

QOTHO CERTIFIED REFERENCE MATERIAL (QCRM)

QCRM-1-196

CHROME ORE

CERTIFICATE OF ANALYSIS

CERTIFIED VALUES			
ANALYTES	UNITS	CONCENTRATIONS	EXPANDED UNCERTAINTY
Al ₂ O ₃	%	13.37	±0.13
Cr ₂ O ₃	%	36.13	±0.14
FeO	%	22.05	±0.11
MnO	%	0.21	±0.01
S	%	0.008	±0.002
SiO ₂	%	12.29	±0.23
TiO ₂	%	0.58	±0.01
ASSIGNED VALUES (FOR INFORMATION ONLY)			
ANALYTES	UNITS	CONCENTRATIONS	EXPANDED UNCERTAINTY
CaO	%	0.99	±0.07
MgO	%	12.67	±0.16
P	%	0.005	±0.002
V ₂ O ₅	%	0.31	±0.02

1. Use:

QCRM-1-196 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 analysing similar materials.

2. Origin of Material:

This standard was sponsored by Samancor Western Chrome, 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. This material is classified as a LG6 ore, and originates from the Western Limb of the Bushveld Complex

4. Date of Initial Issue:

27 January 2022.

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:

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 , Cr:Fe Ratio, FeO, MgO, MnO, P, S, SiO_2 , TiO_2 and V_2O_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.	Chromtech	South Africa
7.	Cotecna Richards Bay	South Africa
8.	Dwarsrivier Chrome Mine	South Africa
9.	Glencore Boshhoek	South Africa
10.	Glencore Eastern Mines	South Africa
11.	Glencore Kroondal	South Africa
12.	Glencore Rustenburg Smelter	South Africa
13.	Glencore UG2 Alloys	South Africa
14.	GNK Laboratories Zimlabs	Zimbabwe
15.	Intertek Kathu	South Africa
16.	Intertek Steelpoort	South Africa
17.	Jubilee Metals Group	South Africa
18.	Mitra SK South Africa	South Africa
19.	Northam Booyssendal Fire Assay Lab	South Africa
20.	PCL Rustenburg	South Africa
21.	PCL Steelpoort	South Africa
22.	Pilanesberg Platinum Mine	South Africa
23.	Quality Laboratory Services	South Africa
24.	Samancor Ferrometals	South Africa
25.	Samancor Tubatse Alloy Smelter	South Africa
26.	SGS Randfontein	South Africa
27.	SGS Richards Bay	South Africa
28.	UIS Analytical Services ICP	South Africa
29.	UIS Analytical Services XRF	South Africa
30.	Zimasco Kwekwe	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	13.264		1.044	36.579		22.435	12.384		0.006	0.015	12.609	0.584	
LAB002				35.882									
LAB003	13.555		0.735	36.66		22.2	12.52			0.007	12.64		
LAB004	13.43		1.083			21.927	13.033						
LAB005	13.411		1.027	35.99	1.425	22.227	12.547	0.209			12.295	0.607	0.294
LAB006	13.7		0.74	36.953	1.465	22.242	12.922	0.21	0.009	0.006	12.165	0.573	0.269
LAB007	13.474		0.941	35.758	1.44	21.891	12.674				12.386	0.571	
LAB008				35.808									
LAB009	13.25		0.935	36.18	1.422	22.375	12.88		0.007	0.009	11.585	0.585	0.33
LAB010				36.15									
LAB011	13.368		0.91	35.65	1.436		12.61	0.213	0.003		12.259	0.587	0.321
LAB012		0.045	1.186	35.98		22.015	12.395	0.219	< 0.005		12.18	0.579	0.331
LAB013	13.315			36.09	1.44	22.055	12.565	0.21				0.575	
LAB014				35.96									
LAB015				36.275		21.575					11.991		
LAB016	13.165			35.35		21.462	12.322	0.206	0.01	0.007	11.623	0.56	0.305
LAB017			1.128		1.43						12.342		
LAB018	13.375		1.02	36.65		21.835	12.265	0.215			12.8	0.565	
LAB019				36.645									
LAB020	13.31			35.995		22.03	12.88	0.215			11.84	0.58	0.3
LAB021				36.015									
LAB022			1.035	36.555				0.21			13.87		
LAB023				36.32									
LAB024	13.424		0.873	35.754		21.916	12.561				11.878		
LAB025				35.905									

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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	%	%	%	%		%	%	%	%	%	%	%	%
LAB026	12.995		0.89			21.99	12.4		0.005	0.006	12.665		
LAB027				36.31									
LAB028	13.49					21.905	12.685	0.21			12.19		0.305
LAB029				36.145									
LAB030				37.41		22.075							
LAB031	14.39		0.985	35.835		22.115	12.525		0.006		12.135		
LAB032				36.26							12.175		
LAB033	13.385	0.034	0.985	36.005	1.445	21.985	12.78		0.003	0.009	12.365		
LAB034				36.06									
LAB035				35.72									
LAB036				35.985		22.25							
LAB037	13.63		1.275	36.015	1.43	22.13	12.59	0.211	0.005		12.855	0.605	0.333
LAB038				36.2									
LAB039	13.091		1.014	36.608	1.464	22.008	13.029		0.004	0.01	12.076	0.587	0.308
LAB040	14.614		0.93	36.712	1.457	22.178	13.782	0.247	0.004	0.007	13.172	0.635	0.356
LAB041	13.355	0.07	0.945	35.965	1.439	22.015	12.83	0.22	< 0.010	< 0.010	12.185	0.575	
LAB042				36.21									
LAB043				35.7									
LAB044				35.88									
LAB045			1.00				12.66		0.003				

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 4 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:

Standard 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. The measurement uncertainty of the certified value is therefore calculated as follows: $U_{CRM} = k u_{CRM}$, 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	s (Standard Deviation of Dataset)	ν (degrees of freedom)	k (coverage factor)	u (Standard uncertainty)	95% measurement uncertainty	Expanded measurement uncertainty
Al ₂ O ₃	%	0.224	20	2.086	0.06	± 0.12	± 0.13
CaO	%	0.115	20	2.086	0.033	± 0.07	± 0.07
Cr ₂ O ₃	%	0.372	39	2.023	0.069	± 0.14	± 0.14
FeO	%	0.231	23	2.069	0.053	± 0.11	± 0.11
MgO	%	0.325	24	2.064	0.076	± 0.15	± 0.16
MnO	%	0.004	12	2.179	0.002	± 0.01	± 0.01
P	%	0.002	13	2.160	0.001	± 0.002	± 0.002
S	%	0.002	9	2.262	0.001	± 0.002	± 0.002
SiO ₂	%	0.442	23	2.069	0.108	± 0.22	± 0.23
TiO ₂	%	0.019	14	2.145	0.005	± 0.01	± 0.01
V ₂ O ₅	%	0.027	10	2.228	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. 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	27 January 2022

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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