

**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-5-165****COPPER ORE****CERTIFICATE OF ANALYSIS**

CERTIFIED VALUES			
ANALYTES	UNITS	CONCENTRATIONS	EXPANDED UNCERTAINTY
Ca	%	27.5	±1.6
Co	µg/g	102	±11
Cu	%	0.75	±0.01
Cu (Soluble)	%	0.09	±0.02
Fe	%	10.53	±0.17
Mg	%	4.48	±0.13
Mn	µg/g	650	±29
S	%	1.13	±0.07
ASSIGNED VALUES (FOR INFORMATION ONLY)			
ANALYTES	UNITS	CONCENTRATIONS	EXPANDED UNCERTAINTY
Al	%	0.17	±0.04
Ni	µg/g	180	±26
Pb	µg/g	77	±12
Si	%	0.62	±0.06
Zn	µg/g	34	±14



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1. Use:

QCRM-5-165 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
- Pressed Powder with XRF finish
- Peroxide Fusion with AAS or ICP-OES finish
- Multi-acid Digestion with AAS, ICP-OES or ICP-MS finish
- Copper by multi-acid digestion with Electro Gravimetric finish
- Copper & Chloride by multi-acid digestion with Potentiometric Titration
- Oxide copper by 5-10% H₂SO₄ Leach with AAS Finish
- Gold by fire assay and gravimetric of AAS 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, Bi, C, Ca, Cd, Cl, Co, Cu, Cu(Soluble), F, Fe, Hg, K, LOI (1000°C), Mg, Mn, Mo, Na, Ni, Pb, S, Sb, Se, Si, U, Zn.



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9. Participating Laboratories:

No	LABORATORY	COUNTRY
1.	Acme Analytik Lab Hiz. Ltd.	Turkey
2.	Africa Laboratory Specialists	Namibia
3.	AHK Botswana	Botswana
4.	AHK DRC South	Democratic Republic of Congo
5.	AHK Kitwe	Zambia
6.	ALS Geochemistry Kempton Park	South Africa
7.	ALS Kansanshi	Zambia
8.	Bureau Veritas Chile - Coquimbo	Chile
9.	Bureau Veritas Minerals - Sorbonne	Australia
10.	CCIC Africa Lab	South Africa
11.	Ero Brasil Cariaba	Brazil
12.	Inspectorate - Shanghai	China
13.	Inspectorate Griffith India - Gandhidham	India
14.	Inspectorate Services Peru - Constancia	Peru
15.	Inspectorate Services Peru - El Porvenir	Peru
16.	Inspectorate Services Peru - Huarón	Peru
17.	Inspectorate Services Peru - Lima	Peru
18.	Inspectorate Services Peru - Marcobre	Peru
19.	Kamoto Copper Company	Democratic Republic of Congo
20.	Metalkol	Democratic Republic of Congo
21.	Mopani Copper Mines - Mufulira	Zambia
22.	Mopani Copper Mines - Nkana	Zambia
23.	MSALabs Canada	Canada
24.	Mutanda Mining	Democratic Republic of Congo
25.	Palabora Mining Company	South Africa
26.	Rio Tinto Kennecott	United States of America
27.	Robinson International	Democratic Republic of Congo
28.	SGS Randfontein	South Africa

10. Assay Data:

Data used for Assigning Values and Certification.

LABORATORY	Ag	Al	As	Au	Bi	C	Ca	Cd	Cl	Co	Cu	Cu (Soluble)	F	Fe	Hg
UNIT	g/t	%	µg/g	g/t	µg/g	%	%	µg/g	µg/g	µg/g	%	%	%	%	µg/g
LAB001	< 1.000										0.756				
LAB002							31.785			80	0.753			10.491	
LAB003	4.25	0.125	< 20.000				10	< 9.000		119.945	0.72	0.061		10.63	
LAB004		0.212					10			116.204	0.748			10.602	
LAB005		0.3								109	0.734	0.09		10.855	
LAB006											0.754				
LAB007	0.451					9.135			419		0.748	0.09		10.661	
LAB008	< 1.000	0.235		< 0.200											
LAB009	<0.5			0.118		9.125					0.747	0.074		10.754	
LAB010		0.149					25.144				0.815				
LAB011		0.289					29.952			85	0.736	0.092		10.044	
LAB012	0.645	0.117	< 23.000	0.096	< 39.000	8.885	28.21	< 18.000		91.5	0.717			10.63	
LAB013			< 9.000		< 25.000									8.31	
LAB014	8.974										0.739				
LAB015	0.45	0.215	< 10.000	0.115	0.29		27.15	< 0.100	265	100	0.755	0.092		10.75	
LAB016		0.208					26.691							10.293	
LAB017											0.74				
LAB018											0.735				
LAB019										96.5	0.75			10.295	
LAB020	< 4.000			0.128							0.754			10.45	
LAB021											0.583				
LAB022	3	0.1	9	0.11	17	9.155	26.81	3		103	0.71		0.234	10.375	< 2.000
LAB023		0.246				10.445	28.375	0.4		109.4	0.766			10.4	
LAB024		0.11	32.5		4		28.82			89	0.755	0.071		11.765	
LAB025		0.064					27.79	2.29		144.344	0.704			9.498	
LAB026										< 250.000	0.811	0.101		9.293	
LAB027	< 0.500	0.155	< 5.000		7.5		26.8	< 0.500		108	0.77	0.082		10.7	
LAB028											0.8				
LAB029	0.8		6.5	0.15			23.165			99.5	0.802			10.625	
LAB030												0.09			
LAB031											0.736				
LAB032	< 1.000	0.135	< 50.000		< 50.000		26.005	< 10.000		95	0.73			10.7	
LAB033	0.663	0.122		0.177	0.493	10.02	26.89	0.1	200	121.5				10.54	< 0.010
LAB034		0.159	120				33.308	< 50.000	485				0.166		< 50.000
LAB035	< 0.500	0.107	51.92	0.115	< 20.000	9.22	25.83	< 10.000	299.5	90	0.753		0.285	10.795	< 0.080

LABORATORY	K	LOI (1000°C)	Mg	Mn	Mo	Na	Ni	Pb	S	Sb	Se	Si	U	Zn
UNIT	µg/g	%	%	µg/g	µg/g	µg/g	µg/g	µg/g	%	µg/g	µg/g	%	µg/g	µg/g
LAB001								111						< 100.000
LAB002			4.796	522.8										62.62
LAB003	446.224		4.425	657.233		307.992	199.382	184.72						46.773
LAB004			4.324	661.476		524.725	196.878	96.007						51.082
LAB005			4.385	667.5				67.5	1.105					
LAB006														
LAB007									1.194					
LAB008												0.655		< 100.000
LAB009			4.045						1.157					20
LAB010			4.989											
LAB011			4.877	625								0.988		
LAB012	< 1138.000		4.37	615	< 9.000	204	172.5	87		< 16.000	70.5	0.585		< 13.000
LAB013					< 4.000		135.5	< 18.000		< 19.000	< 25.000			< 20.000
LAB014								72.675						11.705
LAB015	330	30.85	4.52	700	< 0.200		205	80	1.195	0.5	< 5.000	0.62	81.2	40
LAB016			4.397	650					1.091			0.574		
LAB017														
LAB018														
LAB019			4.43	755			115	35						40
LAB020								< 100.000						< 100.000
LAB021														
LAB022	390		4.57	650	< 5.000	290	190	70	1.653	3	< 5.000	0.64		30
LAB023	2200		4.293	635.6			75		1.045			0.605		
LAB024			4.52	600			197.5	65.5	1.245					
LAB025			4.646	656.45			197.195							20.12
LAB026			4.715	660					1.07					
LAB027	400		4.485	632	< 1.000	300	218	72	1.155	< 5.000			30	18.5
LAB028														
LAB029			4.255	652.5			185.5	69						
LAB030														
LAB031														
LAB032	< 1000.000		4.21	600	< 10.000	< 500.000	145	< 100.000	1.08	< 50.000				< 100.000
LAB033	420	31.63	4.53	595		815		75	1.095	0.25	13.75	0.605	91	19
LAB034	452.469			836.432		< 50.000	286.837	< 50.000				1.139		56.234
LAB035	316.5		4.325		< 10.000	396	174.5	97		< 40.000		0.645		24.26



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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 3 of 2024. 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, u_{CRM} , 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: $U_{CRM} = k u_{CRM}$, 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: $x_{CRM} \pm U_{CRM}$.

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)	ν (Degrees of Freedom)	k (Coverage Factor)	u (Standard Uncertainty)	95% Measurement Uncertainty	Expanded Uncertainty
Al	%	0.066	17	2.110	0.021	± 0.04	± 0.04
Ca	%	2.236	15	2.131	0.721	± 1.4	± 1.6
Co	$\mu\text{g/g}$	16.451	16	2.120	5.298	± 11	± 11
Cu	%	0.024	28	2.048	0.006	± 0.01	± 0.01
Cu (Soluble)	%	0.015	9	2.262	0.006	± 0.01	± 0.02
Fe	%	0.393	22	2.074	0.080	± 0.16	± 0.17
Mg	%	0.242	20	2.086	0.063	± 0.13	± 0.13
Mn	$\mu\text{g/g}$	57.825	19	2.093	13.824	± 28	± 29
Ni	$\mu\text{g/g}$	35.051	14	2.145	12.176	± 24	± 26
Pb	$\mu\text{g/g}$	20.073	13	2.160	5.463	± 11	± 12
S	%	0.086	11	2.201	0.031	± 0.06	± 0.07
Si	%	0.060	9	2.262	0.025	± 0.05	± 0.06
Zn	$\mu\text{g/g}$	18.333	12	2.179	6.204	± 12	± 14



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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	
<i>Dr Hannelie de Beer (Pr. Sci. Nat.)</i>	<i>Takudzwa Tsapayi (Pr. Sci. Nat.)</i>
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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