

QOTHO CERTIFIED REFERENCE MATERIAL (QCRM)

QCRM-1-156

CHROME SLAG

CERTIFICATE OF ANALYSIS

CERTIFIED VALUES			
ANALYTES	UNITS	CONCENTRATIONS	EXPANDED UNCERTAINTY
Al ₂ O ₃	%	20.11	±0.43
CaO	%	3.72	±0.17
Cr ₂ O ₃	%	16.04	±0.12
FeO	%	11.05	±0.14
MgO	%	15.99	±0.31
SiO ₂	%	34.26	±0.18

1. Use:

QCRM-1-156 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 Slag and as a calibration standard for the calibration of equipment used for analyzing similar materials.

2. Origin of Material:

This standard was sponsored by Samancor FMT.

3. Mineral and Chemical Composition:

Chromite is found as ortho-cumulate 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 chrome slag is a by-product of the manufacturing of ferrochrome, from chrome concentrates.

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
- Calcium by aqua regia or perchloric digestion and ICP-OES finish
- Carbon by combustion analysis.

8. Analysis required:

Instruction letter was sent to all participants. The analysis required was noted in the instruction letters and reporting templates, including but not limited to Al_2O_3 , C, CaO, Cr_2O_3 , FeO, MgO and SiO_2 .

9. Participating Laboratories:

NO	LABORATORY	COUNTRY
1.	AHK Steelpoort	South Africa
2.	ALS Geochemistry	South Africa
3.	ALS Inspection Richards Bay	South Africa
4.	ARM Machadodorp	South Africa
5.	Chromtech	South Africa
6.	Glencore Lydenburg Smelter	South Africa
7.	Mitra Sk South Africa	South Africa
8.	Northam Booyesendal Fire Assay Lab	South Africa
9.	Samancor Dikwena	South Africa
10.	Samancor Ferrometals	South Africa
11.	Samancor TCS Laboratory	South Africa
12.	Samancor Tubatse Alloy Smelter	South Africa
13.	SGS Richards Bay	South Africa
14.	Tharisa	South Africa
15.	Zimasco Kwekwe	Zimbabwe

10. Assay Data:

Data used for Assigning Values and Certification.

LABORATORY	Al ₂ O ₃	C	CaO	Cr ₂ O ₃	FeO	MgO	SiO ₂
UNIT	%	%	%	%	%	%	%
LAB001	19.895		3.82	15.99	11.34	16.065	
LAB002				16.125			
LAB003				15.732	11.107		
LAB004				15.979			
LAB005	20.335		3.765	16.385	11.175	16.51	34.33
LAB006				15.995			
LAB007	19.569		3.39	16.116	11.215	16.195	34.144
LAB008	19.635		3.858	16.264	11.221	15.273	34.359
LAB009	21.45		3.585		10.475	19.955	
LAB010	20.955				10.945	15.72	
LAB011				16.275			
LAB012	20.025		3.642	16.336	11.189	16.009	34.17
LAB013	20.282		5.559	16.282	10.955	15.786	34.269
LAB014	20.773		3.358	16.206	11.219	16.356	33.406
LAB015					11.335		34.07
LAB016				16.295			
LAB017	20.74	1.025	3.545	15.805	10.812	15.855	
LAB018				15.875			
LAB019	19.51				11.125	15.515	
LAB020				15.825			
LAB021	20.515	0.14	3.555	15.735	10.65	15.615	
LAB022				16			
LAB023	20.265			16.34	11.162	15.994	
LAB024				15.491	10.906		
LAB025	19.21		3.76	15.695	11.025		
LAB026				15.95			
LAB027	19.935		3.69	15.89	10.93	15.535	34.07
LAB028			4.09	16.04	8.525		
LAB029				16.025			
LAB030	19.718		3.848	16.267	10.633	16.305	34.56
LAB031	20.006		3.67	15.785	11.114	16.233	34.284
LAB032	19.309		4.098	15.482	10.968	15.816	34.58
LAB033	19.428			16.062	11.025	16.374	34.077
LAB034					11.095		
LAB035				16.175			
LAB036	20.845		3.845	16.355	11.835	16.655	34.405
LAB037				16.1			

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 2020 and 3 of 2021. The participating laboratories were each given 1 randomly selected sample from the batch, to analyze 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	%	19	2.093	0.202	± 0.40	± 0.43
CaO	%	16	2.120	0.081	± 0.16	± 0.17
Cr ₂ O ₃	%	31	2.040	0.057	± 0.11	± 0.12
FeO	%	24	2.064	0.066	± 0.13	± 0.14
MgO	%	18	2.101	0.145	± 0.29	± 0.31
SiO ₂	%	12	2.179	0.083	± 0.17	± 0.18

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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