

## QOTHO CERTIFIED REFERENCE MATERIAL (QCRM)

### QCRM-1-225

#### CHROME ORE

#### CERTIFICATE OF ANALYSIS

CERTIFIED VALUES			
ANALYTES	UNITS	CONCENTRATIONS	EXPANDED UNCERTAINTY
Al <sub>2</sub> O <sub>3</sub>	%	14.98	±0.14
CaO	%	0.70	±0.06
Cr <sub>2</sub> O <sub>3</sub>	%	38.28	±0.12
FeO	%	25.33	±0.25
MgO	%	8.67	±0.18
MnO	%	0.220	±0.004
S	%	0.004	±0.002
SiO <sub>2</sub>	%	8.37	±0.12
TiO <sub>2</sub>	%	1.05	±0.03
V <sub>2</sub> O <sub>5</sub>	%	0.38	±0.01
ASSIGNED VALUES (FOR INFORMATION ONLY)			
ANALYTES	UNITS	CONCENTRATIONS	EXPANDED UNCERTAINTY
P	%	0.006	±0.002

**1. Use:**

QCRM-1-225 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 Chrome Ore and as a calibration standard for the calibration of equipment used for analysing similar materials.

**2. Origin of Material:**

This standard was sponsored by Samancor Dikwena.

**3. Mineral and Chemical Composition:**

Chromite is found as ortho-cumulate lenses of chromitite in peridotite from the Earth's mantle. It also occurs in layered ultramafic intrusive rocks. In addition, it is found in metamorphic rocks such as some serpentinites. Ore deposits of chromite formed as early magmatic differentiates. It is commonly associated with olivine, magnetite, serpentine, and corundum. The vast Bushveld igneous complex of South Africa is a large layered mafic to ultramafic igneous body with some layers consisting of 90% chromite making the rare rock type. This ore originates from the western limb, of the Bushveld Complex

**4. Date of Initial Issue:**

11 November 2022.

**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:**

- Sodium peroxide fusion with ICP-OES or AAS finish
- Fused beads with XRF finish
- Pressed pellet with XRF finish
- Chrome by sodium peroxide fusion with Potentiometric Titration
- Calcium by Aqua Regia digestion and ICP-OES finish
- Phosphorous by sodium peroxide fusion and UV-VIS spectrophotometry finish
- Silica by sodium peroxide fusion and gravimetric 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  $\text{Al}_2\text{O}_3$ , CaO,  $\text{Cr}_2\text{O}_3$ , Cr:Fe Ratio, FeO, MgO, MnO, P, S,  $\text{SiO}_2$ ,  $\text{TiO}_2$  and  $\text{V}_2\text{O}_5$ .

**9. Participating Laboratories:**

NO	LABORATORY	COUNTRY
1.	Afarak Elektrowerk Weisweiler GmbH	Germany
2.	AHK North West	South Africa
3.	AHK Richards Bay	South Africa
4.	ALS Inspection Richards Bay	South Africa
5.	Barplats Mine	South Africa
6.	Chromtech	South Africa
7.	Cotecna Richards Bay	South Africa
8.	Dwarsrivier Chrome Mine	South Africa
9.	Glencore Boshhoek	South Africa
10.	Glencore Eastern Mines	South Africa
11.	Glencore Kroondal	South Africa
12.	Glencore Rustenburg Smelter	South Africa
13.	Glencore UG2 Alloys	South Africa
14.	GNK Laboratories Zimlabs	Zimbabwe
15.	Intertek Kathu	South Africa
16.	Intertek Steelpoort	South Africa
17.	Jubilee Metals Group	South Africa
18.	Mitra Sk South Africa	South Africa
19.	Northam Booyseendal Fire Assay Lab	South Africa
20.	Northam Booyseendal South	South Africa
21.	Outokumpu	Finland
22.	PCL Rustenburg	South Africa
23.	PCL Steelpoort	South Africa
24.	Pilanesberg Platinum Mine	South Africa
25.	Quality Laboratory Services	South Africa
26.	RC Inspection SA	South Africa
27.	Samancor Ferrometals	South Africa
28.	Samancor TCS Laboratory	South Africa
29.	Samancor Tubatse Alloy Smelter	South Africa
30.	Samancor Tubatse Chrome	South Africa
31.	Zimasco Kwekwe	Zimbabwe
32.	Zimbabwe Alloy Chrome	Zimbabwe

**10. Assay Data:**

Data used for Assigning Values and Certification.

LABORATORY	Al <sub>2</sub> O <sub>3</sub>	C	CaO	Cr <sub>2</sub> O <sub>3</sub>	Cr:Fe Ratio	FeO	MgO	MnO	P	S	SiO <sub>2</sub>	TiO <sub>2</sub>	V <sub>2</sub> O <sub>5</sub>
UNIT	%	%	%	%		%	%	%	%	%	%	%	%
LAB001	15.235			38.29	1.332	25.32			0.005	0.006	8.455		
LAB002	15.047		0.69	38.196		25.422	8.822	0.221			8.011	0.958	0.371
LAB003				38.088									
LAB004	14.98		0.62	38.67		26.035				0.005	8.495		
LAB005	14.813			38.592	1.496	22.659	8.703				9.174		
LAB006				38.526									
LAB007	15.058		0.58	38.665	1.31	26.002		0.226	0.008	0.003	8.352	1.038	
LAB008				38.58									
LAB009	15.319		0.722	38.547	1.32	25.625	8.807		0.005	0.003	8.508	1.046	
LAB010				38.197									
LAB011	15.16			38.445	1.327	25.59			0.002	0.007	8.365	1.055	0.375
LAB012				38.595									
LAB013	15.023	0.029	0.675	38.25		25.44	8.42	0.22	0.003	0.003	8.202	1.091	0.386
LAB014	15.385			37.93	1.33	25.15	8.63	0.22				1.04	
LAB015				37.865									
LAB016				38.07		25.925					8.498		
LAB017	14.774			37.734		24.808		0.213		< 0.010	7.886	1.054	0.375
LAB018	17.823		0.747	39.114	1.615	24.211		0.197	0.012		9.877	1.151	0.397
LAB019	14.895		0.908	37.806		25.009	8.674	0.216			8.4	1.028	
LAB020				37.858									
LAB021	15.25		0.635	37.984		24.985		0.223			8.58	0.975	
LAB022				37.996									
LAB023	14.78			38.255		25.09		0.225			8.16	1.03	0.375
LAB024				38.275									

LABORATORY	Al <sub>2</sub> O <sub>3</sub>	C	CaO	Cr <sub>2</sub> O <sub>3</sub>	Cr:Fe Ratio	FeO	MgO	MnO	P	S	SiO <sub>2</sub>	TiO <sub>2</sub>	V <sub>2</sub> O <sub>5</sub>
UNIT	%	%	%	%		%	%	%	%	%	%	%	%
LAB025	14.545		0.87	38.425		26.39		0.225			8.51		
LAB026			0.76	39.77	1.42	24.45							
LAB027	14.833		0.737	38.057		25.496					8.355		
LAB028	15.1		0.829			25.895	8.945		0.004	0.004	8.625		
LAB029				37.93									
LAB030	14.3		0.573						0.003	< 0.000			
LAB031				37.48		25.13					8.575		
LAB032	14.61		0.68	38.34		24.915			0.005	0.009	8.175		
LAB033				38.47							8.295		
LAB034	14.995	0.028	0.7	38.22	1.34	25.15	8.72		0.005	0.004	8.37		
LAB035				38.545									
LAB036				38.27									
LAB037	15.02	0.037	0.664	38.332	1.32	25.575	8.529	0.2		< 0.010			0.371
LAB038						25.615							
LAB039	15.114	0.033	0.655	38.282	1.348	25.079		0.217	0.002	0.004	8.44	1.02	0.381
LAB040				38.52									
LAB041	15.066			38.244	1.322	25.442		0.223			8.524	1.082	0.208
LAB042				38.44									
LAB043				38.45	1.4	24.75			0.01				
LAB044	14.959			38.275	1.334	25.258	8.45		0.011	0.003	8.34	1.087	0.398
LAB045				38.315		25.23					8.195		
LAB046				38.22									
LAB047	15.02		0.718	38.515		25.355	8.61	0.226	0.009	0.003	8.105	1.068	0.275

## 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 Chrome PT Round 5 of 2022. The participating laboratories were each 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:  $UCRM = k u_{CRM}$ , 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.

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)	$\nu$ (Degrees of Freedom)	$k$ (Coverage Factor)	$u$ (Standard Uncertainty)	95% Measurement Uncertainty	Expanded Uncertainty
Al <sub>2</sub> O <sub>3</sub>	%	0.254	24	2.064	0.066	± 0.13	± 0.14
CaO	%	0.093	17	2.110	0.027	± 0.05	± 0.06
Cr <sub>2</sub> O <sub>3</sub>	%	0.328	43	2.017	0.058	± 0.12	± 0.12
FeO	%	0.521	29	2.045	0.12	± 0.24	± 0.25
MgO	%	0.207	10	2.228	0.079	± 0.16	± 0.18
MnO	%	0.007	13	2.160	0.002	± 0.004	± 0.004
P	%	0.004	16	2.120	0.001	± 0.002	± 0.002
S	%	0.002	11	2.201	0.001	± 0.002	± 0.002
SiO <sub>2</sub>	%	0.24	25	2.060	0.057	± 0.11	± 0.12
TiO <sub>2</sub>	%	0.044	14	2.145	0.013	± 0.03	± 0.03
V <sub>2</sub> O <sub>5</sub>	%	0.021	10	2.228	0.005	± 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 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	
<b>Qotho Managing Director</b>	<b>11 November 2022</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.*

END