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CERTIFICATE OF ANALYSIS FOR

CERTIFIED REFERENCE MATERIAL

OREAS 249

Gold-Antimony High-Grade Ore (Costerfield, VIC, Australia)

Accredited for compliance with ISO 17034

COA-1946-OREAS 249-R0 BUP-70-10-01 Ver:2.0	22-September-2025

Table 1. Certified Values, Uncertainty & Tolerance Intervals in OREAS 249.

Constituent	Certified Value	95% Expanded Uncertainty		95% Tolerance Limits	
		Low	High	Low	High
Pb Fire Assay					
Au, Gold (ppm)	22.15	21.84	22.46	22.08	22.21
PhotonAssay™ (recommended gross mass 350-380 g)					
Au, Gold (ppm)	23.33	23.11	23.55	23.27	23.40
Aqua Regia Digestion (sample weights 10-50g)					
Au, Gold (ppm)	20.27	19.92	20.63	20.21	20.33
Peroxide Fusion ICP					
Sb, Antimony (wt.%)	8.15	7.78	8.52	8.02	8.29
Borate Fusion XRF					
Sb, Antimony (wt.%)	8.38	8.22	8.54	8.31	8.46
4-Acid Digestion					
Ag, Silver (ppm)	2.22	2.08	2.36	2.09	2.36
Al, Aluminium (wt.%)	5.84	5.63	6.05	5.72	5.96
As, Arsenic (wt.%)	0.182	0.173	0.191	0.176	0.188
Ba, Barium (ppm)	446	411	481	432	460
Be, Beryllium (ppm)	2.29	2.22	2.37	2.22	2.36
Bi, Bismuth (ppm)	3.58	3.32	3.84	3.43	3.73
Ca, Calcium (wt.%)	0.579	0.560	0.597	0.568	0.589
Cd, Cadmium (ppm)	0.31	0.27	0.35	0.27	0.35
Ce, Cerium (ppm)	69	65	73	68	71
Co, Cobalt (ppm)	21.6	19.5	23.6	21.0	22.1
Cr, Chromium (ppm)	196	188	203	189	202
Cs, Caesium (ppm)	11.7	11.1	12.2	11.3	12.0
Cu, Copper (ppm)	257	245	268	250	263
Er, Erbium (ppm)	1.59	1.21	1.97	1.49	1.70
Fe, Iron (wt.%)	3.90	3.77	4.03	3.81	3.99
Ga, Gallium (ppm)	15.0	13.9	16.0	14.3	15.7
Gd, Gadolinium (ppm)	3.83	3.20	4.45	3.68	3.97
Hf, Hafnium (ppm)	2.86	2.70	3.02	2.76	2.97
Ho, Holmium (ppm)	0.55	0.44	0.66	0.50	0.61
In, Indium (ppm)	0.097	0.071	0.124	0.089	0.106
K, Potassium (wt.%)	2.52	2.45	2.59	2.45	2.58
La, Lanthanum (ppm)	37.9	35.7	40.1	36.7	39.1
Li, Lithium (ppm)	25.0	19.9	30.1	23.4	26.5
Lu, Lutetium (ppm)	0.27	0.22	0.32	0.22	0.32
Mg, Magnesium (wt.%)	1.16	1.12	1.19	1.13	1.18
Mn, Manganese (wt.%)	0.072	0.069	0.075	0.070	0.074

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

*Gold Tolerance Limits for typical 30 g lead collection fire assay, 350-380 g PhotonAssay™ and 25 g aqua regia digestion methods are determined from 20 x 85 mg INAA results and the Sampling Constant (Ingamells & Switzer, 1973).

Note: intervals may appear asymmetric due to rounding.

Table 1 continued.

Constituent	Certified Value	95% Expanded Uncertainty		95% Tolerance Limits	
		Low	High	Low	High
4-Acid Digestion continued					
Mo, Molybdenum (ppm)	15.1	13.0	17.2	14.5	15.7
Na, Sodium (wt.%)	0.330	0.319	0.341	0.322	0.338
Nb, Niobium (ppm)	9.42	8.10	10.75	9.00	9.85
Nd, Neodymium (ppm)	30.3	28.2	32.4	29.0	31.6
Ni, Nickel (ppm)	65	59	71	63	67
P, Phosphorus (wt.%)	0.048	0.045	0.050	0.046	0.049
Pb, Lead (ppm)	271	252	290	262	279
Pr, Praseodymium (ppm)	7.96	6.92	9.01	7.71	8.21
Rb, Rubidium (ppm)	154	147	160	149	158
Re, Rhenium (ppm)	0.032	0.027	0.036	0.028	0.036
S, Sulphur (wt.%)	4.25	4.15	4.36	4.18	4.33
Sb, Antimony (wt.%)	7.03	5.27	8.79	6.83	7.23
Sc, Scandium (ppm)	11.1	10.4	11.8	10.8	11.4
Se, Selenium (ppm)	13.8	12.4	15.3	12.3	15.3
Sm, Samarium (ppm)	5.48	4.90	6.07	5.23	5.73
Sr, Strontium (ppm)	130	125	135	127	133
Tb, Terbium (ppm)	0.53	0.41	0.65	0.49	0.58
Th, Thorium (ppm)	13.9	13.1	14.7	13.4	14.4
Ti, Titanium (wt.%)	0.249	0.213	0.285	0.242	0.256
Tl, Thallium (ppm)	0.95	0.87	1.04	0.90	1.01
U, Uranium (ppm)	2.43	2.30	2.56	2.31	2.55
V, Vanadium (ppm)	67	63	72	65	70
W, Tungsten (ppm)	5.06	3.90	6.23	4.54	5.59
Y, Yttrium (ppm)	15.8	14.2	17.4	15.0	16.6
Yb, Ytterbium (ppm)	1.66	1.42	1.91	1.58	1.75
Zn, Zinc (ppm)	250	232	267	242	257
Zr, Zirconium (ppm)	98	94	103	94	102
Aqua Regia Digestion					
Ag, Silver (ppm)	2.17	2.09	2.25	2.08	2.26
Al, Aluminium (wt.%)	1.03	0.95	1.11	1.01	1.06
Ba, Barium (ppm)	94	77	112	91	97
Be, Beryllium (ppm)	0.92	0.85	0.99	0.90	0.95
Bi, Bismuth (ppm)	3.73	3.44	4.01	3.57	3.88
Ca, Calcium (wt.%)	0.550	0.532	0.568	0.538	0.563
Cd, Cadmium (ppm)	0.31	0.28	0.34	0.29	0.33
Ce, Cerium (ppm)	26.4	23.3	29.5	25.3	27.6
Co, Cobalt (ppm)	24.2	23.0	25.5	23.7	24.8

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

Note: intervals may appear asymmetric due to rounding.

Table 1 continued.

Constituent	Certified Value	95% Expanded Uncertainty		95% Tolerance Limits	
		Low	High	Low	High
Aqua Regia Digestion continued					
Cr, Chromium (ppm)	86	80	91	83	88
Cs, Caesium (ppm)	4.13	3.74	4.52	4.00	4.26
Cu, Copper (ppm)	266	259	273	261	270
Fe, Iron (wt.%)	3.55	3.46	3.64	3.49	3.62
Ga, Gallium (ppm)	3.21	2.92	3.51	3.03	3.40
Hf, Hafnium (ppm)	< 0.02	IND	IND	IND	IND
Hg, Mercury (ppm)	0.35	0.31	0.40	0.33	0.38
In, Indium (ppm)	0.074	0.065	0.084	0.070	0.079
K, Potassium (wt.%)	0.480	0.459	0.502	0.470	0.491
La, Lanthanum (ppm)	15.4	13.8	16.9	14.8	16.0
Li, Lithium (ppm)	11.8	10.9	12.7	11.5	12.1
Mg, Magnesium (wt.%)	0.870	0.851	0.889	0.854	0.886
Mn, Manganese (wt.%)	0.073	0.070	0.076	0.072	0.074
Mo, Molybdenum (ppm)	13.5	11.3	15.6	12.9	14.0
Na, Sodium (wt.%)	0.033	0.029	0.036	0.030	0.035
Nb, Niobium (ppm)	0.047	0.023	0.070	IND	IND
Ni, Nickel (ppm)	71	68	75	69	73
P, Phosphorus (wt.%)	0.034	0.029	0.039	0.033	0.035
Rb, Rubidium (ppm)	28.1	26.3	30.0	27.1	29.2
Re, Rhenium (ppm)	0.034	0.031	0.036	0.032	0.035
S, Sulphur (wt.%)	4.22	4.12	4.32	4.16	4.28
Sb, Antimony (wt.%)	7.63	6.92	8.35	7.31	7.96
Sn, Tin (ppm)	5.11	4.88	5.33	4.93	5.28
Sr, Strontium (ppm)	88	84	92	85	91
Ta, Tantalum (ppm)	< 0.01	IND	IND	IND	IND
Ti, Titanium (wt.%)	< 0.005	IND	IND	IND	IND
Tl, Thallium (ppm)	0.45	0.42	0.48	0.43	0.47
U, Uranium (ppm)	0.75	0.59	0.90	0.72	0.77
V, Vanadium (ppm)	16.1	14.8	17.4	15.2	17.0
Y, Yttrium (ppm)	6.06	5.64	6.48	5.85	6.26
Zn, Zinc (ppm)	266	258	274	262	270

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. Indicative Values for OREAS 249.

Constituent	Unit	Value	Constituent	Unit	Value	Constituent	Unit	Value
Peroxide Fusion ICP								
Al	wt.%	*6.10*	K	wt.%	*2.78*	S	wt.%	*4.34*
B	ppm	*152*	La	ppm	*31.6*	Si	wt.%	*27.12*
Ca	wt.%	*0.584*	Mg	wt.%	*1.17*	Ti	wt.%	*0.265*
Co	ppm	*14.7*	Mn	wt.%	*0.073*	V	ppm	*93*
Fe	wt.%	*3.79*	P	wt.%	*0.043*	Zn	ppm	*244*
Borate fusion XRF								
Al_2O_3	wt.%	*11.65*	MgO	wt.%	*2.00*	SiO_2	wt.%	*56.70*
CaO	wt.%	*0.810*	MnO	wt.%	*0.100*	TiO_2	wt.%	*0.575*
Fe_2O_3	wt.%	*5.75*	P_2O_5	wt.%	*0.114*			
K_2O	wt.%	*3.06*	S	wt.%	*4.40*			
Thermogravimetry								
LOI^{1000}	wt.%	*6.63*						
Infrared Combustion								
C	wt.%	*1.02*	S	wt.%	*4.68*			
Laser Ablation ICP-MS								
Ag	ppm	*2.15*	Hf	ppm	*4.09*	Sn	ppm	*783*
As	ppm	*1860*	Ho	ppm	*0.90*	Sr	ppm	*126*
Ba	ppm	*515*	In	ppm	*0.038*	Ta	ppm	*1.29*
Be	ppm	*2.20*	La	ppm	*37.4*	Tb	ppm	*0.76*
Bi	ppm	*3.70*	Lu	ppm	*0.38*	Te	ppm	*< 0.2*
Cd	ppm	*0.13*	Mn	wt.%	*0.075*	Th	ppm	*14.2*
Ce	ppm	*71*	Mo	ppm	*17.4*	Ti	wt.%	*0.332*
Co	ppm	*24.3*	Nb	ppm	*11.6*	Tl	ppm	*0.40*
Cr	ppm	*208*	Nd	ppm	*31.9*	Tm	ppm	*0.39*
Cs	ppm	*11.6*	Ni	ppm	*76*	U	ppm	*2.53*
Cu	ppm	*266*	Pb	ppm	*273*	V	ppm	*79*
Dy	ppm	*4.49*	Pr	ppm	*8.69*	W	ppm	*16.5*
Er	ppm	*2.53*	Rb	ppm	*149*	Y	ppm	*23.5*
Eu	ppm	*1.09*	Re	ppm	*0.060*	Yb	ppm	*2.48*
Ga	ppm	*15.3*	Sb	ppm	*83750*	Zn	ppm	*248*
Gd	ppm	*4.89*	Sc	ppm	*11.6*	Zr	ppm	*148*
Ge	ppm	*1.53*	Sm	ppm	*5.99*			
4-Acid Digestion								
Dy	ppm	*2.54*	Hg	ppm	*0.33*	Te	ppm	*0.18*
Eu	ppm	*0.96*	Sn	ppm	*9.94*	Tm	ppm	*0.23*
Ge	ppm	*0.77*	Ta	ppm	*0.45*			
Aqua Regia Digestion								
As	wt.%	*0.104*	Lu	ppm	*0.093*	Te	ppm	*0.009*
B	ppm	*10.0*	Nd	ppm	*10.4*	Th	ppm	*5.71*
Dy	ppm	*1.19*	Pb	ppm	*135*	Tm	ppm	*0.100*
Er	ppm	*0.62*	Pr	ppm	*2.73*	W	ppm	*0.10*
Eu	ppm	*0.40*	Sc	ppm	*1.93*	Yb	ppm	*0.58*
Gd	ppm	*1.69*	Se	ppm	*7.59*	Zr	ppm	*0.33*
Ge	ppm	*0.079*	Sm	ppm	*2.09*			
Ho	ppm	*0.22*	Tb	ppm	*0.37*			

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 handling and correct use' should be read carefully.

Table 1 presents the certified values together with their associated 95% expanded uncertainties and tolerance intervals. Table 2 provides indicative values, including major and trace element characterisation. Table 3 lists indicative physical properties, while Table 4 reports indicative mineralogy determined by semi-quantitative XRD analysis. Gold homogeneity, assessed by INAA, is shown in Table 5 and is further demonstrated through a nested ANOVA (see *Homogeneity Evaluation* section). Finally, Table 6 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 laboratory means from the corrected mean of means (PDM[3]) are presented in the detailed certification data for this CRM (**OREAS 249-DataPack.1.0.250922_103758.xlsx**). The certified values and uncertainties in this Certificate are the sole authoritative figures. Any additional significant figures in the DataPack are provided for reference only and do not affect the certified results.

Results are also presented in scatter plots for Au by Pb fire assay, Au by PhotonAssay™, Au by aqua regia digestion (sample weights 10-50 g), Sb by peroxide fusion with ICP and Sb by borate fusion with XRF in Figures 1 to 5 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 249 was prepared from a blend of high-grade gold-antimony ore, barren metasediments and Sb-Au concentrate. The ore and concentrate were sourced from the Costerfield Operation (Mandalay Resources Ltd), located ~10 km northeast of Heathcote, Victoria. The deposit is hosted in Lower Silurian metasedimentary rocks and is characterised by narrow, high-grade quartz-stibnite veins. Gold occurs with arsenopyrite and pyrite, as well as in "gold-only" quartz-carbonate veins at depth or beneath stibnite lodes.

COMMINUTION AND HOMOGENISATION PROCEDURES

The materials constituting OREAS 249 was prepared in the following manner:

- Drying of ores and barren materials to constant mass at 105° C;
- Crushing and multi-stage milling of the barren material to >98 % minus 75 microns;

- Crushing and multi-stage milling of the ore to 100 % minus 30 microns;
- Blending the ore and barren material in appropriate proportions to achieve desired grades;
- Homogenisation using OREAS' novel processing technologies;
- Packaging under nitrogen in 10 g and 60 g units in laminated foil pouches.

PHYSICAL PROPERTIES

OREAS 249 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 249.

Bulk Density (kg/m^3)	Moisture (wt.%)	Munsell Notation‡	Munsell Color‡
816	0.60	N6	Medium 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.

MINERALOGY

The semi-quantitative XRD results shown in Table 4 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.

Some amorphous material may be present. 'Clay mineral' appears to be mainly vermiculite, smectite and illite. 'Kandite group' appears to be mainly kaolinite. A trace of epidote and/or dolomite might be present.

Table 4. Indicative mineralogy of OREAS 249 by semi-quantitative XRD analysis.

Mineral / Mineral Group	% (mass ratio)
Stibnite	14
Chlorite	2
Kandite group	< 1
Annite - biotite - phlogopite	11
Muscovite and/or illite	17
Plagioclase	1
K-feldspar and/or rutile	1
Quartz	51
Pyrite	3
Gypsum	< 1

ANALYTICAL PROGRAM

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

- Gold by Pb collection fire assay (25-50 g charge weight) with AAS (16 laboratories), ICP-OES (3 laboratories) and gravimetric finish (5 laboratories);
- Gold by PhotonAssay™ with a recommended gross fill mass of 350-380 g (12 laboratories);
- Gold by 15-50g aqua regia digestion with ICP-MS (8 laboratories) and AAS (9 laboratories) finish;
- Antimony by peroxide fusion with ICP-OES and/or ICP-MS finish (14 laboratories);
- Antimony by borate fusion with XRF finish (12 laboratories except one laboratory that used pressed powder pellet with XRF);
- Full ICP-OES and ICP-MS elemental suites by 4-acid (HNO_3-HF-$HClO_4$-HCl) digestion (up to 17 laboratories depending on the element);
- Full ICP-OES and ICP-MS elemental suites by aqua regia digestion (up to 16 laboratories depending on the element).

For the round robin program, twelve 1.5 kg test units were collected at predetermined intervals during the bagging stage, immediately after homogenisation. Apart from the PhotonAssay™ program, each participating laboratory received six test portions. The samples received by each laboratory were obtained by taking a 110 g sample from six different 1.5 kg test units to maximise representation (i.e., from either the odd or even sampling (lot) intervals to maximise representation).

For the Au by PhotonAssay™ program, each of the participating laboratories received three 500 g samples. Laboratories were instructed to prepare PhotonAssay™ jars from each sample and assay each jar in duplicate, generating a total of six results per laboratory. The 2-cycle assay protocol (PAAU02) and recommended gross fill mass range was specified to all participants to ensure consistency in measurement conditions.

The 20 individual INAA results upon which much of the homogeneity evaluation is based, included paired 10 g samples taken from 10 different sampling units. This format enabled a nested ANOVA treatment of the INAA results to evaluate homogeneity (see ‘Homogeneity Evaluation’ section below).

STATISTICAL ANALYSIS

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

Outlier evaluation was conducted in accordance with ISO 17034:2017 and ISO 33405:2024. While formal statistical tests were applied, professional statistical judgment was also exercised in determining the validity of potential outliers. Assessment of systematic bias and performance using independent control materials (CRMs) was incorporated to ensure compliance with the referenced standards and to establish metrological traceability of the certified values.

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 [5] and [15]. All known or suspected sources of bias have been investigated or taken into account.

Indicative (uncertified) values (Table 2) 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 5, '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-laboratory 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, laboratory 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

For analytes other than gold, the tolerance limits (ISO 16269:2014) shown in Table 1 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 Sb by borate fusion with XRF, where 99 % of the time ($1-\alpha=0.99$) at least 95 % of subsamples ($\rho=0.95$) will have concentrations lying between 8.31 and 8.46 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.***

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 [2]). 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 85 mg subsamples of OREAS 249. 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 0.09 % calculated for a 30 g fire assay sample (1.69 % at 85 mg weights) confirms the high level of gold homogeneity in OREAS 249.

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

Replicate No	Au 85 mg actual	Au 30 g equivalent*
1	23.93	23.91
2	23.83	23.91
3	24.14	23.92
4	24.22	23.93
5	23.74	23.90
6	24.11	23.92
7	23.35	23.88
8	23.44	23.89
9	23.24	23.87
10	23.61	23.89
11	23.76	23.90
12	23.46	23.89
13	24.10	23.92
14	23.58	23.89
15	24.37	23.93
16	24.64	23.95
17	24.60	23.95
18	24.06	23.92
19	23.69	23.90
20	24.32	23.93
Mean	23.91	23.91
Median	23.88	23.91
Std Dev.	0.405	0.022
Rel.Std.Dev.	**1.69%**	**0.09%**

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

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

The homogeneity of OREAS 249 has also been evaluated in an Analysis of Variance (**ANOVA**) of the INAA data. The 20 samples were comprised of paired samples from each of 10 sampling lot intervals (representative of the prepared batch) and were randomised prior to assigning sample numbers. The duplicate samples enabled an ANOVA by comparison of within- and between-unit variances across the 10 pairs. The purpose of the ANOVA 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 249. The test was performed using the following parameters:

- Gold INAA – 20 results (1 laboratory providing duplicate analyses on 10 samples where each sample can be viewed as a ‘unit’);
- 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.

The data was not filtered for outliers prior to the calculation of the *p*-value. This process derived a *p*-value of 0.52, a statistically insignificant result so the Null Hypothesis is accepted.

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 249 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 249 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 249.

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	22.15	0.814	20.52	23.78	19.70	24.59	3.68%	7.35%	11.03%	21.04	23.25
PhotonAssay™ (recommended gross mass 350-380 g)											
Au, ppm	23.33	0.489	22.36	24.31	21.87	24.80	2.10%	4.19%	6.29%	22.17	24.50
Aqua Regia Digestion (sample weights 10-50g)											
Au, ppm	20.27	0.680	18.91	21.63	18.23	22.31	3.36%	6.71%	10.07%	19.26	21.29
Peroxide Fusion ICP											
Sb, wt.%	8.15	0.414	7.32	8.98	6.91	9.40	5.08%	10.16%	15.25%	7.75	8.56
Borate Fusion XRF											
Sb, wt.%	8.38	0.149	8.09	8.68	7.94	8.83	1.78%	3.56%	5.33%	7.96	8.80

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											
Ag, ppm	2.22	0.117	1.99	2.46	1.87	2.57	5.28%	10.57%	15.85%	2.11	2.33
Al, wt.%	5.84	0.203	5.43	6.24	5.23	6.45	3.48%	6.96%	10.45%	5.54	6.13
As, wt.%	0.182	0.010	0.161	0.202	0.151	0.213	5.65%	11.30%	16.95%	0.173	0.191
Ba, ppm	446	46	354	538	308	584	10.32%	20.64%	30.96%	424	469
Be, ppm	2.29	0.062	2.17	2.42	2.11	2.48	2.69%	5.38%	8.07%	2.18	2.41
Bi, ppm	3.58	0.40	2.79	4.38	2.39	4.77	11.10%	22.21%	33.31%	3.40	3.76
Ca, wt.%	0.579	0.019	0.542	0.616	0.523	0.634	3.20%	6.40%	9.59%	0.550	0.608
Cd, ppm	0.31	0.04	0.23	0.38	0.20	0.42	12.25%	24.49%	36.74%	0.29	0.32
Ce, ppm	69	4.5	60	78	56	83	6.44%	12.89%	19.33%	66	73
Co, ppm	21.6	2.6	16.3	26.8	13.7	29.4	12.15%	24.30%	36.45%	20.5	22.6
Cr, ppm	196	7	182	209	176	216	3.38%	6.75%	10.13%	186	205
Cs, ppm	11.7	0.43	10.8	12.5	10.4	13.0	3.72%	7.43%	11.15%	11.1	12.2
Cu, ppm	257	15	226	287	211	303	5.97%	11.93%	17.90%	244	270
Er, ppm	1.59	0.26	1.08	2.11	0.82	2.36	16.16%	32.32%	48.48%	1.51	1.67
Fe, wt.%	3.90	0.114	3.67	4.13	3.56	4.24	2.92%	5.84%	8.76%	3.70	4.09
Ga, ppm	15.0	1.37	12.3	17.7	10.9	19.1	9.14%	18.28%	27.41%	14.2	15.7
Gd, ppm	3.83	0.38	3.06	4.59	2.67	4.98	10.03%	20.06%	30.10%	3.63	4.02
Hf, ppm	2.86	0.143	2.58	3.15	2.44	3.29	4.98%	9.97%	14.95%	2.72	3.01
Ho, ppm	0.55	0.08	0.39	0.71	0.31	0.79	14.49%	28.97%	43.46%	0.52	0.58
In, ppm	0.097	0.016	0.066	0.129	0.050	0.144	16.21%	32.42%	48.63%	0.092	0.102
K, wt.%	2.52	0.069	2.38	2.65	2.31	2.72	2.74%	5.47%	8.21%	2.39	2.64
La, ppm	37.9	3.05	31.8	44.0	28.8	47.1	8.05%	16.11%	24.16%	36.0	39.8
Li, ppm	25.0	7.4	10.1	39.8	2.7	47.2	29.70%	59.39%	89.09%	23.7	26.2
Lu, ppm	0.27	0.03	0.21	0.33	0.18	0.36	10.85%	21.70%	32.54%	0.25	0.28
Mg, wt.%	1.16	0.036	1.09	1.23	1.05	1.27	3.07%	6.14%	9.21%	1.10	1.22
Mn, wt.%	0.072	0.004	0.065	0.079	0.061	0.083	5.07%	10.14%	15.20%	0.069	0.076
Mo, ppm	15.1	3.2	8.6	21.6	5.4	24.8	21.50%	42.99%	64.49%	14.3	15.9
Na, wt.%	0.330	0.009	0.311	0.348	0.302	0.357	2.79%	5.58%	8.37%	0.313	0.346
Nb, ppm	9.42	1.66	6.10	12.74	4.44	14.40	17.62%	35.24%	52.86%	8.95	9.89
Nd, ppm	30.3	1.21	27.9	32.7	26.7	33.9	3.99%	7.99%	11.98%	28.8	31.8
Ni, ppm	65	8	49	81	41	89	12.42%	24.85%	37.27%	62	68
P, wt.%	0.048	0.002	0.044	0.051	0.042	0.053	3.86%	7.71%	11.57%	0.045	0.050
Pb, ppm	271	28	215	326	188	354	10.21%	20.43%	30.64%	257	284
Pr, ppm	7.96	0.735	6.49	9.43	5.76	10.17	9.23%	18.47%	27.70%	7.56	8.36
Rb, ppm	154	7	139	168	132	175	4.68%	9.36%	14.03%	146	161
Re, ppm	0.032	0.004	0.025	0.039	0.021	0.043	11.12%	22.24%	33.36%	0.030	0.034
S, wt.%	4.25	0.071	4.11	4.39	4.04	4.46	1.66%	3.32%	4.97%	4.04	4.47
Sb, wt.%	7.03	1.54	3.95	10.11	2.41	11.65	21.90%	43.79%	65.69%	6.68	7.38
Sc, ppm	11.1	0.35	10.4	11.8	10.0	12.1	3.18%	6.37%	9.55%	10.5	11.6
Se, ppm	13.8	1.4	10.9	16.7	9.5	18.2	10.47%	20.94%	31.41%	13.1	14.5
Sm, ppm	5.48	0.378	4.73	6.24	4.35	6.62	6.89%	13.77%	20.66%	5.21	5.76
Sr, ppm	130	3	124	136	121	139	2.35%	4.71%	7.06%	123	136
Tb, ppm	0.53	0.10	0.33	0.73	0.23	0.83	18.70%	37.39%	56.09%	0.51	0.56

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

Note 1: intervals may appear asymmetric due to rounding. 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
4-Acid Digestion continued											
Th, ppm	13.9	0.97	12.0	15.8	11.0	16.8	6.98%	13.96%	20.94%	13.2	14.6
Ti, wt.%	0.249	0.057	0.136	0.362	0.079	0.419	22.73%	45.46%	68.19%	0.237	0.261
Tl, ppm	0.95	0.12	0.72	1.19	0.60	1.31	12.54%	25.09%	37.63%	0.91	1.00
U, ppm	2.43	0.164	2.10	2.76	1.94	2.92	6.75%	13.51%	20.26%	2.31	2.55
V, ppm	67	5.6	56	79	51	84	8.32%	16.65%	24.97%	64	71
W, ppm	5.06	1.21	2.64	7.49	1.42	8.70	23.96%	47.92%	71.88%	4.81	5.32
Y, ppm	15.8	2.4	10.9	20.7	8.5	23.1	15.44%	30.88%	46.32%	15.0	16.6
Yb, ppm	1.66	0.160	1.34	1.98	1.18	2.15	9.63%	19.25%	28.88%	1.58	1.75
Zn, ppm	250	27	196	303	170	329	10.65%	21.31%	31.96%	237	262
Zr, ppm	98	4.4	89	107	85	111	4.44%	8.87%	13.31%	93	103
Aqua Regia Digestion											
Ag, ppm	2.17	0.049	2.07	2.27	2.02	2.32	2.25%	4.50%	6.75%	2.06	2.28
Al, wt.%	1.03	0.082	0.87	1.20	0.79	1.28	7.96%	15.91%	23.87%	0.98	1.08
Ba, ppm	94	25	45	144	20	169	26.29%	52.57%	78.86%	90	99
Be, ppm	0.92	0.082	0.76	1.09	0.68	1.17	8.90%	17.80%	26.70%	0.88	0.97
Bi, ppm	3.73	0.315	3.10	4.36	2.78	4.67	8.44%	16.88%	25.33%	3.54	3.91
Ca, wt.%	0.550	0.021	0.509	0.592	0.488	0.613	3.76%	7.53%	11.29%	0.523	0.578
Cd, ppm	0.31	0.024	0.27	0.36	0.24	0.39	7.68%	15.36%	23.04%	0.30	0.33
Ce, ppm	26.4	3.7	19.1	33.8	15.5	37.4	13.81%	27.62%	41.43%	25.1	27.8
Co, ppm	24.2	1.11	22.0	26.5	20.9	27.6	4.56%	9.12%	13.68%	23.0	25.5
Cr, ppm	86	7.7	70	101	63	108	8.94%	17.89%	26.83%	81	90
Cs, ppm	4.13	0.50	3.13	5.13	2.63	5.63	12.14%	24.27%	36.41%	3.92	4.34
Cu, ppm	266	7	251	281	243	288	2.80%	5.60%	8.40%	252	279
Fe, wt.%	3.55	0.103	3.35	3.76	3.25	3.86	2.90%	5.79%	8.69%	3.38	3.73
Ga, ppm	3.21	0.320	2.57	3.85	2.25	4.17	9.97%	19.94%	29.90%	3.05	3.37
Hf, ppm	< 0.02	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Hg, ppm	0.35	0.026	0.30	0.41	0.27	0.43	7.51%	15.01%	22.52%	0.34	0.37
In, ppm	0.074	0.005	0.065	0.084	0.061	0.088	6.09%	12.19%	18.28%	0.071	0.078
K, wt.%	0.480	0.023	0.435	0.526	0.412	0.549	4.78%	9.56%	14.34%	0.456	0.504
La, ppm	15.4	1.50	12.3	18.4	10.8	19.9	9.79%	19.58%	29.37%	14.6	16.1
Li, ppm	11.8	1.2	9.4	14.2	8.1	15.5	10.34%	20.69%	31.03%	11.2	12.4
Mg, wt.%	0.870	0.013	0.844	0.896	0.830	0.910	1.52%	3.04%	4.56%	0.827	0.914
Mn, wt.%	0.073	0.003	0.067	0.079	0.065	0.082	3.95%	7.90%	11.84%	0.070	0.077
Mo, ppm	13.5	3.1	7.3	19.6	4.2	22.7	22.82%	45.64%	68.45%	12.8	14.1
Na, wt.%	0.033	0.004	0.025	0.041	0.021	0.045	12.11%	24.23%	36.34%	0.031	0.034
Nb, ppm	0.047	0.031	0.000	0.109	0.000	0.140	66.32%	132.65%	198.97%	0.044	0.049
Ni, ppm	71	2.6	66	76	64	79	3.61%	7.21%	10.82%	68	75
P, wt.%	0.034	0.007	0.021	0.047	0.014	0.054	19.49%	38.98%	58.48%	0.032	0.035
Rb, ppm	28.1	1.97	24.2	32.1	22.3	34.0	6.98%	13.97%	20.95%	26.7	29.6
Re, ppm	0.034	0.002	0.031	0.037	0.029	0.039	4.79%	9.58%	14.38%	0.032	0.035
S, wt.%	4.22	0.108	4.00	4.43	3.90	4.54	2.55%	5.10%	7.65%	4.01	4.43
Sb, wt.%	7.63	0.469	6.70	8.57	6.23	9.04	6.14%	12.28%	18.42%	7.25	8.02
Sn, ppm	5.11	0.181	4.75	5.47	4.56	5.65	3.54%	7.08%	10.62%	4.85	5.36

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											
Sr, ppm	88	5.8	76	100	70	105	6.61%	13.22%	19.83%	84	92
Ta, ppm	< 0.01	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Ti, wt.%	< 0.005	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Tl, ppm	0.45	0.032	0.39	0.51	0.35	0.55	7.09%	14.18%	21.27%	0.43	0.47
U, ppm	0.75	0.21	0.32	1.18	0.10	1.39	28.82%	57.64%	86.45%	0.71	0.78
V, ppm	16.1	1.38	13.4	18.9	12.0	20.2	8.54%	17.09%	25.63%	15.3	16.9
Y, ppm	6.06	0.451	5.15	6.96	4.70	7.41	7.44%	14.88%	22.32%	5.75	6.36
Zn, ppm	266	7	252	280	244	288	2.71%	5.42%	8.14%	253	279

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.

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20. Intertek, Townsville, QLD, Australia
21. Intertek Minerals Ltd, Tarkwa, Western Region, Ghana
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24. MSALABS, Val-d'Or, Quebec, Canada
25. MSALABS Timmins, Timmins, Ontario, Canada
26. Nagrom, Perth, WA, Australia
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39. UIS Analytical Services, Centurion, South Africa

Please note: To maintain anonymity of participating laboratories, the alphabetical list above does not correspond to the Lab ID numbers shown in the scatter plots below.

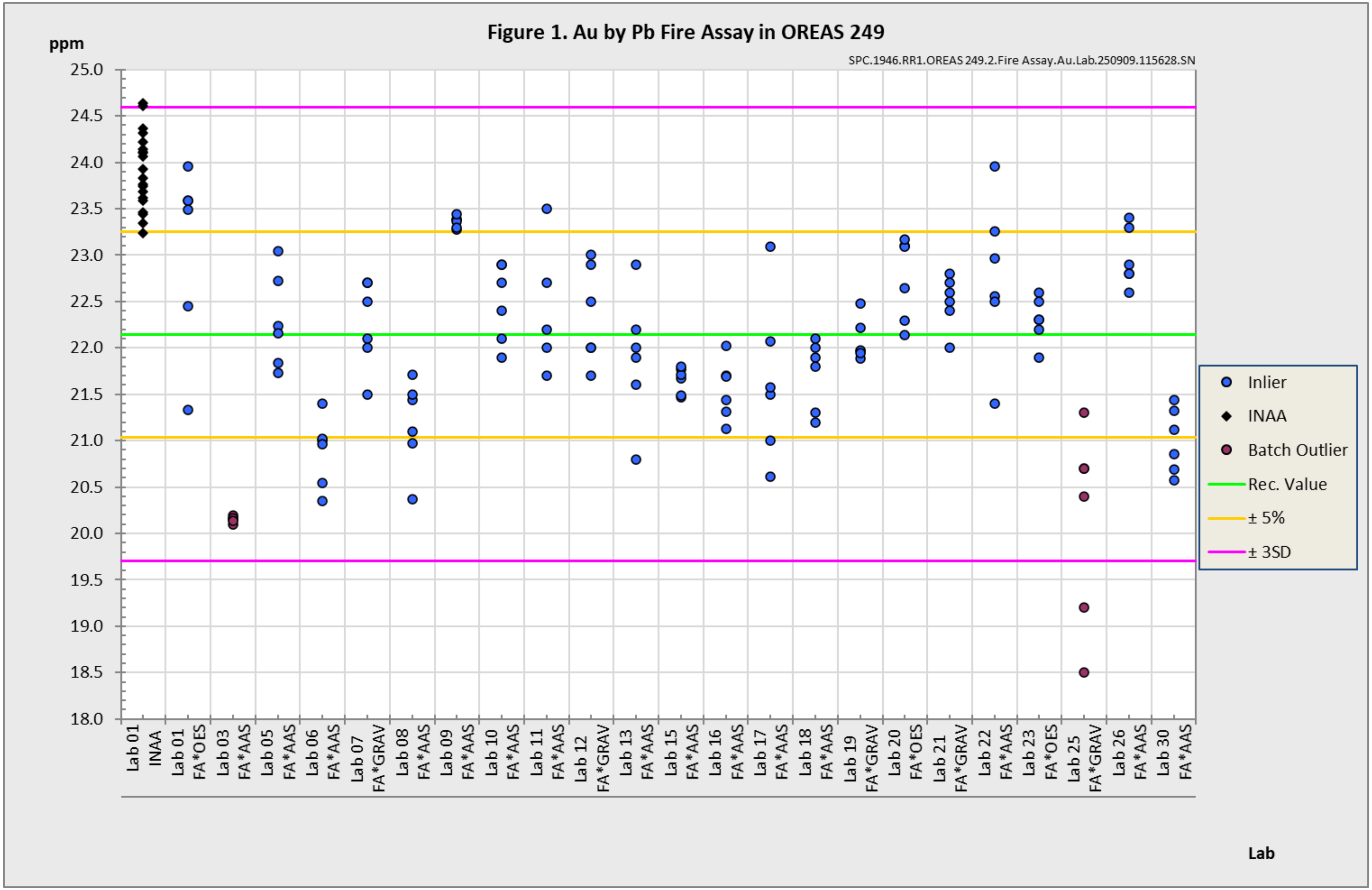
Figure 1. Au by Pb Fire Assay in OREAS 249
SPC.1946.RR1.OREAS 249.2.Fire Assay.Au.Lab.250909.115628.SN
ppm
25.0
24.5
24.0
23.5
23.0
22.5
22.0
21.5
21.0
20.5
20.0
19.5
19.0
18.5
18.0
Lab 01 INAA
Lab 01 FA*OES
Lab 03 FA*AAS
Lab 05 FA*AAS
Lab 06 FA*AAS
Lab 07 FA*GRAV
Lab 08 FA*AAS
Lab 09 FA*AAS
Lab 10 FA*AAS
Lab 11 FA*AAS
Lab 12 FA*GRAV
Lab 13 FA*AAS
Lab 15 FA*AAS
Lab 16 FA*AAS
Lab 17 FA*AAS
Lab 18 FA*AAS
Lab 19 FA*GRAV
Lab 20 FA*OES
Lab 21 FA*GRAV
Lab 22 FA*AAS
Lab 23 FA*OES
Lab 25 FA*GRAV
Lab 26 FA*AAS
Lab 30 FA*AAS
Lab
Inlier
INAA
Batch Outlier
Rec. Value
± 5%
± 3SD

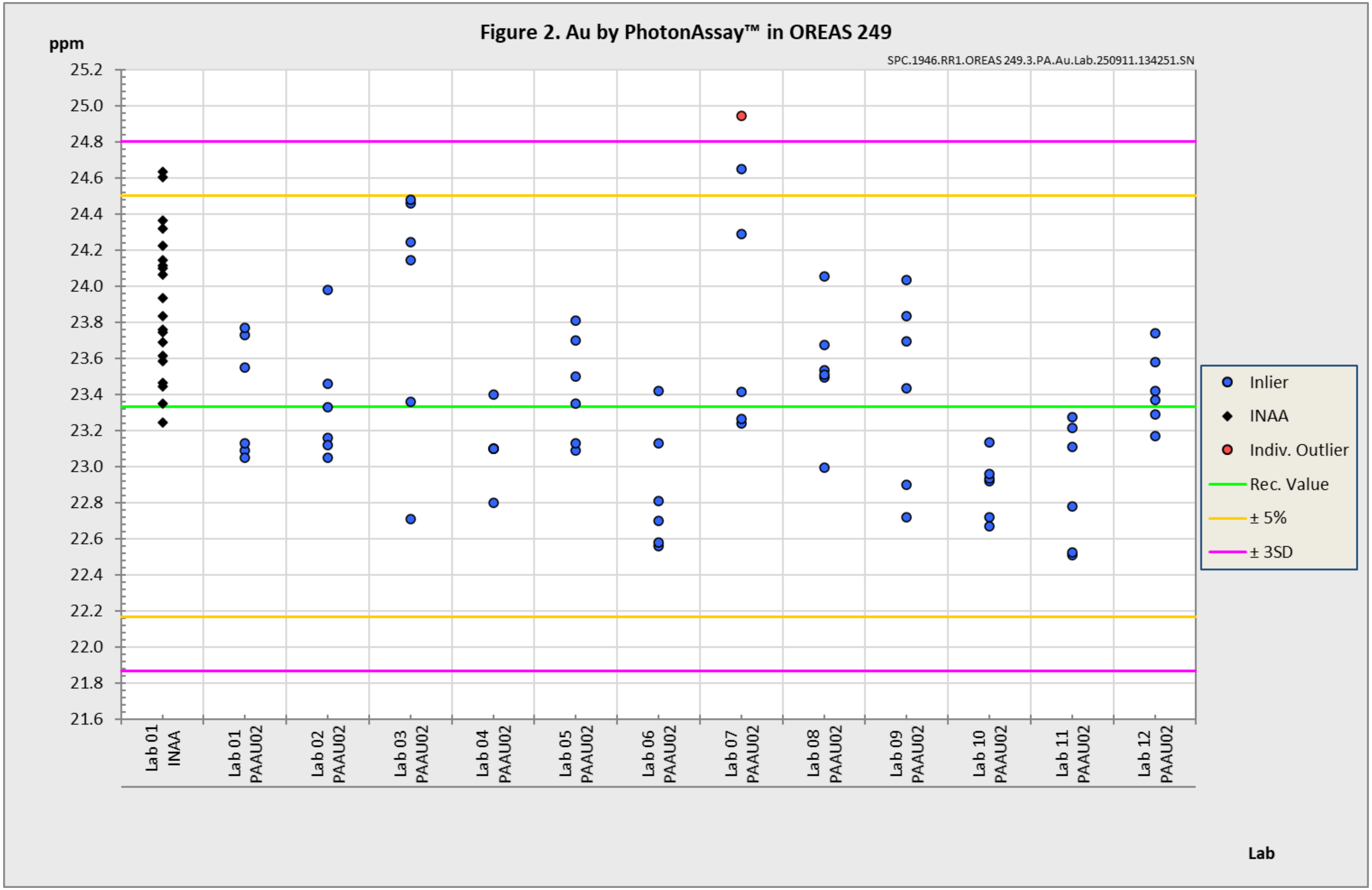
Figure 2. Au by PhotonAssay™ in OREAS 249
SPC.1946.RR1.OREAS 249.3.PA.Au.Lab.250911.134251.SN
ppm
25.2
25.0
24.8
24.6
24.4
24.2
24.0
23.8
23.6
23.4
23.2
23.0
22.8
22.6
22.4
22.2
22.0
21.8
21.6
Lab 01 INAA
Lab 01 PAAU02
Lab 02 PAAU02
Lab 03 PAAU02
Lab 04 PAAU02
Lab 05 PAAU02
Lab 06 PAAU02
Lab 07 PAAU02
Lab 08 PAAU02
Lab 09 PAAU02
Lab 10 PAAU02
Lab 11 PAAU02
Lab 12 PAAU02
Lab
Inlier
INAA
Indiv. Outlier
Rec. Value
± 5%
± 3SD

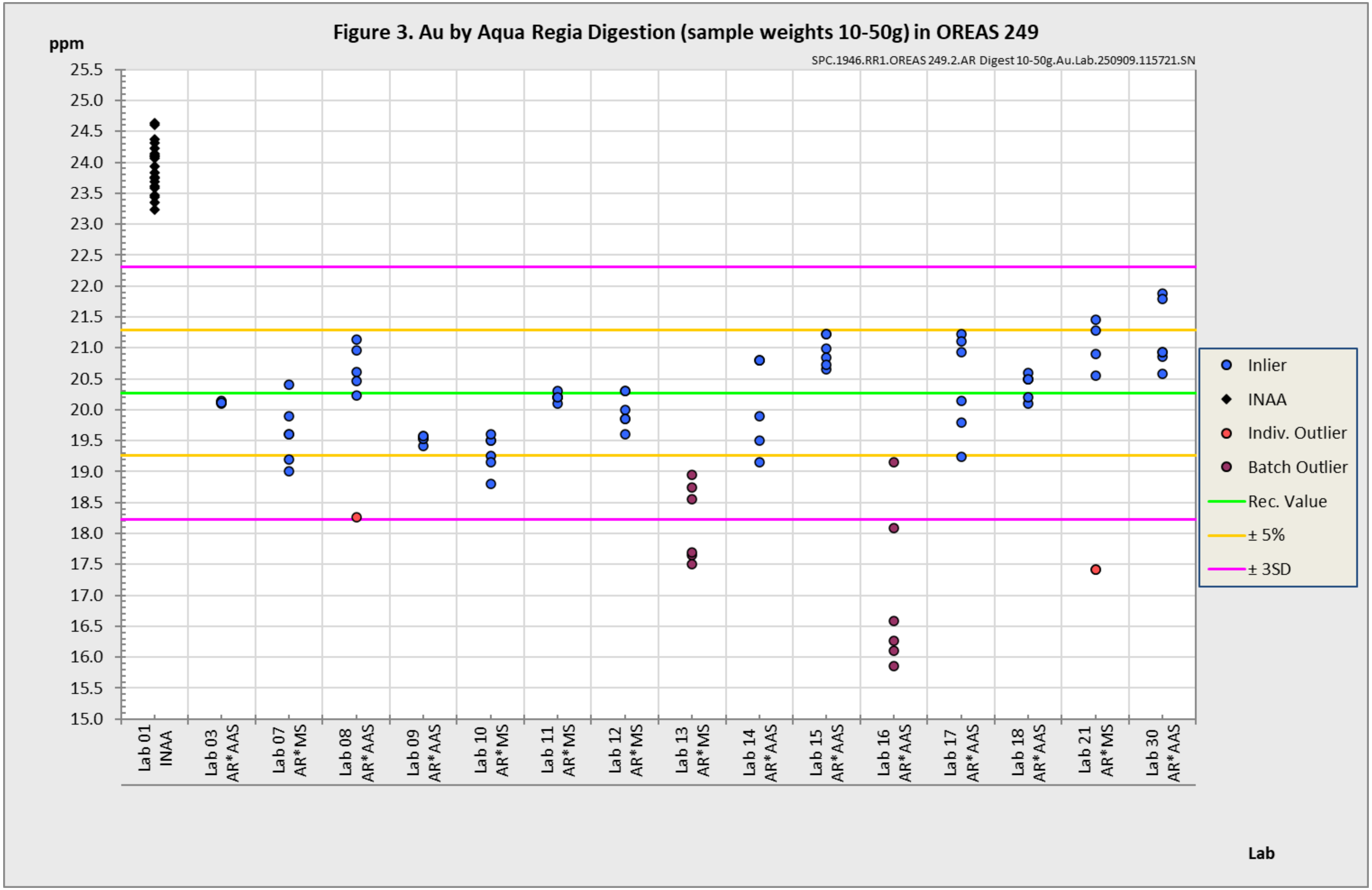
Figure 3. Au by Aqua Regia Digestion (sample weights 10-50g) in OREAS 249
SPC.1946.RR1.OREAS 249.2.AR Digest 10-50g.Au.Lab.250909.115721.SN
ppm
25.5
25.0
24.5
24.0
23.5
23.0
22.5
22.0
21.5
21.0
20.5
20.0
19.5
19.0
18.5
18.0
17.5
17.0
16.5
16.0
15.5
15.0
Lab 01 INAA
Lab 03 AR*AAS
Lab 07 AR*MS
Lab 08 AR*AAS
Lab 09 AR*AAS
Lab 10 AR*MS
Lab 11 AR*MS
Lab 12 AR*MS
Lab 13 AR*MS
Lab 14 AR*AAS
Lab 15 AR*AAS
Lab 16 AR*AAS
Lab 17 AR*AAS
Lab 18 AR*AAS
Lab 21 AR*MS
Lab 30 AR*AAS
Lab
Inlier
INAA
Indiv. Outlier
Batch Outlier
Rec. Value
± 5%
± 3SD

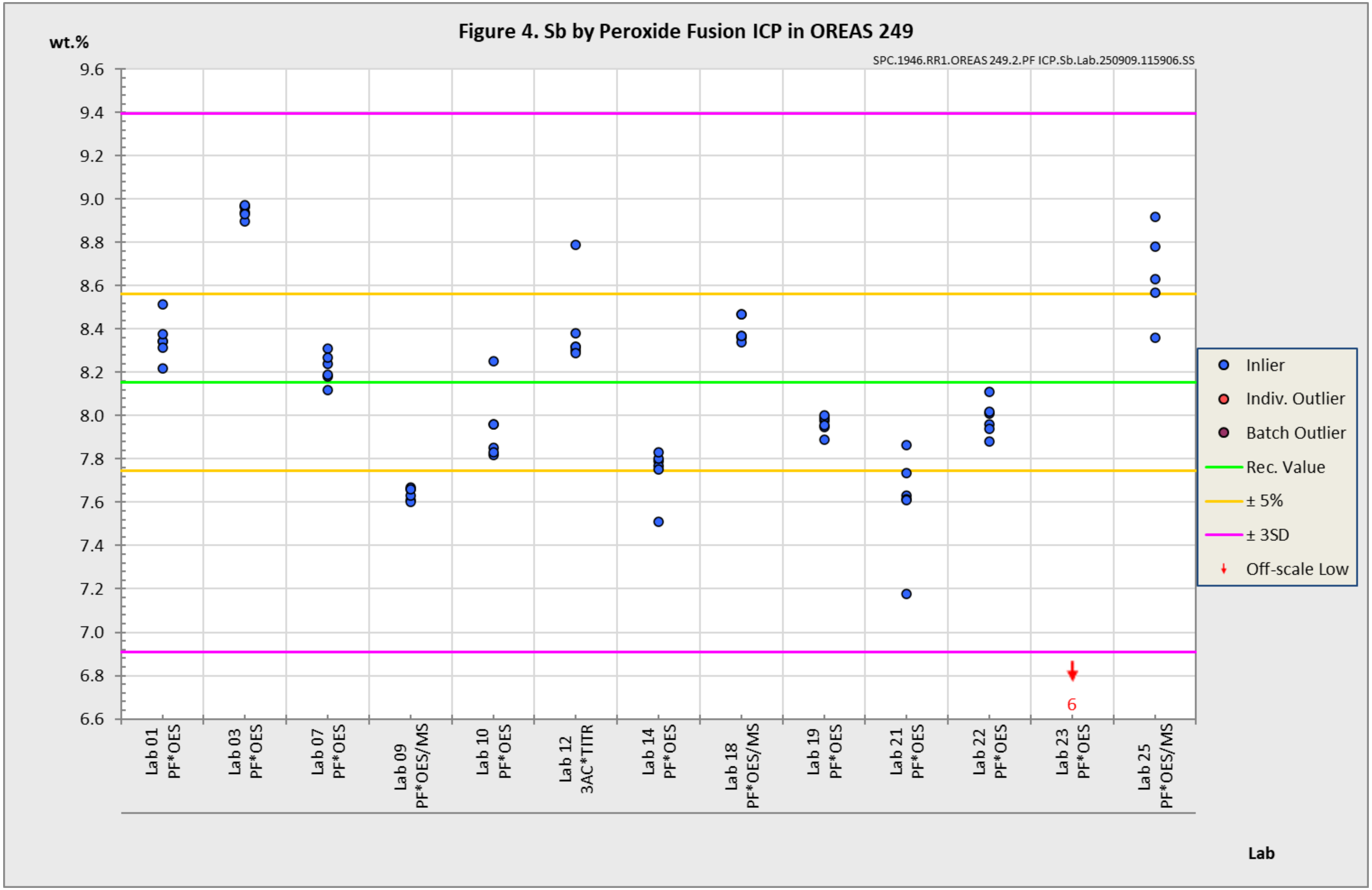
Figure 4. Sb by Peroxide Fusion ICP in OREAS 249
wt.%
SPC.1946.RR1.OREAS 249.2.PF ICP.Sb.Lab.250909.115906.SS
9.6
9.4
9.2
9.0
8.8
8.6
8.4
8.2
8.0
7.8
7.6
7.4
7.2
7.0
6.8
6.6
6
Lab 01 PF*OES
Lab 03 PF*OES
Lab 07 PF*OES
Lab 09 PF*OES/MS
Lab 10 PF*OES
Lab 12 3AC*TITR
Lab 14 PF*OES
Lab 18 PF*OES/MS
Lab 19 PF*OES
Lab 21 PF*OES
Lab 22 PF*OES
Lab 23 PF*OES
Lab 25 PF*OES/MS
Inlier
Indiv. Outlier
Batch Outlier
Rec. Value
± 5%
± 3SD
Off-scale Low
Lab

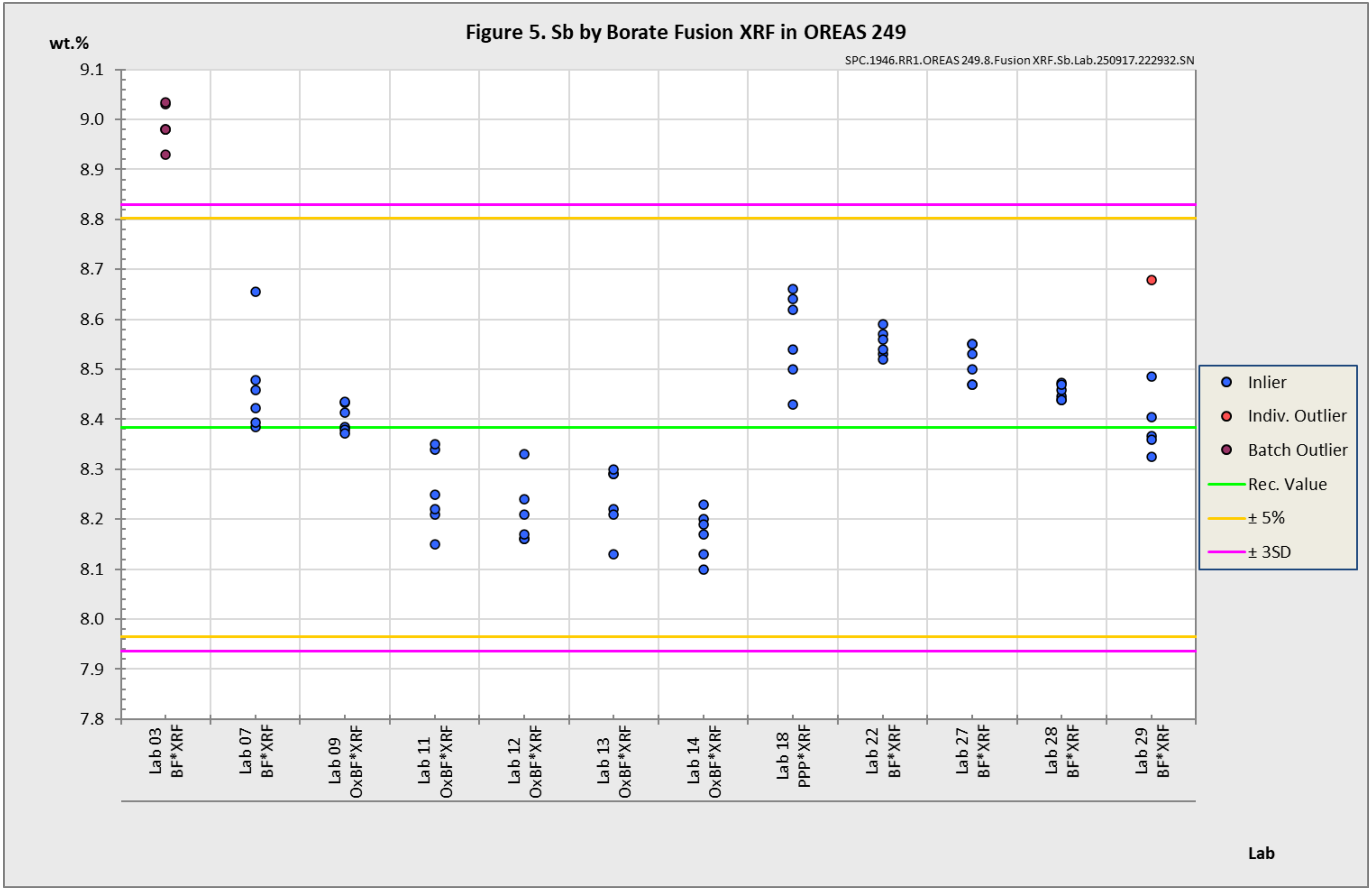
Figure 5. Sb by Borate Fusion XRF in OREAS 249
SPC.1946.RR1.OREAS 249.8.Fusion XRF.Sb.Lab.250917.222932.SN
wt.%
9.1
9.0
8.9
8.8
8.7
8.6
8.5
8.4
8.3
8.2
8.1
8.0
7.9
7.8
Lab 03 BF*XRF
Lab 07 BF*XRF
Lab 09 OxBF*XRF
Lab 11 OxBF*XRF
Lab 12 OxBF*XRF
Lab 13 OxBF*XRF
Lab 14 OxBF*XRF
Lab 18 PPP*XRF
Lab 22 BF*XRF
Lab 27 BF*XRF
Lab 28 BF*XRF
Lab 29 BF*XRF
Lab
Inlier
Indiv. Outlier
Batch Outlier
Rec. Value
± 5%
± 3SD

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.

Participating laboratories were selected based on demonstrated analytical competence, including prior performance in interlaboratory comparison programs conducted by ORE Pty Ltd, with consideration given to their expertise in relevant analytical methods, measurands, and sample matrices. For the measurands reported in this certificate (Table 1), data were sourced from laboratories accredited to ISO/IEC 17025. Where formal accreditation was not held for specific operationally defined measurands, metrological traceability was verified through the use of well-characterised, independently certified reference materials (CRMs) included as control samples in the round robin study.

In accordance with ISO 33405:2024-05 [5], clause 9.2.5, and ISO 17034:2016 [9], clause 7.12.4 b), the use of such control samples provides an acceptable means of demonstrating traceability in the absence of formal accreditation. In this certification program, traceability was further supported by the agreement of measured values for control samples with their known certified values, thereby offering additional confidence in the calibration and validity of measurement results across participating laboratories.

Operationally Defined Measurands

In accordance with ISO 33405:2024-05, Clause 9.2.4, measurands (analytes) may be certified as operationally defined. For these measurands, traceability to the SI may not be achievable because the analytical procedure involves sample transformations (e.g., leaching or extraction). While instrument calibration can be traceable to appropriate units, the transformation steps themselves are not directly traceable and can only be evaluated through reference comparisons or harmonized procedures.

Accordingly, characterisation of these measurands has been based on the concordance of results obtained from multiple laboratories using a common, well-defined procedure. This approach ensures fitness-for-purpose and fulfils the requirements for metrological traceability as specified in ISO 17034 and ISO 33405 for operationally defined measurands.

COMMUTABILITY

The certified values reported herein are derived from measurements performed using analytical methods involving sample pre-treatment steps, such as fusion or acid digestion. These processes convert the sample matrix into a chemically simplified and stable form, facilitating calibration traceable to primary standards via solution-based calibration protocols. Due to the established robustness and effectiveness of these pre-treatment methods, issues related to commutability are not expected to impact the suitability of this Certified Reference Material (CRM) for its intended use.

OREAS CRMs are prepared from natural ore materials, ensuring they retain matrix and mineralogical characteristics representative of typical exploration, mining, and process samples. Consistent with ISO 17034:2016 and ISO Guide 30, users are advised to select CRMs with matrix and mineralisation styles closely matching those of their routine samples to minimize matrix effects and enhance analytical comparability. Detailed descriptions of the CRM's source material and mineralogical characteristics are provided in the 'Source Material' section to guide appropriate CRM selection.

INTENDED USE

OREAS 249 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 249 may be used to calibrate the entire procedure by producing a pure substance CRM transformed into a calibration solution.

OREAS 249 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/ validation 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. 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).

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 lead fire assay: ≥25 g;
- Au by PhotonAssay™: recommended gross fill mass* 350-380 g;
- Au by aqua regia digestion ICP finish: ≥10 g.;
- Peroxide fusion with ICP finish: ≥0.1 g;
- Borate fusion with X-ray fluorescence finish: ≥0.2 g;
- 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;

**Recommended gross fill mass refers to the mass of the jar assembly, including jar base, lid, and contents. This fill range was developed using a ~40g empty jar but should be achievable for any jar-lid combination.*

PERIOD OF VALIDITY & STORAGE INSTRUCTIONS

The certification of OREAS 249 remains valid, within the specified measurement uncertainties, until at least October 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 sealed under nitrogen (10g and 60g units)

OREAS 249 contains sulphides (4.25 wt.% Total Sulphur by 4-acid digestion) and is packaged in single-use sachets sealed under nitrogen. Following analysis, it is the manufacturer's expectation that any remaining material is discarded unless the sachet is promptly resealed under nitrogen or vacuum. It is the user's responsibility to prevent contamination and minimise exposure to the atmosphere to avoid oxidation of the sulphide minerals.

OREAS 249 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.

*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

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

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

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

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

Authoritative Source of Information

This Certificate of Analysis constitutes the primary and authoritative document for the certified values, associated expanded uncertainties, and their correct use. While the accompanying DataPack provides supporting information, including raw data and uncertainty estimates with additional significant figures, these extended figures are provided solely for transparency, convenience and statistical reference. Users must rely exclusively on the values stated in this Certificate, rounded to an appropriate number of significant figures, for all metrological and analytical purposes. Any discrepancy between values presented in the DataPack and those in this Certificate shall be resolved in favour of the information provided herein.

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.

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DOCUMENT HISTORY

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0	22nd September, 2025	First publication.

CERTIFYING OFFICER

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QMS CERTIFICATION

ORE Pty Ltd is accredited for compliance with ISO 17034:2016 (Accreditation number 20483).

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.

REFERENCES

[1] Govett, G.J.S. (1983). Handbook of Exploration Geochemistry, Volume 2: Statistics and Data Analysis in Geochemical Prospecting (Variations of accuracy and precision).

[2] Ingamells, C. O. and Switzer, P. (1973). A Proposed Sampling Constant for Use in Geochemical Analysis, Talanta 20, 547-568.

[3] ISO Guide 30:2015. Terms and definitions used in connection with reference materials.

[4] ISO 33401:2024-01. Reference materials – Contents of certificates, labels and accompanying documentation.

[5] ISO 33405:2024-05. Reference materials – Approaches for characterization and assessment of homogeneity and stability.

[6] ISO Guide 98-3:2008. Guide to the expression of uncertainty in measurement (GUM:1995).

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

[8] ISO 17025:2017, General requirements for the competence of testing and calibration laboratories.

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

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

[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.

[13] OREAS-TN-05-1674: Long-term storage stability; an experimental study of OREAS CRMs.

[14] Thompson, A.; Taylor, B.N. (2008); Guide for the Use of the International System of Units (SI); NIST Special Publication 811; U.S. Government Printing Office: Washington, DC; available at: https://physics.nist.gov/cuu/pdf/sp811.pdf (accessed Nov 2021).

[15] Van der Veen A.M.H. et al. (2001). Uncertainty calculations in the certification of reference materials, Accred Qual Assur 6: 290-294.