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CERTIFICATE OF ANALYSIS FOR

CERTIFIED REFERENCE MATERIAL

OREAS 319

Zinc-Lead-Silver Ore

(Northern Queensland, Australia)

Table 1. Certified Values, Uncertainty & Tolerance Intervals for multi-elements by 4-acid digestion and aqua regia digestion in OREAS 319.

Constituent	Certified Value†	95 % Expanded Uncertainty		95 % Tolerance Limits	
		Low	High	Low	High
4-Acid Digestion					
Ag, Silver (ppm)	149	145	153	146	151
Al, Aluminium (wt.%)	2.51	2.44	2.57	2.46	2.56
As, Arsenic (ppm)	171	165	178	167	175
Be, Beryllium (ppm)	1.61	1.54	1.67	1.56	1.66
Bi, Bismuth (ppm)	0.32	0.30	0.35	0.31	0.34
Ca, Calcium (wt.%)	3.02	2.95	3.09	2.95	3.09
Cd, Cadmium (ppm)	399	382	415	392	405
Ce, Cerium (ppm)	27.7	25.4	30.1	26.8	28.7
Co, Cobalt (ppm)	77	74	80	75	79
Cr, Chromium (ppm)	101	96	106	98	104
Cs, Caesium (ppm)	1.77	1.66	1.87	1.71	1.82
Cu, Copper (wt.%)	0.082	0.080	0.084	0.081	0.084
Dy, Dysprosium (ppm)	1.49	1.36	1.63	1.46	1.53
Er, Erbium (ppm)	0.81	0.72	0.91	0.79	0.84
Eu, Europium (ppm)	0.51	0.46	0.56	0.48	0.55
Fe, Iron (wt.%)	9.35	9.11	9.60	9.22	9.49
Ga, Gallium (ppm)	7.61	7.20	8.02	7.42	7.80
Gd, Gadolinium (ppm)	2.13	1.90	2.37	2.09	2.18
Ge, Germanium (ppm)	0.13	0.09	0.17	IND	IND
Hf, Hafnium (ppm)	1.15	1.06	1.24	1.08	1.22
Ho, Holmium (ppm)	0.29	0.27	0.30	0.28	0.29
In, Indium (ppm)	0.72	0.67	0.77	0.70	0.75
K, Potassium (wt.%)	1.11	1.09	1.14	1.09	1.13
La, Lanthanum (ppm)	13.1	11.8	14.5	12.7	13.6
Li, Lithium (ppm)	16.5	15.6	17.3	16.1	16.9
Lu, Lutetium (ppm)	0.12	0.09	0.15	IND	IND
Mg, Magnesium (wt.%)	1.54	1.50	1.58	1.51	1.56
Mn, Manganese (wt.%)	0.255	0.246	0.264	0.250	0.260
Mo, Molybdenum (ppm)	6.04	5.71	6.37	5.86	6.22
Na, Sodium (wt.%)	0.045	0.043	0.047	0.043	0.047
Nb, Niobium (ppm)	1.89	1.67	2.11	1.77	2.01
Nd, Neodymium (ppm)	13.4	12.4	14.4	13.1	13.6
Ni, Nickel (ppm)	38.4	36.9	39.9	37.3	39.5
P, Phosphorus (wt.%)	0.028	0.027	0.029	0.027	0.028
Pb, Lead (wt.%)	9.88	9.69	10.07	9.76	10.00

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

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

Note: intervals may appear asymmetric due to rounding.

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

Table 1 continued.

Constituent	Certified Value†	95 % Expanded Uncertainty		95 % Tolerance Limits	
		Low	High	Low	High
4-Acid Digestion continued					
Pr, Praseodymium (ppm)	3.30	2.76	3.84	3.24	3.36
Rb, Rubidium (ppm)	54	51	57	52	55
Re, Rhenium (ppm)	< 0.002	IND	IND	IND	IND
S, Sulphur (wt.%)	14.73	13.78	15.67	14.51	14.95
Sb, Antimony (ppm)	80	76	84	77	82
Sc, Scandium (ppm)	4.12	3.82	4.41	4.00	4.24
Sm, Samarium (ppm)	2.49	2.37	2.62	2.39	2.59
Sn, Tin (ppm)	1.51	1.41	1.62	1.39	1.64
Sr, Strontium (ppm)	27.5	25.9	29.1	26.6	28.4
Ta, Tantalum (ppm)	0.15	0.13	0.18	0.14	0.17
Tb, Terbium (ppm)	0.26	0.23	0.30	0.25	0.28
Te, Tellurium (ppm)	0.10	0.07	0.13	IND	IND
Th, Thorium (ppm)	5.04	4.68	5.40	4.85	5.22
Ti, Titanium (wt.%)	0.078	0.074	0.082	0.076	0.080
Tl, Thallium (ppm)	61	58	64	60	63
Tm, Thulium (ppm)	0.12	0.09	0.16	IND	IND
U, Uranium (ppm)	2.10	1.98	2.23	2.02	2.19
V, Vanadium (ppm)	59	57	61	58	60
W, Tungsten (ppm)	0.86	0.77	0.95	0.80	0.92
Y, Yttrium (ppm)	8.74	8.21	9.27	8.40	9.08
Yb, Ytterbium (ppm)	0.85	0.73	0.96	0.83	0.87
Zn, Zinc (wt.%)	13.13	12.90	13.37	12.97	13.30
Zr, Zirconium (ppm)	38.9	36.8	40.9	37.7	40.0
Aqua Regia Digestion					
Ag, Silver (ppm)	148	146	150	146	150
Al, Aluminium (wt.%)	0.474	0.449	0.500	0.460	0.489
As, Arsenic (ppm)	174	167	181	170	178
Au, Gold (ppm)	< 0.02	IND	IND	IND	IND
B, Boron (ppm)	< 10	IND	IND	IND	IND
Be, Beryllium (ppm)	0.46	0.41	0.51	0.44	0.48
Bi, Bismuth (ppm)	0.25	0.23	0.28	0.24	0.27
Ca, Calcium (wt.%)	2.90	2.83	2.98	2.83	2.98
Cd, Cadmium (ppm)	377	359	394	368	385
Ce, Cerium (ppm)	15.0	13.0	16.9	14.6	15.3
Co, Cobalt (ppm)	74	70	78	72	76

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

Note: intervals may appear asymmetric due to rounding.

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

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

Table 1 continued.

Constituent	Certified Value†	95 % Expanded Uncertainty		95 % Tolerance Limits	
		Low	High	Low	High
Aqua Regia Digestion continued					
Cr, Chromium (ppm)	30.4	28.2	32.5	29.2	31.5
Cs, Caesium (ppm)	0.71	0.67	0.76	0.68	0.75
Cu, Copper (wt.%)	0.084	0.081	0.086	0.082	0.085
Fe, Iron (wt.%)	9.08	8.76	9.39	8.93	9.23
Ga, Gallium (ppm)	2.08	1.93	2.23	1.98	2.18
Ge, Germanium (ppm)	0.20	0.14	0.25	0.17	0.23
Hf, Hafnium (ppm)	0.26	0.24	0.29	0.25	0.28
Hg, Mercury (ppm)	1.59	1.49	1.69	1.54	1.64
In, Indium (ppm)	0.68	0.64	0.72	0.66	0.70
K, Potassium (wt.%)	0.167	0.155	0.179	0.161	0.172
La, Lanthanum (ppm)	6.04	5.30	6.78	5.78	6.30
Li, Lithium (ppm)	6.61	6.17	7.05	6.42	6.79
Mg, Magnesium (wt.%)	1.44	1.40	1.48	1.41	1.47
Mn, Manganese (wt.%)	0.249	0.241	0.258	0.244	0.255
Mo, Molybdenum (ppm)	5.83	5.45	6.22	5.65	6.02
Nb, Niobium (ppm)	0.055	0.044	0.066	IND	IND
Ni, Nickel (ppm)	35.5	33.3	37.6	34.4	36.5
P, Phosphorus (wt.%)	0.026	0.025	0.027	0.025	0.027
Pb, Lead (wt.%)	9.73	9.56	9.90	9.65	9.82
Rb, Rubidium (ppm)	9.21	8.55	9.88	8.84	9.58
S, Sulphur (wt.%)	13.43	12.27	14.58	13.19	13.67
Sb, Antimony (ppm)	61	56	66	59	63
Sc, Scandium (ppm)	1.22	1.11	1.33	1.15	1.29
Sn, Tin (ppm)	0.64	0.58	0.70	0.58	0.69
Sr, Strontium (ppm)	16.4	14.9	17.8	15.8	17.0
Ta, Tantalum (ppm)	< 0.01	IND	IND	IND	IND
Tb, Terbium (ppm)	0.18	0.15	0.20	IND	IND
Te, Tellurium (ppm)	0.093	0.066	0.119	IND	IND
Th, Thorium (ppm)	3.10	2.86	3.34	2.98	3.21
Ti, Titanium (wt.%)	0.005	0.004	0.006	0.005	0.005
Tl, Thallium (ppm)	45.0	42.1	47.9	43.8	46.3
U, Uranium (ppm)	1.13	1.06	1.21	1.10	1.17
V, Vanadium (ppm)	9.56	8.76	10.35	8.95	10.17
W, Tungsten (ppm)	0.23	0.21	0.25	0.21	0.25
Y, Yttrium (ppm)	4.13	3.86	4.40	3.97	4.28

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

Note: intervals may appear asymmetric due to rounding.

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

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

Table 1 continued.

Constituent	Certified Value†	95 % Expanded Uncertainty		95 % Tolerance Limits	
		Low	High	Low	High
Aqua Regia Digestion continued					
Yb, Ytterbium (ppm)	0.38	0.34	0.43	0.36	0.41
Zn, Zinc (wt.%)	13.02	12.71	13.34	12.85	13.20
Zr, Zirconium (ppm)	8.24	7.74	8.74	7.90	8.58

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

Note: intervals may appear asymmetric due to rounding.

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

Table 2. Certified Values, Uncertainty & Tolerance Intervals for other measurands in OREAS 319.

Constituent	Certified Value	95 % Expanded Uncertainty		95 % Tolerance Limits	
		Low	High	Low	High
Borate Fusion XRF					
Al_2O_3, Aluminium(III) oxide (wt.%)	4.84	4.73	4.95	4.75	4.93
BaO, Barium oxide (wt.%)	0.184	0.170	0.197	IND	IND
Bi, Bismuth (ppm)	< 100	IND	IND	IND	IND
CaO, Calcium oxide (wt.%)	4.37	4.27	4.47	4.30	4.44
Cr_2O_3, Chromium(III) oxide (ppm)	214	156	272	IND	IND
Cu, Copper (wt.%)	0.081	0.075	0.088	0.080	0.083
Fe_2O_3, Iron(III) oxide (wt.%)	13.75	13.52	13.97	13.62	13.87
HfO_2, Hafnium dioxide (ppm)	< 100	IND	IND	IND	IND
K_2O, Potassium oxide (wt.%)	1.34	1.31	1.38	1.32	1.37
MgO, Magnesium oxide (wt.%)	2.63	2.53	2.74	2.58	2.68
MnO, Manganese oxide (wt.%)	0.344	0.328	0.360	0.334	0.354
P_2O_5, Phosphorus(V) oxide (wt.%)	0.064	0.056	0.072	0.057	0.071
Pb, Lead (wt.%)	9.61	9.39	9.83	9.48	9.74
S, Sulphur (wt.%)	14.29	13.80	14.78	14.02	14.56
SiO_2, Silicon dioxide (wt.%)	29.68	29.21	30.15	29.40	29.95
TiO_2, Titanium dioxide (wt.%)	0.200	0.180	0.220	0.193	0.207
V, Vanadium (ppm)	88	68	109	IND	IND
Zn, Zinc (wt.%)	13.02	12.66	13.38	12.89	13.16
Thermogravimetry					
LOI^{1000}, Loss On Ignition @1000 °C (wt.%)	12.73	12.15	13.31	12.53	12.93
Borate / Peroxide Fusion ICP					
Al, Aluminium (wt.%)	2.55	2.51	2.59	2.52	2.58
As, Arsenic (ppm)	174	168	181	170	179
Ba, Barium (wt.%)	0.156	0.151	0.161	0.153	0.159
Be, Beryllium (ppm)	1.81	1.21	2.40	IND	IND
Bi, Bismuth (ppm)	0.38	0.24	0.52	IND	IND

SI unit equivalents: ppm (parts per million; 1 x 10^{-6}) ≡ mg/kg; wt.% (weight per cent) ≡ % (mass fraction).
Note: intervals may appear asymmetric due to rounding.
IND = indeterminate (due to limited reading resolution of the methods employed. For practical purposes the 95% Expanded Uncertainty can be set between zero and a two times multiple of the upper bound/non-detect limit value)..

Table 2 continued.

Constituent	Certified Value	95 % Expanded Uncertainty		95 % Tolerance Limits	
		Low	High	Low	High
Borate / Peroxide Fusion ICP continued					
Ca, Calcium (wt.%)	3.03	2.91	3.14	2.96	3.09
Cd, Cadmium (ppm)	403	388	418	397	409
Ce, Cerium (ppm)	32.7	30.9	34.4	31.0	34.3
Co, Cobalt (ppm)	78	74	82	76	80
Cr, Chromium (ppm)	122	111	132	117	126
Cs, Caesium (ppm)	1.87	1.76	1.97	1.65	2.08
Cu, Copper (wt.%)	0.082	0.080	0.085	0.081	0.083
Dy, Dysprosium (ppm)	1.92	1.78	2.07	1.74	2.10
Er, Erbium (ppm)	1.11	0.96	1.25	1.04	1.17
Eu, Europium (ppm)	0.58	0.51	0.64	0.53	0.62
Fe, Iron (wt.%)	9.51	9.33	9.68	9.39	9.62
Ga, Gallium (ppm)	8.16	7.39	8.94	7.63	8.69
Gd, Gadolinium (ppm)	2.41	2.18	2.65	2.16	2.67
Ge, Germanium (ppm)	17.6	16.4	18.8	16.6	18.5
Hf, Hafnium (ppm)	1.67	1.28	2.06	IND	IND
Ho, Holmium (ppm)	0.39	0.34	0.44	IND	IND
In, Indium (ppm)	0.74	0.66	0.82	IND	IND
K, Potassium (wt.%)	1.15	1.12	1.19	1.13	1.18
La, Lanthanum (ppm)	17.3	16.5	18.2	16.4	18.3
Li, Lithium (ppm)	17.0	14.2	19.8	IND	IND
Lu, Lutetium (ppm)	0.16	0.14	0.18	IND	IND
Mg, Magnesium (wt.%)	1.58	1.54	1.62	1.55	1.60
Mn, Manganese (wt.%)	0.261	0.255	0.268	0.257	0.266
Mo, Molybdenum (ppm)	6.73	5.30	8.16	IND	IND
Nb, Niobium (ppm)	4.41	3.66	5.15	4.09	4.73
Nd, Neodymium (ppm)	14.7	14.0	15.3	13.9	15.5
Ni, Nickel (ppm)	44.0	34.4	53.5	40.9	47.1
P, Phosphorus (wt.%)	0.030	0.027	0.033	0.029	0.031
Pb, Lead (wt.%)	9.62	9.32	9.91	9.50	9.74
Pr, Praseodymium (ppm)	3.91	3.58	4.24	3.69	4.14
Rb, Rubidium (ppm)	55	52	57	52	57
S, Sulphur (wt.%)	14.38	13.97	14.79	14.14	14.62
Sb, Antimony (ppm)	87	84	90	84	90
Sc, Scandium (ppm)	5.20	3.53	6.86	IND	IND
Si, Silicon (wt.%)	14.27	13.91	14.63	13.98	14.56
Sm, Samarium (ppm)	2.81	2.59	3.03	2.66	2.96

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

Table 2 continued.

Constituent	Certified Value	95 % Expanded Uncertainty		95 % Tolerance Limits	
		Low	High	Low	High
Borate / Peroxide Fusion ICP continued					
Sr, Strontium (ppm)	32.4	29.6	35.1	30.9	33.8
Ta, Tantalum (ppm)	0.40	0.27	0.54	IND	IND
Tb, Terbium (ppm)	0.33	0.29	0.36	0.27	0.38
Th, Thorium (ppm)	5.38	5.19	5.56	5.16	5.59
Ti, Titanium (wt.%)	0.119	0.113	0.124	0.115	0.123
Tl, Thallium (ppm)	60	57	64	58	62
Tm, Thulium (ppm)	0.16	0.14	0.17	IND	IND
U, Uranium (ppm)	2.18	2.07	2.29	2.06	2.30
V, Vanadium (ppm)	62	59	64	59	64
Y, Yttrium (ppm)	10.7	10.3	11.2	10.4	11.1
Yb, Ytterbium (ppm)	1.08	0.94	1.21	1.04	1.12
Zn, Zinc (wt.%)	12.84	12.63	13.04	12.59	13.08
Zr, Zirconium (ppm)	55	50	61	52	58
Infrared Combustion					
C, Carbon (wt.%)	2.31	2.28	2.35	2.28	2.35
S, Sulphur (wt.%)	14.48	14.26	14.70	14.31	14.65

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 3. Indicative Values for OREAS 319.

Constituent	Unit	Value	Constituent	Unit	Value	Constituent	Unit	Value
4-Acid Digestion								
B	ppm	*44.5*	Hg	ppm	*< 1*			
Ba	ppm	*82*	Se	ppm	*2.77*			
Aqua Regia Digestion								
Ba	ppm	*12.8*	Lu	ppm	*0.058*	Re	ppm	*0.001*
Dy	ppm	*0.92*	Na	wt.%	*0.014*	Se	ppm	*1.85*
Er	ppm	*0.43*	Nd	ppm	*8.29*	Sm	ppm	*1.54*
Eu	ppm	*0.34*	Pd	ppb	*125*	Tm	ppm	*0.055*
Gd	ppm	*1.33*	Pr	ppm	*2.04*			
Ho	ppm	*0.16*	Pt	ppb	*< 5*			
Borate Fusion XRF								
Ag	ppm	*< 10*	Ho	ppm	*< 10*	Sn	ppm	*54*
As	ppm	*173*	In	ppm	*< 100*	SrO	ppm	*77*
Au	ppm	*< 10*	La	ppm	*79*	Ta	ppm	*12.0*
Cd	ppm	*353*	Lu	ppm	*< 10*	Tb	ppm	*< 10*
Ce	ppm	*54*	Mo	ppm	*52*	Te	ppm	*< 100*
Cl	wt.%	*1.12*	Na_2O	wt.%	*0.171*	Th	ppm	*1236*
Co	ppm	*100*	Nb	ppm	*104*	Tl	ppm	*< 10*
Cs	ppm	*49.7*	Nd	ppm	*183*	Tm	ppm	*< 10*
Dy	ppm	*100*	Ni	ppm	*48.4*	U	ppm	*28.5*
Er	ppm	*< 10*	Pr	ppm	*< 10*	W	ppm	*278*
Eu	ppm	*< 10*	Rb	ppm	*68*	Y	ppm	*57*
Ga	ppm	*233*	Sb	ppm	*77*	Yb	ppm	*14.5*
Gd	ppm	*< 10*	Sc	ppm	*18.8*	Zr	ppm	*188*
Ge	ppm	*< 10*	Se	ppm	*< 10*			
Hg	ppm	*< 100*	Sm	ppm	*23.8*			
Borate / Peroxide Fusion ICP								
Ag	ppm	*149*	Na	wt.%	*0.040*	Sn	ppm	*1.98*
B	ppm	*45.4*	Re	ppm	*< 0.1*	Te	ppm	*< 1*
Hg	ppm	*< 5*	Se	ppm	*< 10*	W	ppm	*1.25*
Laser Ablation ICP-MS								
Ag	ppm	*143*	Hf	ppm	*1.63*	Sm	ppm	*2.50*
As	ppm	*179*	Ho	ppm	*0.37*	Sn	ppm	*1.60*
Ba	wt.%	*0.153*	In	ppm	*0.73*	Sr	ppm	*31.6*
Be	ppm	*1.60*	La	ppm	*15.9*	Ta	ppm	*< 0.01*
Bi	ppm	*0.26*	Lu	ppm	*0.16*	Tb	ppm	*0.34*
Ce	ppm	*30.4*	Mn	wt.%	*0.266*	Te	ppm	*< 0.2*
Co	ppm	*75*	Mo	ppm	*6.30*	Th	ppm	*5.30*
Cr	ppm	*103*	Nb	ppm	*4.24*	Ti	wt.%	*0.119*
Cs	ppm	*1.86*	Nd	ppm	*14.1*	Tm	ppm	*0.16*
Cu	wt.%	*0.084*	Ni	ppm	*43.0*	U	ppm	*2.12*
Dy	ppm	*1.92*	Pb	wt.%	*9.89*	V	ppm	*61*
Er	ppm	*1.08*	Pr	ppm	*3.72*	W	ppm	*0.63*
Eu	ppm	*0.54*	Rb	ppm	*53*	Y	ppm	*10.3*
Ga	ppm	*7.55*	Re	ppm	*< 0.01*	Yb	ppm	*1.16*
Gd	ppm	*2.01*	Sb	ppm	*89*	Zr	ppm	*57*
Ge	ppm	*14.6*	Sc	ppm	*4.10*			

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 OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

OREAS reference materials are intended to provide a low-cost method of evaluating and improving the quality of analysis of geological samples. To the geologist they provide a means of implementing quality control in analytical data sets generated in exploration from the grass roots level through to prospect evaluation, and in grade control at mining operations. To the analyst they provide an effective means of calibrating analytical equipment, assessing new techniques and routinely monitoring in-house procedures. OREAS reference materials enable users to successfully achieve process control of these tasks because the observed variance from repeated analysis has its origin almost exclusively in the analytical process rather than the reference material itself. In evaluating laboratory performance with this CRM, the section headed 'Instructions for correct use' should be read carefully.

Table 1 (generated from data supplied by laboratories all accredited to ISO 17025 for 4-acid and aqua regia digestions) and Table 2 (generated from data supplied by laboratories mostly accredited to ISO 17025) provide the certified values and their associated 95 % expanded uncertainty and tolerance intervals, Table 3 shows indicative values including major and trace element characterisation, Table 4 provides some indicative physical properties and Table 5 presents the performance gate intervals for all certified values.

Tabulated results of all analytes together with uncorrected means, medians, standard deviations, relative standard deviations and per cent deviation of lab means from the corrected mean of means (PDM[3]) are presented in the detailed certification data for this CRM (**OREAS 319-DataPack.1.0.250103_163337.xlsx**).

Results are also presented in scatter plots for Ag, Pb and Zn by 4-acid digestion in 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 319 is a replacement of the OREAS 139. It was prepared from a blend of barren and ore grade zinc-lead-silver materials sourced from Mount Isa (Glencore) George Fisher mine, Mt Isa, NW Queensland, Australia. The mineralisation style is sediment-hosted 'SEDEX' Zn-Pb-Ag within the Urquart Shale Formation of the Mount Isa Group. This Group is a 5 km thick sequence, composed predominantly of Mesoproterozoic carbonate siltstones, mudstones and shales, metamorphosed to greenschist facies. The Zn-Pb-Ag orebodies are concordant with carbonaceous dolomitic sediments and comprised of sphalerite and galena with pyrite and pyrrhotite.

COMMINUTION AND HOMOGENISATION PROCEDURES

The material constituting OREAS 319 was prepared in the following manner:

- Drying the ores and barren black slate to constant mass at 105 °C;
- Multi-stage milling of ores and barren black slate to achieve a particle size distribution of > 99.5 % passing 75 μm;
- Preliminary homogenisation of ore source materials;
- Representative sampling and check assaying of ore source materials;

- Blending the ores and barren black slate in appropriate proportions to achieve target grades;
- Homogenisation using OREAS' novel processing technologies;
- Packaging in 10 g units sealed under nitrogen in laminated foil pouches and in 500 g units in plastic jars.

PHYSICAL PROPERTIES

OREAS 319 was tested at ORE Research & Exploration Pty Ltd's onsite facility for various physical properties. Table 4 presents these findings that should be used for informational purposes only.

Table 4. Physical properties of OREAS 319.

Bulk Density (kg/m^3)	Moisture (wt.%)	Munsell Notation‡	Munsell Color‡
623	0.35	N5	Medium 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.

MINERALOGY

The semi-quantitative XRD results shown in Table 5 below were undertaken by ALS Metallurgy in Balcatta, Western Australia. The results have been normalised to 100 % and represent the relative proportion of crystalline material. Totals greater or less than 100 % are due to rounding errors. The most representative minerals in the sample are quartz, muscovite, followed by annite, sphalerite and galena. A presence of some amorphous material is very likely. A trace amount of epidote and apatite might be present in the sample.

Table 5. Indicative mineralogy of OREAS 331 based on semi-quantitative XRD analysis.

Mineral / Mineral Group	% (mass ratio)
Clay mineral	0
Chlorite	1
Kandite group	1
Serpentine	< 1
Annite - biotite - phlogopite	4
Muscovite	8
Plagioclase	1
K-feldspar and/or rutile	1
Quartz	21
Dolomite - ankerite	8
Siderite-type carbonate	0
Pyrite	9
Pyrrhotite	2
Sphalerite	25
Galena	16
Anglesite	2
Goethite	< 1

ANALYTICAL PROGRAM

Twenty-five commercial analytical laboratories participated in the program to certify the elements reported in Table 1 and 2. The following methods were employed:

- 4-acid (HNO_3-HF-$HClO_4$-HCl) digestion with full suite ICP-OES and ICP-MS elemental packages (up to 25 laboratories depending on the element);
- Aqua regia digestion for full elemental suite ICP-OES and ICP-MS (up to 24 laboratories depending on the element).
- Lithium borate fusion whole rock analysis package by X-ray fluorescence (up to 15 laboratories depending on the element);
- Thermogravimetry: Loss on Ignition (LOI) at 1000 °C (10 laboratories used a thermogravimetric analyser, 4 laboratories used a conventional muffle furnace and 3 laboratories included LOI with their fusion package);
- Lithium borate or sodium peroxide fusion with full suite ICP-OES and ICP-MS elemental packages (up to 21 laboratories depending on the element);
- C and S by infrared combustion furnace/CS analyser (23 laboratories).

For the round robin program ten 350 g test units were taken at predetermined intervals during the bagging stage, immediately following homogenisation and are considered representative of the entire prepared batch. The six samples received by each laboratory were obtained by taking two 15 g scoop splits from each of three separate 350 g test units. This format enabled a nested ANOVA treatment of the results to evaluate homogeneity, i.e. to ascertain whether between-unit variance is greater than within-unit variance (see ‘Homogeneity Evaluation’ section below).

STATISTICAL ANALYSIS

Certified Values and their uncertainty intervals (Tables 1 and 2) have been determined for each analyte following removal of individual, laboratory dataset (batch) and 3SD outliers (single iteration).

For individual outliers within a laboratory batch the z-score test is used in combination with a second method that determines the per cent deviation of the individual value from the batch median. Outliers in general are selected on the basis of z-scores > 2.5 and with per cent deviations (i) > 3 and (ii) more than three times the average absolute per cent deviation for the batch. Each laboratory data set mean is tested for outlying status based on z-score discrimination and rejected if > 2.5. After individual and laboratory data set (batch) outliers have been eliminated a non-iterative 3 standard deviation filter is applied, with those values lying outside this window also relegated to outlying status. However, while statistics are taken into account, the exercise of a statistician's prerogative plays a significant role in identifying outliers.

95 % Expanded Uncertainty provides a 95 % probability that the true value of the analyte under consideration lies between the upper and lower limits and is calculated according to the method outlined in ISO 98-3:2008 [5, 15]. All known or suspected sources of bias have been investigated or taken into account.

Indicative (uncertified) values (Table 3) are present where the number of laboratories reporting a particular analyte is insufficient (< 5) to support certification or where interlaboratory consensus is poor. This data is intended for ‘informational purposes’ only.

Standard Deviation intervals (see Table 6, 'Performance Gates') provide an indication of a level of performance that might reasonably be expected from a laboratory being monitored by this CRM in a QA/QC program. They take into account errors attributable to measurement uncertainty and CRM variability. For an effective CRM the contribution of the latter should be negligible in comparison to measurement errors. The Standard Deviation values include all sources of measurement uncertainty: between-lab variance, within-run variance (precision errors) and CRM variability.

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

Homogeneity Evaluation

The tolerance limits (ISO 16269:2014) [6] shown in Tables 1 and 2 were determined using an analysis of precision errors method and are considered a conservative estimate of true homogeneity. The meaning of tolerance limits may be illustrated for zinc by 4-acid digestion, where 99 % of the time (1-α=0.99) at least 95 % of subsamples (ρ=0.95) will have concentrations lying between 12.97 wt. % and 13.30 wt. %. Put more precisely, this means that if the same number of subsamples were taken and analysed in the same manner repeatedly, 99 % of the tolerance intervals so constructed would cover at least 95 % of the total population, and 1% of the tolerance intervals would cover less than 95 % of the total population. ***Please note that tolerance limits pertain to the homogeneity of the CRM only and should not be used as control limits for laboratory performance.***

Based on the statistical analysis of the results of the interlaboratory certification program, it can be concluded that OREAS 319 is fit-for-purpose as a certified reference material (see 'Intended Use' below).

PERFORMANCE GATES

Table 6 below shows intervals calculated for two and three standard deviations. As a guide these intervals may be regarded as warning or rejection for multiple 2SD outliers, or rejection for individual 3SD outliers in QC monitoring, although their precise application should be at the discretion of the QC manager concerned (also see 'Intended Use' section below). Westgard Rules extend the basics of single-rule QC monitoring using multi-rules (for more information visit www.westgard.com/mltirule.htm). A second method utilises a 5% window calculated directly from the certified value.

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

i.e., Certified Value ±10 % ±2DL [1].

Table 6. Performance Gates for OREAS 319.

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	149	4	140	157	136	162	2.90%	5.80%	8.71%	141	156
Al, wt.%	2.51	0.092	2.32	2.69	2.23	2.78	3.68%	7.36%	11.04%	2.38	2.63
As, ppm	171	9	153	189	144	199	5.34%	10.69%	16.03%	163	180
Be, ppm	1.61	0.102	1.40	1.81	1.30	1.91	6.31%	12.63%	18.94%	1.53	1.69
Bi, ppm	0.32	0.03	0.26	0.39	0.23	0.42	10.05%	20.10%	30.15%	0.31	0.34
Ca, wt.%	3.02	0.082	2.86	3.18	2.78	3.27	2.71%	5.42%	8.13%	2.87	3.17
Cd, ppm	399	27	346	452	319	478	6.65%	13.31%	19.96%	379	419
Ce, ppm	27.7	3.8	20.1	35.3	16.3	39.2	13.72%	27.45%	41.17%	26.3	29.1
Co, ppm	77	3.8	70	85	66	89	4.95%	9.91%	14.86%	73	81
Cr, ppm	101	8	84	118	76	126	8.31%	16.61%	24.92%	96	106
Cs, ppm	1.77	0.122	1.52	2.01	1.40	2.13	6.89%	13.79%	20.68%	1.68	1.85
Cu, wt.%	0.082	0.003	0.077	0.088	0.074	0.091	3.33%	6.66%	9.99%	0.078	0.086
Dy, ppm	1.49	0.099	1.29	1.69	1.19	1.79	6.65%	13.30%	19.95%	1.42	1.57
Er, ppm	0.81	0.060	0.69	0.93	0.63	0.99	7.40%	14.81%	22.21%	0.77	0.85
Eu, ppm	0.51	0.031	0.45	0.58	0.42	0.61	6.10%	12.19%	18.29%	0.49	0.54
Fe, wt.%	9.35	0.336	8.68	10.03	8.35	10.36	3.59%	7.19%	10.78%	8.89	9.82
Ga, ppm	7.61	0.689	6.23	8.99	5.54	9.68	9.06%	18.12%	27.18%	7.23	7.99
Gd, ppm	2.13	0.193	1.75	2.52	1.55	2.71	9.06%	18.12%	27.18%	2.03	2.24
Ge, ppm	0.13	0.03	0.07	0.19	0.04	0.22	21.99%	43.99%	65.98%	0.12	0.14
Hf, ppm	1.15	0.076	1.00	1.30	0.92	1.37	6.59%	13.19%	19.78%	1.09	1.20
Ho, ppm	0.29	0.011	0.26	0.31	0.25	0.32	4.00%	8.00%	12.00%	0.27	0.30
In, ppm	0.72	0.049	0.62	0.82	0.58	0.87	6.76%	13.52%	20.28%	0.69	0.76
K, wt.%	1.11	0.036	1.04	1.18	1.01	1.22	3.19%	6.39%	9.58%	1.06	1.17
La, ppm	13.1	2.1	9.0	17.3	6.9	19.4	15.89%	31.78%	47.68%	12.5	13.8
Li, ppm	16.5	1.59	13.3	19.7	11.7	21.3	9.63%	19.27%	28.90%	15.7	17.3
Lu, ppm	0.12	0.02	0.08	0.16	0.06	0.18	15.77%	31.54%	47.30%	0.12	0.13
Mg, wt.%	1.54	0.049	1.44	1.64	1.39	1.69	3.22%	6.43%	9.65%	1.46	1.61
Mn, wt.%	0.255	0.008	0.239	0.271	0.231	0.279	3.16%	6.31%	9.47%	0.242	0.268
Mo, ppm	6.04	0.368	5.30	6.78	4.93	7.14	6.10%	12.20%	18.30%	5.74	6.34
Na, wt.%	0.045	0.005	0.036	0.054	0.031	0.059	10.29%	20.57%	30.86%	0.043	0.047
Nb, ppm	1.89	0.41	1.06	2.72	0.65	3.13	21.89%	43.78%	65.68%	1.79	1.98
Nd, ppm	13.4	0.80	11.8	15.0	11.0	15.8	5.99%	11.99%	17.98%	12.7	14.0
Ni, ppm	38.4	1.42	35.6	41.2	34.1	42.7	3.70%	7.40%	11.10%	36.5	40.3
P, wt.%	0.028	0.001	0.025	0.030	0.024	0.032	4.86%	9.71%	14.57%	0.026	0.029
Pb, wt.%	9.88	0.191	9.50	10.26	9.31	10.45	1.94%	3.88%	5.81%	9.39	10.37
Pr, ppm	3.30	0.53	2.23	4.37	1.70	4.90	16.17%	32.33%	48.50%	3.14	3.47
Rb, ppm	54	4.3	45	62	41	66	8.03%	16.07%	24.10%	51	56
Re, ppm	< 0.002	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
S, wt.%	14.73	1.033	12.66	16.79	11.63	17.83	7.01%	14.03%	21.04%	13.99	15.46
Sb, ppm	80	6.1	68	92	61	98	7.60%	15.19%	22.79%	76	84
Sc, ppm	4.12	0.46	3.21	5.03	2.75	5.49	11.08%	22.16%	33.24%	3.91	4.32
Sm, ppm	2.49	0.145	2.20	2.78	2.06	2.93	5.82%	11.64%	17.47%	2.37	2.62
Sn, ppm	1.51	0.15	1.21	1.82	1.05	1.97	10.16%	20.31%	30.47%	1.44	1.59

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

Note 1: intervals may appear asymmetric due to rounding.

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

Table 6 continued.

Constituent	Certified Value	Absolute Standard Deviations					Relative Standard Deviations			5 % window	
		1SD	2SD Low	2SD High	3SD Low	3SD High	1RSD	2RSD	3RSD	Low	High
4-Acid Digestion continued											
Sr, ppm	27.5	2.67	22.2	32.8	19.5	35.5	9.70%	19.40%	29.09%	26.1	28.9
Ta, ppm	0.15	0.04	0.07	0.24	0.03	0.28	27.17%	54.33%	81.50%	0.14	0.16
Tb, ppm	0.26	0.03	0.20	0.33	0.17	0.36	11.84%	23.67%	35.51%	0.25	0.28
Te, ppm	0.10	0.02	0.07	0.14	0.05	0.16	17.68%	35.35%	53.03%	0.10	0.11
Th, ppm	5.04	0.406	4.23	5.85	3.82	6.26	8.07%	16.13%	24.20%	4.79	5.29
Ti, wt.%	0.078	0.009	0.061	0.096	0.052	0.104	11.09%	22.19%	33.28%	0.074	0.082
Tl, ppm	61	5.2	51	72	45	77	8.56%	17.11%	25.67%	58	64
Tm, ppm	0.12	0.03	0.06	0.19	0.03	0.22	25.50%	51.01%	76.51%	0.12	0.13
U, ppm	2.10	0.174	1.76	2.45	1.58	2.63	8.26%	16.53%	24.79%	2.00	2.21
V, ppm	59	2.0	55	63	53	65	3.34%	6.68%	10.02%	56	62
W, ppm	0.86	0.084	0.69	1.03	0.61	1.11	9.79%	19.57%	29.36%	0.82	0.90
Y, ppm	8.74	0.91	6.91	10.56	6.00	11.47	10.43%	20.85%	31.28%	8.30	9.17
Yb, ppm	0.85	0.09	0.67	1.03	0.58	1.12	10.67%	21.34%	32.02%	0.80	0.89
Zn, wt.%	13.13	0.353	12.43	13.84	12.08	14.19	2.69%	5.37%	8.06%	12.48	13.79
Zr, ppm	38.9	2.64	33.6	44.2	30.9	46.8	6.80%	13.60%	20.41%	36.9	40.8
Aqua Regia Digestion											
Ag, ppm	148	3	143	153	140	156	1.76%	3.53%	5.29%	141	156
Al, wt.%	0.474	0.047	0.381	0.568	0.334	0.615	9.86%	19.73%	29.59%	0.451	0.498
As, ppm	174	11	153	195	142	206	6.07%	12.14%	18.20%	165	183
Au, ppm	< 0.02	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
B, ppm	< 10	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Be, ppm	0.46	0.06	0.33	0.59	0.27	0.65	13.99%	27.98%	41.97%	0.44	0.48
Bi, ppm	0.25	0.03	0.20	0.31	0.18	0.33	10.43%	20.86%	31.28%	0.24	0.27
Ca, wt.%	2.90	0.109	2.68	3.12	2.57	3.23	3.76%	7.53%	11.29%	2.76	3.05
Cd, ppm	377	27	323	430	296	457	7.11%	14.22%	21.33%	358	395
Ce, ppm	15.0	3.5	7.9	22.0	4.4	25.5	23.61%	47.21%	70.82%	14.2	15.7
Co, ppm	74	6.2	61	86	55	93	8.44%	16.89%	25.33%	70	78
Cr, ppm	30.4	3.1	24.3	36.5	21.2	39.6	10.08%	20.15%	30.23%	28.9	31.9
Cs, ppm	0.71	0.057	0.60	0.83	0.54	0.88	7.95%	15.89%	23.84%	0.68	0.75
Cu, wt.%	0.084	0.004	0.075	0.092	0.071	0.097	5.14%	10.29%	15.43%	0.080	0.088
Fe, wt.%	9.08	0.525	8.03	10.13	7.50	10.65	5.78%	11.56%	17.34%	8.62	9.53
Ga, ppm	2.08	0.24	1.59	2.56	1.35	2.80	11.58%	23.17%	34.75%	1.97	2.18
Ge, ppm	0.20	0.06	0.08	0.32	0.02	0.37	30.53%	61.06%	91.60%	0.19	0.21
Hf, ppm	0.26	0.04	0.19	0.34	0.15	0.38	14.20%	28.41%	42.61%	0.25	0.28
Hg, ppm	1.59	0.142	1.31	1.87	1.16	2.01	8.92%	17.84%	26.75%	1.51	1.67
In, ppm	0.68	0.068	0.54	0.82	0.48	0.88	9.97%	19.94%	29.91%	0.65	0.71
K, wt.%	0.167	0.017	0.133	0.201	0.116	0.218	10.12%	20.24%	30.35%	0.159	0.175
La, ppm	6.04	1.09	3.87	8.22	2.78	9.30	18.00%	36.00%	54.00%	5.74	6.34
Li, ppm	6.61	0.79	5.03	8.19	4.24	8.98	11.94%	23.88%	35.83%	6.28	6.94
Mg, wt.%	1.44	0.058	1.32	1.56	1.26	1.61	4.04%	8.08%	12.12%	1.37	1.51
Mn, wt.%	0.249	0.015	0.219	0.280	0.203	0.295	6.13%	12.25%	18.38%	0.237	0.262
Mo, ppm	5.83	0.62	4.59	7.08	3.96	7.71	10.70%	21.40%	32.11%	5.54	6.13
Nb, ppm	0.055	0.010	0.035	0.075	0.025	0.085	18.16%	36.32%	54.49%	0.052	0.058

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

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

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

Table 6 continued.

Constituent	Certified Value	Absolute Standard Deviations					Relative Standard Deviations			5 % window	
		1SD	2SD Low	2SD High	3SD Low	3SD High	1RSD	2RSD	3RSD	Low	High
Aqua Regia Digestion continued											
Ni, ppm	35.5	3.02	29.4	41.5	26.4	44.5	8.52%	17.05%	25.57%	33.7	37.2
P, wt.%	0.026	0.002	0.022	0.030	0.020	0.032	7.92%	15.85%	23.77%	0.025	0.027
Pb, wt.%	9.73	0.220	9.29	10.17	9.07	10.39	2.26%	4.53%	6.79%	9.25	10.22
Rb, ppm	9.21	0.765	7.68	10.74	6.91	11.51	8.31%	16.62%	24.93%	8.75	9.67
S, wt.%	13.43	1.170	11.09	15.77	9.92	16.94	8.71%	17.42%	26.14%	12.76	14.10
Sb, ppm	61	10	42	80	32	90	15.73%	31.45%	47.18%	58	64
Sc, ppm	1.22	0.16	0.91	1.53	0.75	1.69	12.78%	25.56%	38.33%	1.16	1.28
Sn, ppm	0.64	0.045	0.55	0.73	0.50	0.77	7.11%	14.21%	21.32%	0.60	0.67
Sr, ppm	16.4	2.7	11.0	21.8	8.3	24.5	16.45%	32.91%	49.36%	15.6	17.2
Ta, ppm	< 0.01	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Tb, ppm	0.18	0.016	0.15	0.21	0.13	0.22	8.83%	17.66%	26.50%	0.17	0.19
Te, ppm	0.093	0.022	0.048	0.137	0.026	0.159	23.98%	47.96%	71.94%	0.088	0.097
Th, ppm	3.10	0.38	2.33	3.87	1.95	4.25	12.39%	24.78%	37.18%	2.94	3.25
Ti, wt.%	0.005	0.001	0.003	0.007	0.003	0.007	15.53%	31.05%	46.58%	0.005	0.005
Tl, ppm	45.0	4.6	35.7	54.3	31.1	58.9	10.30%	20.61%	30.91%	42.8	47.3
U, ppm	1.13	0.13	0.88	1.39	0.76	1.51	11.08%	22.16%	33.24%	1.08	1.19
V, ppm	9.56	0.929	7.70	11.41	6.77	12.34	9.72%	19.44%	29.15%	9.08	10.03
W, ppm	0.23	0.016	0.20	0.26	0.18	0.28	7.17%	14.34%	21.51%	0.22	0.24
Y, ppm	4.13	0.310	3.51	4.75	3.20	5.06	7.51%	15.02%	22.53%	3.92	4.34
Yb, ppm	0.38	0.04	0.30	0.46	0.26	0.50	10.68%	21.35%	32.03%	0.36	0.40
Zn, wt.%	13.02	0.431	12.16	13.89	11.73	14.32	3.31%	6.62%	9.93%	12.37	13.68
Zr, ppm	8.24	0.535	7.17	9.31	6.64	9.84	6.49%	12.98%	19.47%	7.83	8.65
Borate Fusion XRF											
Al_2O_3, wt.%	4.84	0.113	4.61	5.07	4.50	5.18	2.34%	4.68%	7.03%	4.60	5.08
BaO, wt.%	0.184	0.011	0.162	0.205	0.151	0.216	5.91%	11.81%	17.72%	0.175	0.193
Bi, ppm	< 100	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
CaO, wt.%	4.37	0.106	4.16	4.59	4.05	4.69	2.43%	4.87%	7.30%	4.15	4.59
Cr_2O_3, ppm	214	65	85	343	20	408	30.24%	60.47%	90.71%	203	225
Cu, wt.%	0.081	0.007	0.066	0.096	0.059	0.104	9.23%	18.47%	27.70%	0.077	0.085
Fe_2O_3, wt.%	13.75	0.157	13.43	14.06	13.28	14.22	1.14%	2.28%	3.42%	13.06	14.43
HfO_2, ppm	< 100	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
K_2O, wt.%	1.34	0.039	1.27	1.42	1.23	1.46	2.87%	5.75%	8.62%	1.28	1.41
MgO, wt.%	2.63	0.140	2.35	2.91	2.21	3.05	5.33%	10.66%	15.99%	2.50	2.76
MnO, wt.%	0.344	0.021	0.303	0.385	0.282	0.406	5.98%	11.97%	17.95%	0.327	0.361
P_2O_5, wt.%	0.064	0.006	0.051	0.077	0.045	0.083	10.04%	20.08%	30.12%	0.061	0.067
Pb, wt.%	9.61	0.155	9.30	9.92	9.15	10.08	1.62%	3.23%	4.85%	9.13	10.09
S, wt.%	14.29	0.339	13.61	14.97	13.27	15.31	2.37%	4.74%	7.11%	13.58	15.01
SiO_2, wt.%	29.68	0.510	28.66	30.70	28.15	31.21	1.72%	3.44%	5.16%	28.19	31.16
TiO_2, wt.%	0.200	0.020	0.161	0.240	0.141	0.260	9.89%	19.77%	29.66%	0.190	0.210
V, ppm	88	15	58	118	44	133	16.90%	33.81%	50.71%	84	93
Zn, wt.%	13.02	0.391	12.24	13.80	11.85	14.19	3.00%	6.01%	9.01%	12.37	13.67
Thermogravimetry											
LOI^{1000}, wt.%	12.73	0.788	11.16	14.31	10.37	15.10	6.19%	12.38%	18.57%	12.10	13.37

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

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

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

Table 6 continued.

Constituent	Certified Value	Absolute Standard Deviations					Relative Standard Deviations			5 % window	
		1SD	2SD Low	2SD High	3SD Low	3SD High	1RSD	2RSD	3RSD	Low	High
Borate / Peroxide Fusion ICP											
Al, wt.%	2.55	0.044	2.46	2.64	2.42	2.68	1.72%	3.44%	5.16%	2.42	2.67
As, ppm	174	7	160	188	153	195	4.01%	8.01%	12.02%	166	183
Ba, wt.%	0.156	0.005	0.145	0.166	0.140	0.171	3.37%	6.73%	10.10%	0.148	0.164
Be, ppm	1.81	0.29	1.23	2.38	0.95	2.67	15.89%	31.77%	47.66%	1.72	1.90
Bi, ppm	0.38	0.05	0.28	0.48	0.23	0.53	13.38%	26.76%	40.14%	0.36	0.40
Ca, wt.%	3.03	0.103	2.82	3.23	2.72	3.33	3.41%	6.82%	10.23%	2.87	3.18
Cd, ppm	403	12	378	428	366	441	3.09%	6.18%	9.27%	383	423
Ce, ppm	32.7	1.06	30.5	34.8	29.5	35.8	3.25%	6.51%	9.76%	31.0	34.3
Co, ppm	78	4.8	68	87	63	92	6.18%	12.35%	18.53%	74	82
Cr, ppm	122	18	85	158	67	176	14.92%	29.83%	44.75%	115	128
Cs, ppm	1.87	0.083	1.70	2.03	1.62	2.11	4.42%	8.85%	13.27%	1.77	1.96
Cu, wt.%	0.082	0.002	0.077	0.087	0.075	0.089	2.97%	5.94%	8.90%	0.078	0.086
Dy, ppm	1.92	0.127	1.67	2.18	1.54	2.30	6.58%	13.16%	19.74%	1.83	2.02
Er, ppm	1.11	0.063	0.98	1.23	0.92	1.30	5.73%	11.46%	17.19%	1.05	1.16
Eu, ppm	0.58	0.030	0.52	0.63	0.49	0.66	5.17%	10.33%	15.50%	0.55	0.60
Fe, wt.%	9.51	0.218	9.07	9.94	8.85	10.16	2.30%	4.60%	6.89%	9.03	9.98
Ga, ppm	8.16	0.547	7.07	9.26	6.52	9.81	6.71%	13.41%	20.12%	7.75	8.57
Gd, ppm	2.41	0.129	2.16	2.67	2.03	2.80	5.33%	10.67%	16.00%	2.29	2.53
Ge, ppm	17.6	0.73	16.1	19.0	15.4	19.8	4.17%	8.35%	12.52%	16.7	18.4
Hf, ppm	1.67	0.24	1.18	2.15	0.94	2.39	14.52%	29.03%	43.55%	1.58	1.75
Ho, ppm	0.39	0.017	0.35	0.42	0.34	0.44	4.34%	8.67%	13.01%	0.37	0.41
In, ppm	0.74	0.069	0.60	0.88	0.53	0.95	9.35%	18.70%	28.05%	0.71	0.78
K, wt.%	1.15	0.069	1.02	1.29	0.95	1.36	5.94%	11.88%	17.83%	1.10	1.21
La, ppm	17.3	0.66	16.0	18.6	15.4	19.3	3.78%	7.56%	11.34%	16.5	18.2
Li, ppm	17.0	2.1	12.8	21.3	10.6	23.4	12.51%	25.02%	37.53%	16.2	17.9
Lu, ppm	0.16	0.02	0.12	0.21	0.09	0.23	14.29%	28.58%	42.87%	0.16	0.17
Mg, wt.%	1.58	0.044	1.49	1.66	1.44	1.71	2.79%	5.59%	8.38%	1.50	1.66
Mn, wt.%	0.261	0.007	0.248	0.275	0.241	0.282	2.57%	5.14%	7.71%	0.248	0.274
Mo, ppm	6.73	1.34	4.04	9.41	2.70	10.75	19.95%	39.89%	59.84%	6.39	7.06
Nb, ppm	4.41	0.87	2.67	6.15	1.80	7.02	19.75%	39.50%	59.26%	4.19	4.63
Nd, ppm	14.7	0.41	13.8	15.5	13.4	15.9	2.79%	5.57%	8.36%	13.9	15.4
Ni, ppm	44.0	9.8	24.4	63.5	14.7	73.3	22.23%	44.45%	66.68%	41.8	46.2
P, wt.%	0.030	0.001	0.027	0.033	0.026	0.034	4.54%	9.08%	13.62%	0.028	0.031
Pb, wt.%	9.62	0.306	9.00	10.23	8.70	10.54	3.18%	6.37%	9.55%	9.14	10.10
Pr, ppm	3.91	0.167	3.58	4.24	3.41	4.41	4.26%	8.52%	12.78%	3.72	4.11
Rb, ppm	55	2.5	50	60	47	62	4.64%	9.28%	13.92%	52	57
S, wt.%	14.38	0.279	13.82	14.94	13.55	15.22	1.94%	3.88%	5.82%	13.66	15.10
Sb, ppm	87	2.9	81	93	78	96	3.34%	6.68%	10.03%	83	91
Sc, ppm	5.20	1.19	2.82	7.58	1.63	8.76	22.86%	45.72%	68.58%	4.94	5.46
Si, wt.%	14.27	0.358	13.55	14.98	13.20	15.34	2.51%	5.01%	7.52%	13.55	14.98
Sm, ppm	2.81	0.171	2.47	3.15	2.29	3.32	6.09%	12.17%	18.26%	2.67	2.95
Sr, ppm	32.4	2.35	27.7	37.1	25.3	39.4	7.25%	14.50%	21.76%	30.8	34.0

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

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

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

Table 6 continued.

Constituent	Certified Value	Absolute Standard Deviations					Relative Standard Deviations			5 % window	
		1SD	2SD Low	2SD High	3SD Low	3SD High	1RSD	2RSD	3RSD	Low	High
Borate / Peroxide Fusion ICP continued											
Ta, ppm	0.40	0.10	0.21	0.60	0.11	0.69	24.14%	48.28%	72.42%	0.38	0.42
Tb, ppm	0.33	0.026	0.27	0.38	0.25	0.41	8.02%	16.03%	24.05%	0.31	0.34
Th, ppm	5.38	0.104	5.17	5.58	5.06	5.69	1.93%	3.87%	5.80%	5.11	5.64
Ti, wt.%	0.119	0.004	0.110	0.127	0.106	0.132	3.64%	7.28%	10.92%	0.113	0.125
Tl, ppm	60	2.3	56	65	53	67	3.84%	7.68%	11.53%	57	63
Tm, ppm	0.16	0.009	0.14	0.17	0.13	0.18	5.98%	11.97%	17.95%	0.15	0.16
U, ppm	2.18	0.111	1.96	2.40	1.85	2.51	5.10%	10.20%	15.30%	2.07	2.29
V, ppm	62	2.2	57	66	55	68	3.63%	7.26%	10.88%	59	65
Y, ppm	10.7	0.51	9.7	11.8	9.2	12.3	4.79%	9.57%	14.36%	10.2	11.3
Yb, ppm	1.08	0.11	0.86	1.30	0.75	1.41	10.24%	20.48%	30.71%	1.02	1.13
Zn, wt.%	12.84	0.194	12.45	13.22	12.25	13.42	1.51%	3.03%	4.54%	12.19	13.48
Zr, ppm	55	3.3	49	62	45	65	6.01%	12.02%	18.04%	53	58
Infrared Combustion											
C, wt.%	2.31	0.058	2.20	2.43	2.14	2.49	2.50%	5.00%	7.51%	2.20	2.43
S, wt.%	14.48	0.312	13.86	15.11	13.55	15.42	2.15%	4.31%	6.46%	13.76	15.21

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

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

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

PARTICIPATING LABORATORIES

1. Actlabs, Ancaster, Ontario, Canada
2. ALS, Brisbane, QLD, Australia
3. ALS, Lima, Peru
4. ALS, Loughrea, Galway, Ireland
5. ALS, Malaga, WA, Australia
6. ALS, Vancouver, BC, Canada
7. American Assay Laboratories, Sparks, Nevada, USA
8. ARGETEST Mineral Processing, Ankara, Central Anatolia, Turkey
9. Bureau Veritas Commodities Canada Ltd, Vancouver, BC, Canada
10. Bureau Veritas Geoanalytical, Perth, WA, Australia
11. Bureau Veritas Minerals, Ankara, Central Anatolia, Turkey
12. CERTIMIN, Lima, Peru
13. Inspectorate (BV), Lima, Peru
14. Intertek, Cupang, Muntinlupa, Philippines
15. Intertek, Perth, WA, Australia
16. Intertek, Townsville, QLD, Australia
17. Intertek Genalysis, Adelaide, SA, Australia
18. MSALABS, Vancouver, BC, Canada
19. Paragon Geochemical Laboratories, Sparks, Nevada, USA
20. PT Geoservices Ltd, Cikarang, Jakarta Raya, Indonesia
21. PT Intertek Utama Services, Jakarta Timur, DKI Jakarta, Indonesia
22. SGS, Ankara, Anatolia, Turkey
23. SGS Canada Inc., Vancouver, BC, Canada
24. Shiva Analyticals Ltd, Bangalore North, Karnataka, India
25. Skyline Assayers & Laboratories, Tucson, Arizona, USA
26. Stewart Assay & Environmental Laboratories LLC, Kara-Balta, Chüy, Kyrgyzstan

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

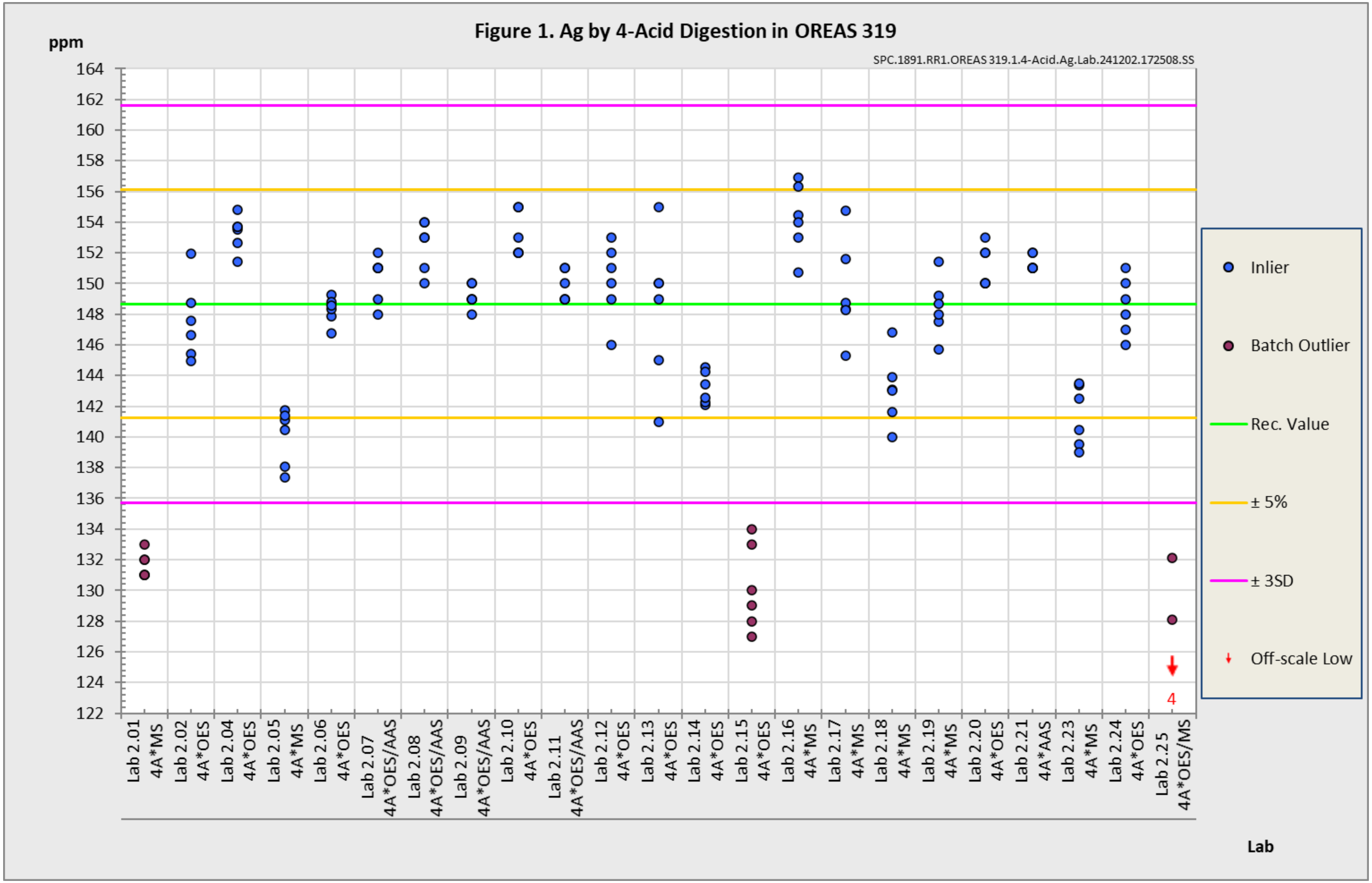
Figure 1. Ag by 4-Acid Digestion in OREAS 319
ppm
SPC.1891.RR1.OREAS 319.1.4-Acid.Ag.Lab.241202.172508.SS
164
162
160
158
156
154
152
150
148
146
144
142
140
138
136
134
132
130
128
126
124
122
4
Lab 2.01 4A*MS
Lab 2.02 4A*OES
Lab 2.04 4A*OES
Lab 2.05 4A*MS
Lab 2.06 4A*OES
Lab 2.07 4A*OES/AAS
Lab 2.08 4A*OES/AAS
Lab 2.09 4A*OES/AAS
Lab 2.10 4A*OES
Lab 2.11 4A*OES/AAS
Lab 2.12 4A*OES
Lab 2.13 4A*OES
Lab 2.14 4A*OES
Lab 2.15 4A*OES
Lab 2.16 4A*MS
Lab 2.17 4A*MS
Lab 2.18 4A*MS
Lab 2.19 4A*MS
Lab 2.20 4A*OES
Lab 2.21 4A*AAS
Lab 2.23 4A*MS
Lab 2.24 4A*OES
Lab 2.25 4A*OES/MS
Lab
Inlier
Batch Outlier
Rec. Value
± 5%
± 3SD
Off-scale Low

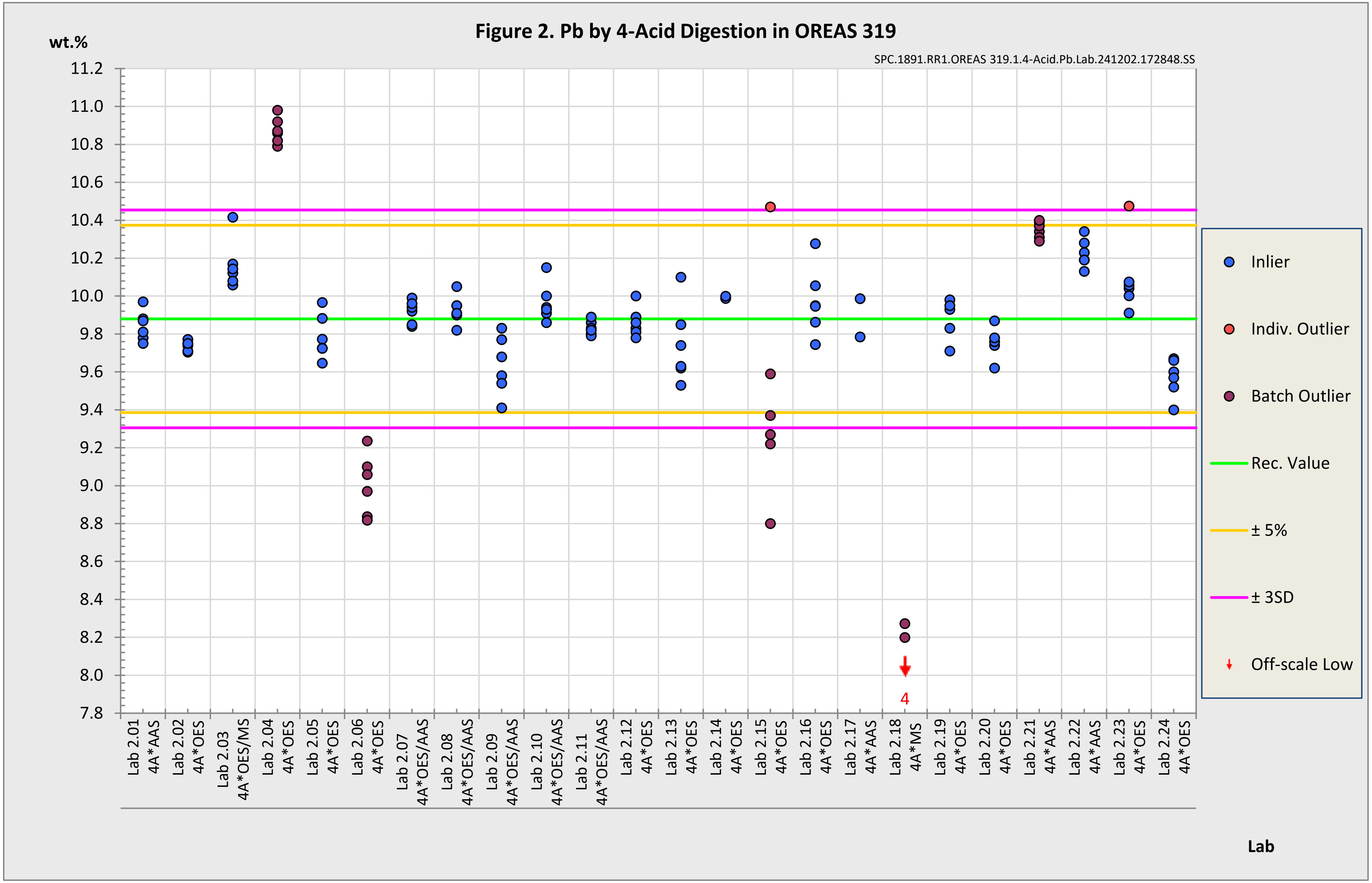
Figure 2. Pb by 4-Acid Digestion in OREAS 319
wt.%
SPC.1891.RR1.OREAS 319.1.4-Acid.Pb.Lab.241202.172848.SS
11.2
11.0
10.8
10.6
10.4
10.2
10.0
9.8
9.6
9.4
9.2
9.0
8.8
8.6
8.4
8.2
8.0
7.8
4
Lab 2.01 4A*AAS
Lab 2.02 4A*OES
Lab 2.03 4A*OES/MS
Lab 2.04 4A*OES
Lab 2.05 4A*OES
Lab 2.06 4A*OES
Lab 2.07 4A*OES/AAS
Lab 2.08 4A*OES/AAS
Lab 2.09 4A*OES/AAS
Lab 2.10 4A*OES/AAS
Lab 2.11 4A*OES/AAS
Lab 2.12 4A*OES
Lab 2.13 4A*OES
Lab 2.14 4A*OES
Lab 2.15 4A*OES
Lab 2.16 4A*OES
Lab 2.17 4A*AAS
Lab 2.18 4A*MS
Lab 2.19 4A*OES
Lab 2.20 4A*OES
Lab 2.21 4A*AAS
Lab 2.22 4A*AAS
Lab 2.23 4A*OES
Lab 2.24 4A*OES
Lab
Inlier
Indiv. Outlier
Batch Outlier
Rec. Value
± 5%
± 3SD
Off-scale Low

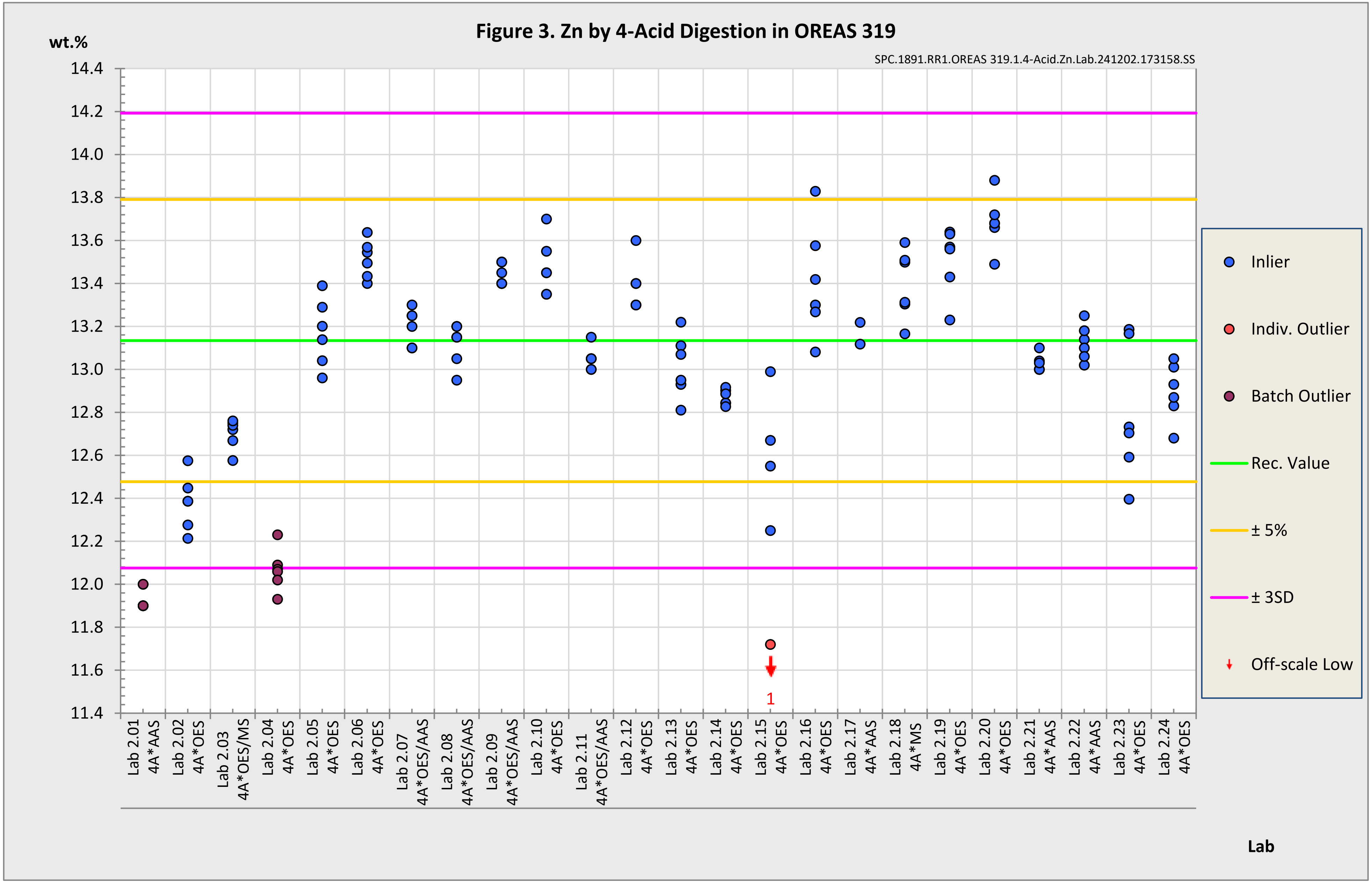
Figure 3. Zn by 4-Acid Digestion in OREAS 319
wt.%
SPC.1891.RR1.OREAS 319.1.4-Acid.Zn.Lab.241202.173158.SS
14.4
14.2
14.0
13.8
13.6
13.4
13.2
13.0
12.8
12.6
12.4
12.2
12.0
11.8
11.6
11.4
1
Lab 2.01 4A*AAS
Lab 2.02 4A*OES
Lab 2.03 4A*OES/MS
Lab 2.04 4A*OES
Lab 2.05 4A*OES
Lab 2.06 4A*OES
Lab 2.07 4A*OES/AAS
Lab 2.08 4A*OES/AAS
Lab 2.09 4A*OES/AAS
Lab 2.10 4A*OES
Lab 2.11 4A*OES/AAS
Lab 2.12 4A*OES
Lab 2.13 4A*OES
Lab 2.14 4A*OES
Lab 2.15 4A*OES
Lab 2.16 4A*OES
Lab 2.17 4A*AAS
Lab 2.18 4A*MS
Lab 2.19 4A*OES
Lab 2.20 4A*OES
Lab 2.21 4A*AAS
Lab 2.22 4A*AAS
Lab 2.23 4A*OES
Lab 2.24 4A*OES
Inlier
Indiv. Outlier
Batch Outlier
Rec. Value
± 5%
± 3SD
Off-scale Low
Lab

PREPARER AND SUPPLIER

Certified reference material OREAS 319 is prepared, certified and supplied by:

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METROLOGICAL TRACEABILITY

The interlaboratory results that underpin the certified values are metrologically traceable to the international measurement scale (SI) of mass (either as a % mass fraction or as milligrams per kilogram (mg/kg)) [14]. In line with popular use, all data within tables in this certificate are expressed as the mass fraction in either weight percent (wt. %) or parts per million (ppm).

The analytical samples sent to participating laboratories were selected in a manner to be representative of the entire prepared batch of CRM. This representativeness was maintained in each submitted laboratory sample batch and ensures the user that the data is traceable from sample selection through to the analytical results. The systematic sampling method was chosen due to the low risk of overlooking repetitive effects or trends in the batch due to the way the CRM was processed. In line with ISO 17025 [8], each analytical data set received from the participating laboratories has been validated by its assayer through the inclusion of internal reference materials and QC checks during and post analysis.

The participating laboratories were chosen on the basis of their competence (from past performance in interlaboratory programs undertaken by ORE Pty Ltd) for a particular analytical method, analyte or analyte suite and sample matrix. These laboratories are accredited to ISO 17025 for 4-acid digestion (Table 1). The other operationally defined measurands characterised in this certificate (Table 2) are derived from data procured mostly from ISO 17025 accredited laboratories. The certified values presented in this report are calculated from the means of accepted data following robust technical and statistical analysis as detailed in this report.

Guide ISO/TR 16476:2016 [7], section 5.3.1 describes metrological traceability in reference materials as it pertains to the transformation of the measurand. In this section it states, *"Although the determination of the property value itself can be made traceable to appropriate units through, for example, calibration of the measurement equipment used, steps like the transformation of the sample from one physical (chemical) state to another cannot. Such transformations may only be compared with a reference (when available), or among themselves. For some transformations, reference methods have been defined and may be used in certification projects to evaluate the uncertainty associated with such a transformation.* ***In other cases, only a comparison among different laboratories using the same procedure is possible. In this case, it is impossible to demonstrate absence of method bias; therefore, the result is an operationally defined measurand*** *(ISO Guide 33405:2024-05, 9.2.4c) [4]."* Certification takes place on the basis of agreement among operationally defined, independent measurement results.

COMMUTABILITY

The measurements of the results that underlie the certified values contained in this report were undertaken by methods involving pre-treatment (fusion/digestion) of the sample. This served to reduce the sample to a simple and well understood form permitting calibration using simple solutions of the CRM. Due to these methods being well understood and highly effective, commutability is not an issue for this CRM. All OREAS CRMs are sourced from natural ore minerals meaning they will display similar behaviour as routine ‘field’ samples in the relevant measurement process. Care should be taken to ensure ‘matrix matching’ as close as practically achievable. The matrix and mineralisation style of the CRM is described in the ‘Source Material’ section and users should select appropriate CRMs matching these attributes to the field samples being analysed.

INTENDED USE

OREAS 319 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 319 may be used to calibrate the entire procedure by producing a pure substance CRM transformed into a calibration solution.

OREAS 319 is intended for the following uses:

- For the monitoring of laboratory performance in the analysis of analytes reported in Tables 1 and 2 in geological samples;
- For the verification of analytical methods for analytes reported in Tables 1 and 2;
- For the calibration of instruments used in the determination of the concentration of analytes reported in Tables 1 and 2. When a value provided in this certificate is used to calibrate a measurement process, the uncertainty associated with that value should be appropriately propagated into the user’s uncertainty calculation. Users can determine an approximation of the standard uncertainty by calculating one fourth of the width of the Expanded Uncertainty interval given in this certificate (Expanded Uncertainty intervals are provided in Tables 1 and 2).

MINIMUM SAMPLE SIZE

To relate analytical determinations to the values in this certificate, the minimum mass of sample used should match the typical mass that the laboratories used in the interlaboratory (round robin) certification program. This means that different minimum sample masses should be used depending on the operationally defined methodology as follows:

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

PERIOD OF VALIDITY & STORAGE INSTRUCTIONS

The certification of OREAS 319 remains valid, within the specified measurement uncertainties, until at least June 2039, provided the CRM is handled and stored in accordance with the instructions given below. This certification is nullified if the CRM is any way changed or contaminated.

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

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

Single-use sachets

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

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

INSTRUCTIONS FOR HANDLING & CORRECT USE

Pre-homogenisation of the CRM prior to subsampling and analysis is not necessary as there is no particle segregation under transport [12].

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

QC monitoring using multiples of the Standard Deviation (SD)

In the application of SD's in monitoring performance it is important to note that not all laboratories function at the same level of proficiency and that different methods in use at a particular laboratory have differing levels of precision. Each laboratory has its own inherent SD (for a specific concentration level and analyte-method pair) based on the analytical process and this SD is not directly related to the round robin program.

The majority of data generated in the round robin program was produced by a selection of world class laboratories. The SD's thus generated are more constrained than those that would be produced across a randomly selected group of laboratories. To produce more generally achievable SD's the 'pooled' SD's provided in this report include interlaboratory bias. This 'one size fits all' approach may require revision at the discretion of the QC manager concerned following careful scrutiny of QC control charts.

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

For use with the aqua regia digestion method

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

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

LEGAL NOTICE

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

QMS CERTIFICATION

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

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

DOCUMENT HISTORY

Revision No.	Date	Changes applied
0	3rd January, 2025	First publication.

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