

QOTHO CERTIFIED REFERENCE MATERIAL (QCRM)

QCRM-5-114

COPPER CONCENTRATE

CERTIFICATE OF ANALYSIS

CERTIFIED VALUES			
ANALYTES	UNITS	CONCENTRATIONS	EXPANDED UNCERTAINTY
Ag	g/t	30.1	±2.3
Al	%	0.36	±0.04
Ca	%	7.80	±0.42
Co	%	0.095	±0.006
Cu	%	26.05	±0.16
Cu (Soluble)	%	1.19	±0.10
Fe	%	20.06	±0.44
Mg	%	2.15	±0.10
Mn	%	0.042	±0.002
Pb	%	0.016	±0.004
S	%	19.86	±0.54
Zn	%	0.07	±0.01
ASSIGNED VALUES (FOR INFORMATION ONLY)			
ANALYTES	UNITS	CONCENTRATIONS	EXPANDED UNCERTAINTY
Au	g/t	1.69	±0.17
Ni	%	0.15	±0.01
Si	%	1.61	±0.11

1. Use:

QCRM-5-114 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 COA has been updated, as more data became available, rendering more analytes, certifiable.

2. Origin of Material:

The material was supplied by Palabora Mining Company Ltd.

3. Mineral and Chemical Composition:

This concentrate traces its origin from a unique geological formation known as the Palabora Igneous Complex. The geology of the ore includes carbonatites and a host of other minerals such as phosphates, vermiculite, phlogopite, magnetite, nickel, gold, silver, platinum and palladium. The concentrate was produced via a flotation process.

4. Date of Initial Issue:

27 January 2023.

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:

- Fused Beads with XRF finish
- Pressed Powder with XRF finish
- Peroxide Fusion with AAS or ICP-OES finish
- Multi-acid Digestion with AAS or ICP-OES finish
- Copper by multi-acid digestion with Electro Gravimetric finish
- Copper by multi-acid digestion with Potentiometric Titration
- Oxide copper by 5-10% H₂SO₄ Leach with AAS Finish
- Gold by fire assay and gravimetric finish
- Sulphur by Thermal Combustion and Infrared detection.

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, Cd, Co, Cu, Cu (Soluble), Fe, Mg, Mn, Ni, Pb, S, Si, U and Zn.

9. Participating Laboratories:

No	LABORATORY	COUNTRY
1.	Africa Laboratory Specialists	Namibia
2.	AHK Kitwe	Zambia
3.	AHK Lumwana	Zambia
4.	Alex Stewart International	United Kingdom
5.	ALS Geochemistry Kempton Park	South Africa
6.	ALS Zambia	Zambia
7.	Bisha Mining Share Company	Eritrea
8.	Black Mountain Mining	South Africa
9.	BMC Analysis	United Kingdom
10.	Dundee Precious Metals	Namibia
11.	Dundee Precious Metals - Process Control	Namibia
12.	Ensayos Tecnicos Labmin SRL	Peru
13.	Ero Brasil Caraiba	Brazil
14.	Intertek Tschudi	Namibia
15.	Kamoto Copper Company	Democratic Republic of Congo
16.	Lubambe Copper Mine	Zambia
17.	Maelgwyn SA	South Africa
18.	Metalkol	Democratic Republic of Congo
19.	Misenge Environmental & Technical	Zambia
20.	Mopani Nkana	Zambia
21.	Mopani Mufulira	Zambia
22.	MSALabs Tanzania	Tanzania
23.	Mutanda Mining	Democratic Republic of Congo
24.	OCC Kolwezi	Democratic Republic of Congo
25.	OCC Lubumbashi	Democratic Republic of Congo
26.	OCC Tenke	Democratic Republic of Congo
27.	Palabora Mining Company	South Africa
28.	Rio Tinto Kennecott	United States of America
29.	Sable Zinc	Zambia
30.	SGS Mineral RDC SAS Kamao	Democratic Republic of Congo
31.	Sherritt International Corporation	Canada
32.	SSM Kolwezi	Democratic Republic of Congo
33.	UIS Analytical Services	South Africa
34.	Zambia Revenue Authority	Zambia



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10. Assay Data:

Data used for Assigning Values and Certification.

LABORATORY	Ag	Al	As	Au	Ca	Cd	Co	Cu	Cu (Soluble)	Fe	Mg	Mn	Ni	Pb	S	Si	U	Zn
UNIT	g/t	%	µg/g	g/t	%	µg/g	%	%	%	%	%	%	%	%	%	%	µg/g	%
LAB001			310		9.453								0.058			1.756		
LAB002	39.5						0.102	27.62	1.234	19.456	2.08	0.04	0.154		20.721			0.068
LAB003									1.097									
LAB004								26.021										
LAB005	29.55		< 100.000	1.725		< 100.000	0.075	26.26				0.045	0.144	0.015		1.539		0.069
LAB006								26.085										
LAB007					6.652		0.131	27.234	1.129		1.771	0.04			18.15			
LAB008						9												
LAB009							0.097	26.276		18.79								
LAB010		0.379			8.093			26.587		20.687	2.302	0.043			18.946	1.499		
LAB011	28.545	0.343	< 26.000	1.72	6.854	< 17.000	0.088	23.9		18.455		0.04	0.132	0.011	20.05	1.915		0.058
LAB012			23					26.195					0.134	0.012				
LAB013								26.335										
LAB014					8.236		0.093	25.309	1.284	19.85	2.325	0.048	0.14					0.066
LAB015		0.42	32		7.755	11.95	0.09			21.3	2.06	0.04	0.15	0.015	19.45		40	0.1
LAB016								26										
LAB017								25.875										
LAB018	22	0.35			6.24					20.175	2.175			0.02	19.49	1.665		0.08
LAB019								25.945										
LAB020							0.102			20.395		0.033	0.146					
LAB021						< 49.000							0.156			1.555		
LAB022	30.12	0.39	5.35	3.285	7.768	26.8	0.103	26.275		20.222	2.139	0.043	0.136	0.016	19.522	1.65	42.95	0.069
LAB023								26.08										
LAB024	31.8	0.318	72.999		7.27	15.159	0.09	26.115	1.105	18.611	2.098	0.042	0.214	0.018		1.423		0.073
LAB025								26.07										
LAB026	27.685	0.345	66.605		7.466	15.455					2.161	0.045	0.232					0.068



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LABORATORY	Ag	Al	As	Au	Ca	Cd	Co	Cu	Cu (Soluble)	Fe	Mg	Mn	Ni	Pb	S	Si	U	Zn
UNIT	g/t	%	µg/g	g/t	%	µg/g	%	%	%	%	%	%	%	%	%	%	µg/g	%
LAB027		0.459			8.037					20.07	2.087				19.898	1.633		
LAB028								25.794										
LAB029	27.907							26.572						0.013				0.059
LAB030					7.916		0.1	25.28	0.965	19.9	2.353	0.05	0.131	0.013				0.075
LAB031								26.125										
LAB032								26.357										
LAB033		0.376			8.238		0.095	25.835		20.13	2.193	0.044	0.151	0.025	19.31	1.482		0.068
LAB034							0.09	25.27		18.5		0.025	0.139					
LAB035	29.001	0.328	53.951	1.633	9.308	10.492	0.097	25.967	1.432	20.439	2.543	0.043	0.148	0.016	20.381	1.634		0.06
LAB036								25.903										
LAB037					8.587		0.084	25.8		19.718	2.345	0.042	0.13					0.073
LAB038			175					26.535		20.31					19.78	1.64		0.075
LAB039	32.898	0.395	7.946				0.09	26.15	1.12	21.705	2.29		0.16	0.02	20.688			0.088
LAB040								26.205										
LAB041	30.559	0.391					0.089	26.27	1.051	21.542	2.073	0.036	0.134	0.017	20.531	1.677		0.034
LAB042	30.25	0.26	24.5		7.775		0.105	26.05	1.38	19.215	1.835	0.04	0.15	0.013	19.55			
LAB043								26.11										
LAB044									1.13									
LAB045								23.325										
LAB046		0.37	< 100.000	1.67	6.485			26.33		20.82	1.635			0.01	21.475	1.58		0.08
LAB047								25.45										
LAB048			255						1.2	19.775				0.02	19.76	3.34		0.08
LAB049								25.72										
LAB050	33.167	0.197	< 0.010				0.086	26.34		20.531	2.105	0.04		0.024				0.063
LAB051					8.125		0.11	25.885	1.17		2.015	0.06					21.2	
LAB052									1.31									
LAB053								25.35										
LAB054		0.341			7.857			26.49	1.37		2.213	0.041	0.148	0.009	20.779	1.735		0.073



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LABORATORY	Ag	Al	As	Au	Ca	Cd	Co	Cu	Cu (Soluble)	Fe	Mg	Mn	Ni	Pb	S	Si	U	Zn
UNIT	g/t	%	µg/g	g/t	%	µg/g	%	%	%	%	%	%	%	%	%	%	µg/g	%
LAB055								25.84										
LAB056								25.795		19.15			0.139	0.022				
LAB057								25.005		19.9		0.038	0.171					
LAB058		0.339			8.047			26.053		20.45	2.283				18.859	1.115		
LAB059								26.41	1.115									
LAB060													0.161			1.59		
LAB061							0.102	24.2		21.55								

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 2023 & Round 6 of 2021. In each round, the participating laboratories were 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:

Standard uncertainty, u_{CRM} , was calculated according to ISO 13528:2022 (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: $U_{CRM} = k u_{CRM}$, 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.

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	3.308	12	2.179	1.051	± 2.1	± 2.3
Al	%	0.048	16	2.120	0.017	± 0.03	± 0.04
Au	g/t	0.238	4	2.776	0.062	± 0.12	± 0.17
Ca	%	0.678	19	2.093	0.198	± 0.40	± 0.42
Co	%	0.010	20	2.086	0.003	± 0.006	± 0.006
Cu	%	0.443	47	2.012	0.08	± 0.16	± 0.16
Cu (Soluble)	%	0.138	15	2.131	0.045	± 0.09	± 0.10
Fe	%	0.925	26	2.056	0.214	± 0.43	± 0.44
Mg	%	0.190	21	2.080	0.047	± 0.09	± 0.10
Mn	%	0.005	21	2.080	0.001	± 0.002	± 0.002
Ni	%	0.016	23	2.069	0.004	± 0.01	± 0.01
Pb	%	0.006	18	2.101	0.002	± 0.004	± 0.004
S	%	0.838	17	2.110	0.256	± 0.51	± 0.54
Si	%	0.151	17	2.110	0.049	± 0.10	± 0.11
Zn	%	0.012	20	2.086	0.003	± 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/IEC 17025:2017 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 33401: 2024, ISO/IEC 17043: 2023 and ISO 17034: 2016 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 Signatories	
<i>Dr Hannelie de Beer (Pr. Sci. Nat.)</i>	<i>Takudzwa Tsapayi (Pr. Sci. Nat.)</i>
15 August 2024	

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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