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CERTIFICATE OF ANALYSIS FOR

PLATINUM GROUP ELEMENT (PGE) ORE CERTIFIED REFERENCE MATERIAL

OREAS 682

Table 1. Certified Values, SDs, 95% Confidence and Tolerance Limits for OREAS 682.

Constituent	Certified Value	1SD	95% Confidence Limits		95% Tolerance Limits	
			Low	High	Low	High
Pb Collection Fire Assay						
Au, Gold (ppb)	75.3	4.0	73.7	76.8	73.6	76.9
Pd, Palladium (ppb)	444	19	436	453	434	455
Pt, Platinum (ppb)	868	38	850	886	846	890
NiS Collection Fire Assay						
Au, Gold (ppb)	71.6	3.3	67.6	75.5	69.9	73.3
Ir, Iridium (ppb)	20.2	1.0	19.3	21.1	IND	IND
Pd, Palladium (ppb)	440	26	422	458	425	455
Pt, Platinum (ppb)	820	52	783	856	791	849
Rh, Rhodium (ppb)	60.3	1.9	59.0	61.7	58.5	62.1
Ru, Ruthenium (ppb)	112	10	105	120	109	116
Peroxide Fusion ICP						
Al, Aluminium (wt.%)	8.87	0.166	8.79	8.95	8.70	9.04
Ba, Barium (ppm)	376	22	363	390	366	387
Ca, Calcium (wt.%)	6.62	0.174	6.54	6.71	6.47	6.78
Co, Cobalt (ppm)	52	3.8	51	53	50	54
Cr, Chromium (ppm)	3701	157	3623	3780	3599	3804
Cs, Cesium (ppm)	3.57	0.223	3.39	3.76	3.40	3.75
Cu, Copper (ppm)	261	15	255	268	248	274
Dy, Dysprosium (ppm)	2.92	0.219	2.74	3.09	2.76	3.07
Er, Erbium (ppm)	1.62	0.147	1.53	1.71	1.54	1.71

SI unit equivalents: ppb (parts per billion; 1 x 10^{-9}) ≡ µg/kg; ppm (parts per million; 1 x 10^{-6}) ≡ mg/kg; wt.% (weight per cent) ≡ % (mass fraction).

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						
Eu, Europium (ppm)	1.25	0.102	1.16	1.33	1.16	1.33
Fe, Iron (wt.%)	6.94	0.217	6.83	7.05	6.84	7.04
Ga, Gallium (ppm)	18.3	1.04	17.6	18.9	IND	IND
Gd, Gadolinium (ppm)	3.66	0.41	3.23	4.09	3.47	3.85
Ho, Holmium (ppm)	0.55	0.06	0.52	0.58	0.51	0.59
K, Potassium (wt.%)	1.18	0.047	1.15	1.20	1.14	1.21
La, Lanthanum (ppm)	17.3	1.09	16.4	18.3	16.7	18.0
Li, Lithium (ppm)	12.8	1.18	12.0	13.5	IND	IND
Lu, Lutetium (ppm)	0.22	0.03	0.20	0.24	0.19	0.25
Mg, Magnesium (wt.%)	4.95	0.157	4.86	5.03	4.84	5.05
Mn, Manganese (wt.%)	0.120	0.004	0.118	0.123	0.118	0.123
Nb, Niobium (ppm)	5.16	0.97	4.47	5.86	IND	IND
Nd, Neodymium (ppm)	19.4	0.76	18.8	20.0	18.6	20.2
Ni, Nickel (ppm)	572	30	556	588	551	593
P, Phosphorus (wt.%)	0.123	0.010	0.117	0.129	IND	IND
Pb, Lead (ppm)	10.1	1.8	8.2	12.0	IND	IND
Pr, Praseodymium (ppm)	4.66	0.137	4.56	4.76	4.49	4.83
Rb, Rubidium (ppm)	72	2.3	70	73	70	74
S, Sulphur (wt.%)	0.111	0.018	0.101	0.120	0.095	0.126
Sc, Scandium (ppm)	21.4	2.3	19.5	23.3	19.5	23.3
Si, Silicon (wt.%)	23.96	0.524	23.71	24.20	23.40	24.51
Sm, Samarium (ppm)	4.03	0.136	3.95	4.12	3.79	4.28
Sr, Strontium (ppm)	455	20	441	468	437	472
Tb, Terbium (ppm)	0.50	0.06	0.46	0.55	0.47	0.53
Th, Thorium (ppm)	5.52	0.323	5.29	5.74	5.04	5.99
Ti, Titanium (wt.%)	0.511	0.014	0.504	0.517	0.500	0.522
Tm, Thulium (ppm)	0.23	0.019	0.21	0.25	0.20	0.26
U, Uranium (ppm)	1.36	0.15	1.25	1.46	1.20	1.51
V, Vanadium (ppm)	231	10	225	238	223	240
Y, Yttrium (ppm)	15.4	0.44	15.0	15.7	14.8	15.9
Yb, Ytterbium (ppm)	1.51	0.070	1.45	1.57	IND	IND
Zn, Zinc (ppm)	90	21	75	105	75	104
4-Acid Digestion						
Ag, Silver (ppm)	0.117	0.018	0.102	0.132	IND	IND
Al, Aluminium (wt.%)	8.84	0.264	8.70	8.98	8.69	8.99
Ba, Barium (ppm)	389	6	387	392	380	399
Be, Beryllium (ppm)	1.24	0.18	1.14	1.34	1.04	1.44
Bi, Bismuth (ppm)	0.099	0.009	0.092	0.106	IND	IND
Ca, Calcium (wt.%)	6.40	0.269	6.25	6.54	6.26	6.53
Ce, Cerium (ppm)	35.9	1.59	35.0	36.7	34.7	37.0
Co, Cobalt (ppm)	50	2.3	49	52	49	52

SI unit equivalents: ppm (parts per million; 1 x 10^{-6}) ≡ mg/kg; wt.% (weight per cent) ≡ % (mass fraction).
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						
Cr, Chromium (ppm)	2807	369	2625	2990	2703	2912
Cs, Cesium (ppm)	3.46	0.117	3.41	3.51	3.33	3.60
Cu, Copper (ppm)	258	10	253	262	249	266
Dy, Dysprosium (ppm)	2.95	0.086	2.88	3.03	2.82	3.08
Er, Erbium (ppm)	1.67	0.064	1.62	1.72	1.59	1.74
Eu, Europium (ppm)	1.21	0.090	1.14	1.28	1.15	1.27
Fe, Iron (wt.%)	6.78	0.206	6.69	6.88	6.64	6.93
Ga, Gallium (ppm)	17.9	0.52	17.6	18.3	17.5	18.4
Gd, Gadolinium (ppm)	3.51	0.252	3.31	3.71	3.40	3.62
Hf, Hafnium (ppm)	1.55	0.19	1.45	1.65	1.43	1.67
Ho, Holmium (ppm)	0.59	0.015	0.58	0.60	0.57	0.61
In, Indium (ppm)	0.038	0.005	0.035	0.041	0.036	0.040
K, Potassium (wt.%)	1.18	0.051	1.16	1.21	1.16	1.21
La, Lanthanum (ppm)	16.6	0.83	16.1	17.0	16.0	17.2
Li, Lithium (ppm)	11.5	0.40	11.3	11.7	11.0	12.0
Lu, Lutetium (ppm)	0.23	0.008	0.23	0.24	0.22	0.24
Mg, Magnesium (wt.%)	4.86	0.207	4.76	4.96	4.76	4.95
Mn, Manganese (wt.%)	0.116	0.005	0.114	0.119	0.114	0.119
Mo, Molybdenum (ppm)	1.45	0.19	1.36	1.55	1.33	1.57
Na, Sodium (wt.%)	1.60	0.044	1.57	1.62	1.57	1.63
Nb, Niobium (ppm)	5.43	0.361	5.24	5.62	5.25	5.61
Nd, Neodymium (ppm)	18.9	0.57	18.4	19.4	18.3	19.5
Ni, Nickel (ppm)	560	30	545	575	547	573
P, Phosphorus (wt.%)	0.122	0.006	0.119	0.125	0.118	0.126
Pb, Lead (ppm)	9.19	0.95	8.46	9.92	8.80	9.59
Pr, Praseodymium (ppm)	4.63	0.137	4.51	4.74	4.48	4.77
Rb, Rubidium (ppm)	70	3.8	68	72	68	72
S, Sulphur (wt.%)	0.114	0.009	0.109	0.119	0.108	0.120
Sb, Antimony (ppm)	0.20	0.05	0.17	0.23	0.18	0.22
Sc, Scandium (ppm)	23.7	1.53	22.7	24.6	22.9	24.5
Sm, Samarium (ppm)	4.05	0.308	3.80	4.31	3.89	4.22
Sn, Tin (ppm)	1.63	0.120	1.55	1.70	IND	IND
Sr, Strontium (ppm)	469	20	458	480	460	479
Ta, Tantalum (ppm)	0.38	0.032	0.35	0.40	0.34	0.41
Tb, Terbium (ppm)	0.52	0.036	0.49	0.54	0.50	0.53
Th, Thorium (ppm)	5.72	0.483	5.50	5.93	5.39	6.04
Ti, Titanium (wt.%)	0.503	0.018	0.494	0.512	0.493	0.514
Tl, Thallium (ppm)	0.15	0.007	0.15	0.15	IND	IND
Tm, Thulium (ppm)	0.24	0.011	0.23	0.25	0.23	0.25
U, Uranium (ppm)	1.28	0.090	1.24	1.31	1.18	1.37
V, Vanadium (ppm)	228	11	223	234	222	234

SI unit equivalents: ppm (parts per million; 1 x 10^{-6}) ≡ mg/kg; wt.% (weight per cent) ≡ % (mass fraction).
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						
W, Tungsten (ppm)	1.08	0.095	1.03	1.12	IND	IND
Y, Yttrium (ppm)	14.9	1.01	14.4	15.5	14.5	15.3
Yb, Ytterbium (ppm)	1.52	0.078	1.47	1.56	1.44	1.59
Zn, Zinc (ppm)	84	5.2	81	86	81	86
Zr, Zirconium (ppm)	52	4.1	49	54	49	55

SI unit equivalents: ppm (parts per million; 1 x 10^{-6}) ≡ mg/kg; wt.% (weight per cent) ≡ % (mass fraction).
Note: intervals may appear asymmetric due to rounding.

Table 2. Indicative Values for OREAS 682.

Constituent	Unit	Value	Constituent	Unit	Value	Constituent	Unit	Value
NiS Collection Fire Assay								
Os	ppb	*14.1*	Re	ppb	*< 1*			
Peroxide Fusion ICP								
Ag	ppm	*< 1*	Ge	ppm	*1.80*	Sn	ppm	*2.05*
As	ppm	*< 100*	Hf	ppm	*2.00*	Ta	ppm	*0.45*
B	ppm	*24.2*	In	ppm	*< 0.2*	Te	ppm	*< 2*
Be	ppm	*1.36*	Mo	ppm	*2.91*	Tl	ppm	*< 0.5*
Bi	ppm	*0.100*	Re	ppm	*< 0.1*	W	ppm	*1.23*
Cd	ppm	*< 10*	Sb	ppm	*0.26*	Zr	ppm	*70*
Ce	ppm	*36.3*	Se	ppm	*< 20*			
4-Acid Digestion								
As	ppm	*1.49*	Hg	ppm	*< 0.01*	Te	ppm	*0.16*
Cd	ppm	*0.058*	Re	ppm	*0.002*			
Ge	ppm	*0.12*	Se	ppm	*0.94*			
Infrared Combustion								
C	wt.%	*0.058*	S	wt.%	*0.095*			

SI unit equivalents: ppb (parts per billion; 1 x 10^{-9}) ≡ µg/kg; ppm (parts per million; 1 x 10^{-6}) ≡ mg/kg; wt.% (weight per cent) ≡ % (mass fraction).

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.

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 682 is a platinum group element (PGE) ore certified reference material (CRM) prepared and certified by Ore Research & Exploration Pty Ltd. OREAS 682 has been prepared from PGE ores blended with barren gabbro-norite. The PGE ores were sourced from the Merensky Reef and foot wall of the Merensky Reef of the Bushveld Complex, from sites owned and operated by Anglo American Platinum, South Africa. The common minerals of economic importance within a pegmatitic pyroxenite host are sulphides of iron, nickel, copper and alloys of the PGE's. The barren gabbro-norite was sourced from the Late Cambrian Black Hill Norite Complex located 85km east of Adelaide, Australia.

OREAS 682 is one of a suite of five PGE ore CRMs ranging in 4E concentrations (4E = 4 elements; platinum (Pt), palladium (Pd), rhodium (Rh) and gold (Au)) from 0.82 to 6.1ppm.

COMMINUTION AND HOMOGENISATION PROCEDURES

The material constituting OREAS 682 was prepared in the following manner:

- Drying all materials to constant mass at 105°C;
- Crushing and milling of the barren gabbronorite to >98% minus 75 microns;
- Crushing and milling of ore materials to 100% minus 30 microns;
- Combining the barren gabbronorite and ore in appropriate proportions to achieve target grades;
- Homogenisation using OREAS' novel processing technologies;
- Packaging in 60g units sealed in laminated foil pouches and 500g units in plastic jars.

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);
- 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 (18 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 104 certified values together with their associated 1SD's, 95% confidence and tolerance limits and Table 2 below shows 31 indicative values. Table 3 provides performance gate intervals for the certified values based on their pooled 1SD's and Table 4 shows the 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 682 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. 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 interlaboratory 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 682.

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
Pb Collection Fire Assay											
Au, ppb	75.3	4.0	67.3	83.2	63.3	87.2	5.29%	10.57%	15.86%	71.5	79.0
Pd, ppb	444	19	406	483	387	502	4.30%	8.60%	12.91%	422	467
Pt, ppb	868	38	792	945	753	983	4.42%	8.84%	13.26%	825	912
NiS Collection Fire Assay											
Au, ppb	71.6	3.3	64.9	78.3	61.5	81.6	4.68%	9.36%	14.04%	68.0	75.2
Ir, ppb	20.2	1.0	18.3	22.1	17.3	23.1	4.74%	9.48%	14.22%	19.2	21.2
Pd, ppb	440	26	387	493	361	520	6.02%	12.03%	18.05%	418	462
Pt, ppb	820	52	716	923	665	975	6.31%	12.61%	18.92%	779	861
Rh, ppb	60.3	1.9	56.6	64.0	54.7	65.9	3.08%	6.17%	9.25%	57.3	63.3
Ru, ppb	112	10	93	131	84	141	8.52%	17.04%	25.57%	107	118
Peroxide Fusion											
Al, wt.%	8.87	0.166	8.53	9.20	8.37	9.37	1.88%	3.75%	5.63%	8.42	9.31
Ba, ppm	376	22	332	421	310	443	5.91%	11.82%	17.73%	358	395
Ca, wt.%	6.62	0.174	6.28	6.97	6.10	7.15	2.62%	5.24%	7.86%	6.29	6.96
Co, ppm	52	3.8	44	60	40	63	7.39%	14.77%	22.16%	49	55
Cr, ppm	3701	157	3388	4015	3232	4171	4.23%	8.46%	12.69%	3516	3886

SI unit equivalents: ppb (parts per billion; 1 x 10^{-9}) ≡ μg/kg; ppm (parts per million; 1 x 10^{-6}) ≡ mg/kg; wt.% (weight per cent) ≡ % (mass fraction).

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											
Cs, ppm	3.57	0.223	3.12	4.02	2.90	4.24	6.25%	12.51%	18.76%	3.39	3.75
Cu, ppm	261	15	231	292	216	307	5.82%	11.64%	17.46%	248	274
Dy, ppm	2.92	0.219	2.48	3.35	2.26	3.57	7.51%	15.03%	22.54%	2.77	3.06
Er, ppm	1.62	0.147	1.33	1.92	1.18	2.06	9.08%	18.16%	27.23%	1.54	1.70
Eu, ppm	1.25	0.102	1.04	1.45	0.94	1.55	8.16%	16.32%	24.48%	1.18	1.31
Fe, wt.%	6.94	0.217	6.51	7.38	6.29	7.59	3.13%	6.26%	9.39%	6.59	7.29
Ga, ppm	18.3	1.04	16.2	20.4	15.2	21.4	5.68%	11.35%	17.03%	17.4	19.2
Gd, ppm	3.66	0.41	2.84	4.47	2.44	4.88	11.13%	22.27%	33.40%	3.48	3.84
Ho, ppm	0.55	0.06	0.43	0.67	0.37	0.73	10.65%	21.30%	31.95%	0.52	0.58
K, wt.%	1.18	0.047	1.08	1.27	1.03	1.32	4.02%	8.04%	12.06%	1.12	1.23
La, ppm	17.3	1.09	15.2	19.5	14.1	20.6	6.27%	12.54%	18.82%	16.5	18.2
Li, ppm	12.8	1.18	10.4	15.1	9.2	16.3	9.25%	18.51%	27.76%	12.1	13.4
Lu, ppm	0.22	0.03	0.17	0.27	0.14	0.30	11.57%	23.15%	34.72%	0.21	0.23
Mg, wt.%	4.95	0.157	4.63	5.26	4.47	5.42	3.18%	6.36%	9.54%	4.70	5.19
Mn, wt.%	0.120	0.004	0.112	0.128	0.108	0.132	3.37%	6.75%	10.12%	0.114	0.126
Nb, ppm	5.16	0.97	3.22	7.10	2.25	8.07	18.82%	37.64%	56.46%	4.90	5.42
Nd, ppm	19.4	0.76	17.9	21.0	17.1	21.7	3.93%	7.87%	11.80%	18.5	20.4
Ni, ppm	572	30	512	632	482	662	5.27%	10.53%	15.80%	544	601
P, wt.%	0.123	0.010	0.102	0.144	0.092	0.155	8.51%	17.02%	25.53%	0.117	0.129
Pb, ppm	10.1	1.8	6.5	13.7	4.6	15.5	17.97%	35.94%	53.91%	9.6	10.6
Pr, ppm	4.66	0.137	4.39	4.93	4.25	5.07	2.93%	5.86%	8.79%	4.43	4.89
Rb, ppm	72	2.3	67	76	65	79	3.17%	6.33%	9.50%	68	75
S, wt.%	0.111	0.018	0.074	0.147	0.056	0.165	16.38%	32.76%	49.15%	0.105	0.116
Sc, ppm	21.4	2.3	16.8	26.0	14.5	28.3	10.72%	21.45%	32.17%	20.3	22.4
Si, wt.%	23.96	0.524	22.91	25.00	22.38	25.53	2.19%	4.37%	6.56%	22.76	25.15
Sm, ppm	4.03	0.136	3.76	4.30	3.63	4.44	3.36%	6.72%	10.09%	3.83	4.24
Sr, ppm	455	20	414	496	394	516	4.47%	8.94%	13.41%	432	478
Tb, ppm	0.50	0.06	0.38	0.62	0.32	0.68	11.99%	23.99%	35.98%	0.48	0.53
Th, ppm	5.52	0.323	4.87	6.16	4.55	6.49	5.85%	11.70%	17.55%	5.24	5.79
Ti, wt.%	0.511	0.014	0.482	0.539	0.468	0.554	2.80%	5.60%	8.41%	0.485	0.536
Tm, ppm	0.23	0.019	0.19	0.27	0.17	0.29	8.18%	16.35%	24.53%	0.22	0.24
U, ppm	1.36	0.15	1.06	1.65	0.91	1.80	10.94%	21.89%	32.83%	1.29	1.43
V, ppm	231	10	212	251	202	261	4.26%	8.53%	12.79%	220	243
Y, ppm	15.4	0.44	14.5	16.2	14.0	16.7	2.88%	5.77%	8.65%	14.6	16.1
Yb, ppm	1.51	0.070	1.37	1.65	1.30	1.72	4.67%	9.34%	14.01%	1.43	1.58
Zn, ppm	90	21	48	132	26	153	23.50%	47.01%	70.51%	85	94
4-Acid Digestion											
Ag, ppm	0.117	0.018	0.081	0.152	0.064	0.169	15.09%	30.19%	45.28%	0.111	0.122
Al, wt.%	8.84	0.264	8.31	9.37	8.05	9.63	2.98%	5.96%	8.95%	8.40	9.28
Ba, ppm	389	6	378	401	372	407	1.52%	3.04%	4.56%	370	409
Be, ppm	1.24	0.18	0.88	1.60	0.69	1.79	14.65%	29.31%	43.96%	1.18	1.30

SI unit equivalents: ppm (parts per million; 1 x 10^{-6}) ≡ mg/kg; wt.% (weight per cent) ≡ % (mass fraction).
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											
Bi, ppm	0.099	0.009	0.081	0.117	0.072	0.125	9.00%	17.99%	26.99%	0.094	0.104
Ca, wt.%	6.40	0.269	5.86	6.93	5.59	7.20	4.20%	8.40%	12.60%	6.08	6.72
Ce, ppm	35.9	1.59	32.7	39.0	31.1	40.6	4.43%	8.85%	13.28%	34.1	37.7
Co, ppm	50	2.3	46	55	43	57	4.66%	9.33%	13.99%	48	53
Cr, ppm	2807	369	2070	3545	1701	3914	13.14%	26.27%	39.41%	2667	2948
Cs, ppm	3.46	0.117	3.23	3.70	3.11	3.81	3.38%	6.76%	10.14%	3.29	3.64
Cu, ppm	258	10	237	278	226	289	4.05%	8.11%	12.16%	245	270
Dy, ppm	2.95	0.086	2.78	3.12	2.70	3.21	2.90%	5.79%	8.69%	2.80	3.10
Er, ppm	1.67	0.064	1.54	1.79	1.47	1.86	3.85%	7.69%	11.54%	1.58	1.75
Eu, ppm	1.21	0.090	1.03	1.39	0.94	1.48	7.40%	14.80%	22.19%	1.15	1.27
Fe, wt.%	6.78	0.206	6.37	7.19	6.17	7.40	3.03%	6.06%	9.09%	6.44	7.12
Ga, ppm	17.9	0.52	16.9	19.0	16.4	19.5	2.92%	5.84%	8.76%	17.0	18.8
Gd, ppm	3.51	0.252	3.01	4.02	2.75	4.27	7.18%	14.36%	21.54%	3.34	3.69
Hf, ppm	1.55	0.19	1.17	1.94	0.97	2.13	12.41%	24.82%	37.23%	1.47	1.63
Ho, ppm	0.59	0.015	0.56	0.62	0.54	0.63	2.63%	5.26%	7.89%	0.56	0.62
In, ppm	0.038	0.005	0.027	0.048	0.022	0.053	13.72%	27.45%	41.17%	0.036	0.040
K, wt.%	1.18	0.051	1.08	1.29	1.03	1.34	4.33%	8.66%	12.99%	1.13	1.24
La, ppm	16.6	0.83	14.9	18.3	14.1	19.1	5.01%	10.02%	15.04%	15.8	17.4
Li, ppm	11.5	0.40	10.7	12.3	10.3	12.7	3.45%	6.91%	10.36%	10.9	12.1
Lu, ppm	0.23	0.008	0.21	0.25	0.21	0.26	3.59%	7.18%	10.77%	0.22	0.24
Mg, wt.%	4.86	0.207	4.44	5.27	4.24	5.48	4.25%	8.50%	12.75%	4.61	5.10
Mn, wt.%	0.116	0.005	0.106	0.127	0.100	0.132	4.58%	9.16%	13.73%	0.111	0.122
Mo, ppm	1.45	0.19	1.07	1.83	0.88	2.02	13.04%	26.09%	39.13%	1.38	1.52
Na, wt.%	1.60	0.044	1.51	1.68	1.46	1.73	2.74%	5.49%	8.23%	1.52	1.68
Nb, ppm	5.43	0.361	4.70	6.15	4.34	6.51	6.66%	13.31%	19.97%	5.16	5.70
Nd, ppm	18.9	0.57	17.8	20.1	17.2	20.6	3.03%	6.06%	9.08%	18.0	19.9
Ni, ppm	560	30	500	620	470	650	5.38%	10.77%	16.15%	532	588
P, wt.%	0.122	0.006	0.110	0.134	0.104	0.140	4.94%	9.88%	14.82%	0.116	0.128
Pb, ppm	9.19	0.95	7.30	11.08	6.36	12.03	10.28%	20.56%	30.84%	8.73	9.65
Pr, ppm	4.63	0.137	4.35	4.90	4.22	5.04	2.96%	5.91%	8.87%	4.39	4.86
Rb, ppm	70	3.8	63	78	59	81	5.37%	10.73%	16.10%	67	74
S, wt.%	0.114	0.009	0.096	0.132	0.087	0.141	7.82%	15.64%	23.46%	0.108	0.120
Sb, ppm	0.20	0.05	0.10	0.30	0.05	0.35	25.22%	50.44%	75.66%	0.19	0.21
Sc, ppm	23.7	1.53	20.6	26.7	19.1	28.3	6.48%	12.96%	19.43%	22.5	24.9
Sm, ppm	4.05	0.308	3.44	4.67	3.13	4.98	7.60%	15.20%	22.81%	3.85	4.26
Sn, ppm	1.63	0.120	1.39	1.87	1.27	1.99	7.35%	14.71%	22.06%	1.55	1.71
Sr, ppm	469	20	429	509	409	529	4.25%	8.50%	12.74%	446	493
Ta, ppm	0.38	0.032	0.31	0.44	0.28	0.47	8.44%	16.88%	25.32%	0.36	0.39
Tb, ppm	0.52	0.036	0.45	0.59	0.41	0.62	6.88%	13.76%	20.64%	0.49	0.54
Th, ppm	5.72	0.483	4.75	6.68	4.27	7.17	8.45%	16.91%	25.36%	5.43	6.00
Ti, wt.%	0.503	0.018	0.466	0.540	0.448	0.559	3.67%	7.34%	11.01%	0.478	0.528

SI unit equivalents: ppm (parts per million; 1 x 10^{-6}) ≡ mg/kg; wt.% (weight per cent) ≡ % (mass fraction).
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											
Tl, ppm	0.15	0.007	0.14	0.17	0.13	0.17	4.77%	9.54%	14.31%	0.14	0.16
Tm, ppm	0.24	0.011	0.22	0.26	0.21	0.27	4.64%	9.28%	13.92%	0.23	0.25
U, ppm	1.28	0.090	1.10	1.46	1.01	1.55	7.06%	14.12%	21.18%	1.21	1.34
V, ppm	228	11	207	249	197	260	4.63%	9.26%	13.89%	217	240
W, ppm	1.08	0.095	0.88	1.27	0.79	1.36	8.86%	17.73%	26.59%	1.02	1.13
Y, ppm	14.9	1.01	12.9	17.0	11.9	18.0	6.77%	13.54%	20.31%	14.2	15.7
Yb, ppm	1.52	0.078	1.36	1.67	1.29	1.75	5.11%	10.21%	15.32%	1.44	1.59
Zn, ppm	84	5.2	73	94	68	99	6.18%	12.36%	18.54%	79	88
Zr, ppm	52	4.1	43	60	39	64	8.05%	16.09%	24.14%	49	54

SI unit equivalents: ppm (parts per million; 1 x 10^{-6}) ≡ mg/kg; wt.% (weight per cent) ≡ % (mass fraction).
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 platinum (Pt) by lead collection fire assay, where 99% of the time (1-α=0.99) at least 95% of subsamples (ρ=0.95) will have concentrations lying between 846 and 890 ppb. 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 0.696% calculated for a 30g lead collection fire assay sample (13.06% at 85mg weights) confirms the high level of gold homogeneity in OREAS 682. 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 682.

Replicate No	INAA 85mg
1	75.5
2	76.9
3	81.8
4	64.5
5	79.3
6	72.2
7	76.1
8	64.2
9	73.0
10	81.8
11	63.4
12	73.7
13	73.7
14	62.1
15	76.8
16	97.4
17	82.5
18	69.5
19	91.3
20	57.9
Mean	74.7
Median	74.6
Std Dev.	9.8
Rel.Std.Dev.	13.06%
PDM[3]	-0.75%

The homogeneity of OREAS 682 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 682. 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.

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 104 certified values. 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 682 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 682 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 682 is prepared, certified and supplied by:

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It is packaged in unit sizes of 60g (single-use laminated foil pouches) and 500g (plastic jars).

INTENDED USE

OREAS 682 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 682 has been prepared from primary PGE ores blended with barren gabbro-norite. It is low in reactive sulphide (~0.11% S) and in its unopened state and under normal conditions of storage 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 682 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.

DOCUMENT HISTORY

Revision No.	Date	Changes applied
1	18th November, 2022	Minor revision to Au by Pb Fire Assay certification.
0	16th March, 2018	First publication.

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

18th November, 2022

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

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