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CERTIFICATE OF ANALYSIS FOR

CERTIFIED REFERENCE MATERIAL

OREAS 290

Gold-Antimony Ore (Costerfield, VIC, Australia)

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Constituent	Certified Value	Absolute Standard Deviations					Relative Standard Deviations			5% window	
		1SD	2SD Low	2SD High	3SD Low	3SD High	1RSD	2RSD	3RSD	Low	High
Pb Fire Assay											
Au, ppm	2.12	0.066	1.98	2.25	1.92	2.31	3.14%	6.28%	9.42%	2.01	2.22
Aqua Regia Digestion (sample weights 10-50g)											
Au, ppm	1.93	0.091	1.75	2.11	1.66	2.21	4.71%	9.42%	14.13%	1.84	2.03
Peroxide Fusion ICP											
Sb, wt.%	0.795	0.030	0.735	0.856	0.705	0.886	3.80%	7.61%	11.41%	0.756	0.835
4-Acid Digestion											
Ag, ppm	0.213	0.040	0.133	0.294	0.093	0.334	18.80%	37.59%	56.39%	0.203	0.224
Al, wt.%	7.21	0.272	6.66	7.75	6.39	8.03	3.78%	7.56%	11.33%	6.85	7.57
As, ppm	313	19	275	352	256	371	6.09%	12.19%	18.28%	298	329
Ba, ppm	739	32	674	803	642	836	4.36%	8.72%	13.09%	702	776
Be, ppm	2.51	0.197	2.12	2.90	1.92	3.10	7.84%	15.67%	23.51%	2.38	2.63
Bi, ppm	0.37	0.031	0.30	0.43	0.27	0.46	8.51%	17.03%	25.54%	0.35	0.39
Ca, wt.%	0.525	0.031	0.463	0.586	0.432	0.617	5.86%	11.73%	17.59%	0.498	0.551
Cd, ppm	0.054	0.013	0.028	0.079	0.016	0.091	23.64%	47.28%	70.92%	0.051	0.056
Ce, ppm	79	6.3	66	91	60	98	8.06%	16.12%	24.18%	75	83
Co, ppm	14.2	0.92	12.4	16.0	11.4	17.0	6.47%	12.94%	19.42%	13.5	14.9
Cr, ppm	123	7	109	136	102	143	5.55%	11.10%	16.65%	117	129
Cs, ppm	10.3	0.62	9.1	11.6	8.5	12.2	6.01%	12.02%	18.03%	9.8	10.8
Cu, ppm	32.6	1.94	28.7	36.4	26.8	38.4	5.96%	11.91%	17.87%	30.9	34.2
Dy, ppm	3.01	0.35	2.31	3.71	1.96	4.06	11.62%	23.24%	34.86%	2.86	3.16
Er, ppm	1.60	0.18	1.24	1.96	1.07	2.13	11.13%	22.25%	33.38%	1.52	1.68
Eu, ppm	1.14	0.097	0.95	1.33	0.85	1.43	8.49%	16.98%	25.48%	1.08	1.20
Fe, wt.%	3.79	0.190	3.41	4.17	3.22	4.36	5.02%	10.04%	15.06%	3.60	3.98
Ga, ppm	18.6	1.17	16.3	21.0	15.1	22.1	6.29%	12.59%	18.88%	17.7	19.6
Gd, ppm	4.47	0.436	3.60	5.35	3.17	5.78	9.74%	19.48%	29.21%	4.25	4.70
Ge, ppm	0.22	0.06	0.10	0.34	0.04	0.40	27.49%	54.99%	82.48%	0.21	0.23
Hf, ppm	3.98	0.261	3.46	4.50	3.20	4.76	6.56%	13.12%	19.68%	3.78	4.18
Ho, ppm	0.56	0.07	0.43	0.70	0.36	0.76	11.95%	23.90%	35.85%	0.53	0.59
In, ppm	0.064	0.007	0.051	0.078	0.044	0.085	10.68%	21.36%	32.04%	0.061	0.068
K, wt.%	2.80	0.099	2.60	3.00	2.50	3.10	3.55%	7.10%	10.65%	2.66	2.94
La, ppm	39.6	3.38	32.8	46.3	29.5	49.7	8.53%	17.06%	25.60%	37.6	41.6
Li, ppm	51	2.8	46	57	43	60	5.54%	11.08%	16.62%	49	54
Lu, ppm	0.24	0.04	0.16	0.31	0.12	0.35	16.38%	32.77%	49.15%	0.22	0.25
Mg, wt.%	1.39	0.072	1.24	1.53	1.17	1.61	5.21%	10.42%	15.64%	1.32	1.46
Mn, wt.%	0.056	0.002	0.052	0.061	0.050	0.063	3.93%	7.86%	11.79%	0.054	0.059
Mo, ppm	1.14	0.17	0.80	1.47	0.63	1.64	14.87%	29.74%	44.61%	1.08	1.19
Na, wt.%	0.613	0.025	0.564	0.663	0.539	0.688	4.03%	8.06%	12.10%	0.583	0.644
Nb, ppm	10.2	2.9	4.4	15.9	1.6	18.8	28.21%	56.42%	84.63%	9.7	10.7
Nd, ppm	34.2	2.26	29.7	38.7	27.4	41.0	6.60%	13.20%	19.79%	32.5	35.9
Ni, ppm	73	3.5	66	80	62	83	4.84%	9.68%	14.53%	69	76
P, wt.%	0.059	0.003	0.052	0.065	0.049	0.068	5.26%	10.51%	15.77%	0.056	0.061
Pb, ppm	22.9	1.38	20.1	25.7	18.7	27.0	6.04%	12.08%	18.12%	21.7	24.0
Pr, ppm	9.13	0.594	7.94	10.32	7.35	10.92	6.51%	13.01%	19.52%	8.68	9.59

SI unit equivalents: ppm (parts per million; 1 x 10^6) ≡ mg/kg ≡ µg/g ≡ 0.0001 wt.%.

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											
Rb, ppm	161	11	139	183	128	194	6.81%	13.63%	20.44%	153	169
Re, ppm	< 0.002	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
S, wt.%	0.528	0.023	0.482	0.573	0.460	0.596	4.30%	8.59%	12.89%	0.501	0.554
Sb, wt.%	0.840	0.029	0.783	0.897	0.754	0.925	3.40%	6.79%	10.19%	0.798	0.882
Sc, ppm	13.2	0.87	11.5	14.9	10.6	15.8	6.58%	13.17%	19.75%	12.5	13.9
Se, ppm	2.64	0.80	1.04	4.25	0.24	5.05	30.37%	60.74%	91.10%	2.51	2.77
Sm, ppm	6.42	0.443	5.54	7.31	5.10	7.75	6.89%	13.78%	20.67%	6.10	6.74
Sn, ppm	3.56	0.324	2.92	4.21	2.59	4.54	9.09%	18.18%	27.28%	3.39	3.74
Sr, ppm	99	4.6	90	108	85	113	4.64%	9.27%	13.91%	94	104
Ta, ppm	0.96	0.20	0.56	1.35	0.36	1.55	20.63%	41.26%	61.89%	0.91	1.01
Tb, ppm	0.55	0.08	0.38	0.72	0.30	0.81	15.35%	30.71%	46.06%	0.53	0.58
Te, ppm	0.072	0.017	0.039	0.105	0.022	0.121	23.12%	46.24%	69.36%	0.068	0.075
Th, ppm	15.1	1.21	12.7	17.6	11.5	18.8	8.00%	16.00%	24.00%	14.4	15.9
Ti, wt.%	0.359	0.031	0.298	0.420	0.267	0.451	8.51%	17.02%	25.53%	0.341	0.377
Tl, ppm	0.86	0.053	0.75	0.97	0.70	1.02	6.20%	12.40%	18.60%	0.82	0.90
Tm, ppm	0.22	0.03	0.16	0.28	0.13	0.31	13.74%	27.48%	41.22%	0.21	0.23
U, ppm	2.79	0.191	2.40	3.17	2.21	3.36	6.88%	13.75%	20.63%	2.65	2.92
V, ppm	92	5.3	81	103	76	108	5.73%	11.46%	17.19%	87	97
W, ppm	2.83	0.34	2.15	3.51	1.81	3.85	12.04%	24.08%	36.12%	2.69	2.97
Y, ppm	15.2	2.0	11.1	19.2	9.1	21.2	13.30%	26.59%	39.89%	14.4	15.9
Yb, ppm	1.58	0.18	1.23	1.94	1.05	2.12	11.20%	22.40%	33.59%	1.51	1.66
Zn, ppm	98	5.4	87	108	81	114	5.58%	11.16%	16.74%	93	102
Zr, ppm	133	9	116	151	107	160	6.57%	13.14%	19.71%	127	140
Aqua Regia Digestion											
Ag, ppm	0.192	0.017	0.159	0.226	0.143	0.242	8.62%	17.25%	25.87%	0.183	0.202
Al, wt.%	2.59	0.28	2.03	3.15	1.75	3.43	10.76%	21.53%	32.29%	2.46	2.72
As, ppm	307	16	275	338	259	354	5.14%	10.29%	15.43%	291	322
Ba, ppm	117	6	104	129	97	136	5.51%	11.01%	16.52%	111	122
Be, ppm	1.26	0.18	0.90	1.62	0.72	1.80	14.30%	28.59%	42.89%	1.20	1.32
Bi, ppm	0.36	0.023	0.32	0.41	0.29	0.43	6.42%	12.84%	19.25%	0.35	0.38
Ca, wt.%	0.312	0.017	0.277	0.347	0.260	0.364	5.55%	11.10%	16.64%	0.297	0.328
Cd, ppm	0.050	0.012	0.026	0.075	0.013	0.087	24.45%	48.90%	73.34%	0.048	0.053
Ce, ppm	50	10	29	71	19	81	20.69%	41.38%	62.07%	48	53
Co, ppm	13.4	0.71	12.0	14.8	11.3	15.5	5.27%	10.54%	15.81%	12.7	14.1
Cr, ppm	98	6.1	86	111	80	117	6.22%	12.43%	18.65%	93	103
Cs, ppm	7.24	0.277	6.69	7.80	6.41	8.07	3.83%	7.66%	11.49%	6.88	7.60
Cu, ppm	31.9	2.22	27.5	36.3	25.2	38.5	6.95%	13.90%	20.85%	30.3	33.5
Fe, wt.%	3.38	0.195	2.99	3.77	2.80	3.97	5.77%	11.54%	17.32%	3.21	3.55
Ga, ppm	8.06	0.551	6.96	9.16	6.40	9.71	6.84%	13.68%	20.53%	7.66	8.46
Ge, ppm	0.097	0.007	0.083	0.110	0.077	0.116	6.84%	13.67%	20.51%	0.092	0.102
Hf, ppm	0.51	0.05	0.40	0.62	0.35	0.67	10.52%	21.05%	31.57%	0.49	0.54
Hg, ppm	0.031	0.006	0.018	0.043	0.012	0.049	20.27%	40.55%	60.82%	0.029	0.032
In, ppm	0.034	0.005	0.025	0.044	0.020	0.048	13.75%	27.49%	41.24%	0.033	0.036

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											
K, wt.%	0.858	0.034	0.790	0.925	0.757	0.959	3.93%	7.86%	11.78%	0.815	0.901
La, ppm	23.7	4.1	15.6	31.8	11.5	35.9	17.19%	34.37%	51.56%	22.5	24.9
Li, ppm	37.6	4.7	28.2	47.0	23.5	51.7	12.54%	25.07%	37.61%	35.7	39.5
Mg, wt.%	1.14	0.052	1.04	1.25	0.99	1.30	4.55%	9.11%	13.66%	1.09	1.20
Mn, wt.%	0.047	0.002	0.043	0.052	0.041	0.054	4.38%	8.76%	13.13%	0.045	0.050
Mo, ppm	1.09	0.109	0.88	1.31	0.77	1.42	9.97%	19.94%	29.91%	1.04	1.15
Na, wt.%	0.047	0.004	0.038	0.055	0.033	0.060	9.50%	19.00%	28.50%	0.044	0.049
Nb, ppm	0.54	0.12	0.29	0.79	0.17	0.91	22.97%	45.95%	68.92%	0.51	0.57
Ni, ppm	68	5.6	57	79	51	84	8.23%	16.46%	24.68%	64	71
P, wt.%	0.050	0.002	0.046	0.054	0.044	0.056	4.04%	8.07%	12.11%	0.048	0.053
Pb, ppm	13.6	0.91	11.7	15.4	10.8	16.3	6.71%	13.42%	20.13%	12.9	14.2
Rb, ppm	81	4.8	71	90	66	95	5.93%	11.85%	17.78%	77	85
Re, ppm	< 0.001	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
S, wt.%	0.533	0.017	0.498	0.567	0.481	0.584	3.23%	6.45%	9.68%	0.506	0.559
Sb, wt.%	0.745	0.082	0.581	0.909	0.499	0.991	11.02%	22.03%	33.05%	0.707	0.782
Sc, ppm	6.78	0.637	5.51	8.06	4.87	8.70	9.40%	18.79%	28.19%	6.44	7.12
Se, ppm	2.09	0.39	1.30	2.87	0.91	3.26	18.78%	37.55%	56.33%	1.98	2.19
Sn, ppm	1.56	0.109	1.35	1.78	1.24	1.89	6.95%	13.90%	20.84%	1.49	1.64
Sr, ppm	32.6	2.00	28.6	36.6	26.6	38.6	6.14%	12.29%	18.43%	31.0	34.2
Ta, ppm	< 0.05	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Te, ppm	0.053	0.008	0.037	0.069	0.029	0.078	15.36%	30.72%	46.07%	0.050	0.056
Th, ppm	11.3	1.2	9.0	13.7	7.8	14.9	10.43%	20.87%	31.30%	10.7	11.9
Ti, wt.%	0.119	0.008	0.104	0.134	0.097	0.142	6.29%	12.59%	18.88%	0.113	0.125
Tl, ppm	0.52	0.030	0.45	0.58	0.42	0.61	5.88%	11.77%	17.65%	0.49	0.54
U, ppm	1.38	0.17	1.04	1.73	0.87	1.90	12.41%	24.82%	37.24%	1.32	1.45
V, ppm	61	2.7	55	66	53	69	4.48%	8.96%	13.43%	58	64
W, ppm	0.54	0.08	0.39	0.70	0.31	0.78	14.32%	28.64%	42.96%	0.52	0.57
Y, ppm	8.21	0.518	7.17	9.24	6.65	9.76	6.32%	12.63%	18.95%	7.80	8.62
Zn, ppm	86	2.9	80	92	78	95	3.33%	6.66%	9.99%	82	91
Zr, ppm	19.8	3.0	13.8	25.9	10.8	28.9	15.22%	30.44%	45.65%	18.8	20.8

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 2. Indicative Values for OREAS 290.

Constituent	Unit	Value	Constituent	Unit	Value	Constituent	Unit	Value
Pb Fire Assay								
Pd	ppb	*< 5*	Pt	ppb	*< 5*			
Peroxide Fusion ICP								
Al	wt.%	*7.41*	Ga	ppm	*14.4*	S	wt.%	*0.513*
As	ppm	*359*	K	wt.%	*2.85*	Sc	ppm	*15.3*
Ba	ppm	*742*	La	ppm	*39.8*	Si	wt.%	*30.60*

SI unit equivalents: ppb (parts per billion; 1 x 10^9) ≡ µg/kg; ppm (parts per million; 1 x 10^6) ≡ mg/kg; wt.% (weight per cent) ≡ % (mass fraction).

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

Table 2. continued.

Constituent	Unit	Value	Constituent	Unit	Value	Constituent	Unit	Value
Peroxide Fusion ICP continued								
Be	ppm	*< 5*	Li	ppm	*< 5*	Sn	ppm	*< 10*
Bi	ppm	*< 5*	Mg	wt.%	*1.44*	Sr	ppm	*87*
Ca	wt.%	*0.572*	Mn	wt.%	*0.062*	Ti	wt.%	*0.437*
Cd	ppm	*< 0.5*	Mo	ppm	*2.83*	V	ppm	*186*
Co	ppm	*20.3*	Nb	ppm	*5.98*	W	ppm	*73*
Cr	ppm	*152*	Ni	ppm	*78*	Y	ppm	*30.7*
Cu	ppm	*62*	P	wt.%	*0.061*	Zn	ppm	*114*
Fe	wt.%	*3.96*	Pb	ppm	*22.5*			
4-Acid Digestion								
Hg	ppm	*0.11*						
Aqua Regia Digestion								
B	ppm	*17.3*	Ho	ppm	*0.32*	Pt	ppb	*2.00*
Dy	ppm	*1.87*	Lu	ppm	*0.11*	Sm	ppm	*3.85*
Er	ppm	*0.87*	Nd	ppm	*19.7*	Tb	ppm	*0.37*
Eu	ppm	*0.53*	Pd	ppb	*< 10*	Tm	ppm	*0.11*
Gd	ppm	*2.96*	Pr	ppm	*5.30*	Yb	ppm	*0.77*
Borate Fusion XRF								
Al_2O_3	wt.%	*14.09*	MgO	wt.%	*2.36*	SiO_2	wt.%	*67.94*
CaO	wt.%	*0.742*	MnO	wt.%	*0.076*	SO_3	wt.%	*1.31*
Fe_2O_3	wt.%	*5.58*	P_2O_5	wt.%	*0.133*	TiO_2	wt.%	*0.730*
K_2O	wt.%	*3.44*	Sb	wt.%	*0.925*			
Thermogravimetry								
LOI^{1000}	wt.%	*2.92*						
Infrared Combustion								
C	wt.%	*0.215*	S	wt.%	*0.510*			
Laser Ablation ICP-MS								
Ag	ppm	*0.500*	Hf	ppm	*7.04*	Sm	ppm	*7.59*
As	ppm	*361*	Ho	ppm	*1.25*	Sn	ppm	*4.40*
Ba	ppm	*760*	In	ppm	*0.050*	Sr	ppm	*101*
Be	ppm	*2.30*	La	ppm	*42.0*	Ta	ppm	*1.18*
Bi	ppm	*0.43*	Lu	ppm	*0.45*	Tb	ppm	*1.01*
Cd	ppm	*< 0.1*	Mn	wt.%	*0.059*	Te	ppm	*0.15*
Ce	ppm	*82*	Mo	ppm	*0.90*	Th	ppm	*16.2*
Co	ppm	*15.2*	Nb	ppm	*15.2*	Ti	wt.%	*0.449*
Cr	ppm	*134*	Nd	ppm	*37.1*	Tl	ppm	*1.10*
Cs	ppm	*11.2*	Ni	ppm	*80*	Tm	ppm	*0.55*
Cu	ppm	*40.0*	Pb	ppm	*30.5*	U	ppm	*3.36*
Dy	ppm	*5.95*	Pr	ppm	*9.71*	V	ppm	*103*
Er	ppm	*3.59*	Rb	ppm	*172*	W	ppm	*3.75*
Eu	ppm	*1.39*	Re	ppm	*0.040*	Y	ppm	*31.6*
Ga	ppm	*19.4*	Sb	wt.%	*0.939*	Yb	ppm	*3.34*
Gd	ppm	*6.07*	Sc	ppm	*14.4*	Zn	ppm	*93*
Ge	ppm	*1.48*	Se	ppm	*< 5*	Zr	ppm	*251*

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

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

INTRODUCTION

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

Table 1 provides performance gate intervals for the certified values, Table 2 shows indicative values, Table 3 provides some indicative physical properties and Table 4 presents the 95% 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 290-DataPack.1.2.220901_135408.xlsx**).

Results are also presented in scatter plots for gold by fire assay, gold by aqua regia digestion, and antimony by peroxide fusion (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 290 was prepared from a blend of high-grade gold-antimony ore and barren metasediments. The ore was sourced from the Costerfield Operation (owned by Mandalay Resources Ltd) located approximately 10km northeast of the town of Heathcote in Victoria, 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.

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].

COMMINUTION AND HOMOGENISATION PROCEDURES

The material constituting OREAS 290 was prepared in the following manner:

- Drying the source materials to constant mass at 85 degrees Celsius;
- Crushing and multi-stage milling of the ore to 100% passing 30 microns;
- Crushing and multi-stage milling of the barren metasediment to >98% minus 75 microns;
- Preliminary homogenisation;
- Check assaying of the ore material;
- Blending the ore and barren materials in a specific ratio to achieve target grades;
- Packaging in 60g units under nitrogen in laminated foil pouches and 1kg units in plastic jars.

PHYSICAL PROPERTIES

OREAS 290 was tested at ORE Research & Exploration Pty Ltd's onsite facility for various physical properties. Table 3 presents these findings that should be used for informational purposes only.

Table 3. Physical properties of OREAS 290.

Bulk Density (g/L)	Moisture%	Munsell Notation‡	Munsell Color‡
913	0.58	N7	Light Gray

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

ANALYTICAL PROGRAM

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

- Au by 25-50g fire assay with AAS (14 laboratories) and ICP-OES (5 laboratories) finish;
- Au by 15-30g aqua regia digestion with ICP-MS (9 laboratories), AAS (2 laboratories) and ICP-OES (1 laboratory) finish;
- Sb by peroxide fusion with ICP-OES (11 laboratories) and ICP-MS (2 laboratories) finish and one laboratory used pressed powder pellet with XRF finish;
- Full ICP-OES and MS elemental suites by 4-acid digestion (up to 18 laboratories depending on the element);
- Full ICP-OES and MS elemental suites by aqua regia digestion (up to 19 laboratories depending on the element);

- Instrumental neutron activation analysis (INAA) for Au on 20 x 85mg subsamples to confirm homogeneity undertaken by the Australian Nuclear Science and Technology Organisation (ANSTO) located in Lucas Heights, NSW, Australia.

For the round robin program, twenty 800g test units were taken at predetermined intervals during the bagging stage, immediately following homogenisation and are considered representative of the entire prepared batch. Six 110g pulp samples were submitted to each laboratory for analysis. The samples received by each laboratory were obtained by taking two 110g samples from each of three separate 800g test units. This format enabled nested ANOVA treatment of the results to evaluate homogeneity, i.e., to ascertain whether between-unit variance is greater than within-unit variance.

STATISTICAL ANALYSIS

Standard Deviation intervals (see Table 1) provide an indication of a level of performance that might reasonably be expected from a laboratory being monitored by this CRM in a QA/QC program. They take into account errors attributable to measurement uncertainty and CRM variability. For an effective CRM the contribution of the latter should be negligible in comparison to measurement errors. The Standard Deviation values include all sources of measurement uncertainty: between-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.

Indicative (uncertified) values (Table 2) are present where the number of laboratories reporting a particular analyte is insufficient (< 5) to support certification or where inter-laboratory consensus is poor.

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 INAA data (see Table 5) is omitted from determination of the certified value for Au and is used solely for the calculation of Tolerance Limits and homogeneity evaluation (see ‘Homogeneity Evaluation’ section below).

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 the ISO Guides [6,15]. All known or suspected sources of bias have been investigated or taken into account. ***The 95% Expanded Uncertainty should not be used as control limits for laboratory performance.***

Table 4. 95% Uncertainty & Tolerance Limits for OREAS 290.

Constituent	Certified Value	95% Expanded Uncertainty		95% Tolerance Limits	
		Low	High	Low	High
Pb Fire Assay					
Au, Gold (ppm)	2.12	2.09	2.14	2.11*	2.12*
Aqua Regia Digestion (sample weights 10-50g)					
Au, Gold (ppm)	1.93	1.87	1.99	1.92*	1.94*
Peroxide Fusion ICP					
Sb, Antimony (wt.%)	0.795	0.765	0.825	0.775	0.816
4-Acid Digestion					
Ag, Silver (ppm)	0.213	0.182	0.245	0.194	0.233
Al, Aluminium (wt.%)	7.21	6.87	7.54	7.00	7.42
As, Arsenic (ppm)	313	294	333	301	326
Ba, Barium (ppm)	739	708	770	722	756
Be, Beryllium (ppm)	2.51	2.31	2.70	2.39	2.63
Bi, Bismuth (ppm)	0.37	0.33	0.40	0.34	0.39
Ca, Calcium (wt.%)	0.525	0.492	0.557	0.510	0.540
Cd, Cadmium (ppm)	0.054	0.034	0.073	IND	IND
Ce, Cerium (ppm)	79	74	84	75	82
Co, Cobalt (ppm)	14.2	13.3	15.1	13.6	14.8
Cr, Chromium (ppm)	123	115	130	118	128
Cs, Caesium (ppm)	10.3	9.8	10.9	9.9	10.7
Cu, Copper (ppm)	32.6	31.2	34.0	31.5	33.7
Dy, Dysprosium (ppm)	3.01	2.51	3.51	2.82	3.21
Er, Erbium (ppm)	1.60	1.33	1.87	IND	IND
Eu, Europium (ppm)	1.14	1.00	1.28	IND	IND
Fe, Iron (wt.%)	3.79	3.62	3.96	3.70	3.88
Ga, Gallium (ppm)	18.6	17.6	19.7	18.0	19.3
Gd, Gadolinium (ppm)	4.47	3.88	5.07	4.13	4.82
Ge, Germanium (ppm)	0.22	0.14	0.30	0.19	0.24
Hf, Hafnium (ppm)	3.98	3.79	4.17	3.84	4.12
Ho, Holmium (ppm)	0.56	0.44	0.68	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.

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

Note: intervals may appear asymmetric due to rounding.

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

Table 4. continued.

Constituent	Certified	95% Expanded Uncertainty		95% Tolerance Limits	
	Value	Low	High	Low	High
4-Acid Digestion continued					
In, Indium (ppm)	0.064	0.055	0.074	0.060	0.069
K, Potassium (wt.%)	2.80	2.68	2.92	2.71	2.90
La, Lanthanum (ppm)	39.6	37.4	41.7	38.4	40.8
Li, Lithium (ppm)	51	49	53	50	53
Lu, Lutetium (ppm)	0.24	0.19	0.28	0.21	0.27
Mg, Magnesium (wt.%)	1.39	1.33	1.45	1.35	1.43
Mn, Manganese (wt.%)	0.056	0.054	0.059	0.055	0.057
Mo, Molybdenum (ppm)	1.14	0.97	1.30	1.08	1.19
Na, Sodium (wt.%)	0.613	0.583	0.644	0.597	0.630
Nb, Niobium (ppm)	10.2	8.3	12.1	9.5	10.9
Nd, Neodymium (ppm)	34.2	31.6	36.9	32.5	35.9
Ni, Nickel (ppm)	73	69	76	70	75
P, Phosphorus (wt.%)	0.059	0.055	0.062	0.057	0.060
Pb, Lead (ppm)	22.9	21.6	24.2	22.0	23.8
Pr, Praseodymium (ppm)	9.13	8.43	9.83	8.75	9.52
Rb, Rubidium (ppm)	161	153	170	156	167
Re, Rhenium (ppm)	< 0.002	IND	IND	IND	IND
S, Sulphur (wt.%)	0.528	0.511	0.544	0.513	0.543
Sb, Antimony (wt.%)	0.840	0.811	0.869	0.820	0.859
Sc, Scandium (ppm)	13.2	12.3	14.1	12.7	13.7
Se, Selenium (ppm)	2.64	1.96	3.32	2.06	3.23
Sm, Samarium (ppm)	6.42	5.79	7.06	6.15	6.69
Sn, Tin (ppm)	3.56	3.31	3.82	3.41	3.72
Sr, Strontium (ppm)	99	94	104	96	102
Ta, Tantalum (ppm)	0.96	0.81	1.10	0.92	1.00
Tb, Terbium (ppm)	0.55	0.47	0.63	0.51	0.60
Te, Tellurium (ppm)	0.072	0.049	0.094	IND	IND
Th, Thorium (ppm)	15.1	14.0	16.3	14.4	15.9
Ti, Titanium (wt.%)	0.359	0.339	0.379	0.344	0.374
Tl, Thallium (ppm)	0.86	0.81	0.91	0.82	0.89
Tm, Thulium (ppm)	0.22	0.18	0.27	IND	IND
U, Uranium (ppm)	2.79	2.58	2.99	2.66	2.91
V, Vanadium (ppm)	92	87	97	88	96
W, Tungsten (ppm)	2.83	2.51	3.15	2.61	3.05
Y, Yttrium (ppm)	15.2	13.9	16.4	14.6	15.8
Yb, Ytterbium (ppm)	1.58	1.37	1.80	IND	IND
Zn, Zinc (ppm)	98	94	101	95	100

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	95% Expanded Uncertainty		95% Tolerance Limits	
	Value	Low	High	Low	High
4-Acid Digestion continued					
Zr, Zirconium (ppm)	133	126	141	129	137
Aqua Regia Digestion					
Ag, Silver (ppm)	0.192	0.174	0.211	0.175	0.210
Al, Aluminium (wt.%)	2.59	2.44	2.75	2.51	2.67
As, Arsenic (ppm)	307	293	321	297	317
Ba, Barium (ppm)	117	111	122	112	121
Be, Beryllium (ppm)	1.26	1.12	1.40	1.20	1.32
Bi, Bismuth (ppm)	0.36	0.34	0.39	0.34	0.39
Ca, Calcium (wt.%)	0.312	0.301	0.323	0.302	0.323
Cd, Cadmium (ppm)	0.050	0.037	0.063	IND	IND
Ce, Cerium (ppm)	50	42	58	48	52
Co, Cobalt (ppm)	13.4	12.9	14.0	13.0	13.9
Cr, Chromium (ppm)	98	95	102	96	101
Cs, Caesium (ppm)	7.24	6.89	7.59	6.96	7.53
Cu, Copper (ppm)	31.9	29.9	33.8	30.6	33.2
Fe, Iron (wt.%)	3.38	3.27	3.49	3.30	3.46
Ga, Gallium (ppm)	8.06	7.55	8.57	7.76	8.36
Ge, Germanium (ppm)	0.097	0.080	0.114	IND	IND
Hf, Hafnium (ppm)	0.51	0.45	0.57	0.48	0.55
Hg, Mercury (ppm)	0.031	0.019	0.043	IND	IND
In, Indium (ppm)	0.034	0.027	0.042	0.026	0.043
K, Potassium (wt.%)	0.858	0.830	0.885	0.834	0.881
La, Lanthanum (ppm)	23.7	21.1	26.3	22.7	24.7
Li, Lithium (ppm)	37.6	34.5	40.7	35.7	39.5
Mg, Magnesium (wt.%)	1.14	1.11	1.18	1.11	1.18
Mn, Manganese (wt.%)	0.047	0.046	0.049	0.046	0.049
Mo, Molybdenum (ppm)	1.09	0.96	1.23	0.97	1.22
Na, Sodium (wt.%)	0.047	0.043	0.051	0.045	0.048
Nb, Niobium (ppm)	0.54	0.41	0.67	0.48	0.60
Ni, Nickel (ppm)	68	65	71	66	69
P, Phosphorus (wt.%)	0.050	0.049	0.051	0.049	0.052
Pb, Lead (ppm)	13.6	12.8	14.3	13.0	14.1
Rb, Rubidium (ppm)	81	77	85	78	84
Re, Rhenium (ppm)	< 0.001	IND	IND	IND	IND
S, Sulphur (wt.%)	0.533	0.517	0.548	0.516	0.550
Sb, Antimony (wt.%)	0.745	0.698	0.791	0.725	0.764
Sc, Scandium (ppm)	6.78	6.32	7.25	6.54	7.02

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					
Se, Selenium (ppm)	2.09	1.66	2.51	1.85	2.32
Sn, Tin (ppm)	1.56	1.45	1.68	IND	IND
Sr, Strontium (ppm)	32.6	31.3	33.9	31.4	33.8
Ta, Tantalum (ppm)	< 0.05	IND	IND	IND	IND
Te, Tellurium (ppm)	0.053	0.041	0.066	IND	IND
Th, Thorium (ppm)	11.3	10.4	12.2	10.9	11.7
Ti, Titanium (wt.%)	0.119	0.112	0.126	0.115	0.123
Tl, Thallium (ppm)	0.52	0.48	0.55	0.48	0.55
U, Uranium (ppm)	1.38	1.27	1.50	1.31	1.46
V, Vanadium (ppm)	61	59	63	59	63
W, Tungsten (ppm)	0.54	0.48	0.61	0.50	0.59
Y, Yttrium (ppm)	8.21	7.75	8.66	7.93	8.48
Zn, Zinc (ppm)	86	84	88	84	89
Zr, Zirconium (ppm)	19.8	17.4	22.3	18.6	21.1

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 antimony by peroxide fusion, where 99% of the time (1-α=0.99) at least 95% of subsamples (ρ=0.95) will have concentrations lying between 0.775 and 0.816 wt.%. Put more precisely, this means that if the same number of subsamples were taken and analysed in the same manner repeatedly, 99% of the tolerance intervals so constructed would cover at least 95% of the total population, and 1% of the tolerance intervals would cover less than 95% of the total population (ISO Guide 35). ***Please note that tolerance limits pertain to the homogeneity of the CRM only and should not be used as control limits for laboratory performance.***

The homogeneity of gold has been determined by INAA at ANSTO using the reduced analytical subsample method which utilises the known relationship between standard deviation and analytical subsample weight (Ingamells and Switzer, 1973). In this approach the sample aliquot is substantially reduced to a point where most of the variability in replicate assays should be due to inhomogeneity of the reference material and measurement error becomes negligible.

Table 5 below shows the gold INAA data determined on 20 x 85mg subsamples of OREAS 290. An equivalent scaled version of the results is also provided to demonstrate an appreciation of what this data means if 30g fire assays were undertaken without the normal measurement error associated with this methodology. In this instance, the 1RSD of 0.125% calculated for a 30g fire assay sample (2.34% at 85mg weights) confirms the high level of gold homogeneity in OREAS 290.

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

Replicate No	Au 85mg actual	Au 30g equivalent*
1	2.27	2.205
2	2.13	2.198
3	2.30	2.207
4	2.27	2.205
5	2.15	2.199
6	2.22	2.202
7	2.17	2.200
8	2.21	2.202
9	2.24	2.204
10	2.24	2.204
11	2.20	2.201
12	2.20	2.201
13	2.13	2.198
14	2.17	2.200
15	2.17	2.200
16	2.22	2.203
17	2.13	2.198
18	2.28	2.206
19	2.19	2.201
20	2.16	2.200
Mean	2.202	2.202
Median	2.196	2.201
Std Dev.	0.051	0.003
Rel.Std.Dev.	**2.337%**	**0.125%**

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

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

The homogeneity of gold in OREAS 290 has also been evaluated in a nested Analysis of Variance (**ANOVA**) of the round robin program. Twenty-one round robin laboratories received six samples per CRM and these samples were made up of paired samples from three different, non-adjacent sampling intervals. The purpose of the ANOVA evaluation is to test that no statistically significant difference exists in the variance between units to that of the variance within units. This allows an assessment of homogeneity across the entire prepared batch of OREAS 290. The test was performed using the following parameters:

- Gold fire assay – 114 samples (19 laboratories each providing analyses on 3 pairs of samples);
- Gold aqua regia digestion – 72 samples (12 laboratories each providing analyses on 3 pairs of samples);
- Null Hypothesis, H_0: Between-unit variance is no greater than within-unit variance (reject H_0 if *p*-value < 0.05);
- Alternative Hypothesis, H_1: Between-unit variance is greater than within-unit variance.

P-values are a measure of probability where values less than 0.05 indicate a greater than 95% probability that the observed differences in within-unit and between-unit variances are real. The datasets were filtered for both individual and laboratory data set (batch) outliers prior to the calculation of the *p*-value.

This process derived *p*-values of 0.98 for Au by fire assay and 0.65 for Au by aqua regia digestion. Both *p*-values are insignificant and the Null Hypothesis is retained. Additionally, none of the other certified values showed significant *p*-values other than Ca by 4-acid digestion. This isolated case is most likely due to random* statistical probability as there is no other supporting evidence to suspect greater between-unit variance compared with within-unit variance. The null hypothesis is therefore retained.

**p-values are calculated at the 95% probability level. Therefore, by definition 5% of p-values calculated will naturally fall as 'significant' (<0.05). For every 100 p-values calculated, 5 could 'fail' naturally meaning a significant difference is detected where, in reality, none exists.*

Please note that only results for constituents present in concentrations well above the detection levels (i.e., >20 x Lower Limit of Detection) for the various methods undertaken were considered for the objective of evaluating homogeneity

It is important to note that ANOVA is not an absolute measure of homogeneity. Rather, it establishes whether or not the analytes are distributed in a similar manner throughout the packaging run of OREAS 290 and whether the variance between two subsamples from the same unit is statistically distinguishable from the variance of two subsamples taken from any two separate units. A reference material therefore can possess poor absolute homogeneity yet still pass a relative homogeneity (ANOVA) test if the within-unit heterogeneity is large and similar across all units. Based on the statistical analysis of ANOVA and the results of the interlaboratory certification program, it can be concluded that OREAS 290 is fit-for-purpose as a certified reference material (see 'Intended Use' below).

PREPARER AND SUPPLIER

Certified reference material OREAS 290 was prepared and certified by:

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20. SGS de Mexico SA de CV, Cd. Industrial, Durango, Mexico
21. SGS del Peru, Lima, Peru
22. SGS Geosol Laboratorios Ltda, Vespasiano, Minas Gerais, Brazil

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

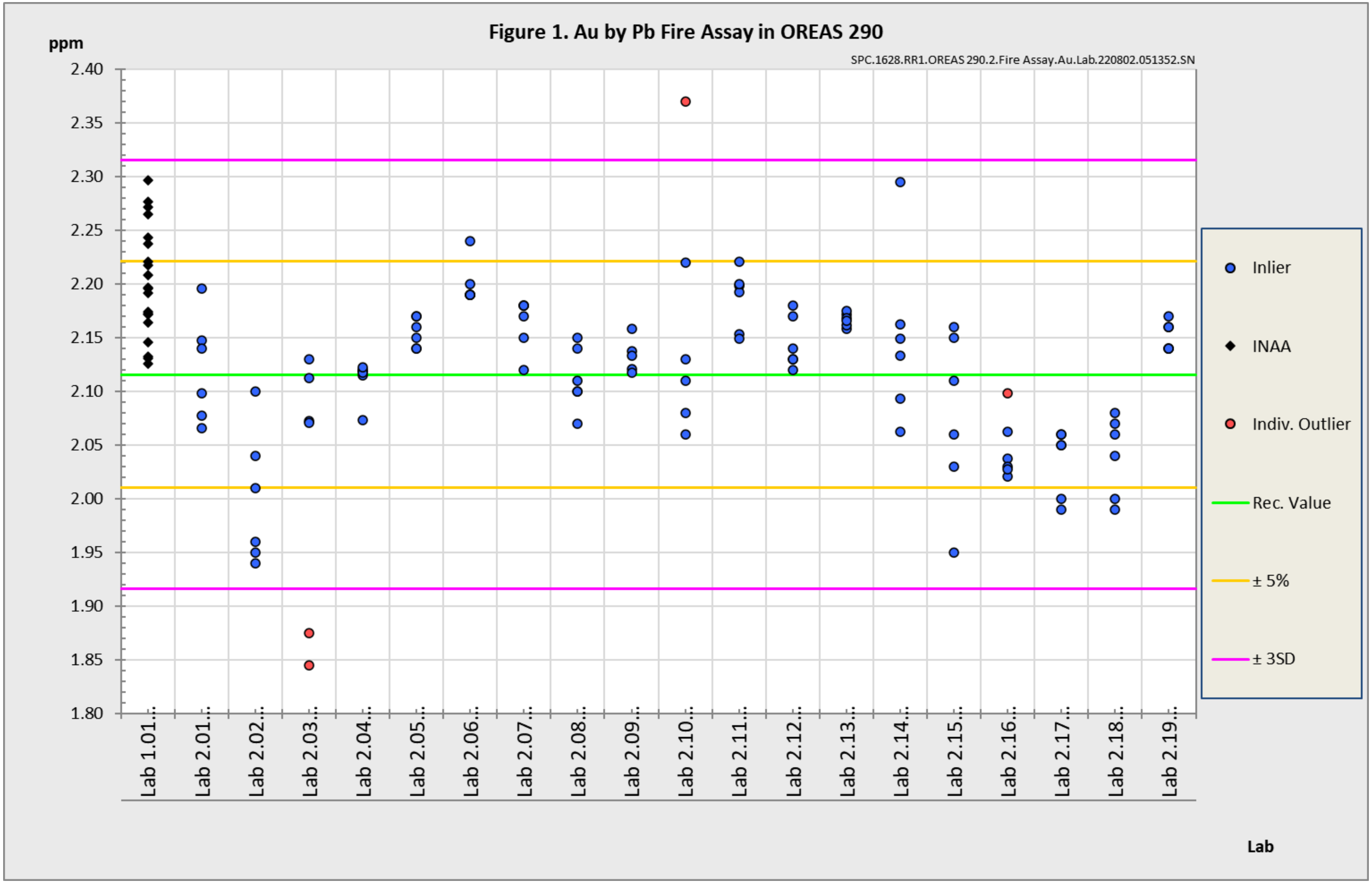
Figure 1. Au by Pb Fire Assay in OREAS 290
SPC.1628.RR1.OREAS 290.2.Fire Assay.Au.Lab.220802.051352.SN
ppm
2.40
2.35
2.30
2.25
2.20
2.15
2.10
2.05
2.00
1.95
1.90
1.85
1.80
Lab 1.01...
Lab 2.01...
Lab 2.02...
Lab 2.03...
Lab 2.04...
Lab 2.05...
Lab 2.06...
Lab 2.07...
Lab 2.08...
Lab 2.09...
Lab 2.10...
Lab 2.11...
Lab 2.12...
Lab 2.13...
Lab 2.14...
Lab 2.15...
Lab 2.16...
Lab 2.17...
Lab 2.18...
Lab 2.19...
Lab
Inlier
INAA
Indiv. Outlier
Rec. Value
± 5%
± 3SD

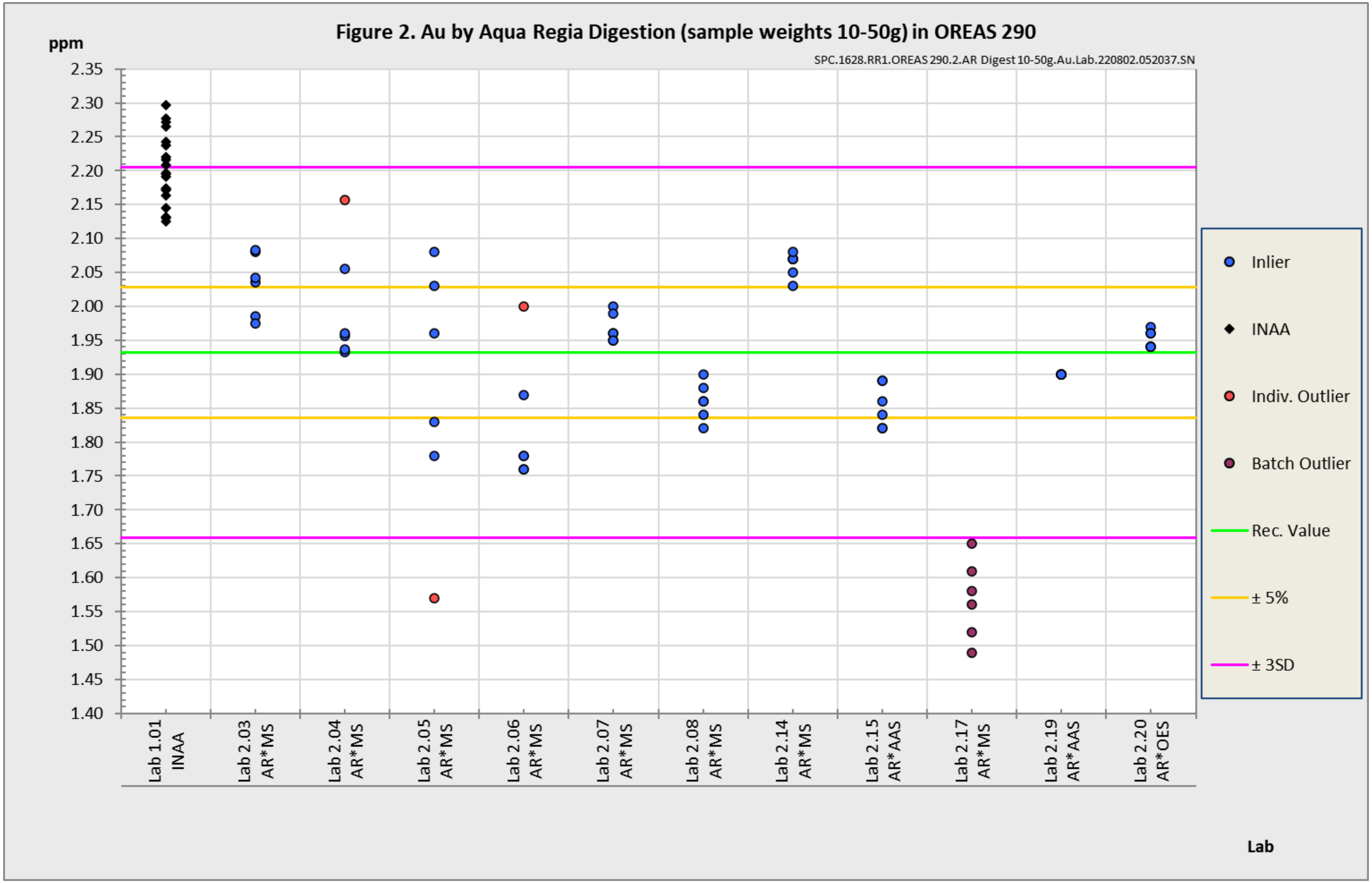
Figure 2. Au by Aqua Regia Digestion (sample weights 10-50g) in OREAS 290
SPC.1628.RR1.OREAS 290.2.AR Digest 10-50g.Au.Lab.220802.052037.SN
ppm
2.35
2.30
2.25
2.20
2.15
2.10
2.05
2.00
1.95
1.90
1.85
1.80
1.75
1.70
1.65
1.60
1.55
1.50
1.45
1.40
Lab 1.01 INAA
Lab 2.03 AR*MS
Lab 2.04 AR*MS
Lab 2.05 AR*MS
Lab 2.06 AR*MS
Lab 2.07 AR*MS
Lab 2.08 AR*MS
Lab 2.14 AR*MS
Lab 2.15 AR*AAS
Lab 2.17 AR*MS
Lab 2.19 AR*AAS
Lab 2.20 AR*OES
Lab
Inlier
INAA
Indiv. Outlier
Batch Outlier
Rec. Value
± 5%
± 3SD

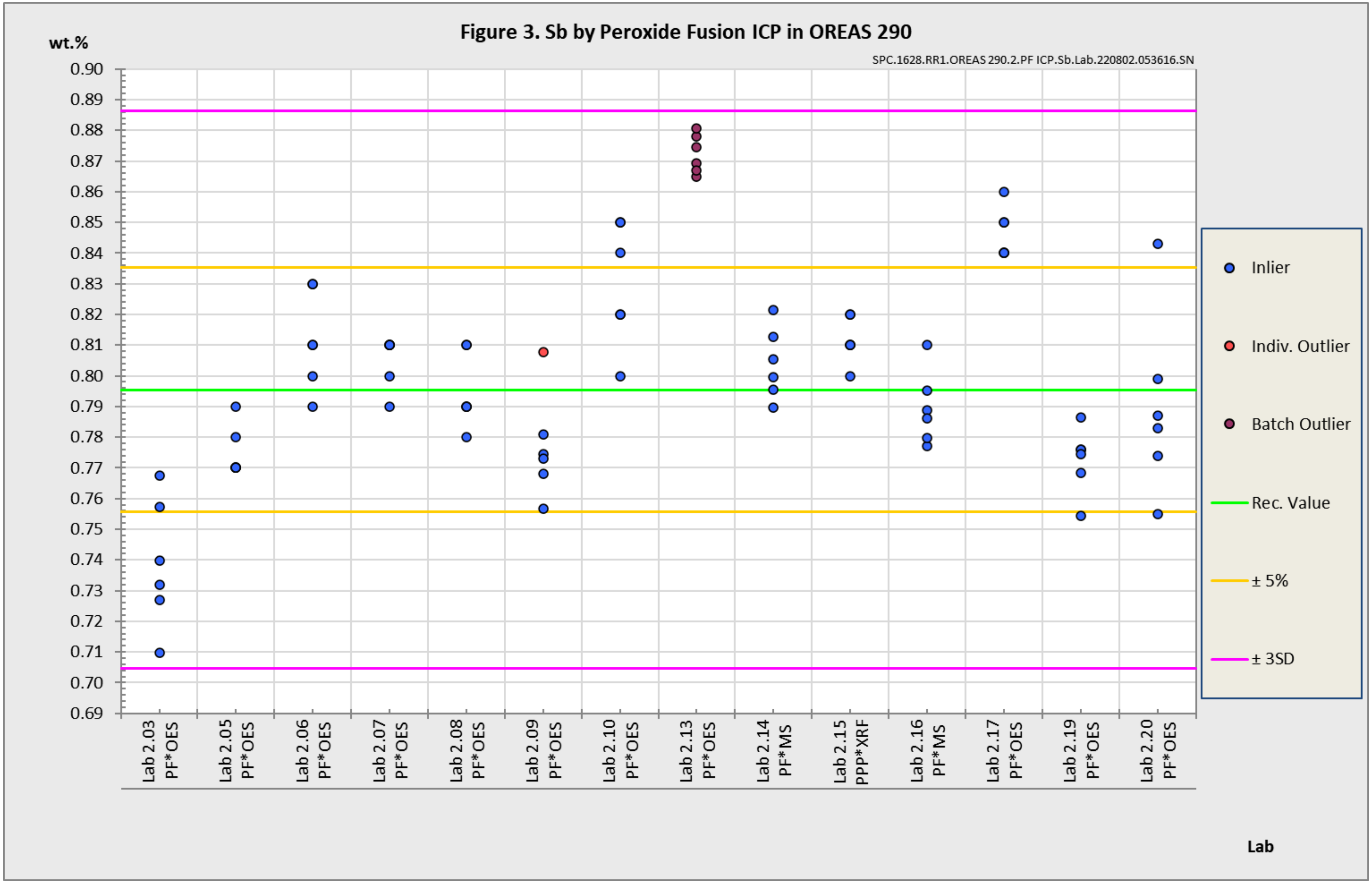
Figure 3. Sb by Peroxide Fusion ICP in OREAS 290
SPC.1628.RR1.OREAS 290.2.PF ICP.Sb.Lab.220802.053616.SN
wt.%
0.90
0.89
0.88
0.87
0.86
0.85
0.84
0.83
0.82
0.81
0.80
0.79
0.78
0.77
0.76
0.75
0.74
0.73
0.72
0.71
0.70
0.69
Lab 2.03 PF*OES
Lab 2.05 PF*OES
Lab 2.06 PF*OES
Lab 2.07 PF*OES
Lab 2.08 PF*OES
Lab 2.09 PF*OES
Lab 2.10 PF*OES
Lab 2.13 PF*OES
Lab 2.14 PF*MS
Lab 2.15 PPP*XRF
Lab 2.16 PF*MS
Lab 2.17 PF*OES
Lab 2.19 PF*OES
Lab 2.20 PF*OES
Lab
Inlier
Indiv. Outlier
Batch Outlier
Rec. Value
± 5%
± 3SD

METROLOGICAL TRACEABILITY

The analytical samples were selected in a manner to represent the entire batch of prepared CRM. This 'representivity' was maintained in each submitted laboratory sample batch and ensures the user that the data is traceable from sample selection through to the analytical results that underlie the consensus values. Each analytical data set has been validated by its assayer through the inclusion of internal reference materials and QC checks during analysis.

The laboratories were chosen on the basis of their competence (from past performance in inter-laboratory programs undertaken by ORE Pty Ltd) for a particular analytical method, analyte or analyte suite, and sample matrix. Most of these laboratories have and maintain ISO 17025 accreditation. The certified values presented in this report are calculated from the means of accepted data following robust statistical treatment as detailed in this report.

Guide ISO/TR 16476:2016, section 5.3.1 describes metrological traceability in reference materials as it pertains to the transformation of the measurand. In this section it states, *"Although the determination of the property value itself can be made traceable to appropriate units through, for example, calibration of the measurement equipment used, steps like the transformation of the sample from one physical (chemical) state to another cannot. Such transformations may only be compared with a reference (when available), or among themselves. For some transformations, reference methods have been defined and may be used in certification projects to evaluate the uncertainty associated with such a transformation.* ***In other cases, only a comparison among different laboratories using the same 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 290 will display similar behaviour in the relevant measurement process to the routine 'process' samples for which OREAS 290 is designated to monitor. To maintain commutability, care should be taken to always ensure 'matrix matching' as close as practically achievable. The matrix of the CRM is described in the 'Source Material' section and users should select appropriate CRMs matching these attributes to their field samples.

INTENDED USE

OREAS 290 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 290 may be used to calibrate the entire procedure by producing a pure substance CRM transformed into a calibration solution. OREAS 290 is intended for the following uses:

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

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:

- Au by fire assay: ≥10g;
- Au by aqua regia digestion ICP finish: ≥1g.;
- Peroxide fusion with ICP 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.

PERIOD OF VALIDITY & STORAGE INSTRUCTIONS

The certification of OREAS 290 remains valid, within the specified measurement uncertainties, until August 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 290 is relatively low in Sulphur (0.53 wt.% S) and is packaged in single-use laminated foil sachets. Following analysis, it is the manufacturer's expectation that any remaining material is discarded. It is the user's responsibility to prevent contamination and avoid prolonged exposure of the sample to the atmosphere prior to analysis.

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

After taking a subsample, users should replace the lid of the jar promptly and securely to prevent accidental spills and airborne contamination. OREAS 290 contains a non-hygroscopic* matrix with an indicative value for moisture provided to enable users to check for changes to stored material by determining moisture in the user's laboratory and comparing the result to the value in Table 3 in this certificate.

The stability of the CRM in regard to oxidation from the breakdown of sulphide minerals to sulphates is negligible given its low sulphur concentration (0.53 wt.% S).

*A non-hygroscopic matrix means exposure to atmospheres significantly different, in terms of temperature and humidity, from the climate during manufacturing should have negligible impact on the precision of results. Hygroscopic moisture is the amount of adsorped moisture (weakly held H_2O- molecules on the surface of exposed material) following exposure to the local atmosphere. Usually, equilibration of material to the local atmosphere will only occur if the material is spread into a thin (~2mm thick) layer and left exposed for a period of 2 hours.

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

For use with the aqua regia digestion method

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

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

LEGAL NOTICE

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

DOCUMENT HISTORY

Revision No.	Date	Changes applied
1	19th September, 2022	Minor revision has been made to the certified values and associated statistics for multi-element aqua regia and 4-acid digestion (one laboratory's aqua regia results were inadvertently mapped as 4-acid digestion and vice versa).
0	9th August, 2022	First publication.

QMS ACCREDITATION

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

Lloyd's Register LRQA

LLOYD'S REGISTER·LRQA ISO 9001 JAS-ANZ

CERTIFYING OFFICER

19th September, 2022

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

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

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

[10] ISO Guide 17034:2016. General requirements for the competence of reference material producers.

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

[12] OREAS-TN-04-1498: Stability under transport; an experimental study of OREAS CRMs.

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