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QOTHO CERTIFIED REFERENCE MATERIAL (QCRM)

QCRM-1-125

CHROME ORE

CERTIFICATE OF ANALYSIS

CERTIFIED VALUES			
ANALYTES	UNITS	CONCENTRATIONS	EXPANDED UNCERTAINTY
Al_2O_3	%	16.330	±0.156
CaO	%	1.226	±0.054
Cr_2O_3	%	33.899	±0.105
FeO	%	23.138	±0.207
MgO	%	10.394	±0.117
MnO	%	0.216	±0.004
P	%	0.005	±0.002
S	%	0.005	±0.002
SiO_2	%	11.562	±0.143
TiO_2	%	0.665	±0.013
ASSIGNED VALUES, FOR INFORMATION ONLY			
ANALYTES	UNITS	CONCENTRATIONS	EXPANDED UNCERTAINTY
V_2O_5	%	0.355	±0.025

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1. **Use:**
QCRM-1-125 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 analyzing similar materials.

The COA was updated, to ensure that its content is compliant with the requirements of ISO 17034. No amendment was made to the certified & assigned values or their expanded uncertainties.

2. **Origin of Material:**
This standard was sponsored by Chromtech, South Africa. It is a composite material collected from milled laboratory pulp rejects after analysis. The ore is fed to the operations' chrome recovery operations.

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. This material originates from the UG2 zones of the Western Limb of the Bushveld Complex.

4. **Date of Initial Issue:**
31 December 2018.

5. **Packaging & Handling instructions:**
The material is packaged as 100g 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, for at least 2 hours, 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 grams zip-lock bags. Randomly selected samples, from the zip-lock bags were tested by XRF, to confirm homogeneity. to confirm homogeneity. Once confirmed and certification completed, the items were placed in geo-envelopes and then vacuum sealed in aluminium foil envelopes.

7. **Methods of Analysis used:**
- Sodium peroxide fusion with AAS/ICP finish
- Sodium peroxide fusion with Auto/Manual Titration
- Fused beads /powder and pressed pellet with XRF finish
- 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, MnO, P, S, SiO_2, TiO_2 and V_2O_5.

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9. Participating Laboratories:

NO	LABORATORY	COUNTRY
1.	Afarak Rustenburg	South Africa
2.	Afarak Elektrowerk Weisweiler GmbH	Germany
3.	AHK North West	South Africa
4.	AHK Richards Bay	South Africa
5.	AHK Steelpoort	South Africa
6.	ALS Geochemistry Kempton Park	South Africa
7.	ALS Inspection Richards Bay	South Africa
8.	Assmang Machadodorp	South Africa
9.	Chromtech	South Africa
10.	Columbus SS Chemical Lab	South Africa
11.	Columbus SS SpectroChem Lab	South Africa
12.	Dwarsrivier	South Africa
13.	Glencore Boshoek	South Africa
14.	Glencore Eastern Mines	South Africa
15.	Glencore Kroondal	South Africa
16.	Glencore Lion	South Africa
17.	Glencore Lydenburg Smelter	South Africa
18.	Glencore Rustenburg Smelter	South Africa
19.	Glencore UG2 Alloys	South Africa
20.	Glencore Wonderkop	South Africa
21.	GNK Laboratories t/a Zimlabs	Zimbabwe
22.	Hernic Ferrochrome	South Africa
23.	Intertek JHB	South Africa
24.	Intertek Steelpoort	South Africa
25.	LANXESS Mining Laboratory	South Africa
26.	Mintek	South Africa
27.	Mitra Sk South Africa	South Africa
28.	Nkomati Joint Venture Laboratory	South Africa
29.	PCL Rustenburg	South Africa
30.	PCL Steelpoort	South Africa
31.	Quality Laboratory Services	South Africa
32.	Samancor ECM	South Africa
33.	Samancor TCS Laboratory	South Africa
34.	Samancor Tubatse	South Africa
35.	Samancor WCM	South Africa
36.	SGS Netherlands BV	Netherlands
37.	SGS Randfontein	South Africa
38.	SGS Richards Bay	South Africa
39.	Tharisa	South Africa
40.	UIS Analytical ICP	South Africa
41.	UIS Analytical XRF	South Africa
42.	Zimasco Kwekwe	Zimbabwe

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10. Assay Data:

Data used for assigning values and certification, after the removal of outliers.

Laboratory	Al_2O_3	CaO	Cr_2O_3	FeO	MgO	MnO	P	S	SiO_2	TiO_2	V_2O_5
Unit	%	%	%	%	%	%	%	%	%	%	%
LAB001	16.273	1.278	33.430	23.257	10.331	0.213	0.006	0.005	11.675	0.674	
LAB002	16.651		33.791	23.431	10.465	0.217			11.532	0.690	0.365
LAB003			34.029								
LAB004	16.454	1.125	33.904	22.657	10.217			0.007	12.271		
LAB005	16.315	1.019	34.240	23.270	10.465				11.453		
LAB006	16.337	1.341	34.060	23.023	10.302	0.217			11.166	0.650	0.346
LAB007	16.098	1.188	34.147	23.573	10.654	0.216	0.002	0.004	11.555	0.643	
LAB008			34.058								
LAB009	16.240	1.230	33.855	22.810	10.485				11.630	0.665	
LAB010			33.925								
LAB011	16.940		34.220	23.355	10.190		0.004	0.005	10.880	0.670	
LAB012			33.820								
LAB013	16.316	1.434	33.853	23.373	10.463	0.223				0.688	0.330
LAB014			33.873								
LAB015	15.938	1.264	34.109	23.130		0.220			11.485	0.671	0.367
LAB016				22.310					11.125		
LAB017			33.735	22.760							
LAB018	16.540	1.210	34.365	23.030	10.225	0.210			11.450	0.645	0.370
LAB019	16.373	1.213	33.618	22.778	10.301	0.208			11.513	0.660	
LAB020			33.555								
LAB021	16.945	1.305	33.720	22.865	10.045	0.212			11.570	0.628	0.387
LAB022			33.685								
LAB023	15.664	1.260	33.638	23.280	10.830	0.210			11.677		
LAB024			33.709								
LAB025	15.631	1.223	33.454	22.798	10.767				11.706		
LAB026	16.390	1.109	34.250	22.390	10.410		0.009	0.008	11.830		
LAB027	16.705	1.208	33.960	23.540	10.355	0.220			11.645	0.688	
LAB028			33.685								
LAB029	16.380	1.205	34.490		10.450				11.605		
LAB030	15.955		34.075	23.290	10.170		0.004		11.525		
LAB031		1.285	33.735	23.225	10.270		0.006	0.007	11.335		
LAB032			33.740						11.210		
LAB033	16.302		33.755	22.703	10.420						
LAB034	16.475	1.181	33.947		10.765					0.655	
LAB035	16.445	1.190	33.770	23.050	10.020		0.003	0.004	11.225		
LAB036			33.985								
LAB037			34.090								
LAB038	16.399	1.145	33.782	23.500	10.481	0.228	0.003	0.008	11.606	0.655	0.359
LAB039			33.512								
LAB040	16.095	1.040	34.175	23.555	10.285		0.004		11.485		
LAB041	16.107	1.240	33.906	23.134	10.593		0.007	0.006	11.874		
LAB042			34.022								
LAB043			34.158					0.004	11.750		
LAB044	16.665		34.253	23.511	10.495	0.209			11.707	0.679	0.365

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Laboratory	Al_2O_3	CaO	Cr_2O_3	FeO	MgO	MnO	P	S	SiO_2	TiO_2	V_2O_5
Unit	%	%	%	%	%	%	%	%	%	%	%
LAB045	16.712		33.775	22.996	10.698	0.227	0.003	0.001	11.878	0.663	0.352
LAB046	16.275	1.230	33.810	22.840	10.320	0.210		< 0.010	11.410	0.680	
LAB047			33.845								

11. Method of Certification:

QLS 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 2018. Forty-Two 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 removed, after which the data was processed using Robust Statistics, through PROLab Plus, and all statistical outliers (as per ISO 5725-2: 1994) as well as data that returned z' scores > |2|, were removed from the dataset.

Not all the participating laboratories were accredited. Equivalence tests were performed on all analytes, of the remaining data, to determine whether the data from the accredited and non-accredited laboratories, can be treated as equal (at a level of significance of $\alpha = 0.05$). Where equivalent, all the data was used. Where not, only the data from the accredited laboratories were considered. Certification of analytes were then done, provided that a minimum of 10 datapoints remained available.

Where analytes cannot be certified, estimate concentrations were assigned, using all the data in the dataset, after the outliers and z'-scores > |2|, were removed.

12. Measurement of Uncertainty:

Measurement uncertainty, uCRM, was calculated according to ISO 13528:2015 (equation 6), and it includes the effects of uncertainty due to inhomogeneity, transport, instability and laboratory uncertainty. Because of all the uncertainties under consideration, QLS further applies an expanded uncertainty, for certification purposes. UCRM = kuCRM, 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: xCRM ± UCRM.

Measurement uncertainty for Assigned values, are calculated in the same manner.

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 standards used by the individual laboratories, the majority of which are accredited and who have maintained measurement traceability during the analytical process.

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.

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16. Legal:

This certificate and the reference material described in it have been 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 Laboratory Services, 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/Analytical Report.

Certifying Signatory		Technical Signatory	
Dr H de Beer		***Mrs L Smit***	
Qotho Managing Director	***29 April 2019***	***Qotho Technical Manager***	***29 April 2019***

END