Ore Research & Exploration P/L **ABN** 28 006 859 856
37A Hosie Street, Bayswater North, VIC 3153, Australia
P +61 3 9729 0333 | **E** info@ore.com.au | **oreas.com**

CERTIFICATE OF ANALYSIS FOR

ZINC CONCENTRATE

(McArthur River Mining operation, NT, Australia)

CERTIFIED REFERENCE MATERIAL

OREAS 349

Table 1. Certified Value, Uncertainty & Tolerances for Zn by classical techniques in OREAS 349.

Constituent	Certified Value†	95 % Expanded Uncertainty		95 % Tolerance Limits	
		Low	High	Low	High
Umpire Labs (dry sample basis)					
Classical Wet Chemistry					
Zn, Zinc (wt.%)	43.49	43.38	43.60	43.42	43.56

SI unit equivalents: wt.% (weight per cent) ≡ % (mass fraction).

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

Note: intervals may appear asymmetric due to rounding.

Accredited for compliance with ISO 17034

Table 2. Certified Values, Uncertainty & Tolerances for multi-elements by 4-acid digestion and S by infrared combustion in OREAS 349.

Constituent	Certified Value†	95 % Expanded Uncertainty		95 % Tolerance Limits	
		Low	High	Low	High
Geoanalytical Labs ('as received' sample basis)					
4-Acid Digestion					
Ag, Silver (ppm)	85.8	83.4	88.2	84.2	87.4
Al, Aluminium (wt.%)	0.816	0.791	0.841	0.800	0.831
As, Arsenic (ppm)	565	542	587	553	576
Be, Beryllium (ppm)	< 0.5	IND	IND	IND	IND
Bi, Bismuth (ppm)	61	57	65	59	63
Ca, Calcium (wt.%)	0.621	0.602	0.639	0.609	0.633
Cd, Cadmium (wt.%)	0.116	0.113	0.119	0.114	0.117
Ce, Cerium (ppm)	10.4	9.1	11.7	9.9	10.9
Co, Cobalt (ppm)	127	121	133	124	130
Cr, Chromium (ppm)	99	88	110	94	103
Cs, Caesium (ppm)	0.59	0.53	0.65	0.56	0.63
Cu, Copper (wt.%)	1.42	1.38	1.45	1.39	1.44
Dy, Dysprosium (ppm)	0.60	0.42	0.78	IND	IND
Er, Erbium (ppm)	0.38	0.27	0.49	IND	IND
Eu, Europium (ppm)	0.29	0.18	0.40	IND	IND
Fe, Iron (wt.%)	9.23	8.99	9.46	9.12	9.33
Ga, Gallium (ppm)	11.6	10.8	12.4	11.1	12.0
Gd, Gadolinium (ppm)	0.82	0.66	0.97	IND	IND
Hf, Hafnium (ppm)	0.64	0.52	0.75	0.60	0.67
In, Indium (ppm)	35.4	33.4	37.4	34.5	36.2
K, Potassium (wt.%)	0.226	0.216	0.236	0.222	0.231
Li, Lithium (ppm)	3.03	2.66	3.40	2.76	3.31
Mg, Magnesium (wt.%)	0.265	0.253	0.276	0.256	0.273
Mn, Manganese (wt.%)	0.464	0.453	0.475	0.455	0.472
Mo, Molybdenum (ppm)	170	164	177	167	174
Na, Sodium (wt.%)	0.173	0.165	0.181	0.170	0.177
Nb, Niobium (ppm)	0.90	0.80	1.01	0.83	0.97
Nd, Neodymium (ppm)	4.88	4.30	5.47	4.64	5.12
Ni, Nickel (ppm)	74	71	78	73	76
P, Phosphorus (wt.%)	0.011	0.010	0.012	IND	IND
Pb, Lead (wt.%)	2.19	2.13	2.25	2.15	2.23
Pr, Praseodymium (ppm)	1.27	1.10	1.45	IND	IND
Rb, Rubidium (ppm)	9.55	8.90	10.19	9.20	9.89
Re, Rhenium (ppm)	0.11	0.09	0.13	0.10	0.12

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

Note: intervals may appear asymmetric due to rounding.

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

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

Table 2 continued.

Constituent	Certified Value†	95 % Expanded Uncertainty		95 % Tolerance Limits	
		Low	High	Low	High
Geoanalytical Labs ('as received' sample basis)					
4-Acid Digestion continued					
S, Sulphur (wt.%)	28.56	27.49	29.63	28.09	29.03
Sb, Antimony (ppm)	689	658	720	678	700
Sc, Scandium (ppm)	1.54	1.37	1.71	IND	IND
Se, Selenium (ppm)	27.1	23.4	30.8	25.7	28.5
Sm, Samarium (ppm)	0.98	0.79	1.16	IND	IND
Sn, Tin (ppm)	11.3	10.1	12.6	10.6	12.0
Sr, Strontium (ppm)	41.2	36.9	45.4	39.4	42.9
Ta, Tantalum (ppm)	0.082	0.064	0.099	IND	IND
Te, Tellurium (ppm)	1.79	1.56	2.01	1.66	1.91
Th, Thorium (ppm)	1.55	1.27	1.84	1.47	1.63
Ti, Titanium (wt.%)	0.040	0.038	0.043	0.039	0.041
Tl, Thallium (ppm)	20.0	18.4	21.6	19.3	20.7
U, Uranium (ppm)	1.59	1.48	1.70	1.55	1.64
V, Vanadium (ppm)	13.2	11.7	14.6	IND	IND
W, Tungsten (ppm)	4.19	3.84	4.54	3.95	4.44
Y, Yttrium (ppm)	3.55	3.25	3.84	3.36	3.74
Yb, Ytterbium (ppm)	0.35	0.24	0.47	IND	IND
Zn, Zinc (wt.%)	44.03	42.64	45.43	43.05	45.02
Zr, Zirconium (ppm)	22.8	21.6	24.0	21.7	23.9
Infrared Combustion					
S, Sulphur (wt.%)	30.22	29.53	30.91	29.99	30.45

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

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

Note: intervals may appear asymmetric due to rounding;

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

Table 3. Certified Values, Uncertainty & Tolerances for other measurands in OREAS 349.

Constituent	Certified Value	95 % Expanded Uncertainty		95 % Tolerance Limits	
		Low	High	Low	High
Geoanalytical Labs ('as received' sample basis)					
Peroxide Fusion ICP					
Al, Aluminium (wt.%)	0.847	0.823	0.871	0.834	0.860
As, Arsenic (ppm)	606	577	634	588	623
Ba, Barium (ppm)	816	775	857	799	833
Be, Beryllium (ppm)	< 1	IND	IND	IND	IND
Bi, Bismuth (ppm)	62	57	66	60	64
Ca, Calcium (wt.%)	0.648	0.593	0.704	0.633	0.664
Cd, Cadmium (wt.%)	0.116	0.108	0.123	0.114	0.118
Ce, Cerium (ppm)	11.3	10.1	12.5	10.7	11.9
Co, Cobalt (ppm)	127	118	136	124	130
Cr, Chromium (ppm)	116	91	141	111	121
Cu, Copper (wt.%)	1.43	1.40	1.46	1.41	1.45
Fe, Iron (wt.%)	9.42	9.20	9.64	9.30	9.54
Ga, Gallium (ppm)	12.2	10.2	14.3	11.3	13.2
Gd, Gadolinium (ppm)	0.95	0.71	1.18	IND	IND
In, Indium (ppm)	36.0	32.6	39.3	35.1	36.8
K, Potassium (wt.%)	0.251	0.220	0.283	0.234	0.268
La, Lanthanum (ppm)	6.57	5.86	7.28	6.31	6.83
Mg, Magnesium (wt.%)	0.280	0.269	0.290	0.272	0.287
Mn, Manganese (wt.%)	0.472	0.457	0.487	0.467	0.478
Mo, Molybdenum (ppm)	176	162	190	170	182
Nd, Neodymium (ppm)	5.14	4.51	5.76	4.60	5.67
Ni, Nickel (ppm)	79	64	93	74	83
Pb, Lead (wt.%)	2.18	2.13	2.24	2.14	2.22
Pr, Praseodymium (ppm)	1.35	1.18	1.52	IND	IND
Rb, Rubidium (ppm)	10.2	9.0	11.3	9.7	10.7
S, Sulphur (wt.%)	29.97	29.22	30.73	29.50	30.45
Sb, Antimony (ppm)	731	684	779	719	744
Si, Silicon (wt.%)	2.96	2.86	3.06	2.89	3.03
Sm, Samarium (ppm)	1.01	0.83	1.20	IND	IND
Sr, Strontium (ppm)	50	46	54	48	52
Th, Thorium (ppm)	1.93	1.71	2.15	IND	IND
Ti, Titanium (wt.%)	0.046	0.041	0.050	IND	IND
Tl, Thallium (ppm)	20.7	19.3	22.1	19.9	21.4
Tm, Thulium (ppm)	< 0.1	IND	IND	IND	IND
U, Uranium (ppm)	1.74	1.55	1.93	IND	IND
V, Vanadium (ppm)	18.0	14.7	21.2	IND	IND

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

Table 3 continued.

Constituent	Certified Value[†]	95 % Expanded Uncertainty		95 % Tolerance Limits	
		Low	High	Low	High
Geoanalytical Labs ('as received' sample basis)					
Peroxide Fusion ICP continued					
W, Tungsten (ppm)	4.94	3.77	6.11	IND	IND
Y, Yttrium (ppm)	4.44	3.91	4.98	4.17	4.72
Yb, Ytterbium (ppm)	0.44	0.23	0.64	IND	IND
Zn, Zinc (wt.%)	43.96	43.10	44.83	43.62	44.31

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. Indicative Values for OREAS 349.

Constituent	Unit	Value	Constituent	Unit	Value	Constituent	Unit	Value
Umpire Labs ('as received' sample basis)								
Thermogravimetry								
H_2O-	wt.%	*0.705*						
Geoanalytical Labs ('as received' sample basis)								
4-Acid Digestion								
B	ppm	*25.7*	Hg	ppm	*10.6*	Lu	ppm	*0.054*
Ba	ppm	*106*	Ho	ppm	*0.12*	Tb	ppm	*0.10*
Ge	ppm	*6.04*	La	ppm	*5.05*	Tm	ppm	*< 0.1*
Infrared Combustion								
C	wt.%	*0.272*						
Peroxide Fusion ICP								
Ag	ppm	*88.4*	Hg	ppm	*< 5*	Re	ppm	*0.14*
B	ppm	*< 50*	Ho	ppm	*0.15*	Sc	ppm	*4.38*
Cs	ppm	*0.66*	Li	ppm	*4.48*	Se	ppm	*29.9*
Dy	ppm	*0.77*	LOI^{1000}	wt.%	*17.15*	Sn	ppm	*44.0*
Er	ppm	*0.46*	Lu	ppm	*0.086*	Ta	ppm	*0.26*
Eu	ppm	*0.35*	Na	wt.%	*0.167*	Tb	ppm	*0.14*
Ge	ppm	*17.7*	Nb	ppm	*1.15*	Te	ppm	*2.33*
Hf	ppm	*0.78*	P	wt.%	*0.011*	Zr	ppm	*32.1*

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

Reference materials are intended to provide a method of evaluating and improving the quality of analysis of geological and downstream metallurgical samples. To the analyst they provide an effective means of calibrating analytical equipment, assessing new techniques and routinely monitoring in-house procedures. OREAS prepared 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.

Tables 1 and 2 (all laboratories accredited to ISO 17025) and Table 3 (most laboratories accredited to ISO 17025) provide the certified values and their associated 95% expanded uncertainty and tolerance intervals, Table 4 shows indicative values including major and trace element characterisation, Table 5 provides some indicative physical properties and Table 6 provides indicative mineralogy based on semi-quantitative XRD analysis. Lastly, Table 7 presents the performance gate intervals for all certified values. Tabulated results of all analytes together with uncorrected means, medians, standard deviations, relative standard deviations and per cent deviation of lab means from the corrected mean of means (PDM[3]) are presented in the detailed certification data for this CRM (**OREAS 349-DataPack.1.0.241219_125105.xlsx**). Results are also presented in scatter plots for Zn by classical wet chemistry and Ag and Pb by 4-acid digestion method in Figures 1 to 3 respectively, together with ±3SD (magenta) and certified value (green line). Accepted individual results are coloured blue and individual and dataset outliers are identified in red and violet, respectively.

SOURCE MATERIAL

OREAS 349 is a replacement of the OREAS 350. It is a zinc concentrate certified reference material (CRM) prepared and certified by Ore Research & Exploration Pty Ltd. The material constituting OREAS 350 was sourced from the McArthur River Mining operation located in the Gulf of Carpentaria region in the Northern Territory of Australia. The mine is situated about 900 km southeast of Darwin. The major sulphides are pyrite, sphalerite and galena, with lesser chalcopyrite, arsenopyrite and marcasite.

COMMINUTION AND HOMOGENISATION PROCEDURES

The material constituting OREAS 349 was prepared in the following manner:

- Drying to constant mass at 85 °C;
- Multi-stage milling to 100 % minus 30 µm;
- Homogenisation using OREAS’ novel processing technologies;
- Packaging into 10 g units sealed under nitrogen in laminated foil pouches.

PHYSICAL PROPERTIES

OREAS 349 was tested at ORE Research & Exploration Pty Ltd’s onsite facility for various physical properties. Table 5 presents these findings that should be used for informational purposes only.

Table 5. Physical properties of OREAS 349.

Bulk Density (kg/m^3)	Moisture (wt.%)	Munsell Notation‡	Munsell Color‡
1013	0.65	5Y 4/1	Olive Gray

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

MINERALOGY

The semi-quantitative XRD results shown in Table 6 below were undertaken by ALS Metallurgy in Balcatta, Western Australia. The results have been normalised to 100 % and represent the relative proportion of crystalline material. Totals greater or less than 100 % are due to rounding errors. The most representative minerals in the sample are sphalerite, followed by pyrite, galena, anglesite and quartz. A presence of some amorphous material is very likely. Quantification of pyrite and sphalerite is based on an overlapping pattern and therefore carries some uncertainty.

Table 6. Indicative mineralogy of OREAS 349 based on semi-quantitative XRD analysis.

Mineral / Mineral Group	% (mass ratio)
Pyrite	10
Sphalerite	81
Galena	2
Chalcopyrite	1
Molybdenite	< 1
Anglesite	2
Chlorite	< 1
Annite - biotite - phlogopite	< 1
Plagioclase	1
Quartz	2
Gypsum	< 1

ANALYTICAL PROGRAM

For the interlaboratory ‘round robin’ certification program, a 400 g sample was taken at each of 6 predetermined sampling intervals immediately following homogenisation and are considered representative of the entire prepared batch of OREAS 349.

Umpire Laboratories

Seventeen ‘umpire’ laboratories each received a single 15 g sample and undertook copper and moisture analysis on the sample as received. The term ‘umpire’ here refers to the routine analysis by these laboratories using classical methodologies for precious and base metals.

Strict, pre-assay instructions were provided to ensure proper handling of moisture including:

- Equilibration of sample material to laboratory atmosphere for a minimum of 2 hours;
- Hygroscopic moisture analysis at 105 °C determined on a separate subsample <u>and weighed for analysis at the same time as the sample aliquots for Zn as per ISO 9599.</u>

The laboratories were requested to report analyte concentrations on both a dry (using the moisture value to correct the sample to dry basis) and moisture-bearing basis and include all results for moisture determinations. **The 'Umpire Lab' certified values shown in Table 1 are on a dry sample basis (see 'Instructions for correct use' section).**

The following analytical methods were undertaken:

- Zinc was determined in 3 trials by ethylenediaminetetraacetic acid (EDTA) with titration finish (8 laboratories) or classical volumetric titration (2 laboratories) and 3-acid digestion titration (1 laboratory).

Geoanalytical Laboratories

Nineteen geoanalytical laboratories also participated in the program where each laboratory received 6 x 15 g samples by taking two samples from each of three separate 400 g test units. This format enabled a nested ANOVA treatment of the results to evaluate homogeneity, i.e., to ascertain whether between-unit variance is greater than within-unit variance. The laboratories were instructed to undertake the following analyses:

- 4-acid (HNO_3-HF-$HClO_4$-HCl) digestion with full suite ICP-OES and ICP-MS elemental packages (up to 16 laboratories depending on the element);
- Total S by infrared combustion furnace/CS analyser (17 laboratories)
- Lithium borate or sodium peroxide fusion with full suite ICP-OES and ICP-MS elemental packages (up to 16 laboratories depending on the element).

For the round robin program, samples were taken at 6 predetermined sampling (lot) intervals during packaging and are considered representative of the entire prepared batch of OREAS 349. Six 15 g samples were dispatched to each laboratory and these were taken from either the *odd* or *even* sampling intervals during packaging in order to maximise representation.

STATISTICAL ANALYSIS

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

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

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

Indicative (uncertified) values (Table 4) are present where the number of laboratories reporting a particular analyte is insufficient (< 5) to support certification or where interlaboratory consensus is poor.

Standard Deviation intervals (see Table 7) 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*** (see 'Instructions for handling and correct use' section for more detail).

Homogeneity Evaluation

The tolerance limits (ISO 16269:2014) [6] shown in Tables 1, 2 and 3 were determined using an analysis of precision errors method and are considered a conservative estimate of true homogeneity. The meaning of tolerance limits may be illustrated for Zn by classical wet chemistry methods, where 99% of the time ($1-\alpha=0.99$) at least 95% of subsamples ($\rho=0.95$) will have concentrations lying between 43.42 and 43.56 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.***

ANOVA Study

In addition to the precision error method outlined above, homogeneity was also evaluated using an ANOVA study. This involved sending 12 x 15 g pulp samples to the ALS Brisbane laboratory for Zn, Pb and S analysis by borate fusion with XRF and Ag analysis by ore grade aqua regia digestion with AAS. The 12 samples consisted of paired samples from each of the six sampling (lot) intervals to enable an Analysis of Variance (ANOVA) by comparison of within- and between-unit variances across the six pairs. The ANOVA enables a relative measure of homogeneity and permits a test of the null hypothesis that all 'units' are drawn from the same population distribution. An ANOVA constructed in this way tests that no statistically significant difference exists in the variance between-units to that of the variance within-units. A *p*-value < 0.05 would indicate rejection of the null hypothesis at the 95 % confidence level (i.e., a significant difference likely does exist; meaning there is evidence of heterogeneity between the sample intervals).

No outliers are removed prior to the calculation of the *p*-values because the presence of outliers could indicate a degree of heterogeneity. The *p*-values were found to be insignificant for all analytes and the Null Hypothesis is therefore retained. It is important to note that ANOVA provides a relative measure of homogeneity and that a CRM having poor absolute homogeneity can still pass these tests if the within-unit heterogeneity is large and similar across all units. Lastly, a high degree of repeatability was in evidence across the 12 samples for each analyte. The calculated RSD's were 0.34 % for Zn, 1.10 % for Pb, 1.66 % for S and 3.58 % for Ag. Based on the homogeneity study and statistical analysis of the results of the interlaboratory certification program, it can be concluded that OREAS 349 is fit-for-purpose as a certified reference material (see ‘Intended Use’ below).

PERFORMANCE GATES

Table 7 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 7. Performance Gates for OREAS 349.

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
Umpire Labs (dry sample basis)											
Classical Wet Chemistry											
Zn, wt.%	43.49	0.185	43.12	43.86	42.93	44.05	0.43%	0.85%	1.28%	41.31	45.66
Geoanalytical Labs ('as received' sample basis)											
4-Acid Digestion											
Ag, ppm	85.8	1.77	82.3	89.3	80.5	91.1	2.06%	4.12%	6.18%	81.5	90.1
Al, wt.%	0.816	0.037	0.741	0.890	0.704	0.928	4.58%	9.15%	13.73%	0.775	0.857
As, ppm	565	17	531	598	514	615	2.96%	5.92%	8.89%	536	593
Be, ppm	< 0.5	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Bi, ppm	61	3.8	53	69	50	72	6.19%	12.39%	18.58%	58	64
Ca, wt.%	0.621	0.020	0.581	0.660	0.561	0.680	3.19%	6.38%	9.57%	0.590	0.652
Cd, wt.%	0.116	0.004	0.109	0.123	0.105	0.126	3.05%	6.10%	9.15%	0.110	0.121
Ce, ppm	10.4	1.3	7.7	13.1	6.4	14.4	12.83%	25.65%	38.48%	9.9	10.9
Co, ppm	127	9	109	144	101	153	6.89%	13.77%	20.66%	121	133
Cr, ppm	99	13	72	125	59	138	13.39%	26.77%	40.16%	94	104
Cs, ppm	0.59	0.036	0.52	0.67	0.48	0.70	6.13%	12.26%	18.39%	0.56	0.62
Cu, wt.%	1.42	0.031	1.35	1.48	1.32	1.51	2.16%	4.32%	6.48%	1.34	1.49
Dy, ppm	0.60	0.08	0.44	0.76	0.36	0.84	13.22%	26.43%	39.65%	0.57	0.63
Er, ppm	0.38	0.04	0.30	0.46	0.26	0.50	10.69%	21.38%	32.07%	0.36	0.40
Eu, ppm	0.29	0.05	0.20	0.38	0.15	0.43	15.76%	31.52%	47.27%	0.28	0.30

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

IND = indeterminate. 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 7 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
Geoanalytical Labs ('as received' sample basis)											
4-Acid Digestion continued											
Fe, wt.%	9.23	0.306	8.61	9.84	8.31	10.14	3.32%	6.64%	9.97%	8.76	9.69
Ga, ppm	11.6	0.67	10.2	12.9	9.6	13.6	5.79%	11.58%	17.37%	11.0	12.1
Gd, ppm	0.82	0.072	0.67	0.96	0.60	1.03	8.84%	17.67%	26.51%	0.78	0.86
Hf, ppm	0.64	0.07	0.50	0.77	0.44	0.83	10.31%	20.62%	30.94%	0.60	0.67
In, ppm	35.4	2.05	31.3	39.5	29.2	41.5	5.79%	11.58%	17.37%	33.6	37.1
K, wt.%	0.226	0.006	0.214	0.238	0.208	0.244	2.64%	5.28%	7.92%	0.215	0.237
Li, ppm	3.03	0.31	2.40	3.66	2.09	3.98	10.37%	20.73%	31.10%	2.88	3.19
Mg, wt.%	0.265	0.014	0.238	0.292	0.224	0.305	5.11%	10.22%	15.33%	0.251	0.278
Mn, wt.%	0.464	0.008	0.448	0.480	0.440	0.488	1.71%	3.41%	5.12%	0.441	0.487
Mo, ppm	170	7	157	184	150	190	3.91%	7.83%	11.74%	162	179
Na, wt.%	0.173	0.007	0.159	0.187	0.152	0.194	4.00%	8.01%	12.01%	0.164	0.182
Nb, ppm	0.90	0.09	0.72	1.08	0.63	1.17	10.01%	20.02%	30.03%	0.86	0.95
Nd, ppm	4.88	0.305	4.27	5.49	3.97	5.80	6.25%	12.49%	18.74%	4.64	5.13
Ni, ppm	74	4.0	66	82	62	86	5.46%	10.91%	16.37%	71	78
P, wt.%	0.011	0.001	0.009	0.013	0.008	0.014	8.17%	16.35%	24.52%	0.010	0.012
Pb, wt.%	2.19	0.062	2.07	2.32	2.00	2.38	2.84%	5.68%	8.53%	2.08	2.30
Pr, ppm	1.27	0.118	1.04	1.51	0.92	1.63	9.25%	18.50%	27.75%	1.21	1.34
Rb, ppm	9.55	0.323	8.90	10.19	8.58	10.51	3.38%	6.76%	10.14%	9.07	10.02
Re, ppm	0.11	0.01	0.09	0.13	0.08	0.15	10.21%	20.42%	30.63%	0.11	0.12
S, wt.%	28.56	1.378	25.81	31.32	24.43	32.69	4.82%	9.65%	14.47%	27.13	29.99
Sb, ppm	689	45	598	779	553	825	6.57%	13.14%	19.72%	655	723
Sc, ppm	1.54	0.124	1.29	1.79	1.17	1.91	8.06%	16.13%	24.19%	1.46	1.62
Se, ppm	27.1	4.0	19.1	35.1	15.1	39.0	14.72%	29.44%	44.17%	25.7	28.4
Sm, ppm	0.98	0.080	0.82	1.14	0.74	1.22	8.19%	16.39%	24.58%	0.93	1.02
Sn, ppm	11.3	1.10	9.1	13.5	8.0	14.6	9.69%	19.38%	29.07%	10.8	11.9
Sr, ppm	41.2	5.9	29.4	52.9	23.5	58.8	14.28%	28.57%	42.85%	39.1	43.2
Ta, ppm	0.082	0.013	0.055	0.108	0.042	0.122	16.24%	32.48%	48.72%	0.078	0.086
Te, ppm	1.79	0.22	1.35	2.22	1.13	2.44	12.23%	24.46%	36.69%	1.70	1.88
Th, ppm	1.55	0.29	0.97	2.14	0.68	2.43	18.77%	37.53%	56.30%	1.48	1.63
Ti, wt.%	0.040	0.003	0.035	0.046	0.032	0.048	6.63%	13.27%	19.90%	0.038	0.042
Tl, ppm	20.0	1.78	16.5	23.6	14.7	25.3	8.88%	17.76%	26.64%	19.0	21.0
U, ppm	1.59	0.073	1.45	1.74	1.37	1.81	4.59%	9.18%	13.77%	1.51	1.67
V, ppm	13.2	1.6	10.0	16.4	8.4	18.0	12.15%	24.31%	36.46%	12.5	13.8
W, ppm	4.19	0.268	3.66	4.73	3.39	5.00	6.39%	12.79%	19.18%	3.98	4.40
Y, ppm	3.55	0.202	3.14	3.95	2.94	4.15	5.71%	11.41%	17.12%	3.37	3.72
Yb, ppm	0.35	0.04	0.27	0.44	0.23	0.48	11.90%	23.80%	35.70%	0.34	0.37
Zn, wt.%	44.03	1.067	41.90	46.17	40.83	47.23	2.42%	4.85%	7.27%	41.83	46.23
Zr, ppm	22.8	1.06	20.7	24.9	19.6	26.0	4.67%	9.33%	14.00%	21.7	24.0
Infrared Combustion											
S, wt.%	30.22	0.897	28.42	32.01	27.52	32.91	2.97%	5.94%	8.91%	28.71	31.73

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

Table 7 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
Geoanalytical Labs ('as received' sample basis)											
Peroxide Fusion ICP											
Al, wt.%	0.847	0.020	0.808	0.886	0.788	0.906	2.32%	4.64%	6.97%	0.805	0.889
As, ppm	606	35	535	676	500	711	5.81%	11.63%	17.44%	575	636
Ba, ppm	816	37	741	891	704	929	4.59%	9.19%	13.78%	775	857
Be, ppm	< 1	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Bi, ppm	62	3.3	55	68	52	71	5.29%	10.58%	15.87%	59	65
Ca, wt.%	0.648	0.058	0.532	0.765	0.474	0.823	8.99%	17.97%	26.96%	0.616	0.681
Cd, wt.%	0.116	0.007	0.103	0.129	0.096	0.135	5.64%	11.28%	16.91%	0.110	0.121
Ce, ppm	11.3	0.91	9.5	13.1	8.6	14.0	8.03%	16.07%	24.10%	10.7	11.9
Co, ppm	127	10	107	148	97	158	7.95%	15.90%	23.86%	121	134
Cr, ppm	116	31	53	179	22	210	27.00%	54.00%	81.01%	110	122
Cu, wt.%	1.43	0.019	1.39	1.47	1.37	1.49	1.35%	2.71%	4.06%	1.36	1.50
Fe, wt.%	9.42	0.175	9.07	9.77	8.90	9.95	1.86%	3.72%	5.57%	8.95	9.89
Ga, ppm	12.2	1.4	9.4	15.0	8.0	16.5	11.51%	23.01%	34.52%	11.6	12.8
Gd, ppm	0.95	0.11	0.74	1.16	0.63	1.26	11.09%	22.18%	33.27%	0.90	1.00
In, ppm	36.0	2.32	31.3	40.6	29.0	43.0	6.46%	12.92%	19.37%	34.2	37.8
K, wt.%	0.251	0.043	0.166	0.337	0.124	0.379	16.92%	33.85%	50.77%	0.239	0.264
La, ppm	6.57	0.473	5.62	7.52	5.15	7.99	7.20%	14.40%	21.60%	6.24	6.90
Mg, wt.%	0.280	0.012	0.257	0.303	0.245	0.314	4.12%	8.24%	12.36%	0.266	0.294
Mn, wt.%	0.472	0.014	0.445	0.500	0.432	0.513	2.89%	5.78%	8.66%	0.449	0.496
Mo, ppm	176	15	145	207	130	222	8.69%	17.39%	26.08%	167	185
Nd, ppm	5.14	0.392	4.35	5.92	3.96	6.31	7.64%	15.27%	22.91%	4.88	5.39
Ni, ppm	79	12	55	102	44	113	14.76%	29.52%	44.29%	75	82
Pb, wt.%	2.18	0.055	2.07	2.29	2.02	2.35	2.53%	5.07%	7.60%	2.07	2.29
Pr, ppm	1.35	0.081	1.19	1.51	1.11	1.60	6.01%	12.02%	18.03%	1.28	1.42
Rb, ppm	10.2	0.67	8.9	11.5	8.2	12.2	6.55%	13.10%	19.64%	9.7	10.7
S, wt.%	29.97	0.769	28.44	31.51	27.67	32.28	2.56%	5.13%	7.69%	28.48	31.47
Sb, ppm	731	46	639	824	593	870	6.30%	12.60%	18.90%	695	768
Si, wt.%	2.96	0.087	2.78	3.13	2.70	3.22	2.95%	5.90%	8.84%	2.81	3.11
Sm, ppm	1.01	0.075	0.86	1.16	0.79	1.24	7.40%	14.80%	22.20%	0.96	1.06
Sr, ppm	50	3.9	42	58	39	62	7.77%	15.54%	23.31%	48	53
Th, ppm	1.93	0.171	1.59	2.27	1.42	2.44	8.86%	17.71%	26.57%	1.83	2.02
Ti, wt.%	0.046	0.004	0.038	0.054	0.034	0.058	8.84%	17.68%	26.52%	0.043	0.048
Tl, ppm	20.7	0.98	18.7	22.6	17.7	23.6	4.74%	9.48%	14.22%	19.7	21.7
Tm, ppm	< 0.1	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
U, ppm	1.74	0.155	1.43	2.05	1.27	2.20	8.95%	17.89%	26.84%	1.65	1.82
V, ppm	18.0	3.1	11.8	24.1	8.7	27.2	17.23%	34.46%	51.69%	17.1	18.9
W, ppm	4.94	0.62	3.69	6.18	3.07	6.81	12.62%	25.23%	37.85%	4.69	5.18
Y, ppm	4.44	0.414	3.61	5.27	3.20	5.68	9.32%	18.64%	27.96%	4.22	4.66
Yb, ppm	0.44	0.08	0.27	0.60	0.19	0.68	18.56%	37.11%	55.67%	0.42	0.46
Zn, wt.%	43.96	0.725	42.51	45.41	41.79	46.14	1.65%	3.30%	4.95%	41.76	46.16

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

PREPARER

Certified reference material OREAS 349 is prepared and certified by:

ORE Research & Exploration Pty Ltd
37A Hosie Street
Bayswater North VIC 3153
AUSTRALIA

Tel: +613-9729 0333
Fax: +613-9729 8338
Web: www.oreas.com
Email: info@ore.com.au

PARTICIPATING LABORATORIES

1. ♦*Actlabs, Ancaster, Ontario, Canada
2. ♦AH Knight, St Helens, Merseyside, UK
3. ♦AH Knight, Tianjin, China
4. ♦Alex Stewart International, Liverpool, UK
5. *ALS, Brisbane, QLD, Australia
6. *ALS, Lima, Peru
7. *ALS, Loughrea, Galway, Ireland
8. *ALS, Malaga, WA, Australia
9. *ALS, Vancouver, BC, Canada
10. *American Assay Laboratories, Sparks, Nevada, USA
11. *ARGETEST Mineral Processing, Ankara, Central Anatolia, Turkey
12. ♦Bachelet, Angleur, Liege, Belgium
13. *Bureau Veritas Commodities Canada Ltd, Vancouver, BC, Canada
14. *Bureau Veritas Geoanalytical, Adelaide, SA, Australia
15. *CERTIMIN, Lima, Peru
16. ♦Erdenet Central Chemical Laboratory, Erdenet, Orkhon province, Mongolia
17. ♦*Inspectorate (BV), Lima, Peru
18. ♦Inspectorate (BV), Shanghai, Bao Shan District, China
19. ♦Inspectorate (BV), Witham, Essex, UK
20. ♦Inspectorate Griffith India, Gandhidham, Gujarat, India
21. *Intertek, Cupang, Muntinlupa, Philippines
22. *Intertek, Perth, WA, Australia
23. *PT Geoservices Ltd, Cikarang, Jakarta Raya, Indonesia
24. *PT Intertek Utama Services, Jakarta Timur, DKI Jakarta, Indonesia
25. ♦SGS Lakefield Research Ltd, Lakefield, Ontario, Canada
26. *Shiva Analyticals Ltd, Bangalore North, Karnataka, India
27. *Skyline Assayers & Laboratories, Tucson, Arizona, USA
28. *Stewart Assay & Environmental Laboratories LLC, Kara-Balta, Chüy, Kyrgyzstan

*♦= Umpire laboratory (classical methods); * = Geoanalytical laboratory (instrumental methods).*

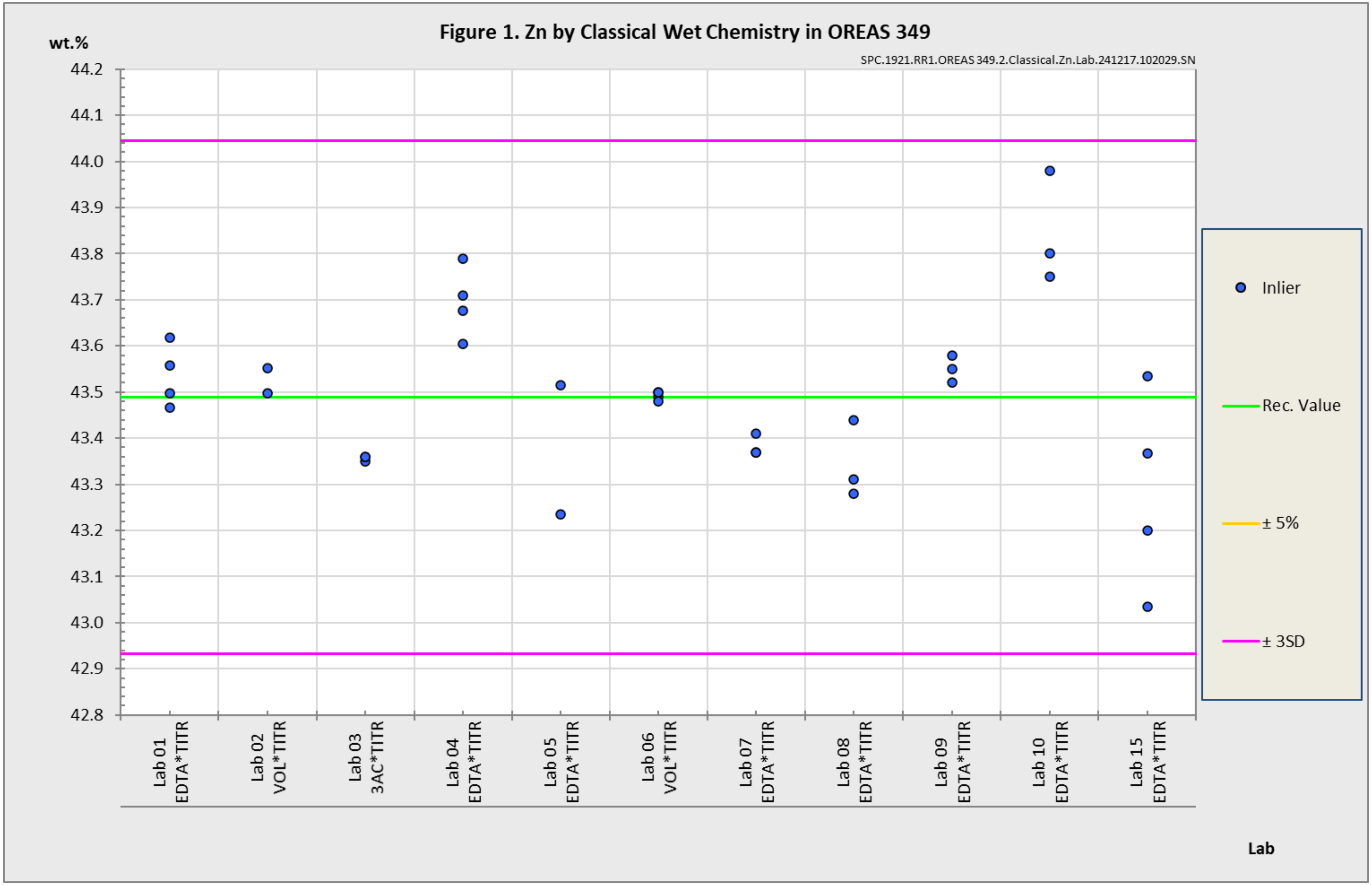


Figure 1. Zn by Classical Wet Chemistry in OREAS 349
SPC.1921.RR1.OREAS 349.2.Classical.Zn.Lab.241217.102029.SN
wt.%
44.2
44.1
44.0
43.9
43.8
43.7
43.6
43.5
43.4
43.3
43.2
43.1
43.0
42.9
42.8
Lab 01 EDTA*TITR
Lab 02 VOL*TITR
Lab 03 3AC*TITR
Lab 04 EDTA*TITR
Lab 05 EDTA*TITR
Lab 06 VOL*TITR
Lab 07 EDTA*TITR
Lab 08 EDTA*TITR
Lab 09 EDTA*TITR
Lab 10 EDTA*TITR
Lab 15 EDTA*TITR
Lab
Inlier
Rec. Value
± 5%
± 3SD

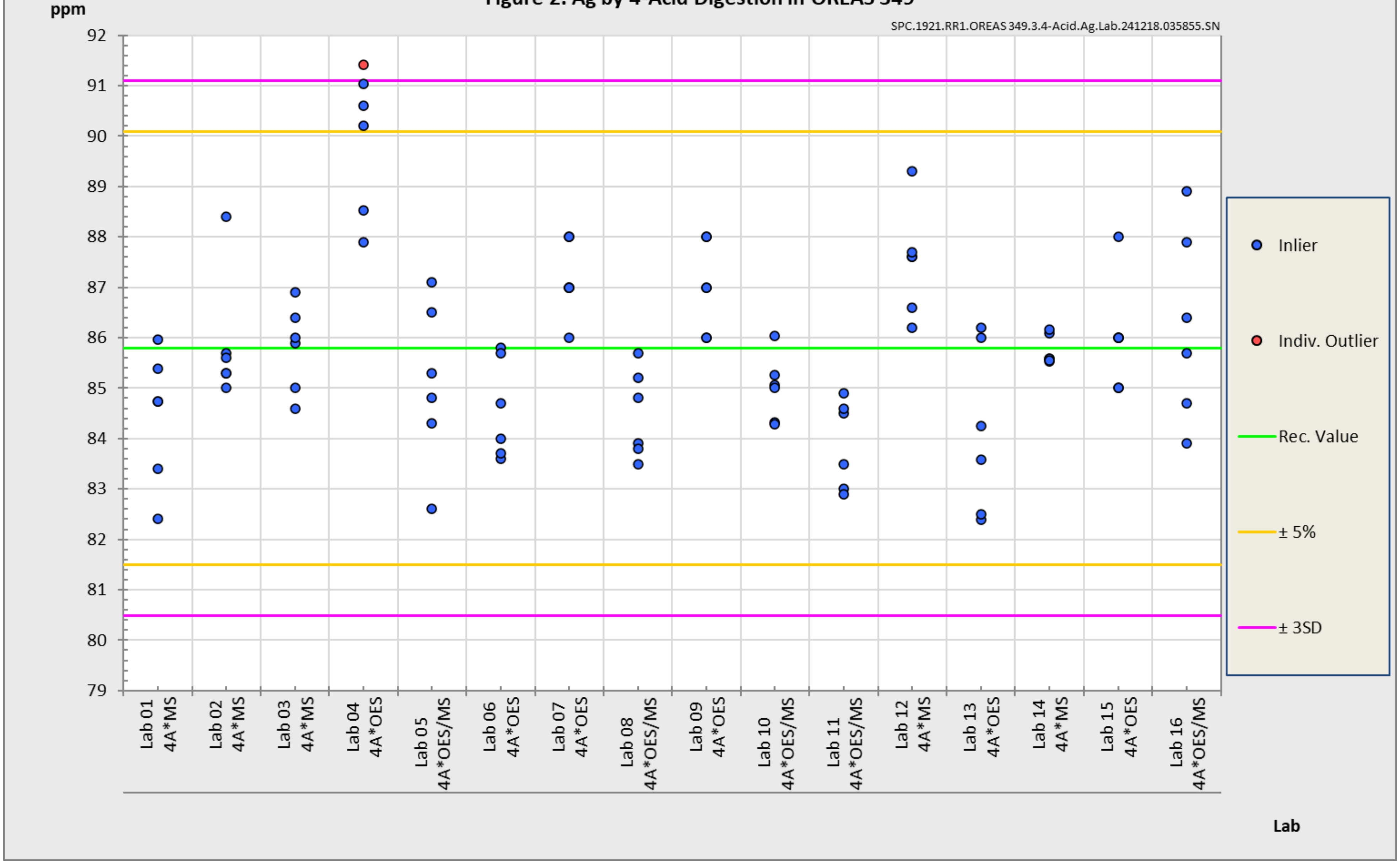
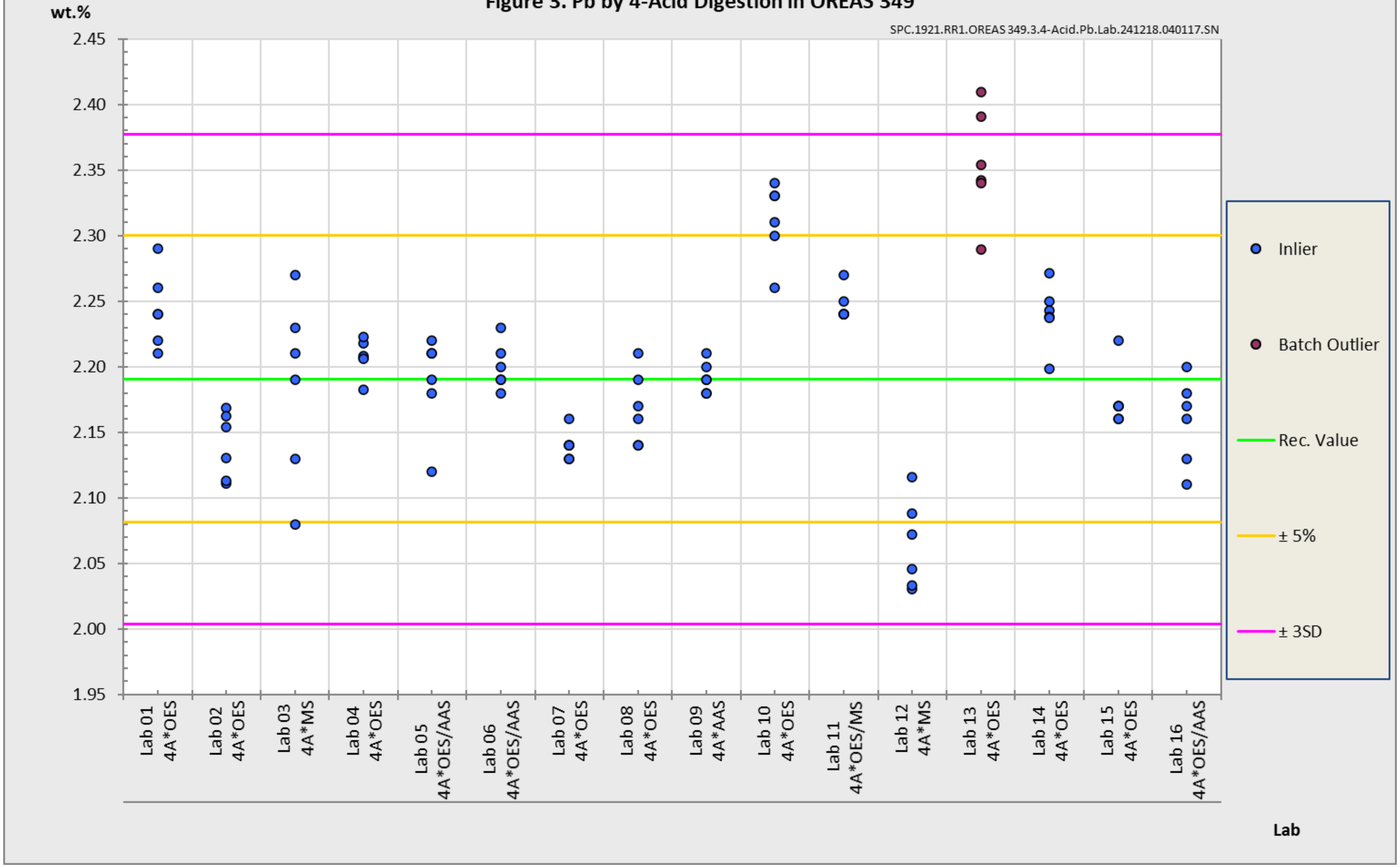


Figure 2. Ag by 4-Acid Digestion in OREAS 349

Figure 3. Pb by 4-Acid Digestion in OREAS 349



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 [10], each analytical data set received from the participating laboratories has been validated by its assayer through the inclusion of internal reference materials and QC checks during and post analysis.

The participating laboratories were chosen on the basis of their competence (from past performance in interlaboratory programs undertaken by ORE Pty Ltd) for a particular analytical method, analyte or analyte suite and sample matrix. These laboratories are accredited to ISO 17025 for Zn by classical wet chemistry methods, multi-elements by 4-acid digestion and Total S by IR combustion furnace (Tables 1 and 2). The other operationally defined measurands characterised in this certificate are derived from data procured mostly from ISO 17025 accredited laboratories (Table 3). The certified values presented in this report are calculated from the means of accepted data following robust technical and statistical analysis as detailed in this report.

Guide ISO/TR 16476:2016 [7], section 5.3.1 describes metrological traceability in reference materials as it pertains to the transformation of the measurand. In this section it states, *"Although the determination of the property value itself can be made traceable to appropriate units through, for example, calibration of the measurement equipment used, steps like the transformation of the sample from one physical (chemical) state to another cannot. Such transformations may only be compared with a reference (when available), or among themselves. For some transformations, reference methods have been defined and may be used in certification projects to evaluate the uncertainty associated with such a transformation.* ***In other cases, only a comparison among different laboratories using the same procedure is possible. In this case, it is impossible to demonstrate absence of method bias; therefore, the result is an operationally defined measurand*** *(ISO Guide 35:2017, 9.2.4c) [4]."* Certification takes place on the basis of agreement among operationally defined, independent measurement results.

COMMUTABILITY

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

INTENDED USE

OREAS 349 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 349 may be used to calibrate the entire procedure by producing a pure substance CRM transformed into a calibration solution.

OREAS 349 is intended for the following uses:

- For the monitoring of laboratory performance in the analysis of analytes reported in Tables 1, 2 and 3 in geological samples;
- For the verification of analytical methods for analytes reported in Tables 1, 2 and 3;
- For the calibration of instruments used in the determination of the concentration of analytes reported in Tables 1, 2 and 3. 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, 2 and 3).

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:

- Zn by classical wet chemistry: ≥ 0.5 g;
- 4-acid digestion with ICP-OES and/or MS finish: ≥ 0.25 g;
- Total S by Infrared combustion furnace/CS analyser: ≥ 0.1 g;
- Peroxide fusion with ICP-OES and/or MS finish: ≥ 0.1 g.

PERIOD OF VALIDITY & STORAGE INSTRUCTIONS

OREAS 349 is high in reactive sulphide content and has been packaged under a nitrogen environment in robust laminated foil pouches in single-use 10 g units. In its unopened state in the sachets (sealed under nitrogen), OREAS 349 has a shelf life of at least ten years (August 2034). OREAS Pty Ltd will monitor this CRM over the period of its validity and if substantive technical changes occur that affect value assignment before expiration, OREAS will notify the purchaser (using the contact’s email address on the Sales Order).

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

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 [15].

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

Umpire laboratories using classical methods:

The umpire laboratory certified value for Zn refers to the concentration level on a dry sample basis. At each laboratory, analyses were performed on the sample as received (without drying) with the subsample for moisture analysis weighed simultaneously with the subsamples for the Zn assay. The Zn data was then corrected to dry basis using the moisture value obtained at each laboratory.

With the exception of one laboratory, moisture content varied amongst the laboratories from 0.50-0.89 % with a best consensus value of 0.70 %. The indicative value provided for moisture (H_2O-) should be viewed as informational only. Hygroscopic moisture is a dynamic property of pulp materials and will vary in response to the local laboratory atmosphere following equilibration.

Geoanalytical laboratories using instrumental methods:

All analyses were performed on the samples as received and reported as such in line with conventional instrumental method procedures.

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 7 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 interval then generally there is no cause for concern in regard to bias.

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

DOCUMENT HISTORY

Revision No.	Date	Changes applied
1	5th May, 2025	Changed ‘Pb Fire Assay’ Table 7 header to ‘4 Acid Digestion’.
0	15th Jan, 2025	First publication.

QMS CERTIFICATION

ORE Pty Ltd is accredited for compliance with ISO 17034.

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

CERTIFYING OFFICER

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

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

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

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

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

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

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

[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.