

QOTHO CERTIFIED REFERENCE MATERIAL (QCRM)

QCRM-1-183

CHROME CONCENTRATE

CERTIFICATE OF ANALYSIS

CERTIFIED VALUES			
ANALYTES	UNITS	CONCENTRATIONS	EXPANDED UNCERTAINTY
Al ₂ O ₃	%	15.40	±0.13
CaO	%	0.18	±0.03
Cr ₂ O ₃	%	42.28	±0.10
FeO	%	28.24	±0.21
MgO	%	9.29	±0.11
MnO	%	0.25	±0.01
P	%	0.004	±0.002
S	%	0.010	±0.002
SiO ₂	%	2.11	±0.06
TiO ₂	%	1.06	±0.02
ASSIGNED VALUES (FOR INFORMATION ONLY)			
ANALYTES	UNITS	CONCENTRATIONS	EXPANDED UNCERTAINTY
V ₂ O ₅	%	0.39	±0.02

1. Use:

QCRM-1-183 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 Concentrate and as a calibration standard for the calibration of equipment used for analysing similar materials.

2. Origin of Material:

This standard was sponsored by PCL Laboratory in Rustenburg, South Africa. It is a composite material collected from milled laboratory pulp rejects, after analysis.

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 is produced from chrome ores, originating from the Western Limb of the Bushveld complex.

4. Date of Initial Issue:

3 December 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
- 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
- Phosphorous by Aqua Regia digestion and ICP-OES 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.	ALS Inspection UK	UK
7.	ARM Machadodorp	South Africa
8.	Chromtech	South Africa
9.	Dwarsrivier Chrome Mine	South Africa
10.	Glencore Boshhoek	South Africa
11.	Glencore Eastern Mines	South Africa
12.	Glencore Kroondal	South Africa
13.	Glencore Lion	South Africa
14.	Glencore Rustenburg Smelter	South Africa
15.	Glencore UG2 Alloys	South Africa
16.	Glencore Wonderkop Smelter	South Africa
17.	Intertek JHB	South Africa
18.	Intertek Steelpoort	South Africa
19.	Jubilee Metals Group	South Africa
20.	Mintek	South Africa
21.	Mitra SK South Africa	South Africa
22.	Nkomati JV	South Africa
23.	Northam Booyseindal Fire Assay Lab	South Africa
24.	PCL Rustenburg	South Africa
25.	PCL Steelpoort	South Africa
26.	Pilanesberg Platinum Mine	South Africa
27.	Quality Laboratory Services	South Africa
28.	Samancor Dikwena	South Africa
29.	Samancor ECM	South Africa
30.	Samancor TCS Laboratory	South Africa
31.	Samancor WCM	South Africa
32.	SGS Randfontein	South Africa
33.	SGS Richards Bay	South Africa
34.	Tharisa	South Africa
35.	Zimasco Kwekwe	Zimbabwe
36.	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	15.633		0.172				9.175	0.804		0.017	2.072	1.057	
LAB002				42.07									
LAB003	15.585		0.445	42.375		28.65	9.39			0.012	2.13		
LAB004	16.478		0.16				10.335				2.851		
LAB005	15.265		0.24	42.233	1.29	28.8	9.285	0.248		0.011	2.155	1.102	0.35
LAB006				42.215									
LAB007	15.545		0.15	42.42	1.327	28.13	9.332				2.143	1.055	
LAB008				41.968									
LAB009	15.355		0.155	42.45	1.33	27.94	9.62			0.009	1.99	1.065	0.4
LAB010				42.18									
LAB011	15.344		0.229	42.171		28.25	9.294	0.248			2.162	1.071	0.355
LAB012				42.127									
LAB013				41.983		28.22		0.252			1.851	1.034	
LAB014				42.048									
LAB015				42.39		28.17							
LAB016	15.375		0.22	42.22		28.6	9.08	0.245	0.005		2.125	1.005	0.395
LAB017									0.005	0.004		1.044	0.397
LAB018											2.167		
LAB019					1.416								
LAB020	15.307		0.179	42.371		28.29	9.168	0.246			2.068	1.071	
LAB021				42.286									
LAB022	14.55	0.01	< 0.350	42.05		27.75		0.25		0.01	2.245	1.045	
LAB023	15.355		0.195			28.03	9.31	0.24			2.43	1.055	0.405
LAB024				42.3									
LAB025	14.73		0.19	43.385		30.16		0.255			2.265		
LAB026				43.02									
LAB027	15.319		0.191	42.188		28.18					2.086		

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	%	%	%	%		%	%	%	%	%	%	%	%
LAB028				41.767									
LAB029	15.47		0.383			28.48	9.43		0.005	0.011	2.095		
LAB030				42.26									
LAB031	15.27					27.79	9.21	0.245			2.165		
LAB032				42.22									
LAB033	15.65		0.4			28.45	9.2		0.005	0.012	2.2		
LAB034				42.2									
LAB035	15.025		0.145	42.69		28	9.155		0.005	0.005	1.9		
LAB036				42.395							1.975		
LAB037	14.531			41.741		27.01	8.831				2.011		
LAB038	15.356	0.044	0.41			28.29	9.498		0.007	0.089	2.107	1.116	
LAB039				42.419									
LAB040	15.395	0.018	0.19	42.34	1.325	28.17	9.24		0.002	0.009	2.085		
LAB041				42.345									
LAB042		0.03							0.001	0.02			0.41
LAB043	15.49		0.195	42.415		28.59	9.21		0.004		1.96		
LAB044	15.413			42.459	1.312	28.49	9.46	0.248	0.005		2.175	1.082	0.251
LAB045				42.45									
LAB046					1.45						3.3		
LAB047	15.554		0.161	42.612	1.354	27.70		0.195	0.006	0.011	2.11	0.984	0.381
LAB048	15.715			42.09	1.335	27.87	9.317	0.248			2.03	1.112	0.405
LAB049				42.425									
LAB050	16.27		0.172	42.305	1.309	28.43	9.733	0.25	0.004		2.202	1.092	0.419
LAB051						28.70							
LAB052				42.53							2.165		
LAB053	15.49	0.03	0.165	42.14	1.316	28.19	9.285	0.26	< 0.010	< 0.010	2.26	1.05	
LAB054				42.06									
LAB055				42.945		30							

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 1 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. $U_{CRM} = k u_{CRM}$, 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	%	25	2.060	0.061	± 0.12	± 0.13
CaO	%	21	2.080	0.011	± 0.02	± 0.03
Cr ₂ O ₃	%	41	2.020	0.047	± 0.09	± 0.10
FeO	%	27	2.052	0.103	± 0.21	± 0.21
MgO	%	21	2.080	0.053	± 0.11	± 0.11
MnO	%	14	2.145	0.002	± 0.01	± 0.01
P	%	12	2.179	0.001	± 0.002	± 0.002
S	%	13	2.160	0.001	± 0.002	± 0.002
SiO ₂	%	30	2.042	0.029	± 0.06	± 0.06
TiO ₂	%	16	2.120	0.01	± 0.02	± 0.02
V ₂ O ₅	%	10	2.228	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. 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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