

CERTIFICATE OF ANALYSIS FOR

CERTIFIED REFERENCE MATERIAL

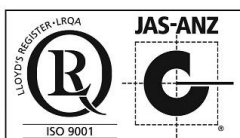
OREAS 22j

Primary Quartz Blank

Grey pigmented quartz, Australia



Accredited for compliance with ISO 17034



COA-2136-OREAS 22j-R1

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Table 1. Certified Values, Uncertainty & Tolerance Intervals in OREAS 22j.

Constituent	Certified Value	95% Expanded Uncertainty		95% Tolerance Limits	
		Low	High	Low	High
Pb Fire Assay					
Au, Gold (ppb)	< 1	IND	IND	IND	IND
4-Acid Digestion					
Al, Aluminium (wt.%)	0.073	0.066	0.081	0.070	0.077
Be, Beryllium (ppm)	0.069	0.050	0.087	IND	IND
Cd, Cadmium (ppm)	< 0.02	IND	IND	IND	IND
Ce, Cerium (ppm)	1.90	1.60	2.21	1.74	2.07
Co, Cobalt (ppm)	0.84	0.73	0.94	0.79	0.88
Cs, Caesium (ppm)	0.091	0.072	0.110	IND	IND
Cu, Copper (ppm)	8.52	7.89	9.14	8.09	8.95
Er, Erbium (ppm)	0.067	0.054	0.081	IND	IND
Fe, Iron (wt.%)	0.351	0.338	0.364	0.341	0.361
Ga, Gallium (ppm)	0.17	0.13	0.21	0.15	0.18
Gd, Gadolinium (ppm)	0.14	0.11	0.17	IND	IND
Hf, Hafnium (ppm)	0.19	0.16	0.23	0.17	0.22
In, Indium (ppm)	< 0.005	IND	IND	IND	IND
K, Potassium (wt.%)	< 0.01	IND	IND	IND	IND
La, Lanthanum (ppm)	0.89	0.74	1.03	0.83	0.95
Li, Lithium (ppm)	15.0	14.1	15.9	14.5	15.4
Mg, Magnesium (wt.%)	0.004	0.003	0.004	0.003	0.004
Mn, Manganese (wt.%)	0.012	0.012	0.013	0.012	0.013
Mo, Molybdenum (ppm)	0.57	0.49	0.66	0.55	0.60
Nb, Niobium (ppm)	0.41	0.36	0.46	0.37	0.44
Nd, Neodymium (ppm)	0.82	0.68	0.97	0.78	0.87
Ni, Nickel (ppm)	5.44	5.03	5.86	5.15	5.74
P, Phosphorus (wt.%)	< 0.005	IND	IND	IND	IND
Pr, Praseodymium (ppm)	0.23	0.18	0.27	0.19	0.27
Rb, Rubidium (ppm)	0.28	0.21	0.34	0.23	0.33
Re, Rhenium (ppm)	< 0.002	IND	IND	IND	IND
S, Sulphur (wt.%)	< 0.01	IND	IND	IND	IND
Sb, Antimony (ppm)	0.15	0.11	0.18	IND	IND
Sc, Scandium (ppm)	0.13	0.10	0.16	IND	IND
Se, Selenium (ppm)	< 0.5	IND	IND	IND	IND
Sm, Samarium (ppm)	0.15	0.12	0.18	IND	IND
Sn, Tin (ppm)	0.54	0.48	0.60	0.51	0.58
Sr, Strontium (ppm)	0.44	0.34	0.53	0.38	0.49
Tb, Terbium (ppm)	0.022	0.020	0.025	IND	IND
Te, Tellurium (ppm)	< 0.05	IND	IND	IND	IND
Th, Thorium (ppm)	0.65	0.57	0.74	0.60	0.71
Ti, Titanium (wt.%)	0.014	0.013	0.015	0.013	0.015

SI unit equivalents: ppb (parts per billion; 1×10^{-9}) $\equiv$ $\mu\text{g/kg}$; ppm (parts per million; 1×10^{-6}) $\equiv$ mg/kg ; wt.% (weight per cent) $\equiv$ % (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 1 continued.

Constituent	Certified Value	95% Expanded Uncertainty		95% Tolerance Limits	
		Low	High	Low	High
4-Acid Digestion continued					
U, Uranium (ppm)	0.15	0.12	0.18	0.12	0.18
V, Vanadium (ppm)	1.98	1.85	2.12	IND	IND
W, Tungsten (ppm)	0.12	0.10	0.14	0.10	0.14
Y, Yttrium (ppm)	0.59	0.49	0.69	0.53	0.65
Yb, Ytterbium (ppm)	0.071	0.035	0.107	IND	IND
Zn, Zinc (ppm)	13.4	12.1	14.7	12.9	13.9
Zr, Zirconium (ppm)	5.90	5.01	6.78	5.50	6.29

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

Note: intervals may appear asymmetric due to rounding.

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

Table 2. Indicative Values for OREAS 22j.

Constituent	Unit	Value	Constituent	Unit	Value	Constituent	Unit	Value
Pb Fire Assay								
Pd	ppb	< 2	Pt	ppb	< 3			
4-Acid Digestion								
Ag	ppm	0.043	Dy	ppm	0.11	Pb	ppm	0.57
As	ppm	0.55	Eu	ppm	< 0.03	SiO ₂	wt. %	99.04
B	ppm	3.58	Ge	ppm	0.060	Ta	ppm	0.026
Ba	ppm	2.02	Hg	ppm	< 0.01	Tl	ppm	0.003
Bi	ppm	0.011	Ho	ppm	0.023	Tm	ppm	< 0.01
Ca	wt. %	0.007	Lu	ppm	< 0.01			
Cr	ppm	5.69	Na	wt. %	0.002			
Borate Fusion XRF								
Al ₂ O ₃	wt. %	0.195	MgO	wt. %	0.015	SiO ₂	wt. %	99.21
CaO	wt. %	0.015	MnO	wt. %	0.016	SO ₃	wt. %	0.003
Fe ₂ O ₃	wt. %	0.515	Na ₂ O	wt. %	0.010	TiO ₂	wt. %	0.026
K ₂ O	wt. %	0.002	P ₂ O ₅	wt. %	0.003			
Thermogravimetry								
H ₂ O-	wt. %	0.037	LOI ¹⁰⁰⁰	wt. %	0.099			
Laser Ablation ICP-MS								
Ag	ppm	< 0.1	Hf	ppm	0.40	Sn	ppm	0.60
As	ppm	0.40	Ho	ppm	0.030	Sr	ppm	0.30
Ba	ppm	0.63	In	ppm	< 0.05	Ta	ppm	0.065
Be	ppm	< 0.2	La	ppm	0.92	Tb	ppm	0.030
Bi	ppm	< 0.02	Lu	ppm	0.020	Te	ppm	< 0.2
Cd	ppm	< 0.1	Mn	wt. %	0.012	Th	ppm	0.66
Ce	ppm	2.03	Mo	ppm	1.00	Ti	wt. %	0.014
Co	ppm	0.70	Nb	ppm	0.38	Tl	ppm	< 0.2
Cr	ppm	5.00	Nd	ppm	0.89	Tm	ppm	0.015
Cs	ppm	0.080	Ni	ppm	6.00	U	ppm	0.15
Cu	ppm	8.00	Pb	ppm	< 1	V	ppm	1.75
Dy	ppm	0.17	Pr	ppm	0.23	W	ppm	< 0.5
Er	ppm	0.12	Rb	ppm	0.18	Y	ppm	1.02
Eu	ppm	0.008	Re	ppm	0.008	Yb	ppm	0.12
Ga	ppm	0.20	Sb	ppm	0.10	Zn	ppm	12.5
Gd	ppm	0.14	Sc	ppm	< 0.1	Zr	ppm	12.0
Ge	ppm	0.70	Sm	ppm	0.19			

SI unit equivalents: ppb (parts per billion; 1×10^{-9}) $\equiv$ $\mu\text{g/kg}$; ppm (parts per million; 1×10^{-6}) $\equiv$ mg/kg ; wt. % (weight per cent) $\equiv$ % (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.

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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 'Instructions for handling and correct use' should be read carefully.

Table 1 presents the certified values together with their associated 95 % expanded uncertainty and tolerance intervals. Table 2 provides indicative values, including major and trace element characterisation, Table 3 lists indicative physical properties. Finally, Table 4 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 laboratory means from the corrected mean of means (PDM³) are presented in the detailed certification data for this CRM (**OREAS 22j-DataPack.1.1.260930_171434.xlsx**). The certified values and uncertainties in this Certificate are the sole authoritative figures. Any additional significant figures in the DataPack are provided for reference only and do not affect the certified results.

INTENDED USE

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

OREAS 22j 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/ validation 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. 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 Table 1)

SOURCE MATERIAL

OREAS 22j has been prepared from quartz sand to which 0.5% iron oxide (pigment) 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 µg/kg (1 part per billion).

MINIMUM SAMPLE SIZE

For application of the certified values in this certificate, the following minimum test portions apply to the respective operationally defined methods:

- Au by lead collection fire assay: ≥ 25 g
- 4-acid digestion with ICP-OES and/or MS finish: ≥ 0.25 g

The stated minimum test portions above are supported by the INAA homogeneity assessment and by the interlaboratory certification data, which showed no evidence of a significant effect of sample mass on measurement repeatability over the test portions represented in the program. Applicability of the certified values to smaller test portions has not been established.

INSTRUCTIONS FOR HANDLING, STORAGE & CORRECT USE

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

Pre-homogenisation of the CRM prior to subsampling and analysis is not necessary as there is no particle segregation under transport [12].

All certified values contained within this report refer to the concentration levels in the packaged state. There is no need for drying prior to weighing and analysis.

Single-use Sachets

OREAS 22j is available in single-use, 10 g and 60 g laminated foil sachets. Following analysis, it is the manufacturer's expectation that any remaining material is discarded. It is the user's responsibility to prevent contamination and avoid prolonged exposure of the sample to the atmosphere prior to analysis.

Repeat-use Packaging (e.g., 1 kg Plastic Jars)

After taking a subsample, users should replace the lid of the jar promptly and securely to prevent accidental spills and airborne contamination. OREAS 22j contains a non-hygroscopic* matrix with an indicative value for moisture provided to enable users to check for changes to stored material by determining moisture in the user's laboratory and comparing the result to the value in Table 3 in this certificate.

The risk to stability of the CRM in regard to oxidation from the breakdown of sulphide minerals to sulphates is minimal given its negligible sulphur concentration (<0.1 wt.% S).

*A non-hygroscopic matrix means exposure to atmospheres significantly different, in terms of temperature and humidity, from the climate during manufacturing should have negligible impact on the precision of results. Hygroscopic moisture is the amount of adsorbed moisture (weakly held H₂O- molecules on the surface of exposed material) following exposure to the local atmosphere. Usually, equilibration of material to the local atmosphere will only occur if the material is spread into a thin (~2mm thick) layer and left exposed for a period of 2 hours.

Authoritative Source of Information

This Certificate of Analysis constitutes the primary and authoritative document for the certified values, associated expanded uncertainties, and their correct use. While the accompanying DataPack provides supporting information, including raw data and uncertainty estimates with additional significant figures, these extended figures are provided solely for transparency, convenience and statistical reference. Users must rely exclusively on the values stated in this Certificate, rounded to an appropriate number of significant figures, for all metrological and analytical purposes. Any discrepancy between values presented in the DataPack and those in this Certificate shall be resolved in favour of the information provided herein.

Notice on Certificate Updates

The version of the Certificate of Analysis (COA) available on the OREAS website is considered the official and most current version. As COAs may be revised following periodic reviews, re-evaluation of data, or the availability of new information, users are strongly advised to refer to the latest online version prior to each use.

It is the user's responsibility to ensure that the most recent and applicable certificate is used to support the traceability, validity, and fitness-for-purpose of the certified reference material (CRM). Any significant changes to the sections of this certificate will be clearly documented in the revised certificate.

QC Monitoring Using Multiples of the Standard Deviation (SD)

When applying SDs to monitor performance, it is important to recognise that laboratories differ in proficiency, and that different methods have differing levels of precision. Each laboratory has its own inherent SD (specific to an analyte–method–concentration combination), which is not directly comparable to SDs derived from a round robin.

As most data in this round robin came from world-class laboratories, the interlaboratory SDs are narrower than would be expected across a broader mix. To provide more realistic benchmarks, this report presents pooled interlaboratory SDs, incorporating both within-lab variation and between-lab bias. These should be treated as a starting point only, with QC managers refining them against their own control charts.

The performance gates shown in Table 4 are intended only to be used as an initial 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, SDs 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 differs from the certified value, the significance of this bias should be assessed against the combined standard uncertainty of the certified value and the laboratory's own measurement uncertainty. Where the observed difference lies within this combined uncertainty, the bias is generally not considered significant.

PERIOD OF VALIDITY

The certification of OREAS 22j remains valid, within the specified measurement uncertainties, until at least April 2041, provided the CRM is handled and stored in accordance with the instructions given below. This certification is nullified if the CRM is any way changed or contaminated.

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

Long-term stability will be monitored at appropriate intervals and purchasers notified if any changes are observed. The period of validity may well be indefinite and will be reassessed prior to expiry with the aim of extending the validity if possible.

COMMINUTION AND HOMOGENISATION PROCEDURES

The materials constituting OREAS 22j was prepared in the following manner:

- Drying to constant mass at 105 °C
- Preliminary blending of quartz sand with black iron oxide pigment
- Milling to >99 % passing 75 microns
- Homogenisation using OREAS' novel processing technologies
- Packaging in 10 g and 60 g laminated foil pouches, and 1 kg plastic wide-mouth jars

PHYSICAL PROPERTIES

OREAS 22j 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 22j.

Bulk Density (kg/m ³)	Moisture (wt.%)	Munsell Notation [‡]	Munsell Color [‡]
904	0.07	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.

ANALYTICAL PROGRAM

Nineteen commercial analytical laboratories participated in the program to certify the elements reported in Table 1. The following methods were employed:

- Gold by Pb collection fire assay (25-50 g charge weight) with ICP-OES (12 laboratories), ICP-MS (4 laboratories) and AAS (1 laboratory) finish
- Full ICP-OES and ICP-MS elemental suites by 4-acid (HNO₃-HF-HClO₄-HCl) digestion (up to 19 laboratories depending on the element)

Major and trace elements were also characterised by Bureau Veritas Geoanalytical (Perth, Australia) using borate fusion XRF (Al₂O₃ to TiO₂), laser ablation ICP-MS (Ag to Zr), loss on ignition (LOI) at 1000 °C, and C and S by infrared combustion furnace (see Table 2, 'Indicative Values').

For the round robin program, sixteen 3 kg test units were collected at predetermined intervals during the bagging stage, immediately after homogenisation. Each participating laboratory received six test portions. The samples received by each laboratory were obtained by taking a 110 g sample from six different 3 kg test units to maximise representation.

The 20 individual INAA results upon which much of the homogeneity evaluation is based, included paired 10 g samples taken from 10 different sampling units. This format enabled a nested ANOVA treatment of the INAA results to evaluate homogeneity (see 'Homogeneity Evaluation' section below).

PARTICIPATING LABORATORIES

1. Actlabs, Ancaster, Ontario, Canada
2. Alex Stewart International, Mendoza, Argentina
3. ALS, Johannesburg, South Africa
4. ALS, Lima, Peru
5. ALS, Loughrea, Galway, Ireland
6. ALS, Malaga, WA, Australia
7. ALS, Vancouver, BC, Canada
8. American Assay Laboratories, Sparks, Nevada, USA
9. ARGETEST Mineral Processing, Ankara, Central Anatolia, Turkey
10. Bureau Veritas Geoanalytical, Perth, WA, Australia
11. Bureau Veritas Minerals, Ankara, Central Anatolia, Turkey
12. Intertek, Cupang, Muntinlupa, Philippines
13. Intertek, Perth, WA, Australia
14. Intertek, Townsville, QLD, Australia
15. Intertek Genalysis, Adelaide, SA, Australia
16. Nagrom, Perth, WA, Australia
17. PT Geoservices Ltd, Cikarang, Jakarta Raya, Indonesia
18. PT Intertek Utama Services, Jakarta Timur, DKI Jakarta, Indonesia
19. SGS Canada Inc., Vancouver, BC, Canada
20. SGS Geosol Laboratorios Ltda, Vespasiano, Minas Gerais, Brazil
21. UIS Analytical Services, Centurion, South Africa

Please note: To maintain anonymity of participating laboratories, the alphabetical list above does not correspond to the Lab ID numbers shown in the scatter plots below.

STATISTICAL ANALYSIS

Certified Values and their uncertainty intervals (Table 1) have been determined for each analyte following removal of individual, laboratory dataset (batch) and 3SD outliers (single iteration). Outlier evaluation was conducted in accordance with ISO 17034:2016 and ISO 33405:2024. While formal statistical tests were applied, professional statistical judgment was also exercised in determining the validity of potential outliers. Assessment of systematic bias and performance using independent control materials (CRMs) was incorporated to ensure compliance with the referenced standards and to establish metrological traceability of the certified values.

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 [6] and [15]. All known or suspected sources of bias have been investigated or taken into account.

Indicative (uncertified) values (Table 2) are present where the number of laboratories reporting a particular analyte is insufficient (< 5) to support certification or where interlaboratory consensus is poor. This data is intended for 'informational purposes' only.

Standard Deviation intervals (see Table 4, 'Performance Gates') 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.***

Homogeneity Evaluation

The tolerance limits (ISO 16269:2014) shown in Table 1 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 Cu by 4-acid digestion, where 99 % of the time ($1-\alpha=0.99$) at least 95 % of subsamples ($p=0.95$) will have concentrations lying between 8.09 and 8.95 ppm. 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.***

Analysis of Variance (ANOVA) Study

In addition to the precision error method outlined above, homogeneity was also evaluated using an ANOVA study. This involved sending 20 x 10 g pulp samples to the ANSTO laboratory for Cr, Fe, La, Co, Sc and Sb analysis by INAA. The 20 samples consisted of paired samples from each of the ten sampling units to enable an Analysis of Variance (ANOVA) by comparison of within- and between-unit variances across the ten 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).

The data were not filtered for outliers prior to calculation of the p -values. The analysis returned no significant p -values across the six reported elements, indicating no statistically significant evidence that between-unit variance exceeded within-unit variance. Therefore, H_0 was not rejected.

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. Based on the statistical analysis of the results of the interlaboratory certification program, it can be concluded that OREAS 22j is fit-for-purpose as a certified reference material (see 'Intended Use' above).

METROLOGICAL TRACEABILITY

The measurement scale for the certified values is mass fraction (mass/mass), with the mass measurements underpinning this scale metrologically traceable to the International System of Units (SI) through the SI unit of mass. In accordance with common geoanalytical practice, results presented in this certificate are reported as weight percent (wt.%), parts per million (ppm) or parts per billion (ppb).

Samples submitted to the interlaboratory certification program were selected to be representative of the entire prepared batch of CRM, with this representativeness maintained across the laboratory sample sets. Each analytical dataset was subject to the participating laboratory's internal quality-control procedures, including the use of reference materials and other appropriate QC checks.

Participating laboratories were selected on the basis of demonstrated analytical competence, including prior performance in interlaboratory comparison programs conducted by ORE Pty Ltd, with consideration given to their expertise in the relevant analytical methods, measurands and sample matrices. For the measurands reported in this certificate (Table 1), data were obtained from laboratories accredited to ISO/IEC 17025 where applicable. Where formal accreditation was not held for a specific measurand, evidence supporting analytical competence and metrological traceability was obtained through the inclusion of well-characterised, independently certified reference materials as control samples in the round robin study.

Consistent with ISO 33405:2024 [5], clause 9.2.5, and ISO 17034:2016 [9], clause 7.12.4, the metrological traceability and validity of measurement results used for characterisation were evaluated using appropriate supporting evidence. Agreement of measured control-sample values with their certified values provided additional evidence of the validity of results generated by participating laboratories. The certified values were assigned from the means of accepted laboratory datasets following the statistical procedures described in this report.

Operationally Defined Measurands

The certified values assigned to OREAS reference materials are operationally defined. The value obtained is therefore dependent, to some degree, on the measurement approach and conditions under which the measurand is realised and cannot necessarily be defined independently of them. Accordingly, while the mass-fraction measurement scale is underpinned by mass measurements traceable to the SI, metrological traceability of the certified value is established with reference to the applicable operationally defined measurand.

In accordance with ISO 33405:2024 [5], clause 9.5, characterisation is based on results obtained from a network of competent laboratories working within the applicable operational definition, with concordance of the results assessed as part of the value-assignment

process. Individual laboratory implementations may vary, and the resulting interlaboratory variation reflects, in part, differences inherent in the practical realisation of the measurand.

The certified value is therefore applicable to measurements consistent with the stated operational definition. Relevant interlaboratory variation is incorporated, as appropriate, into the uncertainty associated with the certified value. This approach provides the basis for metrological traceability appropriate to operationally defined measurands and supports the requirements of ISO 17034:2016 and ISO 33405:2024.

COMMUTABILITY

Commutability has been considered in relation to the intended use of this CRM. For most conventional geoanalytical measurement procedures, sample preparation and analytical treatment reduce or otherwise condition the material to a form suitable for measurement using well-established calibration procedures. Under these circumstances, significant commutability effects are not generally expected, and a dedicated experimental assessment of commutability was not considered necessary for this CRM.

OREAS CRMs are prepared from naturally occurring geological materials and are intended to behave similarly to routine geological samples when subjected to appropriate measurement procedures. Matrix composition, mineralogy and physical characteristics can nevertheless influence analytical response for some measurement procedures. Users should therefore select CRMs that are sufficiently representative of their routine samples and appropriate for the measurement procedure being monitored. The source material, matrix characteristics and intended use of this CRM are described elsewhere in this certificate to assist users in assessing its suitability for their particular application.

PERFORMANCE GATES

Table 4 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 % $\pm 2DL$ [1].

Table 4. Performance Gates for OREAS 22j.

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											
Al, wt. %	0.073	0.008	0.058	0.089	0.050	0.097	10.65%	21.31%	31.96%	0.070	0.077
Be, ppm	0.069	0.009	0.052	0.086	0.043	0.094	12.43%	24.85%	37.28%	0.065	0.072
Cd, ppm	< 0.02	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Ce, ppm	1.90	0.20	1.50	2.31	1.30	2.51	10.51%	21.02%	31.53%	1.81	2.00
Co, ppm	0.84	0.067	0.70	0.97	0.63	1.04	8.08%	16.16%	24.23%	0.79	0.88
Cs, ppm	0.091	0.014	0.062	0.120	0.048	0.134	15.92%	31.85%	47.77%	0.086	0.096
Cu, ppm	8.52	0.543	7.43	9.60	6.89	10.14	6.37%	12.75%	19.12%	8.09	8.94
Er, ppm	0.067	0.010	0.048	0.087	0.038	0.097	14.57%	29.14%	43.71%	0.064	0.071
Fe, wt. %	0.351	0.016	0.318	0.384	0.302	0.400	4.68%	9.35%	14.03%	0.334	0.369
Ga, ppm	0.17	0.03	0.11	0.23	0.08	0.26	17.53%	35.06%	52.59%	0.16	0.18
Gd, ppm	0.14	0.02	0.10	0.17	0.09	0.19	12.51%	25.03%	37.54%	0.13	0.14
Hf, ppm	0.19	0.02	0.15	0.23	0.13	0.25	10.37%	20.74%	31.10%	0.18	0.20
In, ppm	< 0.005	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
K, wt. %	< 0.01	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
La, ppm	0.89	0.10	0.70	1.08	0.60	1.18	10.83%	21.67%	32.50%	0.84	0.93
Li, ppm	15.0	0.83	13.3	16.6	12.5	17.4	5.53%	11.05%	16.58%	14.2	15.7
Mg, wt. %	0.004	0.001	0.002	0.005	0.002	0.005	15.29%	30.59%	45.88%	0.003	0.004
Mn, wt. %	0.012	0.000	0.012	0.013	0.011	0.013	2.53%	5.06%	7.59%	0.012	0.013
Mo, ppm	0.57	0.08	0.42	0.73	0.35	0.80	13.07%	26.15%	39.22%	0.55	0.60
Nb, ppm	0.41	0.04	0.32	0.49	0.28	0.54	10.41%	20.83%	31.24%	0.39	0.43
Nd, ppm	0.82	0.10	0.61	1.03	0.51	1.14	12.68%	25.37%	38.05%	0.78	0.86
Ni, ppm	5.44	0.486	4.47	6.42	3.99	6.90	8.93%	17.86%	26.79%	5.17	5.72
P, wt. %	< 0.005	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Pr, ppm	0.23	0.019	0.19	0.26	0.17	0.28	8.21%	16.42%	24.64%	0.22	0.24
Rb, ppm	0.28	0.04	0.20	0.35	0.17	0.39	13.29%	26.57%	39.86%	0.26	0.29
Re, ppm	< 0.002	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
S, wt. %	< 0.01	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Sb, ppm	0.15	0.02	0.11	0.18	0.09	0.20	12.67%	25.34%	38.01%	0.14	0.15
Sc, ppm	0.13	0.02	0.09	0.17	0.07	0.20	16.46%	32.92%	49.38%	0.12	0.14
Se, ppm	< 0.5	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Sm, ppm	0.15	0.02	0.12	0.19	0.10	0.21	12.09%	24.19%	36.28%	0.15	0.16
Sn, ppm	0.54	0.06	0.43	0.66	0.37	0.72	10.67%	21.34%	32.01%	0.51	0.57
Sr, ppm	0.44	0.08	0.27	0.60	0.19	0.69	19.14%	38.29%	57.43%	0.41	0.46
Tb, ppm	0.022	0.003	0.016	0.028	0.013	0.031	13.77%	27.55%	41.32%	0.021	0.023
Te, ppm	< 0.05	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Th, ppm	0.65	0.053	0.55	0.76	0.49	0.81	8.13%	16.25%	24.38%	0.62	0.69
Ti, wt. %	0.014	0.001	0.011	0.016	0.010	0.017	8.75%	17.50%	26.25%	0.013	0.014
U, ppm	0.15	0.02	0.11	0.19	0.09	0.21	13.67%	27.33%	41.00%	0.14	0.16
V, ppm	1.98	0.108	1.76	2.20	1.66	2.30	5.45%	10.90%	16.35%	1.88	2.08
W, ppm	0.12	0.012	0.09	0.14	0.08	0.15	9.83%	19.67%	29.50%	0.11	0.12

SI unit equivalents: ppb (parts per billion; 1×10^{-9}) $\equiv$ $\mu\text{g/kg}$; ppm (parts per million; 1×10^{-6}) $\equiv$ mg/kg ; wt.% (weight per cent) $\equiv$ % (mass fraction).

Note 1: intervals may appear asymmetric due to rounding; IND = indeterminate.

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 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											
Y, ppm	0.59	0.042	0.51	0.67	0.46	0.72	7.12%	14.24%	21.36%	0.56	0.62
Yb, ppm	0.071	0.014	0.044	0.098	0.030	0.112	19.05%	38.10%	57.15%	0.068	0.075
Zn, ppm	13.4	1.5	10.5	16.3	9.1	17.8	10.82%	21.63%	32.45%	12.7	14.1
Zr, ppm	5.90	0.471	4.95	6.84	4.48	7.31	7.99%	15.97%	23.96%	5.60	6.19

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

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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DOCUMENT HISTORY

Revision No.	Date	Changes applied
1	1 st October, 2026	Removed 4-acid results incorrectly reported in oxide form under IRC.
0	30 th September, 2026	First publication.

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