QOTHO MINERALS (PTY) LTD
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QOTHO CERTIFIED REFERENCE MATERIAL (QCRM)

QCRM-5-064

COPPER CONCENTRATE

CERTIFICATE OF ANALYSIS

CERTIFIED VALUES			
ANALYTES	**UNITS**	**CONCENTRATIONS**	**EXPANDED UNCERTAINTY**
Ag	g/t	89.3	±1.5
Al	%	2.10	±0.08
Ca	%	1.06	±0.06
Cu	%	14.93	±0.09
Fe	%	18.00	±0.37
Mg	%	1.39	±0.07
Mn	%	0.023	±0.002
Mo	%	0.98	±0.02
Pb	%	0.242	±0.006
S	%	22.06	±0.57
Si	%	13.55	±0.75
Zn	%	0.222	±0.008

ASSIGNED VALUES (FOR INFORMATION ONLY)			
ANALYTES	**UNITS**	**CONCENTRATIONS**	**EXPANDED UNCERTAINTY**
As	ppm	1327	±47
Au	g/t	7.7	±1.6
Bi	ppm	149	±42
Co	%	0.008	±0.002
Cu (soluble)	%	0.57	±0.10
K	%	1.66	±0.15
Na	%	0.23	±0.08
Ni	%	0.008	±0.002
Se	ppm	116	±22

1. **Use:**
QCRM-5-064 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.

This document was updated, as more data became available for As, Bi, Mo and Se. Only the data for these for analytes were received during this update, with two of the analytes becoming certifiable.

2. **Origin of Material:**
This composite mill feed copper ore sample was sponsored by Rio Tinto, Kennecott, in the USA.

3. **Mineral and Chemical Composition:**
The head or mill feed is dominated by meta-sediments with minor amounts of intermediate to felsic intrusive rocks of the Bingham Stock. The metasedimentary rocks comprise roughly equal proportions of pyrite-poor and -rich clean, orthoquartzite and hornfels with accessory amounts of skarn. Intrusive rocks are dominated by molybdenum-enriched monzonite and lesser quartz monzonite. The mineralogy of this ore is compositionally in agreement with the above ore-based assessment. Relative to historic data, 2006 through 2019, the ore exhibits higher concentrations of quartz, pyrite and magnesium-rich clay minerals. Lower than historic percentages of the economic minerals, i.e. Cu sulfides and molybdenite, as well as typical rock forming minerals, such as: feldspars, biotite and amphibole / pyroxenes are observed.

4. **Date of Initial Issue:**
2 June 2020.

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:**
- 4-Acid digestion with ICP-OES or AAS finish
- 3-Acid digestion with IC-OES or AAS Finish
- Aqua Regia digestion with ICP-OES finish
- Aqua Regia digestion with Electro Gravimetric Finish
- Sodium peroxide fusion with ICP-OES finish
- 3 Acid digestion with Manual Titration
- Fused beads with XRF finish
- Pressed powder with XRF 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, Bi, Ca, Co, Cu, Cu (Soluble), Fe, K, Mg, Mn, Mo, Na, Ni, Pb, S, Se, 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 Inspection UK	United Kingdom
5.	ALS Zambia	Zambia
6.	Dundee Precious Metals	Namibia
7.	Intertek LSI	Netherlands
8.	Kamoto Copper Company	Democratic Republic of Congo
9.	Lubambe Copper Mine	Zambia
10.	Mintek	South Africa
11.	Mopani Mufulira	Zambia
12.	Mutanda Mining	Democratic Republic of Congo
13.	OCC Kolwezi	Democratic Republic of Congo
14.	OCC Likasi	Democratic Republic of Congo
15.	OCC Lubumbashi	Democratic Republic of Congo
16.	OCC Tenke	Democratic Republic of Congo
17.	Palabora Mining Company	South Africa
18.	Rio Tinto Kennecott	United States of America
19.	Robinson International	Democratic Republic of Congo
20.	SGS Lakefield	Canada
21.	SGS Netherlands BV	Netherlands
22.	Societe de Surveilance Mine Lab	Democratic Republic of Congo
23.	UIS Analytical Services ICP	South Africa
24.	UIS Analytical Services XRF	South Africa

10. Assay Data:

Data used for Assigning Values and Certification.

LAB	Ag	Al	As	Au	Bi	Ca	Co	Cu	Cu (Soluble)	Fe	K
UNIT	g/t	%	ppm	g/t	ppm	%	%	%	%	%	%
LAB001			1300		< 1000.00						
LAB002			1300		< 1000.00						
LAB003			1300								
LAB004			1300								
LAB005			1255.5		135						
LAB006			1208.5		130						
LAB007			1425		167.5						
LAB008			1395		141						
LAB009			1980								
LAB010			2020								
LAB011					101.5						
LAB012					106.5						
LAB013											
LAB014											
LAB015											
LAB016											
LAB017											
LAB018											
LAB019											
LAB020											
LAB021											
LAB022											
LAB023											
LAB024											
LAB025		1.836	1215	36.99	159.5	1.042	0.007	15.175		17.2	1.649
LAB026								14.45			
LAB027		2.04				0.887		15.545		18.752	
LAB028		2.181	1410.25			1.121	0.01	14.931		18.326	1.722
LAB029							0.033	15.56		17.715	
LAB030		1.68				1.041	0.007	12.19		16.35	1.577
LAB031							0.02	16.369		17.247	
LAB032		2.216	1348.22				0.007	14.79	0.335	18.305	
LAB033		1.569				0.96	0.053	15.177	0.319	18.548	
LAB034	89.5	2.26				0.93		14.855	0.655		
LAB035								14.775			
LAB036								15			
LAB037		2.422				0.91	0.027	13.463	0.549	16.16	
LAB038								13.88			
LAB039							0.009	15.779		17.918	

LAB	Ag	Al	As	Au	Bi	Ca	Co	Cu	Cu (Soluble)	Fe	K
UNIT	g/t	%	ppm	g/t	ppm	%	%	%	%	%	%
LAB040	89.85	2.06	1371	8.2		1.2	0.007	14.87		18.4	
LAB041	89.5	2.1	1383.75			1.08	0.006	15.075	0.637	18	
LAB042								14.965			
LAB043	143.85	2.143	1210	6.56				14.775	0.805	19.268	
LAB044	87.5	2.145	1400	7.8		1.12	< 0.010	14.89		18.17	
LAB045	88.75	2.13	1370		120.5	1.1	< 0.020	15	0.743	18.195	1.715
LAB046								14.88			
LAB047									0.725		
LAB048								15.07			
LAB049	90.515	2.05	1214		220	1.215	0.006	14.975		19.535	
LAB050								14.805		17.04	
LAB051								14.891			
LAB052	90.495	2.11	1248.5		205	1.225	0.006	14.955		19.035	3.945
LAB053		2.224	1347.41				0.007	14.755	0.35	18.175	
LAB054	92.1	2.205	1425		< 1000.000	1.145	< 0.020	14.8	0.686	18.775	1.78
LAB055								14.835			
LAB056	86.5	2.13				0.965		14.86	0.595		
LAB057								14.605			
LAB058		2.461				1.02	0.035	14.265	0.67	16.75	
LAB059								13.915			
LAB060									0.725		
LAB061								14.975			
LAB062	145.5	2.143	1245	6.45				14.775	< 0.010	19.191	
LAB063								14.83			
LAB064							0.024	15.265		17.355	
LAB065								14.86		17.255	
LAB066								14.888			
LAB067							0.009	15.883		17.788	
LAB068		2.04				0.887		15.545		18.752	
LAB069		1.819	1205	36.995	154.5	1.018	0.007	14.785		17.05	1.647
LAB070								14.3			
LAB071		1.789				0.94	0.051	15.175	0.322	18.528	
LAB072							0.026	15.581		18.242	
LAB073		1.411				1.134	0.007	10.715		16.63	1.365
LAB074		2.182	1461.65			1.12	0.009	14.892		18.226	1.706
LAB075	90	2.09	1387.79			1.07	0.006	15.005	0.621	17.88	
LAB076								14.985			
LAB077	90.1	2.055	1367.5	8.25		1.17	0.007	14.85		18.455	
LAB078	87	2.13	1400	8.7		1.105	< 0.010	14.905		18.14	

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LAB	Mg	Mn	Mo	Na	Ni	Pb	S	Se	Si	U	Zn
UNIT	%	%	%	%	%	%	%	ppm	%	ppm	%
LAB001								< 200.00			
LAB002								< 200.00			
LAB003											
LAB004											
LAB005								128			
LAB006								118.5			
LAB007								136.5			
LAB008								126			
LAB009											
LAB010											
LAB011								86.65			
LAB012								88.15			
LAB013			0.985								
LAB014			0.945								
LAB015			0.985								
LAB016			0.98								
LAB017			0.97								
LAB018			0.975								
LAB019			0.95								
LAB020			0.98								
LAB021			0.96								
LAB022			0.975								
LAB023			1								
LAB024			1.005								
LAB025	1.341	0.02		0.186	0.007	0.229	20.95	173.5			0.198
LAB026											
LAB027	1.493								13.13		
LAB028		0.027			0.142	0.247	21.787		14.596		0.214
LAB029		0.019									
LAB030	1.192	0.021			0.007	0.246	21		12.369		0.22
LAB031											
LAB032	1.535					0.227	23.326		13.344		0.203
LAB033	1.449	0.022			0.039	0.24			6.848		0.332
LAB034	1.345					0.255					0.23
LAB035											
LAB036											
LAB037	0.865	0.03				0.181	23.4		13.95		0.222
LAB038											
LAB039					0.027						0.258
LAB040	1.42	0.021			0.008	0.24	21.28		13.82	< 10.00	0.23
LAB041	1.355	0.025			0.008	0.24			14.227	< 5.00	0.22
LAB042											

LAB	Mg	Mn	Mo	Na	Ni	Pb	S	Se	Si	U	Zn
UNIT	%	%	%	%	%	%	%	ppm	%	ppm	%
LAB043	1.477	0.045					22.655		12.808		0.227
LAB044	1.49	0.02			< 0.010	0.245	22.775		13.99		0.22
LAB045	1.32	0.019		0.22	0.01	0.235	20.65	200		< 10.00	0.22
LAB046											
LAB047											
LAB048											
LAB049	1.325	0.033		0.285	0.01	0.25	21.386				0.227
LAB050											
LAB051											
LAB052	1.265	0.033		0.285	0.01	0.25	21.782				0.226
LAB053	1.57					0.229	23.581		13.143		0.203
LAB054	1.37	0.02		0.23	0.007	0.25	22	< 200.00		< 10.00	0.225
LAB055											
LAB056	1.325					0.245					0.23
LAB057											
LAB058	0.83	0.026				0.203	23.3		14.02		0.201
LAB059											
LAB060											
LAB061											
LAB062	1.479	0.045					22.651		12.416		0.229
LAB063											
LAB064		0.023									
LAB065											
LAB066											
LAB067					0.026						0.253
LAB068	1.493								13.072		
LAB069	1.317	0.019		0.187	0.007	0.229	21.45	99			0.201
LAB070											
LAB071	1.397	0.024			0.04	0.254			6.93		0.344
LAB072											
LAB073	1.063	0.018			0.007	0.252	21.55		11.636		0.248
LAB074		0.024			0.056	0.245	21.68		14.585		0.212
LAB075	1.345	0.02			0.008	0.24			14.726	< 5.00	0.22
LAB076											
LAB077	1.42	0.021			0.009	0.24	21.175		13.91	< 10.00	0.23
LAB078	1.485	0.02			< 0.010	0.245	22.88		14.225		0.22

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 6 of 2019. 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. Additional commercial assays were done for certain analytes, upon the request of the client. 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 13528:2015 (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. 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
Ag	g/t	2.241	13	2.160	0.717	± 1.4	± 1.5
Al	%	0.148	27	2.052	0.036	± 0.07	± 0.08
As	ppm	101.494	27	2.052	23.115	± 46	± 47
Au	g/t	2.105	7	2.365	0.687	± 1.4	± 1.6
Bi	ppm	73.963	13	2.160	19.606	± 39	± 42
Ca	%	0.118	23	2.069	0.03	± 0.06	± 0.06
Co	%	0.004	27	2.052	0.001	± 0.002	± 0.002
Cu	%	0.321	51	2.008	0.044	± 0.09	± 0.09
Cu (Soluble)	%	0.163	15	2.131	0.048	± 0.10	± 0.10
Fe	%	0.87	33	2.035	0.183	± 0.37	± 0.37
K	%	0.138	8	2.306	0.062	± 0.12	± 0.15
Mg	%	0.127	25	2.060	0.031	± 0.06	± 0.07
Mn	%	0.004	23	2.069	0.001	± 0.002	± 0.002
Mo	%	0.021	11	2.201	0.007	± 0.01	± 0.02
Na	%	0.065	5	2.571	0.031	± 0.06	± 0.08

Analyte	Unit of measure	*s* (Standard Deviation of Dataset)	*v* (Degrees of Freedom)	*k* (Coverage Factor)	*u* (Standard Uncertainty)	95% Measurement Uncertainty	Expanded Uncertainty
Ni	%	0.004	19	2.093	0.001	± 0.002	± 0.002
Pb	%	0.012	23	2.069	0.003	± 0.006	± 0.006
S	%	0.962	19	2.093	0.27	± 0.54	± 0.57
Se	ppm	27.418	11	2.201	9.767	± 20	± 22
Si	%	1.301	19	2.093	0.357	± 0.71	± 0.75
Zn	%	0.017	27	2.052	0.004	± 0.008	± 0.008

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	
	
Qotho Managing Director	***29 April 2022***

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.

END