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CERTIFICATE OF ANALYSIS FOR

CERTIFIED REFERENCE MATERIAL

OREAS 464b

Carbonatite Supergene REE-Nb Ore (TREO + Y_2O_3 ~4.84%)

(Mount Weld Mine, Western Australia)

Accredited for compliance with ISO 17034

ISO 9001

COA-1936-OREAS 464b-R1 BUP-70-10-01 Ver:2.0	15-Dec-2025

Table 1. Certified Values, Uncertainty & Tolerance Intervals for multi-elements by 4-acid digestion in OREAS 464b.

Constituent	Certified Value†	95% Expanded Uncertainty		95% Tolerance Limits	
		Low	High	Low	High
4-Acid Digestion					
Ag, Silver (ppm)	3.31	2.82	3.80	3.20	3.42
Al, Aluminium (wt.%)	4.08	3.93	4.24	4.01	4.15
Ba, Barium (wt.%)	0.146	0.138	0.155	0.142	0.150
Be, Beryllium (ppm)	14.2	12.7	15.6	13.7	14.6
Bi, Bismuth (ppm)	3.51	3.32	3.71	3.40	3.63
Ca, Calcium (wt.%)	0.667	0.620	0.714	0.652	0.682
Ce, Cerium (wt.%)	1.42	1.31	1.52	1.36	1.47
Co, Cobalt (ppm)	15.6	14.8	16.5	14.9	16.4
Cr, Chromium (ppm)	231	213	248	224	237
Cu, Copper (ppm)	82	78	87	80	85
Dy, Dysprosium (ppm)	148	133	162	144	151
Er, Erbium (ppm)	31.6	28.4	34.8	30.6	32.5
Eu, Europium (ppm)	281	251	312	275	288
Fe, Iron (wt.%)	32.48	31.54	33.42	31.84	33.12
Gd, Gadolinium (ppm)	582	495	668	566	598
Ho, Holmium (ppm)	17.3	15.6	19.0	16.6	18.0
In, Indium (ppm)	1.74	1.65	1.84	1.68	1.80
K, Potassium (wt.%)	0.072	0.063	0.081	0.070	0.073
Li, Lithium (ppm)	7.33	6.94	7.71	7.13	7.53
Mg, Magnesium (wt.%)	0.666	0.615	0.716	0.652	0.680
Mn, Manganese (wt.%)	0.242	0.225	0.258	0.235	0.248
Mo, Molybdenum (ppm)	69	65	73	67	71
Na, Sodium (wt.%)	0.119	0.110	0.128	0.115	0.123
Nb, Niobium (wt.%)	0.183	0.167	0.198	0.178	0.187
Nd, Neodymium (wt.%)	0.888	0.795	0.981	0.862	0.914
Ni, Nickel (ppm)	65	60	69	61	69
P, Phosphorus (wt.%)	1.10	0.98	1.22	1.07	1.13
Pb, Lead (ppm)	175	159	190	169	181
Pr, Praseodymium (wt.%)	0.238	0.219	0.257	0.230	0.246
Rb, Rubidium (ppm)	3.87	3.51	4.22	3.70	4.04
S, Sulphur (wt.%)	0.099	0.090	0.109	0.095	0.104
Sb, Antimony (ppm)	1.69	1.53	1.85	1.61	1.78
Sm, Samarium (wt.%)	0.137	0.126	0.148	0.133	0.142
Sn, Tin (ppm)	33.9	32.4	35.4	32.9	34.9
Sr, Strontium (wt.%)	0.163	0.155	0.171	0.157	0.168
Ta, Tantalum (ppm)	22.1	20.9	23.3	21.2	23.0

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.

Table 1 continued.

Constituent	Certified Value†	95% Expanded Uncertainty		95% Tolerance Limits	
		Low	High	Low	High
4-Acid Digestion continued					
Tb, Terbium (ppm)	49.2	42.3	56.1	47.6	50.8
Te, Tellurium (ppm)	0.32	0.27	0.37	0.28	0.37
Ti, Titanium (wt.%)	1.43	1.32	1.53	1.39	1.47
Tl, Thallium (ppm)	0.13	0.12	0.15	0.12	0.15
Tm, Thulium (ppm)	2.84	2.56	3.11	2.73	2.94
U, Uranium (ppm)	15.5	14.7	16.2	14.9	16.0
V, Vanadium (ppm)	191	181	201	187	195
W, Tungsten (ppm)	2.40	2.19	2.61	2.23	2.58
Yb, Ytterbium (ppm)	13.7	11.1	16.3	13.3	14.1
Zn, Zinc (wt.%)	0.101	0.095	0.107	0.099	0.103

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.

Table 2. Certified Values, Uncertainty & Tolerance Intervals for other measurands in OREAS 464b.

Constituent	Certified Value	95 % Expanded Uncertainty		95 % Tolerance Limits	
		Low	High	Low	High
Borate / Peroxide Fusion ICP (majors and REE's shown in both oxide and elemental format)					
Al, Aluminium (wt.%)	4.34	4.24	4.45	4.26	4.43
Al_2O_3, Aluminium(III) oxide (wt.%)	8.21	8.02	8.40	8.05	8.37
Ba, Barium (wt.%)	0.159	0.151	0.167	0.154	0.163
BaO, Barium oxide (wt.%)	0.177	0.168	0.186	0.172	0.183
Be, Beryllium (ppm)	15.3	13.7	16.8	13.6	16.9
Bi, Bismuth (ppm)	3.64	2.73	4.55	IND	IND
Ca, Calcium (wt.%)	0.725	0.685	0.766	0.698	0.752
CaO, Calcium oxide (wt.%)	1.01	0.96	1.07	0.98	1.05
Cd, Cadmium (ppm)	< 10	IND	IND	IND	IND
Ce, Cerium (wt.%)	1.46	1.41	1.52	1.42	1.51
CeO_2, Cerium(IV) oxide (wt.%)	1.80	1.73	1.87	1.75	1.85
Co, Cobalt (ppm)	16.4	15.1	17.7	15.3	17.6
Cr, Chromium (ppm)	263	242	284	246	279
Cr_2O_3, Chromium(III) oxide (ppm)	384	353	415	360	408
Cu, Copper (ppm)	95	78	112	88	102
Dy, Dysprosium (ppm)	158	152	163	154	161
Dy_2O_3, Dysprosium(III) oxide (ppm)	181	174	187	177	184
Er, Erbium (ppm)	33.8	31.9	35.7	32.5	35.1
Er_2O_3, Erbium(III) oxide (ppm)	38.6	36.5	40.8	37.1	40.1

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 (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 2 continued.

Constituent	Certified Value	95 % Expanded Uncertainty		95 % Tolerance Limits	
		Low	High	Low	High
Borate / Peroxide Fusion ICP continued (majors and REE's shown in both oxide and elemental format)					
Eu, Europium (ppm)	292	280	303	285	299
Eu_2O_3, Europium(III) oxide (ppm)	338	325	351	330	346
Fe, Iron (wt.%)	33.42	32.22	34.62	32.37	34.46
Fe_2O_3, Iron(III) oxide (wt.%)	47.78	46.07	49.49	46.29	49.27
Gd, Gadolinium (ppm)	600	574	627	579	621
Gd_2O_3, Gadolinium(III) oxide (ppm)	692	661	723	668	716
Hf, Hafnium (ppm)	10.6	9.4	11.7	10.1	11.0
HfO_2, Hafnium dioxide (ppm)	12.5	11.1	13.8	11.9	13.0
Ho, Holmium (ppm)	18.7	18.0	19.4	18.1	19.2
Ho_2O_3, Holmium(III) oxide (ppm)	21.3	20.4	22.2	20.7	21.9
In, Indium (ppm)	1.75	1.54	1.95	IND	IND
La, Lanthanum (wt.%)	1.10	1.06	1.15	1.07	1.13
La_2O_3, Lanthanum(III) oxide (wt.%)	1.29	1.24	1.34	1.26	1.32
Lu, Lutetium (ppm)	1.39	1.24	1.55	1.31	1.48
Lu_2O_3, Lutetium(III) oxide (ppm)	1.58	1.40	1.76	1.48	1.68
Mg, Magnesium (wt.%)	0.689	0.656	0.722	0.674	0.703
MgO, Magnesium oxide (wt.%)	1.14	1.09	1.20	1.12	1.17
Mn, Manganese (wt.%)	0.255	0.242	0.267	0.247	0.262
MnO, Manganese oxide (wt.%)	0.329	0.313	0.344	0.320	0.338
Mo, Molybdenum (ppm)	68	60	75	64	71
Nb, Niobium (wt.%)	0.182	0.170	0.193	0.174	0.189
Nd, Neodymium (wt.%)	0.936	0.894	0.978	0.910	0.962
Nd_2O_3, Neodymium(III) oxide (wt.%)	1.09	1.04	1.14	1.06	1.12
Ni, Nickel (ppm)	66	56	76	IND	IND
P, Phosphorus (wt.%)	1.24	1.09	1.39	1.15	1.32
P_2O_5, Phosphorus(V) oxide (wt.%)	2.84	2.50	3.18	2.65	3.03
Pb, Lead (ppm)	178	158	197	168	187
Pr, Praseodymium (wt.%)	0.238	0.227	0.248	0.231	0.245
Pr_6O_{11}, Praseodymium(III,IV) oxide (wt.%)	0.287	0.274	0.300	0.279	0.296
Rb, Rubidium (ppm)	3.98	3.17	4.79	3.54	4.42
S, Sulphur (wt.%)	0.096	0.082	0.110	IND	IND
Sc, Scandium (ppm)	125	112	138	118	132
Si, Silicon (wt.%)	8.40	7.68	9.11	8.14	8.65
SiO_2, Silicon dioxide (wt.%)	17.96	16.42	19.49	17.42	18.50
Sm, Samarium (wt.%)	0.131	0.125	0.138	0.128	0.135
Sm_2O_3, Samarium(III) oxide (wt.%)	0.152	0.145	0.159	0.148	0.157
Sn, Tin (ppm)	40.4	37.8	43.0	38.5	42.3

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

Table 2 continued.

Constituent	Certified Value	95 % Expanded Uncertainty		95 % Tolerance Limits	
		Low	High	Low	High
Borate / Peroxide Fusion ICP continued (majors and REE's shown in both oxide and elemental format)					
Sr, Strontium (wt.%)	0.182	0.172	0.191	0.177	0.186
Ta, Tantalum (ppm)	22.8	21.8	23.9	22.1	23.6
Tb, Terbium (ppm)	48.2	45.8	50.7	46.0	50.5
Tb_4O_7, Terbium(III,IV) oxide (ppm)	57	54	60	54	59
Th, Thorium (ppm)	470	452	489	460	480
Ti, Titanium (wt.%)	1.76	1.69	1.82	1.72	1.79
TiO_2, Titanium dioxide (wt.%)	2.93	2.82	3.04	2.87	2.99
Tm, Thulium (ppm)	3.15	2.95	3.36	3.06	3.25
Tm_2O_3, Thulium(III) oxide (ppm)	3.59	3.37	3.81	3.48	3.70
U, Uranium (ppm)	15.8	15.2	16.5	15.3	16.3
V, Vanadium (ppm)	203	186	219	196	209
V_2O_5, Vanadium(V) oxide (ppm)	362	333	391	351	373
Y, Yttrium (ppm)	389	373	404	378	399
Y_2O_3, Yttrium(III) oxide (ppm)	494	474	513	480	507
Yb, Ytterbium (ppm)	13.5	12.6	14.4	13.0	13.9
Yb_2O_3, Ytterbium(III) oxide (ppm)	15.5	14.4	16.6	15.0	16.0
Zn, Zinc (wt.%)	0.101	0.095	0.107	0.097	0.105
Zr, Zirconium (ppm)	420	390	451	401	440
Borate Fusion XRF					
Al_2O_3, Aluminium(III) oxide (wt.%)	8.05	7.84	8.26	7.95	8.16
BaO, Barium oxide (wt.%)	0.177	0.165	0.189	0.174	0.180
CaO, Calcium oxide (wt.%)	1.01	0.98	1.05	1.00	1.03
CeO_2, Cerium(IV) oxide (wt.%)	1.79	1.76	1.82	1.77	1.81
Cr_2O_3, Chromium(III) oxide (ppm)	383	298	469	IND	IND
Eu_2O_3, Europium(III) oxide (ppm)	318	234	401	IND	IND
Fe_2O_3, Iron(III) oxide (wt.%)	47.84	46.87	48.81	47.33	48.35
Gd_2O_3, Gadolinium(III) oxide (ppm)	687	569	805	IND	IND
Ho_2O_3, Holmium(III) oxide (ppm)	< 100	IND	IND	IND	IND
K_2O, Potassium oxide (wt.%)	0.089	0.077	0.101	IND	IND
La_2O_3, Lanthanum(III) oxide (wt.%)	1.32	1.30	1.35	1.30	1.35
Lu_2O_3, Lutetium(III) oxide (ppm)	< 100	IND	IND	IND	IND
MgO, Magnesium oxide (wt.%)	1.18	1.15	1.22	1.16	1.21
MnO, Manganese oxide (wt.%)	0.347	0.330	0.364	0.337	0.357
Nb_2O_5, Niobium(V) oxide (wt.%)	0.250	0.240	0.261	0.245	0.256
Nd_2O_3, Neodymium(III) oxide (wt.%)	1.09	1.07	1.11	1.07	1.11
P_2O_5, Phosphorus(V) oxide (wt.%)	2.90	2.80	3.01	2.88	2.93
Pr_6O_{11}, Praseodymium(III,IV) oxide (wt.%)	0.293	0.276	0.310	0.282	0.304

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 (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 2 continued.

Constituent	Certified Value	95 % Expanded Uncertainty		95 % Tolerance Limits	
		Low	High	Low	High
Borate Fusion XRF continued					
SiO_2, Silicon dioxide (wt.%)	18.26	17.81	18.70	18.02	18.50
Sm_2O_3, Samarium(III) oxide (wt.%)	0.156	0.143	0.170	IND	IND
SnO_2, Tin dioxide (ppm)	< 100	IND	IND	IND	IND
SrO, Strontium oxide (wt.%)	0.220	0.196	0.244	0.215	0.225
Tb_4O_7, Terbium(III,IV) oxide (ppm)	< 100	IND	IND	IND	IND
ThO_2, Thorium dioxide (ppm)	526	482	570	511	540
TiO_2, Titanium dioxide (wt.%)	2.96	2.89	3.02	2.92	3.00
Tm_2O_3, Thulium(III) oxide (ppm)	< 100	IND	IND	IND	IND
U_3O_8, Uranium(V,VI) oxide (ppm)	< 100	IND	IND	IND	IND
V_2O_5, Vanadium(V) oxide (ppm)	392	253	531	IND	IND
Y_2O_3, Yttrium(III) oxide (ppm)	491	409	572	IND	IND
Yb_2O_3, Ytterbium(III) oxide (ppm)	< 100	IND	IND	IND	IND
ZrO_2, Zirconium dioxide (ppm)	559	522	596	530	589
Thermogravimetry					
LOI^{1000}, Loss on ignition @1000 °C (wt.%)	10.43	9.80	11.06	10.33	10.54

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.
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 3. Indicative Values for OREAS 464b.

Constituent	Unit	Value	Constituent	Unit	Value	Constituent	Unit	Value
4-Acid Digestion								
As	ppm	*27.8*	Hf	ppm	*4.88*	Sc	ppm	*101*
Cd	ppm	*0.51*	Hg	ppm	*0.067*	Se	ppm	*1.41*
Cs	ppm	*0.25*	La	wt.%	*0.835*	Th	ppm	*299*
Ga	ppm	*39.5*	Lu	ppm	*1.58*	Y	ppm	*304*
Ge	ppm	*13.1*	Re	ppm	*0.009*	Zr	ppm	*159*
Borate / Peroxide Fusion ICP								
K	wt.%	*0.121*	Ga	ppm	*92*	Sb	ppm	*1.79*
Na	wt.%	*0.114*	Ge	ppm	*81*	Se	ppm	*404*
Ag	ppm	*< 1*	K_2O	wt.%	*0.146*	Te	ppm	*< 1*
As	ppm	*242*	Li	ppm	*8.15*	Tl	ppm	*< 0.5*
B	ppm	*108*	Na_2O	wt.%	*0.153*	W	ppm	*3.61*
Cs	ppm	*0.56*	Re	ppm	*0.009*			
Borate Fusion XRF								
As_2O_3	ppm	*< 100*	F	ppm	*< 5000*	Sb_2O_3	ppm	*< 100*
Bi_2O_3	ppm	*142*	Ga_2O_3	ppm	*< 100*	Sc_2O_3	ppm	*177*
Cl	ppm	*< 100*	HfO_2	ppm	*< 100*	SO_3	wt.%	*0.251*

Table 3 continued.

Constituent	Unit	Value	Constituent	Unit	Value	Constituent	Unit	Value
Borate Fusion XRF continued								
Co_3O_4	ppm	*< 100*	MoO_3	ppm	*167*	Ta_2O_5	ppm	*< 100*
Cs_2O	ppm	*< 100*	Na_2O	wt.%	*0.124*	TOT_XRF	wt.%	*100.09*
CuO	ppm	*113*	NiO	ppm	*128*	WO_3	ppm	*< 100*
Dy_2O_3	ppm	*158*	PbO	ppm	*182*	ZnO	wt.%	*0.139*
Er_2O_3	ppm	*413*	Rb_2O	ppm	*< 100*			
Thermogravimetry								
H_2O-	wt.%	*2.26*						

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 laboratories all accredited to ISO 17025 for 4-acid digestion) and Table 2 (generated from data supplied by laboratories mostly accredited to ISO 17025) provide the certified values and their associated 95 % expanded uncertainty and tolerance intervals, Table 3 shows indicative values including major and trace element characterisation, Table 4 provides some indicative physical properties, Table 5 shows indicative mineralogy by semi-quantitative XRD analysis and Table 6 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 464b-DataPack.1.1.251215_132102.xlsx**).

OREAS 464b belongs to a CRM suite covering 0.11 – 9.88% TREO + Y_2O_3, with method-specific certification for REEs, major elements, and trace elements using fusion with XRF, fusion with ICP-OES and/or ICP-MS, and 4-acid digestion with ICP-OES and/or ICP-MS.

Results are also presented in scatter plots for CeO_2, La_2O_3, Nd_2O_3 and Pr_6O_{11} by borate / peroxide fusion with ICP in Figures 1 to 4 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 464b is a certified reference material (CRM) prepared from a blend of rare earth element (REE)–bearing ores sourced from Lynas Corporation’s Mount Weld Central Lanthanide Deposit. The Mount Weld deposit is a Proterozoic, carbonatite-hosted, deeply weathered monazite-rich REE deposit located ~35 km south of Laverton in Western Australia. The REE-bearing ores are predominantly comprised of secondary REE phosphates such as monazite and other alteration products formed through intense tropical weathering.

The Mt Weld carbonatite has a thick weathering/regolith layer (10 to >70 m) of laterite overlying the unweathered carbonatite that contains high-grade REO deposits and concentrations of niobium, zirconium, and other 'rare' metals. A zone of supergene-enrichment contains abundant insoluble phosphates, aluminophosphates, clays, crandallite group minerals, iron and manganese-bearing oxides that contain elevated concentrations of

REE, Ba, Cr, Nb, Sr, Ta, Ti, Th, U, V, Y and Zr, including economic accumulations of REE, niobium-tantalum and phosphatic minerals. Extreme lateritic weathering prevailed in the supergene zone over a protracted period of time and resulted in the degradation of the residual magmatic REE-bearing minerals. The majority of the REOs are contained within secondary, low Th phosphate minerals with low levels of deleterious elements (e.g. F and Ca). The Central lanthanide deposit contains an indicative mix of predominantly LREE and shows the following proportions when summed to 100%: CeO_2 (37.0%), La_2O_3 (27.4%), Nd_2O_3 (22.5%), Pr_6O_{11} (6.06%), Sm_2O_3 (3.24%) and Eu_2O_3 (0.657%), together with minor components of HREE: Dy_2O_3 (0.374%) and Tb_4O_7 (0.117%).

COMMINUTION AND HOMOGENISATION PROCEDURES

The materials constituting OREAS 464b was prepared in the following manner:

- Drying to constant mass at 105 °C;
- Crushing and multi-stage milling to >99.5% 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 464b was tested at ORE Research & Exploration Pty Ltd’s onsite facility for various physical properties. Table 4 presents these findings that should be used for informational purposes only.

Table 4. Physical properties of OREAS 464b.

Bulk Density (kg/m^3)	Moisture (wt.%)	Munsell Notation‡	Munsell Color‡
983	2.78	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 5 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 montmorillonite and/or illite. 'Crandallite group' appears to be mainly florencite. The samples might comprise svanbergite and, if present, is reported under 'Crandallite group'. A trace amount of magnesite might be present and, if present, is reported under 'Ilmenite". Some amorphous material might be present in the sample.

Table 5. Indicative mineralogy of OREAS 464b by semi-quantitative XRD analysis.

Mineral / Mineral Group	% (mass ratio)
Crandallite group	6
Monazite	6
Hematite	19
Maghemite	1
Ilmenite	1
Goethite	37
Zircon	< 1
Clay mineral	9
Kaolinite	13
Quartz	5
Anatase	< 1
K-feldspar and/or rutile	< 1
Dolomite - ankerite	3

ANALYTICAL PROGRAM

Twenty-five commercial analytical laboratories participated in the program to certify the elements reported in Table 1 and 2. The following methods were employed:

- 4-acid (HNO_3-HF-$HClO_4$-HCl) digestion with full suite ICP-OES and ICP-MS elemental packages (up to 21 laboratories depending on the element);
- Sodium peroxide/borate fusion with full suite ICP-OES and ICP-MS elemental packages (up to 18 laboratories depending on the element);
- Lithium borate fusion whole rock analysis package with X-ray fluorescence (up to 12 laboratories depending on the element);
- Thermogravimetry: Loss on Ignition (LOI) at 1000 °C (9 laboratories used a thermogravimetric analyser, 5 laboratories included LOI with their fusion package and 3 laboratories used a conventional muffle furnace).

For the round robin program six 600 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 600 g test units (either from the odd or even numbered test units). Homogeneity was evaluated using 12 subsamples analysed by sodium peroxide fusion with ICP finish. ANOVA was applied to triplicates from four test units to compare within- and between-unit variances, providing a statistical measure of batch homogeneity (see ‘Homogeneity Evaluation’ section below).

STATISTICAL ANALYSIS

Certified Values and their uncertainty intervals (Tables 1 and 2) 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 3) 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 6, '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 Tables 1 and 2 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 CeO_2 by fusion ICP, where 99 % of the time ($1-\alpha=0.99$) at least 95 % of subsamples ($\rho=0.95$) will have concentrations lying between 1.75 and 1.85 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 borate fusion with ICP finish (code ME-MS81h). The 12 samples consisted of triplicate samples from four of the six sampling units to enable an Analysis of

Variance (ANOVA) by comparison of within- and between-unit variances across the four triplicates. 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 464b is fit-for-purpose as a certified reference material (see ‘Intended Use’ below).

PERFORMANCE GATES

Table 6 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 6. Performance Gates for OREAS 464b.

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	3.31	0.62	2.07	4.55	1.45	5.17	18.69%	37.38%	56.07%	3.15	3.48
Al, wt.%	4.08	0.187	3.71	4.45	3.52	4.64	4.58%	9.16%	13.75%	3.88	4.29
Ba, wt.%	0.146	0.009	0.129	0.163	0.120	0.172	5.90%	11.80%	17.70%	0.139	0.153
Be, ppm	14.2	2.4	9.4	18.9	7.1	21.2	16.71%	33.42%	50.13%	13.4	14.9
Bi, ppm	3.51	0.184	3.15	3.88	2.96	4.07	5.23%	10.46%	15.70%	3.34	3.69
Ca, wt.%	0.667	0.076	0.515	0.819	0.439	0.895	11.40%	22.81%	34.21%	0.634	0.700
Ce, wt.%	1.42	0.140	1.14	1.70	1.00	1.84	9.89%	19.79%	29.68%	1.34	1.49
Co, ppm	15.6	0.88	13.9	17.4	13.0	18.3	5.60%	11.19%	16.79%	14.9	16.4

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 6 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											
Cr, ppm	231	29	173	289	144	318	12.60%	25.20%	37.80%	219	242
Cu, ppm	82	6.0	70	94	64	100	7.26%	14.52%	21.78%	78	87
Dy, ppm	148	17	114	181	97	198	11.45%	22.91%	34.36%	140	155
Er, ppm	31.6	3.4	24.8	38.4	21.3	41.8	10.81%	21.63%	32.44%	30.0	33.2
Eu, ppm	281	38	205	358	167	396	13.57%	27.13%	40.70%	267	295
Fe, wt.%	32.48	1.472	29.53	35.42	28.06	36.89	4.53%	9.06%	13.60%	30.85	34.10
Gd, ppm	582	101	379	784	278	885	17.40%	34.80%	52.20%	553	611
Ho, ppm	17.3	1.8	13.6	21.0	11.8	22.8	10.59%	21.19%	31.78%	16.4	18.2
In, ppm	1.74	0.105	1.53	1.95	1.43	2.06	6.05%	12.10%	18.15%	1.65	1.83
K, wt.%	0.072	0.011	0.049	0.094	0.038	0.105	15.59%	31.19%	46.78%	0.068	0.075
Li, ppm	7.33	0.504	6.32	8.34	5.82	8.84	6.88%	13.75%	20.63%	6.96	7.70
Mg, wt.%	0.666	0.083	0.500	0.831	0.417	0.914	12.43%	24.86%	37.29%	0.632	0.699
Mn, wt.%	0.242	0.024	0.193	0.290	0.169	0.315	10.03%	20.05%	30.08%	0.230	0.254
Mo, ppm	69	5.5	58	80	53	86	7.95%	15.91%	23.86%	66	73
Na, wt.%	0.119	0.012	0.096	0.142	0.084	0.154	9.77%	19.53%	29.30%	0.113	0.125
Nb, wt.%	0.183	0.023	0.137	0.228	0.115	0.250	12.40%	24.80%	37.20%	0.173	0.192
Nd, wt.%	0.888	0.125	0.638	1.138	0.513	1.263	14.08%	28.17%	42.25%	0.843	0.932
Ni, ppm	65	4.5	56	74	51	78	6.89%	13.78%	20.66%	62	68
P, wt.%	1.10	0.22	0.66	1.54	0.43	1.76	20.15%	40.30%	60.45%	1.04	1.15
Pb, ppm	175	28	119	231	90	259	16.11%	32.22%	48.33%	166	184
Pr, wt.%	0.238	0.011	0.216	0.260	0.205	0.271	4.68%	9.35%	14.03%	0.226	0.250
Rb, ppm	3.87	0.44	2.98	4.75	2.54	5.20	11.44%	22.88%	34.32%	3.67	4.06
S, wt.%	0.099	0.007	0.086	0.113	0.079	0.120	6.75%	13.50%	20.25%	0.094	0.104
Sb, ppm	1.69	0.124	1.44	1.94	1.32	2.06	7.35%	14.71%	22.06%	1.61	1.78
Sm, wt.%	0.137	0.010	0.117	0.157	0.107	0.167	7.38%	14.75%	22.13%	0.130	0.144
Sn, ppm	33.9	2.10	29.7	38.1	27.6	40.2	6.19%	12.37%	18.56%	32.2	35.6
Sr, wt.%	0.163	0.007	0.148	0.177	0.141	0.184	4.41%	8.82%	13.23%	0.155	0.171
Ta, ppm	22.1	1.50	19.1	25.1	17.6	26.6	6.76%	13.52%	20.28%	21.0	23.2
Tb, ppm	49.2	8.5	32.2	66.2	23.7	74.6	17.24%	34.49%	51.73%	46.7	51.6
Te, ppm	0.32	0.05	0.22	0.43	0.16	0.48	16.25%	32.50%	48.76%	0.30	0.34
Ti, wt.%	1.43	0.16	1.11	1.75	0.95	1.90	11.08%	22.16%	33.25%	1.36	1.50
Tl, ppm	0.13	0.013	0.11	0.16	0.09	0.17	9.89%	19.78%	29.67%	0.13	0.14
Tm, ppm	2.84	0.29	2.26	3.41	1.97	3.70	10.19%	20.38%	30.57%	2.69	2.98
U, ppm	15.5	0.91	13.6	17.3	12.7	18.2	5.87%	11.73%	17.60%	14.7	16.2
V, ppm	191	17	157	225	141	241	8.80%	17.60%	26.40%	181	201
W, ppm	2.40	0.218	1.97	2.84	1.75	3.05	9.07%	18.15%	27.22%	2.28	2.52
Yb, ppm	13.7	3.6	6.6	20.8	3.0	24.4	25.92%	51.84%	77.76%	13.0	14.4
Zn, wt.%	0.101	0.010	0.081	0.121	0.071	0.131	9.79%	19.57%	29.36%	0.096	0.106
Borate / Peroxide Fusion ICP											
Al, wt.%	4.34	0.095	4.16	4.53	4.06	4.63	2.18%	4.35%	6.53%	4.13	4.56
Al_2O_3, wt.%	8.21	0.179	7.85	8.57	7.67	8.75	2.18%	4.35%	6.53%	7.80	8.62
Ba, wt.%	0.159	0.007	0.146	0.172	0.139	0.179	4.15%	8.30%	12.45%	0.151	0.167
BaO, wt.%	0.177	0.007	0.163	0.192	0.155	0.199	4.15%	8.30%	12.45%	0.168	0.186

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 6 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											
Be, ppm	15.3	1.40	12.5	18.1	11.1	19.5	9.14%	18.27%	27.41%	14.5	16.0
Bi, ppm	3.64	0.343	2.95	4.33	2.61	4.67	9.42%	18.85%	28.27%	3.46	3.82
Ca, wt.%	0.725	0.025	0.675	0.776	0.649	0.801	3.48%	6.97%	10.45%	0.689	0.762
CaO, wt.%	1.01	0.035	0.94	1.09	0.91	1.12	3.48%	6.97%	10.45%	0.96	1.07
Cd, ppm	< 10	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Ce, wt.%	1.46	0.067	1.33	1.60	1.26	1.67	4.61%	9.21%	13.82%	1.39	1.54
CeO_2, wt.%	1.80	0.083	1.63	1.96	1.55	2.05	4.61%	9.21%	13.82%	1.71	1.89
Co, ppm	16.4	1.08	14.3	18.6	13.2	19.7	6.56%	13.12%	19.68%	15.6	17.2
Cr, ppm	263	19	225	301	206	320	7.26%	14.52%	21.79%	250	276
Cr_2O_3, ppm	384	28	328	440	300	468	7.26%	14.52%	21.79%	365	403
Cu, ppm	95	11	72	118	61	129	12.08%	24.16%	36.24%	90	100
Dy, ppm	158	6	146	169	141	175	3.59%	7.18%	10.77%	150	165
Dy_2O_3, ppm	181	6	168	194	161	200	3.59%	7.18%	10.77%	172	190
Er, ppm	33.8	2.32	29.2	38.4	26.8	40.7	6.86%	13.72%	20.58%	32.1	35.5
Er_2O_3, ppm	38.6	2.65	33.3	43.9	30.7	46.6	6.86%	13.72%	20.58%	36.7	40.6
Eu, ppm	292	14	263	320	249	334	4.87%	9.73%	14.60%	277	306
Eu_2O_3, ppm	338	16	305	371	289	387	4.87%	9.73%	14.60%	321	355
Fe, wt.%	33.42	0.758	31.90	34.93	31.14	35.69	2.27%	4.54%	6.80%	31.75	35.09
Fe_2O_3, wt.%	47.78	1.084	45.61	49.95	44.53	51.03	2.27%	4.54%	6.80%	45.39	50.17
Gd, ppm	600	28	544	657	516	685	4.69%	9.39%	14.08%	570	631
Gd_2O_3, ppm	692	32	627	757	595	790	4.69%	9.39%	14.08%	658	727
Hf, ppm	10.6	0.61	9.4	11.8	8.7	12.4	5.80%	11.60%	17.40%	10.1	11.1
HfO_2, ppm	12.5	0.72	11.0	13.9	10.3	14.6	5.80%	11.60%	17.40%	11.9	13.1
Ho, ppm	18.7	0.77	17.1	20.2	16.4	21.0	4.10%	8.21%	12.31%	17.7	19.6
Ho_2O_3, ppm	21.3	0.92	19.4	23.1	18.5	24.1	4.34%	8.68%	13.03%	20.2	22.4
In, ppm	1.75	0.080	1.59	1.90	1.51	1.98	4.58%	9.16%	13.74%	1.66	1.83
La, wt.%	1.10	0.048	1.01	1.20	0.96	1.24	4.32%	8.64%	12.97%	1.05	1.16
La_2O_3, wt.%	1.29	0.056	1.18	1.40	1.12	1.46	4.32%	8.64%	12.97%	1.23	1.36
Lu, ppm	1.39	0.075	1.24	1.54	1.17	1.61	5.38%	10.76%	16.14%	1.32	1.46
Lu_2O_3, ppm	1.58	0.085	1.41	1.75	1.33	1.84	5.38%	10.76%	16.14%	1.50	1.66
Mg, wt.%	0.689	0.033	0.624	0.754	0.591	0.786	4.73%	9.46%	14.20%	0.654	0.723
MgO, wt.%	1.14	0.054	1.03	1.25	0.98	1.30	4.73%	9.46%	14.20%	1.08	1.20
Mn, wt.%	0.255	0.013	0.229	0.280	0.216	0.293	5.01%	10.02%	15.04%	0.242	0.267
MnO, wt.%	0.329	0.016	0.296	0.362	0.279	0.378	5.01%	10.02%	15.04%	0.312	0.345
Mo, ppm	68	4.6	58	77	54	81	6.78%	13.56%	20.34%	64	71
Nb, wt.%	0.182	0.016	0.149	0.214	0.133	0.231	8.96%	17.91%	26.87%	0.173	0.191
Nd, wt.%	0.936	0.056	0.824	1.049	0.767	1.105	6.02%	12.03%	18.05%	0.889	0.983
Nd_2O_3, wt.%	1.09	0.066	0.96	1.22	0.89	1.29	6.02%	12.03%	18.05%	1.04	1.15
Ni, ppm	66	9	49	83	41	92	12.81%	25.62%	38.43%	63	70
P, wt.%	1.24	0.076	1.09	1.39	1.01	1.47	6.14%	12.28%	18.42%	1.18	1.30
P_2O_5, wt.%	2.84	0.174	2.49	3.19	2.31	3.36	6.14%	12.28%	18.42%	2.69	2.98
Pb, ppm	178	19	139	216	120	236	10.87%	21.73%	32.60%	169	186
Pr, wt.%	0.238	0.009	0.220	0.255	0.211	0.264	3.72%	7.44%	11.16%	0.226	0.250

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 6 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											
Pr_6O_{11}, wt.%	0.287	0.011	0.266	0.309	0.255	0.319	3.72%	7.44%	11.16%	0.273	0.302
Rb, ppm	3.98	0.52	2.94	5.02	2.42	5.54	13.07%	26.14%	39.22%	3.78	4.18
S, wt.%	0.096	0.008	0.080	0.112	0.072	0.120	8.34%	16.68%	25.02%	0.091	0.101
Sc, ppm	125	11	102	148	91	159	9.12%	18.25%	27.37%	119	131
Si, wt.%	8.40	0.564	7.27	9.52	6.70	10.09	6.72%	13.44%	20.16%	7.98	8.81
SiO_2, wt.%	17.96	1.207	15.55	20.37	14.34	21.58	6.72%	13.44%	20.16%	17.06	18.86
Sm, wt.%	0.131	0.007	0.117	0.145	0.110	0.152	5.36%	10.73%	16.09%	0.125	0.138
Sm_2O_3, wt.%	0.152	0.008	0.136	0.169	0.128	0.177	5.36%	10.73%	16.09%	0.145	0.160
Sn, ppm	40.4	2.33	35.7	45.0	33.4	47.4	5.76%	11.52%	17.28%	38.4	42.4
Sr, wt.%	0.182	0.010	0.161	0.203	0.151	0.213	5.67%	11.34%	17.02%	0.173	0.191
Ta, ppm	22.8	1.22	20.4	25.3	19.2	26.5	5.33%	10.67%	16.00%	21.7	24.0
Tb, ppm	48.2	2.80	42.6	53.8	39.8	56.6	5.80%	11.60%	17.40%	45.8	50.6
Tb_4O_7, ppm	57	3.3	50	63	47	67	5.80%	11.60%	17.40%	54	60
Th, ppm	470	22	427	513	405	535	4.58%	9.17%	13.75%	447	494
Ti, wt.%	1.76	0.048	1.66	1.85	1.61	1.90	2.73%	5.47%	8.20%	1.67	1.84
TiO_2, wt.%	2.93	0.080	2.77	3.09	2.69	3.17	2.73%	5.47%	8.20%	2.78	3.07
Tm, ppm	3.15	0.229	2.69	3.61	2.47	3.84	7.26%	14.51%	21.77%	2.99	3.31
Tm_2O_3, ppm	3.59	0.256	3.08	4.10	2.82	4.36	7.13%	14.27%	21.40%	3.41	3.77
U, ppm	15.8	0.48	14.9	16.8	14.4	17.3	3.01%	6.03%	9.04%	15.0	16.6
V, ppm	203	18	167	238	149	256	8.79%	17.59%	26.38%	193	213
V_2O_5, ppm	362	32	298	425	266	457	8.79%	17.59%	26.38%	344	380
Y, ppm	389	19	351	427	332	446	4.88%	9.77%	14.65%	369	408
Y_2O_3, ppm	494	24	445	542	421	566	4.88%	9.77%	14.65%	469	518
Yb, ppm	13.5	0.60	12.3	14.7	11.7	15.3	4.42%	8.83%	13.25%	12.8	14.2
Yb_2O_3, ppm	15.5	0.89	13.7	17.3	12.8	18.2	5.75%	11.50%	17.25%	14.7	16.3
Zn, wt.%	0.101	0.007	0.087	0.115	0.080	0.122	6.84%	13.69%	20.53%	0.096	0.106
Zr, ppm	420	23	374	467	351	490	5.50%	10.99%	16.49%	399	441
Borate Fusion XRF											
Al_2O_3, wt.%	8.05	0.257	7.54	8.57	7.28	8.82	3.19%	6.39%	9.58%	7.65	8.46
BaO, wt.%	0.177	0.008	0.162	0.192	0.154	0.200	4.37%	8.74%	13.11%	0.168	0.186
CaO, wt.%	1.01	0.038	0.94	1.09	0.90	1.13	3.75%	7.51%	11.26%	0.96	1.06
CeO_2, wt.%	1.79	0.035	1.72	1.86	1.68	1.89	1.94%	3.88%	5.82%	1.70	1.88
Cr_2O_3, ppm	383	67	250	517	183	583	17.41%	34.82%	52.22%	364	402
Eu_2O_3, ppm	318	97	123	512	26	610	30.65%	61.31%	91.96%	302	334
Fe_2O_3, wt.%	47.84	1.106	45.63	50.05	44.52	51.16	2.31%	4.62%	6.94%	45.45	50.23
Gd_2O_3, ppm	687	101	485	889	384	990	14.70%	29.41%	44.11%	653	721
Ho_2O_3, ppm	< 100	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
K_2O, wt.%	0.089	0.012	0.064	0.114	0.052	0.126	13.98%	27.96%	41.95%	0.085	0.093
La_2O_3, wt.%	1.32	0.032	1.26	1.39	1.23	1.42	2.40%	4.80%	7.19%	1.26	1.39
Lu_2O_3, ppm	< 100	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
MgO, wt.%	1.18	0.040	1.10	1.26	1.06	1.30	3.39%	6.79%	10.18%	1.12	1.24
MnO, wt.%	0.347	0.015	0.318	0.376	0.303	0.391	4.23%	8.46%	12.69%	0.330	0.364
Nb_2O_5, wt.%	0.250	0.008	0.235	0.266	0.228	0.273	3.04%	6.09%	9.13%	0.238	0.263

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 6 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 Fusion XRF continued											
Nd_2O_3, wt.%	1.09	0.028	1.03	1.15	1.01	1.17	2.55%	5.11%	7.66%	1.04	1.14
P_2O_5, wt.%	2.90	0.143	2.62	3.19	2.47	3.33	4.93%	9.87%	14.80%	2.76	3.05
Pr_6O_{11}, wt.%	0.293	0.019	0.255	0.331	0.235	0.351	6.57%	13.14%	19.71%	0.278	0.308
SiO_2, wt.%	18.26	0.553	17.15	19.36	16.60	19.92	3.03%	6.05%	9.08%	17.35	19.17
Sm_2O_3, wt.%	0.156	0.015	0.127	0.186	0.112	0.201	9.39%	18.78%	28.17%	0.149	0.164
SnO_2, ppm	< 100	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
SrO, wt.%	0.220	0.018	0.183	0.257	0.164	0.275	8.41%	16.83%	25.24%	0.209	0.231
Tb_4O_7, ppm	< 100	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
ThO_2, ppm	526	36	455	597	419	633	6.76%	13.52%	20.29%	500	552
TiO_2, wt.%	2.96	0.071	2.82	3.10	2.75	3.17	2.38%	4.77%	7.15%	2.81	3.11
Tm_2O_3, ppm	< 100	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
U_3O_8, ppm	< 100	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
V_2O_5, ppm	392	75	242	543	167	618	19.18%	38.36%	57.53%	373	412
Y_2O_3, ppm	491	40	410	571	370	611	8.20%	16.40%	24.60%	466	515
Yb_2O_3, ppm	< 100	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
ZrO_2, ppm	559	41	478	641	437	682	7.32%	14.64%	21.95%	531	587
Nd_2O_3, wt.%	1.09	0.028	1.03	1.15	1.01	1.17	2.55%	5.11%	7.66%	1.04	1.14
P_2O_5, wt.%	2.90	0.143	2.62	3.19	2.47	3.33	4.93%	9.87%	14.80%	2.76	3.05
Pr_6O_{11}, wt.%	0.293	0.019	0.255	0.331	0.235	0.351	6.57%	13.14%	19.71%	0.278	0.308
SiO_2, wt.%	18.26	0.553	17.15	19.36	16.60	19.92	3.03%	6.05%	9.08%	17.35	19.17
Thermogravimetry											
LOI^{1000}, wt.%	10.43	1.15	8.13	12.73	6.99	13.88	11.01%	22.02%	33.03%	9.91	10.95

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. 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. Bureau Veritas Commodities Canada Ltd, Vancouver, BC, Canada
10. Bureau Veritas Minerals, Ankara, Central Anatolia, Turkey
11. CRS Laboratories Oy, Kempele, Northern Ostrobothnia, Finland
12. Inspectorate (BV), Lima, Peru
13. Intertek, Perth, WA, Australia
14. Intertek Genalysis, Adelaide, SA, Australia
15. Ontario Geological Survey, Sudbury, Ontario, Canada
16. Paragon Geochemical Laboratories, Sparks, Nevada, USA
17. PT Geoservices Ltd, Cikarang, Jakarta Raya, Indonesia
18. PT Intertek Utama Services, Jakarta Timur, DKI Jakarta, Indonesia
19. Reminex Centre de Recherche, Marrakesh, Marrakesh-Safi, Morocco
20. SGS, Ankara, Anatolia, Turkey
21. SGS, Randfontein, Gauteng, South Africa
22. SGS Australia Mineral Services, Perth, WA, Australia
23. SGS Geosol Laboratorios Ltda, Vespasiano, Minas Gerais, Brazil
24. Shiva Analyticals Ltd, Bangalore North, Karnataka, India
25. 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.

PREPARER AND SUPPLIER

Certified reference material OREAS 464b is prepared, certified and supplied by:

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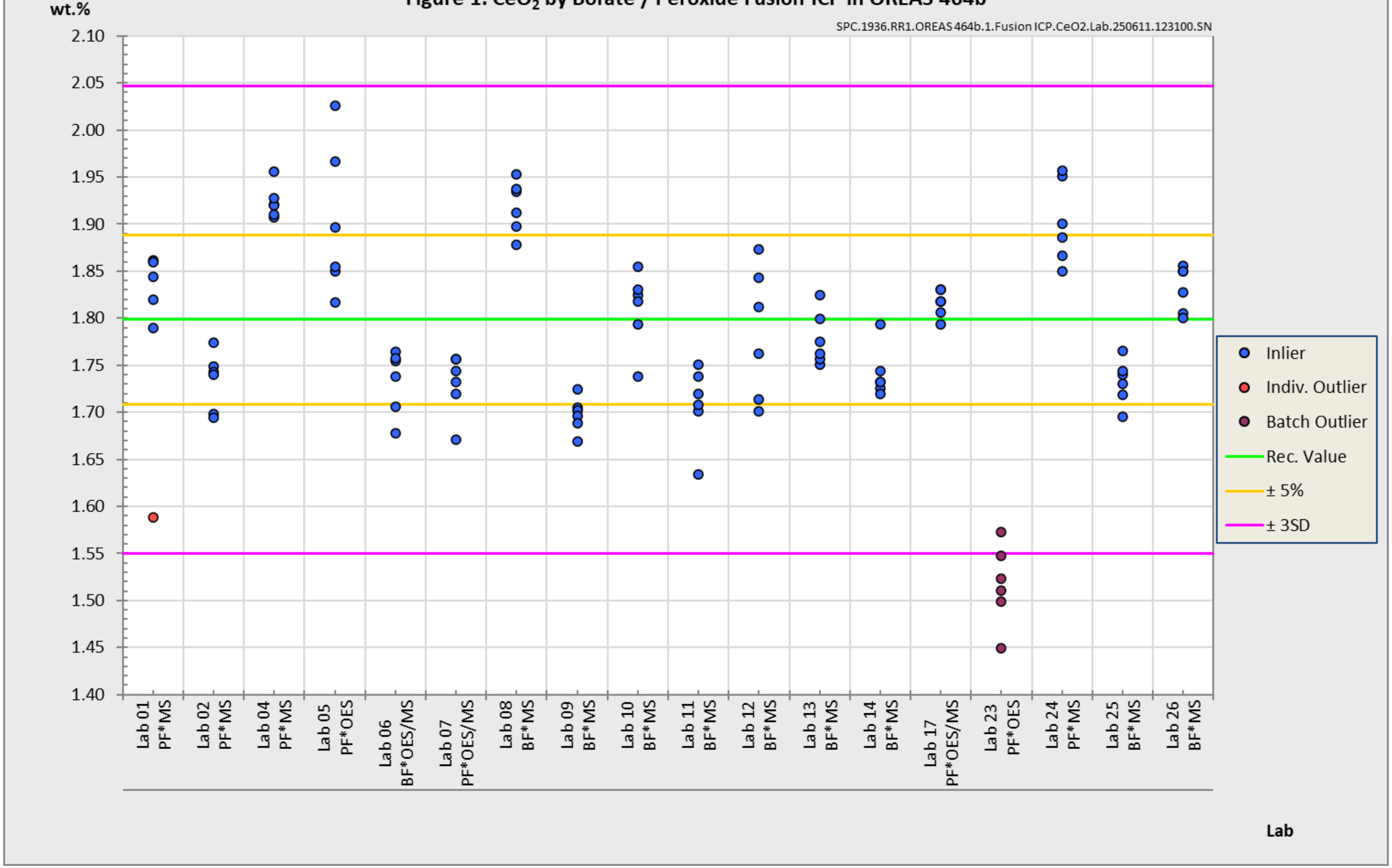
Figure 1. CeO_2 by Borate / Peroxide Fusion ICP in OREAS 464b



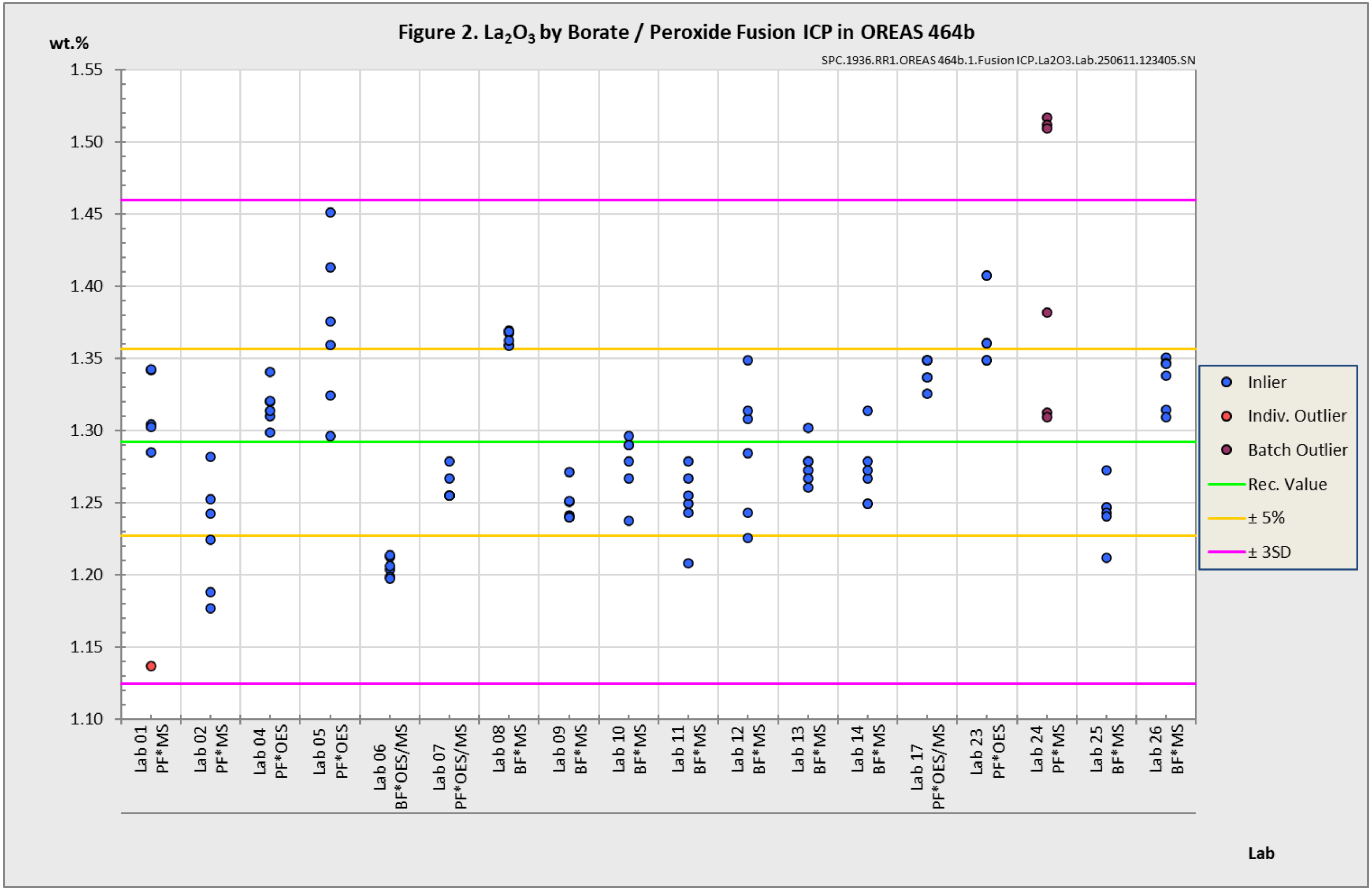


Figure 2. La_2O_3 by Borate / Peroxide Fusion ICP in OREAS 464b
SPC.1936.RR1.OREAS 464b.1.Fusion ICP.La2O3.Lab.250611.123405.SN
wt.%
1.55
1.50
1.45
1.40
1.35
1.30
1.25
1.20
1.15
1.10
Lab 01 PF*MS
Lab 02 PF*MS
Lab 04 PF*OES
Lab 05 PF*OES
Lab 06 BF*OES/MS
Lab 07 PF*OES/MS
Lab 08 BF*MS
Lab 09 BF*MS
Lab 10 BF*MS
Lab 11 BF*MS
Lab 12 BF*MS
Lab 13 BF*MS
Lab 14 BF*MS
Lab 17 PF*OES/MS
Lab 23 PF*OES
Lab 24 PF*MS
Lab 25 BF*MS
Lab 26 BF*MS
Inlier
Indiv. Outlier
Batch Outlier
Rec. Value
± 5%
± 3SD
Lab

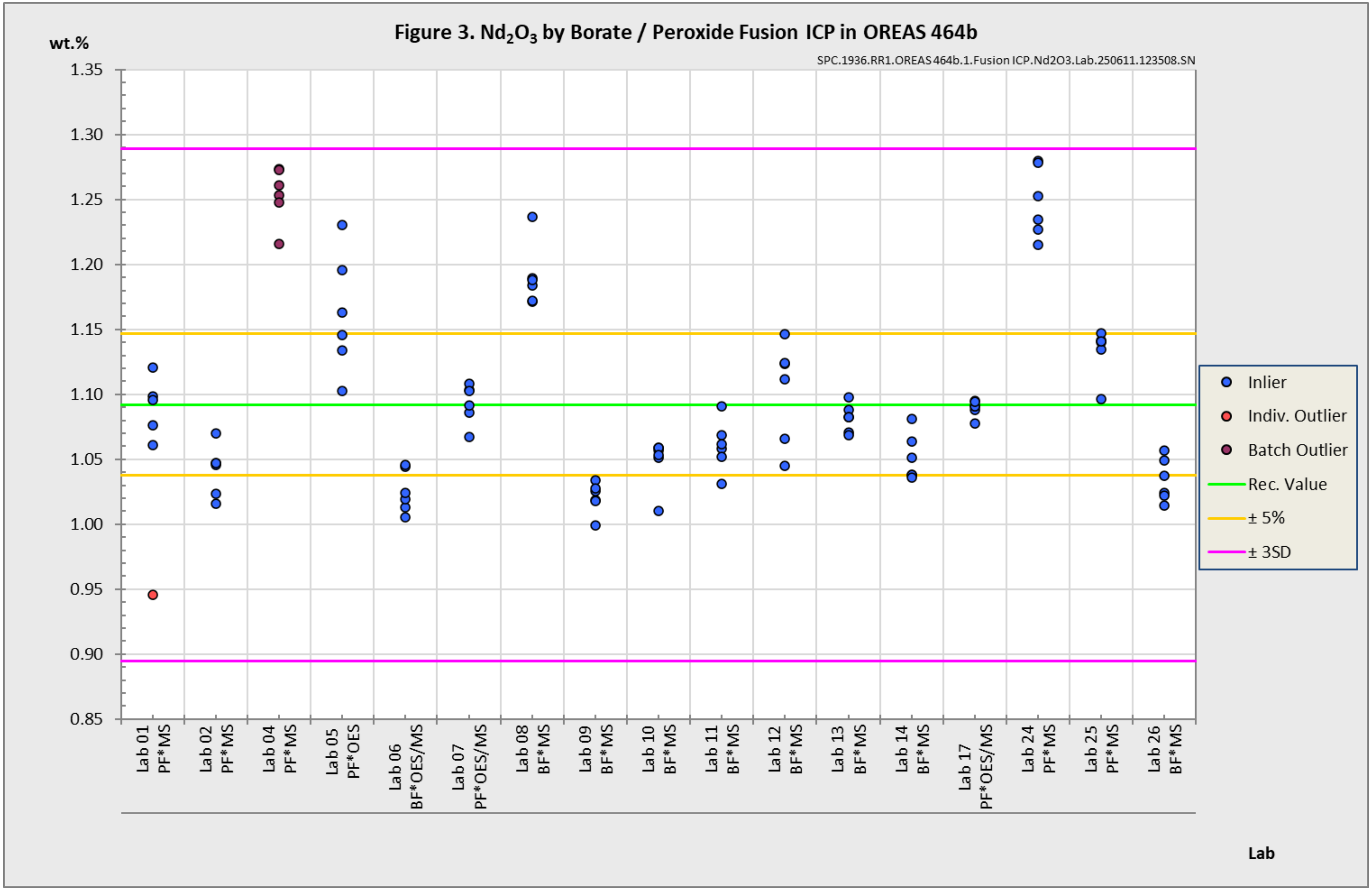


Figure 3. Nd_2O_3 by Borate / Peroxide Fusion ICP in OREAS 464b

SPC.1936.RR1.OREAS 464b.1.Fusion ICP.Nd2O3.Lab.250611.123508.SN

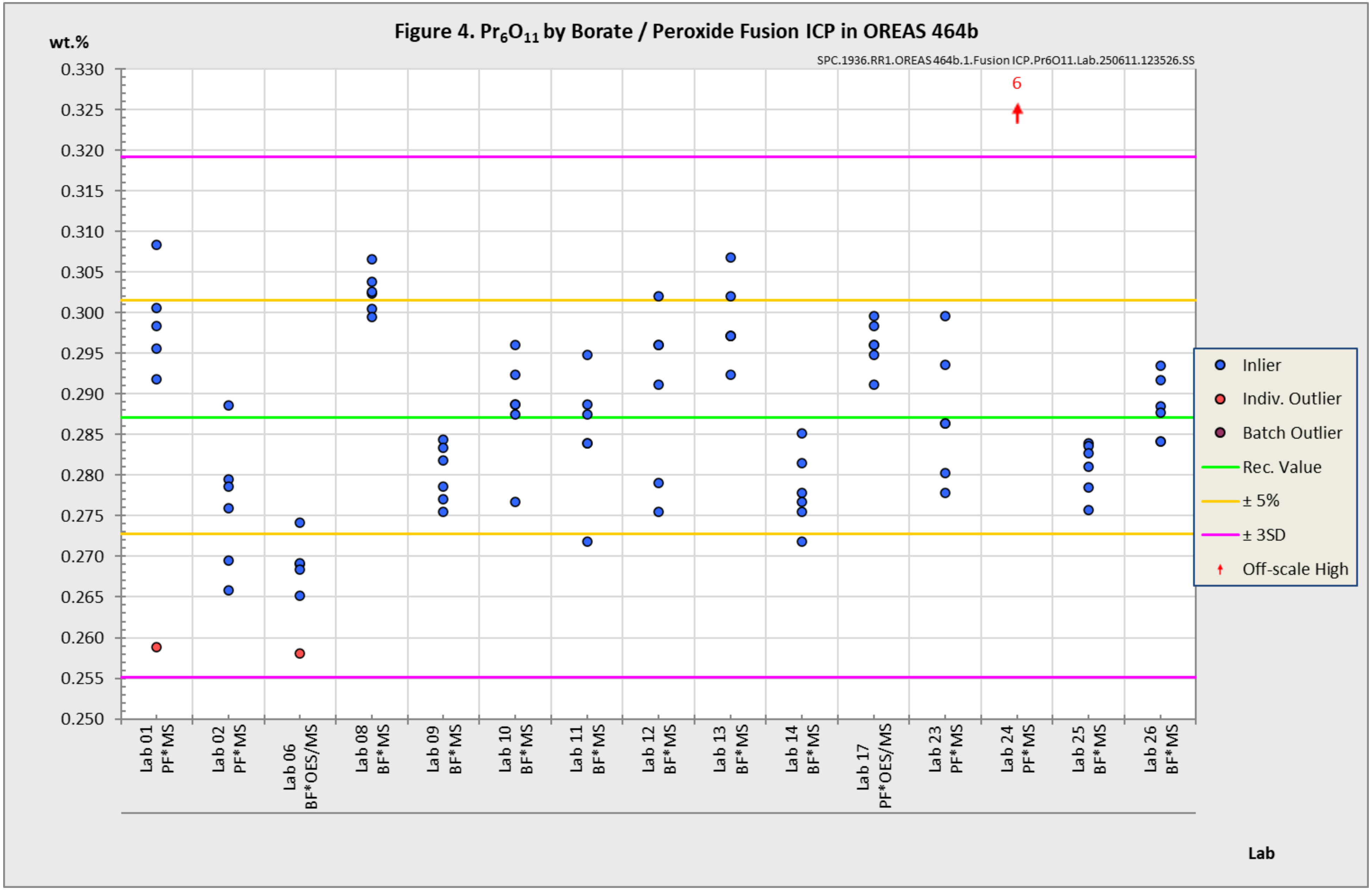


Figure 4. Pr_6O_{11} by Borate / Peroxide Fusion ICP in OREAS 464b
SPC.1936.RR1.OREAS 464b.1.Fusion ICP.Pr6O11.Lab.250611.123526.SS
wt.%
0.330
0.325
0.320
0.315
0.310
0.305
0.300
0.295
0.290
0.285
0.280
0.275
0.270
0.265
0.260
0.255
0.250
6
Lab 01 PF*MS
Lab 02 PF*MS
Lab 06 BF*OES/MS
Lab 08 BF*MS
Lab 09 BF*MS
Lab 10 BF*MS
Lab 11 BF*MS
Lab 12 BF*MS
Lab 13 BF*MS
Lab 14 BF*MS
Lab 17 PF*OES/MS
Lab 23 PF*MS
Lab 24 PF*MS
Lab 25 BF*MS
Lab 26 BF*MS
Lab
Inlier
Indiv. Outlier
Batch Outlier
Rec. Value
± 5%
± 3SD
Off-scale High

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 4-acid digestion (Table 1). The other operationally defined measurands characterised in this certificate (Table 2) are derived from data procured mostly from ISO 17025 accredited laboratories. 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 464b 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 464b may be used to calibrate the entire procedure by producing a pure substance CRM transformed into a calibration solution.

OREAS 464b is intended for the following uses:

- For the monitoring of laboratory performance in the analysis of analytes reported in Tables 1 and 2 in geological samples;
- For the verification/ validation of analytical methods for analytes reported in Tables 1 and 2;
- For the calibration of instruments used in the determination of the concentration of analytes reported in Tables 1 and 2. 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 Tables 1 and 2).

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:

- 4-acid digestion with ICP-OES and/or MS finish: ≥ 0.25 g
- Sodium peroxide / Lithium Borate fusion with ICP-OES and/or MS finish: ≥0.2 g;
- Borate fusion with X-ray fluorescence finish: ≥0.2 g;
- Loss on Ignition (LOI) at 1000 °C: ≥1 g.

PERIOD OF VALIDITY & STORAGE INSTRUCTIONS

The certification of OREAS 464b remains valid, within the specified measurement uncertainties, until at least August 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 464b 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 464b 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 4 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 (~0.10 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 6 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
1	15th December, 2025	Updated certified values for selected REE elements (4-acid digestion).
0	15th July, 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

[1] Govett, G.J.S. (1983). Handbook of Exploration Geochemistry, Volume 2: Statistics and Data Analysis in Geochemical Prospecting (Variations of accuracy and precision).

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

[3] ISO 33401:2024-01. Reference materials – Contents of certificates, labels and accompanying documentation.

[4] ISO 33405:2024-05. Reference materials – Approaches for characterization and assessment of homogeneity and stability.

[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/TR 16476:2016, Reference Materials – Establishing and expressing metrological traceability of quantity values assigned to reference materials.

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

[9] ISO 17034:2016. General requirements for the competence of reference material producers.

[10] Munsell Rock Color Book (2014). Rock-Color Chart Committee, Geological Society of America (GSA), Minnesota (USA).

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

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[15] Van der Veen A.M.H. et al. (2001). Uncertainty calculations in the certification of reference materials, Accred Qual Assur 6: 290-294.