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CERTIFICATE OF ANALYSIS FOR

CERTIFIED REFERENCE MATERIAL

OREAS 470

Clay-Hosted Rare Earth Element (REE) Ore

TREO + Y_2O_3 = 330 ppm

Jupiter REE Project, Laverton Region, Western Australia

Accredited for compliance with ISO 17034

Table 1. Certified Values, Uncertainty & Tolerance Intervals in OREAS 470.

Constituent	Certified Value	95% Expanded Uncertainty		95% Tolerance Limits	
		Low	High	Low	High
Borate / Peroxide Fusion ICP					
Al_2O_3, Aluminium(III) oxide (wt.%)	13.88	13.54	14.21	13.66	14.09
Ba, Barium (wt.%)	0.101	0.097	0.104	0.098	0.103
Be, Beryllium (ppm)	2.00	1.86	2.13	1.93	2.06
Bi, Bismuth (ppm)	0.40	0.32	0.48	IND	IND
CaO, Calcium oxide (wt.%)	0.220	0.200	0.241	0.204	0.237
CeO_2, Cerium(IV) oxide (ppm)	139	135	144	135	143
Co, Cobalt (ppm)	3.93	3.56	4.30	3.60	4.27
Cr, Chromium (ppm)	73	68	78	69	76
Cs, Caesium (ppm)	7.95	7.43	8.48	7.64	8.27
Cu, Copper (ppm)	21.1	18.3	23.9	18.7	23.5
Dy_2O_3, Dysprosium(III) oxide (ppm)	4.35	4.00	4.70	4.20	4.51
Er_2O_3, Erbium(III) oxide (ppm)	2.33	2.14	2.52	2.23	2.43
Eu_2O_3, Europium(III) oxide (ppm)	1.63	1.49	1.77	1.57	1.69
Fe_2O_3, Iron(III) oxide (wt.%)	3.90	3.82	3.98	3.82	3.97
Ga, Gallium (ppm)	18.2	16.9	19.4	17.6	18.8
Gd_2O_3, Gadolinium(III) oxide (ppm)	5.80	5.48	6.12	5.55	6.05
Hf, Hafnium (ppm)	6.95	6.47	7.43	6.55	7.34
Ho_2O_3, Holmium(III) oxide (ppm)	0.81	0.74	0.88	0.77	0.84
In, Indium (ppm)	< 0.1	IND	IND	IND	IND
K_2O, Potassium oxide (wt.%)	2.65	2.59	2.71	2.60	2.71
La_2O_3, Lanthanum(III) oxide (ppm)	72	69	74	70	73
Li, Lithium (ppm)	19.3	18.1	20.4	IND	IND
Lu_2O_3, Lutetium(III) oxide (ppm)	0.34	0.30	0.39	0.32	0.37
MgO, Magnesium oxide (wt.%)	0.645	0.621	0.670	0.630	0.661
MnO, Manganese oxide (wt.%)	0.0103	0.0099	0.0106	0.0100	0.0105
Mo, Molybdenum (ppm)	2.08	1.75	2.41	1.92	2.24
Na_2O, Sodium oxide (wt.%)	0.478	0.459	0.498	0.460	0.497
Nb, Niobium (ppm)	11.3	10.3	12.3	10.7	11.9
Nd_2O_3, Neodymium(III) oxide (ppm)	51	49	53	50	53
Ni, Nickel (ppm)	18.5	14.0	23.1	16.2	20.9
P_2O_5, Phosphorus(V) oxide (wt.%)	0.083	0.078	0.088	0.079	0.087
Pb, Lead (ppm)	27.6	25.0	30.3	26.1	29.2
Pr_6O_{11}, Praseodymium(III,IV) oxide (ppm)	15.5	14.9	16.1	15.1	15.8
Rb, Rubidium (ppm)	114	109	118	110	117
Sb, Antimony (ppm)	2.72	2.39	3.05	2.54	2.91
Sc, Scandium (ppm)	12.1	10.5	13.7	11.5	12.8
SiO_2, Silicon dioxide (wt.%)	72.38	71.13	73.63	71.60	73.16

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 1 continued.

Constituent	Certified Value	95% Expanded Uncertainty		95% Tolerance Limits	
		Low	High	Low	High
Borate / Peroxide Fusion ICP continued					
Sm_2O_3, Samarium(III) oxide (ppm)	8.42	7.92	8.93	8.16	8.68
Sn, Tin (ppm)	3.06	2.59	3.54	2.72	3.40
Sr, Strontium (ppm)	142	138	146	138	146
Ta, Tantalum (ppm)	0.90	0.80	1.00	0.79	1.00
Tb_4O_7, Terbium(III,IV) oxide (ppm)	0.81	0.73	0.88	0.77	0.84
Th, Thorium (ppm)	20.3	19.4	21.2	19.8	20.9
Ti, Titanium (wt.%)	0.411	0.390	0.433	0.401	0.422
Tl, Thallium (ppm)	0.61	0.51	0.70	0.55	0.66
Tm_2O_3, Thulium(III) oxide (ppm)	0.34	0.30	0.38	0.32	0.36
TREO, Total Rare Earth Oxides (ppm)	307	295	318	301	312
TREO+Y_2O_3, Total Rare Earth Oxides + Yttrium oxide (ppm)	330	318	342	323	336
U, Uranium (ppm)	2.58	2.42	2.75	2.48	2.69
V, Vanadium (ppm)	82	77	87	78	86
W, Tungsten (ppm)	4.18	3.60	4.75	3.77	4.58
Y_2O_3, Yttrium(III) oxide (ppm)	25.0	23.8	26.3	24.1	26.0
Yb_2O_3, Ytterbium(III) oxide (ppm)	2.28	2.13	2.44	2.17	2.40
Zn, Zinc (ppm)	59	55	63	57	61
Zr, Zirconium (ppm)	263	250	275	254	271
Borate Fusion XRF					
Al_2O_3, Aluminium(III) oxide (wt.%)	14.10	13.90	14.30	13.98	14.22
BaO, Barium oxide (wt.%)	0.110	0.099	0.121	IND	IND
CaO, Calcium oxide (wt.%)	0.207	0.196	0.219	0.201	0.214
CeO_2, Cerium(IV) oxide (ppm)	141	80	202	134	148
Dy_2O_3, Dysprosium(III) oxide (ppm)	< 100	IND	IND	IND	IND
Eu_2O_3, Europium(III) oxide (ppm)	< 100	IND	IND	IND	IND
Fe_2O_3, Iron(III) oxide (wt.%)	3.89	3.83	3.95	3.85	3.93
Gd_2O_3, Gadolinium(III) oxide (ppm)	< 100	IND	IND	IND	IND
Ho_2O_3, Holmium(III) oxide (ppm)	< 100	IND	IND	IND	IND
K_2O, Potassium oxide (wt.%)	2.65	2.61	2.69	2.63	2.67
La_2O_3, Lanthanum(III) oxide (ppm)	96	65	126	IND	IND
Lu_2O_3, Lutetium(III) oxide (ppm)	< 100	IND	IND	IND	IND
MgO, Magnesium oxide (wt.%)	0.647	0.627	0.666	0.636	0.657
MnO, Manganese oxide (wt.%)	0.0098	0.0073	0.0123	IND	IND
Na_2O, Sodium oxide (wt.%)	0.477	0.445	0.508	0.462	0.491
P_2O_5, Phosphorus(V) oxide (wt.%)	0.080	0.069	0.091	0.077	0.083
Pr_6O_{11}, Praseodymium(III,IV) oxide (ppm)	< 100	IND	IND	IND	IND
SiO_2, Silicon dioxide (wt.%)	72.60	71.93	73.27	72.36	72.83

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 1 continued.

Constituent	Certified Value	95% Expanded Uncertainty		95% Tolerance Limits	
		Low	High	Low	High
Borate Fusion XRF continued					
Sm_2O_3, Samarium(III) oxide (ppm)	< 100	IND	IND	IND	IND
SO_3, Sulphur trioxide (wt.%)	0.021	0.012	0.029	IND	IND
Tb_4O_7, Terbium(III,IV) oxide (ppm)	< 100	IND	IND	IND	IND
TiO_2, Titanium dioxide (wt.%)	0.692	0.673	0.711	0.683	0.701
Tm_2O_3, Thulium(III) oxide (ppm)	< 100	IND	IND	IND	IND
V_2O_5, Vanadium(V) oxide (ppm)	131	95	166	109	153
Yb_2O_3, Ytterbium(III) oxide (ppm)	< 100	IND	IND	IND	IND
ZnO, Zinc oxide (ppm)	84	61	107	IND	IND
ZrO_2, Zirconium dioxide (ppm)	321	241	402	304	339
Thermogravimetry					
LOI^{1000}, Loss on ignition @1000 °C (wt.%)	4.19	3.98	4.40	4.15	4.23
4-Acid Digestion					
Al, Aluminium (wt.%)	7.18	7.04	7.31	7.08	7.27
As, Arsenic (ppm)	38.1	36.5	39.7	36.8	39.4
Ba, Barium (wt.%)	0.101	0.098	0.104	0.099	0.103
Be, Beryllium (ppm)	1.98	1.88	2.08	1.90	2.05
Bi, Bismuth (ppm)	0.37	0.35	0.39	0.35	0.39
Ca, Calcium (wt.%)	0.153	0.145	0.161	0.150	0.156
Ce, Cerium (ppm)	113	109	118	111	116
Co, Cobalt (ppm)	4.18	3.97	4.39	4.05	4.32
Cr, Chromium (ppm)	57	53	61	56	59
Cs, Caesium (ppm)	7.91	7.56	8.26	7.66	8.16
Cu, Copper (ppm)	21.2	20.3	22.1	20.5	21.9
Dy, Dysprosium (ppm)	3.09	2.91	3.26	2.96	3.21
Er, Erbium (ppm)	1.56	1.46	1.67	1.47	1.66
Eu, Europium (ppm)	1.37	1.30	1.44	1.32	1.42
Fe, Iron (wt.%)	2.67	2.61	2.74	2.63	2.71
Ga, Gallium (ppm)	18.1	17.4	18.9	17.7	18.6
Gd, Gadolinium (ppm)	4.71	4.45	4.97	4.57	4.84
Hf, Hafnium (ppm)	3.72	3.46	3.98	3.57	3.86
Ho, Holmium (ppm)	0.56	0.52	0.59	0.53	0.58
In, Indium (ppm)	0.053	0.046	0.061	0.050	0.057
K, Potassium (wt.%)	2.19	2.13	2.24	2.16	2.22
La, Lanthanum (ppm)	61	59	64	60	63
Li, Lithium (ppm)	19.4	18.8	20.0	18.9	19.9
Lu, Lutetium (ppm)	0.24	0.22	0.26	0.23	0.25
Mg, Magnesium (wt.%)	0.368	0.356	0.380	0.361	0.376

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 1 continued.

Constituent	Certified Value	95% Expanded Uncertainty		95% Tolerance Limits	
		Low	High	Low	High
4-Acid Digestion continued					
Mn, Manganese (wt.%)	0.0078	0.0076	0.0080	0.0076	0.0080
Mo, Molybdenum (ppm)	1.65	1.56	1.75	1.57	1.74
Na, Sodium (wt.%)	0.359	0.347	0.371	0.352	0.366
Nb, Niobium (ppm)	10.1	9.4	10.7	9.7	10.4
Nd, Neodymium (ppm)	44.1	42.0	46.2	43.0	45.3
Ni, Nickel (ppm)	20.0	19.2	20.7	19.5	20.5
P, Phosphorus (wt.%)	0.036	0.035	0.038	0.035	0.037
Pb, Lead (ppm)	26.1	24.8	27.4	25.2	27.0
Pr, Praseodymium (ppm)	12.9	12.3	13.6	12.6	13.3
Rb, Rubidium (ppm)	115	110	119	112	117
Re, Rhenium (ppm)	< 0.002	IND	IND	IND	IND
S, Sulphur (wt.%)	0.011	0.010	0.013	0.011	0.012
Sb, Antimony (ppm)	2.71	2.58	2.85	2.60	2.82
Sc, Scandium (ppm)	11.3	10.8	11.8	11.1	11.6
Sm, Samarium (ppm)	7.08	6.73	7.44	6.88	7.29
Sn, Tin (ppm)	2.97	2.80	3.13	2.82	3.11
Sr, Strontium (ppm)	140	135	144	137	142
Ta, Tantalum (ppm)	0.76	0.67	0.85	0.72	0.80
Tb, Terbium (ppm)	0.58	0.54	0.61	0.55	0.60
Th, Thorium (ppm)	21.2	20.4	22.0	20.6	21.8
Ti, Titanium (wt.%)	0.357	0.340	0.374	0.346	0.369
Tl, Thallium (ppm)	0.59	0.56	0.63	0.58	0.61
Tm, Thulium (ppm)	0.23	0.21	0.24	0.21	0.24
U, Uranium (ppm)	2.41	2.29	2.53	2.33	2.49
V, Vanadium (ppm)	79	76	81	77	80
W, Tungsten (ppm)	3.66	3.41	3.90	3.54	3.78
Y, Yttrium (ppm)	14.4	13.4	15.4	14.0	14.8
Yb, Ytterbium (ppm)	1.51	1.41	1.61	1.45	1.56
Zn, Zinc (ppm)	57	55	59	56	58
Zr, Zirconium (ppm)	133	126	140	130	136

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. Indicative Values for OREAS 470.

Constituent	Unit	Value	Constituent	Unit	Value	Constituent	Unit	Value
Borate / Peroxide Fusion ICP								
Ag	ppm	*0.166*	Cd	ppm	*< 10*	S	wt.%	*0.025*
As	ppm	*38.1*	Ge	ppm	*1.19*	Se	ppm	*< 20*
B	ppm	*71*	Re	ppm	*< 0.1*	Te	ppm	*< 1*
Borate Fusion XRF								
As_2O_3	ppm	*77*	Hg	ppm	*< 20*	Rh	ppm	*< 1*
Au	ppm	*< 20*	I	ppm	*< 10*	Ru	ppm	*< 1*
Bi_2O_3	ppm	*< 11*	In	ppm	*< 10*	Sb_2O_3	ppm	*< 36*
Cd	ppm	*< 10*	Ir	ppm	*< 10*	Sc_2O_3	ppm	*15.4*
Cl	wt.%	*0.185*	MoO_3	ppm	*< 1.5*	Se	ppm	*< 1*
Co_3O_4	ppm	*< 50*	Nb_2O_5	ppm	*84*	SnO_2	ppm	*< 100*
Cr_2O_3	ppm	*131*	Nd_2O_3	ppm	*69*	SrO	ppm	*183*
Cs_2O	ppm	*< 11*	NiO	ppm	*56*	Ta_2O_5	ppm	*< 100*
CuO	ppm	*35.6*	Os	ppm	*< 10*	Tc	ppm	*< 1*
Er_2O_3	ppm	*94*	PbO	ppm	*39.1*	Te	ppm	*38.0*
F	ppm	*< 5000*	Pd	ppb	*< 1000*	Th	ppm	*47.7*
Fr	ppm	*< 30*	Pm	ppm	*64*	Tl	ppm	*< 50*
Ga_2O_3	ppm	*103*	Pt	ppb	*< 1000*	U_3O_8	ppm	*8.48*
Ge	ppm	*< 30*	Ra	ppm	*< 20*	WO_3	ppm	*< 100*
H_2O-	wt.%	*0.808*	Rb_2O	ppm	*143*	Y	ppm	*63*
HfO_2	ppm	*< 100*	Re	ppm	*< 10*			
Infrared Combustion								
C	wt.%	*0.050*	S	wt.%	*< 0.02*			
4-Acid Digestion								
Ag	ppm	*0.055*	Ge	ppm	*0.18*	Se	ppm	*1.09*
Cd	ppm	*0.041*	Hg	ppm	*0.020*	Te	ppm	*0.046*

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

Note: the number of significant figures reported is not a reflection of the level of certainty of stated values. They are instead an artefact of ORE’s in-house CRM-specific LIMS.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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 handling and 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 470-DataPack.1.0.260218_084223.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 Dy_2O_3, Nd_2O_3, Pr_6O_{11} and Tb_4O_7 by borate/peroxide fusion 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.

INTENDED USE

OREAS 470 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 470 may be used to calibrate the entire procedure by producing a pure substance CRM transformed into a calibration solution.

OREAS 470 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).

SOURCE MATERIAL

OREAS 470 is a certified reference material (CRM) produced from a blend of clay-hosted rare earth element (REE) ores, siltstone, silica and kaolin. The REE-bearing ores were sourced from the Jupiter deposit in the Laverton region of Western Australia.

Mineralisation occurs within a deeply weathered regolith developed over an underlying carbonatite–alkaline volcanic sequence. Supergene processes have resulted in enrichment of total rare earth oxides (TREO), including a significant proportion of magnet rare earth oxides (MREO), notably neodymium and praseodymium, with subordinate dysprosium and terbium. The CRM matrix is quartz-rich and comprises abundant mica–illite and kaolinite-group clays, with additional smectite/vermiculite-type clay minerals. Minor iron oxides (goethite and magnetite), traces of hematite and anatase are present as accessory phases. Rare earth elements are interpreted to occur predominantly within fine-grained secondary phases associated with the clay fraction.

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

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.

Notice on Certificate Updates

The version of the Certificate of Analysis (COA) available on the OREAS website is considered the official and most current version. As COAs may be revised following periodic reviews, re-evaluation of data, or the availability of new information, users are strongly advised to refer to the latest online version prior to each use.

It is the user's responsibility to ensure that the most recent and applicable certificate is used to support the traceability, validity, and fitness-for-purpose of the certified reference material (CRM).

Any significant changes to the sections of this certificate will be clearly documented in the revised certificate.

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.

PERIOD OF VALIDITY & STORAGE INSTRUCTIONS

The certification of OREAS 470 remains valid, within the specified measurement uncertainties, until at least May 2040, 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 470 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.

Repeat-use packaging (e.g., 500 g 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 470 contains a non-hygroscopic* matrix with an indicative value for moisture provided to enable users to check for changes to stored material by determining moisture in the user's laboratory and comparing the result to the value in Table 3 in this certificate. The stability of the CRM in regard to oxidation from the breakdown of sulphide minerals to sulphates is minimal given its low sulphur concentration (< 0.02 wt.% S).

*A non-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 only occur if the material is spread into a thin (~2mm thick) layer and left exposed for a period of 2 hours.

COMMINUTION AND HOMOGENISATION PROCEDURES

The materials constituting OREAS 470 was prepared in the following manner:

- 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 470 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 470.

Bulk Density (kg/m^3)	Moisture (wt.%)	Munsell Notation‡	Munsell Color‡
573	0.69	10YR 8/2	Very Pale Orange

‡The Munsell Rock Color Chart helps geologists and archaeologists 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. Some amorphous material may be present. 'Clay minerals' appears to be mainly smectite, vermiculite and/or illite. A trace of anatase may be present in the samples. A trace of hematite may also be present in the sample.

Table 4. Indicative mineralogy of OREAS 470 by semi-quantitative XRD analysis.

Mineral / Mineral Group	% (mass ratio)
Magnetite	1
Goethite	2
Clay minerals	5
Serpentine	1
Kandite group	9
Annite - biotite - phlogopite	1
Muscovite - illite	15
Ca amphibole	1
Plagioclase	3
K-feldspar and/or rutile	6
Quartz	57
Dolomite - ankerite	< 1

ANALYTICAL PROGRAM

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

- Lithium borate or sodium peroxide fusion with full suite ICP-OES and ICP-MS elemental packages (up to 27 laboratories depending on the element);
- 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 (8 laboratories used a thermogravimetric analyser, 6 laboratories included LOI with their fusion package and 3 laboratories used a conventional muffle furnace);
- 4-acid (HNO_3-HF-$HClO_4$-HCl) digestion with full suite ICP-OES and ICP-MS elemental packages (up to 26 laboratories depending on the element).

Samples of this CRM were analysed by Intertek Genalysis Laboratory (Perth, Australia) using ammonium sulphate ionic leaching followed by ICP-MS (method ICL/MS16). A range of ammonium sulphate concentrations and leach pH conditions were tested to assess the method’s effectiveness. Despite these variations, recoveries of rare earth elements remained consistently low, indicating that ammonium sulphate leaching is ineffective for extracting REEs from this material. Therefore, this CRM represents a clay-hosted REE deposit without significant ion-exchangeable rare earth element content typical of ion-adsorbed clays.

For the round robin program, six 2 kg 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 15 g from each of the six distinct 2 kg units.

Homogeneity was assessed by submitting 12 pulp samples to a single laboratory for analysis. Paired 15 g 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).

PARTICIPATING LABORATORIES

1. Actlabs, Ancaster, Ontario, Canada
2. African Natural Resources & Mines Ltd, Suleja, Niger State, Nigeria
3. AGAT Laboratories, Calgary, Alberta, Canada
4. Alex Stewart International, Mendoza, Argentina
5. ALS, Brisbane, QLD, Australia
6. ALS, Lima, Peru
7. ALS, Loughrea, Galway, Ireland
8. ALS, Malaga, WA, Australia
9. ALS, Vancouver, BC, Canada
10. American Assay Laboratories, Sparks, Nevada, USA
11. ARGETEST Mineral Processing, Ankara, Central Anatolia, Turkey
12. Bureau Veritas Commodities Canada Ltd, Vancouver, BC, Canada
13. CERTIMIN, Lima, Peru
14. Inspectorate (BV), Lima, Peru
15. Intertek, Perth, WA, Australia
16. Intertek, Townsville, QLD, Australia
17. Intertek Genalysis, Adelaide, SA, Australia
18. Lucid Laboratories Private Limited, Hyderabad, Telangana, India
19. Ontario Geological Survey, Sudbury, Ontario, Canada
20. Performance Laboratories, Ruwa, Harare, Zimbabwe
21. PT Geoservices Ltd, Cikarang, Jakarta Raya, Indonesia
22. PT Indo Mineral Research, Bungursari, West Java, Indonesia
23. PT Intertek Utama Services, Jakarta Timur, DKI Jakarta, Indonesia
24. SGS, Randfontein, Gauteng, South Africa
25. SGS Australia Mineral Services, Perth, WA, Australia
26. SGS Geosol Laboratorios Ltda, Vespasiano, Minas Gerais, Brazil
27. Shiva Analyticals Ltd, Bangalore North, Karnataka, India
28. Stewart Assay & Environmental Laboratories LLC, Kara-Balta, Chüy, Kyrgyzstan
29. UIS Analytical Services, Centurion, South Africa

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.

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). Outlier evaluation was conducted in accordance with ISO 17034:2017 and ISO 33405:2024. While formal statistical tests were applied, professional statistical judgment was also exercised in determining the validity of potential outliers. Assessment of systematic bias and performance using independent control materials (CRMs) was incorporated to ensure compliance with the referenced standards and to establish metrological traceability of the certified values.

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 individuals, 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 Nd_2O_3 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 50 and 53 ppm. 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 lithium borate fusion with ICP-MS finish (code ME- MS81). 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).

Of the fifteen analytes evaluated by ANOVA, only Sm showed a statistically significant *p*-value (0.048). Statistically significant results should be assessed for technical significance as well. The RSD for Sm across the 12 samples is 5.87 %, which indicates that the variation is tightly constrained given the low concentration of Sm_2O_3 (8.42 ppm). The magnitude of any between-unit variation is therefore minor relative to typical measurement uncertainty. Furthermore, round-robin data for Sm_2O_3 determined by fusion with ICP and Sm determined by four-acid digestion with ICP show no evidence of systematic grouping when plotted by sampling interval. All other *p*-values were not significant, and the null hypothesis is retained. The apparent significance for Sm is considered a statistical anomaly rather than evidence of CRM heterogeneity.

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 470 is fit-for-purpose as a certified reference material (see ‘Intended Use’ below).

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 [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.

OREAS CRMs are prepared from natural ore materials, ensuring the presence of matrix and mineralogical characteristics representative of typical exploration and mining 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.

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 470.

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_2O_3, wt.%	13.88	0.311	13.26	14.50	12.95	14.81	2.24%	4.48%	6.72%	13.18	14.57
Ba, wt.%	0.101	0.004	0.093	0.109	0.089	0.113	3.99%	7.98%	11.96%	0.096	0.106
Be, ppm	2.00	0.068	1.86	2.13	1.79	2.20	3.43%	6.86%	10.29%	1.90	2.10
Bi, ppm	0.40	0.05	0.29	0.51	0.24	0.56	13.68%	27.35%	41.03%	0.38	0.42
CaO, wt.%	0.220	0.025	0.171	0.269	0.147	0.294	11.12%	22.24%	33.36%	0.209	0.231
CeO_2, ppm	139	5	129	150	123	156	3.87%	7.75%	11.62%	132	146
Co, ppm	3.93	0.39	3.14	4.72	2.75	5.12	10.03%	20.06%	30.09%	3.74	4.13
Cr, ppm	73	4.7	63	82	59	87	6.45%	12.90%	19.34%	69	76
Cs, ppm	7.95	0.465	7.02	8.88	6.56	9.35	5.85%	11.70%	17.56%	7.56	8.35
Cu, ppm	21.1	2.1	16.9	25.3	14.7	27.4	10.04%	20.09%	30.13%	20.0	22.1
Dy_2O_3, ppm	4.35	0.346	3.66	5.05	3.31	5.39	7.96%	15.92%	23.87%	4.13	4.57
Er_2O_3, ppm	2.33	0.131	2.07	2.59	1.94	2.72	5.61%	11.21%	16.82%	2.21	2.45
Eu_2O_3, ppm	1.63	0.108	1.41	1.84	1.31	1.95	6.61%	13.22%	19.83%	1.55	1.71
Fe_2O_3, wt.%	3.90	0.134	3.63	4.16	3.50	4.30	3.43%	6.87%	10.30%	3.70	4.09
Ga, ppm	18.2	0.98	16.2	20.1	15.2	21.1	5.37%	10.75%	16.12%	17.3	19.1
Gd_2O_3, ppm	5.80	0.410	4.98	6.62	4.57	7.03	7.08%	14.15%	21.23%	5.51	6.09
Hf, ppm	6.95	0.454	6.04	7.85	5.59	8.31	6.53%	13.06%	19.60%	6.60	7.29
Ho_2O_3, ppm	0.81	0.047	0.71	0.90	0.67	0.95	5.76%	11.52%	17.28%	0.77	0.85
In, ppm	< 0.1	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
K_2O, wt.%	2.65	0.065	2.52	2.78	2.46	2.85	2.46%	4.92%	7.38%	2.52	2.79
La_2O_3, ppm	72	3.1	65	78	62	81	4.30%	8.60%	12.90%	68	75
Li, ppm	19.3	0.83	17.6	20.9	16.8	21.7	4.30%	8.61%	12.91%	18.3	20.2
Lu_2O_3, ppm	0.34	0.027	0.29	0.40	0.26	0.43	7.91%	15.83%	23.74%	0.33	0.36
MgO, wt.%	0.645	0.022	0.601	0.690	0.578	0.712	3.46%	6.92%	10.38%	0.613	0.677
MnO, wt.%	0.010	0.000	0.009	0.011	0.009	0.012	4.79%	9.57%	14.36%	0.010	0.011
Mo, ppm	2.08	0.46	1.17	2.99	0.71	3.45	21.97%	43.95%	65.92%	1.98	2.18
Na_2O, wt.%	0.478	0.017	0.444	0.513	0.427	0.530	3.60%	7.20%	10.80%	0.455	0.502
Nb, ppm	11.3	0.97	9.3	13.2	8.4	14.2	8.58%	17.16%	25.74%	10.7	11.8
Nd_2O_3, ppm	51	2.3	47	56	44	58	4.54%	9.09%	13.63%	49	54
Ni, ppm	18.5	3.0	12.5	24.6	9.5	27.6	16.34%	32.68%	49.02%	17.6	19.5
P_2O_5, wt.%	0.083	0.008	0.068	0.098	0.060	0.106	9.31%	18.62%	27.93%	0.079	0.087
Pb, ppm	27.6	2.48	22.7	32.6	20.2	35.1	8.96%	17.92%	26.89%	26.3	29.0
Pr_6O_{11}, ppm	15.5	0.56	14.4	16.6	13.8	17.1	3.60%	7.21%	10.81%	14.7	16.2
Rb, ppm	114	5	104	123	99	128	4.31%	8.61%	12.92%	108	119
Sb, ppm	2.72	0.240	2.24	3.20	2.00	3.44	8.80%	17.61%	26.41%	2.59	2.86

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

Notes: intervals may appear asymmetric due to rounding; 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.

IND = indeterminate.

Table 5 continued.

Constituent	Certified Value	Absolute Standard Deviations					Relative Standard Deviations			5 % window	
		1SD	2SD Low	2SD High	3SD Low	3SD High	1RSD	2RSD	3RSD	Low	High
Borate / Peroxide Fusion ICP continued											
Sc, ppm	12.1	1.11	9.9	14.4	8.8	15.5	9.14%	18.29%	27.43%	11.5	12.8
SiO_2, wt.%	72.38	0.837	70.71	74.06	69.87	74.89	1.16%	2.31%	3.47%	68.76	76.00
Sm_2O_3, ppm	8.42	0.421	7.58	9.26	7.16	9.68	4.99%	9.99%	14.98%	8.00	8.84
Sn, ppm	3.06	0.37	2.32	3.80	1.95	4.17	12.06%	24.12%	36.19%	2.91	3.22
Sr, ppm	142	4	134	150	131	154	2.74%	5.48%	8.23%	135	149
Ta, ppm	0.90	0.078	0.74	1.05	0.66	1.13	8.71%	17.42%	26.13%	0.85	0.94
Tb_4O_7, ppm	0.81	0.062	0.68	0.93	0.62	0.99	7.69%	15.38%	23.07%	0.77	0.85
Th, ppm	20.3	0.92	18.5	22.2	17.5	23.1	4.55%	9.10%	13.65%	19.3	21.3
Ti, wt.%	0.411	0.020	0.371	0.452	0.350	0.472	4.96%	9.91%	14.87%	0.391	0.432
Tl, ppm	0.61	0.047	0.51	0.70	0.46	0.75	7.78%	15.55%	23.33%	0.58	0.64
Tm_2O_3, ppm	0.34	0.025	0.29	0.39	0.26	0.41	7.31%	14.62%	21.93%	0.32	0.36
TREO, ppm	307	8	290	323	281	332	2.74%	5.48%	8.22%	291	322
TREO+Y_2O_3, ppm	330	10	309	350	299	360	3.12%	6.24%	9.35%	313	346
U, ppm	2.58	0.139	2.31	2.86	2.17	3.00	5.39%	10.79%	16.18%	2.45	2.71
V, ppm	82	6.0	70	94	64	100	7.36%	14.73%	22.09%	78	86
W, ppm	4.18	0.46	3.26	5.09	2.80	5.55	10.98%	21.97%	32.95%	3.97	4.39
Y_2O_3, ppm	25.0	1.24	22.6	27.5	21.3	28.7	4.94%	9.89%	14.83%	23.8	26.3
Yb_2O_3, ppm	2.28	0.111	2.06	2.51	1.95	2.62	4.85%	9.69%	14.54%	2.17	2.40
Zn, ppm	59	5.5	48	70	43	75	9.24%	18.48%	27.72%	56	62
Zr, ppm	263	11	240	285	229	296	4.25%	8.50%	12.74%	249	276
Borate Fusion XRF											
Al_2O_3, wt.%	14.10	0.230	13.64	14.56	13.41	14.79	1.63%	3.27%	4.90%	13.40	14.81
BaO, wt.%	0.110	0.007	0.095	0.124	0.088	0.132	6.63%	13.25%	19.88%	0.104	0.115
CaO, wt.%	0.207	0.010	0.188	0.227	0.178	0.237	4.69%	9.37%	14.06%	0.197	0.218
CeO_2, ppm	141	39	63	219	24	258	27.71%	55.42%	83.13%	134	148
Dy_2O_3, ppm	< 100	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Eu_2O_3, ppm	< 100	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Fe_2O_3, wt.%	3.89	0.076	3.74	4.04	3.66	4.12	1.96%	3.92%	5.88%	3.70	4.09
Gd_2O_3, ppm	< 100	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Ho_2O_3, ppm	< 100	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
K_2O, wt.%	2.65	0.046	2.56	2.74	2.51	2.79	1.72%	3.44%	5.17%	2.52	2.78
La_2O_3, ppm	96	26	45	147	19	172	26.68%	53.36%	80.04%	91	100
Lu_2O_3, ppm	< 100	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
MgO, wt.%	0.647	0.022	0.604	0.690	0.582	0.712	3.34%	6.69%	10.03%	0.614	0.679
MnO, wt.%	0.010	0.001	0.007	0.012	0.006	0.013	12.36%	24.73%	37.09%	0.009	0.010
Na_2O, wt.%	0.477	0.041	0.394	0.559	0.352	0.601	8.70%	17.40%	26.11%	0.453	0.500
P_2O_5, wt.%	0.080	0.009	0.062	0.098	0.053	0.107	11.26%	22.52%	33.78%	0.076	0.084
Pr_6O_{11}, ppm	< 100	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
SiO_2, wt.%	72.60	0.705	71.19	74.01	70.48	74.71	0.97%	1.94%	2.91%	68.97	76.23
Sm_2O_3, ppm	< 100	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
SO_3, wt.%	0.021	0.006	0.009	0.032	0.004	0.037	26.92%	53.84%	80.76%	0.020	0.022
Tb_4O_7, ppm	< 100	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
TiO_2, wt.%	0.692	0.025	0.643	0.741	0.618	0.766	3.55%	7.11%	10.66%	0.658	0.727

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

Notes: intervals may appear asymmetric due to rounding; 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.

IND = indeterminate.

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 Fusion XRF continued											
Tm_2O_3, ppm	< 100	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
V_2O_5, ppm	131	25	80	181	55	207	19.39%	38.77%	58.16%	124	137
Yb_2O_3, ppm	< 100	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
ZnO, ppm	84	17	49	119	32	136	20.71%	41.42%	62.13%	80	88
ZrO_2, ppm	321	49	224	419	175	468	15.20%	30.41%	45.61%	305	338
Thermogravimetry											
LOI^{1000}, wt.%	4.19	0.368	3.45	4.92	3.08	5.29	8.79%	17.58%	26.37%	3.98	4.40
4-Acid Digestion											
Al, wt.%	7.18	0.145	6.89	7.47	6.74	7.61	2.02%	4.04%	6.06%	6.82	7.53
As, ppm	38.1	1.52	35.1	41.2	33.6	42.7	3.98%	7.96%	11.94%	36.2	40.0
Ba, wt.%	0.101	0.004	0.093	0.109	0.089	0.113	3.97%	7.95%	11.92%	0.096	0.106
Be, ppm	1.98	0.134	1.71	2.25	1.58	2.38	6.76%	13.51%	20.27%	1.88	2.08
Bi, ppm	0.37	0.021	0.33	0.41	0.31	0.44	5.74%	11.48%	17.21%	0.35	0.39
Ca, wt.%	0.153	0.008	0.137	0.169	0.128	0.177	5.33%	10.66%	15.99%	0.145	0.161
Ce, ppm	113	8	97	130	89	138	7.22%	14.43%	21.65%	108	119
Co, ppm	4.18	0.240	3.70	4.66	3.46	4.90	5.74%	11.48%	17.22%	3.97	4.39
Cr, ppm	57	5.5	46	68	41	74	9.55%	19.09%	28.64%	55	60
Cs, ppm	7.91	0.394	7.12	8.70	6.73	9.09	4.98%	9.96%	14.95%	7.51	8.30
Cu, ppm	21.2	0.80	19.6	22.8	18.8	23.6	3.76%	7.53%	11.29%	20.2	22.3
Dy, ppm	3.09	0.269	2.55	3.63	2.28	3.89	8.72%	17.44%	26.16%	2.93	3.24
Er, ppm	1.56	0.110	1.34	1.78	1.23	1.89	7.02%	14.04%	21.06%	1.48	1.64
Eu, ppm	1.37	0.101	1.17	1.57	1.07	1.67	7.39%	14.78%	22.17%	1.30	1.44
Fe, wt.%	2.67	0.082	2.51	2.84	2.43	2.92	3.08%	6.15%	9.23%	2.54	2.81
Ga, ppm	18.1	0.84	16.4	19.8	15.6	20.6	4.66%	9.31%	13.97%	17.2	19.0
Gd, ppm	4.71	0.403	3.90	5.51	3.50	5.92	8.57%	17.13%	25.70%	4.47	4.94
Hf, ppm	3.72	0.253	3.21	4.22	2.96	4.47	6.80%	13.59%	20.39%	3.53	3.90
Ho, ppm	0.56	0.06	0.45	0.67	0.39	0.73	10.19%	20.38%	30.57%	0.53	0.59
In, ppm	0.053	0.004	0.045	0.062	0.040	0.067	8.37%	16.74%	25.11%	0.051	0.056
K, wt.%	2.19	0.056	2.07	2.30	2.02	2.35	2.56%	5.11%	7.67%	2.08	2.30
La, ppm	61	3.5	54	68	51	72	5.63%	11.27%	16.90%	58	64
Li, ppm	19.4	0.50	18.4	20.4	17.9	20.9	2.56%	5.12%	7.68%	18.4	20.4
Lu, ppm	0.24	0.022	0.19	0.28	0.17	0.30	9.35%	18.71%	28.06%	0.23	0.25
Mg, wt.%	0.368	0.016	0.336	0.401	0.320	0.417	4.41%	8.81%	13.22%	0.350	0.387
Mn, wt.%	0.008	0.000	0.007	0.008	0.007	0.009	3.57%	7.14%	10.71%	0.007	0.008
Mo, ppm	1.65	0.067	1.52	1.79	1.45	1.85	4.03%	8.06%	12.09%	1.57	1.74
Na, wt.%	0.359	0.017	0.325	0.393	0.308	0.410	4.75%	9.49%	14.24%	0.341	0.377
Nb, ppm	10.1	0.80	8.5	11.6	7.7	12.4	7.90%	15.81%	23.71%	9.6	10.6
Nd, ppm	44.1	3.02	38.1	50.2	35.1	53.2	6.83%	13.66%	20.50%	41.9	46.3
Ni, ppm	20.0	0.91	18.2	21.8	17.2	22.7	4.58%	9.15%	13.73%	19.0	21.0
P, wt.%	0.036	0.001	0.034	0.038	0.034	0.039	2.51%	5.02%	7.53%	0.034	0.038
Pb, ppm	26.1	1.38	23.3	28.9	21.9	30.2	5.30%	10.59%	15.89%	24.8	27.4
Pr, ppm	12.9	0.89	11.2	14.7	10.3	15.6	6.91%	13.82%	20.72%	12.3	13.6
Rb, ppm	115	5	105	124	100	129	4.21%	8.41%	12.62%	109	120

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

Notes: intervals may appear asymmetric due to rounding; 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.

IND = indeterminate.

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											
Re, ppm	< 0.002	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
S, wt.%	0.011	0.002	0.008	0.015	0.006	0.016	15.61%	31.23%	46.84%	0.011	0.012
Sb, ppm	2.71	0.103	2.51	2.92	2.40	3.02	3.79%	7.58%	11.38%	2.58	2.85
Sc, ppm	11.3	0.43	10.4	12.2	10.0	12.6	3.84%	7.68%	11.52%	10.8	11.9
Sm, ppm	7.08	0.464	6.16	8.01	5.69	8.48	6.55%	13.09%	19.64%	6.73	7.44
Sn, ppm	2.97	0.159	2.65	3.29	2.49	3.45	5.37%	10.74%	16.11%	2.82	3.12
Sr, ppm	140	5	130	149	125	154	3.47%	6.95%	10.42%	133	147
Ta, ppm	0.76	0.16	0.44	1.07	0.28	1.23	20.81%	41.63%	62.44%	0.72	0.80
Tb, ppm	0.58	0.040	0.50	0.66	0.46	0.69	6.88%	13.76%	20.64%	0.55	0.60
Th, ppm	21.2	1.20	18.8	23.6	17.6	24.8	5.68%	11.36%	17.04%	20.1	22.3
Ti, wt.%	0.357	0.023	0.312	0.402	0.290	0.425	6.31%	12.61%	18.92%	0.339	0.375
Tl, ppm	0.59	0.046	0.50	0.69	0.46	0.73	7.69%	15.37%	23.06%	0.56	0.62
Tm, ppm	0.23	0.02	0.18	0.27	0.15	0.30	10.45%	20.91%	31.36%	0.21	0.24
U, ppm	2.41	0.154	2.10	2.72	1.95	2.87	6.39%	12.77%	19.16%	2.29	2.53
V, ppm	79	3.2	72	85	69	88	4.04%	8.07%	12.11%	75	83
W, ppm	3.66	0.275	3.11	4.21	2.83	4.48	7.52%	15.03%	22.55%	3.47	3.84
Y, ppm	14.4	1.6	11.1	17.7	9.5	19.3	11.44%	22.88%	34.32%	13.7	15.1
Yb, ppm	1.51	0.115	1.28	1.74	1.16	1.85	7.64%	15.27%	22.91%	1.43	1.58
Zn, ppm	57	1.9	53	61	51	63	3.39%	6.77%	10.16%	54	60
Zr, ppm	133	10	113	153	104	163	7.38%	14.76%	22.14%	126	140

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

Notes: intervals may appear asymmetric due to rounding; 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.

IND = indeterminate.

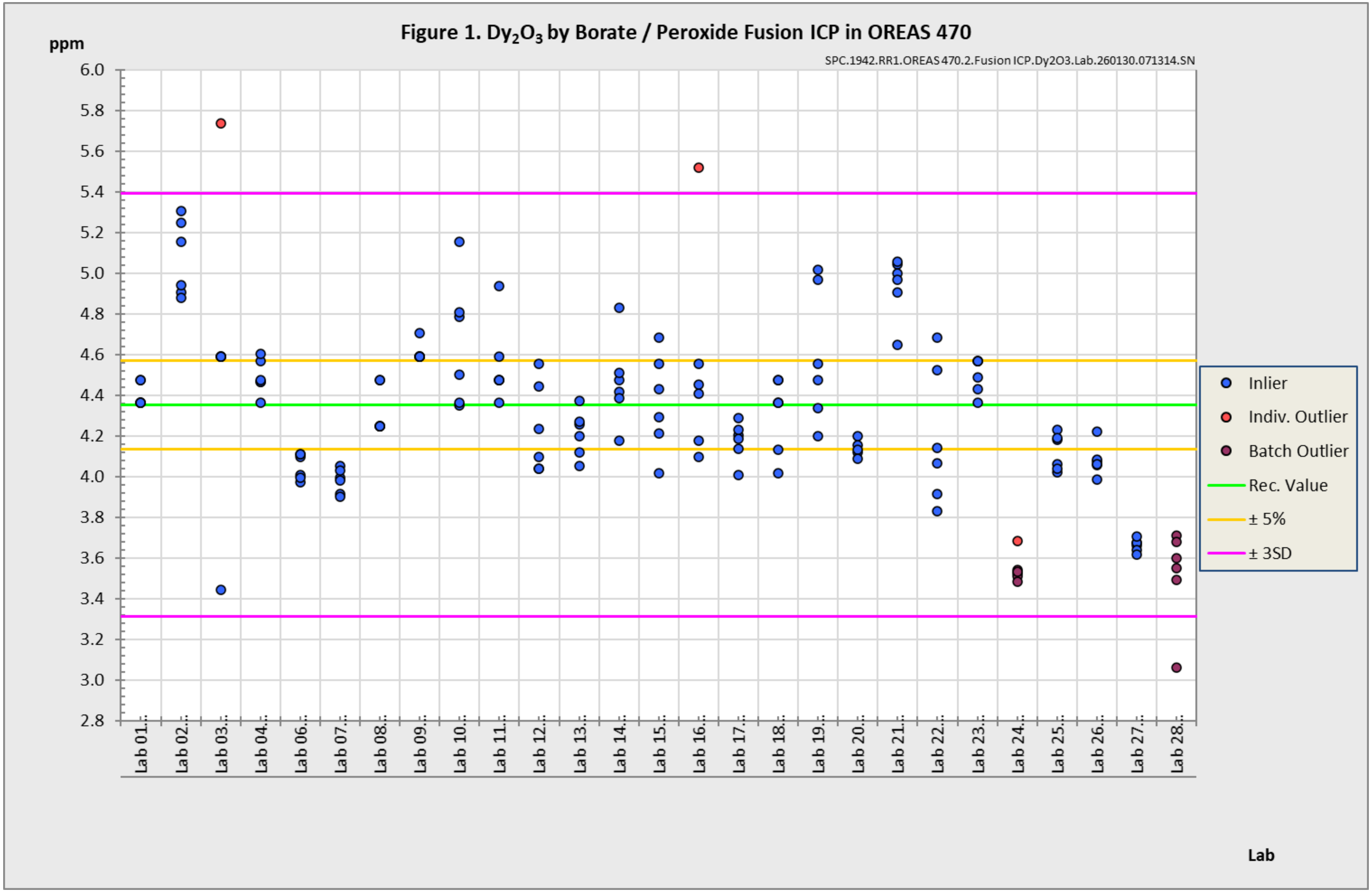


Figure 1. Dy_2O_3 by Borate / Peroxide Fusion ICP in OREAS 470
SPC.1942.RR1.OREAS 470.2.Fusion ICP.Dy2O3.Lab.260130.071314.SN
ppm
6.0
5.8
5.6
5.4
5.2
5.0
4.8
4.6
4.4
4.2
4.0
3.8
3.6
3.4
3.2
3.0
2.8
Lab 01.:
Lab 02.:
Lab 03.:
Lab 04.:
Lab 06.:
Lab 07.:
Lab 08.:
Lab 09.:
Lab 10.:
Lab 11.:
Lab 12.:
Lab 13.:
Lab 14.:
Lab 15.:
Lab 16.:
Lab 17.:
Lab 18.:
Lab 19.:
Lab 20.:
Lab 21.:
Lab 22.:
Lab 23.:
Lab 24.:
Lab 25.:
Lab 26.:
Lab 27.:
Lab 28.:
Inlier
Indiv. Outlier
Batch Outlier
Rec. Value
± 5%
± 3SD
Lab

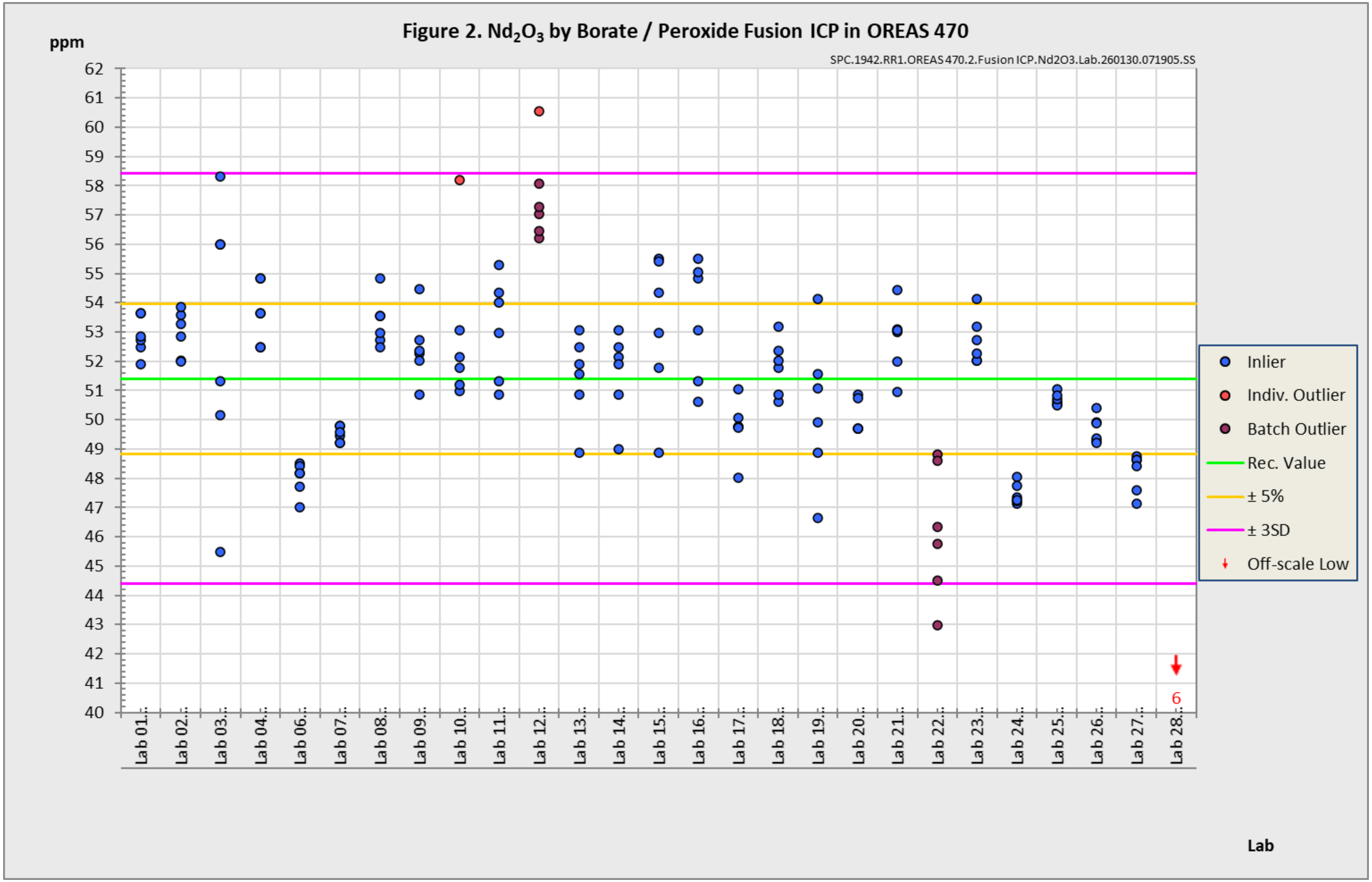


Figure 2. Nd_2O_3 by Borate / Peroxide Fusion ICP in OREAS 470
SPC.1942.RR1.OREAS 470.2.Fusion ICP.Nd2O3.Lab.260130.071905.SS
ppm
62
61
60
59
58
57
56
55
54
53
52
51
50
49
48
47
46
45
44
43
42
41
40
Lab 01
Lab 02
Lab 03
Lab 04
Lab 06
Lab 07
Lab 08
Lab 09
Lab 10
Lab 11
Lab 12
Lab 13
Lab 14
Lab 15
Lab 16
Lab 17
Lab 18
Lab 19
Lab 20
Lab 21
Lab 22
Lab 23
Lab 24
Lab 25
Lab 26
Lab 27
Lab 28
6
Inlier
Indiv. Outlier
Batch Outlier
Rec. Value
± 5%
± 3SD
Off-scale Low
Lab

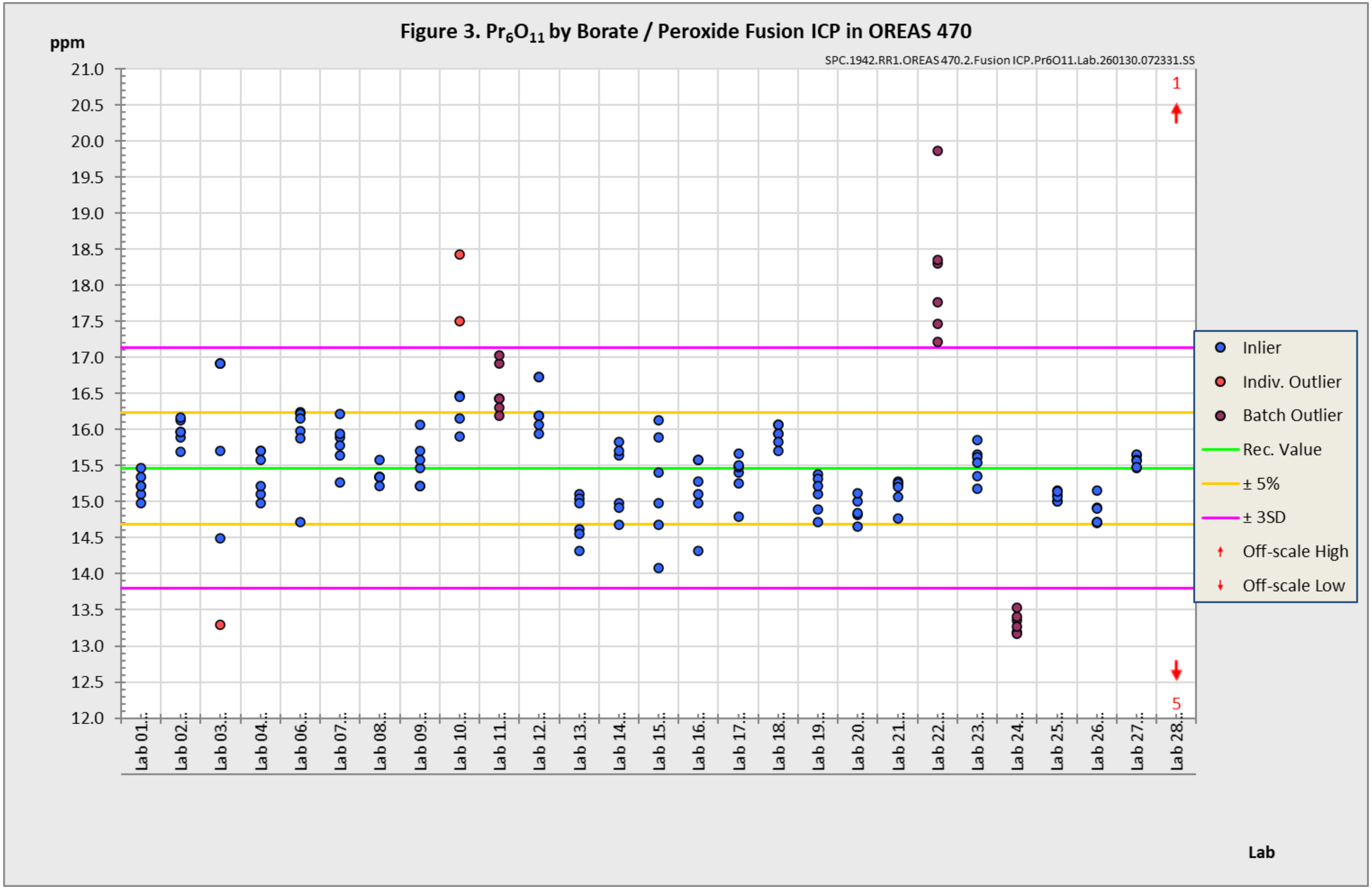
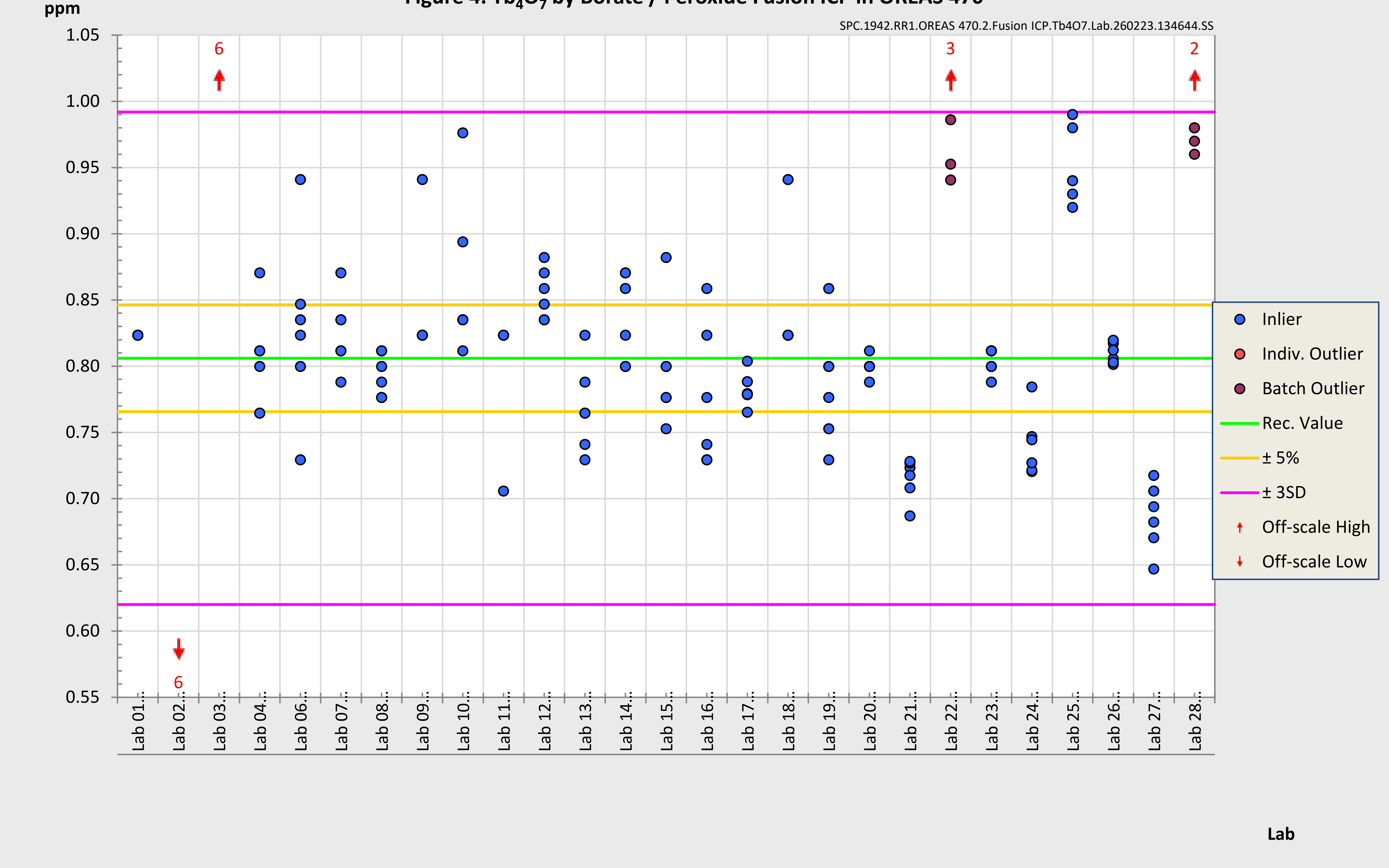


Figure 3. Pr_6O_{11} by Borate / Peroxide Fusion ICP in OREAS 470
ppm
SPC.1942.RR1.OREAS 470.2.Fusion ICP.Pr6O11.Lab.260130.072331.SS
21.0
20.5
20.0
19.5
19.0
18.5
18.0
17.5
17.0
16.5
16.0
15.5
15.0
14.5
14.0
13.5
13.0
12.5
12.0
1
5
Lab 01...
Lab 02...
Lab 03...
Lab 04...
Lab 06...
Lab 07...
Lab 08...
Lab 09...
Lab 10...
Lab 11...
Lab 12...
Lab 13...
Lab 14...
Lab 15...
Lab 16...
Lab 17...
Lab 18...
Lab 19...
Lab 20...
Lab 21...
Lab 22...
Lab 23...
Lab 24...
Lab 25...
Lab 26...
Lab 27...
Lab 28...
Lab
Inlier
Indiv. Outlier
Batch Outlier
Rec. Value
± 5%
± 3SD
Off-scale High
Off-scale Low

Figure 4. Tb_4O_7 by Borate / Peroxide Fusion ICP in OREAS 470



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Revision No.	Date	Changes applied
0	18th February 2026	First publication.

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