

# AMIS0466

## *Certified Reference Material*

### Gold and Uranium Ore Witwatersrand, South Africa

## *Certificate of Analysis*

### Recommended Concentrations and Limits<sup>1, 2.</sup> (at two Standard Deviations)

#### *Certified Concentration*

Au Pb Collection	42.4	±	1.8	g/t
SG	2.78	±	0.02	Dimensionless
U 4A_MICP	3424	±	130	ppm
U XRF	3301	±	149	ppm
LOI	4.45	±	0.02	%

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 page 2 and uncertified trace element data presented as an appendix*

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#### AMIS

(A Division of Torre Analytical Services (Pty) Limited)  
(Reg. No. 1989/000201/07)

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## Major Oxides

### *Certified Concentrations (at two Standard Deviations)*

Al <sub>2</sub> O <sub>3</sub> XRF	5.67	±	0.04	%
CaO XRF	0.112	±	0.008	%
Fe <sub>2</sub> O <sub>3</sub> XRF	5.8	±	0.2	%
K <sub>2</sub> O XRF	0.92	±	0.01	%
MgO XRF	0.31	±	0.01	%
MnO XRF	0.03	±	0.002	%
P <sub>2</sub> O <sub>5</sub> XRF	0.084	±	0.004	%
SiO <sub>2</sub> XRF	80.5	±	1.4	%
TiO <sub>2</sub> XRF	0.36	±	0.06	%
U <sub>3</sub> O <sub>8</sub> XRF	0.39	±	0.02	%

### *Informational Concentrations*

Cr <sub>2</sub> O <sub>3</sub> XRF	0.075	%
Na <sub>2</sub> O XRF	0.14	%
S 4A_MICP	2.8	%
S Comb/LECO	3.1	%

1. **Intended Use:** AMIS0466 can be used to check the analysis of gold and uranium ores, hosted by siliceous 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.

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**2. Origin of Material:** This standard is a blend of Ventersdorp Contact Reef, Carbon Leader Reef and Vaal Reef material provided by Anglo Gold Ashanti in South Africa. It was made from a mixture of pulp reject sample material, collected during routine underground sampling.

**3. Approximate Mineral and Chemical Composition:** The major gangue mineral is quartz with minor pyrite, uraninite and thucolite. It is more enriched in gold and quartz content although high uranium and carbon concentrations are also found. Uraninite grains are penetrated by the carbonaceous matter through cracks and further fragmented into smaller grain.

**4. Appearance:** The material is a very fine powder. It is colored Medium Dark Grey.

**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. Radioactivity:** Shipments of this material require special labelling and placarding. AMIS0466 contains U (42.80 Bq/g) and Th 1.14 Bq/g) and is classified as EXCEPTED MATERIAL in terms of "Safety Standards Series No. TS-R-1: Regulations for the Safe Transport of Radioactive Material, International Atomic Energy Agency, 2005, para 403, Table 1".

**7. 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 scientifically selected for homogeneity testing and third party analysis. Statistical analysis of both homogeneity and the consensus test results were carried out by independent statisticians.

**8. Methods of Analysis requested:**

1. Au – Pb collection with either ICP-OES or ICP-MS or AAS finish
2. 4-acid digest, including HF finished with either ICP- OES or ICP-MS or AAS. Multi element scan to include U
3. U – XRF
4. Majors (Al<sub>2</sub>O<sub>3</sub>, CaO, Cr<sub>2</sub>O<sub>3</sub>, Fe<sub>2</sub>O<sub>3</sub>, K<sub>2</sub>O, MgO, MnO, Na<sub>2</sub>O, P<sub>2</sub>O<sub>5</sub>, SiO<sub>2</sub>, TiO<sub>2</sub>, U<sub>3</sub>O<sub>8</sub>, LOI) XRF fusion
5. S – Combustion analysis
6. SG – Gas Pycnometer

**9. Information requested**

1. State aliquots used for all determinations
2. Report all results for gold and uranium in ppm
3. All results for major elements to be reported as oxides in percentages
4. All results for multi-element scans to be reported in ppm
5. Report all QC data, to include replicates, blanks and certified reference materials used
6. State and provide brief description of analytical techniques used.

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**10. Method of Certification:** Eighteen laboratories were each given eight scientifically selected packages of sample. Twelve laboratories submitted 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 13), 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”.

**11. Participating Laboratories:** The 12 out of 18 laboratories that provided results timeously were (not in same order as in the table of assays)

1. Anglo Gold Ashanti - Vaal River Laboratory SA
2. Argetest Ankara Turkey
3. Bureau Veritas Ultratrace Australia
4. Bureau Veritas Namibia
5. Chromatech Services SA
6. Dundee Precious Metals Tsumeb Laboratory (Namibia)
7. Genalysis Laboratory Services Perth
8. Ready Lead Assay Laboratory
9. Set Point Laboratories Husab Namibia
10. Set Point Laboratories (Isando) SA
11. SGS Welkom
12. Shiva Analyticals India (Pty) Ltd

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

Pb Coll Au g/t	Pb Coll Au g/t	4A_MICP S %	Comb/LECO S %	SG Dimensionless	4A_MICP U ppm	XRF U ppm	XRF U <sub>2</sub> O <sub>3</sub> ppm	LOI %
42.50	41.33	3.11	2.95	2.78	3378	3241	0.39	4.44
42.17	41.85	3.11	3.01	2.78	3386	3227	0.39	4.44
41.50	42.12	3.08	2.98	2.78	3410	3237	0.40	4.45
42.96	40.85	3.11	3.05	2.76	3383	3239	0.41	4.45
42.40	41.30	3.13	3.00	2.76	3405	3236	0.39	4.47
42.63	42.00	3.10	2.98	2.77	3402	3230	0.39	4.50
42.94	42.70	3.10	3.03	2.75	3397	3223	0.40	4.44
42.06	42.90	3.08	3.06	2.78	3383	3220	0.40	4.46
43.52	42.00	3.09	3.10	2.79	3368	3256	0.38	4.47
43.65	43.00	3.04	3.09	2.78	3358	3226	0.38	4.45
43.58	43.00	3.09	3.11	2.78	3447	3236	0.38	4.43
43.67	42.40	3.06	3.11	2.78	3385	3251	0.38	4.45
43.71	42.70	3.06	3.12	2.79	3419	3240	0.38	4.44
43.44	42.75	3.10	3.12	2.79	3468	3276	0.39	4.45
43.77	43.25	3.05	3.12	2.78	3404	3250	0.38	4.45
43.60	42.84	3.05	3.09	2.78	3493	3265	0.39	4.43
43.26	41.35	2.15			3485	3390	0.40	
43.22	41.01	2.17			3512	3380	0.40	
43.01	41.99	2.18			3561	3370	0.40	
42.93	41.79	2.12			3470	3380	0.40	
43.23	42.41	2.16			3567	3360	0.40	
42.91	42.53	2.15			3503	3380	0.40	
42.94	42.67	2.15			3430	3380	0.40	
43.18	42.47	2.15			3330	3380	0.40	
42.97	42.27				3420	3316	0.39	
42.73	42.33				3380	3396	0.40	
43.17	42.50				3430	3314	0.39	
42.89	42.33				3480	3346	0.39	
43.34	42.00				3380	3318	0.39	
42.53	41.52				3320	3410	0.40	
42.80	41.00					3298	0.39	
43.25	40.50					3364	0.40	
41.79	40.00							
43.18	41.60							
42.13	40.90							
40.14	40.98							

XRF Al <sub>2</sub> O <sub>3</sub> %	XRF CaO %	XRF Cr <sub>2</sub> O <sub>3</sub> %	XRF Fe <sub>2</sub> O <sub>3</sub> %	XRF K <sub>2</sub> O %	XRF MgO %	XRF MnO %	XRF Na <sub>2</sub> O %	XRF P <sub>2</sub> O <sub>5</sub> %	XRF SiO <sub>2</sub> %	XRF TiO <sub>2</sub> %
5.67	0.11	0.10	5.69	0.93	0.31	0.03	0.13	0.08	80.57	0.36
5.67	0.11	0.10	5.71	0.93	0.31	0.03	0.13	0.08	80.71	0.37
5.67	0.11	0.09	5.67	0.93	0.32	0.03	0.13	0.08	80.41	0.37
5.66	0.11	0.10	5.68	0.92	0.32	0.03	0.14	0.08	80.33	0.38
5.65	0.11	0.09	5.62	0.93	0.32	0.03	0.14	0.08	80.35	0.37
5.63	0.11	0.09	5.68	0.92	0.31	0.03	0.13	0.08	80.08	0.37
5.65	0.11	0.09	5.68	0.92	0.32	0.03	0.13	0.08	80.31	0.37
5.66	0.11	0.10	5.70	0.93	0.32	0.03	0.12	0.08	80.54	0.37
5.67	0.11	0.06	5.80	0.92	0.31	0.03	0.12	0.09	81.23	0.38
5.70	0.11	0.05	5.80	0.92	0.31	0.03	0.12	0.09	81.28	0.38
5.69	0.11	0.06	5.76	0.92	0.32	0.03	0.12	0.09	81.17	0.38
5.66	0.11	0.06	5.77	0.92	0.31	0.03	0.12	0.08	81.18	0.38
5.70	0.11	0.06	5.76	0.92	0.31	0.03	0.12	0.09	81.17	0.38
5.67	0.11	0.05	5.76	0.92	0.31	0.03	0.11	0.09	81.11	0.38
5.68	0.11	0.05	5.78	0.92	0.31	0.03	0.12	0.09	81.19	0.38
5.67	0.11	0.05	5.78	0.92	0.31	0.03	0.12	0.09	81.13	0.38
	0.12		5.83			0.03	0.18		79.69	0.32
	0.12		5.88			0.03	0.16		79.87	0.31
	0.12		5.80			0.03	0.17		80.30	0.32
	0.11		5.90			0.03	0.16		79.82	0.33
	0.11		5.85			0.03	0.18		79.70	0.33
	0.14		5.89				0.17		80.04	0.33
	0.11		5.88				0.17		79.93	0.32
	0.117516									0.32

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**13. 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 <sup>1</sup>	σL <sup>2</sup>	SW <sup>3</sup>	CSU <sup>4</sup>
Au	Pb Collection	g/t	0.915	0.697	0.539	0.241
SG	SG	Dimensionless	0.013	0.018	0.009	0.013
U	4A_MICP	ppm	65.094	67.856	43.988	34.866
U	XRF	ppm	74.411	100.119	22.914	50.223
LOI	LOI	%	0.018	0.007	0.017	0.007
Al <sub>2</sub> O <sub>3</sub>	XRF	%	0.021	0.030	0.015	0.022
CaO	XRF	%	0.004	0.005	0.002	0.003
Fe <sub>2</sub> O <sub>3</sub>	XRF	%	0.098	0.143	0.028	0.083
K <sub>2</sub> O	XRF	%	0.006	0.008	0.004	0.006
MgO	XRF	%	0.005	0.006	0.004	0.005
MnO	XRF	%	0.001	0.001	0.001	0.001
P <sub>2</sub> O <sub>5</sub>	XRF	%	0.002	0.004	0.001	0.003
SiO <sub>2</sub>	XRF	%	0.685	1.015	0.166	0.587
TiO <sub>2</sub>	XRF	%	0.030	0.048	0.005	0.028
U3O8	XRF	%	0.007	0.009	0.004	0.005

- 1 S - Std Dev for use on control charts.
- 2 σL - 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.

**14. 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 Allan Fraser.

**15. 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.

**16. Certification:** AMIS0466 is a new material.

**17. 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](http://www.amis.co.za) website.

**18. 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.

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**19. 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.

**20. 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.

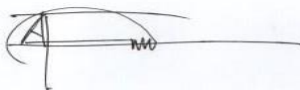
**21. Legal Notice:** This certificate and the reference material described in it have been prepared with due care and attention. However AMIS, a part of Torre Industries, Thivhafuni Matodzi, and Allan Fraser; accept no liability for any decisions or actions taken following the use of the reference material.

**25 January 2017**

**Certifying Officers:**



**African Mineral Standards:** \_\_\_\_\_  
**Thivhafuni Matodzi**



**Geochemist:** \_\_\_\_\_  
**Allan Fraser**  
**M.Sc. (Geology), N.D. (Analytical Chem.), Pr.Sci.Nat.**

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### Appendix – uncertified element statistics

Element	Gen Method	N	Std Mean	SD	RSD %	Unit
Ag	4A_MICP	24	5.005	1.519	30.355	ppm
Al	4A_MICP	32	28882.467	894.106	3.096	ppm
As	4A_MICP	24	649.646	65.129	10.025	ppm
Au	AR_GAAS	7	43.593	0.585	1.342	g/t
Ba	4A_MICP	31	254.850	73.665	28.905	ppm
BaO	XRF	8	0.024	0.007	31.327	%
Be	4A_MICP	23	2.241	0.121	5.404	ppm
Bi	4A_MICP	24	4.687	0.482	10.273	ppm
Ca	4A_MICP	31	811.089	110.897	13.673	ppm
CaO	XRF	23	0.112	0.003	2.927	%
Cd	4A_MICP	32	4.307	5.589	129.746	ppm
Ce	4A_MICP	32	262.925	10.857	4.129	ppm
Co	4A_MICP	40	160.816	6.267	3.897	ppm
Cr	4A_MICP	24	446.279	99.370	22.266	ppm
Cs	4A_MICP	24	5.472	0.319	5.832	ppm
Cu	4A_MICP	39	78.007	8.821	11.308	ppm
Dy	4A_MICP	16	33.357	1.308	3.921	ppm
Er	4A_MICP	16	16.633	0.498	2.992	ppm
Eu	4A_MICP	15	3.950	0.071	1.793	ppm
Fe	4A_MICP	32	39722.693	3308.168	8.328	ppm
Ga	4A_MICP	24	7.714	0.654	8.472	ppm
Gd	4A_MICP	15	28.949	0.389	1.345	ppm
Ge	4A_MICP	16	0.433	0.250	57.682	ppm
Hf	4A_MICP	24	11.447	1.006	8.792	ppm
Ho	4A_MICP	16	6.306	0.141	2.234	ppm
Ind	4A_MICP	23	0.050	0.008	16.558	ppm
K	4A_MICP	32	7049.501	855.723	12.139	ppm
La	4A_MICP	30	140.976	6.068	4.304	ppm
Li	4A_MICP	36	8.664	0.404	4.665	ppm
Lu	4A_MICP	16	1.626	0.057	3.527	ppm
Mg	4A_MICP	32	1805.300	73.567	4.075	ppm
Mn	4A_MICP	32	225.964	14.436	6.389	ppm
MnO	XRF	21	0.030	0.001	2.693	%
Mo	4A_MICP	24	3.349	0.252	7.525	ppm
Na	4A_MICP	31	1011.547	193.750	19.154	ppm
Nb	4A_MICP	22	13.122	0.342	2.606	ppm
Nd	4A_MICP	16	104.878	3.782	3.606	ppm
Ni	4A_MICP	38	347.203	19.873	5.724	ppm
P	4A_MICP	24	298.038	160.113	53.722	ppm
Pb	4A_MICP	32	1549.334	100.495	6.486	ppm
Pd	Pb Collection	8	0.023	0.005	20.574	g/t
Pr	4A_MICP	16	30.889	1.175	3.804	ppm
Pt	Pb Collection	7	0.010	<0.001	<0.001	g/t
Rb	4A_MICP	24	35.395	0.827	2.337	ppm
Sb	4A_MICP	23	11.877	0.696	5.860	ppm
Sc	4A_MICP	32	6.445	0.458	7.100	ppm
Se	4A_MICP	16	3.875	1.204	31.075	ppm
Sm	4A_MICP	15	25.852	0.300	1.162	ppm
Sn	4A_MICP	15	2.907	0.116	4.001	ppm
SO3	XRF	8	7.396	0.305	4.122	%
Sr	4A_MICP	30	77.841	2.455	3.154	ppm
Ta	4A_MICP	23	5.298	0.244	4.610	ppm
Tb	4A_MICP	16	5.517	0.131	2.372	ppm
Te	4A_MICP	15	0.413	0.035	8.513	ppm
Th	4A_MICP	32	277.667	135.936	48.956	ppm
Ti	4A_MICP	32	0.160	0.023	14.155	%
Tl	4A_MICP	24	0.459	0.052	11.423	ppm
Tm	4A_MICP	16	2.328	0.075	3.200	ppm
V	4A_MICP	32	21.747	9.030	41.524	ppm
W	4A_MICP	23	0.939	0.052	5.574	ppm
Y	4A_MICP	24	120.322	4.892	4.065	ppm
Yb	4A_MICP	16	13.431	0.483	3.593	ppm
Zn	4A_MICP	31	319.541	15.550	4.866	ppm
Zr	4A_MICP	36	420.354	8.842	2.104	ppm

#### AMIS

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