

QOTHO CERTIFIED REFERENCE MATERIAL (QCRM)

QCRM-1-186

CHROME ORE

CERTIFICATE OF ANALYSIS

CERTIFIED VALUES			
ANALYTES	UNITS	CONCENTRATIONS	EXPANDED UNCERTAINTY
Al ₂ O ₃	%	14.09	±0.13
Cr ₂ O ₃	%	36.86	±0.14
FeO	%	23.02	±0.15
MgO	%	11.25	±0.11
MnO	%	0.215	±0.004
P	%	0.005	±0.002
S	%	0.008	±0.002
SiO ₂	%	10.22	±0.14
TiO ₂	%	0.66	±0.01
ASSIGNED VALUES (FOR INFORMATION ONLY)			
ANALYTES	UNITS	CONCENTRATIONS	EXPANDED UNCERTAINTY
C	%	0.06	±0.03
CaO	%	1.01	±0.08
V ₂ O ₅	%	0.33	±0.02

1. Use:

QCRM-1-186 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 ore originated from the Western Limb of the Bushveld complex.

4. Date of Initial Issue:

24 October 2021.

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
- 2-acid digestion with ICP-OES finish
- Chrome via sodium peroxide fusion with Potentiometric Titration
- Fused beads with XRF finish
- Pressed pellet with XRF finish
- Sulphur by combustion analysis.
- Phosphorous by perchloric digestion with UV-VIS finish
- Phosphorous by sodium peroxide fusion with 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.	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 SAIL - Limpopo	South Africa
8.	Chromtech	South Africa
9.	Cotecna Richards Bay	South Africa
10.	Dwarsrivier Chrome Mine	South Africa
11.	Glencore Boshhoek	South Africa
12.	Glencore Eastern Mines	South Africa
13.	Glencore Kroondal	South Africa
14.	Glencore Rustenburg Smelter	South Africa
15.	Glencore UG2 Alloys	South Africa
16.	GNK Laboratories Zimlabs	Zimbabwe
17.	Intertek JHB	South Africa
18.	Intertek Steelpoort	South Africa
19.	Jubilee Metals Group	South Africa
20.	Mitra SK South Africa	South Africa
21.	Nkomati JV	South Africa
22.	Northam Booyseindal Fire Assay Lab	South Africa
23.	Outokumpu	Finland
24.	PCL Rustenburg	South Africa
25.	PCL Steelpoort	South Africa
26.	Pilanesberg Platinum Mine	South Africa
27.	Quality Laboratory Services	South Africa
28.	Samancor Ferrometals	South Africa
29.	Samancor Tubatse Alloy Smelter	South Africa
30.	SGS Randfontein	South Africa
31.	SGS Richards Bay	South Africa
32.	UIS Analytical Services	South Africa
33.	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	14.568	0.063	1.03	36.701	1.394	23.162	11.479	0.227	0.004	0.007	10.409	0.665	0.332
LAB002	14.055			36.95		23.035	11.12	0.21			10.145	0.675	0.32
LAB003				36.92									
LAB004	14.155	0.052	1.095	36.585	1.41	22.87	11.27		0.005	0.009	10.245		
LAB005				36.68									
LAB006	14.31					23.165	11.175	0.22			10.38		
LAB007				36.795									
LAB008	14.11	0.055	1.055	37.125	1.409	23.193	11.355	0.225	< 0,010	0.01	10.21	0.655	
LAB009				37.355									
LAB010			0.7	37.103	1.417	23.036	11.328	0.21	0.006	0.009	10.298	0.662	0.349
LAB011						24.071							
LAB012				37.651									
LAB013	14.12		1.035			23.46	11.03	0.21			10.33		
LAB014	14.276	0.084	1.008	36.3		23.63	11.158	0.215		0.007	10.204	0.661	0.333
LAB015	13.173		1.026			22.557					11.405		
LAB016	14.035		1.025			22.99	11.12		0.004	0.012	10.16		
LAB017				37.285									
LAB018	13.808		1.132	36.762		22.83	11.52				10.448		
LAB019				36.654									
LAB020	13.99		0.985	37.03		23.18	10.995			0.009	10.28		
LAB021	14.238		1.067	36.576	1.415	22.736	11.115				10.129	0.659	
LAB022				36.547									
LAB023				36.34		22.5							
LAB024	14.26		1.095	37.24		22.895	11.15	0.21	0.006		10.125	0.675	0.326
LAB025				36.985									

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				36.73									
LAB027				36.89									
LAB028	13.695		1.19	37.35		22.625	12.09		0.005	0.006	10.2		
LAB029				37.335							10.08		
LAB030	14.181			36.512		22.693	11.296				9.926		
LAB031					1.464						8.729		
LAB032		0.064	0.945		1.39								0.335
LAB033	13.945		0.89	36.73	1.37	23.545	11.24	0.214		0.007	10.192	0.668	0.285
LAB034				36.803									
LAB035	14.047		1.283	37.318	1.409	23.309	11.471	0.208	0.005		10.794	0.675	0.343
LAB036				37.33									
LAB037										0.007		0.656	0.32
LAB038				36.685		22.635					9.735		
LAB039	13.82		0.595	36.69	1.43	22.625	11.06	0.21			9.97	0.65	
LAB040				36.585									
LAB041	14.246		0.803	36.412		22.944	11.226	0.211				0.621	
LAB042				36.58									
LAB043	14.349		0.971	37.535	1.424	23.135	11.707		0.006	0.007	10.744	0.701	0.327
LAB044	14.005		1.101			23.099	11.245		0.003	0.007	10.59	0.663	
LAB045				36.868									
LAB046	13.57		1.08	36.94	1.41	23.07			< 0,005	0.004	9.935	0.679	0.34
LAB047	14.177			36.801	1.404	23.073	11.19	0.223			10.215	0.655	0.315
LAB048	14.195		0.84	36.69	1.385	23.185	11.37			0.009	9.61	0.66	0.27
LAB049				36.505									

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 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:

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	%	23	2.069	0.063	± 0.13	± 0.13
C	%	4	2.776	0.01	± 0.02	± 0.03
CaO	%	21	2.080	0.035	± 0.07	± 0.08
Cr ₂ O ₃	%	39	2.023	0.066	± 0.13	± 0.14
FeO	%	27	2.052	0.074	± 0.15	± 0.15
MgO	%	22	2.074	0.051	± 0.10	± 0.11
MnO	%	12	2.179	0.002	± 0.004	± 0.004
P	%	10	2.228	0.001	± 0.002	± 0.002
S	%	13	2.160	0.001	± 0.002	± 0.002
SiO ₂	%	26	2.056	0.069	± 0.14	± 0.14
TiO ₂	%	16	2.120	0.004	± 0.01	± 0.01
V ₂ O ₅	%	12	2.179	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, 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	24 October 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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