

QOTHO CERTIFIED REFERENCE MATERIAL (QCRM)

QCRM-1-242

CHROME ORE

CERTIFICATE OF ANALYSIS

CERTIFIED VALUES			
ANALYTES	UNITS	CONCENTRATIONS	EXPANDED UNCERTAINTY
Al ₂ O ₃	%	15.08	±0.18
CaO	%	0.77	±0.07
Cr ₂ O ₃	%	40.16	±0.14
FeO	%	22.92	±0.15
MgO	%	11.01	±0.14
MnO	%	0.29	±0.01
P	%	0.005	±0.002
SiO ₂	%	7.49	±0.09
TiO ₂	%	0.62	±0.01
ASSIGNED VALUES (FOR INFORMATION ONLY)			
ANALYTES	UNITS	CONCENTRATIONS	EXPANDED UNCERTAINTY
S	%	0.008	±0.005
V ₂ O ₅	%	0.32	±0.04

1. Use:

QCRM-1-242 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 Glencore Kroondal.

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 standard was produced from ores which originated from the Western 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 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
- Fused beads with XRF finish
- Pressed pellets with XRF finish
- Chrome & Iron by sodium peroxide fusion with Potentiometric Titration
- Sulphur by combustion analysis.
- Silica by perchloric digestion and gravimetric finish.
- 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 Steelpoort	South Africa
3.	ALS Geochemistry Kempton Park	South Africa
4.	Barplats Mine	South Africa
5.	CCIC Middle East FZE	Dubai
6.	Cotecna Richards Bay	South Africa
7.	Dwarsrivier Chrome Mine	South Africa
8.	Glencore Boshhoek	South Africa
9.	Glencore Eastern Mines	South Africa
10.	Glencore Kroondal	South Africa
11.	Glencore Rustenburg Smelter	South Africa
12.	Glencore UG2 Alloys	South Africa
13.	GNK Laboratories Zimlabs	Zimbabwe
14.	IMEC Laboratory Services	South Africa
15.	Intertek Durban	South Africa
16.	Intertek Jhb	South Africa
17.	Intertek Steelpoort	South Africa
18.	Jubilee Metals Group	South Africa
19.	Mitra Sk South Africa	South Africa
20.	Northam Booyensdal Fire Assay Lab	South Africa
21.	Northam Booyensdal South	South Africa
22.	Outokumpu	Finland
23.	PCL Rustenburg	South Africa
24.	PCL Steelpoort	South Africa
25.	Pilanesberg Platinum Mine	South Africa
26.	Quality Laboratory Services Rustenburg	South Africa
27.	Samancor Ferrometals	South Africa
28.	Samancor TCS Laboratory	South Africa
29.	Samancor Tubatse Alloy Smelter	South Africa
30.	Samancor Tubatse Ferrochrome	South Africa
31.	Zimasco Kwekwe	Zimbabwe
32.	Zimbabwe Alloy Chrome	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				39.205	1.515	22.775					7.97	0.575	0.36
LAB002						23.02							
LAB003				39.355									
LAB004	15.398		0.687	39.667		23.157	11.323	0.289			7.549	0.604	
LAB005				39.675									
LAB006	15.566		0.422	40.663		22.602	10.422	0.277			7.172	0.63	
LAB007				40.575									
LAB008	15.15			40.39		22.69	11.055	0.29			7.345	0.62	0.33
LAB009				40.385									
LAB010				39.97									
LAB011	15.41		0.85	39.815	1.565	22.355	10.975	0.28			7.69	0.63	
LAB012				39.745									
LAB013	14.525		0.865	39.275		23.085	10.935		0.005	0.008	7.095		
LAB014				39.135							7.245		
LAB015	15.085	0.05	0.8	39.9			10.91	0.29		0.01	7.55	0.615	
LAB016				39.935									
LAB017	15.209		0.716	40.071		23.341	11.164	0.284			7.521	0.606	0.326
LAB018				40.067									
LAB019				40.43		23.3							
LAB020	14.646			40.052		22.677	10.652			0.005			
LAB021				40.166							7.641		
LAB022	14.868		0.54	40.258	1.545	23.02	11.259	0.29	0.006	0.006	7.579	0.617	0.288
LAB023				40.35									
LAB024	16.43		0.845	41.05		22.75							0.345
LAB025	14.995		0.859	40.015		23.099	10.94	0.277	0.007	0.01	7.575		0.231
LAB026	15.43			40.46	1.57	22.65	10.905		0.009		7.51		0.207



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



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	%	%	%	%		%	%	%	%	%	%	%	%
LAB027				40.445									
LAB028	14.785			40.46		22.715	10.71	0.29			7.48	0.62	0.32
LAB029				40.41									
LAB030	15.256			40.744		23.215		0.29		< 0.010	7.606	0.631	0.335
LAB031				40.653									
LAB032				40.06									
LAB033	15.284	0.041	0.741	40.075	1.519	23.227	11.033	0.255	0.003	0.01		0.661	0.401
LAB034	15.134		0.857	39.867	1.551	22.627	11.156		0.003	0.013			0.302
LAB035	15.064		0.756	40.04		22.817	11.069				7.5		
LAB036				39.445									
LAB037	15.055		0.76	40.215		23.065	11.12	0.28			7.125	0.625	0.33
LAB038	15.026		0.799	40.081	1.545	22.825	10.961		0.005	0.006	7.449	0.623	
LAB039				40.017									
LAB040	15.115		0.425			22.94	11.315		0.004	0.004	7.62		
LAB041				40.435									
LAB042			0.837			22.486		0.29					
LAB043				40.52									
LAB044	15.335			40.5		23.26	11.095		0.005	0.004	7.515		
LAB045	14.365		0.76	39.81	1.476		11.335		0.005		7.75		
LAB046				40.35									
LAB047				40.145		23.01					7.475		
LAB048				39.9		23			0.005				
LAB049	14.518		0.923	40.344	1.526	23.281	10.75				7.747		
LAB050				40.38									
LAB051				40.325		22.65					7.41		
LAB052				40.46									
LAB053	15.19			40.375	1.567	22.59	10.92		0.002	0.007	7.21	0.62	
LAB054				40.255									

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 3 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	%	0.335	23	2.069	0.084	± 0.17	± 0.18
CaO	%	0.109	17	2.110	0.032	± 0.06	± 0.07
Cr ₂ O ₃	%	0.397	50	2.009	0.066	± 0.13	± 0.14
FeO	%	0.328	27	2.052	0.07	± 0.14	± 0.15
MgO	%	0.237	21	2.080	0.064	± 0.13	± 0.14
MnO	%	0.008	12	2.179	0.002	± 0.01	± 0.01
P	%	0.002	11	2.201	0.001	± 0.002	± 0.002
S	%	0.004	10	2.228	0.002	± 0.004	± 0.005
SiO ₂	%	0.207	23	2.069	0.044	± 0.09	± 0.09
TiO ₂	%	0.017	13	2.160	0.004	± 0.01	± 0.01
V ₂ O ₅	%	0.043	11	2.201	0.017	± 0.03	± 0.04

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	
<i>Dr Hannelie de Beer (Pr. Sci. Nat.)</i>	<i>Takudzwa Tsapayi (Pr. Sci. Nat.)</i>
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.

END