

QOTHO CERTIFIED REFERENCE MATERIAL (QCRM)

QCRM-1-227

CHROME SLAG

CERTIFICATE OF ANALYSIS

CERTIFIED VALUES			
ANALYTES	UNITS	CONCENTRATIONS	EXPANDED UNCERTAINTY
Al ₂ O ₃	%	27.45	±0.22
Cr ₂ O ₃	%	6.36	±0.11
FeO	%	4.41	±0.06
MgO	%	19.51	±0.34
SiO ₂	%	33.37	±0.31
ASSIGNED VALUES (FOR INFORMATION ONLY)			
ANALYTES	UNITS	CONCENTRATIONS	EXPANDED UNCERTAINTY
CaO	%	8.50	±0.24

1. **Use:**

QCRM-1-227 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 analysing similar materials.

2. **Origin of Material:**

This standard was sponsored by Samancor MFC.

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. In the Eastern Limb, it is predominantly the MG1, LG5 and LG6 Chromitite layers that are being mined. The slag is a by-product of the manufacturing of ferrochrome.

4. **Date of Initial Issue:**

27 June 2023.

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 pellet with XRF finish
- Chrome and/or Iron by sodium peroxide fusion with Potentiometric Titration
- Sulphur by combustion analysis.

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 , CaO, Cr_2O_3 , FeO, MgO and SiO_2 .

9. Participating Laboratories:

NO	LABORATORY	COUNTRY
1.	AHK Steelpoort	South Africa
2.	ALS Geochemistry Kempton Park	South Africa
3.	ALS Inspection Richards Bay	South Africa
4.	ARM Machadodorp	South Africa
5.	Chromtech	South Africa
6.	Glencore Boshhoek	South Africa
7.	Northam Booyendal Fire Assay Lab	South Africa
8.	Northam Booyendal South	South Africa
9.	Outokumpu	Finland
10.	Samancor Dikwena	South Africa
11.	Samancor Ferrometals	South Africa
12.	Samancor TCS Laboratory	South Africa
13.	Samancor Tubatse Alloy Smelter	South Africa
14.	Samancor Tubatse Chrome	South Africa
15.	Tharisa Minerals	South Africa
16.	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	27.313		8.7775	6.3138	4.5113	19.245	33.536
LAB002	26.976		8.753	6.249	4.48	19.724	34.443
LAB003	26.93		8.935	6.43	4.495	19.585	33.185
LAB004	26.999		8.6107	6.4165	4.5008	19.211	33.231
LAB005	28.06	0.175	8.28	6.26		19.125	33.625
LAB006				6.5			
LAB007	27.674		8.705	6.4165	4.38	19.608	33.835
LAB008			7.76				
LAB009					4.48		33.465
LAB010				5.5365			
LAB011	27.65			5.95	4.485	18.96	32.84
LAB012				5.06			
LAB013	27.767	0.1995	7.583	5.933		19.06	
LAB014	27.57		9.305	6.61	3.455	20.375	33.61
LAB015			7.5565				
LAB016				7.7585			
LAB017	27.485		7.625	6.235	4.285	19	32.34
LAB018				6.615			
LAB019	27.909			6.3065	4.492		32.873
LAB020				6.4165	4.1175		32.549
LAB021				6.3435			
LAB022	27.485		8.76	6.645	4.49		32.67
LAB023	27.56	0.41	8.83	6.275	3.97	19.475	33.38
LAB024	27.116	0.194	7.4905	5.9615	4.0765	18.723	
LAB025	27.438		8.4275	6.5495	4.4125	19.483	33.153
LAB026	27.6			6.35	4.28	20.15	33.94
LAB027	26.643		8.791	6.313	4.511	19.774	33.577
LAB028	27.29		8.969	6.421	4.413	19.367	33.851
LAB029	27.49		8.425	6.657	4.295	19.95	33.403
LAB030					4.445		33.96
LAB031				6.58			
LAB032	27.905		8.74	6.355	4.55	20.61	33.365
LAB033				6.43			

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 5 of 2022 and 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 13528:2015 (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)	v (Degrees of Freedom)	k (Coverage Factor)	u (Standard Uncertainty)	95% Measurement Uncertainty	Expanded Uncertainty
Al ₂ O ₃	%	0.386	19	2.093	0.105	± 0.21	± 0.22
CaO	%	0.4141	18	2.101	0.1128	± 0.23	± 0.24
Cr ₂ O ₃	%	0.2493	28	2.048	0.0524	± 0.10	± 0.11
FeO	%	0.1349	20	2.086	0.0297	± 0.06	± 0.06
MgO	%	0.555	17	2.110	0.158	± 0.32	± 0.34
SiO ₂	%	0.563	20	2.086	0.147	± 0.29	± 0.31

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 Signatories	
<i>Dr Hannelie de Beer (Pr. Sci. Nat.)</i>	<i>Takudzwa Tsapayi (Pr. Sci. Nat.)</i>
27 June 2023	

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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