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CERTIFICATE OF ANALYSIS FOR

CERTIFIED REFERENCE MATERIAL

OREAS 180b

Lateritic Nickel-Cobalt Ore

(Bulong Deposit, Kalgoorlie, Western Australia)

Accredited for compliance with ISO 17034

Table 1. Certified Values, Uncertainty & Tolerance Intervals for OREAS 180b.

Constituent	Certified Value†	95% Expanded Uncertainty		95% Tolerance Limits	
		Low	High	Low	High
Borate Fusion XRF					
Al_2O_3, Aluminium(III) oxide (wt.%)	8.60	8.51	8.68	8.53	8.66
BaO, Barium oxide (ppm)	240	156	324	IND	IND
CaO, Calcium oxide (wt.%)	0.969	0.958	0.981	0.960	0.978
Co, Cobalt (ppm)	261	241	282	249	274
Cr_2O_3, Chromium(III) oxide (wt.%)	0.688	0.672	0.703	0.676	0.699
Fe, Iron (wt.%)	19.21	19.02	19.39	19.11	19.31
K_2O, Potassium oxide (wt.%)	0.717	0.707	0.728	0.708	0.727
Mg, Magnesium (wt.%)	5.34	5.30	5.39	5.31	5.37
MnO, Manganese oxide (wt.%)	0.134	0.128	0.140	0.132	0.136
Na_2O, Sodium oxide (wt.%)	0.281	0.240	0.322	0.263	0.299
Ni, Nickel (wt.%)	0.329	0.320	0.338	0.325	0.333
P_2O_5, Phosphorus(V) oxide (wt.%)	0.038	0.032	0.044	0.035	0.040
SiO_2, Silicon dioxide (wt.%)	38.99	38.70	39.27	38.80	39.17
Sn, Tin (ppm)	< 50	IND	IND	IND	IND
SO_3, Sulphur trioxide (wt.%)	0.165	0.153	0.177	0.161	0.169
TiO_2, Titanium dioxide (wt.%)	0.335	0.324	0.347	0.327	0.344
V_2O_5, Vanadium(V) oxide (ppm)	178	148	208	IND	IND
Zn, Zinc (ppm)	76	61	91	IND	IND
Thermogravimetry					
LOI^{1000}, Loss on ignition @1000 °C (wt.%)	12.30	12.07	12.53	12.21	12.39
Borate / Peroxide Fusion ICP					
Al, Aluminium (wt.%)	4.50	4.40	4.60	4.43	4.57
As, Arsenic (ppm)	114	102	126	108	120
B, Boron (ppm)	353	304	402	335	371
Ba, Barium (ppm)	212	202	222	205	220
Be, Beryllium (ppm)	1.11	0.86	1.35	IND	IND
Bi, Bismuth (ppm)	4.98	3.93	6.03	4.02	5.93
Ca, Calcium (wt.%)	0.660	0.595	0.724	0.643	0.676
Cd, Cadmium (ppm)	< 10	IND	IND	IND	IND
Ce, Cerium (ppm)	28.7	25.7	31.7	27.3	30.1
Co, Cobalt (ppm)	247	230	263	240	253
Cr, Chromium (wt.%)	0.467	0.453	0.482	0.455	0.480
Cs, Caesium (ppm)	2.85	2.54	3.17	2.54	3.17
Cu, Copper (ppm)	48.0	42.8	53.3	44.6	51.5
Dy, Dysprosium (ppm)	1.99	1.81	2.16	1.84	2.13

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.

†These operationally defined measurands meet the requirements of ISO 17034 and all participating laboratories comply with the requirements of ISO 17025.

IND = indeterminate (due to limited reading resolution of the methods employed. For practical purposes the 95% Expanded Uncertainty can be set between zero and a two times multiple of the upper bound/non-detect limit value).

Table 1 continued.

Constituent	Certified Value[†]	95% Expanded Uncertainty		95% Tolerance Limits	
		Low	High	Low	High
Borate / Peroxide Fusion ICP continued					
Er, Erbium (ppm)	1.15	1.00	1.29	1.03	1.26
Eu, Europium (ppm)	0.53	0.43	0.62	0.48	0.57
Fe, Iron (wt.%)	19.18	18.70	19.66	18.79	19.57
Ga, Gallium (ppm)	9.58	8.30	10.86	8.60	10.56
Gd, Gadolinium (ppm)	2.01	1.79	2.24	1.91	2.11
Ge, Germanium (ppm)	1.10	0.80	1.41	IND	IND
Ho, Holmium (ppm)	0.40	0.34	0.45	0.36	0.44
In, Indium (ppm)	< 0.1	IND	IND	IND	IND
K, Potassium (wt.%)	0.614	0.571	0.658	0.586	0.642
La, Lanthanum (ppm)	12.8	11.1	14.4	11.9	13.6
Li, Lithium (ppm)	15.5	12.4	18.6	13.0	18.0
Lu, Lutetium (ppm)	0.18	0.14	0.21	IND	IND
Mg, Magnesium (wt.%)	5.24	5.12	5.37	5.18	5.31
Mn, Manganese (wt.%)	0.104	0.098	0.109	0.102	0.105
Mo, Molybdenum (ppm)	2.35	1.99	2.71	IND	IND
Nd, Neodymium (ppm)	11.4	10.3	12.4	10.7	12.0
Ni, Nickel (wt.%)	0.325	0.316	0.334	0.319	0.331
Pr, Praseodymium (ppm)	3.23	2.85	3.62	3.03	3.44
Rb, Rubidium (ppm)	33.4	31.8	35.0	32.2	34.6
Re, Rhenium (ppm)	< 0.1	IND	IND	IND	IND
S, Sulphur (wt.%)	0.061	0.049	0.074	IND	IND
Sb, Antimony (ppm)	3.44	2.08	4.80	3.10	3.79
Sc, Scandium (ppm)	21.4	19.6	23.1	20.6	22.2
Se, Selenium (ppm)	< 20	IND	IND	IND	IND
Si, Silicon (wt.%)	18.09	17.58	18.59	17.64	18.54
Sm, Samarium (ppm)	2.18	1.94	2.41	1.94	2.42
Sr, Strontium (ppm)	51	47	55	49	53
Tb, Terbium (ppm)	0.33	0.27	0.38	0.29	0.36
Te, Tellurium (ppm)	< 1	IND	IND	IND	IND
Th, Thorium (ppm)	5.12	4.72	5.51	4.90	5.34
Ti, Titanium (wt.%)	0.199	0.190	0.208	0.191	0.206
Tl, Thallium (ppm)	< 0.5	IND	IND	IND	IND
Tm, Thulium (ppm)	0.17	0.13	0.21	0.14	0.20
U, Uranium (ppm)	1.25	1.07	1.42	IND	IND
V, Vanadium (ppm)	101	94	107	98	103

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.

[†] These operationally defined measurands meet the requirements of ISO 17034 and all participating laboratories comply with the requirements of ISO 17025.

IND = indeterminate (due to limited reading resolution of the methods employed. For practical purposes the 95% Expanded Uncertainty can be set between zero and a two times multiple of the upper bound/non-detect limit value).

Table 1 continued.

Constituent	Certified Value[†]	95% Expanded Uncertainty		95% Tolerance Limits	
		Low	High	Low	High
Borate / Peroxide Fusion ICP continued					
W, Tungsten (ppm)	24.5	21.5	27.5	23.2	25.8
Y, Yttrium (ppm)	10.8	10.1	11.6	10.4	11.3
Yb, Ytterbium (ppm)	1.15	1.02	1.29	IND	IND
Zn, Zinc (ppm)	84	72	96	78	90
Infrared Combustion					
C, Carbon (wt.%)	2.04	2.00	2.07	2.01	2.06
S, Sulphur (wt.%)	0.062	0.054	0.069	0.058	0.065

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. IND = indeterminate.

[†] These operationally defined measurands meet the requirements of ISO 17034 and all participating laboratories comply with the requirements of ISO 17025.

Table 2. Indicative Values for OREAS 180b.

Constituent	Unit	Value	Constituent	Unit	Value	Constituent	Unit	Value
Borate Fusion XRF								
As	ppm	*98*	HfO_2	ppm	*< 100*	Sc	ppm	*18.7*
Bi	ppm	*< 100*	Hg	ppm	*< 100*	Se	ppm	*< 100*
Cd	ppm	*< 100*	In	ppm	*< 100*	SrO	ppm	*73*
Ce	ppm	*< 80*	La	ppm	*< 90*	Ta	ppm	*< 100*
Cl	ppm	*380*	Mo	ppm	*< 50*	Te	ppm	*< 100*
Cs	ppm	*< 100*	Nb	ppm	*< 50*	Tl	ppm	*< 100*
Cu	ppm	*41.0*	Pb	ppm	*27.6*	W	ppm	*12.2*
Ga	ppm	*< 100*	Rb	ppm	*< 50*	Y	ppm	*< 39*
Ge	ppm	*< 100*	Sb	ppm	*< 50*	Zr	ppm	*101*
Thermogravimetry								
H_2O-	wt.%	*2.08*						
Borate / Peroxide Fusion ICP								
Ag	ppm	*4.36*	Nb	ppm	*4.93*	Ta	ppm	*0.59*
Hf	ppm	*2.57*	P	wt.%	*0.017*	Zr	ppm	*81*
Hg	ppm	*0.26*	Pb	ppm	*17.7*			
Na	wt.%	*0.273*	Sn	ppm	*4.51*			
4-Acid Digestion								
Co	ppm	*263*	Mg	wt.%	*5.21*			
Fe	wt.%	*18.08*	Ni	wt.%	*0.328*			

SI unit equivalents: 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.

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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. In evaluating laboratory performance with this CRM, the section headed ‘Instructions for correct use’ should be read carefully.

Table 1 (generated from data supplied by ISO 17025 accredited laboratories for the analytical methods employed) provides the certified values and their associated 95 % expanded uncertainty and tolerance intervals, Table 2 shows indicative values, Table 3 provides some indicative physical properties, Table 4 shows indicative mineralogy by semi-quantitative XRD analysis and Table 5 presents performance gate intervals for all certified values.

Tabulated results of all analytes together with 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 180b-DataPack.1.0.250519_171608.xlsx**). Results are also presented in scatter plots for Ni and Co by borate fusion XRF in Figures 1 and 2 respectively, together with ±3 SD (magenta) and ±5 % (yellow) control lines and certified value (green line). Accepted individual results are coloured blue and individual and dataset outliers are identified in red and violet, respectively.

SOURCE MATERIAL

OREAS 180b has been prepared from a blend of Ni-Co lateritic ores and barren siliclastic sedimentary rock sourced from Victoria, Australia. The Ni-Co lateritic ores were sourced predominantly from the Bulong deposit located 35km east of Kalgoorlie in Western Australia with minor additions of Ni-Co lateritic ores from other regions. The Bulong deposit formed from prolonged lateritic weathering of Archaean (Yilgarn Craton) olivine rich ultramafic/komatiite flows. Grades of >1% Ni were generated in zones of more intense weathering associated with faulting and bedrock alteration. The Ni-Co nontronitic (Fe-Ni smectite clays) siliceous ores at Bulong formed with a goethitic overprint in the upper laterite profile.

COMMINUTION AND HOMOGENISATION PROCEDURES

The material constituting OREAS 180b was prepared in the following manner:

- Drying to constant mass at 105 °C;
- Crushing and milling of the ore materials to 100 % minus 30 microns;
- Crushing and multi-stage milling of the barren siliclastic rocks to >98% minus 75 microns;
- Blending the ores and barren materials in appropriate proportions to achieve desired grades;

- Homogenisation using OREAS' novel processing technologies;
- Packaging in 10 g units in laminated foil pouches and 1 kg units in plastic wide-mouth jars.

PHYSICAL PROPERTIES

OREAS 180b was tested at ORE Research & Exploration Pty Ltd's onsite facility for various physical properties. Table 3 presents these findings that should be used for informational purposes only.

Table 3. Physical properties of OREAS 180b.

Bulk Density (kg/m^3)	Moisture (wt.%)	Munsell Notation‡	Munsell Color‡
839	3.01	5YR 5/6	Light Brown

‡The Munsell Rock Color Chart helps geologists and archeologists communicate with colour more effectively by cross-referencing ISCC-NBS colour names with unique Munsell alpha-numeric colour notations for rock colour samples.

MINERALOGY

The semi-quantitative XRD results shown in Table 4 below were undertaken by ALS Metallurgy in Balcatta, Western Australia. The results have been normalised to 100 % and represent the relative proportion of crystalline material. Totals greater or less than 100 % are due to rounding errors. A presence of some amorphous material is very likely. Clay mineral appears to be mainly smectite and vermiculite. Kandite group appears to be mainly kaolinite. A trace of calcite might be present. Fe-spinel appears to include a variety of Fe-bearing spinel group minerals, such as magnetite, magnesioferrite, chromite, trevorite, ulvospinel, titanomagnetite etc. Some maghemite and Ni-spinel (e.g. nichromite) may be present and are reported under Fe-spinel.

Table 4. Indicative mineralogy of OREAS 180b by semi-quantitative XRD analysis.

Mineral / Mineral Group	% (mass ratio)
Clay mineral	1
Kandite group	5
Serpentine	1
Annite - biotite - phlogopite	2
Muscovite	12
Clinopyroxene	1
Orthopyroxene	3
K-feldspar and/or rutile	< 1
Tourmaline	1
Olivine	1
Quartz	30
Dolomite - ankerite	< 1
Magnesite	19
Hematite	10
Goethite	11
Fe-spinel	3

ANALYTICAL PROGRAM

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

- Lithium borate fusion whole rock analysis package with X-ray fluorescence (up to 19 laboratories depending on the element);
- Thermogravimetry: Loss on Ignition (LOI) at 1000 °C (12 laboratories used a thermogravimetric analyser, 4 laboratories included LOI with their fusion package and 3 laboratories used a conventional muffle furnace);
- Sodium peroxide/borate fusion with full suite ICP-OES and ICP-MS elemental packages (up to 15 laboratories depending on the element);
- Total C and S by infrared combustion furnace (19 laboratories).

For the round robin program twelve 300 g test units were taken at predetermined intervals during the bagging stage, immediately following homogenisation and are considered representative of the entire prepared batch. The six samples received by each laboratory were obtained by taking a 20 g subsample from six different 300 g test units (either from the odd or even numbered test units). Homogeneity was evaluated by submitting 12 x 20 g pulp samples to a single laboratory for XRF analysis. Paired samples were taken from each of the odd-numbered sampling units, allowing for an Analysis of Variance (ANOVA) to compare within- and between-unit variances across the six pairs. This statistical approach provides a relative measure of homogeneity and tests the null hypothesis that all sampling units originate from the same population distribution (see ‘Homogeneity Evaluation’ section below).

STATISTICAL ANALYSIS

Certified Values and their uncertainty intervals (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. 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. However, while statistics are taken into account, the exercise of a statistician's prerogative plays a significant role in identifying outliers.

95% Expanded Uncertainty provides a 95 % probability that the true value of the analyte under consideration lies between the upper and lower limits and is calculated according to the method outlined in [5] and [15]. All known or suspected sources of bias have been investigated or taken into account.

Indicative (uncertified) values (Table 2) are present where the number of laboratories reporting a particular analyte is insufficient (< 5) to support certification or where interlaboratory consensus is poor. This data is intended for ‘informational purposes’ only.

Standard Deviation intervals (see Table 5, 'Performance Gates') 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. They 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 Standard Deviation values include all sources of measurement uncertainty: between-lab variance, within-run variance (precision errors) and CRM variability.

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 all 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.***

Homogeneity Evaluation

The tolerance limits (ISO 16269:2014) shown in Table 1 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 fusion XRF, where 99 % of the time (1-α=0.99) at least 95 % of subsamples (ρ=0.95) will have concentrations lying between 0.325 and 0.333 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. ***Please note that tolerance limits pertain to the homogeneity of the CRM only and should not be used as control limits for laboratory performance.***

Analysis of Variance (ANOVA) Study

In addition to the precision error method outlined above, homogeneity was also evaluated using an ANOVA study. This involved sending 12 x 20 g pulp samples to the BV Geoanalytical laboratory in Perth, Western Australia for analysis by borate fusion with XRF finish (code XRF202). The 12 samples consisted of paired samples from each of the odd numbered sampling units to enable an Analysis of Variance (ANOVA) by comparison of within- and between-unit variances across the six pairs. The ANOVA enables a relative measure of homogeneity and permits a test of the null hypothesis that all 'units' are drawn from the same population distribution. An ANOVA constructed in this way tests that no statistically significant difference exists in the variance between-units to that of the variance within-units. A *p*-value < 0.05 would indicate rejection of the null hypothesis at the 95 % confidence level (i.e., a significant difference likely does exist; meaning there is evidence of heterogeneity between the sample intervals).

With the exception of Aluminium (Al), all *p*-values were found to be statistically insignificant. Any statistically significant result should be investigated to determine whether it is also technically significant. The repeatability across the twelve results is tightly constrained (RSD = 0.25 %) which is at the level of typical analytical measurement error associated with XRF data. The Null Hypothesis is therefore retained. It is important to note that ANOVA provides a relative measure of homogeneity and that a CRM having poor absolute homogeneity can still pass these tests if the within-unit heterogeneity is large and similar across all units. Based on the statistical analysis of the results of the interlaboratory certification program, it can be concluded that OREAS 180b is fit-for-purpose as a certified reference material (see 'Intended Use' below).

PERFORMANCE GATES

Table 5 below shows intervals 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 (also see ‘Intended Use’ section below). Westgard Rules extend the basics of single-rule QC monitoring using multi-rules (for more information visit www.westgard.com/mltirule.htm). 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. One approach used at commercial laboratories is to set the acceptance criteria at twice the detection level (DL) ± 10 %.

i.e., Certified Value ±10 % ±2DL [1].

Table 5. Performance Gates for OREAS 180b.

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
Borate Fusion XRF											
Al_2O_3, wt.%	8.60	0.110	8.37	8.82	8.26	8.93	1.28%	2.56%	3.84%	8.17	9.02
BaO, ppm	240	41	157	323	116	364	17.23%	34.45%	51.68%	228	252
CaO, wt.%	0.969	0.011	0.947	0.992	0.935	1.003	1.17%	2.33%	3.50%	0.921	1.018
Co, ppm	261	17	227	296	210	313	6.53%	13.06%	19.60%	248	274
Cr_2O_3, wt.%	0.688	0.014	0.659	0.716	0.645	0.730	2.07%	4.14%	6.21%	0.653	0.722
Fe, wt.%	19.21	0.200	18.81	19.61	18.61	19.81	1.04%	2.09%	3.13%	18.25	20.17
K_2O, wt.%	0.717	0.010	0.697	0.738	0.687	0.748	1.43%	2.86%	4.29%	0.682	0.753
Mg, wt.%	5.34	0.063	5.22	5.47	5.15	5.53	1.18%	2.36%	3.55%	5.08	5.61
MnO, wt.%	0.134	0.005	0.124	0.144	0.119	0.149	3.82%	7.65%	11.47%	0.127	0.141
Na_2O, wt.%	0.281	0.049	0.183	0.379	0.133	0.429	17.52%	35.05%	52.57%	0.267	0.295
Ni, wt.%	0.329	0.007	0.316	0.342	0.309	0.349	1.99%	3.99%	5.98%	0.313	0.346
P_2O_5, wt.%	0.038	0.005	0.028	0.048	0.023	0.053	13.09%	26.18%	39.27%	0.036	0.040
SiO_2, wt.%	38.99	0.237	38.51	39.46	38.27	39.70	0.61%	1.22%	1.83%	37.04	40.93
Sn, ppm	< 50	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
SO_3, wt.%	0.165	0.010	0.144	0.185	0.134	0.196	6.22%	12.44%	18.65%	0.157	0.173
TiO_2, wt.%	0.335	0.013	0.308	0.362	0.295	0.376	4.02%	8.04%	12.07%	0.319	0.352
V_2O_5, ppm	178	11	156	201	145	212	6.32%	12.63%	18.95%	169	187
Zn, ppm	76	13	49	102	36	116	17.60%	35.21%	52.81%	72	79
Thermogravimetry											
LOI^{1000}, wt.%	12.30	0.404	11.49	13.11	11.08	13.51	3.29%	6.57%	9.86%	11.68	12.91
Borate / Peroxide Fusion ICP											
Al, wt.%	4.50	0.078	4.34	4.66	4.27	4.73	1.74%	3.48%	5.21%	4.27	4.72
As, ppm	114	12	90	138	78	150	10.44%	20.87%	31.31%	108	120

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

Note 1: intervals may appear asymmetric due to rounding; IND = indeterminate.

Note 2: the number of decimal places quoted does not imply accuracy of the certified value to this level but are given to minimise rounding errors when calculating 2SD and 3SD windows.

Table 5 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
Borate / Peroxide Fusion ICP continued											
B, ppm	353	46	261	445	215	491	13.03%	26.07%	39.10%	336	371
Ba, ppm	212	11	189	235	178	246	5.38%	10.75%	16.13%	202	223
Be, ppm	1.11	0.108	0.89	1.32	0.78	1.43	9.79%	19.57%	29.36%	1.05	1.16
Bi, ppm	4.98	0.57	3.84	6.11	3.27	6.68	11.45%	22.89%	34.34%	4.73	5.22
Ca, wt.%	0.660	0.048	0.564	0.755	0.516	0.803	7.25%	14.51%	21.76%	0.627	0.693
Cd, ppm	< 10	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Ce, ppm	28.7	2.66	23.4	34.0	20.7	36.7	9.29%	18.58%	27.86%	27.3	30.1
Co, ppm	247	11	224	270	212	281	4.65%	9.30%	13.94%	234	259
Cr, wt.%	0.467	0.019	0.429	0.506	0.409	0.525	4.12%	8.24%	12.36%	0.444	0.490
Cs, ppm	2.85	0.263	2.33	3.38	2.06	3.64	9.22%	18.44%	27.66%	2.71	3.00
Cu, ppm	48.0	3.96	40.1	56.0	36.1	59.9	8.25%	16.50%	24.75%	45.6	50.4
Dy, ppm	1.99	0.089	1.81	2.17	1.72	2.26	4.49%	8.97%	13.46%	1.89	2.09
Er, ppm	1.15	0.064	1.02	1.27	0.95	1.34	5.57%	11.13%	16.70%	1.09	1.20
Eu, ppm	0.53	0.043	0.44	0.61	0.40	0.65	8.19%	16.38%	24.57%	0.50	0.55
Fe, wt.%	19.18	0.392	18.39	19.96	18.00	20.35	2.04%	4.09%	6.13%	18.22	20.14
Ga, ppm	9.58	0.913	7.75	11.41	6.84	12.32	9.53%	19.07%	28.60%	9.10	10.06
Gd, ppm	2.01	0.146	1.72	2.30	1.58	2.45	7.24%	14.47%	21.71%	1.91	2.11
Ge, ppm	1.10	0.15	0.79	1.41	0.64	1.57	14.02%	28.04%	42.06%	1.05	1.16
Ho, ppm	0.40	0.020	0.36	0.44	0.34	0.46	5.05%	10.10%	15.15%	0.38	0.42
In, ppm	< 0.1	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
K, wt.%	0.614	0.051	0.511	0.717	0.460	0.768	8.37%	16.74%	25.10%	0.583	0.645
La, ppm	12.8	1.19	10.4	15.1	9.2	16.3	9.31%	18.61%	27.92%	12.1	13.4
Li, ppm	15.5	2.1	11.4	19.6	9.4	21.7	13.21%	26.42%	39.63%	14.8	16.3
Lu, ppm	0.18	0.02	0.13	0.22	0.11	0.24	12.63%	25.25%	37.88%	0.17	0.19
Mg, wt.%	5.24	0.106	5.03	5.46	4.93	5.56	2.02%	4.04%	6.06%	4.98	5.51
Mn, wt.%	0.104	0.003	0.097	0.110	0.094	0.113	3.13%	6.26%	9.39%	0.098	0.109
Mo, ppm	2.35	0.46	1.42	3.28	0.96	3.74	19.71%	39.42%	59.13%	2.23	2.47
Nd, ppm	11.4	0.49	10.4	12.3	9.9	12.8	4.29%	8.58%	12.86%	10.8	11.9
Ni, wt.%	0.325	0.009	0.306	0.344	0.297	0.353	2.91%	5.83%	8.74%	0.309	0.341
Pr, ppm	3.23	0.271	2.69	3.77	2.42	4.05	8.37%	16.73%	25.10%	3.07	3.40
Rb, ppm	33.4	1.96	29.5	37.3	27.5	39.3	5.87%	11.75%	17.62%	31.7	35.1
Re, ppm	< 0.1	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
S, wt.%	0.061	0.011	0.039	0.084	0.027	0.095	18.49%	36.98%	55.47%	0.058	0.064
Sb, ppm	3.44	0.79	1.87	5.02	1.08	5.81	22.90%	45.80%	68.70%	3.27	3.61
Sc, ppm	21.4	1.34	18.7	24.1	17.4	25.4	6.27%	12.54%	18.81%	20.3	22.4
Se, ppm	< 20	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Si, wt.%	18.09	0.444	17.20	18.98	16.75	19.42	2.46%	4.91%	7.37%	17.18	18.99
Sm, ppm	2.18	0.151	1.88	2.48	1.72	2.63	6.94%	13.89%	20.83%	2.07	2.29
Sr, ppm	51	3.4	44	58	41	61	6.68%	13.37%	20.05%	49	54
Tb, ppm	0.33	0.030	0.27	0.39	0.24	0.42	9.04%	18.09%	27.13%	0.31	0.34
Te, ppm	< 1	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Th, ppm	5.12	0.261	4.60	5.64	4.34	5.90	5.10%	10.20%	15.30%	4.86	5.37
Ti, wt.%	0.199	0.007	0.184	0.213	0.177	0.221	3.66%	7.31%	10.97%	0.189	0.209

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

Note 1: intervals may appear asymmetric due to rounding; IND = indeterminate.

Note 2: the number of decimal places quoted does not imply accuracy of the certified value to this level but are given to minimise rounding errors when calculating 2SD and 3SD windows.

Table 5 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
Borate / Peroxide Fusion ICP continued											
Tl, ppm	< 0.5	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Tm, ppm	0.17	0.03	0.12	0.23	0.09	0.25	16.24%	32.47%	48.71%	0.16	0.18
U, ppm	1.25	0.13	0.99	1.51	0.86	1.64	10.47%	20.93%	31.40%	1.19	1.31
V, ppm	101	6	89	112	84	118	5.63%	11.27%	16.90%	96	106
W, ppm	24.5	2.37	19.8	29.2	17.4	31.6	9.67%	19.33%	29.00%	23.3	25.7
Y, ppm	10.8	0.34	10.2	11.5	9.8	11.9	3.16%	6.32%	9.48%	10.3	11.4
Yb, ppm	1.15	0.12	0.91	1.39	0.79	1.51	10.49%	20.99%	31.48%	1.09	1.21
Zn, ppm	84	10	64	104	53	115	12.14%	24.27%	36.41%	80	88
Infrared Combustion											
C, wt.%	2.04	0.046	1.94	2.13	1.90	2.17	2.27%	4.53%	6.80%	1.93	2.14
S, wt.%	0.062	0.005	0.052	0.071	0.047	0.076	7.78%	15.55%	23.33%	0.059	0.065

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

Note 1: intervals may appear asymmetric due to rounding; IND = indeterminate.

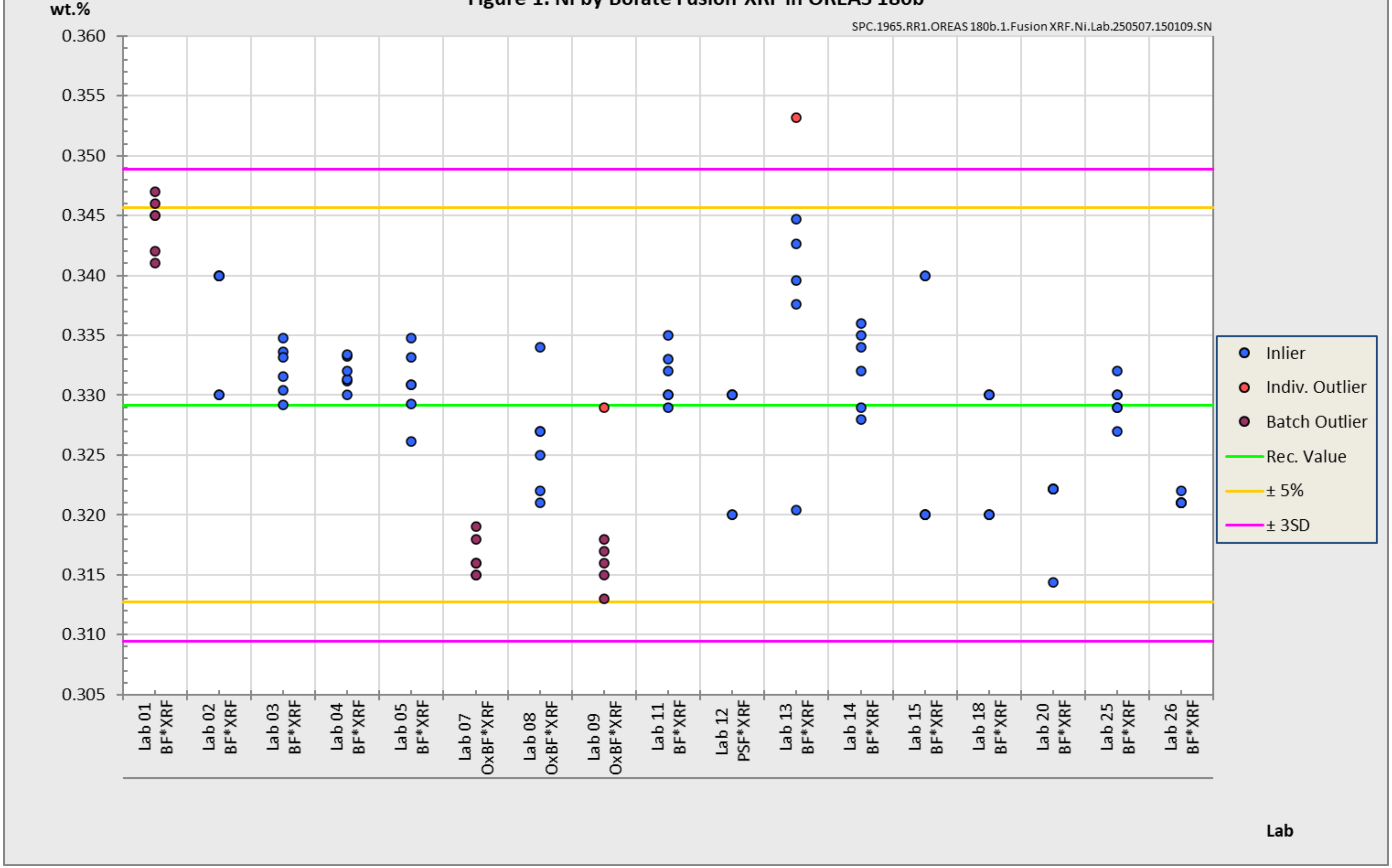
Note 2: the number of decimal places quoted does not imply accuracy of the certified value to this level but are given to minimise rounding errors when calculating 2SD and 3SD windows.

PARTICIPATING LABORATORIES

1. Actlabs, Ancaster, Ontario, Canada
2. ALS, Brisbane, QLD, Australia
3. ALS, Lima, Peru
4. ALS, Loughrea, Galway, Ireland
5. American Assay Laboratories, Sparks, Nevada, USA
6. ARGETEST Mineral Processing, Ankara, Central Anatolia, Turkey
7. Bureau Veritas Commodities Canada Ltd, Vancouver, BC, Canada
8. Bureau Veritas Geoanalytical, Adelaide, SA, Australia
9. Bureau Veritas Geoanalytical, Perth, WA, Australia
10. Bureau Veritas Minerals, Ankara, Central Anatolia, Turkey
11. CERTIMIN, Lima, Peru
12. Inspectorate (BV), Lima, Peru
13. Inspectorate Griffith India, Gandhidham, Gujarat, India
14. Intertek, Cupang, Muntinlupa, Philippines
15. Intertek, Perth, WA, Australia
16. Labwest Minerals Analysis, Perth, WA, Australia
17. MSALABS, Vancouver, BC, Canada
18. Ni Lab, Pouembout, New Caledonia
19. Paragon Geochemical Laboratories, Sparks, Nevada, USA
20. PT Geoservices Ltd, Cikarang, Jakarta Raya, Indonesia
21. PT Intertek Utama Services, Jakarta Timur, DKI Jakarta, Indonesia
22. SGS Australia Mineral Services, Perth, WA, Australia
23. SGS Canada Inc., Vancouver, BC, Canada
24. Shiva Analyticals Ltd, Bangalore North, Karnataka, India
25. Skyline Assayers & Laboratories, Tucson, Arizona, USA
26. Stewart Assay & Environmental Laboratories LLC, Kara-Balta, Chüy, Kyrgyzstan

Please note: To preserve anonymity, the above numbered alphabetical list of participating laboratories <u>does not</u> correspond with the Lab ID numbering on the scatter plots below.

Figure 1. Ni by Borate Fusion XRF in OREAS 180b



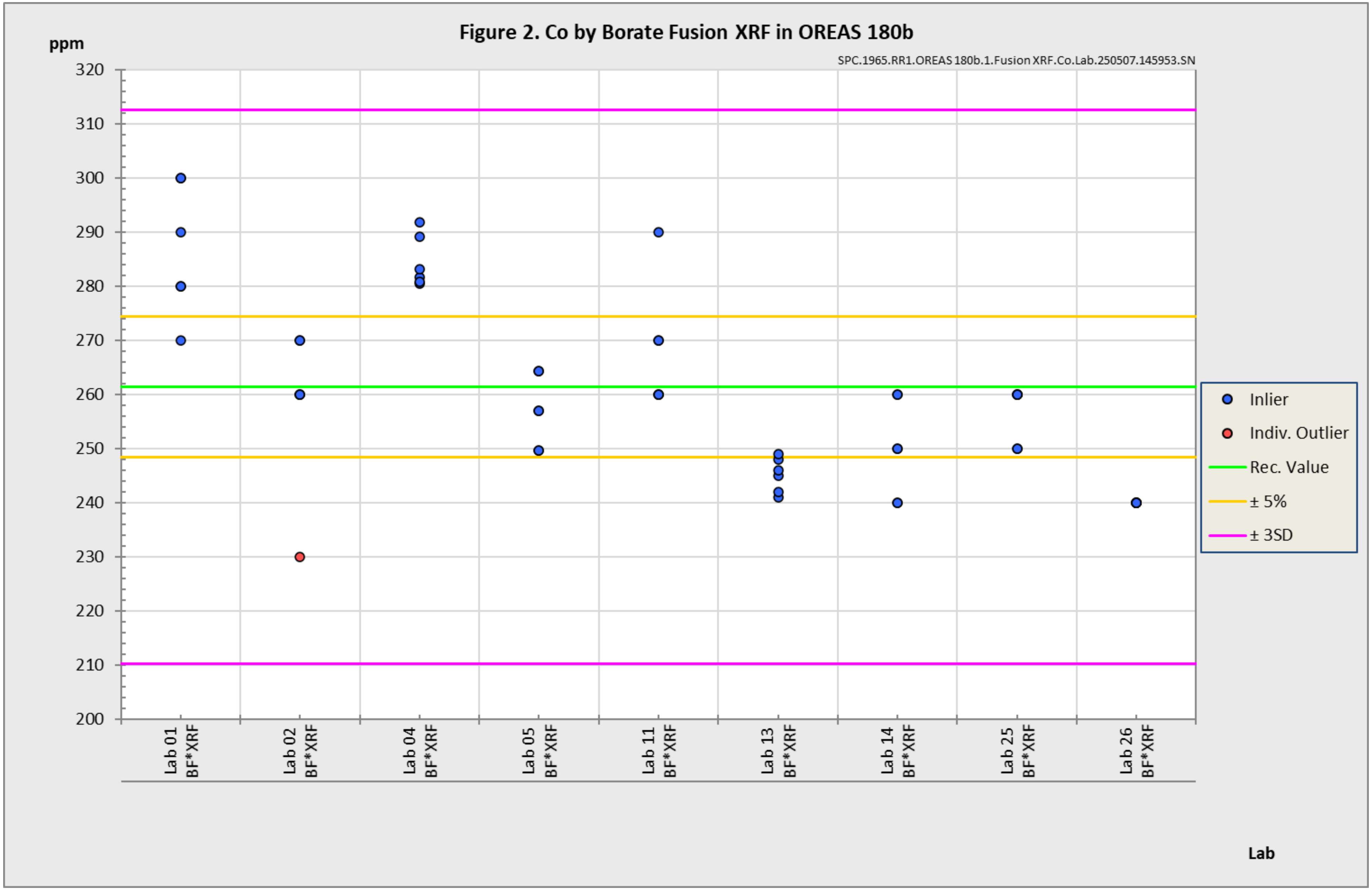


Figure 2. Co by Borate Fusion XRF in OREAS 180b
SPC.1965.RR1.OREAS 180b.1.Fusion XRF.Co.Lab.250507.145953.SN
ppm
320
310
300
290
280
270
260
250
240
230
220
210
200
Lab 01 BF*XRF
Lab 02 BF*XRF
Lab 04 BF*XRF
Lab 05 BF*XRF
Lab 11 BF*XRF
Lab 13 BF*XRF
Lab 14 BF*XRF
Lab 25 BF*XRF
Lab 26 BF*XRF
Lab
Inlier
Indiv. Outlier
Rec. Value
± 5%
± 3SD

PREPARER AND SUPPLIER

Certified reference material OREAS 180b is prepared, certified and supplied by:

ORE Research & Exploration Pty Ltd	Tel: +613-9729 0333
37A Hosie Street	Web: www.oreas.com
Bayswater North VIC 3153	Email: info@ore.com.au
AUSTRALIA	

METROLOGICAL TRACEABILITY

The interlaboratory results that underpin the certified values are metrologically traceable to the international measurement scale (SI) of mass (either as a % mass fraction or as milligrams per kilogram (mg/kg)) [14]. In line with popular use, all data within tables in this certificate are expressed as the mass fraction in either weight percent (wt.%) or parts per million (ppm).

The analytical samples sent to participating laboratories were selected in a manner to be representative of the entire prepared batch of CRM. This representativeness 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. The systematic sampling method was chosen due to the low risk of overlooking repetitive effects or trends in the batch due to the way the CRM was processed. In line with ISO 17025 [8], each analytical data set received from the participating laboratories has been validated by its assayer through the inclusion of internal reference materials and QC checks during and post analysis.

The participating laboratories were chosen on the basis of their competence (from past performance in interlaboratory programs undertaken by ORE Pty Ltd) for a particular analytical method, analyte or analyte suite and sample matrix. These laboratories are accredited to ISO 17025 for all methods (Table 1). The certified values presented in this report are calculated from the means of accepted data following robust technical and statistical analysis as detailed in this report.

Guide ISO/TR 16476:2016 [7], section 5.3.1 describes metrological traceability in reference materials as it pertains to the transformation of the measurand. In this section it states, *"Although the determination of the property value itself can be made traceable to appropriate units through, for example, calibration of the measurement equipment used, steps like the transformation of the sample from one physical (chemical) state to another cannot. Such transformations may only be compared with a reference (when available), or among themselves. For some transformations, reference methods have been defined and may be used in certification projects to evaluate the uncertainty associated with such a transformation.* ***In other cases, only a comparison among different laboratories using the same procedure is possible. In this case, it is impossible to demonstrate absence of method bias; therefore, the result is an operationally defined measurand*** *(ISO 33405:2024-05, 9.2.4c) [4]."* Certification takes place on the basis of agreement among operationally defined, independent measurement results.

COMMUTABILITY

The measurements of the results that underlie the certified values contained in this report were undertaken by methods involving pre-treatment (fusion/digestion) of the sample. This served to reduce the sample to a simple and well understood form permitting calibration using simple solutions of the CRM. Due to these methods being well understood and highly effective, commutability is not an issue for this CRM. All OREAS CRMs are sourced from natural ore minerals meaning they will display similar behaviour as routine ‘field’ samples in the relevant measurement process. Care should be taken to ensure ‘matrix matching’ as close as practically achievable. The matrix and mineralisation style of the CRM is described in the ‘Source Material’ section and users should select appropriate CRMs matching these attributes to the field samples being analysed.

INTENDED USE

OREAS 180b is intended to cover all activities needed to produce a measurement result. This includes extraction, possible separation steps and the actual measurement process (the signal producing step). OREAS 180b may be used to calibrate the entire procedure by producing a pure substance CRM transformed into a calibration solution.

OREAS 180b is intended for the following uses:

- For the monitoring of laboratory performance in the analysis of analytes reported in Table 1 geological samples;
- For the verification/ validation 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. When a value provided in this certificate is used to calibrate a measurement process, the uncertainty associated with that value should be appropriately propagated into the user’s uncertainty calculation. Users can determine an approximation of the standard uncertainty by calculating one fourth of the width of the Expanded Uncertainty interval given in this certificate (Expanded Uncertainty intervals are provided in Table 1).

MINIMUM SAMPLE SIZE

To relate analytical determinations to the values in this certificate, the minimum mass of sample used should match the typical mass that the laboratories used in the interlaboratory (round robin) certification program. This means that different minimum sample masses should be used depending on the operationally defined methodology as follows:

- Borate fusion with X-ray fluorescence finish: ≥0.2 g;
- Loss on Ignition (LOI) at 1000 °C: ≥1 g;
- Sodium peroxide / Lithium Borate fusion with ICP-OES and/or MS finish: ≥0.2 g;
- Total C and S by infrared combustion furnace: ≥0.1 g.

PERIOD OF VALIDITY & STORAGE INSTRUCTIONS

The certification of OREAS 180b remains valid, within the specified measurement uncertainties, until at least July 2039, provided the CRM is handled and stored in accordance with the instructions given below. This certification is nullified if the CRM is any way changed or contaminated.

Store in a clean and cool dry place away from direct sunlight.

Long-term stability will be monitored at appropriate intervals and purchasers notified if any changes are observed. The period of validity may well be indefinite and will be reassessed prior to expiry with the aim of extending the validity if possible.

Single-use sachets

OREAS 180b is packaged in single-use laminated foil sachets. Following analysis, it is the manufacturer's expectation that any remaining material is discarded. It is the user's responsibility to prevent contamination and avoid prolonged exposure of the sample to the atmosphere prior to analysis.

Repeat-use packaging (e.g., 1 kg plastic jars)

After taking a subsample, users should replace the lid of the jar promptly and securely to prevent accidental spills and airborne contamination. OREAS 180b contains a pre-equilibrated hygroscopic* matrix with an indicative value for moisture provided to enable users to check for changes to stored material by determining moisture in the user's laboratory and comparing the result to the value in Table 3 in this certificate.

The stability of the CRM in regard to oxidation from the breakdown of sulphide minerals to sulphates is negligible given its low sulphur concentration (~0.06 wt.% S).

*A pre-equilibrated hygroscopic matrix means exposure to atmospheres significantly different, in terms of temperature and humidity, from the climate during manufacturing should have negligible impact on the precision of results. Hygroscopic moisture is the amount of adsorped moisture (weakly held H_2O- molecules on the surface of exposed material) following exposure to the local atmosphere. Usually, equilibration of material to the local atmosphere will occur if the material is spread into a thin (~2mm thick) layer and left exposed for a period of 2 hours.

INSTRUCTIONS FOR HANDLING & CORRECT USE

Pre-homogenisation of the CRM prior to subsampling and analysis is not necessary as there is no particle segregation under transport [12].

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

As per routine analysis at commercial laboratories, the certified values derived by borate fusion with XRF finish are on a dry sample basis.

Analytes by all other methods refer to the concentration levels in the packaged state. There is no need for drying prior to weighing and analysis for these methods.

QC monitoring using multiples of the Standard Deviation (SD)

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.

The performance gates shown in Table 5 are intended only to be used as a preliminary guide as to what a laboratory may be able to achieve. Over a period of time monitoring your own laboratory’s data for this CRM, SD's should be calculated directly from your own laboratory's process. This will enable you to establish more specific performance gates that are fit for purpose for your application as well as the ability to monitor bias. If your long-term trend analysis shows an average value that is within the 95 % expanded uncertainty then generally there is no cause for concern in regard to bias.

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
0	27th May, 2025	First publication.

CERTIFYING OFFICER

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

QMS CERTIFICATION

ORE Pty Ltd is accredited for compliance with ISO 17034:2016 (Accreditation number 20483).

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

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