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CERTIFICATE OF ANALYSIS FOR

Primary Quartz Blank (Grey pigmented quartz, Australia)

CERTIFIED REFERENCE MATERIAL

OREAS 22f

Table 1. Certified Values, SDs, 95% Confidence and Tolerance Limits for OREAS 22f.

Constituent	Certified Value	SD	95% Confidence Limits		95% Tolerance Limits	
			Low	High	Low	High
Pb Fire Assay						
Au, Gold (ppb)	< 1	IND	IND	IND	IND	IND
4-Acid Digestion						
Ag, Silver (ppm)	< 0.03	IND	IND	IND	IND	IND
Al, Aluminium (wt.%)	0.110	0.010	0.102	0.118	0.104	0.116
Ba, Barium (ppm)	4.79	0.55	4.39	5.20	IND	IND
Be, Beryllium (ppm)	0.067	0.014	0.056	0.078	IND	IND
Ca, Calcium (wt.%)	0.027	0.003	0.026	0.029	IND	IND
Ce, Cerium (ppm)	1.90	0.157	1.78	2.01	1.61	2.19
Co, Cobalt (ppm)	1.03	0.058	1.00	1.07	IND	IND
Cs, Cesium (ppm)	0.081	0.006	0.077	0.085	IND	IND
Cu, Copper (ppm)	10.6	0.50	10.1	11.1	10.1	11.2
Fe, Iron (wt.%)	0.575	0.023	0.560	0.590	0.561	0.589
Ga, Gallium (ppm)	0.32	0.05	0.27	0.37	0.27	0.37
Hf, Hafnium (ppm)	0.20	0.018	0.18	0.21	IND	IND
K, Potassium (wt.%)	0.010	0.001	0.009	0.010	IND	IND
La, Lanthanum (ppm)	0.98	0.12	0.90	1.05	IND	IND
Li, Lithium (ppm)	16.2	0.73	15.7	16.7	15.4	17.0
Mg, Magnesium (wt.%)	0.020	0.001	0.020	0.020	0.019	0.021
Mn, Manganese (wt.%)	0.008	0.000	0.007	0.008	0.007	0.008
Mo, Molybdenum (ppm)	2.00	0.109	1.94	2.05	1.85	2.14
Na, Sodium (wt.%)	0.010	0.000	0.010	0.011	0.009	0.011
Nb, Niobium (ppm)	1.19	0.16	1.09	1.28	1.08	1.29
Ni, Nickel (ppm)	6.78	0.491	6.40	7.17	6.39	7.18
Rb, Rubidium (ppm)	0.42	0.033	0.40	0.43	0.36	0.48
Sb, Antimony (ppm)	0.18	0.009	0.17	0.19	IND	IND
Sc, Scandium (ppm)	0.29	0.04	0.27	0.31	IND	IND
Sn, Tin (ppm)	0.73	0.057	0.69	0.77	IND	IND
Sr, Strontium (ppm)	3.75	0.211	3.62	3.87	3.51	3.98
Th, Thorium (ppm)	0.54	0.030	0.52	0.56	0.50	0.58
Ti, Titanium (wt.%)	0.030	0.002	0.029	0.032	0.029	0.031
U, Uranium (ppm)	0.11	0.01	0.10	0.12	IND	IND
V, Vanadium (ppm)	2.98	0.35	2.80	3.16	IND	IND
W, Tungsten (ppm)	0.20	0.04	0.18	0.21	IND	IND
Y, Yttrium (ppm)	0.59	0.07	0.55	0.62	0.51	0.67
Zn, Zinc (ppm)	5.31	0.70	4.97	5.65	IND	IND
Zr, Zirconium (ppm)	6.90	0.475	6.63	7.18	6.31	7.50

SI unit equivalents: ppm, parts per million ≡ mg/kg ≡ µg/g ≡ 0.0001 wt.% ≡ 1000 ppb, parts per billion.
Note: intervals may appear asymmetric due to rounding.

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

OREAS 22f has been prepared from quartz sand to which 0.5% iron oxide has been added to produce a pale grey pulp. This colouring gives the material an appearance of primary origin (i.e. non-oxide). It is characterised by extremely low background gold of less than 1 part per billion.

COMMINUTION AND HOMOGENISATION PROCEDURES

The material constituting OREAS 22f was prepared in the following manner:

- drying to constant mass at 105°C;
- preliminary blending of quartz sand with 0.5% iron oxide pigment;
- milling to approximately >99% less than 75 microns;
- final homogenisation;
- packaging in 10 and 60g units in laminated foil pouches and 1kg units in jars.

ANALYTICAL PROGRAM

Ten commercial analytical laboratories participated in the program to characterise:

- Au by low level (1ppb reading resolution) fire assay with ICP-OES (6 labs) or ICP-MS (4 labs) finish and
- Full ICP-OES and ICP-MS elemental suites by 4-acid (HF-HNO_3-HCl-$HClO_4$) digestion.

For the round robin program ten 700g test units were taken at predetermined intervals during the bagging stage, immediately following homogenisation and are considered representative of the entire batch. The six samples received by each laboratory were obtained by taking a 110g split from every odd or even numbered test unit plus an additional opposite numbered test unit (E.g, from test units: 1, 3, 5, 7, 9 and 2).

Table 1 presents the certified values together with their associated 1SD's, 95% confidence and tolerance limits and Table 2 shows indicative (non-certified) values including major and trace element composition. Table 3 provides performance gate intervals for the certified values based on their associated standard deviations. Tabulated results of all elements together with analytical method codes, 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 22f DataPack-1.0.181002_143824.xlsx**).

Table 2. Indicative Values for OREAS 22f.

Constituent	Unit	Value	Constituent	Unit	Value	Constituent	Unit	Value
Pb Fire Assay								
Pd	ppb	*< 1*	Pt	ppb	*< 1*			
4-Acid Digestion								
As	ppm	*0.94*	Ho	ppm	*0.028*	Se	ppm	*< 0.5*
Bi	ppm	*0.009*	In	ppm	*< 0.005*	Sm	ppm	*0.18*
Cd	ppm	*< 0.02*	Lu	ppm	*0.008*	Ta	ppm	*0.050*
Cr	ppm	*26.2*	Nd	ppm	*0.77*	Tb	ppm	*0.021*
Dy	ppm	*0.13*	P	wt.%	*0.002*	Te	ppm	*< 0.05*
Er	ppm	*0.090*	Pb	ppm	*0.85*	Tl	ppm	*< 0.02*
Eu	ppm	*0.022*	Pr	ppm	*0.23*	Tm	ppm	*0.012*
Gd	ppm	*0.16*	Re	ppm	*< 0.002*	Yb	ppm	*0.091*
Ge	ppm	*0.34*	S	wt.%	*< 0.01*			
Borate Fusion XRF								
Al_2O_3	wt.%	*0.255*	K_2O	wt.%	*0.009*	SiO_2	wt.%	*98.69*
BaO	ppm	*< 100*	MgO	wt.%	*0.030*	SO_3	wt.%	*0.005*
CaO	wt.%	*0.040*	MnO	wt.%	*0.010*	SrO	ppm	*< 100*
Cl	ppm	*< 10*	Na_2O	wt.%	*0.020*	TiO_2	wt.%	*0.050*
Cr_2O_3	ppm	*90*	Ni	ppm	*20.0*	V_2O_5	ppm	*10.0*
Cu	ppm	*30.0*	P_2O_5	wt.%	*0.004*	Zn	ppm	*< 10*
Fe_2O_3	wt.%	*0.795*	Pb	ppm	*10.0*	ZrO_2	ppm	*20.0*
Thermogravimetry								
LOI^{1000}	wt.%	*0.030*						
Laser Ablation ICP-MS								
Ag	ppm	*0.075*	Hf	ppm	*0.54*	Sm	ppm	*0.22*
As	ppm	*1.10*	Ho	ppm	*0.040*	Sn	ppm	*1.20*
Ba	ppm	*7.75*	In	ppm	*< 0.05*	Sr	ppm	*4.45*
Be	ppm	*0.25*	La	ppm	*1.01*	Ta	ppm	*0.080*
Bi	ppm	*< 0.02*	Lu	ppm	*0.020*	Tb	ppm	*0.030*
Cd	ppm	*< 0.1*	Mn	wt.%	*0.008*	Te	ppm	*< 0.2*
Ce	ppm	*2.06*	Mo	ppm	*2.60*	Th	ppm	*0.64*
Co	ppm	*1.15*	Nb	ppm	*1.42*	Ti	wt.%	*0.033*
Cr	ppm	*37.5*	Nd	ppm	*0.97*	Tl	ppm	*< 0.2*
Cs	ppm	*0.12*	Ni	ppm	*13.0*	Tm	ppm	*0.020*
Cu	ppm	*18.0*	Pb	ppm	*< 1*	U	ppm	*0.16*
Dy	ppm	*0.16*	Pr	ppm	*0.26*	V	ppm	*3.40*
Er	ppm	*0.13*	Rb	ppm	*0.50*	W	ppm	*< 0.5*
Eu	ppm	*0.025*	Re	ppm	*< 0.01*	Y	ppm	*0.93*
Ga	ppm	*0.40*	Sb	ppm	*0.30*	Yb	ppm	*0.13*
Gd	ppm	*0.18*	Sc	ppm	*0.95*	Zn	ppm	*< 5*
Ge	ppm	*0.85*	Se	ppm	*< 5*	Zr	ppm	*19.3*

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.

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 22f.

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 ZrO_2), laser ablation with ICP-MS (Ag to Zr) and LOI at 1000°C 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 3 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. 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 4. Pooled-Lab Performance Gates for OREAS 22f.

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	< 1	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
4-Acid Digestion											
Ag, ppm	< 0.03	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Al, wt.%	0.110	0.010	0.089	0.131	0.079	0.141	9.43%	18.86%	28.29%	0.105	0.116
Ba, ppm	4.79	0.55	3.69	5.90	3.14	6.45	11.53%	23.05%	34.58%	4.55	5.03
Be, ppm	0.067	0.014	0.039	0.096	0.024	0.110	21.24%	42.48%	63.73%	0.064	0.070
Ca, wt.%	0.027	0.003	0.021	0.034	0.018	0.037	11.18%	22.36%	33.53%	0.026	0.029
Ce, ppm	1.90	0.157	1.58	2.21	1.43	2.37	8.27%	16.54%	24.81%	1.80	1.99
Co, ppm	1.03	0.058	0.92	1.15	0.86	1.21	5.60%	11.20%	16.80%	0.98	1.09
Cs, ppm	0.081	0.006	0.069	0.093	0.062	0.099	7.62%	15.25%	22.87%	0.077	0.085
Cu, ppm	10.6	0.50	9.6	11.7	9.1	12.2	4.74%	9.47%	14.21%	10.1	11.2
Fe, wt.%	0.575	0.023	0.530	0.620	0.507	0.643	3.93%	7.87%	11.80%	0.546	0.604
Ga, ppm	0.32	0.05	0.23	0.41	0.18	0.46	14.61%	29.21%	43.82%	0.30	0.33

SI unit equivalents: ppm, parts per million ≡ mg/kg ≡ µg/g ≡ 0.0001 wt.% ≡ 1000 ppb, parts per billion.
Note: intervals may appear asymmetric due to rounding.

Table 4 continued.

Constituent	Certified Value	Absolute Standard Deviations					Relative Standard Deviations			5% window	
		1SD	2SD Low	2SD High	3SD Low	3SD High	1RSD	2RSD	3RSD	Low	High
4-Acid Digestion continued											
Hf, ppm	0.20	0.018	0.16	0.23	0.14	0.25	9.10%	18.20%	27.30%	0.19	0.21
K, wt.%	0.010	0.001	0.009	0.011	0.008	0.012	6.22%	12.44%	18.66%	0.009	0.010
La, ppm	0.98	0.12	0.74	1.21	0.63	1.32	11.90%	23.80%	35.70%	0.93	1.02
Li, ppm	16.2	0.73	14.7	17.7	14.0	18.4	4.53%	9.06%	13.59%	15.4	17.0
Mg, wt.%	0.020	0.001	0.019	0.021	0.018	0.022	3.06%	6.13%	9.19%	0.019	0.021
Mn, wt.%	0.008	0.000	0.007	0.008	0.007	0.009	4.28%	8.55%	12.83%	0.007	0.008
Mo, ppm	2.00	0.109	1.78	2.21	1.67	2.32	5.45%	10.90%	16.34%	1.90	2.10
Na, wt.%	0.010	0.000	0.009	0.011	0.009	0.012	4.40%	8.80%	13.20%	0.010	0.011
Nb, ppm	1.19	0.16	0.87	1.51	0.71	1.67	13.47%	26.93%	40.40%	1.13	1.25
Ni, ppm	6.78	0.491	5.80	7.77	5.31	8.26	7.23%	14.46%	21.70%	6.45	7.12
Rb, ppm	0.42	0.033	0.35	0.48	0.32	0.52	7.93%	15.85%	23.78%	0.40	0.44
Sb, ppm	0.18	0.009	0.16	0.20	0.15	0.20	5.27%	10.53%	15.80%	0.17	0.19
Sc, ppm	0.29	0.04	0.21	0.37	0.17	0.41	13.79%	27.58%	41.37%	0.27	0.30
Sn, ppm	0.73	0.057	0.62	0.85	0.56	0.90	7.86%	15.72%	23.57%	0.69	0.77
Sr, ppm	3.75	0.211	3.32	4.17	3.11	4.38	5.64%	11.28%	16.92%	3.56	3.93
Th, ppm	0.54	0.030	0.48	0.60	0.45	0.63	5.56%	11.11%	16.67%	0.51	0.57
Ti, wt.%	0.030	0.002	0.027	0.033	0.026	0.035	5.17%	10.33%	15.50%	0.029	0.032
U, ppm	0.11	0.01	0.08	0.14	0.07	0.15	13.01%	26.02%	39.04%	0.10	0.11
V, ppm	2.98	0.35	2.29	3.67	1.94	4.02	11.60%	23.21%	34.81%	2.83	3.13
W, ppm	0.20	0.04	0.12	0.27	0.09	0.31	18.49%	36.98%	55.47%	0.19	0.21
Y, ppm	0.59	0.07	0.46	0.72	0.39	0.79	11.26%	22.53%	33.79%	0.56	0.62
Zn, ppm	5.31	0.70	3.90	6.71	3.20	7.41	13.24%	26.48%	39.72%	5.04	5.57
Zr, ppm	6.90	0.475	5.95	7.85	5.48	8.33	6.88%	13.77%	20.65%	6.56	7.25

SI unit equivalents: ppm, parts per million ≡ mg/kg ≡ µg/g ≡ 0.0001 wt.% ≡ 1000 ppb, parts per billion.
Note: intervals may appear asymmetric due to rounding.

PARTICIPATING LABORATORIES

1. ALS, Lima, Peru
2. ALS, Perth, WA, Australia
3. ALS, Vancouver, BC, Canada
4. Bureau Veritas Commodities Canada Ltd, Vancouver, BC, Canada
5. Bureau Veritas Geoanalytical, Perth, WA, Australia
6. Intertek Genalysis, Adelaide, SA, Australia
7. Intertek Genalysis, Perth, WA, Australia
8. MinAnalytical Services, Perth, WA, Australia
9. SGS Australia Mineral Services, Perth, WA, Australia
10. SGS Lakefield Research Ltd, Lakefield, Ontario, Canada

PREPARER AND SUPPLIER

Certified reference material OREAS 22f is prepared, certified and supplied by:

ORE RESEARCH & EXPLORATION

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It is packaged in 10 and 60g units in laminated foil pouches and 1kg units in plastic jars.

METROLOGICAL 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 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 22f 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 22f may be used to calibrate the entire procedure by producing a pure substance CRM transformed into a calibration solution.

OREAS 22f 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.

STABILITY AND STORAGE INSTRUCTIONS

OREAS 22e has been prepared from barren quartz blended with a small amount of iron oxide (0.5%). In its unopened state and under normal conditions of storage it 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 22f refer to the concentration levels in its packaged state. There is no need for drying 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.

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
1	12th Dec, 2019	Corrected 'Au Fire Assay' data in Table 4 (Pooled-Lab Performance Gates).
0	4th Oct, 2018	First publication.

QMS ACCREDITED

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

CERTIFYING OFFICER

12th December, 2019

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

REFERENCES

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