

QOTHO CERTIFIED REFERENCE MATERIAL (QCRM)

QCRM-1-117

CHROME ORE

CERTIFICATE OF ANALYSIS

CERTIFIED VALUES			
ANALYTES	UNITS	CONCENTRATIONS	EXPANDED UNCERTAINTY
Al ₂ O ₃	%	15.07	±0.08
CaO	%	0.48	±0.03
Cr ₂ O ₃	%	39.30	±0.09
FeO	%	26.51	±0.11
MgO	%	10.55	±0.08
MnO	%	0.249	±0.004
S	%	0.12	±0.01
SiO ₂	%	5.50	±0.08
TiO ₂	%	0.85	±0.01
V ₂ O ₅	%	0.36	±0.02
ASSIGNED VALUES (FOR INFORMATION ONLY)			
ANALYTES	UNITS	CONCENTRATIONS	EXPANDED UNCERTAINTY
P	%	0.004	±0.002

1. Use:

QCRM-1-117 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 data became available. The combined new dataset was processed through our updated and accredited certification protocol.

2. Origin of Material:

This standard was sponsored by Tubatse Chrome Mine, Steelpoort, South Africa.

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. In the Eastern Limb, it is predominantly the MG1, LG5 and LG6 Chromitite layers that are being mined.

4. Date of Initial Issue:

8 April 2019.

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 or perchloric digestion and ICP-OES 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.	Afarak Elektrowerk Weisweiler GmbH	Germany
2.	AHK North West	South Africa
3.	AHK SA Richards Bay	South Africa
4.	AHK Steelpoort	South Africa
5.	ALS Geochemistry Kempton Park	South Africa
6.	ALS Inspection Richards Bay	South Africa
7.	Chromtech	South Africa
8.	Cotecna Richards Bay	South Africa
9.	Dwarsrivier	South Africa
10.	Element Materials Technology	Oman
11.	Glencore Boshoeck	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.	IMEC Laboratory Services	South Africa
20.	Intertek JHB	South Africa
21.	Intertek Kathu	South Africa
22.	Intertek Steelpoort	South Africa
23.	Jubilee Metals Group	South Africa
24.	LANXESS Mining Laboratory	South Africa
25.	Mitra Sk South Africa	South Africa
26.	Northam Booyssendal Fire Assay Lab	South Africa
27.	Nkomati Joint Venture Laboratory	South Africa
28.	PCL Rustenburg	South Africa
29.	PCL Steelpoort	South Africa
30.	Pilanesberg Platinum Mine	South Africa
31.	Quality Laboratory Services	South Africa
32.	Samancor ECM	South Africa
33.	Samancor Ferrometals	South Africa
34.	Samancor TCS Laboratory	South Africa
35.	Samancor Tubatse Alloy Smelter	South Africa
36.	Samancor Tubatse Chrome	South Africa
37.	Samancor WCM	South Africa
38.	SGS Randfontein	South Africa
39.	SGS Richards Bay	South Africa
40.	UIS Analytical Services ICP	South Africa
41.	UIS Analytical Services XRF	South Africa
42.	Zimasco Kwekwe	Zimbabwe
43.	Zimbabwe Alloys 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					1.315				0.003				
LAB002	14.805		0.45	39.345		26.735	10.475			0.125	5.59		
LAB003	15.171		0.538	39.62		26.581							
LAB004	14.858		0.333	39.145	1.315	26.156	10.36	0.248	0.007	0.124	5.492	0.845	
LAB005	15.18		0.532	39.291	1.3	26.558	10.494				5.561	0.849	
LAB006				39.115									
LAB007	14.98		0.485	39.26	1.298	26.61	10.465		0.005	0.098	5.285	0.845	
LAB008				39.32									
LAB009										0.129			
LAB010	14.88		0.33	38.87	1.325	25.935	10.455	0.24			5.415	0.845	
LAB011				38.875									
LAB012				39.29		26.52							
LAB013	14.837			39.716		26.436	10.323	0.244	0.007	0.116	5.22	0.837	0.343
LAB014	15.071			40.665	1.49								
LAB015	15.165		0.225	39.225		26.27	10.555	0.25			5.55		
LAB016				39.295									
LAB017	15.045			38.82		26.54	10.55	0.25			5.53	0.835	0.35
LAB018				38.825									
LAB019			0.415	38.54				0.23			5.53		
LAB020				38.62									
LAB021	14.905		0.508	40.046		26.83	10.878				5.682		
LAB022				40.148									
LAB023	14.86		0.45			26.395	10.675		0.006	0.115	5.665		
LAB024				39.665									
LAB025	15.055					26.565	10.4	0.245			5.54		0.355
LAB026				39.265									

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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	%	%	%	%		%	%	%	%	%	%	%	%
LAB027				39.47		26.69							
LAB028			0.486	39.565		26.335	11.07		0.006	0.007	5.265		
LAB029				39.66							5.145		
LAB030	15.1	0.073	0.495	39.155	1.31	26.325	10.43		0.004	0.125	5.485		
LAB031				39.385									
LAB032				39.225									
LAB033						26.4							
LAB034				37.47									
LAB035	15.048	0.075	0.576	39.615	1.324	25.992	10.531	0.255	0.003	0.125	5.519	0.872	0.355
LAB036				39.615									
LAB037	15.313		0.801	38.933	1.274	26.89	10.803	0.247	0.002		5.582	0.88	0.304
LAB038				38.87									
LAB039				39	1.4	24.85			0.014				
LAB040	15.257		0.461	39.516	1.316	26.437	10.473		0.004	0.128	5.014	0.866	0.357
LAB041			0.452	39.202	1.297	26.605			0.003	0.17	5.773		
LAB042	15.21	0.07	0.47	39.76	0.904	26.5	10.6		< 0.010	0.1	5.53	0.85	
LAB043				39.98									
LAB044				39.48		27.2							
LAB045				39.235									
LAB046	14.745		0.69			25.455	10.115	0.225	0.005			0.63	
LAB047	15.2		0.495	39.215		26.4	10.4	0.25				0.85	
LAB048				38.85									
LAB049	15.185		0.475	38.955		26.435	10.405		0.003	0.112	5.415		
LAB050				39.165									
LAB051	14.29					26.565	10.16	0.238			5.32	0.833	
LAB052				39.075									
LAB053	14.96		0.455	38.65		26.172	10.545	0.26	0.005	0.1	5.48	0.855	
LAB054				39.26									

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	%	%	%	%		%	%	%	%	%	%	%	%
LAB055	15.2			39.343		26.406	9.525	0.269	0.003	0.121	5.108	0.737	0.366
LAB056	15.31		0.505	39.38		27	10.695	0.245			5.405		
LAB057				39.235									
LAB058	14.947		0.382	40.001		26.908	10.773				5.84		
LAB059				39.828									
LAB060	14.945		0.495			26.065	10.86		0.005	0.11	5.68		
LAB061				39.355									
LAB062			0.535	39.19		26.24	10.635				5.55		
LAB063	15.31		0.46	39.5		26.775	10.595		0.005		5.59		
LAB064	15.405		0.5	39.46		26.575	10.485		0.002		5.505		
LAB065	15.128		0.518	39.512		26.054	10.543			0.12	5.701		
LAB066	14.922		0.529	39.222		26.403	10.57						
LAB067				39.357									
LAB068	15.125		0.48	39.495		26.544	10.4	0.25		0.13	5.44	0.84	0.351
LAB069			0.408	39.1			10.705					0.856	0.417
LAB070				39.045									
LAB071	14.672		0.417	39.326		26.398			0.005	0.005	5.157		
LAB072				39.273							5.197		
LAB073	14.993					26.524	10.522				5.739		
LAB074	15.115		0.665	39.642		26.81	10.72	0.255	0.003	0.127	5.565	0.823	
LAB075				39.37									
LAB076	14.929		0.819	39.406		26.557	10.887		0.003		5.748		
LAB077				39.406									
LAB078						26.7					4.915		
LAB079				38.72									
LAB080	15.055		0.538	39.495		26.732	10.671	0.254			5.418	0.85	0.361
LAB081				39.373									
LAB082	15.165		0.351	39.626		26.545	10.357	0.248			5.591	0.845	

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	%	%	%	%		%	%	%	%	%	%	%	%
LAB083				39.4									
LAB084	15.006		0.594	39.486		26.731	10.429	0.255			5.549	0.859	0.356
LAB085				39.541									
LAB086	15.18			39.325		26.808	10.499	0.257			5.965		0.364
LAB087				39.231									
LAB088	15.027		0.504	38.851		26.617	10.703	0.252		0.11	5.707	0.929	0.376
LAB089	15.445		0.478	39.33		26.4	10.875	0.256	0.005		5.601	0.923	0.39
LAB090	15.148		0.488	39.215		26.231	10.299	0.244			5.397	0.813	0.333
LAB091	15.36			39.215		26.93	10.295				5.465	0.865	
LAB092				39.03									

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 4 of 2018 and Round 5 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. $UCRM = k u_{CRM}$, 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	ν (degrees of freedom)	k (coverage factor)	u (standard error)	95% measurement uncertainty	Expanded Uncertainty
Al ₂ O ₃	%	43	2.017	0.039	± 0.08	± 0.08
CaO	%	39	2.023	0.015	± 0.03	± 0.03
Cr ₂ O ₃	%	81	1.990	0.043	± 0.09	± 0.09
FeO	%	51	2.008	0.053	± 0.11	± 0.11
MgO	%	43	2.017	0.04	± 0.08	± 0.08
MnO	%	23	2.069	0.002	± 0.004	± 0.004
P	%	23	2.069	0.001	± 0.002	± 0.002
S	%	20	2.086	0.004	± 0.01	± 0.01
SiO ₂	%	45	2.014	0.036	± 0.07	± 0.08
TiO ₂	%	24	2.064	0.005	± 0.01	± 0.01
V ₂ O ₅	%	14	2.145	0.006	± 0.01	± 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	
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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