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CERTIFICATE OF ANALYSIS FOR

COPPER-NICKEL-PLATINUM GROUP ELEMENT (PGE) ORE CERTIFIED REFERENCE MATERIAL

OREAS 680

Summary Statistics for Key Analytes.

Constituent	Certified Value	1SD	95% Confidence Limits		95% Tolerance Limits	
			Low	High	Low	High
Pb Collection Fire Assay						
Au, Gold (ppb)	161	8	157	164	157	165
Pd, Palladium (ppb)	218	13	213	223	211	225
Pt, Platinum (ppb)	405	17	398	411	393	417
NiS Collection Fire Assay						
Au, Gold (ppb)	147	5	143	151	141	153
Ir, Iridium (ppb)	32.0	3.1	29.5	34.6	31.0	33.0
Pd, Palladium (ppb)	215	10	207	222	209	220
Pt, Platinum (ppb)	401	19	390	412	391	410
Rh, Rhodium (ppb)	40.4	3.5	38.7	42.0	39.4	41.3
Ru, Ruthenium (ppb)	84.9	5.5	82.6	87.3	82.6	87.3
4-Acid Digestion						
Co, Cobalt (ppm)	334	20	322	346	325	344
Cu, Copper (wt.%)	0.904	0.018	0.896	0.912	0.886	0.922
Ni, Nickel (wt.%)	2.15	0.056	2.13	2.18	2.11	2.19

Note: intervals may appear asymmetric due to rounding.
Full certified elements list available in Table 1 below.

Table 1. Certified Values, SDs, 95% Confidence and Tolerance Limits for OREAS 680.

Constituent	Certified Value	1SD	95% Confidence Limits		95% Tolerance Limits	
			Low	High	Low	High
Fire Assay						
Au, Gold (ppb)	161	8	157	164	157	165
Pd, Palladium (ppb)	218	13	213	223	211	225
Pt, Platinum (ppb)	405	17	398	411	393	417
NiS Collection						
Au, Gold (ppb)	147	5	143	151	141	153
Ir, Iridium (ppb)	32.0	3.1	29.5	34.6	31.0	33.0
Pd, Palladium (ppb)	215	10	207	222	209	220
Pt, Platinum (ppb)	401	19	390	412	391	410
Rh, Rhodium (ppb)	40.4	3.5	38.7	42.0	39.4	41.3
Ru, Ruthenium (ppb)	84.9	5.5	82.6	87.3	82.6	87.3
Peroxide Fusion ICP						
Ag, Silver (ppm)	10.5	1.2	9.6	11.5	IND	IND
Al, Aluminium (wt.%)	7.19	0.138	7.14	7.24	7.05	7.32
As, Arsenic (ppm)	120	11	110	129	115	124
Ba, Barium (ppm)	649	43	622	675	630	668
Bi, Bismuth (ppm)	1.66	0.29	1.36	1.96	IND	IND
Ca, Calcium (wt.%)	5.80	0.188	5.70	5.89	5.68	5.91
Cd, Cadmium (ppm)	8.18	0.86	7.27	9.09	7.90	8.45
Ce, Cerium (ppm)	38.7	2.37	37.0	40.4	37.4	40.0
Co, Cobalt (ppm)	334	20	322	346	325	344
Cr, Chromium (ppm)	2139	93	2093	2185	2090	2188
Cs, Cesium (ppm)	3.94	0.232	3.80	4.08	3.70	4.18
Cu, Copper (wt.%)	0.904	0.018	0.896	0.912	0.886	0.922
Dy, Dysprosium (ppm)	3.07	0.128	2.97	3.17	2.93	3.21
Er, Erbium (ppm)	1.74	0.19	1.59	1.88	1.66	1.81
Eu, Europium (ppm)	1.30	0.077	1.26	1.35	1.24	1.37
Fe, Iron (wt.%)	11.93	0.555	11.67	12.20	11.70	12.17
Ga, Gallium (ppm)	16.5	1.22	15.7	17.3	IND	IND
Gd, Gadolinium (ppm)	3.77	0.233	3.52	4.02	3.49	4.06
Ho, Holmium (ppm)	0.58	0.042	0.54	0.61	0.53	0.62
K, Potassium (wt.%)	1.29	0.083	1.25	1.33	1.25	1.32
La, Lanthanum (ppm)	18.6	1.64	17.4	19.8	17.7	19.5
Li, Lithium (ppm)	14.5	1.6	13.0	15.9	IND	IND
Lu, Lutetium (ppm)	0.23	0.03	0.20	0.26	0.19	0.28
Mg, Magnesium (wt.%)	3.71	0.154	3.63	3.79	3.64	3.77
Mn, Manganese (wt.%)	0.124	0.004	0.121	0.126	0.121	0.126
Nb, Niobium (ppm)	5.09	0.92	4.35	5.82	IND	IND
Nd, Neodymium (ppm)	20.8	0.74	20.2	21.4	20.0	21.6
Ni, Nickel (wt.%)	2.15	0.056	2.13	2.18	2.11	2.19
P, Phosphorus (wt.%)	0.122	0.014	0.113	0.130	IND	IND
Pb, Lead (ppm)	2579	103	2517	2642	2525	2633

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
Peroxide Fusion ICP continued						
Pr, Praseodymium (ppm)	4.99	0.190	4.85	5.13	4.83	5.15
Rb, Rubidium (ppm)	76	3.6	74	78	73	80
S, Sulphur (wt.%)	5.14	0.155	5.03	5.25	5.01	5.27
Sb, Antimony (ppm)	19.7	1.66	18.5	20.9	17.9	21.5
Sc, Scandium (ppm)	21.3	1.20	20.0	22.5	19.8	22.7
Si, Silicon (wt.%)	20.62	0.549	20.33	20.91	20.13	21.11
Sm, Samarium (ppm)	4.26	0.279	4.10	4.42	4.01	4.51
Sr, Strontium (ppm)	420	9	415	425	409	431
Tb, Terbium (ppm)	0.55	0.039	0.52	0.58	0.51	0.59
Th, Thorium (ppm)	6.73	0.461	6.52	6.94	5.70	7.76
Ti, Titanium (wt.%)	0.523	0.020	0.513	0.532	0.510	0.536
U, Uranium (ppm)	1.55	0.111	1.48	1.61	1.38	1.71
V, Vanadium (ppm)	224	15	213	235	217	231
Y, Yttrium (ppm)	16.2	0.45	15.8	16.5	15.9	16.5
Yb, Ytterbium (ppm)	1.52	0.127	1.40	1.63	IND	IND
Zn, Zinc (ppm)	2321	159	2237	2406	2261	2382
4-Acid Digestion						
Ag, Silver (ppm)	9.88	0.851	9.42	10.34	9.58	10.17
Al, Aluminium (wt.%)	7.13	0.159	7.04	7.21	7.00	7.25
As, Arsenic (ppm)	110	7	106	115	107	114
Be, Beryllium (ppm)	1.29	0.18	1.20	1.37	1.08	1.50
Bi, Bismuth (ppm)	1.64	0.064	1.61	1.68	1.57	1.71
Ca, Calcium (wt.%)	5.58	0.183	5.49	5.67	5.46	5.70
Cd, Cadmium (ppm)	8.15	0.548	7.85	8.45	7.89	8.41
Ce, Cerium (ppm)	39.2	1.96	38.2	40.2	37.9	40.5
Co, Cobalt (ppm)	317	16	309	325	311	324
Cr, Chromium (ppm)	1458	286	1312	1603	1390	1526
Cs, Cesium (ppm)	3.87	0.156	3.79	3.94	3.72	4.01
Cu, Copper (wt.%)	0.897	0.029	0.884	0.910	0.881	0.913
Dy, Dysprosium (ppm)	3.05	0.143	2.94	3.17	2.83	3.27
Er, Erbium (ppm)	1.75	0.087	1.68	1.82	1.69	1.81
Eu, Europium (ppm)	1.27	0.046	1.23	1.31	1.23	1.30
Fe, Iron (wt.%)	11.68	0.395	11.49	11.87	11.49	11.87
Ga, Gallium (ppm)	16.0	0.51	15.7	16.3	15.5	16.5
Gd, Gadolinium (ppm)	3.80	0.293	3.56	4.04	3.56	4.05
Hf, Hafnium (ppm)	1.64	0.148	1.57	1.71	1.53	1.76
Ho, Holmium (ppm)	0.62	0.023	0.60	0.63	0.59	0.64
In, Indium (ppm)	0.13	0.010	0.12	0.13	0.11	0.14
K, Potassium (wt.%)	1.24	0.065	1.21	1.28	1.22	1.27
La, Lanthanum (ppm)	18.1	1.18	17.6	18.7	17.6	18.7
Li, Lithium (ppm)	12.9	0.54	12.6	13.3	12.1	13.7
Lu, Lutetium (ppm)	0.24	0.009	0.23	0.24	0.23	0.25

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
4-Acid Digestion continued						
Mg, Magnesium (wt.%)	3.58	0.123	3.52	3.64	3.52	3.64
Mn, Manganese (wt.%)	0.122	0.006	0.119	0.124	0.119	0.124
Mo, Molybdenum (ppm)	1.94	0.36	1.73	2.14	1.84	2.03
Na, Sodium (wt.%)	1.45	0.040	1.43	1.46	1.42	1.47
Nb, Niobium (ppm)	5.82	0.282	5.69	5.95	5.50	6.15
Nd, Neodymium (ppm)	20.2	0.58	19.8	20.6	19.5	21.0
Ni, Nickel (wt.%)	2.12	0.075	2.09	2.16	2.08	2.16
P, Phosphorus (wt.%)	0.126	0.007	0.122	0.129	0.122	0.129
Pb, Lead (ppm)	2505	139	2428	2582	2457	2553
Pr, Praseodymium (ppm)	4.98	0.181	4.85	5.10	4.81	5.14
Rb, Rubidium (ppm)	74	4.1	72	76	71	76
S, Sulphur (wt.%)	4.98	0.108	4.91	5.05	4.88	5.08
Sb, Antimony (ppm)	19.9	0.99	19.4	20.4	19.1	20.7
Sc, Scandium (ppm)	21.9	0.89	21.5	22.4	21.2	22.7
Se, Selenium (ppm)	4.74	0.56	4.47	5.01	IND	IND
Sm, Samarium (ppm)	4.25	0.281	4.03	4.47	4.04	4.46
Sn, Tin (ppm)	2.22	0.204	2.11	2.33	2.12	2.33
Sr, Strontium (ppm)	429	17	420	438	420	439
Ta, Tantalum (ppm)	0.41	0.036	0.39	0.44	0.39	0.44
Tb, Terbium (ppm)	0.53	0.035	0.51	0.56	0.51	0.55
Te, Tellurium (ppm)	0.69	0.08	0.67	0.72	0.61	0.78
Th, Thorium (ppm)	6.56	0.626	6.29	6.83	6.03	7.10
Ti, Titanium (wt.%)	0.513	0.019	0.504	0.523	0.499	0.528
Tl, Thallium (ppm)	0.48	0.021	0.46	0.49	0.45	0.50
Tm, Thulium (ppm)	0.25	0.008	0.24	0.26	0.23	0.26
U, Uranium (ppm)	1.53	0.089	1.48	1.57	1.44	1.62
V, Vanadium (ppm)	221	9	216	225	215	226
W, Tungsten (ppm)	1.67	0.108	1.61	1.73	IND	IND
Y, Yttrium (ppm)	15.3	0.91	14.9	15.8	14.9	15.8
Yb, Ytterbium (ppm)	1.57	0.080	1.52	1.62	1.50	1.64
Zn, Zinc (ppm)	2308	70	2271	2345	2268	2348
Zr, Zirconium (ppm)	54	6	51	58	50	59

Note: intervals may appear asymmetric due to rounding

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.

SOURCE MATERIALS

OREAS 680 is a copper-nickel-platinum group element (PGE) ore certified reference material (CRM) prepared and certified by Ore Research & Exploration Pty Ltd. OREAS 680 has been prepared from PGE-rich ore blended with barren mafic dolerite and high grade copper and nickel ores. The PGE ore was sourced from the Dishaba mine site owned and operated by Anglo American Platinum Ltd. The Dishaba mine is located in the west of Limpopo province, South Africa, approximately 250 kilometres north of Johannesburg. The common minerals of economic importance are sulphides of iron, nickel, copper and alloys of the PGE's. The barren mafic dolerite was sourced from the Late Cambrian Black Hills dolerite complex located in eastern Adelaide, Australia. The high grade nickel ores were sourced from the Prospero & Tapinos deposits located in Western Australia. The high grade copper ore was sourced from the Sepon copper deposit located in south-central Laos. OREAS 680 is one of a suite of five PGE ore CRMs ranging in 4E concentrations (4E = 4 elements; platinum (Pt), palladium (Pd), rhodium (Ro) and gold (Au)) from 0.82 to 6.1ppm.

COMMINUTION AND HOMOGENISATION PROCEDURES

The material constituting OREAS 680 was prepared in the following manner:

- drying of barren dolerite and Dishaba PGE ore to constant mass at 105°C;
- drying of high grade copper and nickel sulphide ores to constant mass at 85°C;
- crushing and milling of the barren dolerite to >98% minus 75 microns;
- crushing and milling of the ore materials to 100% minus 30 microns;
- blending in appropriate proportions to achieve the desired grades;
- packaging in 60g units sealed under nitrogen in laminated foil pouches.

ANALYTICAL PROGRAM

Twenty three geochemical laboratories participated in the program to certify the analytes reported in Table 1. The following methods were employed:

- Four acid digestion for full ICP-OES and ICP-MS elemental suites (up to 18 laboratories depending on the element) except for one laboratory for Cu and four laboratories for Ni who used an AAS finish;
- Peroxide fusion for full ICP-OES and ICP-MS elemental suites (up to 18 laboratories depending on the element);
- Au, Pt, Pd, Ir, Rh and Ru by nickel sulphide (NiS) collection fire assay with ICP-MS (8 laboratories) or ICP-OES (1 laboratory) finish (9 laboratories reported Ir, Pd, Pt, Rh and Ru, 7 laboratories reported Au, 2 laboratories reported Os and 1 laboratory reported Re);
- Au, Pt and Pd by lead collection fire assay with ICP-OES (17 laboratories) and ICP-MS (3 laboratories) finish;
- Instrumental neutron activation analysis for Au on 20 x 85mg subsamples to confirm homogeneity (1 laboratory – analyses currently underway with results expected 5 March, 2018).

For the round robin program twenty 1kg test units were taken at predetermined intervals during the bagging stage, immediately following homogenisation and are considered representative of the entire batch. The six samples received by each laboratory were obtained by taking two 100g scoop splits from each of three separate 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 112 certified values together with their associated 1SD's, 95% confidence and tolerance limits and Table 2 below shows 23 indicative values. Table 3 provides performance gate intervals for the certified values based on their pooled 1SD's and Table 4 shows gold instrumental neutron activation analysis (INAA) results for twenty 85 milligram subsamples determined by ANSTO in Lucas Heights, NSW, Australia.

Tabulated results of all elements together with analytical method codes, uncorrected means, medians, standard deviations, relative standard deviations and per cent deviation of lab means from the corrected mean of means (PDM[3]) are presented in the detailed certification data for this CRM (**OREAS 680 DataPack.xlsx**).

Table 2. Indicative Values for OREAS 680.

Constituent	Unit	Value	Constituent	Unit	Value	Constituent	Unit	Value
NiS Fire Assay								
Os	ppb	*32.3*	Re	ppb	*0.833*			
Peroxide Fusion ICP								
B	ppm	*< 20*	Mo	ppm	*3.83*	Te	ppm	*0.98*
Be	ppm	*1.57*	Re	ppm	*< 0.1*	Tl	ppm	*0.50*
Ge	ppm	*2.35*	Se	ppm	*< 20*	Tm	ppm	*0.25*
Hf	ppm	*2.00*	Sn	ppm	*2.33*	W	ppm	*2.32*
In	ppm	*< 0.2*	Ta	ppm	*0.45*	Zr	ppm	*76*
4-Acid Digestion								
Ba	ppm	*416*	Hg	ppm	*0.12*			
Ge	ppm	*0.26*	Re	ppm	*0.005*			
Infrared Combustion								
CO_2	wt.%	*0.198*	S	wt.%	*5.41*			

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.

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. The Certified Values are the means of accepted laboratory means after outlier filtering.

The 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 prepared 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 3. Performance Gates for OREAS 680.

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	161	8	144	177	136	185	5.07%	10.14%	15.20%	153	169
Pd, ppb	218	13	193	243	180	255	5.74%	11.47%	17.21%	207	229
Pt, ppb	405	17	370	440	352	457	4.32%	8.64%	12.96%	384	425
NiS Collection											
Au, ppb	147	5	138	156	133	161	3.13%	6.26%	9.38%	140	154
Ir, ppb	32.0	3.1	25.9	38.2	22.8	41.2	9.58%	19.17%	28.75%	30.4	33.6
Pd, ppb	215	10	195	235	185	245	4.65%	9.30%	13.95%	204	226
Pt, ppb	401	19	363	438	344	457	4.72%	9.45%	14.17%	381	421
Rh, ppb	40.4	3.5	33.4	47.3	30.0	50.7	8.57%	17.14%	25.70%	38.3	42.4
Ru, ppb	84.9	5.5	74.0	95.8	68.6	101.3	6.42%	12.83%	19.25%	80.7	89.2
Peroxide Fusion											
Ag, ppm	10.5	1.2	8.2	12.9	7.0	14.1	11.11%	22.23%	33.34%	10.0	11.1
Al, wt.%	7.19	0.138	6.91	7.46	6.77	7.60	1.92%	3.84%	5.77%	6.83	7.55
As, ppm	120	11	98	141	87	152	8.95%	17.90%	26.85%	114	126
Ba, ppm	649	43	562	735	519	779	6.69%	13.37%	20.06%	616	681
Bi, ppm	1.66	0.29	1.08	2.25	0.79	2.54	17.49%	34.97%	52.46%	1.58	1.75
Ca, wt.%	5.80	0.188	5.42	6.17	5.23	6.36	3.25%	6.50%	9.75%	5.51	6.09
Cd, ppm	8.18	0.86	6.45	9.90	5.59	10.76	10.54%	21.07%	31.61%	7.77	8.59
Ce, ppm	38.7	2.37	34.0	43.5	31.6	45.8	6.13%	12.26%	18.39%	36.8	40.6
Co, ppm	334	20	294	375	274	395	6.03%	12.05%	18.08%	318	351
Cr, ppm	2139	93	1954	2324	1861	2417	4.33%	8.65%	12.98%	2032	2246
Cs, ppm	3.94	0.232	3.47	4.40	3.24	4.63	5.89%	11.77%	17.66%	3.74	4.13
Cu, wt.%	0.904	0.018	0.867	0.940	0.849	0.959	2.02%	4.03%	6.05%	0.859	0.949
Dy, ppm	3.07	0.128	2.81	3.33	2.69	3.45	4.16%	8.31%	12.47%	2.92	3.22
Er, ppm	1.74	0.19	1.36	2.11	1.17	2.30	10.79%	21.58%	32.38%	1.65	1.82
Eu, ppm	1.30	0.077	1.15	1.46	1.07	1.54	5.91%	11.81%	17.72%	1.24	1.37
Fe, wt.%	11.93	0.555	10.82	13.04	10.27	13.60	4.65%	9.31%	13.96%	11.34	12.53
Ga, ppm	16.5	1.22	14.1	19.0	12.8	20.2	7.42%	14.84%	22.25%	15.7	17.3
Gd, ppm	3.77	0.233	3.31	4.24	3.08	4.47	6.17%	12.33%	18.50%	3.59	3.96
Ho, ppm	0.58	0.042	0.49	0.66	0.45	0.71	7.33%	14.67%	22.00%	0.55	0.61
K, wt.%	1.29	0.083	1.12	1.45	1.04	1.54	6.42%	12.84%	19.26%	1.22	1.35
La, ppm	18.6	1.64	15.3	21.9	13.7	23.5	8.80%	17.60%	26.40%	17.7	19.5
Li, ppm	14.5	1.6	11.3	17.6	9.7	19.2	10.94%	21.87%	32.81%	13.7	15.2
Lu, ppm	0.23	0.03	0.17	0.29	0.14	0.33	13.63%	27.27%	40.90%	0.22	0.24
Mg, wt.%	3.71	0.154	3.40	4.02	3.25	4.17	4.15%	8.30%	12.45%	3.52	3.89
Mn, wt.%	0.124	0.004	0.115	0.133	0.110	0.137	3.63%	7.27%	10.90%	0.117	0.130
Nb, ppm	5.09	0.92	3.25	6.93	2.33	7.85	18.10%	36.19%	54.29%	4.83	5.34
Nd, ppm	20.8	0.74	19.3	22.3	18.6	23.0	3.57%	7.14%	10.71%	19.8	21.8
Ni, wt.%	2.15	0.056	2.04	2.26	1.98	2.32	2.61%	5.22%	7.84%	2.04	2.26
P, wt.%	0.122	0.014	0.094	0.149	0.080	0.163	11.43%	22.86%	34.29%	0.115	0.128
Pb, ppm	2579	103	2374	2785	2271	2887	3.98%	7.96%	11.94%	2450	2708
Pr, ppm	4.99	0.190	4.61	5.37	4.42	5.56	3.81%	7.61%	11.42%	4.74	5.24

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
Peroxide Fusion continued											
Rb, ppm	76	3.6	69	83	65	87	4.72%	9.44%	14.16%	72	80
S, wt.%	5.14	0.155	4.83	5.45	4.67	5.60	3.02%	6.03%	9.05%	4.88	5.39
Sb, ppm	19.7	1.66	16.4	23.0	14.7	24.7	8.45%	16.90%	25.35%	18.7	20.7
Sc, ppm	21.3	1.20	18.8	23.7	17.6	24.9	5.67%	11.33%	17.00%	20.2	22.3
Si, wt.%	20.62	0.549	19.52	21.72	18.97	22.27	2.66%	5.32%	7.99%	19.59	21.65
Sm, ppm	4.26	0.279	3.70	4.81	3.42	5.09	6.55%	13.09%	19.64%	4.04	4.47
Sr, ppm	420	9	402	438	393	447	2.15%	4.30%	6.45%	399	441
Tb, ppm	0.55	0.039	0.47	0.63	0.43	0.67	7.11%	14.21%	21.32%	0.52	0.58
Th, ppm	6.73	0.461	5.81	7.65	5.35	8.11	6.85%	13.70%	20.55%	6.39	7.07
Ti, wt.%	0.523	0.020	0.483	0.562	0.463	0.582	3.80%	7.59%	11.39%	0.497	0.549
U, ppm	1.55	0.111	1.32	1.77	1.21	1.88	7.16%	14.33%	21.49%	1.47	1.62
V, ppm	224	15	194	254	179	269	6.65%	13.31%	19.96%	213	235
Y, ppm	16.2	0.45	15.3	17.1	14.8	17.5	2.76%	5.52%	8.28%	15.4	17.0
Yb, ppm	1.52	0.127	1.26	1.77	1.14	1.90	8.37%	16.75%	25.12%	1.44	1.59
Zn, ppm	2321	159	2004	2639	1845	2798	6.84%	13.68%	20.52%	2205	2437
4-Acid Digestion											
Ag, ppm	9.88	0.851	8.18	11.58	7.33	12.43	8.61%	17.22%	25.83%	9.38	10.37
Al, wt.%	7.13	0.159	6.81	7.44	6.65	7.60	2.23%	4.45%	6.68%	6.77	7.48
As, ppm	110	7	96	125	88	133	6.75%	13.50%	20.25%	105	116
Be, ppm	1.29	0.18	0.93	1.64	0.76	1.82	13.74%	27.48%	41.21%	1.22	1.35
Bi, ppm	1.64	0.064	1.51	1.77	1.45	1.83	3.88%	7.76%	11.65%	1.56	1.72
Ca, wt.%	5.58	0.183	5.21	5.95	5.03	6.13	3.28%	6.56%	9.85%	5.30	5.86
Cd, ppm	8.15	0.548	7.05	9.25	6.51	9.79	6.72%	13.45%	20.17%	7.74	8.56
Ce, ppm	39.2	1.96	35.3	43.1	33.3	45.0	5.00%	9.99%	14.99%	37.2	41.1
Co, ppm	317	16	286	348	270	364	4.91%	9.82%	14.73%	301	333
Cr, ppm	1458	286	885	2031	599	2317	19.65%	39.30%	58.95%	1385	1531
Cs, ppm	3.87	0.156	3.55	4.18	3.40	4.33	4.03%	8.06%	12.09%	3.67	4.06
Cu, wt.%	0.897	0.029	0.839	0.955	0.810	0.984	3.23%	6.47%	9.70%	0.852	0.942
Dy, ppm	3.05	0.143	2.77	3.34	2.62	3.48	4.69%	9.38%	14.06%	2.90	3.21
Er, ppm	1.75	0.087	1.57	1.92	1.48	2.01	5.01%	10.02%	15.02%	1.66	1.83
Eu, ppm	1.27	0.046	1.18	1.36	1.13	1.41	3.63%	7.25%	10.88%	1.20	1.33
Fe, wt.%	11.68	0.395	10.89	12.47	10.49	12.86	3.38%	6.76%	10.15%	11.09	12.26
Ga, ppm	16.0	0.51	15.0	17.0	14.5	17.5	3.20%	6.40%	9.60%	15.2	16.8
Gd, ppm	3.80	0.293	3.22	4.39	2.92	4.68	7.70%	15.39%	23.09%	3.61	3.99
Hf, ppm	1.64	0.148	1.34	1.94	1.20	2.09	9.04%	18.08%	27.12%	1.56	1.72
Ho, ppm	0.62	0.023	0.57	0.66	0.55	0.69	3.80%	7.61%	11.41%	0.58	0.65
In, ppm	0.13	0.010	0.11	0.15	0.10	0.16	7.78%	15.56%	23.35%	0.12	0.13
K, wt.%	1.24	0.065	1.11	1.37	1.05	1.44	5.25%	10.49%	15.74%	1.18	1.31
La, ppm	18.1	1.18	15.8	20.5	14.6	21.7	6.51%	13.02%	19.53%	17.2	19.0
Li, ppm	12.9	0.54	11.9	14.0	11.3	14.6	4.18%	8.35%	12.53%	12.3	13.6
Lu, ppm	0.24	0.009	0.22	0.25	0.21	0.26	3.77%	7.53%	11.30%	0.22	0.25
Mg, wt.%	3.58	0.123	3.33	3.82	3.21	3.95	3.43%	6.85%	10.28%	3.40	3.76

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											
Mn, wt.%	0.122	0.006	0.110	0.134	0.104	0.140	4.90%	9.81%	14.71%	0.116	0.128
Mo, ppm	1.94	0.36	1.22	2.66	0.86	3.02	18.59%	37.18%	55.77%	1.84	2.03
Na, wt.%	1.45	0.040	1.37	1.53	1.33	1.57	2.73%	5.47%	8.20%	1.37	1.52
Nb, ppm	5.82	0.282	5.26	6.39	4.98	6.67	4.85%	9.69%	14.54%	5.53	6.11
Nd, ppm	20.2	0.58	19.1	21.4	18.5	21.9	2.85%	5.70%	8.55%	19.2	21.2
Ni, wt.%	2.12	0.075	1.97	2.27	1.90	2.35	3.55%	7.09%	10.64%	2.02	2.23
P, wt.%	0.126	0.007	0.111	0.140	0.104	0.147	5.77%	11.53%	17.30%	0.119	0.132
Pb, ppm	2505	139	2227	2782	2088	2921	5.54%	11.09%	16.63%	2380	2630
Pr, ppm	4.98	0.181	4.61	5.34	4.43	5.52	3.64%	7.28%	10.92%	4.73	5.22
Rb, ppm	74	4.1	66	82	61	86	5.60%	11.21%	16.81%	70	78
S, wt.%	4.98	0.108	4.77	5.20	4.66	5.30	2.16%	4.32%	6.48%	4.73	5.23
Sb, ppm	19.9	0.99	17.9	21.9	16.9	22.9	5.00%	10.00%	15.00%	18.9	20.9
Sc, ppm	21.9	0.89	20.2	23.7	19.3	24.6	4.06%	8.13%	12.19%	20.8	23.0
Se, ppm	4.74	0.56	3.63	5.86	3.07	6.42	11.79%	23.58%	35.36%	4.51	4.98
Sm, ppm	4.25	0.281	3.69	4.81	3.41	5.09	6.61%	13.21%	19.82%	4.04	4.46
Sn, ppm	2.22	0.204	1.82	2.63	1.61	2.83	9.17%	18.34%	27.51%	2.11	2.33
Sr, ppm	429	17	395	463	378	480	3.98%	7.96%	11.94%	408	451
Ta, ppm	0.41	0.036	0.34	0.49	0.31	0.52	8.63%	17.25%	25.88%	0.39	0.44
Tb, ppm	0.53	0.035	0.46	0.60	0.43	0.64	6.53%	13.06%	19.58%	0.51	0.56
Te, ppm	0.69	0.08	0.54	0.85	0.47	0.92	10.94%	21.87%	32.81%	0.66	0.73
Th, ppm	6.56	0.626	5.31	7.81	4.68	8.44	9.54%	19.08%	28.62%	6.23	6.89
Ti, wt.%	0.513	0.019	0.476	0.551	0.457	0.570	3.67%	7.33%	11.00%	0.488	0.539
Tl, ppm	0.48	0.021	0.43	0.52	0.41	0.54	4.41%	8.81%	13.22%	0.45	0.50
Tm, ppm	0.25	0.008	0.23	0.26	0.23	0.27	3.06%	6.13%	9.19%	0.24	0.26
U, ppm	1.53	0.089	1.35	1.70	1.26	1.79	5.85%	11.69%	17.54%	1.45	1.60
V, ppm	221	9	202	239	193	248	4.18%	8.36%	12.54%	210	232
W, ppm	1.67	0.108	1.45	1.89	1.35	1.99	6.47%	12.94%	19.40%	1.59	1.75
Y, ppm	15.3	0.91	13.5	17.2	12.6	18.1	5.95%	11.90%	17.85%	14.6	16.1
Yb, ppm	1.57	0.080	1.41	1.73	1.33	1.81	5.12%	10.24%	15.36%	1.49	1.65
Zn, ppm	2308	70	2168	2447	2098	2517	3.02%	6.04%	9.07%	2192	2423
Zr, ppm	54	6	41	67	35	74	11.95%	23.90%	35.85%	52	57

Note: intervals may appear asymmetric due to rounding.

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 nickel (Ni) by 4-acid digestion, where 99% of the time (1-α=0.99) at least 95% of subsamples (ρ=0.95) will have concentrations lying between 2.08 and 2.16 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). *Please note that tolerance limits pertain to the homogeneity of the CRM only and should not be used as control limits for laboratory performance.*

For gold, tolerance can be 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 latter parameter is substantially reduced to a point where most of the variability in replicate assays is due to inhomogeneity of the reference material and measurement error becomes negligible. In this instance a subsample weight of 85 milligrams was employed and the 1RSD of 0.437% calculated for a 30g lead collection fire assay sample (8.16% at 85mg weights) confirms the high level of gold homogeneity in OREAS 680. The homogeneity is of a level such that ***sampling error is almost negligible*** for a conventional lead collection fire assay determination.

Table 4. Instrumental Neutron Activation Analysis of Au (ppb) on 20 x 85mg subsamples of OREAS 680.

Replicate No	INAA 85mg
1	173
2	142
3	135
4	183
5	164
6	153
7	145
8	135
9	158
10	150
11	148
12	161
13	163
14	173
15	164
16	155
17	142
18	151
19	165
20	162
Mean	156
Median	157
Std Dev.	13
Rel.Std.Dev.	8.16%
PDM[3]	-2.26%

The homogeneity of OREAS 680 has also been evaluated in a **nested ANOVA** of the round robin program. Each of the twenty three round robin laboratories received six samples per CRM and these samples were made up of paired samples from three different, non-adjacent sampling intervals selected from the pool of twenty 1kg test units. The purpose of the ANOVA evaluation is to test that no statistically significant difference exists in the variance between-units to that of the variance within-units. This allows an assessment of homogeneity across the entire prepared batch of OREAS 680. The test was performed using the following parameters:

- Null Hypothesis, H_0: Between-unit variance is no greater than within-unit variance (reject H_0 if *p*-value < 0.05);
- Alternative Hypothesis, H_1: Between-unit variance is greater than within-unit variance.

P-values are a measure of probability where values less than 0.05 indicate a greater than 95% probability that the observed differences in within-unit and between-unit variances are real. The datasets were filtered for both individual and laboratory data set (batch) outliers prior to the calculation of *p*-values. This process derived no significant *p*-values across the entire 112 certified values except for Beryilium (Be) and Gallium (Ga) by peroxide fusion and Hafnium (Hf) and Tin (Sn) by 4-acid digestion. These cases are all for elements in very low concentration levels close to their lower levels of detection (LLD) where reading resolution errors can lead to 'false negatives' ('significant' *p*-values that are in fact irrelevant). Usually data becomes more reliable and meaningful when the concentration levels are at least twenty times the LLD. There are no other supporting evidence to suspect greater between-unit variance compared with within-unit variance so the null hypothesis is retained.

It is important to note that ANOVA is not an absolute measure of homogeneity. Rather, it establishes whether or not the analytes are distributed in a similar manner throughout the packaging run of OREAS 680 and whether the variance between two subsamples from the same unit is statistically distinguishable to the variance from two subsamples taken from any two separate units. A reference material therefore, can possess poor absolute homogeneity yet still pass a relative homogeneity test if the within-unit heterogeneity is large and similar across all units.

Based on the statistical analysis of the results of the inter-laboratory certification program it can be concluded that OREAS 680 is fit-for-purpose as a certified reference material (see 'Intended Use' below).

PARTICIPATING LABORATORIES

1. Actlabs, Ancaster, Ontario, Canada
2. AGAT Laboratories, Mississauga, Ontario, Canada
3. ALS, Johannesburg, South Africa
4. ALS, Loughrea, Galway, Ireland
5. ALS, Perth, WA, Australia
6. ALS, Vancouver, BC, Canada
7. Anglo Research Iron Ore Laboratory, Johannesburg, South Africa
8. Bureau Veritas Commodities Canada Ltd, Vancouver, BC, Canada
9. Bureau Veritas Geoanalytical, Adelaide, SA, Australia
10. Bureau Veritas Geoanalytical, Perth, WA, Australia
11. Bureau Veritas Kalassay, Perth, WA, Australia
12. Intertek Genalysis, Perth, WA, Australia
13. Labtium Oy, Saarenkylä, Rovaniemi, Finland
14. MINTEK Analytical Services, Randburg, South Africa
15. Ontario Geological Survey, Sudbury, Ontario, Canada
16. Set Point Laboratory, Mokopane, Limpopo, South Africa
17. SGS, Randfontein, Gauteng, South Africa

18. SGS Australia Mineral Services, Perth, WA, Australia
19. SGS Canada Inc., Vancouver, BC, Canada
20. SGS Lakefield Research Ltd, Lakefield, Ontario, Canada
21. SGS Mineral Services, Townsville, QLD, Australia
22. SGS South Africa Pty Ltd, Rustenburg, South Africa
23. Trojan Ni Mine Lab, Bindura, Zimbabwe

PREPARER AND SUPPLIER

Certified reference material OREAS 680 is prepared, certified and supplied by:

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It is packaged under nitrogen in unit sizes of 60g (single-use laminated foil pouches).

INTENDED USE

OREAS 680 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 680 has been prepared from primary sulphide bearing ores from the Dishaba deposit. It contains reactive sulphide (~5% S) and has been packaged under a nitrogen environment (single use 60g units in laminated foil pouches). In its unopened state and under normal conditions of storage the CRM 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 680 refer to the concentration level in its packaged state. It should not be dried prior to weighing and analysis.

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.

TRACEABILITY

The analytical samples were selected in a manner to represent the entire batch of prepared CRM. This 'representivity' was maintained in each submitted laboratory sample batch and ensures the user that the data is traceable from sample selection through to the analytical results that underlie the consensus values. Each analytical data set has been validated by its assayer through the inclusion of internal reference materials and QC checks during analysis. The laboratories were chosen on the basis of their competence (from past performance in inter-laboratory programs) for a particular analytical method, analyte or analyte suite, and sample matrix. Most of these laboratories have and maintain ISO 17025 accreditation. The certified values presented in this report are calculated from the means of accepted data following robust statistical treatment as detailed in this report.

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 9001:2015 by Lloyd's Register Quality Assurance Ltd for its quality management system including development, manufacturing, certification and supply of CRMs.

CERTIFYING OFFICER

7th March, 2018

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

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