Ore Research & Exploration P/L **ABN** 28 006 859 856
37A Hosie Street, Bayswater North, VIC 3153, Australia
P +61 3 9729 0333 | **E** info@ore.com.au | **oreas.com**

CERTIFICATE OF ANALYSIS FOR

CERTIFIED REFERENCE MATERIAL

OREAS 144

Sn Ore

(Renison Bell Tin Mine, Tasmania, Australia)

Accredited for compliance with ISO 17034

COA-1939-OREAS 144-R0 BUP-70-10-01 Ver:2.0	04-August-2025

Table 1. Certified Values, Uncertainty & Tolerance Intervals in OREAS 144.

Constituent	Certified Value†	95% Expanded Uncertainty		95% Tolerance Limits	
		Low	High	Low	High
Borate Fusion XRF					
Al_2O_3, Aluminium(III) oxide (wt.%)	11.13	10.97	11.28	11.02	11.23
As, Arsenic (wt.%)	0.254	0.233	0.275	0.245	0.263
BaO, Barium oxide (ppm)	584	517	652	572	596
CaO, Calcium oxide (wt.%)	10.89	10.74	11.05	10.79	11.00
Co, Cobalt (ppm)	< 100	IND	IND	IND	IND
Cu, Copper (ppm)	745	697	792	717	773
Fe_2O_3, Iron(III) oxide (wt.%)	9.63	9.49	9.77	9.55	9.71
HfO_2, Hafnium dioxide (ppm)	< 100	IND	IND	IND	IND
K_2O, Potassium oxide (wt.%)	2.33	2.29	2.37	2.31	2.35
MgO, Magnesium oxide (wt.%)	2.09	2.05	2.12	2.06	2.11
MnO, Manganese oxide (wt.%)	0.064	0.061	0.067	0.062	0.067
Mo, Molybdenum (ppm)	< 50	IND	IND	IND	IND
Na_2O, Sodium oxide (wt.%)	1.07	0.96	1.18	1.05	1.09
P_2O_5, Phosphorus(V) oxide (wt.%)	0.117	0.108	0.126	0.114	0.120
SiO_2, Silicon dioxide (wt.%)	49.93	49.28	50.58	49.66	50.20
Sn, Tin (wt.%)	0.607	0.586	0.628	0.590	0.624
SO_3, Sulphur trioxide (wt.%)	6.67	6.49	6.85	6.59	6.75
SrO, Strontium oxide (ppm)	125	102	147	IND	IND
TiO_2, Titanium dioxide (wt.%)	0.512	0.498	0.527	0.499	0.526
V_2O_5, Vanadium(V) oxide (ppm)	127	79	175	IND	IND
Zn, Zinc (ppm)	80	59	101	IND	IND
Thermogravimetry					
LOI^{1000}, Loss on ignition @1000 °C (wt.%)	6.48	5.82	7.13	6.28	6.67
Borate / Peroxide Fusion ICP					
Al, Aluminium (wt.%)	5.88	5.72	6.03	5.77	5.98
As, Arsenic (wt.%)	0.251	0.237	0.265	0.246	0.257
Ba, Barium (ppm)	528	505	551	518	539
Be, Beryllium (ppm)	3.31	2.14	4.48	IND	IND
Ca, Calcium (wt.%)	7.83	7.44	8.21	7.68	7.97
Ce, Cerium (ppm)	57	50	64	55	59
Co, Cobalt (ppm)	14.5	13.3	15.6	13.9	15.1
Cr, Chromium (ppm)	69	55	83	IND	IND
Cs, Caesium (ppm)	7.53	6.62	8.44	7.04	8.02
Cu, Copper (ppm)	771	742	800	760	783

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

†These operationally defined measurands comply with the requirements of ISO 17034. Metrological traceability has been established either through the exclusive use of laboratories accredited to ISO/IEC 17025:2017, or through validated performance against existing Certified Reference Materials (CRMs).

Note: intervals may appear asymmetric due to rounding.

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					
Dy, Dysprosium (ppm)	4.54	3.86	5.22	4.10	4.98
Er, Erbium (ppm)	2.62	2.14	3.10	2.44	2.81
Eu, Europium (ppm)	1.10	0.93	1.26	IND	IND
Fe, Iron (wt.%)	6.78	6.57	6.98	6.66	6.90
Ga, Gallium (ppm)	18.6	17.5	19.6	18.0	19.1
Gd, Gadolinium (ppm)	4.89	4.02	5.77	4.65	5.13
Ho, Holmium (ppm)	0.91	0.73	1.10	IND	IND
K, Potassium (wt.%)	1.99	1.91	2.07	1.94	2.03
La, Lanthanum (ppm)	27.7	24.1	31.3	26.1	29.3
Li, Lithium (ppm)	66	54	77	64	68
Mg, Magnesium (wt.%)	1.23	1.19	1.27	1.20	1.26
Mn, Manganese (wt.%)	0.053	0.051	0.055	0.052	0.054
Nd, Neodymium (ppm)	27.5	25.0	30.0	26.0	29.0
Ni, Nickel (ppm)	31.0	19.8	42.3	IND	IND
P, Phosphorus (wt.%)	0.051	0.049	0.053	IND	IND
Pr, Praseodymium (ppm)	6.88	5.70	8.05	6.26	7.49
Rb, Rubidium (ppm)	127	112	143	121	134
S, Sulphur (wt.%)	2.62	2.55	2.68	2.58	2.66
Si, Silicon (wt.%)	23.65	22.78	24.52	23.14	24.15
Sm, Samarium (ppm)	5.23	4.40	6.06	4.78	5.68
Sn, Tin (wt.%)	0.570	0.540	0.601	0.562	0.579
Sr, Strontium (ppm)	125	117	133	122	129
Ta, Tantalum (ppm)	0.98	0.74	1.22	IND	IND
Tb, Terbium (ppm)	0.77	0.66	0.88	IND	IND
Th, Thorium (ppm)	11.4	10.3	12.4	10.9	11.8
Ti, Titanium (wt.%)	0.302	0.293	0.311	0.294	0.310
Tm, Thulium (ppm)	0.37	0.27	0.46	IND	IND
U, Uranium (ppm)	2.76	2.37	3.15	2.46	3.07
V, Vanadium (ppm)	62	48	76	59	65
Y, Yttrium (ppm)	23.7	20.3	27.0	22.1	25.3
Yb, Ytterbium (ppm)	2.43	1.95	2.90	2.14	2.71
Zn, Zinc (ppm)	81	65	97	77	85
4-Acid Digestion					
Ag, Silver (ppm)	0.838	0.777	0.898	0.801	0.874
Al, Aluminium (wt.%)	5.72	5.52	5.91	5.60	5.84

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

[†] These operationally defined measurands comply with the requirements of ISO 17034. Metrological traceability has been established either through the exclusive use of laboratories accredited to ISO/IEC 17025:2017, or through validated performance against existing Certified Reference Materials (CRMs).

Note: intervals may appear asymmetric due to rounding.

IND = indeterminate (due to limited reading resolution of the methods employed).

Table 1 continued.

Constituent	Certified Value†	95% Expanded Uncertainty		95% Tolerance Limits	
		Low	High	Low	High
4-Acid Digestion continued					
As, Arsenic (wt.%)	0.255	0.248	0.263	0.249	0.262
Ba, Barium (ppm)	534	519	549	522	546
Be, Beryllium (ppm)	3.13	2.99	3.28	2.99	3.28
Bi, Bismuth (ppm)	45.3	42.8	47.9	43.5	47.2
Ca, Calcium (wt.%)	7.64	7.35	7.92	7.49	7.78
Ce, Cerium (ppm)	59	55	63	57	61
Co, Cobalt (ppm)	13.5	12.4	14.6	13.0	14.1
Cr, Chromium (ppm)	55	50	61	52	58
Cs, Caesium (ppm)	7.80	7.31	8.28	7.51	8.08
Cu, Copper (ppm)	769	748	789	755	782
Dy, Dysprosium (ppm)	2.84	2.52	3.15	2.72	2.95
Er, Erbium (ppm)	1.35	1.14	1.56	1.27	1.43
Eu, Europium (ppm)	1.00	0.91	1.09	0.93	1.08
Fe, Iron (wt.%)	6.67	6.50	6.85	6.52	6.82
Ga, Gallium (ppm)	18.3	17.2	19.4	17.8	18.8
Gd, Gadolinium (ppm)	4.11	3.62	4.60	3.88	4.35
Hf, Hafnium (ppm)	2.44	2.23	2.65	2.32	2.56
Ho, Holmium (ppm)	0.50	0.43	0.58	0.47	0.54
In, Indium (ppm)	2.00	1.66	2.34	1.69	2.31
K, Potassium (wt.%)	1.94	1.89	2.00	1.90	1.98
La, Lanthanum (ppm)	29.1	27.1	31.1	28.0	30.2
Li, Lithium (ppm)	71	67	74	69	72
Lu, Lutetium (ppm)	0.18	0.16	0.21	IND	IND
Mg, Magnesium (wt.%)	1.16	1.12	1.19	1.13	1.18
Mn, Manganese (wt.%)	0.050	0.048	0.052	0.049	0.051
Mo, Molybdenum (ppm)	2.08	1.89	2.27	1.91	2.25
Na, Sodium (wt.%)	0.836	0.805	0.867	0.813	0.860
Nb, Niobium (ppm)	10.2	9.2	11.3	9.4	11.1
Nd, Neodymium (ppm)	25.5	22.5	28.4	24.1	26.8
Ni, Nickel (ppm)	28.1	26.3	29.9	26.9	29.3
P, Phosphorus (wt.%)	0.052	0.050	0.055	0.051	0.054
Pb, Lead (ppm)	20.6	19.3	21.9	19.2	22.0
Pr, Praseodymium (ppm)	7.20	6.64	7.76	6.94	7.46
Rb, Rubidium (ppm)	126	118	135	122	130
S, Sulphur (wt.%)	2.62	2.55	2.68	2.57	2.66

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

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Note: intervals may appear asymmetric due to rounding.

IND = indeterminate (due to limited reading resolution of the methods employed).

Table 1 continued.

Constituent	Certified Value†	95% Expanded Uncertainty		95% Tolerance Limits	
		Low	High	Low	High
4-Acid Digestion continued					
Sb, Antimony (ppm)	2.50	2.17	2.82	2.31	2.68
Sc, Scandium (ppm)	9.13	8.57	9.70	8.74	9.53
Sm, Samarium (ppm)	5.06	4.55	5.56	4.69	5.42
Sr, Strontium (ppm)	124	119	130	121	128
Ta, Tantalum (ppm)	0.84	0.74	0.93	0.78	0.89
Tb, Terbium (ppm)	0.54	0.49	0.59	0.52	0.57
Th, Thorium (ppm)	11.3	10.6	11.9	10.9	11.6
Ti, Titanium (wt.%)	0.279	0.268	0.291	0.272	0.287
Tl, Thallium (ppm)	0.67	0.64	0.71	0.64	0.70
Tm, Thulium (ppm)	0.17	0.14	0.20	IND	IND
U, Uranium (ppm)	2.55	2.24	2.86	2.34	2.77
V, Vanadium (ppm)	63	61	65	62	65
W, Tungsten (ppm)	35.6	33.1	38.1	34.2	37.0
Y, Yttrium (ppm)	12.8	11.8	13.8	12.3	13.3
Yb, Ytterbium (ppm)	1.19	1.00	1.37	1.11	1.26
Zn, Zinc (ppm)	72	68	76	70	75
Zr, Zirconium (ppm)	79	70	89	75	83

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

†These operationally defined measurands comply with the requirements of ISO 17034. Metrological traceability has been established either through the exclusive use of laboratories accredited to ISO/IEC 17025:2017, or through validated performance against existing Certified Reference Materials (CRMs).

Note: intervals may appear asymmetric due to rounding.

IND = indeterminate (due to limited reading resolution of the methods employed).

Table 2. Indicative Values for OREAS 144.

Constituent	Unit	Value	Constituent	Unit	Value	Constituent	Unit	Value
Borate Fusion XRF								
Bi	ppm	*99*	Hg	ppm	*< 100*	Sc	ppm	*< 100*
Cd	ppm	*< 10*	In	ppm	*< 100*	Se	ppm	*< 100*
Ce	ppm	*< 80*	La	ppm	*< 90*	Ta	ppm	*< 100*
Cl	ppm	*< 50*	Nb	ppm	*< 50*	Te	ppm	*< 100*
Cr_2O_3	ppm	*101*	NiO	ppm	*< 64*	Tl	ppm	*< 100*
Cs	ppm	*< 100*	Pb	ppm	*115*	W	ppm	*40.5*
Ga	ppm	*< 100*	Rb	ppm	*90*	Y	ppm	*41.6*
Ge	ppm	*< 100*	Sb	ppm	*< 50*	ZrO_2	ppm	*187*
Thermogravimetry								
H_2O-	wt.%	*0.248*						

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.

Table 2 continued.

Constituent	Unit	Value	Constituent	Unit	Value	Constituent	Unit	Value
Borate / Peroxide Fusion ICP								
Ag	ppm	*< 0.5*	In	ppm	*12.2*	Sb	ppm	*3.43*
B	ppm	*1662*	Lu	ppm	*0.38*	Sc	ppm	*9.10*
Bi	ppm	*45.7*	Mo	ppm	*3.17*	Se	ppm	*< 20*
Cd	ppm	*67*	Na	wt.%	*0.459*	Te	ppm	*< 1*
Ge	ppm	*1.93*	Nb	ppm	*11.9*	Tl	ppm	*0.71*
Hf	ppm	*5.12*	Pb	ppm	*38.4*	W	ppm	*46.4*
Hg	ppm	*< 5*	Re	ppm	*< 0.1*	Zr	ppm	*128*
4-Acid Digestion								
B	ppm	*14.6*	Hg	ppm	*0.10*	Sn	wt.%	*0.024*
Cd	ppm	*0.29*	Re	ppm	*0.002*	Te	ppm	*0.051*
Ge	ppm	*0.14*	Se	ppm	*1.44*			
Infrared Combustion								
S	wt.%	*2.58*						

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 provides the certified values and their associated 95 % expanded uncertainty and tolerance intervals, Table 2 shows indicative values including major and trace element characterisation, Table 3 provides some indicative physical properties, Table 4 shows indicative mineralogy by semi-quantitative XRD analysis and Table 5 presents the 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 144-DataPack.1.0.250724_134505.xlsx**). The certified values and uncertainties in this Certificate are the sole authoritative figures. Any additional significant figures in the DataPack are provided for reference only and do not affect the certified results.

Results are also presented in scatter plots for Sn and Cu by fusion XRF, Sn and Cu by fusion ICP and Cu by 4-aicd digestion in Figures 1 to 5 respectively, together with ±3SD (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 144 is a certified reference material (CRM) produced from a blend of tin-copper sulphide ores, hornfels, granodiorite, and calcium carbonate. The ores were sourced from the Renison Bell tin deposit in western Tasmania, Australia. Mineralisation is structurally controlled, with cassiterite hosted in silica- and tourmaline-altered veins within carbonate-rich metasedimentary rocks of the Mount Read Volcanics. The deposit is genetically linked to Devonian granite intrusions. Cassiterite (SnO_2) is the dominant tin-bearing mineral, accompanied by sulphide phases such as pyrrhotite, arsenopyrite, chalcopyrite, and stannite.

COMMINUTION AND HOMOGENISATION PROCEDURES

The materials constituting OREAS 144 was prepared in the following manner:

- Drying the barren materials to constant mass at 105 °C;
- Drying the sulphide ores to constant mass at 85 °C;
- Crushing and multi-stage milling of the barren materials to >95% minus 75 microns;

- Crushing and multi-stage milling of the ores to 100% minus 30 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 500 g units in plastic wide-mouth jars.

PHYSICAL PROPERTIES

OREAS 144 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 144.

Bulk Density (kg/m^3)	Moisture (wt.%)	Munsell Notation‡	Munsell Color‡
751	0.40	N6	Medium Light Gray

‡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. 'Clay mineral' appears to be mainly illite, vermiculite, and smectite. 'Kandite group' appears to be mainly kaolinite. A trace of serpentine and pentlandite may be present and some amorphous material may also be present in the sample.

Table 4. Indicative mineralogy of OREAS 144 by semi-quantitative XRD analysis.

Mineral / Mineral Group	% (mass ratio)
Clay mineral	1
Chlorite	3
Kandite group	< 1
Annite - biotite - phlogopite	24
Muscovite	3
Talc	< 1
Plagioclase	7
K-feldspar	4
Cordierite	1
Tourmaline	2
Quartz	32
Calcite	15
Siderite	1
Pyrite	1
Pyrrhotite	5
Cassiterite	1

ANALYTICAL PROGRAM

Eighteen 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 by X-ray fluorescence (up to 14 laboratories depending on the element);
- Thermogravimetry: Loss on Ignition (LOI) at 1000 °C (9 laboratories used a thermogravimetric analyser, 2 laboratories included LOI with their fusion package and 3 laboratories used a conventional muffle furnace);
- Lithium borate or sodium peroxide fusion with full suite ICP-OES and ICP-MS elemental packages (up to 12 laboratories depending on the element);
- 4-acid (HNO_3-HF-$HClO_4$-HCl) digestion with full suite ICP-OES and ICP-MS elemental packages (up to 16 laboratories depending on the element).

For the round robin program, six 800 g test units were collected at predetermined intervals during the bagging stage, immediately after homogenisation. These units are considered representative of the entire prepared batch. Each participating laboratory received six test portions, obtained by subsampling 10 g from each of the six distinct 800 g units.

Homogeneity was assessed by submitting 12 pulp samples to a single laboratory for analysis. Paired samples were drawn from each of the six test units, enabling an Analysis of Variance (ANOVA) to compare within-unit and between-unit variances. This statistical method provides a relative measure of homogeneity and tests the null hypothesis that all units derive from the same population distribution (refer to the ‘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 [14]. 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 Sn by fusion XRF, where 99 % of the time ($1-\alpha=0.99$) at least 95 % of subsamples ($\rho=0.95$) will have concentrations lying between 0.590 and 0.624 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 ALS Brisbane, laboratory for analysis by oxidising fusion with X-ray fluorescence finish (code ME- XRF15b). The 12 samples consisted of paired samples from each of the six 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).

All *p*-values were found to be statistically insignificant, and 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 144 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 144.

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.%	11.13	0.160	10.81	11.45	10.65	11.61	1.44%	2.87%	4.31%	10.57	11.68
As, wt.%	0.254	0.023	0.207	0.301	0.183	0.324	9.24%	18.49%	27.73%	0.241	0.266
BaO, ppm	584	39	507	661	469	700	6.60%	13.20%	19.80%	555	614
CaO, wt.%	10.89	0.127	10.64	11.15	10.51	11.27	1.16%	2.33%	3.49%	10.35	11.44
Co, ppm	< 100	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Cu, ppm	745	28	689	801	661	829	3.76%	7.51%	11.27%	708	782
Fe_2O_3, wt.%	9.63	0.159	9.31	9.95	9.15	10.11	1.65%	3.30%	4.95%	9.15	10.11
HfO_2, ppm	< 100	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
K_2O, wt.%	2.33	0.030	2.27	2.39	2.24	2.42	1.27%	2.55%	3.82%	2.21	2.45
MgO, wt.%	2.09	0.036	2.01	2.16	1.98	2.19	1.72%	3.43%	5.15%	1.98	2.19
MnO, wt.%	0.064	0.004	0.056	0.073	0.052	0.077	6.59%	13.18%	19.77%	0.061	0.067
Mo, ppm	< 50	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Na_2O, wt.%	1.07	0.11	0.85	1.28	0.74	1.39	10.20%	20.40%	30.60%	1.01	1.12
P_2O_5, wt.%	0.117	0.007	0.103	0.132	0.095	0.139	6.20%	12.39%	18.59%	0.111	0.123
SiO_2, wt.%	49.93	0.766	48.40	51.46	47.63	52.23	1.53%	3.07%	4.60%	47.43	52.43
Sn, wt.%	0.607	0.014	0.578	0.636	0.564	0.651	2.38%	4.77%	7.15%	0.577	0.638
SO_3, wt.%	6.67	0.147	6.38	6.97	6.23	7.12	2.21%	4.42%	6.63%	6.34	7.01
SrO, ppm	125	28	68	181	40	210	22.72%	45.43%	68.15%	118	131
TiO_2, wt.%	0.512	0.014	0.484	0.541	0.469	0.555	2.79%	5.58%	8.37%	0.487	0.538
V_2O_5, ppm	127	25	78	176	53	201	19.40%	38.79%	58.19%	121	133
Zn, ppm	80	22	36	124	14	147	27.68%	55.36%	83.03%	76	84
Thermogravimetry											
LOI^{1000}, wt.%	6.48	1.06	4.36	8.59	3.31	9.64	16.31%	32.61%	48.92%	6.15	6.80

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											
Al, wt.%	5.88	0.156	5.56	6.19	5.41	6.34	2.65%	5.31%	7.96%	5.58	6.17
As, wt.%	0.251	0.016	0.219	0.284	0.202	0.300	6.47%	12.93%	19.40%	0.239	0.264
Ba, ppm	528	16	497	560	481	575	2.97%	5.94%	8.91%	502	555
Be, ppm	3.31	0.85	1.61	5.01	0.76	5.86	25.68%	51.37%	77.05%	3.14	3.48
Ca, wt.%	7.83	0.270	7.29	8.37	7.02	8.63	3.44%	6.89%	10.33%	7.43	8.22
Ce, ppm	57	5.3	46	68	41	73	9.35%	18.71%	28.06%	54	60
Co, ppm	14.5	0.57	13.3	15.6	12.7	16.2	3.96%	7.93%	11.89%	13.7	15.2
Cr, ppm	69	8	53	86	44	94	12.08%	24.16%	36.24%	66	73
Cs, ppm	7.53	0.637	6.26	8.80	5.62	9.44	8.46%	16.92%	25.38%	7.15	7.91
Cu, ppm	771	22	727	816	705	838	2.87%	5.74%	8.61%	733	810
Dy, ppm	4.54	0.352	3.83	5.24	3.48	5.60	7.77%	15.53%	23.30%	4.31	4.76
Er, ppm	2.62	0.30	2.02	3.22	1.72	3.52	11.43%	22.85%	34.28%	2.49	2.75
Eu, ppm	1.10	0.077	0.94	1.25	0.86	1.33	7.05%	14.11%	21.16%	1.04	1.15
Fe, wt.%	6.78	0.157	6.46	7.09	6.31	7.25	2.32%	4.64%	6.96%	6.44	7.12
Ga, ppm	18.6	0.52	17.5	19.6	17.0	20.1	2.78%	5.55%	8.33%	17.6	19.5
Gd, ppm	4.89	0.57	3.75	6.04	3.18	6.61	11.68%	23.36%	35.04%	4.65	5.14
Ho, ppm	0.91	0.11	0.70	1.13	0.59	1.23	11.63%	23.25%	34.88%	0.87	0.96
K, wt.%	1.99	0.039	1.91	2.06	1.87	2.10	1.95%	3.89%	5.84%	1.89	2.09
La, ppm	27.7	2.9	22.0	33.4	19.1	36.3	10.33%	20.67%	31.00%	26.3	29.1
Li, ppm	66	11	44	87	34	98	16.14%	32.27%	48.41%	62	69
Mg, wt.%	1.23	0.028	1.18	1.29	1.15	1.31	2.26%	4.53%	6.79%	1.17	1.29
Mn, wt.%	0.053	0.002	0.049	0.056	0.048	0.058	3.21%	6.41%	9.62%	0.050	0.055
Nd, ppm	27.5	1.77	24.0	31.0	22.2	32.8	6.42%	12.84%	19.26%	26.1	28.9
Ni, ppm	31.0	6.1	18.8	43.3	12.7	49.4	19.73%	39.46%	59.18%	29.5	32.6
P, wt.%	0.051	0.002	0.048	0.055	0.046	0.056	3.41%	6.81%	10.22%	0.049	0.054
Pr, ppm	6.88	0.82	5.24	8.51	4.43	9.33	11.87%	23.75%	35.62%	6.53	7.22
Rb, ppm	127	8	111	144	103	152	6.44%	12.89%	19.33%	121	134
S, wt.%	2.62	0.037	2.54	2.69	2.51	2.73	1.40%	2.81%	4.21%	2.49	2.75
Si, wt.%	23.65	0.811	22.03	25.27	21.21	26.08	3.43%	6.86%	10.29%	22.47	24.83
Sm, ppm	5.23	0.57	4.10	6.36	3.53	6.93	10.83%	21.65%	32.48%	4.97	5.49
Sn, wt.%	0.570	0.043	0.485	0.656	0.443	0.698	7.46%	14.93%	22.39%	0.542	0.599
Sr, ppm	125	6	114	137	108	143	4.69%	9.38%	14.06%	119	132
Ta, ppm	0.98	0.12	0.74	1.22	0.62	1.33	12.12%	24.24%	36.37%	0.93	1.03
Tb, ppm	0.77	0.08	0.60	0.94	0.52	1.02	10.88%	21.75%	32.63%	0.73	0.81
Th, ppm	11.4	0.66	10.0	12.7	9.4	13.3	5.83%	11.66%	17.49%	10.8	11.9
Ti, wt.%	0.302	0.007	0.288	0.317	0.280	0.324	2.42%	4.85%	7.27%	0.287	0.317
Tm, ppm	0.37	0.05	0.27	0.46	0.22	0.51	13.44%	26.88%	40.32%	0.35	0.38
U, ppm	2.76	0.36	2.04	3.48	1.68	3.84	13.03%	26.05%	39.08%	2.63	2.90
V, ppm	62	10	42	82	33	91	15.80%	31.60%	47.40%	59	65
Y, ppm	23.7	3.0	17.8	29.6	14.8	32.5	12.46%	24.93%	37.39%	22.5	24.9
Yb, ppm	2.43	0.29	1.85	3.00	1.57	3.28	11.78%	23.56%	35.34%	2.30	2.55
Zn, ppm	81	20	40	122	20	143	25.22%	50.45%	75.67%	77	85

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.

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
4-Acid Digestion											
Ag, ppm	0.838	0.030	0.777	0.899	0.747	0.929	3.63%	7.27%	10.90%	0.796	0.880
Al, wt.%	5.72	0.200	5.32	6.12	5.12	6.32	3.51%	7.01%	10.52%	5.43	6.00
As, wt.%	0.255	0.008	0.240	0.271	0.232	0.279	3.07%	6.15%	9.22%	0.243	0.268
Ba, ppm	534	14	505	563	491	577	2.70%	5.41%	8.11%	507	561
Be, ppm	3.13	0.107	2.92	3.35	2.81	3.46	3.41%	6.82%	10.23%	2.98	3.29
Bi, ppm	45.3	2.27	40.8	49.9	38.5	52.2	5.01%	10.02%	15.03%	43.1	47.6
Ca, wt.%	7.64	0.322	6.99	8.28	6.67	8.60	4.22%	8.43%	12.65%	7.25	8.02
Ce, ppm	59	2.9	53	65	50	68	4.88%	9.76%	14.64%	56	62
Co, ppm	13.5	0.85	11.8	15.2	11.0	16.1	6.30%	12.60%	18.90%	12.8	14.2
Cr, ppm	55	6	43	68	36	75	11.64%	23.28%	34.92%	53	58
Cs, ppm	7.80	0.449	6.90	8.69	6.45	9.14	5.76%	11.52%	17.27%	7.41	8.19
Cu, ppm	769	20	729	809	709	828	2.60%	5.20%	7.80%	730	807
Dy, ppm	2.84	0.29	2.26	3.42	1.97	3.71	10.23%	20.47%	30.70%	2.69	2.98
Er, ppm	1.35	0.21	0.93	1.77	0.72	1.98	15.51%	31.01%	46.52%	1.29	1.42
Eu, ppm	1.00	0.061	0.88	1.12	0.82	1.18	6.09%	12.17%	18.26%	0.95	1.05
Fe, wt.%	6.67	0.111	6.45	6.90	6.34	7.01	1.67%	3.33%	5.00%	6.34	7.01
Ga, ppm	18.3	1.03	16.2	20.4	15.2	21.4	5.65%	11.30%	16.95%	17.4	19.2
Gd, ppm	4.11	0.42	3.28	4.94	2.87	5.36	10.11%	20.22%	30.34%	3.91	4.32
Hf, ppm	2.44	0.234	1.97	2.91	1.74	3.14	9.57%	19.15%	28.72%	2.32	2.56
Ho, ppm	0.50	0.07	0.37	0.63	0.31	0.70	13.05%	26.10%	39.15%	0.48	0.53
In, ppm	2.00	0.28	1.44	2.56	1.17	2.83	13.89%	27.79%	41.68%	1.90	2.10
K, wt.%	1.94	0.059	1.83	2.06	1.77	2.12	3.04%	6.08%	9.12%	1.85	2.04
La, ppm	29.1	1.75	25.6	32.6	23.9	34.4	6.01%	12.03%	18.04%	27.7	30.6
Li, ppm	71	4.2	62	79	58	83	5.97%	11.93%	17.90%	67	74
Lu, ppm	0.18	0.017	0.15	0.22	0.13	0.23	9.36%	18.72%	28.09%	0.17	0.19
Mg, wt.%	1.16	0.036	1.08	1.23	1.05	1.26	3.09%	6.18%	9.28%	1.10	1.21
Mn, wt.%	0.050	0.002	0.046	0.054	0.043	0.056	4.27%	8.55%	12.82%	0.047	0.052
Mo, ppm	2.08	0.147	1.79	2.37	1.64	2.52	7.05%	14.10%	21.14%	1.98	2.18
Na, wt.%	0.836	0.028	0.780	0.893	0.751	0.921	3.39%	6.77%	10.16%	0.794	0.878
Nb, ppm	10.2	1.3	7.7	12.8	6.5	14.0	12.31%	24.62%	36.93%	9.7	10.8
Nd, ppm	25.5	2.29	20.9	30.0	18.6	32.3	8.99%	17.98%	26.98%	24.2	26.7
Ni, ppm	28.1	1.90	24.3	31.9	22.4	33.8	6.77%	13.54%	20.31%	26.7	29.5
P, wt.%	0.052	0.001	0.049	0.055	0.048	0.056	2.72%	5.44%	8.16%	0.050	0.055
Pb, ppm	20.6	1.79	17.0	24.2	15.2	26.0	8.68%	17.36%	26.04%	19.6	21.6
Pr, ppm	7.20	0.483	6.23	8.16	5.75	8.65	6.70%	13.41%	20.11%	6.84	7.56
Rb, ppm	126	7	112	141	104	148	5.79%	11.58%	17.37%	120	133
S, wt.%	2.62	0.049	2.52	2.71	2.47	2.76	1.87%	3.74%	5.62%	2.48	2.75
Sb, ppm	2.50	0.32	1.86	3.14	1.54	3.46	12.81%	25.62%	38.43%	2.37	2.62
Sc, ppm	9.13	0.604	7.93	10.34	7.32	10.95	6.62%	13.24%	19.85%	8.68	9.59
Sm, ppm	5.06	0.316	4.42	5.69	4.11	6.00	6.25%	12.50%	18.75%	4.80	5.31
Sr, ppm	124	5	113	135	108	141	4.41%	8.82%	13.23%	118	130
Ta, ppm	0.84	0.13	0.58	1.10	0.45	1.23	15.47%	30.93%	46.40%	0.80	0.88
Tb, ppm	0.54	0.045	0.45	0.63	0.41	0.68	8.25%	16.51%	24.76%	0.52	0.57

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.

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
4-Acid Digestion continued											
Th, ppm	11.3	0.40	10.5	12.1	10.1	12.5	3.58%	7.16%	10.73%	10.7	11.8
Ti, wt.%	0.279	0.017	0.245	0.314	0.227	0.331	6.20%	12.41%	18.61%	0.265	0.293
Tl, ppm	0.67	0.029	0.61	0.73	0.59	0.76	4.27%	8.54%	12.81%	0.64	0.70
Tm, ppm	0.17	0.03	0.11	0.23	0.08	0.26	17.70%	35.41%	53.11%	0.16	0.18
U, ppm	2.55	0.228	2.10	3.01	1.87	3.24	8.92%	17.85%	26.77%	2.43	2.68
V, ppm	63	2.4	58	68	56	70	3.77%	7.53%	11.30%	60	66
W, ppm	35.6	1.83	31.9	39.3	30.1	41.1	5.15%	10.30%	15.46%	33.8	37.4
Y, ppm	12.8	1.3	10.2	15.4	8.8	16.8	10.29%	20.58%	30.87%	12.2	13.4
Yb, ppm	1.19	0.16	0.87	1.50	0.71	1.66	13.37%	26.74%	40.11%	1.13	1.24
Zn, ppm	72	4.5	63	81	59	86	6.28%	12.57%	18.85%	69	76
Zr, ppm	79	10	60	99	50	108	12.27%	24.54%	36.81%	75	83

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.

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. ALS, Malaga, WA, Australia
6. ALS, Vancouver, BC, Canada
7. American Assay Laboratories, Sparks, Nevada, USA
8. ARGETEST Mineral Processing, Ankara, Central Anatolia, Turkey
9. Intertek, Perth, WA, Australia
10. Paragon Geochemical Laboratories, Sparks, Nevada, USA
11. PT Geoservices Ltd, Cikarang, Jakarta Raya, Indonesia
12. PT Intertek Utama Services, Jakarta Timur, DKI Jakarta, Indonesia
13. Reminex Centre de Recherche, Marrakesh, Marrakesh-Safi, Morocco
14. SGS, Ankara, Anatolia, Turkey
15. SGS Australia Mineral Services, Perth, WA, Australia
16. SGS de Mexico SA de CV, Cd. Industrial, Durango, Mexico
17. Shiva Analyticals Ltd, Bangalore North, Karnataka, India
18. Stewart Assay & Environmental Laboratories LLC, Kara-Balta, Chüy, Kyrgyzstan

Please note: To maintain anonymity of participating laboratories, the alphabetical list above does not correspond to the Lab ID numbers shown in the scatter plots below.

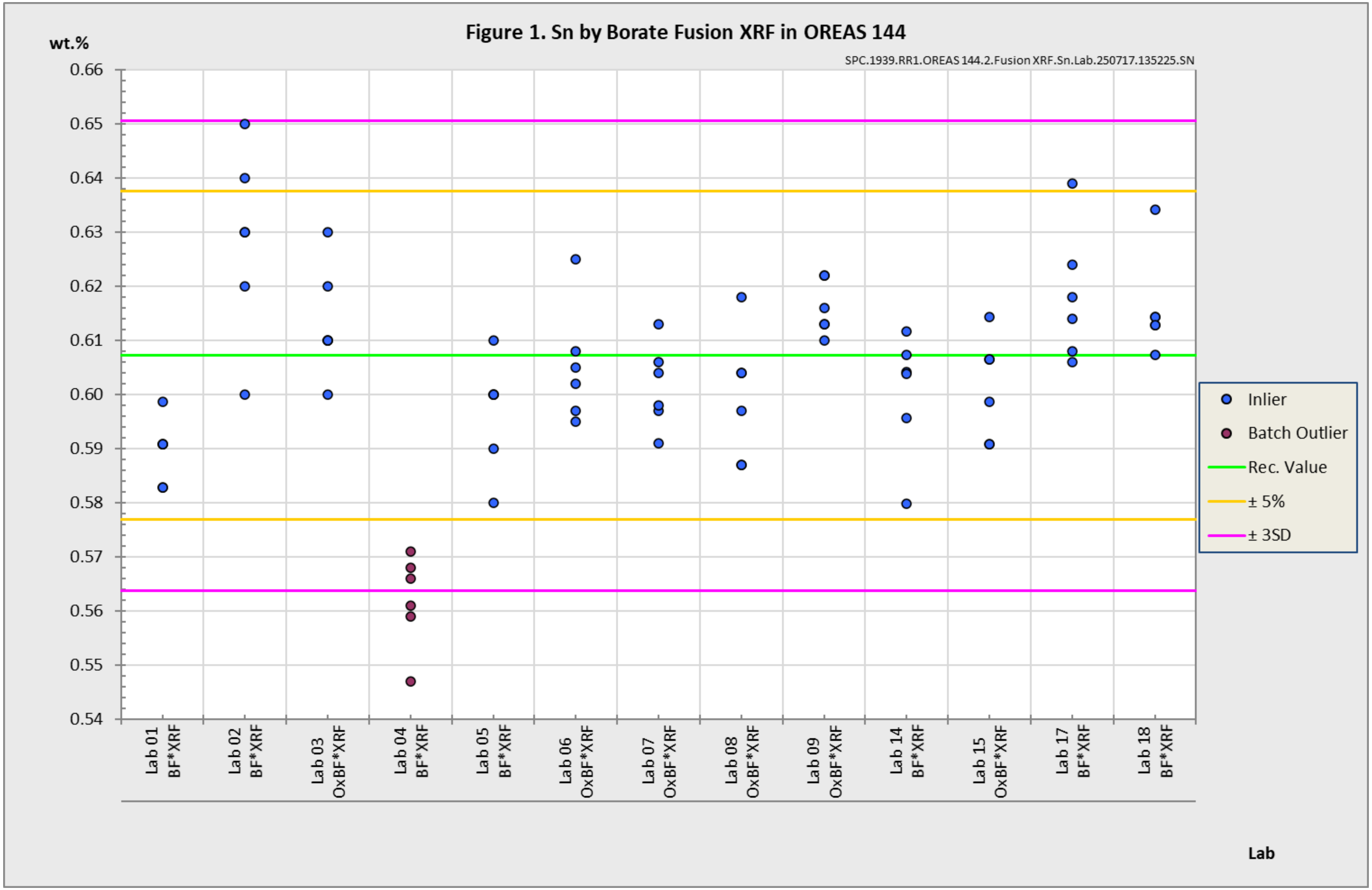


Figure 1. Sn by Borate Fusion XRF in OREAS 144
SPC.1939.RR1.OREAS 144.2.Fusion XRF.Sn.Lab.250717.135225.SN
wt.%
0.66
0.65
0.64
0.63
0.62
0.61
0.60
0.59
0.58
0.57
0.56
0.55
0.54
Lab 01 BF*XRF
Lab 02 BF*XRF
Lab 03 OxBF*XRF
Lab 04 BF*XRF
Lab 05 BF*XRF
Lab 06 OxBF*XRF
Lab 07 OxBF*XRF
Lab 08 OxBF*XRF
Lab 09 OxBF*XRF
Lab 14 BF*XRF
Lab 15 OxBF*XRF
Lab 17 BF*XRF
Lab 18 BF*XRF
Lab
Inlier
Batch Outlier
Rec. Value
± 5%
± 3SD

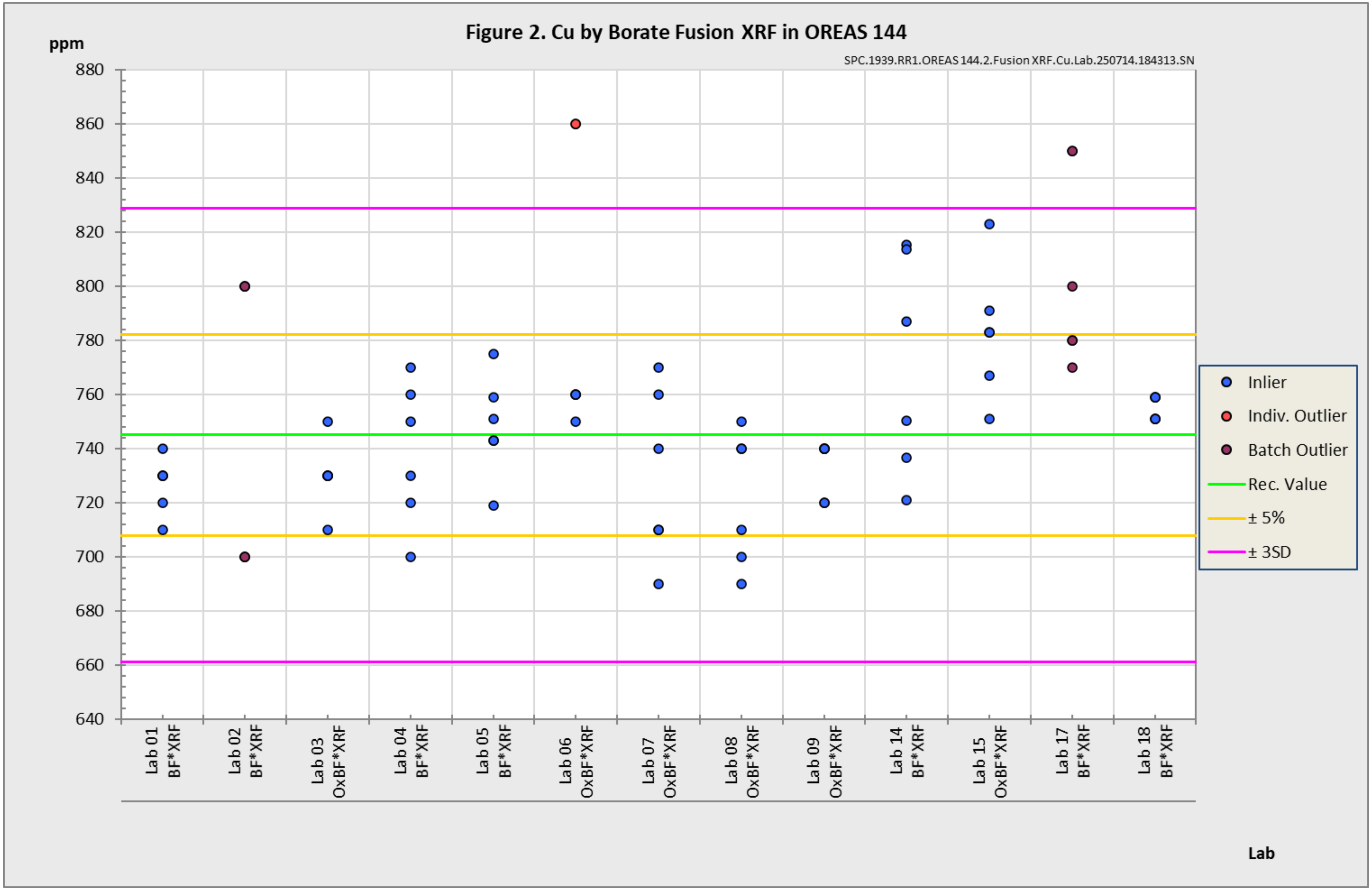
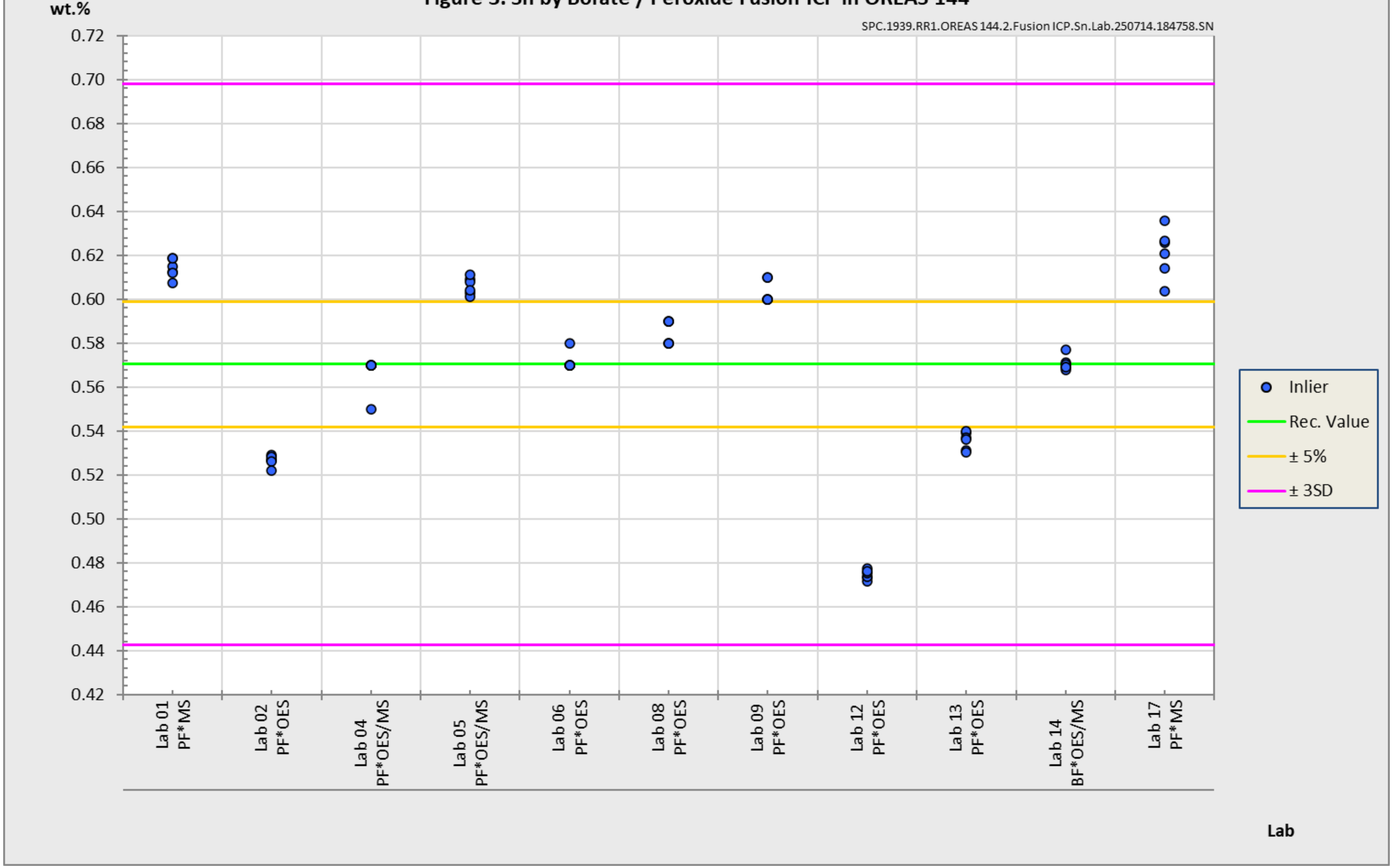


Figure 2. Cu by Borate Fusion XRF in OREAS 144

Figure 3. Sn by Borate / Peroxide Fusion ICP in OREAS 144



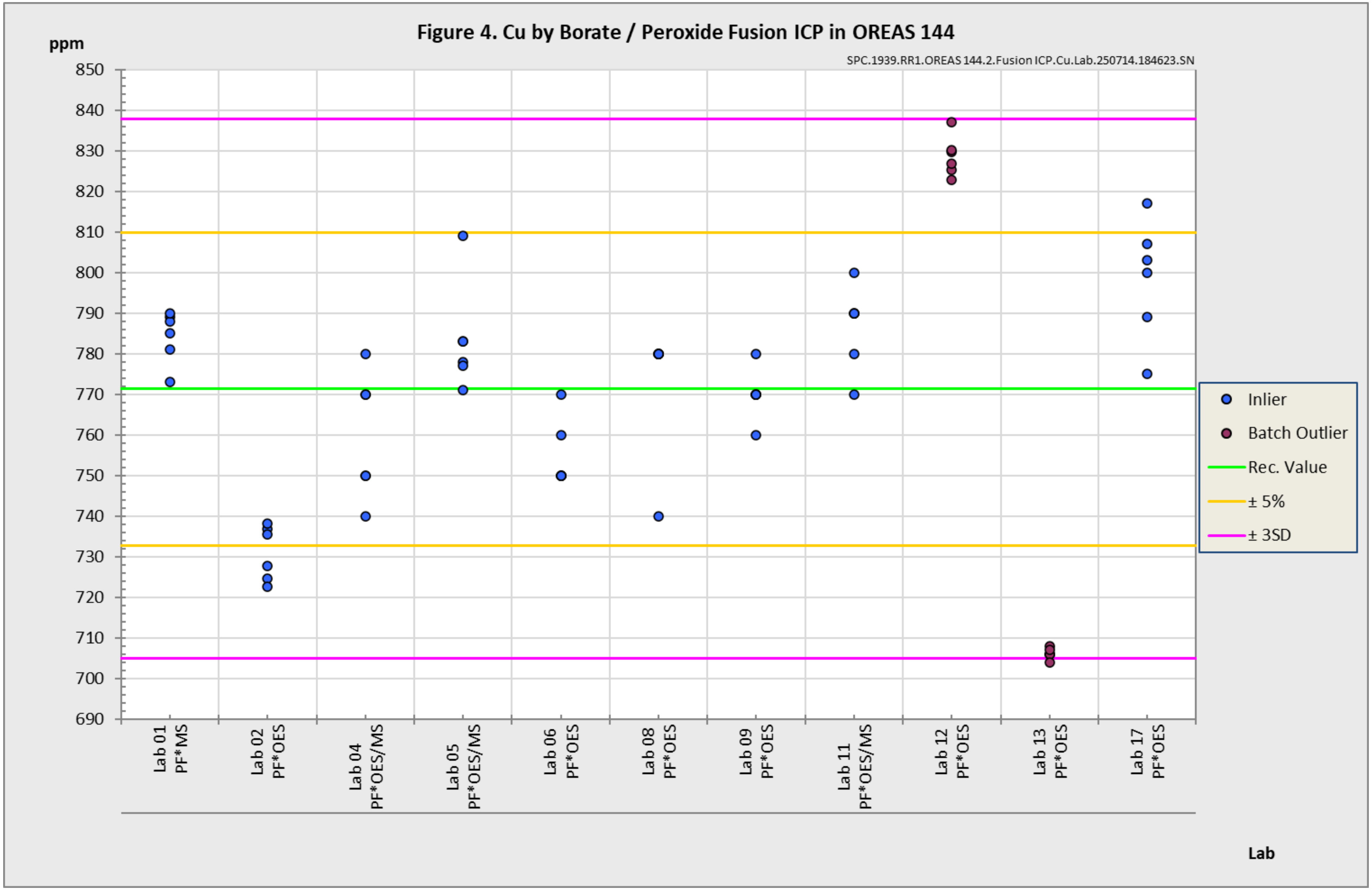


Figure 4. Cu by Borate / Peroxide Fusion ICP in OREAS 144

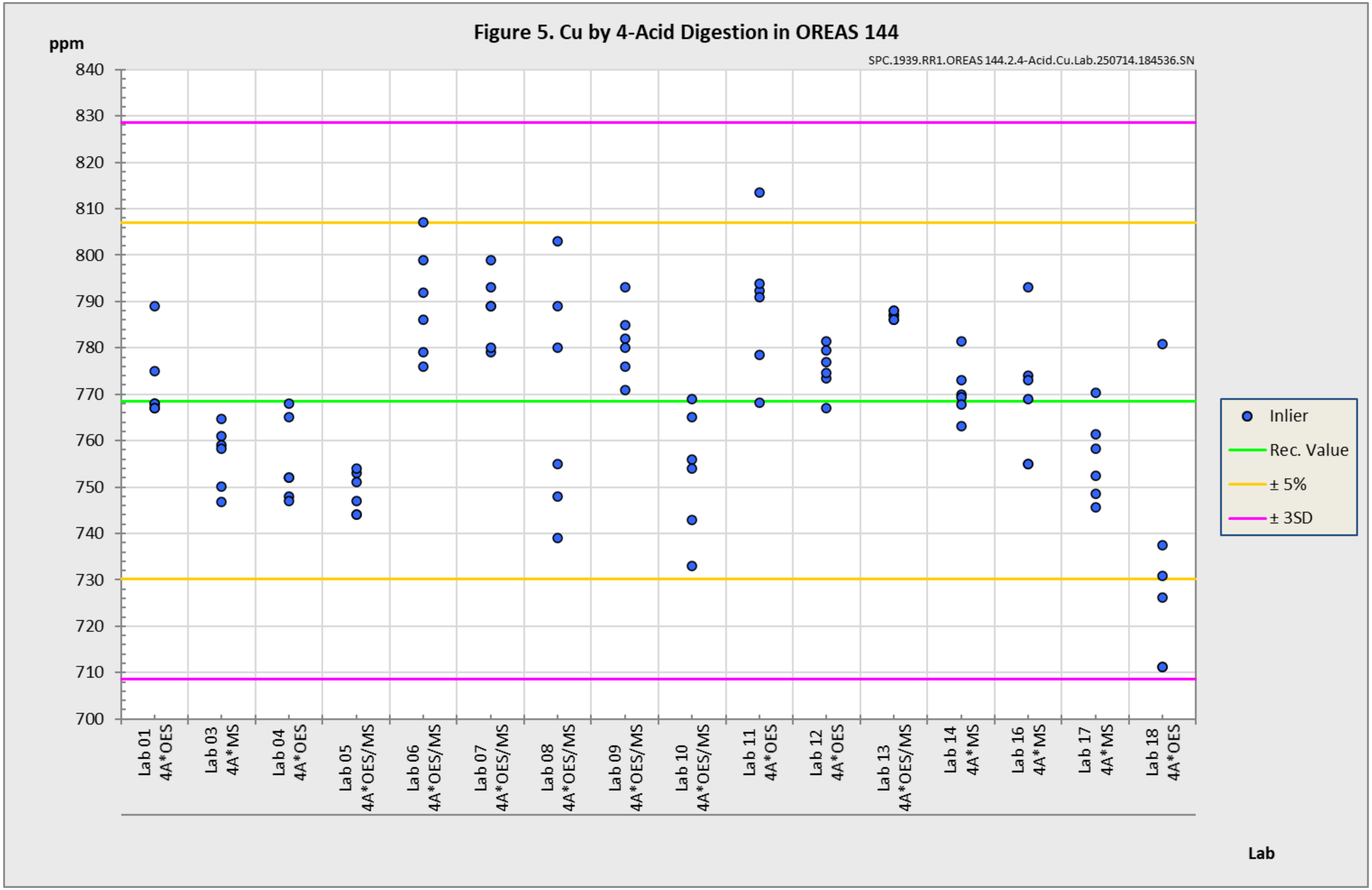


Figure 5. Cu by 4-Acid Digestion in OREAS 144
SPC.1939.RR1.OREAS 144.2.4-Acid.Cu.Lab.250714.184536.SN
ppm
840
830
820
810
800
790
780
770
760
750
740
730
720
710
700
Lab 01 4A*OES
Lab 03 4A*MS
Lab 04 4A*OES
Lab 05 4A*OES/MS
Lab 06 4A*OES/MS
Lab 07 4A*OES/MS
Lab 08 4A*OES/MS
Lab 09 4A*OES/MS
Lab 10 4A*OES/MS
Lab 11 4A*OES
Lab 12 4A*OES
Lab 13 4A*OES/MS
Lab 14 4A*MS
Lab 16 4A*MS
Lab 17 4A*MS
Lab 18 4A*OES
Lab
Inlier
Rec. Value
± 5%
± 3SD

PREPARER AND SUPPLIER

Certified reference material OREAS 144 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)) [13]. 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 [7], 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.

Participating laboratories were selected based on demonstrated analytical competence, including prior performance in interlaboratory comparison programs conducted by ORE Pty Ltd, with consideration given to their expertise in relevant analytical methods, measurands, and sample matrices. For the measurands reported in this certificate (Table 1), data were sourced from laboratories accredited to ISO/IEC 17025. Where formal accreditation was not held for specific operationally defined measurands, metrological traceability was verified through the use of well-characterised, independently certified reference materials (CRMs) included as control samples in the round robin study.

In accordance with ISO 33405:2024-05 [4], clause 9.2.5, and ISO 17034:2016 [8], clause 7.12.4 b), the use of such control samples provides an acceptable means of demonstrating traceability in the absence of formal accreditation. In this certification program, traceability was further supported by the agreement of measured values for control samples with their known certified values, thereby offering additional confidence in the calibration and validity of measurement results across participating laboratories.

Operationally Defined Measurands

In accordance with ISO 33405:2024-05, Clause 9.2.4, measurands (analytes) may be certified as operationally defined. For these measurands, traceability to the SI may not be achievable because the analytical procedure involves sample transformations (e.g., leaching or extraction). While instrument calibration can be traceable to appropriate units, the transformation steps themselves are not directly traceable and can only be evaluated through reference comparisons or harmonized procedures.

Accordingly, characterisation of these measurands has been based on the concordance of results obtained from multiple laboratories using a common, well-defined procedure. This approach ensures fitness-for-purpose and fulfils the requirements for metrological traceability as specified in ISO 17034 and ISO 33405 for operationally defined measurands.

COMMUTABILITY

The certified values reported herein are derived from measurements performed using analytical methods involving sample pre-treatment steps, such as fusion or acid digestion. These processes convert the sample matrix into a chemically simplified and stable form, facilitating calibration traceable to primary standards via solution-based calibration protocols. Due to the established robustness and effectiveness of these pre-treatment methods, issues related to commutability are not expected to impact the suitability of this Certified Reference Material (CRM) for its intended use (cf. ISO/TR 16476:2016, Clause 5.2.3).

OREAS CRMs are prepared from natural ore materials, ensuring the presence of matrix and mineralogical characteristics representative of typical exploration and process samples. Consistent with ISO 17034:2016 and ISO Guide 30, users are advised to select CRMs with matrix and mineralisation styles closely matching those of their routine samples to minimize matrix effects and enhance analytical comparability. Detailed descriptions of the CRM’s source material and mineralogical characteristics are provided in the ‘Source Material’ section to guide appropriate CRM selection.

INTENDED USE

OREAS 144 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 144 may be used to calibrate the entire procedure by producing a pure substance CRM transformed into a calibration solution.

OREAS 144 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/ 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;

- Borate fusion /Sodium peroxide with ICP-OES and/or MS finish: ≥0.2 g;
- 4-acid digestion with ICP-OES and/or MS finish: ≥ 0.25 g.

PERIOD OF VALIDITY & STORAGE INSTRUCTIONS

The certification of OREAS 144 remains valid, within the specified measurement uncertainties, until at least September 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 144 is packaged in single-use, 10 g 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.

INSTRUCTIONS FOR HANDLING & CORRECT USE

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

Pre-homogenisation of the CRM prior to subsampling and analysis is not necessary as there is no particle segregation under transport [11].

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.

Authoritative Source of Information

This Certificate of Analysis constitutes the primary and authoritative document for the certified values, associated expanded uncertainties, and their correct use. While the accompanying DataPack provides supporting information, including raw data and uncertainty estimates with additional significant figures, these extended figures are provided solely for transparency, convenience and statistical reference. Users must rely exclusively on the values stated in this Certificate, rounded to an appropriate number of significant figures, for all metrological and analytical purposes. Any discrepancy between values presented in the DataPack and those in this Certificate shall be resolved in favour of the information provided herein.

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	4th August, 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.

REFERENCES

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[2] ISO Guide 30:2015. Terms and definitions used in connection with reference materials.

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[5] ISO Guide 98-3:2008. Guide to the expression of uncertainty in measurement (GUM:1995).

[6] ISO 16269:2014. Statistical interpretation of data – Part 6: Determination of statistical tolerance intervals.

[7] ISO 17025:2017, General requirements for the competence of testing and calibration laboratories.

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[10] OREAS-BUP-70-09-11: Statistical Analysis - OREAS Evaluation Method.

[11] OREAS-TN-04-1498: Stability under transport; an experimental study of OREAS CRMs.

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