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CERTIFICATE OF ANALYSIS FOR

Porphyry Cu-Au Ore

(Waisoi East and West deposit, Viti Levu, Fiji)

CERTIFIED REFERENCE MATERIAL

OREAS 152a

Table 1. Certified Values and Performance Gates for OREAS 152a.

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, ppb	116	5	106	126	101	131	4.31%	8.62%	12.93%	110	122
4-Acid Digestion											
Cu, wt.%	0.385	0.009	0.366	0.404	0.356	0.413	2.47%	4.94%	7.40%	0.365	0.404
Mo, ppm	80	5	70	89	65	94	5.98%	11.96%	17.95%	76	84
S, wt.%	0.921	0.046	0.828	1.013	0.782	1.059	5.03%	10.06%	15.08%	0.874	0.967

SI unit equivalents: ppm (parts per million) ≡ mg/kg ≡ µg/g ≡ 0.0001 wt.% ≡ 1000 ppb (parts per billion).

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.

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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 ‘Intended Use’ should be read carefully.

SOURCE MATERIAL

OREAS 152a is one of three porphyry Cu-Au-Mo-S certified reference materials prepared from copper ore from the Waisoi district, Viti Levu, Fiji. The two deposits in the area are the Waisoi East deposit (quartz porphyry) and the Waisoi West deposit (diorite porphyry). Copper mineralisation in the region is accompanied by stockwork quartz veinlets and is characterised by bornite-chalcopyrite-pyrite assemblages.

PERFORMANCE GATES

Table 1 above shows intervals calculated for two and three standard deviations. As a guide these intervals may be regarded as warning or rejection for multiple 2SD outliers, or rejection for individual 3SD outliers in QC monitoring, although their precise application should be at the discretion of the QC manager concerned (also see ‘Intended Use’ section below). Westgard Rules extend the basics of single-rule QC monitoring using multi-rules (for more information visit www.westgard.com/mltirule.htm). A second method utilises a 5% window calculated directly from the certified value.

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

i.e. Certified Value ± 10% ± 2DL (adapted from Govett, 1983).

Table 2. Indicative Values for OREAS 152a.

Constituent	Unit	Value	Constituent	Unit	Value	Constituent	Unit	Value
Borate Fusion XRF								
Al_2O_3	wt.%	*16.13*	MgO	wt.%	*3.59*	SiO_2	wt.%	*61.70*
CaO	wt.%	*2.21*	MnO	wt.%	*0.039*	TiO_2	wt.%	*0.70*
Fe_2O_3	wt.%	*5.22*	Na_2O	wt.%	*3.14*			
K_2O	wt.%	*1.75*	P_2O_5	wt.%	*0.150*			
4-Acid Digestion								
Ag	ppm	*1.00*	Hf	ppm	*0.2*	Sc	ppm	*23*
As	ppm	*32*	Ho	ppm	*0.48*	Sm	ppm	*2.2*
Ba	ppm	*86*	In	ppm	*<0.02*	Sn	ppm	*2*
Be	ppm	*0.40*	La	ppm	*4.4*	Sr	ppm	*113*
Bi	ppm	*0.10*	Li	ppm	*6.3*	Ta	ppm	*<0.1*
Cd	ppm	*<0.5*	Lu	ppm	*0.14*	Tb	ppm	*0.36*
Ce	ppm	*11.1*	Mo	ppm	*77.8*	Te	ppm	*0.4*
Co	ppm	*15*	Nb	ppm	*1*	Th	ppm	*0.5*
Cs	ppm	*0.7*	Nd	ppm	*7.85*	U	ppm	*0.1*
Cu	ppm	*3875*	Ni	ppm	*14*	W	ppm	*4.0*
Dy	ppm	*2.30*	Pb	ppm	*7*	Y	ppm	*13.1*
Er	ppm	*1.2*	Pr	ppm	*1.62*	Yb	ppm	*1.1*
Eu	ppm	*0.73*	Rb	ppm	*28.1*	Zn	ppm	*81*
Ga	ppm	*17.8*	Re	ppm	*0.3*	Zr	ppm	*10*
Gd	ppm	*2.4*	Sb	ppm	*1.4*		ppm	
Thermogravimetry								
LOI^{1000}	wt.%	*3.96*						
Infrared Combustion								
C	wt.%	*0.28*	S	wt.%	*0.90*			

SI unit equivalents: ppm (parts per million) ≡ mg/kg ≡ µg/g ≡ 0.0001 wt.% ≡ 1000 ppb (parts per billion).

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.

PHYSICAL PROPERTIES

OREAS 152a 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 152a.

Bulk Density (g/L)	Moisture%	Munsell Notation‡	Munsell Color‡
547.5	1.37	N8	Very 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.

COMMINUTION AND HOMOGENISATION PROCEDURES

The material constituting OREAS 152a was prepared in the following manner:

- Jaw crushing to minus 3mm;
- Drying to constant mass at 105°C;
- Multi-stage milling to 100% minus 30 microns;
- Homogenisation;
- Blending and bagging into 25kg sublots;
- Packaging into 60g (laminated foil pouches) and 1kg (plastic jars) units.

ANALYTICAL PROGRAM

Twenty-one commercial analytical laboratories participated in the program to certify the elements reported in Table 1. Each laboratory received two scoop-split 110g subsamples from each of three 800g test units (6 samples in total). A total of 20 of these 800g test units were taken at regular intervals during the bagging stage and are considered representative of the entire batch. The following methods were employed:

- Gold by fire assay (25-50g charge weight) with AAS (11 laboratories), ICP-OES (9 laboratories) finish and ICP-MS (1 laboratory);
- Copper, molybdenum and sulphur by 4-acid (HNO_3-HF-$HClO_4$-HCl) digestion followed by ICP-OES and/or ICP-MS finish.

For the determination of a statistical tolerance interval for gold a 10g scoop split was taken from each of the 20 test units and submitted to ‘Actlabs Ancaster’ for analysis via instrumental neutron activation analysis on a reduced analytical subsample weight of ~1.3 g.

The approximate major and trace element composition of OREAS 152a is given in Table 2. The constituents SiO_2 to LOI (1000°C) are the means of duplicate XRF analyses determined using a lithium borate fusion method, C and S are means of duplicate IR combustion furnace analyses, while the remaining constituents, Ag to Zr, are means of duplicate analyses determined by 4-acid digestion with ICP-MS finish (except for Cu, Zn, Co, Ni and Sc via ICP-OES finish).

Tabulated results of all elements (including Au INAA analyses) together with uncorrected means, medians, standard deviations, relative standard deviations and percent deviation of lab means from the corrected mean of means (PDM[3]) are presented in the detailed certification data for this CRM (**OREAS 152a-DataPack.xlsx**).

Results are also presented in scatter plots for gold by fire assay and copper by 4-acid digestion in Figure 1 and 2, 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.

STATISTICAL ANALYSIS

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

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 (see Intended Use section for more detail).

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.***

Certified Values, Standard Deviations, Confidence Limits and Tolerance Limits (Table 4) have been determined for each analyte following removal of individual, laboratory dataset (batch) and 3SD outliers (single iteration).

For individual outliers within a laboratory batch the z-score test is used in combination with a second method that determines the per cent deviation of the individual value from the batch median. Outliers in general are selected on the basis of z-scores > 2.5 and with per cent deviations (i) > 3 and (ii) more than three times the average absolute per cent deviation for the batch. In certain instances, statistician's prerogative has been employed in discriminating outliers.

Each laboratory data set mean is tested for outlying status based on z-score discrimination and rejected if > 2.5. After individual and laboratory data set (batch) outliers have been eliminated a non-iterative 3 standard deviation filter is applied, with those values lying outside this window also relegated to outlying status.

Certified Values are the means of accepted laboratory means after outlier filtering. The INAA data (see Table 5) is omitted from determination of the certified value for Au and is used solely for the calculation of Tolerance Limits and homogeneity evaluation of OREAS 152a (see 'Homogeneity Evaluation' section below).

95% Confidence Limits are inversely proportional to the number of participating laboratories and inter-laboratory agreement. It is a measure of the reliability of the certified value. A 95% confidence interval indicates a 95% probability that the true value of the analyte under consideration lies between the upper and lower limits. ***95% Confidence Limits should not be used as control limits for laboratory performance.***

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

Homogeneity Evaluation

For analytes other than gold the tolerance limits (ISO 16269:2014) shown in Table 4 were determined using an analysis of precision errors method and are considered a conservative estimate of true homogeneity. The meaning of tolerance limits may be illustrated for gold by fire assay, where 99% of the time ($1-\alpha=0.99$) at least 95% of subsamples ($\rho=0.95$) will have concentrations lying between 114.4 and 117.2 ppb. 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.***

Table 4. 95% Confidence & Tolerance Limits for OREAS 152a.

Constituent	Certified	95% Confidence Limits		95% Tolerance Limits	
	Value	Low	High	Value	Low
Pb Fire Assay					
Au, Gold (ppb)	115.8	114	118	114.4*	117.2*
4-Acid Digestion					
Cu, Copper (wt.%)	0.385	0.379	0.391	0.374	0.396
Mo, Molybdenum (ppm)	79.5	77.3	81.8	77.7	81.4
S, Sulphur (wt.%)	0.921	0.900	0.941	0.897	0.944

SI unit equivalents: ppm (parts per million) ≡ mg/kg ≡ µg/g ≡ 0.0001 wt.% ≡ 1000 ppb (parts per billion).

*Gold Tolerance Limits for typical 30g fire assay methods are determined from 20 x ~1.3g INAA results and the Sampling Constant (Ingamells & Switzer, 1973).

Note: intervals may appear asymmetric due to rounding.

Table 5 below shows the gold INAA data determined on 20 x ~1.3g subsamples of OREAS 152a. An equivalent scaled version of the results is also provided to demonstrate the level of repeatability that would be achieved if 30g fire assay determinations were undertaken without the normal measurement error associated with this methodology. The homogeneity of gold has been determined by INAA using the reduced analytical subsample method which utilises the known relationship between standard deviation and analytical subsample weight (Ingamells and Switzer, 1973). In this approach the sample aliquot is substantially reduced to a point where most of the variability in replicate assays should be due to inhomogeneity of the reference material (i.e. sampling error) and measurement error becomes negligible. In this instance a subsample weight of ~1.3g was employed and the 1RSD of 0.49% was calculated for a 30g fire assay sample (2.40% at 1.3g weights) and confirms the high level of gold homogeneity in OREAS 152a.

The sampling format for OREAS 152a was structured to enable nested ANOVA treatment of the round robin results. All laboratories were included in this treatment for gold, copper, molybdenum and sulphur. During the bagging stage, immediately following homogenization, twenty 800g samples were taken at regular intervals representative of the entire batch of OREAS 152a. Each laboratory received paired samples from three different, non-adjacent 800g samples. For example, the six samples that any one of the twenty-one participating labs could have received are:

- Sample 1 (from sampling interval 3)
- Sample 2 (from sampling interval 10)
- Sample 3 (from sampling interval 17)
- Sample 4 (from sampling interval 3)
- Sample 5 (from sampling interval 10)
- Sample 6 (from sampling interval 17)

The purpose of the ANOVA investigation was to compare the within-unit variance with that of the between-unit variance. This approach permitted an assessment of homogeneity across the entire batch of OREAS 152a. The test was performed using the following parameters:

- Significance Level α = P (type I error) = 0.05
- 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

Table 5. Neutron Activation Analysis of Au (in ppb) on 20 x ~1.3g subsamples and showing the equivalent results scaled to a 30g sample mass typical of fire assay determination.

Replicate No	Au 1.3g approximate	Au 30g equivalent*
1	107	108
2	108	108
3	110	109
4	105	108
5	106	108
6	109	109
7	110	109
8	106	108
9	106	108
10	110	109
11	109	109
12	114	110
13	105	108
14	108	108
15	109	109
16	113	109
17	111	109
18	109	109
19	105	108
20	111	109
Mean	109	109
Median	109	109
Std Dev.	2.61	0.53
Rel.Std.Dev.	**2.40%**	**0.49%**

*Results calculated for a 30g equivalent sample mass using the formula: $x^{30g\ Eq} = \frac{(x^{INAA} - \bar{X}) \times RSD@30g}{RSD@1.3g} + \bar{X}$

where $x^{30g\ Eq}$ = equivalent result calculated for a 30g sample mass
(x^{INAA}) = raw INAA result at 1.3g
$\bar{X}$ = mean of 1.3g INAA results

P-values are a measure of probability whereby values less than 0.05 indicate a greater than 95% probability that the observed differences in within-unit and between-unit variances are real. The dataset was filtered for both individual and laboratory outliers prior to the calculation of the p-value. This process derived p-values of 0.991 for gold, 0.84 for copper, 0.999 for molybdenum and 0.999 for sulphur and indicates no evidence that between-unit variance is greater than within-unit variance. The Null Hypothesis (H_0) is therefore retained.

Note that ANOVA is not an absolute measure of homogeneity. Rather, it establishes that the analytes are distributed in a uniform manner throughout OREAS 152a and that the variance between two subsamples from the same unit is statistically indistinguishable to the variance from two subsamples taken from any two separate units.

Based on the statistical analysis of the results of the inter-laboratory certification program it can be concluded that OREAS 152a is fit-for-purpose as a certified reference material (see 'Intended Use' below).

PARTICIPATING LABORATORIES

1. Accurassay Laboratories, Thunder Bay, ON, Canada
2. Bureau Veritas Commodities Canada Ltd, Vancouver, BC, Canada (formerly Acme Laboratories)
3. Actlabs, Ancaster, ON, Canada
4. Alaska Assay Laboratories, Fairbanks, AK, USA
5. ALS, La Serena, Chile
6. ALS, Loughrea, County Galway, Ireland (formerly OMAC Laboratories)
7. ALS, Perth, WA, Australia
8. ALS, Sparks, Nevada, USA
9. ALS, Townsville, QLD, Australia
10. ALS, Val-d'or, QC, Canada
11. ALS, Vancouver, BC, Canada
12. Bureau Veritas Geoanalytical, Adelaide, SA, Australia (formerly Amdel Laboratories)
13. Intertek Genalysis, Perth, WA, Australia (formerly Genalysis Laboratory Services)
14. PT Intertek Utama Services, Jakarta Timur, Indonesia
15. Intertek Testing Services, Cupang, Muntinlupa, Philippines (formerly McPhar (Geoservices Inc.))
16. SGS, Perth, WA, Australia
17. SGS Lakefield Research, Lakefield, ON, Canada
18. SGS Mineral Services, Toronto, ON, Canada
19. SGS, Townsville, QLD, Australia
20. Ultra Trace, Perth, WA, Australia
21. Zarazma, Tehran, Iran

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.

PREPARER AND SUPPLIER

Certified reference material OREAS 152a was prepared, certified and supplied by:

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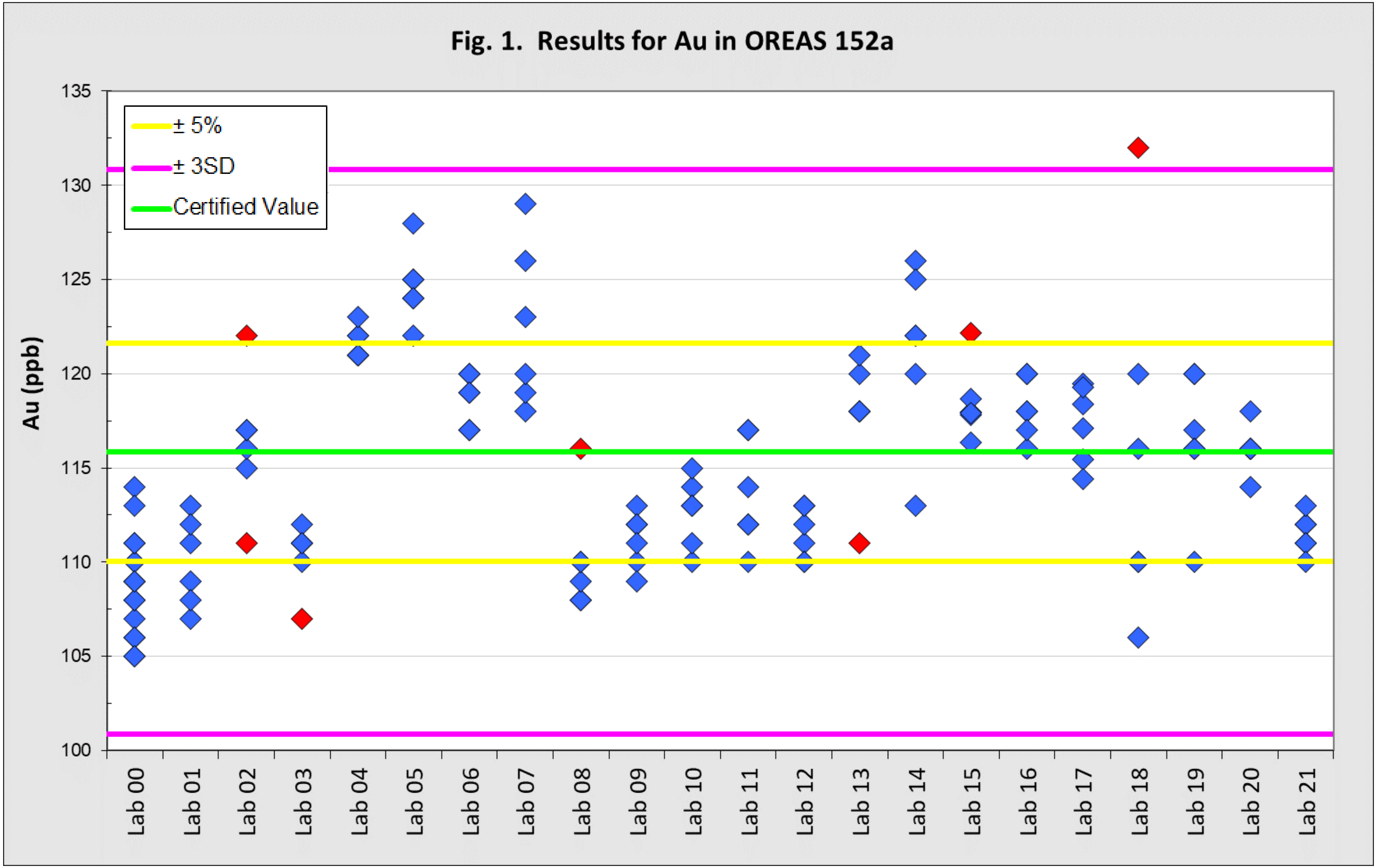
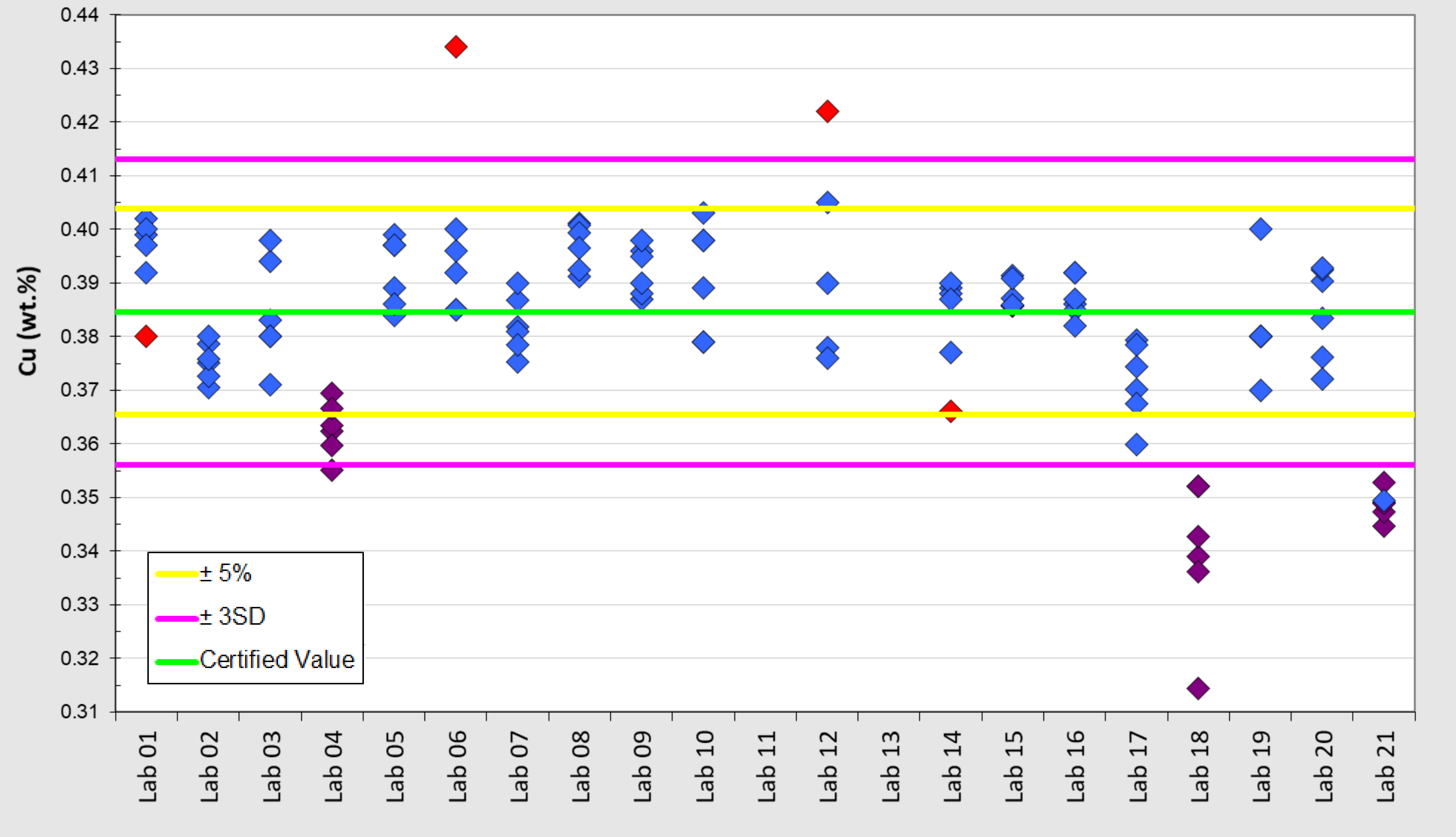


Fig. 1. Results for Au in OREAS 152a
± 5%
± 3SD
Certified Value
Au (ppb)
135
130
125
120
115
110
105
100
Lab 00
Lab 01
Lab 02
Lab 03
Lab 04
Lab 05
Lab 06
Lab 07
Lab 08
Lab 09
Lab 10
Lab 11
Lab 12
Lab 13
Lab 14
Lab 15
Lab 16
Lab 17
Lab 18
Lab 19
Lab 20
Lab 21

Fig. 2. Results for Cu in OREAS 152a



METROLOGICAL TRACEABILITY

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

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

Guide ISO/TR 16476:2016, section 5.3.1 describes metrological traceability in reference materials as it pertains to the transformation of the measurand. In this section it states, *"Although the determination of the property value itself can be made traceable to appropriate units through, for example, calibration of the measurement equipment used, steps like the transformation of the sample from one physical (chemical) state to another cannot. Such transformations may only be compared with a reference (when available), or among themselves. For some transformations, reference methods have been defined and may be used in certification projects to evaluate the uncertainty associated with such a transformation. In other cases,* ***only a comparison among different laboratories using the same method is possible. In this case, certification takes place on the basis of agreement among independent measurement results*** *(see ISO Guide 35:2006, Clause 10)."*

COMMUTABILITY

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

INTENDED USE

OREAS 152a 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 152a may be used to calibrate the entire procedure by producing a pure substance CRM transformed into a calibration solution.

OREAS 152a is intended for the following uses:

- For the monitoring of laboratory performance in the analysis of analytes reported in Table 1 in geological samples;

- For the verification of analytical methods for analytes reported in Table 1;
- For the calibration of instruments used in the determination of the concentration of analytes reported in Table 1.

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 inter-laboratory 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.

STABILITY AND STORAGE INSTRUCTIONS

OREAS 152a has been prepared from mineralised porphyry copper samples. The robust foil laminate packaging film is an effective barrier to oxygen and moisture and the sealed CRM is considered to have long-term stability (beyond 2030) under normal storage conditions.

INSTRUCTIONS FOR CORRECT USE

The certified values for OREAS 152a refer to the concentration levels of copper, gold, molybdenum and sulphur after removal of hygroscopic moisture by drying in air to constant mass at 105° Celsius. If the reference material is not dried by the user prior to analysis, the moisture content should be verified and the certified values corrected to the moisture-bearing basis. The 'Physical Properties' section above indicates an approximate moisture concentration of 1.4 wt.% although this value may change following a period of equilibration if the material is left exposed in a local atmosphere that is significantly different (in terms of temperature and humidity) from the climate during manufacturing.

HANDLING INSTRUCTIONS

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

DOCUMENT HISTORY

Revision No.	Date	Changes applied
1	11th June, 2020	Revised certificate to the 2020 template.
0	July 2010	First publication

LEGAL NOTICE

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

QMS CERTIFICATION

ORE Pty Ltd is 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

17th June, 2020

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

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ISO Guide 35:2017. Certification of reference materials - General and statistical principals.

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