QOTHO MINERALS (PTY) LTD
Physical Address: 36 Pelindaba Road, Broederstroom, Madibeng, 0240
PostNet Suite 173, Private Bag X0003, Ifafi, North West Province, 0260
South Africa
+27 (0)87 004 3200 / admin@qotho.co.za / www.qotho.co.za

QOTHO CERTIFIED REFERENCE MATERIAL (QCRM)

QCRM-1-141

COPPER ORE

CERTIFICATE OF ANALYSIS

CERTIFIED VALUES			
ANALYTES	**UNITS**	**CONCENTRATIONS**	**EXPANDED UNCERTAINTY**
Al	%	0.21	±0.05
Co	%	0.007	±0.002
Cu	%	1.17	±0.01
Fe	%	11.58	±0.27
Mg	%	4.67	±0.22
Mn	%	0.088	±0.002
Ni	%	0.011	±0.002
S	%	0.92	±0.05
Zn	%	0.004	±0.002
ASSIGNED VALUES (FOR INFORMATION ONLY)			
ANALYTES	**UNITS**	**CONCENTRATIONS**	**EXPANDED UNCERTAINTY**
Ca	%	25.29	±0.61
Cu (Soluble)	%	0.20	±0.02
Pb	%	0.016	±0.002
Si	%	0.79	±0.05

1. **Use:**
QCRM-1-141 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:**
15 August 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:**
   - Fused Beads with XRF finish
   - Peroxide Fusion with AAS or ICP-OES finish
   - Multi-acid Digestion with AAS or ICP-OES finish
   - Copper by multi-acid digestion with Electro Gravimetric finish
   - Copper by multi-acid digestion with Potentiometric Titration
   - Oxide copper by 5-10% H_2SO_4 Leach with AAS Finish
   - Gold by fire assay and gravimetric or ICP-OES finish
   - Sulphur by Thermal Combustion and Infrared detection.

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, Cd, Co, Cu, Cu (Soluble), Fe, Mg, Mn, Ni, Pb, S, Si, U, 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.	Black Mountain Mining	South Africa
6.	Ero Brasil Caraiba	Brazil
7.	Intertek Tschudi	Namibia
8.	Kamoto Copper Company	Democratic Republic of Congo
9.	Lubambe Copper Mine	Zambia
10.	Metalkol	Democratic Republic of Congo
11.	Misenge Environmental & Technical	Zambia
12.	Mopani Nkana	Zambia
13.	Mutanda Mining	Democratic Republic of Congo
14.	Palabora Mining Company	South Africa
15.	Rio Tinto Kennecott	United States of America
16.	Robinson International	Democratic Republic of Congo
17.	Sable Zinc	Zambia
18.	SGS Randfontein	South Africa
19.	SSM Kolwezi	Democratic Republic of Congo
20.	UIS Analytical Services	South Africa

10. Assay Data:

Data used for Assigning Values and Certification.

LABORATORY	Ag	Al	As	Au	Ca	Cd	Co	Cu	Cu (Soluble)	Fe	Mg	Mn	Ni	Pb	S	Si	U	Zn
UNIT	g/t	%	µg/g	g/t	%	µg/g	%	%	%	%	%	%	%	%	%	%	µg/g	%
LAB001	2.121	0.13	28.166		24.07	< 8.000	0.006		0.176	11.401	4.627	0.089	0.019	0.017	0.9	0.757		0.007
LAB002	2.876	0.142	27.575		23.975	< 8.000						0.094		0.018				0.005
LAB003								1.16						0.014				0.002
LAB004									0.178									
LAB005								1.159										
LAB006		0.18			25.1	0.7	< 0.020		0.211	12.05	4.725	0.081	0.01	0.01	0.89		140	0.03
LAB007								1.2										
LAB008								1.18										
LAB009								1.195										
LAB010	15					< 0.001								0.032	< 0.000			
LAB011					26.018		0.019	1.143	0.186	12.373	4.405	0.095		0.026				
LAB012					25.977		0.007	1.207	0.25		4.082				0.853			
LAB013									0.269									
LAB014								1.151										
LAB015		0.136			25.586		0.008			10.989	4.294	0.083	0.01					0.005
LAB016	3.515								0.147					0.02				
LAB017		0.299					0.005		0.178	11.705		0.088	0.012	0.011				0.004
LAB018					26.44		0.008	1.185		11.13	4.59	0.083	0.01					0.005
LAB019		0.373			23.91					11.167	4.427	0.087	0.009		1.13	0.857		0.005
LAB020								1.175										
LAB021		0.276			30.468		0.007	1.167	0.183	11.576	5.015	0.093	0.014	0.017		0.782		0.012
LAB022	0.75	0.143	< 26.000	0.04	24.99	< 17.000	0.006			10.97		0.088	0.011	0.012	0.973	1.08		0.002
LAB023			< 9.000										0.01	0.013				
LAB024									0.225									
LAB025								1.133										
LAB026								1.16										
LAB027							0.01			11.64								
LAB028		0.214			25.605		0.007			11.645	4.829	0.09	0.017	0.013	0.929	0.742		
LAB029		0.241			25.178					12.177	5.137	0.089			0.883	0.733		

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LABORATORY	Ag	Al	As	Au	Ca	Cd	Co	Cu	Cu (Soluble)	Fe	Mg	Mn	Ni	Pb	S	Si	U	Zn
UNIT	g/t	%	µg/g	g/t	%	µg/g	%	%	%	%	%	%	%	%	%	%	µg/g	%
LAB030								1.148						0.014				0.002
LAB031	2.125	0.13	20.822		24.755	< 8.000	0.006		0.185	11.38	4.7	0.088	0.019	0.017	0.856	0.775		0.005
LAB032	2.402	0.16	25.705		24.715	< 8.000						0.093		0.02				0.005
LAB033		0.175			25.3	0.75	< 0.020		0.212	11.85	4.815	0.084	0.01	0.015	0.95		145	0.02
LAB034								1.2										
LAB035								1.165										
LAB036								1.215										
LAB037									0.176									
LAB038								1.169										
LAB039	16.5													1.712	< 0.000			
LAB040					26.05		0.02	1.16	0.185	12.341	4.46	0.08		0.015				
LAB041					26.024		0.007	1.276	0.247		4.77				0.883			
LAB042									0.268									
LAB043								1.176										
LAB044		0.136			25.665		0.009			11.04	4.262	0.083	0.011					0.005
LAB045	4.23								0.149					0.02				
LAB046		0.299					0.005		0.178	11.705		0.088	0.012	0.011				0.004
LAB047					26.175		0.008	1.154		11.12	4.659	0.081	0.009					0.005
LAB048		0.378			23.965					11.417	4.377	0.089	0.007		1.014	0.83		0.003
LAB049								1.178										
LAB050	0.62	0.136	< 26.000	0.036	23.45	< 17.000	0.006			10.895		0.084	0.011	0.012	1.015	0.93		0.003
LAB051			< 9.000										0.009	0.012				
LAB052		0.278			30.502		0.007	1.163	0.188	11.639	5.008	0.097	0.014	0.018		0.767		0.012
LAB053									0.225									
LAB054								1.187										
LAB055							0.011			11.425								
LAB056		0.22			26.955		0.008			12.058	5.022	0.09	0.011	0.019	0.893	0.758		
LAB057		0.229			25.359					12.185	5.129	0.091			0.884	0.721		

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 2 of 2023. 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: 2022 (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	%	0.08	19	2.093	0.023	± 0.05	± 0.05
Ca	%	1.285	23	2.069	0.295	± 0.59	± 0.61
Co	%	0.002	19	2.093	0.001	± 0.002	± 0.002
Cu	%	0.028	24	2.064	0.006	± 0.01	± 0.01
Cu (Soluble)	%	0.035	19	2.093	0.007	± 0.01	± 0.02
Fe	%	0.502	23	2.069	0.131	± 0.26	± 0.27
Mg	%	0.347	19	2.093	0.103	± 0.21	± 0.22
Mn	%	0.005	23	2.069	0.001	± 0.002	± 0.002
Ni	%	0.002	19	2.093	0.001	± 0.002	± 0.002
Pb	%	0.005	23	2.069	0.001	± 0.002	± 0.002
S	%	0.06	13	2.160	0.022	± 0.04	± 0.05
Si	%	0.08	11	2.201	0.02	± 0.04	± 0.05
Zn	%	0.002	19	2.093	0.001	± 0.002	± 0.002

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/IEC 17025: 2017 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 33401: 2024, ISO/IEC 17043: 2023 and ISO 17034: 2016 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.)***
15 August 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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