



African Mineral Standards

MATRIX REFERENCE MATERIALS

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AMIS0246

Certified Reference Material

**Copper cobalt oxide ore
Kinsevere, DRC**

Certificate of Analysis

Recommended Concentrations and Limits¹ (at two Standard Deviations)

Certified Concentrations²

Co M/ICP	1973	±	156	ppm
Co P	1934	±	168	ppm
Cu F	1.762	±	0.114	%
Cu M/ICP	1.752	±	0.099	%
Cu P	1.748	±	0.076	%
Specific Gravity	2.81	±	0.18	

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	14.23	±	0.40	%
Fe ₂ O ₃	5.25	±	0.10	%
K ₂ O	3.46	±	0.06	%
MgO	1.73	±	0.06	%
MnO	0.040	±	0.004	%
SiO ₂	59.30	±	0.80	%
TiO ₂	0.96	±	0.02	%
LOI	11.91	±	1.04	%
S Comb / LECO	2.37	±	0.24	%

Provisional Concentration

Cr ₂ O ₃	0.09	±	0.01	%
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Indicated Mean

CaO	0.04	%
Na ₂ O	0.08	%

1. **Intended Use:** AMIS0246 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:** AMIS0246 is a commissioned CRM made from "BSHS" 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.

Within the oxide zone, cobalt mineralogy is composed predominantly of rare intergrown heterogenite (CoO(OH)). Heterogenite is generally limited to vuggy infills in well-developed malachite veins along with manganese oxides.

Within the sulfide zone, carrollite is the dominant cobalt mineral. It appears to be an early formed mineral since it is rimmed or replaced by chalcopyrite or bornite. It is more resistant to weathering than Cu sulfides and often survives into the supergene and mixed zones. The presence of very coarse and disseminated carrollite plus pyrite in late stage siliceous and dolomitic veins appears to denote another phase of mineralization that may postdate the principal copper mineralizing event.

4. Appearance: The material is a very fine Dark Blueish Grey powder (Corstor colour chart – 10B 2.5/1).

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. Eighteen 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 18 out of 23 laboratories that provided results timeously were (not in same order as in the table of assays):

1. Activation Laboratories Pty Ltd (ActLabs) CA
2. ALS Chemex Laboratory Group Brisbane Australia
3. ALS Chemex Laboratory Group Johannesburg SA
4. ALS Chemex Laboratory Group Perth WA
5. ALS Chemex Laboratory Group Vancouver CA
6. Genalysis Laboratory Services (W Australia P)
7. Intertek Utama Services (Indonesia)
8. Set Point Laboratories (Isando) SA
9. SGS Australia Pty Ltd (Newburn) WA
10. SGS Chelopech (Bulgaria)
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. SGS Townsville (Australia)
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.

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 LECCO %	SG pyc
A	2000	1870	1870		17000	17200	17100		14.35	0.03	0.09	5.23	3.46	1.75	0.04	59.73	0.96	11.46			3.09
A	2050	1920	1850		17100	17800	17100		14.37	0.04	0.09	5.22	3.48	1.76	0.04	59.77	0.96	11.45			3.10
A	2000	1880	1920		16900	17400	17300		14.35	0.04	0.09	5.21	3.48	1.75	0.04	59.71	0.96	11.49			3.08
A	2050	1860	1990		17000	17400	17600		14.38	0.04	0.09	5.22	3.47	1.76	0.04	59.76	0.95	11.43			3.04
A	2000	1790	1890		17400	16600	16800		14.33	0.04	0.09	5.22	3.46	1.75	0.04	59.78	0.95	11.43			3.00
A	1900	1860	1920		16000	17400	17300		14.37	0.04	0.09	5.24	3.47	1.76	0.04	59.80	0.95	11.42			3.05
A	2000	1910	1960		17300	17600	17500		14.37	0.03	0.09	5.24	3.48	1.76	0.04	59.79	0.95	11.38			3.00
A	2000	1910	1960		17200	17300	17500		14.35	0.04	0.09	5.23	3.46	1.75	0.04	59.69	0.96	11.44			3.02
B	2260	2110		2000	18400	16500		18100	14.00	0.04	0.09	5.29	3.45	1.73	0.04	0.07	58.70	0.95	11.50	2.38	
B	2140	2280		2000	17000	16500		18200	14.00	0.04	0.09	5.27	3.44	1.71	0.04	0.08	58.70	0.95	11.50	2.35	
B	2080	2040		2000	18300	16000		18100	14.00	0.05	0.09	5.33	3.42	1.72	0.04	0.08	58.80	0.95	11.50	2.35	
B	2290	2050		2000	17100	16800		18200	14.00	0.04	0.09	5.26	3.42	1.73	0.04	0.08	58.90	0.94	11.50	2.34	
B	2200	2130		2000	17500	16100		18000	14.00	0.04	0.09	5.28	3.42	1.72	0.04	0.09	58.70	0.94	11.50	2.35	
B	2210	2060		2000	17800	16600		18100	13.90	0.05	0.09	5.29	3.44	1.72	0.04	0.08	58.40	0.95	11.50	2.36	
B	2240	2030		2000	17300	16500		18100	13.90	0.04	0.09	5.30	3.45	1.73	0.04	0.08	58.70	0.96	11.50	2.33	
B	2260	2070		2000	17600	16500		17900	13.90	0.04	0.09	5.29	3.44	1.71	0.04	0.07	58.60	0.96	11.50	2.34	
C	1990	2030	2040	2050	17500	16900		17400	13.82	0.04	0.09	5.25	3.40	1.71	0.04		58.97	0.96	12.44		
C	2010	2040	2070	2040	17200	17600		17300	13.93	0.03	0.09	5.30	3.42	1.70	0.04		59.32	0.96	12.32		
C	2010	2040	2040	2040	17900	17800		17300	13.77	0.04	0.09	5.32	3.42	1.72	0.04		59.12	0.96	12.41		
C	2000	2020	2090	2050	18400	18000		17300	13.83	0.03	0.09	5.28	3.40	1.71	0.04		59.17	0.97	12.49		
C	2010	2030	2100	2050	18800	17900		17300	13.86	0.03	0.09	5.29	3.41	1.71	0.04		59.34	0.97	12.48		
C	1990	1980	2030	2040	17800	18100		17400	13.91	0.04	0.09	5.32	3.39	1.72	0.04		58.92	0.97	12.57		
C	2190	2060	2070	2050	16800	17700		17400	13.78	0.04	0.09	5.22	3.38	1.69	0.04		59.05	0.96	12.50		
C	1960	2120	2020	2060	17500	18200		17500	13.80	0.03	0.09	5.28	3.39	1.71	0.04		59.22	0.97	12.50		

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

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

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

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

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

Analyte	Method	Unit	S ¹	σ_L^2	Sw ³	CSU ⁴
Co	M/ICP	ppm	78.320	55.057	32.027	15.031
Co	P	ppm	83.783	60.287	35.950	17.103
Cu	F	ppm	599.110	334.328	492.237	126.019
Cu	M/ICP	ppm	494.573	344.328	240.370	98.478
Cu	P	ppm	380.818	253.872	293.008	97.165
Al ₂ O ₃	XRF	%	0.197	0.189	0.078	0.067
CaO	XRF	%	0.010	0.009	0.005	0.003
Cr ₂ O ₃	XRF	%	0.006	0.005	0.003	0.002
Fe ₂ O ₃	XRF	%	0.053	0.044	0.030	0.016
K ₂ O	XRF	%	0.034	0.030	0.017	0.011
LOI		%	0.525	0.520	0.038	0.173
MgO	XRF	%	0.027	0.023	0.013	0.008
MnO	XRF	%	0.002	0.002	0.001	0.001
Na ₂ O	XRF	%	0.020	0.027	0.005	0.012
SiO ₂	XRF	%	0.403	0.343	0.236	0.125
TiO ₂	XRF	%	0.009	0.004	0.008	0.002
S Comb	LECO	%	0.122	0.118	0.023	0.039
SG	pyc		0.086	0.085	0.038	0.033

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: AMIS0246 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.

28 June 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.)

Appendix 1 - Uncertified trace element statistics

Analyte	Method	Unit	Mean	RSD%	n
Ag	M/ICP	ppm	0.81	34.6	62
Al	M/ICP	ppm	6.82	21.4	80
As	M/ICP	ppm	199	7.88	88
B	M/ICP	ppm	190	13.6	16
Ba	M/ICP	ppm	222	8.22	73
Be	M/ICP	ppm	3.86	17.0	70
Bi	M/ICP	ppm	17.1	17.7	68
Ca	M/ICP	ppm	0.03	23.3	88
Cd	M/ICP	ppm	0.65	98.1	45
Ce	M/ICP	ppm	125	22.3	48
Cr	M/ICP	ppm	486	19.7	91
Cs	M/ICP	ppm	3.10	7.43	24
Dy	M/ICP	ppm	5.42	4.96	31
Er	M/ICP	ppm	3.35	6.77	32
Eu	M/ICP	ppm	0.92	5.03	31
Fe	M/ICP	ppm	3.59	5.41	95
Ga	M/ICP	ppm	24.7	13.4	53
Gd	M/ICP	ppm	5.64	13.0	32
Ge	M/ICP	ppm	0.23	20.6	8
Hf	M/ICP	ppm	6.22	10.9	39
Ho	M/ICP	ppm	1.13	5.02	30
In	M/ICP	ppm	3.06	18.5	39
K	M/ICP	ppm	2.75	7.22	87
La	M/ICP	ppm	59.8	19.4	79
Li	M/ICP	ppm	45.2	9.13	80
Lu	M/ICP	ppm	0.47	8.90	40
Mg	M/ICP	ppm	1.02	4.99	88
Mn	M/ICP	ppm	309	5.01	88
Mo	M/ICP	ppm	16.5	11.1	86
Na	M/ICP	ppm	0.06	51.9	87
Nb	M/ICP	ppm	17.1	50.0	49
Nd	M/ICP	ppm	60.6	5.02	31
Ni	M/ICP	ppm	75.4	10.8	106
P	M/ICP	ppm	282	24.5	71
Pb	M/ICP	ppm	40.4	15.3	106
Pr	M/ICP	ppm	17.3	3.86	31
Rb	M/ICP	ppm	102	8.93	45
Re	M/ICP	ppm	0.08	16.3	24
S	M/ICP	ppm	2.29	2.49	68
Sb	M/ICP	ppm	8.90	30.9	64
Sc	M/ICP	ppm	15.7	10.4	80
Se	M/ICP	ppm	6.24	20.0	34
Si	M/ICP	ppm	27.2	1.29	8
Sm	M/ICP	ppm	8.83	4.10	31
Sn	M/ICP	ppm	10.7	17.1	67
Sr	M/ICP	ppm	70.7	6.20	79
Ta	M/ICP	ppm	1.37	39.7	39
Tb	M/ICP	ppm	0.86	12.0	39
Te	M/ICP	ppm	0.59	92.6	36
Th	M/ICP	ppm	15.4	18.3	47
Ti	M/ICP	ppm	0.32	44.2	63
Tl	M/ICP	ppm	0.81	8.88	40
Tm	M/ICP	ppm	0.50	2.67	29
U	M/ICP	ppm	8.43	5.22	39
V	M/ICP	ppm	403	4.46	95
W	M/ICP	ppm	2.59	10.1	38
Y	M/ICP	ppm	26.1	14.8	77
Yb	M/ICP	ppm	3.31	5.66	37
Zn	M/ICP	ppm	79.8	7.64	104
Zr	M/ICP	ppm	199	11.9	73