

## QOTHO CERTIFIED REFERENCE MATERIAL (QCRM)

### QCRM-5-081

#### COPPER ORE

#### CERTIFICATE OF ANALYSIS

CERTIFIED VALUES			
ANALYTES	UNITS	CONCENTRATIONS	EXPANDED UNCERTAINTY
Al	%	8.89	±0.53
Ca	%	0.27	±0.03
Co	%	0.013	±0.002
Cu	%	1.93	±0.04
Cu (Soluble)	%	0.42	±0.03
Fe	%	2.53	±0.12
Mg	%	1.38	±0.06
Mn	%	0.022	±0.002
Pb	%	0.004	±0.002
Zn	%	0.005	±0.004
ASSIGNED VALUES (FOR INFORMATION ONLY)			
ANALYTES	UNITS	CONCENTRATIONS	EXPANDED UNCERTAINTY
Ni	%	0.005	±0.002
S	%	0.51	±0.10
Si	%	27.60	±0.93

**1. Use:**

QCRM-5-081 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 standard was sponsored by Lubambe Copper Mine, situated in the Konkola section of the Zambian Copperbelt.

**3. Mineral and Chemical Composition:**

The Konkola section of the Zambian Copper Belt comprises a near continuous ribbon of ore within the Neoproterozoic Lower Roan Subgroup. At Lubambe, although copper mineralisation occurs mostly within the OS1 Member, it is crosscutting on a gross scale, and pinches out towards the east within the overlying OS2 Member. The overall paragenetic sequence of the major primary ore sulphides is carrollite → chalcopyrite → bornite → chalcocite. At Lubambe and the bornite zone is to the east, passing westward into chalcopyrite and then to pyritic, carbonaceous shale.

**4. Date of Initial Issue:**

25 August 2021.

**5. Packaging & Handling instructions:**

The material is packaged as 100g 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 Electro-Gravimetric finish
- Soluble copper by mild sulfuric acid leach and ICP-OES or AAS finish
- Multiple acid digestion with ICP-OES or AAS finish
- Gold and silver by Fire Assay and ICP-OES finish
- Sodium peroxide fusion with ICP-OES or AAS finish
- 4-acid digestion with Potentiometric Titration
- Pressed powder with XRF finish
- Sulphur by combustion analysis.
- Fused beads with XRF finish

**8. Analysis required:**

An instruction letter was sent to all participants within the PT Scheme. 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.	AHK Kitwe	Zambia
2.	AHK Lumwana	Zambia
3.	ALS Geochemistry Kempton Park	South Africa
4.	ALS Zambia	Zambia
5.	Bitri	Botswana
6.	CCIC Africa	South Africa
7.	Intertek Tschudi	Namibia
8.	Kamoto Copper Company	DRC
9.	Lubambe Copper Mine	Zambia
10.	Mintek	South Africa
11.	Mopani Mufulira	Zambia
12.	Mutanda Mining	DRC
13.	OCC Kolwezi	DRC
14.	OCC Likasi	DRC
15.	Palabora Mining Company	South Africa
16.	Rio Tinto Kennecott	USA
17.	Robinson International	DRC
18.	Sable Zinc	Zambia
19.	Societe de Surveillance Mine Lab	DRC
20.	Suntech Geomet Labs	South Africa
21.	UIS Analytical Services	South Africa
22.	Zambia Revenue Authority	Zambia

**10. Assay Data:**

Data used for Assigning Values and Certification.

LABORATORY	Ag	Al	As	Au	Ca	Co	Cu	Cu (Soluble)
UNIT	g/t	%	ppm	g/t	%	%	%	%
LAB001								
LAB002	0.526		45.5	< 0.030	0.239	0.011		
LAB003			15					
LAB004		8.594					1.886	
LAB005		9.3			0.258	0.017	1.933	
LAB006							1.905	0.44
LAB007							1.76	
LAB008							2.02	
LAB009	< 50.000	8.62			0.204	0.011	1.815	
LAB010						0.019	2.018	
LAB011		9.285		0.195	0.31		1.845	
LAB012		8.959				0.011	1.88	0.378
LAB013		9.158			0.268		1.979	0.453
LAB014							1.99	
LAB015					0.4	0.01		0.495
LAB016		8.055	< 0.001		0.224	< 0.001	1.984	0.381
LAB017	< 0.500	8.715	< 5.000	0.025	0.25	< 0.020	1.95	0.449
LAB018							1.91	
LAB019								0.445
LAB020							1.941	
LAB021		6.37	100		0.336	0.02	1.982	
LAB022	1.401	9.072	87.743		0.246	0.01	1.915	0.362
LAB023						0.015		
LAB024							2.034	
LAB025	2.728	8.652	9		0.263	0.011	2.008	
LAB026		9.836					1.864	0.358
LAB027	< 0.500	8.22	< 100.000	0.02	0.25	0.02	2	0.437
LAB028							1.96	
LAB029								0.451
LAB030		10.057			0.375	0.014		
LAB031					0.325	0.01	1.895	0.42
LAB032							1.912	0.394
LAB033								
LAB034						0.017		
LAB035							1.886	
LAB036							1.884	
LAB037		8.813					1.864	
LAB038					0.242		2.063	0.455
LAB039						0.016	1.851	
LAB040							1.955	

LABORATORY	Fe	Mg	Mn	Ni	Pb	S	Si	U	Zn
UNIT	%	%	%	%	%	%	%	ppm	%
LAB001				0.018		0.264	27.16		
LAB002	2.743	1.306	0.021	0.002	0.005	0.635	28.99		0.003
LAB003	2.3			0.002	0.003				0.002
LAB004	2.614	1.276					28.121		
LAB005	2.823						27.553		
LAB006									
LAB007									
LAB008									
LAB009	2.689	1.418	0.022	< 0.005	< 0.005		26.81		< 0.005
LAB010	2.639								
LAB011	2.67	1.605	< 0.050	< 0.050	< 0.050	0.585	28.35		< 0.050
LAB012	2.393	1.367	0.022	0.003	0.004		26.464		0.003
LAB013	2.529	1.276	0.025	0.005	0.005		29.223		0.01
LAB014	2.195		0.02						
LAB015	2.25					0.593			
LAB016	8.055	1.457	0.001	< 0.001	< 0.001	0.612	26.942		< 0.001
LAB017	2.33	1.335	0.022	0.007	< 0.010	0.545		< 10.000	0.02
LAB018									
LAB019									
LAB020									
LAB021	2.658	1.473	0.011						
LAB022	2.659	1.344	0.024	0.003	0.009	0.534	26.347		0.005
LAB023	2.187		0.021						0.003
LAB024									
LAB025	2.54	1.448	0.024	0.003	0.007	0.422			0.005
LAB026	2.775	1.495	0.023		0.002	0.244			0.007
LAB027	2.34	1.305		< 0.010	< 0.010	0.475		< 10.000	0.02
LAB028									
LAB029									
LAB030	2.468	1.295	0.015						
LAB031						0.512			
LAB032									
LAB033	2.659			0.007					
LAB034	2.45		0.021	0.007					
LAB035									
LAB036									
LAB037	2.638	1.34					28.409		
LAB038	2.697		0.025	0.015			26.876		
LAB039	2.341								
LAB040									

## 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 Rounds 4 of 2020 and 3 of 2021. 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 and not all laboratories participated in both rounds. 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 to analyse this material. 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 analytes cannot be certified, due to inability to demonstrate laboratory competence for at least 10 datasets, as is the case for this report, 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	$\nu$ (degrees of freedom)	$k$ (coverage factor)	$u$ (standard error)	95% measurement uncertainty	Expanded Uncertainty
Al	%	14	2.145	0.244	$\pm 0.49$	$\pm 0.53$
Ca	%	14	2.145	0.013	$\pm 0.03$	$\pm 0.03$
Co	%	16	2.120	0.001	$\pm 0.002$	$\pm 0.002$
Cu	%	29	2.045	0.017	$\pm 0.03$	$\pm 0.04$
Cu (Soluble)	%	13	2.160	0.012	$\pm 0.02$	$\pm 0.03$
Fe	%	24	2.064	0.055	$\pm 0.11$	$\pm 0.12$
Mg	%	15	2.131	0.027	$\pm 0.05$	$\pm 0.06$
Mn	%	15	2.131	0.001	$\pm 0.002$	$\pm 0.002$
Ni	%	14	2.145	0.001	$\pm 0.002$	$\pm 0.002$
Pb	%	11	2.201	0.001	$\pm 0.002$	$\pm 0.002$
S	%	10	2.228	0.043	$\pm 0.09$	$\pm 0.10$
Si	%	11	2.201	0.423	$\pm 0.85$	$\pm 0.93$
Zn	%	12	2.179	0.002	$\pm 0.004$	$\pm 0.004$

**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 are 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, only the metrologically traceable data was considered. As mentioned in Section 11, certification of analytes could only be done, if a minimum of 10 qualifying datasets, were available.

**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 have been 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	
<b>Qotho Managing Director</b>	<b>25 August 2021</b>

*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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