

QOTHO CERTIFIED REFERENCE MATERIAL (QCRM)

QCRM-5-079

COPPER CONCENTRATE

CERTIFICATE OF ANALYSIS

CERTIFIED VALUES			
ANALYTES	UNITS	CONCENTRATIONS	EXPANDED UNCERTAINTY
Cu	%	24.56	±0.21
Fe	%	18.97	±0.46
ASSIGNED VALUES (FOR INFORMATION ONLY)			
ANALYTES	UNITS	CONCENTRATIONS	EXPANDED UNCERTAINTY
Ag	g/t	33.8	±5.9
Al	%	0.40	±0.07
Ca	%	8.20	±0.73
Co	%	0.09	±0.01
Cu (Soluble)	%	1.28	±0.61
Mg	%	2.33	±0.21
Mn	%	0.06	±0.01
Ni	%	0.14	±0.02
Pb	%	0.02	±0.01
S	%	17.7	±1.1
Si	%	2.48	±0.73
Zn	%	0.06	±0.01

1. Use:

QCRM-5-079 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 Concentrate 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, copper, nickel, gold, silver, platinum, and palladium. This concentrate is the product of a copper flotation process.

4. Date of Initial Issue:

3 January 2022.

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 finish
- Multi-acid digestion with ICP-OES finish
- Peroxide fusion with ICP-OES finish
- Copper by multi-acid digestion and Electro-gravimetric finish
- Copper by multi-acid digestion and Potentiometric titration
- Silver by Fire Assay and ICP-OES finish
- Acid soluble (oxide) copper by mild sulphuric acid leach and AAS finish
- Silica by multi-acid digestion and gravimetric finish
- Sulphur by 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 (Oxide/Soluble), Fe, Mg, Mn, Ni, Pb, S, Si, U, and Zn.

9. Participating Laboratories:

No	LABORATORY	COUNTRY
1.	AHK DRC South	Democratic Republic of Congo
2.	AHK Kitwe	Zambia
3.	AHK Lumwana	Zambia
4.	ALS Geochemistry Kempton Park	South Africa
5.	ALS Zambia	Zambia
6.	Dundee Precious Metals	Namibia
7.	Dundee Precious Metals - Process Control	Namibia
8.	Kamoto Copper Company	Democratic Republic of Congo
9.	Lubambe Copper Mine	Zambia
10.	OCC Kolwezi	Democratic Republic of Congo
11.	OCC Likasi	Democratic Republic of Congo
12.	OCC Tenke	Democratic Republic of Congo
13.	Palabora Mining Company	South Africa
14.	Rio-Tinto Kennecott	United States of America
15.	Robinson International	Democratic Republic of Congo
16.	Societe de Surveillance Mine Lab	Democratic Republic of Congo
17.	UIS Analytical Services ICP	South Africa
18.	Zambia Revenue Authority	Zambia

10. Assay Data:

Data used for Assigning Values and Certification.

LAB	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	32.505	0.371	< 10.00	2.045	8.013	0.084	24.45		19.37	2.361	0.05	0.134	0.015	17.8	2.4		0.05
LAB002							22.355										
LAB003							24.845										
LAB004		0.434			8.643		24.375		19.477	2.215				17.012	2.139		
LAB005						0.083	25.02		18.639		0.065	0.148					
LAB006		0.423			8.36	0.09			19.265	2.593	0.057	0.149	0.037	18.2	3.057		0.058
LAB007	33.85					0.086	24.565	1.703	18.651		0.058		0.012	16.8			0.051
LAB008						0.092	24.686		18.071								
LAB009			6.178			0.082	24.695	0.756	18.276	2.2	0.048	0.128		19.48			0.067
LAB010		0.252			8.153	0.082		1.197	18.86	2.413	0.06	0.225	0.075		2.646		0.067
LAB011	37.5	0.42	< 0.010		10.085		24.535		19.04	0.76			0.02		2.745		0.07
LAB012							24.79										
LAB013					7.415	0.09		0.955		2.22	0.06			18.75			
LAB014			0.177					1.255	19.845				0.01	17.61	1.585		
LAB015						0.108			19.215		0.037	0.139					0.062
LAB016							24.383										
LAB017	30.8	0.4	< 5.000	1.495	7.475	0.09	24.7	2.105	18.895	2.225	0.05	0.15	0.01	17.1		35	0.06
LAB018							24.52										
LAB019								0.975									
LAB020							24.1										
LAB021	34.5	0.615	355.5		8.305	0.1	24.665			2.425	0.07	0.15		17.105	2.765		0.06
LAB022							24.24										
LAB023							24.415										

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 2020. 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:

Measurement uncertainty, u_{CRM} , was calculated according to ISO 13528:2015 (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. $U_{CRM} = k u_{CRM}$, 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.

For laboratories 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	ν (degrees of freedom)	k (coverage factor)	u (standard error)	95% measurement uncertainty	Expanded Uncertainty
Ag	g/t	4	2.776	2.115	± 4.2	± 5.9
Al	%	6	2.447	0.029	± 0.06	± 0.07
Ca	%	7	2.365	0.309	± 0.62	± 0.73
Co	%	10	2.228	0.003	± 0.01	± 0.01
Cu	%	16	2.120	0.096	± 0.19	± 0.21
Cu (Oxide/Soluble)	%	6	2.447	0.249	± 0.50	± 0.61
Fe	%	11	2.201	0.21	± 0.42	± 0.46
Mg	%	8	2.306	0.092	± 0.18	± 0.21
Mn	%	9	2.262	0.005	± 0.01	± 0.01
Ni	%	7	2.365	0.006	± 0.01	± 0.02
Pb	%	6	2.447	0.005	± 0.01	± 0.01
S	%	8	2.306	0.469	± 0.9	± 1.1
Si	%	6	2.447	0.298	± 0.60	± 0.73
Zn	%	8	2.306	0.004	± 0.01	± 0.01

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 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 Signatory	
<i>Qotho Managing Director</i>	<i>3 January 2022</i>

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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