

## QOTHO CERTIFIED REFERENCE MATERIAL (QCRM)

### QCRM-1-217

#### CHROME ORE

#### CERTIFICATE OF ANALYSIS

CERTIFIED VALUES			
ANALYTES	UNITS	CONCENTRATIONS	EXPANDED UNCERTAINTY
Al <sub>2</sub> O <sub>3</sub>	%	12.95	±0.14
CaO	%	0.49	±0.05
Cr <sub>2</sub> O <sub>3</sub>	%	40.79	±0.10
FeO	%	23.69	±0.19
MgO	%	11.97	±0.14
MnO	%	0.21	±0.01
P	%	0.005	±0.002
S	%	0.005	±0.002
SiO <sub>2</sub>	%	7.23	±0.14
TiO <sub>2</sub>	%	0.52	±0.02
V <sub>2</sub> O <sub>5</sub>	%	0.30	±0.02

**1. Use:**

QCRM-1-217 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 ECM.

**3. Mineral and Chemical Composition:**

Chromite is found as orthocumulate 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. The concentrate was produced from ores which originated from the Eastern Limb of the Bushveld complex.

**4. Date of Initial Issue:**

14 July 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 finish
- Chrome by sodium peroxide fusion with Potentiometric Titration
- Calcium Perchloric digestion and ICP-OES finish
- Silica by perchloric acid digestion and gravimetric finish
- Phosphorous by perchloric acid digestion and UV-VIS spectrophotometric finish
- Fused beads with XRF finish
- Pressed pellets 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  $\text{Al}_2\text{O}_3$ , C, 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.	AHK North West	South Africa
2.	AHK Richards Bay	South Africa
3.	ALS Geochemistry Kempton Park	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	South Africa
18.	Mitra SK	South Africa
19.	Northam Booyssendal Fire Assay Lab	South Africa
20.	Northam Booyssendal 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 Alloys 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	12.92			40.82	1.52	23.665			0.007				
LAB002	13.04		0.317	40.965		23.686	11.764	0.212			7.29	0.527	0.294
LAB003				40.922									
LAB004	13.425		0.495	40.68		24.995	11.865			0.004	7.385		
LAB005	13.204		0.735	40.513		23.927	12.122						
LAB006	13.545			40.623	1.48	24.198	12.102	0.211	0.005	0.003	7.168	0.544	
LAB007				40.782									
LAB008	12.55		0.425	40.273	1.52	23.33	11.645			0.002	7.508	0.51	
LAB009				40.733									
LAB010	12.935			40.665	1.516	23.65	12.31		0.004	0.005	6.95	0.51	0.28
LAB011				40.755									
LAB012	13.002	0.173	0.474	40.685		24.13	12.202	0.216	0.002	0.005	7.06	0.524	0.305
LAB013	13.05		0.455	40.46	1.54	23.145	12.06	0.21			7.245	0.51	
LAB014				40.4									
LAB015				40.97		23.845					7.155		
LAB016	12.495			40.849		23.587	11.65	0.207		< 0.010	7.032	0.496	0.286
LAB017				41.212									
LAB018	12.487		0.552	41.28	1.519	23.914		0.213			8.795	0.532	0.303
LAB019	12.891		0.369	40.335		23.353	11.77	0.205			7.054	0.517	
LAB020				40.21									
LAB021	13.312		0.579	41.213		23.363	11.79	0.21			7.4	0.532	
LAB022				41.336									
LAB023	13.08			40.83		23.425	12.08	0.215			7.09	0.52	0.295
LAB024				40.805									
LAB025			0.52	42.515		25.47		0.22			7.64		

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	%	%	%	%		%	%	%	%	%	%	%	%
LAB026				42.77									
LAB027	12.914		0.553	40.763		23.658	11.85				6.677		
LAB028	13.055		0.44			23.67	11.98		0.004	0.005	7.14		
LAB029				40.775									
LAB030	14.151		0.544		1.435		12.187		0.002				
LAB031				39.795							8.473		
LAB032				40.885		23.6					7.345		
LAB033	12.4		0.5	41.305		24.475	11.58		0.005	0.009	7.59		
LAB034				41.095							7.695		
LAB035	13.07	0.121	0.49	40.875	1.53	23.56	12		0.004	0.005	7.225		
LAB036				40.755									
LAB037				40.84									
LAB038	12.924	0.139	0.485	40.564	1.503	23.744	11.843			0.003		0.484	0.276
LAB039				40.64		23.6							
LAB040	12.91			40.81	1.51	23.805	12.355	0.22	0.002		7.22	0.554	0.317
LAB041				40.755									
LAB042				40.75	1.6	22.9			0.007				
LAB043	12.803			41.007	1.515	23.819	12.073		0.006	0.001	7.168	0.518	0.318
LAB044	12.945	0.12	0.495	40.905			12.165	0.22		0.01	7.195	0.52	
LAB045				40.935									
LAB046				40.575							7.265		
LAB047				40.7									
LAB048	12.885		0.494	40.89		23.843	11.925	0.242	0.007	0.005	6.955	0.494	0.299

**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 3 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 13528:2015 (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:  $U_{CRM} = k u_{CRM}$ , 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)	$\nu$ (Degrees of Freedom)	$k$ (Coverage Factor)	$u$ (Standard Uncertainty)	95% Measurement Uncertainty	Expanded Uncertainty
Al <sub>2</sub> O <sub>3</sub>	%	0.259	23	2.069	0.067	± 0.13	± 0.14
CaO	%	0.079	17	2.110	0.021	± 0.04	± 0.05
Cr <sub>2</sub> O <sub>3</sub>	%	0.284	45	2.014	0.049	± 0.10	± 0.10
FeO	%	0.371	26	2.056	0.093	± 0.19	± 0.19
MgO	%	0.249	21	2.080	0.068	± 0.14	± 0.14
MnO	%	0.008	12	2.179	0.003	± 0.01	± 0.01
P	%	0.002	11	2.201	0.001	± 0.002	± 0.002
S	%	0.003	11	2.201	0.001	± 0.002	± 0.002
SiO <sub>2</sub>	%	0.285	25	2.060	0.065	± 0.13	± 0.14
TiO <sub>2</sub>	%	0.02	15	2.131	0.006	± 0.01	± 0.02
V <sub>2</sub> O <sub>5</sub>	%	0.018	9	2.262	0.008	± 0.02	± 0.02

**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>14 July 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.*

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