

QOTHO CERTIFIED REFERENCE MATERIAL (QCRM)

QCRM-1-182

CHROME ORE

CERTIFICATE OF ANALYSIS

CERTIFIED VALUES			
ANALYTES	UNITS	CONCENTRATIONS	EXPANDED UNCERTAINTY
Al ₂ O ₃	%	13.59	±0.09
CaO	%	0.63	±0.06
Cr ₂ O ₃	%	37.68	±0.08
FeO	%	22.42	±0.12
MgO	%	12.64	±0.12
MnO	%	0.210	±0.002
P	%	0.004	±0.002
S	%	0.009	±0.002
SiO ₂	%	10.39	±0.09
TiO ₂	%	0.60	±0.01
V ₂ O ₅	%	0.32	±0.01
ASSIGNED VALUES (FOR INFORMATION ONLY)			
ANALYTES	UNITS	CONCENTRATIONS	EXPANDED UNCERTAINTY
C	%	0.05	±0.03

1. Use:

QCRM-1-182 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.

The document was amended, as more data became available, which enabled the certification of more analytes.

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 concentrate was produced from ore that originated predominantly from the LG6 seam within 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
- Multi-acid digestion with ICP-OES finish
- Chrome by sodium peroxide fusion with Potentiometric Titration
- Fused beads with XRF finish
- Pressed pellets with XRF 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 Kempton Park	South Africa
5.	ALS Inspection Richards Bay	South Africa
6.	ALS Inspection UK	United Kingdom
7.	Chromtech	South Africa
8.	Cotecna Richards Bay	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 Rustenburg Smelter	South Africa
14.	Glencore UG2 Alloys	South Africa
15.	GNK Laboratories Zimlabs	Zimbabwe
16.	Intertek JHB	South Africa
17.	Intertek Kathu	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 Booyesendal Fire Assay Lab	South Africa
23.	Northam Booyesendal South	South Africa
24.	Outokumpu	Finland
25.	PCL Rustenburg	South Africa
26.	PCL Steelpoort	South Africa
27.	Pilanesberg Platinum Mine	South Africa
28.	Quality Laboratory Services	South Africa
29.	RC Inspection SA	South Africa
30.	Samancor Ferrometals	South Africa
31.	Samancor TCS Laboratory	South Africa
32.	Samancor Tubatse Alloy Smelter	South Africa
33.	Samancor Tubatse Chrome	South Africa
34.	SGS Randfontein	South Africa
35.	SGS Richards Bay	South Africa
36.	Zimasco Kwekwe	Zimbabwe
37.	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	FeO	MgO	MnO	P	S	SiO ₂	TiO ₂	V ₂ O ₅
UNIT	%	%	%	%		%	%	%	%	%	%	%	%
LAB001	13.629		0.659	38.135			12.563	0.204			10.142	0.603	0.318
LAB002								0.208				0.599	0.311
LAB003	14.06		0.485	37.575		22.525	12.59			0.007	10.26		
LAB004	13.391		0.612	37.344		22.082							
LAB005	14.093		0.258	37.715	1.45	22.922	12.87	0.212		0.008	10.277	0.586	
LAB006	13.435		0.627	37.248	1.48	22.104	12.323				10.116	0.595	
LAB007				37.403									
LAB008	13.4			38.37	1.494	22.645	13.155		0.005	0.01	9.765	0.615	0.32
LAB009				38.435									
LAB010	13.668	0.086	0.766	37.712		22.45	12.656	0.21	0.003	0.013	10.478	0.602	0.322
LAB011	13.46		0.36	37.715	1.49	22.13	12.86	0.21				0.59	
LAB012				37.665									
LAB013				37.68		22.085					10.6		
LAB014				37.285			12.104	0.194		< 0.009	10.194	0.583	0.308
LAB015	13.563		0.624			22.342	11.908	0.211			10.389	0.605	
LAB016	13.865		0.75	37.515		22.355	13.195	0.21			9.98	0.6	
LAB017				37.415									
LAB018	13.615			37.725		22.245	13	0.21			10.25	0.6	0.32
LAB019				37.72									
LAB020			0.525	38.825		22.525		0.21			10.485		
LAB021				38.51									
LAB022	13.523		0.705	37.527		22.196	12.744				10.313		
LAB023				37.262									
LAB024	13.49		0.5			22.125	12.66		0.004	0.01	10.26		
LAB025				37.88									
LAB026	13.51					22.34	12.53	0.205			10.36		0.315
LAB027				37.775									
LAB028				38.255		22.795					10.31		

LABORATORY	Al ₂ O ₃	C	CaO	Cr ₂ O ₃	Cr:Fe	FeO	MgO	MnO	P	S	SiO ₂	TiO ₂	V ₂ O ₅
UNIT	%	%	%	%		%	%	%	%	%	%	%	%
LAB029	14.46		1.02	37.62		22.2	12.245		0.005	0.021	10.68		
LAB030				37.66							10.55		
LAB031	13.505	0.03	0.665	37.665	1.49	22.25	12.585		0.003	0.01	10.43		
LAB032				37.635									
LAB033		0.033											
LAB034	13.805	0.046	0.602	37.639	1.466		12.793	0.196	0.002	0.007		0.559	0.313
LAB035											10.647		
LAB036						22.1							
LAB037	13.549			37.203	1.478	22.163	13.032	0.206	0.002		10.394		0.336
LAB038				37.105									
LAB039				38.6	1.5						9.8		
LAB040			0.457	37.615	1.465	22.596	12.62		0.004	0.007	10.155	0.608	
LAB041	13.26	0.045	0.66	37.35			12.635			0.01	10.46	0.6	
LAB042				37.695									
LAB043				37.575		23.425							
LAB044				37.61									
LAB045	13.875		0.683	37.48			12.765	0.219	0.005		10.57	0.564	0.324
LAB046	13.48		0.635			22.68	12.485	0.21			10.49	0.61	0.31
LAB047				37.65									
LAB048	13.54	0.033	0.67	37.65	1.475	22.445	12.72		0.004	0.007	10.46		
LAB049				37.7									
LAB050	13.41					22.435	12.71	0.215			10.32		
LAB051				37.705									
LAB052	13.655	0.06	0.64	37.7	1.485	22.352	12.725	0.22	< 0.010	< 0.010	10.58	0.58	
LAB053				37.71									
LAB054	14.117		0.599	37.631	1.468	22.566	13.082	0.208	0.004		10.597	0.615	0.33
LAB055	23.135		0.88	38.645		23.775		0.22			11.135		
LAB056				38.695									
LAB057	13.509		0.565				13.624				10.973		
LAB058	13.34		0.849			22.465	12.485		0.004	0.009	10.235		
LAB059				37.475									

LABORATORY UNIT	Al ₂ O ₃ %	C %	CaO %	Cr ₂ O ₃ %	Cr:Fe	FeO %	MgO %	MnO %	P %	S %	SiO ₂ %	TiO ₂ %	V ₂ O ₅ %
LAB060	13.595		0.666	37.639		22.492					10.378		
LAB061				37.211									
LAB062	13.72		0.755	37.645		22.41	12.49			0.01	10.57		
LAB063	13.44		0.627	37.375	1.482	22.207	12.703				10.497	0.603	
LAB064				37.4									
LAB065				37.55							11.31		
LAB066	13.495		0.695	37.34		22.665	12.545	0.21	0.004		10.395	0.595	0.313
LAB067				38.195	1.34	23.74							
LAB068	14.125		0.585	37.805		22.255	12.075		0.005	0.008	10.325		
LAB069				37.85							10.385		
LAB070	13.09			37.143		21.976	12.337				10.469		
LAB071	13.623		0.815	37.608	1.475	22.487	12.58	0.212		0.009	10.27	0.616	
LAB072				37.612									
LAB073	13.386			38.206	1.469	22.901	12.721	0.202	0.005		10.344	0.645	
LAB074				38.22									
LAB075										0.003		0.59	0.318
LAB076				37.955		22.835							
LAB077	13.54		0.435	37.57	1.47	22.48	12.795	0.21				0.585	
LAB078				37.48									
LAB079	13.762		0.476	37.838		22.677	12.305	0.211			11.426	0.609	
LAB080				38.05									
LAB081	13.348		0.669				12.633	0.554		0.013	10.372	0.613	
LAB082				37.496									
LAB083	13.725		0.749	37.956	1.513	22.089		0.162	0.005	0.007	10.855	0.552	0.296
LAB084	13.52		0.505	37.57	1.485	22.595	12.445			0.007	9.88	0.605	
LAB085				38.14									
LAB086					1.56						9.34		

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 1 of 2021 and 1 of 2022. 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.

Laboratories which 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 Uncertainty
Al ₂ O ₃	%	0.265	40	2.021	0.043	± 0.09	± 0.09
C	%	0.021	6	2.447	0.013	± 0.03	± 0.03
CaO	%	0.131	35	2.030	0.028	± 0.06	± 0.06
Cr ₂ O ₃	%	0.305	71	1.994	0.041	± 0.08	± 0.08
FeO	%	0.323	42	2.018	0.059	± 0.12	± 0.12
MgO	%	0.298	38	2.024	0.058	± 0.12	± 0.12
MnO	%	0.005	25	2.060	0.001	± 0.002	± 0.002
P	%	0.002	15	2.131	0.001	± 0.002	± 0.002
S	%	0.003	18	2.101	0.001	± 0.002	± 0.002
SiO ₂	%	0.262	47	2.012	0.045	± 0.09	± 0.09
TiO ₂	%	0.019	27	2.052	0.004	± 0.01	± 0.01
V ₂ O ₅	%	0.012	14	2.145	0.003	± 0.01	± 0.01

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	29 April 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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