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CERTIFICATE OF ANALYSIS FOR

CERTIFIED REFERENCE MATERIAL

OREAS 713

Heavy Mineral Sand (20 wt.% TiO_2, 0.25 wt.% ZrO_2)

West Coast, South Island, New Zealand

Table 1. Certified Values, Uncertainty & Tolerance Intervals in OREAS 713.

Constituent	Certified Value	95% Expanded Uncertainty		95% Tolerance Limits	
		Low	High	Low	High
Borate Fusion XRF					
Al_2O_3, Aluminium(III) oxide (wt.%)	10.94	10.81	11.07	10.88	11.00
As, Arsenic (ppm)	< 100	IND	IND	IND	IND
Bi, Bismuth (ppm)	< 100	IND	IND	IND	IND
CaO, Calcium oxide (wt.%)	4.78	4.72	4.83	4.75	4.81
CeO_2, Cerium(IV) oxide (ppm)	719	572	867	IND	IND
Co, Cobalt (ppm)	< 100	IND	IND	IND	IND
Cr, Chromium (ppm)	217	196	238	203	231
Cu, Copper (ppm)	< 50	IND	IND	IND	IND
Fe, Iron (wt.%)	21.76	21.56	21.96	21.68	21.84
HfO_2, Hafnium dioxide (ppm)	< 100	IND	IND	IND	IND
K_2O, Potassium oxide (wt.%)	0.374	0.365	0.383	0.368	0.380
La_2O_3, Lanthanum(III) oxide (ppm)	446	353	540	IND	IND
MgO, Magnesium oxide (wt.%)	0.864	0.840	0.887	0.851	0.876
Mn, Manganese (wt.%)	2.02	2.00	2.04	2.01	2.03
Na_2O, Sodium oxide (wt.%)	0.439	0.401	0.477	0.425	0.453
Nb, Niobium (ppm)	178	142	215	IND	IND
Ni, Nickel (ppm)	< 50	IND	IND	IND	IND
P_2O_5, Phosphorus(V) oxide (wt.%)	0.190	0.184	0.196	0.185	0.195
SiO_2, Silicon dioxide (wt.%)	30.01	29.75	30.26	29.88	30.14
Sr, Strontium (ppm)	256	194	317	244	268
TiO_2, Titanium dioxide (wt.%)	19.94	19.76	20.11	19.88	20.00
Y_2O_3, Yttrium(III) oxide (ppm)	249	215	283	232	266
Zn, Zinc (ppm)	90	78	103	IND	IND
ZrO_2, Zirconium dioxide (wt.%)	0.253	0.240	0.266	0.247	0.258
Thermogravimetry					
LOI^{1000}, Loss on ignition @1000 °C (wt.%)	-1.96	-2.05	-1.86	-1.99	-1.93
4-Acid Digestion					
Al, Aluminium (wt.%)	5.59	5.42	5.75	5.47	5.70
Ba, Barium (ppm)	84	79	89	81	86
Be, Beryllium (ppm)	0.57	0.47	0.67	0.53	0.61
Bi, Bismuth (ppm)	0.28	0.25	0.30	0.26	0.30
Ca, Calcium (wt.%)	3.40	3.30	3.50	3.35	3.45
Cd, Cadmium (ppm)	0.41	0.39	0.44	0.39	0.43
Ce, Cerium (ppm)	599	570	628	588	610
Co, Cobalt (ppm)	15.9	15.1	16.8	15.4	16.5
Cr, Chromium (ppm)	179	166	191	172	185
Cs, Caesium (ppm)	0.82	0.77	0.86	0.78	0.86

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

Note: intervals may appear asymmetric due to rounding.

IND = indeterminate (due to limited reading resolution of the methods employed. For practical purposes the 95% Expanded Uncertainty can be set between zero and a two times multiple of the upper bound/non-detect limit value).

Table 1 continued.

Constituent	Certified Value	95% Expanded Uncertainty		95% Tolerance Limits	
		Low	High	Low	High
4-Acid Digestion continued					
Dy, Dysprosium (ppm)	23.4	22.0	24.7	22.6	24.1
Er, Erbium (ppm)	23.1	22.0	24.1	22.3	23.8
Eu, Europium (ppm)	3.52	3.32	3.72	3.37	3.68
Fe, Iron (wt.%)	21.38	20.78	21.97	21.07	21.68
Ga, Gallium (ppm)	9.88	8.93	10.83	9.51	10.25
Gd, Gadolinium (ppm)	20.9	19.2	22.7	20.1	21.7
Hf, Hafnium (ppm)	2.30	1.92	2.67	2.12	2.47
Ho, Holmium (ppm)	6.30	5.93	6.67	6.11	6.49
In, Indium (ppm)	0.10	0.09	0.11	0.10	0.11
K, Potassium (wt.%)	0.308	0.295	0.320	0.301	0.314
La, Lanthanum (ppm)	316	301	330	308	323
Li, Lithium (ppm)	18.8	17.8	19.8	18.2	19.5
Lu, Lutetium (ppm)	4.50	3.91	5.09	4.37	4.64
Mg, Magnesium (wt.%)	0.481	0.451	0.511	0.473	0.489
Mn, Manganese (wt.%)	1.92	1.82	2.02	1.89	1.95
Mo, Molybdenum (ppm)	2.30	2.04	2.56	2.17	2.43
Na, Sodium (wt.%)	0.319	0.305	0.333	0.311	0.327
Nb, Niobium (ppm)	164	155	172	158	170
Nd, Neodymium (ppm)	198	191	205	193	203
Ni, Nickel (ppm)	12.4	11.6	13.2	11.7	13.1
P, Phosphorus (wt.%)	0.077	0.073	0.081	0.074	0.080
Pb, Lead (ppm)	10.0	9.0	11.0	9.5	10.5
Pr, Praseodymium (ppm)	59	56	63	58	61
Rb, Rubidium (ppm)	16.1	15.2	16.9	15.5	16.7
S, Sulphur (wt.%)	< 0.01	IND	IND	IND	IND
Sb, Antimony (ppm)	0.43	0.39	0.47	0.39	0.47
Sc, Scandium (ppm)	49.2	46.5	51.8	47.4	50.9
Sm, Samarium (ppm)	28.6	27.2	30.0	27.8	29.4
Sn, Tin (ppm)	4.06	3.77	4.36	3.80	4.33
Sr, Strontium (ppm)	269	257	280	263	274
Ta, Tantalum (ppm)	16.3	15.0	17.6	15.6	17.1
Tb, Terbium (ppm)	3.10	2.91	3.30	2.98	3.23
Te, Tellurium (ppm)	< 0.05	IND	IND	IND	IND
Th, Thorium (ppm)	96	91	101	94	99
Ti, Titanium (wt.%)	11.32	10.66	11.97	11.22	11.41
Tl, Thallium (ppm)	0.093	0.081	0.106	IND	IND
Tm, Thulium (ppm)	4.23	3.95	4.51	4.13	4.33

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

Note: intervals may appear asymmetric due to rounding.

IND = indeterminate (due to limited reading resolution of the methods employed. For practical purposes the 95% Expanded Uncertainty can be set between zero and a two times multiple of the upper bound/non-detect limit value).

Table 1 continued.

Constituent	Certified Value	95% Expanded Uncertainty		95% Tolerance Limits	
		Low	High	Low	High
4-Acid Digestion continued					
U, Uranium (ppm)	10.2	9.5	10.9	9.8	10.5
V, Vanadium (ppm)	128	119	137	125	132
W, Tungsten (ppm)	4.03	3.67	4.38	3.83	4.22
Y, Yttrium (ppm)	173	164	183	169	177
Yb, Ytterbium (ppm)	30.4	28.8	32.0	29.5	31.3
Zn, Zinc (ppm)	92	87	97	89	95
Zr, Zirconium (wt.%)	0.007	0.006	0.009	0.007	0.008
Gas / Liquid Pycnometry					
SG, Specific Gravity (Unity)	3.86	3.77	3.94	3.82	3.90

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

Note: intervals may appear asymmetric due to rounding.

IND = indeterminate (due to limited reading resolution of the methods employed. For practical purposes the 95% Expanded Uncertainty can be set between zero and a two times multiple of the upper bound/non-detect limit value).

Table 2. Indicative Values for OREAS 713.

Constituent	Unit	Value	Constituent	Unit	Value	Constituent	Unit	Value
Borate Fusion XRF								
BaO	ppm	*241*	Ho	ppm	*< 90*	Sm	ppm	*86*
Cd	ppm	*< 100*	In	ppm	*< 100*	Sn	ppm	*< 50*
Cl	ppm	*60*	Lu	ppm	*81*	Ta	ppm	*14.3*
Cs	ppm	*< 100*	Mo	ppm	*< 50*	Tb	ppm	*< 90*
Dy	ppm	*80*	Nd	ppm	*209*	Te	ppm	*< 100*
Er	ppm	*102*	Pb	ppm	*83*	Th	ppm	*94*
Eu	ppm	*115*	Pr	ppm	*86*	Tl	ppm	*< 100*
F	ppm	*< 5000*	Rb	ppm	*< 50*	Tm	ppm	*< 90*
Ga	ppm	*< 100*	S	wt.%	*0.003*	U	ppm	*17.9*
Gd	ppm	*< 170*	Sb	ppm	*< 50*	V	ppm	*165*
Ge	ppm	*< 100*	Sc	ppm	*< 100*	W	ppm	*28.9*
Hg	ppm	*< 100*	Se	ppm	*< 100*	Yb	ppm	*66*
Thermogravimetry								
H_2O-	wt.%	*0.088*						
4-Acid Digestion								
Ag	ppm	*0.116*	Ge	ppm	*1.10*	Se	ppm	*2.86*
As	ppm	*2.78*	Hg	ppm	*< 1*			
Cu	ppm	*6.59*	Re	ppm	*0.004*			
Borate / Peroxide Fusion ICP								
Ce	ppm	*569*	La	ppm	*311*	Th	ppm	*83*
Dy	ppm	*23.5*	Lu	ppm	*4.82*	Ti	wt.%	*11.67*
Er	ppm	*24.5*	Mn	wt.%	*2.03*	Tm	ppm	*4.24*
Eu	ppm	*3.39*	Nd	ppm	*187*	U	ppm	*8.41*
Fe	wt.%	*22.23*	Pr	ppm	*58*	W	ppm	*3.92*
Gd	ppm	*22.6*	Sm	ppm	*27.5*	Yb	ppm	*30.9*
Ho	ppm	*6.49*	Tb	ppm	*3.33*	Zr	wt.%	*0.191*

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

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

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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 provides the certified values and their associated 95 % expanded uncertainty and tolerance intervals, Table 2 shows indicative values including major and trace element characterisation, Table 3 provides some indicative physical properties, Table 4 shows indicative mineralogy by semi-quantitative XRD analysis and Table 5 presents the performance gate intervals for all certified values.

Tabulated results of all analytes together with uncorrected means, medians, standard deviations, relative standard deviations and per cent deviation of lab means from the corrected mean of means (PDM^3) are presented in the detailed certification data for this CRM (**OREAS 713-DataPack.1.0.260313_192031.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.

Results are also presented in scatter plots for TiO_2 and ZrO_2 by fusion XRF and SG by Gas / Liquid Pycnometry in Figures 1 to 3 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.

INTENDED USE

OREAS 713 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 713 may be used to calibrate the entire procedure by producing a pure substance CRM transformed into a calibration solution.

OREAS 713 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 713 was prepared from a blend of heavy mineral sand (HMS) materials sourced from the West Coast of South Island, New Zealand. The source materials comprised high-grade HMS ore and HMS concentrate. The material is dominated by Fe–Ti-bearing minerals, principally garnet and ilmenite, with subordinate silicate gangue minerals including quartz, plagioclase and feldspar, and minor zircon and rare earth–bearing phases. Iron occurs primarily within garnet and Ti–Fe oxide minerals, with trace contributions from accessory heavy minerals.

MINIMUM SAMPLE SIZE

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

- Borate fusion with X-ray fluorescence finish: ≥0.2 g;
- Loss on Ignition (LOI) at 1000 °C: ≥1 g;
- 4-acid digestion with ICP-OES and/or MS finish: ≥ 0.25 g;
- Specific gravity by pycnometer: ≥ 3 g.

INSTRUCTIONS FOR HANDLING & 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 [11].

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.

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)

In the application of SD's in monitoring performance it is important to note that not all laboratories function at the same level of proficiency and that different methods in use at a particular laboratory have differing levels of precision. Each laboratory has its own inherent SD (for a specific concentration level and analyte-method pair) based on the analytical process and this SD is not directly related to the round robin program.

The majority of data generated in the round robin program was produced by a selection of world class laboratories. The SD's thus generated are more constrained than those that would be produced across a randomly selected group of laboratories. To produce more generally achievable SD's the 'pooled' SD's provided in this report include interlaboratory bias. This 'one size fits all' approach may require revision at the discretion of the QC manager concerned following careful scrutiny of QC control charts.

The performance gates shown in Table 5 are intended only to be used as a preliminary guide as to what a laboratory may be able to achieve. Over a period of time monitoring your own laboratory's data for this CRM, SD's should be calculated directly from your own laboratory's process. This will enable you to establish more specific performance gates that are fit for purpose for your application as well as the ability to monitor bias. If your long-term trend analysis shows an average value that is within the 95 % expanded uncertainty then generally there is no cause for concern in regard to bias.

PERIOD OF VALIDITY & STORAGE INSTRUCTIONS

The certification of OREAS 713 remains valid, within the specified measurement uncertainties, until at least June 2040, 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.

Single-use sachets

OREAS 713 is packaged in single-use, 10 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 713 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 stability of the CRM in regard to oxidation from the breakdown of sulphide minerals to sulphates is minimal given its low sulphur concentration (< 0.01 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 adsorped moisture (weakly held H_2O- 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.

COMMINUTION AND HOMOGENISATION PROCEDURES

The materials constituting OREAS 713 was prepared in the following manner:

- Drying to constant mass at 105 °C;
- Crushing and multi-stage milling of the ores to >95% minus 75 microns;
- Homogenisation using OREAS' novel processing technologies;
- Packaging in 10 g units in laminated foil pouches and 1 kg units in plastic wide-mouth jars.

PHYSICAL PROPERTIES

OREAS 713 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 713.

Bulk Density (kg/m^3)	Moisture (wt.%)	Munsell Notation‡	Munsell Color‡
874	0.33	N3	Dark 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.

MINERALOGY

The semi-quantitative XRD results shown in Table 4 below were undertaken by ALS Metallurgy in Balcatta, Western Australia. The results have been normalised to 100 % and represent the relative proportion of crystalline material. Totals greater or less than 100 % are due to rounding errors. Some amorphous material may be present. A trace of clinopyroxene and pyrrhotite may be present.

Table 4. Indicative mineralogy of OREAS 713 by semi-quantitative XRD analysis.

Mineral / Mineral Group	% (mass ratio)
Chlorite	1
Annite - biotite - phlogopite	1
Muscovite	1
Ca amphibole	1
Plagioclase	4
K-feldspar and/or rutile	2
Epidote group	6
Quartz	12
Pyralspite garnet	40
Ilmenite	32

ANALYTICAL PROGRAM

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

- Lithium borate fusion whole rock analysis package by X-ray fluorescence (up to 20 laboratories depending on the element);
- Thermogravimetry: Loss on Ignition (LOI) at 1000 °C (11 laboratories used a thermogravimetric analyser, 3 laboratories included LOI with their fusion package and 6 laboratories used a conventional muffle furnace);
- 4-acid (HNO_3-HF-$HClO_4$-HCl) digestion with full suite ICP-OES and ICP-MS elemental packages (up to 19 laboratories depending on the element);
- Specific gravity by gas (16 laboratories) or liquid (1 laboratory) pycnometry.

For the round robin program, six 2 kg test units were collected at predetermined intervals during the bagging stage, immediately after homogenisation. These units are considered representative of the entire prepared batch. Each participating laboratory received six test portions, obtained by subsampling 50 g from each of the six distinct 2 kg units.

Homogeneity was assessed by submitting 12 pulp samples to a single laboratory for analysis. Paired samples were drawn from each of the six test units, enabling an Analysis of Variance (ANOVA) to compare within-unit and between-unit variances. This statistical method provides a relative measure of homogeneity and tests the null hypothesis that all units derive from the same population distribution (refer to the 'Homogeneity Evaluation' section below).

PARTICIPATING LABORATORIES

1. Actlabs, Ancaster, Ontario, Canada
2. African Natural Resources & Mines Ltd, Suleja, Niger State, Nigeria
3. Alex Stewart International, Mendoza, Argentina
4. ALS, Brisbane, QLD, Australia
5. ALS, Lima, Peru

6. ALS, Loughrea, Galway, Ireland
7. ALS, Malaga, WA, Australia
8. ALS, Vancouver, BC, Canada
9. American Assay Laboratories, Sparks, Nevada, USA
10. ARGETEST Mineral Processing, Ankara, Central Anatolia, Turkey
11. Bureau Veritas Geoanalytical, Perth, WA, Australia
12. Intertek, Perth, WA, Australia
13. Lucid Laboratories Private Limited, Hyderabad, Telangana, India
14. Ontario Geological Survey, Sudbury, Ontario, Canada
15. PT Geoservices Ltd, Cikarang, Jakarta Raya, Indonesia
16. PT Intertek Utama Services, Jakarta Timur, DKI Jakarta, Indonesia
17. Reminex Centre de Recherche, Marrakesh, Marrakesh-Safi, Morocco
18. SGS, Randfontein, Gauteng, South Africa
19. SGS Australia Mineral Services, Perth, WA, Australia
20. SGS Geosol Laboratorios Ltda, Vespasiano, Minas Gerais, Brazil
21. Shiva Analyticals Ltd, Bangalore North, Karnataka, India
22. Skyline Assayers & Laboratories, Tucson, Arizona, USA
23. Stewart Assay & Environmental Laboratories LLC, Kara-Balta, Chüy, Kyrgyzstan
24. 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 17034:2017 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 [5] and [14]. 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 5, ‘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 TiO_2 by oxidising fusion XRF, where 99 % of the time (1-α=0.99) at least 95 % of subsamples (ρ=0.95) will have concentrations lying between 19.88 and 20.00 wt.%. Put more precisely, this means that if the same number of subsamples were taken and analysed in the same manner repeatedly, 99 % of the tolerance intervals so constructed would cover at least 95 % of the total population, and 1 % of the tolerance intervals would cover less than 95 % of the total population. ***Please note that tolerance limits pertain to the homogeneity of the CRM only and should not be used as control limits for laboratory performance.***

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 12 x 10 g pulp samples to the ALS Brisbane, laboratory for analysis by oxidising fusion with X-ray fluorescence finish (code ME- XRF26). The 12 samples consisted of paired samples from each of the six sampling units to enable an Analysis of Variance (ANOVA) by comparison of within- and between-unit variances across the six pairs. The ANOVA enables a relative measure of homogeneity and permits a test of the null hypothesis that all 'units' are drawn from the same population distribution. An ANOVA constructed in this way tests that no statistically significant difference exists in the variance between-units to that of the variance within-units. A *p*-value < 0.05 would indicate rejection of the null hypothesis at the 95 % confidence level (i.e., a significant difference likely does exist; meaning there is evidence of heterogeneity between the sample intervals).

Only the results for constituents present in concentrations well above the detection levels (i.e. >20 x Lower Limit of Detection) for the various methods undertaken have been considered for the objective of evaluating homogeneity. All *p*-values were found to be statistically insignificant, and the Null Hypothesis is therefore retained. It is important to note that ANOVA provides a relative measure of homogeneity and that a CRM having poor absolute homogeneity can still pass these tests if the within-unit heterogeneity is large and similar across all units. Based on the statistical analysis of the results of the interlaboratory certification program, it can be concluded that OREAS 712 is fit-for-purpose as a certified reference material (see 'Intended Use' above).

METROLOGICAL TRACEABILITY

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

certificate are expressed as the mass fraction in either weight percent (wt.%) or parts per million (ppm).

The analytical samples sent to participating laboratories were selected in a manner to be representative of the entire prepared batch of CRM. This representativeness was maintained in each submitted laboratory sample batch and ensures the user that the data is traceable from sample selection through to the analytical results. The systematic sampling method was chosen due to the low risk of overlooking repetitive effects or trends in the batch due to the way the CRM was processed. In line with ISO 17025 [7], each analytical data set received from the participating laboratories has been validated by its assayer through the inclusion of internal reference materials and QC checks during and post analysis.

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

In accordance with ISO 33405:2024-05 [4], clause 9.2.5, and ISO 17034:2016 [8], clause 7.12.4 b), the use of such control samples provides an acceptable means of demonstrating traceability in the absence of formal accreditation. In this certification program, traceability was further supported by the agreement of measured values for control samples with their known certified values, thereby offering additional confidence in the calibration and validity of measurement results across participating laboratories.

Operationally Defined Measurands
In accordance with ISO 33405:2024-05, Clause 9.2.4, measurands (analytes) may be certified as operationally defined. For these measurands, traceability to the SI may not be achievable because the analytical procedure involves sample transformations (e.g., leaching or extraction). While instrument calibration can be traceable to appropriate units, the transformation steps themselves are not directly traceable and can only be evaluated through reference comparisons or harmonized procedures.

Accordingly, characterisation of these measurands has been based on the concordance of results obtained from multiple laboratories using a common, well-defined procedure. This approach ensures fitness-for-purpose and fulfils the requirements for metrological traceability as specified in ISO 17034 and ISO 33405 for operationally defined measurands.

COMMUTABILITY

The certified values reported herein are derived from measurements performed using analytical methods involving sample pre-treatment steps, such as fusion or acid digestion. These processes convert the sample matrix into a chemically simplified and stable form, facilitating calibration traceable to primary standards via solution-based calibration protocols. Due to the established robustness and effectiveness of these pre-treatment methods, issues related to commutability are not expected to impact the suitability of this Certified Reference Material (CRM) for its intended use.

OREAS CRMs are prepared from natural ore materials, ensuring the presence of matrix and mineralogical characteristics representative of typical exploration and process samples. Consistent with ISO 17034:2016 and ISO Guide 30, users are advised to select CRMs with matrix and mineralisation styles closely matching those of their routine samples to minimize matrix effects and enhance analytical comparability. Detailed descriptions of the CRM's source material and mineralogical characteristics are provided in the 'Source Material' section to guide appropriate CRM selection.

PERFORMANCE GATES

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

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

i.e., Certified Value ±10 % ±2DL [1].

Table 5. Performance Gates for OREAS 713.

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
Borate Fusion XRF											
Al_2O_3, wt.%	10.94	0.144	10.65	11.23	10.51	11.37	1.31%	2.62%	3.94%	10.39	11.49
As, ppm	< 100	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Bi, ppm	< 100	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
CaO, wt.%	4.78	0.092	4.59	4.96	4.50	5.06	1.93%	3.86%	5.78%	4.54	5.02
CeO_2, ppm	719	125	470	969	345	1094	17.35%	34.69%	52.04%	683	755
Co, ppm	< 100	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Cr, ppm	217	16	184	250	167	266	7.60%	15.21%	22.81%	206	228
Cu, ppm	< 50	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Fe, wt.%	21.76	0.234	21.29	22.23	21.06	22.46	1.07%	2.15%	3.22%	20.67	22.85
HfO_2, ppm	< 100	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
K_2O, wt.%	0.374	0.009	0.356	0.392	0.347	0.401	2.38%	4.76%	7.14%	0.355	0.393
La_2O_3, ppm	446	66	314	579	248	645	14.84%	29.68%	44.51%	424	469
MgO, wt.%	0.864	0.028	0.808	0.919	0.781	0.946	3.19%	6.39%	9.58%	0.820	0.907
Mn, wt.%	2.02	0.036	1.95	2.09	1.91	2.13	1.78%	3.56%	5.34%	1.92	2.12
Na_2O, wt.%	0.439	0.056	0.327	0.551	0.270	0.608	12.80%	25.59%	38.39%	0.417	0.461
Nb, ppm	178	29	121	236	92	265	16.14%	32.29%	48.43%	170	187
Ni, ppm	< 50	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
P_2O_5, wt.%	0.190	0.005	0.180	0.200	0.175	0.205	2.61%	5.23%	7.84%	0.181	0.200
SiO_2, wt.%	30.01	0.285	29.44	30.58	29.15	30.86	0.95%	1.90%	2.85%	28.51	31.51
Sr, ppm	256	40	176	335	136	375	15.54%	31.09%	46.63%	243	268
TiO_2, wt.%	19.94	0.152	19.63	20.24	19.48	20.39	0.76%	1.52%	2.28%	18.94	20.93
Y_2O_3, ppm	249	18	214	285	196	303	7.16%	14.32%	21.48%	237	262
Zn, ppm	90	10	69	111	59	122	11.56%	23.11%	34.67%	86	95
ZrO_2, wt.%	0.253	0.008	0.237	0.269	0.229	0.277	3.20%	6.41%	9.61%	0.240	0.266
Thermogravimetry											
LOI^{1000}, wt.%	-1.96	0.082	-2.12	-1.79	-2.20	-1.71	4.19%	8.37%	12.56%	-2.05	-1.86
4-Acid Digestion											
Al, wt.%	5.59	0.237	5.11	6.06	4.88	6.30	4.24%	8.48%	12.72%	5.31	5.87
Ba, ppm	84	4.6	75	93	70	98	5.49%	10.98%	16.47%	80	88
Be, ppm	0.57	0.11	0.35	0.79	0.24	0.90	19.38%	38.77%	58.15%	0.54	0.60
Bi, ppm	0.28	0.018	0.24	0.31	0.22	0.33	6.34%	12.67%	19.01%	0.26	0.29
Ca, wt.%	3.40	0.129	3.14	3.66	3.01	3.79	3.81%	7.62%	11.43%	3.23	3.57
Cd, ppm	0.41	0.013	0.38	0.44	0.37	0.45	3.27%	6.54%	9.81%	0.39	0.43
Ce, ppm	599	24	551	648	526	672	4.05%	8.09%	12.14%	569	629
Co, ppm	15.9	0.87	14.2	17.7	13.3	18.6	5.49%	10.97%	16.46%	15.1	16.7
Cr, ppm	179	19	140	217	121	236	10.80%	21.59%	32.39%	170	187
Cs, ppm	0.82	0.045	0.73	0.91	0.68	0.95	5.55%	11.10%	16.65%	0.78	0.86
Dy, ppm	23.4	1.65	20.1	26.7	18.4	28.3	7.07%	14.14%	21.21%	22.2	24.5
Er, ppm	23.1	0.87	21.3	24.8	20.4	25.7	3.77%	7.55%	11.32%	21.9	24.2
Eu, ppm	3.52	0.174	3.17	3.87	3.00	4.04	4.95%	9.89%	14.84%	3.35	3.70
Fe, wt.%	21.38	0.625	20.13	22.63	19.50	23.25	2.92%	5.85%	8.77%	20.31	22.45
Ga, ppm	9.88	1.24	7.41	12.35	6.17	13.59	12.50%	25.01%	37.51%	9.39	10.37
Gd, ppm	20.9	1.50	17.9	23.9	16.4	25.4	7.14%	14.29%	21.43%	19.9	22.0

SI unit equivalents: ppm (parts per million; 1 x 10^{-6}) ≡ mg/kg; wt.% (weight per cent) ≡ % (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 5 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	2.30	0.42	1.45	3.14	1.03	3.57	18.40%	36.81%	55.21%	2.18	2.41
Ho, ppm	6.30	0.411	5.48	7.12	5.07	7.53	6.53%	13.05%	19.58%	5.99	6.62
In, ppm	0.10	0.009	0.08	0.12	0.08	0.13	8.39%	16.77%	25.16%	0.10	0.11
K, wt.%	0.308	0.013	0.282	0.333	0.269	0.346	4.13%	8.26%	12.39%	0.292	0.323
La, ppm	316	15	286	345	271	360	4.71%	9.41%	14.12%	300	331
Li, ppm	18.8	1.48	15.9	21.8	14.4	23.3	7.87%	15.74%	23.61%	17.9	19.8
Lu, ppm	4.50	0.76	2.99	6.02	2.23	6.77	16.83%	33.65%	50.48%	4.28	4.73
Mg, wt.%	0.481	0.045	0.390	0.572	0.345	0.617	9.43%	18.87%	28.30%	0.457	0.505
Mn, wt.%	1.92	0.151	1.62	2.22	1.47	2.37	7.85%	15.70%	23.55%	1.82	2.02
Mo, ppm	2.30	0.213	1.87	2.72	1.66	2.94	9.27%	18.54%	27.82%	2.18	2.41
Na, wt.%	0.319	0.019	0.281	0.357	0.263	0.375	5.90%	11.79%	17.69%	0.303	0.335
Nb, ppm	164	10	144	184	134	194	6.17%	12.34%	18.51%	156	172
Nd, ppm	198	5	187	208	182	214	2.67%	5.34%	8.02%	188	208
Ni, ppm	12.4	0.89	10.6	14.2	9.8	15.1	7.17%	14.33%	21.50%	11.8	13.0
P, wt.%	0.077	0.005	0.067	0.087	0.062	0.092	6.38%	12.77%	19.15%	0.073	0.081
Pb, ppm	10.0	1.0	7.9	12.1	6.9	13.2	10.45%	20.90%	31.35%	9.5	10.5
Pr, ppm	59	2.9	54	65	51	68	4.83%	9.65%	14.48%	56	62
Rb, ppm	16.1	1.01	14.1	18.1	13.0	19.1	6.28%	12.56%	18.83%	15.3	16.9
S, wt.%	< 0.01	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Sb, ppm	0.43	0.025	0.38	0.48	0.35	0.50	5.90%	11.80%	17.70%	0.41	0.45
Sc, ppm	49.2	2.89	43.4	54.9	40.5	57.8	5.89%	11.77%	17.66%	46.7	51.6
Sm, ppm	28.6	1.02	26.6	30.6	25.6	31.7	3.55%	7.09%	10.64%	27.2	30.1
Sn, ppm	4.06	0.250	3.56	4.56	3.31	4.81	6.15%	12.30%	18.45%	3.86	4.27
Sr, ppm	269	15	240	298	225	312	5.40%	10.80%	16.20%	255	282
Ta, ppm	16.3	1.00	14.3	18.3	13.3	19.3	6.10%	12.20%	18.30%	15.5	17.1
Tb, ppm	3.10	0.182	2.74	3.47	2.56	3.65	5.87%	11.74%	17.61%	2.95	3.26
Te, ppm	< 0.05	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Th, ppm	96	5.4	85	107	80	112	5.64%	11.28%	16.93%	91	101
Ti, wt.%	11.32	0.859	9.60	13.03	8.74	13.89	7.59%	15.18%	22.77%	10.75	11.88
Tl, ppm	0.093	0.007	0.078	0.108	0.071	0.116	8.01%	16.01%	24.02%	0.089	0.098
Tm, ppm	4.23	0.329	3.57	4.89	3.24	5.21	7.78%	15.55%	23.33%	4.02	4.44
U, ppm	10.2	0.78	8.6	11.7	7.8	12.5	7.71%	15.41%	23.12%	9.7	10.7
V, ppm	128	15	98	158	84	172	11.55%	23.10%	34.66%	122	134
W, ppm	4.03	0.281	3.46	4.59	3.18	4.87	6.97%	13.95%	20.92%	3.82	4.23
Y, ppm	173	10	152	194	142	205	6.03%	12.06%	18.08%	165	182
Yb, ppm	30.4	0.97	28.5	32.3	27.5	33.3	3.18%	6.37%	9.55%	28.9	31.9
Zn, ppm	92	7.7	76	107	69	115	8.40%	16.81%	25.21%	87	96
Zr, wt.%	0.007	0.001	0.005	0.010	0.004	0.011	16.55%	33.09%	49.64%	0.007	0.008
Gas / Liquid Pycnometry											
SG, Unity	3.86	0.092	3.68	4.04	3.58	4.13	2.37%	4.75%	7.12%	3.67	4.05

SI unit equivalents: ppm (parts per million; 1 x 10^{-6}) ≡ mg/kg; wt.% (weight per cent) ≡ % (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.

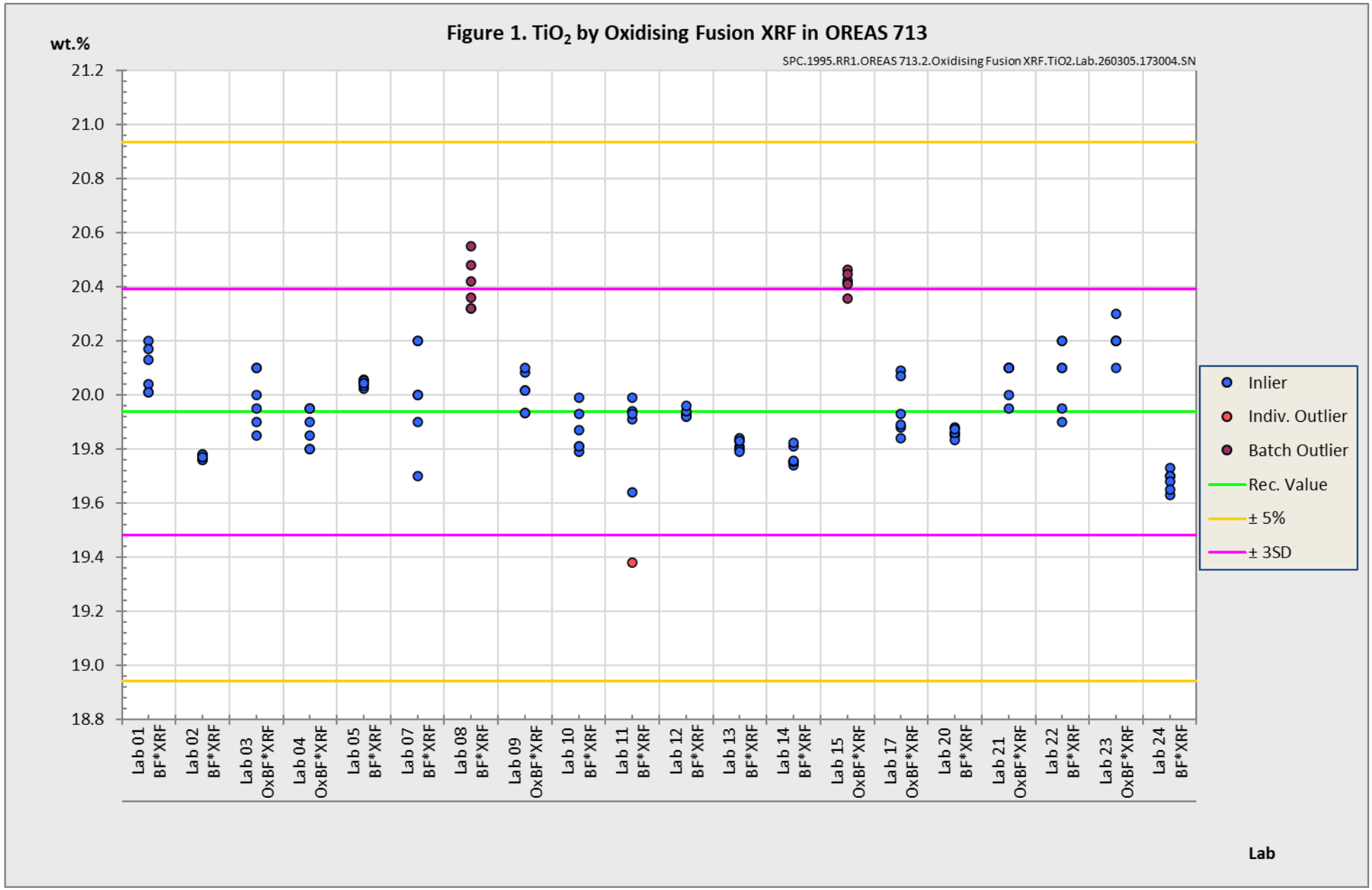
Figure 1. TiO2 by Oxidising Fusion XRF in OREAS 713
wt.%
SPC.1995.RR1.OREAS 713.2.Oxidising Fusion XRF.TiO2.Lab.260305.173004.SN
21.2
21.0
20.8
20.6
20.4
20.2
20.0
19.8
19.6
19.4
19.2
19.0
18.8
Lab 01 BF*XRF
Lab 02 BF*XRF
Lab 03 OxBF*XRF
Lab 04 OxBF*XRF
Lab 05 BF*XRF
Lab 07 BF*XRF
Lab 08 BF*XRF
Lab 09 OxBF*XRF
Lab 10 BF*XRF
Lab 11 BF*XRF
Lab 12 BF*XRF
Lab 13 BF*XRF
Lab 14 BF*XRF
Lab 15 OxBF*XRF
Lab 17 OxBF*XRF
Lab 20 BF*XRF
Lab 21 OxBF*XRF
Lab 22 BF*XRF
Lab 23 OxBF*XRF
Lab 24 BF*XRF
Lab
Inlier
Indiv. Outlier
Batch Outlier
Rec. Value
± 5%
± 3SD

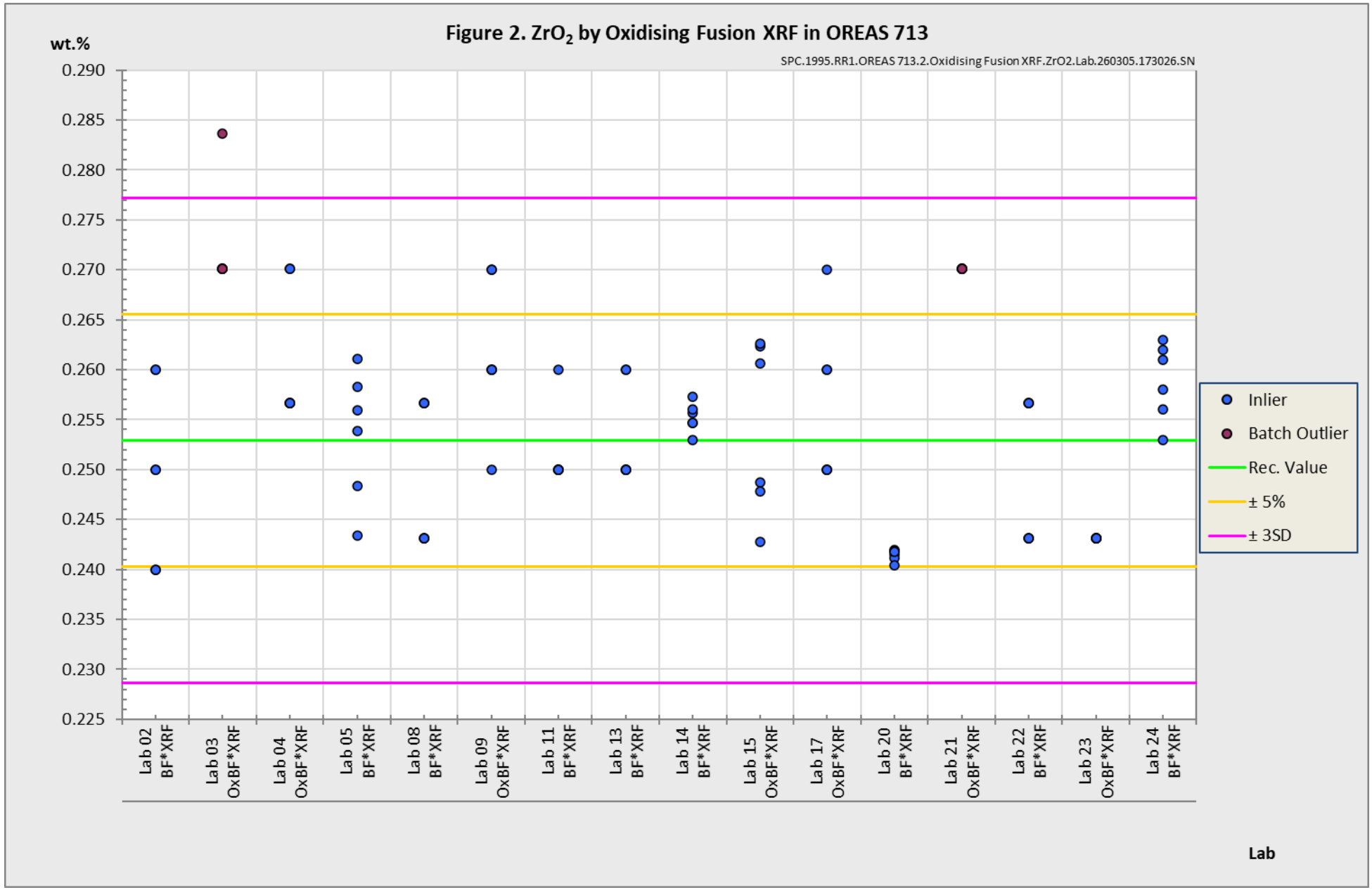
Figure 2. ZrO2 by Oxidising Fusion XRF in OREAS 713
wt.%
SPC.1995.RR1.OREAS 713.2.Oxidising Fusion XRF.ZrO2.Lab.260305.173026.SN
0.290
0.285
0.280
0.275
0.270
0.265
0.260
0.255
0.250
0.245
0.240
0.235
0.230
0.225
Lab 02 BF*XRF
Lab 03 OxBF*XRF
Lab 04 OxBF*XRF
Lab 05 BF*XRF
Lab 08 BF*XRF
Lab 09 OxBF*XRF
Lab 11 BF*XRF
Lab 13 BF*XRF
Lab 14 BF*XRF
Lab 15 OxBF*XRF
Lab 17 OxBF*XRF
Lab 20 BF*XRF
Lab 21 OxBF*XRF
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Lab 23 OxBF*XRF
Lab 24 BF*XRF
Lab
Inlier
Batch Outlier
Rec. Value
± 5%
± 3SD

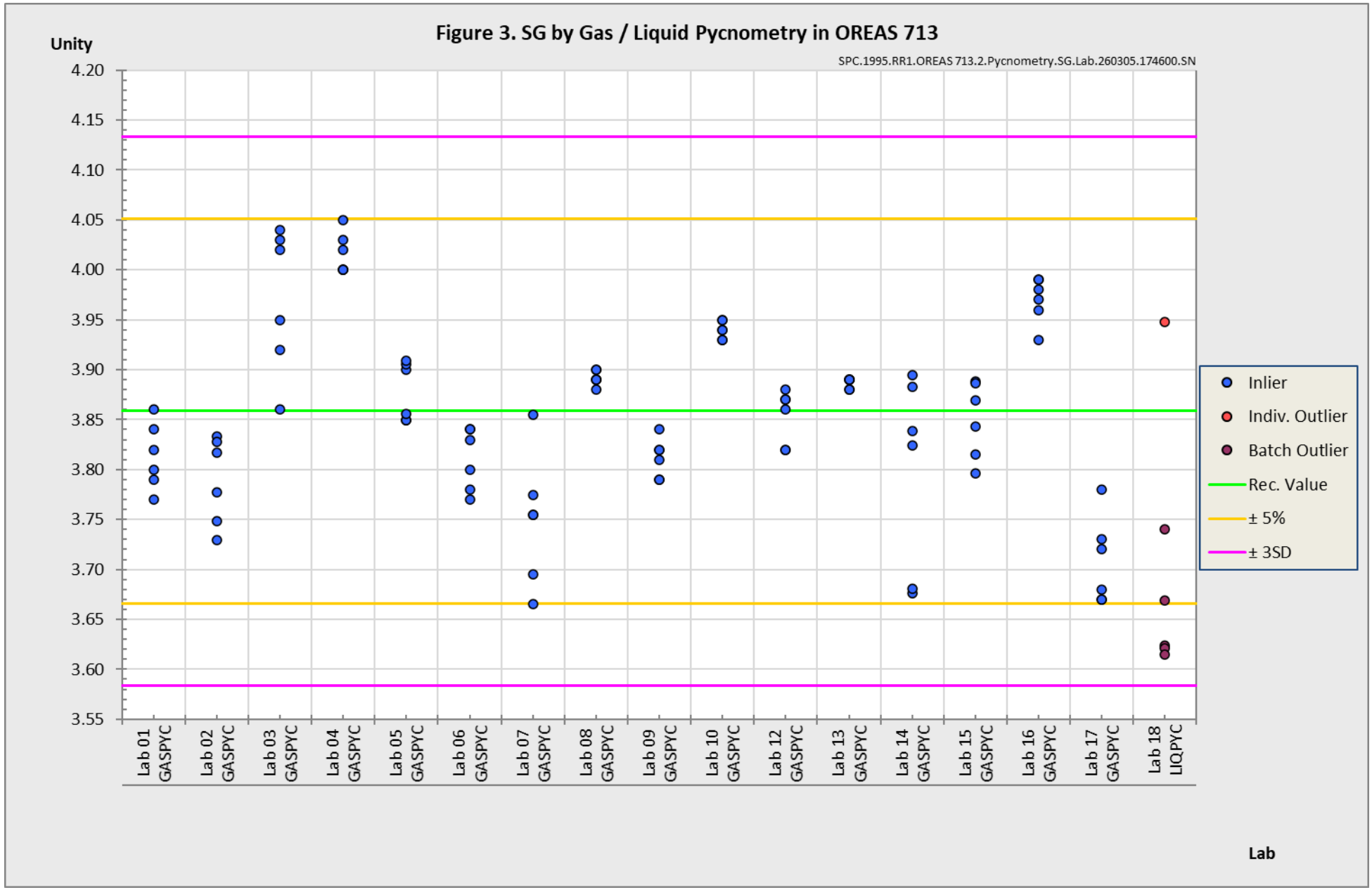
Figure 3. SG by Gas / Liquid Pycnometry in OREAS 713
SPC.1995.RR1.OREAS 713.2.Pycnometry.SG.Lab.260305.174600.SN
Unity
4.20
4.15
4.10
4.05
4.00
3.95
3.90
3.85
3.80
3.75
3.70
3.65
3.60
3.55
Lab 01 GASPYC
Lab 02 GASPYC
Lab 03 GASPYC
Lab 04 GASPYC
Lab 05 GASPYC
Lab 06 GASPYC
Lab 07 GASPYC
Lab 08 GASPYC
Lab 09 GASPYC
Lab 10 GASPYC
Lab 12 GASPYC
Lab 13 GASPYC
Lab 14 GASPYC
Lab 15 GASPYC
Lab 16 GASPYC
Lab 17 GASPYC
Lab 18 LIQPYC
Lab
Inlier
Indiv. Outlier
Batch Outlier
Rec. Value
± 5%
± 3SD

PREPARER AND SUPPLIER

Certified reference material OREAS 713 is prepared, certified and supplied by:

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QMS CERTIFICATION

ORE Pty Ltd is accredited for compliance with ISO 17034:2016 (Accreditation number 20483).

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

LEGAL NOTICE

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

DOCUMENT HISTORY

Revision No.	Date	Changes applied
0	2nd April 2026	First publication.

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