

QOTHO CERTIFIED REFERENCE MATERIAL (QCRM)

QCRM-1-172

CHROME ORE

CERTIFICATE OF ANALYSIS

CERTIFIED VALUES			
ANALYTES	UNITS	CONCENTRATIONS	EXPANDED UNCERTAINTY
Al ₂ O ₃	%	14.36	±0.10
CaO	%	1.15	±0.10
Cr ₂ O ₃	%	36.54	±0.10
FeO	%	23.53	±0.15
MgO	%	10.88	±0.09
MnO	%	0.22	±0.01
P	%	0.006	±0.002
S	%	0.014	±0.004
SiO ₂	%	10.36	±0.24
TiO ₂	%	0.67	±0.03
ASSIGNED VALUES (FOR INFORMATION ONLY)			
ANALYTES	UNITS	CONCENTRATIONS	EXPANDED UNCERTAINTY
V ₂ O ₅	%	0.32	±0.02

1. Use:

QCRM-1-172 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.

2. Origin of Material:

This standard was sponsored by Samancor Western Chrome, South Africa. It is a composite material collected from milled laboratory pulp rejects after analysis. The material has been through a heavy media separation and flotation processes to concentrate the chromite.

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 concentrate was produced from ore originates from the Western Limb of the Bushveld complex.

4. Date of Initial Issue:

12 November 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 Auto/Manual 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 within the PT Scheme. 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 , 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.	ALS SAIL - Limpopo	South Africa
7.	CCIC Middle East FZE	United Arab Emirates
8.	Chromtech	South Africa
9.	Cotecna Richards Bay	South Africa
10.	Dwarsrivier Chrome Mine	South Africa
11.	Glencore Boshoeck	South Africa
12.	Glencore Eastern Mines	South Africa
13.	Glencore Kroondal	South Africa
14.	Glencore Lydenburg Smelter	South Africa
15.	Glencore Rustenburg Smelter	South Africa
16.	Glencore UG2 Alloys	South Africa
17.	Intertek JHB	South Africa
18.	Intertek Steelpoort	South Africa
19.	Mitra SK South Africa	South Africa
20.	Nkomati JV	South Africa
21.	PCL Rustenburg	South Africa
22.	PCL Steelpoort	South Africa
23.	Pilanesberg Platinum Mine	South Africa
24.	Quality Laboratory Services	South Africa
25.	Samancor Dikwena	South Africa
26.	Samancor Ferrometals	South Africa
27.	Samancor Tubatse Alloy Smelter	South Africa
28.	SGS Richards Bay	South Africa
29.	Suntech Geomet Labs	South Africa
30.	Zimasco Kwekwe	Zimbabwe
31.	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			1.06	36.525		23.855	10.88			0.009	9.98		
LAB002			1.223				10.836				10.201		
LAB003				37.401									
LAB004	14.203		0.895	36.707	1.36	23.735	10.883	0.211	0.007	0.011	10.075	0.669	0.285
LAB005				36.642									
LAB006	14.27		1.114	36.543	1.335	23.747	10.613				10.671	0.665	
LAB007				36.462									
LAB008	14.3			36.51	1.36	23.665	10.79		0.008	0.014	9.86	0.675	
LAB009				36.555									
LAB010	14.455	0.085	1.087	35.741		23.673	10.715	0.216			10.435	0.667	0.335
LAB011	14.39		1.01	36.44	1.375	23.375	10.785	0.21			10.495	0.64	
LAB012				36.34									
LAB013				36.465		23.06					11.085		
LAB014	14.32		1.195	36.23		23.855	11.03	0.215	0.007	0.022	10.34	0.7	0.326
LAB015								0.134			9.554	0.615	0.304
LAB016	14.372		1.145	36.644		23.056	10.855	0.213			11.418	0.724	
LAB017				36.7									
LAB018	14.35				1.38	23.275	10.745	0.21				0.66	0.32
LAB019				36.47							10.715		
LAB020			1.155	36.975		23.245		0.21			10.265		
LAB021				36.855									
LAB022	14.295		1.315	36.6		23.6	11.035				10.56		
LAB023			1.25			23.77	11.205		0.005	0.004	9.665		
LAB024				36.64									
LAB025	14.535					23.31	10.67				10.425		

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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				36.685									
LAB027	14.65		1.135	38.02		24.42	11.4				8.86		
LAB028	14.695		1.715	36.975		23.55	11.035		0.008		11.36		
LAB029						23.005							
LAB030				36.38							10.935		
LAB031	14.19		1.32	36.295		23.155	11.335	0.215	0.005	0.01	10.55	0.591	0.311
LAB032				36.48							10.675		
LAB033	14.174			36.541		23.7	10.721				10.591		
LAB034	14.34	0.047	1.16	36.495	1.37	23.445	10.775		0.004	0.013	10.46		
LAB035				36.525									
LAB036				36.49									
LAB037	14.378		1.345	36.375	1.353	23.676	11.352	0.218	0.007		10.666	0.68	0.342
LAB038				36.195									
LAB039				35.45	1.455	21.45				0.021	9.59		
LAB040	14.543			36.176	1.34	23.59		0.215		0.014	10.947	0.665	0.323
LAB041	14.445		0.964	36.435		23.689	10.759	0.221	0.006	0.011	10.369	0.685	0.321
LAB042	14.305	0.05	1.145	36.61	1.372	23.481	10.805	0.22	< 0.010	0.025	10.495	0.65	
LAB043				36.74									
LAB044				37.3									
LAB045				38.36									
LAB046	13.995		0.636	36.556	1.357	23.723	10.771		0.007	0.01	9.643		
LAB047				36.558							9.546		

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 5 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. 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. 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	ν (degrees of freedom)	k (coverage factor)	u (standard error)	95% measurement uncertainty	Expanded Uncertainty
Al ₂ O ₃	%	19	2.093	0.048	± 0.10	± 0.10
CaO	%	18	2.101	0.048	± 0.10	± 0.10
Cr ₂ O ₃	%	40	2.021	0.046	± 0.09	± 0.10
FeO	%	25	2.060	0.071	± 0.14	± 0.15
MgO	%	21	2.080	0.044	± 0.09	± 0.09
MnO	%	12	2.179	0.002	± 0.01	± 0.01
P	%	10	2.228	0.001	± 0.002	± 0.002
S	%	11	2.201	0.002	± 0.004	± 0.004
SiO ₂	%	29	2.045	0.118	± 0.24	± 0.24
TiO ₂	%	13	2.160	0.011	± 0.02	± 0.03
V ₂ O ₅	%	8	2.306	0.009	± 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	
Qotho Managing Director	12 November 2020

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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