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CERTIFICATE OF ANALYSIS FOR

CERTIFIED REFERENCE MATERIAL

OREAS 550b

Copper-Cobalt Ore (Democratic Republic of the Congo)

Table 1. Certified Values, Uncertainty & Tolerance Intervals for multi-elements by 4-acid digestion in OREAS 550b.

Constituent	Certified Value†	95 % Expanded Uncertainty		95 % Tolerance Limits	
		Low	High	Low	High
4-Acid Digestion					
Ag, Silver (ppm)	0.323	0.248	0.399	0.257	0.390
Al, Aluminium (wt.%)	5.88	5.73	6.02	5.77	5.98
As, Arsenic (ppm)	61	58	63	59	62
Ba, Barium (ppm)	735	709	762	710	760
Be, Beryllium (ppm)	3.34	3.17	3.50	3.25	3.43
Bi, Bismuth (ppm)	2.10	2.00	2.21	2.04	2.17
Ca, Calcium (wt.%)	1.34	1.31	1.37	1.31	1.37
Cd, Cadmium (ppm)	0.20	0.18	0.23	0.17	0.23
Ce, Cerium (ppm)	120	113	127	117	123
Co, Cobalt (wt.%)	0.143	0.139	0.147	0.141	0.145
Cr, Chromium (ppm)	72	68	76	69	75
Cs, Caesium (ppm)	2.22	2.12	2.31	2.13	2.30
Cu, Copper (wt.%)	1.84	1.81	1.87	1.82	1.86
Dy, Dysprosium (ppm)	3.81	3.41	4.20	3.69	3.93
Er, Erbium (ppm)	2.18	1.96	2.39	2.09	2.27
Eu, Europium (ppm)	0.82	0.75	0.89	0.77	0.88
Fe, Iron (wt.%)	2.74	2.66	2.82	2.69	2.79
Ga, Gallium (ppm)	22.7	21.9	23.6	22.2	23.3
Gd, Gadolinium (ppm)	4.67	4.11	5.23	4.50	4.84
Hf, Hafnium (ppm)	3.83	3.66	4.00	3.65	4.00
Ho, Holmium (ppm)	0.73	0.60	0.87	0.70	0.77
In, Indium (ppm)	0.96	0.92	1.00	0.93	0.99
K, Potassium (wt.%)	2.02	1.97	2.06	1.97	2.07
La, Lanthanum (ppm)	61	57	65	59	62
Li, Lithium (ppm)	77	75	79	75	79
Lu, Lutetium (ppm)	0.33	0.30	0.36	0.31	0.36
Mg, Magnesium (wt.%)	4.31	4.19	4.43	4.22	4.41
Mn, Manganese (wt.%)	0.019	0.018	0.020	0.018	0.020
Mo, Molybdenum (ppm)	6.97	6.71	7.23	6.77	7.18
Na, Sodium (wt.%)	0.053	0.049	0.056	0.051	0.055
Nb, Niobium (ppm)	10.7	9.2	12.2	10.3	11.1
Nd, Neodymium (ppm)	48.4	44.8	52.1	47.0	49.9
Ni, Nickel (ppm)	67	65	69	66	69
P, Phosphorus (wt.%)	0.050	0.048	0.052	0.048	0.051
Pb, Lead (ppm)	13.2	12.4	14.0	12.5	13.8
Pr, Praseodymium (ppm)	13.8	12.9	14.7	13.3	14.2

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

†The operationally defined measurand meets the requirements of ISO 17034 [9] and all participating laboratories comply with the requirements of ISO 17025 [8].

Note: intervals may appear asymmetric due to rounding.

Table 1 continued.

Constituent	Certified Value†	95 % Expanded Uncertainty		95 % Tolerance Limits	
		Low	High	Low	High
4-Acid Digestion continued					
Rb, Rubidium (ppm)	88	85	92	86	91
Re, Rhenium (ppm)	0.014	0.011	0.016	IND	IND
S, Sulphur (wt.%)	1.16	1.12	1.19	1.14	1.18
Sb, Antimony (ppm)	2.62	2.40	2.83	2.47	2.76
Sc, Scandium (ppm)	11.3	10.8	11.8	11.0	11.6
Se, Selenium (ppm)	3.69	2.84	4.55	3.31	4.08
Sm, Samarium (ppm)	7.40	6.68	8.12	7.12	7.68
Sn, Tin (ppm)	2.47	2.32	2.62	2.34	2.61
Sr, Strontium (ppm)	77	75	80	76	79
Ta, Tantalum (ppm)	0.74	0.63	0.86	0.69	0.79
Tb, Terbium (ppm)	0.68	0.61	0.75	0.65	0.71
Te, Tellurium (ppm)	0.070	0.047	0.093	IND	IND
Th, Thorium (ppm)	13.3	12.6	14.0	12.9	13.8
Ti, Titanium (wt.%)	0.214	0.188	0.241	0.207	0.221
Tl, Thallium (ppm)	0.54	0.51	0.57	0.52	0.56
Tm, Thulium (ppm)	0.33	0.29	0.37	0.31	0.35
U, Uranium (ppm)	8.83	8.40	9.26	8.60	9.06
V, Vanadium (ppm)	201	194	208	196	206
W, Tungsten (ppm)	2.71	2.33	3.09	2.43	2.98
Y, Yttrium (ppm)	19.1	18.2	19.9	18.6	19.5
Yb, Ytterbium (ppm)	2.22	2.08	2.36	2.14	2.30
Zn, Zinc (ppm)	26.6	25.0	28.2	25.3	28.0
Zr, Zirconium (ppm)	134	130	139	131	137

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.

†The operationally defined measurand meets the requirements of ISO 17034 [9] and all participating laboratories comply with the requirements of ISO 17025 [8].

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

Table 2. Certified Values, Uncertainty & Tolerance Intervals for other measurands in OREAS 550b.

Constituent	Certified Value	95 % Expanded Uncertainty		95 % Tolerance Limits	
		Low	High	Low	High
Sulphuric Acid 5% Leach					
Co, Cobalt (wt.%)	0.042	0.038	0.046	0.041	0.043
Cu, Copper (wt.%)	0.832	0.805	0.859	0.813	0.851
Infrared Combustion					
C, Carbon (wt.%)	3.12	3.05	3.20	3.09	3.15
S, Sulphur (wt.%)	1.17	1.14	1.20	1.14	1.19
Borate Fusion XRF					
Al_2O_3, Aluminium(III) oxide (wt.%)	11.40	11.22	11.59	11.29	11.52
BaO, Barium oxide (ppm)	824	737	912	IND	IND
CaO, Calcium oxide (wt.%)	1.87	1.85	1.90	1.85	1.90
Co, Cobalt (wt.%)	0.145	0.139	0.150	0.142	0.147
Cu, Copper (wt.%)	1.84	1.81	1.88	1.81	1.87
Fe_2O_3, Iron(III) oxide (wt.%)	4.01	3.95	4.07	3.95	4.07
K_2O, Potassium oxide (wt.%)	2.42	2.39	2.45	2.39	2.45
MgO, Magnesium oxide (wt.%)	7.19	7.05	7.33	7.13	7.25
MnO, Manganese oxide (wt.%)	0.026	0.023	0.028	0.024	0.027
Ni, Nickel (ppm)	57	28	85	IND	IND
P_2O_5, Phosphorus(V) oxide (wt.%)	0.115	0.110	0.120	0.112	0.118
SiO_2, Silicon dioxide (wt.%)	58.18	57.57	58.80	57.78	58.59
SO_3, Sulphur trioxide (wt.%)	3.00	2.88	3.13	2.92	3.08
SrO, Strontium oxide (ppm)	102	87	117	IND	IND
TiO_2, Titanium dioxide (wt.%)	0.646	0.628	0.663	0.632	0.660
V_2O_5, Vanadium(V) oxide (ppm)	363	285	440	IND	IND
Zr, Zirconium (ppm)	184	140	228	IND	IND
Thermogravimetry					
LOI^{1000}, Loss On Ignition @1000°C (wt.%)	9.97	9.67	10.28	9.86	10.09
Peroxide Fusion ICP					
Al, Aluminium (wt.%)	5.88	5.76	6.01	5.78	5.99
As, Arsenic (ppm)	60	54	66	58	62
B, Boron (ppm)	171	147	194	162	179
Ba, Barium (ppm)	735	706	765	720	751
Be, Beryllium (ppm)	3.76	2.88	4.64	IND	IND
Bi, Bismuth (ppm)	2.15	1.91	2.40	2.02	2.29
Ca, Calcium (wt.%)	1.35	1.30	1.41	1.32	1.39
Ce, Cerium (ppm)	126	120	133	123	130
Co, Cobalt (wt.%)	0.145	0.140	0.150	0.142	0.148
Cr, Chromium (ppm)	87	74	101	83	92
Cs, Caesium (ppm)	2.26	2.09	2.43	2.09	2.42

SI unit equivalents: ppm (parts per million; 1×10^{-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
Peroxide Fusion ICP continued					
Cu, Copper (wt.%)	1.83	1.79	1.87	1.80	1.86
Dy, Dysprosium (ppm)	5.78	5.34	6.22	5.56	6.00
Er, Erbium (ppm)	3.14	2.78	3.50	2.89	3.39
Eu, Europium (ppm)	0.92	0.79	1.05	0.83	1.01
Fe, Iron (wt.%)	2.74	2.67	2.81	2.69	2.79
Ga, Gallium (ppm)	23.0	21.6	24.4	21.7	24.3
Gd, Gadolinium (ppm)	6.12	5.61	6.63	5.74	6.50
Ge, Germanium (ppm)	2.01	1.70	2.32	IND	IND
Ho, Holmium (ppm)	1.14	1.03	1.26	1.06	1.22
In, Indium (ppm)	0.98	0.83	1.13	IND	IND
K, Potassium (wt.%)	2.03	1.96	2.10	1.96	2.10
La, Lanthanum (ppm)	66	63	69	64	68
Li, Lithium (ppm)	78	76	81	76	81
Lu, Lutetium (ppm)	0.48	0.41	0.54	0.44	0.52
Mg, Magnesium (wt.%)	4.35	4.24	4.46	4.27	4.43
Mn, Manganese (wt.%)	0.020	0.019	0.020	0.019	0.020
Mo, Molybdenum (ppm)	7.07	6.22	7.92	IND	IND
Nb, Niobium (ppm)	19.5	18.2	20.7	18.1	20.8
Nd, Neodymium (ppm)	53	51	55	50	55
Ni, Nickel (ppm)	70	59	80	66	73
P, Phosphorus (wt.%)	0.052	0.046	0.058	IND	IND
Pb, Lead (ppm)	15.0	11.9	18.0	IND	IND
Pr, Praseodymium (ppm)	14.4	13.3	15.5	13.7	15.1
Rb, Rubidium (ppm)	88	81	94	85	90
Re, Rhenium (ppm)	< 0.1	IND	IND	IND	IND
S, Sulphur (wt.%)	1.18	1.12	1.23	1.15	1.21
Sb, Antimony (ppm)	2.67	2.27	3.06	2.27	3.06
Sc, Scandium (ppm)	11.1	10.3	12.0	IND	IND
Si, Silicon (wt.%)	27.28	26.61	27.96	26.85	27.71
Sm, Samarium (ppm)	7.70	7.20	8.20	7.33	8.06
Sn, Tin (ppm)	3.02	2.22	3.82	IND	IND
Sr, Strontium (ppm)	78	74	83	76	81
Ta, Tantalum (ppm)	1.53	1.30	1.77	1.20	1.86
Tb, Terbium (ppm)	0.96	0.89	1.03	0.91	1.02
Th, Thorium (ppm)	13.7	13.1	14.2	13.3	14.1
Ti, Titanium (wt.%)	0.374	0.361	0.388	0.363	0.385
Tl, Thallium (ppm)	0.60	0.51	0.69	IND	IND

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
Peroxide Fusion ICP continued					
Tm, Thulium (ppm)	0.49	0.43	0.54	0.46	0.51
U, Uranium (ppm)	9.12	8.71	9.52	8.85	9.38
V, Vanadium (ppm)	214	205	223	209	218
W, Tungsten (ppm)	3.40	2.73	4.07	IND	IND
Y, Yttrium (ppm)	29.4	27.9	30.9	27.8	31.0
Yb, Ytterbium (ppm)	3.13	2.86	3.40	2.85	3.41
Aqua Regia Digestion					
Ag, Silver (ppm)	0.233	0.176	0.290	0.207	0.259
Al, Aluminium (wt.%)	1.31	1.25	1.37	1.27	1.35
As, Arsenic (ppm)	58	56	60	57	60
Au, Gold (ppm)	< 0.02	IND	IND	IND	IND
B, Boron (ppm)	< 10	IND	IND	IND	IND
Ba, Barium (ppm)	103	96	111	99	108
Be, Beryllium (ppm)	1.63	1.52	1.74	1.59	1.67
Bi, Bismuth (ppm)	1.91	1.83	1.99	1.86	1.96
Ca, Calcium (wt.%)	1.32	1.28	1.35	1.29	1.34
Cd, Cadmium (ppm)	0.20	0.18	0.21	0.18	0.22
Ce, Cerium (ppm)	43.3	40.4	46.3	41.4	45.2
Co, Cobalt (wt.%)	0.131	0.125	0.137	0.128	0.133
Cr, Chromium (ppm)	28.5	27.1	29.9	27.2	29.8
Cs, Caesium (ppm)	0.45	0.41	0.50	0.44	0.47
Cu, Copper (wt.%)	1.82	1.78	1.85	1.80	1.84
Dy, Dysprosium (ppm)	1.17	1.02	1.32	1.13	1.21
Er, Erbium (ppm)	0.52	0.47	0.56	0.49	0.54
Eu, Europium (ppm)	0.39	0.33	0.45	0.37	0.41
Fe, Iron (wt.%)	2.46	2.39	2.52	2.41	2.50
Ga, Gallium (ppm)	7.31	6.80	7.82	7.04	7.58
Gd, Gadolinium (ppm)	2.19	1.94	2.45	2.10	2.28
Hf, Hafnium (ppm)	0.32	0.29	0.35	0.30	0.34
Hg, Mercury (ppm)	0.047	0.034	0.060	IND	IND
Ho, Holmium (ppm)	0.20	0.17	0.22	0.18	0.21
In, Indium (ppm)	0.63	0.60	0.66	0.61	0.64
K, Potassium (wt.%)	0.205	0.193	0.217	0.197	0.213
La, Lanthanum (ppm)	19.2	18.1	20.3	18.6	19.9
Li, Lithium (ppm)	49.9	46.0	53.8	48.0	51.7
Lu, Lutetium (ppm)	0.065	0.059	0.071	0.061	0.070
Mg, Magnesium (wt.%)	3.53	3.40	3.67	3.46	3.61

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
Aqua Regia Digestion continued					
Mn, Manganese (wt.%)	0.018	0.017	0.019	0.017	0.018
Mo, Molybdenum (ppm)	6.56	6.33	6.79	6.37	6.75
Na, Sodium (wt.%)	0.010	0.009	0.011	IND	IND
Nd, Neodymium (ppm)	17.5	13.8	21.2	17.3	17.7
Ni, Nickel (ppm)	60	58	62	58	62
P, Phosphorus (wt.%)	0.039	0.038	0.041	0.038	0.041
Pb, Lead (ppm)	9.13	8.44	9.83	8.75	9.52
Pr, Praseodymium (ppm)	4.68	3.75	5.61	4.59	4.76
Rb, Rubidium (ppm)	8.70	8.03	9.37	8.37	9.03
Re, Rhenium (ppm)	0.012	0.010	0.014	IND	IND
S, Sulphur (wt.%)	1.16	1.13	1.19	1.14	1.18
Sb, Antimony (ppm)	1.62	1.46	1.77	1.52	1.72
Sc, Scandium (ppm)	3.68	3.51	3.86	3.53	3.84
Se, Selenium (ppm)	3.50	3.13	3.88	3.21	3.80
Sm, Samarium (ppm)	3.00	2.50	3.51	2.90	3.11
Sn, Tin (ppm)	0.83	0.79	0.88	0.79	0.87
Sr, Strontium (ppm)	29.6	28.2	31.0	28.7	30.6
Ta, Tantalum (ppm)	< 0.01	IND	IND	IND	IND
Tb, Terbium (ppm)	0.26	0.24	0.28	0.25	0.27
Te, Tellurium (ppm)	0.048	0.035	0.062	IND	IND
Th, Thorium (ppm)	6.10	5.69	6.51	5.86	6.34
U, Uranium (ppm)	4.61	4.39	4.84	4.49	4.73
V, Vanadium (ppm)	45.9	42.9	49.0	44.5	47.4
W, Tungsten (ppm)	1.00	0.77	1.24	0.87	1.13
Y, Yttrium (ppm)	4.55	4.32	4.77	4.40	4.69
Yb, Ytterbium (ppm)	0.43	0.39	0.46	0.40	0.46
Zn, Zinc (ppm)	22.9	21.7	24.0	21.7	24.0
Zr, Zirconium (ppm)	11.0	10.3	11.7	10.6	11.4

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 550b.

Constituent	Unit	Value	Constituent	Unit	Value	Constituent	Unit	Value
4-Acid Digestion								
B	ppm	*18.5*	Hg	ppm	*0.056*			
Ge	ppm	*0.23*	Pt	ppb	*7.83*			
Borate Fusion XRF								
Ag	ppm	*0.039*	Hf	ppm	*< 80*	Se	ppm	*3.50*
As	ppm	*86*	Ho	ppm	*1.08*	Sm	ppm	*7.05*
Be	ppm	*2.00*	In	ppm	*0.98*	Sn	ppm	*< 50*
Bi	ppm	*< 100*	La	ppm	*73*	Ta	ppm	*34.8*
Cd	ppm	*< 10*	Lu	ppm	*0.42*	Tb	ppm	*0.90*
Ce	ppm	*123*	Mo	ppm	*16.8*	Te	ppm	*< 0.1*
Cl	ppm	*350*	Na_2O	wt.%	*0.084*	Th	ppm	*13.8*
Cr_2O_3	ppm	*118*	Nb	ppm	*25.4*	Tl	ppm	*0.47*
Cs	ppm	*2.12*	Nd	ppm	*49.4*	Tm	ppm	*0.44*
Dy	ppm	*5.28*	Pb	ppm	*48.2*	U	ppm	*7.20*
Er	ppm	*2.99*	Pr	ppm	*14.8*	W	ppm	*< 10*
Eu	ppm	*0.86*	Rb	ppm	*60*	Y	ppm	*38.9*
F	ppm	*< 5000*	Re	ppm	*< 0.1*	Yb	ppm	*2.85*
Ga	ppm	*22.3*	Sb	ppm	*< 50*	Zn	ppm	*< 50*
Gd	ppm	*5.83*	Sc	ppm	*11.7*			
Peroxide Fusion ICP continued								
Ag	ppm	*0.633*	Hg	ppm	*< 5*	Te	ppm	*< 1*
Cd	ppm	*< 10*	Na	wt.%	*0.039*	Zn	ppm	*31.5*
Hf	ppm	*6.29*	Se	ppm	*7.58*	Zr	ppm	*174*
Aqua Regia Digestion								
Ge	ppm	*0.077*	Pt	ppb	*1.67*	Tm	ppm	*0.071*
Nb	ppm	*0.048*	Ti	wt.%	*0.003*			
Pd	ppb	*< 10*	Tl	ppm	*0.18*			
3-Acid Digestion (no HF)								
As	ppm	*< 10*	Ni	ppm	*73*	V	ppm	*72*
Co	wt.%	*0.135*	Pb	ppm	*53*	Zn	ppm	*75*
Cu	wt.%	*1.81*	S	wt.%	*1.16*			

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 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 550b-DataPack.1.0.240828_095520.xlsx**).

Results are also presented in scatter plots for Co and Cu by multiple operationally defined methods including 4-acid digestion with ICP-OES/MS finish (and/or AAS finish), borate fusion with XRF finish, peroxide fusion with ICP-OES/MS finish, and aqua regia digestion with ICP-OES/MS finish (and/or AAS finish) in Figures 1 to 8 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 550b was prepared from copper-cobalt sulphide ore samples sourced from MMG's Kinsevere Mine blended with barren black slate. The Kinsevere Mine is located in the Haut-Katanga province about 30 km from Lubumbashi in the south-east of the Democratic Republic of the Congo (DRC). The hypogene mineralisation at Kinsevere occurs as stratabound, veins and breccias consisting of mainly chalcopyrite, carrolite, bornite and occasionally pyrite and chalcocite, hosted within the Mine series carbonaceous shales, siltstones, and dolomites of the Roan Group belonging to the Katangan Supergroup stratigraphy.

COMMINUTION AND HOMOGENISATION PROCEDURES

The material constituting OREAS 550b was prepared in the following manner:

- Drying the ores and barren black slate to constant mass at 105 °C;

- Multi-stage milling of ores and barren black slate to achieve a particle size distribution of > 99.5 % passing 75 μm;
- Preliminary homogenisation of ore source materials;
- Representative sampling and check assaying of ore source materials;
- Blending the ores and barren black slate in appropriate proportions to achieve target grades;
- Homogenisation using OREAS' novel processing technologies;
- Packaging in 10 g units sealed in laminated foil pouches and 500 g units in plastic jars.

PHYSICAL PROPERTIES

OREAS 550b 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 550b.

Bulk Density (kg/m^3)	Moisture (wt.%)	Munsell Notation‡	Munsell Color‡
621	0.74	N4	Medium Dark Gray

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

ANALYTICAL PROGRAM

Twenty-six 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 23 laboratories depending on the element);
- Aqua regia digestion for full elemental suite ICP-OES and ICP-MS (up to 26 laboratories depending on the element).
- Lithium borate fusion whole rock analysis package by X-ray fluorescence (up to 17 laboratories depending on the element);
- Thermogravimetry: Loss on Ignition (LOI) at 1000 °C (14 laboratories used a thermogravimetric analyser, 4 laboratories used a conventional muffle furnace and 3 laboratories included LOI with their fusion package);
- C and S by infrared combustion furnace/CS analyser (23 laboratories);
- Cu and Co by 5 % sulphuric acid leach* with ICP or AAS finish (up to 20 laboratories);
- Lithium borate or sodium peroxide fusion with full suite ICP-OES and ICP-MS elemental packages (up to 22 laboratories depending on the element).

*See 'Appendix' for specified methodology.

For the round robin program twelve 800 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 two 30 g scoop splits from each of three separate 800 g test units. This format enabled a nested ANOVA treatment of the results to evaluate homogeneity, i.e.

to ascertain whether between-unit variance is greater than within-unit variance (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 ISO 98-3:2008 [5, 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 5, ‘Performance Gates’) provide an indication of a level of performance that might reasonably be expected from a laboratory being monitored by this CRM in a QA/QC program. They take into account errors attributable to measurement uncertainty and CRM variability. For an effective CRM the contribution of the latter should be negligible in comparison to measurement errors. The Standard Deviation values include all sources of measurement uncertainty: between-lab variance, within-run variance (precision errors) and CRM variability.

The SD for each analyte’s certified value is calculated from the same filtered data set used to determine the certified value, i.e., after removal of all individual, lab dataset (batch) and 3SD outliers (single iteration). These outliers can only be removed after the absolute homogeneity of the CRM has been independently established, i.e., the outliers must be confidently deemed to be analytical rather than arising from inhomogeneity of the CRM. ***The standard deviation is then calculated for each analyte from the pooled accepted analyses generated from the certification program.***

Homogeneity Evaluation

The tolerance limits (ISO 16269:2014) [6] 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 copper by 4-acid digestion, where 99 % of the time ($1-\alpha=0.99$) at least 95 % of subsamples ($\rho=0.95$) will have concentrations lying between 1.82 wt. % and 1.86 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.***

Based on the statistical analysis of the results of the interlaboratory certification program, it can be concluded that OREAS 550b is fit-for-purpose as a certified reference material (see 'Intended Use' below).

PERFORMANCE GATES

Table 5 below shows intervals calculated for two and three standard deviations. As a guide these intervals may be regarded as warning or rejection for multiple 2SD outliers, or rejection for individual 3SD outliers in QC monitoring, although their precise application should be at the discretion of the QC manager concerned (also see 'Intended Use' section below). Westgard Rules extend the basics of single-rule QC monitoring using multi-rules (for more information visit www.westgard.com/mltirule.htm). A second method utilises a 5% window calculated directly from the certified value.

Standard deviation is also shown in relative percent for one, two and three relative standard deviations (1RSD, 2RSD and 3RSD) to facilitate an appreciation of the magnitude of these numbers and a comparison with the 5% window. Caution should be exercised when concentration levels approach lower limits of detection of the analytical methods employed as performance gates calculated from standard deviations tend to be excessively wide whereas those determined by the 5% method are too narrow. One approach used at commercial laboratories is to set the acceptance criteria at twice the detection level (DL) ± 10 %.

i.e., Certified Value ± 10 % ± 2DL [1].

Table 5. Performance Gates for OREAS 550b.

Constituent	Certified Value	Absolute Standard Deviations					Relative Standard Deviations			5 % window	
		1SD	2SD Low	2SD High	3SD Low	3SD High	1RSD	2RSD	3RSD	Low	High
4-Acid Digestion											
Ag, ppm	0.323	0.053	0.218	0.429	0.165	0.481	16.28%	32.56%	48.83%	0.307	0.340
Al, wt.%	5.88	0.190	5.50	6.26	5.31	6.45	3.23%	6.47%	9.70%	5.58	6.17
As, ppm	61	3.2	54	67	51	70	5.24%	10.48%	15.73%	58	64
Ba, ppm	735	42	652	818	611	860	5.65%	11.29%	16.94%	699	772
Be, ppm	3.34	0.213	2.91	3.77	2.70	3.98	6.39%	12.77%	19.16%	3.17	3.51
Bi, ppm	2.10	0.119	1.86	2.34	1.74	2.46	5.68%	11.37%	17.05%	2.00	2.21
Ca, wt.%	1.34	0.032	1.27	1.40	1.24	1.43	2.38%	4.76%	7.14%	1.27	1.41
Cd, ppm	0.20	0.015	0.17	0.23	0.16	0.25	7.28%	14.55%	21.83%	0.19	0.21
Ce, ppm	120	9	102	138	94	146	7.33%	14.66%	21.98%	114	126
Co, wt.%	0.143	0.005	0.133	0.153	0.128	0.158	3.41%	6.83%	10.24%	0.136	0.150
Cr, ppm	72	6.3	59	85	53	91	8.73%	17.45%	26.18%	68	76
Cs, ppm	2.22	0.108	2.00	2.43	1.89	2.54	4.85%	9.71%	14.56%	2.11	2.33

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

Note 1: intervals may appear asymmetric due to rounding.

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

Table 5 continued.

Constituent	Certified Value	Absolute Standard Deviations					Relative Standard Deviations			5 % window	
		1SD	2SD Low	2SD High	3SD Low	3SD High	1RSD	2RSD	3RSD	Low	High
4-Acid Digestion continued											
Cu, wt.%	1.84	0.032	1.78	1.90	1.74	1.94	1.75%	3.51%	5.26%	1.75	1.93
Dy, ppm	3.81	0.288	3.23	4.38	2.94	4.67	7.56%	15.11%	22.67%	3.62	4.00
Er, ppm	2.18	0.184	1.81	2.55	1.63	2.73	8.44%	16.89%	25.33%	2.07	2.29
Eu, ppm	0.82	0.053	0.72	0.93	0.66	0.98	6.48%	12.95%	19.43%	0.78	0.86
Fe, wt.%	2.74	0.082	2.58	2.90	2.49	2.99	3.00%	6.00%	9.00%	2.60	2.88
Ga, ppm	22.7	1.14	20.5	25.0	19.3	26.1	4.99%	9.99%	14.98%	21.6	23.9
Gd, ppm	4.67	0.429	3.81	5.53	3.38	5.96	9.19%	18.37%	27.56%	4.44	4.91
Hf, ppm	3.83	0.185	3.46	4.20	3.27	4.38	4.83%	9.67%	14.50%	3.64	4.02
Ho, ppm	0.73	0.13	0.47	1.00	0.34	1.13	17.85%	35.71%	53.56%	0.70	0.77
In, ppm	0.96	0.049	0.86	1.06	0.82	1.11	5.06%	10.12%	15.18%	0.91	1.01
K, wt.%	2.02	0.047	1.92	2.11	1.88	2.16	2.32%	4.64%	6.96%	1.92	2.12
La, ppm	61	5.7	49	72	43	78	9.43%	18.86%	28.29%	58	64
Li, ppm	77	2.8	71	82	69	85	3.61%	7.22%	10.83%	73	81
Lu, ppm	0.33	0.017	0.30	0.37	0.28	0.38	5.22%	10.45%	15.67%	0.32	0.35
Mg, wt.%	4.31	0.129	4.05	4.57	3.93	4.70	2.98%	5.97%	8.95%	4.10	4.53
Mn, wt.%	0.019	0.001	0.018	0.020	0.017	0.021	3.16%	6.31%	9.47%	0.018	0.020
Mo, ppm	6.97	0.346	6.28	7.67	5.93	8.01	4.96%	9.93%	14.89%	6.62	7.32
Na, wt.%	0.053	0.007	0.039	0.067	0.032	0.074	13.29%	26.58%	39.87%	0.050	0.055
Nb, ppm	10.7	3.2	4.4	17.1	1.2	20.2	29.67%	59.34%	89.01%	10.2	11.2
Nd, ppm	48.4	2.95	42.5	54.3	39.6	57.3	6.09%	12.18%	18.27%	46.0	50.9
Ni, ppm	67	1.9	63	71	61	73	2.88%	5.76%	8.64%	64	71
P, wt.%	0.050	0.002	0.045	0.055	0.043	0.057	4.58%	9.15%	13.73%	0.047	0.052
Pb, ppm	13.2	1.3	10.5	15.8	9.2	17.2	10.11%	20.22%	30.33%	12.5	13.8
Pr, ppm	13.8	0.76	12.3	15.3	11.5	16.0	5.51%	11.02%	16.54%	13.1	14.5
Rb, ppm	88	4.3	80	97	75	101	4.87%	9.75%	14.62%	84	93
Re, ppm	0.014	0.002	0.010	0.017	0.009	0.018	11.35%	22.70%	34.04%	0.013	0.014
S, wt.%	1.16	0.041	1.08	1.24	1.03	1.28	3.54%	7.09%	10.63%	1.10	1.22
Sb, ppm	2.62	0.228	2.16	3.07	1.93	3.30	8.73%	17.47%	26.20%	2.49	2.75
Sc, ppm	11.3	0.58	10.1	12.5	9.6	13.0	5.12%	10.23%	15.35%	10.7	11.9
Se, ppm	3.69	0.52	2.65	4.74	2.13	5.26	14.11%	28.22%	42.33%	3.51	3.88
Sm, ppm	7.40	0.704	5.99	8.81	5.29	9.51	9.52%	19.04%	28.56%	7.03	7.77
Sn, ppm	2.47	0.175	2.12	2.82	1.95	3.00	7.06%	14.13%	21.19%	2.35	2.59
Sr, ppm	77	3.2	71	84	68	87	4.15%	8.30%	12.45%	74	81
Ta, ppm	0.74	0.20	0.34	1.14	0.14	1.34	27.17%	54.35%	81.52%	0.70	0.78
Tb, ppm	0.68	0.040	0.60	0.76	0.56	0.80	5.91%	11.81%	17.72%	0.65	0.71
Te, ppm	0.070	0.017	0.036	0.105	0.019	0.122	24.46%	48.93%	73.39%	0.067	0.074
Th, ppm	13.3	0.68	12.0	14.7	11.3	15.4	5.11%	10.21%	15.32%	12.7	14.0
Ti, wt.%	0.214	0.053	0.108	0.320	0.055	0.373	24.70%	49.41%	74.11%	0.204	0.225
Tl, ppm	0.54	0.046	0.44	0.63	0.40	0.67	8.60%	17.19%	25.79%	0.51	0.56
Tm, ppm	0.33	0.032	0.27	0.40	0.24	0.43	9.55%	19.09%	28.64%	0.32	0.35
U, ppm	8.83	0.491	7.85	9.81	7.36	10.30	5.56%	11.11%	16.67%	8.39	9.27
V, ppm	201	6	188	213	182	220	3.14%	6.28%	9.42%	191	211
W, ppm	2.71	0.33	2.04	3.37	1.71	3.70	12.30%	24.60%	36.90%	2.57	2.84

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

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

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

Table 5 continued.

Constituent	Certified Value	Absolute Standard Deviations					Relative Standard Deviations			5 % window	
		1SD	2SD Low	2SD High	3SD Low	3SD High	1RSD	2RSD	3RSD	Low	High
4-Acid Digestion continued											
Y, ppm	19.1	1.03	17.0	21.1	16.0	22.2	5.39%	10.77%	16.16%	18.1	20.0
Yb, ppm	2.22	0.154	1.91	2.52	1.75	2.68	6.95%	13.90%	20.85%	2.11	2.33
Zn, ppm	26.6	1.63	23.3	29.9	21.7	31.5	6.14%	12.29%	18.43%	25.3	27.9
Zr, ppm	134	6	123	146	117	152	4.37%	8.74%	13.11%	128	141
Sulphuric Acid 5% Leach											
Co, wt.%	0.042	0.004	0.034	0.050	0.030	0.054	9.51%	19.02%	28.54%	0.040	0.044
Cu, wt.%	0.832	0.044	0.744	0.921	0.699	0.965	5.32%	10.64%	15.96%	0.791	0.874
Infrared Combustion											
C, wt.%	3.12	0.080	2.96	3.28	2.88	3.36	2.58%	5.16%	7.73%	2.97	3.28
S, wt.%	1.17	0.034	1.10	1.23	1.06	1.27	2.92%	5.83%	8.75%	1.11	1.22
Borate Fusion XRF											
Al_2O_3, wt.%	11.40	0.169	11.07	11.74	10.90	11.91	1.48%	2.97%	4.45%	10.83	11.97
BaO, ppm	824	72	681	967	610	1039	8.68%	17.36%	26.03%	783	865
CaO, wt.%	1.87	0.021	1.83	1.91	1.81	1.93	1.10%	2.20%	3.29%	1.78	1.97
Co, wt.%	0.145	0.005	0.135	0.154	0.131	0.158	3.16%	6.31%	9.47%	0.137	0.152
Cu, wt.%	1.84	0.030	1.78	1.90	1.75	1.93	1.64%	3.29%	4.93%	1.75	1.93
Fe_2O_3, wt.%	4.01	0.070	3.87	4.15	3.80	4.22	1.76%	3.51%	5.27%	3.81	4.21
K_2O, wt.%	2.42	0.041	2.34	2.50	2.30	2.54	1.69%	3.38%	5.06%	2.30	2.54
MgO, wt.%	7.19	0.156	6.88	7.50	6.72	7.66	2.17%	4.34%	6.51%	6.83	7.55
MnO, wt.%	0.026	0.003	0.019	0.032	0.015	0.036	13.15%	26.31%	39.46%	0.024	0.027
Ni, ppm	57	14	28	85	14	99	24.89%	49.77%	74.66%	54	60
P_2O_5, wt.%	0.115	0.007	0.100	0.130	0.093	0.138	6.49%	12.98%	19.47%	0.110	0.121
SiO_2, wt.%	58.18	0.522	57.14	59.23	56.62	59.75	0.90%	1.79%	2.69%	55.28	61.09
SO_3, wt.%	3.00	0.105	2.79	3.21	2.69	3.32	3.49%	6.98%	10.47%	2.85	3.15
SrO, ppm	102	13	76	129	62	142	12.96%	25.91%	38.87%	97	107
TiO_2, wt.%	0.646	0.015	0.615	0.677	0.600	0.692	2.38%	4.75%	7.13%	0.614	0.678
V_2O_5, ppm	363	67	228	497	161	565	18.57%	37.15%	55.72%	344	381
Zr, ppm	184	31	123	245	92	276	16.60%	33.20%	49.80%	175	193
Thermogravimetry											
LOI^{1000}, wt.%	9.97	0.563	8.85	11.10	8.29	11.66	5.64%	11.28%	16.92%	9.48	10.47
Peroxide Fusion ICP											
Al, wt.%	5.88	0.157	5.57	6.20	5.41	6.36	2.67%	5.33%	8.00%	5.59	6.18
As, ppm	60	4.6	51	69	46	74	7.66%	15.32%	22.98%	57	63
B, ppm	171	20	132	210	112	229	11.45%	22.90%	34.35%	162	179
Ba, ppm	735	18	700	771	682	788	2.40%	4.80%	7.21%	699	772
Be, ppm	3.76	0.51	2.74	4.78	2.23	5.29	13.57%	27.14%	40.70%	3.57	3.95
Bi, ppm	2.15	0.151	1.85	2.46	1.70	2.61	7.03%	14.05%	21.08%	2.05	2.26
Ca, wt.%	1.35	0.070	1.21	1.49	1.14	1.56	5.20%	10.40%	15.60%	1.29	1.42
Ce, ppm	126	5	117	136	112	141	3.83%	7.66%	11.48%	120	133
Co, wt.%	0.145	0.003	0.139	0.151	0.136	0.155	2.19%	4.37%	6.56%	0.138	0.152
Cr, ppm	87	17	53	121	36	138	19.46%	38.92%	58.38%	83	92
Cs, ppm	2.26	0.131	2.00	2.52	1.87	2.65	5.79%	11.58%	17.37%	2.14	2.37
Cu, wt.%	1.83	0.048	1.73	1.93	1.69	1.97	2.61%	5.22%	7.83%	1.74	1.92

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

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

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

Table 5 continued.

Constituent	Certified Value	Absolute Standard Deviations					Relative Standard Deviations			5 % window	
		1SD	2SD Low	2SD High	3SD Low	3SD High	1RSD	2RSD	3RSD	Low	High
Peroxide Fusion ICP continued											
Dy, ppm	5.78	0.324	5.14	6.43	4.81	6.75	5.60%	11.20%	16.80%	5.49	6.07
Er, ppm	3.14	0.34	2.46	3.81	2.12	4.15	10.77%	21.54%	32.31%	2.98	3.30
Eu, ppm	0.92	0.060	0.80	1.04	0.74	1.10	6.47%	12.95%	19.42%	0.88	0.97
Fe, wt.%	2.74	0.090	2.56	2.92	2.47	3.01	3.28%	6.56%	9.84%	2.61	2.88
Ga, ppm	23.0	1.02	21.0	25.0	19.9	26.1	4.44%	8.87%	13.31%	21.9	24.2
Gd, ppm	6.12	0.357	5.40	6.83	5.05	7.19	5.84%	11.68%	17.52%	5.81	6.42
Ge, ppm	2.01	0.119	1.77	2.25	1.65	2.37	5.92%	11.84%	17.76%	1.91	2.11
Ho, ppm	1.14	0.071	1.00	1.29	0.93	1.36	6.24%	12.48%	18.72%	1.09	1.20
In, ppm	0.98	0.10	0.78	1.18	0.68	1.29	10.28%	20.56%	30.85%	0.93	1.03
K, wt.%	2.03	0.063	1.90	2.16	1.84	2.22	3.12%	6.25%	9.37%	1.93	2.13
La, ppm	66	3.2	60	72	56	75	4.79%	9.59%	14.38%	63	69
Li, ppm	78	5.3	68	89	62	94	6.77%	13.54%	20.30%	74	82
Lu, ppm	0.48	0.028	0.42	0.53	0.39	0.56	5.89%	11.77%	17.66%	0.45	0.50
Mg, wt.%	4.35	0.126	4.10	4.60	3.97	4.73	2.90%	5.81%	8.71%	4.13	4.57
Mn, wt.%	0.020	0.002	0.016	0.023	0.014	0.025	10.05%	20.10%	30.15%	0.019	0.020
Mo, ppm	7.07	0.80	5.47	8.66	4.68	9.46	11.28%	22.56%	33.84%	6.72	7.42
Nb, ppm	19.5	1.31	16.8	22.1	15.5	23.4	6.73%	13.46%	20.19%	18.5	20.4
Nd, ppm	53	2.1	48	57	46	59	3.94%	7.89%	11.83%	50	55
Ni, ppm	70	9	52	87	43	96	12.66%	25.32%	37.97%	66	73
P, wt.%	0.052	0.005	0.042	0.061	0.038	0.066	9.11%	18.21%	27.32%	0.049	0.054
Pb, ppm	15.0	1.28	12.4	17.5	11.1	18.8	8.55%	17.09%	25.64%	14.2	15.7
Pr, ppm	14.4	0.97	12.5	16.4	11.5	17.3	6.74%	13.49%	20.23%	13.7	15.2
Rb, ppm	88	3.6	81	95	77	99	4.08%	8.15%	12.23%	83	92
Re, ppm	< 0.1	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
S, wt.%	1.18	0.060	1.06	1.30	1.00	1.36	5.12%	10.23%	15.35%	1.12	1.24
Sb, ppm	2.67	0.206	2.25	3.08	2.05	3.28	7.73%	15.46%	23.19%	2.53	2.80
Sc, ppm	11.1	0.76	9.6	12.6	8.8	13.4	6.83%	13.65%	20.48%	10.6	11.7
Si, wt.%	27.28	0.856	25.57	28.99	24.71	29.85	3.14%	6.28%	9.42%	25.92	28.65
Sm, ppm	7.70	0.419	6.86	8.54	6.44	8.96	5.44%	10.88%	16.33%	7.31	8.08
Sn, ppm	3.02	0.58	1.86	4.18	1.27	4.77	19.27%	38.55%	57.82%	2.87	3.17
Sr, ppm	78	4.0	70	86	66	90	5.05%	10.10%	15.16%	74	82
Ta, ppm	1.53	0.24	1.06	2.01	0.82	2.24	15.49%	30.98%	46.47%	1.46	1.61
Tb, ppm	0.96	0.060	0.84	1.08	0.78	1.14	6.22%	12.44%	18.66%	0.91	1.01
Th, ppm	13.7	0.40	12.9	14.5	12.5	14.9	2.93%	5.86%	8.80%	13.0	14.4
Ti, wt.%	0.374	0.012	0.349	0.399	0.337	0.412	3.33%	6.66%	9.99%	0.356	0.393
Tl, ppm	0.60	0.07	0.46	0.73	0.40	0.80	11.17%	22.35%	33.52%	0.57	0.63
Tm, ppm	0.49	0.029	0.43	0.54	0.40	0.57	5.90%	11.80%	17.70%	0.46	0.51
U, ppm	9.12	0.572	7.97	10.26	7.40	10.83	6.28%	12.55%	18.83%	8.66	9.57
V, ppm	214	11	192	235	182	246	4.99%	9.97%	14.96%	203	224
W, ppm	3.40	0.55	2.30	4.50	1.75	5.06	16.21%	32.42%	48.63%	3.23	3.57
Y, ppm	29.4	1.05	27.3	31.5	26.3	32.6	3.58%	7.16%	10.74%	27.9	30.9
Yb, ppm	3.13	0.188	2.76	3.51	2.57	3.70	6.00%	12.00%	18.00%	2.97	3.29

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

IND = indeterminate.

Note 1: intervals may appear asymmetric due to rounding.

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

Table 5 continued.

Constituent	Certified Value	Absolute Standard Deviations					Relative Standard Deviations			5 % window	
		1SD	2SD Low	2SD High	3SD Low	3SD High	1RSD	2RSD	3RSD	Low	High
Aqua Regia Digestion											
Ag, ppm	0.233	0.035	0.163	0.304	0.128	0.339	15.10%	30.19%	45.29%	0.221	0.245
Al, wt.%	1.31	0.111	1.09	1.53	0.98	1.64	8.45%	16.89%	25.34%	1.25	1.38
As, ppm	58	3.0	53	64	50	67	5.06%	10.13%	15.19%	55	61
Au, ppm	< 0.02	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
B, ppm	< 10	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Ba, ppm	103	14	75	132	61	146	13.64%	27.27%	40.91%	98	109
Be, ppm	1.63	0.134	1.36	1.90	1.23	2.03	8.23%	16.46%	24.70%	1.55	1.71
Bi, ppm	1.91	0.093	1.72	2.10	1.63	2.19	4.89%	9.78%	14.67%	1.81	2.00
Ca, wt.%	1.32	0.048	1.22	1.41	1.17	1.46	3.64%	7.29%	10.93%	1.25	1.38
Cd, ppm	0.20	0.013	0.17	0.22	0.16	0.24	6.86%	13.72%	20.58%	0.19	0.21
Ce, ppm	43.3	5.1	33.2	53.4	28.1	58.5	11.68%	23.37%	35.05%	41.1	45.5
Co, wt.%	0.131	0.012	0.107	0.154	0.096	0.166	8.93%	17.86%	26.79%	0.124	0.137
Cr, ppm	28.5	1.98	24.5	32.5	22.6	34.4	6.95%	13.91%	20.86%	27.1	29.9
Cs, ppm	0.45	0.07	0.31	0.60	0.24	0.67	15.66%	31.33%	46.99%	0.43	0.48
Cu, wt.%	1.82	0.033	1.75	1.88	1.72	1.92	1.82%	3.65%	5.47%	1.73	1.91
Dy, ppm	1.17	0.116	0.94	1.40	0.82	1.52	9.94%	19.88%	29.82%	1.11	1.23
Er, ppm	0.52	0.038	0.44	0.60	0.40	0.63	7.41%	14.81%	22.22%	0.49	0.54
Eu, ppm	0.39	0.05	0.29	0.49	0.24	0.54	12.51%	25.02%	37.54%	0.37	0.41
Fe, wt.%	2.46	0.070	2.32	2.60	2.25	2.67	2.85%	5.70%	8.55%	2.33	2.58
Ga, ppm	7.31	0.74	5.83	8.79	5.09	9.53	10.11%	20.22%	30.33%	6.95	7.68
Gd, ppm	2.19	0.174	1.84	2.54	1.67	2.71	7.94%	15.88%	23.82%	2.08	2.30
Hf, ppm	0.32	0.03	0.25	0.39	0.22	0.42	10.69%	21.38%	32.06%	0.30	0.34
Hg, ppm	0.047	0.010	0.028	0.066	0.019	0.076	20.20%	40.39%	60.59%	0.045	0.050
Ho, ppm	0.20	0.016	0.16	0.23	0.15	0.24	8.41%	16.83%	25.24%	0.19	0.21
In, ppm	0.63	0.035	0.56	0.70	0.52	0.73	5.58%	11.15%	16.73%	0.59	0.66
K, wt.%	0.205	0.021	0.164	0.246	0.143	0.267	10.07%	20.13%	30.20%	0.195	0.215
La, ppm	19.2	2.0	15.2	23.3	13.1	25.3	10.54%	21.09%	31.63%	18.3	20.2
Li, ppm	49.9	6.6	36.7	63.1	30.1	69.7	13.22%	26.43%	39.65%	47.4	52.4
Lu, ppm	0.065	0.006	0.054	0.077	0.048	0.083	8.86%	17.71%	26.57%	0.062	0.069
Mg, wt.%	3.53	0.167	3.20	3.87	3.03	4.03	4.72%	9.45%	14.17%	3.36	3.71
Mn, wt.%	0.018	0.001	0.016	0.020	0.015	0.020	4.70%	9.40%	14.11%	0.017	0.019
Mo, ppm	6.56	0.285	5.99	7.13	5.71	7.42	4.34%	8.67%	13.01%	6.24	6.89
Na, wt.%	0.010	0.001	0.007	0.012	0.006	0.014	13.92%	27.83%	41.75%	0.009	0.010
Nd, ppm	17.5	3.1	11.2	23.8	8.1	26.9	17.97%	35.93%	53.90%	16.6	18.4
Ni, ppm	60	2.3	55	65	53	67	3.82%	7.63%	11.45%	57	63
P, wt.%	0.039	0.002	0.035	0.044	0.032	0.046	5.94%	11.87%	17.81%	0.037	0.041
Pb, ppm	9.13	1.36	6.41	11.85	5.06	13.21	14.89%	29.77%	44.66%	8.68	9.59
Pr, ppm	4.68	0.81	3.05	6.31	2.23	7.12	17.42%	34.84%	52.26%	4.44	4.91
Rb, ppm	8.70	1.18	6.35	11.05	5.17	12.23	13.51%	27.02%	40.53%	8.27	9.14
Re, ppm	0.012	0.001	0.010	0.014	0.009	0.015	8.88%	17.76%	26.64%	0.011	0.012
S, wt.%	1.16	0.054	1.05	1.27	1.00	1.32	4.66%	9.31%	13.97%	1.10	1.22
Sb, ppm	1.62	0.29	1.04	2.20	0.75	2.49	17.92%	35.85%	53.77%	1.54	1.70
Sc, ppm	3.68	0.267	3.15	4.22	2.88	4.49	7.24%	14.49%	21.73%	3.50	3.87

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

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

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

Table 5 continued.

Constituent	Certified Value	Absolute Standard Deviations					Relative Standard Deviations			5 % window	
		1SD	2SD Low	2SD High	3SD Low	3SD High	1RSD	2RSD	3RSD	Low	High
Aqua Regia Digestion continued											
Se, ppm	3.50	0.40	2.70	4.31	2.30	4.71	11.45%	22.91%	34.36%	3.33	3.68
Sm, ppm	3.00	0.46	2.07	3.93	1.61	4.40	15.46%	30.92%	46.39%	2.85	3.15
Sn, ppm	0.83	0.045	0.74	0.92	0.70	0.97	5.41%	10.82%	16.23%	0.79	0.87
Sr, ppm	29.6	2.47	24.7	34.6	22.2	37.1	8.32%	16.65%	24.97%	28.2	31.1
Ta, ppm	< 0.01	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Tb, ppm	0.26	0.023	0.21	0.31	0.19	0.33	8.83%	17.66%	26.49%	0.25	0.27
Te, ppm	0.048	0.016	0.017	0.080	0.001	0.095	32.46%	64.92%	97.38%	0.046	0.051
Th, ppm	6.10	0.574	4.95	7.25	4.38	7.82	9.40%	18.81%	28.21%	5.80	6.41
U, ppm	4.61	0.290	4.03	5.19	3.74	5.48	6.29%	12.58%	18.88%	4.38	4.84
V, ppm	45.9	5.9	34.2	57.6	28.4	63.5	12.74%	25.48%	38.23%	43.6	48.2
W, ppm	1.00	0.19	0.63	1.37	0.45	1.56	18.47%	36.95%	55.42%	0.95	1.05
Y, ppm	4.55	0.305	3.94	5.16	3.63	5.46	6.71%	13.41%	20.12%	4.32	4.77
Yb, ppm	0.43	0.039	0.35	0.51	0.31	0.54	8.99%	17.97%	26.96%	0.41	0.45
Zn, ppm	22.9	1.53	19.8	25.9	18.3	27.5	6.69%	13.38%	20.07%	21.7	24.0
Zr, ppm	11.0	1.3	8.3	13.6	7.0	14.9	12.01%	24.02%	36.03%	10.4	11.5

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. CERTIMIN, Lima, Peru
11. ESAN Istanbul, Istanbul, Turkey
12. Inspectorate (BV), Lima, Peru
13. Intertek, Cupang, Muntinlupa, Philippines
14. Intertek, Perth, WA, Australia
15. Intertek, Townsville, QLD, Australia
16. Labwest Minerals Analysis, Perth, WA, Australia
17. PT Geoservices Ltd, Cikarang, Jakarta Raya, Indonesia
18. PT Intertek Utama Services, Jakarta Timur, DKI Jakarta, Indonesia
19. Saskatchewan Research Council, Saskatoon, Saskatchewan, Canada
20. SGS, Randfontein, Gauteng, South Africa
21. SGS Australia Mineral Services, Perth, WA, Australia
22. SGS Canada Inc., Vancouver, BC, Canada
23. SGS del Peru, Lima, Peru
24. Shiva Analyticals Ltd, Bangalore North, Karnataka, India
25. Skyline Assayers & Laboratories, Tucson, Arizona, USA
26. Stewart Assay & Environmental Laboratories LLC, Kara-Balta, Chüy, Kyrgyzstan

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

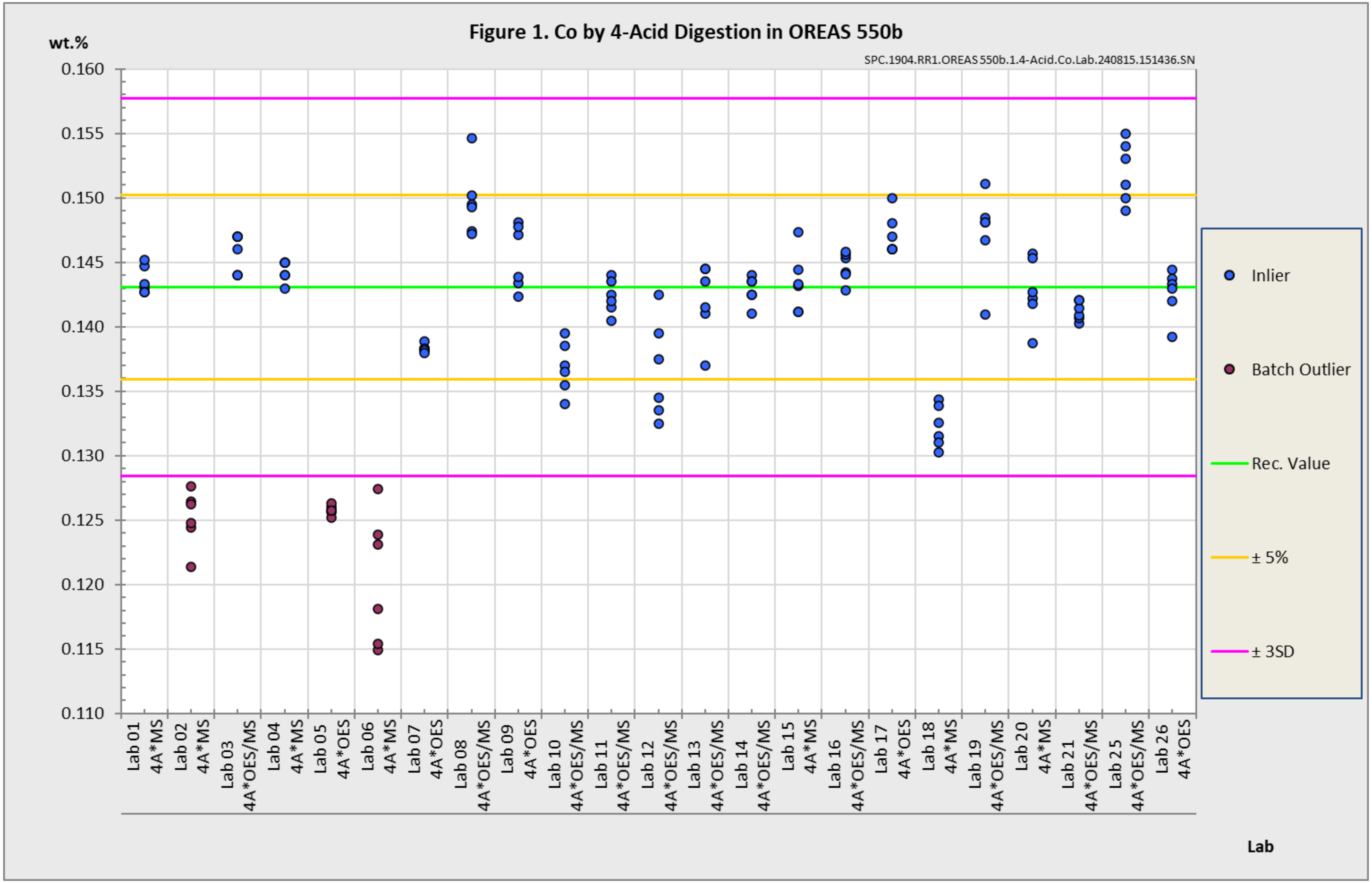
Figure 1. Co by 4-Acid Digestion in OREAS 550b
SPC.1904.RR1.OREAS 550b.1.4-Acid.Co.Lab.240815.151436.SN
wt.%
0.160
0.155
0.150
0.145
0.140
0.135
0.130
0.125
0.120
0.115
0.110
Lab 01 4A*MS
Lab 02 4A*MS
Lab 03 4A*OES/MS
Lab 04 4A*MS
Lab 05 4A*OES
Lab 06 4A*MS
Lab 07 4A*OES
Lab 08 4A*OES/MS
Lab 09 4A*OES
Lab 10 4A*OES/MS
Lab 11 4A*OES/MS
Lab 12 4A*OES/MS
Lab 13 4A*OES/MS
Lab 14 4A*OES/MS
Lab 15 4A*MS
Lab 16 4A*OES/MS
Lab 17 4A*OES
Lab 18 4A*MS
Lab 19 4A*OES/MS
Lab 20 4A*MS
Lab 21 4A*OES/MS
Lab 25 4A*OES/MS
Lab 26 4A*OES
Lab
Inlier
Batch Outlier
Rec. Value
± 5%
± 3SD

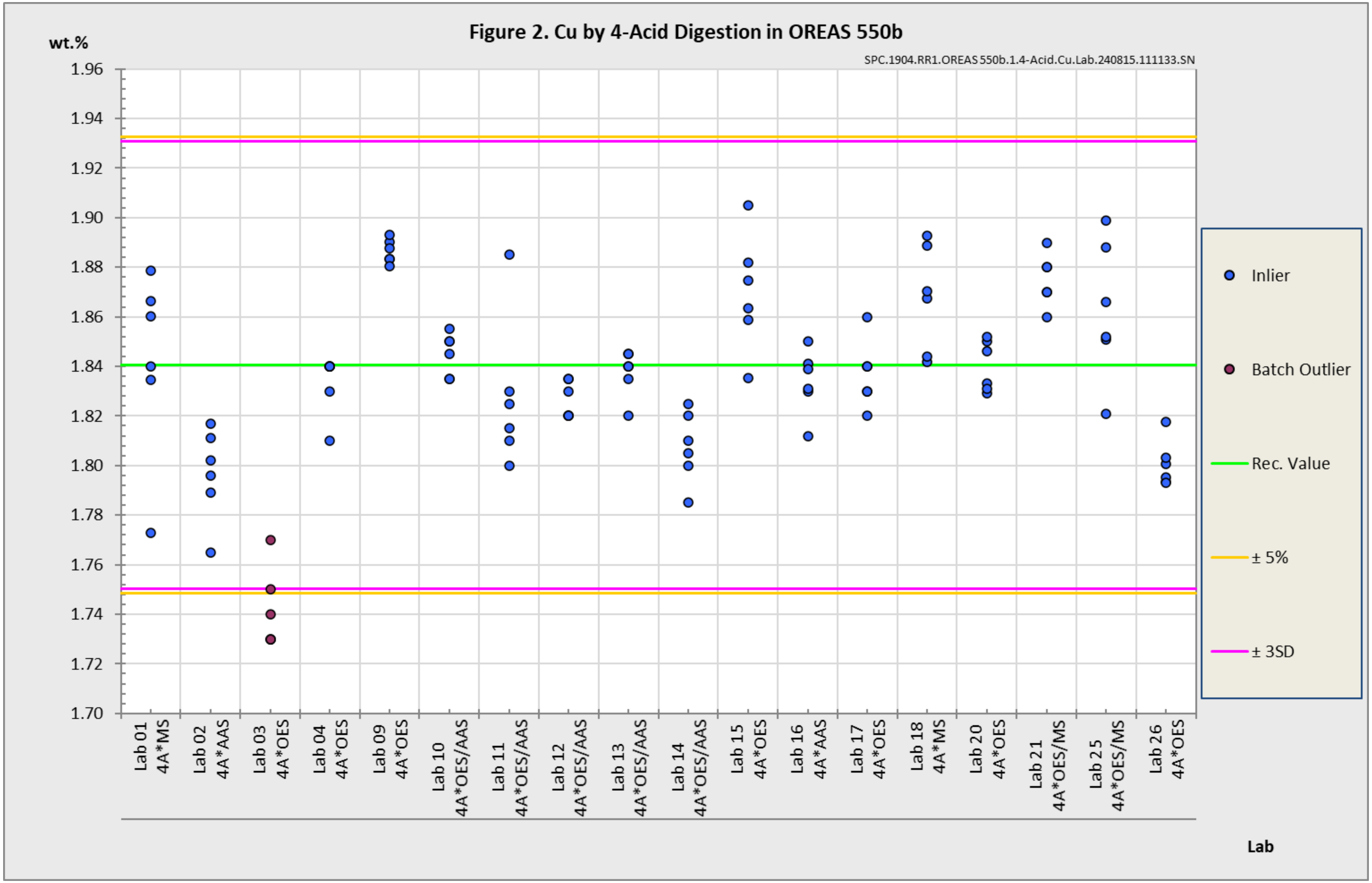

Figure 2. Cu by 4-Acid Digestion in OREAS 550b
wt.%
SPC.1904.RR1.OREAS 550b.1.4-Acid.Cu.Lab.240815.111133.SN
1.96
1.94
1.92
1.90
1.88
1.86
1.84
1.82
1.80
1.78
1.76
1.74
1.72
1.70
Lab 01 4A*MS
Lab 02 4A*AAS
Lab 03 4A*OES
Lab 04 4A*OES
Lab 09 4A*OES
Lab 10 4A*OES/AAS
Lab 11 4A*OES/AAS
Lab 12 4A*OES/AAS
Lab 13 4A*OES/AAS
Lab 14 4A*OES/AAS
Lab 15 4A*OES
Lab 16 4A*AAS
Lab 17 4A*OES
Lab 18 4A*MS
Lab 20 4A*OES
Lab 21 4A*OES/MS
Lab 25 4A*OES/MS
Lab 26 4A*OES
Lab
Inlier
Batch Outlier
Rec. Value
± 5%
± 3SD

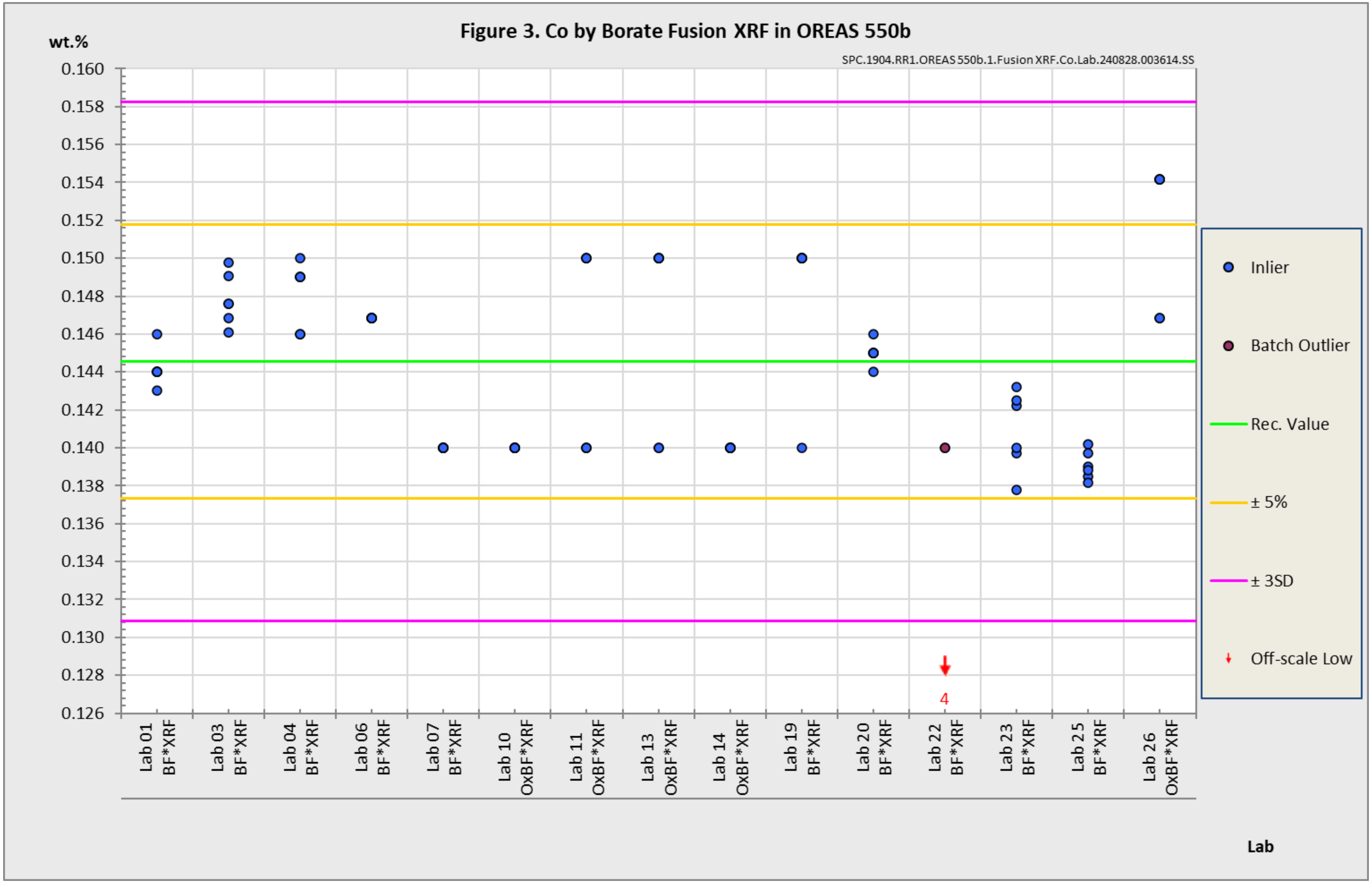

Figure 3. Co by Borate Fusion XRF in OREAS 550b
wt.%
SPC.1904.RR1.OREAS 550b.1.Fusion XRF.Co.Lab.240828.003614.SS
0.160
0.158
0.156
0.154
0.152
0.150
0.148
0.146
0.144
0.142
0.140
0.138
0.136
0.134
0.132
0.130
0.128
0.126
4
Lab 01 BF*XRF
Lab 03 BF*XRF
Lab 04 BF*XRF
Lab 06 BF*XRF
Lab 07 BF*XRF
Lab 10 OxBF*XRF
Lab 11 OxBF*XRF
Lab 13 OxBF*XRF
Lab 14 OxBF*XRF
Lab 19 BF*XRF
Lab 20 BF*XRF
Lab 22 BF*XRF
Lab 23 BF*XRF
Lab 25 BF*XRF
Lab 26 OxBF*XRF
Inlier
Batch Outlier
Rec. Value
± 5%
± 3SD
Off-scale Low
Lab

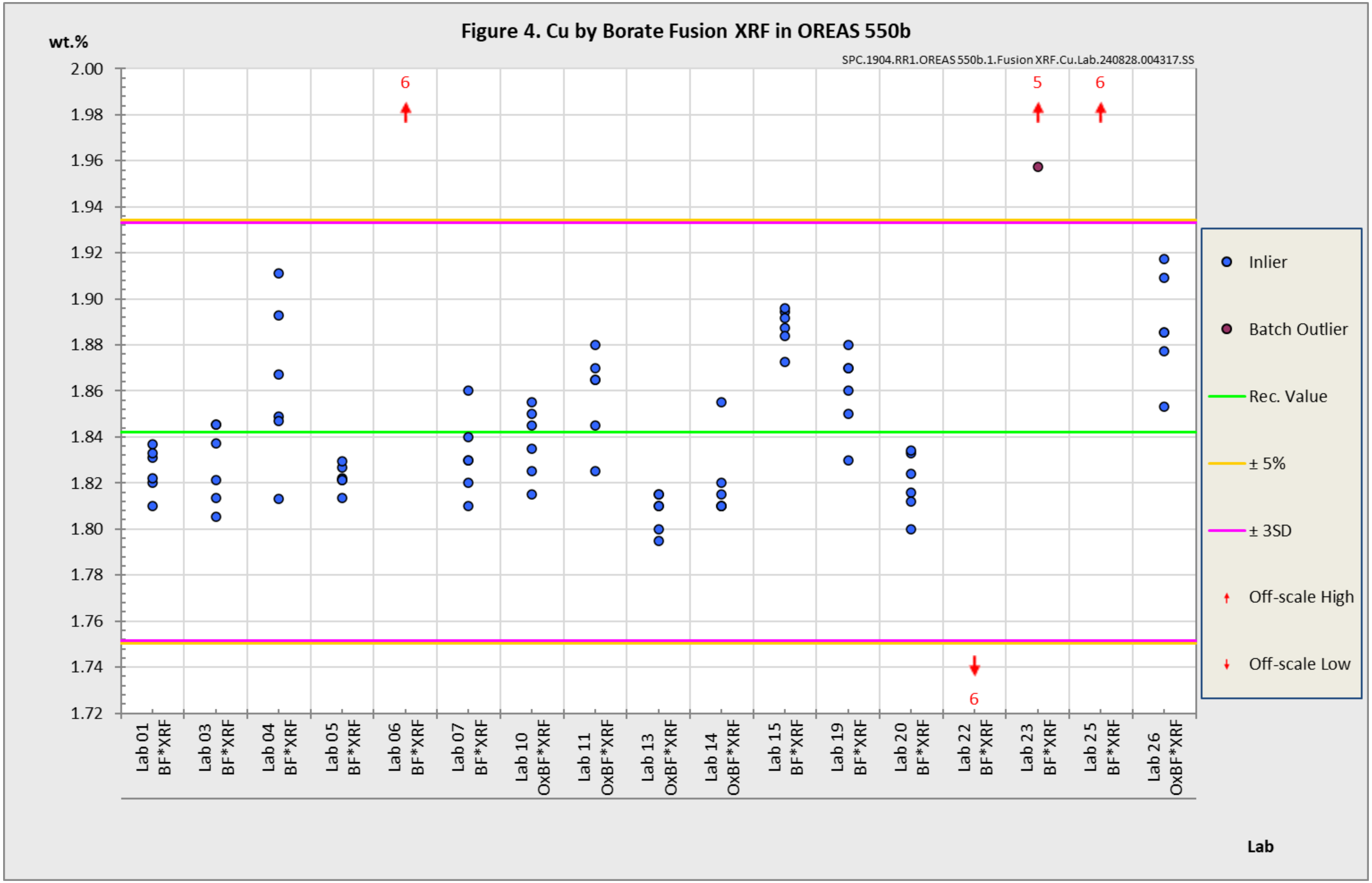

Figure 4. Cu by Borate Fusion XRF in OREAS 550b
wt.%
SPC.1904.RR1.OREAS 550b.1.Fusion XRF.Cu.Lab.240828.004317.SS
2.00
1.98
1.96
1.94
1.92
1.90
1.88
1.86
1.84
1.82
1.80
1.78
1.76
1.74
1.72
6
5
6
6
Lab 01 BF*XRF
Lab 03 BF*XRF
Lab 04 BF*XRF
Lab 05 BF*XRF
Lab 06 BF*XRF
Lab 07 BF*XRF
Lab 10 OxBF*XRF
Lab 11 OxBF*XRF
Lab 13 OxBF*XRF
Lab 14 OxBF*XRF
Lab 15 BF*XRF
Lab 19 BF*XRF
Lab 20 BF*XRF
Lab 22 BF*XRF
Lab 23 BF*XRF
Lab 25 BF*XRF
Lab 26 OxBF*XRF
Lab
Inlier
Batch Outlier
Rec. Value
± 5%
± 3SD
Off-scale High
Off-scale Low

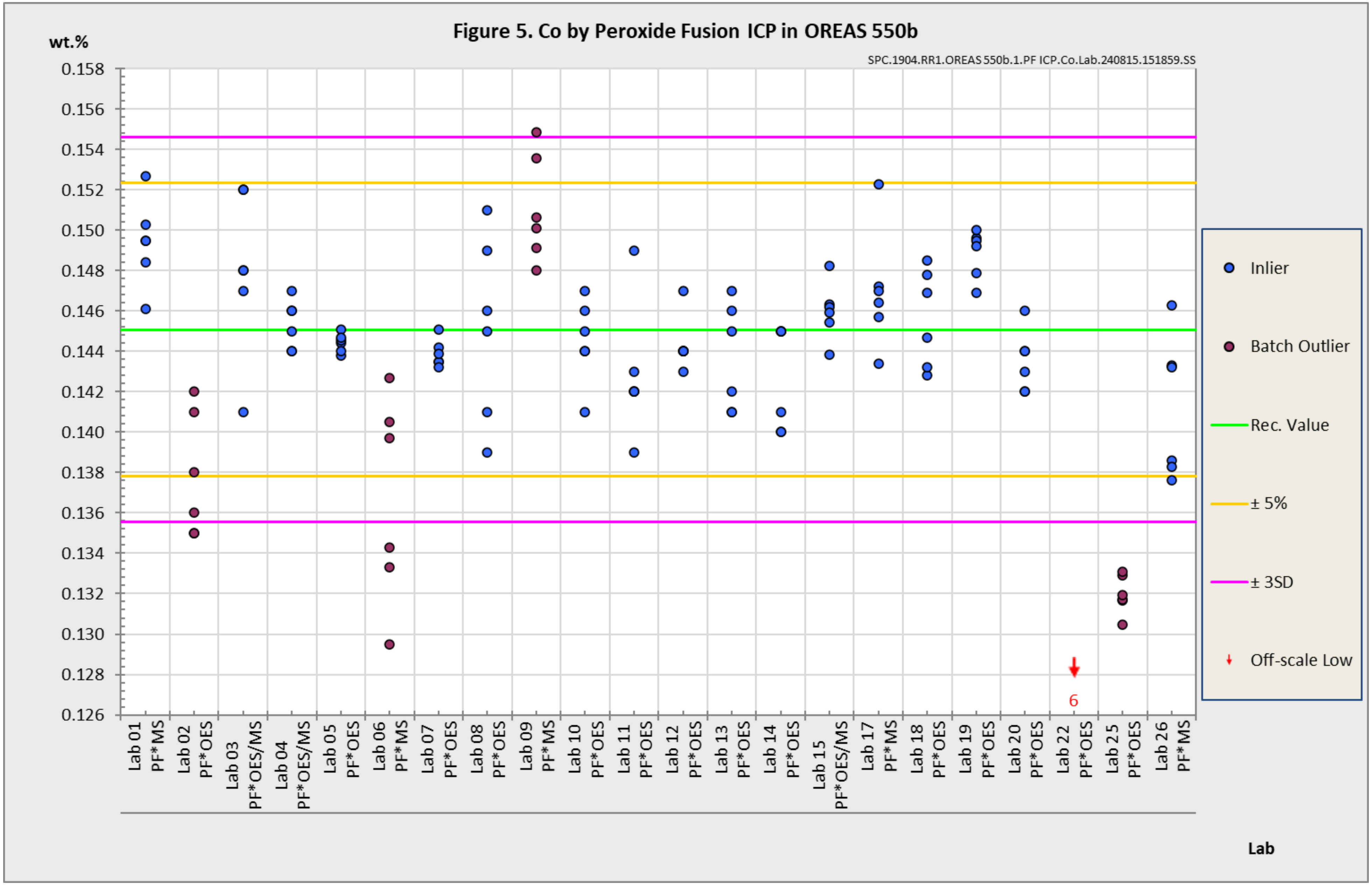

Figure 5. Co by Peroxide Fusion ICP in OREAS 550b
wt.%
SPC.1904.RR1.OREAS 550b.1.PF ICP.Co.Lab.240815.151859.SS
0.158
0.156
0.154
0.152
0.150
0.148
0.146
0.144
0.142
0.140
0.138
0.136
0.134
0.132
0.130
0.128
0.126
6
Lab 01 PF*MS
Lab 02 PF*OES
Lab 03 PF*OES/MS
Lab 04 PF*OES/MS
Lab 05 PF*OES
Lab 06 PF*MS
Lab 07 PF*OES
Lab 08 PF*OES
Lab 09 PF*MS
Lab 10 PF*OES
Lab 11 PF*OES
Lab 12 PF*OES
Lab 13 PF*OES
Lab 14 PF*OES
Lab 15 PF*OES/MS
Lab 17 PF*MS
Lab 18 PF*OES
Lab 19 PF*OES
Lab 20 PF*OES
Lab 22 PF*OES
Lab 25 PF*OES
Lab 26 PF*MS
Lab
Inlier
Batch Outlier
Rec. Value
± 5%
± 3SD
Off-scale Low

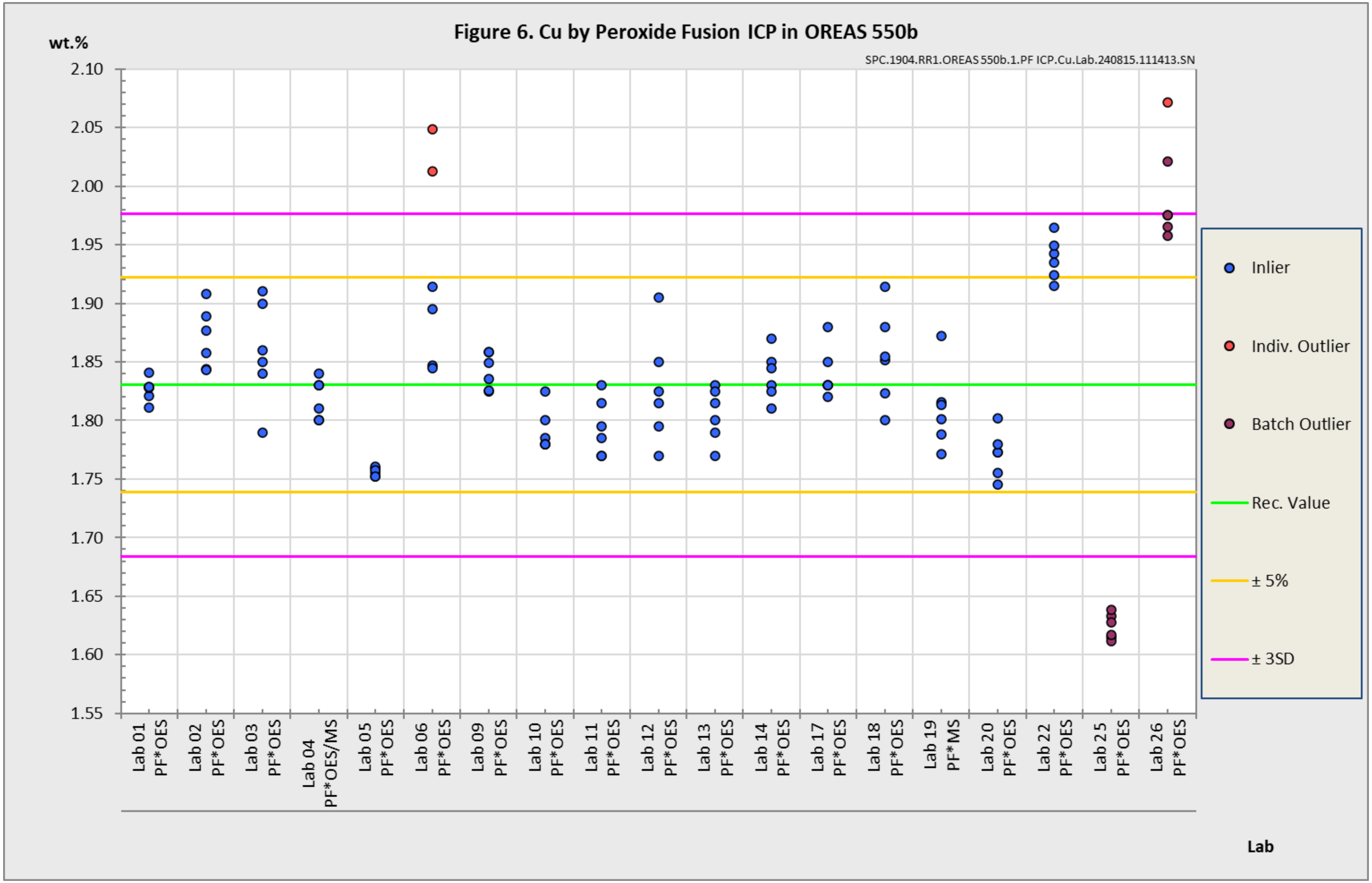

Figure 6. Cu by Peroxide Fusion ICP in OREAS 550b
SPC.1904.RR1.OREAS 550b.1.PF ICP.Cu.Lab.240815.111413.SN
wt.%
2.10
2.05
2.00
1.95
1.90
1.85
1.80
1.75
1.70
1.65
1.60
1.55
Lab 01 PF*OES
Lab 02 PF*OES
Lab 03 PF*OES
Lab 04 PF*OES/MS
Lab 05 PF*OES
Lab 06 PF*OES
Lab 09 PF*OES
Lab 10 PF*OES
Lab 11 PF*OES
Lab 12 PF*OES
Lab 13 PF*OES
Lab 14 PF*OES
Lab 17 PF*OES
Lab 18 PF*OES
Lab 19 PF*MS
Lab 20 PF*OES
Lab 22 PF*OES
Lab 25 PF*OES
Lab 26 PF*OES
Lab
Inlier
Indiv. Outlier
Batch Outlier
Rec. Value
± 5%
± 3SD

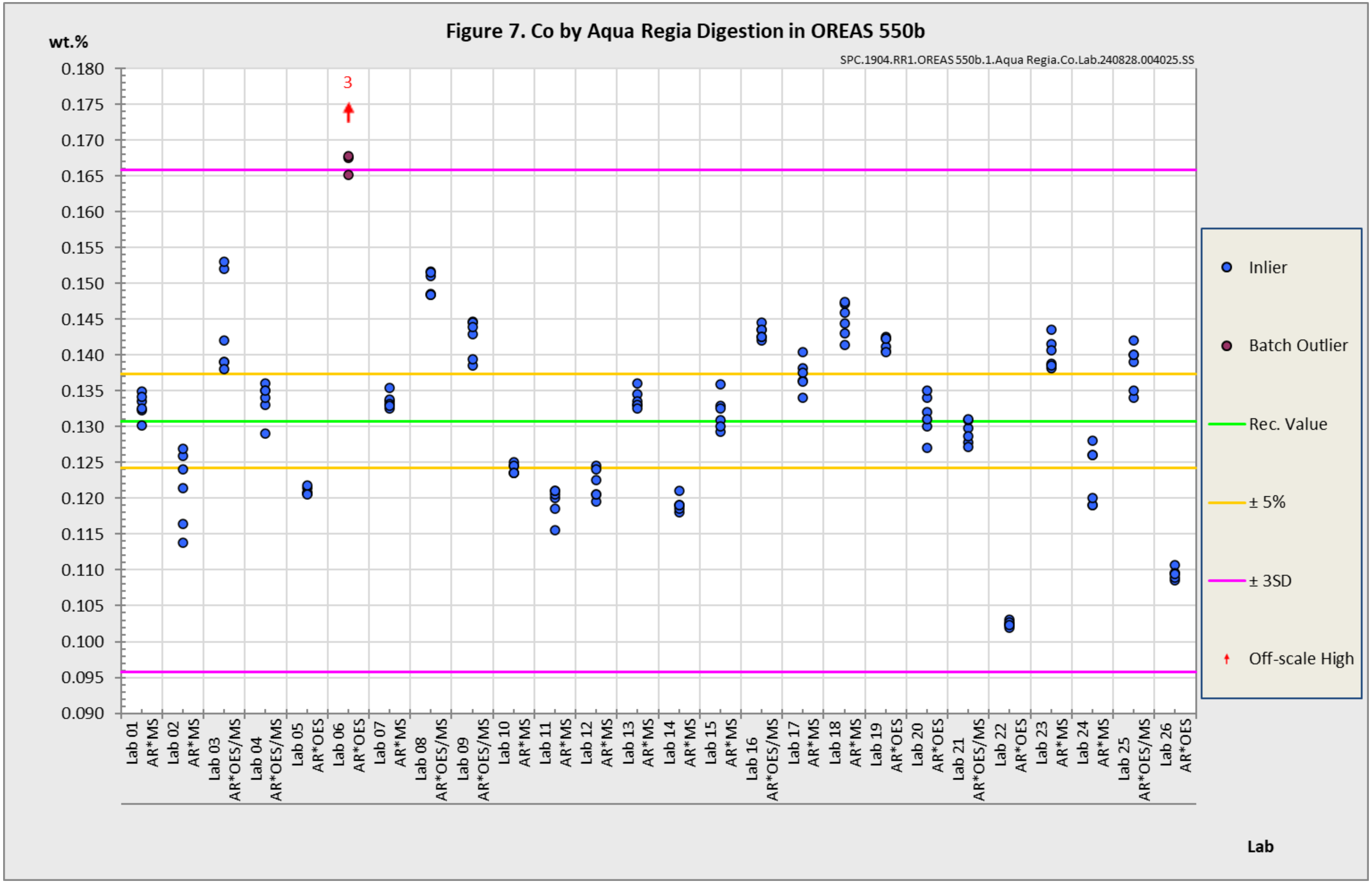

Figure 7. Co by Aqua Regia Digestion in OREAS 550b
wt.%
SPC.1904.RR1.OREAS 550b.1.Aqua Regia.Co.Lab.240828.004025.SS
0.180
0.175
0.170
0.165
0.160
0.155
0.150
0.145
0.140
0.135
0.130
0.125
0.120
0.115
0.110
0.105
0.100
0.095
0.090
3
Lab 01 AR*MS
Lab 02 AR*MS
Lab 03 AR*OES/MS
Lab 04 AR*OES/MS
Lab 05 AR*OES
Lab 06 AR*OES
Lab 07 AR*MS
Lab 08 AR*OES/MS
Lab 09 AR*OES/MS
Lab 10 AR*MS
Lab 11 AR*MS
Lab 12 AR*MS
Lab 13 AR*MS
Lab 14 AR*MS
Lab 15 AR*MS
Lab 16 AR*OES/MS
Lab 17 AR*MS
Lab 18 AR*MS
Lab 19 AR*OES
Lab 20 AR*OES
Lab 21 AR*OES/MS
Lab 22 AR*OES
Lab 23 AR*MS
Lab 24 AR*MS
Lab 25 AR*OES/MS
Lab 26 AR*OES
Inlier
Batch Outlier
Rec. Value
± 5%
± 3SD
Off-scale High
Lab

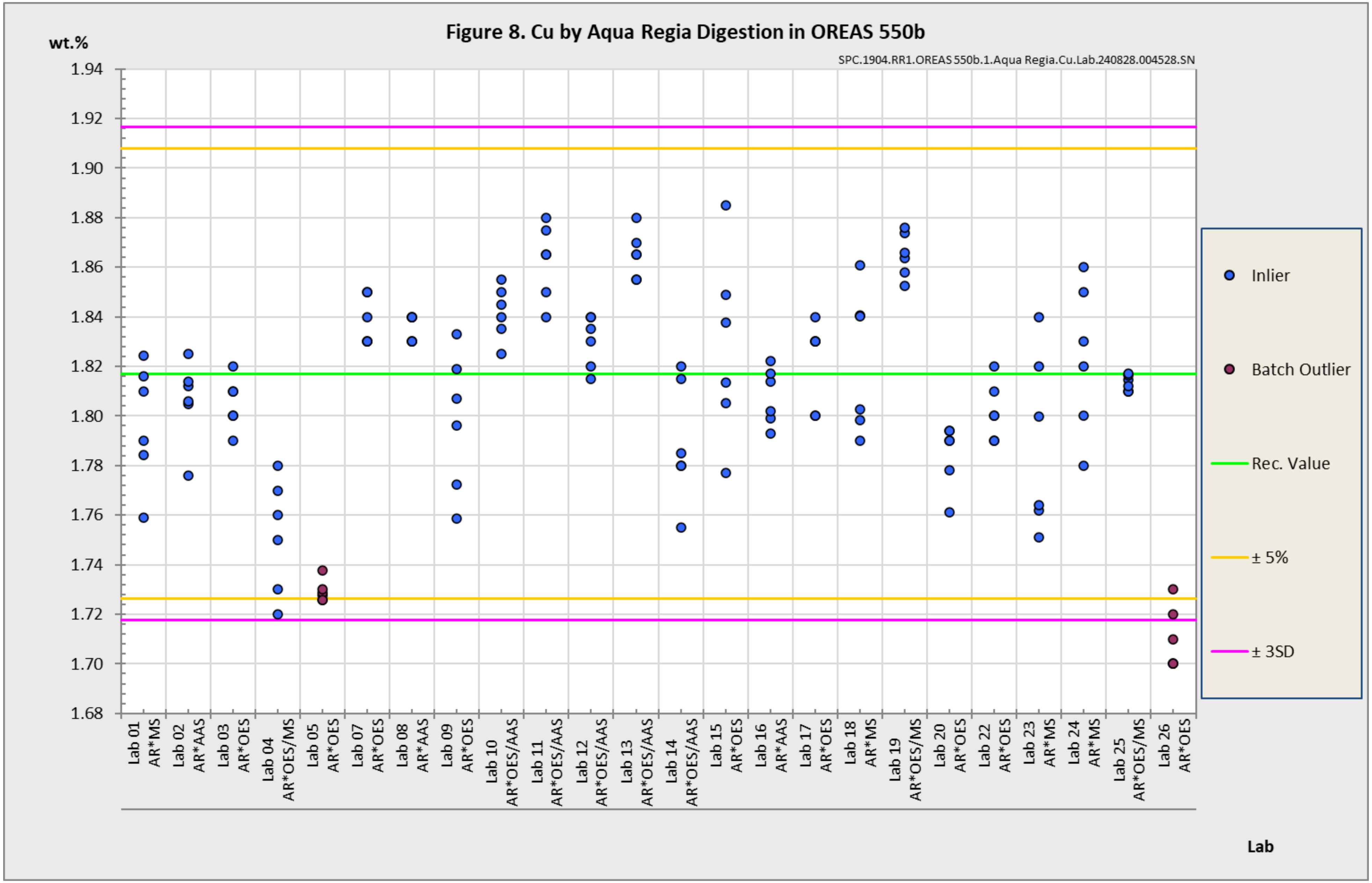
Figure 8. Cu by Aqua Regia Digestion in OREAS 550b
SPC.1904.RR1.OREAS 550b.1.Aqua Regia.Cu.Lab.240828.004528.SN
wt.%
1.94
1.92
1.90
1.88
1.86
1.84
1.82
1.80
1.78
1.76
1.74
1.72
1.70
1.68
Lab 01 AR*MS
Lab 02 AR*AAS
Lab 03 AR*OES
Lab 04 AR*OES/MS
Lab 05 AR*OES
Lab 07 AR*OES
Lab 08 AR*AAS
Lab 09 AR*OES
Lab 10 AR*OES/AAS
Lab 11 AR*OES/AAS
Lab 12 AR*OES/AAS
Lab 13 AR*OES/AAS
Lab 14 AR*OES/AAS
Lab 15 AR*OES
Lab 16 AR*AAS
Lab 17 AR*OES
Lab 18 AR*MS
Lab 19 AR*OES/MS
Lab 20 AR*OES
Lab 22 AR*OES
Lab 23 AR*MS
Lab 24 AR*MS
Lab 25 AR*OES/MS
Lab 26 AR*OES
Inlier
Batch Outlier
Rec. Value
± 5%
± 3SD
Lab

PREPARER AND SUPPLIER

Certified reference material OREAS 550b is prepared, certified and supplied by:

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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 Guide 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 550b 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 550b may be used to calibrate the entire procedure by producing a pure substance CRM transformed into a calibration solution.

OREAS 550b 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 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;
- Cu and Co by 5 % sulphuric acid leach with ICP or AAS finish: 0.5 g;
- C and S by infrared combustion furnace/CS analyser: ≥ 0.1 g;
- Lithium borate fusion with X-ray fluorescence finish: ≥ 0.2 g;
- Loss on Ignition (LOI) at 1000 °C: ≥ 1 g;
- Sodium peroxide fusion with ICP-OES and/or MS finish: ≥ 0.2 g;
- Aqua regia digestion with ICP-OES and/or MS finish: ≥ 0.5 g.

PERIOD OF VALIDITY & STORAGE INSTRUCTIONS

The certification of OREAS 550b remains valid, within the specified measurement uncertainties, until at least March 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

Following analysis of the CRM subsample it is the manufacturers' expectation that any remaining material is discarded. The stability of the material after opening the sachet is not within the scope of proper use. However, if opened sachets are resealed after opening, then under ordinary* storage conditions the CRM will have a shelf-life beyond ten years.

**ordinary storage conditions: means storage not in direct sunlight in a dry, clean, well-ventilated area at temperatures between -5 °C and 50 °C.*

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.

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.

For use with the aqua regia digestion method

It is important to note that in the analytical industry there is no standardisation of the aqua regia digestion process. This method is a partial empirical digest and differences in recoveries for various analytes are commonplace. These are caused by variations in the digest conditions and can include the ratio of nitric to hydrochloric acids, acid strength, temperatures, leach times and secondary digestions. Recoveries for sulphide-hosted base metal sulphides approach total values, however, other analytes, in particular the lithophile elements, show greater sensitivity to method parameters. This can result in lack of consensus in an inter-laboratory certification program for these elements.

The approach applied here is to report certified values in those instances where reasonable agreement exists amongst a majority of participating laboratories. The results of specific laboratories may differ significantly from the certified values, but will, nonetheless, be valid and reproducible in the context of the specifics of the aqua regia method in use. Users of this reference material should, therefore, be mindful of this limitation when applying the certified values in a quality control program.

LEGAL NOTICE

Ore Research & Exploration Pty Ltd has prepared and statistically evaluated the property values of this reference material to the best of its ability. The Purchaser by receipt hereof releases and indemnifies Ore Research & Exploration Pty Ltd from and against all liability and costs arising from the use of this material and information.

DOCUMENT HISTORY

Revision No.	Date	Changes applied
0	12th November, 2024	First publication.

CERTIFYING OFFICER

12th November, 2024

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

QMS CERTIFICATION

ORE Pty Ltd is accredited for compliance with ISO 17034:2016.

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 Guide 33401:2024-01. Reference materials – Contents of certificates, labels and accompanying documentation.

[4] ISO Guide 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.

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

[13] OREAS-TN-05-1674: Long-term storage stability; an experimental study of OREAS CRMs.

[14] Thompson, A.; Taylor, B.N. (2008); Guide for the Use of the International System of Units (SI); NIST Special Publication 811; U.S. Government Printing Office: Washington, DC; available at: https://physics.nist.gov/cuu/pdf/sp811.pdf (accessed Nov 2021).

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

APPENDIX

For Cu and Co by sulphuric acid leach, a specific methodology was detailed for the participating laboratories to follow:

5 % sulphuric acid leach

1. Weigh 0.500 ± 0.002 g of sample pulp into a clean 250 mL flask.
2. Add to the flask 0.5 g of Sodium Sulphite (AR Grade).
3. Add 50 mL of approximately 55 g/L Sulphuric acid solution (prepared from a 98 % pure concentrated sulphuric acid).
4. Put the cap on the flask and start automatic shaking. Leave the sample on continuous shaking to leach for four (4) hours.
5. Remove the cap and add 25 mL of hydrochloric acid.
6. Dilute to a final volume of 250 mL with distilled/deionised water up to the mark and mix again by inverting at least 10 times. Allow the solution to settle for 30 minutes.

The solution is now ready to be analysed by ICP or AAS