

## QOTHO CERTIFIED REFERENCE MATERIAL (QCRM)

### QCRM-1-130

#### CHROME ORE

#### CERTIFICATE OF ANALYSIS

CERTIFIED VALUES			
ANALYTES	UNITS	CONCENTRATIONS	EXPANDED UNCERTAINTY
Al <sub>2</sub> O <sub>3</sub>	%	14.308	±0.180
CaO	%	0.721	±0.028
Cr <sub>2</sub> O <sub>3</sub>	%	38.345	±0.111
FeO	%	24.393	±0.123
MgO	%	10.333	±0.137
MnO	%	0.230	±0.011
P	%	0.005	±0.001
S	%	0.008	±0.001
SiO <sub>2</sub>	%	8.242	±0.126
TiO <sub>2</sub>	%	0.654	±0.013
ASSIGNED VALUES, FOR INFORMATION ONLY			
ANALYTES	UNITS	CONCENTRATIONS	EXPANDED UNCERTAINTY
V <sub>2</sub> O <sub>5</sub>	%	0.357	±0.017

1. **Use:**

QCRM-1-130 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.
2. **Origin of Material:**

This standard was sponsored by International Ferrometals, South Africa. It is a composite material collected from milled laboratory pulp rejects after analysis. The material originates from the Western Limb of the Bushveld Complex in 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.
4. **Date of Initial Issue:**

13 June 2019
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 in-house, to confirm homogeneity. Once confirmed and certification completed, the items were placed in geo-envelopes and vacuum sealed in aluminium foil envelopes.
7. **Methods of Analysis used:**
  1. Sodium peroxide fusion with AAS/ICP finish
  2. Multi acid digestion with AAS/ICP finish
  3. Aqua Regia digestion with AAS/ICP finish
  4. Sodium peroxide fusion with Auto/Manual Titration
  5. Fused beads /powder and pressed pellet with XRF finish
  6. 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  $Al_2O_3$ ,  $CaO$ ,  $Cr_2O_3$ ,  $FeO$ ,  $MgO$ ,  $MnO$ ,  $P$ ,  $S$ ,  $SiO_2$ ,  $TiO_2$  &  $V_2O_5$ .

## 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 Analysis and Inspection Durban	South Africa
5.	ALS Geochemistry Kempton Park	South Africa
6.	ALS Inspection Richards Bay	South Africa
7.	ALS Inspection UK	UK
8.	Assmang Machadodorp	South Africa
9.	Chromtech	South Africa
10.	Columbus SS Chemical Lab	South Africa
11.	Columbus SS SpectroChem Lab	South Africa
12.	Cotecna Turkey	Turkey
13.	Dwarsrivier	South Africa
14.	Glencore Boshhoek	South Africa
15.	Glencore Eastern Mines	South Africa
16.	Glencore Kroondal	South Africa
17.	Glencore Lion	South Africa
18.	Glencore Lydenburg Smelter	South Africa
19.	Glencore Rustenburg Smelter	South Africa
20.	Glencore UG2 Alloys	South Africa
21.	Glencore Wonderkop	South Africa
22.	GNK Laboratories t/a Zimlabs	Zimbabwe
23.	Hernic Ferrochrome	South Africa
24.	Intertek JHB	South Africa
25.	Intertek Steelpoort	South Africa
26.	LANXESS Mining Laboratory	South Africa
27.	Metchem Rustenburg	South Africa
28.	Mintek	South Africa
29.	Mitra Sk South Africa	South Africa
30.	Nkomati JV	South Africa
31.	PCL Rustenburg	South Africa
32.	PCL Steelpoort	South Africa
33.	Quality Laboratory Services	South Africa
34.	Samancor ECM	South Africa
35.	Samancor Ferrometals	South Africa
36.	Samancor TCS Laboratory	South Africa
37.	Samancor Tubatse	South Africa
38.	Samancor Tubatse Alloy Smelter	South Africa
39.	Samancor WCM	South Africa
40.	SGS Netherlands BV	Netherlands
41.	SGS Randfontein	South Africa
42.	SGS Richards Bay	South Africa
43.	Tharisa	South Africa
44.	Zimasco Kwekwe	Zimbabwe
45.	Zimbabwe Alloys Chrome	Zimbabwe

## 10. Assay Data:

Data used for certification, after removal of outliers.

Laboratory	Al <sub>2</sub> O <sub>3</sub>	CaO	Cr <sub>2</sub> O <sub>3</sub>	FeO	MgO	MnO	P	S	SiO <sub>2</sub>	TiO <sub>2</sub>	V <sub>2</sub> O <sub>5</sub>
Unit	%	%	%	%	%	%	%	%	%	%	%
LAB001	14.166	0.731	38.157	24.516	10.149	0.230	0.008	0.007	8.238	0.648	
LAB002			38.184								
LAB003	14.460	0.734	38.678	24.596	10.490	0.226			8.910	0.658	0.356
LAB004			38.605								
LAB005	13.759		38.520	24.544	9.807			0.007	8.358		
LAB006	13.973	0.756		24.428							
LAB007	14.221	0.835	38.641	24.688	10.373	0.221	0.004	0.009	8.200	0.631	
LAB008			38.535								
LAB009	14.641	0.790	38.507	24.447	10.418					0.690	
LAB010			38.355								
LAB011	14.845		38.330	24.840	10.035		0.006	0.009		0.650	
LAB012			38.150								
LAB013	14.230		38.302	23.890	10.305		0.004	0.009			0.346
LAB014			37.915	24.165					7.828		
LAB015	14.245	0.715	38.235	24.209	10.465	0.210	0.005	0.010	8.230	0.630	0.359
LAB016	14.160	0.686	37.849	24.017	10.185	0.220				0.635	
LAB017			37.849								
LAB018	14.670	0.693	38.087	24.514	10.593	0.234				0.657	
LAB019			38.060								
LAB020			38.360	24.535	10.720						
LAB021	14.245		38.270	23.810		0.250					
LAB022		0.700	38.572			0.230					
LAB023			38.440								
LAB024	13.783		38.935	24.754	10.301						
LAB025	13.940		38.505	24.390	9.995			0.009	8.195		
LAB026	14.005	0.754	38.150		10.460	0.240					
LAB027	14.590	0.685	38.560	24.420	10.415						
LAB028	14.520	0.715	38.505	24.510	10.340		0.003		8.235		
LAB029				24.420			0.005	0.005	8.530		
LAB030			38.315						8.400		
LAB031	14.159		38.481	24.250	10.263				8.114		
LAB032		0.661	38.775							0.691	0.373
LAB033			38.655								
LAB034	14.365	0.690	38.205	24.250	10.115		0.004	0.007	8.145		
LAB035			38.240								
LAB036			38.455								
LAB037			37.810	23.770					7.935		
LAB038	14.430	0.730	37.810	24.500	10.325		0.003		8.210		
LAB039	14.391		38.362	24.402	10.696		0.004	0.009			
LAB040			38.388								
LAB041			38.300								
LAB042			38.276	24.355				0.009			
LAB043	14.665		38.942	24.913	10.572	0.218			8.293	0.656	0.347
LAB044			38.892								
LAB045	14.547	0.726	38.264	24.237	10.233	0.246	0.004	0.008	8.373	0.653	0.358
LAB046	14.330	0.700	38.125	24.309	10.265	0.230	< 0.010			0.665	
LAB047			38.080								

**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 Manganese PT round 1 of 2019. Forty-five 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 = k uCRM, 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:  $x_{CRM} \pm UCRM$ .

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.

**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	
<i>Dr H de Beer</i>		<i>Ms L Smit</i>	
<i>Qotho Managing Director</i>	<i>13 June 2019</i>	<i>Qotho Technical Manager</i>	<i>13 June 2019</i>

END