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CERTIFICATE OF ANALYSIS FOR

Pegmatitic Li-Nb-Sn ORE
CERTIFIED REFERENCE MATERIAL
OREAS 147

Summary Statistics for Key Analytes.

Constituent	Certified Value	1SD	95% Confidence Limits		95% Tolerance Limits	
			Low	High	Low	High
Peroxide Fusion ICP						
Li, Lithium (wt.%)	0.227	0.011	0.221	0.232	0.221	0.233
Li_2O, Lithium oxide (wt.%)	0.488	0.023	0.477	0.500	0.476	0.501
Nb, Niobium (wt.%)	0.115	0.007	0.111	0.118	0.111	0.119
Sn, Tin (ppm)	699	37	676	723	659	739

Note: intervals may appear asymmetric due to rounding.

Table 1. Certified Values, SDs, 95% Confidence and Tolerance Limits for OREAS 147.

Constituent	Certified Value	1SD	95% Confidence Limits		95% Tolerance Limits	
			Low	High	Low	High
4-Acid Digestion						
Al, Aluminium (wt.%)	4.90	0.187	4.81	5.00	4.79	5.02
As, Arsenic (ppm)	36.0	2.72	34.8	37.1	33.8	38.2
Ba, Barium (ppm)	1936	86	1896	1976	1890	1981
Be, Beryllium (ppm)	31.2	2.33	30.2	32.3	29.8	32.7
Bi, Bismuth (ppm)	12.5	1.05	12.0	13.0	12.1	12.9
Ca, Calcium (wt.%)	1.09	0.050	1.06	1.11	1.06	1.11
Ce, Cerium (ppm)	1106	90	1037	1176	1070	1143
Co, Cobalt (ppm)	6.90	0.393	6.71	7.09	6.69	7.11
Cr, Chromium (ppm)	57	8	53	61	54	59
Cs, Cesium (ppm)	238	12	231	244	231	244
Cu, Copper (ppm)	298	15	292	305	291	306
Dy, Dysprosium (ppm)	9.20	1.10	7.99	10.42	8.65	9.76
Er, Erbium (ppm)	3.00	0.38	2.58	3.43	2.81	3.20
Eu, Europium (ppm)	10.4	0.80	9.6	11.3	9.9	11.0
Fe, Iron (wt.%)	3.23	0.122	3.18	3.29	3.18	3.29
Ga, Gallium (ppm)	22.6	3.6	20.4	24.8	21.8	23.4
Gd, Gadolinium (ppm)	24.2	3.6	20.2	28.3	23.2	25.3
Ge, Germanium (ppm)	0.75	0.15	0.58	0.92	0.65	0.84
Hf, Hafnium (ppm)	2.99	0.32	2.84	3.14	2.82	3.16
In, Indium (ppm)	2.61	0.162	2.52	2.71	2.48	2.75
K, Potassium (wt.%)	1.60	0.053	1.58	1.62	1.56	1.63
La, Lanthanum (ppm)	663	47	641	685	644	682
Li, Lithium (wt.%)	0.226	0.012	0.221	0.232	0.221	0.231
Li_2O, Lithium oxide (wt.%)	0.487	0.026	0.475	0.499	0.476	0.498
Lu, Lutetium (ppm)	0.20	0.009	0.19	0.21	0.19	0.21
Mg, Magnesium (wt.%)	0.535	0.022	0.525	0.546	0.520	0.551
Mn, Manganese (wt.%)	0.039	0.002	0.038	0.040	0.038	0.040
Mo, Molybdenum (ppm)	7.99	0.296	7.87	8.11	7.68	8.30
Na, Sodium (wt.%)	0.948	0.043	0.925	0.972	0.925	0.972
Nb, Niobium (wt.%)	0.111	0.008	0.105	0.117	0.107	0.115
Ni, Nickel (ppm)	21.2	1.49	20.6	21.8	20.3	22.1
P, Phosphorus (wt.%)	0.155	0.009	0.151	0.160	0.151	0.160
Pb, Lead (ppm)	27.8	2.02	26.7	28.8	26.7	28.8
Pr, Praseodymium (ppm)	121	3	120	122	116	126
Rb, Rubidium (ppm)	1162	63	1128	1196	1129	1195
S, Sulphur (wt.%)	0.030	0.003	0.028	0.031	0.027	0.032
Sb, Antimony (ppm)	10.6	0.68	10.2	10.9	10.0	11.1
Sc, Scandium (ppm)	10.7	0.75	10.3	11.1	10.3	11.1
Sm, Samarium (ppm)	48.7	1.48	47.1	50.4	46.5	51.0
Sr, Strontium (ppm)	299	12	293	305	292	306
Ta, Tantalum (ppm)	17.8	2.3	16.3	19.3	17.1	18.5

Note: intervals may appear asymmetric due to rounding

Table 1 continued.

Constituent	Certified Value	1SD	95% Confidence Limits		95% Tolerance Limits	
			Low	High	Low	High
4-Acid Digestion continued						
Tb, Terbium (ppm)	2.35	0.205	2.15	2.54	2.25	2.44
Th, Thorium (ppm)	93	5.5	91	96	91	96
Ti, Titanium (wt.%)	0.470	0.022	0.460	0.480	0.458	0.482
Tl, Thallium (ppm)	10.8	0.67	10.4	11.1	10.4	11.1
Tm, Thulium (ppm)	0.27	0.04	0.22	0.31	IND	IND
U, Uranium (ppm)	15.8	0.60	15.6	16.1	15.4	16.3
V, Vanadium (ppm)	60	2.5	59	62	59	62
Y, Yttrium (ppm)	26.3	1.46	25.6	27.0	25.6	27.1
Yb, Ytterbium (ppm)	1.46	0.123	1.36	1.55	1.35	1.56
Zn, Zinc (ppm)	138	5	136	141	134	143
Zr, Zirconium (ppm)	105	7	102	109	101	110
Peroxide Fusion ICP						
Al, Aluminium (wt.%)	5.04	0.111	4.98	5.09	4.93	5.14
As, Arsenic (ppm)	35.9	3.37	33.4	38.5	32.4	39.5
Ba, Barium (ppm)	1956	106	1891	2020	1904	2007
Be, Beryllium (ppm)	36.1	4.8	32.9	39.4	33.8	38.5
Bi, Bismuth (ppm)	12.6	1.00	11.7	13.5	11.8	13.4
Ca, Calcium (wt.%)	1.12	0.053	1.10	1.14	1.07	1.16
Ce, Cerium (ppm)	1198	73	1142	1253	1164	1231
Cr, Chromium (ppm)	68	7	63	74	63	74
Cs, Cesium (ppm)	234	11	226	242	227	241
Cu, Copper (ppm)	300	16	289	311	286	314
Dy, Dysprosium (ppm)	8.52	0.657	8.07	8.97	8.13	8.91
Er, Erbium (ppm)	2.79	0.276	2.60	2.98	2.58	3.00
Eu, Europium (ppm)	10.2	0.59	9.8	10.6	9.7	10.7
Fe, Iron (wt.%)	3.27	0.085	3.23	3.31	3.20	3.33
Ga, Gallium (ppm)	22.1	1.92	19.8	24.3	20.9	23.3
Gd, Gadolinium (ppm)	21.8	0.86	21.2	22.5	20.7	23.0
Hf, Hafnium (ppm)	5.45	0.84	4.54	6.35	IND	IND
Ho, Holmium (ppm)	1.33	0.18	1.20	1.46	1.29	1.38
In, Indium (ppm)	2.85	0.183	2.71	2.99	2.64	3.06
K, Potassium (wt.%)	1.64	0.059	1.62	1.66	1.58	1.70
La, Lanthanum (ppm)	698	27	676	720	684	712
Li, Lithium (wt.%)	0.227	0.011	0.221	0.232	0.221	0.233
Li_2O, Lithium oxide (wt.%)	0.488	0.023	0.477	0.500	0.476	0.501
Mg, Magnesium (wt.%)	0.549	0.024	0.538	0.560	0.537	0.561
Mn, Manganese (wt.%)	0.039	0.001	0.039	0.040	0.038	0.041
Mo, Molybdenum (ppm)	9.60	1.47	8.48	10.72	IND	IND
Nb, Niobium (wt.%)	0.115	0.007	0.111	0.118	0.111	0.119
Nd, Neodymium (ppm)	379	19	365	393	367	390
P, Phosphorus (wt.%)	0.156	0.009	0.151	0.160	0.150	0.161

Note: intervals may appear asymmetric due to rounding.

Table 1 continued.

Constituent	Certified Value	1SD	95% Confidence Limits		95% Tolerance Limits	
			Low	High	Low	High
Peroxide Fusion ICP continued						
Pr, Praseodymium (ppm)	122	3	120	123	119	124
Rb, Rubidium (ppm)	1184	94	1109	1260	1152	1216
Sb, Antimony (ppm)	10.5	0.86	9.9	11.1	9.4	11.6
Si, Silicon (wt.%)	35.58	0.779	35.01	36.15	34.76	36.40
Sm, Samarium (ppm)	47.9	3.42	45.3	50.5	46.3	49.6
Sn, Tin (ppm)	699	37	676	723	659	739
Sr, Strontium (ppm)	302	15	293	312	290	315
Ta, Tantalum (ppm)	17.8	1.9	15.3	20.3	16.6	19.0
Tb, Terbium (ppm)	2.30	0.32	2.07	2.53	2.20	2.40
Th, Thorium (ppm)	95	3.4	93	98	92	99
Ti, Titanium (wt.%)	0.483	0.018	0.475	0.490	0.467	0.498
Tl, Thallium (ppm)	10.8	0.82	10.1	11.5	10.3	11.3
Tm, Thulium (ppm)	0.33	0.06	0.30	0.37	0.30	0.37
V, Vanadium (ppm)	64	4.0	61	67	59	68
Y, Yttrium (ppm)	27.6	1.17	26.6	28.5	26.8	28.4
Yb, Ytterbium (ppm)	1.63	0.18	1.56	1.70	IND	IND
Zn, Zinc (ppm)	142	12	135	150	133	152
Zr, Zirconium (ppm)	194	29	166	222	183	205
Borate Fusion XRF						
Al_2O_3, Aluminium(III) oxide (wt.%)	9.48	0.078	9.44	9.52	9.44	9.52
BaO, Barium oxide (ppm)	2180	40	2166	2194	2108	2252
CaO, Calcium oxide (wt.%)	1.56	0.014	1.55	1.57	1.55	1.57
Fe_2O_3, Iron(III) oxide (wt.%)	4.67	0.055	4.64	4.70	4.64	4.70
K_2O, Potassium oxide (wt.%)	1.97	0.020	1.96	1.98	1.96	1.99
MgO, Magnesium oxide (wt.%)	0.945	0.018	0.937	0.954	0.932	0.958
MnO, Manganese oxide (wt.%)	0.051	0.001	0.050	0.051	0.048	0.053
Na_2O, Sodium oxide (wt.%)	1.31	0.029	1.29	1.32	1.29	1.33
Nb_2O_5, Niobium(V) oxide (wt.%)	0.169	0.005	0.165	0.172	0.163	0.174
P_2O_5, Phosphorus(V) oxide (wt.%)	0.368	0.008	0.364	0.372	0.361	0.375
SiO_2, Silicon dioxide (wt.%)	76.34	0.491	76.11	76.57	76.10	76.57
Sn, Tin (ppm)	764	47	740	788	728	799
SO_3, Sulphur trioxide (wt.%)	0.067	0.004	0.064	0.069	0.064	0.069
SrO, Strontium oxide (ppm)	332	35	305	358	IND	IND
TiO_2, Titanium dioxide (wt.%)	0.808	0.010	0.804	0.813	0.797	0.820
Thermogravimetry						
LOI^{1000}, Loss on ignition @1000°C (wt.%)	0.919	0.048	0.893	0.946	0.874	0.964

Note: intervals may appear asymmetric due to rounding.

INTRODUCTION

OREAS reference materials are intended to provide a low cost method of evaluating and improving the quality of analysis of geological samples. To the geologist they provide a means of implementing quality control in analytical data sets generated in exploration from the grass roots level through to prospect evaluation, and in grade control at mining operations. To the analyst they provide an effective means of calibrating analytical equipment, assessing new techniques and routinely monitoring in-house procedures.

SOURCE MATERIALS

Certified Reference Material OREAS 147 has been prepared from spodumene $LiAl(Si_2O_5)$-rich pegmatite ore blended with granodiorite and with minor additions of Sn oxide ore and Nb concentrate. The pegmatite was sourced from stockpile grab samples from the Greenbushes Mine owned by Talison Lithium Ltd located just south of the town of Greenbushes in the south-western corner of Western Australia. The barren I-type hornblende-bearing granodiorite was sourced from the Late Devonian Lysterfield granodiorite complex located in eastern Melbourne, Australia. The Sn lateritic ore material was sourced from the Doradilla Project located in north central NSW and the Nb concentrate was sourced from Anglo American Brasil Catalão's niobium mine in Goiás, Brazil. The Nb concentrate was produced from niobium-rich ore developed in the saprolite zone over alkaline-carbonatite complexes.

COMMINUTION AND HOMOGENISATION PROCEDURES

The material constituting OREAS 147 was prepared in the following manner:

- Drying to constant mass at 105°C;
- Milling of Li and Nb ores to 100% minus 30 microns;
- Milling of Sn ore and granodiorite to 98% minus 75 microns;
- Preliminary homogenisation and check assaying of source materials;
- Final homogenisation by blending the source materials in specific ratios to achieve target grades;
- Packaging in 10g units in laminated foil pouches.

ANALYTICAL PROGRAM

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

- Four acid digestion for full ICP-OES and ICP-MS elemental suites (up to 22 laboratories depending on the element) except for one laboratory who used an AAS finish for Li only;
- Peroxide fusion for full ICP-OES and ICP-MS elemental suites (up to 21 laboratories depending on the element);
- Lithium borate fusion with XRF finish for whole rock package including Nb and Ta (up to 22 laboratories depending on the element);
- Thermogravimetry for LOI at 1000° C; (9 laboratories used a conventional muffle furnace and 6 laboratories used a thermogravimetric analyser).

For the round robin program ten test units were taken at predetermined intervals during the bagging stage, immediately following homogenisation and are considered representative of the entire batch. The six samples received by each laboratory were obtained by taking two 20g scoop splits from each of three separate 300g test units. This format enabled nested ANOVA treatment of the results to evaluate homogeneity, i.e. to ascertain whether between-unit variance is greater than within-unit variance.

Table 1 presents the 114 certified values together with their associated 1SD's, 95% confidence and tolerance limits and Table 2 shows 59 indicative values (uncertified). Table 3 provides the indicative mineralogical composition based on semi-quantitative X-ray diffraction at one laboratory and Table 4 provides performance gate intervals for the certified values based on their associated pooled standard deviations. Tabulated results of all elements together with analytical method codes, uncorrected means, medians, standard deviations, relative standard deviations and per cent deviation of lab means from the corrected mean of means (PDM[3]) are presented in the detailed certification data for this CRM (**OREAS 147 DataPack-1.1.190226_162221.xlsx**).

Table 2. Indicative Values for OREAS 147.

Constituent	Unit	Value	Constituent	Unit	Value	Constituent	Unit	Value
4-Acid Digestion								
Ag	ppm	*0.706*	Ho	ppm	*1.26*	Se	ppm	*2.46*
Au	ppm	*0.172*	Ir	ppm	*0.010*	Si	wt.%	*34.39*
B	ppm	*2.68*	Nd	ppm	*386*	Sn	ppm	*503*
Cd	ppm	*0.46*	Pt	ppm	*0.024*	Te	ppm	*0.077*
Hg	ppm	*0.042*	Re	ppm	*< 0.002*	W	ppm	*4.88*
Peroxide Fusion ICP								
Ag	ppm	*3.00*	Lu	ppm	*0.22*	Sc	ppm	*9.82*
B	ppm	*29.2*	Ni	ppm	*23.2*	Se	ppm	*< 20*
Cd	ppm	*< 10*	Pb	ppm	*30.0*	Te	ppm	*< 1*
Co	ppm	*7.39*	Re	ppm	*< 0.1*	U	ppm	*16.4*
Ge	ppm	*3.20*	S	wt.%	*0.024*	W	ppm	*6.46*
Borate Fusion XRF								
As	ppm	*52*	Gd_2O_3	ppm	*< 100*	Sm_2O_3	ppm	*< 100*
Bi	ppm	*< 100*	HfO_2	ppm	*< 100*	Ta_2O_5	ppm	*< 24*
CeO_2	ppm	*1417*	La_2O_3	ppm	*761*	ThO_2	ppm	*< 100*
Cl	ppm	*106*	Mo	ppm	*< 10*	U_3O_8	ppm	*15.0*
Co	ppm	*47.3*	Nd_2O_3	ppm	*583*	V_2O_5	ppm	*128*
Cr_2O_3	ppm	*104*	Ni	ppm	*38.6*	W	ppm	*19.2*
Cu	ppm	*291*	Pb	ppm	*36.1*	Y_2O_3	ppm	*150*
Dy_2O_3	ppm	*< 100*	Pr_6O_{11}	ppm	*483*	Yb_2O_3	ppm	*< 100*
Er_2O_3	ppm	*< 100*	Rb	ppm	*1219*	Zn	ppm	*139*
Ga_2O_3	ppm	*41.7*	Sb	ppm	*< 50*			

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

Table 3. Indicative mineralogical composition of OREAS 147 based on semi-quantitative X-ray diffraction.

Minerals	% (mass fraction)
Quartz	70.0
Plagioclase Feldspar	11.2
K-Feldspar	3.2
Spodumene	5.9
Biotite-Phlogopite	8.3
Muscovite-Illite	-
Cordierite	<1
Chlorite	0.6
Epidote	0.7
Kandite Group	-
Pyrite	-
Pyrrhotite	-
Sphalerite	-
Pentlandite	-
Chalcopyrite	-
Calcite?	-
Pyroxenes	-
Amphibole	-
Talc	-
Total	100.1

Note:

1. Samples were pulverized and then ground under ethyl alcohol in a vibratory McCrone Micronizing Mill for 7 min.
2. Step-scan X-ray powder diffraction data collected over a range of 5-80°2θ with CoKα radiation using Bruker XRD D4 diffractometer.
3. X-ray powder diffraction data analyzed using search-match software by Malvern Panalytical Highscore+ and refined using Rietveld program Highscore+5.1 and structures from the ICSD Database.
4. Minerals with a % mass fraction of less than 1 % were mostly unidentified and are shown as '-'.
5. The values displayed in the table above are a summary of the XRD results. Detailed information is included in the following footnotes and in the diffractograms (available upon request).
6. Plagioclase Feldspar includes Albite and Anorthite Sodian.
7. K-Feldspar includes Orthoclase and Microcline.
8. Spodumene includes Spodumene and Bikitaite?
9. Biotite-Phlogopite includes Biotite 1M and Biotite 2M1.
10. Muscovite-Illite includes Muscovite 2M1.
11. Epidote includes Clinozoisite.
12. Kandite Group includes Kaolinite.
13. Pyrrhotite includes Pyrrhotite 5C.
14. The presence of Calcite is uncertain due to peak overlaps with Chalcopyrite.
15. Pyroxenes includes Enstatite Ferroan and Diopside.
16. Amphibole includes Actinolite
17. XRD data results were quantified by an external source.

STATISTICAL ANALYSIS

Certified Values, Confidence Limits, Standard Deviations and Tolerance Limits (Table 1) have been determined for each analyte following removal of individual, laboratory dataset (batch) and 3SD outliers (single iteration). For individual outliers within a laboratory batch the z-score test is used in combination with a second method that determines the per cent deviation of the individual value from the batch median. Outliers in general are selected on the basis of z-scores > 2.5 and with per cent deviations (i) > 3 and (ii) more than three times the average absolute per cent deviation for the batch. In certain instances statistician's prerogative has been employed in discriminating outliers. Each laboratory data set mean is tested for outlying status based on z-score discrimination and rejected if > 2.5. After individual and laboratory data set (batch) outliers have been eliminated a non-iterative 3 standard deviation filter is applied, with those values lying outside this window also relegated to outlying status. The Certified Values are the means of accepted laboratory means after outlier filtering.

The 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.*

Standard Deviation values (1SDs) are reported in Table 1 and provide an indication of a level of performance that might reasonably be expected from a laboratory being monitored by this CRM in a QA/QC program. The SD's take into account errors attributable to measurement uncertainty and CRM variability. For an effective CRM the contribution of the latter should be negligible in comparison to measurement errors. The SD values thus include all sources of measurement uncertainty: between-lab variance, within-run variance (precision errors) and CRM variability. OREAS prepared reference materials have a level of homogeneity such that the observed variance from repeated analysis has its origin almost exclusively in the analytical process rather than the reference material itself.

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

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

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

Table 4 shows **Performance Gates** calculated for two and three standard deviations. As a guide these intervals may be regarded as warning or rejection for multiple 2SD outliers, or rejection for individual 3SD outliers in QC monitoring, although their precise application should be at the discretion of the QC manager concerned. A second method utilises a 5% window calculated directly from the certified value. Standard deviation is also shown in relative percent for one, two and three relative standard deviations (1RSD, 2RSD and 3RSD) to facilitate an appreciation of the magnitude of these numbers and a comparison with the 5% window. Caution should be exercised when concentration levels approach lower limits of detection of the analytical methods employed as performance gates calculated from standard deviations tend to be excessively wide whereas those determined by the 5% method are too narrow.

Tolerance Limits (ISO Guide 3207) were determined 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 tin (Sn) by fusion XRF, where 99% of the time ($1-\alpha=0.99$) at least 95% of subsamples ($\rho=0.95$) will have concentrations lying between 728 and 799 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 (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 147 has also been evaluated in a **nested ANOVA** of the round robin program. Each of the twenty four round robin laboratories received six samples per CRM and these samples were made up of paired samples from three different, non-adjacent sampling intervals. The purpose of the ANOVA evaluation is to test that no statistically significant difference exists in the variance between-units to that of the variance within-units. This allows an assessment of homogeneity across the entire prepared batch of OREAS 147. The test was performed using the following parameters:

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

P-values are a measure of probability where values less than 0.05 indicate a greater than 95% probability that the observed differences in within-unit and between-unit variances are real. The datasets were filtered for both individual and laboratory data set (batch) outliers prior to the calculation of *p*-values. This process derived no significant *p*-values across the entire 114 certified values except for indium (In) by Peroxide Fusion ICP. This isolated case is most likely due to random statistical probability as there is no other supporting evidence to suspect greater between-unit variance compared with within-unit variance. The null hypothesis is therefore retained.

It is important to note that ANOVA is not an absolute measure of homogeneity. Rather, it establishes whether or not the analytes are distributed in a similar manner throughout the packaging run of OREAS 147 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 147 is fit-for-purpose as a certified reference material (see ‘Intended Use’ below).

Table 4. Pooled-Lab Performance Gates for OREAS 147.

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											
Al, wt.%	4.90	0.187	4.53	5.28	4.34	5.46	3.81%	7.62%	11.42%	4.66	5.15
As, ppm	36.0	2.72	30.5	41.4	27.8	44.1	7.55%	15.10%	22.65%	34.2	37.8
Ba, ppm	1936	86	1764	2107	1678	2193	4.43%	8.87%	13.30%	1839	2032
Be, ppm	31.2	2.33	26.6	35.9	24.2	38.2	7.45%	14.90%	22.35%	29.7	32.8
Bi, ppm	12.5	1.05	10.4	14.6	9.4	15.6	8.39%	16.78%	25.17%	11.9	13.1
Ca, wt.%	1.09	0.050	0.99	1.19	0.93	1.24	4.64%	9.28%	13.92%	1.03	1.14
Ce, ppm	1106	90	926	1287	836	1377	8.16%	16.32%	24.47%	1051	1162
Co, ppm	6.90	0.393	6.12	7.69	5.72	8.08	5.70%	11.40%	17.10%	6.56	7.25
Cr, ppm	57	8	41	73	32	81	14.27%	28.55%	42.82%	54	60
Cs, ppm	238	12	214	261	202	273	5.05%	10.10%	15.15%	226	249
Cu, ppm	298	15	269	327	255	342	4.86%	9.72%	14.58%	283	313
Dy, ppm	9.20	1.10	7.00	11.41	5.90	12.51	11.95%	23.91%	35.86%	8.74	9.67
Er, ppm	3.00	0.38	2.24	3.77	1.86	4.15	12.73%	25.46%	38.19%	2.85	3.15
Eu, ppm	10.4	0.80	8.8	12.1	8.0	12.9	7.67%	15.33%	23.00%	9.9	11.0
Fe, wt.%	3.23	0.122	2.99	3.48	2.87	3.60	3.77%	7.55%	11.32%	3.07	3.39
Ga, ppm	22.6	3.6	15.4	29.9	11.7	33.5	16.05%	32.10%	48.15%	21.5	23.7
Gd, ppm	24.2	3.6	17.0	31.5	13.4	35.1	14.91%	29.82%	44.73%	23.0	25.5
Ge, ppm	0.75	0.15	0.45	1.05	0.30	1.20	19.93%	39.86%	59.78%	0.71	0.79
Hf, ppm	2.99	0.32	2.36	3.63	2.04	3.94	10.62%	21.24%	31.85%	2.84	3.14
In, ppm	2.61	0.162	2.29	2.94	2.13	3.10	6.21%	12.43%	18.64%	2.48	2.74
K, wt.%	1.60	0.053	1.49	1.70	1.44	1.76	3.28%	6.57%	9.85%	1.52	1.68
La, ppm	663	47	568	758	520	805	7.16%	14.33%	21.49%	630	696
Li, wt.%	0.226	0.012	0.202	0.251	0.190	0.263	5.37%	10.75%	16.12%	0.215	0.238
Li_2O, wt.%	0.49	0.03	0.43	0.54	0.41	0.57	5.37%	10.75%	16.12%	0.463	0.512
Lu, ppm	0.20	0.009	0.18	0.22	0.17	0.23	4.71%	9.42%	14.13%	0.19	0.21
Mg, wt.%	0.535	0.022	0.491	0.580	0.469	0.602	4.13%	8.26%	12.39%	0.509	0.562
Mn, wt.%	0.039	0.002	0.035	0.044	0.033	0.046	5.63%	11.25%	16.88%	0.037	0.041
Mo, ppm	7.99	0.296	7.40	8.58	7.10	8.87	3.70%	7.40%	11.10%	7.59	8.39
Na, wt.%	0.948	0.043	0.862	1.035	0.819	1.078	4.55%	9.10%	13.66%	0.901	0.996
Nb, wt.%	0.111	0.008	0.095	0.127	0.087	0.136	7.31%	14.62%	21.94%	0.106	0.117
Ni, ppm	21.2	1.49	18.2	24.2	16.7	25.6	7.03%	14.07%	21.10%	20.1	22.2
P, wt.%	0.155	0.009	0.137	0.173	0.128	0.182	5.78%	11.55%	17.33%	0.147	0.163
Pb, ppm	27.8	2.02	23.7	31.8	21.7	33.8	7.29%	14.58%	21.88%	26.4	29.1
Pr, ppm	121	3	116	126	113	129	2.14%	4.28%	6.43%	115	127
Rb, ppm	1162	63	1035	1289	972	1352	5.46%	10.92%	16.38%	1104	1220
S, wt.%	0.030	0.003	0.024	0.035	0.021	0.038	9.91%	19.82%	29.73%	0.028	0.031
Sb, ppm	10.6	0.68	9.2	11.9	8.5	12.6	6.41%	12.82%	19.23%	10.0	11.1
Sc, ppm	10.7	0.75	9.1	12.2	8.4	12.9	7.07%	14.15%	21.22%	10.1	11.2
Sm, ppm	48.7	1.48	45.8	51.7	44.3	53.2	3.05%	6.09%	9.14%	46.3	51.2
Sr, ppm	299	12	274	324	262	336	4.15%	8.30%	12.45%	284	314
Ta, ppm	17.8	2.3	13.1	22.5	10.8	24.8	13.09%	26.17%	39.26%	16.9	18.7
Tb, ppm	2.35	0.205	1.93	2.76	1.73	2.96	8.75%	17.51%	26.26%	2.23	2.46

Note: intervals may appear asymmetric due to rounding.

Table 4 continued.

Constituent	Certified Value	Absolute Standard Deviations					Relative Standard Deviations			5% window	
		1SD	2SD Low	2SD High	3SD Low	3SD High	1RSD	2RSD	3RSD	Low	High
4-Acid Digestion continued											
Th, ppm	93	5.5	82	104	77	110	5.89%	11.79%	17.68%	89	98
Ti, wt.%	0.470	0.022	0.426	0.513	0.405	0.535	4.63%	9.26%	13.88%	0.446	0.493
Tl, ppm	10.8	0.67	9.4	12.1	8.8	12.8	6.26%	12.52%	18.78%	10.2	11.3
Tm, ppm	0.27	0.04	0.19	0.34	0.16	0.37	13.79%	27.59%	41.38%	0.25	0.28
U, ppm	15.8	0.60	14.7	17.0	14.1	17.6	3.76%	7.51%	11.27%	15.1	16.6
V, ppm	60	2.5	55	66	53	68	4.20%	8.41%	12.61%	57	64
Y, ppm	26.3	1.46	23.4	29.2	21.9	30.7	5.54%	11.07%	16.61%	25.0	27.6
Yb, ppm	1.46	0.123	1.21	1.70	1.09	1.83	8.47%	16.95%	25.42%	1.38	1.53
Zn, ppm	138	5	129	148	124	153	3.39%	6.77%	10.16%	132	145
Zr, ppm	105	7	92	118	86	125	6.26%	12.52%	18.78%	100	111
Peroxide Fusion ICP											
Al, wt.%	5.04	0.111	4.81	5.26	4.70	5.37	2.20%	4.40%	6.59%	4.78	5.29
As, ppm	35.9	3.37	29.2	42.7	25.8	46.0	9.37%	18.73%	28.10%	34.1	37.7
Ba, ppm	1956	106	1744	2167	1639	2273	5.40%	10.81%	16.21%	1858	2053
Be, ppm	36.1	4.8	26.5	45.8	21.7	50.6	13.31%	26.63%	39.94%	34.3	37.9
Bi, ppm	12.6	1.00	10.6	14.6	9.6	15.6	7.92%	15.84%	23.76%	11.9	13.2
Ca, wt.%	1.12	0.053	1.01	1.22	0.96	1.28	4.72%	9.44%	14.15%	1.06	1.17
Ce, ppm	1198	73	1051	1344	978	1417	6.11%	12.22%	18.33%	1138	1257
Cr, ppm	68	7	54	83	47	90	10.37%	20.73%	31.10%	65	72
Cs, ppm	234	11	211	257	200	269	4.88%	9.76%	14.65%	223	246
Cu, ppm	300	16	268	332	252	348	5.32%	10.65%	15.97%	285	315
Dy, ppm	8.52	0.657	7.21	9.83	6.55	10.49	7.71%	15.42%	23.13%	8.09	8.95
Er, ppm	2.79	0.276	2.24	3.35	1.96	3.62	9.89%	19.78%	29.67%	2.65	2.93
Eu, ppm	10.2	0.59	9.0	11.4	8.4	12.0	5.82%	11.64%	17.46%	9.7	10.7
Fe, wt.%	3.27	0.085	3.10	3.44	3.01	3.52	2.60%	5.20%	7.81%	3.10	3.43
Ga, ppm	22.1	1.92	18.2	25.9	16.3	27.8	8.72%	17.44%	26.16%	20.9	23.2
Gd, ppm	21.8	0.86	20.1	23.6	19.2	24.4	3.95%	7.91%	11.86%	20.7	22.9
Hf, ppm	5.45	0.84	3.77	7.12	2.94	7.96	15.37%	30.73%	46.10%	5.17	5.72
Ho, ppm	1.33	0.18	0.97	1.69	0.79	1.87	13.45%	26.91%	40.36%	1.27	1.40
In, ppm	2.85	0.183	2.48	3.22	2.30	3.40	6.43%	12.85%	19.28%	2.71	2.99
K, wt.%	1.64	0.059	1.52	1.76	1.46	1.82	3.59%	7.18%	10.77%	1.56	1.72
La, ppm	698	27	645	752	618	779	3.83%	7.66%	11.49%	663	733
Li, wt.%	0.227	0.011	0.206	0.248	0.195	0.259	4.69%	9.37%	14.06%	0.215	0.238
Li_2O, wt.%	0.49	0.02	0.44	0.53	0.42	0.56	4.69%	9.37%	14.06%	0.464	0.513
Mg, wt.%	0.549	0.024	0.502	0.596	0.478	0.620	4.29%	8.57%	12.86%	0.522	0.576
Mn, wt.%	0.039	0.001	0.037	0.041	0.036	0.042	2.77%	5.53%	8.30%	0.037	0.041
Mo, ppm	9.60	1.47	6.67	12.54	5.20	14.00	15.28%	30.56%	45.84%	9.12	10.08
Nb, wt.%	0.115	0.007	0.101	0.128	0.094	0.135	5.93%	11.85%	17.78%	0.109	0.120
Nd, ppm	379	19	341	416	322	435	4.98%	9.96%	14.94%	360	398
P, wt.%	0.156	0.009	0.137	0.174	0.128	0.183	5.79%	11.59%	17.38%	0.148	0.163
Pr, ppm	122	3	116	127	114	130	2.19%	4.37%	6.56%	116	128
Rb, ppm	1184	94	996	1372	902	1466	7.94%	15.88%	23.82%	1125	1243
Sb, ppm	10.5	0.86	8.8	12.2	7.9	13.1	8.21%	16.43%	24.64%	10.0	11.0

Note: intervals may appear asymmetric due to rounding.

Table 4 continued.

Constituent	Certified Value	Absolute Standard Deviations					Relative Standard Deviations			5% window	
		1SD	2SD Low	2SD High	3SD Low	3SD High	1RSD	2RSD	3RSD	Low	High
Peroxide Fusion ICP continued											
Si, wt.%	35.58	0.779	34.02	37.14	33.25	37.92	2.19%	4.38%	6.57%	33.80	37.36
Sm, ppm	47.9	3.42	41.1	54.8	37.7	58.2	7.15%	14.29%	21.44%	45.5	50.3
Sn, ppm	699	37	626	773	589	810	5.28%	10.55%	15.83%	664	734
Sr, ppm	302	15	273	332	259	346	4.82%	9.65%	14.47%	287	318
Ta, ppm	17.8	1.9	14.0	21.7	12.1	23.6	10.78%	21.57%	32.35%	16.9	18.7
Tb, ppm	2.30	0.32	1.65	2.95	1.33	3.27	14.10%	28.19%	42.29%	2.19	2.42
Th, ppm	95	3.4	89	102	85	106	3.54%	7.07%	10.61%	91	100
Ti, wt.%	0.483	0.018	0.446	0.519	0.428	0.537	3.79%	7.57%	11.36%	0.459	0.507
Tl, ppm	10.8	0.82	9.2	12.4	8.3	13.3	7.59%	15.18%	22.77%	10.3	11.3
Tm, ppm	0.33	0.06	0.22	0.44	0.16	0.50	17.15%	34.30%	51.44%	0.31	0.35
V, ppm	64	4.0	56	72	52	76	6.26%	12.52%	18.78%	61	67
Y, ppm	27.6	1.17	25.2	29.9	24.1	31.1	4.23%	8.47%	12.70%	26.2	28.9
Yb, ppm	1.63	0.18	1.26	2.00	1.08	2.18	11.31%	22.62%	33.93%	1.55	1.71
Zn, ppm	142	12	119	166	107	177	8.26%	16.52%	24.78%	135	149
Zr, ppm	194	29	136	252	107	281	14.92%	29.84%	44.75%	184	204
Borate Fusion XRF											
Al_2O_3, wt.%	9.48	0.078	9.32	9.63	9.24	9.71	0.82%	1.64%	2.46%	9.00	9.95
BaO, ppm	2180	40	2100	2259	2061	2299	1.82%	3.65%	5.47%	2071	2289
CaO, wt.%	1.56	0.014	1.53	1.59	1.52	1.60	0.91%	1.81%	2.72%	1.48	1.64
Fe_2O_3, wt.%	4.67	0.055	4.56	4.78	4.50	4.83	1.17%	2.35%	3.52%	4.43	4.90
K_2O, wt.%	1.97	0.020	1.93	2.01	1.91	2.03	1.01%	2.02%	3.04%	1.87	2.07
MgO, wt.%	0.945	0.018	0.908	0.982	0.890	1.000	1.94%	3.89%	5.83%	0.898	0.993
MnO, wt.%	0.051	0.001	0.048	0.053	0.047	0.054	2.02%	4.04%	6.05%	0.048	0.053
Na_2O, wt.%	1.31	0.029	1.25	1.37	1.22	1.40	2.23%	4.46%	6.68%	1.24	1.37
Nb_2O_5, wt.%	0.169	0.005	0.159	0.179	0.154	0.183	2.94%	5.88%	8.81%	0.160	0.177
P_2O_5, wt.%	0.368	0.008	0.352	0.384	0.344	0.392	2.18%	4.37%	6.55%	0.350	0.386
SiO_2, wt.%	76.34	0.491	75.36	77.32	74.86	77.81	0.64%	1.29%	1.93%	72.52	80.15
Sn, ppm	764	47	670	858	623	904	6.15%	12.29%	18.44%	725	802
SO_3, wt.%	0.067	0.004	0.058	0.075	0.054	0.079	6.36%	12.72%	19.07%	0.063	0.070
SrO, ppm	332	35	263	401	228	435	10.41%	20.81%	31.22%	315	348
TiO_2, wt.%	0.808	0.010	0.789	0.828	0.779	0.837	1.20%	2.40%	3.59%	0.768	0.849
Zr, ppm	200	35	130	271	95	306	17.56%	35.13%	52.69%	190	210
Thermogravimetry											
LOI^{1000}, wt.%	0.919	0.048	0.823	1.016	0.774	1.064	5.25%	10.50%	15.74%	0.873	0.965

Note: intervals may appear asymmetric due to rounding.

PARTICIPATING LABORATORIES

1. Actlabs, Ancaster, Ontario, Canada
2. ALS, Brisbane, QLD, Australia
3. ALS, Lima, Peru
4. ALS, Loughrea, Galway, Ireland
5. ALS, Perth, WA, Australia

6. ALS, Vancouver, BC, Canada
7. Bureau Veritas Commodities Canada Ltd, Vancouver, BC, Canada
8. Bureau Veritas Geoanalytical, Adelaide, SA, Australia
9. Bureau Veritas Geoanalytical, Perth, WA, Australia
10. Intertek Genalysis, Perth, WA, Australia
11. Intertek Testing Services Philippines, Cupang, Muntinlupa, Philippines
12. MinAnalytical Services, Perth, WA, Australia
13. Nagrom, Perth, WA, Australia
14. PT Geoservices Ltd, Cikarang, Jakarta Raya, Indonesia
15. SGS Australia Mineral Services, Perth, WA, Australia
16. SGS Canada Inc., Vancouver, BC, Canada
17. SGS del Peru, Lima, Peru
18. SGS Geosol Laboratorios Ltda, Vespasiano, Minas Gerais, Brazil
19. SGS Lakefield Research Ltd, Lakefield, Ontario, Canada
20. UIS Analytical Services, Centurion , South Africa
21. Zarazma Mahan Company, Mahan, Kerrman, Iran
22. Zarazma Mineral Studies Company, Tehran, Iran

PREPARER AND SUPPLIER

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It is packaged in 10g units in robust single-use laminated foil pouches.

INTENDED USE

OREAS 147 is intended for the following uses:

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

STABILITY AND STORAGE INSTRUCTIONS

OREAS 147 has been prepared from spodumene $LiAl(Si_2O_5)$-rich pegmatite ore with minor additions of Sn oxide ore and Nb concentrate. It contains very little reactive sulphide and in its unopened state and under normal conditions of storage it has a shelf life beyond ten years. Its stability will be monitored at regular intervals and purchasers notified if any changes are observed.

INSTRUCTIONS FOR CORRECT USE

The certified values determined by 4-acid digestion and peroxide fusion ICP refer to the concentration levels in the packaged state. There is no need for drying prior to weighing and analysis.

In contrast the certified values determined by borate fusion XRF and for LOI at 1000° C 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.

HANDLING INSTRUCTIONS

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

TRACEABILITY

The analytical samples were selected in a manner to represent the entire batch of prepared CRM. This 'representivity' was maintained in each submitted laboratory sample batch and ensures the user that the data is traceable from sample selection through to the analytical results that underlie the consensus values. Each analytical data set has been validated by its assayer through the inclusion of internal reference materials and QC checks during analysis.

The laboratories were chosen on the basis of their competence (from past performance in inter-laboratory programs) for a particular analytical method, analyte or analyte suite, and sample matrix. Most of these laboratories have and maintain ISO 17025 accreditation. The certified values presented in this report are calculated from the means of accepted data following robust statistical treatment as detailed in this report.

LEGAL NOTICE

DOCUMENT HISTORY

Revision No.	Date	Changes applied
2	25th July, 2022	Added Table 3 'XRDSQ mineralogical data'.
1	26th Feb, 2019	Updated reference to new format 'DataPack' file.
0	17th Aug, 2017	First publication.

QMS ACCREDITED

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

CERTIFYING OFFICER

25th July, 2022

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

REFERENCES

ISO Guide 30 (1992), Terms and definitions used in connection with reference materials.

ISO Guide 31 (2000), Reference materials – Contents of certificates and labels.

ISO Guide 3207 (1975), Statistical interpretation of data - Determination of a statistical tolerance interval.

ISO Guide 35 (2006), Certification of reference materials - General and statistical principals.