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

CERTIFIED REFERENCE MATERIAL

OREAS 353c

Lead-Silver Concentrate
(Cannington Mine, Northwest Queensland, Australia)

Table 1. Certified Value, Uncertainty & Tolerance Intervals for OREAS 353c.

Constituent	Certified Value†	95 % Expanded Uncertainty		95 % Tolerance Limits	
		Low	High	Low	High
Umpire Labs (dry sample basis)					
Classical Wet Chemistry					
Pb, Lead (wt.%)	72.29	72.20	72.37	72.21	72.37
Pb Fire Assay					
Ag, Silver (wt.%)	0.269	0.267	0.270	0.267	0.270

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

†These operationally defined measurands meet the requirements of ISO 17034 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 1 continued.

Constituent	Certified Value†	95 % Expanded Uncertainty		95 % Tolerance Limits	
		Low	High	Low	High
Geoanalytical Labs ('as received' sample basis)					
4-Acid Digestion					
Ag, Silver (wt.%)	0.268	0.259	0.278	0.263	0.274
Al, Aluminium (wt.%)	0.098	0.086	0.110	0.092	0.104
As, Arsenic (ppm)	296	285	307	288	304
Ba, Barium (ppm)	33.8	29.1	38.5	31.2	36.4
Be, Beryllium (ppm)	< 0.5	IND	IND	IND	IND
Bi, Bismuth (ppm)	113	109	117	110	116
Ca, Calcium (wt.%)	0.329	0.316	0.343	0.322	0.337
Cd, Cadmium (ppm)	156	149	163	151	160
Ce, Cerium (ppm)	15.8	13.2	18.4	15.2	16.3
Co, Cobalt (ppm)	18.4	17.3	19.5	17.7	19.1
Cr, Chromium (ppm)	112	104	119	108	116
Cs, Caesium (ppm)	0.15	0.11	0.19	IND	IND
Cu, Copper (wt.%)	0.347	0.335	0.359	0.340	0.354
Fe, Iron (wt.%)	2.88	2.79	2.97	2.83	2.93
Ga, Gallium (ppm)	1.00	0.87	1.14	0.97	1.04
In, Indium (ppm)	1.63	1.45	1.82	1.55	1.72
La, Lanthanum (ppm)	9.89	8.46	11.31	9.46	10.32
Li, Lithium (ppm)	1.41	1.10	1.71	1.32	1.49
Mg, Magnesium (wt.%)	0.152	0.143	0.161	0.149	0.155
Mn, Manganese (wt.%)	0.136	0.131	0.141	0.134	0.138
Mo, Molybdenum (ppm)	9.95	8.90	11.00	9.55	10.35
Ni, Nickel (ppm)	15.8	14.2	17.4	15.1	16.5
P, Phosphorus (wt.%)	0.013	0.012	0.015	0.013	0.014
Pb, Lead (wt.%)	70.09	64.43	75.75	69.06	71.13
S, Sulphur (wt.%)	14.23	13.82	14.63	13.98	14.47
Sb, Antimony (wt.%)	0.266	0.253	0.279	0.259	0.272
Sc, Scandium (ppm)	< 1	IND	IND	IND	IND
Sn, Tin (ppm)	12.5	10.2	14.9	11.8	13.2
Ta, Tantalum (ppm)	< 0.05	IND	IND	IND	IND
Th, Thorium (ppm)	0.41	0.35	0.48	0.39	0.43
Tl, Thallium (ppm)	1.92	1.75	2.09	1.83	2.02
U, Uranium (ppm)	1.05	0.93	1.16	1.01	1.09
V, Vanadium (ppm)	5.02	4.48	5.57	4.65	5.40
Zn, Zinc (wt.%)	2.79	2.72	2.87	2.75	2.83

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.

†These operationally defined measurands meet the requirements of ISO 17034 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. Certified Values, Uncertainty & Tolerances for other measurands in OREAS 353c.

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.%)	0.100	0.085	0.115	0.092	0.108
As, Arsenic (ppm)	292	273	311	278	305
Ba, Barium (ppm)	38.6	33.0	44.3	35.3	41.9
Bi, Bismuth (ppm)	111	105	118	108	115
Ca, Calcium (wt.%)	0.337	0.300	0.374	0.314	0.360
Cd, Cadmium (ppm)	154	144	165	149	160
Co, Cobalt (ppm)	18.1	16.1	20.1	IND	IND
Cr, Chromium (ppm)	117	94	141	108	127
Cu, Copper (wt.%)	0.348	0.335	0.361	0.342	0.354
Er, Erbium (ppm)	0.62	0.48	0.77	IND	IND
Fe, Iron (wt.%)	2.95	2.84	3.06	2.89	3.01
Ga, Gallium (ppm)	1.02	0.89	1.14	IND	IND
In, Indium (ppm)	1.64	1.48	1.81	IND	IND
Mg, Magnesium (wt.%)	0.156	0.146	0.166	0.149	0.162
Mn, Manganese (wt.%)	0.137	0.132	0.143	0.134	0.141
Mo, Molybdenum (ppm)	11.0	9.4	12.6	IND	IND
S, Sulphur (wt.%)	14.69	14.16	15.22	14.49	14.90
Sb, Antimony (wt.%)	0.280	0.258	0.301	0.270	0.289
Si, Silicon (wt.%)	1.48	1.41	1.56	1.45	1.52
Sm, Samarium (ppm)	1.42	1.14	1.70	IND	IND
Sr, Strontium (ppm)	< 10	IND	IND	IND	IND
Tl, Thallium (ppm)	2.02	1.84	2.20	IND	IND
U, Uranium (ppm)	1.26	1.06	1.46	IND	IND
Y, Yttrium (ppm)	7.79	6.73	8.85	7.44	8.14
Yb, Ytterbium (ppm)	0.50	0.36	0.64	IND	IND
Zn, Zinc (wt.%)	2.86	2.76	2.96	2.80	2.91
Infrared Combustion					
C, Carbon (wt.%)	0.387	0.370	0.403	0.375	0.398
S, Sulphur (wt.%)	14.03	13.66	14.41	13.90	14.17

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. Indicative Values for OREAS 353c.

Constituent	Unit	Value	Constituent	Unit	Value	Constituent	Unit	Value
Umpire Labs ('as received' sample basis)								
Thermogravimetry								
H_2O-	wt.%	*0.130*						
Geoanalytical Labs ('as received' sample basis)								
4-Acid Digestion								
Dy	ppm	*0.76*	Lu	ppm	*0.044*	Sr	ppm	*2.15*
Er	ppm	*0.35*	Na	wt.%	*0.014*	Tb	ppm	*0.16*
Eu	ppm	*1.73*	Nb	ppm	*0.26*	Te	ppm	*0.69*
Gd	ppm	*1.09*	Nd	ppm	*6.44*	Ti	wt.%	*0.010*
Ge	ppm	*0.36*	Pr	ppm	*1.76*	Tm	ppm	*0.045*
Hf	ppm	*0.13*	Rb	ppm	*1.27*	W	ppm	*1.94*
Hg	ppm	*13.3*	Re	ppm	*< 0.05*	Y	ppm	*5.81*
Ho	ppm	*0.12*	Se	ppm	*5.16*	Yb	ppm	*0.28*
K	wt.%	*0.020*	Sm	ppm	*1.25*	Zr	ppm	*2.53*
Peroxide Fusion ICP								
Ag	wt.%	*0.275*	La	ppm	*9.96*	Se	ppm	*< 20*
B	ppm	*< 50*	Li	ppm	*5.04*	Sn	ppm	*15.3*
Be	ppm	*< 1*	Lu	ppm	*0.064*	Ta	ppm	*0.21*
Ce	ppm	*16.5*	Nb	ppm	*< 5*	Tb	ppm	*0.19*
Cs	ppm	*0.21*	Nd	ppm	*7.09*	Te	ppm	*4.98*
Dy	ppm	*1.33*	Ni	ppm	*15.7*	Th	ppm	*0.41*
Eu	ppm	*1.90*	P	wt.%	*0.021*	Ti	wt.%	*0.008*
Gd	ppm	*1.54*	Pb	wt.%	*71.33*	Tm	ppm	*0.076*
Ge	ppm	*< 1*	Pr	ppm	*1.89*	V	ppm	*< 10*
Hf	ppm	*0.10*	Rb	ppm	*1.35*	W	ppm	*4.99*
Ho	ppm	*0.23*	Re	ppm	*< 0.1*	Zr	ppm	*4.83*
K	wt.%	*0.042*	Sc	ppm	*< 5*			

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

INTRODUCTION 6
SOURCE MATERIAL 6
COMMINUTION AND HOMOGENISATION PROCEDURES 6
PHYSICAL PROPERTIES....6
MINERALOGY....7
ANALYTICAL PROGRAM 7
STATISTICAL ANALYSIS 8
    Homogeneity Evaluation....9
    ANOVA Study 9
PERFORMANCE GATES 10
PREPARER....12
PARTICIPATING LABORATORIES....12
METROLOGICAL TRACEABILITY 16
COMMUTABILITY 16
INTENDED USE....17
MINIMUM SAMPLE SIZE....17
PERIOD OF VALIDITY & STORAGE INSTRUCTIONS 17
INSTRUCTIONS FOR HANDLING & CORRECT USE 18
LEGAL NOTICE....18
DOCUMENT HISTORY....19
QMS CERTIFICATION....19
CERTIFYING OFFICER....19
REFERENCES 19

LIST OF TABLES

Table 1. Certified Value, Uncertainty & Tolerance Intervals for OREAS 353c.... 1
Table 2. Certified Values, Uncertainty & Tolerances for other measurands in OREAS 353c.... 3
Table 3. Indicative Values for OREAS 353c. 4
Table 4. Physical properties of OREAS 353c. 7
Table 5. Indicative mineralogy of OREAS 353c by semi-quantitative XRD analysis. 7
Table 6. Performance Gates for OREAS 353c. 10

LIST OF FIGURES

Figure 1. Pb by classical wet chemistry in OREAS 353c 14
Figure 2. Ag by Pb fire assay in OREAS 353c.... 15

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 (all laboratories accredited to ISO 17025) and Table 2 (most laboratories accredited to ISO 17025) provide the certified values and their associated 95% expanded uncertainty and tolerance intervals, Table 3 shows indicative values including major and trace element characterisation, Table 4 provides some indicative physical properties and Table 5 provides indicative mineralogy based on semi-quantitative XRD analysis. Lastly, 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 lab means from the corrected mean of means (PDM[3]) are presented in the detailed certification data for this CRM (**OREAS 353c-DataPack.1.0.250528_093331.xlsx**). Results are also presented in scatter plots for Pb by classical titration and Ag by fire assay with gravimetric finish in Figures 1 and 2 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 353c is a certified reference material (CRM) prepared from a Pb-Ag concentrate sample sourced from South32 Ltd's Cannington mine plant. The stratabound, metasediment hosted (Broken Hill Type) deposit is located ~200 kms south-east of Mount Isa in north-west Queensland, Australia. The major sulphides occur as argentiferous galena and sphalerite with subordinate magnetite-pyrrhotite and minor marcasite and arsenopyrite-lollingite-chalcopyrite.

COMMINUTION AND HOMOGENISATION PROCEDURES

The material constituting OREAS 353c 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 and 50 g units sealed under nitrogen in laminated foil pouches.

PHYSICAL PROPERTIES

OREAS 353c was tested at ORE Research & Exploration Pty Ltd's onsite facility for various physical properties. Table 4 presents these findings that should be used for informational purposes only.

Table 4. Physical properties of OREAS 353c.

Bulk Density (kg/m^3)	Moisture (wt.%)	Munsell Notation‡	Munsell Color‡
906	0.23	N2	Grayish Black

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

MINERALOGY

The semi-quantitative XRD results shown in Table 5 below were undertaken by ALS Metallurgy in Balcatta, Western Australia. The results have been normalised to 100 % and represent the relative proportion of crystalline material. Totals greater or less than 100 % are due to rounding errors. 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 5. Indicative mineralogy of OREAS 353c based on semi-quantitative XRD analysis.

Mineral / Mineral Group	% (mass ratio)
Chlorite	< 1
Talc	< 1
Serpentine	1
Na-Ca amphibole	< 1
Quartz	1
Pyrite	1
Galena	90
Sphalerite	4
Anglesite	2
Gypsum	< 1

ANALYTICAL PROGRAM

For the interlaboratory ‘round robin’ certification program, a 1500 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 353c.

Umpire Laboratories

Eleven ‘umpire’ laboratories each received a single 60 g sample and undertook silver, lead 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 and weighed for analysis at the same time as the sample aliquots for Pb and Ag as per ISO 9599.

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:

- Lead was determined in 3 trials by classical wet chemistry titration (10 laboratories, except 1 laboratory who performed a borate fusion with XRF finish);
- Silver by reduced charge (mostly 10-30g) fire assay with gravimetric finish (11 laboratories).

Geoanalytical Laboratories

Fifteen geoanalytical laboratories also participated in the program where each laboratory received 6 x 15 g randomised samples comprising one subsample from each of the six 1500 g test units. The laboratories were instructed to undertake the following analyses:

- 4-acid digestion ($HF-HNO_3-HClO_4-HCl$) with ICP-OES and/or ICP-MS finish (up to 14 laboratories depending on the element);
- Peroxide fusion with ICP-OES and/or ICP-MS finish (up to 14 laboratories depending on the element);
- Infrared combustion furnace for C (15 laboratories) and S (13 laboratories).

Homogeneity was evaluated by submitting 12 x 15 g pulp samples to a single laboratory for borate fusion with XRF finish and Ag by ore grade 4-acid digestion with ICP-OES finish. Paired subsamples were taken from each of the six 1500 g test units, enabling an Analysis of Variance (ANOVA) to compare within- and between-unit variances across the six pairs. This statistical approach provides a relative measure of homogeneity and tests the null hypothesis that all sampling units originate from the same population distribution (see 'Homogeneity Evaluation' section below).

STATISTICAL ANALYSIS

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

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

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

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

Standard Deviation intervals (see Table 6) 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 and 2 were determined using an analysis of precision errors method and are considered a conservative estimate of true homogeneity. The meaning of tolerance limits may be illustrated for lead (Pb) 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 72.21 and 72.37 wt.%. Put more precisely, this means that if the same number of subsamples were taken and analysed in the same manner repeatedly, 99% of the tolerance intervals so constructed would cover at least 95% of the total population, and 1% of the tolerance intervals would cover less than 95% of the total population. ***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 analysis of variance (ANOVA). 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 4-acid digestion with ICP-OES. The 12 samples consisted of paired samples from each of the six sampling (lot) intervals to enable an 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 0.78 % for Ag, 0.32 % for Pb, 0.99 % for S and 0.20 % for Zn. Based on the homogeneity study and statistical analysis of the results of the interlaboratory certification program, it can be concluded that OREAS 353c 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 353c.

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											
Pb, wt.%	72.29	0.125	72.04	72.54	71.91	72.66	0.17%	0.35%	0.52%	68.67	75.90
Pb Fire Assay											
Ag, wt.%	0.269	0.002	0.264	0.273	0.262	0.275	0.80%	1.60%	2.40%	0.255	0.282
Geoanalytical Labs ('as received' sample basis)											
4-Acid Digestion											
Ag, wt.%	0.268	0.010	0.248	0.289	0.238	0.299	3.80%	7.61%	11.41%	0.255	0.282
Al, wt.%	0.098	0.008	0.082	0.114	0.074	0.122	8.05%	16.10%	24.16%	0.093	0.103
As, ppm	296	7	283	309	276	316	2.21%	4.42%	6.63%	281	311
Ba, ppm	33.8	5.8	22.1	45.4	16.3	51.3	17.23%	34.47%	51.70%	32.1	35.5
Be, ppm	< 0.5	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Bi, ppm	113	4	105	122	101	126	3.70%	7.40%	11.10%	108	119
Ca, wt.%	0.329	0.010	0.308	0.350	0.298	0.361	3.18%	6.36%	9.55%	0.313	0.346
Cd, ppm	156	10	137	175	127	185	6.12%	12.23%	18.35%	148	164
Ce, ppm	15.8	2.2	11.4	20.1	9.2	22.3	13.79%	27.58%	41.37%	15.0	16.6
Co, ppm	18.4	0.85	16.7	20.1	15.8	20.9	4.62%	9.24%	13.85%	17.5	19.3
Cr, ppm	112	11	90	133	80	144	9.59%	19.18%	28.77%	106	117

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 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
Geoanalytical Labs ('as received' sample basis)											
4-Acid Digestion continued											
Cs, ppm	0.15	0.02	0.11	0.19	0.09	0.21	14.40%	28.81%	43.21%	0.14	0.16
Cu, wt.%	0.347	0.015	0.317	0.377	0.302	0.392	4.31%	8.63%	12.94%	0.330	0.364
Fe, wt.%	2.88	0.115	2.65	3.11	2.54	3.23	3.98%	7.96%	11.94%	2.74	3.03
Ga, ppm	1.00	0.17	0.67	1.34	0.50	1.51	16.83%	33.66%	50.49%	0.95	1.05
In, ppm	1.63	0.111	1.41	1.86	1.30	1.97	6.80%	13.60%	20.40%	1.55	1.72
La, ppm	9.89	1.16	7.56	12.21	6.40	13.37	11.75%	23.50%	35.24%	9.39	10.38
Li, ppm	1.41	0.17	1.07	1.75	0.90	1.91	12.02%	24.03%	36.05%	1.34	1.48
Mg, wt.%	0.152	0.008	0.137	0.167	0.130	0.175	4.93%	9.87%	14.80%	0.145	0.160
Mn, wt.%	0.136	0.007	0.122	0.150	0.115	0.157	5.05%	10.11%	15.16%	0.129	0.143
Mo, ppm	9.95	1.26	7.42	12.48	6.16	13.74	12.71%	25.41%	38.12%	9.45	10.45
Ni, ppm	15.8	1.6	12.6	19.1	11.0	20.7	10.25%	20.49%	30.74%	15.0	16.6
P, wt.%	0.013	0.002	0.010	0.016	0.009	0.018	11.84%	23.67%	35.51%	0.013	0.014
Pb, wt.%	70.09	5.084	59.92	80.26	54.84	85.34	7.25%	14.51%	21.76%	66.59	73.60
S, wt.%	14.23	0.401	13.42	15.03	13.02	15.43	2.82%	5.64%	8.47%	13.51	14.94
Sb, wt.%	0.266	0.018	0.230	0.302	0.212	0.320	6.74%	13.48%	20.22%	0.253	0.279
Sc, ppm	< 1	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Sn, ppm	12.5	2.3	7.9	17.1	5.6	19.4	18.30%	36.60%	54.90%	11.9	13.1
Ta, ppm	< 0.05	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Th, ppm	0.41	0.038	0.34	0.49	0.30	0.53	9.16%	18.31%	27.47%	0.39	0.43
Tl, ppm	1.92	0.148	1.63	2.22	1.48	2.37	7.70%	15.39%	23.09%	1.83	2.02
U, ppm	1.05	0.102	0.85	1.25	0.74	1.35	9.69%	19.38%	29.07%	1.00	1.10
V, ppm	5.02	0.61	3.81	6.24	3.21	6.84	12.05%	24.09%	36.14%	4.77	5.28
Zn, wt.%	2.79	0.104	2.59	3.00	2.48	3.11	3.72%	7.44%	11.16%	2.65	2.93
Peroxide Fusion ICP											
Al, wt.%	0.100	0.010	0.079	0.121	0.069	0.131	10.43%	20.86%	31.29%	0.095	0.105
As, ppm	292	17	257	326	239	344	5.97%	11.94%	17.91%	277	306
Ba, ppm	38.6	4.5	29.5	47.7	25.0	52.2	11.76%	23.52%	35.28%	36.7	40.5
Bi, ppm	111	5	101	122	96	127	4.72%	9.44%	14.16%	106	117
Ca, wt.%	0.337	0.029	0.280	0.395	0.251	0.423	8.52%	17.03%	25.55%	0.320	0.354
Cd, ppm	154	8	138	171	129	179	5.39%	10.79%	16.18%	147	162
Co, ppm	18.1	2.0	14.1	22.1	12.1	24.1	11.07%	22.14%	33.22%	17.2	19.0
Cr, ppm	117	23	71	164	48	187	19.85%	39.69%	59.54%	112	123
Cu, wt.%	0.348	0.011	0.325	0.371	0.314	0.383	3.29%	6.58%	9.87%	0.331	0.366
Er, ppm	0.62	0.09	0.45	0.80	0.36	0.88	13.96%	27.91%	41.87%	0.59	0.65
Fe, wt.%	2.95	0.078	2.79	3.10	2.72	3.18	2.64%	5.27%	7.91%	2.80	3.10
Ga, ppm	1.02	0.051	0.91	1.12	0.86	1.17	5.03%	10.06%	15.08%	0.96	1.07
In, ppm	1.64	0.099	1.44	1.84	1.34	1.94	6.04%	12.09%	18.13%	1.56	1.72
Mg, wt.%	0.156	0.007	0.143	0.169	0.136	0.176	4.22%	8.45%	12.67%	0.148	0.164
Mn, wt.%	0.137	0.004	0.129	0.146	0.125	0.150	3.13%	6.26%	9.40%	0.131	0.144

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 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
Geoanalytical Labs ('as received' sample basis)											
Peroxide Fusion ICP											
Mo, ppm	11.0	1.3	8.3	13.7	7.0	15.0	12.13%	24.26%	36.39%	10.5	11.6
S, wt.%	14.69	0.545	13.60	15.78	13.06	16.33	3.71%	7.42%	11.13%	13.96	15.43
Sb, wt.%	0.280	0.022	0.236	0.323	0.215	0.345	7.78%	15.55%	23.33%	0.266	0.294
Si, wt.%	1.48	0.041	1.40	1.56	1.36	1.60	2.75%	5.50%	8.25%	1.41	1.56
Sm, ppm	1.42	0.26	0.90	1.94	0.64	2.20	18.33%	36.66%	54.99%	1.35	1.49
Sr, ppm	< 10	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Tl, ppm	2.02	0.103	1.82	2.23	1.71	2.33	5.07%	10.15%	15.22%	1.92	2.12
U, ppm	1.26	0.15	0.96	1.56	0.80	1.72	12.05%	24.11%	36.16%	1.20	1.32
Y, ppm	7.79	1.37	5.05	10.52	3.68	11.89	17.57%	35.13%	52.70%	7.40	8.18
Yb, ppm	0.50	0.07	0.36	0.64	0.29	0.71	13.99%	27.98%	41.98%	0.48	0.53
Zn, wt.%	2.86	0.096	2.67	3.05	2.57	3.15	3.37%	6.75%	10.12%	2.72	3.00
Infrared Combustion											
C, wt.%	0.387	0.019	0.349	0.424	0.330	0.443	4.90%	9.80%	14.70%	0.367	0.406
S, wt.%	14.03	0.463	13.11	14.96	12.64	15.42	3.30%	6.60%	9.90%	13.33	14.74

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.

PREPARER

Certified reference material OREAS 353c is prepared and certified by:

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

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

PARTICIPATING LABORATORIES

1. ♦Actlabs, Ancaster, Ontario, Canada
2. *AGAT Laboratories, Calgary, Alberta, Canada
3. ♦AH Knight, Spartanburg, SC, USA
4. ♦AH Knight, St Helens, Merseyside, UK
5. ♦AH Knight, Tianjin, China
6. *ALS, Brisbane, QLD, Australia
7. *ALS, Lima, Peru
8. *ALS, Loughrea, Galway, Ireland
9. *ALS, Malaga, WA, Australia

10. *ALS, Vancouver, BC, Canada
11. ♦ALS Inspection, Prescot, Merseyside, UK
12. *American Assay Laboratories, Sparks, Nevada, USA
13. ♦Bachelet, Angleur, Liege, Belgium
14. ♦Inspectorate (BV), Lima, Peru
15. ♦Inspectorate (BV), Shanghai, Bao Shan District, China
16. ♦Inspectorate (BV), Witham, Essex, UK
17. *Intertek, Cupang, Muntinlupa, Philippines
18. *Intertek, Perth, WA, Australia
19. *Intertek, Townsville, QLD, Australia
20. *Intertek Genalysis, Adelaide, SA, Australia
21. ♦Intertek LSI, Rotterdam, Zuid-Holland, Netherlands
22. *PT Geoservices Ltd, Cikarang, Jakarta Raya, Indonesia
23. *PT Intertek Utama Services, Jakarta Timur, DKI Jakarta, Indonesia
24. *SGS, Ankara, Anatolia, Turkey
25. ♦SGS Lakefield Research Ltd, Lakefield, Ontario, Canada
26. *Shiva Analyticals Ltd, Bangalore North, Karnataka, India

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

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

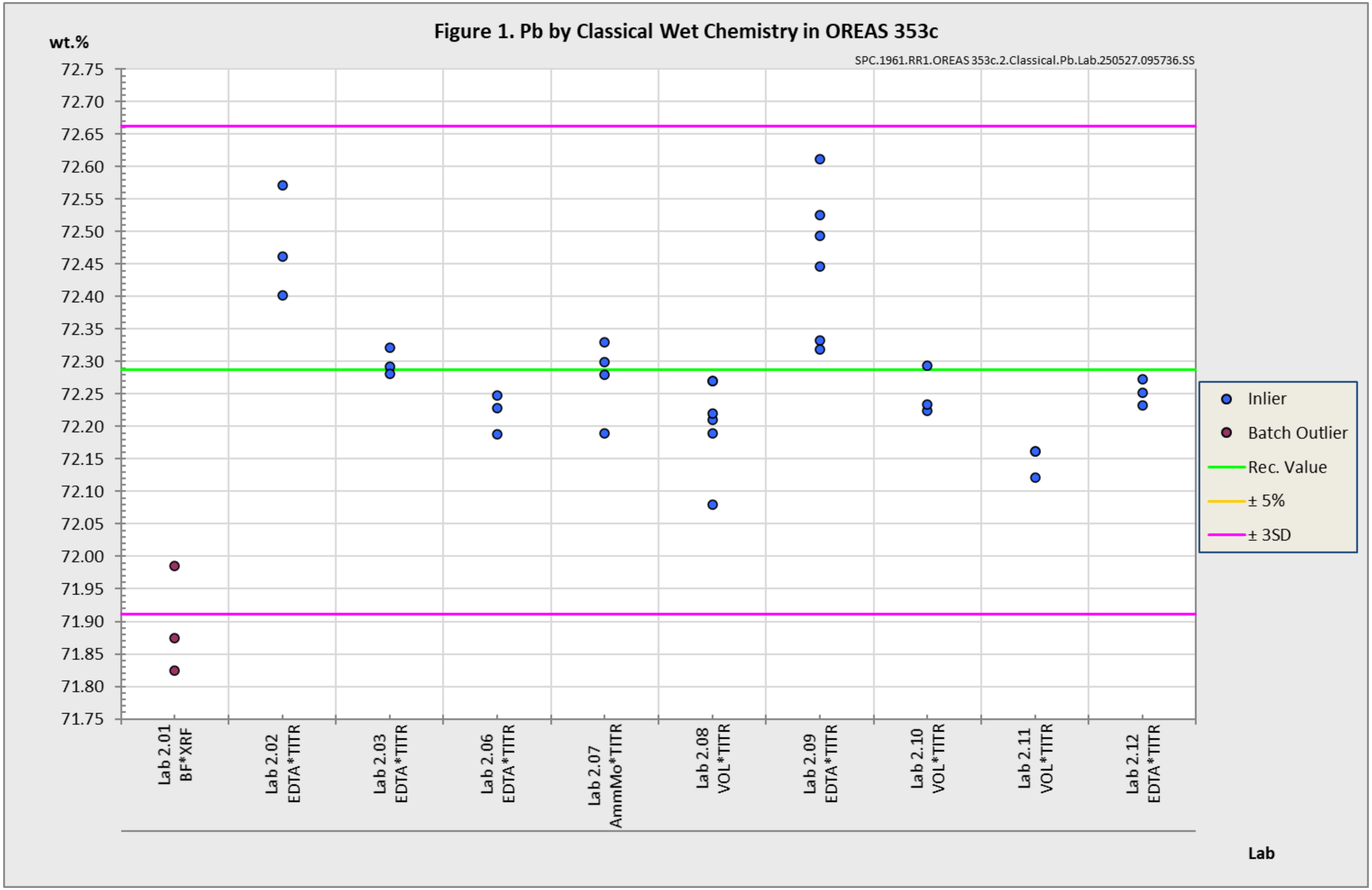
Figure 1. Pb by Classical Wet Chemistry in OREAS 353c
SPC.1961.RR1.OREAS 353c.2.Classical.Pb.Lab.250527.095736.SS
wt.%
72.75
72.70
72.65
72.60
72.55
72.50
72.45
72.40
72.35
72.30
72.25
72.20
72.15
72.10
72.05
72.00
71.95
71.90
71.85
71.80
71.75
Lab 2.01 BF*XRF
Lab 2.02 EDTA*TITR
Lab 2.03 EDTA*TITR
Lab 2.06 EDTA*TITR
Lab 2.07 AmmMo*TITR
Lab 2.08 VOL*TITR
Lab 2.09 EDTA*TITR
Lab 2.10 VOL*TITR
Lab 2.11 VOL*TITR
Lab 2.12 EDTA*TITR
Lab
Inlier
Batch Outlier
Rec. Value
± 5%
± 3SD

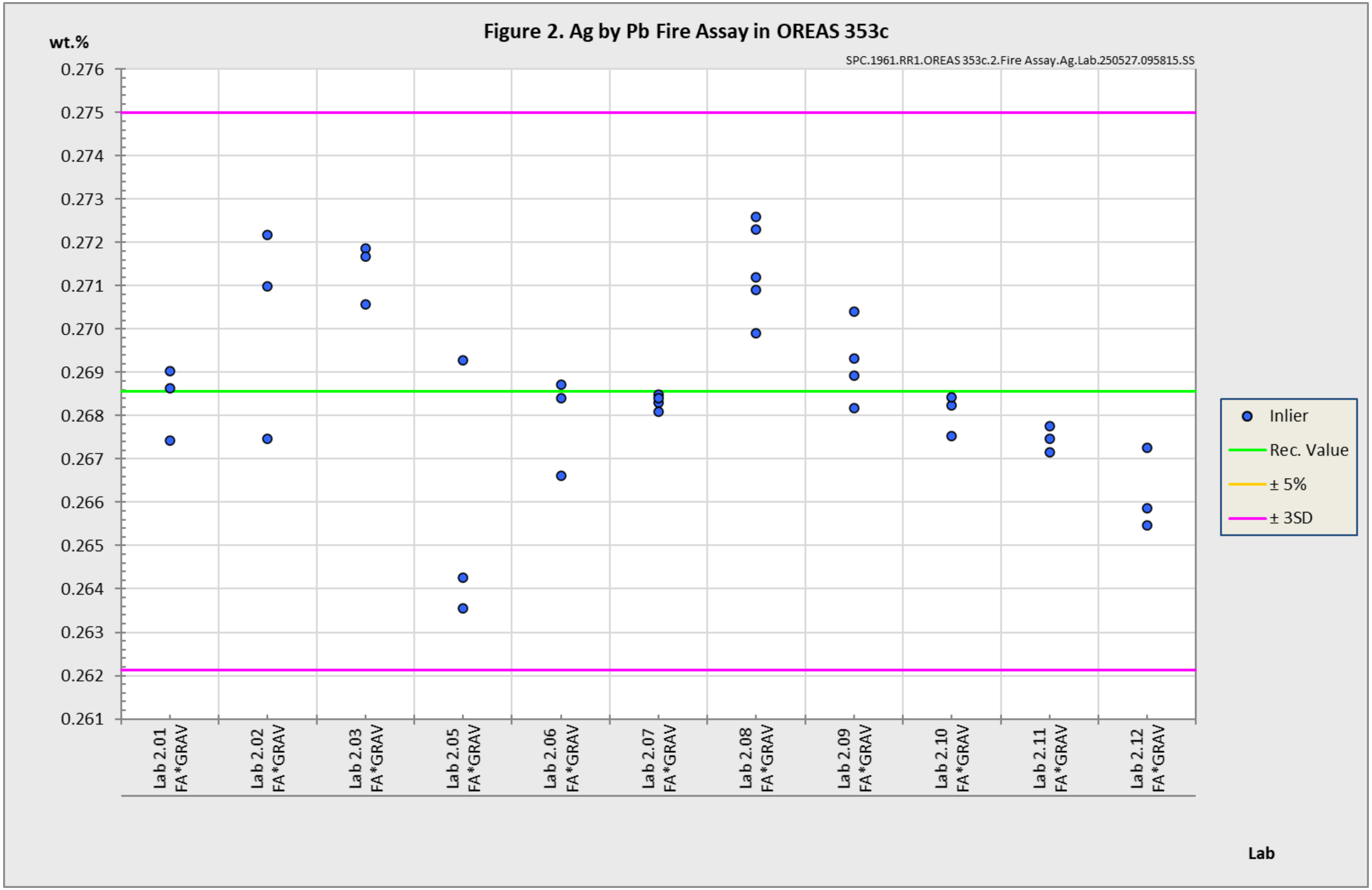
Figure 2. Ag by Pb Fire Assay in OREAS 353c
wt.%
SPC.1961.RR1.OREAS 353c.2.Fire Assay.Ag.Lab.250527.095815.SS
0.276
0.275
0.274
0.273
0.272
0.271
0.270
0.269
0.268
0.267
0.266
0.265
0.264
0.263
0.262
0.261
Lab 2.01 FA*GRAV
Lab 2.02 FA*GRAV
Lab 2.03 FA*GRAV
Lab 2.05 FA*GRAV
Lab 2.06 FA*GRAV
Lab 2.07 FA*GRAV
Lab 2.08 FA*GRAV
Lab 2.09 FA*GRAV
Lab 2.10 FA*GRAV
Lab 2.11 FA*GRAV
Lab 2.12 FA*GRAV
Inlier
Rec. Value
± 5%
± 3SD
Lab

METROLOGICAL TRACEABILITY

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

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

The participating laboratories were chosen on the basis of their competence (from past performance in interlaboratory programs undertaken by ORE Pty Ltd) for a particular analytical method, analyte or analyte suite and sample matrix. These laboratories are accredited to ISO 17025 for Ag and Pb by classical methods and multi-elements by 4-acid digestion (Table 1). The other operationally defined measurands characterised in this certificate are derived from data procured mostly from ISO 17025 accredited laboratories (Table 2). 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 33405:2024-05, 9.2.4c) [4]."* Certification takes place on the basis of agreement among operationally defined, independent measurement results.

COMMUTABILITY

The measurements of the results that underlie the certified values contained in this report were undertaken by methods involving pre-treatment (fusion/digestion) of the sample. This served to reduce the sample to a simple and well understood form permitting calibration using simple solutions of the CRM. Due to these methods being well understood and highly effective, commutability is not an issue for this CRM. All OREAS CRMs are sourced from natural ore minerals meaning they will display similar behaviour as routine '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 353c 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 353c may be used to calibrate the entire procedure by producing a pure substance CRM transformed into a calibration solution.

OREAS 353c is intended for the following uses:

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

MINIMUM SAMPLE SIZE

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

- Pb by classical wet chemistry: ≥0.5 g;
- Ag by fire assay with gravimetric finish: ≥10 g;
- 4-acid digestion with ICP-OES and/or MS finish: ≥0.25 g;
- Peroxide fusion with ICP-OES and/or MS finish: ≥0.1 g;
- Total S and C by Infrared combustion furnace/CS analyser: ≥0.1 g.

PERIOD OF VALIDITY & STORAGE INSTRUCTIONS

OREAS 353c is high in reactive sulphide content and has been packaged under a nitrogen environment in robust laminated foil pouches in single-use 10g and 50g units. In its unopened state in the sachets (sealed under nitrogen), OREAS 353c has a shelf life of at least ten years (October 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 [12].

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

Umpire laboratories using classical methods:

The umpire laboratory certified values for Ag and Pb refer to the concentration levels 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 Ag and Pb assay. The Ag and Pb 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 0.04 - 0.21 % with an average of 0.13 %. 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 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 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 releases and indemnifies Ore Research & Exploration Pty Ltd from and against all liability and costs arising from the use of this material and information.

DOCUMENT HISTORY

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

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.

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

[4] ISO 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.