

QOTHO CERTIFIED REFERENCE MATERIAL (QCRM)

QCRM-1-247

CHROME CONCENTRATE

CERTIFICATE OF ANALYSIS

CERTIFIED VALUES			
ANALYTES	UNITS	CONCENTRATIONS	EXPANDED UNCERTAINTY
Al ₂ O ₃	%	14.07	±0.05
CaO	%	0.35	±0.03
Cr ₂ O ₃	%	44.01	±0.09
FeO	%	25.12	±0.08
MgO	%	10.60	±0.11
MnO	%	0.24	±0.01
P	%	0.005	±0.002
SiO ₂	%	3.58	±0.06
TiO ₂	%	0.59	±0.01
V ₂ O ₅	%	0.36	±0.02
ASSIGNED VALUES (FOR INFORMATION ONLY)			
ANALYTES	UNITS	CONCENTRATIONS	EXPANDED UNCERTAINTY
C	%	0.018	±0.006

1. Use:

QCRM-1-247 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 Glencore Eastern Chrome Mines Thorncliffe.

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. The concentrate was produced from ores which originated from the Eastern Limb of the Bushveld complex.

4. Date of Initial Issue:

04 June 2024.

5. Packaging & Handling instructions:

The material was packaged as 100g unit sizes, placed in geo-envelopes, within a vacuum sealed aluminium 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
- Fused beads with XRF finish
- Pressed pellets with XRF finish
- Chrome & Iron by sodium peroxide fusion with Potentiometric Titration
- Sulphur by combustion analysis.
- Phosphorous by sodium peroxide fusion with UV-VIS spectrophotometric 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.	ALS Geochemistry Kempton Park	South Africa
4.	Barplats Mine	South Africa
5.	Cotecna Richards Bay	South Africa
6.	Glencore Boshhoek	South Africa
7.	Glencore Eastern Mines	South Africa
8.	Glencore Kroondal	South Africa
9.	Glencore Lion	South Africa
10.	Glencore Rustenburg Smelter	South Africa
11.	Glencore UG2 Alloys	South Africa
12.	Glencore Wonderkop Smelter	South Africa
13.	IMEC Laboratory Services	South Africa
14.	Intertek Durban	South Africa
15.	Jubilee Metals Group	South Africa
16.	Mintek	South Africa
17.	Northam Booyesendal Fire Assay Lab	South Africa
18.	Northam Booyesendal South	South Africa
19.	Outokumpu	Finland
20.	PCL Rustenburg	South Africa
21.	PCL Steelpoort	South Africa
22.	Pilanesberg Platinum Mine	South Africa
23.	Quality Laboratory Services Rustenburg	South Africa
24.	Samancor Dikwena	South Africa
25.	Samancor ECM	South Africa
26.	Samancor WCM	South Africa
27.	SGS Richards Bay	South Africa
28.	Tharisa Minerals	South Africa
29.	UIS Analytical Services	South Africa
30.	Zimasco Kwekwe	Zimbabwe



QOTHO MINERALS (PTY) LTD

Physical Address: 36 Pelindaba Road, Broederstroom, Madibeng, 0240
 PostNet Suite 173, Private Bag X0003, Ifafi, North West Province, 0260
 South Africa
 +27 (0)87 004 3200 / admin@qotho.co.za / www.qotho.co.za



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				43.605	1.54	24.96						0.585	0.38
LAB002	14.075			43.955		25.13	10.66	0.24			3.595	0.59	0.35
LAB003				43.985									
LAB004	14.15		0.35	44.15		25.3	10.55		0.004	0.003	3.5		
LAB005	14.09	0.018	0.34	44.155	1.55	25.085	10.61		0.003	0.007	3.57		
LAB006				44.25									
LAB007	14.001		0.359	43.909	1.543	25.026	10.741	0.23	< 0.006		3.497	0.599	0.375
LAB008	14.031		0.357	43.942		25.12	10.639				3.546	0.592	
LAB009	14.005			44.255	1.55	25.145	10.395	0.287	0.007	0.003	3.405	0.601	0.326
LAB010	14.015	0.02	0.335	43.785			10.475	0.24		0.01	3.6	0.575	
LAB011				44.02									
LAB012				43.98		26.33					3.665		
LAB013	13.817		0.227	43.88	1.55	24.959	10.511	0.238	0.006	0.009	3.428	0.595	0.316
LAB014				43.793									
LAB015	14.03		0.335	43.825		25.2	10.52		0.005		3.54		
LAB016			0.357		1.582			0.232					0.372
LAB017				45.195									
LAB018	14.155		0.391	43.815		24.925	10.72	0.267	0.004	0.058	3.62		
LAB019	14.025			43.79	1.54	24.975	10.395		0.006		3.48	0.612	
LAB020				43.825									
LAB021						25.57							
LAB022				44.18							3.585		
LAB023	14.204					24.916	10.303	0.234			3.539	0.577	0.355
LAB024	14.33			43.94	1.755	25.035	10.495	0.236			3.56	0.598	0.353
LAB025				43.95									



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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	14.1	0.009		44.245		25.155	10.425	0.262			3.65	0.589	0.348
LAB027	14.284	0.022		44.096	1.539	25.219	10.713	0.234		< 0.010		0.619	
LAB028	14.017		0.319	44.1		25.166	10.465				3.679		
LAB029	14.09		0.412	44.084		25.185	10.604	0.24			3.764	0.575	0.357
LAB030				44.122									
LAB031	14.045	0.018	0.295	44		26.055	10.835	0.235	0.003		3.48	0.585	0.355
LAB032	14.015		0.316	44.165	1.53	25.168	10.61		0.005	0.005	3.527	0.585	
LAB033				44.147									
LAB034	14.06		0.4			25.23	10.69		0.004	0.005	3.735		
LAB035				43.83									
LAB036			0.345		1.603	24.508		0.23				0.61	0.372
LAB037				44.54									
LAB038	14.065			43.77		24.965	10.76		0.005	0.003	3.545		
LAB039			0.361	44.035	1.445	26.855	10.87		0.005		2.805		
LAB040				44.18									
LAB041				43.105		25.15					4.05		
LAB042				43.91		25.145							
LAB043				43.965							3.51		
LAB044	13.975			44.1	1.55	25.09	13.075		0.002	0.004	3.655	0.565	
LAB045				44.19									
LAB046	14.55			44.9		26	11.35	0.27		0.013	3.995	0.57	

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 2023. 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 13528:2022 (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	%	0.106	22	2.074	0.024	± 0.05	± 0.05
C	%	0.004	4	2.776	0.002	± 0.004	± 0.006
CaO	%	0.047	15	2.131	0.012	± 0.02	± 0.03
Cr ₂ O ₃	%	0.241	40	2.021	0.042	± 0.08	± 0.09
FeO	%	0.263	28	2.048	0.039	± 0.08	± 0.08
MgO	%	0.199	23	2.069	0.054	± 0.11	± 0.11
MnO	%	0.01	14	2.145	0.003	± 0.01	± 0.01
P	%	0.002	12	2.179	0.001	± 0.002	± 0.002
SiO ₂	%	0.131	26	2.056	0.029	± 0.06	± 0.06
TiO ₂	%	0.018	17	2.110	0.005	± 0.01	± 0.01
V ₂ O ₅	%	0.019	11	2.201	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/IEC 17025:2017 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/IEC 17043:2023 and ISO 17034:2016 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 Signatories	
Dr Hannelie de Beer (Pr. Sci. Nat.)	Takudzwa Tsapayi (Pr. Sci. Nat.)
04 June 2024	

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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