

CERTIFICATE OF ANALYSIS FOR

PORPHYRY COPPER-GOLD ORE

CERTIFIED REFERENCE MATERIAL

OREAS 153b

Table 1. Certified Values, SD's, 95% Confidence and Tolerance Limits for OREAS 153b.

Constituent	Certified Value	1SD	95% Confidence Limits		95% Tolerance Limits	
			Low	High	Low	High
Fire Assay						
Au, Gold (ppb)	313	9	310	317	308*	319*
4-Acid Digestion						
Ag, Silver (ppm)	1.4	0.09	1.4	1.5	1.4	1.5
Al, Aluminium (wt.%)	7.94	0.314	7.82	8.07	7.75	8.14
As, Arsenic (ppm)	79	5.4	76	82	77	81
Ba, Barium (ppm)	103	3.6	101	104	100	105
Be, Beryllium (ppm)	0.52	0.041	0.49	0.54	0.49	0.54
Bi, Bismuth (ppm)	1.61	0.144	1.51	1.71	1.57	1.65
Ca, Calcium (wt.%)	1.83	0.078	1.80	1.86	1.79	1.87
Cd, Cadmium (ppm)	0.26	0.05	0.22	0.31	0.24	0.29
Ce, Cerium (ppm)	11.7	1.9	10.0	13.4	11.3	12.1
Co, Cobalt (ppm)	15.4	1.35	14.8	16.0	14.9	15.9
Cr, Chromium (ppm)	17.3	2.9	16.0	18.7	IND	IND
Cs, Cesium (ppm)	0.44	0.041	0.42	0.46	IND	IND
Cu, Copper (wt.%)	0.678	0.015	0.672	0.684	0.667	0.689
Dy, Dysprosium (ppm)	2.11	0.133	2.02	2.20	1.94	2.29
Er, Erbium (ppm)	1.23	0.087	1.13	1.33	1.13	1.33
Eu, Europium (ppm)	0.67	0.035	0.64	0.70	IND	IND
Fe, Iron (wt.%)	3.86	0.140	3.79	3.92	3.77	3.94
Ga, Gallium (ppm)	18.8	1.26	18.1	19.5	18.2	19.5
Gd, Gadolinium (ppm)	2.15	0.130	2.04	2.27	IND	IND
Hf, Hafnium (ppm)	< 0.5	IND	IND	IND	IND	IND

Note: intervals may appear asymmetric due to rounding; *determined from RSD of gold INAA data for 30g analytical subsample weight.

Table 1 continued.

Constituent	Certified Value	1SD	95% Confidence Limits		95% Tolerance Limits	
			Low	High	Low	High
4-Acid Digestion continued						
Ho, Holmium (ppm)	0.43	0.042	0.37	0.48	0.39	0.46
In, Indium (ppm)	0.23	0.013	0.22	0.24	0.22	0.25
K, Potassium (wt.%)	1.16	0.047	1.13	1.18	1.13	1.18
La, Lanthanum (ppm)	5.03	0.77	4.52	5.54	4.87	5.20
Li, Lithium (ppm)	5.69	0.328	5.50	5.88	5.34	6.04
Lu, Lutetium (ppm)	0.16	0.02	0.14	0.18	IND	IND
Mg, Magnesium (wt.%)	1.64	0.065	1.62	1.67	1.61	1.68
Mn, Manganese (wt.%)	0.028	0.001	0.028	0.029	0.027	0.029
Mo, Molybdenum (ppm)	163	10.5	158	168	159	168
Na, Sodium (wt.%)	2.46	0.064	2.43	2.49	2.41	2.51
Nb, Niobium (ppm)	1.42	0.25	1.23	1.61	IND	IND
Nd, Neodymium (ppm)	7.40	0.432	6.92	7.87	7.05	7.75
Ni, Nickel (ppm)	11.9	1.6	11.2	12.6	11.0	12.8
P, Phosphorus (wt.%)	0.053	0.004	0.051	0.055	0.051	0.055
Pb, Lead (ppm)	13.1	1.20	12.6	13.6	12.6	13.6
Pr, Praseodymium (ppm)	1.72	0.102	1.60	1.85	1.63	1.81
Rb, Rubidium (ppm)	20.5	1.38	19.5	21.5	19.2	21.9
Re, Rhenium (ppm)	0.18	0.017	0.16	0.19	0.15	0.20
S, Sulphur (wt.%)	1.28	0.034	1.27	1.29	1.25	1.31
Sb, Antimony (ppm)	3.04	0.36	2.77	3.31	2.89	3.19
Sc, Scandium (ppm)	16.8	1.20	16.2	17.4	16.4	17.2
Se, Selenium (ppm)	11.2	1.3	10.2	12.1	IND	IND
Sm, Samarium (ppm)	1.93	0.175	1.71	2.15	1.80	2.06
Sn, Tin (ppm)	3.97	0.391	3.73	4.22	3.75	4.19
Sr, Strontium (ppm)	164	7.2	160	167	159	168
Ta, Tantalum (ppm)	< 0.5	IND	IND	IND	IND	IND
Tb, Terbium (ppm)	0.36	0.035	0.32	0.39	0.34	0.37
Te, Tellurium (ppm)	0.27	0.05	0.25	0.28	0.21	0.32
Th, Thorium (ppm)	0.45	0.044	0.42	0.48	0.41	0.50
Ti, Titanium (wt.%)	0.285	0.033	0.269	0.301	0.273	0.297
Tl, Thallium (ppm)	0.16	0.03	0.15	0.18	IND	IND
Tm, Thulium (ppm)	0.18	0.02	0.15	0.20	IND	IND
U, Uranium (ppm)	0.11	0.01	0.10	0.11	IND	IND
V, Vanadium (ppm)	230	10.5	225	235	225	235
W, Tungsten (ppm)	2.02	0.37	1.76	2.28	1.86	2.18
Y, Yttrium (ppm)	11.1	0.80	10.6	11.5	10.7	11.4
Yb, Ytterbium (ppm)	1.17	0.16	1.03	1.32	1.05	1.30
Zn, Zinc (ppm)	122	4.7	119	124	118	125
Zr, Zirconium (ppm)	< 10	IND	IND	IND	IND	IND
Aqua Regia Digestion						
Ag, Silver (ppm)	1.4	0.10	1.4	1.5	1.4	1.5
Al, Aluminium (wt.%)	2.28	0.111	2.22	2.33	2.23	2.32

Note: intervals may appear asymmetric due to rounding.

Table 1 continued.

Constituent	Certified Value	1SD	95% Confidence Limits		95% Tolerance Limits	
			Low	High	Low	High
Aqua Regia Digestion continued						
As, Arsenic (ppm)	80	3.1	79	81	78	82
Au, Gold (ppb)	320	13	314	325	314*	326*
B, Boron (ppm)	< 10	IND	IND	IND	IND	IND
Ba, Barium (ppm)	22.8	2.8	21.4	24.2	21.4	24.1
Be, Beryllium (ppm)	0.18	0.03	0.15	0.20	IND	IND
Bi, Bismuth (ppm)	1.81	0.25	1.66	1.95	1.73	1.88
Ca, Calcium (wt.%)	1.32	0.055	1.30	1.35	1.29	1.35
Cd, Cadmium (ppm)	0.24	0.05	0.21	0.27	0.23	0.25
Ce, Cerium (ppm)	9.11	0.856	8.44	9.77	8.77	9.44
Co, Cobalt (ppm)	14.9	1.04	14.5	15.4	14.4	15.5
Cr, Chromium (ppm)	16.2	1.08	15.7	16.6	IND	IND
Cs, Cesium (ppm)	0.26	0.04	0.22	0.29	0.24	0.27
Cu, Copper (wt.%)	0.670	0.013	0.664	0.676	0.657	0.683
Dy, Dysprosium (ppm)	1.92	0.35	1.44	2.40	1.78	2.06
Fe, Iron (wt.%)	3.60	0.107	3.55	3.65	3.52	3.68
Ga, Gallium (ppm)	8.06	1.36	7.34	8.78	7.68	8.44
Hg, Mercury (ppm)	0.066	0.013	0.059	0.074	IND	IND
In, Indium (ppm)	0.21	0.014	0.20	0.22	0.20	0.23
K, Potassium (wt.%)	0.365	0.030	0.351	0.378	0.351	0.378
La, Lanthanum (ppm)	3.79	0.238	3.65	3.94	3.65	3.94
Li, Lithium (ppm)	3.28	0.64	2.77	3.80	3.12	3.44
Lu, Lutetium (ppm)	0.11	0.01	0.10	0.12	0.10	0.12
Mg, Magnesium (wt.%)	1.47	0.053	1.45	1.50	1.44	1.50
Mn, Manganese (wt.%)	0.024	0.001	0.024	0.025	0.024	0.025
Mo, Molybdenum (ppm)	156	5.6	154	159	153	160
Na, Sodium (wt.%)	0.148	0.008	0.144	0.151	0.140	0.155
Nb, Niobium (ppm)	< 0.2	IND	IND	IND	IND	IND
Nd, Neodymium (ppm)	6.31	0.70	5.39	7.23	6.04	6.57
Ni, Nickel (ppm)	11.1	0.97	10.7	11.5	10.6	11.6
P, Phosphorus (wt.%)	0.047	0.002	0.046	0.047	0.045	0.048
Pb, Lead (ppm)	12.4	1.2	11.8	12.9	11.9	12.8
Rb, Rubidium (ppm)	7.34	0.86	6.60	8.08	7.12	7.55
Re, Rhenium (ppm)	0.17	0.02	0.15	0.20	IND	IND
S, Sulphur (wt.%)	1.27	0.053	1.25	1.30	1.25	1.30
Sb, Antimony (ppm)	2.12	0.38	1.90	2.33	1.99	2.24
Sc, Scandium (ppm)	9.98	0.675	9.66	10.30	9.73	10.24
Se, Selenium (ppm)	10.5	1.00	9.9	11.2	10.1	11.0
Sm, Samarium (ppm)	1.71	0.19	1.47	1.95	1.61	1.81
Sn, Tin (ppm)	3.27	0.43	2.89	3.64	3.12	3.42
Sr, Strontium (ppm)	31.4	1.70	30.6	32.1	30.4	32.3
Tb, Terbium (ppm)	0.31	0.018	0.29	0.34	0.29	0.33
Te, Tellurium (ppm)	0.25	0.04	0.23	0.28	0.22	0.28

Note: intervals may appear asymmetric due to rounding.

Table 1 continued.

Constituent	Certified Value	1SD	95% Confidence Limits		95% Tolerance Limits	
			Low	High	Low	High
Aqua Regia Digestion continued						
Th, Thorium (ppm)	0.35	0.04	0.33	0.37	0.33	0.37
Ti, Titanium (wt.%)	0.050	0.004	0.048	0.052	0.049	0.051
Tl, Thallium (ppm)	0.064	0.007	0.058	0.070	IND	IND
Tm, Thulium (ppm)	0.13	0.012	0.11	0.14	0.11	0.14
U, Uranium (ppm)	0.061	0.007	0.056	0.066	IND	IND
V, Vanadium (ppm)	153	5.4	150	156	150	156
W, Tungsten (ppm)	< 1	IND	IND	IND	IND	IND
Y, Yttrium (ppm)	9.38	0.415	9.11	9.64	9.10	9.65
Yb, Ytterbium (ppm)	0.83	0.08	0.74	0.93	0.79	0.88
Zn, Zinc (ppm)	118	4.8	116	121	115	122
Zr, Zirconium (ppm)	0.86	0.13	0.69	1.02	IND	IND
Cyanide Leach[#]						
Cu-Sol, Copper Soluble (wt.%)	0.157	0.005	0.154	0.161	0.153	0.162

Note: intervals may appear asymmetric due to rounding; [#]Cyanide leach methodology is shown below in the 'Analytical Program' section.

INTRODUCTION

OREAS reference materials are intended to provide a low cost method of evaluating and improving the quality of analysis of geological samples. To the geologist they provide a means of implementing quality control in analytical data sets generated in exploration from the grass roots level through to prospect evaluation, and in grade control at mining operations. To the analyst they provide an effective means of calibrating analytical equipment, assessing new techniques and routinely monitoring in-house procedures.

OREAS reference materials enable users to successfully achieve process control of these tasks because the observed variance from repeated analysis has its origin almost exclusively in the analytical process rather than the reference material itself.

SOURCE MATERIALS

OREAS 153b is one of three (second generation) porphyry Cu-Au certified reference materials (CRMs). It has been prepared from copper ore drilling reject material from 27 drill holes from the Waisoi district, Viti Levu, Fiji, with the addition of a minor quantity of Cu concentrate (0.76%). The two deposits in the Waisoi district are the Waisoi East deposit (quartz porphyry) and the Waisoi West deposit (diorite porphyry). Copper mineralisation in the region is accompanied by stockwork quartz veinlets and is characterised by bornite-chalcopyrite-pyrite assemblages formed under a high sulphidation environment.

COMMUNITION AND HOMOGENISATION PROCEDURES

The material constituting OREAS 153b was prepared in the following manner:

- drying to constant mass at 105°C;
- crushing and milling of the ore and concentrate material to 100% minus 30 microns;
- blending in appropriate proportions to achieve the desired grade;
- packaging in 60g units sealed in laminated foil pouches and 500g units in plastic jars.

ANALYTICAL PROGRAM

Twenty eight commercial analytical laboratories participated in the program to certify the 116 elements reported in Table 1. The following methods were employed:

- Gold by 25-40g fire assay with AAS (12 labs) or ICP-OES (9 labs) finish;
- Instrumental neutron activation analysis for Au on 1g subsamples to confirm homogeneity (1 laboratory).
- Gold by 15-40g aqua regia digestion with ICP-MS (11 labs), AAS (5 labs) or graphite furnace AAS (1 lab) finish;
- Aqua regia digestion for full elemental suite ICP-OES and ICP-MS (up to 21 laboratories depending on the element). It is important to note that in the analytical industry there is no standardisation of the aqua regia digestion process. Aqua regia is a partial empirical digest and differences in recoveries for various analytes are commonplace. These are caused by variations in the digest conditions which can include the ratio of nitric to hydrochloric acids, acid strength, temperatures, leach times and secondary digestions. Recoveries for sulphide-hosted base metal sulphides approach total values, however, other analytes, in particular the lithophile elements, show greater sensitivity to method parameters. This can result in lack of consensus in an inter-laboratory certification program for these elements. The approach applied here is to report certified values in those instances where reasonable agreement exists amongst a majority of participating laboratories. The results of specific laboratories may differ significantly from the certified values, but will, nonetheless, be valid and reproducible in the context of the specifics of the aqua regia method in use. Users of this reference material should, therefore, be mindful of this limitation when applying the certified values in a quality control program.
- 4-Acid digestion for full elemental suite ICP-OES and ICP-MS (up to 21 laboratories depending on the element);
- Copper soluble by cyanide leach with AAS finish (13 labs) employing the following specified methodology:
 - 0.5% NaCN solution is added to the sample and tumbled for 90 minutes at room temperature. The solution containing dissolved copper sulphide minerals is measured via AAS.
 - Steps -
 - Weigh 0.3 g of sample into a 20 mL PS tube;
 - Dispense 12 mL of 0.5% NaCN solution into sample tube;
 - Place sample tube into tumbler and tumble/ agitate for 90 minutes;
 - Stand sample upright and allow to settle for 90 minutes;
 - Analyse sample by AAS.

For the round robin program twenty 1kg test units were taken at predetermined intervals during the bagging stage, immediately following final blending and are considered representative of the entire batch. The six samples received by each laboratory were obtained by taking two 110g scoop splits from each of three separate 1kg test units. This format enabled nested ANOVA treatment of the results to evaluate homogeneity, i.e. to ascertain whether between-unit variance is greater than within-unit variance. Table 1 presents the 116 certified values together with their associated 1SD's, 95% confidence and tolerance limits and Table 2 shows 86 indicative values. Table 3 provides performance gate intervals for the certified values of each method group based on their pooled 1SD's. Tabulated results of all elements (including Au INAA analyses) together with uncorrected means, medians, standard deviations, relative standard deviations and percent deviation of lab means from the corrected mean of means (PDM³) are presented in the detailed certification data for this CRM (**OREAS 153b Datapack.xlsx**).

STATISTICAL ANALYSIS

Certified Values, Confidence Limits, Standard Deviations and Tolerance Limits (Table 1) have been determined for each analyte following removal of individual, laboratory dataset (batch) and 3SD outliers (single iteration). For individual outliers within a laboratory batch the z-score test is used in combination with a second method that determines the per cent deviation of the individual value from the batch median. Outliers in general are selected on the basis of z-scores > 2.5 and with per cent deviations (i) > 3 and (ii) more than three times the average absolute per cent deviation for the batch. In certain instances statistician's prerogative has been employed in discriminating outliers. Each laboratory data set mean is tested for outlying status based on z-score discrimination and rejected if > 2.5. After individual and laboratory data set (batch) outliers have been eliminated a non-iterative 3 standard deviation filter is applied, with those values lying outside this window also relegated to outlying status.

Certified Values are the means of accepted laboratory means after outlier filtering. The INAA data is omitted from determination of the certified value for Au and is used solely for the calculation of Tolerance Limits and homogeneity evaluation of OREAS 153b.

Indicative (uncertified) values (Table 2) are provided for the major and trace elements determined by borate fusion XRF (Al₂O₃ to Zn) and laser ablation with ICP-MS (Ag to Zr) and are the means of duplicate assays from Bureau Veritas, Perth. Additional indicative values by other analytical methods are present where the number of laboratories reporting a particular analyte is insufficient (< 5) to support certification or where inter-laboratory consensus is poor.

95% Confidence Limits are inversely proportional to the number of participating laboratories and inter-laboratory agreement. It is a measure of the reliability of the certified value. A 95% confidence interval indicates a 95% probability that the true value of the analyte under consideration lies between the upper and lower limits. *95% Confidence Limits should not be used as control limits for laboratory performance.*

Standard Deviation values (1SDs) are reported in Table 1 and provide an indication of a level of performance that might reasonably be expected from a laboratory being monitored by this CRM in a QA/QC program. The SD's take into account errors attributable to measurement uncertainty and CRM variability. For an effective CRM the contribution of the latter should be negligible in comparison to measurement errors. The SD values thus

include all sources of measurement uncertainty: between-lab variance, within-run variance (precision errors) and CRM variability. OREAS reference materials have a level of homogeneity such that the observed variance from repeated analysis has its origin almost exclusively in the analytical process rather than the reference material itself.

The SD for each analyte's certified value is calculated from the same filtered data set used to determine the certified value, i.e. after removal of any individual, lab dataset (batch) and 3SD outliers (single iteration). These outliers can only be removed after the absolute homogeneity of the CRM has been independently established, i.e. the outliers must be confidently deemed to be analytical rather than arising from inhomogeneity of the CRM. **The standard deviation is then calculated for each analyte from the pooled accepted analyses generated from the certification program.**

In the application of SD's in monitoring performance it is important to note that not all laboratories function at the same level of proficiency and that different methods in use at a particular laboratory have differing levels of precision. Each laboratory has its own inherent SD (for a specific concentration level and analyte-method pair) based on the analytical process and this SD is not directly related to the round robin program.

The majority of data generated in the round robin program was produced by a selection of world class laboratories. The SD's thus generated are more constrained than those that would be produced across a randomly selected group of laboratories. To produce more generally achievable SD's the 'pooled' SD's provided in this report include inter-lab bias. This 'one size fits all' approach may require revision at the discretion of the QC manager concerned following careful scrutiny of QC control charts.

Table 3 shows **Performance Gates** calculated for two and three standard deviations. As a guide these intervals may be regarded as warning or rejection for multiple 2SD outliers, or rejection for individual 3SD outliers in QC monitoring, although their precise application should be at the discretion of the QC manager concerned. A second method utilises a 5% window calculated directly from the certified value. Standard deviation is also shown in relative percent for one, two and three relative standard deviations (1RSD, 2RSD and 3RSD) to facilitate an appreciation of the magnitude of these numbers and a comparison with the 5% window. Caution should be exercised when concentration levels approach lower limits of detection of the analytical methods employed as performance gates calculated from standard deviations tend to be excessively wide whereas those determined by the 5% method are too narrow.

Table 2. Indicative Values for OREAS 153b.

Constituent	Unit	Value	Constituent	Unit	Value	Constituent	Unit	Value
Fire Assay								
Pd	ppb	28	Pt	ppb	17			
Borate Fusion XRF								
Al ₂ O ₃	wt.%	15.84	Fe ₂ O ₃	wt.%	5.63	Pb	ppm	25.0
As	ppm	90	K ₂ O	wt.%	1.43	SiO ₂	wt.%	62.10
Ba	ppm	125	MgO	wt.%	2.87	Sn	ppm	12.5
CaO	wt.%	2.63	MnO	wt.%	0.040	SO ₃	wt.%	3.22
Co	ppm	20.0	Na ₂ O	wt.%	3.43	TiO ₂	wt.%	0.588
Cr	ppm	10.0	Ni	ppm	< 10	U	ppm	< 10
Cu	ppm	6710	P ₂ O ₅	wt.%	0.127	Zn	ppm	125

Note: the number of significant figures reported is not a reflection of the level of certainty of stated values. They are instead an artefact of ORE's in-house CRM-specific LIMS.

Table 2 continued.

Constituent	Unit	Value	Constituent	Unit	Value	Constituent	Unit	Value
Thermogravimetry								
LOI ¹⁰⁰⁰	wt.%	3.53						
Laser Ablation ICP-MS								
Ag	ppm	1.55	Ho	ppm	0.52	Sn	ppm	5.20
As	ppm	78	In	ppm	0.20	Sr	ppm	163
Ba	ppm	108	La	ppm	5.13	Ta	ppm	0.080
Be	ppm	1.00	Lu	ppm	0.28	Tb	ppm	0.31
Bi	ppm	1.66	Mn	wt.%	0.028	Te	ppm	1.30
Cd	ppm	< 0.1	Mo	ppm	158	Th	ppm	0.55
Ce	ppm	11.1	Nb	ppm	1.47	Ti	wt.%	0.348
Co	ppm	15.9	Nd	ppm	8.18	Tl	ppm	0.15
Cr	ppm	18.0	Ni	ppm	14.0	Tm	ppm	0.25
Cs	ppm	0.36	Pb	ppm	12.5	U	ppm	0.30
Cu	ppm	6650	Pr	ppm	1.70	V	ppm	238
Dy	ppm	2.19	Rb	ppm	20.7	W	ppm	2.18
Er	ppm	1.58	Re	ppm	0.17	Y	ppm	14.4
Eu	ppm	0.87	Sb	ppm	2.60	Yb	ppm	1.53
Ga	ppm	18.4	Sc	ppm	16.7	Zn	ppm	103
Gd	ppm	2.00	Se	ppm	< 5	Zr	ppm	66
Hf	ppm	1.96	Sm	ppm	2.24			
4-Acid Digestion								
Ge	ppm	0.96	Hg	ppm	0.055			
Aqua Regia Digestion								
Er	ppm	1.02	Hf	ppm	< 0.05	Pr	ppm	1.29
Eu	ppm	0.51	Ho	ppm	0.34	Pt	ppb	< 5
Gd	ppm	1.84	Os	ppm	< 1	Ru	ppm	0.015
Ge	ppm	0.41	Pd	ppb	18	Ta	ppm	< 0.05

Note: the number of significant figures reported is not a reflection of the level of certainty of stated values. They are instead an artefact of ORE's in-house CRM-specific LIMS.

Table 3. Performance Gates for OREAS 153b.

Constituent	Certified Value	Absolute Standard Deviations					Relative Standard Deviations			5% window	
		1SD	2SD Low	2SD High	3SD Low	3SD High	1RSD	2RSD	3RSD	Low	High
Fire Assay											
Au, ppb	313	9	295	331	286	340	2.86%	5.72%	8.58%	298	329
4-Acid Digestion											
Ag, ppm	1.45	0.090	1.27	1.63	1.18	1.72	6.21%	12.41%	18.62%	1.38	1.52
Al, wt.%	7.94	0.314	7.32	8.57	7.00	8.89	3.95%	7.89%	11.84%	7.55	8.34
As, ppm	79	5.4	68	90	63	95	6.79%	13.57%	20.36%	75	83
Ba, ppm	103	4	96	110	92	114	3.48%	6.97%	10.45%	98	108
Be, ppm	0.52	0.041	0.43	0.60	0.39	0.64	7.89%	15.77%	23.66%	0.49	0.54
Bi, ppm	1.61	0.144	1.32	1.90	1.18	2.04	8.95%	17.91%	26.86%	1.53	1.69
Ca, wt.%	1.83	0.078	1.67	1.99	1.60	2.07	4.28%	8.56%	12.85%	1.74	1.92

Note: intervals may appear asymmetric due to rounding.

Table 3 continued.

Constituent	Certified Value	Absolute Standard Deviations					Relative Standard Deviations			5% window	
		1SD	2SD Low	2SD High	3SD Low	3SD High	1RSD	2RSD	3RSD	Low	High
4-Acid Digestion continued											
Cd, ppm	0.26	0.05	0.17	0.36	0.12	0.41	18.15%	36.30%	54.45%	0.25	0.28
Ce, ppm	11.7	1.9	7.9	15.5	6.0	17.4	16.17%	32.33%	48.50%	11.1	12.3
Co, ppm	15.4	1.35	12.7	18.1	11.3	19.5	8.79%	17.58%	26.38%	14.6	16.2
Cr, ppm	17.3	2.9	11.6	23.0	8.7	25.9	16.49%	32.99%	49.48%	16.4	18.2
Cs, ppm	0.44	0.041	0.36	0.52	0.32	0.56	9.26%	18.52%	27.78%	0.42	0.46
Cu, wt. %	0.678	0.015	0.648	0.709	0.632	0.724	2.25%	4.50%	6.74%	0.644	0.712
Dy, ppm	2.11	0.133	1.84	2.38	1.71	2.51	6.32%	12.63%	18.95%	2.01	2.22
Er, ppm	1.23	0.087	1.06	1.40	0.97	1.49	7.06%	14.12%	21.17%	1.17	1.29
Eu, ppm	0.67	0.035	0.60	0.74	0.56	0.78	5.30%	10.59%	15.89%	0.64	0.70
Fe, wt. %	3.86	0.140	3.58	4.13	3.44	4.27	3.62%	7.24%	10.86%	3.66	4.05
Ga, ppm	18.8	1.26	16.3	21.4	15.1	22.6	6.67%	13.35%	20.02%	17.9	19.8
Gd, ppm	2.15	0.130	1.89	2.41	1.77	2.54	6.02%	12.03%	18.05%	2.05	2.26
Hf, ppm	< 0.5	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Ho, ppm	0.43	0.042	0.34	0.51	0.30	0.56	9.89%	19.79%	29.68%	0.41	0.45
In, ppm	0.23	0.013	0.21	0.26	0.19	0.27	5.63%	11.25%	16.88%	0.22	0.24
K, wt. %	1.16	0.047	1.06	1.25	1.01	1.30	4.10%	8.20%	12.30%	1.10	1.21
La, ppm	5.03	0.77	3.48	6.58	2.71	7.36	15.40%	30.79%	46.19%	4.78	5.28
Li, ppm	5.69	0.328	5.03	6.35	4.71	6.67	5.76%	11.53%	17.29%	5.41	5.97
Lu, ppm	0.16	0.02	0.11	0.20	0.09	0.23	14.84%	29.68%	44.51%	0.15	0.16
Mg, wt. %	1.64	0.065	1.51	1.77	1.45	1.84	3.96%	7.93%	11.89%	1.56	1.73
Mn, wt. %	0.028	0.001	0.026	0.030	0.025	0.032	4.11%	8.23%	12.34%	0.027	0.029
Mo, ppm	163	10	142	184	132	195	6.41%	12.82%	19.23%	155	171
Na, wt. %	2.46	0.064	2.33	2.59	2.27	2.65	2.60%	5.21%	7.81%	2.34	2.58
Nb, ppm	1.42	0.25	0.92	1.93	0.66	2.19	17.82%	35.63%	53.45%	1.35	1.50
Nd, ppm	7.40	0.432	6.53	8.26	6.10	8.70	5.84%	11.69%	17.53%	7.03	7.77
Ni, ppm	11.9	1.6	8.6	15.1	7.0	16.7	13.60%	27.19%	40.79%	11.3	12.5
P, wt. %	0.053	0.004	0.045	0.061	0.040	0.065	7.79%	15.59%	23.38%	0.050	0.055
Pb, ppm	13.1	1.20	10.7	15.5	9.5	16.7	9.16%	18.33%	27.49%	12.4	13.8
Pr, ppm	1.72	0.102	1.52	1.92	1.42	2.03	5.90%	11.80%	17.71%	1.63	1.81
Rb, ppm	20.5	1.38	17.8	23.3	16.4	24.6	6.70%	13.40%	20.10%	19.5	21.5
Re, ppm	0.18	0.017	0.14	0.21	0.12	0.23	9.71%	19.43%	29.14%	0.17	0.18
S, wt. %	1.28	0.034	1.21	1.35	1.18	1.38	2.66%	5.32%	7.98%	1.22	1.34

Note: intervals may appear asymmetric due to rounding.

Table 3 continued.

Constituent	Certified Value	Absolute Standard Deviations					Relative Standard Deviations			5% window	
		1SD	2SD Low	2SD High	3SD Low	3SD High	1RSD	2RSD	3RSD	Low	High
4-Acid Digestion continued											
Sb, ppm	3.04	0.36	2.32	3.76	1.97	4.11	11.78%	23.56%	35.34%	2.89	3.19
Sc, ppm	16.8	1.20	14.4	19.2	13.2	20.4	7.17%	14.33%	21.50%	16.0	17.6
Se, ppm	11.2	1.3	8.6	13.7	7.4	15.0	11.29%	22.59%	33.88%	10.6	11.7
Sm, ppm	1.93	0.175	1.58	2.28	1.41	2.46	9.07%	18.14%	27.21%	1.84	2.03
Sn, ppm	3.97	0.391	3.19	4.75	2.80	5.15	9.84%	19.68%	29.52%	3.77	4.17
Sr, ppm	164	7	149	178	142	185	4.39%	8.78%	13.18%	155	172
Ta, ppm	< 0.5	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Tb, ppm	0.36	0.035	0.29	0.43	0.25	0.46	9.81%	19.62%	29.43%	0.34	0.37
Te, ppm	0.27	0.05	0.17	0.36	0.13	0.41	17.41%	34.81%	52.22%	0.25	0.28
Th, ppm	0.45	0.044	0.37	0.54	0.32	0.59	9.73%	19.46%	29.19%	0.43	0.48
Ti, wt. %	0.285	0.033	0.219	0.351	0.186	0.383	11.54%	23.09%	34.63%	0.271	0.299
Tl, ppm	0.16	0.03	0.11	0.22	0.08	0.24	16.34%	32.68%	49.02%	0.16	0.17
Tm, ppm	0.18	0.02	0.13	0.22	0.11	0.24	12.64%	25.29%	37.93%	0.17	0.19
U, ppm	0.11	0.01	0.08	0.13	0.07	0.15	12.62%	25.25%	37.87%	0.10	0.11
V, ppm	230	11	209	251	199	262	4.57%	9.15%	13.72%	219	242
W, ppm	2.02	0.37	1.29	2.75	0.93	3.12	18.05%	36.11%	54.16%	1.92	2.12
Y, ppm	11.1	0.80	9.5	12.7	8.7	13.5	7.23%	14.45%	21.68%	10.5	11.6
Yb, ppm	1.17	0.16	0.86	1.48	0.71	1.64	13.22%	26.45%	39.67%	1.11	1.23
Zn, ppm	122	5	112	131	107	136	3.85%	7.71%	11.56%	115	128
Zr, ppm	< 10	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Aqua Regia Digestion											
Ag, ppm	1.43	0.103	1.23	1.64	1.12	1.74	7.20%	14.40%	21.60%	1.36	1.51
Al, wt. %	2.28	0.111	2.05	2.50	1.94	2.61	4.89%	9.78%	14.67%	2.16	2.39
As, ppm	80	3.1	74	86	71	89	3.85%	7.69%	11.54%	76	84
Au, ppb	320	13	295	345	282	357	3.92%	7.83%	11.75%	304	336
B, ppm	< 10	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Ba, ppm	22.8	2.8	17.1	28.4	14.3	31.2	12.35%	24.71%	37.06%	21.6	23.9
Be, ppm	0.18	0.03	0.11	0.24	0.08	0.27	17.93%	35.85%	53.78%	0.17	0.19
Bi, ppm	1.81	0.25	1.31	2.30	1.07	2.55	13.63%	27.26%	40.89%	1.72	1.90
Ca, wt. %	1.32	0.055	1.21	1.43	1.16	1.49	4.14%	8.29%	12.43%	1.26	1.39
Cd, ppm	0.24	0.05	0.15	0.34	0.10	0.39	19.98%	39.97%	59.95%	0.23	0.25
Ce, ppm	9.11	0.856	7.39	10.82	6.54	11.67	9.40%	18.80%	28.20%	8.65	9.56

Note: intervals may appear asymmetric due to rounding.

Table 3 continued.

Constituent	Certified Value	Absolute Standard Deviations					Relative Standard Deviations			5% window	
		1SD	2SD Low	2SD High	3SD Low	3SD High	1RSD	2RSD	3RSD	Low	High
Aqua Regia Digestion continued											
Co, ppm	14.9	1.04	12.9	17.0	11.8	18.1	6.99%	13.99%	20.98%	14.2	15.7
Cr, ppm	16.2	1.08	14.0	18.3	12.9	19.4	6.70%	13.39%	20.09%	15.4	17.0
Cs, ppm	0.26	0.04	0.17	0.34	0.13	0.38	16.65%	33.30%	49.95%	0.24	0.27
Cu, wt.%	0.670	0.013	0.643	0.697	0.630	0.710	2.01%	4.01%	6.02%	0.637	0.704
Dy, ppm	1.92	0.35	1.22	2.63	0.86	2.98	18.37%	36.75%	55.12%	1.83	2.02
Fe, wt.%	3.60	0.107	3.39	3.82	3.28	3.93	2.98%	5.96%	8.94%	3.42	3.78
Ga, ppm	8.06	1.36	5.34	10.78	3.98	12.14	16.89%	33.77%	50.66%	7.66	8.46
Hg, ppm	0.066	0.013	0.040	0.093	0.027	0.106	19.87%	39.75%	59.62%	0.063	0.070
In, ppm	0.21	0.014	0.19	0.24	0.17	0.26	6.62%	13.24%	19.86%	0.20	0.22
K, wt.%	0.365	0.030	0.305	0.424	0.275	0.454	8.18%	16.36%	24.54%	0.346	0.383
La, ppm	3.79	0.238	3.32	4.27	3.08	4.51	6.26%	12.53%	18.79%	3.60	3.98
Li, ppm	3.28	0.64	2.00	4.57	1.35	5.21	19.58%	39.16%	58.74%	3.12	3.45
Lu, ppm	0.11	0.01	0.09	0.13	0.07	0.14	10.75%	21.50%	32.25%	0.10	0.11
Mg, wt.%	1.47	0.053	1.37	1.58	1.31	1.63	3.59%	7.19%	10.78%	1.40	1.55
Mn, wt.%	0.024	0.001	0.022	0.026	0.021	0.027	3.73%	7.47%	11.20%	0.023	0.025
Mo, ppm	156	6	145	168	140	173	3.61%	7.22%	10.83%	149	164
Na, wt.%	0.148	0.008	0.131	0.164	0.122	0.173	5.74%	11.49%	17.23%	0.140	0.155
Nb, ppm	< 0.2	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Nd, ppm	6.31	0.70	4.91	7.71	4.21	8.40	11.07%	22.14%	33.21%	5.99	6.62
Ni, ppm	11.1	0.97	9.2	13.1	8.2	14.0	8.74%	17.49%	26.23%	10.6	11.7
P, wt.%	0.047	0.002	0.043	0.050	0.042	0.052	3.69%	7.37%	11.06%	0.044	0.049
Pb, ppm	12.4	1.2	9.9	14.9	8.7	16.1	10.04%	20.08%	30.11%	11.8	13.0
Rb, ppm	7.34	0.86	5.61	9.06	4.75	9.93	11.76%	23.53%	35.29%	6.97	7.70
Re, ppm	0.17	0.02	0.13	0.21	0.11	0.23	11.10%	22.21%	33.31%	0.16	0.18
S, wt.%	1.27	0.053	1.17	1.38	1.11	1.43	4.19%	8.38%	12.58%	1.21	1.34
Sb, ppm	2.12	0.38	1.36	2.87	0.98	3.25	17.95%	35.90%	53.85%	2.01	2.22
Sc, ppm	9.98	0.675	8.63	11.33	7.96	12.01	6.76%	13.53%	20.29%	9.48	10.48
Se, ppm	10.5	1.00	8.5	12.5	7.5	13.5	9.46%	18.92%	28.38%	10.0	11.1
Sm, ppm	1.71	0.19	1.33	2.09	1.14	2.28	11.13%	22.26%	33.39%	1.62	1.79
Sn, ppm	3.27	0.43	2.40	4.14	1.97	4.57	13.29%	26.57%	39.86%	3.10	3.43
Sr, ppm	31.4	1.70	28.0	34.8	26.3	36.5	5.41%	10.82%	16.23%	29.8	32.9
Tb, ppm	0.31	0.018	0.28	0.35	0.26	0.37	5.81%	11.62%	17.43%	0.30	0.33

Note: intervals may appear asymmetric due to rounding.

Table 3 continued.

Constituent	Certified Value	Absolute Standard Deviations					Relative Standard Deviations			5% window	
		1SD	2SD Low	2SD High	3SD Low	3SD High	1RSD	2RSD	3RSD	Low	High
Aqua Regia Digestion continued											
Te, ppm	0.25	0.04	0.17	0.33	0.13	0.37	16.04%	32.09%	48.13%	0.24	0.27
Th, ppm	0.35	0.04	0.28	0.42	0.24	0.46	10.47%	20.95%	31.42%	0.33	0.37
Ti, wt. %	0.050	0.004	0.042	0.058	0.038	0.062	8.14%	16.27%	24.41%	0.048	0.053
Tl, ppm	0.064	0.007	0.050	0.079	0.043	0.086	11.24%	22.49%	33.73%	0.061	0.067
Tm, ppm	0.13	0.012	0.10	0.15	0.09	0.16	9.54%	19.09%	28.63%	0.12	0.13
U, ppm	0.061	0.007	0.047	0.075	0.040	0.083	11.67%	23.34%	35.01%	0.058	0.064
V, ppm	153	5	142	164	137	169	3.55%	7.11%	10.66%	145	161
W, ppm	< 1	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Y, ppm	9.38	0.415	8.55	10.20	8.13	10.62	4.42%	8.85%	13.27%	8.91	9.84
Yb, ppm	0.83	0.08	0.66	1.00	0.58	1.09	10.18%	20.36%	30.54%	0.79	0.87
Zn, ppm	118	5	109	128	104	133	4.05%	8.09%	12.14%	113	124
Zr, ppm	0.86	0.13	0.60	1.11	0.48	1.24	14.85%	29.69%	44.54%	0.81	0.90
Cyanide Leach[#]											
Cu-Sol, wt. %	0.157	0.005	0.148	0.167	0.144	0.171	2.92%	5.85%	8.77%	0.150	0.165

Note: intervals may appear asymmetric due to rounding; [#]Cyanide leach methodology is described in the 'Analytical Program' section above.

Tolerance Limits (ISO Guide 3207) were determined using an analysis of precision errors method and are considered a conservative estimate of true homogeneity. The meaning of tolerance limits may be illustrated for copper by 4-acid digestion, where 99% of the time ($1-\alpha=0.99$) at least 95% of subsamples ($\rho=0.95$) will have concentrations lying between 0.667 and 0.689 wt.%. Put more precisely, this means that if the same number of subsamples were taken and analysed in the same manner repeatedly, 99% of the tolerance intervals so constructed would cover at least 95% of the total population, and 1% of the tolerance intervals would cover less than 95% of the total population (ISO Guide 35).

For gold the tolerance has been determined by INAA using the reduced analytical subsample method which utilises the known relationship between standard deviation and analytical subsample weight (Ingamells and Switzer, 1973). In this approach the sample aliquot is substantially reduced to a point where most of the variability in replicate assays should be due to inhomogeneity of the reference material and measurement error becomes negligible. In this instance a subsample weight of 1.0 gram was employed and the 1RSD of 2.94% (or 0.55% at a 30g charge weight) confirms the high level of gold homogeneity in OREAS 153b.

The homogeneity of OREAS 153b has also been evaluated in an ANOVA study for all certified analytes. This study tests the null hypothesis that no statistically significant difference exists between the *between-unit variance* and the *within-unit variance* (i.e. p-values <0.05 indicate rejection of the null hypothesis). Of the 116 certified values, no failures were observed indicating no evidence to reject the null hypothesis.

Based on the statistical analysis of the results of the inter-laboratory certification program it can be concluded that OREAS 153b is fit-for-purpose as a certified reference material (see 'Intended Use' below).

PARTICIPATING LABORATORIES

1. Acme (BV), Santiago, Chile
2. Acme (BV), Vancouver, BC, Canada
3. Actlabs, Ancaster, Ontario, Canada
4. Actlabs, Ancaster, Ontario, Canada
5. Actlabs, Thunder Bay, Ontario, Canada
6. ALS, Brisbane, QLD, Australia
7. ALS, Johannesburg, South Africa
8. ALS, Loughrea, Galway, Ireland
9. ALS, Perth, WA, Australia
10. ALS, Vancouver, BC, Canada
11. Bureau Veritas Geoanalytical, Adelaide, SA, Australia
12. Bureau Veritas Geoanalytical, Perth, WA, Australia
13. Inspectorate (BV), Lima, Peru
14. Intertek Genalysis, Adelaide, SA, Australia
15. Intertek Genalysis, Perth, WA, Australia
16. Intertek Minerals (IMI), Jakarta, Indonesia
17. Intertek Testing Services, Cotia, São Paulo, Brazil
18. Intertek Testing Services, Cupang, Muntinlupa, Philippines
19. Intertek Testing Services, Hidden Valley, Wau, PNG
20. Intertek Testing Services, Shunyi, Beijing, China
21. Labtium Oy, Saarenkylä, Rovaniemi, Finland
22. Newcrest Services Laboratory (NSL), Orange, NSW, Australia
23. Ok Tedi Mine Lab, Mt Fubilan, Western Province, PNG
24. PT Geoservices Ltd, Cikarang, Jakarta Raya, Indonesia
25. Quantum Analytical Services, Perth, WA, Australia
26. SGS Canada Inc., Vancouver, BC, Canada
27. SGS Geosol Laboratorios Ltda, Vespasiano, Minas Gerais, Brazil
28. SGS Mineral Services, Townsville, QLD, Australia

PREPARER AND SUPPLIER OF THE REFERENCE MATERIAL

Certified reference material OREAS 153b is prepared, certified and supplied by:



ORE Research & Exploration Pty Ltd
37A Hosie Street
Bayswater North VIC 3153
AUSTRALIA

Tel: +613-9729 0333
Fax: +613-9729 8338
Web: www.ore.com.au
Email: info@ore.com.au

It is available in unit sizes of 60g (single-use laminated foil sachet) and 500g (plastic jar).

INTENDED USE

OREAS 153b is intended for the following uses:

- for the monitoring of laboratory performance in the analysis of analytes reported in Table 1 in geological samples;
- for the verification of analytical methods for analytes reported in Table 1;
- for the calibration of instruments used in the determination of the concentration of analytes reported in Table 1.

STABILITY AND STORAGE INSTRUCTIONS

OREAS 153b has been prepared from porphyry copper ore and is low in reactive sulphide (1.28% S). In its unopened state and under normal conditions of storage it has a shelf life beyond ten years. Its stability will be monitored at regular intervals and purchasers notified if any changes are observed.

INSTRUCTIONS FOR CORRECT USE

The certified values for OREAS 153b refer to the concentration level in its packaged state. It should not be dried prior to weighing and analysis. The aqua regia results of specific laboratories may differ significantly from the certified values reported here but nonetheless be valid and reproducible in the context of the specifics of the aqua regia method in use. Please be mindful of this limitation when applying the certified values in a quality control program.

HANDLING INSTRUCTIONS

Fine powders pose a risk to eyes and lungs and therefore standard precautions such as the use of safety glasses and dust masks are advised.

LEGAL NOTICE

Ore Research & Exploration Pty Ltd has prepared and statistically evaluated the property values of this reference material to the best of its ability. The Purchaser by receipt hereof releases and indemnifies Ore Research & Exploration Pty Ltd from and against all liability and costs arising from the use of this material and information.

QMS ACCREDITED

ORE Pty Ltd is accredited to ISO 9001:2008 by Lloyd's Register Quality Assurance Ltd for its quality management system including development, manufacturing, certification and supply of CRMs.



CERTIFYING OFFICER



Craig Hamlyn (B.Sc. Hons - Geology), Technical Manager - ORE P/L

REFERENCES

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