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CERTIFICATE OF ANALYSIS FOR

Copper-Cobalt Ore (Democratic Republic of the Congo)

CERTIFIED REFERENCE MATERIAL

OREAS 551

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Table 1. Certified Values and Performance Gates for OREAS 551.

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.%	4.50	0.055	4.39	4.61	4.33	4.67	1.23%	2.46%	3.69%	4.27	4.72
BaO, ppm	457	71	314	599	243	670	15.59%	31.19%	46.78%	434	479
CaO, wt.%	8.18	0.092	7.99	8.36	7.90	8.45	1.12%	2.24%	3.36%	7.77	8.59
Co, wt.%	0.303	0.008	0.287	0.319	0.279	0.327	2.65%	5.31%	7.96%	0.288	0.318
Cr_2O_3, ppm	< 100	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Cu, wt.%	0.569	0.015	0.539	0.598	0.525	0.613	2.58%	5.16%	7.73%	0.540	0.597
Fe_2O_3, wt.%	1.52	0.018	1.48	1.55	1.47	1.57	1.15%	2.31%	3.46%	1.44	1.59
K_2O, wt.%	0.803	0.015	0.772	0.834	0.757	0.849	1.91%	3.82%	5.73%	0.763	0.843
MgO, wt.%	8.13	0.106	7.92	8.34	7.81	8.45	1.31%	2.62%	3.93%	7.72	8.54
MnO, wt.%	0.187	0.005	0.176	0.197	0.171	0.202	2.75%	5.50%	8.25%	0.177	0.196
P_2O_5, wt.%	0.080	0.005	0.070	0.091	0.065	0.096	6.39%	12.78%	19.17%	0.076	0.084
SiO_2, wt.%	60.59	0.609	59.37	61.81	58.76	62.42	1.00%	2.01%	3.01%	57.56	63.62
SO_3, wt.%	0.418	0.011	0.396	0.440	0.385	0.451	2.66%	5.33%	7.99%	0.397	0.439
SrO, ppm	< 100	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
TiO_2, wt.%	0.253	0.009	0.234	0.271	0.224	0.281	3.72%	7.44%	11.16%	0.240	0.265
Thermogravimetry											
LOI^{1000}, wt.%	14.18	0.133	13.91	14.45	13.78	14.58	0.94%	1.88%	2.82%	13.47	14.89
Infrared Combustion											
C, wt.%	3.51	0.072	3.36	3.65	3.29	3.72	2.06%	4.12%	6.19%	3.33	3.68
S, wt.%	0.163	0.009	0.145	0.181	0.135	0.190	5.60%	11.19%	16.79%	0.155	0.171
Sulphuric Acid 5% Leach											
Co, wt.%	0.217	0.027	0.163	0.271	0.136	0.298	12.42%	24.85%	37.27%	0.206	0.228
Cu, wt.%	0.419	0.018	0.384	0.454	0.366	0.472	4.20%	8.40%	12.59%	0.398	0.440
Sulphuric Acid 10% Leach											
Co, wt.%	0.203	0.036	0.131	0.275	0.094	0.311	17.81%	35.62%	53.44%	0.193	0.213
Cu, wt.%	0.445	0.042	0.361	0.528	0.319	0.570	9.44%	18.87%	28.31%	0.422	0.467
Peroxide Fusion ICP											
Ag, ppm	< 1	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Al, wt.%	2.39	0.050	2.29	2.49	2.24	2.54	2.11%	4.21%	6.32%	2.27	2.51
B, ppm	198	8	181	215	173	224	4.27%	8.54%	12.80%	188	208
Ba, ppm	441	16	410	473	394	488	3.55%	7.10%	10.65%	419	464
Bi, ppm	1.46	0.27	0.92	2.01	0.64	2.28	18.65%	37.31%	55.96%	1.39	1.53
Ca, wt.%	5.89	0.108	5.67	6.10	5.56	6.21	1.84%	3.68%	5.51%	5.59	6.18
Ce, ppm	34.5	2.24	30.0	38.9	27.7	41.2	6.50%	13.00%	19.49%	32.7	36.2
Co, wt.%	0.306	0.006	0.294	0.319	0.287	0.325	2.05%	4.09%	6.14%	0.291	0.322
Cs, ppm	0.70	0.08	0.54	0.85	0.46	0.93	11.08%	22.15%	33.23%	0.66	0.73
Cu, wt.%	0.566	0.012	0.541	0.590	0.529	0.602	2.17%	4.34%	6.52%	0.537	0.594
Dy, ppm	2.95	0.203	2.54	3.35	2.34	3.56	6.89%	13.78%	20.67%	2.80	3.09
Er, ppm	1.58	0.115	1.35	1.81	1.23	1.92	7.29%	14.59%	21.88%	1.50	1.66
Eu, ppm	0.71	0.11	0.49	0.93	0.38	1.04	15.54%	31.08%	46.61%	0.67	0.75
Fe, wt.%	1.08	0.030	1.02	1.14	0.98	1.17	2.82%	5.64%	8.46%	1.02	1.13
Ga, ppm	6.25	0.74	4.78	7.73	4.05	8.46	11.77%	23.54%	35.31%	5.94	6.57
Gd, ppm	3.71	0.44	2.82	4.60	2.38	5.05	11.98%	23.97%	35.95%	3.53	3.90
Ho, ppm	0.56	0.039	0.49	0.64	0.45	0.68	6.87%	13.73%	20.60%	0.54	0.59

SI unit equivalents: ppm, parts per million ≡ mg/kg ≡ µg/g ≡ 0.0001 wt.% ≡ 1000 ppb, parts per billion.

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

Table 1 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											
K, wt.%	0.710	0.026	0.657	0.763	0.631	0.789	3.73%	7.46%	11.18%	0.674	0.745
La, ppm	21.3	1.04	19.2	23.4	18.2	24.4	4.88%	9.76%	14.64%	20.2	22.4
Li, ppm	79	3.7	72	87	68	90	4.73%	9.46%	14.18%	75	83
Lu, ppm	0.21	0.018	0.18	0.25	0.16	0.27	8.41%	16.82%	25.23%	0.20	0.23
Mg, wt.%	4.88	0.066	4.75	5.01	4.68	5.08	1.36%	2.72%	4.09%	4.64	5.12
Mn, wt.%	0.144	0.006	0.132	0.155	0.126	0.161	4.08%	8.16%	12.23%	0.136	0.151
Mo, ppm	2.57	0.49	1.60	3.55	1.11	4.04	18.93%	37.86%	56.79%	2.45	2.70
Nd, ppm	17.0	1.19	14.6	19.4	13.5	20.6	6.98%	13.96%	20.93%	16.2	17.9
P, wt.%	0.038	0.006	0.026	0.049	0.021	0.055	15.22%	30.45%	45.67%	0.036	0.040
Pb, ppm	9.90	2.92	4.06	15.74	1.14	18.66	29.49%	58.98%	88.47%	9.41	10.40
Pr, ppm	4.57	0.279	4.01	5.13	3.73	5.41	6.11%	12.22%	18.33%	4.34	4.80
Rb, ppm	25.8	2.27	21.3	30.4	19.0	32.6	8.77%	17.54%	26.31%	24.6	27.1
S, wt.%	0.167	0.015	0.137	0.198	0.121	0.213	9.12%	18.25%	27.37%	0.159	0.176
Sb, ppm	< 1	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Si, wt.%	28.94	0.586	27.77	30.11	27.18	30.70	2.02%	4.05%	6.07%	27.49	30.39
Sm, ppm	3.66	0.280	3.11	4.22	2.83	4.50	7.63%	15.26%	22.90%	3.48	3.85
Sr, ppm	67	4.1	59	76	55	80	6.10%	12.21%	18.31%	64	71
Tb, ppm	0.53	0.06	0.42	0.65	0.36	0.71	11.01%	22.01%	33.02%	0.51	0.56
Th, ppm	4.20	0.363	3.48	4.93	3.11	5.29	8.63%	17.27%	25.90%	3.99	4.41
Ti, wt.%	0.152	0.006	0.140	0.164	0.134	0.170	4.01%	8.02%	12.03%	0.144	0.159
Tl, ppm	< 0.5	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Tm, ppm	0.22	0.03	0.16	0.28	0.13	0.31	13.86%	27.72%	41.58%	0.21	0.23
U, ppm	8.73	0.612	7.51	9.96	6.90	10.57	7.01%	14.02%	21.03%	8.30	9.17
V, ppm	54	7	41	67	34	74	12.10%	24.21%	36.31%	51	57
Y, ppm	15.2	0.96	13.3	17.1	12.3	18.0	6.31%	12.61%	18.92%	14.4	15.9
Yb, ppm	1.45	0.121	1.20	1.69	1.08	1.81	8.39%	16.77%	25.16%	1.37	1.52
Zn, ppm	41.1	11.1	18.8	63.3	7.7	74.5	27.07%	54.15%	81.22%	39.0	43.1
***4-Acid Digestion**											
Ag, ppm	0.125	0.029	0.067	0.182	0.038	0.211	23.14%	46.28%	69.43%	0.118	0.131
Al, wt.%	2.36	0.056	2.25	2.47	2.19	2.53	2.39%	4.78%	7.17%	2.24	2.48
As, ppm	6.50	0.79	4.91	8.09	4.12	8.89	12.22%	24.45%	36.67%	6.18	6.83
Ba, ppm	437	18	401	473	383	492	4.13%	8.26%	12.40%	415	459
Be, ppm	1.21	0.107	1.00	1.42	0.89	1.53	8.80%	17.60%	26.40%	1.15	1.27
Bi, ppm	1.51	0.100	1.31	1.71	1.21	1.81	6.66%	13.33%	19.99%	1.43	1.58
Ca, wt.%	5.81	0.170	5.47	6.15	5.30	6.32	2.92%	5.84%	8.77%	5.52	6.10
Cd, ppm	0.12	0.011	0.09	0.14	0.08	0.15	9.59%	19.17%	28.76%	0.11	0.12
Ce, ppm	29.5	4.2	21.0	38.0	16.8	42.2	14.39%	28.78%	43.17%	28.0	31.0
Co, wt.%	0.305	0.015	0.274	0.336	0.259	0.351	5.04%	10.08%	15.12%	0.290	0.320
Cr, ppm	20.3	5.1	10.1	30.5	5.0	35.6	25.17%	50.35%	75.52%	19.2	21.3
Cs, ppm	0.63	0.038	0.55	0.70	0.51	0.74	6.07%	12.13%	18.20%	0.60	0.66
Cu, wt.%	0.565	0.017	0.530	0.600	0.513	0.617	3.08%	6.16%	9.24%	0.537	0.593
Dy, ppm	2.80	0.116	2.57	3.04	2.45	3.15	4.15%	8.30%	12.45%	2.66	2.94
Er, ppm	1.49	0.055	1.38	1.59	1.32	1.65	3.68%	7.36%	11.04%	1.41	1.56

SI unit equivalents: ppm, parts per million ≡ mg/kg ≡ µg/g ≡ 0.0001 wt.% ≡ 1000 ppb, parts per billion.
*Four acid digestion quantitatively dissolves nearly all minerals in the majority of geological samples however, some refractory minerals may only be partially digested.
Note: intervals may appear asymmetric due to rounding; the number of decimal places quoted does not imply accuracy of the certified value to this level but are given to minimise rounding errors when calculating 2SD and 3SD windows.

Table 1 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**											
Eu, ppm	0.68	0.027	0.62	0.73	0.60	0.76	3.99%	7.98%	11.97%	0.64	0.71
Fe, wt.%	1.05	0.048	0.95	1.15	0.91	1.19	4.58%	9.15%	13.73%	1.00	1.10
Ga, ppm	6.06	0.260	5.54	6.58	5.28	6.84	4.29%	8.58%	12.88%	5.76	6.36
Gd, ppm	3.43	0.179	3.07	3.78	2.89	3.96	5.21%	10.43%	15.64%	3.26	3.60
Hf, ppm	1.58	0.16	1.25	1.90	1.09	2.06	10.30%	20.61%	30.91%	1.50	1.65
Ho, ppm	0.52	0.05	0.41	0.62	0.36	0.67	10.03%	20.07%	30.10%	0.49	0.54
In, ppm	0.16	0.008	0.14	0.17	0.13	0.18	5.09%	10.18%	15.26%	0.15	0.16
K, wt.%	0.689	0.035	0.618	0.760	0.583	0.796	5.15%	10.29%	15.44%	0.655	0.724
La, ppm	16.4	2.7	10.9	21.9	8.2	24.6	16.72%	33.45%	50.17%	15.6	17.2
Li, ppm	79	4.1	71	87	67	91	5.19%	10.39%	15.58%	75	83
Lu, ppm	0.19	0.011	0.17	0.22	0.16	0.23	5.78%	11.56%	17.34%	0.18	0.20
Mg, wt.%	4.90	0.127	4.64	5.15	4.52	5.28	2.60%	5.20%	7.79%	4.65	5.14
Mn, wt.%	0.141	0.006	0.130	0.152	0.124	0.158	3.99%	7.97%	11.96%	0.134	0.148
Mo, ppm	2.41	0.160	2.09	2.73	1.93	2.89	6.63%	13.26%	19.88%	2.29	2.53
Na, wt.%	0.024	0.006	0.011	0.036	0.005	0.042	25.83%	51.67%	77.50%	0.022	0.025
Nb, ppm	4.00	0.88	2.24	5.75	1.37	6.63	21.95%	43.89%	65.84%	3.80	4.20
Nd, ppm	15.0	1.6	11.9	18.2	10.3	19.7	10.49%	20.97%	31.46%	14.3	15.8
Ni, ppm	17.7	1.68	14.3	21.1	12.7	22.7	9.47%	18.93%	28.40%	16.8	18.6
P, wt.%	0.035	0.002	0.031	0.040	0.029	0.042	6.17%	12.34%	18.52%	0.033	0.037
Pb, ppm	7.72	0.78	6.16	9.28	5.37	10.06	10.12%	20.24%	30.35%	7.33	8.10
Pr, ppm	3.71	0.45	2.80	4.61	2.35	5.06	12.21%	24.42%	36.64%	3.52	3.89
Rb, ppm	25.1	1.21	22.7	27.6	21.5	28.8	4.81%	9.62%	14.43%	23.9	26.4
Re, ppm	0.005	0.001	0.003	0.007	0.001	0.009	24.20%	48.41%	72.61%	0.005	0.005
S, wt.%	0.172	0.009	0.154	0.189	0.145	0.198	5.10%	10.21%	15.31%	0.163	0.180
Sb, ppm	0.29	0.025	0.24	0.34	0.21	0.37	8.80%	17.60%	26.40%	0.28	0.30
Sc, ppm	5.13	0.259	4.61	5.65	4.35	5.91	5.05%	10.10%	15.15%	4.88	5.39
Sm, ppm	3.38	0.255	2.87	3.89	2.62	4.15	7.54%	15.08%	22.62%	3.22	3.55
Sn, ppm	0.97	0.12	0.73	1.20	0.62	1.32	12.11%	24.22%	36.32%	0.92	1.02
Sr, ppm	62	2.8	57	68	54	71	4.51%	9.02%	13.54%	59	66
Ta, ppm	0.28	0.09	0.10	0.46	0.01	0.56	32.51%	65.01%	97.52%	0.27	0.30
Tb, ppm	0.51	0.022	0.47	0.56	0.45	0.58	4.36%	8.72%	13.08%	0.49	0.54
Th, ppm	4.01	0.307	3.40	4.62	3.09	4.93	7.66%	15.31%	22.97%	3.81	4.21
Ti, wt.%	0.088	0.023	0.043	0.134	0.020	0.157	25.85%	51.70%	77.55%	0.084	0.093
Tl, ppm	0.089	0.008	0.074	0.104	0.066	0.111	8.49%	16.97%	25.46%	0.084	0.093
Tm, ppm	0.20	0.008	0.19	0.22	0.18	0.23	3.87%	7.73%	11.60%	0.19	0.22
U, ppm	8.81	0.711	7.39	10.24	6.68	10.95	8.06%	16.12%	24.18%	8.37	9.26
V, ppm	51	2.8	45	57	42	59	5.56%	11.13%	16.69%	48	53
W, ppm	0.82	0.18	0.46	1.17	0.28	1.35	21.79%	43.58%	65.37%	0.78	0.86
Y, ppm	14.0	0.81	12.4	15.6	11.6	16.4	5.78%	11.55%	17.33%	13.3	14.7
Yb, ppm	1.35	0.125	1.10	1.60	0.98	1.73	9.25%	18.50%	27.75%	1.29	1.42
Zn, ppm	31.3	2.18	27.0	35.7	24.8	37.8	6.96%	13.91%	20.87%	29.7	32.9
Zr, ppm	56	2.9	50	62	47	65	5.15%	10.30%	15.45%	53	59

SI unit equivalents: ppm, parts per million ≡ mg/kg ≡ µg/g ≡ 0.0001 wt.% ≡ 1000 ppb, parts per billion.

*Four acid digestion quantitatively dissolves nearly all minerals in the majority of geological samples however, some refractory minerals may only be partially digested.

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Table 1 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	0.086	0.009	0.068	0.104	0.059	0.113	10.33%	20.65%	30.98%	0.082	0.090
Al, wt.%	0.987	0.085	0.816	1.158	0.731	1.243	8.64%	17.28%	25.92%	0.938	1.036
As, ppm	5.69	0.557	4.58	6.81	4.02	7.36	9.79%	19.59%	29.38%	5.41	5.98
Au, ppm	0.005	0.001	0.003	0.006	0.002	0.007	19.86%	39.72%	59.59%	0.004	0.005
B, ppm	9.07	1.20	6.66	11.47	5.46	12.67	13.25%	26.50%	39.76%	8.61	9.52
Ba, ppm	393	28	337	448	309	476	7.08%	14.15%	21.23%	373	412
Be, ppm	0.84	0.051	0.74	0.94	0.69	0.99	6.09%	12.18%	18.27%	0.80	0.88
Bi, ppm	1.24	0.057	1.12	1.35	1.07	1.41	4.61%	9.23%	13.84%	1.18	1.30
Ca, wt.%	5.70	0.094	5.51	5.88	5.41	5.98	1.65%	3.30%	4.96%	5.41	5.98
Cd, ppm	0.11	0.01	0.09	0.14	0.08	0.15	10.46%	20.93%	31.39%	0.11	0.12
Ce, ppm	11.3	0.98	9.3	13.2	8.3	14.2	8.71%	17.41%	26.12%	10.7	11.8
Co, wt.%	0.287	0.012	0.263	0.310	0.252	0.322	4.08%	8.17%	12.25%	0.272	0.301
Cr, ppm	18.2	1.82	14.6	21.9	12.8	23.7	10.00%	19.99%	29.99%	17.3	19.1
Cs, ppm	0.12	0.03	0.06	0.18	0.03	0.22	26.29%	52.57%	78.86%	0.11	0.13
Cu, wt.%	0.561	0.015	0.530	0.591	0.514	0.607	2.75%	5.50%	8.25%	0.533	0.589
Dy, ppm	1.83	0.093	1.64	2.01	1.55	2.11	5.07%	10.13%	15.20%	1.74	1.92
Er, ppm	0.82	0.028	0.76	0.88	0.74	0.91	3.47%	6.93%	10.40%	0.78	0.86
Eu, ppm	0.50	0.010	0.48	0.52	0.47	0.53	2.07%	4.13%	6.20%	0.48	0.53
Fe, wt.%	0.885	0.035	0.815	0.956	0.780	0.991	3.97%	7.94%	11.91%	0.841	0.930
Ga, ppm	2.75	0.203	2.35	3.16	2.14	3.36	7.38%	14.76%	22.14%	2.62	2.89
Gd, ppm	2.46	0.25	1.96	2.95	1.72	3.20	10.08%	20.16%	30.24%	2.34	2.58
Ge, ppm	< 0.05	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Hf, ppm	0.24	0.04	0.16	0.31	0.12	0.35	16.10%	32.20%	48.29%	0.23	0.25
Hg, ppm	0.027	0.006	0.014	0.040	0.008	0.046	23.96%	47.91%	71.87%	0.026	0.028
Ho, ppm	0.32	0.017	0.28	0.35	0.27	0.37	5.31%	10.62%	15.93%	0.30	0.33
In, ppm	0.14	0.007	0.12	0.15	0.12	0.16	4.99%	9.98%	14.97%	0.13	0.14
K, wt.%	0.129	0.016	0.097	0.162	0.081	0.178	12.51%	25.02%	37.52%	0.123	0.136
La, ppm	4.60	0.62	3.35	5.84	2.72	6.47	13.58%	27.16%	40.73%	4.37	4.83
Li, ppm	61	6	49	74	43	80	10.19%	20.37%	30.56%	58	64
Lu, ppm	0.099	0.009	0.081	0.117	0.073	0.126	8.96%	17.93%	26.89%	0.094	0.104
Mg, wt.%	4.60	0.195	4.21	4.99	4.01	5.18	4.24%	8.49%	12.73%	4.37	4.83
Mn, wt.%	0.140	0.008	0.123	0.157	0.115	0.166	6.05%	12.10%	18.14%	0.133	0.147
Mo, ppm	2.29	0.130	2.03	2.55	1.90	2.68	5.68%	11.35%	17.03%	2.17	2.40
Na, wt.%	0.010	0.003	0.005	0.015	0.003	0.018	24.49%	48.97%	73.46%	0.010	0.011
Nb, ppm	< 0.05	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Nd, ppm	7.34	0.300	6.74	7.94	6.44	8.24	4.09%	8.18%	12.27%	6.97	7.71
Ni, ppm	16.7	1.35	14.0	19.4	12.7	20.7	8.06%	16.13%	24.19%	15.9	17.5
P, wt.%	0.033	0.002	0.029	0.037	0.027	0.039	5.97%	11.95%	17.92%	0.031	0.035
Pb, ppm	6.69	0.559	5.58	7.81	5.02	8.37	8.35%	16.70%	25.05%	6.36	7.03
Pr, ppm	1.41	0.21	0.99	1.83	0.78	2.05	14.98%	29.96%	44.94%	1.34	1.48
Rb, ppm	4.16	0.49	3.18	5.14	2.69	5.63	11.77%	23.55%	35.32%	3.95	4.37
Re, ppm	0.005	0.001	0.003	0.006	0.003	0.006	14.10%	28.19%	42.29%	0.004	0.005
S, wt.%	0.157	0.015	0.127	0.187	0.112	0.201	9.50%	19.00%	28.50%	0.149	0.165

SI unit equivalents: ppm, parts per million ≡ mg/kg ≡ µg/g ≡ 0.0001 wt.% ≡ 1000 ppb, parts per billion.

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

Table 1 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											
Sb, ppm	0.18	0.018	0.15	0.22	0.13	0.24	9.66%	19.31%	28.97%	0.17	0.19
Sc, ppm	3.78	0.317	3.15	4.42	2.83	4.73	8.39%	16.79%	25.18%	3.59	3.97
Se, ppm	1.02	0.24	0.54	1.51	0.29	1.75	23.80%	47.59%	71.39%	0.97	1.07
Sn, ppm	0.31	0.03	0.24	0.37	0.21	0.40	10.76%	21.53%	32.29%	0.29	0.32
Sr, ppm	49.7	3.06	43.6	55.9	40.6	58.9	6.16%	12.31%	18.47%	47.2	52.2
Ta, ppm	< 0.01	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Tb, ppm	0.35	0.019	0.32	0.39	0.30	0.41	5.23%	10.46%	15.70%	0.34	0.37
Th, ppm	1.80	0.145	1.51	2.09	1.36	2.23	8.07%	16.13%	24.20%	1.71	1.89
Tl, ppm	0.046	0.006	0.034	0.058	0.028	0.063	12.78%	25.56%	38.34%	0.044	0.048
U, ppm	6.71	0.410	5.89	7.53	5.48	7.94	6.11%	12.23%	18.34%	6.37	7.05
V, ppm	29.8	1.54	26.7	32.8	25.2	34.4	5.16%	10.32%	15.48%	28.3	31.3
W, ppm	0.42	0.08	0.27	0.58	0.19	0.66	18.55%	37.11%	55.66%	0.40	0.44
Y, ppm	8.46	0.350	7.76	9.16	7.40	9.51	4.14%	8.29%	12.43%	8.03	8.88
Yb, ppm	0.66	0.048	0.57	0.76	0.52	0.81	7.24%	14.49%	21.73%	0.63	0.69
Zn, ppm	28.6	1.56	25.5	31.7	24.0	33.3	5.44%	10.89%	16.33%	27.2	30.1
Zr, ppm	7.42	0.437	6.55	8.29	6.11	8.73	5.88%	11.77%	17.65%	7.05	7.79

SI unit equivalents: ppm, parts per million ≡ mg/kg ≡ µg/g ≡ 0.0001 wt.% ≡ 1000 ppb, parts per billion.

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

Table 2. Indicative Values for OREAS 551.

Constituent	Unit	Value	Constituent	Unit	Value	Constituent	Unit	Value
Borate Fusion XRF								
As	ppm	*28.3*	Na_2O	wt.%	*0.032*	V_2O_5	ppm	*113*
Bi	ppm	*< 10*	Ni	ppm	*63*	Zn	ppm	*36.7*
Cd	ppm	*< 10*	Pb	ppm	*< 90*	Zr	ppm	*65*
Cl	ppm	*258*	Sb	ppm	*< 10*			
Mo	ppm	*31.2*	Sn	ppm	*< 10*			
Thermogravimetry								
H_2O-	wt.%	*0.553*						
Peroxide Fusion ICP								
As	ppm	*9.31*	Hg	ppm	*0.080*	Se	ppm	*9.34*
Be	ppm	*1.39*	In	ppm	*0.19*	Sn	ppm	*4.05*
Cd	ppm	*< 10*	Nb	ppm	*6.69*	Ta	ppm	*0.62*
Cr	ppm	*60*	Ni	ppm	*25.7*	Te	ppm	*< 1*
Ge	ppm	*0.84*	Re	ppm	*< 0.1*	W	ppm	*1.39*
Hf	ppm	*2.57*	Sc	ppm	*4.75*	Zr	ppm	*81*
4-Acid Digestion								
B	ppm	*7.43*	Hg	ppm	*0.057*	Te	ppm	*< 0.05*
Ge	ppm	*0.084*	Se	ppm	*1.35*			

SI unit equivalents: ppm (parts per million) ≡ mg/kg ≡ µg/g ≡ 0.0001 wt.% ≡ 1000 ppb (parts per billion).

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

Table 2 continued.

Constituent	Unit	Value	Constituent	Unit	Value	Constituent	Unit	Value
Aqua Regia Digestion								
Pd	ppb	*< 10*	Sm	ppm	*2.30*	Tm	ppm	*0.11*
Pt	ppb	*11.7*	Te	ppm	*0.021*			
Si	wt.%	*0.077*	Ti	wt.%	*0.003*			

SI unit equivalents: ppm (parts per million) ≡ mg/kg ≡ µg/g ≡ 0.0001 wt.% ≡ 1000 ppb (parts per billion).

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 provides performance gate intervals for the certified values. Table 2 shows indicative values, Table 3 provides some indicative physical properties and Table 4 presents the 95% confidence and tolerance limits 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 551-DataPack.1.1.210420_163736.xlsx**).

Results are also presented in scatter plots for Co and Cu by 4-acid digestion and peroxide fusion ICP in Figures 1 to 4 respectively, together with ±3SD (magenta) and ±5% (yellow) control lines and certified value (green line). Accepted individual results are coloured blue and individual and dataset outliers are identified in red and violet, respectively.

SOURCE MATERIAL

OREAS 551 was prepared from a blend of copper-cobalt oxide ore materials supplied by Metorex (subsidiary of Jinchuan Group) from the Dilala Est Copper Cobalt Project, located within the Kolwezi Klippe area of Lualaba Province (Democratic Republic of the Congo). Kolwezi is ~320 kilometres northwest from Lubumbashi, the provincial capital of Haut Katanga Province. Copper-cobalt ores within the Kolwezi Klippe area are stratiform, sediment-hosted deposits hosted within Neoproterozoic sedimentary rocks of the Central African Copperbelt. Primary mineralisation typically consists of bornite, chalcopyrite and cobalt sulphides hosted within dolomitic argillite, shales, sandstone and dolomite horizons. Significant oxide minerals include malachite, chalcocite, digenite and hetrogenite.

PERFORMANCE GATES

Table 1 above 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 (adapted from Govett, 1983).

COMMINUTION AND HOMOGENISATION PROCEDURES

The material constituting OREAS 551 was prepared in the following manner:

- Drying to constant mass at 105° Celsius;
- Multi-stage milling of each source material to achieve a particle size distribution of >98% passing 75 microns;
- Preliminary homogenisation of each source material;
- Representative sampling and check assaying of each source material;
- Blending in appropriate proportions to achieve target grades;
- Packaging in 10g units sealed in laminated foil pouches and 1000g units in plastic jars.

PHYSICAL PROPERTIES

OREAS 551 was tested at ORE Research & Exploration Pty Ltd's onsite facility for various physical properties. Table 3 presents these findings that should be used for informational purposes only.

Table 3. Physical properties of OREAS 551.

Bulk Density (g/L)	Moisture%	Munsell Notation‡	Munsell Color‡
824	0.26	5YR 8/1	Pinkish 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

Thirty analytical laboratories participated in the program to characterise the elements reported in Table 1. The following methods were employed:

- Lithium borate fusion whole rock analysis package by X-ray fluorescence (up to 19 laboratories depending on the element);
- Thermogravimetry: Loss on Ignition (LOI) at 1000°C (13 laboratories used a thermogravimetric analyser, 7 laboratories included LOI with their fusion package and 4 laboratories used conventional muffle furnace);
- C and S by infrared combustion furnace/CS analyser (27 laboratories);
- Cu and Co by *5% sulphuric acid leach with ICP or AAS finish (up to 19 laboratories);
- Cu and Co by *10% sulphuric acid leach with ICP or AAS finish (up to 12 laboratories);
- Sodium peroxide fusion with full suite elemental package by ICP-OES and/or MS finish (up to 20 laboratories depending on the element);
- 4-acid digestion for full suite elemental package by ICP-OES and MS finish (up to 26 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).

*See 'Appendix' for specified methodology.

For the round robin program ten 400g 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 25g scoop splits from each of three separate 400g test units. This format enabled 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

Standard Deviation intervals (see Table 1) 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-laboratory 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.***

Certified Values, Confidence Limits and Tolerance Limits (Table 4) have been determined for each analyte following removal of individual, laboratory dataset (batch) and 3SD outliers (single iteration).

95% Confidence Limits are inversely proportional to the number of participating laboratories and inter-laboratory agreement. It is a measure of the reliability of the certified value. A 95% confidence interval indicates a 95% probability that the true value of the analyte under consideration lies between the upper and lower limits. ***95% Confidence Limits should not be used as control limits for laboratory performance.***

Indicative (uncertified) values (Table 2) are provided where i) a laboratory reported analytes beyond those requested; ii) the number of laboratories reporting a particular analyte is insufficient (< 5) to support certification; iii) inter-laboratory consensus is poor; or iv) a significant proportion of results are outlying.

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. In certain instances, statistician's prerogative has been employed in discriminating outliers. 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.

Table 4. 95% Confidence & Tolerance Limits for OREAS 551.

Constituent	Certified Value	95% Confidence Limits		95% Tolerance Limits	
		Low	High	Low	High
Borate Fusion XRF					
Al_2O_3, Aluminium(III) oxide (wt.%)	4.50	4.48	4.52	4.46	4.54
BaO, Barium oxide (ppm)	457	410	504	429	485
CaO, Calcium oxide (wt.%)	8.18	8.14	8.22	8.13	8.22
Co, Cobalt (wt.%)	0.303	0.299	0.308	0.299	0.308
Cr_2O_3, Chromium(III) oxide (ppm)	< 100	IND	IND	IND	IND
Cu, Copper (wt.%)	0.569	0.561	0.577	0.560	0.577
Fe_2O_3, Iron(III) oxide (wt.%)	1.52	1.51	1.53	1.50	1.54
K_2O, Potassium oxide (wt.%)	0.803	0.796	0.810	0.791	0.815
MgO, Magnesium oxide (wt.%)	8.13	8.07	8.19	8.08	8.18
MnO, Manganese oxide (wt.%)	0.187	0.184	0.189	0.185	0.189
P_2O_5, Phosphorus(V) oxide (wt.%)	0.080	0.078	0.083	0.079	0.082
SiO_2, Silicon dioxide (wt.%)	60.59	60.31	60.87	60.34	60.84
SO_3, Sulphur trioxide (wt.%)	0.418	0.410	0.426	0.407	0.429

SI unit equivalents: ppm, parts per million ≡ mg/kg ≡ µg/g ≡ 0.0001 wt.% ≡ 1000 ppb, parts per billion.
Note: intervals may appear asymmetric due to rounding; IND = indeterminate (due to reading resolution error).

Table 4 continued.

Constituent	Certified Value	95% Confidence Limits		95% Tolerance Limits	
		Low	High	Low	High
Borate Fusion XRF continued					
SrO, Strontium oxide (ppm)	< 100	IND	IND	IND	IND
TiO_2, Titanium dioxide (wt.%)	0.253	0.249	0.256	0.241	0.264
Thermogravimetry					
LOI^{1000}, Loss On Ignition @1000°C (wt.%)	14.18	14.12	14.24	14.12	14.25
Infrared Combustion					
C, Carbon (wt.%)	3.51	3.48	3.54	3.47	3.54
S, Sulphur (wt.%)	0.163	0.160	0.166	0.159	0.166
Sulphuric Acid 5% Leach					
Co, Cobalt (wt.%)	0.217	0.193	0.241	0.210	0.223
Cu, Copper (wt.%)	0.419	0.410	0.428	0.412	0.426
Sulphuric Acid 10% Leach					
Co, Cobalt (wt.%)	0.203	0.179	0.227	0.199	0.207
Cu, Copper (wt.%)	0.445	0.416	0.473	0.432	0.457
Peroxide Fusion ICP					
Ag, Silver (ppm)	< 1	IND	IND	IND	IND
Al, Aluminium (wt.%)	2.39	2.37	2.41	2.35	2.43
B, Boron (ppm)	198	191	206	IND	IND
Ba, Barium (ppm)	441	434	449	428	455
Bi, Bismuth (ppm)	1.46	1.23	1.69	IND	IND
Ca, Calcium (wt.%)	5.89	5.84	5.93	5.79	5.98
Ce, Cerium (ppm)	34.5	32.4	36.5	33.1	35.8
Co, Cobalt (wt.%)	0.306	0.304	0.309	0.301	0.311
Cs, Caesium (ppm)	0.70	0.64	0.75	IND	IND
Cu, Copper (wt.%)	0.566	0.561	0.570	0.551	0.580
Dy, Dysprosium (ppm)	2.95	2.85	3.04	2.76	3.14
Er, Erbium (ppm)	1.58	1.51	1.65	1.43	1.72
Eu, Europium (ppm)	0.71	0.64	0.78	0.63	0.79
Fe, Iron (wt.%)	1.08	1.06	1.09	1.05	1.10
Ga, Gallium (ppm)	6.25	5.82	6.69	5.88	6.63
Gd, Gadolinium (ppm)	3.71	3.37	4.05	3.49	3.94
Ho, Holmium (ppm)	0.56	0.54	0.58	0.52	0.61
K, Potassium (wt.%)	0.710	0.693	0.727	0.686	0.734
La, Lanthanum (ppm)	21.3	20.8	21.8	20.2	22.4
Li, Lithium (ppm)	79	76	82	76	82
Lu, Lutetium (ppm)	0.21	0.20	0.23	0.19	0.24
Mg, Magnesium (wt.%)	4.88	4.85	4.91	4.82	4.94
Mn, Manganese (wt.%)	0.144	0.141	0.146	0.139	0.148
Mo, Molybdenum (ppm)	2.57	2.17	2.98	IND	IND

SI unit equivalents: ppm, parts per million ≡ mg/kg ≡ µg/g ≡ 0.0001 wt.% ≡ 1000 ppb, parts per billion.
Note: intervals may appear asymmetric due to rounding; IND = indeterminate (due to reading resolution error).

Table 4 continued.

Constituent	Certified Value	95% Confidence Limits		95% Tolerance Limits	
		Low	High	Low	High
Peroxide Fusion ICP continued					
Nd, Neodymium (ppm)	17.0	16.1	18.0	16.2	17.8
P, Phosphorus (wt.%)	0.038	0.033	0.043	IND	IND
Pb, Lead (ppm)	9.90	7.82	11.99	IND	IND
Pr, Praseodymium (ppm)	4.57	4.41	4.73	4.33	4.81
Rb, Rubidium (ppm)	25.8	24.7	27.0	24.4	27.2
S, Sulphur (wt.%)	0.167	0.159	0.176	IND	IND
Sb, Antimony (ppm)	< 1	IND	IND	IND	IND
Si, Silicon (wt.%)	28.94	28.61	29.27	28.44	29.44
Sm, Samarium (ppm)	3.66	3.56	3.77	3.32	4.00
Sr, Strontium (ppm)	67	65	69	65	70
Tb, Terbium (ppm)	0.53	0.50	0.56	0.50	0.56
Th, Thorium (ppm)	4.20	3.99	4.41	3.93	4.48
Ti, Titanium (wt.%)	0.152	0.150	0.154	0.146	0.158
Tl, Thallium (ppm)	< 0.5	IND	IND	IND	IND
Tm, Thulium (ppm)	0.22	0.20	0.23	0.19	0.25
U, Uranium (ppm)	8.73	8.30	9.17	8.32	9.14
V, Vanadium (ppm)	54	50	58	51	57
Y, Yttrium (ppm)	15.2	14.5	15.9	14.6	15.8
Yb, Ytterbium (ppm)	1.45	1.37	1.52	IND	IND
Zn, Zinc (ppm)	41.1	35.4	46.8	35.2	47.0
Nd, Neodymium (ppm)	17.0	16.1	18.0	16.2	17.8
P, Phosphorus (wt.%)	0.038	0.033	0.043	IND	IND
***4-Acid Digestion**					
Ag, Silver (ppm)	0.125	0.111	0.139	IND	IND
Al, Aluminium (wt.%)	2.36	2.34	2.38	2.31	2.41
As, Arsenic (ppm)	6.50	6.16	6.85	6.21	6.80
Ba, Barium (ppm)	437	430	445	428	447
Be, Beryllium (ppm)	1.21	1.19	1.24	1.16	1.26
Bi, Bismuth (ppm)	1.51	1.47	1.55	1.46	1.56
Ca, Calcium (wt.%)	5.81	5.74	5.88	5.71	5.92
Cd, Cadmium (ppm)	0.12	0.11	0.12	IND	IND
Ce, Cerium (ppm)	29.5	27.5	31.6	28.5	30.5
Co, Cobalt (wt.%)	0.305	0.299	0.311	0.299	0.311
Cr, Chromium (ppm)	20.3	18.0	22.6	18.8	21.7
Cs, Caesium (ppm)	0.63	0.61	0.64	0.60	0.65
Cu, Copper (wt.%)	0.565	0.559	0.571	0.554	0.576
Dy, Dysprosium (ppm)	2.80	2.68	2.93	2.71	2.89

SI unit equivalents: ppm, parts per million ≡ mg/kg ≡ µg/g ≡ 0.0001 wt.% ≡ 1000 ppb, parts per billion.

*Four acid digestion quantitatively dissolves nearly all minerals in the majority of geological samples however, some refractory minerals may only be partially digested.

Note: intervals may appear asymmetric due to rounding; IND = indeterminate (due to reading resolution error).

Table 4 continued.

Constituent	Certified Value	95% Confidence Limits		95% Tolerance Limits	
		Low	High	Low	High
***4-Acid Digestion continued**					
Er, Erbium (ppm)	1.49	1.44	1.53	1.42	1.55
Eu, Europium (ppm)	0.68	0.66	0.70	0.64	0.71
Fe, Iron (wt.%)	1.05	1.03	1.07	1.03	1.07
Ga, Gallium (ppm)	6.06	5.95	6.17	5.87	6.25
Gd, Gadolinium (ppm)	3.43	3.31	3.54	3.28	3.57
Hf, Hafnium (ppm)	1.58	1.51	1.64	1.49	1.66
Ho, Holmium (ppm)	0.52	0.48	0.56	0.50	0.53
In, Indium (ppm)	0.16	0.15	0.16	0.15	0.16
K, Potassium (wt.%)	0.689	0.673	0.705	0.676	0.702
La, Lanthanum (ppm)	16.4	15.1	17.7	15.8	17.0
Li, Lithium (ppm)	79	77	81	77	81
Lu, Lutetium (ppm)	0.19	0.19	0.20	IND	IND
Mg, Magnesium (wt.%)	4.90	4.85	4.95	4.80	4.99
Mn, Manganese (wt.%)	0.141	0.139	0.143	0.138	0.144
Mo, Molybdenum (ppm)	2.41	2.34	2.48	2.31	2.51
Na, Sodium (wt.%)	0.024	0.021	0.027	0.022	0.025
Nb, Niobium (ppm)	4.00	3.59	4.41	3.85	4.15
Nd, Neodymium (ppm)	15.0	14.0	16.1	14.4	15.7
Ni, Nickel (ppm)	17.7	17.0	18.4	17.2	18.2
P, Phosphorus (wt.%)	0.035	0.035	0.036	0.034	0.037
Pb, Lead (ppm)	7.72	7.28	8.15	7.25	8.18
Pr, Praseodymium (ppm)	3.71	3.40	4.01	3.57	3.85
Rb, Rubidium (ppm)	25.1	24.6	25.7	24.5	25.7
Re, Rhenium (ppm)	0.005	0.004	0.006	IND	IND
S, Sulphur (wt.%)	0.172	0.168	0.175	0.164	0.179
Sb, Antimony (ppm)	0.29	0.28	0.30	0.26	0.32
Sc, Scandium (ppm)	5.13	5.01	5.26	4.97	5.29
Sm, Samarium (ppm)	3.38	3.22	3.55	3.23	3.54
Sn, Tin (ppm)	0.97	0.92	1.02	IND	IND
Sr, Strontium (ppm)	62	61	64	61	64
Ta, Tantalum (ppm)	0.28	0.23	0.33	0.26	0.30
Tb, Terbium (ppm)	0.51	0.50	0.53	0.49	0.54
Th, Thorium (ppm)	4.01	3.88	4.13	3.89	4.13
Ti, Titanium (wt.%)	0.088	0.078	0.099	0.085	0.092
Tl, Thallium (ppm)	0.089	0.086	0.091	IND	IND
Tm, Thulium (ppm)	0.20	0.20	0.21	0.18	0.23
U, Uranium (ppm)	8.81	8.56	9.07	8.34	9.29

SI unit equivalents: ppm, parts per million ≡ mg/kg ≡ µg/g ≡ 0.0001 wt.% ≡ 1000 ppb, parts per billion.

*Four acid digestion quantitatively dissolves nearly all minerals in the majority of geological samples however, some refractory minerals may only be partially digested.

Note: intervals may appear asymmetric due to rounding; IND = indeterminate (due to reading resolution error).

Table 4 continued.

Constituent	Certified Value	95% Confidence Limits		95% Tolerance Limits	
		Low	High	Low	High
***4-Acid Digestion continued**					
V, Vanadium (ppm)	51	50	52	50	52
W, Tungsten (ppm)	0.82	0.76	0.88	IND	IND
Y, Yttrium (ppm)	14.0	13.6	14.3	13.6	14.3
Yb, Ytterbium (ppm)	1.35	1.28	1.43	1.27	1.43
Zn, Zinc (ppm)	31.3	30.4	32.2	30.0	32.6
Zr, Zirconium (ppm)	56	55	57	54	58
Aqua Regia Digestion					
Ag, Silver (ppm)	0.086	0.083	0.089	0.066	0.106
Al, Aluminium (wt.%)	0.987	0.946	1.028	0.951	1.022
As, Arsenic (ppm)	5.69	5.35	6.03	5.42	5.96
Au, Gold (ppm)	0.005	0.004	0.005	0.003	0.006
B, Boron (ppm)	9.07	7.45	10.68	IND	IND
Ba, Barium (ppm)	393	379	407	383	402
Be, Beryllium (ppm)	0.84	0.82	0.86	0.80	0.88
Bi, Bismuth (ppm)	1.24	1.21	1.26	1.21	1.27
Ca, Calcium (wt.%)	5.70	5.66	5.74	5.59	5.80
Cd, Cadmium (ppm)	0.11	0.11	0.12	IND	IND
Ce, Cerium (ppm)	11.3	10.8	11.7	10.9	11.6
Co, Cobalt (wt.%)	0.287	0.282	0.292	0.281	0.293
Cr, Chromium (ppm)	18.2	17.4	19.1	17.0	19.5
Cs, Caesium (ppm)	0.12	0.10	0.14	IND	IND
Cu, Copper (wt.%)	0.561	0.554	0.567	0.550	0.571
Dy, Dysprosium (ppm)	1.83	1.74	1.92	IND	IND
Er, Erbium (ppm)	0.82	0.78	0.86	IND	IND
Eu, Europium (ppm)	0.50	0.49	0.51	IND	IND
Fe, Iron (wt.%)	0.885	0.869	0.901	0.863	0.908
Ga, Gallium (ppm)	2.75	2.65	2.86	2.64	2.86
Gd, Gadolinium (ppm)	2.46	2.13	2.79	2.30	2.61
Ge, Germanium (ppm)	< 0.05	IND	IND	IND	IND
Hf, Hafnium (ppm)	0.24	0.22	0.26	0.22	0.26
Hg, Mercury (ppm)	0.027	0.023	0.031	IND	IND
Ho, Holmium (ppm)	0.32	0.30	0.33	IND	IND
In, Indium (ppm)	0.14	0.13	0.14	0.13	0.14
K, Potassium (wt.%)	0.129	0.122	0.137	0.122	0.136
La, Lanthanum (ppm)	4.60	4.30	4.89	4.40	4.79
Li, Lithium (ppm)	61	58	65	60	63
Lu, Lutetium (ppm)	0.099	0.090	0.109	IND	IND

SI unit equivalents: ppm, parts per million ≡ mg/kg ≡ µg/g ≡ 0.0001 wt.% ≡ 1000 ppb, parts per billion.

*Four acid digestion quantitatively dissolves nearly all minerals in the majority of geological samples however, some refractory minerals may only be partially digested.

Note: intervals may appear asymmetric due to rounding; IND = indeterminate (due to reading resolution error).

Table 4 continued.

Constituent	Certified Value	95% Confidence Limits		95% Tolerance Limits	
		Low	High	Low	High
Aqua Regia Digestion continued					
Mg, Magnesium (wt.%)	4.60	4.51	4.69	4.50	4.70
Mn, Manganese (wt.%)	0.140	0.137	0.144	0.137	0.143
Mo, Molybdenum (ppm)	2.29	2.23	2.34	2.21	2.36
Na, Sodium (wt.%)	0.010	0.009	0.012	IND	IND
Nb, Niobium (ppm)	< 0.05	IND	IND	IND	IND
Nd, Neodymium (ppm)	7.34	7.02	7.65	6.94	7.74
Ni, Nickel (ppm)	16.7	16.0	17.4	16.3	17.1
P, Phosphorus (wt.%)	0.033	0.032	0.034	0.032	0.034
Pb, Lead (ppm)	6.69	6.41	6.98	6.46	6.93
Pr, Praseodymium (ppm)	1.41	1.13	1.69	IND	IND
Rb, Rubidium (ppm)	4.16	3.91	4.42	3.96	4.36
Re, Rhenium (ppm)	0.005	0.004	0.005	IND	IND
S, Sulphur (wt.%)	0.157	0.150	0.164	IND	IND
Sb, Antimony (ppm)	0.18	0.18	0.19	0.16	0.21
Sc, Scandium (ppm)	3.78	3.61	3.96	3.64	3.93
Se, Selenium (ppm)	1.02	0.89	1.16	IND	IND
Sn, Tin (ppm)	0.31	0.29	0.32	0.27	0.34
Sr, Strontium (ppm)	49.7	48.2	51.2	48.6	50.8
Ta, Tantalum (ppm)	< 0.01	IND	IND	IND	IND
Tb, Terbium (ppm)	0.35	0.34	0.37	0.34	0.37
Th, Thorium (ppm)	1.80	1.74	1.86	1.71	1.88
Tl, Thallium (ppm)	0.046	0.043	0.048	IND	IND
U, Uranium (ppm)	6.71	6.56	6.86	6.40	7.02
V, Vanadium (ppm)	29.8	29.0	30.5	28.6	31.0
W, Tungsten (ppm)	0.42	0.40	0.45	0.34	0.51
Y, Yttrium (ppm)	8.46	8.26	8.65	8.26	8.65
Yb, Ytterbium (ppm)	0.66	0.63	0.70	IND	IND
Zn, Zinc (ppm)	28.6	27.9	29.4	27.7	29.6
Zr, Zirconium (ppm)	7.42	7.16	7.68	7.15	7.69

SI unit equivalents: ppm, parts per million ≡ mg/kg ≡ µg/g ≡ 0.0001 wt.% ≡ 1000 ppb, parts per billion.
Note: intervals may appear asymmetric due to rounding; IND = indeterminate (due to reading resolution error).

Homogeneity Evaluation

The tolerance limits (ISO 16269:2014) shown in Table 4 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-α=0.99) at least 95% of subsamples (ρ=0.95) will have concentrations lying between 0.560 and 0.577 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.

Based on the statistical analysis of the results of the inter-laboratory certification program it can be concluded that OREAS 551 is sufficiently homogenous and fit-for-purpose as a certified reference material (see 'Intended Use' below).

PARTICIPATING LABORATORIES

1. Actlabs, Ancaster, Ontario, Canada
2. AGAT Laboratories, Mississauga, Ontario, Canada
3. AH Knight, Kitwe, Copperbelt, Zambia
4. AH Knight, Lumwana, Mwinilunga, Zambia
5. ALS, Brisbane, QLD, Australia
6. ALS, Johannesburg, South Africa
7. ALS, Lima, Peru
8. ALS, Loughrea, Galway, Ireland
9. ALS, Vancouver, BC, Canada
10. American Assay Laboratories, Sparks, Nevada, USA
11. Bureau Veritas Commodities Canada Ltd, Vancouver, BC, Canada
12. Bureau Veritas Geoanalytical, Adelaide, SA, Australia
13. Bureau Veritas Geoanalytical, Perth, WA, Australia
14. Carsurin, Kendari, Sulawesi, Indonesia
15. Inspectorate (BV), Lima, Peru
16. Intertek Genalysis, Perth, WA, Australia
17. Intertek Testing Services Philippines, Cupang, Muntinlupa, Philippines
18. MSALABS, Vancouver, BC, Canada
19. Nagrom, Perth, WA, Australia
20. Ontario Geological Survey, Sudbury, Ontario, Canada
21. PT Geoservices Ltd, Cikarang, Jakarta Raya, Indonesia
22. PT Intertek Utama Services, Jakarta Timur, DKI Jakarta, Indonesia
23. Robinson International Afrique SAS, Lubumbashi, Katanga, Democratic Republic of the Congo
24. Ruashi Mine Site Laboratory, Lubumbashi, Katanga, Democratic Republic of the Congo
25. Saskatchewan Research Council, Saskatoon, Saskatchewan, Canada
26. SGS, Randfontein, Gauteng, South Africa
27. SGS Canada Inc., Vancouver, BC, Canada
28. SGS del Peru, Lima, Peru
29. SGS Geosol Laboratorios Ltda, Vespasiano, Minas Gerais, Brazil
30. UIS Analytical Services, Centurion, South Africa

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

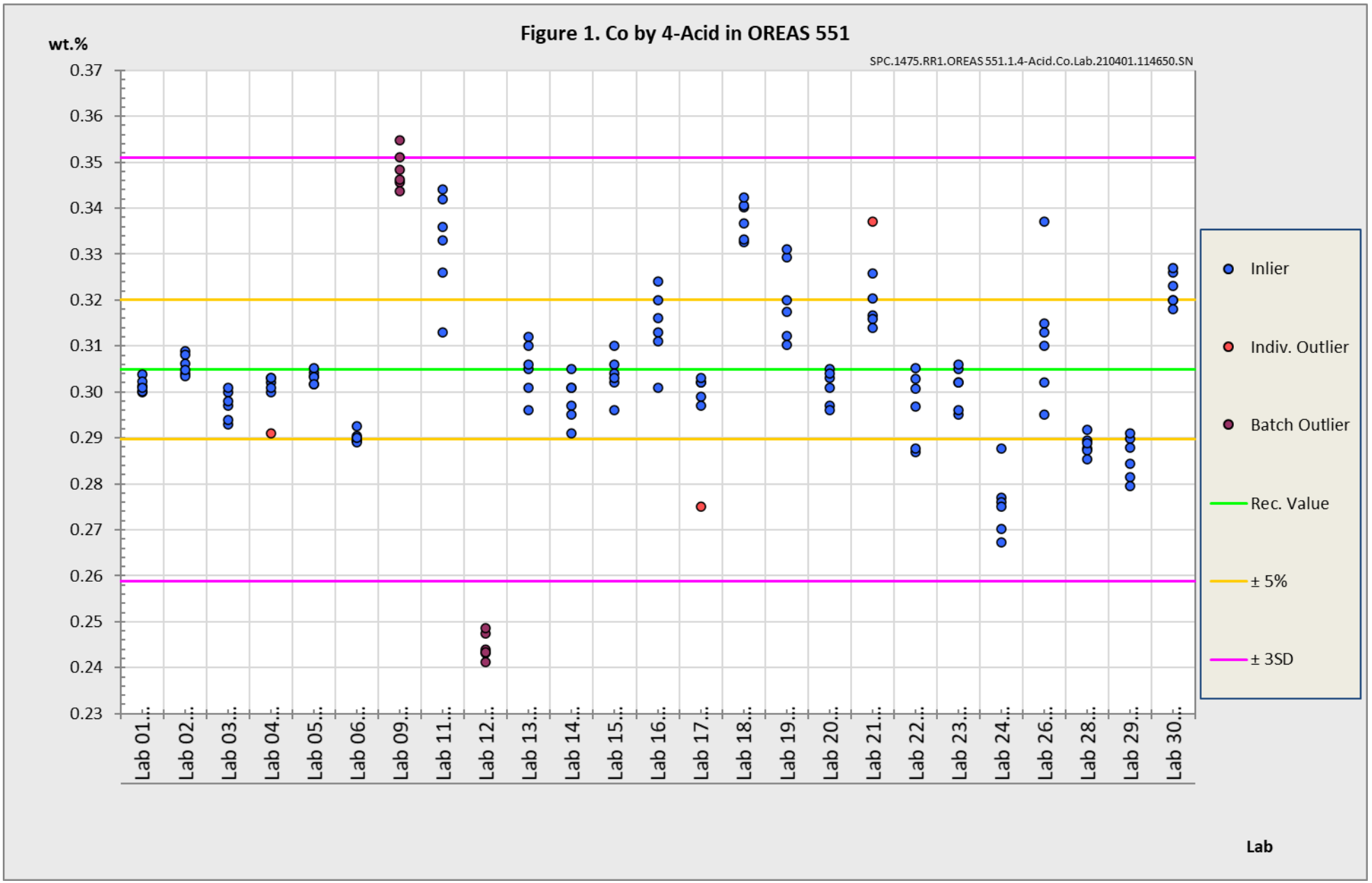
Figure 1. Co by 4-Acid in OREAS 551
wt.%
SPC.1475.RR1.OREAS 551.1.4-Acid.Co.Lab.210401.114650.SN
0.37
0.36
0.35
0.34
0.33
0.32
0.31
0.30
0.29
0.28
0.27
0.26
0.25
0.24
0.23
Lab 01...
Lab 02...
Lab 03...
Lab 04...
Lab 05...
Lab 06...
Lab 09...
Lab 11...
Lab 12...
Lab 13...
Lab 14...
Lab 15...
Lab 16...
Lab 17...
Lab 18...
Lab 19...
Lab 20...
Lab 21...
Lab 22...
Lab 23...
Lab 24...
Lab 26...
Lab 28...
Lab 29...
Lab 30...
Inlier
Indiv. Outlier
Batch Outlier
Rec. Value
± 5%
± 3SD
Lab

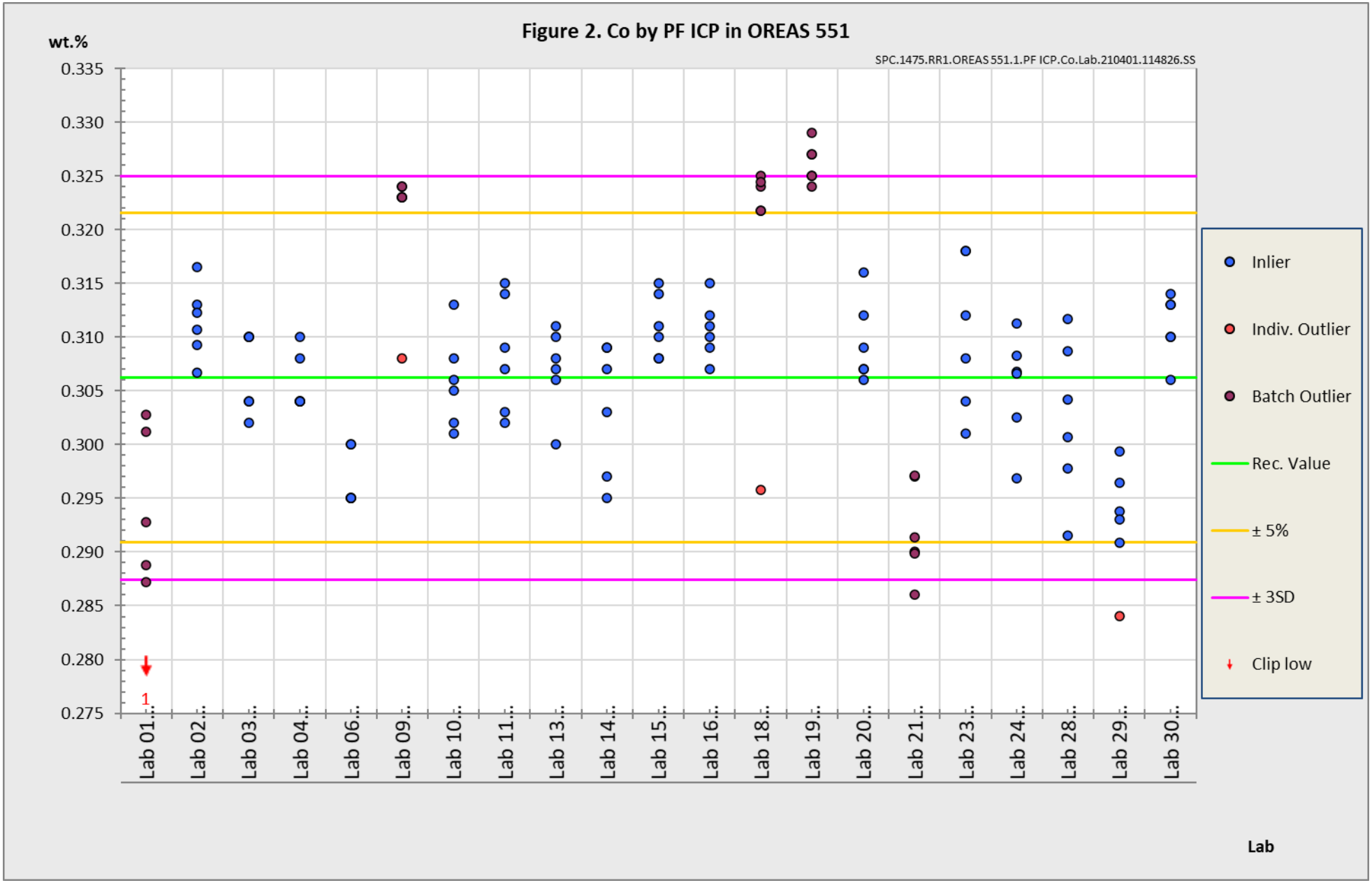
Figure 2. Co by PF ICP in OREAS 551
wt.%
SPC.1475.RR1.OREAS 551.1.PF ICP.Co.Lab.210401.114826.SS
0.335
0.330
0.325
0.320
0.315
0.310
0.305
0.300
0.295
0.290
0.285
0.280
0.275
1
Lab 01...
Lab 02...
Lab 03...
Lab 04...
Lab 06...
Lab 09...
Lab 10...
Lab 11...
Lab 13...
Lab 14...
Lab 15...
Lab 16...
Lab 18...
Lab 19...
Lab 20...
Lab 21...
Lab 23...
Lab 24...
Lab 28...
Lab 29...
Lab 30...
Inlier
Indiv. Outlier
Batch Outlier
Rec. Value
± 5%
± 3SD
Clip low
Lab

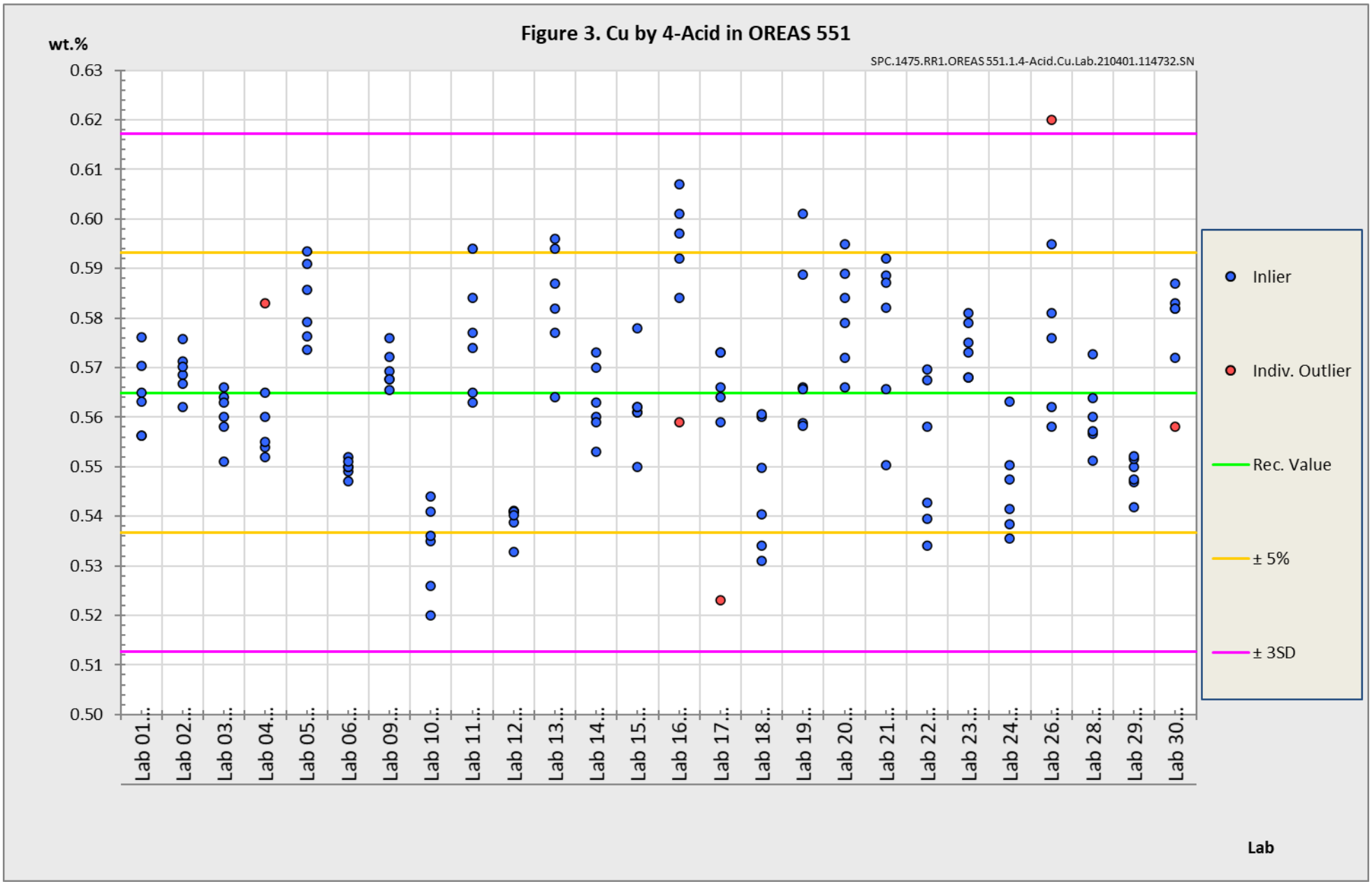
Figure 3. Cu by 4-Acid in OREAS 551
wt.%
SPC.1475.RR1.OREAS 551.1.4-Acid.Cu.Lab.210401.114732.SN
0.63
0.62
0.61
0.60
0.59
0.58
0.57
0.56
0.55
0.54
0.53
0.52
0.51
0.50
Lab 01...
Lab 02...
Lab 03...
Lab 04...
Lab 05...
Lab 06...
Lab 09...
Lab 10...
Lab 11...
Lab 12...
Lab 13...
Lab 14...
Lab 15...
Lab 16...
Lab 17...
Lab 18...
Lab 19...
Lab 20...
Lab 21...
Lab 22...
Lab 23...
Lab 24...
Lab 26...
Lab 28...
Lab 29...
Lab 30...
Lab
Inlier
Indiv. Outlier
Rec. Value
± 5%
± 3SD

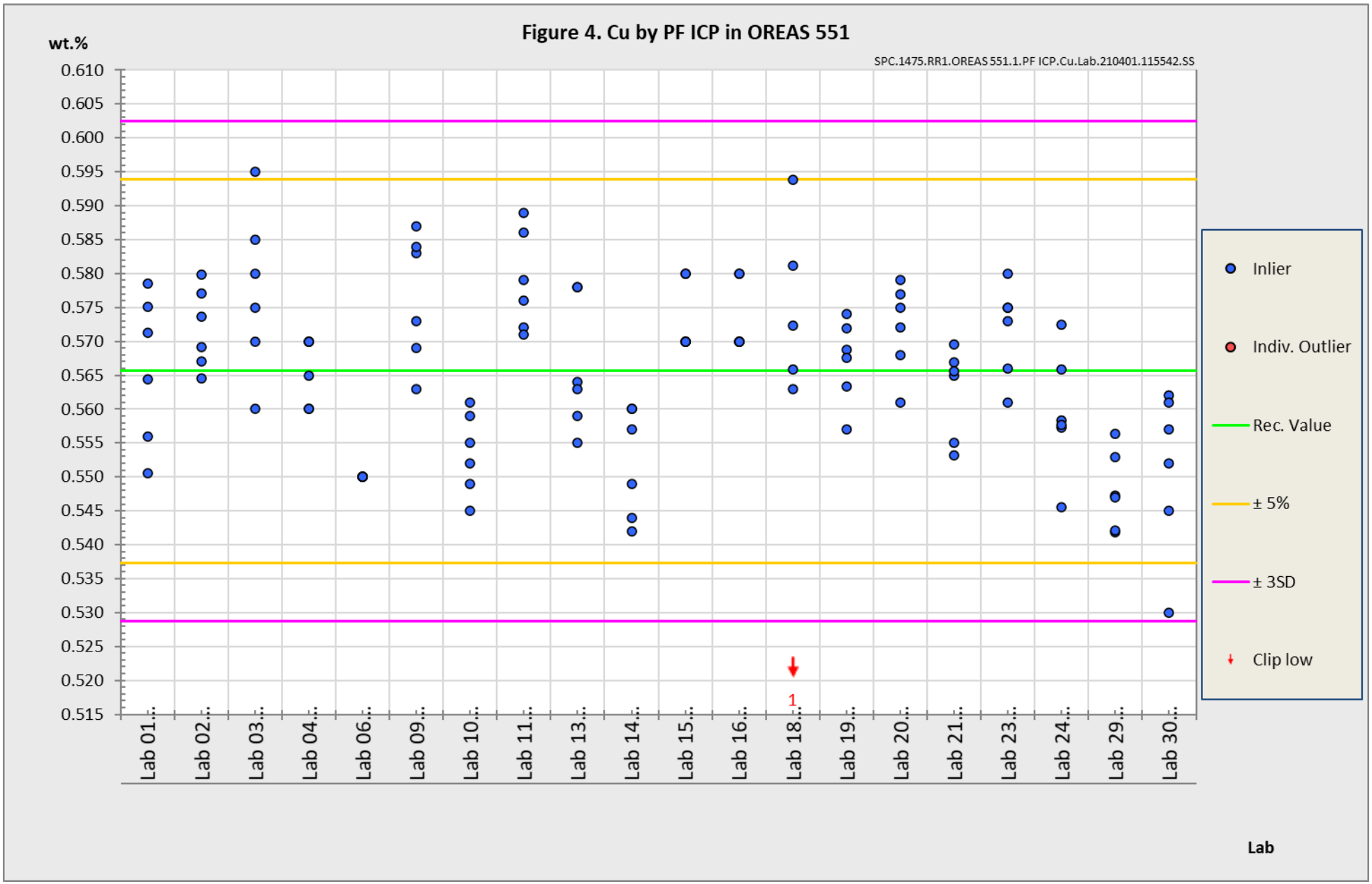
Figure 4. Cu by PF ICP in OREAS 551
wt.%
SPC.1475.RR1.OREAS 551.1.PF ICP.Cu.Lab.210401.115542.SS
0.610
0.605
0.600
0.595
0.590
0.585
0.580
0.575
0.570
0.565
0.560
0.555
0.550
0.545
0.540
0.535
0.530
0.525
0.520
0.515
Lab 01...
Lab 02...
Lab 03...
Lab 04...
Lab 06...
Lab 09...
Lab 10...
Lab 11...
Lab 13...
Lab 14...
Lab 15...
Lab 16...
Lab 18...
Lab 19...
Lab 20...
Lab 21...
Lab 23...
Lab 24...
Lab 29...
Lab 30...
1
Inlier
Indiv. Outlier
Rec. Value
± 5%
± 3SD
Clip low
Lab

PREPARER AND SUPPLIER

Certified reference material OREAS 551 was prepared and certified by:

ORE RESEARCH & EXPLORATION

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METROLOGICAL TRACEABILITY

The analytical samples were selected in a manner to represent the entire batch of prepared 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 that underlie the consensus values. Each analytical data set has been validated by its assayer through the inclusion of internal reference materials and QC checks during analysis.

The laboratories were chosen on the basis of their competence (from past performance in inter-laboratory programs undertaken by ORE Pty Ltd) for a particular analytical method, analyte or analyte suite, and sample matrix. Most of these laboratories have and maintain ISO 17025 accreditation. The certified values presented in this report are calculated from the means of accepted data following robust statistical treatment 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 method is possible. In this case, certification takes place on the basis of agreement among independent measurement results*** *(see ISO Guide 35:2006, Clause 10)."*

COMMUTABILITY

The measurements of the results that underlie the certified values contained in this report were undertaken by methods involving pre-treatment (digestion/fusion) 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. Being matrix-matched, OREAS 551 will display similar behaviour in the relevant measurement process to the routine 'field' samples for which OREAS 551 is designated to monitor. To maintain commutability, care should be taken to always 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 their field samples.

INTENDED USE

OREAS 551 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 551 may be used to calibrate the entire procedure by producing a pure substance CRM transformed into a calibration solution. OREAS 551 is intended for the following uses:

- For the monitoring of laboratory performance in the analysis of analytes reported in Table 1 in geological samples;
- For the verification of analytical methods for analytes reported in Table 1;
- For the calibration of instruments used in the determination of the concentration of analytes reported in Table 1.

STABILITY AND STORAGE INSTRUCTIONS

OREAS 551 has been prepared from a blend of copper-cobalt oxide ore samples. It is low in reactive sulphide (0.16 wt.% S) and in its unopened state and under normal conditions of storage has a shelf life beyond ten years. Its stability will be monitored at regular intervals and purchasers notified if any changes are observed.

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° and 50°C.*

Repeat-use packaging (e.g., 1kg plastic jars)

The stability of the CRM after opening the lid of the plastic jar is only affected by local atmospheric conditions with regard to oxidation and hygroscopic change. There is no segregation affect (please see our Technical Note on Particle Segregation).

The primary cause of change through oxidation is in relation to the breakdown of sulphide minerals to sulphates and is negligible for OREAS 551 given its low sulphur concentration (0.16 wt.% S).

Hygroscopic change is the amount of absorbed moisture (weakly held H_2O- molecules on the surface of exposed material) following exposure to the local atmosphere. Usually, equilibration of material to the local atmosphere will only occur if the material is spread into a thin (~2mm thick) layer and left exposed for a period of 2 hours. OREAS 551 contains a non-hygroscopic matrix and therefore, exposure to a local atmosphere that is significantly different (in terms of temperature and humidity) from the climate during manufacturing will have negligible impact on the precision of results. The 'Physical Properties' section indicates the approximate moisture concentration.

INSTRUCTIONS FOR CORRECT USE

The certified values for OREAS 551 refer to the concentration level in its packaged state. It should not be dried prior to weighing and analysis.

1kg jars permit repeated sampling as long as the lid is promptly re-secured to prevent airborne contamination.

Minimum sample size

As a practical guide, 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 sample masses should be used depending on the operationally defined methodology.

- 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;
- Cu and Co by 10% 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.

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 inter-laboratory 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 1 are intended only to be used as a first principle 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% confidence interval then generally there is no cause for concern in regard to bias.

It is important to note that in the analytical industry there is no standardisation of the aqua regia digestion process nor the 5% and 10% sulphuric acid leach process. These methods are partial empirical digests and differences in recoveries for various analytes are commonplace. These are caused by variations in the digest conditions and in the case for aqua regia digestion 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.

HANDLING INSTRUCTIONS

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

LEGAL NOTICE

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

DOCUMENT HISTORY

Revision No.	Date	Changes applied
1	21st April, 2021	Applied minor statistical correction to Cobalt by XRF method results.
0	7th April, 2021	First publication.

QMS ACCREDITATION

ORE Pty Ltd is accredited to ISO 9001:2015 by Lloyd's Register Quality Assurance Ltd for its quality management system including development, manufacturing, certification and supply of CRMs.

CERTIFYING OFFICER

21st April, 2021

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

REFERENCES

Govett, G.J.S. (1983), ed. Handbook of Exploration Geochemistry, Volume 2: Statistics and Data Analysis in Geochemical Prospecting (Variations of accuracy and precision), P.O. Box 330, 1000 AH Amsterdam, The Netherlands.

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ISO Guide 31:2015, Reference materials – Contents of certificates and labels.

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

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

ISO 17025:2005, General requirements for the competence of testing and calibration laboratories.

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

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.

10% 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 110 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.