

QOTHO CERTIFIED REFERENCE MATERIAL (QCRM)

QCRM-1-229

CHROME ORE

CERTIFICATE OF ANALYSIS

CERTIFIED VALUES			
ANALYTES	UNITS	CONCENTRATIONS	EXPANDED UNCERTAINTY
Al ₂ O ₃	%	13.67	±0.12
Cr ₂ O ₃	%	36.37	±0.11
FeO	%	22.07	±0.15
MgO	%	12.22	±0.16
MnO	%	0.22	±0.01
P	%	0.005	±0.002
S	%	0.006	±0.002
SiO ₂	%	12.31	±0.13
TiO ₂	%	0.59	±0.02
V ₂ O ₅	%	0.31	±0.02
ASSIGNED VALUES (FOR INFORMATION ONLY)			
ANALYTES	UNITS	CONCENTRATIONS	EXPANDED UNCERTAINTY
CaO	%	1.01	±0.06

1. Use:

QCRM-1-229 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, 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. The ore originates from Glencore Mining operations in 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 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.	AHK Steelpoort	South Africa
4.	ALS Geochemistry Kempton Park	South Africa
5.	ALS Inspection Richards Bay	South Africa
6.	Barplats Mine	South Africa
7.	Chromtech	South Africa
8.	Cotecna Richards Bay	South Africa
9.	Dwarsrivier Chrome Mine	South Africa
10.	Glencore Boshoeck	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.	IMEC Laboratory Services	South Africa
17.	Intertek Steelpoort	South Africa
18.	Jubilee Metals Group	South Africa
19.	Northam Booyesendal Fire Assay Lab	South Africa
20.	Northam Booyesendal South	South Africa
21.	Outokumpu	Finland
22.	PCL Rustenburg	South Africa
23.	PCL Steelpoort	South Africa
24.	Pilanesberg Platinum Mine	South Africa
25.	Quality Laboratory Services	South Africa
26.	RC Inspection SA	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.	UIS Analytical Services	South Africa
32.	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	14.125			36.31	1.45	22.04	11.71		0.004	0.005	12.16		
LAB002				36.17	1.44	22.065						0.555	0.32
LAB003	13.83		0.98	36.365		22.645	12.15	0.217			12.553	0.596	0.297
LAB004				36.32									
LAB005	13.75		0.97	36.375		22.105	12.215			0.005	12.16		
LAB006	13.743		1.093	35.615		21.783	11.844				12.533		
LAB007				35.675									
LAB008	13.581		1.091	36.49	1.446	22.208	12.21	0.215			12.313	0.578	0.314
LAB009	13.648		0.925	36.47	1.45	22.16	12.303	0.222	0.007	0.005	12.043	0.611	
LAB010				36.543									
LAB011	13.648		1.034	36.46	1.445	22.204	12.291		0.005	0.005	12.105	0.583	
LAB012				36.221									
LAB013	13.72		1.035	36.85	1.45	22.26	12.265		0.002	0.008	12.085	0.595	
LAB014				36.69									
LAB015	13.548	0.032	0.912	36.595			12.149	0.22	0.003	0.007	12.489	0.584	0.308
LAB016	13.6	0.027	0.995	36.5	1.46	21.915	12.385		0.005	0.008	12.255		
LAB017				36.655									
LAB018	14.35	0.028	1.125	36.695		22.05	12.575	0.228	< 0.005	0.005	12.615	0.633	
LAB019	13.605		0.465	36.4	1.47	21.94	12.205	0.21				0.585	
LAB020				36.205									
LAB021				36.07		22.08					12.82		
LAB022	13.344			36.028		21.701	11.855	0.209		< 0.010	11.537	0.577	0.304
LAB023	13.954		1.08		1.497	21.545		0.206	0.004			0.613	0.317
LAB024	13.432		1.113	36.744		22.168	11.937	0.215			12.701	0.574	
LAB025				36.563									



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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	13.657		0.9	36.197		21.88	12.569	0.21			12.255	0.565	
LAB027				36.293									
LAB028	13.46			35.99		22.055	12.535	0.22			12.255	0.575	0.305
LAB029				35.95									
LAB030	13.805		1.015	36.315		21.115	12.715	0.22			12.315		
LAB031			1.081	37.125	1.502	21.474		0.215				0.608	0.314
LAB032				36.335									
LAB033	14.6		0.827	35.664		21.877	11.885				12.543		
LAB034	13.615	0.02	1.025	36.59			12.29	0.22		< 0.010	12.375	0.58	
LAB035				36.69									
LAB036	13.515		0.81			22.235	12.26		0.005	0.007	12.24		
LAB037				36.25									
LAB038	13.67					22.38	12.12	0.23			12.22	0.575	0.305
LAB039				36.435									
LAB040	13.805		1.002	36.05			12.05		0.005				
LAB041				36.38		22.3					12.4		
LAB042				36.365									
LAB043	13.817		1.07	36.216	1.455	21.904	12.488						0.28
LAB044		0.039	0.958	36.4	1.436						11.269		
LAB045						22.39							
LAB046				36.625									
LAB047	13.375		1.203	36.649	1.445	22.335	12.887	0.272	0.004		12.062		0.328
LAB048				36.645									
LAB049	13.483		0.964	36.428	1.434	22.349	11.765		0.007	0.006	12.366	0.587	0.282
LAB050				36.085		22.085					12.285		
LAB051				36.115									

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 6 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 13528:2022 (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	%	0.244	25	2.060	0.055	± 0.11	± 0.12
CaO	%	0.110	23	2.069	0.03	± 0.06	± 0.06
Cr ₂ O ₃	%	0.299	46	2.013	0.054	± 0.11	± 0.11
FeO	%	0.300	28	2.048	0.07	± 0.14	± 0.15
MgO	%	0.336	24	2.064	0.078	± 0.16	± 0.16
MnO	%	0.009	15	2.131	0.003	± 0.01	± 0.01
P	%	0.002	10	2.228	0.001	± 0.002	± 0.002
S	%	0.002	9	2.262	0.001	± 0.002	± 0.002
SiO ₂	%	0.262	25	2.060	0.063	± 0.13	± 0.13
TiO ₂	%	0.020	17	2.110	0.006	± 0.01	± 0.02
V ₂ O ₅	%	0.016	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	
<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.

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