ORE RESEARCH & EXPLORATION P/L ABN 28 006 859 856
37A Hosie Street · Bayswater North · VIC 3153 · AUSTRALIA
☎ 61 3 9729 0333 Fx 61 3 9729 8338
ⓘ info@ore.com.au 🌐 www.ore.com.au

CERTIFICATE OF ANALYSIS FOR

GOLD ORE
CERTIFIED REFERENCE MATERIAL
OREAS 218

Table 1. Certified Values, SD's, 95% Confidence and Tolerance Limits for OREAS 218.

Constituent	Certified Value	1SD	95% Confidence Limits		95% Tolerance Limits	
			Low	High	Low	High
Pb Fire Assay						
Au, Gold (ppm)	0.531	0.017	0.526	0.536	0.508*	0.554*
Aqua Regia Digestion						
Au, Gold (ppm)	0.524	0.020	0.516	0.532	0.499†	0.549†
Gas / Liquid Pycnometry						
SG, Specific Gravity (Unity)	3.01	0.059	2.98	3.04	2.98	3.04

*Gold Tolerance Limits for typical 30g fire assay charge weight determined from 20 x 1g INAA results and the Sampling Constant (Ingamells & Switzer, 1973);
†Gold Tolerance Limits for typical 25g aqua regia sample weight determined as above;
Please note: intervals may appear asymmetric due to rounding.

The homogeneity of OREAS 218 is of a level such that ***sampling error is minor*** for a conventional fire assay or aqua regia determination.

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.

SOURCE MATERIALS

Certified Reference Material (CRM) OREAS 218 was prepared from a blend of Archean greenstone-hosted Wilber Lode primary ore from the Andy Well Gold Mine and barren Cambrian greenstone sourced from a quarry north of Melbourne, Australia. The Wilber Lode is a shear-hosted, narrow vein, quartz lode-style gold deposit situated within the Meekatharra-Wydgee greenstone belt in the Archean Yilgarn Craton of Western Australia. The common primary mineral assemblage, as stated by Mason and Harris (2011, 2012, cited in Hingston et al, 2014), is quartz, calcite, chlorite, fuchsite, pyrite, galena, sphalerite, chalcopyrite and gold. The host rock consists of a complex sequence of Archean meta-basalt and meta-porphyritic rocks derived from a primary mineralogy of albite, actinolite, chlorite, sericite, biotite, calcite, zoisite, muscovite, quartz and titanate. The Andy Well deposit is located approximately 45km north of Meekatharra in the Murchison region of Western Australia.

The approximate major and trace element composition of OREAS 218 is provided in Table 2. The non-certified values contained in this table are the means of duplicate assays from one laboratory.

COMMINUTION AND HOMOGENISATION PROCEDURES

The material constituting OREAS 218 was prepared in the following manner:

- drying to constant mass at 105°C;
- crushing and milling of the barren material to 98% minus 75 microns;
- crushing and milling of the ore material to 100% minus 30 microns;
- blending in appropriate proportions to achieve the desired grade;
- packaging in 60g units sealed in laminated foil pouches and 1kg units in plastic jars.

ANALYTICAL PROGRAM

Thirty commercial analytical laboratories participated in the program to certify gold (as reported in Table 1) by the following methods:

- Gold via 10-50g fire assay with AAS (24 labs) or ICP-OES (6 labs) finish;
- Instrumental neutron activation analysis for Au on 20 x 1g subsamples to confirm homogeneity (1 laboratory).
- Gold via 15-50g aqua regia digestion with ICP-MS (12 labs), AAS (8 labs) or ICP-OES (1 lab) finish. It is important to note that in the analytical industry there is no

standardisation of the aqua regia digestion process. Aqua regia is a partial empirical digest and differences in recoveries for various analytes are commonplace. These are caused by variations in the digest conditions which can include the ratio of nitric to hydrochloric acids, acid strength, temperatures, leach times and secondary digestions.

- Specific gravity by gas (15 labs) or liquid (4 labs) pycnometry.

For the round robin program twenty 1.5kg test units were taken at predetermined intervals during the bagging stage, immediately following final blending, and are considered representative of the entire batch. The six samples received by each laboratory were obtained by taking two 110g scoop splits from each of three separate 1kg test units. This format enabled nested ANOVA treatment of the results to evaluate homogeneity, i.e. to ascertain whether between-unit variance is greater than within-unit variance. Table 1 presents the certified values together with their associated 1SD's, 95% confidence and tolerance limits and Table 2 shows 66 indicative values for major and trace element composition. Gold homogeneity has been evaluated and confirmed by instrumental neutron activation analysis (INAA) on twenty 1 gram sample portions (see Table 3 below) and by a nested ANOVA program for both fire assay and aqua regia digestion (see '**nested ANOVA**' section). Table 4 provides performance gate intervals for the certified values based on their pooled 1SD's. 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 218 DataPack.xlsx**).

Table 2. Approximate major and trace element data for OREAS 218.

Constituent	Unit	Value	Constituent	Unit	Value	Constituent	Unit	Value
Pb Fire Assay								
Pd	ppb	*8.33*	Pt	ppb	*10.0*			
Borate Fusion XRF								
Al_2O_3	wt.%	*13.50*	K_2O	wt.%	*0.233*	P_2O_5	wt.%	*0.103*
CaO	wt.%	*10.10*	MgO	wt.%	*7.10*	S	wt.%	*0.144*
Cl	ppm	*10.0*	MnO	wt.%	*0.190*	SiO_2	wt.%	*49.20*
Fe_2O_3	wt.%	*12.05*	Na_2O	wt.%	*2.90*	TiO_2	wt.%	*1.12*
Thermogravimetry								
LOI^{1000}	wt.%	*3.16*						
Laser Ablation								
Ag	ppm	*0.150*	Hf	ppm	*1.67*	Sm	ppm	*2.60*
As	ppm	*4.60*	Ho	ppm	*0.83*	Sn	ppm	*1.20*
Ba	ppm	*144*	In	ppm	*0.038*	Sr	ppm	*113*
Be	ppm	*0.40*	La	ppm	*3.74*	Ta	ppm	*0.18*
Bi	ppm	*0.060*	Lu	ppm	*0.36*	Tb	ppm	*0.57*
Cd	ppm	*0.10*	Mn	wt.%	*0.147*	Te	ppm	*< 0.2*
Ce	ppm	*9.72*	Mo	ppm	*1.00*	Th	ppm	*0.34*
Co	ppm	*48.3*	Nb	ppm	*3.36*	Ti	wt.%	*0.640*
Cr	ppm	*203*	Nd	ppm	*7.64*	Tl	ppm	*< 0.2*
Cs	ppm	*0.18*	Ni	ppm	*99*	Tm	ppm	*0.33*

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

Table 2 continued.

Constituent	Unit	Value	Constituent	Unit	Value	Constituent	Unit	Value
Laser Ablation continued								
Cu	ppm	*152*	Pb	ppm	*2.50*	U	ppm	*0.013*
Dy	ppm	*3.92*	Pr	ppm	*1.53*	V	ppm	*304*
Er	ppm	*2.38*	Rb	ppm	*3.68*	W	ppm	*1.13*
Eu	ppm	*0.99*	Re	ppm	*0.008*	Y	ppm	*21.7*
Ga	ppm	*14.9*	Sb	ppm	*0.45*	Yb	ppm	*2.48*
Gd	ppm	*2.84*	Sc	ppm	*42.0*	Zn	ppm	*85*
Ge	ppm	*1.45*	Se	ppm	*< 5*	Zr	ppm	*60*

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.

STATISTICAL ANALYSIS

Certified Values, Confidence Limits, Standard Deviations and Tolerance Limits (Table 1) 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 3) 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 218.

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 provided for the major and trace elements determined by borate fusion XRF (Al_2O_3 to TiO_2) and laser ablation with ICP-MS (Ag to Zr) and are the means of duplicate assays from Bureau Veritas, Perth. Additional indicative values by other analytical methods are present where the number of laboratories reporting a particular analyte is insufficient (< 5) to support certification or where inter-laboratory consensus is poor.

Standard Deviation values (1SDs) are reported in Table 1 and 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. The SD's 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 SD values thus include all sources of measurement uncertainty: between-lab variance, within-run variance (precision errors) and CRM variability. OREAS prepared reference materials have a level of homogeneity such that the observed variance from repeated analysis has its origin almost exclusively in the analytical process rather than the reference material itself.

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 any 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.**

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-lab 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.

Table 4 shows **Performance Gates** 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. 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.

Tolerance Limits (ISO Guide 3207) were determined by INAA using the reduced analytical subsample method that 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 (a sampling error is thereby induced) and measurement error becomes negligible.

In this instance a subsample weight of 1 gram was employed and the 1RSD of 1.35% calculated for a 30g fire assay or aqua regia sample (7.22% at 1g weight) confirms the high level of gold homogeneity in OREAS 218. The homogeneity is of a level such that ***sampling error is minor*** for a conventional fire assay or aqua regia determination.

Please note that these RSD's and tolerance limits pertain to the homogeneity of the CRM only and should not be used as control limits for laboratory performance.

Table 3. Instrumental Neutron Activation Analysis of Au (ppm) on 20 x 1g subsamples.

Replicate No	INAA 1g
1	0.489
2	0.545
3	0.522
4	0.465
5	0.506
6	0.506
7	0.536
8	0.541
9	0.534
10	0.475
11	0.516
12	0.468
13	0.566
14	0.506
15	0.588
16	0.579
17	0.542
18	0.521
19	0.503
20	0.598
Mean	0.525
Median	0.522
Std Dev.	0.038
Rel.Std.Dev.	7.22%
PDM[3]	-1.10%

The meaning of tolerance limits may be illustrated for gold by fire assay, where 99% of the time (1-α=0.99) at least 95% of subsamples (ρ=0.95) will have concentrations lying between 0.508 and 0.554ppm. 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).

The gold homogeneity of OREAS 218 has also been evaluated in a **nested ANOVA** of the round robin program. Each of the thirty round robin laboratories received six samples per CRM and these samples were made up of paired samples from three different, non-adjacent sampling intervals. The purpose of the ANOVA evaluation is to test that no statistically significant difference exists in the variance between-units to that of the variance within-units. This allows an assessment of homogeneity across the entire prepared batch of OREAS 218. The test was performed using the following parameters:

- Gold fire assay – 174 samples (29 laboratories each providing analyses on 3 pairs of samples);
- Gold aqua regia digestion – 126 samples (21 laboratories each providing analyses on 3 pairs of samples);

- Null Hypothesis, H_0: Between-unit variance is no greater than within-unit variance (reject H_0 if p-value < 0.05);
- Alternative Hypothesis, H_1: Between-unit variance is greater than within-unit variance.

P-values are a measure of probability where values less than 0.05 indicate a greater than 95% probability that the observed differences in within-unit and between-unit variances are real. The dataset was filtered for both individual and laboratory data set (batch) outliers prior to the calculation of the *p*-value. This process derived *p*-values of 1.00 for Au by fire assay and 0.99 for Au by aqua regia digestion. Both p-values are insignificant and the Null Hypothesis is retained.

It is important to note that ANOVA is not an absolute measure of homogeneity. Rather, it establishes whether or not the analytes are distributed in a similar manner throughout the packaging run of OREAS 218 and whether the variance between two subsamples from the same unit is statistically distinguishable to the variance from two subsamples taken from any two separate units. A reference material therefore, can possess poor absolute homogeneity yet still pass a relative homogeneity test if the within-unit heterogeneity is large and similar across all units.

Based on the statistical analysis of the results of the inter-laboratory certification program it can be concluded that OREAS 218 is fit-for-purpose as a certified reference material (see ‘Intended Use’ below).

Table 4. Performance Gates for OREAS 218.

Constituent	Certified Value	Absolute Standard Deviations					Relative Standard Deviations			5% window	
		1SD	2SD Low	2SD High	3SD Low	3SD High	1RSD	2RSD	3RSD	Low	High
Pb Fire Assay											
Au, ppm	0.531	0.017	0.497	0.565	0.480	0.582	3.21%	6.41%	9.62%	0.505	0.558
Aqua Regia Digestion											
Au, ppm	0.524	0.020	0.484	0.564	0.464	0.584	3.85%	7.69%	11.54%	0.498	0.550
Gas / Liquid Pycnometry											
SG, Unity	3.01	0.059	2.89	3.13	2.83	3.19	1.96%	3.93%	5.89%	2.86	3.16

PARTICIPATING LABORATORIES

1. Actlabs, Ancaster, Ontario, Canada
2. Actlabs, Coquimbo, Curarta, Chile
3. ALS, Brisbane, QLD, Australia
4. ALS, Lima, Peru
5. ALS, Loughrea, Galway, Ireland
6. ALS, Perth, WA, Australia
7. ALS, Vancouver, BC, Canada
8. American Assay Laboratories, Sparks, Nevada, USA
9. Bureau Veritas Commodities Canada Ltd, Vancouver, BC, Canada

10. Bureau Veritas Geoanalytical, Adelaide, SA, Australia
11. Bureau Veritas Geoanalytical, Perth, WA, Australia
12. Bureau Veritas Kalassay, Kalgoorlie, WA, Australia
13. Bureau Veritas Minerals, Hermosillo, Sonora, Mexico
14. Bureau Veritas, Abidjan, Cote D'ivoire
15. Intertek Genalysis, Perth, WA, Australia
16. Intertek Testing Services, Cupang, Muntinlupa, Philippines
17. Kinross Brasil Mineração, Paracatu, Minas Gerais, Brazil
18. McClelland Laboratories Inc., Sparks, Nevada, USA
19. MinAnalytical Services, Perth, WA, Australia
20. Nagrom, Perth, WA, Australia
21. Newcrest Laboratory Services, Orange, NSW, Australia
22. PT Geoservices Ltd, Cikarang, Jakarta Raya, Indonesia
23. PT Intertek Utama Services, Jakarta Timur, DKI Jakarta, Indonesia
24. SGS Australia Mineral Services, Perth, WA, Australia
25. SGS del Peru, Lima, Peru
26. SGS Lakefield Research Ltd, Lakefield, Ontario, Canada
27. SGS Mineral Services, Townsville, QLD, Australia
28. SGS, Randfontein, Gauteng, South Africa
29. Shiva Analyticals Ltd, Bangalore North, Karnataka, India
30. Sucofindo Mineral Lab, Cibitung, West Java, Indonesia

PREPARER AND SUPPLIER

Certified reference material OREAS 218 is prepared, certified and supplied by:

ORE RESEARCH & EXPLORATION

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

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

It is available in unit sizes of 60 and 100g (single-use laminated foil pouches) and 1kg (plastic jars).

INTENDED USE

OREAS 218 is intended for the following uses:

- for the monitoring of laboratory performance in the analysis of gold by fire assay, gold by aqua regia digestion and specific gravity by pycnometry in geological samples;
- for the verification of analytical methods (gold fire assay, gold aqua regia digestion and specific gravity by pycnometry);
- for the calibration of instruments used in the determination of gold or specific gravity.

STABILITY AND STORAGE INSTRUCTIONS

OREAS 218 has been prepared from primary gold ore diluted with barren greenstone. It is low in reactive sulphide (~0.14 wt.% S) and in its unopened state and under normal conditions of storage has a shelf life beyond ten years. Its stability will be monitored at regular intervals and purchasers notified if any changes are observed.

INSTRUCTIONS FOR CORRECT USE

The certified values for OREAS 218 refer to the concentration level in its packaged state. It should not be dried prior to weighing and analysis.

HANDLING INSTRUCTIONS

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

TRACEABILITY

The analytical samples were selected in a manner to represent the entire batch of prepared CRM. This ‘representivity’ was maintained in each submitted laboratory sample batch and ensures the user that the data is traceable from sample selection through to the analytical results that underlie the consensus values. Each analytical data set has been validated by its assayer through the inclusion of internal reference materials and QC checks during analysis. The laboratories were chosen on the basis of their competence (from past performance in inter-laboratory programs) 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.

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 ACCREDITED

ORE Pty Ltd is accredited to ISO 9001:2008 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

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