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QOTHO CERTIFIED REFERENCE MATERIAL (QCRM)

QCRM-5-148

COPPER ORE

CERTIFICATE OF ANALYSIS

CERTIFIED VALUES			
ANALYTES	**UNITS**	**CONCENTRATIONS**	**EXPANDED UNCERTAINTY**
Co	%	0.008	±0.003
Cu	%	0.91	±0.04
Mn	%	0.097	±0.007
Zn	%	0.004	±0.001
ASSIGNED VALUES (FOR INFORMATION ONLY)			
ANALYTES	**UNITS**	**CONCENTRATIONS**	**EXPANDED UNCERTAINTY**
Al	%	0.18	±0.03
Ca	%	24.9	±1.7
Cu (Soluble)	%	0.18	±0.02
Fe	%	14.2	±1.0
Mg	%	4.12	±0.18
Ni	%	0.012	±0.002
S	%	0.79	±0.13

1. **Use:**
QCRM-5-148 is a certified reference material which is suitable for use as random control samples in routine analytical laboratory quality control, when inserted within a batch of samples and measured in parallel to the unknown. The QCRM can also be used as a control sample in the analysis of samples of a similar type, verification of analytical methods for Copper Ore and as a calibration standard for the calibration of equipment used for analysing similar materials.

2. **Origin of Material:**
The material was supplied by Palabora Mining Company Ltd. It is a copper mine that also operates a smelter and refinery complex based in the town of Phalaborwa, in South Africa's Limpopo Province.

3. **Mineral and Chemical Composition:**
The ore traces its origin from a unique geological formation known as the Palabora Igneous Complex. The geology of the ore includes carbonitites and a host of other minerals such as phosphates, vermiculite, phlogopite, magnetite, nickel, gold, silver, platinum and palladium.

4. **Date of Initial Issue:**
20 March 2024.

5. **Packaging & Handling instructions:**
The material was packaged as 100g unit sizes, placed in geo-envelopes, within a vacuum sealed aluminium foil bag. Open the seal of the foil with care and shake or otherwise agitate prior to use. Normal safety precautions for handling fine particulate matter are recommended, such as the use of safety glasses, breathing protection, gloves, and a laboratory coat. Once opened, material must be stored in a cool, dry environment. Results on page 1 is presented on dry basis. Analysis should therefore be done on dry basis, after drying to constant mass, at 105 degrees Celsius.

6. **Method of Preparation:**
The material was sieved through a 75-micron screen and the oversize was re-milled to ensure 100% passing through the screen. It was then blended, systematically divided, and packaged into 100-gram zip-lock bags. Randomly selected samples, from the bags, were tested in-house via XRF, to confirm homogeneity. Once confirmed and certification completed, the items were placed in geo-envelopes and vacuum sealed in aluminium foil bags.

7. **Methods of Analysis used:**
   - Multi-acid digestion with AAS or ICP-OES finish
   - Sodium peroxide fusion with ICP-OES finish
   - Fused beads with XRF finish
   - Copper by multi-acid digestion and electro-gravimetric finish
   - Acid soluble copper by weak sulphuric acid leach and AAS finish
   - Cadmium by multi-acid UltraWAVE digestion and ICP-MS finish
   - Silver by fire assay and ICO-OES finish
   - Sulphur by thermal combustion analysis.

8. **Analysis required:**
An instruction letter was sent to all participants. The analysis required was noted in the instruction letter and reporting template, including but not limited to Ag, Al, As, Au, C, Ca, Cd, Co, Cu, Cu (Soluble), F, Fe, Mg, Mn, Ni, Pb, S, Si, U and Zn.

9. Participating Laboratories:

No	LABORATORY	COUNTRY
1.	Africa Laboratory Specialists	Namibia
2.	AHK Kitwe	Zambia
3.	ALS Geochemistry Kempton Park	South Africa
4.	ALS Kansanshi	Zambia
5.	Ero Brasil Caraiba	Brazil
6.	Intertek Tschudi	Namibia
7.	Kamoto Copper Company	Democratic Republic of Congo
8.	Metalkol	Democratic Republic of Congo
9.	Mintek	South Africa
10.	MSALabs Tanzania	Tanzania
11.	Mutanda Mining	Democratic Republic of Congo
12.	Palabora Mining Company	South Africa
13.	Rio Tinto International	United States of America
14.	SSM Kolwezi	Democratic Republic of Congo
15.	S.T.L DRC	Democratic Republic of Congo
16.	UIS Analytical Services	South Africa

10. Assay Data:

Data used for Assigning Values and Certification.

LABORATORY	Ag	Al	As	Au	C	Ca	Cd	Co	Cu	Cu (Soluble)	F	Fe	Mg	Mn	Ni	Pb	S	Si	U	Zn
UNIT	g/t	%	ppm	g/t	%	%	ppm	%	%	%	ppm	%	%	%	%	%	%	%	ppm	%
LAB001	4	0.16				21.512			0.912	0.165		13.363	4.306	0.102	0.017	0.026	0.929			0.004
LAB002		0.148						0.011				15.885			0.01	< 0.001				
LAB003									0.919											
LAB004									0.82											
LAB005						25.477		< 0.025	0.976	0.185		12.912	4.043				0.669			
LAB006						26.619		0.009		0.165		13.736	3.894	0.098	0.01					0.005
LAB007		0.178				24.805			0.892			14.826	4.509	0.094	0.024			0.538		
LAB008	1.545	0.174	< 26.0	0.1	8.665	28.34	< 17.0	0.007	0.949			15.905	4.143	0.098	0.011	0.005	0.825	0.349		0.004
LAB009			< 9.00						0.786			13.695			0.009	0.004				0.004
LAB010		0.146						0.006	0.88			13.049	3.846	0.086	0.012					0.004
LAB011		0.19				24.1	1.5	< 0.02				14.4	4.11	0.057	0.014	0.01	0.725		25	
LAB012									0.202											
LAB013									0.915											
LAB014									0.894											
LAB015	4.682	0.15	< 20.0		9.242		< 9.00	0.01	0.96	0.19		14.39	3.935	0.086	0.011	0.009	0.72	0.973		0.011
LAB016	< 1.40	0.164	15.186				8.75	0.008	0.965			15.05	3.958	0.098	0.012	0.006				0.008
LAB017		0.417				22.076			0.8			14.035	3.917				0.877	0.485		
LAB018									0.937											
LAB019	0.186								0.892							0.005				0.003
LAB020	3.288	0.271			8.776	25.66	0.19	0.007	0.911		2374.162	14.435	4.31	0.108	0.009	0.002	0.796	0.706	16.248	0.004
LAB021						25.05		0.007	0.934	0.184		12.1	4.23	0.098	0.012					0.004
LAB022		0.265				25.6			0.995			14.4	4.375	0.097			0.785	0.675		
LAB023										0.175										
LAB024									0.872											

11. Method of Certification:

QM is a SANAS Accredited Proficiency Testing Scheme Provider, No. PTS0012

This material was distributed as test items, in the Qotho Copper PT Round 4 of 2023. The participating laboratories were each given 1 randomly selected sample from the batch, to analyse and report on in duplicate. Some laboratories reported results via more than one analytical method. Obvious blunders were resolved with the laboratories (if any), after which the data was processed using Robust Statistics, through PROLab Plus.

Not all the participating laboratories were accredited. Historical performance in Qotho PT Schemes, as well as an evaluation of the CRM QA/QC data generated by the laboratories, during the analysis of this QRM, were considered, to evaluate the competence of laboratories. Where competence could not be confirmed, the affected data was deselected from the dataset. Certification of analytes was then done, provided that a minimum of 10 qualifying datapoints remained available.

Where analytes could not be certified, estimate concentrations were assigned, using all the data in the dataset.

12. Measurement of Uncertainty:

Standard uncertainty, uCRM, was calculated according to ISO 13528 (equation 6), and it includes the effects of uncertainty due to inhomogeneity, transport, potential instability, and laboratory uncertainty. Because of all the uncertainties under consideration, QM further applies an expanded uncertainty, for certification purposes. The measurement uncertainty of the certified value is therefore calculated as follows: UCRM = kuCRM, where k is a coverage factor, which is determined from the Student's t-distribution, based on the degrees of freedom, per analyte.
This presents a certified value, as follows: xCRM ± UCRM.

Measurement uncertainty for Assigned values, are calculated in the same manner.

Laboratories which prefer to use the 95% measurement uncertainty, rather than the expanded uncertainty, all available information relating to measurement uncertainty of the certified/assigned values, are given below:

Analyte	Unit of measure	*s* (Standard Deviation of Dataset)	*v* (Degrees of Freedom)	*k* (Coverage Factor)	*u* (Standard Uncertainty)	95% Measurement Uncertainty	Expanded Uncertainty
Al	%	0.04	10	2.228	0.013	± 0.03	± 0.03
Ca	%	2.013	9	2.262	0.737	± 1.5	± 1.7
Co	%	0.002	9	2.262	0.001	± 0.002	± 0.003
Cu	%	0.059	19	2.093	0.016	± 0.03	± 0.04
Cu (Soluble)	%	0.013	5	2.571	0.008	± 0.02	± 0.02
Fe	%	1.299	14	2.145	0.464	± 0.9	± 1.0
Mg	%	0.254	12	2.179	0.083	± 0.17	± 0.18
Mn	%	0.006	10	2.228	0.003	± 0.006	± 0.007
Ni	%	0.003	11	2.201	0.001	± 0.002	± 0.002
S	%	0.114	7	2.365	0.053	± 0.11	± 0.13
Zn	%	0.002	9	2.262	0.001	± 0.001	± 0.001

13. Metrological Traceability:

The values quoted herein are based on the consensus values derived from statistical analysis of the data from an inter laboratory measurement program. Traceability to SI units is via the accredited laboratories, as ISO 17025 requires laboratories to use CRM's traceable to the SI units, during the calibration of their equipment. Not all laboratories were accredited.

Fortunately, most laboratories reported on the QA/QC CRMs used during the analysis of this QRM and reported the values obtained during the sample run. Evaluation of their QA/QC performance serves as further evidence of metrological traceability.

Equivalence tests were performed on all analytes to determine whether the metrologically traceable data and those for which traceability evidence was not available, could be treated as equal (at a level of significance of $\alpha = 0.05$). Where equivalent, all the data was used. Where not equivalent, only the metrologically traceable data was considered.

14. Minimum sample size:

The recommended minimum sample size for the use of this material is as per the participants method validation criteria.

15. Period of validity:

The certified values are valid for this product, while still sealed in its original packaging, for a minimum period of 5 years from date of Initial Certification. Stability monitoring of inventory will be done at regular intervals. Any concerns regarding potential instability of the material, will immediately be communicated to all consumers.

16. Legal:

This certificate and the reference material described in it were prepared with due care and attention. The requirements of ISO Guide 31, ISO/IEC 17043 and ISO 17034 were followed in the preparation of this reference material and certificate of analysis.

Qotho Minerals, however, accepts no liability for any decisions or actions taken following the use of the reference material. The company has a complaints procedure, which will be made available upon request, should there be any dissatisfaction with either the product or the COA.

Certifying & Technical Signatories	
	
Dr Hannelie de Beer (Pr. Sci. Nat.)	***Takudzwa Tsapayi (Pr. Sci. Nat.)***
20 March 2024	

This Certificate of Analysis (CoA) has been electronically signed using an Advanced Electronic Signature (AES) in terms of the Electronic Communications and Transactions Act No. 15, 2002 (ECT Act). Any amendments to the CoA can be detected by reference to the Signature Panel displayed in the electronic pdf version of the CoA.

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