

## QOTHO CERTIFIED REFERENCE MATERIAL (QCRM)

### QCRM-1-188

#### CHROME CONCENTRATE

#### CERTIFICATE OF ANALYSIS

CERTIFIED VALUES			
ANALYTES	UNITS	CONCENTRATIONS	EXPANDED UNCERTAINTY
Al <sub>2</sub> O <sub>3</sub>	%	14.71	±0.15
CaO	%	0.16	±0.04
Cr <sub>2</sub> O <sub>3</sub>	%	45.67	±0.13
FeO	%	25.96	±0.18
MnO	%	0.227	±0.004
P	%	0.004	±0.002
S	%	0.006	±0.002
SiO <sub>2</sub>	%	1.36	±0.05
TiO <sub>2</sub>	%	0.69	±0.02
V <sub>2</sub> O <sub>5</sub>	%	0.38	±0.02
ASSIGNED VALUES (FOR INFORMATION ONLY)			
ANALYTES	UNITS	CONCENTRATIONS	EXPANDED UNCERTAINTY
MgO	%	9.75	±0.09

**1. Use:**

QCRM-1-188 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 Concentrate and as a calibration standard for the calibration of equipment used for analysing similar materials.

**2. Origin of Material:**

This standard was sponsored by Lanxess Chrome Mine, South Africa. It is a composite material collected from milled laboratory pulp rejects after analysis.

**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. This concentrate was produced from ore that originated from the Western Limb of the Bushveld complex.

**4. Date of Initial Issue:**

3 December 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.

**7. Methods of Analysis used:**

- Sodium peroxide fusion with ICP-OES finish
- Chrome by sodium peroxide fusion with Potentiometric Titration
- Fused beads with XRF finish
- Pressed pellet with XRF finish
- Calcium by aqua regia digestion and ICP-OES finish
- Sulphur by combustion analysis.
- Phosphorous by perchloric digestion and UV-VIS finish

**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.	Afarak Elektrowerk Weisweiler GmbH	Germany
2.	AHK North West	South Africa
3.	AHK Richards Bay	South Africa
4.	AHK Steelpoort	South Africa
5.	ALS Geochemistry	South Africa
6.	ALS Inspection Richards Bay	South Africa
7.	ALS SAIL - Limpopo	South Africa
8.	ARM Machadodorp	South Africa
9.	Chromtech	South Africa
10.	Cotecna Richards Bay	South Africa
11.	Dwarsrivier Chrome Mine	South Africa
12.	Glencore Boshhoek	South Africa
13.	Glencore Eastern Mines	South Africa
14.	Glencore Kroondal	South Africa
15.	Glencore Lion	South Africa
16.	Glencore Rustenburg Smelter	South Africa
17.	Glencore UG2 Alloys	South Africa
18.	Glencore Wonderkop Smelter	South Africa
19.	Intertek JHB	South Africa
20.	Intertek Steelpoort	South Africa
21.	Jubilee Metals Group	South Africa
22.	Mitra SK South Africa	South Africa
23.	Nkomati JV	South Africa
24.	Northam Booyssendal Fire Assay Lab	South Africa
25.	Outokumpu	Finland
26.	PCL Rustenburg	South Africa
27.	PCL Steelpoort	South Africa
28.	Pilanesberg Platinum Mine	South Africa
29.	Quality Laboratory Services	South Africa
30.	Samancor Dikwena	South Africa
31.	Samancor ECM	South Africa
32.	Samancor TCS Laboratory	South Africa
33.	Samancor WCM	South Africa
34.	SGS Randfontein	South Africa
35.	SGS Richards Bay	South Africa
36.	Tharisa	South Africa
37.	UIS Analytical Services ICP	South Africa
38.	UIS Analytical Services XRF	South Africa
39.	Zimasco Kwekwe	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	14.716		0.153			26.159	9.713		0.002	0.003	1.642	0.679	
LAB002				45.999									
LAB003	14.355		0.205	46.125			9.51			0.007	1.355		
LAB004	14.772		0.175				9.522				1.392		
LAB005	14.93			45.673			9.739	0.228			1.166	0.757	
LAB006	14.652		0.213	45.585	1.535	26.248	9.64	0.226		0.007	1.365	0.683	
LAB007				45.66									
LAB008	14.823		0.116	45.56	1.552		9.565				1.454	0.677	
LAB009				45.44									
LAB010	14.895		0.28	45.285	1.52		9.74			0.063	1.405	0.65	0.32
LAB011				45.125									
LAB012	14.729		0.22	45.716		26.063	9.758	0.23			1.406	0.702	0.353
LAB013				45.77									
LAB014	15.087	0.049	0.19	45.24			9.527	0.229		0.004	1.249	0.681	0.392
LAB015				45.483				0.238			1.958	0.665	
LAB016				45.829									
LAB017	14.075	0.018	0.112	45.71	1.54		9.42		< 0.005	< 0.003	1.305	0.696	0.403
LAB018				45.38		25.665					0.835		
LAB019	14.765		0.15	45.985		25.945	9.47	0.225	0.007		1.4	0.685	0.379
LAB020							9.553			0.005		0.672	0.375
LAB021					1.535						1.309		
LAB022	14.404		0.26	45.729			9.659	0.215			1.296	0.664	
LAB023				45.7									
LAB024	15.03						9.785	0.23			1.045	0.705	0.375
LAB025				45.56									
LAB026	14.215		1.235				9.675	0.22			1.335		
LAB027	14.542		0.11	45.804			10.216				1.418		
LAB028				45.55									

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	%	%	%	%		%	%	%	%	%	%	%	%
LAB029	14.535						10.13		0.004	0.007	1.315		
LAB030				46.255									
LAB031	15.19						9.625	0.23			1.43		
LAB032				45.555									
LAB033	14.45		0.1				10.1		0.004	0.007	1.35		
LAB034				46.45									
LAB035				46.518									
LAB036	14.31		0.17	45.725		26.03	9.52		0.005	0.005	1.125		
LAB037				45.985							1.195		
LAB038	14.926			45.263		25.584	9.781				1.545		
LAB039	14.56		0.163	46.752	1.547		10.027		0.007	0.007	1.375	0.757	0.3
LAB040	14.85	0.013	0.15	45.66	1.55	26.025	9.7		0.003	0.005	1.345		
LAB041				45.87									
LAB042				45.365									
LAB043		0.025			1.535		9.795	0.23					
LAB044	14.887	0.03		45.475	1.551		9.823	0.24	0.004	0.005	1.407	0.678	0.385
LAB045				45.636									
LAB046	14.44		0.175	45.905			10.19		0.005		1.415		
LAB047	14.654			45.972	1.559	25.958	9.848	0.219	0.004		1.323	0.687	0.401
LAB048				45.935									
LAB049	15.158		0.093	45.512	1.523		10.16		0.004	0.006	1.485	0.714	0.382
LAB050	14.97			45.425	1.57	25.795	10.17	0.227			1.31	0.706	0.37
LAB051				45.255									
LAB052			0.087	45.852	1.546	26.093	9.767	0.218	0.004	0.006	1.435	0.684	0.409
LAB053						27.5							
LAB054				45.99							1.55		
LAB055	14.79	0.02	0.1	45.5	1.543	25.951	9.765	0.23	< 0.010	0.007	1.38	0.66	
LAB056				45.4									
LAB057				45.425									
LAB058				45.175									

#### 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 2 of 2021. 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:

Measurement 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.  $U_{CRM} = k u_{CRM}$ , 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.

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	$\nu$ (degrees of freedom)	$k$ (coverage factor)	$u$ (standard error)	95% measurement uncertainty	Expanded Uncertainty
Al <sub>2</sub> O <sub>3</sub>	%	27	2.052	0.072	± 0.14	± 0.15
CaO	%	20	2.086	0.018	± 0.04	± 0.04
Cr <sub>2</sub> O <sub>3</sub>	%	46	2.013	0.061	± 0.12	± 0.13
FeO	%	12	2.179	0.08	± 0.16	± 0.18
MgO	%	26	2.056	0.045	± 0.09	± 0.09
MnO	%	15	2.131	0.002	± 0.004	± 0.004
P	%	13	2.160	0.001	± 0.002	± 0.002
S	%	15	2.131	0.001	± 0.002	± 0.002
SiO <sub>2</sub>	%	33	2.035	0.025	± 0.05	± 0.05
TiO <sub>2</sub>	%	19	2.093	0.006	± 0.01	± 0.02
V <sub>2</sub> O <sub>5</sub>	%	12	2.179	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>3 December 2021</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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