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QOTHO CERTIFIED REFERENCE MATERIAL (QCRM)

QCRM-5-096

COPPER CONCENTRATE

CERTIFICATE OF ANALYSIS

CERTIFIED VALUES			
ANALYTES	**UNITS**	**CONCENTRATIONS**	**EXPANDED UNCERTAINTY**
Ag	g/t	311	±5.6
Al	%	0.85	±0.06
As	%	1.84	±0.04
Au	g/t	17.22	±0.53
Ca	%	2.38	±0.12
Co	%	0.009	±0.002
Cu	%	29.48	±0.43
Cu (Soluble)	%	4.37	±0.40
Mg	%	0.41	±0.03
Mn	%	0.04	±0.01
Ni	%	0.009	±0.004
S	%	10.72	±0.37
Zn	%	2.59	±0.17
ASSIGNED VALUES (FOR INFORMATION ONLY)			
ANALYTES	**UNITS**	**CONCENTRATIONS**	**EXPANDED UNCERTAINTY**
Bi	ppm	676	±38
Cd	ppm	74	±15
Fe	%	19.92	±0.97
Pb	%	2.29	±0.08
Sb	%	0.57	±0.15
Si	%	6.77	±0.30

1. **Use:**
QCRM-5-096 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 has been amended, as more data became available (through commercial analysis), thus enabling the certification of additional analytes.

2. **Origin of Material:**
This standard originates from the Dundee Precious Metals, Tsumeb Copper Smelter in Namibia.

3. **Mineral and Chemical Composition:**
The material is a Copper Concentrate that originates from the flotation process product stream of Dundee Precious Metals Tsumeb Smelter, in the Oshikoto Region of Namibia. Slag material skimmed from the various furnaces is cooled and passed to the slag mill for milling, followed by the concentration of copper by conventional flotation. The concentrates produced are incorporated into the smelting process. The feed slag material contains mainly Copper, Silica and Calcium Carbonate which is the typical content of the Slags.

4. **Date of Initial Issue:**
21 October 2021.

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. On special request of the client, a portion of the material was packaged as 500g plastic tubs (by combining individual zip-lock units), for the client.

7. **Methods of Analysis used:**
- 4-acid digestion with either AAS or ICP-OES finish
- 3-acid digestion with AAS, ICP-OES or ICP-MS finish
- 2 or 3-acid digestion with electro-gravimetric finish
- Aqua Regia digestion with ICP-OES finish
- Sodium peroxide fusion with ICP-OES finish
- Fused beads with XRF finish
- Acid soluble copper by dilute sulphuric leach and AAS finish
- Gold by lead collection fire assay with AAS or ICP-OES 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, Mg, Mn, Ni, Pb, S, Sb, Si and Zn.

9. Participating Laboratories:

NO	LABORATORY	COUNTRY
1.	Alex Stewart International	United Kingdom
2.	ALS Geochemistry Kempton Park	South Africa
3.	ALS Zambia	Zambia
4.	BMC Analysis	United Kingdom
5.	Dundee Precious Metals	Namibia
6.	Dundee Precious Metals – Process Control	Namibia
7.	Intertek LSI	Netherlands
8.	Intertek Tschudi	Namibia
9.	Kamoto Copper Company	Democratic Republic of Congo
10.	Lubambe Copper Mine	Zambia
11.	Mintek	South Africa
12.	Mopani Mufulira	Zambia
13.	Mutanda Mining	Democratic Republic of Congo
14.	OCC Kolwezi	Democratic Republic of Congo
15.	OCC Likasi	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.	Sable Zinc	Zambia
20.	SGS Lakefield	Canada
21.	SGS Netherlands	Netherlands
22.	SGS Randfontein	South Africa
23.	SGS Vaal River	South Africa
24.	Zambia revenue Authority	Zambia

10. Assay Data:

Data used for Assigning Values and Certification.

LABORATORY	Ag	Al	As	Au	Bi	Ca	Cd	Co	Cu	Cu (Soluble)	Fe	Hg	Mg	Mn	Ni	Pb	S	Sb	Si	U	Zn
UNIT	g/t	%	%	g/t	ppm	%	ppm	%	%	%	%	ppm	%	%	%	%	%	%	%	ppm	%
LAB001	316.096																				
LAB002	315.863																				
LAB003	316.21																				
LAB004	316.242																				
LAB005	313.121																				
LAB006	300																				
LAB007	301.5																				
LAB008	307																				
LAB009	297.5																				
LAB010	465																				
LAB011			1.845																		
LAB012			1.795																		
LAB013			1.8																		
LAB014			1.835																		
LAB015			1.795																		
LAB016			1.845																		
LAB017			1.8																		
LAB018			1.805																		
LAB019			1.81																		
LAB020			1.8																		
LAB021				17.225																	
LAB022				17.23																	

LABORATORY	Ag	Al	As	Au	Bi	Ca	Cd	Co	Cu	Cu (Soluble)	Fe	Hg	Mg	Mn	Ni	Pb	S	Sb	Si	U	Zn
UNIT	g/t	%	%	g/t	ppm	%	ppm	%	%	%	%	ppm	%	%	%	%	%	%	%	ppm	%
LAB023				17.045																	
LAB024				17.045																	
LAB025				18.46																	
LAB026				19.348																	
LAB027				17.444																	
LAB028				17.404																	
LAB029	312.21		1.765		670.5	2.386	77	0.008			21.53		0.391	0.042	0.008	2.21	10.5	0.603	5.476		2.579
LAB030			1.815		666.5						17.35				< 0.012	2.07		0.529			2.285
LAB031																			6.497		
LAB032		0.849				2.631			31.523		21.935		0.362				10.316		6.337		
LAB033										3.72	19.663			0.055		2.229					2.97
LAB034								0.012			19.66			0.041	0.013						
LAB035		0.79				2.395			29.25				0.43	< 0.050	< 0.050	2.375	11.25		7.26	< 10.000	
LAB036									29.275												
LAB037		0.905	1.936			2.16			29.145		22.16					2.505	10.265		6.67		2.68
LAB038									29.835												
LAB039								0.009	30.2					0.028							
LAB040						0.702		0.007	28.874	4.654	17.081		0.684	0.035			11.6				
LAB041										4.265	20.94					2.425	11.125		6.705		2.69
LAB042								0.035			18.045			0.03							
LAB043									27.549												
LAB044	315.5	0.855	1.98	16.3	685	2.43	85.5	0.008	28.855		21.625	2	0.41		0.009	2.435	10.76	0.680	7.2	4.5	2.415
LAB045										4.9											
LAB046	125.5	1.048	0.057			2.314		< 0.001		3.845	20.43		0.397	0.043	< 0.001	2.365	9.768		7.075		2.792

LABORATORY	Ag	Al	As	Au	Bi	Ca	Cd	Co	Cu	Cu (Soluble)	Fe	Hg	Mg	Mn	Ni	Pb	S	Sb	Si	U	Zn
UNIT	g/t	%	%	g/t	ppm	%	ppm	%	%	%	%	ppm	%	%	%	%	%	%	%	ppm	%
LAB047		0.813			531.7	2.29	< 100.000					3.01			0.01	2.135		0.463	7.1		2.405
LAB048	25.75	0.645	< 0.001			4.33		< 0.020		4.75	17.465		1.185	0.04	0.01	2.115	10.35			12.5	2.455
LAB049										4.025											
LAB050									31.045												
LAB051		0.905				2.574		0.015	29.192		20.563		0.42	0.035							
LAB052									29.17												
LAB053									29.46												
LAB054	36.6	0.745	0.002			7.88		< 0.020		4.685	19.35		1.91	0.05	0.01	2.11	10.35			30	2.46
LAB055										5.07											
LAB056									29.32												
LAB057		0.865	1.926			2.195			29.135		22.88					2.49	10.21		6.74		2.64
LAB058									30.08												
LAB059										4.285	21.35					2.42	11.235		6.695		2.725
LAB060	313.5	0.855	1.97	16.6	690	2.45	85.5	0.008	28.93		21.455	2	0.425		0.009	2.415	10.87	0.680	7.155	4.5	2.445
LAB061		0.9																			
LAB062						2.316		0.01	28.703		19.697		0.395	0.035							
LAB063						0.674		0.007	30.029	4.616	17.006		0.672	0.03			11.9				
LAB064										4.405											
LAB065									29.745												
LAB066		0.795		16.85		2.405			29.65				0.435	< 0.050	< 0.050	2.37	11.2		7.415	< 10.000	
LAB067	144	1.039	0.588			2.364		< 0.001		4.015	20.823		0.408	0.045	< 0.001	2.383	10.364		7.067		2.84
LAB068								0.009	30.365					0.028							
LAB069								0.015			18.56			0.041	0.014						
LAB070									29.25												

LABORATORY	Ag	Al	As	Au	Bi	Ca	Cd	Co	Cu	Cu (Soluble)	Fe	Hg	Mg	Mn	Ni	Pb	S	Sb	Si	U	Zn
UNIT	g/t	%	%	g/t	ppm	%	ppm	%	%	%	%	ppm	%	%	%	%	%	%	%	ppm	%
LAB071									29.155												
LAB072								0.033			18.015			0.03							
LAB073		0.855				2.408			30.64		22.211		0.398				10.218		6.248		
LAB074	313.635		1.837		691	2.454	83	0.008			21.44		0.402	0.042	0.009	2.266	10.95	0.619	5.592		2.657
LAB075			1.84		652.5						17.55				< 0.010	2.097		0.530			2.28
LAB076																			6.451		
LAB077										3.985	19.276			0.069		2.244					3.327
LAB078		0.808			526.72	2.28	< 100.000					3.01			0.01	2.115		0.454	7.125		2.375
LAB079									27.441												

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 2 of 2021. 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. 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.

After the initial certification, commercial analysis was initiated for Ag, Au and As, at global facilities that are ISO 17025 accredited to perform these analyses. This data was added to the original dataset and the certification protocol was repeated, enabling the certification of the three additional analytes.

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.

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	*s* (Standard deviation of dataset)	*v* (degrees of freedom)	k (coverage factor)	*u* (Standard uncertainty)	95% measurement uncertainty	Expanded measurement uncertainty
Ag	g/t	20.139	17	2.110	2.633	± 5.3	± 5.6
Al	%	0.097	15	2.131	0.029	± 0.06	± 0.06
As	%	0.08	21	2.080	0.020	± 0.04	± 0.04
Au	g/t	0.656	10	2.228	0.237	± 0.47	± 0.53
Bi	ppm	28.731	7	2.365	15.937	± 32	± 38
Ca	%	0.198	19	2.093	0.057	± 0.11	± 0.12
Cd	ppm	11.383	5	2.571	5.765	± 12	± 15
Co	%	0.004	17	2.110	0.001	± 0.002	± 0.002
Cu	%	0.798	23	2.069	0.21	± 0.42	± 0.43
Cu (Soluble)	%	0.524	13	2.160	0.185	± 0.37	± 0.40
Fe	%	1.924	25	2.060	0.47	± 0.94	± 0.97
Mg	%	0.043	15	2.131	0.012	± 0.02	± 0.03

Analyte	Unit of measure	*s* (Standard deviation of dataset)	*v* (degrees of freedom)	k (coverage factor)	*u* (Standard uncertainty)	95% measurement uncertainty	Expanded measurement uncertainty
Mn	%	0.01	19	2.093	0.003	± 0.01	± 0.01
Ni	%	0.003	15	2.131	0.002	± 0.004	± 0.004
Pb	%	0.149	19	2.093	0.038	± 0.08	± 0.08
S	%	0.653	17	2.110	0.174	± 0.35	± 0.37
Sb	%	0.138	7	2.365	0.061	± 0.12	± 0.15
Si	%	0.49	17	2.110	0.143	± 0.29	± 0.30
Zn	%	0.258	17	2.110	0.078	± 0.16	± 0.17

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	***27 January 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.

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