials used.

9. Method of Certification: Twenty two laboratories were each given eight packages, comprising eight samples scientifically selected from throughout the batch. Seventeen laboratories reported 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 17 out of 22 laboratories that provided results timeously were (not in same order as in the table of assays):

1. Activation Laboratories Pty Ltd (ActLabs) CA
2. Alex Stewart International Corporation Zambia
3. ALS Chemex Laboratory Group Brisbane Australia
4. ALS Chemex Laboratory Group Johannesburg SA
5. ALS Chemex Laboratory Group Vancouver CA
6. Genalysis Laboratory Services (South Africa) Pty
7. Genalysis Laboratory Services W Australia
8. Intertek Utama Services (Indonesia)
9. Set Point Laboratories (Isando) SA
10. SGS Australia Pty Ltd (Newburn) WA
11. SGS Durango (Mexico)
12. SGS Geosol Laboratories Ltda (Brazil)
13. SGS Mineral Services Callao (Peru)
14. SGS Mineral Services Lakefield (Canada)
15. SGS South Africa (Pty) Ltd - Booyens JHB
16. SGS Toronto (Canada)
17. 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

Lab Code	Co F ppm	Co M/ICP ppm	Co P ppm	Co XRF ppm	Cu F ppm	Cu M/ICP ppm	Cu P ppm	Cu XRF ppm	Al2O3 XRF %	CaO XRF %	Cr2O3 XRF %	Fe2O3 XRF %	K2O XRF %	MgO XRF %	MnO XRF %	Na2O XRF %	SiO2 XRF %	TiO2 XRF %	LOI %	S Comb LECO %	SG pyc
C	4710	4800			180000				5.84	0.13		8.74	0.87	3.08	0.09	0.09					
C		4570	4870		184000				5.91	0.11		8.98	0.88	3.03	0.09	0.08					
C		4560	4760		186000				5.93	0.11		8.94	0.87	3.10	0.09	0.08					
C		4510	4770		186000				5.93	0.11		8.84	0.86	3.03	0.09	0.08					
C		4440	4790		187000				5.80	0.11		8.86	0.88	2.92	0.09	0.08					
C		4510	4740		185000				5.95	0.11		8.65	0.86	2.92	0.09	0.11					
C		4570	4760		181000				5.59	0.11		8.66	0.86	2.95	0.09	0.08					
C		4630	4760		186000				5.74	0.11		8.69	0.88	2.92	0.09	0.08					
D	4666	4209	4310						6.01	0.11		9.26	0.90	2.98	0.10	0.08					
D	5155	4060	4459						5.84	0.11		9.18	0.88	2.87	0.09	0.08					
D	5072	4181	4420						6.01	0.11		8.96	0.89	2.98	0.10	0.08					
D	5033	4199	4475						5.95	0.11		8.85	0.87	2.97	0.09	0.08					
D	4978	4220	4464						5.73	0.11		8.94	0.89	2.85	0.09	0.08					
D	4361	3901	4407						5.90	0.11		8.66	0.88	2.95	0.09	0.08					
D	4408	4089	4610						5.93	0.11		9.24	0.89	2.95	0.09	0.08					
D	4682	4179	4508						5.97	0.11		9.25	0.89	2.97	0.09	0.08					
E		4350	4650		191000											0.07					
E		4420	4780		187000											0.08					
E		4300	4900		188000											0.07					
E		4380	4740		186000											0.08					
E		4470	5170		187000											0.07					
E		4360	4840		189000											0.07					
E		4500	4710		187000											0.07					
E		4580	4800		186000											0.08					
G	4420	4760	4620		181000	181000	185000		6.03	0.11	0.03	9.24	0.88	2.97	0.09	0.08	43.15	0.45	12.21		3.30
G	4620	4800	4620		184000	184000	180000		6.05	0.11	0.03	9.25	0.88	2.97	0.09	0.08	43.18	0.44	12.16		3.31
G	4520	4840	4720		182000	184000	186000		6.05	0.11	0.03	9.23	0.88	2.95	0.09	0.08	43.19	0.44	12.19		3.29
G	4380	4830	4700		181000	181000	188000		6.04	0.11	0.03	9.23	0.88	2.95	0.09	0.08	43.18	0.44	12.15		3.31
G	4540	4850	4720		183000	184000	183000		6.05	0.11	0.03	9.21	0.88	2.95	0.09	0.08	43.18	0.43	12.20		3.29
G	4820	4820	4760		187000	187000	187000		6.04	0.11	0.03	9.22	0.88	2.95	0.09	0.08	43.14	0.44	12.12		3.31
G	4680	4740	4660		187000	180000	183000		6.06	0.11	0.03	9.22	0.88	2.97	0.09	0.08	43.20	0.44	12.18		3.30
G	4680	4780	4670		186000	179000	187000		6.05	0.11	0.03	9.24	0.89	2.97	0.09	0.08	43.18	0.44	12.13		3.29
H	4840		4480		191000				5.95	0.13	0.06	9.35	0.93	2.75	0.12	0.05	42.81	0.47	9.10		
H	4790		4510		189000				6.09	0.13	0.04	9.35	0.90	2.78	0.11	0.08	42.83	0.47	9.17		
H	4800		4510		190000				6.07	0.14	0.05	9.33	0.90	2.74	0.11	0.07	42.72	0.47	9.10		
H	4750		4430		190000				5.99	0.12	0.06	9.39	0.92	2.76	0.11	0.05	42.89	0.49	9.10		
H	4780		4530		193000				5.91	0.15	0.06	9.36	0.92	2.79	0.11	0.05	42.93	0.50	9.07		
H	4770		4470		187000				6.04	0.15	0.05	9.29	0.94	2.82	0.11	0.07	42.79	0.47	9.03		
H	4690		4540		182000				6.07	0.15	0.06	9.29	0.93	2.82	0.12	0.05	42.88	0.47	8.97		
H	4810		4460		190000				6.04	0.14	0.04	9.35	0.92	2.84	0.12	0.07	42.78	0.47	9.02		

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 ¹	σ _L ²	SW ³	CSU ⁴
Co	F	ppm	174.2	133.6	126.3	53.39
Co	M/ICP	ppm	235.7	187.9	70.07	54.72
Co	P	ppm	141.5	110.3	64.00	33.97
Cu	F	ppm	4824	3631	2768	1191
Cu	M/ICP	ppm	3111	1915	2408	701.1
Cu	P	ppm	4700	4641	2241	1781
Al ₂ O ₃	XRF	%	0.145	0.121	0.057	0.039
CaO	XRF	%	0.016	0.012	0.008	0.003
Cr ₂ O ₃	XRF	%	0.004	0.004	0.002	0.001
Fe ₂ O ₃	XRF	%	0.300	0.246	0.105	0.000
K ₂ O	XRF	%	0.038	0.031	0.011	0.010
LOI		%	0.168	0.213	0.055	0.096
MgO	XRF	%	0.063	0.049	0.037	0.017
MnO	XRF	%	0.005	0.003	0.004	0.001
Na ₂ O	XRF	%	0.050	0.044	0.008	0.013
SiO ₂	XRF	%	0.392	0.409	0.135	0.156
TiO ₂	XRF	%	0.024	0.024	0.009	0.009
SG	pycnometer		0.058	0.053	0.034	0.020

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 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: AMIS0248 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.

18 October 2012

Certifying Officers:



African Mineral Standards: _____
Mike McWha
BSc (Hons), FGSSA, MAusIMM, Pr.Sci.Nat



Geochemist: _____
Barry W. Smee
BSc, PhD, P.Geo, (B.C.)

Uncertified trace element statistics

Analyte	Method	Unit	Mean	2SD	RSD%	n
Ag	M/ICP	ppm	0.98	3.03	155	33
Al	M/ICP	%	3.18	0.31	4.8	75
As	M/ICP	ppm	90.7	32.5	17.9	85
Ba	M/ICP	ppm	106	20.0	9.5	63
Be	M/ICP	ppm	9.8	3.73	19.1	72
Bi	M/ICP	ppm	11.7	6.22	26.5	42
Ca	M/ICP	%	0.08	0.02	10.6	80
Cd	M/ICP	ppm	0.23	0.38	82.6	40
Ce	M/ICP	ppm	76.5	13.6	8.86	38
Co	XRF	ppm	4725	559	5.91	16
Cr	M/ICP	ppm	213	66.0	15.5	75
Cs	M/ICP	ppm	0.6	0.1	10.8	32
Cu	XRF	ppm	193703	5123	1.32	24
Dy	M/ICP	ppm	3.22	0.59	9.16	31
Er	M/ICP	ppm	1.71	0.21	6.08	29
Eu	M/ICP	ppm	0.44	0.05	5.37	31
Fe	M/ICP	%	6.59	0.66	5.0	88
Ga	M/ICP	ppm	18.9	9.0	23.7	55
Gd	M/ICP	ppm	3.66	0.64	8.82	31
Ge	M/ICP	ppm	0.35	0.15	21.6	8
Hf	M/ICP	ppm	2.25	1.89	41.8	26
Ho	M/ICP	ppm	0.61	0.10	7.76	31
In	M/ICP	ppm	3.13	0.65	10.3	38
K	M/ICP	%	0.72	0.11	7.66	80
La	M/ICP	ppm	38.2	16.7	21.9	79
Li	M/ICP	ppm	58.0	14.1	12.2	80
Lu	M/ICP	ppm	0.22	0.03	7.98	38
Mg	M/ICP	%	1.80	0.22	6.14	81
Mn	M/ICP	ppm	730	86.6	5.9	80
Mo	M/ICP	ppm	8.05	3.04	18.9	88
Na	M/ICP	%	0.06	0.02	15.6	80
Nb	M/ICP	ppm	7.51	3.06	20.4	38
Nd	M/ICP	ppm	27.9	2.31	4.14	31
Ni	M/ICP	ppm	134	25.0	9.34	90
P	M/ICP	ppm	3983	563	7.07	64
Pb	M/ICP	ppm	28.1	42.3	75.2	79
Pr	M/ICP	ppm	8.36	1.38	8.26	32
Rb	M/ICP	ppm	23.1	10.7	23.1	40
S	M/ICP	%	0.85	0.07	4.17	55
S	Comb/LECO	%	0.86	0.10	6.05	23
Sb	M/ICP	ppm	3.02	4.85	80.4	48
Sc	M/ICP	ppm	14.5	3.5	12.0	71
Se	M/ICP	ppm	21.2	10.1	23.8	40
Si	M/ICP	%	19.9	0.3	0.86	7
Sm	M/ICP	ppm	4.0	0.38	4.78	31
Sn	M/ICP	ppm	2.2	0.36	7.98	34
Sr	M/ICP	ppm	42.2	4.83	5.72	73
Ta	M/ICP	ppm	0.52	0.51	48.6	37
Tb	M/ICP	ppm	0.55	0.13	11.9	38
Te	M/ICP	ppm	0.14	0.10	36.8	21
Th	M/ICP	ppm	7.26	1.05	7.23	37
Ti	M/ICP	%	0.12	0.13	50.1	69
Tl	M/ICP	ppm	0.58	2.28	197.7	43
Tm	M/ICP	ppm	0.23	0.04	8.89	29
U	M/ICP	ppm	25.3	3.41	6.73	38
V	M/ICP	ppm	208	31.6	7.61	85
W	M/ICP	ppm	1.26	0.8	32.9	39
Y	M/ICP	ppm	14.1	5.8	20.4	79
Yb	M/ICP	ppm	1.58	0.31	9.68	40
Zn	M/ICP	ppm	69.1	22.2	16.1	80
Zr	M/ICP	ppm	75.6	46.1	30.5	73