

## QOTHO CERTIFIED REFERENCE MATERIAL (QCRM)

### QCRM-1-113

#### CHROME ORE

#### CERTIFICATE OF ANALYSIS

CERTIFIED VALUES			
ANALYTES	UNITS	CONCENTRATIONS	EXPANDED UNCERTAINTY
Al <sub>2</sub> O <sub>3</sub>	%	13.27	±0.08
CaO	%	1.14	±0.07
Cr <sub>2</sub> O <sub>3</sub>	%	37.36	±0.10
FeO	%	22.40	±0.15
MgO	%	12.06	±0.10
MnO	%	0.22	±0.01
P	%	0.004	±0.001
S	%	0.008	±0.002
SiO <sub>2</sub>	%	11.25	±0.11
TiO <sub>2</sub>	%	0.56	±0.01
V <sub>2</sub> O <sub>5</sub>	%	0.31	±0.02

**1. Use:**

QCRM-1-113 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 updated, as more analytical data became available, enabling the certification of all analytes. The report format was also updated, to be in line with our accredited format.

**2. Origin of Material:**

This standard was sponsored by and prepared for Dwarsrivier Chrome Mine, South Africa.

**3. Mineral and Chemical Composition:**

Chromite is found as ortho-cumulate lenses of chromitite in peridotite from the Earth's mantle. Ore deposits of chromite formed as early magmatic differentiates. The ore originates from the Dwarsrivier Chrome Mine, which falls within the so called Tweefontein section of the Rustenburg Layered Suite of the Eastern Limb of the Bushveld Complex. This ore was mined from the so-called Steelpoort Chromitite Seam.

**4. Date of Initial Issue:**

21 July 2020.

**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 wotj XRF finish
- Sodium peroxide fusion with UV-VIS 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  $Al_2O_3$ , C, CaO,  $Cr_2O_3$ , FeO, MgO, MnO, P, S,  $SiO_2$ ,  $TiO_2$  and  $V_2O_5$ .

## 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 Inspection UK	UK
8.	ALS SAIL - Limpopo	South Africa
9.	ARM Machadodorp	South Africa
10.	Chromtech	South Africa
11.	Columbus Analytical Lab	South Africa
12.	Cotecna Richards Bay	South Africa
13.	Dwarsrivier Chrome Mine	South Africa
14.	Glencore Boshhoek	South Africa
15.	Glencore Eastern Mines	South Africa
16.	Glencore Kroondal	South Africa
17.	Glencore Lion	South Africa
18.	Glencore Lydenburg Smelter	South Africa
19.	Glencore Rustenburg Smelter	South Africa
20.	Glencore UG2 Alloys	South Africa
21.	Glencore Wonderkop Smelter	South Africa
22.	Hernic Ferrochrome	South Africa
23.	Intertek JHB	South Africa
24.	Intertek Steelpoort	South Africa
25.	Lanxess Rustenburg	South Africa
26.	Mintek	South Africa
27.	Mitra Sk South Africa	South Africa
28.	Nkomati JV	South Africa
29.	PCL Rustenburg	South Africa
30.	PCL Steelpoort	South Africa
31.	Pilanesberg Platinum Mine	South Africa
32.	Quality Laboratory Services	South Africa
33.	Samancor ECM	South Africa
34.	Samancor Ferrometals	South Africa
35.	Samancor TCS Laboratory	South Africa
36.	Samancor Tubatse Alloy Smelter	South Africa
37.	Samancor Tubatse Chrome	South Africa
38.	Samancor WCM	South Africa
39.	SGS Netherlands BV	Netherlands
40.	SGS Randfontein	South Africa
41.	SGS Richards Bay	South Africa
42.	Tharisa	South Africa
43.	UIS Analytical Services ICP	South Africa
44.	UIS Analytical Services XRF	South Africa
45.	Zimasco Kwekwe	Zimbabwe
46.	Zimlabs (GNK Laboratories)	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>	FeO	MgO	MnO	P	S	SiO <sub>2</sub>	TiO <sub>2</sub>	V <sub>2</sub> O <sub>5</sub>
Unit	%	%	%	%	%	%	%	%	%	%	%	%
LAB001	13.242		1.211	36.856	22.526	11.939	0.183	0.002	0.015	11.118	0.573	
LAB002	13.615		0.97	37.84	21.9	11.54			0.009	11.5		
LAB003	13.042		1.26		21.424	11.653				10.509		
LAB004	13.29		0.85	37.595	22.953	12.438	0.223	0.004	0.011	10.93	0.556	0.271
LAB005				37.59								
LAB006	13.284		1.195	37.147	22.032	12.073				10.899		
LAB007				37.22								
LAB008	12.805	0.11	0.97	37.78	22.17	12		0.001	0.009	11.055	0.55	
LAB009				37.35								
LAB010	13.229		1.269	37.265	22.402	12.265	0.225			11.26	0.59	0.316
LAB011	13.337		0.975	36.412	22.038	12.123	0.215			11.735	0.547	
LAB012				36.453								
LAB013				37.2	22.3					10.942		
LAB014	13.18		1.175	37.065	22.16	12.205	0.21		0.01	11.235	0.62	0.293
LAB015	13.264		0.853	37.575	21.67	12.453	0.215			11.491		
LAB016				37.13								
LAB017	13.42		0.435		22.165	11.8	0.217			12.65	0.542	0.296
LAB018				37.405								
LAB019			1.225	38.459	23.175	13.145	0.235					
LAB020				38.535								
LAB021	13.034		1.104	37.42	22.477	12.211				11.186		
LAB022				37.183								
LAB023	13.475		1.055		21.775	11.81		0.005	0.008	11.61		
LAB024				37.71								
LAB025	12.86				22.115	11.965				10.825		
LAB026				37.43								
LAB027	13.585		1.04	38.01	22.695	12.245		0.005		11.95		
LAB028					24.15							
LAB029				38.095								
LAB030	13.375		1.205	37.2	22.865	12.15		0.005	0.007	11.295		
LAB031				37.135						11.3		
LAB032	13.386			37.075	22.262	11.942				11.406		
LAB033	13.27	0.069	1.225	37.23	22.34	12.155		0.005	0.007	11.27		
LAB034				37.28								
LAB035				37.62								
LAB036					24.815							
LAB037	13.538	0.069	1.107	37.314	22.232	12.318	0.246	0.005	0.007	11.756	0.55	0.348
LAB038				37.831								
LAB039	12.912			37.695	22.386	11.4	0.175		0.009	11.658	0.534	0.289
LAB040	13.404		1.312	37.254	22.332	12.061	0.224	0.005	0.008	11.163	0.554	0.318
LAB041	13.376		1.177	37.037	22.171	11.834		0.004	0.005	11.079		
LAB042				37.285								
LAB043	13.22			36.78	22.11	11.55	0.215			11.425	0.568	0.334
LAB044	13.365			37.27	22.345	12.23	0.22			11.3		
LAB045				36.88								

Laboratory	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	%	%	%	%	%	%	%	%	%	%	%	%
LAB046	13.195		1.2	37.335	22.253	12.195	0.215	0.005	0.005	11.155	0.55	
LAB047				37.07								
LAB048	13.085		2.452	37.284	22.352	12.172	0.227	0.004	0.003	11.181	0.552	0.316
LAB049	12.975		1.18	36.999	22.84	12.422	0.225			11.345		
LAB050				37.04								
LAB051	12.924		1.099	37.044	22.88	12.107				10.741		
LAB052				38.008								
LAB053	13.455		1.035	37.82	22.54	12.1				11.365		
LAB054				37.315								
LAB055	13.255		1.235		22.425	12.025		0.009	0.009	11.19		
LAB056				37.09								
LAB057			1.18	37.337	22.317	11.893				11.165		
LAB058				37.326								
LAB059			1.095	37.285	22.51					11.1		
LAB060	13.2		1.13	37.39	22.435	11.89		0.005		11.125		
LAB061	13.64		1.18	37.04	22.41	12.025		0.002		11.185		
LAB062	13.45		1.28	37.094	22.498	11.962			0.007	11.316		
LAB063	13.35		1.19	37.555	22.466	12.14	0.21		0.008	11.195	0.535	0.32
LAB064				37.565								
LAB065			1.081	37.529		12.008					0.558	0.37
LAB066				37.66						8.05		
LAB067	14.02		0.9	37.075	23.075	11.805		0.005	0.006	11.085		
LAB068				37.05						11.015		
LAB069	13.218			36.716	21.866	12.188			0.044	11.011		
LAB070	13.162		1.08	37.972	22.815	12.688	0.222	0.003	0.008	11.343	0.526	0.281
LAB071				37.705								
LAB072	13.273		1.245	37.318	22.461	12.419		0.004		11.642		
LAB073				37.405								
LAB074				36.93	21.93					15.428		
LAB075	13.369		1.317	37.707	22.662	12.093	0.224			11.051	0.572	0.315
LAB076				37.619								
LAB077	13.206		0.984	37.45	22.153	11.826	0.214			11.353	0.549	
LAB078				37.728								
LAB079	13.185		1.391	37.628	22.507		0.224			11.352	0.567	
LAB080				37.647								
LAB081	13.212			37.453	22.682	12.067	0.212			11.378	0.643	0.306
LAB082				37.559								
LAB083	13.38			37.43	23.135	11.95				11.585	0.557	
LAB084				37.07								
LAB085				37.35	23.37	14.85			0.012			

#### 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 2018 and Round 2 of 2020. In each round, the participating laboratories were given 1 randomly selected sample from the batch, to analyze and report on in duplicate. The data from the two rounds were collated, after which it 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.  $U_{CRM} = k u_{CRM}$ , 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>	%	42	2.018	0.038	± 0.08	± 0.08
CaO	%	38	2.024	0.031	± 0.06	± 0.07
Cr <sub>2</sub> O <sub>3</sub>	%	77	1.991	0.05	± 0.10	± 0.10
FeO	%	50	2.009	0.071	± 0.14	± 0.15
MgO	%	45	2.014	0.05	± 0.10	± 0.10
MnO	%	21	2.080	0.003	± 0.01	± 0.01
P	%	17	2.110	0.0005	± 0.001	± 0.001
S	%	20	2.086	0.001	± 0.002	± 0.002
SiO <sub>2</sub>	%	49	2.010	0.053	± 0.11	± 0.11
TiO <sub>2</sub>	%	20	2.086	0.005	± 0.01	± 0.01
V <sub>2</sub> O <sub>5</sub>	%	13	2.160	0.01	± 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. 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>21 July 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.*

END