ORE RESEARCH & EXPLORATION

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CERTIFICATE OF ANALYSIS FOR

URANIUM ORE REFERENCE MATERIAL

OREAS 122

Table 1. Fusion XRF - Certified Values, SDs, 95% Confidence and Tolerance Limits for OREAS 122

Constituent	Certified Value	1SD	95% Confidence Limits		95% Tolerance Limits	
			Low	High	Low	High
Fusion XRF						
Aluminium Oxide, Al2O3 (wt.%)	9.11	0.129	9.01	9.21	9.04	9.17
Barium Oxide, BaO (ppm)	1114	33.9	1090	1139	1084	1144
Calcium Oxide, CaO (wt.%)	0.130	0.008	0.124	0.135	0.130	0.130
Iron tri-Oxide, Fe2O3 (wt.%)	2.34	0.026	2.33	2.36	2.31	2.38
Magnesium Oxide, MgO (wt.%)	0.437	0.029	0.414	0.459	0.429	0.444
Manganese Oxide, MnO (wt.%)	0.103	0.002	0.102	0.104	0.102	0.103
Phosphorus Oxide, P2O5 (wt.%)	0.043	0.003	0.041	0.045	0.042	0.044
Potassium Oxide, K2O (wt.%)	3.29	0.040	3.26	3.32	3.26	3.32
Silicon Dioxide, SiO2 (wt.%)	81.7	0.45	81.4	82.0	81.4	82.0
Titanium Oxide, TiO2 (wt.%)	0.431	0.012	0.423	0.440	0.416	0.447
Uranium, U (ppm)	423	13.0	413	433	419	427

Note: intervals may appear asymmetric due to rounding.

Table 2. Fusion ICP - Certified Values, SDs, 95% Confidence and Tolerance Limits for OREAS 122

Constituent	Certified Value	1SD	95% Confidence Limits		95% Tolerance Limits	
			Low	High	Low	High
Fusion ICP-OES/MS						
Aluminium, Al (wt.%)	4.69	0.121	4.59	4.79	4.60	4.78
Barium, Ba (ppm)	974	35.2	936	1012	959	989
Calcium, Ca (wt.%)	0.095	0.009	0.088	0.103	IND	IND
Cerium, Ce (ppm)	46.1	2.54	44.5	47.8	43.3	49.0
Dysprosium, Dy (ppm)	2.48	0.181	2.33	2.62	2.34	2.62
Erbium, Er (ppm)	1.39	0.110	1.30	1.48	IND	IND
Europium, Eu (ppm)	1.05	0.11	0.96	1.14	1.00	1.11
Gadolinium, Gd (ppm)	3.10	0.44	2.99	3.20	2.88	3.32
Gallium, Ga (ppm)	10.6	0.59	10.1	11.1	IND	IND
Hafnium, Hf (ppm)	5.94	0.588	5.42	6.45	5.36	6.51
Holmium, Ho (ppm)	0.50	0.014	0.49	0.51	IND	IND
Iron, Fe (wt.%)	1.63	0.031	1.60	1.65	1.59	1.66
Lanthanum, La (ppm)	20.9	1.56	19.8	22.0	19.7	22.1
Lutetium, Lu (ppm)	0.23	0.04	0.20	0.27	0.20	0.27
Magnesium, Mg (wt.%)	0.252	0.009	0.246	0.259	0.245	0.260
Manganese, Mn (wt.%)	0.077	0.003	0.075	0.079	IND	IND
Neodymium, Nd (ppm)	19.3	1.03	18.5	20.0	17.6	21.0
Potassium, K (wt.%)	2.71	0.096	2.65	2.78	2.64	2.79
Praseodymium, Pr (ppm)	5.06	0.332	4.78	5.34	4.83	5.29
Rubidium, Rb (ppm)	87	1.7	86	89	85	90
Samarium, Sm (ppm)	3.74	0.279	3.53	3.95	3.41	4.07
Silicon, Si (wt.%)	37.45	0.568	37.10	37.80	36.97	37.93
Strontium, Sr (ppm)	141	3.3	137	145	132	151
Terbium, Tb (ppm)	0.47	0.05	0.44	0.49	0.42	0.51
Thorium, Th (ppm)	5.56	0.554	5.23	5.89	4.97	6.15
Thulium, Tm (ppm)	0.20	0.010	0.19	0.21	IND	IND
Titanium, Ti (wt.%)	0.249	0.013	0.238	0.259	0.240	0.258
Uranium, U (ppm)	418	16.7	406	430	409	426
Vanadium, V (ppm)	23.9	1.82	21.6	26.2	21.6	26.2
Ytterbium, Yb (ppm)	1.41	0.112	1.34	1.49	IND	IND
Yttrium, Y (ppm)	12.8	0.75	12.3	13.3	11.9	13.6

Note: intervals may appear asymmetric due to rounding.

Table 3. 4-Acid ICP - Certified Values, SDs, 95% Confidence and Tolerance Limits for OREAS 122

Constituent	Certified Value	1SD	95% Confidence Limits		95% Tolerance Limits	
			Low	High	Low	High
Four Acid Digestion ICP-OES/MS						
Aluminium, Al (wt.%)	4.63	0.181	4.52	4.73	4.50	4.75
Barium, Ba (ppm)	1000	40.0	978	1022	981	1019
Beryllium, Be (ppm)	1.63	0.154	1.55	1.71	1.56	1.70
Calcium, Ca (wt.%)	0.092	0.006	0.089	0.096	0.088	0.097
Cerium, Ce (ppm)	45.3	1.95	44.4	46.2	43.4	47.2
Cesium, Cs (ppm)	0.75	0.048	0.72	0.78	0.72	0.78
Cobalt, Co (ppm)	4.36	0.45	4.11	4.61	4.20	4.53
Copper, Cu (ppm)	3.38	0.62	3.05	3.70	3.12	3.63
Dysprosium, Dy (ppm)	2.44	0.093	2.34	2.54	2.27	2.62
Europium, Eu (ppm)	1.13	0.14	0.95	1.31	IND	IND
Gallium, Ga (ppm)	10.8	1.1	10.2	11.4	10.5	11.1
Hafnium, Hf (ppm)	1.46	0.16	1.36	1.57	IND	IND
Indium, In (ppm)	0.014	0.002	0.012	0.016	0.000	0.000
Iron, Fe (wt.%)	1.61	0.052	1.58	1.65	1.58	1.65
Lanthanum, La (ppm)	20.4	0.96	20.0	20.8	19.4	21.4
Lead, Pb (ppm)	17.6	0.85	17.2	18.0	16.8	18.4
Lithium, Li (ppm)	4.79	0.61	4.50	5.09	4.51	5.08
Magnesium, Mg (wt.%)	0.247	0.017	0.237	0.258	0.240	0.254
Molybdenum, Mo (ppm)	7.45	0.307	7.31	7.60	7.24	7.67
Nickel, Ni (ppm)	9.57	0.853	9.23	9.90	8.62	10.52
Niobium, Nb (ppm)	7.76	0.310	7.58	7.93	7.50	8.02
Phosphorus, P (wt.%)	0.017	0.002	0.016	0.018	0.016	0.017
Potassium, K (wt.%)	2.60	0.120	2.52	2.67	2.53	2.67
Rubidium, Rb (ppm)	87	5.0	85	90	85	90
Scandium, Sc (ppm)	2.96	0.121	2.86	3.05	2.84	3.07
Sodium, Na (wt.%)	0.244	0.024	0.230	0.258	0.235	0.253
Strontium, Sr (ppm)	139	7.8	135	144	137	142
Tantalum, Ta (ppm)	0.53	0.033	0.52	0.55	0.49	0.58
Terbium, Tb (ppm)	0.42	0.08	0.37	0.48	IND	IND
Thallium, Tl (ppm)	0.41	0.016	0.40	0.42	0.39	0.43
Thorium, Th (ppm)	5.50	0.516	5.24	5.77	5.13	5.87
Tin, Sn (ppm)	0.68	0.048	0.66	0.70	IND	IND
Titanium, Ti (wt.%)	0.247	0.012	0.239	0.254	0.238	0.255
Uranium, U (ppm)	407	13.4	400	413	397	416
Vanadium, V (ppm)	22.2	1.60	21.4	23.0	21.4	23.0
Ytterbium, Yb (ppm)	1.19	0.053	1.16	1.21	IND	IND
Yttrium, Y (ppm)	10.5	0.59	10.2	10.8	10.1	10.9
Zinc, Zn (ppm)	13.5	2.0	12.5	14.6	12.7	14.3
Zirconium, Zr (ppm)	46.1	5.0	42.9	49.2	43.6	48.6

Note: intervals may appear asymmetric due to rounding.

Table 4. IR Furnace - Certified Values, SDs, 95% Confidence and Tolerance Limits for OREAS 122

Constituent	Certified Value	1SD	95% Confidence Limits		95% Tolerance Limits	
			Low	High	Low	High
IR Combustion Furnace						
Carbon, C (wt.%)	0.046	0.009	0.042	0.051	IND	IND

Note: intervals may appear asymmetric due to rounding.

Table 5. Thermograv - Certified Values, SDs, 95% Confidence and Tolerance Limits for OREAS 122

Constituent	Certified Value	1SD	95% Confidence Limits		95% Tolerance Limits	
			Low	High	Low	High
Thermogravimetry						
Loss On Ignition, LOI (wt.%)	2.18	0.23	2.03	2.32	2.10	2.25

Note: intervals may appear asymmetric due to rounding.

Table 6. Indicative Values for OREAS 122

Constituent	Unit	Value	Constituent	Unit	Value	Constituent	Unit	Value
Fusion XRF								
Co	ppm	< 100	Pb	ppm	< 10	S	wt.%	< 0.01
Na2O	wt.%	0.358	Rb	ppm	100	Zr	ppm	204
Fusion ICP-OES/MS								
B	ppm	26.7	Mo	ppm	6.98	S	wt.%	< 0.01
Be	ppm	1.28	Na	wt.%	0.246	Sc	ppm	2.97
Co	ppm	4.22	Nb	ppm	8.68	Sn	ppm	< 1
Cr	ppm	48.1	Ni	ppm	10.6	Ta	ppm	0.51
Cs	ppm	0.71	P	wt.%	0.018	Tl	ppm	0.45
In	ppm	< 0.2	Pb	ppm	19.4	W	ppm	< 1
Li	ppm	5.00	Re	ppm	< 0.1	Zr	ppm	254
Four Acid Digestion ICP-OES/MS								
Ag	ppm	0.046	Ge	ppm	0.21	Ru	ppm	< 0.1
As	ppm	4.70	Hg	ppm	0.020	S	wt.%	< 0.01
Au	ppm	0.003	Ho	ppm	0.44	Sb	ppm	0.073
Bi	ppm	0.026	Lu	ppm	0.17	Se	ppm	1.22
Cd	ppm	< 0.02	Mn	wt.%	0.078	Sm	ppm	3.86
Cr	ppm	35.9	Nd	ppm	19.9	Te	ppm	< 0.05
Er	ppm	1.23	Pr	ppm	5.21	Tm	ppm	0.17
Gd	ppm	3.21	Re	ppm	0.002	W	ppm	0.45
IR Combustion Furnace								
S	wt.%	0.011						
Pressed Powder Pellet XRF								
U	ppm	465						
Thermogravimetry								
H2O-	wt.%	1.67						

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 122 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 122 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^3) are available upon request for this CRM (**OREAS 122 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 ($\rho=0.95$) will have concentrations lying between 419 and 427 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 (IS0 Guide 35).
The homogeneity of OREAS 122 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 122 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 122 has been prepared, certified and is supplied by:

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It is available in unit sizes of 10g (single-use laminated foil pouches) and 1kg (plastic jars).

INTENDED USE

OREAS 122 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 122 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 ~1.7 wt.% has been determined for OREAS 122 in its packaged state.

HANDLING INSTRUCTIONS

Being a fine radioactive powder, safety precautions should be observed when handling OREAS 122 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

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

PARTICIPATING LABORATORIES

Acme Analytical Laboratories, Vancouver, BC, Canada
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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
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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.