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CERTIFICATE OF ANALYSIS FOR

COPPER ORE

CERTIFIED REFERENCE MATERIAL

OREAS 903

Table 1. 4-Acid ICP-OES/MS - Certified Values, SDs, 95% Confidence and Tolerance Limits for OREAS 903

Constituent	Certified Value	1SD	95% Confidence Limits		95% Tolerance Limits	
			Low	High	Low	High
Four Acid Digestion ICP-OES/MS						
Aluminium, Al (wt.%)	5.89	0.279	5.75	6.03	5.75	6.03
Antimony, Sb (ppm)	1.57	0.141	1.49	1.65	1.51	1.63
Arsenic, As (ppm)	49.7	3.77	48.0	51.3	47.2	52.1
Barium, Ba (ppm)	197	8.8	193	202	191	204
Beryllium, Be (ppm)	4.42	0.387	4.23	4.62	4.27	4.57
Bismuth, Bi (ppm)	8.9	0.48	8.7	9.2	8.7	9.2
Cadmium, Cd (ppm)	0.20	0.019	0.19	0.21	0.18	0.22
Calcium, Ca (wt.%)	0.625	0.029	0.613	0.637	0.605	0.646
Cerium, Ce (ppm)	82	5.6	79	86	79	85
Cesium, Cs (ppm)	3.57	0.121	3.50	3.63	3.46	3.68
Chromium, Cr (ppm)	73	4.6	70	75	70	76
Cobalt, Co (ppm)	131	8.4	127	135	127	135
Copper, Cu (wt.%)	0.652	0.020	0.642	0.661	0.639	0.665
Gallium, Ga (ppm)	15.0	1.7	14.4	15.6	14.5	15.5
Hafnium, Hf (ppm)	4.56	0.350	4.35	4.77	4.44	4.68
Indium, In (ppm)	0.16	0.02	0.15	0.17	0.15	0.17
Iron, Fe (wt.%)	4.16	0.179	4.07	4.25	4.06	4.26
Lanthanum, La (ppm)	40	4.0	38	42	39	41
Lead, Pb (ppm)	11.3	1.7	10.4	12.1	10.8	11.8
Lithium, Li (ppm)	18.3	0.72	18.0	18.7	17.7	19.0
Lutetium, Lu (ppm)	0.36	0.04	0.34	0.39	0.34	0.39
Magnesium, Mg (wt.%)	0.714	0.051	0.687	0.741	0.695	0.733
Manganese, Mn (wt.%)	0.069	0.003	0.067	0.071	0.067	0.071
Molybdenum, Mo (ppm)	4.32	0.335	4.17	4.47	4.08	4.56
Nickel, Ni (ppm)	54	4.7	52	56	52	56
Phosphorus, P (wt.%)	0.107	0.009	0.102	0.112	0.104	0.110
Potassium, K (wt.%)	3.31	0.207	3.19	3.42	3.20	3.41
Rubidium, Rb (ppm)	137	19	126	148	131	142
Scandium, Sc (ppm)	10.2	0.50	10.0	10.5	9.9	10.6
Selenium, Se (ppm)	6.06	0.85	5.59	6.54	IND	IND
Silver, Ag (ppm)	0.432	0.051	0.406	0.458	0.409	0.455
Sodium, Na (wt.%)	0.030	0.001	0.029	0.031	0.029	0.031
Strontium, Sr (ppm)	77	3.7	75	79	75	79
Sulphur, S (wt.%)	0.500	0.036	0.481	0.518	0.483	0.516
Tantalum, Ta (ppm)	0.54	0.08	0.48	0.59	0.48	0.59
Terbium, Tb (ppm)	0.83	0.09	0.76	0.91	0.79	0.88
Thallium, Tl (ppm)	0.62	0.041	0.60	0.64	0.60	0.65
Thorium, Th (ppm)	13.6	0.71	13.2	14.1	13.2	14.1
Tin, Sn (ppm)	2.63	0.261	2.50	2.76	2.49	2.77
Titanium, Ti (wt.%)	0.192	0.037	0.171	0.214	0.181	0.204
Uranium, U (ppm)	7.58	0.584	7.26	7.90	7.32	7.84
Vanadium, V (ppm)	74	2.3	73	75	72	76
Ytterbium, Yb (ppm)	2.36	0.163	2.23	2.50	2.22	2.50
Yttrium, Y (ppm)	22.5	2.3	21.2	23.7	21.8	23.2
Zinc, Zn (ppm)	24.3	2.24	23.1	25.4	22.6	26.0
Zirconium, Zr (ppm)	152	10.7	146	158	147	157

Note: intervals may appear asymmetric due to rounding.

Table 2. Aqua Regia ICP-OES/MS - Certified Values, SDs, 95% Confidence and Tolerance Limits for OREAS 903

Constituent	Certified Value	1SD	95% Confidence Limits		95% Tolerance Limits	
			Low	High	Low	High
Aqua Regia Digestion ICP-OES/MS						
Aluminium, Al (wt.%)	0.538	0.036	0.516	0.559	0.513	0.562
Antimony, Sb (ppm)	0.96	0.11	0.89	1.02	0.92	1.00
Arsenic, As (ppm)	47.5	2.12	46.6	48.4	46.2	48.8
Barium, Ba (ppm)	63	4.3	60	65	60	66
Beryllium, Be (ppm)	2.69	0.268	2.54	2.85	2.62	2.77
Bismuth, Bi (ppm)	8.8	0.77	8.4	9.2	8.5	9.0
Cadmium, Cd (ppm)	0.208	0.0120	0.202	0.214	0.195	0.221
Calcium, Ca (wt.%)	0.633	0.030	0.618	0.649	0.618	0.649
Cerium, Ce (ppm)	46.2	2.56	44.5	48.0	44.3	48.2
Cesium, Cs (ppm)	0.28	0.04	0.25	0.31	0.27	0.30
Chromium, Cr (ppm)	26.1	1.81	25.2	27.1	24.6	27.7
Cobalt, Co (ppm)	131	7.5	127	134	128	134
Copper, Cu (wt.%)	0.671	0.020	0.663	0.679	0.659	0.682
Gallium, Ga (ppm)	1.58	0.22	1.42	1.73	1.49	1.66
Germanium, Ge (ppm)	0.098	0.015	0.087	0.109	IND	IND
Hafnium, Hf (ppm)	0.61	0.052	0.57	0.65	0.58	0.64
Gold, Au (ppb)	<5	IND	IND	IND	IND	IND
Indium, In (ppm)	0.112	0.0105	0.106	0.119	0.107	0.118
Iron, Fe (wt.%)	3.94	0.266	3.80	4.08	3.85	4.03
Lanthanum, La (ppm)	22.8	3.8	20.7	24.9	22.0	23.6
Lead, Pb (ppm)	8.95	0.91	8.49	9.41	8.68	9.22
Lutetium, Lu (ppm)	0.099	0.010	0.089	0.109	IND	IND
Magnesium, Mg (wt.%)	0.234	0.030	0.217	0.251	0.224	0.244
Manganese, Mn (wt.%)	0.071	0.004	0.069	0.073	0.069	0.073
Molybdenum, Mo (ppm)	4.26	0.47	4.01	4.50	4.10	4.41
Nickel, Ni (ppm)	48.7	3.06	47.1	50.3	47.3	50.1
Phosphorus, P (wt.%)	0.103	0.005	0.100	0.105	0.100	0.106
Potassium, K (wt.%)	0.331	0.029	0.314	0.348	0.314	0.348
Rubidium, Rb (ppm)	12.6	1.13	11.9	13.3	11.8	13.4
Scandium, Sc (ppm)	3.15	0.211	3.03	3.27	3.03	3.27
Selenium, Se (ppm)	5.34	0.57	5.04	5.64	5.07	5.62
Silver, Ag (ppm)	0.349	0.038	0.331	0.366	0.332	0.365
Strontium, Sr (ppm)	17.7	1.36	16.9	18.4	17.0	18.4
Sulphur, S (wt.%)	0.501	0.036	0.481	0.521	0.485	0.516
Tellurium, Te (ppm)	0.034	0.006	0.031	0.037	IND	IND
Terbium, Tb (ppm)	0.47	0.05	0.42	0.52	0.46	0.48
Thallium, Tl (ppm)	0.14	0.02	0.13	0.15	IND	IND
Thorium, Th (ppm)	6.36	0.563	6.03	6.68	6.19	6.52
Titanium, Ti (wt.%)	0.008	0.001	0.007	0.009	0.008	0.009
Tungsten, W (ppm)	0.53	0.08	0.48	0.58	0.47	0.59
Uranium, U (ppm)	3.24	0.293	3.06	3.41	3.15	3.33
Vanadium, V (ppm)	13.3	0.72	12.9	13.7	IND	IND
Ytterbium, Yb (ppm)	0.69	0.07	0.62	0.76	IND	IND
Yttrium, Y (ppm)	9.23	0.654	8.83	9.62	8.96	9.50
Zinc, Zn (ppm)	21.3	1.46	20.6	22.1	20.2	22.5
Zirconium, Zr (ppm)	18.2	1.73	16.9	19.4	17.5	18.8

Note: intervals may appear asymmetric due to rounding.

Table 3. Copper Soluble - Certified Values, SDs, 95% Confidence and Tolerance Limits for OREAS 903

Constituent	Certified Value	1SD	95% Confidence Limits		95% Tolerance Limits	
			Low	High	Low	High
Acid Leach 5% H₂SO₄						
Copper Soluble, Cu-Sol (wt.%)	0.434	0.030	0.417	0.451	0.426	0.442

Note: intervals may appear asymmetric due to rounding.

Table 4. Indicative Values for OREAS 903

Constituent	Unit	Value	Constituent	Unit	Value	Constituent	Unit	Value
Four Acid Digestion ICP-OES/MS								
Dy	ppm	4.4	Ho	ppm	0.8	Sm	ppm	6.9
Er	ppm	2.5	Nb	ppm	6.5	Te	ppm	0.04
Eu	ppm	1.3	Nd	ppm	32	Tm	ppm	0.4
Gd	ppm	5.8	Pr	ppm	8.8	W	ppm	1.9
Ge	ppm	0.2	Re	ppb	< 2			
Aqua Regia Digestion ICP-OES/MS								
B	ppm	12	Ho	ppm	0.4	Re	ppb	< 1
Dy	ppm	1.9	Li	ppm	2.0	Sm	ppm	4.4
Er	ppm	0.8	Na	wt.%	0.01	Sn	ppm	0.4
Eu	ppm	0.8	Nb	ppm	0.1	Ta	ppm	< 0.01
Gd	ppm	3.6	Nd	ppm	20	Tm	ppm	0.10
Hg	ppm	0.06	Pr	ppm	4.9			
Fire Assay								
Au	ppb	50						

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

OREAS 903 is a medium grade transitional-oxide copper ore certified reference material. It is one of a suite of four transitional to oxide copper CRMs prepared from samples sourced from CST's Lady Annie Mine, located 120 kms northwest of Mount Isa, Queensland, Australia. Mineralisation at Lady Annie is hosted in dolomitic, carbonaceous and argillaceous sandstones and siltstones. The oxide deposits consist primarily of near surface malachite mineralisation with minor cuprite, chrysocolla and chalcocite extending from surface to a depth of 60 to 100 m. The oxide copper deposit is underlain by deeper transition and sulphide mineralisation. The primary copper sulphide mineralisation at depth is dominated by chalcocite and chalcopyrite and appears to be structurally controlled, being commonly associated with fault-related silicification.

COMMINATION AND HOMOGENISATION PROCEDURES

The material constituting OREAS 903 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 and into 1kg units in plastic jars.

ANALYTICAL PROGRAM

Nineteen commercial analytical laboratories participated in the program to characterise the elements reported in Tables 1 to 4. The following methods were employed:

- Four acid digestion with ICP-OES and ICP-MS finish (18 laboratories)
- Aqua regia digestion with ICP-OES and ICP-MS finish (19 laboratories)
- 5% H₂SO₄ acid leach with AAS or ICP-OES finish (14 laboratories)

For the round robin program twenty 1kg test units were taken at predetermined intervals during the bagging stage after final blending and are considered representative of the entire batch. The six samples received by each laboratory were obtained by taking two 110g scoop splits from each of three separate 1kg test units. This format enabled nested ANOVA treatment of the results to evaluate homogeneity.

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 (PDM³) are presented in the detailed certification data for this CRM (**Datapack for OREAS 903.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 1-3). 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 4) 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 1-3 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 copper by 4-acid digestion, where 99% of the time ($1-\alpha=0.99$) at least 95% of subsamples ($p=0.95$) will have concentrations lying between 0.639 and 0.665 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).

The homogeneity of OREAS 903 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 903 is fit-for-purpose as a certified reference material (see 'Intended Use' below).

PARTICIPATING LABORATORIES

Acme Analytical Laboratories, Vancouver, BC, Canada
Activation Laboratories, Ancaster, Ontario, Canada
Activation Laboratories, Thunder Bay, Ontario, Canada
ALS, Brisbane, QLD, Australia
ALS, Callao, Lima, Peru
ALS, Johannesburg, Gauteng, South Africa
ALS, La Serena, Coquimbo, Chile
ALS, Perth, WA, Australia
ALS, Vancouver, BC, Canada
BV Amdel, Adelaide, SA, Australia
BV Ultra Trace, Perth, WA, Australia
Intertek Genalysis, Perth, WA, Australia
McPhar Geoservices (Phil) Inc., Manila, Philippines
SGS Mineral Services, Lakefield, Ontario, Canada

SGS Mineral Services, Perth, WA, Australia
SGS Mineral Services, Toronto, Ontario, Canada
SGS Mineral Services, Townsville, QLD, Australia
SGS Mineral Services, Vancouver, BC, Canada
Zarazma Mineral Studies, Tehran, Iran

PREPARER AND SUPPLIER OF THE REFERENCE MATERIAL

Medium grade transitional-oxide copper ore reference material OREAS 903 has been prepared, certified and is supplied by:

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OREAS 903 has been packaged in single-use laminated foil pouches in 10g units. 1kg units in plastic jars are also available upon request.

INTENDED USE

OREAS 903 is intended for the following uses:

- for the monitoring of laboratory performance in the analysis of analytes reported in Tables 1-3 in geological samples
- for the verification of analytical methods for analytes reported in Tables 1-3
- for the calibration of instruments used in the determination of the concentration of analytes reported in Tables 1-3

STABILITY AND STORAGE INSTRUCTIONS

OREAS 903 has been sourced from medium grade transitional-oxide copper ore. 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 refer to the concentration level of analytes in their packaged state. The CRM should therefore not be dried prior to weighing and analysis.

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.

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

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.