

**CERTIFICATE OF ANALYSIS FOR**

**URANIUM ORE REFERENCE MATERIAL**

**OREAS 124**

**Table 1. Fusion XRF - Certified Values, SDs, 95% Confidence and Tolerance Limits for OREAS 124**

Constituent	Certified Value	1SD	95% Confidence Limits		95% Tolerance Limits	
			Low	High	Low	High
<b>Fusion XRF</b>						
Aluminium Oxide, Al <sub>2</sub> O <sub>3</sub> (wt.%)	8.99	0.143	8.88	9.10	8.91	9.06
Barium Oxide, BaO (ppm)	1131	34.2	1115	1148	1124	1139
Calcium Oxide, CaO (wt.%)	0.123	0.008	0.119	0.126	0.122	0.123
Magnesium Oxide, MgO (wt.%)	0.382	0.021	0.364	0.400	0.368	0.397
Manganese Oxide, MnO (wt.%)	0.090	0.002	0.090	0.091	0.090	0.091
Phosphorus Oxide, P <sub>2</sub> O <sub>5</sub> (wt.%)	0.075	0.005	0.072	0.079	0.074	0.076
Potassium Oxide, K <sub>2</sub> O (wt.%)	3.23	0.049	3.20	3.27	3.21	3.26
Silicon Dioxide, SiO <sub>2</sub> (wt.%)	81.5	0.68	81.0	82.0	81.1	81.9
Titanium Oxide, TiO <sub>2</sub> (wt.%)	0.441	0.010	0.435	0.447	0.427	0.454
Uranium, U (ppm)	1845	40.0	1814	1877	1832	1858

Note: intervals may appear asymmetric due to rounding.

**Table 2. Fusion ICP - Certified Values, SDs, 95% Confidence and Tolerance Limits for OREAS 124**

Constituent	Certified Value	1SD	95% Confidence Limits		95% Tolerance Limits	
			Low	High	Low	High
<b>Fusion ICP-OES/MS</b>						
Aluminium, Al (wt.%)	4.62	0.120	4.53	4.72	4.54	4.71
Barium, Ba (ppm)	1017	33.5	987	1047	986	1047
Beryllium, Be (ppm)	1.83	0.33	1.62	2.04	0.00	0.00
Calcium, Ca (wt.%)	0.088	0.009	0.079	0.097	IND	IND
Cerium, Ce (ppm)	47.6	2.87	45.5	49.8	46.1	49.2
Chromium, Cr (ppm)	51	10	43	60	47	55
Dysprosium, Dy (ppm)	2.82	0.170	2.72	2.93	2.61	3.04
Erbium, Er (ppm)	1.60	0.138	1.54	1.67	IND	IND
Europium, Eu (ppm)	1.15	0.098	1.07	1.22	1.10	1.19
Gadolinium, Gd (ppm)	3.47	0.346	3.16	3.78	3.22	3.71
Gallium, Ga (ppm)	10.5	0.53	10.2	10.9	IND	IND
Hafnium, Hf (ppm)	6.22	0.414	5.88	6.56	5.70	6.74
Holmium, Ho (ppm)	0.58	0.033	0.56	0.59	IND	IND
Iron, Fe (wt.%)	1.56	0.045	1.53	1.59	1.53	1.59
Lanthanum, La (ppm)	21.6	1.30	20.6	22.6	20.6	22.5
Lutetium, Lu (ppm)	0.26	0.04	0.22	0.29	0.23	0.29
Magnesium, Mg (wt.%)	0.224	0.006	0.220	0.228	0.216	0.233
Manganese, Mn (wt.%)	0.070	0.001	0.070	0.070	IND	IND
Neodymium, Nd (ppm)	20.8	1.44	19.5	22.0	19.7	21.9
Phosphorus, P (wt.%)	0.033	0.003	0.032	0.034	IND	IND
Potassium, K (wt.%)	2.62	0.058	2.59	2.66	2.54	2.70
Praseodymium, Pr (ppm)	5.39	0.366	5.06	5.73	5.19	5.59
Rubidium, Rb (ppm)	86	3.6	83	89	83	89
Samarium, Sm (ppm)	4.21	0.221	4.08	4.33	3.99	4.43
Silicon, Si (wt.%)	38.16	0.906	37.45	38.87	37.90	38.43
Terbium, Tb (ppm)	0.48	0.044	0.47	0.49	0.46	0.51
Thorium, Th (ppm)	5.74	0.290	5.63	5.86	5.27	6.22
Thulium, Tm (ppm)	0.22	0.021	0.20	0.24	IND	IND
Titanium, Ti (wt.%)	0.254	0.013	0.245	0.264	0.247	0.262
Uranium, U (ppm)	1794	73.9	1738	1850	1754	1834
Vanadium, V (ppm)	23.3	4.6	18.3	28.2	20.6	25.9
Ytterbium, Yb (ppm)	1.63	0.151	1.53	1.73	IND	IND
Yttrium, Y (ppm)	14.2	0.61	13.8	14.5	13.4	15.0
Zirconium, Zr (ppm)	260	21.0	244	275	242	278

Note: intervals may appear asymmetric due to rounding.

**Table 3. 4-Acid ICP - Certified Values, SDs, 95% Confidence and Tolerance Limits for OREAS 124**

Constituent	Certified Value	1SD	95% Confidence Limits		95% Tolerance Limits	
			Low	High	Low	High
<b>Four Acid Digestion ICP-OES/MS</b>						
Aluminium, Al (wt.%)	4.61	0.098	4.57	4.66	4.50	4.72
Antimony, Sb (ppm)	0.083	0.013	0.080	0.087	0.000	0.000
Barium, Ba (ppm)	1046	49.3	1020	1071	1015	1077
Beryllium, Be (ppm)	1.94	0.156	1.86	2.03	1.86	2.03
Calcium, Ca (wt.%)	0.089	0.006	0.085	0.092	0.085	0.092
Cerium, Ce (ppm)	48.9	2.62	47.4	50.4	47.4	50.4
Cesium, Cs (ppm)	0.78	0.059	0.75	0.81	0.73	0.83
Chromium, Cr (ppm)	37.5	6.8	33.5	41.6	35.2	39.8
Cobalt, Co (ppm)	4.26	0.45	4.00	4.51	4.05	4.46
Dysprosium, Dy (ppm)	2.71	0.080	2.63	2.79	2.48	2.94
Europium, Eu (ppm)	1.23	0.14	1.05	1.42	1.11	1.35
Gallium, Ga (ppm)	11.2	0.74	10.7	11.6	10.7	11.6
Hafnium, Hf (ppm)	1.56	0.17	1.46	1.66	IND	IND
Indium, In (ppm)	0.014	0.002	0.012	0.016	0.000	0.000
Iron, Fe (wt.%)	1.57	0.055	1.54	1.60	1.51	1.62
Lanthanum, La (ppm)	21.4	1.23	20.8	22.1	20.5	22.3
Lead, Pb (ppm)	20.2	1.47	19.5	20.9	19.2	21.2
Lithium, Li (ppm)	4.61	0.410	4.41	4.80	4.27	4.94
Magnesium, Mg (wt.%)	0.221	0.014	0.212	0.229	0.213	0.228
Manganese, Mn (wt.%)	0.069	0.002	0.067	0.070	0.067	0.071
Molybdenum, Mo (ppm)	7.36	0.296	7.21	7.51	7.09	7.62
Nickel, Ni (ppm)	9.31	0.754	8.94	9.67	8.46	10.15
Niobium, Nb (ppm)	7.84	0.509	7.55	8.13	7.56	8.12
Phosphorus, P (wt.%)	0.032	0.004	0.030	0.034	0.031	0.034
Potassium, K (wt.%)	2.56	0.116	2.49	2.63	2.48	2.63
Rubidium, Rb (ppm)	85	7.3	81	89	82	88
Scandium, Sc (ppm)	3.01	0.089	2.97	3.06	2.87	3.16
Sodium, Na (wt.%)	0.232	0.022	0.219	0.245	0.226	0.239
Strontium, Sr (ppm)	188	9.9	183	194	182	194
Tantalum, Ta (ppm)	0.56	0.06	0.53	0.59	0.51	0.61
Terbium, Tb (ppm)	0.50	0.06	0.45	0.55	0.46	0.54
Thallium, Tl (ppm)	0.41	0.029	0.40	0.43	0.40	0.43
Thorium, Th (ppm)	5.79	0.568	5.48	6.10	5.52	6.06
Tin, Sn (ppm)	0.71	0.041	0.69	0.73	IND	IND
Titanium, Ti (wt.%)	0.252	0.015	0.244	0.260	0.241	0.263
Tungsten, W (ppm)	0.71	0.067	0.67	0.75	IND	IND
Uranium, U (ppm)	1779	89.7	1733	1826	1742	1817
Vanadium, V (ppm)	23.0	1.82	22.1	24.0	22.1	23.9
Yttrium, Y (ppm)	12.1	0.68	11.7	12.5	11.7	12.5
Zinc, Zn (ppm)	14.3	1.9	13.2	15.4	13.3	15.4
Zirconium, Zr (ppm)	49.8	4.79	47.1	52.4	45.3	54.2

Note: intervals may appear asymmetric due to rounding.

**Table 4. IR Furnace - Certified Values, SDs, 95% Confidence and Tolerance Limits for OREAS 124**

Constituent	Certified Value	1SD	95% Confidence Limits		95% Tolerance Limits	
			Low	High	Low	High
<b>IR Combustion Furnace</b>						
Carbon, C (wt.%)	0.061	0.009	0.056	0.065	IND	IND

Note: intervals may appear asymmetric due to rounding.

**Table 5. Thermograv - Certified Values, SDs, 95% Confidence and Tolerance Limits for OREAS 124**

Constituent	Certified Value	1SD	95% Confidence Limits		95% Tolerance Limits	
			Low	High	Low	High
<b>Thermogravimetry</b>						
Loss On Ignition, LOI (wt.%)	2.29	0.34	2.07	2.50	2.18	2.39

Note: intervals may appear asymmetric due to rounding.

**Table 6. Indicative Values for OREAS 124**

Constituent	Unit	Value	Constituent	Unit	Value	Constituent	Unit	Value
<b>Fusion XRF</b>								
Fe <sub>2</sub> O <sub>3</sub>	wt.%	2.25	Rb	ppm	97	Zr	ppm	209
Na <sub>2</sub> O	wt.%	0.326	S	wt.%	< 0.01			
<b>Fusion ICP-OES/MS</b>								
B	ppm	< 20	Na	wt.%	0.235	Sc	ppm	3.04
Co	ppm	4.17	Nb	ppm	8.34	Sn	ppm	< 1
Cs	ppm	0.76	Ni	ppm	12.3	Sr	ppm	188
In	ppm	< 0.2	Pb	ppm	21.2	Ta	ppm	0.53
Li	ppm	4.08	Re	ppm	< 0.1	Tl	ppm	0.43
Mo	ppm	7.32	S	wt.%	< 0.01	W	ppm	< 1
<b>Four Acid Digestion ICP-OES/MS</b>								
Ag	ppm	0.043	Ge	ppm	0.26	S	wt.%	< 0.01
As	ppm	3.34	Hg	ppm	0.077	Se	ppm	0.89
Au	ppm	0.002	Ho	ppm	0.47	Sm	ppm	4.29
Bi	ppm	0.037	Lu	ppm	0.21	Te	ppm	< 0.05
Cd	ppm	< 0.02	Nd	ppm	22.3	Tm	ppm	0.20
Cu	ppm	3.89	Pr	ppm	5.68	Yb	ppm	1.36
Er	ppm	1.43	Re	ppm	0.002			
Gd	ppm	3.66	Ru	ppm	< 0.1			
<b>IR Combustion Furnace</b>								
S	wt.%	0.007						
<b>Pressed Powder Pellet XRF</b>								
U	ppm	2041						
<b>Thermogravimetry</b>								
H <sub>2</sub> O-	wt.%	1.55						

## 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

Reference material OREAS 124 is one of a suite of five uranium CRMs prepared from material sourced from trenching at Mantra Resources Nyota Prospect, Tanzania. The Nyota Prospect is a Karoo sandstone-hosted tabular deposit. Mineralisation is secondary and typically concentrated within medium to very coarse grained sandstone units interbedded with greywackes, siltstones or mudstones. The distribution of mineralisation is controlled by primary sedimentary features, consistent with fluid migrating along permeable coarse grained units, along bedding planes, up cross bedding and with preferential deposition occurring around ferruginous concretions and claystone clasts. Supergene enrichment is interpreted to have contributed to the high grade nature of the secondary mineralisation observed in the trenches.

## COMMINUTION AND HOMOGENISATION PROCEDURES

The material constituting OREAS 124 was prepared in the following manner:

- drying to constant mass at 105°C;
- crushing;
- milling to 100% minus 30 microns;
- homogenisation;
- packaging into 10g units in laminated foil pouches.

## ANALYTICAL PROGRAM

Seventeen commercial analytical laboratories participated in the program to characterise the elements reported in Tables 1 to 6. The following methods were employed:

- Lithium borate fusion with X-ray fluorescence (9 laboratories)
- Sodium peroxide fusion or lithium borate fusion with ICP-OES and ICP-MS (10 laboratories)
- Four acid digestion with ICP-OES and ICP-MS (16 laboratories)
- Thermogravimetry for Loss On Ignition (12 laboratories)
- Infra-red combustion furnace for carbon and sulphur (11 laboratories)
- Pressed powder pellet XRF for U (2 laboratories)

For the round robin program ten 450g test units were taken at predetermined intervals during the bagging stage, immediately following final blending, and are considered representative of the entire batch. The six samples received by each laboratory were obtained by taking two 25g scoop splits from each of three separate 450g test units. This format enabled nested ANOVA treatment of the results to evaluate homogeneity.

Tabulated results, together with uncorrected means, medians, standard deviations, relative standard deviations and percent deviation of lab means from the corrected mean of means (PDM<sup>3</sup>) are available upon request for this CRM (**OREAS 124 Datapack.xlsx**).

## STATISTICAL ANALYSIS

**Certified Values, Standard Deviations, Confidence and Tolerance Limits** have been determined for each analytical method following removal of individual and laboratory outliers (see Tables 1-5). Certified Values are the mean of means after outlier filtering. The 95% Confidence Limit is a measure of the reliability of the certified value, i.e. the narrower the Confidence Interval the greater the certainty in the Certified Value. It should not be used as a control limit for laboratory performance.

Indicative values (Table 6) are provided where i) the number of laboratories reporting a particular analyte is insufficient (< 5) to support certification; ii) interlaboratory consensus is poor; or iii) a significant proportion of results are outlying or reported as less than detection limits.

**Standard Deviation** values (1SDs) are reported in Tables 1-5 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. 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.

As a guide two or more analytical results lying outside the 2SD window may be regarded as warning or rejection, and rejection for single results lying outside the 3SD window in QC monitoring, although their precise application should be at the discretion of the QC manager concerned.

**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 uranium by lithium borate fusion XRF, where 99% of the time ( $1-\alpha=0.99$ ) at least 95% of subsamples ( $p=0.95$ ) will have concentrations lying between 1832 and 1858 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).

The homogeneity of OREAS 124 has also been evaluated in an ANOVA study for all certified analytes. This study indicates no evidence that between-unit variance is greater than within-unit variance.

Based on the statistical analysis of the results of the interlaboratory certification program it can be concluded that OREAS 124 is fit-for-purpose as a certified reference material (see 'Intended Use' below).

## **PREPARER AND SUPPLIER OF THE REFERENCE MATERIAL**

Uranium ore reference material OREAS 124 has been prepared, certified and is supplied by:

ORE Research & Exploration Pty Ltd  
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It is available in unit sizes of 10g (single-use laminated foil pouches) and 1kg (plastic jars).

## **INTENDED USE**

OREAS 124 is intended for the following uses:

- for the monitoring of laboratory performance in the analysis of analytes reported in Tables 1-5 in geological samples
- for the verification of analytical methods for analytes reported in Tables 1-5
- for the calibration of instruments used in the determination of the concentration of analytes reported in Tables 1-5

## **STABILITY AND STORAGE INSTRUCTIONS**

OREAS 124 has been sourced from samples of secondary uranium mineralisation. 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 THE CORRECT USE OF THE REFERENCE MATERIAL**

The certified values for lithium borate fusion XRF and for LOI are on a dry basis whilst all other certified values are reported on an "as received" basis. A moisture content of ~1.6 wt.% has been determined for OREAS 124 in its packaged state.

## **HANDLING INSTRUCTIONS**

Being a fine radioactive powder, safety precautions should be observed when handling OREAS 124 to protect against inhalation and ingestion. Personal Protective Equipment is required for the respiratory system, eyes and skin.

## **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.

## **CERTIFYING OFFICER**

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## **PARTICIPATING LABORATORIES**

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ALS, Perth, WA, Australia  
ALS, Vancouver, BC, Canada  
BV Amdel, Adelaide, SA, Australia  
BV Ultra Trace, Perth, WA, Australia  
Intertek Genalysis, Perth, WA, Australia  
Intertek Testing Services, Beijing, China  
OMAC Laboratories, Loughrea, County Galway, Ireland  
SGS Mineral Services, Lakefield, Ontario, Canada  
SGS Mineral Services, Perth, WA, Australia  
SGS Mineral Services, Toronto, Ontario, Canada  
Shiva Analyticals, Bangalore North, Karnataka, India  
Zarazma Mineral Studies, Tehran, Iran

## **REFERENCES**

ISO Guide 35 (2006), Certification of reference materials - General and statistical principals.  
ISO Guide 3207 (1975), Statistical interpretation of data - Determination of a statistical tolerance interval.