

QOTHO CERTIFIED REFERENCE MATERIAL (QCRM)

QCRM-1-109

CHROME ORE

CERTIFICATE OF ANALYSIS

CERTIFIED VALUES			
ANALYTES	UNITS	CONCENTRATIONS	EXPANDED UNCERTAINTY
Al ₂ O ₃	%	11.95	±0.11
CaO	%	1.67	±0.08
Cr ₂ O ₃	%	30.11	±0.11
FeO	%	19.81	±0.13
MgO	%	14.38	±0.11
MnO	%	0.211	±0.004
P	%	0.006	±0.002
S	%	0.008	±0.002
SiO ₂	%	19.53	±0.21
TiO ₂	%	0.51	±0.01
ASSIGNED VALUES (FOR INFORMATION ONLY)			
ANALYTES	UNITS	CONCENTRATIONS	EXPANDED UNCERTAINTY
V ₂ O ₅	%	0.26	±0.01

1. Use:

QCRM-1-109 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 document has been updated, as more analytical data became available, which resulted in a more robust dataset which enabled additional analytes to be certified.

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:

1 July 2018.

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
- Sulphur by combustion analysis.
- Phosphorous by perchloric digestion and UV-VIS finish

8. Analysis required:

Instruction letters were sent to all participants. The analysis required was noted in the instruction letters and reporting templates, including but not limited to Al_2O_3 , C, CaO, Cr_2O_3 , Cr:Fe Ratio, FeO, MgO, MnO, P, S, SiO_2 , TiO_2 and V_2O_5 .

9. Participating Laboratories:

No	LABORATORY	COUNTRY
1.	Alfred H Knight (North West)	South Africa
2.	Alfred H Knight (Richards Bay)	South Africa
3.	Alfred H Knight (Steelpoort)	South Africa
4.	ALS Geochemistry Kempton Park	South Africa
5.	ALS Inspection (Richards Bay)	South Africa
6.	ALS SAIL (Limpopo)	South Africa
7.	CCIC Africa Lab	South Africa
8.	CCIC Middle East FZE	United Arab Emirates
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 Lydenburg Smelter	South Africa
17.	Glencore Rustenburg Smelter	South Africa
18.	Glencore UG2 Alloys	South Africa
19.	GNK Laboratories Zimlabs	Zimbabwe
20.	Intertek (JHB)	South Africa
21.	Intertek (Steelpoort)	South Africa
22.	Jubilee Metals Group	South Africa
23.	Lanxess Mining Laboratory	South Africa
24.	MITRA SK -SA	South Africa
25.	Nkomati Joint Venture Laboratory	South Africa
26.	Northam Booyendal Fire Assay Lab	South Africa
27.	PCL - Rustenburg	South Africa
28.	PCL - Steelpoort	South Africa
29.	Pilanesberg Platinum Mine	South Africa
30.	Quality Laboratory Services	South Africa
31.	Samancor ECM	South Africa
32.	Samancor Ferrometals	South Africa
33.	Samancor TCS Laboratory	South Africa
34.	Samancor Tubatse Alloy Smelter	South Africa
35.	Samancor Tubatse Chrome	South Africa
36.	Samancor WCM	South Africa
37.	SGS Randfontein	South Africa
38.	SGS Richards Bay	South Africa
39.	UIS Analytical Services ICP	South Africa
40.	UIS Analytical Services XRF	South Africa
41.	Zimasco Kwekwe	Zimbabwe
42.	Zimbabwe Alloy Chrome	Zimbabwe

10. Assay Data:

Data used for Assigning Values and Certification.

LABORATORY	Al ₂ O ₃	C	CaO	Cr ₂ O ₃	Cr:Fe Ratio	FeO	MgO	MnO	P	S	SiO ₂	TiO ₂	V ₂ O ₅
UNIT	%	%	%	%		%	%	%	%	%	%	%	%
LAB001			1.814								18.983		
LAB002	12.253		1.888	31.328	1.34	20.608	14.86	0.212		0.007	18.49	0.504	0.215
LAB003	11.878		1.784	29.782	1.354	19.365	14.357				20.045	0.492	
LAB004				29.797									
LAB005	12.195		0.71	30.42	1.361	19.655	14.27		0.007	0.008	19.155	0.515	0.295
LAB006				30.4									
LAB007	11.887	0.106	1.468	29.85	1.3	20.203	14.439	0.213	0.004	0.007	19.986	0.501	0.268
LAB008	11.945			30.08	1.36	19.51	14.48	0.21				0.48	
LAB009				30.055									
LAB010				29.305		20.25							
LAB011	11.965		1.735	30.19		19.755	14.56	0.205	0.01		19.31	0.525	0.248
LAB012	12.224			30.954				0.21		0.007	19.785	0.498	0.259
LAB013	12.441		1.583	30.718		19.208	14.994	0.205				0.473	
LAB014				30.55									
LAB015	12.005			30.32		19.665	14.115	0.22			19.335	0.51	0.253
LAB016				30.36									
LAB017	18.745		1.585			17.985	18.135	0.21			19.91		
LAB018	11.775		1.586	29.804		19.705	14.056				18.711		
LAB019	11.66		1.41			19.52	14.465		0.006	0.009	20.21		
LAB020				30.2									
LAB021	11.74					19.505	14.265	0.205			19.49		0.24
LAB022				29.92									

LABORATORY	Al ₂ O ₃	C	CaO	Cr ₂ O ₃	Cr:Fe Ratio	FeO	MgO	MnO	P	S	SiO ₂	TiO ₂	V ₂ O ₅
UNIT	%	%	%	%		%	%	%	%	%	%	%	%
LAB023				31.24							17.495		
LAB024						19.405							
LAB025	10.855		1.208	30.735		20.71	15.135		0.007	0.005	19.635		
LAB026				30.495							19.385		
LAB027	11.865	0.073	1.72	30.27	1.41	19.775	14.505		0.006	0.008	19.675		
LAB028				30.195									
LAB029				30.26									
LAB030				30.265	1.31	20.3					18.115		
LAB031	11.95			29.834	1.32	19.913	14.89	0.204	0.007		20.093	0.509	0.272
LAB032				30.11									
LAB033					1.4					0.01			
LAB034	11.648		2.229	29.67	1.325	19.705	14.406			0.01	20.273	0.503	0.253
LAB035	11.814		1.39	30.174	1.317	20.172	14.415	0.213	0.006	0.009	18.998	0.506	0.265
LAB036	11.87	0.065	1.675	29.885	1.347	19.536	14.145	0.21	0.004	0.01	19.43	0.505	
LAB037				30.275									
LAB038				29.38	1.355								
LAB039				30.245									
LAB040	12.147		1.641	29.76		19.578	14.133		0.006	0.01	19.302		
LAB041				29.655									
LAB042	11.645		0.48	30.065		19.405	14.05	0.21			20.255		
LAB043				29.855									
LAB044	11.595		1.685			19.695		0.215			19.525		0.29
LAB045				30.4									

LABORATORY	Al ₂ O ₃	C	CaO	Cr ₂ O ₃	Cr:Fe Ratio	FeO	MgO	MnO	P	S	SiO ₂	TiO ₂	V ₂ O ₅
UNIT	%	%	%	%		%	%	%	%	%	%	%	%
LAB046	11.86		1.725	29.67		19.432	14.42	0.22	0.004	0.005	19.63	0.495	
LAB047				29.92									
LAB048	12.021			30.149		19.771	14.274	0.213	0.005	0.004	18.13	0.522	0.251
LAB049	11.84		1.815	29.49		19.895		0.2			20.18		
LAB050	11.61		1.81	29.715		19.595	14.485						
LAB051				29.835							19.76		
LAB052	11.98		1.785			19.885	14.595		0.007	0.006	19.965		
LAB053				29.97									
LAB054			1.667	29.359		19.304	13.875				19.397		
LAB055				29.811									
LAB056			1.67	29.59							18.34		
LAB057	12.35		1.735	30.295		20.075	14.25		0.005		19.85		
LAB058	12.3		1.705	29.685		19.72	14.465				20.045		
LAB059	12.114		1.889	29.861		20.107	14.425			0.007	20.222		
LAB060	12.777		1.387	29.719		19.813	14.412		0.006		20.043	0.506	
LAB061	11.935		1.675	30.06		19.658	14.445	0.2		0.02	19.485	0.5	0.238
LAB062				30.2									
LAB063			1.76	24.175			14.78	0.22				0.507	0.262
LAB064				29.6									
LAB065	12.21		1.485	30.225		20.27			0.007		19.56		
LAB066				30.195							19.47		
LAB067	11.844					19.538	13.832		0.007		19.576		
LAB068	11.995		1.58	30.782		20.29	14.85		0.004	0.013	18.777		

LABORATORY	Al ₂ O ₃	C	CaO	Cr ₂ O ₃	Cr:Fe Ratio	FeO	MgO	MnO	P	S	SiO ₂	TiO ₂	V ₂ O ₅
UNIT	%	%	%	%		%	%	%	%	%	%	%	%
LAB069				30.255									
LAB070	12.076		1.833	29.741		19.511	15.125		0.007		20.004		
LAB071				30.273									
LAB072						19.91							
LAB073				29.88									
LAB074	11.994		1.687	30.7		20.21	14.375	0.215			19.286	0.512	0.26
LAB075				30.454									
LAB076	12.185		0.175	29.985		19.612	13.937	0.218			16.676	0.525	
LAB077				29.992									
LAB078	12.096		1.261	30.392		20.09	14.462	0.213			19.875	0.512	0.253
LAB079				30.378									
LAB080	11.836			29.968		19.715	14.201	0.203			20.165		0.243
LAB081				30.343									
LAB082	12.073		1.785	30.365		19.822	14.491	0.204		0.006	19.589	0.5	0.257
LAB083				30.031									
LAB084	12.075			30.54		20.069	14.36	0.213			19.895	0.502	0.251
LAB085	11.906		1.669	30.529		20.029	14.377	0.223			19.034	0.491	0.24
LAB086	11.335			30.14		19.655	13.905				18.925	0.505	
LAB087				30.28									
LAB088	11.34					20.36	13.825						

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 2018 and Round 3 2021. 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. 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	ν (degrees of freedom)	k (coverage factor)	u (standard error)	95% measurement uncertainty	Expanded Uncertainty
Al ₂ O ₃	%	44	2.015	0.052	± 0.10	± 0.11
CaO	%	37	2.026	0.04	± 0.08	± 0.08
Cr ₂ O ₃	%	76	1.992	0.055	± 0.11	± 0.11
FeO	%	48	2.011	0.063	± 0.13	± 0.13
MgO	%	42	2.018	0.055	± 0.11	± 0.11
MnO	%	25	2.060	0.002	± 0.004	± 0.004
P	%	18	2.101	0.001	± 0.002	± 0.002
S	%	18	2.101	0.001	± 0.002	± 0.002
SiO ₂	%	48	2.011	0.105	± 0.21	± 0.21
TiO ₂	%	24	2.064	0.003	± 0.01	± 0.01
V ₂ O ₅	%	19	2.093	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	
Qotho Managing Director	3 December 2021

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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