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CERTIFICATE OF ANALYSIS FOR

CERTIFIED REFERENCE MATERIAL

OREAS 601c

High Sulphidation Epithermal Au-Ag-Cu Ore

(Mt Carlton Mine, Queensland, Australia)

Statistics for *Key Economic Elements.

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
Pb Fire Assay											
Au, ppm	0.996	0.048	0.899	1.093	0.851	1.142	4.86%	9.73%	14.59%	0.947	1.046
Aqua Regia Digestion (sample weights 10-50g)											
Au, ppm	0.993	0.040	0.914	1.072	0.874	1.111	3.98%	7.97%	11.95%	0.943	1.042
4-Acid Digestion											
Ag, ppm	50.3	2.31	45.7	55.0	43.4	57.3	4.59%	9.17%	13.76%	47.8	52.9
Cu, wt.%	0.116	0.005	0.107	0.125	0.102	0.129	3.90%	7.80%	11.70%	0.110	0.121

*See Table 1 for full list of certified values.

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.

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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
Pb Fire Assay											
Au, ppm	0.996	0.048	0.899	1.093	0.851	1.142	4.86%	9.73%	14.59%	0.947	1.046
Aqua Regia Digestion (sample weights 10-50g)											
Au, ppm	0.993	0.040	0.914	1.072	0.874	1.111	3.98%	7.97%	11.95%	0.943	1.042
Infrared Combustion											
S, wt.%	1.59	0.065	1.46	1.72	1.39	1.78	4.07%	8.14%	12.21%	1.51	1.67
4-Acid Digestion											
Ag, ppm	50.3	2.31	45.7	55.0	43.4	57.3	4.59%	9.17%	13.76%	47.8	52.9
Al, wt.%	7.06	0.272	6.52	7.61	6.25	7.88	3.85%	7.70%	11.55%	6.71	7.42
As, wt.%	0.039	0.002	0.035	0.043	0.033	0.045	4.81%	9.61%	14.42%	0.037	0.041
Be, ppm	2.46	0.157	2.15	2.78	1.99	2.94	6.38%	12.76%	19.14%	2.34	2.59
Bi, ppm	21.1	1.91	17.3	24.9	15.4	26.8	9.04%	18.08%	27.12%	20.0	22.1
Ca, wt.%	0.953	0.039	0.875	1.032	0.835	1.071	4.12%	8.25%	12.37%	0.906	1.001
Cd, ppm	2.77	0.275	2.22	3.32	1.94	3.59	9.93%	19.87%	29.80%	2.63	2.91
Ce, ppm	75	3.7	68	82	64	86	4.90%	9.79%	14.69%	71	79
Co, ppm	4.99	0.272	4.45	5.54	4.18	5.81	5.45%	10.90%	16.35%	4.74	5.24
Cr, ppm	17.5	2.4	12.6	22.3	10.2	24.7	13.93%	27.86%	41.79%	16.6	18.3
Cs, ppm	5.17	0.343	4.48	5.86	4.14	6.20	6.64%	13.28%	19.91%	4.91	5.43
Cu, wt.%	0.116	0.005	0.107	0.125	0.102	0.129	3.90%	7.80%	11.70%	0.110	0.121
Dy, ppm	2.66	0.246	2.17	3.15	1.92	3.40	9.23%	18.45%	27.68%	2.53	2.79
Er, ppm	0.78	0.09	0.60	0.97	0.50	1.06	11.95%	23.89%	35.84%	0.74	0.82
Eu, ppm	1.08	0.096	0.89	1.28	0.80	1.37	8.83%	17.66%	26.49%	1.03	1.14
Fe, wt.%	2.41	0.100	2.21	2.61	2.11	2.71	4.14%	8.29%	12.43%	2.29	2.53
Ga, ppm	23.5	1.61	20.3	26.7	18.7	28.3	6.85%	13.69%	20.54%	22.3	24.7
Gd, ppm	4.65	0.213	4.23	5.08	4.01	5.29	4.58%	9.17%	13.75%	4.42	4.88
Ge, ppm	0.18	0.06	0.05	0.31	0.00	0.37	36.81%	73.63%	110.44 %	0.17	0.19
Hf, ppm	4.93	0.280	4.37	5.49	4.09	5.77	5.68%	11.36%	17.04%	4.68	5.17
Ho, ppm	0.38	0.029	0.32	0.43	0.29	0.46	7.84%	15.69%	23.53%	0.36	0.39
In, ppm	0.56	0.050	0.46	0.66	0.41	0.71	8.96%	17.92%	26.88%	0.53	0.59
K, wt.%	2.72	0.139	2.44	3.00	2.30	3.14	5.12%	10.25%	15.37%	2.59	2.86
La, ppm	37.1	2.59	31.9	42.3	29.3	44.9	6.98%	13.95%	20.93%	35.3	39.0
Li, ppm	26.7	1.41	23.8	29.5	22.4	30.9	5.29%	10.58%	15.86%	25.3	28.0
Lu, ppm	0.077	0.010	0.057	0.097	0.047	0.107	12.86%	25.73%	38.59%	0.073	0.081
Mg, wt.%	0.169	0.011	0.147	0.192	0.135	0.203	6.67%	13.33%	20.00%	0.161	0.178
Mn, wt.%	0.023	0.001	0.021	0.025	0.021	0.026	3.70%	7.40%	11.10%	0.022	0.024
Mo, ppm	3.66	0.249	3.16	4.16	2.91	4.41	6.82%	13.64%	20.45%	3.48	3.84
Na, wt.%	1.94	0.091	1.76	2.13	1.67	2.22	4.70%	9.40%	14.10%	1.85	2.04
Nb, ppm	14.7	1.17	12.4	17.1	11.2	18.2	7.91%	15.83%	23.74%	14.0	15.5
Nd, ppm	29.8	2.57	24.7	35.0	22.1	37.5	8.61%	17.23%	25.84%	28.3	31.3
Ni, ppm	6.83	0.85	5.14	8.53	4.29	9.37	12.40%	24.81%	37.21%	6.49	7.17
P, wt.%	0.039	0.003	0.033	0.046	0.029	0.049	8.43%	16.86%	25.29%	0.037	0.041

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 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											
Pb, ppm	328	18	292	364	274	382	5.49%	10.98%	16.46%	311	344
Pr, ppm	8.41	0.486	7.44	9.38	6.95	9.87	5.78%	11.56%	17.34%	7.99	8.83
Rb, ppm	115	13	89	141	76	154	11.37%	22.74%	34.11%	109	120
Re, ppm	< 0.002	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
S, wt.%	1.58	0.055	1.47	1.69	1.42	1.75	3.47%	6.94%	10.42%	1.51	1.66
Sb, ppm	37.2	3.70	29.8	44.6	26.1	48.3	9.94%	19.88%	29.81%	35.4	39.1
Sc, ppm	4.01	0.206	3.60	4.43	3.40	4.63	5.14%	10.27%	15.41%	3.81	4.22
Se, ppm	8.75	0.834	7.08	10.42	6.25	11.25	9.54%	19.07%	28.61%	8.31	9.19
Sm, ppm	5.76	0.59	4.58	6.95	3.99	7.54	10.29%	20.58%	30.87%	5.48	6.05
Sn, ppm	4.23	0.384	3.46	5.00	3.08	5.39	9.08%	18.16%	27.24%	4.02	4.44
Sr, ppm	230	11	207	253	196	264	4.96%	9.92%	14.88%	218	241
Ta, ppm	1.11	0.14	0.84	1.39	0.70	1.53	12.43%	24.85%	37.28%	1.06	1.17
Tb, ppm	0.55	0.054	0.44	0.66	0.39	0.71	9.80%	19.61%	29.41%	0.52	0.58
Te, ppm	7.50	0.82	5.86	9.15	5.04	9.97	10.96%	21.92%	32.88%	7.13	7.88
Th, ppm	12.4	1.23	10.0	14.9	8.8	16.1	9.87%	19.74%	29.61%	11.8	13.1
Ti, wt.%	0.135	0.007	0.120	0.150	0.113	0.158	5.53%	11.07%	16.60%	0.129	0.142
Tl, ppm	1.75	0.119	1.51	1.99	1.39	2.11	6.81%	13.62%	20.44%	1.66	1.84
Tm, ppm	0.094	0.008	0.078	0.109	0.071	0.117	8.17%	16.33%	24.50%	0.089	0.098
U, ppm	4.40	0.307	3.78	5.01	3.47	5.32	6.99%	13.99%	20.98%	4.18	4.62
V, ppm	15.5	1.13	13.2	17.8	12.1	18.9	7.30%	14.60%	21.90%	14.7	16.3
W, ppm	4.67	0.356	3.96	5.38	3.60	5.74	7.61%	15.23%	22.84%	4.44	4.90
Y, ppm	11.5	0.66	10.2	12.8	9.5	13.5	5.77%	11.54%	17.30%	10.9	12.1
Yb, ppm	0.54	0.06	0.42	0.65	0.37	0.70	10.52%	21.04%	31.56%	0.51	0.56
Zn, ppm	425	16	393	456	377	472	3.71%	7.42%	11.14%	404	446
Zr, ppm	178	9	160	196	151	205	4.99%	9.97%	14.96%	169	187
Aqua Regia Digestion											
Ag, ppm	50.4	1.39	47.6	53.2	46.2	54.6	2.76%	5.53%	8.29%	47.9	52.9
Al, wt.%	0.663	0.071	0.522	0.804	0.451	0.875	10.64%	21.29%	31.93%	0.630	0.696
As, wt.%	0.038	0.002	0.034	0.042	0.031	0.044	5.57%	11.14%	16.71%	0.036	0.040
B, ppm	< 10	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Be, ppm	0.59	0.08	0.42	0.76	0.33	0.84	14.40%	28.80%	43.21%	0.56	0.62
Bi, ppm	21.3	0.97	19.4	23.3	18.4	24.2	4.55%	9.11%	13.66%	20.3	22.4
Ca, wt.%	0.779	0.039	0.701	0.857	0.662	0.896	5.00%	10.01%	15.01%	0.740	0.818
Cd, ppm	2.70	0.200	2.30	3.10	2.10	3.30	7.41%	14.82%	22.23%	2.57	2.84
Ce, ppm	34.7	4.5	25.8	43.7	21.3	48.1	12.88%	25.75%	38.63%	33.0	36.5
Co, ppm	4.27	0.167	3.94	4.61	3.77	4.77	3.90%	7.79%	11.69%	4.06	4.49
Cr, ppm	14.7	1.39	12.0	17.5	10.6	18.9	9.44%	18.87%	28.31%	14.0	15.5
Cs, ppm	1.32	0.13	1.06	1.59	0.92	1.72	10.03%	20.06%	30.09%	1.26	1.39
Cu, wt.%	0.116	0.003	0.111	0.121	0.108	0.123	2.19%	4.38%	6.57%	0.110	0.122

SI unit equivalents: ppm (parts per million; 1×10^6) ≡ 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.

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

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											
Dy, ppm	1.36	0.122	1.12	1.61	1.00	1.73	8.96%	17.92%	26.88%	1.29	1.43
Er, ppm	0.37	0.037	0.29	0.44	0.26	0.48	9.94%	19.87%	29.81%	0.35	0.39
Eu, ppm	0.51	0.07	0.36	0.65	0.29	0.73	14.24%	28.48%	42.72%	0.48	0.54
Fe, wt.%	1.84	0.077	1.68	1.99	1.61	2.07	4.18%	8.36%	12.55%	1.74	1.93
Ga, ppm	3.86	0.57	2.73	5.00	2.16	5.56	14.68%	29.37%	44.05%	3.67	4.06
Gd, ppm	2.38	0.176	2.03	2.73	1.85	2.91	7.39%	14.78%	22.18%	2.26	2.50
Ge, ppm	0.084	0.015	0.053	0.114	0.037	0.130	18.39%	36.77%	55.16%	0.079	0.088
Hf, ppm	0.97	0.13	0.72	1.23	0.59	1.36	13.14%	26.27%	39.41%	0.92	1.02
Hg, ppm	0.22	0.016	0.18	0.25	0.17	0.27	7.52%	15.03%	22.55%	0.21	0.23
Ho, ppm	0.18	0.018	0.14	0.21	0.13	0.23	9.92%	19.84%	29.75%	0.17	0.19
In, ppm	0.50	0.022	0.45	0.54	0.43	0.56	4.49%	8.99%	13.48%	0.47	0.52
K, wt.%	0.254	0.033	0.188	0.319	0.156	0.352	12.89%	25.78%	38.67%	0.241	0.266
La, ppm	17.3	2.1	13.1	21.5	11.0	23.6	12.13%	24.25%	36.38%	16.4	18.1
Li, ppm	7.56	0.623	6.31	8.81	5.69	9.43	8.24%	16.48%	24.73%	7.18	7.94
Lu, ppm	0.028	0.003	0.021	0.035	0.018	0.038	11.90%	23.79%	35.69%	0.027	0.030
Mg, wt.%	0.084	0.005	0.074	0.094	0.069	0.099	5.93%	11.86%	17.80%	0.080	0.089
Mn, wt.%	0.021	0.001	0.019	0.023	0.019	0.024	4.19%	8.39%	12.58%	0.020	0.022
Mo, ppm	3.35	0.231	2.89	3.82	2.66	4.05	6.88%	13.76%	20.64%	3.19	3.52
Na, wt.%	0.053	0.009	0.035	0.071	0.026	0.080	17.15%	34.31%	51.46%	0.050	0.055
Nd, ppm	15.3	3.1	9.2	21.4	6.1	24.5	20.00%	39.99%	59.99%	14.5	16.1
Ni, ppm	6.00	0.397	5.21	6.80	4.81	7.19	6.61%	13.21%	19.82%	5.70	6.30
P, wt.%	0.024	0.001	0.022	0.027	0.021	0.028	4.93%	9.85%	14.78%	0.023	0.026
Pb, ppm	248	10	227	269	217	279	4.16%	8.31%	12.47%	236	260
Pr, ppm	3.97	0.71	2.55	5.40	1.83	6.11	17.96%	35.92%	53.88%	3.77	4.17
Rb, ppm	12.4	1.5	9.4	15.4	7.9	16.9	12.07%	24.14%	36.22%	11.8	13.1
Re, ppm	< 0.001	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
S, wt.%	0.909	0.053	0.803	1.015	0.749	1.069	5.85%	11.70%	17.55%	0.864	0.954
Sb, ppm	29.7	3.3	23.0	36.4	19.7	39.8	11.25%	22.51%	33.76%	28.2	31.2
Sc, ppm	1.03	0.17	0.69	1.36	0.53	1.53	16.22%	32.43%	48.65%	0.98	1.08
Se, ppm	8.02	0.604	6.81	9.23	6.21	9.83	7.53%	15.05%	22.58%	7.62	8.42
Sm, ppm	2.97	0.45	2.08	3.86	1.63	4.31	15.02%	30.04%	45.06%	2.82	3.12
Sn, ppm	1.59	0.16	1.26	1.92	1.09	2.08	10.36%	20.71%	31.07%	1.51	1.67
Sr, ppm	36.3	2.60	31.1	41.5	28.5	44.1	7.17%	14.33%	21.50%	34.5	38.1
Ta, ppm	< 0.05	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Tb, ppm	0.30	0.013	0.28	0.33	0.27	0.34	4.33%	8.66%	12.99%	0.29	0.32
Te, ppm	7.22	0.694	5.83	8.61	5.14	9.30	9.62%	19.23%	28.85%	6.86	7.58
Th, ppm	6.13	0.384	5.36	6.90	4.98	7.28	6.26%	12.51%	18.77%	5.82	6.44
Ti, wt.%	0.010	0.002	0.006	0.013	0.004	0.015	19.29%	38.58%	57.87%	0.009	0.010
Tl, ppm	1.20	0.072	1.05	1.34	0.98	1.41	6.02%	12.04%	18.06%	1.14	1.25

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.

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

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											
U, ppm	2.04	0.159	1.72	2.36	1.56	2.52	7.79%	15.58%	23.37%	1.94	2.14
V, ppm	4.75	1.06	2.64	6.86	1.58	7.91	22.22%	44.44%	66.66%	4.51	4.99
W, ppm	1.16	0.16	0.85	1.48	0.69	1.64	13.63%	27.27%	40.90%	1.11	1.22
Y, ppm	5.10	0.455	4.19	6.01	3.74	6.47	8.92%	17.83%	26.75%	4.85	5.36
Yb, ppm	0.23	0.07	0.09	0.37	0.02	0.44	30.74%	61.47%	92.21%	0.22	0.24
Zn, ppm	381	12	356	405	344	417	3.19%	6.38%	9.57%	362	400
Zr, ppm	33.5	6.6	20.3	46.8	13.6	53.5	19.79%	39.59%	59.38%	31.9	35.2

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.

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 provides some indicative physical properties, Table 3 shows indicative values and Table 4 presents the 95% expanded uncertainty and tolerance limits for all certified values. Tabulated results of all analytes together with uncorrected means, medians, standard deviations, relative standard deviations and per cent deviation of lab means from the corrected mean of means (PDM[3]) are presented in the detailed certification data for this CRM (**OREAS 601c-DataPack.1.1.220414_150711.xlsx**).

Results are also presented in scatter plots for gold by fire assay, silver by 4-acid digestion and copper by 4-acid digestion (Figures 1 to 3, 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 601c was prepared from a blend of gold-silver-copper bearing ores from Evolution Mining's Mount Carlton Operation in Queensland, Australia and argillic rhyodacite waste rock sourced from a quarry east of Melbourne, Australia. A small quantity of copper-gold-silver concentrate (Mount Carlton) was added to help achieve the desired grades.

The mineralisation assemblage at Mount Carlton consists of pyrite, enargite/tennantite, tetrahedrite, digenite, covellite, sphalerite, galena, alunite, dickite, kaolinite and vuggy silica, hosted in advanced argillic altered rhyodacite containing sulphur-salts.

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. For information on the calculation of standard deviations see the 'Statistical Analysis' section below.

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 601c was prepared in the following manner:

- Drying of the sulphide-rich ore materials to constant mass at 85°C;
- Drying of rhyodacite waste rock to constant mass at 105°C;
- Crushing and milling of the ore materials to 100% minus 30 microns;
- Crushing and milling of the rhyodacite waste rock to 98% minus 75 microns;
- Blending in appropriate proportions to achieve the desired grades;
- Packaging in 10g and 60g units in laminated foil pouches and 500g units in plastic jars.

PHYSICAL PROPERTIES

OREAS 601c was tested at ORE Research & Exploration Pty Ltd's onsite facility for various physical properties. Table 2 presents these findings that should be used for informational purposes only.

Table 2. Physical properties of OREAS 601c.

Bulk Density (g/L)	Moisture%	Munsell Notation‡	Munsell Color‡
771	0.38	N7	Light Gray

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

ANALYTICAL PROGRAM

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

- Gold via 25-50g fire assay with AAS finish (19 laboratories) and ICP-OES (3 laboratories) finish;
- Gold via 10-40g aqua regia digestion with ICP-OES or ICP-MS finish (13 laboratories) and AAS (5 laboratories) finish;
- Sulphur by infra-red combustion analysis (23 laboratories);
- Full ICP-OES and MS elemental suites by 4-acid digestion (up to 25 laboratories depending on the element);

- Full ICP-OES and MS elemental suites by aqua regia digestion (up to 25 laboratories depending on the element);

The following Sulphur “species” were also requested from the laboratories offering this methodology:

- Sulphate S by Na_2CO_3 leach of sulphates, precipitation as barium sulphate with gravimetric finish (or by difference using the Total S value minus the Sulphide S);
- Sulphide S by Na_2CO_3 leach of sulphates followed by infrared combustion furnace (or by difference using the Total S value minus the Sulphate S).

Unfortunately, the resulting round robin data for Sulphate S and Sulphide S showed poor interlaboratory consensus. The values of best consensus are thus relegated to indicative value status (see Table 3).

Gold was also determined by instrumental neutron activation analysis (INAA) on 20 x 85mg subsamples to confirm homogeneity. This was undertaken at ANSTO, Australia (see Table 5 below). Homogeneity was also evaluated using a nested ANOVA (see ‘nested ANOVA’ section).

For the round robin program twenty 1.2kg test units were taken at predetermined intervals during the bagging stage, immediately following homogenisation and are considered representative of the entire prepared batch. Six 110g pulp samples were submitted to each laboratory for analysis received by each laboratory were obtained by taking two 110g samples from each of three separate 1.2kg 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.

STATISTICAL ANALYSIS

Certified Values and their uncertainty intervals (Table 4) 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. 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.

Certified Values are the means of accepted laboratory means after outlier filtering and are the present best estimate of the true value.

The 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 in ISO Guides [6,16]. 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. These major and trace element characterisation values are presented for informational purposes only.

Standard Deviation intervals (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-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 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 3. Indicative Values for OREAS 601c.

Constituent	Unit	Value	Constituent	Unit	Value	Constituent	Unit	Value
Infrared Combustion								
C	wt.%	*0.244*						
4-Acid Digestion								
Ba	ppm	*1842*	Hg	ppm	*< 2*			
Aqua Regia Digestion								
Ba	ppm	*547*	Pd	ppb	*8.58*	Tm	ppm	*0.040*
Nb	ppm	*0.46*	Pt	ppb	*< 10*			
Alkaline Leach								
S-(Sulphate)	wt.%	*0.862*	S-(Sulphide)	wt.%	*0.815*			

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

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

Table 4. 95% Uncertainty & Tolerance Limits for OREAS 601c.

Constituent	Certified	95% Expanded Uncertainty		95% Tolerance Limits	
	Value	Low	High	Low	High
Pb Fire Assay					
Au, Gold (ppm)	0.996	0.976	1.017	0.993*	1.000*
Aqua Regia Digestion (sample weights 10-50g)					
Au, Gold (ppm)	0.993	0.972	1.014	0.989*	0.997*
Infrared Combustion					
S, Sulphur (wt.%)	1.59	1.54	1.64	1.56	1.61
4-Acid Digestion					
Ag, Silver (ppm)	50.3	48.8	51.9	49.1	51.6
Al, Aluminium (wt.%)	7.06	6.81	7.32	6.91	7.22
As, Arsenic (wt.%)	0.039	0.037	0.040	0.038	0.040
Be, Beryllium (ppm)	2.46	2.26	2.67	2.35	2.58
Bi, Bismuth (ppm)	21.1	20.0	22.1	20.3	21.9
Ca, Calcium (wt.%)	0.953	0.922	0.985	0.934	0.973
Cd, Cadmium (ppm)	2.77	2.60	2.93	2.65	2.89
Ce, Cerium (ppm)	75	72	78	73	78
Co, Cobalt (ppm)	4.99	4.60	5.38	4.76	5.22
Cr, Chromium (ppm)	17.5	15.9	19.0	15.7	19.2
Cs, Caesium (ppm)	5.17	4.91	5.43	4.98	5.36
Cu, Copper (wt.%)	0.116	0.111	0.120	0.113	0.119
Dy, Dysprosium (ppm)	2.66	2.43	2.89	2.51	2.82
Er, Erbium (ppm)	0.78	0.68	0.89	0.74	0.83
Eu, Europium (ppm)	1.08	1.00	1.17	1.03	1.13
Fe, Iron (wt.%)	2.41	2.32	2.50	2.35	2.46
Ga, Gallium (ppm)	23.5	22.3	24.7	22.7	24.4
Gd, Gadolinium (ppm)	4.65	4.45	4.86	4.44	4.86
Ge, Germanium (ppm)	0.18	0.12	0.24	IND	IND
Hf, Hafnium (ppm)	4.93	4.69	5.16	4.73	5.12
Ho, Holmium (ppm)	0.38	0.35	0.40	0.35	0.40
In, Indium (ppm)	0.56	0.53	0.59	0.54	0.58
K, Potassium (wt.%)	2.72	2.64	2.81	2.65	2.79
La, Lanthanum (ppm)	37.1	35.0	39.2	35.9	38.4
Li, Lithium (ppm)	26.7	25.2	28.1	25.8	27.5
Lu, Lutetium (ppm)	0.077	0.062	0.092	IND	IND
Mg, Magnesium (wt.%)	0.169	0.160	0.178	0.163	0.175
Mn, Manganese (wt.%)	0.023	0.022	0.024	0.023	0.024
Mo, Molybdenum (ppm)	3.66	3.46	3.85	3.43	3.88
Na, Sodium (wt.%)	1.94	1.88	2.01	1.90	1.99
Nb, Niobium (ppm)	14.7	13.9	15.6	14.1	15.3
Nd, Neodymium (ppm)	29.8	27.8	31.9	28.6	31.1
Ni, Nickel (ppm)	6.83	6.19	7.47	6.51	7.16

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

*Gold Tolerance Limits for typical 30g fire assay, 25g aqua regia digestion and 200g cyanide leach methods are determined from 20 x 85mg INAA results and the Sampling Constant (Ingamells & Switzer, 1973).

Note: intervals may appear asymmetric due to rounding.

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

Table 4. continued.

Constituent	Certified	95% Expanded Uncertainty		95% Tolerance Limits	
	Value	Low	High	Low	High
4-Acid Digestion continued					
P, Phosphorus (wt.%)	0.039	0.038	0.041	0.038	0.040
Pb, Lead (ppm)	328	315	341	319	337
Pr, Praseodymium (ppm)	8.41	7.87	8.95	8.04	8.78
Rb, Rubidium (ppm)	115	107	122	110	120
Re, Rhenium (ppm)	< 0.002	IND	IND	IND	0.000
S, Sulphur (wt.%)	1.58	1.53	1.64	1.54	1.63
Sb, Antimony (ppm)	37.2	35.0	39.4	35.9	38.6
Sc, Scandium (ppm)	4.01	3.81	4.22	3.79	4.24
Se, Selenium (ppm)	8.75	7.90	9.59	7.82	9.68
Sm, Samarium (ppm)	5.76	5.32	6.21	5.52	6.01
Sn, Tin (ppm)	4.23	3.98	4.49	3.99	4.48
Sr, Strontium (ppm)	230	222	238	223	236
Ta, Tantalum (ppm)	1.11	1.02	1.21	1.06	1.16
Tb, Terbium (ppm)	0.55	0.49	0.61	0.52	0.57
Te, Tellurium (ppm)	7.50	6.98	8.03	7.06	7.94
Th, Thorium (ppm)	12.4	11.6	13.3	12.0	12.9
Ti, Titanium (wt.%)	0.135	0.128	0.142	0.131	0.140
Tl, Thallium (ppm)	1.75	1.66	1.84	1.69	1.81
Tm, Thulium (ppm)	0.094	0.084	0.103	IND	IND
U, Uranium (ppm)	4.40	4.12	4.67	4.23	4.56
V, Vanadium (ppm)	15.5	14.6	16.4	14.3	16.7
W, Tungsten (ppm)	4.67	4.39	4.95	4.45	4.89
Y, Yttrium (ppm)	11.5	11.0	12.0	11.1	11.9
Yb, Ytterbium (ppm)	0.54	0.49	0.58	IND	IND
Zn, Zinc (ppm)	425	411	439	415	434
Zr, Zirconium (ppm)	178	171	185	174	182
Aqua Regia Digestion					
Ag, Silver (ppm)	50.4	49.2	51.6	49.5	51.3
Al, Aluminium (wt.%)	0.663	0.627	0.699	0.638	0.688
As, Arsenic (wt.%)	0.038	0.037	0.039	0.037	0.039
B, Boron (ppm)	< 10	IND	IND	IND	0.0
Be, Beryllium (ppm)	0.59	0.52	0.66	0.56	0.62
Bi, Bismuth (ppm)	21.3	20.3	22.4	20.7	21.9
Ca, Calcium (wt.%)	0.779	0.755	0.804	0.765	0.793
Cd, Cadmium (ppm)	2.70	2.57	2.83	2.61	2.79
Ce, Cerium (ppm)	34.7	32.1	37.4	33.5	35.9
Co, Cobalt (ppm)	4.27	4.09	4.46	4.12	4.43
Cr, Chromium (ppm)	14.7	13.7	15.8	13.6	15.9
Cs, Caesium (ppm)	1.32	1.24	1.41	1.26	1.38
Cu, Copper (wt.%)	0.116	0.113	0.119	0.113	0.118
Dy, Dysprosium (ppm)	1.36	1.23	1.49	1.31	1.41

SI unit equivalents: ppm (parts per million; 1 x 106) ≡ 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 4. continued.

Constituent	Certified	95% Expanded Uncertainty		95% Tolerance Limits	
	Value	Low	High	Low	High
Aqua Regia Digestion continued					
Er, Erbium (ppm)	0.37	0.32	0.41	0.34	0.39
Eu, Europium (ppm)	0.51	0.43	0.59	0.49	0.53
Fe, Iron (wt.%)	1.84	1.78	1.89	1.81	1.87
Ga, Gallium (ppm)	3.86	3.51	4.22	3.66	4.07
Gd, Gadolinium (ppm)	2.38	2.19	2.56	2.29	2.46
Ge, Germanium (ppm)	0.084	0.064	0.103	IND	IND
Hf, Hafnium (ppm)	0.97	0.89	1.06	0.93	1.01
Hg, Mercury (ppm)	0.22	0.20	0.24	0.20	0.23
Ho, Holmium (ppm)	0.18	0.16	0.20	IND	IND
In, Indium (ppm)	0.50	0.47	0.52	0.48	0.51
K, Potassium (wt.%)	0.254	0.237	0.271	0.245	0.263
La, Lanthanum (ppm)	17.3	15.9	18.6	16.6	17.9
Li, Lithium (ppm)	7.56	7.03	8.09	7.33	7.79
Lu, Lutetium (ppm)	0.028	0.022	0.035	IND	IND
Mg, Magnesium (wt.%)	0.084	0.082	0.087	0.083	0.085
Mn, Manganese (wt.%)	0.021	0.021	0.022	0.021	0.022
Mo, Molybdenum (ppm)	3.35	3.18	3.53	3.25	3.46
Na, Sodium (wt.%)	0.053	0.049	0.057	0.050	0.056
Nd, Neodymium (ppm)	15.3	12.6	18.0	14.8	15.8
Ni, Nickel (ppm)	6.00	5.67	6.34	5.65	6.36
P, Phosphorus (wt.%)	0.024	0.024	0.025	0.024	0.025
Pb, Lead (ppm)	248	241	255	243	253
Pr, Praseodymium (ppm)	3.97	3.28	4.67	3.86	4.09
Rb, Rubidium (ppm)	12.4	11.5	13.4	12.0	12.9
Re, Rhenium (ppm)	< 0.001	IND	IND	IND	0.000
S, Sulphur (wt.%)	0.909	0.874	0.944	0.892	0.926
Sb, Antimony (ppm)	29.7	27.8	31.6	28.6	30.9
Sc, Scandium (ppm)	1.03	0.90	1.15	0.95	1.11
Se, Selenium (ppm)	8.02	7.30	8.74	7.52	8.53
Sm, Samarium (ppm)	2.97	2.47	3.47	2.83	3.11
Sn, Tin (ppm)	1.59	1.46	1.71	1.44	1.73
Sr, Strontium (ppm)	36.3	34.7	37.8	35.3	37.2
Ta, Tantalum (ppm)	< 0.05	IND	IND	IND	0.000
Tb, Terbium (ppm)	0.30	0.28	0.33	0.30	0.31
Te, Tellurium (ppm)	7.22	6.78	7.66	6.96	7.48
Th, Thorium (ppm)	6.13	5.82	6.44	5.92	6.34
Ti, Titanium (wt.%)	0.010	0.009	0.011	0.009	0.010
Tl, Thallium (ppm)	1.20	1.14	1.25	1.15	1.24
U, Uranium (ppm)	2.04	1.92	2.16	1.96	2.12
V, Vanadium (ppm)	4.75	4.28	5.21	4.39	5.11
W, Tungsten (ppm)	1.16	1.04	1.29	1.10	1.23

SI unit equivalents: ppm (parts per million; 1 x 106) ≡ 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 4. continued.

Constituent	Certified	95% Expanded Uncertainty		95% Tolerance Limits	
	Value	Low	High	Low	High
Aqua Regia Digestion continued					
Y, Yttrium (ppm)	5.10	4.82	5.38	4.99	5.22
Yb, Ytterbium (ppm)	0.23	0.16	0.30	0.21	0.25
Zn, Zinc (ppm)	381	370	391	374	387
Zr, Zirconium (ppm)	33.5	30.1	37.0	32.3	34.8

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.

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 Cu by 4-acid digestion, where 99% of the time ($1-\alpha=0.99$) at least 95% of subsamples ($\rho=0.95$) will have concentrations lying between 0.113 and 0.119 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 601c has also been evaluated in a **nested ANOVA** of the round robin program. Each of the twenty-five round robin laboratories received six samples per CRM and these samples were made up of paired samples from three different, non-adjacent sampling intervals. The purpose of the ANOVA evaluation is to test that no statistically significant difference exists in the variance between-units to that of the variance within-units. This allows an assessment of homogeneity across the entire prepared batch of OREAS 601c. The test was performed using the following parameters:

- Gold fire assay – 132 samples (22 laboratories each providing analyses on 3 pairs of samples);
- Gold aqua regia digestion – 107 samples (18 laboratories each providing analyses on 3 pairs of samples);
- Null Hypothesis, H_0: Between-unit variance is no greater than within-unit variance (reject H_0 if p-value < 0.05);
- Alternative Hypothesis, H_1: Between-unit variance is greater than within-unit variance.

P-values are a measure of probability where values less than 0.05 indicate a greater than 95% probability that the observed differences in within-unit and between-unit variances are real. The datasets were filtered for both individual and laboratory data set (batch) outliers prior to the calculation of *p*-values. This process derived *p*-values of 0.95 for Au by fire assay and 0.93 for Au by aqua regia digestion. Both *p*-values are insignificant and the Null Hypothesis is retained.

Please note that only results for constituents present in concentrations well above the detection levels (i.e., >20 x Lower Limit of Detection) for the various methods undertaken were considered for the objective of evaluating homogeneity. It is important to note that ANOVA is not an absolute measure of homogeneity. Rather, it establishes whether or not the analytes are distributed in a similar manner throughout the packaging run of OREAS 601c and whether the variance between two subsamples from the same unit is statistically distinguishable to the variance from two subsamples taken from any two separate units. A reference material therefore, can possess poor absolute homogeneity yet still pass a relative homogeneity test if the within-unit heterogeneity is large and similar across all units.

Table 5 below shows the INAA data determined on 20 x 85mg subsamples of OREAS 601c. An equivalent scaled version of the results is also provided to demonstrate an appreciation of what this data means if 30g fire assay determinations were undertaken without the normal measurement error associated with this methodology.

Table 5. Neutron Activation Analysis of Au (in ppm) on 20 x 85mg subsamples showing the equivalent results scaled to a 30g sample mass typical of fire assay determination.

Replicate No	Au 85mg actual	Au 30g equivalent*
1	1.109	1.104
2	1.099	1.104
3	1.128	1.105
4	1.107	1.104
5	1.040	1.101
6	1.111	1.104
7	1.064	1.102
8	1.076	1.102
9	1.102	1.104
10	1.122	1.105
11	1.104	1.104
12	1.092	1.103
13	1.138	1.106
14	1.135	1.106
15	1.099	1.104
16	1.140	1.106
17	1.110	1.104
18	1.083	1.103
19	1.118	1.105
20	1.100	1.104
Mean	1.104	1.104
Median	1.106	1.104
Std Dev.	0.025	0.001
Rel.Std.Dev.	**2.26%**	**0.12%**

*Results calculated for a 30g equivalent sample mass using the formula: $x^{30g\,Eq} = \frac{(x^{INAA} - \bar{X}) \times RSD@30g}{RSD@85mg} + \bar{X}$

where $x^{30g\,Eq}$ = equivalent result calculated for a 30g sample mass
(x^{INAA}) = raw INAA result at 85mg
$\bar{X}$ = mean of 85mg INAA results

The homogeneity of gold has been determined by INAA using the reduced analytical subsample method which utilises the known relationship between standard deviation and analytical subsample weight (Ingamells and Switzer, 1973). In this approach the sample aliquot is substantially reduced to a point where most of the variability in replicate assays should be due to inhomogeneity of the reference material and measurement error becomes negligible. In this instance a subsample weight of 85 milligrams was employed and the 1RSD of 0.12% was calculated for a 30g fire assay or aqua regia sample (2.26% at 85mg weights) confirms the high level of gold homogeneity in OREAS 601c.

Based on the statistical analysis of the results of the inter-laboratory certification program it can be concluded that OREAS 601c is fit-for-purpose as a certified reference material (see 'Intended Use' below).

PARTICIPATING LABORATORIES

1. Actlabs, Ancaster, Ontario, Canada
2. AGAT Laboratories, Calgary, Alberta, Canada
3. Alex Stewart International, Mendoza, Argentina
4. ALS, Johannesburg, South Africa
5. ALS, Lima, Peru
6. ALS, Loughrea, Galway, Ireland
7. ALS, Vancouver, BC, Canada
8. ANSTO, Lucas Heights, NSW, Australia
9. ARGETEST Mineral Processing, Ankara, Central Anatolia, Turkey
10. Bureau Veritas Geoanalytical, Adelaide, SA, Australia
11. Geo Assay Group, Antofagasta, Chile
12. Geo Assay Group, Santiago, Chile
13. Inspectorate (BV), Lima, Peru
14. Inspectorate Griffith India, Gandhidham, Gujarat, India
15. Intertek Genalysis, Perth, WA, Australia
16. MinAnalytical Services, Perth, WA, Australia
17. MSALABS, Vancouver, BC, Canada
18. PT Geoservices Ltd, Cikarang, Jakarta Raya, Indonesia
19. PT Intertek Utama Services, Jakarta Timur, DKI Jakarta, Indonesia
20. Saskatchewan Research Council, Saskatoon, Saskatchewan, Canada
21. SGS, Randfontein, Gauteng, South Africa
22. SGS Australia Mineral Services, Perth, WA, Australia
23. SGS Canada Inc., Vancouver, BC, Canada
24. SGS del Peru, Lima, Peru
25. SGS Mineral Services, Townsville, QLD, Australia
26. Shiva Analyticals Ltd, Bangalore North, Karnataka, India
27. 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.

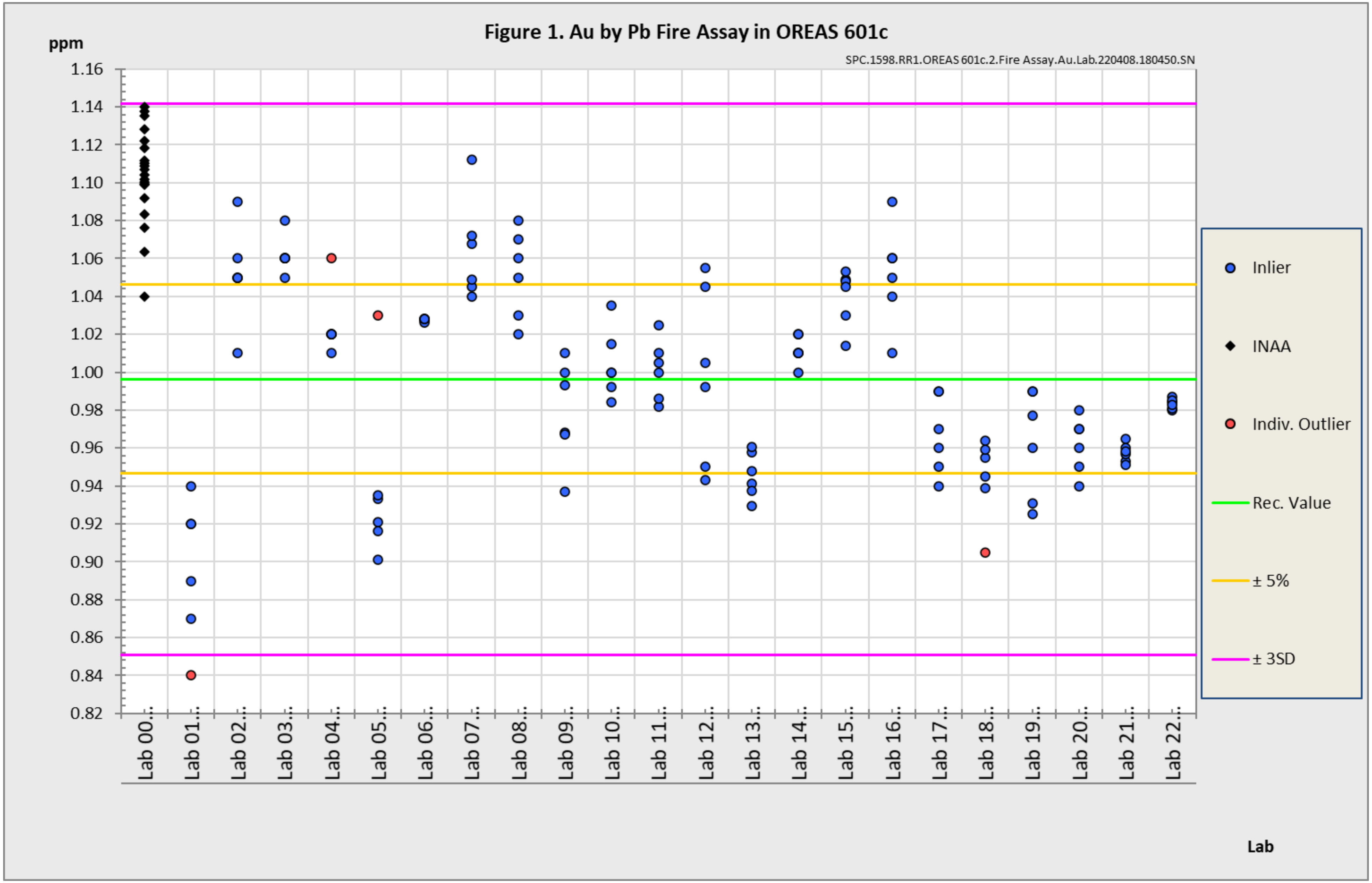

Figure 1. Au by Pb Fire Assay in OREAS 601c

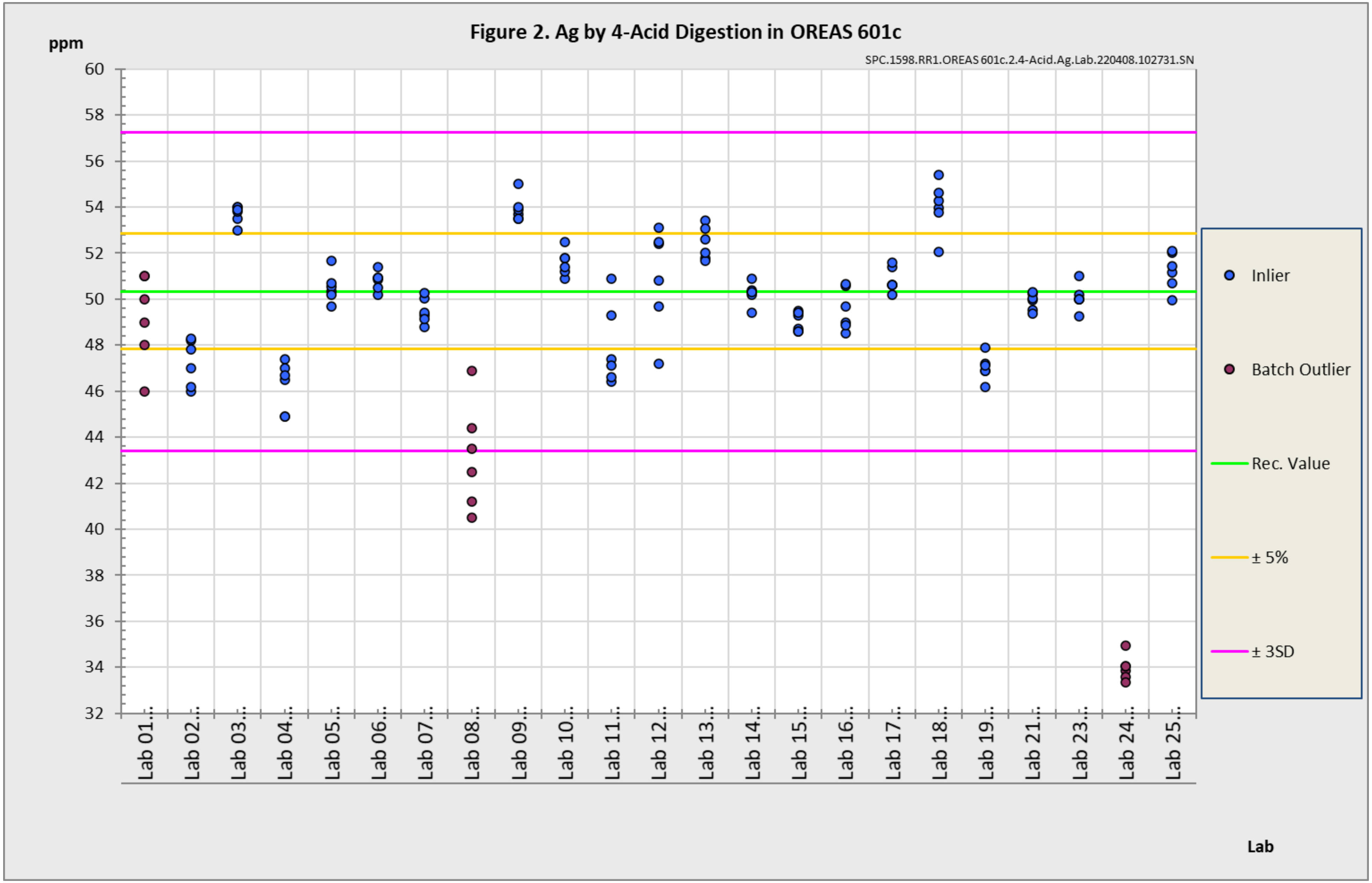
Figure 2. Ag by 4-Acid Digestion in OREAS 601c
SPC.1598.RR1.OREAS 601c.2.4-Acid.Ag.Lab.220408.102731.SN
ppm
60
58
56
54
52
50
48
46
44
42
40
38
36
34
32
Lab 01...
Lab 02...
Lab 03...
Lab 04...
Lab 05...
Lab 06...
Lab 07...
Lab 08...
Lab 09...
Lab 10...
Lab 11...
Lab 12...
Lab 13...
Lab 14...
Lab 15...
Lab 16...
Lab 17...
Lab 18...
Lab 19...
Lab 21...
Lab 23...
Lab 24...
Lab 25...
Lab
Inlier
Batch Outlier
Rec. Value
± 5%
± 3SD

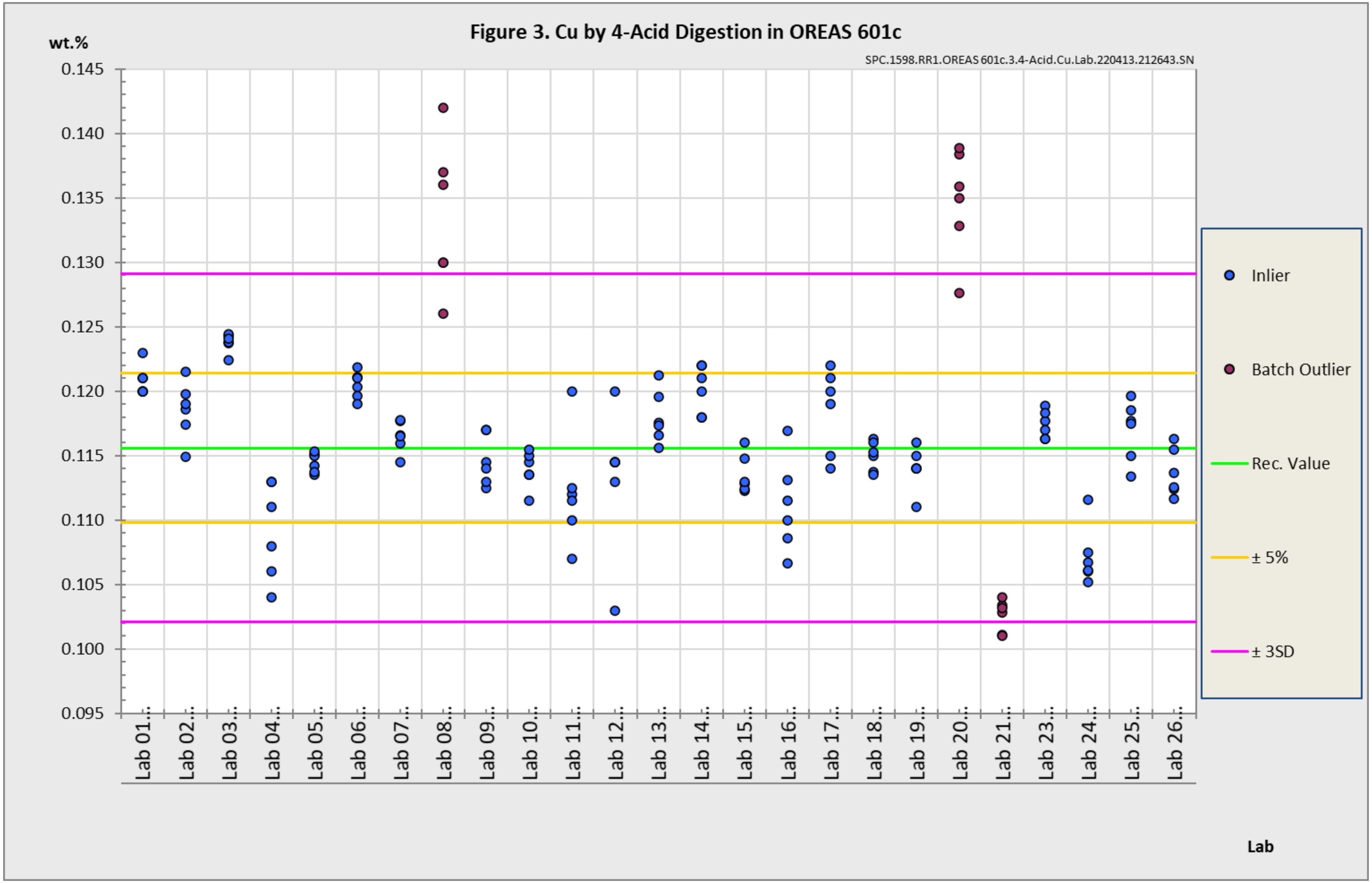
Figure 3. Cu by 4-Acid Digestion in OREAS 601c
SPC.1598.RR1.OREAS 601c.3.4-Acid.Cu.Lab.220413.212643.SN
wt.%
0.145
0.140
0.135
0.130
0.125
0.120
0.115
0.110
0.105
0.100
0.095
Lab 01...
Lab 02...
Lab 03...
Lab 04...
Lab 05...
Lab 06...
Lab 07...
Lab 08...
Lab 09...
Lab 10...
Lab 11...
Lab 12...
Lab 13...
Lab 14...
Lab 15...
Lab 16...
Lab 17...
Lab 18...
Lab 19...
Lab 20...
Lab 21...
Lab 23...
Lab 24...
Lab 25...
Lab 26...
Inlier
Batch Outlier
Rec. Value
± 5%
± 3SD
Lab

PREPARER

Certified reference material OREAS 601c was prepared and certified by:

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METROLOGICAL TRACEABILITY

The analytical samples were selected in a manner representative of the entire batch of the 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 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 (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 601c will display similar behaviour in the relevant measurement process to the routine field samples for which OREAS 601c 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 metallurgical plant samples.

INTENDED USE

OREAS 601c 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 601c may be used to calibrate the entire procedure by producing a pure substance CRM transformed into a calibration solution.

OREAS 601c is intended for the following uses:

- For the monitoring of laboratory performance in the analysis of analytes reported in Table 1 in sulphide concentrate 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.

PERIOD OF VALIDITY & STORAGE INSTRUCTIONS

The certification of OREAS 601c remains valid, within the specified measurement uncertainties, until March 2037, provided the CRM is handled and stored in accordance with the instructions given below. This certification is nullified if the CRM is any way changed or contaminated.

Store in a clean and cool dry place away from direct sunlight.

Long-term stability will be monitored at appropriate intervals and purchasers notified if any changes are observed. The period of validity may well be indefinite and will be reassessed prior to expiry with the aim of extending the validity if possible.

Single-use sachets

OREAS 601c is relatively low in Sulphur (1.6 wt.% S) and is packaged in single-use laminated foil sachets. Following analysis, it is the manufacturer’s expectation that any remaining material is discarded. It is the user’s responsibility to prevent contamination and avoid prolonged exposure of the sample to the atmosphere prior to analysis.

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 [13].

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

Certified values refer to the concentration levels in the packaged state. There is no need for drying prior to weighing and analysis.

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.

- Au by fire assay: ≥25g;
- Au by aqua regia digestion ICP finish: ≥1g.;
- Total S by IR combustion furnace: ≥0.1g
- 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% expanded uncertainty interval 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. Aqua regia is a partial empirical digest and differences in recoveries for various analytes are commonplace. These are caused by variations in the digest conditions which 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 from 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.

DOCUMENT HISTORY

Revision No.	Date	Changes applied
1	14th April, 2022	Revised certification of aqua regia and 4-acid digestion values (due to incorrect aqua regia mapping of one laboratory's 4-acid digestion data).
0	11th April, 2022	First publication.

QMS CERTIFICATION

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.

CERTIFYING OFFICER

14th April, 2022

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

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.

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