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CERTIFICATE OF ANALYSIS FOR

CERTIFIED REFERENCE MATERIAL

OREAS 555b

Copper-Cobalt Ore (Kinsevere Mine, Katanga Province, Democratic Republic of the Congo)

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Constituent	Certified Value†	95% Expanded Uncertainty		95% Tolerance Limits	
		Low	High	Low	High
4-Acid Digestion					
Ag, Silver (ppm)	0.098	0.073	0.123	IND	IND
Al, Aluminium (wt.%)	6.40	6.29	6.52	6.27	6.53
As, Arsenic (ppm)	64	61	67	61	67
Ba, Barium (ppm)	254	245	264	248	260
Be, Beryllium (ppm)	4.76	4.61	4.90	4.60	4.92
Bi, Bismuth (ppm)	1.48	1.41	1.54	1.44	1.52
Ca, Calcium (wt.%)	0.145	0.138	0.151	0.140	0.149
Cd, Cadmium (ppm)	0.46	0.42	0.49	0.43	0.48
Ce, Cerium (ppm)	148	142	155	144	153
Co, Cobalt (wt.%)	1.10	1.07	1.13	1.08	1.13
Cr, Chromium (ppm)	93	89	97	90	97
Cs, Caesium (ppm)	2.03	1.94	2.12	1.97	2.10
Cu, Copper (wt.%)	4.58	4.47	4.69	4.50	4.67
Dy, Dysprosium (ppm)	4.68	4.02	5.34	4.41	4.95
Er, Erbium (ppm)	2.76	2.39	3.12	2.60	2.92
Eu, Europium (ppm)	0.91	0.86	0.97	0.86	0.97
Fe, Iron (wt.%)	3.83	3.73	3.94	3.76	3.90
Ga, Gallium (ppm)	28.4	27.2	29.5	27.7	29.1
Gd, Gadolinium (ppm)	5.18	4.42	5.93	4.91	5.44
Ge, Germanium (ppm)	0.20	0.16	0.24	0.17	0.22
Hf, Hafnium (ppm)	5.37	5.14	5.60	5.19	5.55
Ho, Holmium (ppm)	0.90	0.79	1.01	0.85	0.95
In, Indium (ppm)	2.51	2.35	2.66	2.42	2.59
K, Potassium (wt.%)	2.54	2.48	2.60	2.48	2.60
La, Lanthanum (ppm)	72	68	75	70	74
Li, Lithium (ppm)	59	58	61	58	61
Lu, Lutetium (ppm)	0.44	0.41	0.48	0.42	0.46
Mg, Magnesium (wt.%)	3.07	2.99	3.15	3.00	3.14
Mn, Manganese (wt.%)	0.089	0.085	0.093	0.087	0.091
Mo, Molybdenum (ppm)	17.1	16.4	17.8	16.6	17.6
Na, Sodium (wt.%)	0.052	0.049	0.055	0.049	0.055
Nb, Niobium (ppm)	17.1	14.9	19.3	16.5	17.6
Nd, Neodymium (ppm)	64	62	66	62	66
Ni, Nickel (ppm)	220	212	229	214	226
P, Phosphorus (wt.%)	0.035	0.033	0.036	0.033	0.036
Pb, Lead (ppm)	13.6	12.8	14.4	13.2	14.0

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

†This operationally defined measurand meets the requirements of ISO 17034 and all participating laboratories comply with the requirements of ISO 17025.

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					
Pr, Praseodymium (ppm)	16.9	15.8	18.0	16.5	17.4
Rb, Rubidium (ppm)	94	89	100	91	98
Re, Rhenium (ppm)	0.030	0.027	0.033	0.027	0.033
S, Sulphur (wt.%)	4.39	4.29	4.50	4.31	4.47
Sb, Antimony (ppm)	3.72	3.50	3.94	3.56	3.88
Sc, Scandium (ppm)	12.6	12.0	13.2	12.2	13.0
Se, Selenium (ppm)	6.97	5.99	7.95	6.55	7.39
Sm, Samarium (ppm)	8.87	8.25	9.50	8.51	9.24
Sn, Tin (ppm)	2.99	2.79	3.19	2.85	3.13
Sr, Strontium (ppm)	70	67	72	68	71
Ta, Tantalum (ppm)	1.19	1.05	1.33	1.14	1.25
Tb, Terbium (ppm)	0.81	0.65	0.98	0.77	0.86
Te, Tellurium (ppm)	0.060	0.024	0.096	IND	IND
Th, Thorium (ppm)	16.0	15.3	16.7	15.4	16.5
Ti, Titanium (wt.%)	0.274	0.237	0.311	0.265	0.282
Tl, Thallium (ppm)	0.99	0.94	1.03	0.96	1.02
Tm, Thulium (ppm)	0.42	0.36	0.48	0.40	0.44
U, Uranium (ppm)	9.24	8.69	9.78	8.99	9.49
V, Vanadium (ppm)	357	344	369	349	365
W, Tungsten (ppm)	2.78	2.60	2.96	2.68	2.88
Y, Yttrium (ppm)	24.4	23.4	25.5	23.7	25.1
Yb, Ytterbium (ppm)	2.88	2.61	3.16	2.76	3.01
Zn, Zinc (ppm)	29.0	27.5	30.5	27.7	30.3
Zr, Zirconium (ppm)	188	183	193	183	193
Aqua Regia Digestion					
Ag, Silver (ppm)	0.076	0.060	0.091	IND	IND
Al, Aluminium (wt.%)	0.959	0.868	1.049	0.922	0.995
As, Arsenic (ppm)	62	59	64	60	63
Au, Gold (ppm)	< 0.02	IND	IND	IND	IND
B, Boron (ppm)	< 10	IND	IND	IND	IND
Ba, Barium (ppm)	57	51	62	55	59
Be, Beryllium (ppm)	2.21	2.05	2.37	2.14	2.28
Bi, Bismuth (ppm)	1.39	1.33	1.45	1.35	1.42
Ca, Calcium (wt.%)	0.137	0.129	0.144	0.134	0.140
Cd, Cadmium (ppm)	0.46	0.42	0.51	0.44	0.49
Ce, Cerium (ppm)	43.7	39.5	47.8	42.0	45.4

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

†This operationally defined measurand meets the requirements of ISO 17034 and all participating laboratories comply with the requirements of ISO 17025.

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
Aqua Regia Digestion continued					
Co, Cobalt (wt.%)	1.08	1.04	1.11	1.05	1.10
Cr, Chromium (ppm)	35.2	33.3	37.2	34.2	36.3
Cs, Caesium (ppm)	0.32	0.27	0.38	0.31	0.34
Cu, Copper (wt.%)	4.57	4.50	4.64	4.51	4.63
Dy, Dysprosium (ppm)	1.00	0.85	1.14	0.96	1.03
Er, Erbium (ppm)	0.41	0.29	0.52	0.38	0.43
Eu, Europium (ppm)	0.39	0.34	0.44	0.36	0.41
Fe, Iron (wt.%)	3.66	3.56	3.77	3.58	3.75
Ga, Gallium (ppm)	8.22	7.45	9.00	7.92	8.52
Gd, Gadolinium (ppm)	2.03	1.82	2.23	1.90	2.15
Ge, Germanium (ppm)	0.095	0.066	0.125	IND	IND
Hf, Hafnium (ppm)	0.33	0.30	0.36	0.31	0.35
Hg, Mercury (ppm)	0.060	0.044	0.076	IND	IND
Ho, Holmium (ppm)	0.17	0.13	0.21	IND	IND
In, Indium (ppm)	1.83	1.75	1.90	1.79	1.86
K, Potassium (wt.%)	0.196	0.180	0.212	0.182	0.210
La, Lanthanum (ppm)	20.4	18.9	21.9	19.4	21.3
Li, Lithium (ppm)	35.3	31.7	39.0	34.0	36.7
Mg, Magnesium (wt.%)	2.42	2.30	2.53	2.36	2.48
Mn, Manganese (wt.%)	0.089	0.085	0.092	0.086	0.091
Mo, Molybdenum (ppm)	16.2	15.7	16.8	15.9	16.6
Na, Sodium (wt.%)	0.011	0.009	0.012	0.010	0.011
Nb, Niobium (ppm)	0.094	0.074	0.114	IND	IND
Nd, Neodymium (ppm)	23.0	18.7	27.2	21.4	24.6
Ni, Nickel (ppm)	214	206	221	208	219
P, Phosphorus (wt.%)	0.020	0.019	0.021	0.019	0.021
Pb, Lead (ppm)	10.9	10.3	11.5	10.6	11.2
Pr, Praseodymium (ppm)	5.43	3.81	7.05	5.23	5.64
Rb, Rubidium (ppm)	6.50	5.76	7.23	6.09	6.90
Re, Rhenium (ppm)	0.027	0.024	0.029	0.025	0.028
S, Sulphur (wt.%)	4.31	4.19	4.43	4.22	4.40
Sb, Antimony (ppm)	2.17	1.92	2.41	2.05	2.28
Sc, Scandium (ppm)	3.30	3.02	3.57	3.13	3.46
Se, Selenium (ppm)	6.70	6.08	7.32	6.48	6.92
Sm, Samarium (ppm)	3.51	2.80	4.22	3.31	3.71
Sn, Tin (ppm)	1.54	1.42	1.65	1.47	1.60

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

†This operationally defined measurand meets the requirements of ISO 17034 and all participating laboratories comply with the requirements of ISO 17025.

Note: intervals may appear asymmetric due to rounding; IND = indeterminate (due to limited reading resolution of the methods employed).

Table 1 continued.

Constituent	Certified Value†	95% Expanded Uncertainty		95% Tolerance Limits	
		Low	High	Low	High
Aqua Regia Digestion continued					
Sr, Strontium (ppm)	15.1	13.7	16.5	14.4	15.8
Ta, Tantalum (ppm)	< 0.01	IND	IND	IND	IND
Tb, Terbium (ppm)	0.21	0.16	0.25	0.19	0.22
Te, Tellurium (ppm)	0.054	0.033	0.074	IND	IND
Th, Thorium (ppm)	6.32	5.77	6.87	6.00	6.64
U, Uranium (ppm)	3.49	3.31	3.67	3.36	3.62
V, Vanadium (ppm)	62	58	67	60	64
W, Tungsten (ppm)	1.08	0.99	1.18	1.02	1.15
Y, Yttrium (ppm)	3.94	3.67	4.20	3.79	4.09
Yb, Ytterbium (ppm)	0.32	0.21	0.42	0.30	0.34
Zn, Zinc (ppm)	26.6	25.3	27.9	25.6	27.6
Zr, Zirconium (ppm)	10.1	9.3	10.9	9.7	10.5

SI unit equivalents: ppm (parts per million; 1 x 10^{-6}) ≡ mg/kg. Note: intervals may appear asymmetric due to rounding.

†This operationally defined measurand meets the requirements of ISO 17034 and all participating laboratories comply with the requirements of ISO 17025.

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

Table 2. Certified Value, Uncertainty & Tolerance Intervals for other measurands in OREAS 555b.

Constituent	Certified Value	95% Expanded Uncertainty		95% Tolerance Limits	
		Low	High	Low	High
Borate Fusion XRF					
Al_2O_3, Aluminium(III) oxide (wt.%)	12.39	12.26	12.51	12.27	12.51
BaO, Barium oxide (ppm)	316	257	376	298	334
CaO, Calcium oxide (wt.%)	0.201	0.194	0.209	0.193	0.210
Co, Cobalt (wt.%)	1.08	1.06	1.11	1.07	1.10
Cu, Copper (wt.%)	4.57	4.47	4.68	4.52	4.62
Fe_2O_3, Iron(III) oxide (wt.%)	5.55	5.45	5.65	5.50	5.61
K_2O, Potassium oxide (wt.%)	3.08	3.04	3.11	3.05	3.11
MgO, Magnesium oxide (wt.%)	5.13	5.07	5.20	5.08	5.18
MnO, Manganese oxide (wt.%)	0.117	0.110	0.123	0.114	0.120
Ni, Nickel (ppm)	233	198	267	214	252
P_2O_5, Phosphorus(V) oxide (wt.%)	0.083	0.080	0.087	0.082	0.085
SiO_2, Silicon dioxide (wt.%)	51.77	51.31	52.23	51.42	52.12
SO_3, Sulphur trioxide (wt.%)	11.05	10.56	11.55	10.93	11.17
Sr, Strontium (ppm)	67	47	87	IND	IND
TiO_2, Titanium dioxide (wt.%)	0.789	0.765	0.812	0.773	0.804
V_2O_5, Vanadium(V) oxide (ppm)	692	631	753	641	742
Zr, Zirconium (ppm)	238	227	249	IND	IND

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

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

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
Thermogravimetry					
LOI[1000], Loss On Ignition @1000°C (wt.%)	12.92	12.75	13.09	12.83	13.01
Infrared Combustion					
C, Carbon (wt.%)	4.53	4.43	4.63	4.49	4.57
S, Sulphur (wt.%)	4.48	4.40	4.57	4.44	4.52
Sulphuric Acid 5% Leach					
Co, Cobalt (wt.%)	0.432	0.388	0.475	0.410	0.454
Cu, Copper (wt.%)	1.19	1.15	1.23	1.17	1.21
Peroxide Fusion ICP					
Al, Aluminium (wt.%)	6.42	6.28	6.56	6.35	6.49
As, Arsenic (ppm)	66	58	73	64	68
B, Boron (ppm)	232	209	254	220	244
Ba, Barium (ppm)	259	248	270	251	266
Be, Beryllium (ppm)	5.33	4.64	6.01	IND	IND
Bi, Bismuth (ppm)	1.56	1.28	1.83	IND	IND
Ca, Calcium (wt.%)	0.143	0.124	0.162	0.130	0.156
Ce, Cerium (ppm)	161	140	182	146	176
Co, Cobalt (wt.%)	1.11	1.07	1.15	1.07	1.14
Cr, Chromium (ppm)	112	99	125	105	118
Cs, Caesium (ppm)	2.26	1.98	2.53	2.06	2.46
Cu, Copper (wt.%)	4.57	4.45	4.68	4.51	4.62
Dy, Dysprosium (ppm)	6.70	6.15	7.25	6.24	7.15
Er, Erbium (ppm)	3.83	3.52	4.13	3.59	4.06
Eu, Europium (ppm)	0.97	0.86	1.07	0.91	1.02
Fe, Iron (wt.%)	3.87	3.76	3.98	3.81	3.93
Ga, Gallium (ppm)	29.1	27.8	30.4	27.7	30.6
Gd, Gadolinium (ppm)	7.26	6.36	8.15	6.70	7.82
Ge, Germanium (ppm)	2.01	1.95	2.06	IND	IND
Ho, Holmium (ppm)	1.38	1.21	1.55	1.28	1.48
In, Indium (ppm)	2.47	2.18	2.76	2.34	2.59
K, Potassium (wt.%)	2.58	2.47	2.69	2.52	2.64
La, Lanthanum (ppm)	77	71	82	72	81
Li, Lithium (ppm)	60	56	64	58	62
Lu, Lutetium (ppm)	0.58	0.44	0.71	0.52	0.63
Mg, Magnesium (wt.%)	3.09	3.00	3.19	3.04	3.15
Mn, Manganese (wt.%)	0.093	0.088	0.097	0.090	0.095
Mo, Molybdenum (ppm)	17.3	15.5	19.1	16.5	18.1
Nb, Niobium (ppm)	25.4	24.0	26.8	23.7	27.1

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

Note: intervals may appear asymmetric due to rounding; IND = indeterminate (due to limited reading resolution of the methods employed).

Table 2 continued.

Constituent	Certified Value	95% Expanded Uncertainty		95% Tolerance Limits	
		Low	High	Low	High
Peroxide Fusion ICP continued					
Nd, Neodymium (ppm)	68	63	72	63	72
Ni, Nickel (ppm)	228	214	243	219	237
P, Phosphorus (wt.%)	0.040	0.030	0.050	IND	IND
Pb, Lead (ppm)	< 100	IND	IND	IND	IND
Pr, Praseodymium (ppm)	18.6	17.5	19.8	17.4	19.9
Rb, Rubidium (ppm)	96	91	101	93	99
S, Sulphur (wt.%)	4.45	4.33	4.57	4.37	4.53
Sb, Antimony (ppm)	4.00	3.59	4.41	IND	IND
Sc, Scandium (ppm)	11.8	10.8	12.8	IND	IND
Si, Silicon (wt.%)	24.62	24.14	25.09	24.32	24.92
Sm, Samarium (ppm)	9.07	8.10	10.03	8.24	9.89
Sr, Strontium (ppm)	75	70	80	73	77
Ta, Tantalum (ppm)	1.96	1.72	2.21	IND	IND
Tb, Terbium (ppm)	1.19	1.07	1.32	1.11	1.28
Th, Thorium (ppm)	15.7	15.1	16.3	15.1	16.3
Ti, Titanium (wt.%)	0.464	0.453	0.475	0.455	0.474
Tl, Thallium (ppm)	1.02	0.91	1.13	IND	IND
Tm, Thulium (ppm)	0.57	0.50	0.64	0.52	0.61
U, Uranium (ppm)	9.51	8.99	10.03	9.16	9.86
V, Vanadium (ppm)	379	362	396	367	390
W, Tungsten (ppm)	2.94	1.60	4.28	IND	IND
Y, Yttrium (ppm)	36.5	34.6	38.5	35.1	38.0
Yb, Ytterbium (ppm)	3.49	3.07	3.92	3.25	3.74
Zn, Zinc (ppm)	31.7	24.1	39.2	29.3	34.1

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

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

Table 3. Indicative Values for OREAS 555b.

Constituent	Unit	Value	Constituent	Unit	Value	Constituent	Unit	Value
Borate Fusion XRF continued								
Ag	ppm	*0.035*	HfO_2	ppm	*253*	Sc	ppm	*13.9*
As	ppm	*60*	Hg	ppm	*< 100*	Se	ppm	*2.67*
Be	ppm	*3.00*	Ho	ppm	*1.39*	Sm	ppm	*9.25*
Bi	ppm	*< 100*	In	ppm	*2.78*	Sn	ppm	*93*
Cd	ppm	*< 100*	La	ppm	*78*	Ta	ppm	*1.47*
Ce	ppm	*130*	Lu	ppm	*0.58*	Tb	ppm	*1.15*
Cl	ppm	*224*	Mo	ppm	*< 50*	Te	ppm	*10.9*
Cr_2O_3	ppm	*159*	Na_2O	wt.%	*0.103*	Th	ppm	*15.7*
Cs	ppm	*2.22*	Nb	ppm	*40.0*	Tl	ppm	*0.80*
Dy	ppm	*6.71*	Nd	ppm	*63*	Tm	ppm	*0.57*
Er	ppm	*3.87*	Pb	ppm	*< 100*	U	ppm	*9.13*
Eu	ppm	*0.89*	Pr	ppm	*17.4*	W	ppm	*12.7*
Ga	ppm	*28.6*	Rb	ppm	*103*	Y	ppm	*34.0*
Gd	ppm	*7.11*	Re	ppm	*18.3*	Yb	ppm	*3.64*
Ge	ppm	*< 100*	Sb	ppm	*< 50*	Zn	ppm	*43.6*
Peroxide Fusion ICP								
Ag	ppm	*0.426*	Na	wt.%	*0.050*	Te	ppm	*< 2*
Cd	ppm	*< 10*	Re	ppm	*0.059*	Zr	ppm	*247*
Hf	ppm	*6.84*	Se	ppm	*10.5*			
Hg	ppm	*< 0.1*	Sn	ppm	*3.47*			
4-Acid Digestion								
Hg	ppm	*0.073*	Pt	ppb	*10.5*			
Aqua Regia Digestion								
Ir	ppm	*< 0.003*	Pt	ppb	*< 5*	Tm	ppm	*0.051*
Lu	ppm	*0.058*	Ti	wt.%	*0.002*			
Pd	ppb	*< 10*	Tl	ppm	*0.36*			
3-Acid Digestion (no HF)								
Ag	ppm	*0.383*	Gd	ppm	*5.63*	S	wt.%	*4.19*
Al_2O_3	wt.%	*12.17*	Hf	ppm	*5.97*	Sc	ppm	*13.0*
Ba	ppm	*247*	Ho	ppm	*0.93*	Sm	ppm	*8.12*
Be	ppm	*5.85*	K_2O	wt.%	*3.10*	Sn	ppm	*2.97*
Bi	ppm	*1.95*	La	ppm	*79*	Sr	ppm	*72*
CaO	wt.%	*0.190*	Li	ppm	*62*	Ta	ppm	*0.35*
Cd	ppm	*0.58*	MgO	wt.%	*5.12*	Tb	ppm	*0.74*
Ce	ppm	*142*	MnO	wt.%	*0.115*	Th	ppm	*17.6*
Co	wt.%	*1.17*	Mo	ppm	*19.6*	TiO_2	wt.%	*0.782*
Cr	ppm	*104*	Na_2O	wt.%	*0.073*	U	ppm	*10.5*
Cs	ppm	*2.15*	Nb	ppm	*23.4*	V	ppm	*374*
Cu	wt.%	*4.84*	Nd	ppm	*65*	W	ppm	*3.70*
Dy	ppm	*4.83*	Ni	ppm	*254*	Y	ppm	*27.7*
Er	ppm	*2.90*	P_2O_5	wt.%	*< 0.002*	Yb	ppm	*2.90*
Eu	ppm	*0.96*	Pb	ppm	*15.8*	Zn	ppm	*67*
Fe_2O_3	wt.%	*5.41*	Pr	ppm	*17.4*	Zr	ppm	*198*
Ga	ppm	*28.3*	Rb	ppm	*103*			

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.

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 and 2 provides the certified values and their associated 95% expanded uncertainty and tolerance intervals, Table 3 shows indicative values, Table 4 provides some indicative physical properties, Table 5 provides indicative mineralogy based on semi-quantitative XRD analysis and Table 6 presents the performance gate intervals for all certified values. Tabulated results of all elements 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 555b-DataPack.1.0.240216_185412.xlsx**).

Results are also presented in scatter plots for Co and Cu by multiple operationally defined methods including borate fusion with XRF finish, peroxide fusion with ICP-OES/MS finish, 4-acid digestion with ICP-OES/MS finish (and/or AAS 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 555b was prepared from copper-cobalt sulphide ore samples sourced from MMG’s Kinsevere Mine blended with barren black slate and a minor addition of cobalt concentrate. 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 555b was prepared in the following manner:

- Drying of ore and barren materials to constant mass at 105°C;
- Drying of cobalt concentrate to constant mass at 95°C;
- Crushing and milling of the ore materials to 100% minus 30 microns;
- Crushing and milling of the barren materials to >98% minus 75 microns;

- Deagglomeration of cobalt concentrate and screening at 150 microns;
- Check analysis of ores and concentrate for contained Co and Cu concentrations;
- Blending ores, Co concentrate and barren materials in appropriate proportions to achieve the desired grades;
- Homogenisation using OREAS' novel processing technologies;
- Packaging in 10g units sealed under nitrogen in laminated foil pouches.

PHYSICAL PROPERTIES

OREAS 555b 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 555b.

Bulk Density (kg/m^3)	Moisture (wt.%)	Munsell Notation‡	Munsell Color‡
805	0.82	N2	GrayishBlack

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

MINERALOGY

The semi-quantitative XRD results shown in Table 5 below 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 might be present. A trace amount of plagioclase appears to be present. The quantification of the kandite group is performed on a largely overlapped pattern and carriers high than usual uncertainty. A trace amount of arsenopyrite and pyrite may also be present.

Table 5. Indicative mineralogy of OREAS 555b based on semi-quantitative XRD analysis.

Mineral / Mineral Group	% (mass ratio)
Chlorite	5
Kandite group	2
Annite - biotite - phlogopite	3
Muscovite	15
K-feldspar and/or rutile	0
Tourmaline	1
Quartz	43
Dolomite - ankerite	1
Pyrite	0
Chalcopyrite	9
Linnaeite group	3
Magnetite and/or antlerite	1
Goethite	< 1
Malachite	0
Magnesite	16
Rutile	1

ANALYTICAL PROGRAM

Thirty analytical laboratories participated in the program to characterise the elements reported in Tables 1 and 2. The following elements and methods were undertaken:

- Lithium borate fusion whole rock analysis package by X-ray fluorescence (up to 20 laboratories depending on the element; except for one laboratory that used pressed powder pellet with XRF);
- Loss on Ignition (LOI) at 1000° C (14 laboratories used a thermogravimetric analyser, 6 laboratories included LOI with their fusion package and 4 laboratories used a conventional muffle furnace);
- Infrared combustion furnace/CS analyser to determine C (25 laboratories) and S (26 laboratories);
- Co (9 laboratories) and Cu (19 laboratories) by *5% sulphuric acid leach with ICP-OES or AAS finish;
- Full ICP-OES and ICP-MS elemental suites by sodium peroxide fusion (up to 22 laboratories depending on the element);
- Full ICP-OES and ICP-MS elemental suites by 4-acid (HCl-HNO_3-HF-$HClO_4$) digestion (up to 27 laboratories depending on the element);
- Full ICP-OES and ICP-MS elemental suites by aqua regia digestion (up to 27 laboratories depending on the element).

*See 'Appendix' for specified methodology.

For the round robin program, ten 800g test units were taken at predetermined intervals immediately following homogenisation and are considered representative of the entire prepared batch. The six samples received by each laboratory were obtained by taking two 30g scoop splits from each of three separate 800g 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]. 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.

Standard Deviation intervals (see Table 5) 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.

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 (see 'Intended Use' section for more detail).

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

Homogeneity Evaluation

The tolerance limits (ISO 16269:2014) shown in Tables 1 and 2 were determined using an analysis of precision errors method and are considered a conservative estimate of true homogeneity. The meaning of tolerance limits may be illustrated for copper by fusion with XRF, where 99% of the time ($1-\alpha=0.99$) at least 95% of subsamples ($\rho=0.95$) will have concentrations lying between 4.52 and 4.62 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 (ISO Guide 35). ***Please note that tolerance limits pertain to the homogeneity of the CRM only and should not be used as control limits for laboratory performance.***

The homogeneity of OREAS 555b has also been evaluated in an ANOVA study for all certified analytes present in concentrations well above detection levels (i.e. >20 x Lower Limit of Detection) for the various methods undertaken. This study tests the null hypothesis that no statistically significant difference exists between the between-unit variance and the within-unit variance (i.e. *p*-values <0.05 indicate rejection of the null hypothesis). Of the 194 certified values, no failures were observed indicating no evidence to reject the null hypothesis.

Based on the statistical analysis of ANOVA and the results of the interlaboratory certification program, it can be concluded that OREAS 555b is fit-for-purpose as a certified reference material (see 'Intended Use' below).

PERFORMANCE GATES

The standard deviations (SD's) intervals reported in Table 6 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.

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 (see 'Instructions for handling and correct use' section for more detail). 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.

Table 6 below shows intervals calculated for two and three standard deviations. As a guide these intervals may be regarded as warning or rejection for multiple 2SD outliers, or rejection for individual 3SD outliers in QC monitoring, although their precise application should be at the discretion of the QC manager concerned (also see 'Intended Use' section below). Westgard Rules extend the basics of single-rule QC monitoring using multi-rules (for more information visit www.westgard.com/mltirule.htm). A second method utilises a 5% window calculated directly from the certified value. Standard deviation is also shown in relative percent for one, two and three relative standard deviations (1RSD, 2RSD and 3RSD) to facilitate an appreciation of the magnitude of these numbers and a comparison with the 5% window. Caution should be exercised when concentration levels approach lower limits of detection of the analytical methods employed as performance gates calculated from standard deviations tend to be excessively wide whereas those determined by the 5% method are too narrow. One approach used at commercial laboratories is to set the acceptance criteria at twice the detection level (DL) ± 10%.

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

Table 6. Performance Gates for OREAS 555b.

Constituent	Certified Value	Absolute Standard Deviations					Relative Standard Deviations			5% window	
		1SD	2SD Low	2SD High	3SD Low	3SD High	1RSD	2RSD	3RSD	Low	High
Borate Fusion XRF											
Al_2O_3, wt.%	12.39	0.184	12.02	12.76	11.84	12.94	1.48%	2.96%	4.44%	11.77	13.01
BaO, ppm	316	63	191	442	128	504	19.84%	39.67%	59.51%	300	332
CaO, wt.%	0.201	0.007	0.188	0.215	0.182	0.221	3.25%	6.50%	9.75%	0.191	0.212
Co, wt.%	1.08	0.036	1.01	1.16	0.98	1.19	3.32%	6.65%	9.97%	1.03	1.14
Cu, wt.%	4.57	0.183	4.21	4.94	4.02	5.12	4.01%	8.01%	12.02%	4.34	4.80
Fe_2O_3, wt.%	5.55	0.176	5.20	5.90	5.02	6.08	3.18%	6.35%	9.53%	5.27	5.83
K_2O, wt.%	3.08	0.052	2.97	3.18	2.92	3.24	1.69%	3.39%	5.08%	2.93	3.23
MgO, wt.%	5.13	0.111	4.91	5.36	4.80	5.47	2.16%	4.32%	6.47%	4.88	5.39
MnO, wt.%	0.117	0.005	0.108	0.126	0.103	0.131	3.93%	7.86%	11.79%	0.111	0.123
Ni, ppm	233	27	178	287	151	314	11.63%	23.27%	34.90%	221	244
P_2O_5, wt.%	0.083	0.006	0.071	0.096	0.065	0.102	7.50%	14.99%	22.49%	0.079	0.088
SiO_2, wt.%	51.77	0.676	50.42	53.12	49.75	53.80	1.30%	2.61%	3.91%	49.18	54.36
SO_3, wt.%	11.05	0.591	9.87	12.24	9.28	12.83	5.35%	10.69%	16.04%	10.50	11.61
Sr, ppm	67	20	27	107	7	127	29.63%	59.26%	88.88%	64	71
TiO_2, wt.%	0.789	0.036	0.716	0.861	0.680	0.897	4.61%	9.21%	13.82%	0.749	0.828
V_2O_5, ppm	692	62	568	816	505	878	8.98%	17.96%	26.94%	657	726
Zr, ppm	238	27	183	292	156	319	11.46%	22.91%	34.37%	226	250
Thermogravimetry											
LOI^{1000}, wt.%	12.92	0.344	12.23	13.61	11.89	13.95	2.66%	5.32%	7.98%	12.27	13.57
Infrared Combustion											
C, wt.%	4.53	0.185	4.16	4.90	3.97	5.09	4.09%	8.18%	12.27%	4.30	4.76
S, wt.%	4.48	0.096	4.29	4.67	4.20	4.77	2.13%	4.26%	6.40%	4.26	4.71
Sulphuric Acid 5% Leach											
Co, wt.%	0.432	0.036	0.360	0.503	0.324	0.539	8.32%	16.64%	24.95%	0.410	0.453
Cu, wt.%	1.19	0.052	1.08	1.29	1.03	1.34	4.38%	8.76%	13.13%	1.13	1.25
Peroxide Fusion ICP											
Al, wt.%	6.42	0.180	6.06	6.78	5.88	6.96	2.80%	5.60%	8.40%	6.10	6.74
As, ppm	66	5.8	54	77	48	83	8.81%	17.62%	26.42%	62	69
B, ppm	232	29	173	290	144	320	12.64%	25.29%	37.93%	220	243
Ba, ppm	259	12	234	284	221	296	4.82%	9.64%	14.46%	246	272
Be, ppm	5.33	0.388	4.55	6.10	4.16	6.49	7.28%	14.56%	21.84%	5.06	5.59
Bi, ppm	1.56	0.23	1.10	2.01	0.88	2.23	14.51%	29.01%	43.52%	1.48	1.63
Ca, wt.%	0.143	0.026	0.091	0.195	0.064	0.222	18.31%	36.61%	54.92%	0.136	0.150
Ce, ppm	161	16	130	192	114	207	9.66%	19.32%	28.99%	153	169
Co, wt.%	1.11	0.034	1.04	1.17	1.00	1.21	3.12%	6.23%	9.35%	1.05	1.16
Cr, ppm	112	23	66	157	43	180	20.37%	40.74%	61.10%	106	117
Cs, ppm	2.26	0.215	1.83	2.69	1.62	2.90	9.50%	19.00%	28.51%	2.15	2.37
Cu, wt.%	4.57	0.141	4.28	4.85	4.14	4.99	3.09%	6.17%	9.26%	4.34	4.79
Dy, ppm	6.70	0.458	5.78	7.61	5.32	8.07	6.83%	13.67%	20.50%	6.36	7.03
Er, ppm	3.83	0.221	3.38	4.27	3.16	4.49	5.78%	11.57%	17.35%	3.64	4.02
Eu, ppm	0.97	0.070	0.83	1.11	0.76	1.18	7.25%	14.49%	21.74%	0.92	1.02
Fe, wt.%	3.87	0.143	3.59	4.16	3.44	4.30	3.70%	7.39%	11.09%	3.68	4.07
Ga, ppm	29.1	1.42	26.3	31.9	24.9	33.4	4.86%	9.73%	14.59%	27.7	30.6
Gd, ppm	7.26	0.73	5.81	8.71	5.08	9.43	10.00%	20.00%	30.01%	6.89	7.62

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

Note 1: intervals may appear asymmetric due to rounding.

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

Table 6 continued.

Constituent	Certified Value	Absolute Standard Deviations					Relative Standard Deviations			5% window	
		1SD	2SD Low	2SD High	3SD Low	3SD High	1RSD	2RSD	3RSD	Low	High
Peroxide Fusion ICP continued											
Ge, ppm	2.01	0.049	1.91	2.11	1.86	2.16	2.45%	4.90%	7.35%	1.91	2.11
Ho, ppm	1.38	0.100	1.18	1.58	1.08	1.68	7.24%	14.48%	21.72%	1.31	1.45
In, ppm	2.47	0.149	2.17	2.77	2.02	2.92	6.05%	12.10%	18.15%	2.34	2.59
K, wt.%	2.58	0.145	2.29	2.87	2.15	3.02	5.61%	11.23%	16.84%	2.45	2.71
La, ppm	77	6.4	64	89	57	96	8.36%	16.72%	25.08%	73	80
Li, ppm	60	4.5	51	69	46	73	7.61%	15.22%	22.83%	57	63
Lu, ppm	0.58	0.09	0.39	0.76	0.30	0.85	16.16%	32.31%	48.47%	0.55	0.60
Mg, wt.%	3.09	0.112	2.87	3.32	2.76	3.43	3.63%	7.26%	10.89%	2.94	3.25
Mn, wt.%	0.093	0.004	0.085	0.100	0.081	0.104	4.04%	8.08%	12.12%	0.088	0.097
Mo, ppm	17.3	2.0	13.4	21.2	11.4	23.2	11.35%	22.70%	34.05%	16.4	18.2
Nb, ppm	25.4	1.01	23.4	27.4	22.4	28.4	3.98%	7.96%	11.94%	24.1	26.7
Nd, ppm	68	4.3	59	76	55	81	6.41%	12.81%	19.22%	64	71
Ni, ppm	228	22	185	272	163	293	9.51%	19.02%	28.52%	217	240
P, wt.%	0.040	0.009	0.023	0.057	0.015	0.066	21.21%	42.42%	63.63%	0.038	0.042
Pb, ppm	< 100	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Pr, ppm	18.6	0.89	16.9	20.4	16.0	21.3	4.78%	9.57%	14.35%	17.7	19.6
Rb, ppm	96	5.1	85	106	80	111	5.38%	10.77%	16.15%	91	100
S, wt.%	4.45	0.144	4.16	4.74	4.02	4.88	3.23%	6.46%	9.69%	4.23	4.68
Sb, ppm	4.00	0.140	3.72	4.28	3.58	4.42	3.50%	6.99%	10.49%	3.80	4.20
Sc, ppm	11.8	1.01	9.8	13.8	8.8	14.8	8.57%	17.13%	25.70%	11.2	12.4
Si, wt.%	24.62	0.480	23.66	25.58	23.18	26.06	1.95%	3.90%	5.85%	23.39	25.85
Sm, ppm	9.07	0.846	7.38	10.76	6.53	11.61	9.33%	18.66%	27.99%	8.61	9.52
Sr, ppm	75	5.4	64	86	59	91	7.21%	14.41%	21.62%	71	79
Ta, ppm	1.96	0.129	1.71	2.22	1.58	2.35	6.57%	13.14%	19.72%	1.87	2.06
Tb, ppm	1.19	0.101	0.99	1.40	0.89	1.50	8.45%	16.91%	25.36%	1.13	1.25
Th, ppm	15.7	0.40	14.9	16.5	14.5	16.9	2.58%	5.15%	7.73%	14.9	16.5
Ti, wt.%	0.464	0.014	0.437	0.491	0.424	0.505	2.91%	5.82%	8.73%	0.441	0.488
Tl, ppm	1.02	0.065	0.89	1.15	0.83	1.21	6.33%	12.66%	18.98%	0.97	1.07
Tm, ppm	0.57	0.036	0.49	0.64	0.46	0.68	6.38%	12.77%	19.15%	0.54	0.60
U, ppm	9.51	0.473	8.57	10.46	8.09	10.93	4.97%	9.95%	14.92%	9.04	9.99
V, ppm	379	25	328	429	303	455	6.67%	13.35%	20.02%	360	398
W, ppm	2.94	1.01	0.92	4.95	0.00	5.96	34.35%	68.69%	103.04%	2.79	3.08
Y, ppm	36.5	2.03	32.5	40.6	30.4	42.6	5.56%	11.12%	16.68%	34.7	38.4
Yb, ppm	3.49	0.211	3.07	3.92	2.86	4.13	6.05%	12.09%	18.14%	3.32	3.67
Zn, ppm	31.7	5.1	21.5	41.8	16.4	46.9	16.06%	32.11%	48.17%	30.1	33.2
4-Acid Digestion											
Ag, ppm	0.098	0.014	0.069	0.127	0.055	0.141	14.62%	29.25%	43.87%	0.093	0.103
Al, wt.%	6.40	0.143	6.12	6.69	5.98	6.83	2.23%	4.45%	6.68%	6.08	6.72
As, ppm	64	3.4	57	71	54	74	5.27%	10.54%	15.81%	61	67
Ba, ppm	254	13	229	280	216	293	5.05%	10.11%	15.16%	242	267
Be, ppm	4.76	0.254	4.25	5.26	3.99	5.52	5.34%	10.67%	16.01%	4.52	4.99
Bi, ppm	1.48	0.098	1.28	1.67	1.18	1.77	6.67%	13.33%	20.00%	1.40	1.55
Ca, wt.%	0.145	0.008	0.128	0.161	0.119	0.170	5.80%	11.60%	17.40%	0.137	0.152
Cd, ppm	0.46	0.06	0.34	0.58	0.28	0.63	13.03%	26.07%	39.10%	0.43	0.48

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

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

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

Table 6 continued.

Constituent	Certified Value	Absolute Standard Deviations					Relative Standard Deviations			5% window	
		1SD	2SD Low	2SD High	3SD Low	3SD High	1RSD	2RSD	3RSD	Low	High
4-Acid Digestion continued											
Ce, ppm	148	6	136	161	130	167	4.21%	8.43%	12.64%	141	156
Co, wt.%	1.10	0.036	1.03	1.17	0.99	1.21	3.30%	6.60%	9.89%	1.05	1.16
Cr, ppm	93	8.6	76	110	68	119	9.19%	18.38%	27.57%	89	98
Cs, ppm	2.03	0.104	1.82	2.24	1.72	2.34	5.10%	10.20%	15.30%	1.93	2.13
Cu, wt.%	4.58	0.140	4.30	4.86	4.16	5.00	3.05%	6.09%	9.14%	4.35	4.81
Dy, ppm	4.68	0.64	3.40	5.95	2.77	6.59	13.62%	27.25%	40.87%	4.45	4.91
Er, ppm	2.76	0.34	2.07	3.45	1.73	3.79	12.47%	24.94%	37.41%	2.62	2.90
Eu, ppm	0.91	0.045	0.83	1.00	0.78	1.05	4.91%	9.82%	14.73%	0.87	0.96
Fe, wt.%	3.83	0.145	3.54	4.12	3.40	4.27	3.78%	7.55%	11.33%	3.64	4.02
Ga, ppm	28.4	1.34	25.7	31.0	24.3	32.4	4.73%	9.46%	14.19%	26.9	29.8
Gd, ppm	5.18	0.91	3.36	6.99	2.45	7.90	17.55%	35.09%	52.64%	4.92	5.44
Ge, ppm	0.20	0.03	0.13	0.26	0.10	0.29	16.06%	32.13%	48.19%	0.19	0.21
Hf, ppm	5.37	0.218	4.94	5.81	4.72	6.02	4.05%	8.10%	12.16%	5.10	5.64
Ho, ppm	0.90	0.11	0.68	1.12	0.57	1.23	12.23%	24.45%	36.68%	0.86	0.95
In, ppm	2.51	0.165	2.18	2.84	2.01	3.00	6.59%	13.17%	19.76%	2.38	2.63
K, wt.%	2.54	0.076	2.38	2.69	2.31	2.77	3.01%	6.01%	9.02%	2.41	2.66
La, ppm	72	5.1	62	82	57	87	7.04%	14.09%	21.13%	68	75
Li, ppm	59	2.7	54	65	51	67	4.53%	9.06%	13.58%	56	62
Lu, ppm	0.44	0.026	0.39	0.49	0.36	0.52	5.98%	11.95%	17.93%	0.42	0.46
Mg, wt.%	3.07	0.092	2.89	3.26	2.80	3.35	3.00%	6.00%	9.00%	2.92	3.23
Mn, wt.%	0.089	0.004	0.082	0.096	0.078	0.100	4.11%	8.22%	12.33%	0.085	0.093
Mo, ppm	17.1	0.95	15.2	19.0	14.2	19.9	5.56%	11.13%	16.69%	16.2	17.9
Na, wt.%	0.052	0.007	0.039	0.065	0.032	0.072	12.90%	25.81%	38.71%	0.049	0.055
Nb, ppm	17.1	3.8	9.5	24.7	5.6	28.5	22.33%	44.67%	67.00%	16.2	17.9
Nd, ppm	64	2.0	60	68	58	70	3.12%	6.24%	9.35%	61	67
Ni, ppm	220	9	202	238	193	247	4.12%	8.24%	12.36%	209	231
P, wt.%	0.035	0.003	0.028	0.041	0.025	0.044	9.26%	18.52%	27.78%	0.033	0.036
Pb, ppm	13.6	1.25	11.1	16.1	9.8	17.4	9.20%	18.41%	27.61%	12.9	14.3
Pr, ppm	16.9	1.38	14.2	19.7	12.8	21.1	8.16%	16.32%	24.48%	16.1	17.8
Rb, ppm	94	4.4	86	103	81	108	4.68%	9.36%	14.04%	90	99
Re, ppm	0.030	0.003	0.024	0.036	0.020	0.039	10.49%	20.98%	31.48%	0.028	0.031
S, wt.%	4.39	0.167	4.06	4.73	3.89	4.89	3.79%	7.58%	11.37%	4.17	4.61
Sb, ppm	3.72	0.252	3.22	4.22	2.97	4.48	6.77%	13.53%	20.30%	3.54	3.91
Sc, ppm	12.6	0.78	11.0	14.1	10.3	14.9	6.18%	12.35%	18.53%	12.0	13.2
Se, ppm	6.97	0.90	5.18	8.76	4.28	9.66	12.86%	25.72%	38.57%	6.62	7.32
Sm, ppm	8.87	0.595	7.69	10.06	7.09	10.66	6.70%	13.40%	20.10%	8.43	9.32
Sn, ppm	2.99	0.250	2.49	3.49	2.24	3.74	8.36%	16.71%	25.07%	2.84	3.14
Sr, ppm	70	3.6	63	77	59	81	5.19%	10.38%	15.58%	66	73
Ta, ppm	1.19	0.24	0.72	1.66	0.49	1.90	19.75%	39.50%	59.24%	1.13	1.25
Tb, ppm	0.81	0.15	0.52	1.11	0.37	1.26	18.17%	36.34%	54.51%	0.77	0.85
Te, ppm	0.060	0.026	0.008	0.111	0.000	0.137	43.19%	86.37%	129.56%	0.057	0.063
Th, ppm	16.0	0.96	14.1	17.9	13.1	18.9	6.00%	12.00%	17.99%	15.2	16.8
Ti, wt.%	0.274	0.080	0.113	0.434	0.033	0.514	29.27%	58.54%	87.82%	0.260	0.287
Tl, ppm	0.99	0.068	0.85	1.12	0.78	1.19	6.92%	13.85%	20.77%	0.94	1.04

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

Note 1: intervals may appear asymmetric due to rounding.

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

Table 6 continued.

Constituent	Certified Value	Absolute Standard Deviations					Relative Standard Deviations			5% window	
		1SD	2SD Low	2SD High	3SD Low	3SD High	1RSD	2RSD	3RSD	Low	High
4-Acid Digestion continued											
Tm, ppm	0.42	0.06	0.30	0.54	0.24	0.60	14.30%	28.60%	42.89%	0.40	0.44
U, ppm	9.24	0.712	7.81	10.66	7.10	11.37	7.70%	15.41%	23.11%	8.77	9.70
V, ppm	357	16	325	388	309	404	4.42%	8.83%	13.25%	339	374
W, ppm	2.78	0.254	2.27	3.29	2.02	3.54	9.15%	18.29%	27.44%	2.64	2.92
Y, ppm	24.4	1.00	22.4	26.4	21.4	27.4	4.09%	8.19%	12.28%	23.2	25.7
Yb, ppm	2.88	0.31	2.26	3.51	1.94	3.83	10.90%	21.80%	32.69%	2.74	3.03
Zn, ppm	29.0	2.08	24.8	33.2	22.8	35.3	7.19%	14.37%	21.56%	27.6	30.5
Zr, ppm	188	6	175	201	169	207	3.40%	6.80%	10.20%	179	197
Aqua Regia Digestion											
Ag, ppm	0.076	0.013	0.050	0.101	0.037	0.114	16.88%	33.76%	50.65%	0.072	0.079
Al, wt.%	0.959	0.187	0.585	1.332	0.398	1.519	19.48%	38.96%	58.45%	0.911	1.006
As, ppm	62	3.2	55	68	52	71	5.21%	10.41%	15.62%	59	65
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	57	9	40	74	31	82	15.13%	30.26%	45.39%	54	59
Be, ppm	2.21	0.27	1.67	2.75	1.40	3.02	12.24%	24.48%	36.71%	2.10	2.32
Bi, ppm	1.39	0.078	1.23	1.54	1.15	1.62	5.61%	11.23%	16.84%	1.32	1.46
Ca, wt.%	0.137	0.007	0.122	0.151	0.115	0.158	5.32%	10.63%	15.95%	0.130	0.143
Cd, ppm	0.46	0.025	0.41	0.51	0.39	0.54	5.41%	10.82%	16.23%	0.44	0.49
Ce, ppm	43.7	8.0	27.7	59.6	19.8	67.6	18.25%	36.50%	54.74%	41.5	45.9
Co, wt.%	1.08	0.039	1.00	1.15	0.96	1.19	3.59%	7.17%	10.76%	1.02	1.13
Cr, ppm	35.2	3.8	27.7	42.8	24.0	46.5	10.65%	21.31%	31.96%	33.5	37.0
Cs, ppm	0.32	0.10	0.12	0.53	0.01	0.63	32.01%	64.01%	96.02%	0.31	0.34
Cu, wt.%	4.57	0.108	4.36	4.79	4.25	4.90	2.36%	4.72%	7.09%	4.34	4.80
Dy, ppm	1.00	0.10	0.79	1.20	0.69	1.30	10.34%	20.69%	31.03%	0.95	1.05
Er, ppm	0.41	0.08	0.24	0.57	0.16	0.65	19.93%	39.86%	59.79%	0.39	0.43
Eu, ppm	0.39	0.035	0.32	0.46	0.28	0.49	9.04%	18.07%	27.11%	0.37	0.41
Fe, wt.%	3.66	0.178	3.31	4.02	3.13	4.20	4.87%	9.74%	14.61%	3.48	3.85
Ga, ppm	8.22	1.49	5.24	11.20	3.75	12.69	18.13%	36.26%	54.38%	7.81	8.63
Gd, ppm	2.03	0.140	1.75	2.30	1.61	2.44	6.90%	13.80%	20.70%	1.92	2.13
Ge, ppm	0.095	0.027	0.041	0.150	0.013	0.178	28.76%	57.51%	86.27%	0.091	0.100
Hf, ppm	0.33	0.05	0.24	0.42	0.19	0.47	14.22%	28.43%	42.65%	0.31	0.35
Hg, ppm	0.060	0.012	0.037	0.084	0.025	0.096	19.58%	39.15%	58.73%	0.057	0.063
Ho, ppm	0.17	0.03	0.11	0.22	0.09	0.25	16.43%	32.85%	49.28%	0.16	0.18
In, ppm	1.83	0.109	1.61	2.05	1.50	2.15	5.98%	11.96%	17.93%	1.74	1.92
K, wt.%	0.196	0.030	0.136	0.255	0.106	0.285	15.24%	30.49%	45.73%	0.186	0.205
La, ppm	20.4	3.2	14.0	26.8	10.8	30.0	15.67%	31.34%	47.01%	19.4	21.4
Li, ppm	35.3	7.3	20.7	50.0	13.3	57.4	20.75%	41.50%	62.25%	33.6	37.1
Mg, wt.%	2.42	0.239	1.94	2.89	1.70	3.13	9.87%	19.74%	29.61%	2.30	2.54
Mn, wt.%	0.089	0.004	0.080	0.097	0.076	0.101	4.61%	9.21%	13.82%	0.084	0.093
Mo, ppm	16.2	0.91	14.4	18.0	13.5	19.0	5.61%	11.21%	16.82%	15.4	17.0
Na, wt.%	0.011	0.002	0.006	0.015	0.004	0.018	21.14%	42.28%	63.42%	0.010	0.011
Nb, ppm	0.094	0.024	0.046	0.142	0.022	0.166	25.65%	51.29%	76.94%	0.089	0.098
Nd, ppm	23.0	3.1	16.9	29.1	13.8	32.2	13.34%	26.67%	40.01%	21.8	24.1

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

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

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

Table 6 continued.

Constituent	Certified Value	Absolute Standard Deviations					Relative Standard Deviations			5% window	
		1SD	2SD Low	2SD High	3SD Low	3SD High	1RSD	2RSD	3RSD	Low	High
Aqua Regia Digestion continued											
Ni, ppm	214	13	189	239	176	252	5.88%	11.75%	17.63%	203	225
P, wt.%	0.020	0.001	0.018	0.022	0.017	0.023	5.67%	11.34%	17.02%	0.019	0.021
Pb, ppm	10.9	1.08	8.8	13.1	7.7	14.2	9.89%	19.78%	29.67%	10.4	11.5
Pr, ppm	5.43	1.43	2.57	8.30	1.13	9.73	26.38%	52.76%	79.14%	5.16	5.70
Rb, ppm	6.50	1.12	4.26	8.73	3.15	9.84	17.18%	34.37%	51.55%	6.17	6.82
Re, ppm	0.027	0.003	0.021	0.032	0.018	0.035	10.25%	20.49%	30.74%	0.025	0.028
S, wt.%	4.31	0.170	3.97	4.65	3.80	4.82	3.94%	7.87%	11.81%	4.10	4.53
Sb, ppm	2.17	0.40	1.36	2.97	0.96	3.38	18.61%	37.23%	55.84%	2.06	2.27
Sc, ppm	3.30	0.35	2.60	3.99	2.26	4.33	10.50%	21.00%	31.51%	3.13	3.46
Se, ppm	6.70	0.528	5.64	7.76	5.11	8.28	7.89%	15.77%	23.66%	6.36	7.03
Sm, ppm	3.51	0.47	2.56	4.45	2.09	4.93	13.49%	26.98%	40.47%	3.33	3.68
Sn, ppm	1.54	0.152	1.23	1.84	1.08	1.99	9.92%	19.83%	29.75%	1.46	1.61
Sr, ppm	15.1	2.6	9.9	20.4	7.2	23.0	17.36%	34.72%	52.09%	14.4	15.9
Ta, ppm	< 0.01	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Tb, ppm	0.21	0.03	0.14	0.28	0.10	0.31	17.02%	34.04%	51.05%	0.20	0.22
Te, ppm	0.054	0.013	0.028	0.079	0.015	0.092	24.19%	48.39%	72.58%	0.051	0.056
Th, ppm	6.32	0.91	4.50	8.14	3.59	9.05	14.39%	28.79%	43.18%	6.01	6.64
U, ppm	3.49	0.280	2.93	4.05	2.65	4.33	8.02%	16.04%	24.06%	3.32	3.67
V, ppm	62	9	45	79	36	88	14.04%	28.08%	42.11%	59	65
W, ppm	1.08	0.15	0.79	1.38	0.65	1.52	13.41%	26.82%	40.23%	1.03	1.14
Y, ppm	3.94	0.49	2.96	4.91	2.48	5.40	12.37%	24.73%	37.10%	3.74	4.13
Yb, ppm	0.32	0.07	0.17	0.46	0.09	0.54	23.46%	46.93%	70.39%	0.30	0.33
Zn, ppm	26.6	1.29	24.0	29.2	22.7	30.5	4.84%	9.68%	14.51%	25.3	27.9
Zr, ppm	10.1	1.3	7.5	12.8	6.1	14.1	13.12%	26.25%	39.37%	9.6	10.6

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

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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.

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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.

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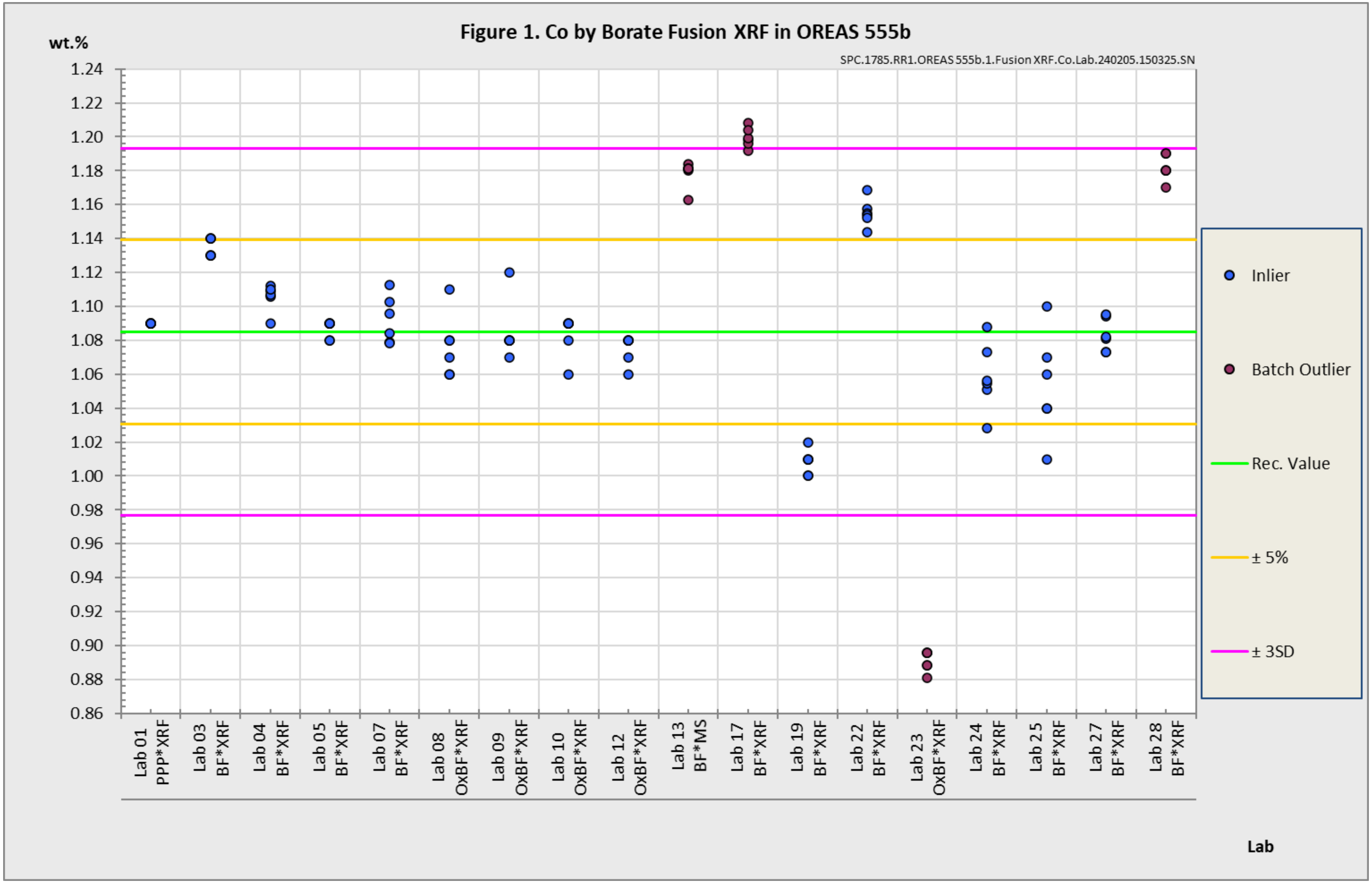
Figure 1. Co by Borate Fusion XRF in OREAS 555b
wt.%
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1.24
1.22
1.20
1.18
1.16
1.14
1.12
1.10
1.08
1.06
1.04
1.02
1.00
0.98
0.96
0.94
0.92
0.90
0.88
0.86
Lab 01 PPP*XRF
Lab 03 BF*XRF
Lab 04 BF*XRF
Lab 05 BF*XRF
Lab 07 BF*XRF
Lab 08 OxBF*XRF
Lab 09 OxBF*XRF
Lab 10 OxBF*XRF
Lab 12 OxBF*XRF
Lab 13 BF*MS
Lab 17 BF*XRF
Lab 19 BF*XRF
Lab 22 BF*XRF
Lab 23 OxBF*XRF
Lab 24 BF*XRF
Lab 25 BF*XRF
Lab 27 BF*XRF
Lab 28 BF*XRF
Inlier
Batch Outlier
Rec. Value
± 5%
± 3SD
Lab

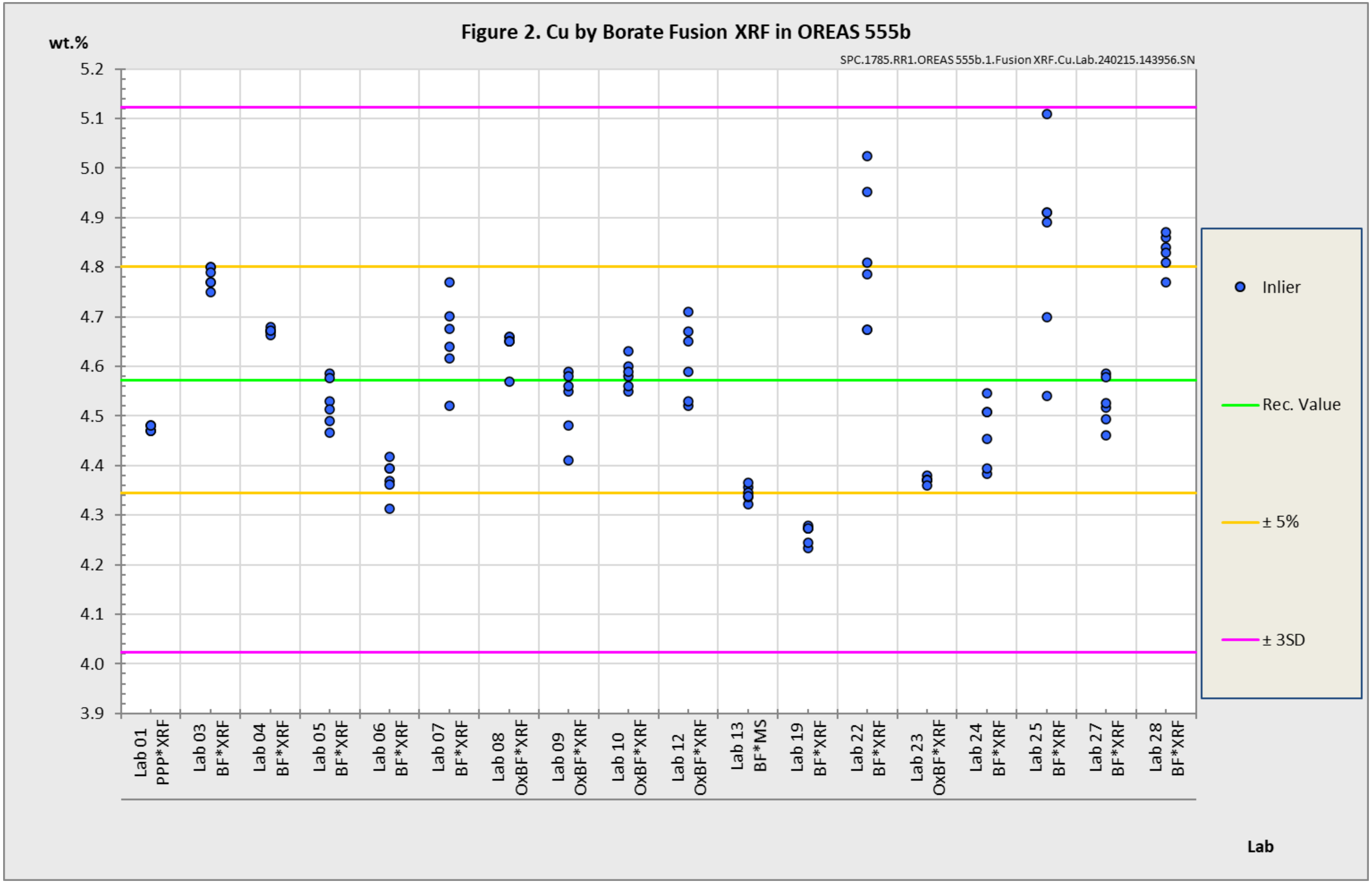
Figure 2. Cu by Borate Fusion XRF in OREAS 555b
SPC.1785.RR1.OREAS 555b.1.Fusion XRF.Cu.Lab.240215.143956.SN
wt.%
5.2
5.1
5.0
4.9
4.8
4.7
4.6
4.5
4.4
4.3
4.2
4.1
4.0
3.9
Lab 01 PPP*XRF
Lab 03 BF*XRF
Lab 04 BF*XRF
Lab 05 BF*XRF
Lab 06 BF*XRF
Lab 07 BF*XRF
Lab 08 OxBF*XRF
Lab 09 OxBF*XRF
Lab 10 OxBF*XRF
Lab 12 OxBF*XRF
Lab 13 BF*MS
Lab 19 BF*XRF
Lab 22 BF*XRF
Lab 23 OxBF*XRF
Lab 24 BF*XRF
Lab 25 BF*XRF
Lab 27 BF*XRF
Lab 28 BF*XRF
Inlier
Rec. Value
± 5%
± 3SD
Lab

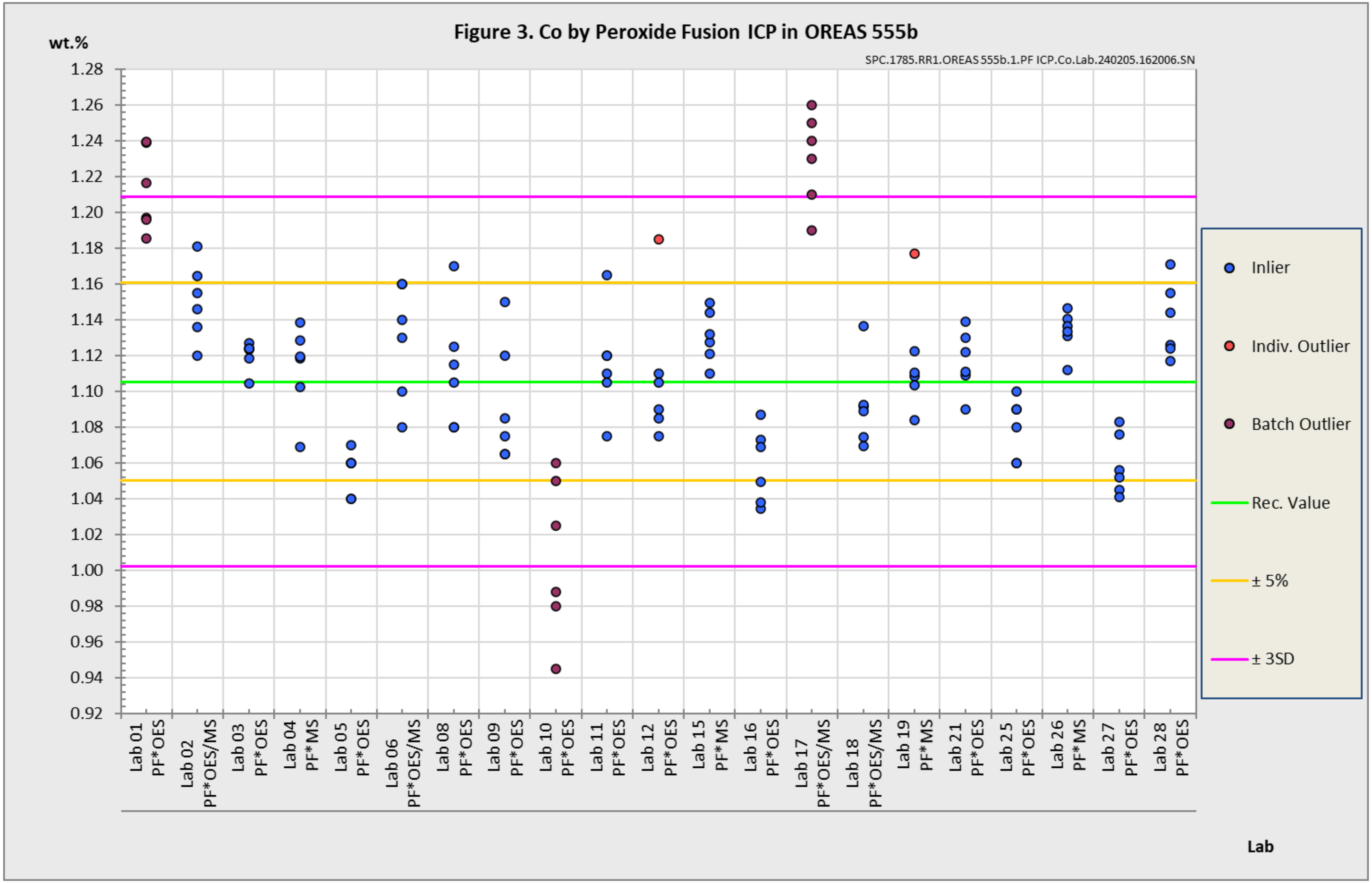

Figure 3. Co by Peroxide Fusion ICP in OREAS 555b
wt.%
SPC.1785.RR1.OREAS 555b.1.PF ICP.Co.Lab.240205.162006.SN
1.28
1.26
1.24
1.22
1.20
1.18
1.16
1.14
1.12
1.10
1.08
1.06
1.04
1.02
1.00
0.98
0.96
0.94
0.92
Lab 01 PF*OES
Lab 02 PF*OES/MS
Lab 03 PF*OES
Lab 04 PF*MS
Lab 05 PF*OES
Lab 06 PF*OES/MS
Lab 08 PF*OES
Lab 09 PF*OES
Lab 10 PF*OES
Lab 11 PF*OES
Lab 12 PF*OES
Lab 15 PF*MS
Lab 16 PF*OES
Lab 17 PF*OES/MS
Lab 18 PF*OES/MS
Lab 19 PF*MS
Lab 21 PF*OES
Lab 25 PF*OES
Lab 26 PF*MS
Lab 27 PF*OES
Lab 28 PF*OES
Inlier
Indiv. Outlier
Batch Outlier
Rec. Value
± 5%
± 3SD
Lab

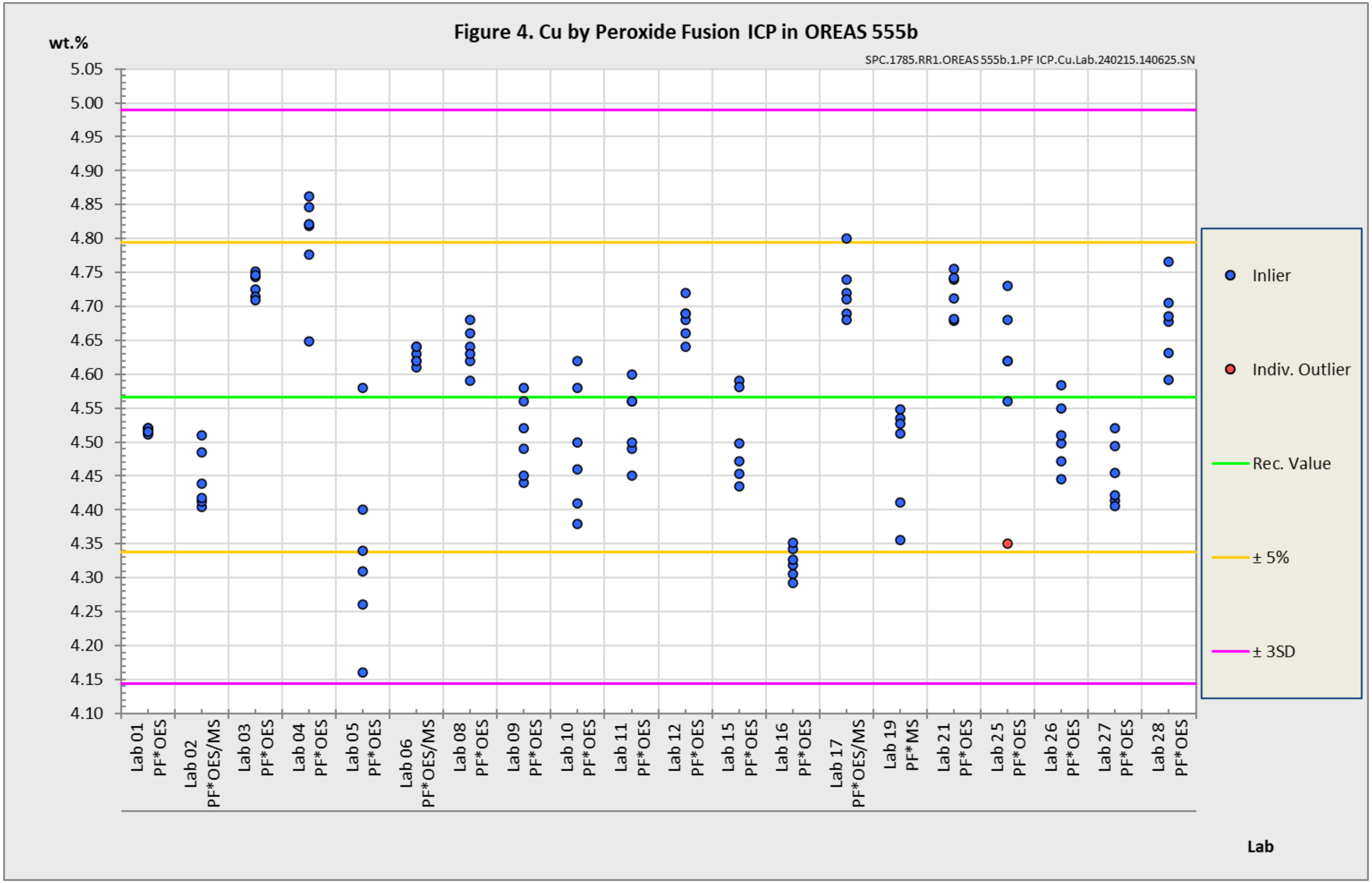
Figure 4. Cu by Peroxide Fusion ICP in OREAS 555b
SPC.1785.RR1.OREAS 555b.1.PF ICP.Cu.Lab.240215.140625.SN
wt.%
5.05
5.00
4.95
4.90
4.85
4.80
4.75
4.70
4.65
4.60
4.55
4.50
4.45
4.40
4.35
4.30
4.25
4.20
4.15
4.10
Lab 01 PF*OES
Lab 02 PF*OES/MS
Lab 03 PF*OES
Lab 04 PF*OES
Lab 05 PF*OES
Lab 06 PF*OES/MS
Lab 08 PF*OES
Lab 09 PF*OES
Lab 10 PF*OES
Lab 11 PF*OES
Lab 12 PF*OES
Lab 15 PF*OES
Lab 16 PF*OES
Lab 17 PF*OES/MS
Lab 19 PF*MS
Lab 21 PF*OES
Lab 25 PF*OES
Lab 26 PF*OES
Lab 27 PF*OES
Lab 28 PF*OES
Lab
Inlier
Indiv. Outlier
Rec. Value
± 5%
± 3SD

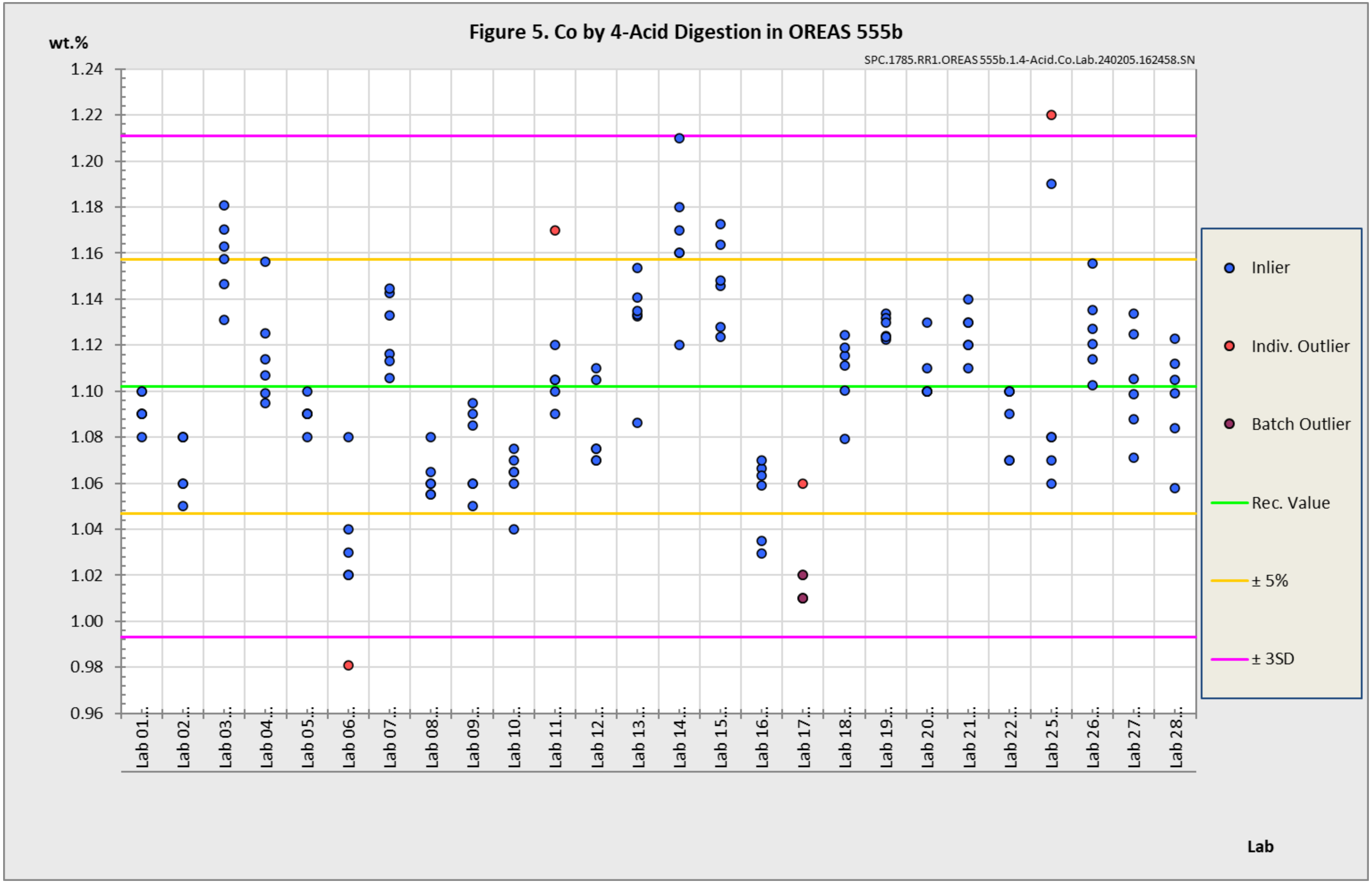
Figure 5. Co by 4-Acid Digestion in OREAS 555b
SPC.1785.RR1.OREAS 555b.1.4-Acid.Co.Lab.240205.162458.SN
wt.%
1.24
1.22
1.20
1.18
1.16
1.14
1.12
1.10
1.08
1.06
1.04
1.02
1.00
0.98
0.96
Lab 01...
Lab 02...
Lab 03...
Lab 04...
Lab 05...
Lab 06...
Lab 07...
Lab 08...
Lab 09...
Lab 10...
Lab 11...
Lab 12...
Lab 13...
Lab 14...
Lab 15...
Lab 16...
Lab 17...
Lab 18...
Lab 19...
Lab 20...
Lab 21...
Lab 22...
Lab 25...
Lab 26...
Lab 27...
Lab 28...
Lab
Inlier
Indiv. Outlier
Batch Outlier
Rec. Value
± 5%
± 3SD

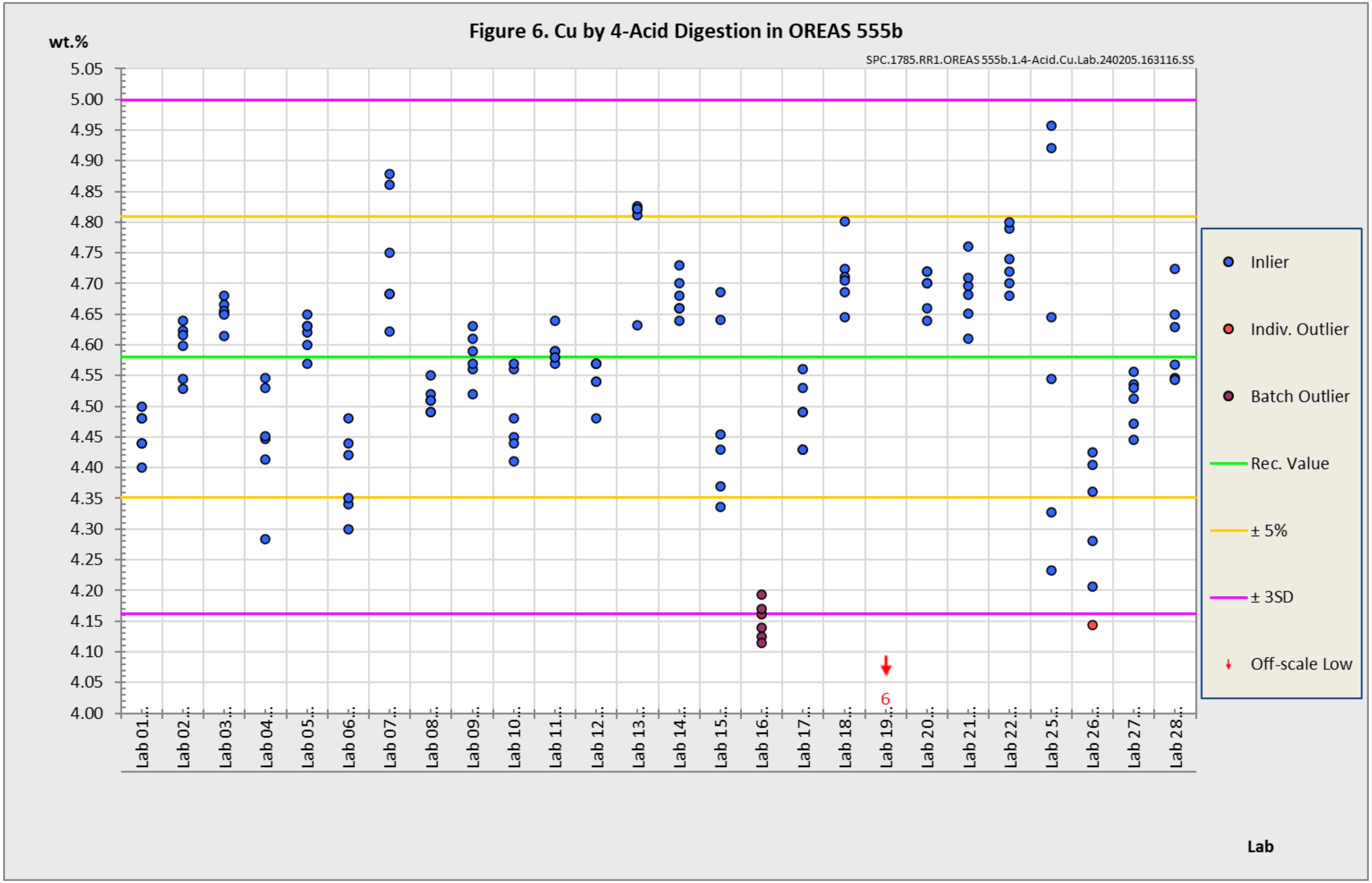

Figure 6. Cu by 4-Acid Digestion in OREAS 555b
SPC.1785.RR1.OREAS 555b.1.4-Acid.Cu.Lab.240205.163116.SS
wt.%
5.05
5.00
4.95
4.90
4.85
4.80
4.75
4.70
4.65
4.60
4.55
4.50
4.45
4.40
4.35
4.30
4.25
4.20
4.15
4.10
4.05
4.00
6
Lab 01...
Lab 02...
Lab 03...
Lab 04...
Lab 05...
Lab 06...
Lab 07...
Lab 08...
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 25...
Lab 26...
Lab 27...
Lab 28...
Lab
Inlier
Indiv. Outlier
Batch Outlier
Rec. Value
± 5%
± 3SD
Off-scale Low

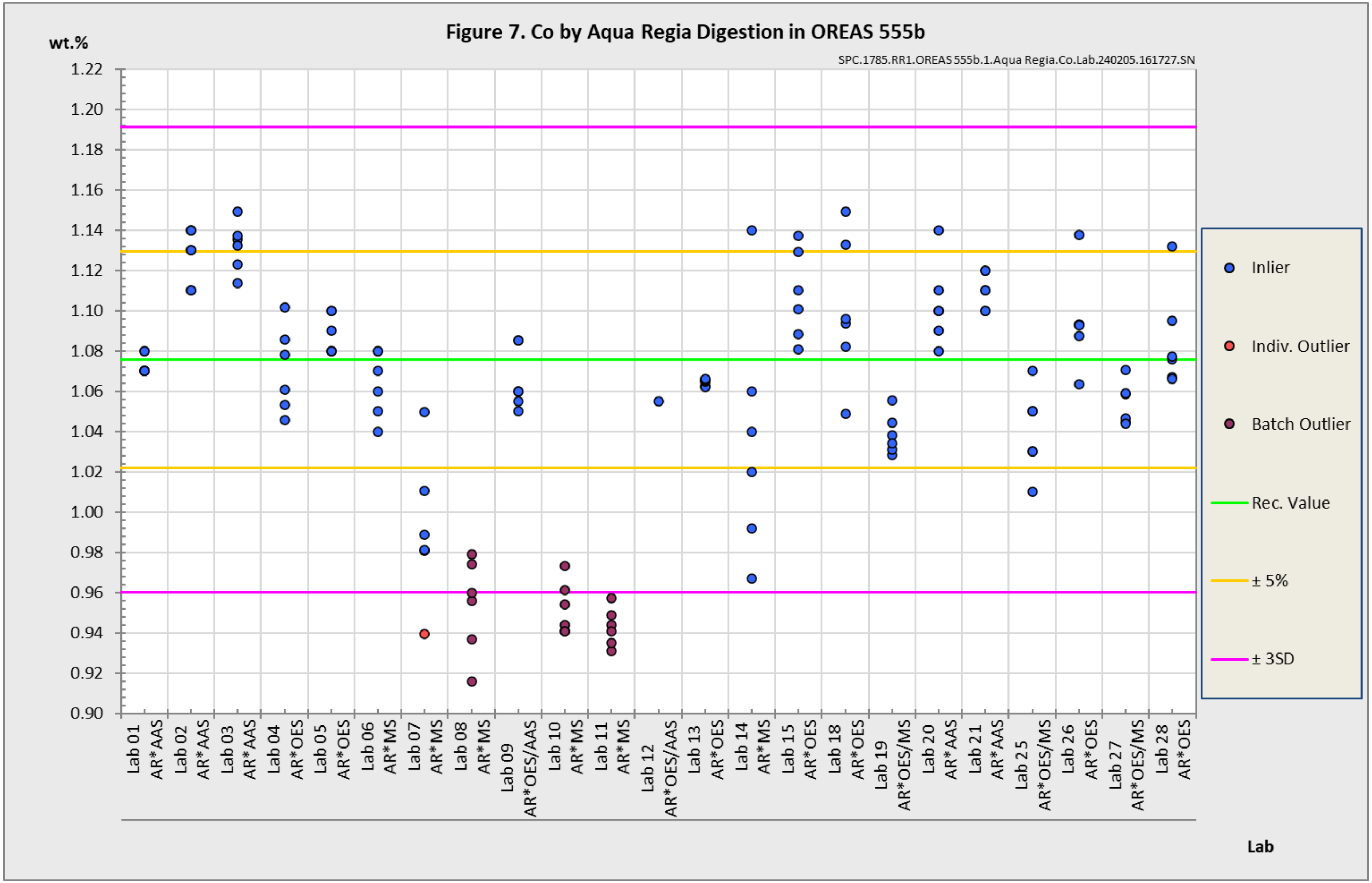
Figure 7. Co by Aqua Regia Digestion in OREAS 555b
wt.%
SPC.1785.RR1.OREAS 555b.1.Aqua Regia.Co.Lab.240205.161727.SN
1.22
1.20
1.18
1.16
1.14
1.12
1.10
1.08
1.06
1.04
1.02
1.00
0.98
0.96
0.94
0.92
0.90
Lab 01 AR*AAS
Lab 02 AR*AAS
Lab 03 AR*AAS
Lab 04 AR*OES
Lab 05 AR*OES
Lab 06 AR*MS
Lab 07 AR*MS
Lab 08 AR*MS
Lab 09 AR*OES/AAS
Lab 10 AR*MS
Lab 11 AR*MS
Lab 12 AR*OES/AAS
Lab 13 AR*OES
Lab 14 AR*MS
Lab 15 AR*OES
Lab 18 AR*OES
Lab 19 AR*OES/MS
Lab 20 AR*AAS
Lab 21 AR*AAS
Lab 25 AR*OES/MS
Lab 26 AR*OES
Lab 27 AR*OES/MS
Lab 28 AR*OES
Lab
Inlier
Indiv. Outlier
Batch Outlier
Rec. Value
± 5%
± 3SD

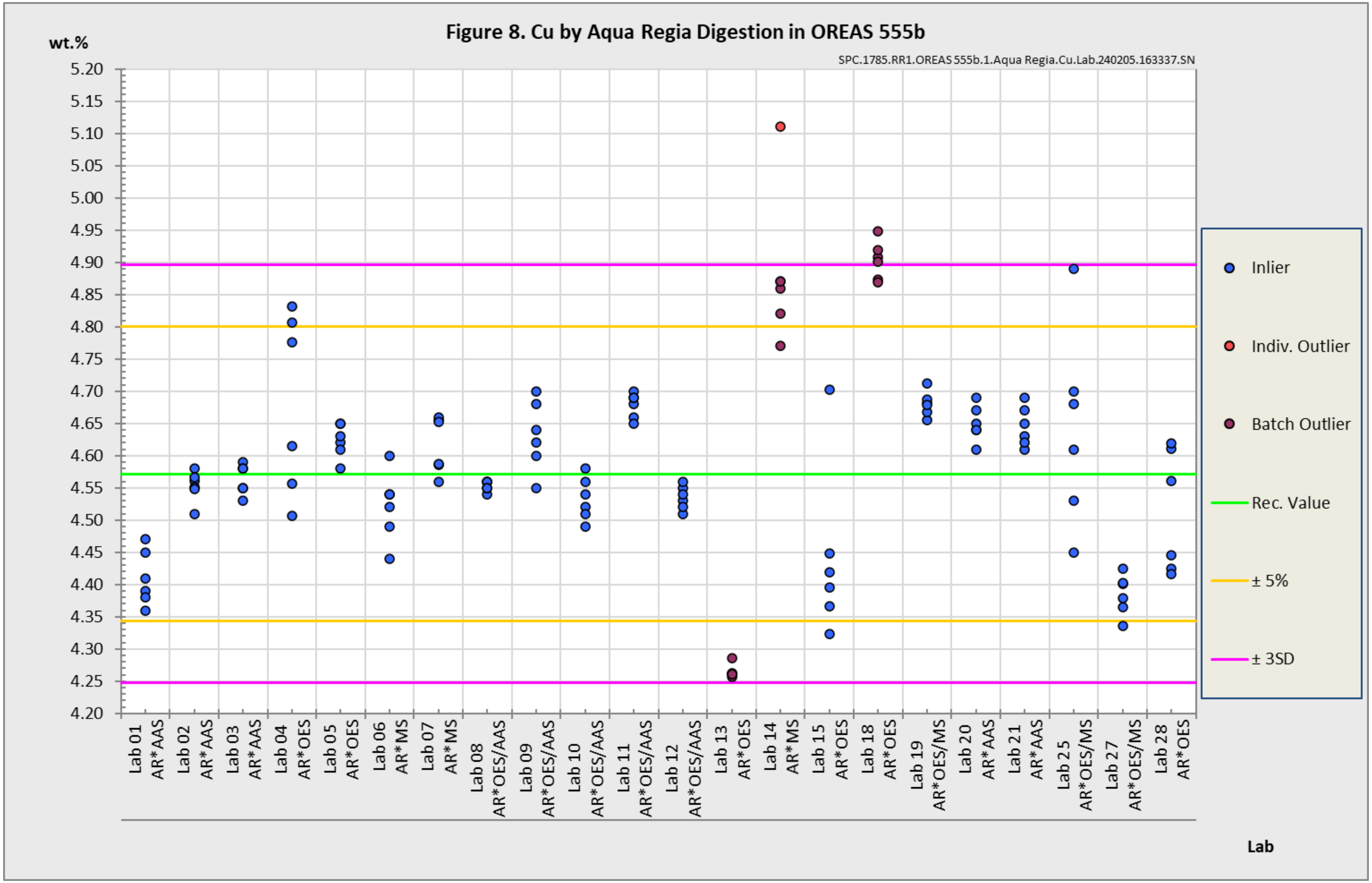
Figure 8. Cu by Aqua Regia Digestion in OREAS 555b
SPC.1785.RR1.OREAS 555b.1.Aqua Regia.Cu.Lab.240205.163337.SN
wt.%
5.20
5.15
5.10
5.05
5.00
4.95
4.90
4.85
4.80
4.75
4.70
4.65
4.60
4.55
4.50
4.45
4.40
4.35
4.30
4.25
4.20
Lab 01 AR*AAS
Lab 02 AR*AAS
Lab 03 AR*AAS
Lab 04 AR*OES
Lab 05 AR*OES
Lab 06 AR*MS
Lab 07 AR*MS
Lab 08 AR*OES/AAS
Lab 09 AR*OES/AAS
Lab 10 AR*OES/AAS
Lab 11 AR*OES/AAS
Lab 12 AR*OES/AAS
Lab 13 AR*OES
Lab 14 AR*MS
Lab 15 AR*OES
Lab 18 AR*OES
Lab 19 AR*OES/MS
Lab 20 AR*AAS
Lab 21 AR*AAS
Lab 25 AR*OES/MS
Lab 27 AR*OES/MS
Lab 28 AR*OES
Lab
Inlier
Indiv. Outlier
Batch Outlier
Rec. Value
± 5%
± 3SD

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)). 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 'representivity' 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 and aqua regia digestion methods (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, 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 35:2017, 9.2.4c)."* 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 555b 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 555b may be used to calibrate the entire procedure by producing a pure substance CRM transformed into a calibration solution.

OREAS 555b 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:

- Lithium borate fusion with X-ray fluorescence finish: ≥0.2g;
- Loss on Ignition (LOI) at 1000°C: ≥1g;
- C and S by infrared combustion furnace/CS analyser: ≥0.1g;
- Cu and Co by 5% sulphuric acid leach with ICP or AAS finish: 0.5g;
- Sodium peroxide fusion with ICP-OES and/or MS finish: ≥0.2g;
- 4-acid digestion with ICP-OES and/or MS finish: ≥0.25g;
- Aqua regia digestion with ICP-OES and/or MS finish: ≥0.5g.

PERIOD OF VALIDITY & STORAGE INSTRUCTIONS

The certification of OREAS 555b remains valid, within the specified measurement uncertainties, until September 2033, 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 (e.g., 10g units)

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

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	7th March, 2024	First publication.

CERTIFYING OFFICER

7th March, 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.

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

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

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

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APPENDIX

For Cu and Co by the two sulphuric acid leaches, specific methodologies were detailed for the participating laboratories to follow:

5% sulphuric acid leach

1. Weigh 0.500 ± 0.002g of sample pulp into a clean 250 ml flask.
2. Add to the flask 0.5g 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.
7. The solution is now ready to be analysed by ICP or AAS.