

QOTHO CERTIFIED REFERENCE MATERIAL (QCRM)

QCRM-3-044

LOW GRADE NICKEL ORE

CERTIFICATE OF ANALYSIS

CERTIFIED VALUES			
ANALYTES	UNITS	CONCENTRATIONS	EXPANDED UNCERTAINTY
As (soluble)	ppm	31.420	±3.268
Co	%	0.015	±0.004
Co (soluble)	ppm	113.917	±2.758
Cr ₂ O ₃	%	0.248	±0.006
Cu	%	0.087	±0.004
Cu (soluble)	ppm	816.191	±29.032
Fe	%	9.095	±0.160
Ni	%	0.190	±0.004
Ni (soluble)	ppm	1666.151	±30.590
S	%	1.409	±0.042
ASSIGNED VALUES FOR INFORMATION ONLY			
ANALYTES	UNITS	CONCENTRATIONS	EXPANDED UNCERTAINTY
Al ₂ O ₃	%	6.750	±0.057
As	ppm	46.859	±11.404
CaO	%	10.196	±0.150
MgO	%	16.581	±0.346
MnO	%	0.215	±0.011
Pb	ppm	34.900	±11.659
SiO ₂	%	45.324	±1.114
TiO ₂	%	0.756	±0.028
Zn	%	0.015	±0.004

1. Use:

QCRM-3-044 is a certified reference material that is matrix matched. It 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 nickel ore analysis and as a calibration standard for the calibration of equipment used for analyzing similar grade 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:

The material was sponsored by Nkomati Nickel Mine, Mpumalanga, South Africa. It is a product from their flotation process plant.

3. Mineral and Chemical Composition:

The material originates from the Uitkomst Complex, which is a Bushveld-age, layered body that intruded into the basal sediments of the Transvaal Supergroup. The complex is cogenetic with the Rustenburg Layered Suite (RLS) of the Bushveld Complex. Mafic-ultramafic rocks of the complex host sulfide mineralization. The nickel is mined in the shallower economically mineralized parts of the Main Mineralized Zone (MMZ) of the Complex.

4. Date of Initial Issue:

4 March 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 geo-envelopes. Randomly selected samples, from the geo-envelopes, were tested by an ISO17025 accredited third party laboratory, to confirm homogeneity. Once confirmed and certification completed, the items were vacuum sealed in aluminium foil envelopes.

7. Methods of Analysis used:

1. Sodium Peroxide Fusion with ICP-OES and/or ICP-MS finish
2. Aqua Regia ICP-OES or AAS Finish
3. S by combustion (Leco finish)

8. Analysis required:

The following analysis were requested from the commercial laboratories: Acid soluble Ni, Co & Cu. Total As, Al₂O₃, CaO, Cr₂O₃, Fe, MgO, Pb, S, SiO₂, TiO₂ & Zn.

9. Participating Laboratories

No	LABORATORY	COUNTRY
1.	ALS Chemex	South Africa
2.	Mintek	South Africa
3.	Nkomati Nickel Mine	South Africa
4.	SGS	South Africa

10. Assay Data:

Data used for the certification or value assignment of the analytes, after removal of outliers:

Laboratory	Al ₂ O ₃	As	As (Sol)	CaO	Co	Co (Sol)	Cr ₂ O ₃	Cu	Cu (Sol)
Unit	%	ppm	ppm	%	%	ppm	%	%	ppm
A1	6.850		30.500	10.625	0.010	115.000	0.240	0.090	894.500
A2	6.835		28.000	10.425	0.010	114.500	0.242	0.090	869.500
A3	6.665		30.000	10.075	0.015	112.000	0.233	0.090	868.000
A4	6.700		30.000	10.275	0.010	115.000	0.240	0.090	865.500
A5	6.650		33.000	10.150	0.010	113.500	0.235	0.090	877.000
A6	6.750			10.275	0.015		0.235	0.090	
A7			29.500			113.500			867.000
B1	6.710		33.800	9.680	< 0.050		0.260	0.090	852.000
B2	6.820		32.600	9.640	< 0.050		0.250	0.090	849.000
B3	6.730			9.680	< 0.050		0.230	0.090	845.000
B4	6.950		34.900	10.130	< 0.050		0.250	0.090	841.000
B5	6.650		31.900		< 0.050		0.230	0.090	832.000
B6	6.650		23.200	9.670	< 0.050		0.280	0.090	832.000
B7	6.880		37.600	9.920	< 0.050		0.250	0.080	839.000
C1		82.340		10.355	0.010	69.330	0.250	0.090	794.000
C2		70.195		10.505	0.010	72.500	0.260	0.090	786.330
C3		56.875		10.490	0.010	68.330	0.250	0.090	802.500
C4		79.985		10.340	0.010	67.670	0.270	0.090	780.670
C5		69.800		10.210	0.010	71.835	0.250	0.090	784.670
D1	6.710	25.500		10.370	0.010		0.250	0.080	741.500
D2	6.755	27.500		10.260	0.010		0.255	0.080	741.000
D3	6.710	27.000		10.340	0.010		0.255	0.080	745.000
D4	6.790	25.000		10.330	0.010		0.245	0.080	724.000
D5	6.735	27.000		10.090	0.010		0.250	0.080	726.500

Laboratory	Fe	MgO	MnO	Ni	Ni (Sol)	Pb	S	SiO ₂	TiO ₂	Zn
Unit	%	%	%	%	ppm	ppm	%	%	%	%
A1	9.020	16.700	0.210	0.195	1765.000		1.373	45.350	0.740	0.010
A2	9.010	16.650	0.205	0.190	1780.000		1.355	45.250	0.745	0.010
A3	8.770	16.100	0.200	0.190	1760.000		1.380	43.850	0.720	0.010
A4	8.830	16.325	0.200	0.185	1765.000		1.343	44.400	0.725	0.010
A5	8.665	16.075	0.200	0.185	1760.000		1.393	43.000	0.720	0.010
A6	8.810	16.375	0.200	0.190			1.350	43.100	0.725	0.010
A7					1760.000		1.410			
B1	9.390	16.910	0.230	0.200			1.390	45.350	0.780	< 0.050
B2	9.410	17.410	0.230	0.200				46.420	0.800	< 0.050
B3	9.370	16.750	0.220	0.200			1.380	45.350	0.750	< 0.050
B4	9.480	17.410	0.230	0.200			1.480	47.490	0.800	< 0.050
B5	8.980	16.530	0.220	0.190			1.500	44.920	0.770	< 0.050
B6	9.210	16.910	0.220	0.200				45.140	0.750	< 0.050
B7	9.500	17.580	0.230	0.200			1.290	46.420	0.800	< 0.050
C1	8.950	16.050		0.190	1484.500	26.000		44.530		0.010
C2	8.815	15.840		0.190	1472.670	19.500		44.260		0.010
C3	8.700	15.630		0.180	1531.170	46.000		43.390		0.010
C4	9.315	15.900		0.190	1469.500	66.500		43.985		0.010
C5	8.655	15.560		0.180	1505.830	63.000		43.410		0.010
D1	9.325	16.830		0.180		31.500	1.430	50.055		0.010
D2	9.215	17.080		0.185		27.000	1.485			0.010
D3	9.300	17.080		0.190		33.500	1.460			0.010
D4	9.270	17.000		0.180		24.000	1.485	50.270		0.010
D5	9.190	16.665		0.180		21.000	1.435	49.950		0.010

11. Method of Certification:

QLS is a SANAS Accredited Proficiency Testing Scheme Provider, No. PTS0012

This material was distributed as test items, to four accredited and/or commercial laboratories. Each Laboratory received five to seven samples and all laboratories (bar One) reported results in duplicate. The fourth laboratory reported one result only, per analyte. 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: $x_{CRM} \pm U_{CRM}$.

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.

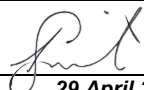
15. Period of validity:

The certified values are valid for this product while still sealed in its original packaging, for a period of minimum 5 years from date of certification. Stability testing 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>Mrs L Smit</i>	
<i>(Qotho Managing Director)</i>	<i>29 April 2019</i>	<i>(Qotho Technical Manager)</i>	<i>29 April 2019</i>

END