QOTHO MINERALS (PTY) LTD
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QOTHO CERTIFIED REFERENCE MATERIAL (QCRM)

QCRM-5-134

COPPER ORE

CERTIFICATE OF ANALYSIS

CERTIFIED VALUES			
ANALYTES	**UNITS**	**CONCENTRATIONS**	**EXPANDED UNCERTAINTY**
Al	%	7.02	±0.17
Ca	%	3.54	±0.24
Co	%	0.008	±0.002
Cu	%	0.52	±0.02
Fe	%	7.58	±0.16
Mg	%	3.94	±0.10
Ni	%	0.042	±0.005
S	%	0.65	±0.03
Zn	%	0.014	±0.001
ASSIGNED VALUES (FOR INFORMATION ONLY)			
ANALYTES	**UNITS**	**CONCENTRATIONS**	**EXPANDED UNCERTAINTY**
Cu (Soluble)	%	0.08	±0.02
Mn	%	0.107	±0.006
Si	%	28.1	±2.4

1. **Use:**
QCRM-5-134 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:**
This material was sponsored by Ero Brasil Caraiba in Brazil.

3. **Mineral and Chemical Composition:**
This exploration grade chrome ore originates from the Caraíba Operations, located in northeastern Bahia State of Brazil. The ore is hosted within mafic-ultramafic rocks. There is a fair amount of Fe-bearing ores, such as pyroxenes, serpentine, some amphiboles, spinels (including magnetite) and the usual chalcopyrite, with less pyrite and pyrrhotite.

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 aluminum 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
   - Silica by multi-acid digestion and gravimetric finish.
   - Silver by Fire Assay and ICP-OES finish.
   - Acid soluble copper by weak sulphuric acid leach and AAS 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, Ca, Co, Cu, Cu (Soluble), Fe, Mg, Mn, Ni, Pb, S, Si, U and Zn.

9. Participating Laboratories:

No	LABORATORY	COUNTRY
1.	Africa Laboratory Specialists	Namibia
2.	AHK DRC South	Democratic Republic of Congo
3.	AHK Kitwe	Zambia
4.	ALS Geochemistry Kempton Park	South Africa
5.	ALS Kansanshi	Zambia
6.	Aurubis Bulgaria	Bulgaria
7.	Ero Brasil Caraiba	Brazil
8.	Intertek Tschudi	Namibia
9.	Kamoto Copper Company	Democratic Republic of Congo
10.	Lubambe Copper Mine	Zambia
11.	Metalkol	Democratic Republic of Congo
12.	Mintek	South Africa
13.	Mopani Mufulira	Zambia
14.	Mopani Nkana	Zambia
15.	Mutanda Mining	Democratic Republic of Congo
16.	Palabora Mining Company	South Africa
17.	Rio Tinto Kennecott	United States of America
18.	Robinson International	Democratic Republic of Congo
19.	SSM Kolwezi	Democratic Republic of Congo

10. Assay Data:

Data used for Assigning Values and Certification.

LABORATORY	Ag	Al	As	Au	Ca	Co	Cu	Cu (Soluble)	Fe	Mg	Mn	Ni	Pb	S	Si	U	Zn
UNIT	g/t	%	ppm	g/t	%	%	%	%	%	%	%	%	%	%	%	ppm	%
LAB001	0.85	6.809	14.5	< 0.030	3.16	0.006			7.341	3.338	0.106	0.041			27.796		0.015
LAB002			< 21.00									0.035					
LAB003		7.093			3.111				7.71	3.942					26.393		
LAB004							0.514										
LAB005						0.011	0.551		7.299								
LAB006						0.01		0.092	7.484	3.895	0.116			0.6	53.56		0.015
LAB007		6.93			3.59		0.52			4.06	0.11			0.645	27.3		< 0.050
LAB008		7.127				0.007	0.538		8.315		0.105	0.041					0.014
LAB009								0.069									
LAB010							0.506										
LAB011		7.014			2.934	0.007	0.514	0.074	5.129		0.032	0.046			37.871		0.013
LAB012					3.79	0.007			7.909	3.861	0.108	0.031					0.013
LAB013	0.5	7.025	< 5.00		3.57	0.005	0.51	0.09	7.405	3.915	0.102	0.044	0.001	0.63		< 10.00	0.014
LAB014							0.475										
LAB015					1.259	< 0.010	0.532	0.104		1.637	0.033			0.748			
LAB016		7.725			3.692	0.007			7.562	4.078	0.111						0.014
LAB017	0.492						0.478						0.001				0.012
LAB018	1.506		< 10.00	0.068		0.006	0.535		7.659		0.099		0.003			< 10.00	0.012
LAB019					4.037	0.013		0.045	8.258	4.457	0.12	0.045	0.003				0.013
LAB020								0.077									
LAB021		8.455			4.104		0.507	0.055	7.604	3.897	0.11						0.014
LAB022	1.071	6.785	48.671		3.63	0.009	0.59	0.065	7.395	3.945	0.09	0.051	0.004	0.644			0.021
LAB023	0.573						0.487						0.001				0.012
LAB024						0.009		0.093	7.457	3.976	0.116			0.655	53.725		0.016

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LABORATORY	Ag	Al	As	Au	Ca	Co	Cu	Cu (Soluble)	Fe	Mg	Mn	Ni	Pb	S	Si	U	Zn
UNIT	g/t	%	ppm	g/t	%	%	%	%	%	%	%	%	%	%	%	ppm	%
LAB025	0.914	6.765	518.706		3.585	0.007	0.595	0.065	7.58	3.915	0.1	0.053	0.004	0.587			0.027
LAB026	0.55	7.155	< 5.000		3.605	0.005	0.526	0.09	7.54	3.945	0.103	0.044	0.002	0.65		< 10.00	0.014
LAB027							0.51										
LAB028								0.069									
LAB029							0.504										
LAB030	2.569		< 10.00	0.084		0.005			7.684		0.098		0.005			< 10.00	0.017
LAB031		8.308			3.981		0.493	0.048	7.633	3.71	0.113						
LAB032					1.301	< 0.010	0.521	0.107		1.589	0.046			0.733			
LAB033								0.077									
LAB034		7.513			3.688	0.008			7.517	4.026	0.106						0.013
LAB035		6.95			3.66		0.525		7.22	4.105	0.11			0.665	27.65		< 0.050
LAB036					4.169	0.013		0.044	8.199	4.512	0.123	0.045	0.003				0.015
LAB037		6.949				0.007	0.536		8.082		0.103	0.041					0.015
LAB038					3.521	0.007			7.474	3.895	0.108	0.032					0.013
LAB039		7.034			2.872				7.168	3.849					26.23		
LAB040							0.522										
LAB041	0.745	6.742	15.5	< 0.020	3.146	0.006			7.306	3.309	0.105	0.04			28.392		0.014
LAB042			< 21.00									0.035					
LAB043		7.002			2.984	0.006	0.535	0.076	5.151		0.033	0.051			37.542		0.013
LAB044						0.012	0.553		7.184								

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 6 of 2022. The participating laboratories were each given 2 randomly selected samples 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	%	0.292	17	2.110	0.079	± 0.16	± 0.17
Ca	%	0.5	21	2.080	0.112	± 0.22	± 0.24
Co	%	0.002	23	2.069	0.001	± 0.002	± 0.002
Cu	%	0.031	24	2.064	0.007	± 0.01	± 0.02
Cu (Soluble)	%	0.023	17	2.110	0.007	± 0.01	± 0.02
Fe	%	0.338	26	2.056	0.079	± 0.16	± 0.16
Mg	%	0.24	21	2.080	0.046	± 0.09	± 0.10
Mn	%	0.012	25	2.060	0.003	± 0.006	± 0.006
Ni	%	0.008	15	2.131	0.002	± 0.004	± 0.005
S	%	0.042	9	2.262	0.014	± 0.03	± 0.03
Si	%	2.663	9	2.262	1.066	± 2.1	± 2.4
Zn	%	0.002	24	2.064	0.0005	± 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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