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CERTIFICATE OF ANALYSIS FOR

CERTIFIED REFERENCE MATERIAL

OREAS 316

Zinc-Lead-Silver Ore

(Northern 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
4-Acid Digestion											
Ag, ppm	103	3	98	109	95	111	2.62%	5.23%	7.85%	98	108
Pb, wt.%	5.02	0.169	4.68	5.36	4.51	5.53	3.38%	6.76%	10.13%	4.77	5.27
Zn, wt.%	11.16	0.311	10.54	11.78	10.23	12.09	2.78%	5.57%	8.35%	10.60	11.72

*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.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Table 1. Certified Values and Performance Gates for OREAS 316.

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
Oxidising Fusion XRF											
Al_2O_3, wt.%	8.43	0.135	8.16	8.70	8.03	8.84	1.60%	3.21%	4.81%	8.01	8.85
As, ppm	415	123	168	662	45	785	29.72%	59.44%	89.17%	394	436
BaO, wt.%	0.211	0.025	0.161	0.261	0.136	0.286	11.89%	23.78%	35.67%	0.200	0.221
CaO, wt.%	1.32	0.051	1.22	1.42	1.16	1.47	3.90%	7.80%	11.71%	1.25	1.38
Cu, ppm	1612	208	1195	2028	987	2237	12.92%	25.84%	38.76%	1531	1693
Fe, wt.%	6.10	0.089	5.92	6.28	5.83	6.37	1.47%	2.93%	4.40%	5.80	6.41
K_2O, wt.%	2.57	0.102	2.37	2.78	2.26	2.88	3.98%	7.96%	11.95%	2.44	2.70
MgO, wt.%	1.17	0.051	1.07	1.27	1.02	1.32	4.36%	8.72%	13.07%	1.11	1.23
Mn, wt.%	0.461	0.021	0.420	0.503	0.399	0.523	4.49%	8.97%	13.46%	0.438	0.484
P_2O_5, wt.%	0.072	0.009	0.053	0.091	0.044	0.100	13.01%	26.01%	39.02%	0.068	0.076
Pb, wt.%	5.00	0.167	4.67	5.34	4.50	5.50	3.34%	6.69%	10.03%	4.75	5.25
S, wt.%	9.06	0.220	8.62	9.50	8.40	9.72	2.43%	4.87%	7.30%	8.60	9.51
SiO_2, wt.%	47.19	0.754	45.68	48.70	44.92	49.45	1.60%	3.20%	4.80%	44.83	49.55
TiO_2, wt.%	0.340	0.014	0.312	0.368	0.297	0.383	4.17%	8.34%	12.51%	0.323	0.357
Thermogravimetry											
LOI^{1000}, wt.%	8.67	0.371	7.93	9.42	7.56	9.79	4.28%	8.55%	12.83%	8.24	9.11
Infrared Combustion											
C, wt.%	1.18	0.059	1.06	1.30	1.00	1.35	4.97%	9.94%	14.91%	1.12	1.24
S, wt.%	9.22	0.283	8.65	9.78	8.37	10.07	3.08%	6.15%	9.23%	8.75	9.68
Borate / Peroxide Fusion ICP											
Ag, ppm	101	11	80	122	69	132	10.45%	20.91%	31.36%	96	106
Al, wt.%	4.48	0.137	4.20	4.75	4.06	4.89	3.07%	6.13%	9.20%	4.25	4.70
As, ppm	403	50	303	504	252	554	12.46%	24.93%	37.39%	383	423
B, ppm	83	13	56	110	43	123	16.17%	32.33%	48.50%	79	87
Ba, wt.%	0.196	0.011	0.173	0.219	0.162	0.230	5.76%	11.52%	17.27%	0.186	0.206
Be, ppm	2.12	0.39	1.35	2.90	0.96	3.29	18.27%	36.53%	54.80%	2.02	2.23
Bi, ppm	15.3	2.2	10.9	19.7	8.7	21.9	14.44%	28.87%	43.31%	14.5	16.0
Ca, wt.%	0.932	0.073	0.787	1.078	0.714	1.151	7.82%	15.64%	23.46%	0.886	0.979
Cd, ppm	257	14	230	285	216	298	5.33%	10.67%	16.00%	244	270
Ce, ppm	63	1.8	59	67	57	68	2.91%	5.81%	8.72%	60	66
Co, ppm	12.8	1.8	9.2	16.4	7.3	18.3	14.21%	28.42%	42.63%	12.2	13.4
Cr, ppm	130	15	100	161	85	176	11.61%	23.22%	34.84%	124	137
Cs, ppm	2.93	0.40	2.13	3.72	1.73	4.12	13.62%	27.24%	40.85%	2.78	3.07
Cu, wt.%	0.163	0.014	0.135	0.192	0.121	0.206	8.59%	17.18%	25.77%	0.155	0.172
Dy, ppm	3.63	0.197	3.23	4.02	3.04	4.22	5.43%	10.86%	16.29%	3.44	3.81
Er, ppm	2.05	0.074	1.90	2.20	1.83	2.27	3.62%	7.23%	10.85%	1.95	2.15
Eu, ppm	1.23	0.093	1.05	1.42	0.95	1.51	7.55%	15.10%	22.65%	1.17	1.29
Fe, wt.%	6.09	0.249	5.59	6.59	5.34	6.84	4.08%	8.17%	12.25%	5.78	6.39
Ga, ppm	15.6	1.27	13.1	18.2	11.8	19.4	8.12%	16.25%	24.37%	14.8	16.4
Gd, ppm	4.34	0.408	3.52	5.16	3.11	5.56	9.41%	18.81%	28.22%	4.12	4.56

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
Borate / Peroxide Fusion ICP continued											
Ge, ppm	4.22	0.85	2.52	5.91	1.67	6.76	20.16%	40.32%	60.48%	4.00	4.43
Hf, ppm	1.89	0.47	0.95	2.83	0.48	3.30	24.92%	49.85%	74.77%	1.80	1.98
Ho, ppm	0.69	0.048	0.59	0.78	0.54	0.83	6.98%	13.97%	20.95%	0.65	0.72
In, ppm	1.67	0.133	1.41	1.94	1.28	2.07	7.93%	15.85%	23.78%	1.59	1.76
K, wt.%	2.17	0.072	2.03	2.32	1.95	2.39	3.34%	6.67%	10.01%	2.06	2.28
La, ppm	30.0	1.41	27.2	32.8	25.8	34.2	4.70%	9.41%	14.11%	28.5	31.5
Li, ppm	18.4	1.60	15.1	21.6	13.5	23.2	8.73%	17.47%	26.20%	17.4	19.3
Lu, ppm	0.28	0.05	0.18	0.38	0.13	0.43	17.78%	35.56%	53.34%	0.27	0.30
Mg, wt.%	0.684	0.020	0.644	0.725	0.624	0.745	2.93%	5.87%	8.80%	0.650	0.719
Mn, wt.%	0.463	0.017	0.429	0.497	0.412	0.514	3.68%	7.36%	11.04%	0.440	0.486
Mo, ppm	18.3	2.6	13.1	23.4	10.6	26.0	14.08%	28.15%	42.23%	17.4	19.2
Nb, ppm	8.86	1.58	5.71	12.01	4.13	13.58	17.78%	35.56%	53.35%	8.42	9.30
Nd, ppm	26.5	1.35	23.8	29.2	22.5	30.6	5.09%	10.17%	15.26%	25.2	27.9
Ni, ppm	110	12	85	135	73	147	11.23%	22.47%	33.70%	105	116
P, wt.%	0.031	0.004	0.022	0.040	0.018	0.044	14.37%	28.74%	43.10%	0.029	0.032
Pb, wt.%	4.90	0.235	4.43	5.37	4.20	5.61	4.79%	9.59%	14.38%	4.66	5.15
Pr, ppm	6.75	0.494	5.76	7.73	5.26	8.23	7.33%	14.65%	21.98%	6.41	7.08
Rb, ppm	101	6	89	114	83	120	6.12%	12.25%	18.37%	96	106
S, wt.%	9.05	0.302	8.44	9.65	8.14	9.95	3.34%	6.69%	10.03%	8.59	9.50
Sb, ppm	128	6	116	140	110	147	4.72%	9.45%	14.17%	122	135
Sc, ppm	7.59	1.42	4.75	10.42	3.34	11.84	18.67%	37.33%	56.00%	7.21	7.97
Si, wt.%	22.70	1.140	20.42	24.98	19.28	26.12	5.02%	10.05%	15.07%	21.56	23.83
Sm, ppm	4.98	0.396	4.19	5.77	3.79	6.17	7.95%	15.89%	23.84%	4.73	5.23
Sr, ppm	64	6.1	52	76	46	82	9.41%	18.83%	28.24%	61	67
Ta, ppm	0.69	0.15	0.39	0.99	0.25	1.13	21.42%	42.85%	64.27%	0.66	0.73
Tb, ppm	0.61	0.028	0.56	0.67	0.53	0.70	4.57%	9.15%	13.72%	0.58	0.64
Th, ppm	9.55	0.370	8.81	10.30	8.44	10.67	3.87%	7.75%	11.62%	9.08	10.03
Ti, wt.%	0.205	0.009	0.187	0.222	0.178	0.231	4.32%	8.63%	12.95%	0.195	0.215
Tl, ppm	15.5	0.67	14.1	16.8	13.5	17.5	4.31%	8.62%	12.93%	14.7	16.2
Tm, ppm	0.31	0.06	0.20	0.42	0.14	0.47	18.19%	36.39%	54.58%	0.29	0.32
U, ppm	3.57	0.200	3.17	3.97	2.97	4.17	5.61%	11.23%	16.84%	3.39	3.75
V, ppm	102	4	94	111	90	115	3.99%	7.98%	11.97%	97	108
W, ppm	1.98	0.39	1.19	2.77	0.80	3.16	19.84%	39.68%	59.52%	1.88	2.08
Y, ppm	20.6	1.87	16.9	24.4	15.0	26.3	9.08%	18.16%	27.24%	19.6	21.7
Yb, ppm	1.95	0.127	1.70	2.21	1.57	2.33	6.53%	13.05%	19.58%	1.85	2.05
Zn, wt.%	11.04	0.340	10.36	11.72	10.02	12.06	3.08%	6.17%	9.25%	10.49	11.59
Zr, ppm	72	4.5	63	81	58	86	6.28%	12.55%	18.83%	68	76
4-Acid Digestion											
Ag, ppm	103	3	98	109	95	111	2.62%	5.23%	7.85%	98	108
Al, wt.%	4.37	0.220	3.93	4.81	3.71	5.03	5.04%	10.08%	15.12%	4.15	4.59

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

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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
4-Acid Digestion continued											
As, ppm	368	20	327	409	307	430	5.56%	11.12%	16.68%	350	387
Be, ppm	1.89	0.118	1.65	2.12	1.53	2.24	6.25%	12.49%	18.74%	1.79	1.98
Bi, ppm	14.6	1.07	12.5	16.7	11.4	17.8	7.31%	14.61%	21.92%	13.9	15.3
Ca, wt.%	0.935	0.055	0.825	1.044	0.771	1.099	5.86%	11.71%	17.57%	0.888	0.982
Cd, ppm	255	13	229	281	216	294	5.13%	10.26%	15.40%	242	268
Ce, ppm	58	4.7	48	67	44	72	8.10%	16.20%	24.30%	55	61
Co, ppm	12.7	1.23	10.2	15.1	9.0	16.4	9.68%	19.36%	29.04%	12.1	13.3
Cr, ppm	98	10	77	118	67	128	10.50%	21.00%	31.50%	93	102
Cs, ppm	2.60	0.253	2.09	3.11	1.84	3.36	9.74%	19.48%	29.22%	2.47	2.73
Cu, wt.%	0.161	0.012	0.137	0.185	0.125	0.197	7.51%	15.02%	22.54%	0.153	0.169
Dy, ppm	3.10	0.50	2.10	4.10	1.59	4.61	16.19%	32.37%	48.56%	2.95	3.26
Er, ppm	1.59	0.31	0.97	2.22	0.66	2.53	19.51%	39.02%	58.54%	1.52	1.67
Eu, ppm	1.19	0.080	1.03	1.35	0.95	1.43	6.71%	13.42%	20.13%	1.13	1.25
Fe, wt.%	5.97	0.258	5.45	6.48	5.19	6.74	4.33%	8.66%	12.99%	5.67	6.26
Ga, ppm	14.5	1.11	12.3	16.8	11.2	17.9	7.63%	15.26%	22.88%	13.8	15.3
Gd, ppm	4.00	0.40	3.19	4.80	2.79	5.21	10.08%	20.16%	30.25%	3.80	4.20
Hf, ppm	1.71	0.169	1.37	2.04	1.20	2.21	9.88%	19.75%	29.63%	1.62	1.79
Ho, ppm	0.59	0.054	0.48	0.69	0.42	0.75	9.29%	18.58%	27.87%	0.56	0.61
In, ppm	1.64	0.113	1.42	1.87	1.31	1.98	6.85%	13.71%	20.56%	1.56	1.73
K, wt.%	2.13	0.088	1.95	2.30	1.86	2.39	4.15%	8.29%	12.44%	2.02	2.23
La, ppm	29.0	2.68	23.6	34.3	20.9	37.0	9.24%	18.49%	27.73%	27.5	30.4
Li, ppm	17.4	1.25	14.9	19.9	13.7	21.2	7.18%	14.36%	21.53%	16.5	18.3
Lu, ppm	0.23	0.04	0.14	0.31	0.09	0.36	19.50%	39.00%	58.50%	0.21	0.24
Mg, wt.%	0.666	0.037	0.592	0.740	0.555	0.777	5.57%	11.13%	16.70%	0.633	0.699
Mn, wt.%	0.447	0.029	0.390	0.505	0.361	0.533	6.40%	12.80%	19.20%	0.425	0.470
Mo, ppm	16.3	1.28	13.8	18.9	12.5	20.2	7.87%	15.73%	23.60%	15.5	17.1
Na, wt.%	0.070	0.008	0.055	0.085	0.048	0.093	10.70%	21.40%	32.10%	0.067	0.074
Nd, ppm	24.9	0.92	23.1	26.8	22.2	27.7	3.70%	7.41%	11.11%	23.7	26.2
Ni, ppm	108	8	92	124	85	132	7.24%	14.48%	21.72%	103	114
P, wt.%	0.031	0.002	0.027	0.035	0.025	0.037	6.78%	13.56%	20.34%	0.029	0.032
Pb, wt.%	5.02	0.169	4.68	5.36	4.51	5.53	3.38%	6.76%	10.13%	4.77	5.27
Pr, ppm	6.60	0.560	5.49	7.72	4.93	8.28	8.47%	16.95%	25.42%	6.27	6.93
Rb, ppm	99	5.5	88	110	82	115	5.58%	11.16%	16.74%	94	104
S, wt.%	8.89	0.420	8.05	9.73	7.63	10.15	4.73%	9.46%	14.19%	8.44	9.33
Sb, ppm	122	8	105	138	96	147	6.91%	13.82%	20.74%	116	128
Sc, ppm	7.47	0.742	5.99	8.96	5.25	9.70	9.93%	19.86%	29.78%	7.10	7.85
Se, ppm	2.93	0.56	1.82	4.05	1.26	4.60	18.97%	37.94%	56.90%	2.79	3.08
Sm, ppm	4.93	0.58	3.77	6.09	3.20	6.67	11.73%	23.47%	35.20%	4.69	5.18
Sn, ppm	3.17	0.42	2.32	4.02	1.90	4.44	13.38%	26.75%	40.13%	3.01	3.33
Sr, ppm	55	4.1	47	63	43	68	7.41%	14.82%	22.23%	53	58

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											
Tb, ppm	0.57	0.032	0.51	0.64	0.48	0.67	5.60%	11.20%	16.80%	0.54	0.60
Te, ppm	0.25	0.07	0.11	0.40	0.03	0.47	28.80%	57.59%	86.39%	0.24	0.27
Th, ppm	8.97	1.14	6.70	11.24	5.56	12.37	12.66%	25.32%	37.98%	8.52	9.41
Tl, ppm	16.0	0.75	14.5	17.5	13.7	18.2	4.72%	9.44%	14.16%	15.2	16.8
Tm, ppm	0.26	0.025	0.21	0.31	0.19	0.33	9.47%	18.94%	28.41%	0.25	0.27
U, ppm	3.50	0.142	3.22	3.79	3.07	3.93	4.06%	8.12%	12.18%	3.33	3.68
V, ppm	98	3.9	90	106	87	110	3.93%	7.86%	11.78%	93	103
W, ppm	2.16	0.29	1.58	2.74	1.29	3.03	13.41%	26.83%	40.24%	2.05	2.27
Y, ppm	15.7	1.51	12.7	18.7	11.2	20.3	9.62%	19.24%	28.86%	14.9	16.5
Yb, ppm	1.65	0.24	1.18	2.13	0.94	2.36	14.33%	28.67%	43.00%	1.57	1.73
Zn, wt.%	11.16	0.311	10.54	11.78	10.23	12.09	2.78%	5.57%	8.35%	10.60	11.72
Zr, ppm	54	3.9	46	61	42	65	7.17%	14.34%	21.52%	51	56
Aqua Regia Digestion											
Ag, ppm	102	3	96	109	92	113	3.39%	6.78%	10.17%	97	108
Al, wt.%	0.696	0.124	0.448	0.943	0.325	1.066	17.77%	35.53%	53.30%	0.661	0.730
As, ppm	365	25	315	415	290	440	6.83%	13.65%	20.48%	347	383
Be, ppm	0.52	0.07	0.38	0.67	0.31	0.74	13.86%	27.73%	41.59%	0.50	0.55
Bi, ppm	14.7	0.61	13.4	15.9	12.8	16.5	4.17%	8.34%	12.51%	13.9	15.4
Ca, wt.%	0.921	0.040	0.842	1.001	0.802	1.041	4.32%	8.65%	12.97%	0.875	0.968
Cd, ppm	246	19	207	285	188	304	7.91%	15.82%	23.72%	234	258
Ce, ppm	39.5	6.7	26.2	52.9	19.5	59.5	16.90%	33.79%	50.69%	37.5	41.5
Co, ppm	10.9	2.0	7.0	14.9	5.0	16.8	17.98%	35.97%	53.95%	10.4	11.5
Cr, ppm	32.0	1.79	28.4	35.5	26.6	37.3	5.60%	11.21%	16.81%	30.4	33.6
Cs, ppm	0.96	0.067	0.83	1.09	0.76	1.16	7.00%	14.01%	21.01%	0.91	1.01
Cu, wt.%	0.165	0.013	0.138	0.192	0.125	0.206	8.14%	16.28%	24.42%	0.157	0.174
Dy, ppm	1.43	0.25	0.93	1.93	0.69	2.18	17.37%	34.74%	52.11%	1.36	1.50
Er, ppm	0.65	0.12	0.41	0.90	0.28	1.02	18.88%	37.76%	56.63%	0.62	0.69
Eu, ppm	0.73	0.11	0.51	0.94	0.40	1.05	14.83%	29.66%	44.48%	0.69	0.76
Fe, wt.%	5.86	0.323	5.21	6.50	4.89	6.83	5.51%	11.02%	16.53%	5.57	6.15
Ga, ppm	3.83	0.53	2.78	4.88	2.25	5.41	13.77%	27.53%	41.30%	3.64	4.02
Gd, ppm	2.31	0.28	1.75	2.86	1.47	3.14	12.11%	24.22%	36.33%	2.19	2.42
Hf, ppm	0.45	0.07	0.31	0.59	0.24	0.66	15.36%	30.72%	46.08%	0.43	0.47
Hg, ppm	3.83	0.168	3.49	4.16	3.33	4.33	4.38%	8.76%	13.15%	3.64	4.02
Ho, ppm	0.27	0.03	0.21	0.33	0.18	0.36	10.72%	21.44%	32.16%	0.26	0.29
In, ppm	1.53	0.25	1.04	2.03	0.79	2.28	16.12%	32.23%	48.35%	1.46	1.61
K, wt.%	0.264	0.042	0.179	0.348	0.136	0.391	16.11%	32.22%	48.33%	0.250	0.277
La, ppm	16.5	3.5	9.5	23.5	6.1	27.0	21.09%	42.19%	63.28%	15.7	17.3
Li, ppm	4.86	1.27	2.31	7.40	1.04	8.67	26.19%	52.38%	78.57%	4.61	5.10
Lu, ppm	0.089	0.019	0.050	0.127	0.031	0.147	21.73%	43.47%	65.20%	0.084	0.093
Mg, wt.%	0.474	0.037	0.399	0.549	0.362	0.586	7.88%	15.76%	23.63%	0.450	0.498

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
Aqua Regia Digestion continued											
Mn, wt.%	0.428	0.031	0.366	0.490	0.335	0.521	7.26%	14.51%	21.77%	0.407	0.450
Mo, ppm	16.0	1.40	13.2	18.8	11.8	20.2	8.74%	17.48%	26.22%	15.2	16.8
Nd, ppm	13.4	0.56	12.3	14.6	11.7	15.1	4.18%	8.36%	12.54%	12.8	14.1
Ni, ppm	106	4	98	114	93	119	3.95%	7.91%	11.86%	101	111
P, wt.%	0.028	0.001	0.026	0.031	0.025	0.032	4.25%	8.50%	12.75%	0.027	0.030
Pb, wt.%	5.03	0.190	4.65	5.41	4.46	5.60	3.77%	7.55%	11.32%	4.77	5.28
Pr, ppm	3.84	0.79	2.27	5.42	1.48	6.20	20.48%	40.97%	61.45%	3.65	4.03
Rb, ppm	15.9	3.4	9.1	22.7	5.7	26.1	21.37%	42.74%	64.11%	15.1	16.7
S, wt.%	9.06	0.434	8.20	9.93	7.76	10.36	4.79%	9.57%	14.36%	8.61	9.52
Sb, ppm	97	15	68	126	53	141	15.06%	30.13%	45.19%	92	102
Sc, ppm	1.46	0.42	0.61	2.30	0.19	2.72	28.91%	57.81%	86.72%	1.38	1.53
Se, ppm	3.23	0.90	1.43	5.03	0.53	5.93	27.90%	55.81%	83.71%	3.06	3.39
Sm, ppm	2.68	0.37	1.95	3.41	1.58	3.77	13.65%	27.29%	40.94%	2.54	2.81
Sn, ppm	1.42	0.31	0.80	2.03	0.50	2.34	21.64%	43.29%	64.93%	1.35	1.49
Sr, ppm	16.5	1.8	13.0	20.1	11.2	21.8	10.67%	21.33%	32.00%	15.7	17.4
Ta, ppm	< 0.05	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Tb, ppm	0.31	0.04	0.24	0.38	0.20	0.41	11.52%	23.03%	34.55%	0.29	0.32
Te, ppm	0.26	0.10	0.07	0.46	0.00	0.55	36.48%	72.96%	109.44%	0.25	0.28
Th, ppm	6.54	0.70	5.15	7.94	4.45	8.64	10.67%	21.35%	32.02%	6.22	6.87
Ti, wt.%	0.010	0.001	0.007	0.012	0.006	0.013	11.79%	23.58%	35.37%	0.009	0.010
Tl, ppm	11.8	0.80	10.2	13.4	9.4	14.2	6.77%	13.54%	20.31%	11.2	12.4
Tm, ppm	0.081	0.023	0.036	0.126	0.013	0.149	28.00%	56.00%	84.00%	0.077	0.085
U, ppm	2.29	0.173	1.94	2.63	1.77	2.80	7.56%	15.13%	22.69%	2.17	2.40
V, ppm	17.2	3.7	9.9	24.6	6.2	28.2	21.29%	42.58%	63.87%	16.4	18.1
W, ppm	0.75	0.12	0.52	0.98	0.40	1.10	15.46%	30.93%	46.39%	0.71	0.79
Y, ppm	6.35	0.621	5.11	7.59	4.49	8.22	9.78%	19.57%	29.35%	6.03	6.67
Yb, ppm	0.55	0.11	0.33	0.76	0.23	0.87	19.53%	39.06%	58.60%	0.52	0.58
Zn, wt.%	11.10	0.305	10.49	11.71	10.18	12.02	2.75%	5.50%	8.26%	10.55	11.66
Zr, ppm	15.6	3.4	8.7	22.5	5.3	25.9	21.99%	43.99%	65.98%	14.8	16.4

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 316-DataPack.1.0.220329_164924.xlsx**).

Comparisons of interlaboratory bias and precision are graphically presented in scatter plots for Ag, Pb and Zn by 4-acid digestion (Figures 1 to 3, respectively) together with ±3SD (magenta) 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 316 has been prepared from a blend of barren black slate and various Zn-Pb-Ag ore and concentrate materials. This includes materials from the Dugald River, Black Star and Cannington deposits located in Northern Queensland, Australia.

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 316 was prepared in the following manner:

- Drying of ores and concentrates to constant mass at 85°C;
- Drying of barren slate to constant mass at 105°C;
- Crushing and multi-stage milling of ores and concentrates to 100% minus 30 microns;
- Crushing and milling of barren slate to 98% minus 75 microns;
- Preliminary homogenisation and check assaying of ores and concentrates;
- Blending the barren slate, ores and concentrates in specific ratios to achieve target Zn, Pb and Ag values.
- Packaging into 10g units sealed under nitrogen in laminated foil pouches.

PHYSICAL PROPERTIES

OREAS 316 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 316.

Bulk Density (g/L)	Moisture%	Munsell Notation‡	Munsell Color‡
720	0.84	5Y 4/1	Olive 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:

- Majors & base metals by oxidising fusion with X-ray fluorescence finish (up to 20 laboratories depending on the element);
- Loss on ignition at 1000° Celsius (12 laboratories);
- Total Sulphur by infrared combustion furnace or C/S analyser;
- Full ICP-OES and MS elemental suites by peroxide fusion (up to 22 laboratories depending on the element);
- Full ICP-OES and MS elemental suites by 4-acid (HNO_3-HF-$HClO_4$-HCl) digestion (up to 22 laboratories depending on the element);
- Full ICP-OES and MS elemental suites by aqua regia digestion (up to 18 laboratories depending on the element).

For the round robin program ten 500g test units were taken at predetermined intervals during the bagging stage, immediately following homogenisation and are considered representative of the entire prepared batch. Six 20g pulp samples were submitted to each laboratory for analysis. The samples received by each laboratory were obtained by taking two samples from each of three separate 500g test units. This format enabled a nested ANOVA treatment of the results to evaluate homogeneity, i.e., to ascertain whether between-unit variance is greater than within-unit variance (see 'Homogeneity Evaluation' section below).

STATISTICAL ANALYSIS

Certified Values and their uncertainty intervals (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 [5,15]. All known or suspected sources of bias have been investigated or taken into account.

Indicative (uncertified) values (Table 3) are present where the number of laboratories reporting a particular analyte is insufficient (< 5) to support certification. 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 316.

Constituent	Unit	Value	Constituent	Unit	Value	Constituent	Unit	Value
Borate Fusion XRF								
Ag	ppm	*95.8*	Hg	ppm	*< 100*	Se	ppm	*< 100*
Bi	ppm	*150*	In	ppm	*< 100*	Sn	ppm	*< 100*
Cd	ppm	*293*	La	ppm	*71*	SrO	ppm	*83*
Ce	ppm	*115*	Mo	ppm	*< 50*	Ta	ppm	*< 100*
Co	ppm	*< 100*	Na_2O	wt.%	*0.341*	Te	ppm	*< 100*
Cr_2O_3	ppm	*180*	Nb	ppm	*98*	Tl	ppm	*< 100*
Cs	ppm	*< 100*	Ni	ppm	*127*	V_2O_5	ppm	*161*
Ga	ppm	*< 100*	Rb	ppm	*141*	W	ppm	*< 100*
Ge	ppm	*< 100*	Sb	ppm	*120*	Y	ppm	*< 39*
Hf	ppm	*< 80*	Sc	ppm	*< 100*	Zr	ppm	*138*
Borate / Peroxide Fusion ICP								
Na	wt.%	*0.071*	Se	ppm	*< 20*	Te	ppm	*0.94*
Re	ppm	*< 1*	Sn	ppm	*3.51*			
4-Acid Digestion								
Ba	wt.%	*0.090*	Nb	ppm	*4.05*	Ta	ppm	*0.29*
Ge	ppm	*0.24*	Re	ppm	*0.038*	Ti	wt.%	*0.147*
Aqua Regia Digestion								
Au	ppm	*0.133*	Ge	ppm	*0.17*	Pd	ppb	*23.3*
B	ppm	*13.0*	Na	wt.%	*0.013*	Pt	ppb	*< 5*
Ba	wt.%	*0.004*	Nb	ppm	*0.095*	Re	ppm	*0.035*

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 316.

Constituent	Certified Value	95% Expanded Uncertainty		95% Tolerance Limits	
		Low	High	Low	High
Borate Fusion XRF					
Al_2O_3, Aluminium(III) oxide (wt.%)	8.43	8.33	8.53	8.35	8.52
As, Arsenic (ppm)	415	285	546	IND	IND
BaO, Barium oxide (wt.%)	0.211	0.190	0.232	0.198	0.224
CaO, Calcium oxide (wt.%)	1.32	1.28	1.36	1.30	1.34
Cu, Copper (ppm)	1612	1448	1776	1452	1771
Fe, Iron (wt.%)	6.10	6.04	6.17	6.06	6.15
K_2O, Potassium oxide (wt.%)	2.57	2.51	2.64	2.54	2.60
MgO, Magnesium oxide (wt.%)	1.17	1.14	1.20	1.15	1.19
Mn, Manganese (wt.%)	0.461	0.449	0.473	0.454	0.468
P_2O_5, Phosphorus(V) oxide (wt.%)	0.072	0.063	0.081	IND	IND
Pb, Lead (wt.%)	5.00	4.70	5.30	4.88	5.12
S, Sulphur (wt.%)	9.06	8.82	9.29	8.93	9.18
SiO_2, Silicon dioxide (wt.%)	47.19	46.64	47.74	46.82	47.55
TiO_2, Titanium dioxide (wt.%)	0.340	0.329	0.351	0.328	0.352
Zn, Zinc (wt.%)	11.22	11.06	11.38	11.13	11.31
Thermogravimetry					
LOI^{1000}, Loss On Ignition @1000°C (wt.%)	8.67	8.38	8.97	8.57	8.78
Infrared Combustion					
C, Carbon (wt.%)	1.18	1.15	1.21	1.16	1.20
S, Sulphur (wt.%)	9.22	9.04	9.39	9.06	9.37
Borate / Peroxide Fusion ICP					
Ag, Silver (ppm)	101	88	113	93	109
Al, Aluminium (wt.%)	4.48	4.35	4.60	4.37	4.58
As, Arsenic (ppm)	403	359	447	376	430
B, Boron (ppm)	83	68	98	70	96
Ba, Barium (wt.%)	0.196	0.187	0.204	0.188	0.204
Be, Beryllium (ppm)	2.12	1.85	2.40	IND	IND
Bi, Bismuth (ppm)	15.3	12.3	18.2	13.9	16.6
Ca, Calcium (wt.%)	0.932	0.867	0.998	0.893	0.972
Cd, Cadmium (ppm)	257	242	272	243	271
Ce, Cerium (ppm)	63	60	66	60	66
Co, Cobalt (ppm)	12.8	11.0	14.6	IND	IND
Cr, Chromium (ppm)	130	120	141	118	143
Cs, Caesium (ppm)	2.93	2.23	3.62	2.68	3.17
Cu, Copper (wt.%)	0.163	0.142	0.185	0.151	0.176
Dy, Dysprosium (ppm)	3.63	3.33	3.92	3.34	3.91
Er, Erbium (ppm)	2.05	1.83	2.26	1.87	2.22
Eu, Europium (ppm)	1.23	1.05	1.42	1.18	1.29
Fe, Iron (wt.%)	6.09	5.90	6.28	5.97	6.20
Ga, Gallium (ppm)	15.6	14.2	17.1	14.3	17.0
Gd, Gadolinium (ppm)	4.34	3.87	4.81	3.95	4.73

SI unit equivalents: ppm (parts per million; 1 x 10^6) ≡ mg/kg; wt.% (weight per cent) ≡ % (mass fraction).
Note: intervals may appear asymmetric due to rounding.
IND = indeterminate (due to limited reading resolution of the methods employed).

Table 4. continued.

Constituent	Certified Value	95% Expanded Uncertainty		95% Tolerance Limits	
		Low	High	Low	High
Borate / Peroxide Fusion ICP continued					
Ge, Germanium (ppm)	4.22	2.13	6.30	IND	IND
Hf, Hafnium (ppm)	1.89	1.36	2.42	IND	IND
Ho, Holmium (ppm)	0.69	0.58	0.79	0.64	0.74
In, Indium (ppm)	1.67	1.50	1.85	IND	IND
K, Potassium (wt.%)	2.17	2.10	2.25	2.10	2.25
La, Lanthanum (ppm)	30.0	28.2	31.8	27.8	32.1
Li, Lithium (ppm)	18.4	15.8	20.9	15.4	21.3
Lu, Lutetium (ppm)	0.28	0.25	0.31	0.26	0.30
Mg, Magnesium (wt.%)	0.684	0.666	0.703	0.667	0.702
Mn, Manganese (wt.%)	0.463	0.447	0.479	0.448	0.478
Mo, Molybdenum (ppm)	18.3	15.1	21.4	IND	IND
Nb, Niobium (ppm)	8.86	5.50	12.22	IND	IND
Nd, Neodymium (ppm)	26.5	25.0	28.1	25.5	27.5
Ni, Nickel (ppm)	110	93	128	102	118
P, Phosphorus (wt.%)	0.031	0.020	0.042	IND	IND
Pb, Lead (wt.%)	4.90	4.62	5.19	4.67	5.14
Pr, Praseodymium (ppm)	6.75	6.27	7.22	6.40	7.09
Rb, Rubidium (ppm)	101	95	107	97	106
S, Sulphur (wt.%)	9.05	8.76	9.33	8.86	9.23
Sb, Antimony (ppm)	128	119	138	120	136
Sc, Scandium (ppm)	7.59	6.33	8.85	IND	IND
Si, Silicon (wt.%)	22.70	21.78	23.62	22.21	23.18
Sm, Samarium (ppm)	4.98	4.13	5.83	4.55	5.40
Sr, Strontium (ppm)	64	60	68	61	67
Ta, Tantalum (ppm)	0.69	0.46	0.92	IND	IND
Tb, Terbium (ppm)	0.61	0.58	0.65	0.59	0.64
Th, Thorium (ppm)	9.55	9.08	10.03	9.31	9.80
Ti, Titanium (wt.%)	0.205	0.197	0.213	0.197	0.212
Tl, Thallium (ppm)	15.5	14.5	16.5	15.0	16.0
Tm, Thulium (ppm)	0.31	0.21	0.40	0.28	0.33
U, Uranium (ppm)	3.57	3.19	3.95	3.42	3.72
V, Vanadium (ppm)	102	94	111	96	109
W, Tungsten (ppm)	1.98	1.07	2.89	IND	IND
Y, Yttrium (ppm)	20.6	19.1	22.2	19.8	21.5
Yb, Ytterbium (ppm)	1.95	1.73	2.17	1.82	2.08
Zn, Zinc (wt.%)	11.04	10.68	11.39	10.82	11.26
Zr, Zirconium (ppm)	72	63	81	IND	IND
4-Acid Digestion					
Ag, Silver (ppm)	103	100	107	100	106
Al, Aluminium (wt.%)	4.37	4.22	4.53	4.26	4.48
As, Arsenic (ppm)	368	352	385	355	382

SI unit equivalents: ppm (parts per million; 1 x 10^6) ≡ mg/kg; wt.% (weight per cent) ≡ % (mass fraction).
Note: intervals may appear asymmetric due to rounding.
IND = indeterminate (due to limited reading resolution of the methods employed).

Table 4. continued.

Constituent	Certified Value	95% Expanded Uncertainty		95% Tolerance Limits	
		Low	High	Low	High
4-Acid Digestion continued					
Be, Beryllium (ppm)	1.89	1.79	1.99	1.77	2.01
Bi, Bismuth (ppm)	14.6	12.7	16.5	13.5	15.7
Ca, Calcium (wt.%)	0.935	0.901	0.969	0.921	0.949
Cd, Cadmium (ppm)	255	247	263	248	262
Ce, Cerium (ppm)	58	55	61	55	60
Co, Cobalt (ppm)	12.7	11.5	13.8	12.1	13.3
Cr, Chromium (ppm)	98	91	104	94	102
Cs, Caesium (ppm)	2.60	2.42	2.78	2.47	2.74
Cu, Copper (wt.%)	0.161	0.144	0.178	0.152	0.169
Dy, Dysprosium (ppm)	3.10	2.63	3.57	2.93	3.27
Er, Erbium (ppm)	1.59	1.21	1.98	1.49	1.70
Eu, Europium (ppm)	1.19	1.10	1.28	1.12	1.26
Fe, Iron (wt.%)	5.97	5.78	6.15	5.85	6.08
Ga, Gallium (ppm)	14.5	13.5	15.6	13.9	15.1
Gd, Gadolinium (ppm)	4.00	3.63	4.36	3.81	4.19
Hf, Hafnium (ppm)	1.71	1.59	1.83	1.58	1.83
Ho, Holmium (ppm)	0.59	0.51	0.66	0.55	0.62
In, Indium (ppm)	1.64	1.54	1.75	1.57	1.71
K, Potassium (wt.%)	2.13	2.06	2.20	2.07	2.19
La, Lanthanum (ppm)	29.0	27.3	30.6	27.9	30.0
Li, Lithium (ppm)	17.4	16.3	18.6	16.8	18.0
Lu, Lutetium (ppm)	0.23	0.17	0.28	IND	IND
Mg, Magnesium (wt.%)	0.666	0.641	0.690	0.652	0.680
Mn, Manganese (wt.%)	0.447	0.430	0.464	0.439	0.456
Mo, Molybdenum (ppm)	16.3	14.1	18.5	15.2	17.4
Na, Sodium (wt.%)	0.070	0.066	0.075	0.067	0.073
Nd, Neodymium (ppm)	24.9	23.4	26.4	24.2	25.6
Ni, Nickel (ppm)	108	103	113	104	112
P, Phosphorus (wt.%)	0.031	0.029	0.033	0.029	0.032
Pb, Lead (wt.%)	5.02	4.71	5.33	4.83	5.21
Pr, Praseodymium (ppm)	6.60	6.06	7.15	6.30	6.91
Rb, Rubidium (ppm)	99	95	103	96	102
S, Sulphur (wt.%)	8.89	8.62	9.16	8.72	9.06
Sb, Antimony (ppm)	122	113	131	115	128
Sc, Scandium (ppm)	7.47	6.99	7.96	7.08	7.86
Se, Selenium (ppm)	2.93	2.27	3.59	2.42	3.45
Sm, Samarium (ppm)	4.93	4.41	5.46	4.77	5.09
Sn, Tin (ppm)	3.17	2.80	3.54	2.98	3.36
Sr, Strontium (ppm)	55	52	58	53	57
Tb, Terbium (ppm)	0.57	0.53	0.61	0.54	0.60
Te, Tellurium (ppm)	0.25	0.15	0.36	0.14	0.37

SI unit equivalents: ppm (parts per million; 1 x 10^6) ≡ mg/kg; wt.% (weight per cent) ≡ % (mass fraction).
Note: intervals may appear asymmetric due to rounding.
IND = indeterminate (due to limited reading resolution of the methods employed).

Table 4. continued.

Constituent	Certified Value	95% Expanded Uncertainty		95% Tolerance Limits	
		Low	High	Low	High
4-Acid Digestion continued					
Th, Thorium (ppm)	8.97	8.21	9.72	8.53	9.40
Tl, Thallium (ppm)	16.0	15.4	16.5	15.5	16.5
Tm, Thulium (ppm)	0.26	0.22	0.30	IND	IND
U, Uranium (ppm)	3.50	3.32	3.68	3.32	3.68
V, Vanadium (ppm)	98	95	102	95	102
W, Tungsten (ppm)	2.16	1.92	2.39	2.05	2.27
Y, Yttrium (ppm)	15.7	14.3	17.2	14.8	16.7
Yb, Ytterbium (ppm)	1.65	1.40	1.91	1.48	1.82
Zn, Zinc (wt.%)	11.16	10.91	11.41	10.95	11.37
Zr, Zirconium (ppm)	54	51	57	52	56
Aqua Regia Digestion					
Ag, Silver (ppm)	102	100	105	100	105
Al, Aluminium (wt.%)	0.696	0.635	0.756	0.674	0.717
As, Arsenic (ppm)	365	347	383	356	374
Be, Beryllium (ppm)	0.52	0.48	0.56	0.50	0.55
Bi, Bismuth (ppm)	14.7	14.0	15.3	14.0	15.3
Ca, Calcium (wt.%)	0.921	0.892	0.951	0.902	0.941
Cd, Cadmium (ppm)	246	236	256	241	251
Ce, Cerium (ppm)	39.5	34.8	44.2	37.9	41.1
Co, Cobalt (ppm)	10.9	9.9	11.9	10.7	11.2
Cr, Chromium (ppm)	32.0	30.5	33.4	31.0	32.9
Cs, Caesium (ppm)	0.96	0.91	1.01	0.92	1.00
Cu, Copper (wt.%)	0.165	0.156	0.175	0.158	0.173
Dy, Dysprosium (ppm)	1.43	1.14	1.72	1.37	1.49
Er, Erbium (ppm)	0.65	0.51	0.80	0.60	0.70
Eu, Europium (ppm)	0.73	0.60	0.85	0.69	0.77
Fe, Iron (wt.%)	5.86	5.66	6.06	5.74	5.98
Ga, Gallium (ppm)	3.83	3.42	4.24	3.67	3.99
Gd, Gadolinium (ppm)	2.31	1.97	2.64	2.14	2.47
Hf, Hafnium (ppm)	0.45	0.39	0.51	0.43	0.47
Hg, Mercury (ppm)	3.83	3.56	4.10	3.63	4.02
Ho, Holmium (ppm)	0.27	0.24	0.31	0.25	0.29
In, Indium (ppm)	1.53	1.35	1.72	1.49	1.57
K, Potassium (wt.%)	0.264	0.242	0.285	0.254	0.273
La, Lanthanum (ppm)	16.5	14.4	18.6	15.8	17.3
Li, Lithium (ppm)	4.86	3.89	5.83	4.70	5.01
Lu, Lutetium (ppm)	0.089	0.069	0.108	IND	IND
Mg, Magnesium (wt.%)	0.474	0.454	0.494	0.462	0.485
Mn, Manganese (wt.%)	0.428	0.411	0.445	0.420	0.436
Mo, Molybdenum (ppm)	16.0	14.3	17.7	15.2	16.8
Nd, Neodymium (ppm)	13.4	12.4	14.4	12.8	14.1

SI unit equivalents: ppm (parts per million; 1 x 10^6) ≡ mg/kg; wt.% (weight per cent) ≡ % (mass fraction).
Note: intervals may appear asymmetric due to rounding.
IND = indeterminate (due to limited reading resolution of the methods employed).

Table 4. continued.

Constituent	Certified Value	95% Expanded Uncertainty		95% Tolerance Limits	
		Low	High	Low	High
Aqua Regia Digestion continued					
Ni, Nickel (ppm)	106	103	109	104	108
P, Phosphorus (wt.%)	0.028	0.027	0.029	0.027	0.029
Pb, Lead (wt.%)	5.03	4.78	5.28	4.87	5.18
Pr, Praseodymium (ppm)	3.84	2.94	4.74	3.62	4.07
Rb, Rubidium (ppm)	15.9	13.7	18.1	15.2	16.6
S, Sulphur (wt.%)	9.06	8.75	9.37	8.87	9.26
Sb, Antimony (ppm)	97	90	104	94	100
Sc, Scandium (ppm)	1.46	1.22	1.70	1.33	1.58
Se, Selenium (ppm)	3.23	2.52	3.93	2.99	3.46
Sm, Samarium (ppm)	2.68	2.31	3.04	2.54	2.81
Sn, Tin (ppm)	1.42	1.18	1.66	1.37	1.47
Sr, Strontium (ppm)	16.5	15.3	17.7	15.9	17.2
Ta, Tantalum (ppm)	< 0.05	IND	IND	IND	IND
Tb, Terbium (ppm)	0.31	0.27	0.35	0.30	0.32
Te, Tellurium (ppm)	0.26	0.21	0.32	0.23	0.30
Th, Thorium (ppm)	6.54	5.97	7.12	6.30	6.78
Ti, Titanium (wt.%)	0.010	0.009	0.010	0.009	0.010
Tl, Thallium (ppm)	11.8	11.0	12.6	11.4	12.2
Tm, Thulium (ppm)	0.081	0.050	0.111	IND	IND
U, Uranium (ppm)	2.29	2.14	2.43	2.18	2.39
V, Vanadium (ppm)	17.2	15.4	19.0	16.3	18.1
W, Tungsten (ppm)	0.75	0.63	0.87	0.70	0.80
Y, Yttrium (ppm)	6.35	5.89	6.81	6.20	6.51
Yb, Ytterbium (ppm)	0.55	0.40	0.70	0.51	0.59
Zn, Zinc (wt.%)	11.10	10.86	11.34	10.86	11.34
Zr, Zirconium (ppm)	15.6	13.3	17.9	15.1	16.1

SI unit equivalents: ppm (parts per million; 1 x 10^6) ≡ mg/kg; wt.% (weight per cent) ≡ % (mass fraction).
Note: intervals may appear asymmetric due to rounding.

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 Zn 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 10.95 and 11.37 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 316 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. AGAT Laboratories, Mississauga, Ontario, Canada
4. ALS, Brisbane, QLD, Australia
5. ALS, Lima, Peru
6. ALS, Loughrea, Galway, Ireland
7. ALS, Perth, WA, Australia
8. ALS, Vancouver, BC, Canada
9. American Assay Laboratories, Sparks, Nevada, USA
10. ARGETEST Mineral Processing, Ankara, Central Anatolia, Turkey
11. Bureau Veritas Commodities Canada Ltd, Vancouver, BC, Canada
12. Bureau Veritas Geoanalytical, Adelaide, SA, Australia
13. Bureau Veritas Geoanalytical, Perth, WA, Australia
14. ESAN Balya, Balya, Turkey
15. ESAN Istanbul, Istanbul, Turkey
16. Intertek Genalysis, Perth, WA, Australia
17. Intertek Testing Services Philippines, Cupang, Muntinlupa, Philippines
18. MinAnalytical Services, Perth, WA, Australia
19. MSALABS, Vancouver, BC, Canada
20. PT Geoservices Ltd, Cikarang, Jakarta Raya, Indonesia
21. PT Intertek Utama Services, Jakarta Timur, DKI Jakarta, Indonesia
22. Saskatchewan Research Council, Saskatoon, Saskatchewan, Canada
23. SGS, Randfontein, Gauteng, South Africa
24. SGS Australia Mineral Services, Perth, WA, Australia
25. SGS Geosol Laboratorios Ltda, Vespasiano, Minas Gerais, Brazil
26. Shiva Analyticals Ltd, Bangalore North, Karnataka, India

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.

PREPARER

Certified reference material OREAS 316 was prepared and certified by:

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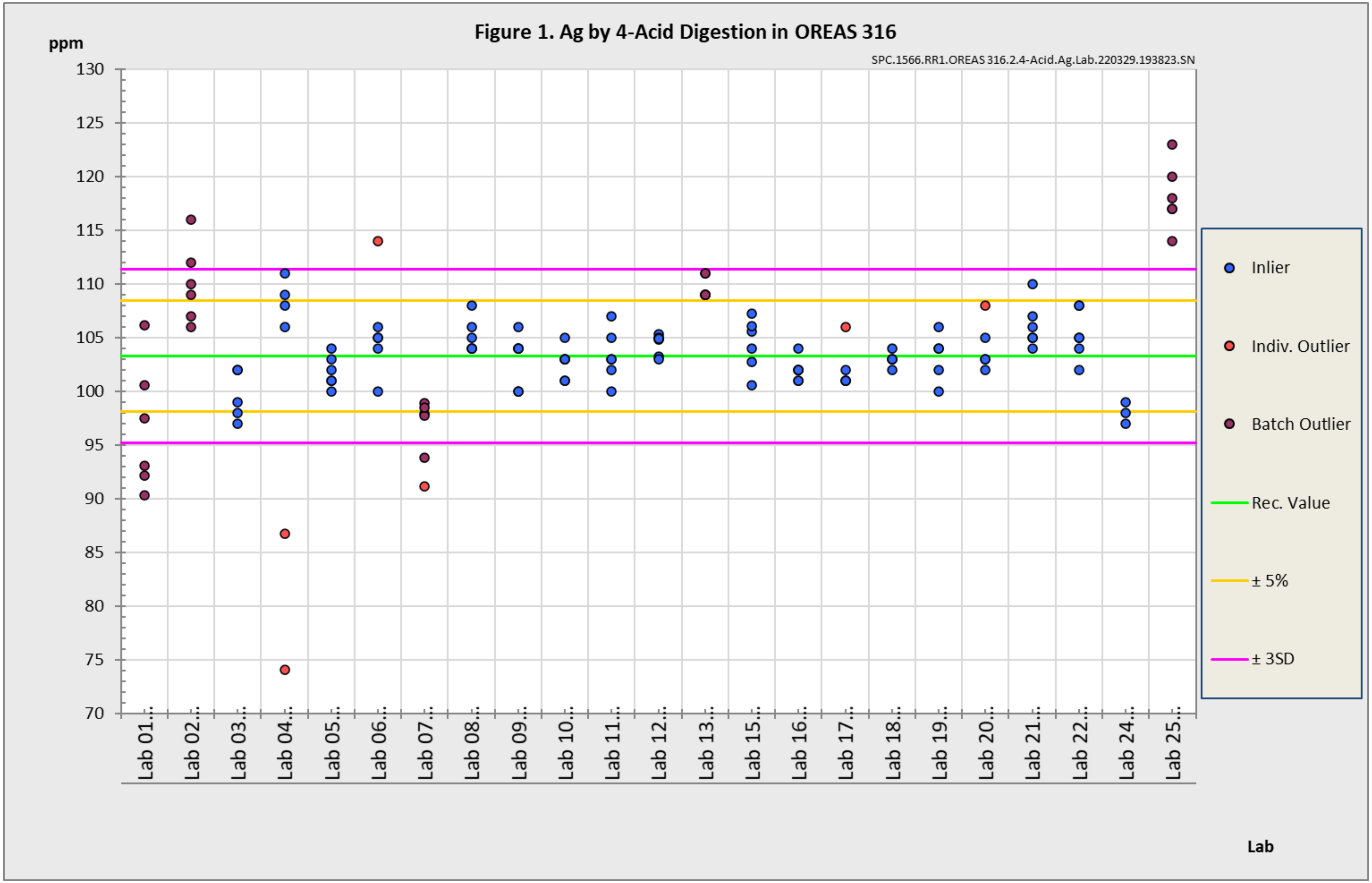
Figure 1. Ag by 4-Acid Digestion in OREAS 316
SPC.1566.RR1.OREAS 316.2.4-Acid.Ag.Lab.220329.193823.SN
ppm
130
125
120
115
110
105
100
95
90
85
80
75
70
Lab 01...
Lab 02...
Lab 03...
Lab 04...
Lab 05...
Lab 06...
Lab 07...
Lab 08...
Lab 09...
Lab 10...
Lab 11...
Lab 12...
Lab 13...
Lab 15...
Lab 16...
Lab 17...
Lab 18...
Lab 19...
Lab 20...
Lab 21...
Lab 22...
Lab 24...
Lab 25...
Lab
Inlier
Indiv. Outlier
Batch Outlier
Rec. Value
± 5%
± 3SD

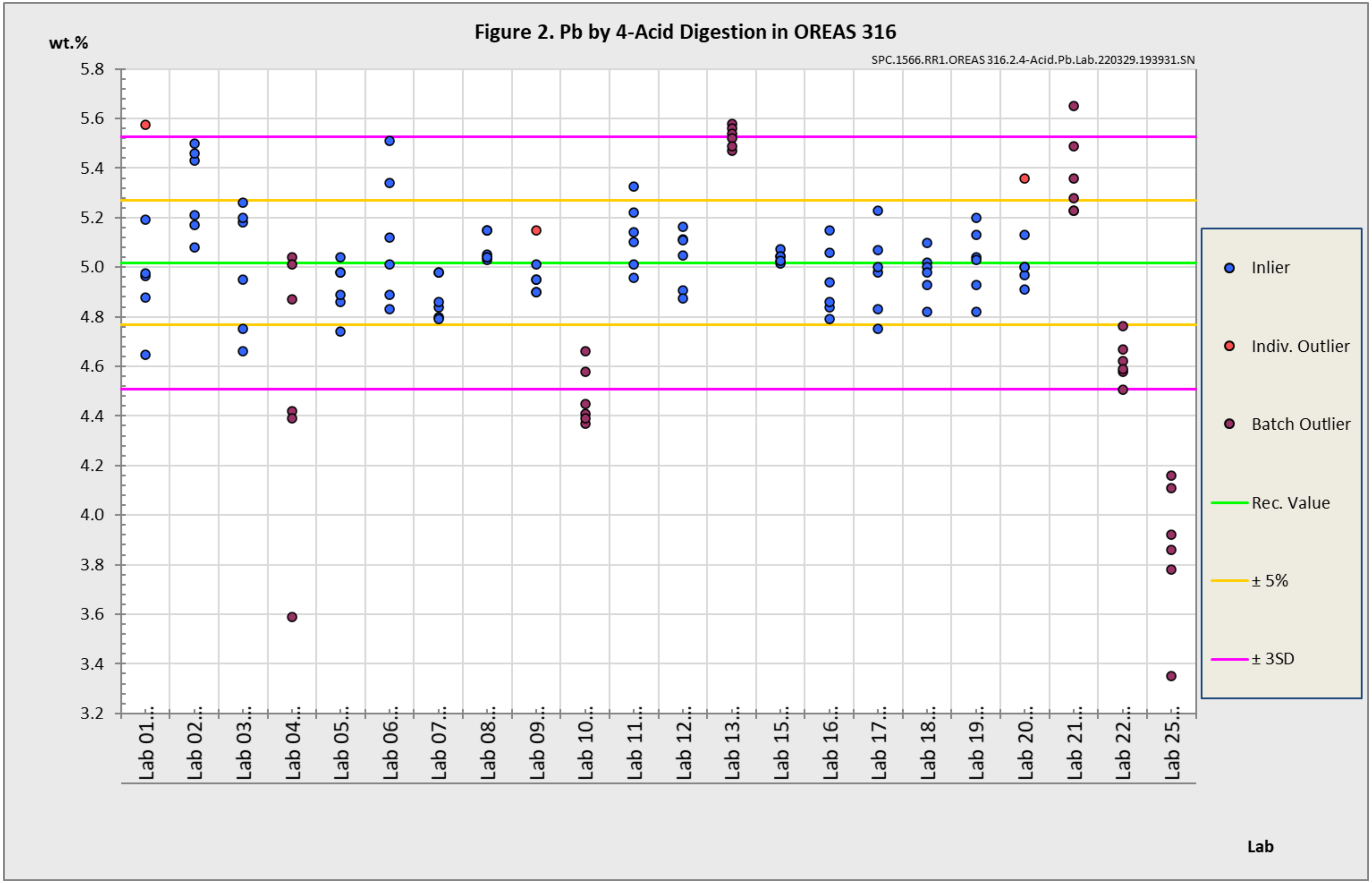

Figure 2. Pb by 4-Acid Digestion in OREAS 316
wt.%
SPC.1566.RR1.OREAS 316.2.4-Acid.Pb.Lab.220329.193931.SN
5.8
5.6
5.4
5.2
5.0
4.8
4.6
4.4
4.2
4.0
3.8
3.6
3.4
3.2
Lab 01...
Lab 02...
Lab 03...
Lab 04...
Lab 05...
Lab 06...
Lab 07...
Lab 08...
Lab 09...
Lab 10...
Lab 11...
Lab 12...
Lab 13...
Lab 15...
Lab 16...
Lab 17...
Lab 18...
Lab 19...
Lab 20...
Lab 21...
Lab 22...
Lab 25...
Inlier
Indiv. Outlier
Batch Outlier
Rec. Value
± 5%
± 3SD
Lab

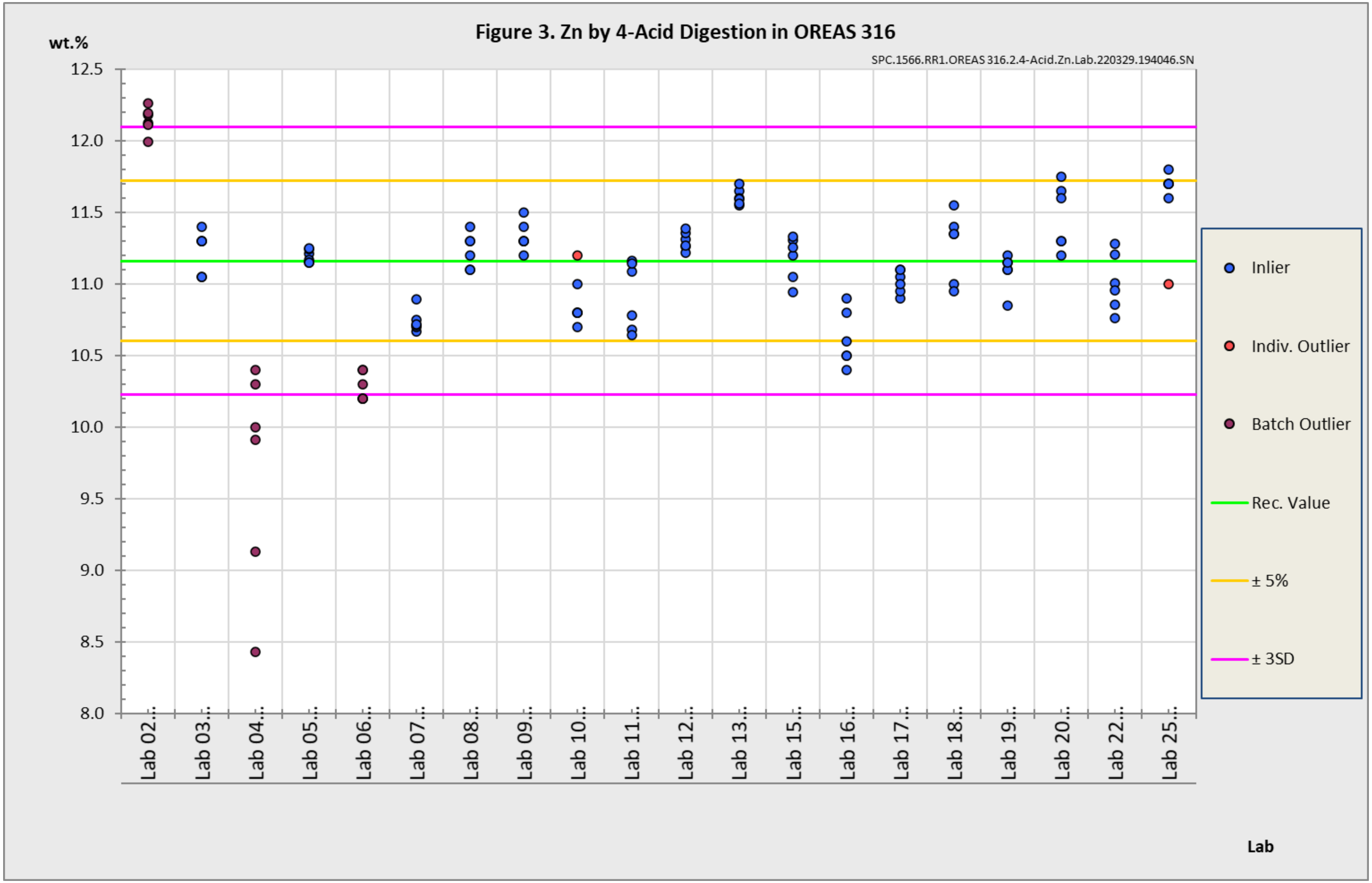
Figure 3. Zn by 4-Acid Digestion in OREAS 316
SPC.1566.RR1.OREAS 316.2.4-Acid.Zn.Lab.220329.194046.SN
wt.%
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
Lab 02...
Lab 03...
Lab 04...
Lab 05...
Lab 06...
Lab 07...
Lab 08...
Lab 09...
Lab 10...
Lab 11...
Lab 12...
Lab 13...
Lab 15...
Lab 16...
Lab 17...
Lab 18...
Lab 19...
Lab 20...
Lab 22...
Lab 25...
Inlier
Indiv. Outlier
Batch Outlier
Rec. Value
± 5%
± 3SD
Lab

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 316 will display similar behaviour in the relevant measurement process to the routine field samples for which OREAS 316 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 316 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 316 may be used to calibrate the entire procedure by producing a pure substance CRM transformed into a calibration solution.

OREAS 316 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 316 remains valid, within the specified measurement uncertainties, until January 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 316 is sulphide rich (9.2 wt.% S) and is packaged in single-use sachets sealed under nitrogen. 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 [12].

Fine powders pose a risk to eyes and lungs and therefore standard precautions including the use of safety glasses and dust masks are advised. Sulphur is a known transitory upper respiratory irritant. Close exposure may cause coughing or throat irritation.

As per routine analysis at commercial laboratories, the certified values derived by oxidising fusion with XRF finish are on a dry sample basis.

Analytes by all other methods refer to the concentration levels in the packaged state. There is no need for drying prior to weighing and analysis for these methods.

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.

- Oxidising fusion with X-ray fluorescence finish: ≥0.2g;
- Loss on Ignition (LOI) at 1000°C: ≥1g.;

- Total C and S by IR induction furnace: ≥0.1g;
- Peroxide or borate fusion with ICP-OES and/or MS finish: ≥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
0	30th March, 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

30th March, 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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