

## QOTHO CERTIFIED REFERENCE MATERIAL (QCRM)

### QCRM-1-134

#### CHROME ORE

#### CERTIFICATE OF ANALYSIS

CERTIFIED VALUES			
ANALYTES	UNITS	CONCENTRATIONS	EXPANDED UNCERTAINTY
Al <sub>2</sub> O <sub>3</sub>	%	14.71	±0.13
CaO	%	0.73	±0.05
Cr <sub>2</sub> O <sub>3</sub>	%	38.73	±0.10
FeO	%	24.37	±0.11
MgO	%	10.00	±0.09
MnO	%	1.28	±0.03
P	%	0.006	±0.002
S	%	0.006	±0.002
SiO <sub>2</sub>	%	7.64	±0.06
TiO <sub>2</sub>	%	0.65	±0.01
V <sub>2</sub> O <sub>5</sub>	%	0.34	±0.01

**1. Use:**

QCRM-1-134 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 analyzing similar materials.

This COA was amended, as more analytical data became available, enabling the certification of more analytes.

**2. Origin of Material:**

This standard was sponsored by ALS Inspection, Johannesburg, 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. The ore originates from the Western Limb of the Bushveld complex.

**4. Date of Initial Issue:**

14 June 2019.

**5. Packaging & Handling instructions:**

The material is packaged as 100g 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
- Sodium peroxide fusion with Potentiometric Titration
- Fused beads with XRF finish
- Pressed pellet 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,  $\text{Cr}_2\text{O}_3$ , 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.	AHK Steelpoort	South Africa
4.	ALS Geochemistry	South Africa
5.	ALS Inspection Richards Bay	South Africa
6.	ALS SAIL - Limpopo	South Africa
7.	Afarak Elektrowerk Weisweiler GmbH	Germany
8.	Chromtech	South Africa
9.	Cotecna Richards Bay	South Africa
10.	Dwarsrivier Chrome Mine	South Africa
11.	Glencore Boshhoek	South Africa
12.	Glencore Eastern Mines	South Africa
13.	Glencore Kroondal	South Africa
14.	Glencore Lion	South Africa
15.	Glencore Lydenburg Smelter	South Africa
16.	Glencore Rustenburg Smelter	South Africa
17.	Glencore UG2 Alloys	South Africa
18.	GNK Laboratories Zimlabs	Zimbabwe
19.	Intertek JHB	South Africa
20.	Intertek Steelpoort	South Africa
21.	Mitra SK South Africa	South Africa
22.	Nkomati JV	South Africa
23.	PCL Rustenburg	South Africa
24.	PCL Steelpoort	South Africa
25.	Quality Laboratory Services	South Africa
26.	Samancor Dikwena	South Africa
27.	Samancor Ferrometals	South Africa
28.	Samancor Tubatse Alloy Smelter	South Africa
29.	Samancor Tubatse Chrome	South Africa
30.	Samancor WCM	South Africa
31.	Setpoint Laboratories	Netherlands
32.	SGS Randfontein	South Africa
33.	SGS Richards Bay	South Africa
34.	Suntech Geomet Labs	South Africa
35.	UIS Analytical Services	South Africa
36.	Zimasco Kwekwe	Zimbabwe

## 10. Assay Data:

Data used for Assigning Values and Certification.

Laborat	Al <sub>2</sub> O <sub>3</sub>	C	CaO	Cr <sub>2</sub> O <sub>3</sub>	FeO	MgO	MnO	P	S	SiO <sub>2</sub>	TiO <sub>2</sub>	V <sub>2</sub> O <sub>5</sub>
Unit	%	%	%	%	%	%	%	%	%	%	%	%
LAB001	15.17		0.85	39.11	24.195	9.915			0.007	7.84		
LAB002	14.413		0.612		23.981	10.112				7.717		
LAB003				39.655								
LAB004	14.592		0.627	38.98	24.5	9.81	1.2	0.011	0.009	7.473	0.667	0.31
LAB005				39								
LAB006	14.631		0.681	39.395	24.866	10.039				7.62	0.665	
LAB007				39.362								
LAB008	14.29		0.73	38.285	24.53	10.135			0.008	7.475	0.675	
LAB009				38.34								
LAB010				38.2		9.863						
LAB011	14.6		0.665	38.05	24.1	9.92	1.16	< 0.010		7.24	0.63	0.35
LAB012	14.841	0.057	0.824	38.495	24.159	9.85	1.264			7.46	0.677	0.355
LAB013	14.895		0.509	38.48	24.383	10.078	1.293			7.628	0.648	
LAB014				38.48								
LAB015				39.22						7.505		
LAB016	14.655		0.745	38.4	24.62	9.795	1.24		0.017	7.595	0.695	0.353
LAB017	15.506		0.968	37.209	24.462	10.261	1.325			8.255	0.677	
LAB018				37.265								
LAB019	14.595		0.485		24.135	10.01	1.27			7.285	0.64	0.29
LAB020				38.485								
LAB021	15.87		0.75	39.25	24.56	11.255	1.245			7.715		
LAB022				39.62								
LAB023	14.928			40.075	25.906	10.541				7.738		
LAB024	15.235		0.889		24.195	10.055		0.007	0.006	7.675		
LAB025				38.815								
LAB026	15.205				24.385	10.22				7.65		
LAB027				39.1								
LAB028	14.765		0.505	38.495	24.475	9.915		0.007		7.52		
LAB029					24.075							
LAB030				38.315						7.735		
LAB031	14.52		0.785	38.485	24.125	11.085		0.005	0.006	7.36		
LAB032				38.27						7.365		
LAB033	14.287			38.709	25.052	10.075				7.729		
LAB034	14.705	0.058	0.77	38.43	24.08	9.875		0.009	0.005	7.635		
LAB035				38.64								
LAB036				38.295								
LAB037	15.71				25.25	9.255				7.755		
LAB038				37.67								
LAB039	14.873		0.997	39.004	24.63	10.364	1.32	0.01		7.963	0.676	0.205
LAB040				39.075								
LAB041	13.975			38.636	24.263	10.694			0.007		0.659	0.36
LAB042	14.597		0.655	38.715	24.231	9.784	1.24	0.007	0.005	7.496	0.666	0.364
LAB043	14.855	0.04	0.73	38.94	24.251	10.005	1.32	0.004	< 0.010	7.55	0.64	
LAB044				38.645								
LAB045	15.093		0.905	38.659	24.236	10.145	1.315	0.004	0.006	7.918	0.643	0.345
LAB046				38.735						7.02		

Laborat	Al <sub>2</sub> O <sub>3</sub>	C	CaO	Cr <sub>2</sub> O <sub>3</sub>	FeO	MgO	MnO	P	S	SiO <sub>2</sub>	TiO <sub>2</sub>	V <sub>2</sub> O <sub>5</sub>
Unit	%	%	%	%	%	%	%	%	%	%	%	%
LAB047	14.665			39.365	24.365		1.43			7.43		
LAB048				39.28								
LAB049	14.775		0.775	38.64	24.34	9.935		0.009	0.01	7.675		
LAB050				38.52								
LAB051	14.605				13.285	9.785	1.27			7.565		
LAB052				39								
LAB053	14.695		0.75	38.515	24.44	10.01	1.315	0.007	0.02	7.585	0.665	
LAB054				38.275								
LAB055	14.881		0.565	38.494	24.096	9.91	1.27	0.007	0.006	7.378	0.629	0.353
LAB056			0.7	38.875	24.825		0.229			7.8		
LAB057				38.815								
LAB058	14.5		0.715		23.98	9.48				8.25		
LAB059	14.495		0.812		24.645	10.05		0.007	0.007	7.755		
LAB060	14.205		0.655	38.555	24.465	10.215				7.53		
LAB061	14.553		0.771	39.626	24.897	10.229				7.761		
LAB062	14.645		0.555	39.075	24.38	10.11		0.005		7.6		
LAB063	14.46		0.825	38.32	24.56	9.785		0.002		7.71		
LAB064	14.39		0.718	38.919	24.593	9.744			0.004	7.819		
LAB065	14.26		0.7	38.58	24.29	9.93				7.525	0.65	
LAB066				38.705								
LAB067	13.212		1.248	39.121	24.622	10.05		0.004	0.008	7.894	0.732	
LAB068	14.845		0.76	38.525	24.335	9.9	1.245	0.011	0.013	7.64	0.645	0.34
LAB069				38.7								
LAB070	13.975		0.815	38.605	23.875	11.3		0.005	0.006	7.455		
LAB071				38.615						7.52		
LAB072	14.476			38.539	23.077	9.849		0.003		7.717		
LAB073	14.825		0.79	38.847	24.498	10.108	1.28	0.006	0.006	7.701	0.64	0.277
LAB074				39.112								
LAB075	14.996			38.668	24.511	10.157		0.007		7.767	0.629	
LAB076				38.715								
LAB077				39.01	24.175					7.88		
LAB078	14.573		0.581	38.57	24.047	9.844	1.266			7.703	0.616	
LAB079				38.425								
LAB080	15.212			39.416	24.844	10.103	1.423			7.84	0.646	0.348
LAB081				38.624								
LAB082	14.567		0.77	38.494	24.231	9.985	1.276	0.007	0.007	7.51	0.644	
LAB083				38.527								
LAB084				38.721	24.331				0.005	7.703		
LAB085	14.799			38.548	24.37	10.072	1.322			7.737	0.672	0.348
LAB086				38.53								
LAB087			0.742	38.463	24.167	10.265	1.254			7.666	0.656	0.349
LAB088	14.738		0.845	38.548	24.117	9.859	1.236			7.648	0.653	0.33
LAB089	14.895			38.975	24.655	9.685		0.005	0.007	7.815	0.645	
LAB090				39.155								
LAB091				38.74	23.8					7.69		

## 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 Rounds 2 of 2019 and 4 of 2020. The participating laboratories were each given 1 randomly selected sample from the batch, to analyze and report on in duplicate. Some laboratories reported results via more than one analytical method. Where relevant, obvious blunders were resolved through consultation with the particular laboratory, after which the data was processed using Robust Statistics, through PROLab Plus.

Not all the participating laboratories were accredited. Equivalence tests were performed on all analytes to determine whether the data from the accredited and non-accredited laboratories, can be treated as equal (at a level of significance of  $\alpha = 0.05$ ). Where equivalent, all the data was used. Where not, only the data from the accredited laboratories were considered. Certification of analytes were then done, provided that a minimum of 10 datapoints remained available.

Where analytes cannot 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.  $UCRM = k u_{CRM}$ , 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.

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>	%	49	2.010	0.062	± 0.12	± 0.13
CaO	%	39	2.023	0.024	± 0.05	± 0.05
Cr <sub>2</sub> O <sub>3</sub>	%	81	1.990	0.05	± 0.10	± 0.10
FeO	%	55	2.004	0.054	± 0.11	± 0.11
MgO	%	49	2.010	0.042	± 0.08	± 0.09
MnO	%	24	2.064	0.014	± 0.03	± 0.03
P	%	23	2.069	0.001	± 0.002	± 0.002
S	%	22	2.074	0.001	± 0.002	± 0.002
SiO <sub>2</sub>	%	58	2.002	0.029	± 0.06	± 0.06
TiO <sub>2</sub>	%	27	2.052	0.005	± 0.01	± 0.01
V <sub>2</sub> O <sub>5</sub>	%	15	2.131	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. Most laboratories reported on the QA/QC CRM's used during the analysis of this QRM and reported the values obtained during the sample run. This provides additional evidence of measurement traceability.

**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 have been 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/Analytical Report.

Certifying & Technical Signatory	
<b>Qotho Managing Director</b>	<b>30 September 2020</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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