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QOTHO CERTIFIED REFERENCE MATERIAL (QCRM)

QCRM-5-151

COPPER ORE

CERTIFICATE OF ANALYSIS

CERTIFIED VALUES			
ANALYTES	**UNITS**	**CONCENTRATIONS**	**EXPANDED UNCERTAINTY**
Cu	%	1.02	±0.02
Fe	%	7.74	±0.18
Mg	%	4.00	±0.13
Mn	%	0.067	±0.004
Pb	%	0.006	±0.002
S	%	1.60	±0.11
Zn	%	0.003	±0.001
ASSIGNED VALUES (FOR INFORMATION ONLY)			
ANALYTES	**UNITS**	**CONCENTRATIONS**	**EXPANDED UNCERTAINTY**
Al	%	0.12	±0.03
Ca	%	27.02	±0.72
Co	%	0.015	±0.005
Cu (Soluble)	%	0.080	±0.005
Ni	%	0.020	±0.002
Si	%	0.68	±0.21

1. **Use:**
QCRM-5-151 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:**
The material was supplied by Palabora Mining Company Ltd. It is a copper mine that also operates a smelter and refinery complex based in the town of Phalaborwa, in South Africa's Limpopo Province.

3. **Mineral and Chemical Composition:**
The ore traces its origin from a unique geological formation known as the Palabora Igneous Complex. The geology of the ore includes carbonitites and a host of other minerals such as phosphates, vermiculite, phlogopite, magnetite, nickel, gold, silver, platinum and palladium.

4. **Date of Initial Issue:**
20 March 2024.

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:**
   - Multi-acid digestion with AAS or ICP-OES finish
   - Fused bead with XRF finish
   - Sodium peroxide fusion with ICP-OES finish
   - Acid soluble copper by weak sulphuric acid leach and AAS finish
   - Fluoride by hydroxide fusion and ISE finish
   - Silica by hydroxide fusion and AAS finish
   - Silver by fire assay and ICP-OES finish
   - Sulphur by thermal 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, C, Ca, Cd, Co, Cu, Cu (Soluble), F, Fe, Mg, Mn, Ni, Pb, S, Si, U and Zn.

9. Participating Laboratories:

No	LABORATORY	COUNTRY
1.	AHK DRC South	Democratic Republic of Congo
2.	AHK Kitwe	Zambia
3.	ALS Kansanshi	Zambia
4.	Aurubis Bulgaria	Bulgaria
5.	Ero Brasil Caraiba	Brazil
6.	Intertek Tschudi	Namibia
7.	Kamoto Copper Company	Democratic Republic of Congo
8.	Metalkol	Democratic Republic of Congo
9.	Mintek	South Africa
10.	Mutanda Mining	Democratic Republic of Congo
11.	OCC Likasi	Democratic Republic of Congo
12.	Palabora Mining Company	South Africa
13.	Quality Laboratory Services (Springbok)	South Africa
14.	Rio Tinto Kennecott	United States of America
15.	S.T.L DRC	Democratic Republic of Congo
16.	SGS Randfontein	South Africa

10. Assay Data:

Data used for Assigning Values and Certification.

LABORATORY	Ag	Al	As	Au	C	Ca	Cd	Co	Cu	Cu (Soluble)	F	Fe	Mg	Mn	Ni	Pb	S	Si	U	Zn
UNIT	g/t	%	ppm	g/t	%	%	ppm	%	%	%	ppm	%	%	%	%	%	%	%	ppm	%
LAB001	5	0.126				28.264			0.996	0.083		7.478	3.9	0.07	0.022	0.007	1.813			0.003
LAB002									0.896			6.724								
LAB003									1.094			7.178		0.078	0.033					0.005
LAB004		0.294						0.03	1.185			8.235			0.015					
LAB005		0.068		0.152	9.744	28.205		0.01				8.152		0.067	0.026	0.001	1.534			0.002
LAB006						26.646		0.018	1.155	0.131							1.49			
LAB007	1.028	0.069	< 26.00	0.091	10.3	24.865	< 17.00					7.499	3.624	0.06	0.021	0.005	1.635	0.62		0.004
LAB008			< 9.000									7.506			0.018	0.004				0.002
LAB009		0.077				26.285			0.985	0.08		7.752	4.101	0.065	0.018					0.002
LAB010									1.029											
LAB011	< 4.00	0.081	22.087			23.14	< 9.00	0.015	1.045	0.071	2103.5	8.075	3.91	0.058	0.021	0.01	1.555	1.234		0.009
LAB012	< 4.00	0.083	27.965				< 4.00	0.013	1.055			7.946	3.836	0.071	0.022	0.006				0.005
LAB013		0.188	22.5			27.19	0.25		1.004			8.181		0.066	0.014				46.04	
LAB014									1.047											
LAB015		0.148				27.682			0.831			8.198	4.086		0.02		1.391	0.472		0.003
LAB016									0.984											
LAB017		0.225						0.013	1.022	0.084		7.55	3.877	0.067	0.024		1.78	0.75		0.003
LAB018									1.009											
LAB019					9.88				0.998			7.63	4.319	0.065	0.015					0.003
LAB020		0.115				27.45			0.955			7.895	4.305	0.069			1.615	0.51		
LAB021										0.079										
LAB022									1.02											
LAB023		0.315						0.014	1.028	0.084		7.56	3.861	0.067	0.024		1.65	0.78		0.002
LAB024									1.009											

LABORATORY	Ag	Al	As	Au	C	Ca	Cd	Co	Cu	Cu (Soluble)	F	Fe	Mg	Mn	Ni	Pb	S	Si	U	Zn
UNIT	g/t	%	ppm	g/t	%	%	ppm	%	%	%	ppm	%	%	%	%	%	%	%	ppm	%
LAB025	< 4.00	0.082	14.499			23.055	< 9.000	0.015	1.025	0.075	2164.5	8.02	4.04	0.056	0.021	0.01	1.52	1.315		0.009
LAB026	< 4.00	0.081	33.14				< 4.000	0.013	1.022			7.923	3.929	0.066	0.021	0.006				0.003
LAB027										0.076										
LAB028									1											
LAB029		0.073		0.105	9.829	28.008		0.012				8.063		0.067	0.025	0.001	1.544			0.002
LAB030	5	0.105				28.483			1.004	0.082		7.522	3.881	0.07	0.022	0.007	1.84			0.003
LAB031						27.564		0.019	1.132	0.186							1.48			
LAB032		0.068				26.622			0.988	0.082		7.478	4.044	0.078	0.017					0.003
LAB033									1.041											
LAB034		0.125				27.85			0.965			7.97	4.35	0.069			1.615	0.51		
LAB035					10.3				1.002			7.57	4.225	0.074	0.015					0.004
LAB036									1.083			7.223		0.073	0.034					0.004
LAB037		0.146				26.748			0.817			7.971	4.019		0.021		1.44	0.524		0.002
LAB038									0.987											
LAB039									0.907			6.794								
LAB040	0.725	0.072	< 26.000	0.058	10.35	26.57	< 17.00					7.803	3.77	0.063	0.022	0.005	1.735	0.625		0.002
LAB041			< 9.000									7.631			0.018	0.004				0.002
LAB042		0.577						0.027	1.135			7.755			0.016					
LAB043		0.189	30			26.67	0.4		1.004			8.206		0.064	0.01				41.19	0.002
LAB044									1.024											

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 5 of 2023. 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.

12. Measurement of Uncertainty:

Standard uncertainty, uCRM, was calculated according to ISO 13528 (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
Al	%	0.057	21	2.080	0.013	± 0.03	± 0.03
Ca	%	1.223	17	2.110	0.341	± 0.68	± 0.72
Co	%	0.004	11	2.201	0.002	± 0.004	± 0.005
Cu	%	0.052	35	2.030	0.01	± 0.02	± 0.02
Cu (Soluble)	%	0.007	11	2.201	0.002	± 0.004	± 0.005
Fe	%	0.427	29	2.045	0.085	± 0.17	± 0.18
Mg	%	0.19	17	2.110	0.062	± 0.12	± 0.13
Mn	%	0.005	21	2.080	0.002	± 0.004	± 0.004
Ni	%	0.005	25	2.060	0.001	± 0.002	± 0.002
Pb	%	0.003	11	2.201	0.001	± 0.002	± 0.002
S	%	0.143	15	2.131	0.049	± 0.10	± 0.11
Si	%	0.221	9	2.262	0.09	± 0.18	± 0.21
Zn	%	0.001	22	2.074	0.0005	± 0.001	± 0.001

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/IEC 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 Signatories	
	
Dr Hannelie de Beer (Pr. Sci. Nat.)	***Takudzwa Tsapayi (Pr. Sci. Nat.)***
20 March 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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