

## QOTHO CERTIFIED REFERENCE MATERIAL (QCRM)

### QCRM-5-043

#### COPPER CONCENTRATE

#### CERTIFICATE OF ANALYSIS

CERTIFIED VALUES			
ANALYTES	UNITS	CONCENTRATIONS	EXPANDED UNCERTAINTY
Cu	%	22.57	±0.44
ASSIGNED VALUES (FOR INFORMATION ONLY)			
ANALYTES	UNITS	CONCENTRATIONS	EXPANDED UNCERTAINTY
Al	%	0.57	±0.09
Ca	%	0.35	±0.04
Co	%	0.82	±0.06
Cu (Soluble)	%	18.8	±1.9
Fe	%	3.87	±0.52
Mg	%	0.69	±0.09
Ni	%	0.08	±0.03
Pb	%	0.45	±0.04
S	%	5.41	±0.21
Si	%	3.12	±0.29
Zn	%	17.9	±2.1

**1. Use:**

QCRM-5-043 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 analyzing similar materials.

**2. Origin of Material:**

This standard was sponsored by ALS Inspection, Johannesburg, South Africa. It is a composite material collected from milled laboratory pulp rejects after analysis. The material originates from the Kalahari Copperbelt, in Botswana.

**3. Mineral and Chemical Composition:**

The concentrate originates from ore from the Kalahari Copper Belt which is a sediment-hosted, stratiform Cu-Ag deposit hosted in Meso- and Neoproterozoic rocks. The Belt extends from northern Botswana into Namibia along the NW edge of the Kalahari Craton, and consists of folded and greenschist metamorphosed Ghanzi (Botswana) and Tsumis (Namibia) Group metasedimentary rocks. The Cu-Ag-Zn deposits occur in chemically reduced shales and siltstones that overlay oxidized sandstones.

**4. Date of Initial Issue:**

4 February 2020.

**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:**

- 2 acid digestion with Manual Titration Finish
- 3 acid digestion with Electro Gravimetric finish
- Aqua Regia digestion with ICP-OES finish
- Aqua Regia digestion with Electro Gravimetric finish
- Sodium peroxide fusion with Auto/Manual Titration
- Pressed Pellet with XRF finish
- 4 acid digestion with AAS finish

**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 Al, Ca, Co, Cu (Total) Cu (soluble), Fe, Mg, Ni, Pb, S, Si and Zn.

## 9. Participating Laboratories:

No	LABORATORY	COUNTRY
1.	AHK DRC South	DRC
2.	AHK Kitwe	Zambia
3.	AHK Lumwana	Zambia
4.	Alex Stewart Zambia	Zambia
5.	ALS Geochemistry Kempton Park	South Africa
6.	ALS Zambia	Zambia
7.	CG Worldwide	DRC
8.	Dundee Precious Metals	Namibia
9.	Intertek Tschudi	Namibia
10.	Lubambe Copper Mine	Zambia
11.	Mopani Mufulira	Zambia
12.	Mopani Nkana	Zambia
13.	Mutanda Mining	DRC
14.	Office Congolais de Controle (OCC)	DRC
15.	Palabora Mining Company	South Africa
16.	Rio Tinto Kennecott	USA
17.	Robinson International	DRC

## 10. Assay Data:

Data used for Assigning Values and Certification.

Laboratory	Al	Ca	Co	Cu	Cu (Soluble)	Fe	Mg	Ni	Pb	S	Si	Zn
	%	%	%	%	%	%	%	%	%	%	%	%
LAB001	0.378	0.346	0.837	22.62			0.643				6.1	17.4
LAB002				19.5								
LAB003				22.605								
LAB004	0.585	0.34		22.945	22.27	4.34	0.805		0.45	5.19	3.19	18.135
LAB005	0.585	0.33	0.71	22.435	19.265	4.3	0.695	0.084	0.425	5.555	3.085	19.79
LAB006	0.628		0.816	23.19	17.81	3.64		0.089	0.431	5.639	3.069	22.831
LAB007	0.508	0.311	0.793	21.915	18.325	3.872	0.555	0.218	0.469		3.195	18.735
LAB008				21.905								
LAB009				22.085								
LAB010			0.975	23.865								
LAB011			0.853	22.707		3.817		0.096	0.465			15.541
LAB012				26.035	17.3							
LAB013	2.755	0.4	0.76	20.03		2.43		0.07	0.275	4.605	3.565	14.65
LAB014	0.554	0.336	0.865	22.56	9018	4.38	0.671	0.026	0.465	5.435	2.16	16.975
LAB015	0.6	0.47	0.82	22.75	19.775	3.455	0.7	0.095	0.435	5.5		18.1
LAB016				22.855								
LAB017				22.176	17.735							
LAB018	0.635	0.355	0.82	23.03	18.935	4.055	0.73	0.1	0.495	5.57	3.22	18.375
LAB019				23.025								

#### 11. Method of Certification:

##### QLS is a SANAS Accredited Proficiency Testing Scheme Provider, No. PTS0012

This material was distributed as test items, in the Qotho Copper PT round 4 of 2018. Seventeen laboratories were each given 1 randomly selected sample from the batch, to analyze and report on in duplicate. Some laboratories reported results via more than one analytical method. All the data was collated, after which it was processed using Robust Statistics, through PROLab Plus.

Not all the participating laboratories were accredited. Equivalence tests were performed on all analytes to determine whether the data from the accredited and non-accredited laboratories, can be treated as equal (at a level of significance of  $\alpha = 0.05$ ). Where equivalent, all the data was used. Where not, only the data from the accredited laboratories were considered. Certification of analytes were then done, provided that a minimum of 10 datapoints remained available.

Where analytes cannot 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, QLS further applies an expanded uncertainty, for certification purposes.  $UCRM = k u_{CRM}$ , 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:  $x_{CRM} \pm UCRM$ .

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	%	8	2.306	0.038	$\pm 0.08$	$\pm 0.09$
Ca	%	7	2.365	0.015	$\pm 0.03$	$\pm 0.04$
Co	%	9	2.262	0.024	$\pm 0.05$	$\pm 0.06$
Cu	%	18	2.101	0.208	$\pm 0.42$	$\pm 0.44$
Cu (Soluble)	%	8	2.306	0.823	$\pm 1.6$	$\pm 1.9$
Fe	%	8	2.306	0.224	$\pm 0.45$	$\pm 0.52$
Mg	%	6	2.447	0.035	$\pm 0.07$	$\pm 0.09$
Ni	%	7	2.365	0.010	$\pm 0.02$	$\pm 0.03$
Pb	%	8	2.306	0.016	$\pm 0.03$	$\pm 0.04$
S	%	6	2.447	0.084	$\pm 0.17$	$\pm 0.21$
Si	%	7	2.365	0.122	$\pm 0.24$	$\pm 0.29$
Zn	%	9	2.262	0.908	$\pm 1.8$	$\pm 2.1$

#### 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. Most laboratories reported on the QA/QC CRM's used during the analysis of this QRM and reported the values obtained during the sample run. This provides additional evidence of measurement traceability.

**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 Laboratory Services, 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/Analytical Report.

Certifying & Technical Signatory	
<i>Dr Hannelie de Beer</i>	
<b>Qotho Managing Director</b>	<b>4 February 2020</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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