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

CERTIFICATE OF ANALYSIS FOR

Manganese Ore

(Postmasburg Manganese Field, Northern Cape, South Africa)

CERTIFIED REFERENCE MATERIAL

OREAS 173

Summary Statistics for Key* Analytes.

Constituent	Certified Value	1SD	95% Confidence Limits		95% Tolerance Limits	
			Low	High	Low	High
Borate Fusion XRF						
Fe, Iron (wt.%)	25.23	25.23	25.11	25.36	25.14	25.33
Fe_2O_3, Iron(III) oxide (wt.%)	36.08	36.08	35.89	36.26	35.94	36.21
Mn, Manganese (wt.%)	28.30	0.275	28.13	28.46	28.21	28.38
MnO, Manganese oxide (wt.%)	36.54	0.355	36.33	36.75	36.42	36.65
P, Phosphorus (ppm)	391	7	388	395	383	400
P_2O_5, Phosphorus(V) oxide (wt.%)	0.090	0.002	0.089	0.090	0.088	0.092

*See Table 1 below for the full list of certified values.
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 OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Table 1. Certified Values and Performance Gates for OREAS 173.

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.%	7.97	0.087	7.79	8.14	7.71	8.23	1.09%	2.19%	3.28%	7.57	8.37
BaO, wt.%	0.894	0.026	0.842	0.946	0.816	0.972	2.89%	5.79%	8.68%	0.849	0.939
CaO, wt.%	0.347	0.009	0.330	0.364	0.322	0.373	2.46%	4.92%	7.38%	0.330	0.365
Cu, ppm	108	13	82	133	69	146	11.93%	23.86%	35.80%	102	113
Fe, wt.%	25.23	0.231	24.77	25.70	24.54	25.93	0.92%	1.83%	2.75%	23.97	26.49
Fe_2O_3, wt.%	36.08	0.331	35.41	36.74	35.08	37.07	0.92%	1.83%	2.75%	34.27	37.88
K_2O, wt.%	0.852	0.018	0.817	0.888	0.799	0.906	2.08%	4.16%	6.23%	0.810	0.895
MgO, wt.%	0.308	0.020	0.267	0.349	0.247	0.369	6.60%	13.20%	19.80%	0.293	0.323
Mn, wt.%	28.30	0.275	27.75	28.85	27.47	29.12	0.97%	1.94%	2.91%	26.88	29.71
MnO, wt.%	36.54	0.355	35.83	37.25	35.47	37.60	0.97%	1.94%	2.91%	34.71	38.36
Na_2O, wt.%	0.437	0.018	0.400	0.474	0.382	0.493	4.22%	8.44%	12.66%	0.415	0.459
P, ppm	391	7	377	406	370	413	1.82%	3.64%	5.45%	372	411
P_2O_5, wt.%	0.090	0.002	0.086	0.093	0.085	0.095	1.82%	3.64%	5.45%	0.085	0.094
SiO_2, wt.%	7.10	0.079	6.94	7.26	6.86	7.34	1.12%	2.23%	3.35%	6.74	7.45
SO_3, wt.%	0.015	0.004	0.007	0.022	0.004	0.026	25.23%	50.47%	75.70%	0.014	0.016
TiO_2, wt.%	0.353	0.008	0.337	0.368	0.330	0.376	2.18%	4.36%	6.55%	0.335	0.370
V_2O_5, ppm	223	40	142	303	102	343	18.06%	36.12%	54.17%	211	234
Thermogravimetry											
LOI^{1000}, wt.%	6.55	0.208	6.14	6.97	5.93	7.18	3.18%	6.35%	9.53%	6.23	6.88
4-Acid Digestion											
Al, wt.%	3.58	0.320	2.94	4.22	2.62	4.54	8.94%	17.88%	26.82%	3.40	3.76
As, ppm	57	8	41	73	33	81	13.95%	27.89%	41.84%	54	60
Ba, wt.%	0.790	0.037	0.717	0.863	0.680	0.900	4.64%	9.28%	13.92%	0.750	0.829
Be, ppm	4.60	0.48	3.64	5.56	3.16	6.04	10.44%	20.89%	31.33%	4.37	4.83
Bi, ppm	0.94	0.079	0.78	1.10	0.70	1.18	8.46%	16.91%	25.37%	0.89	0.98
Ca, wt.%	0.246	0.011	0.224	0.268	0.213	0.280	4.50%	9.01%	13.51%	0.234	0.259
Cd, ppm	0.27	0.04	0.19	0.36	0.15	0.40	14.82%	29.65%	44.47%	0.26	0.29
Ce, ppm	64	3.3	58	71	54	74	5.14%	10.29%	15.43%	61	68
Co, ppm	70	3.2	64	77	61	80	4.62%	9.24%	13.86%	67	74
Cr, ppm	69	6.8	55	82	48	89	9.90%	19.80%	29.70%	65	72
Cs, ppm	0.91	0.09	0.73	1.10	0.64	1.19	10.07%	20.14%	30.21%	0.87	0.96
Cu, ppm	103	4	94	112	90	116	4.21%	8.43%	12.64%	98	108
Dy, ppm	7.54	0.680	6.18	8.90	5.50	9.58	9.02%	18.03%	27.05%	7.16	7.91
Er, ppm	4.39	0.386	3.62	5.16	3.23	5.55	8.79%	17.59%	26.38%	4.17	4.61
Fe, wt.%	25.17	0.660	23.85	26.49	23.19	27.15	2.62%	5.25%	7.87%	23.91	26.43
Ga, ppm	16.3	2.4	11.5	21.2	9.1	23.6	14.85%	29.69%	44.54%	15.5	17.1
Hf, ppm	2.05	0.21	1.64	2.47	1.43	2.68	10.12%	20.23%	30.35%	1.95	2.16
Ho, ppm	1.56	0.18	1.20	1.91	1.03	2.08	11.31%	22.61%	33.92%	1.48	1.63
In, ppm	0.088	0.009	0.071	0.106	0.062	0.115	9.95%	19.91%	29.86%	0.084	0.093
K, wt.%	0.708	0.027	0.655	0.762	0.628	0.788	3.78%	7.56%	11.34%	0.673	0.744
La, ppm	34.5	3.20	28.1	40.9	24.9	44.1	9.27%	18.53%	27.80%	32.8	36.2

SI unit equivalents: ppm, parts per million ≡ mg/kg ≡ µg/g ≡ 0.0001 wt.% ≡ 1000 ppb, parts per billion.
Note 1: intervals may appear asymmetric due to rounding.
Note 2: the number of decimal places quoted does not imply accuracy of the certified value to this level but are given to minimise rounding errors when calculating 2SD and 3SD windows.

Table 1 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											
Li, ppm	1181	65	1051	1311	986	1376	5.50%	11.01%	16.51%	1122	1240
Lu, ppm	0.60	0.046	0.51	0.70	0.46	0.74	7.69%	15.39%	23.08%	0.57	0.63
Mg, wt.%	0.166	0.012	0.141	0.190	0.128	0.203	7.51%	15.01%	22.52%	0.157	0.174
Mn, wt.%	28.25	0.555	27.14	29.36	26.58	29.92	1.97%	3.93%	5.90%	26.84	29.66
Mo, ppm	2.06	0.28	1.50	2.62	1.22	2.90	13.63%	27.26%	40.89%	1.96	2.16
Na, wt.%	0.320	0.023	0.274	0.365	0.251	0.388	7.13%	14.27%	21.40%	0.304	0.336
Nb, ppm	5.10	0.471	4.16	6.05	3.69	6.52	9.23%	18.45%	27.68%	4.85	5.36
Nd, ppm	35.8	3.8	28.3	43.4	24.5	47.1	10.50%	21.01%	31.51%	34.0	37.6
Ni, ppm	137	6	124	150	118	156	4.66%	9.31%	13.97%	130	144
P, wt.%	0.035	0.003	0.029	0.042	0.025	0.045	9.14%	18.28%	27.42%	0.033	0.037
Pb, ppm	282	23	237	328	215	350	7.98%	15.97%	23.95%	268	297
Pr, ppm	8.58	1.13	6.31	10.85	5.18	11.98	13.21%	26.41%	39.62%	8.15	9.01
Rb, ppm	11.9	1.01	9.9	13.9	8.9	14.9	8.52%	17.03%	25.55%	11.3	12.5
Re, ppm	< 0.002	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Sb, ppm	3.23	0.293	2.64	3.82	2.35	4.11	9.08%	18.16%	27.25%	3.07	3.39
Sc, ppm	16.2	1.04	14.2	18.3	13.1	19.4	6.41%	12.83%	19.24%	15.4	17.0
Se, ppm	< 1	IND	IND	IND	IND	IND	IND	IND	IND	IND	IND
Sm, ppm	8.28	1.76	4.76	11.80	3.00	13.56	21.26%	42.53%	63.79%	7.87	8.69
Sn, ppm	1.98	0.180	1.62	2.34	1.44	2.52	9.07%	18.13%	27.20%	1.88	2.08
Sr, ppm	420	24	373	467	350	491	5.60%	11.19%	16.79%	399	441
Ta, ppm	0.35	0.021	0.31	0.40	0.29	0.42	5.94%	11.88%	17.81%	0.34	0.37
Tb, ppm	1.30	0.116	1.07	1.53	0.95	1.65	8.92%	17.84%	26.76%	1.24	1.37
Th, ppm	4.43	0.233	3.97	4.90	3.74	5.13	5.25%	10.51%	15.76%	4.21	4.66
Ti, wt.%	0.199	0.011	0.177	0.220	0.167	0.231	5.37%	10.74%	16.10%	0.189	0.209
Tl, ppm	0.82	0.076	0.67	0.98	0.60	1.05	9.27%	18.53%	27.80%	0.78	0.87
Tm, ppm	0.61	0.060	0.49	0.73	0.43	0.79	9.94%	19.89%	29.83%	0.58	0.64
U, ppm	1.64	0.075	1.49	1.79	1.42	1.87	4.56%	9.11%	13.67%	1.56	1.72
V, ppm	118	6	107	130	101	136	5.01%	10.02%	15.03%	113	124
W, ppm	9.11	0.711	7.69	10.53	6.98	11.24	7.80%	15.61%	23.41%	8.65	9.56
Y, ppm	49.6	4.50	40.6	58.6	36.1	63.1	9.07%	18.14%	27.21%	47.1	52.1
Yb, ppm	3.85	0.318	3.22	4.49	2.90	4.81	8.24%	16.49%	24.73%	3.66	4.05
Zn, ppm	80	9	62	97	53	106	11.12%	22.25%	33.37%	76	84
Zr, ppm	71	2.8	65	76	63	79	3.88%	7.76%	11.64%	67	74
Gas / Liquid Pycnometry											
SG, Unity	4.25	0.326	3.60	4.90	3.27	5.23	7.66%	15.33%	22.99%	4.04	4.46

SI unit equivalents: ppm, parts per million ≡ mg/kg ≡ µg/g ≡ 0.0001 wt.% ≡ 1000 ppb, parts per billion.
Note 1: intervals may appear asymmetric due to rounding.
Note 2: the number of decimal places quoted does not imply accuracy of the certified value to this level but are given to minimise rounding errors when calculating 2SD and 3SD windows.

Table 2. Indicative Values for OREAS 173.

Constituent	Unit	Value	Constituent	Unit	Value	Constituent	Unit	Value
Borate Fusion XRF								
As_2O_3	ppm	*85*	NiO	ppm	*182*	Zn	ppm	*97*
Cl	ppm	*15.0*	Pb	ppm	*285*	ZrO_2	ppm	*118*
CoO	ppm	*262*	Sb_2O_3	ppm	*13.3*			
Cr_2O_3	ppm	*110*	SrO	ppm	*503*			
4-Acid Digestion								
Ag	ppm	*0.061*	Gd	ppm	*8.74*	S	wt.%	*0.060*
Eu	ppm	*2.84*	Ge	ppm	*0.21*	Te	ppm	*0.12*
Infrared Combustion								
C	wt.%	*0.018*	S	wt.%	*0.004*			
Peroxide Fusion ICP								
Al	wt.%	*3.61*	K	wt.%	*0.655*	Si	wt.%	*3.26*
Ca	wt.%	*0.191*	Mg	wt.%	*0.133*	Ti	wt.%	*0.182*
Fe	wt.%	*26.19*	Mn	wt.%	*28.82*			

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.

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.

SOURCE MATERIAL

OREAS 173 has been prepared from manganese ores sourced from the Glosam Mine situated within Postmasburg Manganese Field located in the Northern Cape Province of South Africa. A small quantity of barren oxidised siliciclastic material was added to achieve the desired Mn grade. The ores are composed mainly of braunite group minerals including braunite ($3Mn_2O_3.MnSiO_3$), partridgeite (Mn_2O_3) and bixbyite $(Mn,Fe)_2O_3$.

PERFORMANCE GATES

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

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

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

COMMINUTION AND HOMOGENISATION PROCEDURES

The materials constituting OREAS 173 were prepared in the following manner:

- Drying to constant mass at 105°C;
- Crushing and milling to 98% minus 75 microns;
- Additional milling of the Mn ores to 100 minus 30 microns;
- Blending the ores with a small quantity of barren oxidised siliciclastic material to achieve the desired grade;
- Packaging in 10g units sealed in laminated foil pouches and 1kg units in plastic jars.

PHYSICAL PROPERTIES

OREAS 173 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 173.

Bulk Density (g/L)	Moisture%	Munsell Notation‡	Munsell Color‡
865.6	0.97	5YR 3/2	Grayish Brown

‡The Munsell Rock Colour 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

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

- Mn ore package for Al_2O_3, BaO, CaO, Cr_2O_3, Fe_2O_3, K_2O, MgO, MnO, Na_2O, P_2O_5, S, SiO_2, TiO_2 & V_2O_5 by borate fusion with XRF finish;
- Thermogravimetry: Loss on Ignition (LOI) at 1000°C (6 laboratories used a thermogravimetric analyser, 6 laboratories included LOI with their fusion package and 3 laboratories used conventional muffle furnace);

- 4-acid digestion for full suite elemental package by ICP-OES and MS finish (up to 10 laboratories depending on the element);
- Specific gravity by gas pycnometry (10 laboratories), liquid pycnometry (1 laboratory) or volumetric flask (1 laboratory).

For the round robin program twelve 200g test units were taken at predetermined intervals during the bagging stage, immediately following homogenisation and are considered representative of the entire prepared batch. The six samples received by each laboratory were obtained by taking two 20g scoop splits from each of three separate 200g test units. This format enabled nested ANOVA treatment of the results to evaluate homogeneity, i.e. to ascertain whether between-unit variance is greater than within-unit variance (see 'Homogeneity Evaluation' section below).

Table 1 provides performance gate intervals for the certified values. Table 2 shows indicative values, Table 3 provides some indicative physical properties and Table 4 presents the 95% confidence and tolerance limits for all certified values.

Tabulated results of all elements 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 173-DataPack.2.0.200825_094906.xlsx**).

Results are also presented in scatter plots for Mn by borate fusion with XRF finish and 4-acid digestion in Figures 1 and 2 respectively, together with ±3SD (magenta) and ±5% (yellow) control lines and certified value (green line). Accepted individual results are coloured blue and individual and dataset outliers are identified in red and violet, respectively.

STATISTICAL ANALYSIS

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

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

The SD for each analyte's certified value is calculated from the same filtered data set used to determine the certified value, i.e. after removal of all individual, lab dataset (batch) and 3SD outliers (single iteration). These outliers can only be removed after the absolute homogeneity of the CRM has been independently established, i.e. the outliers must be confidently deemed to be analytical rather than arising from inhomogeneity of the CRM.

The standard deviation is then calculated for each analyte from the pooled accepted analyses generated from the certification program.

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

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

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

Certified Values are the means of accepted laboratory means after outlier filtering.

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

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

Table 4. 95% Confidence & Tolerance Limits for OREAS 173.

Constituent	Certified Value	95% Confidence Limits		95% Tolerance Limits	
		Low	High	Low	High
Borate Fusion XRF					
Al_2O_3, Aluminium(III) oxide (wt.%)	7.97	7.92	8.02	7.93	8.01
BaO, Barium oxide (wt.%)	0.894	0.878	0.910	0.885	0.903
CaO, Calcium oxide (wt.%)	0.347	0.342	0.352	0.337	0.357
Cu, Copper (ppm)	108	98	118	IND	IND
Fe, Iron (wt.%)	25.23	25.11	25.36	25.14	25.33
Fe_2O_3, Iron(III) oxide (wt.%)	36.08	35.89	36.26	35.94	36.21
K_2O, Potassium oxide (wt.%)	0.852	0.843	0.862	0.844	0.861
MgO, Magnesium oxide (wt.%)	0.308	0.296	0.320	0.299	0.317
Mn, Manganese (wt.%)	28.30	28.13	28.46	28.21	28.38
MnO, Manganese oxide (wt.%)	36.54	36.33	36.75	36.42	36.65
Na_2O, Sodium oxide (wt.%)	0.437	0.426	0.449	0.421	0.454
P, Phosphorus (ppm)	391	388	395	383	400

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	95% Confidence Limits		95% Tolerance Limits	
		Low	High	Low	High
Borate Fusion XRF continued					
P_2O_5, Phosphorus(V) oxide (wt.%)	0.090	0.089	0.090	0.088	0.092
SiO_2, Silicon dioxide (wt.%)	7.10	7.06	7.14	7.07	7.13
SO_3, Sulphur trioxide (wt.%)	0.015	0.012	0.018	IND	IND
TiO_2, Titanium dioxide (wt.%)	0.353	0.349	0.357	0.346	0.360
V_2O_5, Vanadium(V) oxide (ppm)	223	196	250	205	240
Thermogravimetry					
LOI^{1000}, Loss on ignition @1000°C (wt.%)	6.55	6.42	6.69	6.48	6.63
4-Acid Digestion					
Al, Aluminium (wt.%)	3.58	3.30	3.86	3.48	3.68
As, Arsenic (ppm)	57	50	65	55	59
Ba, Barium (wt.%)	0.790	0.763	0.817	0.780	0.800
Be, Beryllium (ppm)	4.60	4.26	4.94	4.42	4.78
Bi, Bismuth (ppm)	0.94	0.88	0.99	0.87	1.01
Ca, Calcium (wt.%)	0.246	0.239	0.254	0.241	0.252
Cd, Cadmium (ppm)	0.27	0.24	0.31	0.26	0.29
Ce, Cerium (ppm)	64	62	67	62	66
Co, Cobalt (ppm)	70	68	73	69	72
Cr, Chromium (ppm)	69	63	74	66	72
Cs, Caesium (ppm)	0.91	0.83	1.00	0.89	0.94
Cu, Copper (ppm)	103	99	106	100	106
Dy, Dysprosium (ppm)	7.54	6.63	8.44	7.19	7.88
Er, Erbium (ppm)	4.39	3.87	4.90	4.21	4.56
Fe, Iron (wt.%)	25.17	24.65	25.68	24.55	25.79
Ga, Gallium (ppm)	16.3	14.2	18.5	15.6	17.0
Hf, Hafnium (ppm)	2.05	1.89	2.22	1.95	2.15
Ho, Holmium (ppm)	1.56	1.36	1.75	1.51	1.60
In, Indium (ppm)	0.088	0.081	0.095	0.081	0.096
K, Potassium (wt.%)	0.708	0.688	0.728	0.692	0.724
La, Lanthanum (ppm)	34.5	32.0	37.0	33.5	35.5
Li, Lithium (ppm)	1181	1136	1226	1149	1213
Lu, Lutetium (ppm)	0.60	0.54	0.67	0.56	0.65
Mg, Magnesium (wt.%)	0.166	0.157	0.175	0.162	0.169
Mn, Manganese (wt.%)	28.25	27.79	28.72	27.66	28.85
Mo, Molybdenum (ppm)	2.06	1.80	2.32	1.94	2.18
Na, Sodium (wt.%)	0.320	0.301	0.339	0.307	0.333
Nb, Niobium (ppm)	5.10	4.68	5.53	4.89	5.32
Nd, Neodymium (ppm)	35.8	31.6	40.0	34.7	36.9
Ni, Nickel (ppm)	137	131	143	133	141

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	95% Confidence Limits		95% Tolerance Limits	
		Low	High	Low	High
4-Acid Digestion continued					
P, Phosphorus (wt.%)	0.035	0.033	0.038	0.034	0.036
Pb, Lead (ppm)	282	266	299	276	289
Pr, Praseodymium (ppm)	8.58	7.04	10.12	8.27	8.88
Rb, Rubidium (ppm)	11.9	11.1	12.7	11.5	12.3
Re, Rhenium (ppm)	< 0.002	IND	IND	IND	IND
Sb, Antimony (ppm)	3.23	2.99	3.47	3.10	3.35
Sc, Scandium (ppm)	16.2	15.3	17.1	15.6	16.8
Se, Selenium (ppm)	< 1	IND	IND	IND	IND
Sm, Samarium (ppm)	8.28	5.90	10.66	7.92	8.64
Sn, Tin (ppm)	1.98	1.86	2.10	1.84	2.12
Sr, Strontium (ppm)	420	401	439	415	426
Ta, Tantalum (ppm)	0.35	0.34	0.37	0.32	0.39
Tb, Terbium (ppm)	1.30	1.15	1.45	1.24	1.36
Th, Thorium (ppm)	4.43	4.28	4.59	4.31	4.55
Ti, Titanium (wt.%)	0.199	0.190	0.208	0.195	0.203
Tl, Thallium (ppm)	0.82	0.76	0.89	0.77	0.88
Tm, Thulium (ppm)	0.61	0.53	0.69	IND	IND
U, Uranium (ppm)	1.64	1.59	1.70	1.59	1.69
V, Vanadium (ppm)	118	114	123	115	122
W, Tungsten (ppm)	9.11	8.59	9.63	8.68	9.53
Y, Yttrium (ppm)	49.6	46.3	52.9	48.6	50.7
Yb, Ytterbium (ppm)	3.85	3.43	4.28	3.77	3.94
Zn, Zinc (ppm)	80	72	87	76	83
Zr, Zirconium (ppm)	71	69	73	69	73
Gas / Liquid Pycnometry					
SG, Specific Gravity (Unity)	4.25	4.03	4.47	4.21	4.29

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.

Homogeneity Evaluation

The tolerance limits (ISO 16269:2014) in Table 4 were determined using an analysis of precision errors method and are considered a conservative estimate of true homogeneity. The meaning of tolerance limits may be illustrated for Manganese by borate fusion XRF finish, where 99% of the time (1-α=0.99) at least 95% of subsamples (ρ=0.95) will have concentrations lying between 28.21 and 28.38 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 (ISO Guide 35). ***Please note that tolerance limits pertain to the homogeneity of the CRM only and should not be used as control limits for laboratory performance***.

The homogeneity of OREAS 173 has also been evaluated in an ANOVA study for all certified analytes present in concentrations that are at least 20 times the lower limit of detection. No significant *p*-values were found indicating that no evidence exists that between-unit variance is greater than within-unit variance.

It is important to note that ANOVA is not an absolute measure of homogeneity. Rather, it establishes whether or not the analytes are distributed in a similar manner throughout the packaging run of OREAS 173 and whether the variance between two subsamples from the same unit is statistically distinguishable to the variance from two subsamples taken from any two separate units. A reference material therefore, can possess poor absolute homogeneity yet still pass a relative homogeneity test if the within-unit heterogeneity is large and similar across all units.

Based on the statistical analysis of the results of the inter-laboratory certification program it can be concluded that OREAS 173 is sufficiently homogenous and is fit-for-purpose as a certified reference material (see 'Intended Use' below).

PARTICIPATING LABORATORIES

1. ALS, Brisbane, QLD, Australia
2. ALS, Johannesburg, South Africa
3. ALS, Vancouver, BC, Canada
4. Bureau Veritas Geoanalytical, Adelaide, SA, Australia
5. Bureau Veritas Geoanalytical, Perth, WA, Australia
6. Carsurin, Kendari, Sulawesi, Indonesia
7. Intertek Genalysis, Johannesburg, South Africa
8. Intertek Genalysis, Perth, WA, Australia
9. Intertek Testing Services Philippines, Cupang, Muntinlupa, Philippines
10. Nagrom, Perth, WA, Australia
11. SGS, Randfontein, Gauteng, South Africa
12. SGS Australia Mineral Services, Perth, WA, Australia
13. SGS Canada Inc., Vancouver, BC, Canada
14. Shiva Analyticals Ltd, Bangalore North, Karnataka, India
15. UIS Analytical Services, Centurion, South Africa

Please note: To preserve anonymity, the above numbered alphabetical list of participating laboratories <u>does not</u> correspond with the Lab ID numbering on the scatter plots below.

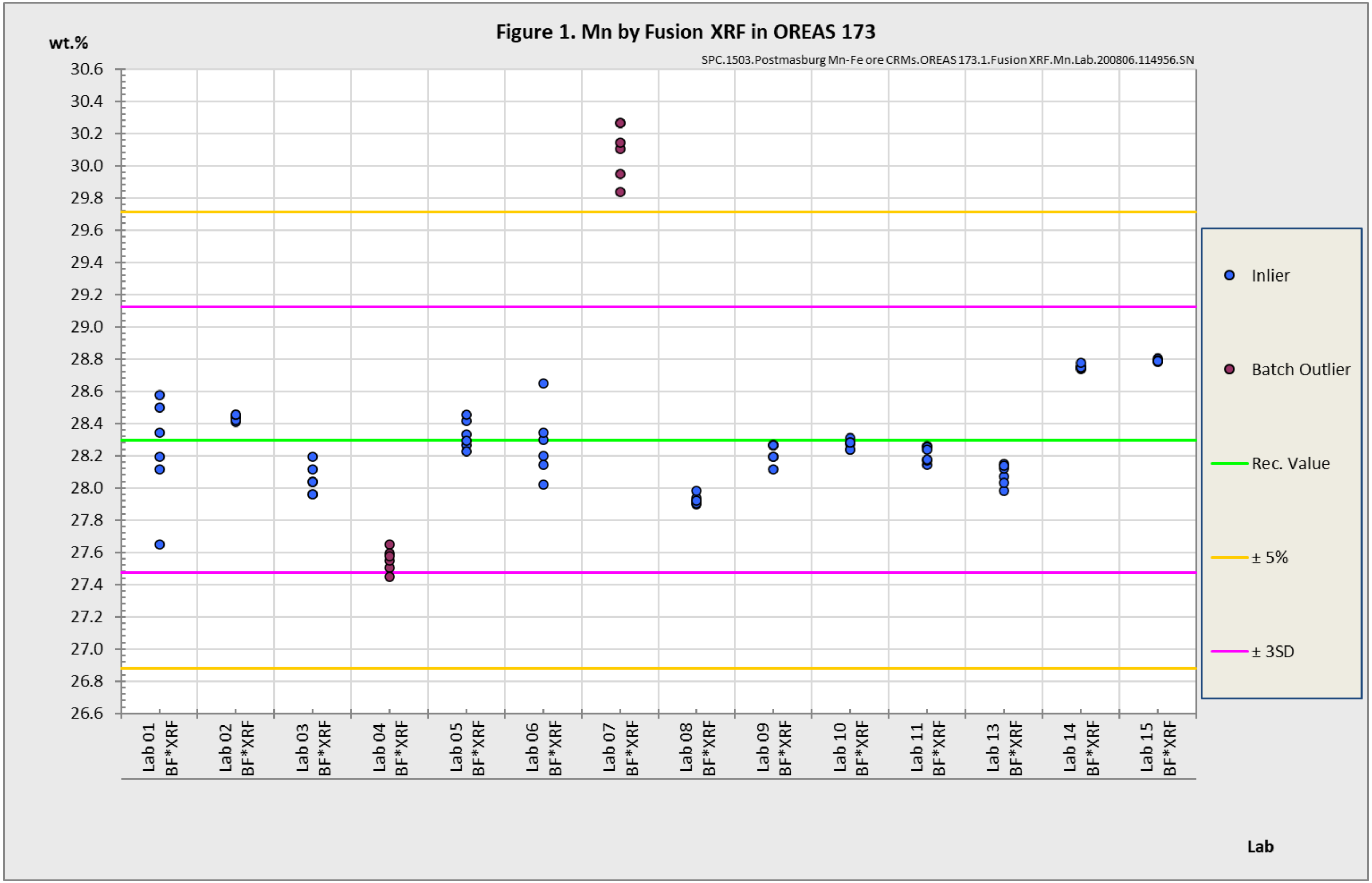
Figure 1. Mn by Fusion XRF in OREAS 173
wt.%
SPC.1503.Postmasburg Mn-Fe ore CRMs.OREAS 173.1.Fusion XRF.Mn.Lab.200806.114956.SN
30.6
30.4
30.2
30.0
29.8
29.6
29.4
29.2
29.0
28.8
28.6
28.4
28.2
28.0
27.8
27.6
27.4
27.2
27.0
26.8
26.6
Lab 01 BF*XRF
Lab 02 BF*XRF
Lab 03 BF*XRF
Lab 04 BF*XRF
Lab 05 BF*XRF
Lab 06 BF*XRF
Lab 07 BF*XRF
Lab 08 BF*XRF
Lab 09 BF*XRF
Lab 10 BF*XRF
Lab 11 BF*XRF
Lab 13 BF*XRF
Lab 14 BF*XRF
Lab 15 BF*XRF
Inlier
Batch Outlier
Rec. Value
± 5%
± 3SD
Lab

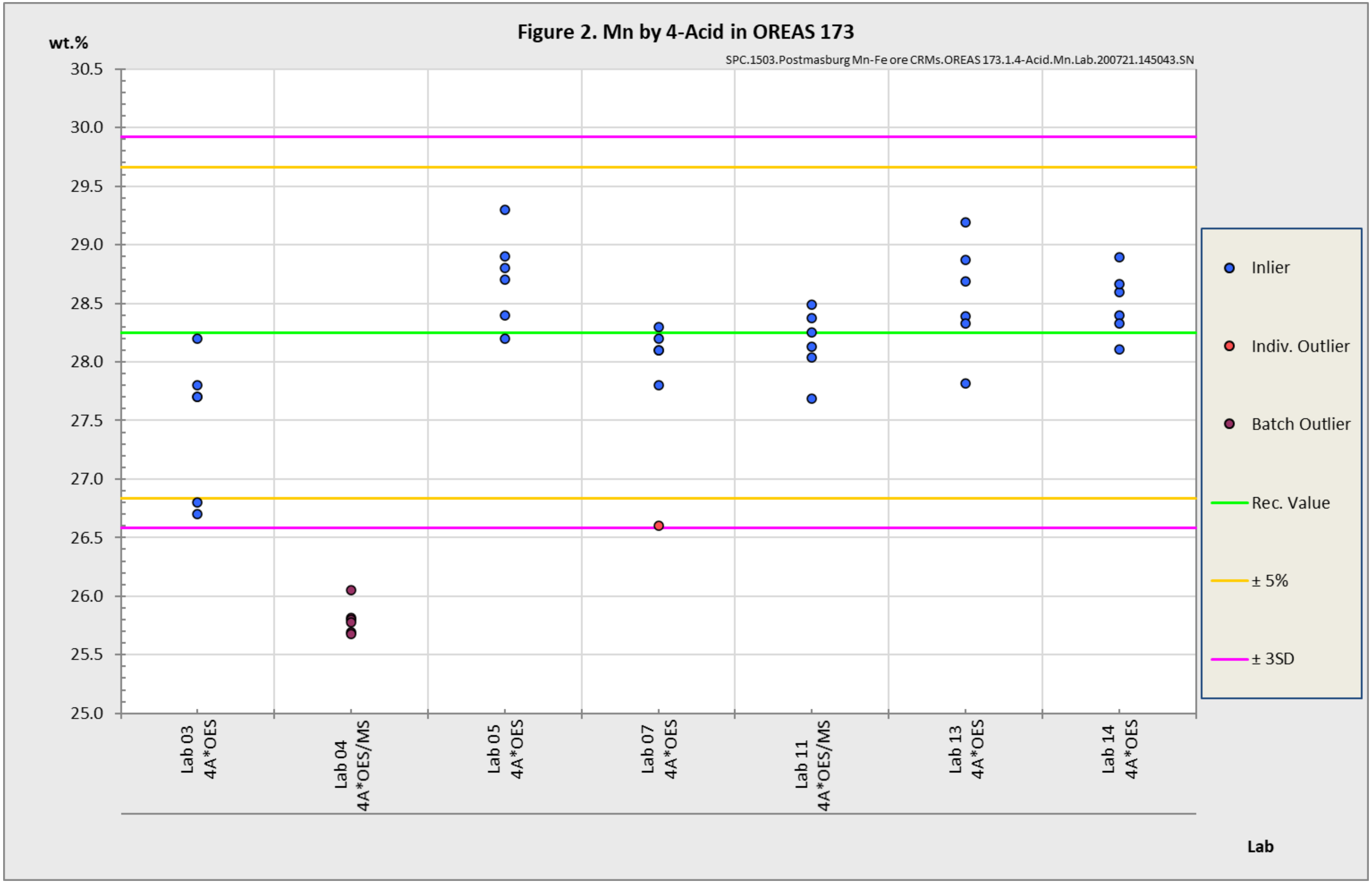
Figure 2. Mn by 4-Acid in OREAS 173
wt.%
SPC.1503.Postmasburg Mn-Fe ore CRMs.OREAS 173.1.4-Acid.Mn.Lab.200721.145043.SN
30.5
30.0
29.5
29.0
28.5
28.0
27.5
27.0
26.5
26.0
25.5
25.0
Lab 03 4A*OES
Lab 04 4A*OES/MS
Lab 05 4A*OES
Lab 07 4A*OES
Lab 11 4A*OES/MS
Lab 13 4A*OES
Lab 14 4A*OES
Inlier
Indiv. Outlier
Batch Outlier
Rec. Value
± 5%
± 3SD
Lab

PREPARER AND SUPPLIER

Certified reference material OREAS 173 was prepared, certified and supplied by:

ORE RESEARCH & EXPLORATION	ORE Research & Exploration Pty Ltd	Tel:	+613-9729 0333
	37A Hosie Street	Fax:	+613-9729 8338
	Bayswater North VIC 3153	Web:	www.ore.com.au
	AUSTRALIA	Email:	info@ore.com.au

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 173 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 173 may be used to calibrate the entire procedure by producing a pure substance CRM transformed into a calibration solution.

OREAS 173 is intended for the following uses:

- For the monitoring of laboratory performance in the analysis of analytes reported in Table 1 in geological samples;
- For the verification of analytical methods for analytes reported in Table 1;
- For the calibration of instruments used in the determination of the concentration of analytes reported in Table 1.

QC monitoring using multiples of the Standard Deviation (SD)

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

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

STABILITY AND STORAGE INSTRUCTIONS

OREAS 173 is an oxidised reference material and is stable in the laminated foil pouches. Under normal conditions of storage, it has a shelf life beyond ten years.

INSTRUCTIONS FOR CORRECT USE

The certified values for lithium borate fusion XRF and for LOI are on a dry basis. This requires the removal of hygroscopic moisture by drying in air to constant mass at 105°C. If the reference material is not dried prior to analysis, the certified values should be corrected to the moisture-bearing basis.

The certified values by 4-acid digestion and Specific Gravity by pycnometry are reported on a 'sample as received' basis.

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.

DOCUMENT HISTORY

Revision No.	Date	Changes applied
0	6th August, 2020	First publication.
1	25th August, 2020	Changed LOI statistics.

LEGAL NOTICE

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

QMS CERTIFICATION

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

CERTIFYING OFFICER

25th August, 2020

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

REFERENCES

Govett, G.J.S. (1983). ed. Handbook of Exploration Geochemistry, Volume 2: Statistics and Data Analysis in Geochemical Prospecting (Variations of accuracy and precision), P.O. Box 330, 1000 AH Amsterdam, The Netherlands.

Grobbelaar, W.S., Beukes, N.J. (1986). The Bishop and Glosam manganese mines and Beeshoek iron ore mine of the Postmasburg area. In: Annhaeusser, C.R., Maske, S. (eds.) Mineral deposits of Southern Africa. Geological Society of South Africa, Johannesburg: pp. 957–961.

ISO Guide 30 (2015). Terms and definitions used in connection with reference materials.

ISO Guide 31 (2015). Reference materials – Contents of certificates and labels.

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

ISO 16269 (2014). Statistical interpretation of data – Part 6: Determination of statistical tolerance intervals.

ISO/TR 16476 (2016). Reference Materials – Establishing and expressing metrological traceability of quantity values assigned to reference materials.

ISO 17025 (2005). General requirements for the competence of testing and calibration laboratories.

Munsell Rock Color Book (2014). Rock-Color Chart Committee, Geological Society of America (GSA), Minnesota (USA).