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AMIS0089

Certified Reference Material

Platinum (PGM) Reference Material
UG2 Reef, Western Limb, Bushveld Complex, South Africa

Certificate of Analysis

Recommended Concentrations and Limits¹
(at two Standard Deviations)

Certified Concentrations²

Pt Pb Col	1.09	±	0.12	g/t
Pd Pb Col	0.70	±	0.06	g/t
Pt NIS	1.11	±	0.12	g/t
Pd NIS	0.71	±	0.08	g/t
Rh	0.22	±	0.02	g/t
Cr XRF	4.15	±	0.17	%
Cu M/ICP	59	±	6	ppm
Cu P	56	±	5	ppm
Ni M/ICP	452	±	52	ppm
Ni P	102	±	12	ppm
Ni XRF	435	±	44	ppm
Specific Gravity	2.97	±	0.18	

Provisional Concentrations

Au Pb Col	0.04	±	0.012	g/t
Au NIS	0.038	±	0.010	g/t
Ir NiS	0.07	±	0.01	g/t
Ru NiS	0.29	±	0.05	g/t
Co M/ICP	73	±	10	ppm
Co P	9.2	±	1.7	ppm

Informational Means

Cr M/ICP	3.24	%
Cu XRF	57	ppm

$$PGM\ 4E\ (Pt\ NiS + Pd\ NiS + Au\ NiS + Rh) = 2.078\ g/t$$

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	5.94	±	0.30
CaO	2.07	±	0.06
Cr ₂ O ₃	6.12	±	0.20
Fe ₂ O ₃	8.46	±	0.20
K ₂ O	0.17	±	0.02
MgO	7.57	±	0.36
SiO ₂	68.44	±	0.42
TiO ₂	0.23	±	0.02

Provisional Concentrations

MnO	0.16	±	0.02
Na ₂ O	0.36	±	0.06

1. **Intended Use:** AMIS0089 is a certified reference material which may be used to demonstrate the validity of measurement results of a single analysis of a chrome rich PGE ore; derived from the UG2 Reef, or from other mafic 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:** This standard was made using Pt/Pd UG2 chromitite rich material supplied by Anglo Platinum Limited from the Western limb of the Bushveld Complex.

3. **Mineral and Chemical Composition:** The UG2 chromitite ore consists of fine to medium size cumulus chromite grains with substantial amounts of post-cumulus orthopyroxene crystals. The footwall is a coarse grained pegmatoidal pyroxenite with sporadic occurrences of chromitite blebs, lenses and stringers. The hanging wall is predominantly fine to medium grained orthopyroxenite with three or more chromitite stringers referred to as the UG2 leaders.

Major element chemistry data from eleven of the labs has been compiled and certified. Uncertified summary statistics for trace element data are set out in the appendix.

4. **Appearance:** The material is a very fine powder. It is colored a Light Grey (Corstor 5Y 7/1).

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 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 the consensus test results were carried out by independent statisticians.

7. Methods of Analysis requested:

1. Pt, Pd and Au. Pb collection with Ag as a co-collector, ICP-OES or ICP-MS.
2. Pt, Pd, Au, Rh, Ru, Ir. NiS collection, ICP-OES or ICP-MS.
3. Multi element scan to include Co, Cu and Ni. Multi-acid total digestion, including HF, ICP-OES or ICP-MS.
4. Co, Cu and Ni. Aqua regia digestion with ICP-OES or ICP-MS.
5. Cr, Co, Cu and Ni. Pressed Pellet, XRF.
6. Majors (Al₂O₃, CaO, Cr₂O₃, Fe₂O₃, K₂O, MgO, MnO, Na₂O, SiO₂, TiO₂. LOI.) XRF fusion.
7. SG, gas pycnometer.

Additionally, XRF analyses were requested for the major elements and a multi-element multi acid digest and ICP scan was requested for the trace elements.

8. Information requested:

1. Aliquots used for all determinations.
2. Results for individual PGM's reported in ppb.
3. Results for base metals reported in ppm.
4. QC data, to include replicates, blanks and certified reference materials used.
5. Analytical techniques used.

9. Method of Certification: Twenty four laboratories were each given eight randomly selected packages of sample. Twenty two of the laboratories submitted results.

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 22 out of 24 laboratories that provided results timeously were(not in same order as in the table of assays):

1. ACME Analytical Laboratories Ltd CA
2. Activation Laboratories Pty Ltd (ActLabs) CA
3. ALS Chemex Laboratory Group Johannesburg SA
4. ALS Chemex Laboratory Group Perth WA
5. ALS Chemex Laboratory Group Vancouver CA
6. ALS OMAC
7. Ammtec Limited WA
8. Anglo Platinum - Eastern Bushveld Regional Laboratory
9. Anglo Research (Crown Campus)
10. Assayers Canada
11. Barplats Laboratory SA
12. Genalysis Laboratory Services (South Africa) Pty
13. Genalysis Laboratory Services (W Australia P)
14. Geoscience Laboratories (GEO LABS) CA
15. Intertek Utama Services (Indonesia)
16. Labtium Inc Finland
17. Set Point Laboratories (Isando) SA
18. Set Point Laboratories (Mokopane) SA
19. SGS Australia Pty Ltd (Newburn) WA
20. SGS South Africa (Pty) Ltd - Booyens JHB
21. Ultra Trace (Pty) Ltd WA
22. Zimplats Head Office Assay Laboratory

11. Assay Data: Data as received from the laboratories for the important certified elements listed on p1 are 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. Note; Rh results were reported by both the NiS and by the Pb Collection method.

Economic element assay data

Lab code	Pt Pb Coll g/t	Pd Pb Coll g/t	Au Pb Coll g/t	Pt NiS g/t	Pd NiS g/t	Au NiS g/t	Ir NiS g/t	Rh NiS g/t	Ru NiS g/t	Co M/ICP ppm	Co P ppm	Co XRF ppm	Cr M/ICP ppm	Cr P ppm	Cr XRF ppm	Cu M/ICP ppm	Cu P ppm	Cu XRF ppm	Ni M/ICP ppm	Ni P ppm	Ni XRF ppm
A										69						55.0	62.0		472.00		
A										76						63.0	64.0		499.00		
A										70						59.0	57.0		466.00		
A										69						57.0	63.0		445.00		
A										69						57.0	66.0		454.00		
A										71						59.0	62.0		466.00		
A										77						65.0	58.0		499.00		
A										70						60.0	57.0		459.00		
B	1.13	0.70	0.05	1.04	0.69	0.04	0.08	0.18	0.29	51	8.20	41.90	26400		41398	62.0	52.4	44.60	340.00	90.5	396.30
B	1.04	0.68	0.05	1.04	0.65	0.04	0.07	0.18	0.26	53	7.80	43.80	28800		41463	57.0	52.4	45.70	370.00	92.4	399.50
B	1.07	0.67	0.04	1.01	0.62	0.04	0.06	0.18	0.27	50	8.60	28.50	26800		41204	57.0	53.6	45.00	353.00	93.4	398.80
B	1.10	0.69	0.04	1.03	0.65	0.04	0.06	0.18	0.27	53	8.90	44.60	28200		41285	61.0	54.6	46.40	370.00	95.9	394.30
B	1.10	0.69	0.04	1.02	0.62	0.03	0.06	0.17	0.29	53	9.80	44.70	27900		41279	59.0	52.3	46.30	364.00	96.2	395.70
B	1.09	0.68	0.05	1.05	0.65	0.04	0.07	0.18	0.28	53	9.50	50.30	26200		41344	62.0	53.0	45.40	352.00	96.0	398.50
B	1.04	0.66	0.05	0.99	0.62	0.04	0.06	0.18	0.26	54	10.00	43.80	28200		41421	59.0	53.2	44.70	362.00	98.0	394.60
B	1.06	0.67	0.04	1.02	0.63	0.04	0.06	0.18	0.26	56	9.00	53.10	28500		41268	57.0	52.3	44.80	378.00	95.9	396.30
C	1.18	0.71	0.04							78	9.00		28400		41700	57.0	55.0		411.00	99.0	
C	1.15	0.70	0.04							78	9.00		28700		42000	59.0	54.0		433.00	98.0	
C	1.20	0.71	0.04							78	10.00		28000		41900	57.0	58.0		425.00	101.0	
C	1.13	0.72	0.04							81	10.00		29300		42200	60.0	56.0		438.00	103.0	
C	1.15	0.72	0.04							82	10.00		27900		41800	60.0	56.0		425.00	101.0	
C	1.12	0.71	0.04							76	10.00		27400		42100	58.0	55.0		414.00	99.0	
C	1.12	0.71	0.04							78	9.00		27500		42000	60.0	55.0		422.00	99.0	
C	1.09	0.71	0.04							78	9.00		28500		41900	59.0	54.0		432.00	97.0	
D	1.14	0.74	0.04	1.16	0.76	0.04	0.08	0.23	0.32	75	10.00				41100	58.0	60.0		472.00	108.0	
D	1.14	0.73	0.04	1.15	0.72	0.04	0.08	0.22	0.32	75	10.00				42300	58.0	58.0		488.00	105.0	
D	1.16	0.73	0.04	1.18	0.76	0.04	0.08	0.23	0.32	70	10.00				41300	56.0	59.0		456.00	106.0	
D	1.14	0.70	0.04	1.14	0.71	0.04	0.08	0.22	0.31	70	10.00				41300	62.0	60.0		462.00	106.0	
D	1.14	0.71	0.04	1.16	0.72	0.05	0.08	0.22	0.30	70	10.00				42200	62.0	59.0		468.00	106.0	
D	1.13	0.72	0.04	1.18	0.73	0.04	0.08	0.24	0.32	75	11.00				41300	62.0	60.0		488.00	106.0	
D	1.15	0.73	0.04	1.14	0.75	0.04	0.08	0.22	0.33	70	10.00				40800	58.0	60.0		460.00	104.0	
D	1.16	0.74	0.04	1.20	0.77	0.04	0.08	0.23	0.33	70	10.00				41700	60.0	60.0		470.00	107.0	
F	1.10	0.71	0.04							36						64.0			266.00		
F	1.12	0.73	0.04							34						57.0			255.00		
F	1.06	0.70	0.03							35						56.0			266.00		
F	1.10	0.73	0.04							34						57.0			262.00		
F	1.08	0.71	0.04							34						64.0			260.00		
F	1.09	0.73	0.04							35						65.0			267.00		
F	1.10	0.74	0.04							35						65.0			275.00		
F	1.12	0.73	0.04							34						57.0			271.00		

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
Pt	Pb Coll	g/t	0.055	0.027	0.039	0.007
Pd	Pb Coll	g/t	0.028	0.016	0.017	0.004
Au	Pb Coll	g/t	0.006	0.002	0.004	0.001
Pt	NIS	g/t	0.057	0.046	0.032	0.016
Pd	NIS	g/t	0.040	0.029	0.026	0.010
Au	NIS	g/t	0.005	0.004	0.003	0.002
Ir	NiS	g/t	0.006	0.006	0.004	0.002
Rh	NiS	g/t	0.011	0.010	0.007	0.004
Ru	NiS	g/t	0.025	0.023	0.012	0.008
Co	M/ICP	ppm	5.048	3.343	3.046	1.016
Co	P	ppm	0.840	0.684	0.388	0.221
Cr	M/ICP	ppm	6880	7766	1133	2939
Cr	XRF	ppm	866.8	773.3	228.7	245.9
Cu	M/ICP	ppm	3.234	1.646	2.496	0.520
Cu	P	ppm	2.467	1.739	1.190	0.496
Cu	XRF	ppm	9.411	9.335	2.688	3.318
Ni	M/ICP	ppm	25.52	17.86	11.99	5.10
Ni	P	ppm	5.948	4.709	2.708	1.449
Ni	XRF	ppm	21.88	23.36	7.38	8.89
Al ₂ O ₃	XRF	%	0.152	0.125	0.048	0.038
CaO	XRF	%	0.034	0.027	0.015	0.008
Cr ₂ O ₃	XRF	%	0.103	0.098	0.024	0.033
Fe ₂ O ₃	XRF	%	0.103	0.101	0.039	0.036
K ₂ O	XRF	%	0.008	0.006	0.004	0.002
MgO	XRF	%	0.176	0.158	0.038	0.050
MnO	XRF	%	0.011	0.009	0.004	0.003
Na ₂ O	XRF	%	0.028	0.021	0.018	0.007
SiO ₂	XRF	%	0.213	0.152	0.154	0.057
TiO ₂	XRF	%	0.012	0.009	0.007	0.003
SG	pyc		0.091	0.073	0.030	0.022

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 Indicated 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 Smeed.

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 and who have maintained measurement traceability during the analytical process.

15. Certification: AMIS0089 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 and a 30g sample size for the fire assay. These are the recommended minimum sample sizes 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 50 to 250g) of material. The Laboratory Packs are sealed bottles delivered in sealed foil pouches. The Explorer Packs contain material in standard geochem envelopes, nitrogen flushed and 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.

26 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 – uncertified trace element statistics

Analyte	Method	Unit	Mean	RSD%	n
Ag	M/ICP	ppm	0.08	82.7	31
Al	M/ICP	%	3.17	5.70	98
As	M/ICP	ppm	3.04	90.2	53
Ba	M/ICP	ppm	43.3	7.69	97
Be	M/ICP	ppm	0.11	16.8	45
Bi	M/ICP	ppm	0.06	94.6	40
Ca	M/ICP	%	1.47	5.90	118
Cd	M/ICP	ppm	0.06	56.6	27
Ce	M/ICP	ppm	7.07	12.0	81
Cs	M/ICP	ppm	0.25	16.0	58
Dy	M/ICP	ppm	0.49	5.35	35
Er	M/ICP	ppm	0.30	6.87	37
Eu	M/ICP	ppm	0.14	7.94	39
Fe	M/ICP	%	5.80	9.32	104
Ga	M/ICP	ppm	12.2	19.4	81
Gd	M/ICP	ppm	0.52	12.0	40
Ge	M/ICP	ppm	0.13	112	39
Hf	M/ICP	ppm	0.59	9.94	66
Ho	M/ICP	ppm	0.10	8.74	39
In	M/ICP	ppm	0.01	17.2	37
K	M/ICP	%	0.14	8.27	111
La	M/ICP	ppm	3.80	9.92	90
Li	M/ICP	ppm	2.27	17.1	73
LOI		%	0.13	45.4	61
Lu	M/ICP	ppm	0.05	13.3	18
Mg	M/ICP	%	4.49	6.35	108
Mn	M/ICP	ppm	1244	4.95	110
Mo	M/ICP	ppm	2.48	14.7	86
Na	M/ICP	%	0.27	8.23	113
Nb	M/ICP	ppm	0.84	16.3	80
Nd	M/ICP	ppm	3.20	5.56	37
P	M/ICP	ppm	93.5	26.6	79
Pb	M/ICP	ppm	4.45	43.1	79
Pr	M/ICP	ppm	0.85	8.92	39
Rb	M/ICP	ppm	5.94	9.25	79
Sb	M/ICP	ppm	3.52	11.0	75
Sc	M/ICP	ppm	9.24	5.22	83
Se	M/ICP	ppm	3.20	37.7	24
Sm	M/ICP	ppm	0.56	8.18	36
Sn	M/ICP	ppm	1.36	33.4	70
Sr	M/ICP	ppm	51.5	6.10	95
Ta	M/ICP	ppm	1.81	226	52
Tb	M/ICP	ppm	0.08	11.2	40
Te	M/ICP	ppm	0.06	16.7	10
Th	M/ICP	ppm	1.50	6.75	74
Ti	M/ICP	%	0.13	10.5	90
Tl	M/ICP	ppm	0.05	59.4	40
Tm	M/ICP	ppm	0.05	15.2	25
U	M/ICP	ppm	0.70	8.27	78
V	M/ICP	ppm	290	21.3	104
W	M/ICP	ppm	0.46	34.9	49
Y	M/ICP	ppm	2.81	9.40	80
Yb	M/ICP	ppm	0.33	14.6	38
Zn	M/ICP	ppm	132	14.5	95
Zr	M/ICP	ppm	19.1	12.7	93