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Premier reference standards • Proficiency testing • Custom standards • Portable XRF calibration service

Premium Certified Reference Material
RRM Fe-122

PRODUCT: IRON ORE
Northern Cape South Africa
CERTIFICATE OF ANALYSIS

Certificate Number: RRM CRM Fe-122 Rev 000 Date: 6 June 2017

Table 1 ***Fe-122 Constituents (ISO 2596:2006 Hygroscopic Moisture Corrected)***

Analyte (Unit)	Assigned value	Standard Deviation		95% Confidence Limits		Number of Laboratories	Number of Analyses	Mean of number of analyses per Laboratory
		Within Laboratory	Between Laboratory	Lower	Upper			
Fe (%)	63,66	0,38	0,38	63,45	63,88	6	10	1,7
Fe calculated (%)	63,50	0,05	0,05	63,48	63,53	6	10	1,7
SiO_2 (%)	5,19	0,02	0,03	5,17	5,21	6	10	1,7
Al_2O_3 (%)	2,07	0,01	0,02	2,05	2,08	6	10	1,7
TiO_2 (%)	0,113	0,003	0,003	0,111	0,114	6	10	1,7
Mn (%)	0,153	0,002	0,002	0,151	0,154	6	10	1,7
CaO (%)	0,043	0,001	0,002	0,042	0,045	6	10	1,7
MgO (%)	0,032	0,002	0,003	0,030	0,034	6	10	1,7
K_2O (%)	0,272	0,005	0,007	0,266	0,277	6	10	1,7
Na_2O (%)	0,029	0,005	0,007	0,023	0,035	5	9	1,8
P (%)	0,042	0,001	0,001	0,042	0,043	6	10	1,7
S (%)	0,017	0,001	0,001	0,016	0,018	6	10	1,7
LOI-371 %	0,477	0,030	0,034	0,453	0,501	2	23	11,5
LOI-425 %	0,556	0,034	0,035	0,543	0,570	5	30	6,0
LOI-650 %	0,823	0,026	0,028	0,810	0,836	5	30	6,0
LOI-1000 %	0,973	0,071	0,071	0,948	0,998	8	34	4,3
Cl (%)	0,003	0,001	0,001	0,002	0,004	4	6	1,5
As (%)	0,013	0,001	0,005	0,009	0,017	5	9	1,8
Ba (%)	0,001	0,001	0,001	-	0,002	4	7	1,8
Co (%)	0,002	-	0,001	0,001	0,003	5	9	1,8
Cu (%)	0,031	0,002	0,002	0,029	0,033	5	9	1,8
Cr (%)	0,001	-	-	-	-	3	7	2,3
Ni (%)	0,030	0,003	0,003	0,027	0,032	5	9	1,8
Pb (%)	0,007	-	0,001	0,006	0,007	5	9	1,8
Sn (%)	0,003	0,001	0,001	0,002	0,004	5	9	1,8
Sr (%)	0,001	0,001	0,002	-	0,003	4	7	1,8
V (%)	0,020	0,001	0,001	0,019	0,021	5	9	1,8
Zn (%)	0,004	0,001	0,001	0,003	0,005	4	8	2,0
Zr (%)	0,005	0,001	0,001	0,004	0,005	4	8	2,0

Table 2 ***Fe-122 Constituents (non-hygroscopically moisture corrected)***

Analyte (Unit)	Assigned value	Standard Deviation		95% Confidence Limits		Number of Laboratories	Number of Analyses	Mean of number of analyses per Laboratory
		Within Laboratory	Between Laboratory	Lower	Upper			
Fe (%)	63,54	0,10	0,20	63,45	63,63	17	68	4,0
Fe calculated (%)	63,47	0,03	0,06	63,44	63,50	17	68	4,0
SiO_2 (%)	5,19	0,03	0,04	5,17	5,21	17	68	4,0
Al_2O_3 (%)	2,04	0,02	0,03	2,03	2,05	17	68	4,0
TiO_2 (%)	0,115	0,002	0,004	0,113	0,117	17	68	4,0
Mn (%)	0,153	0,003	0,003	0,151	0,154	15	60	4,0
CaO (%)	0,040	0,002	0,005	0,037	0,042	17	68	4,0
MgO (%)	0,030	0,007	0,015	0,023	0,037	17	68	4,0
K_2O (%)	0,266	0,003	0,005	0,264	0,268	17	68	4,0
Na_2O (%)	0,024	0,008	0,014	0,017	0,031	12	53	4,4
P (%)	0,043	0,001	0,002	0,042	0,044	17	68	4,0
S (%)	0,015	0,001	0,002	0,014	0,016	15	58	3,9
LOI-371 %	0,563	0,027	0,035	0,546	0,581	8	47	5,9
LOI-425 %	0,591	0,011	0,051	0,550	0,632	7	37	5,3
LOI-650 %	0,885	0,025	0,050	0,857	0,913	10	51	5,1
LOI-1000 %	1,04	0,06	0,08	1,02	1,07	18	85	4,7
Cl (%)	0,003	0,001	0,003	0,002	0,004	8	34	4,3
As (%)	0,014	0,003	0,005	0,011	0,017	10	40	4,0
Ba (%)	0,001	-	-	-	0,001	7	22	3,1
Co (%)	0,002	0,001	0,002	0,001	0,003	9	40	4,4
Cu (%)	0,032	0,002	0,003	0,030	0,033	10	42	4,2
Cr (%)	0,002	-	0,002	-	0,003	5	20	4,0
Ni (%)	0,033	0,002	0,004	0,029	0,036	3	11	3,7
Pb (%)	0,008	0,002	0,002	0,007	0,009	6	25	4,2
Sn (%)	0,005	0,001	0,003	0,003	0,007	8	28	3,5
Sr (%)	0,002	-	0,003	-	0,005	4	11	2,8
V (%)	0,021	0,001	0,002	0,019	0,022	5	19	3,8
Zn (%)	0,005	-	0,001	0,004	0,006	5	19	3,8
Zr (%)	0,004	0,001	0,003	0,001	0,007	6	22	3,7

Introduction:

Certified Reference Materials (CRMs) are used by laboratories to prove the value of their service offerings and for clients of laboratories to evaluate and monitor laboratory performance. CRMs must comply with high metrological requirements and ensuring traceability of measurement results.

Since most techniques employing analytical instrumentation are comparative, these techniques require a sample of known composition (CRM) for accurate calibration. Grade and Matrix matched CRM's are thus vital to the core of the analytical chemistry industry.

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Preparation of Material:

The material constituting RRM Fe-122 has been according to ISO 17034:2016, and includes the following:

- Drying to constant mass
- Crushing and dry milling to nominal 53µm particle size
- Homogenization
- Systematic rotary division of the entire lot, to final aliquot
- Packaging
- Rotary divided to nominal 250g sealed jars
- Rotary divided to nominal 10g geochem pouches, vacuum sealed in barrier foil
- Custom package sizes available on request

Unique to RRM, rotary division of all material to final packaging.

Methods of Analysis:

The analysis of the test samples has been conducted according to each individual laboratory's routine analytical procedures. The material has been dried at 105°C until constant mass was achieved, or corrected for moisture according to ISO 2596:2006. Each test sample has been prepared, analyzed and reported in duplicate; with results reported on a dry basis.

Elements and Oxides determined as follows:

- Multi-element Iron Ore Suite – XRF fused disc analysis
- Loss on Ignition – Thermo Gravimetric Analysis

Homogeneity Evaluation:

For the evaluation of the homogeneity of the Fe-122 material, 14 samples were selected throughout the batch for analysis in duplicate. ANOVA (one-way analysis of variance) was used to assess the homogeneity for measured Iron and total Loss on Ignition. No significant variation was observed for both 'batch' and 'within unit' exercises. The results and statistical evaluation from the interlaboratory studies (presented in Tables 3, 4, 5 and 6) further validate the homogeneity. The material can thus be considered fit for purpose for use as a CRM.

Statistical Evaluation:

We have grouped the laboratories according to the method of determining moisture. Certain laboratories determine the dry weight of iron ore samples at 105°C, whilst some use the ISO 2596:2006 correction for hygroscopic moisture. Some iron ore types report different moisture values for each of these methods, which in turn influences the chemical analysis as the determined moisture content has an influence on the dry starting mass.

A comprehensive statistical evaluation of the results received from the various laboratories was performed. Outliers were identified and removed from the data sets for the certification exercise.

The assigned values are the mean of means after removal of outliers. All constituents reported with a between laboratory % RSD of <5% are regarded as certified values.

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Table 3 ***Fe-122 Statistical Evaluation (Hygroscopic Moisture Corrected)***

Analyte (Unit)	Fe (%)	Fe calc (%)	SiO_2 (%)	Al_2O_3 (%)	TiO_2 (%)	Mn (%)	CaO (%)
Assigned value	63.66	63.50	5.19	2.07	0.113	0.153	0.043
Number of Laboratories	6	6	6	6	6	6	6
Number of Analyses	10	9	10	10	10	10	10
Between Laboratory Standard Deviation	0.38	0.05	0.03	0.02	0.003	0.002	0.002
Within Laboratory Standard Deviation	0.38	0.05	0.02	0.01	0.003	0.002	0.001
Between Laboratory Relative Standard Deviation	0.59 %	0.07 %	0.59 %	0.94 %	2.69 %	1.37 %	4.71 %
Within Laboratory Relative Standard Deviation	0.59 %	0.07 %	0.45 %	0.50 %	2.49 %	1.37 %	2.87 %
Standard Uncertainty	0.109	0.014	0.010	0.007	0.001	0.001	0.001
Lower confidence limit	63.45	63.48	5.17	2.05	0.111	0.151	0.042
Upper confidence limit	63.88	63.53	5.21	2.08	0.114	0.154	0.045
Lower limit of tolerance	62.91	63.41	5.13	2.03	0.107	0.148	0.039
Upper limit of tolerance	64.42	63.60	5.25	2.10	0.119	0.157	0.047

Analyte (Unit)	P (%)	S (%)	MgO (%)	K_2O (%)	Na_2O (%)	As (%)	Cl (%)
Assigned value	0.042	0.017	0.032	0.272	0.029	0.003	0.013
Number of Laboratories	6	6	6	6	5	4	5
Number of Analyses	10	10	10	10	9	6	9
Between Laboratory Standard Deviation	0.001	0.001	0.003	0.007	0.007	0.001	0.005
Within Laboratory Standard Deviation	0.001	0.001	0.002	0.005	0.005	0.001	0.001
Between Laboratory Relative Standard Deviation	2.07 %	8.60 %	9.15 %	2.69 %	25 %	43 %	35 %
Within Laboratory Relative Standard Deviation	1.71 %	4.22 %	7.19 %	2.00 %	16.1 %	43 %	11.5 %
Standard Uncertainty	-	0.001	0.001	0.003	0.003	-	0.002
Lower confidence limit	0.042	0.016	0.030	0.266	0.023	0.002	0.009
Upper confidence limit	0.043	0.018	0.034	0.277	0.035	0.004	0.017
Lower limit of tolerance	0.040	0.014	0.026	0.257	0.014	0.000	0.004
Upper limit of tolerance	0.044	0.020	0.038	0.286	0.043	0.006	0.022

Analyte (Unit)	Co (%)	Cu (%)	Pb (%)	Zn (%)	Ba (%)	Cr (%)	Ni (%)
Assigned value	0.001	0.002	0.031	0,001	0.030	0.007	0.003
Number of Laboratories	4	5	5	3	5	5	5
Number of Analyses	7	9	9	7	9	9	9
Between Laboratory Standard Deviation	0.001	0.001	0.002	-	0.003	0.001	0.001
Within Laboratory Standard Deviation	0.001	-	0.002	-	0.003	-	0.001
Between Laboratory Relative Standard Deviation	91 %	49 %	7.77 %	-	11.8 %	14.0 %	44 %
Within Laboratory Relative Standard Deviation	82 %	23 %	7.58 %	-	11.8 %	6.52 %	25 %
Standard Uncertainty	-	-	0.001	-	0.001	0.000	0.001
Lower confidence limit	-	0.001	0.029	-	0.027	0.006	0.002

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Upper confidence limit	0.002	0.003	0.033	-	0.032	0.007	0.004
Lower limit of tolerance	-	-	0.026	-	0.023	0.005	-
Upper limit of tolerance	0.003	0.004	0.036	-	0.037	0.008	0.005

Analyte (Unit)	**Sn (%)**	**Sr (%)**	**V (%)**	**Zr (%)**
Assigned value	0.001	0.020	0.004	0.005
Number of Laboratories	4	5	4	4
Number of Analyses	7	9	8	8
Between Laboratory Standard Deviation	0.002	0.001	0.001	0.001
Within Laboratory Standard Deviation	0.001	0.001	0.001	0.001
Between Laboratory Relative Standard Deviation	136 %	5.63 %	23 %	19.4 %
Within Laboratory Relative Standard Deviation	51 %	3.26 %	23 %	19.4 %
Standard Uncertainty	0.001	-	-	-
Lower confidence limit	-	0.019	0.003	0.004
Upper confidence limit	0.003	0.021	0.005	0.005
Lower limit of tolerance	-	0.017	0.002	0.003
Upper limit of tolerance	0.005	0.022	0.006	0.006

Table 4 ***Fe-122 Statistical Evaluation (non-hygroscopically moisture corrected)***

Analyte (Unit)	**Fe (%)**	**Fe calc (%)**	**SiO_2 (%)**	**Al_2O_3 (%)**	**TiO_2 (%)**	**Mn (%)**	**CaO (%)**
Assigned value	63.54	63.47	5.19	2.04	0.115	0.153	0.040
Number of Laboratories	17	16	17	17	17	15	17
Number of Analyses	68	62	68	68	68	60	68
Between Laboratory Standard Deviation	0.20	0.06	0.04	0.03	0.004	0.003	0.005
Within Laboratory Standard Deviation	0.10	0.03	0.03	0.02	0.002	0.003	0.002
Between Laboratory Relative Standard Deviation	0.32 %	0.10 %	0.81 %	1.28 %	3.16 %	2.09 %	13.2 %
Within Laboratory Relative Standard Deviation	0.16 %	0.05 %	0.51 %	0.85 %	1.42 %	1.67 %	4.08 %
Standard Uncertainty	0.045	0.014	0.009	0.005	0.001	0.001	0.001
Lower confidence limit	63.45	63.44	5.17	2.03	0.113	0.151	0.037
Upper confidence limit	63.63	63.50	5.21	2.05	0.117	0.154	0.042
Lower limit of tolerance	63.13	63.35	5.11	1.99	0.108	0.146	0.029
Upper limit of tolerance	63.94	63.60	5.27	2.10	0.122	0.159	0.050

Analyte (Unit)	**P (%)**	**S (%)**	**MgO (%)**	**K_2O (%)**	**Na_2O (%)**	**As (%)**	**Cl (%)**
Assigned value	0.043	0.015	0.030	0.266	0.024	0.003	0.014
Number of Laboratories	17	15	17	17	12	8	10
Number of Analyses	68	58	68	68	53	34	40
Between Laboratory Standard Deviation	0.002	0.002	0.015	0.005	0.014	0.002	0.005

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Within Laboratory Standard Deviation	0.001	0.001	0.007	0.003	0.008	0.001	0.003
Between Laboratory Relative Standard Deviation	3.96 %	15.8 %	52 %	1.73 %	60 %	55 %	37 %
Within Laboratory Relative Standard Deviation	2.40 %	5.68 %	24 %	1.01 %	34 %	19.6 %	24 %
Standard Uncertainty	-	0.001	0.004	0.001	0.004	0.001	0.001
Lower confidence limit	0.042	0.014	0.023	0.264	0.017	0.002	0.011
Upper confidence limit	0.044	0.016	0.037	0.268	0.031	0.004	0.017
Lower limit of tolerance	0.040	0.010	-	0.257	-	-	0.004
Upper limit of tolerance	0.046	0.020	0.061	0.275	0.052	0.006	0.024

Analyte (Unit)	**Co (%)**	**Cu (%)**	**Pb (%)**	**Zn (%)**	**Ba (%)**	**Cr (%)**	**Ni (%)**
Assigned value	0.001	0.002	0.032	0.002	0.033	0.008	0.005
Number of Laboratories	7	9	10	5	3	6	8
Number of Analyses	22	40	42	20	11	25	28
Between Laboratory Standard Deviation	-	0.002	0.003	0.002	0.004	0.002	0.003
Within Laboratory Standard Deviation	-	0.001	0.002	-	0.002	0.002	0.001
Between Laboratory Relative Standard Deviation	80 %	78%	8.52 %	108 %	10.9 %	19.8 %	57 %
Within Laboratory Relative Standard Deviation	1.29 %	34 %	5.01 %	-	6.54 %	19.8 %	12.7 %
Standard Uncertainty	-	-	0.001	0.001	0.002	-	0.001
Lower confidence limit	-	0.001	0.030	-	0.029	0.007	0.003
Upper confidence limit	0.001	0.003	0.033	0.003	0.036	0.009	0.007
Lower limit of tolerance	-	-	0.026	-	0.025	0.005	-
Upper limit of tolerance	0.002	0.005	0.037	0.005	0.040	0.011	0.011

Analyte (Unit)	**Sn (%)**	**Sr (%)**	**V (%)**	**Zr (%)**
Assigned value	0.002	0.021	0.005	0.004
Number of Laboratories	4	5	5	6
Number of Analyses	11	19	19	22
Between Laboratory Standard Deviation	0.003	0.002	0.001	0.003
Within Laboratory Standard Deviation	-	0.001	-	0.001
Between Laboratory Relative Standard Deviation	169 %	7.87 %	21 %	84 %
Within Laboratory Relative Standard Deviation		4.96 %	8.23 %	12.7 %
Standard Uncertainty	0.002	0.001	-	0.001
Lower confidence limit	-	0.019	0.004	0.001
Upper confidence limit	0.005	0.022	0.006	0.007
Lower limit of tolerance	-	0.017	0.003	-
Upper limit of tolerance	0.009	0.024	0.007	0.011

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LOI Values:

The LOI statistics from the inter-laboratory study are presented in the table below:

Table 5 ***Fe-122 LOI Certified Values (Hygroscopic Moisture Corrected)***

Determination (Unit)	LOI-371 %	LOI-425 %	LOI-650 %	LOI-1000 %
Assigned value	0.477	0.556	0.823	0.973
Number of Laboratories	2	5	5	8
Number of Analyses	23	30	30	34
Between Laboratory Standard Deviation	0.034	0.035	0.028	0.071
Within Laboratory Standard Deviation	0.030	0.034	0.026	0.071
Between Laboratory Relative Standard Deviation	7.04 %	6.20 %	3.41 %	7.29 %
Within Laboratory Relative Standard Deviation	6.34 %	6.12 %	3.18 %	7.29 %
Standard Uncertainty	0.012	0.007	0.007	0.013
Lower confidence limit	0.453	0.543	0.810	0.948
Upper confidence limit	0.501	0.570	0.836	0.998
Lower limit of tolerance	0.410	0.487	0.767	0.831
Upper limit of tolerance	0.544	0.625	0.879	1.12

Table 6 ***Fe-122 LOI Certified Values (non-hygroscopically corrected moisture)***

Determination (Unit)	LOI-371 %	LOI-425 %	LOI-650 %	LOI-1000 %
Assigned value	0.563	0.591	0.885	1.044
Number of Laboratories	8	7	10	18
Number of Analyses	47	37	51	85
Between Laboratory Standard Deviation	0.035	0.051	0.050	0.077
Within Laboratory Standard Deviation	0.027	0.011	0.025	0.057
Between Laboratory Relative Standard Deviation	6.29 %	8.63 %	5.61 %	7.38 %
Within Laboratory Relative Standard Deviation	4.85 %	1.88 %	2.88 %	5.48 %
Standard Uncertainty	0.009	0.021	0.014	0.014
Lower confidence limit	0.546	0.550	0.857	1.016
Upper confidence limit	0.581	0.632	0.913	1.072
Lower limit of tolerance	0.493	0.489	0.785	0.890
Upper limit of tolerance	0.634	0.693	0.984	1.198

Origin of Material:

This material originates from the iron formations in the Asbestos Hill Subgroup of the Ghaap Group, Griqualand West Basin in the Northern Cape Province. The Asbestos Hill Subgroup succession is Palaeoproterozoic in age, and comprises three iron formation successions; the Kliphuis Formation, Kuruman Formation and Daniëlskuil Formation. The Kuruman Iron Formation (approximately 2460±5 Ma) is the main iron ore zone within the Asbestos Hill Subgroup and is characterized as a finely laminated banded iron formation which consists of macrocycles of sediments. Each cycle starts with a stilpnomelane lutite followed by a light chert and a sideritic and haematitic chert. The upper section of the Kuruman banded iron formation cycle consists of a magnetite rich chert, followed by a white coloured iron-poor chert, which is then overlain by the next cycle of sediments. The iron content of the Kuruman Iron Formation is approximately 66 wt.%.

Beukes, N.J. (1980). Suggestions towards a classification of a nomenclature for iron-formations. Transvaal Geological Society of South Africa.

Johnson, M. R., C. R. Anhaeusser, R. J. Thomas; (2006): The Geology of South Africa.

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Iron by Titrimetric Analysis

Twenty samples were systematically selected to represent the batch Fe-122 and submitted to one laboratory for Iron determination by titration.

Table 7 ***Fe-122 Iron Titration***

Fe (%)	**63.53**
Number of Analyses	20
Standard Deviation	0.23
Relative Standard Deviation	0.36 %

Minor Elements

Informational values for minor elements are provided; results from Lazer Ablation ICP-MS on prepared fused bead (results are for a single analysis at one laboratory):

Table 8 ***Fe-122 Minor Elements***

As ppm	**Ba ppm**	**Be ppm**	**Bi ppm**	**Cd ppm**	**Ce ppm**	**Co ppm**	**Cs ppm**
29,6	282	0,6	0,12	-	24,2	5,2	0,35
Cu ppm	**Dy ppm**	**Er ppm**	**Eu ppm**	**Ga ppm**	**Gd ppm**	**Ge ppm**	**Hf ppm**
16	1,28	0,84	0,38	3,2	1,61	4,15	0,92
Ho ppm	**In ppm**	**La ppm**	**Lu ppm**	**Mn ppm**	**Mo ppm**	**Nb ppm**	**Nd ppm**
0,29	-	11,4	0,16	1600	3,6	2,63	8,87
Ni ppm	**Pb ppm**	**Pr ppm**	**Rb ppm**	**Re ppm**	**Sb ppm**	**Sc ppm**	**Se ppm**
56	288	2,73	5,9	-	2,7	3	-
Sm ppm	**Sn ppm**	**Sr ppm**	**Ta ppm**	**Tb ppm**	**Te ppm**	**Th ppm**	**Tl ppm**
1,58	1	194	0,37	0,25	-	2	-
Tm ppm	**U ppm**	**V ppm**	**W ppm**	**Y ppm**	**Yb ppm**	**Zn ppm**	**Zr ppm**
0,22	0,73	44	3,25	9,22	1,07	-	31,5

Informational values for Copper, Nickel, Cobalt, Chrome and Sulphur are provided; results from multi-acid 'near total' digest ICP-OES (results are for a 6 analyses at one laboratory):

Table 9 ***Fe-122 Multi-acid ICP-OES***

Analyte (Unit)	**Cu ppm**	**Ni ppm**	**Co ppm**	**Cr ppm**	**S ppm**
Mean	12	42	22	83	191
Number of Analyses	6	6	6	6	6
Standard Deviation	0,63	2,28	1,27	1,75	4,04
Relative Standard Deviation	5,27	5,43	5,73	2,10	2,12

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Specific Gravity:

Informational value for Specific Gravity by Helium Pycnometer (results are for a single analysis at one laboratory):

SG (Helium Pycnometer) 5.11

XRD Analysis:

A sample of Fe-122 was submitted for Quantiiative X-Ray Diffraction Analysis after drying at 50°C.
XRDQUANT01 - Quantitative analysis, crystalline and amorphous content

Table 10 ***Fe-122 Mineral Abundance (XRD)***

Mineral	% mass fraction
Hematite Fe_2O_3	87
Goethite FeO(OH)	2
Magnetite Fe_3O_4	ND
Quartz SiO_2	3
Kaolin $Al_2Si_2O_5(OH)_4$	ND
Illite/Muscovite $K(Al,Mg,Fe)_2(Si,Al)_4O_{10}(OH)_2$	1
Amorphous content	8

Particle Size Distribution:

A sample of Fe-122 was submitted for particle size analysis by MICROTRAC S3500 Lazer Diffraction System.

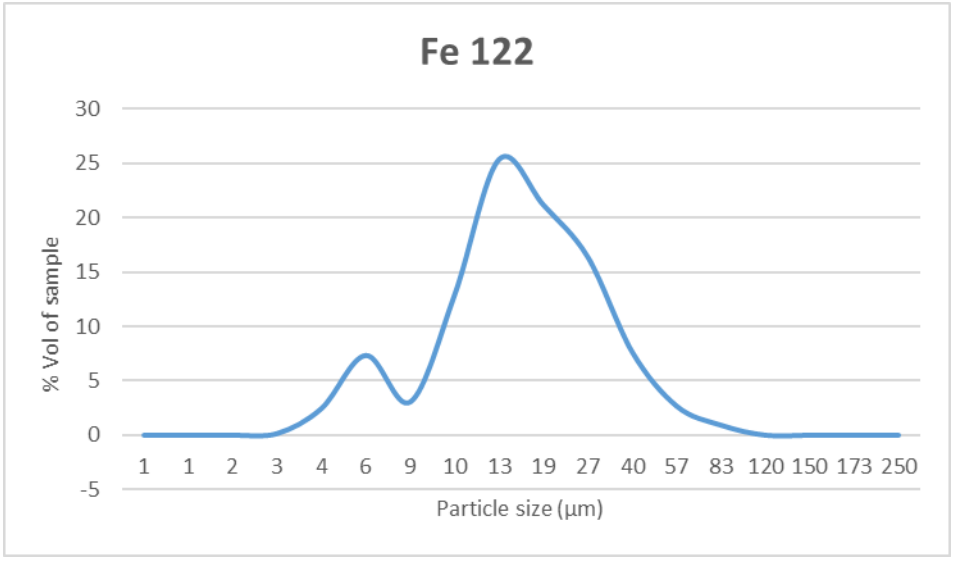

Figure 1 Fe-122 Particle Size Distribution

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Spectral Analysis:

A sample of Fe-122 was submitted for analysis by TerraSpec 4 VNIR-SWIR.

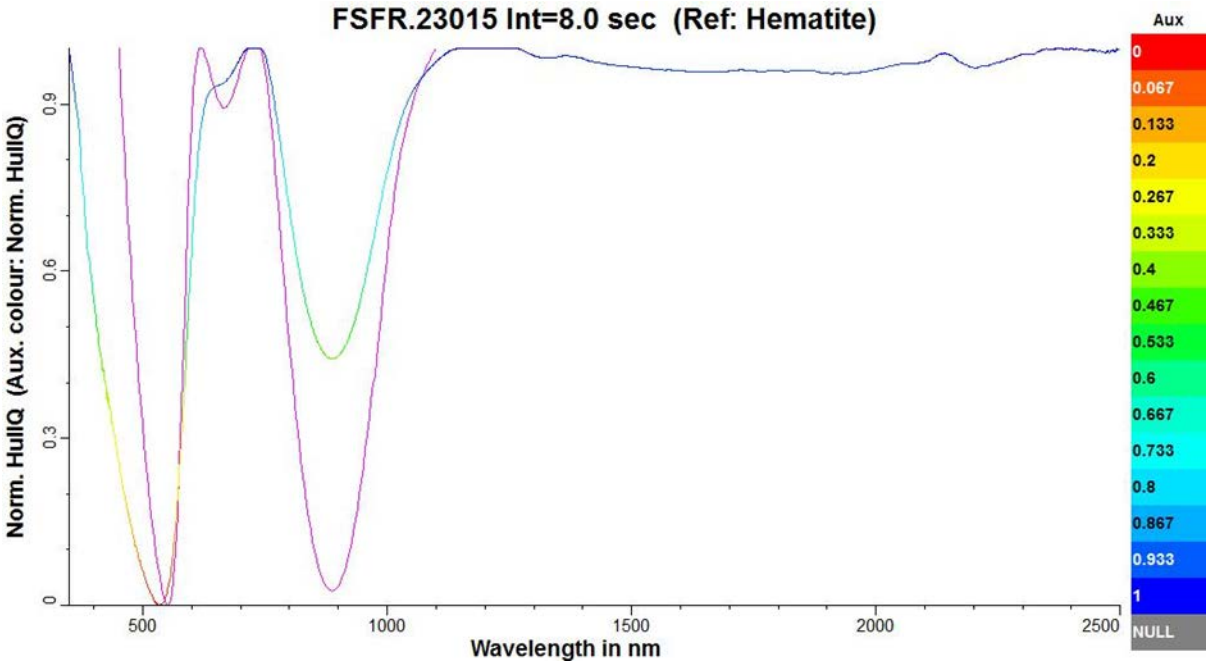

Figure 2 Fe-122 VNIR

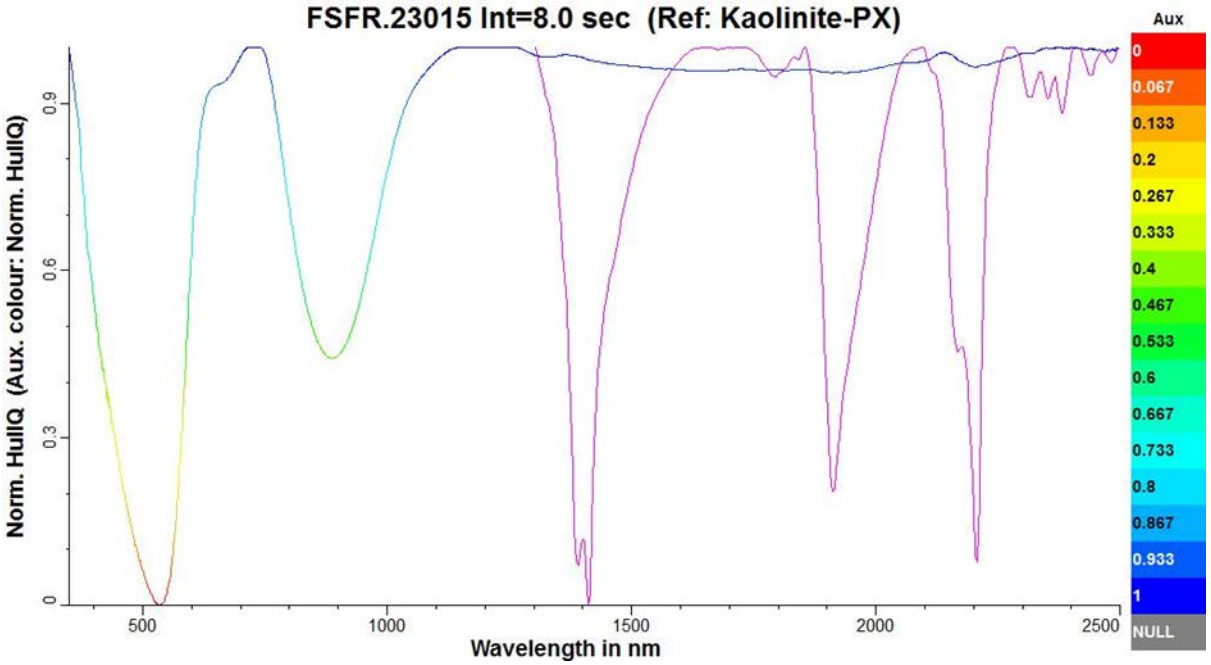

Figure 3 Fe-122 SWIR

FTIR Analysis:

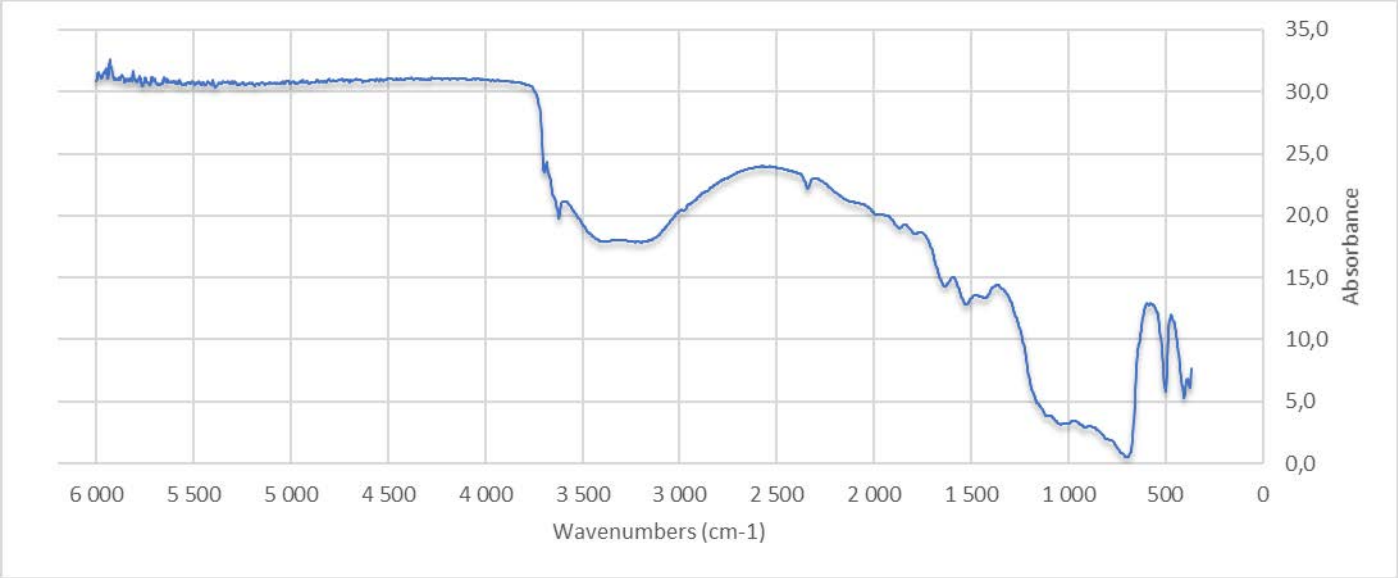

Figure 4 Fe-122 FTIR Spectra

Hygroscopic Moisture:

To illustrate the effect of hygroscopic moisture a sample of RRM Fe-122 underwent water vapour sorption testing.

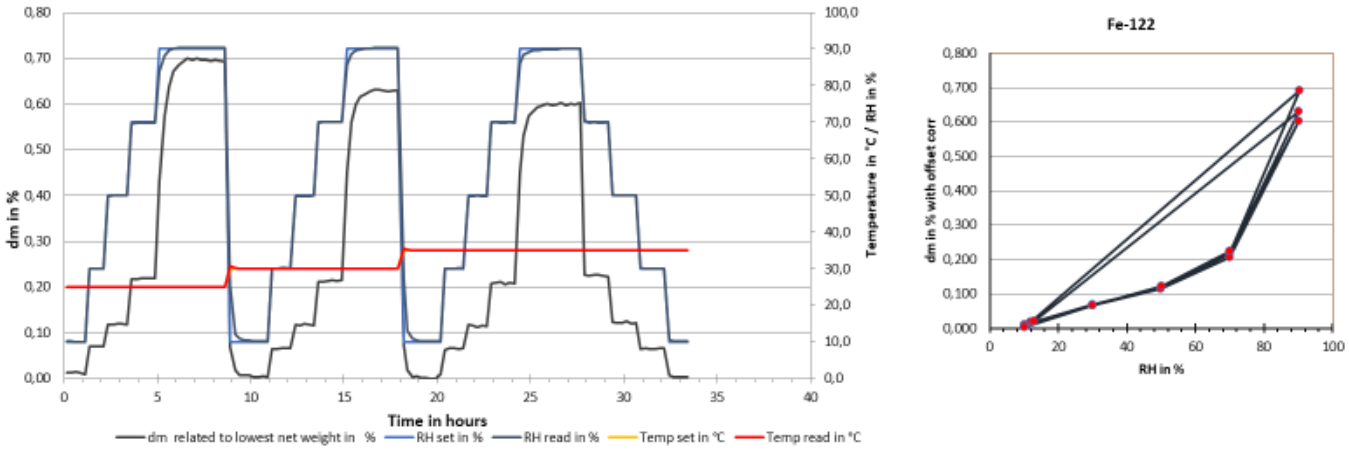

Figure 5 Fe-122 Sorption Testing

From the tests it is clear that hygroscopic moisture could have an impact on the quality of the chemical analysis results and appropriate storage and pre-treatment is highly recommended.

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Participating Laboratories:

Table 11 ***Fe-122 Participating Laboratories***

ALS Metallurgy, Australia
ALS Iron Ore, Australia
BHP Billiton Nelson Point Laboratory, Australia
BHP Billiton Newman Laboratory Line 1, Australia
Bureau Veritas, Western Australia
Citic Pacific Mining Laboratory, Australia
IMP Automation, Australia
Intertek Maddington, Australia
Intertek Robotic Laboratories Anderson Point, Australia
Intertek Robotic Laboratories Christmas Creek, Australia
Intertek Robotic Laboratories Cloudbreak, Australia
Intertek Robotic Laboratories FMG Port, Australia
Intertek Robotic Laboratories Mt Webber, Australia
Intertek Robotic Laboratories Roy Hill Port, Australia
Intertek Robotic Laboratories Solomon, Australia
Intertek, South Africa
Kumba Iron Ore Sishen Mine Laboratory, South Africa
MinAnalytical Laboratory Services, Australia
Rio Tinto Cape Lambert Port A Laboratory, Australia
Rio Tinto Cape Lambert Port B Laboratory, Australia
Rio Tinto Dampier Laboratory, Australia
Rio Tinto Marandoo Laboratory, Australia
Rio Tinto Paraburdoo Laboratory, Australia
Rio Tinto West Angelas Laboratory, Australia
Rio Tinto Yandicoogina Laboratory, Australia
Set Point Laboratories, South Africa

Intended Use:

The Certified Reference Material RRM Fe-122 is intended to be used in analytical laboratories that analyse samples of similar grades (as presented in this certificate of analysis) and matrix.

- Monitoring of routine laboratory performance (both internal and external)
- Method development and method validation
- Instrument calibration

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Instructions before Use:

Safety precautions (in-line with safe laboratory practices) for handling fine particulate matter are advised; such as the use of safety glasses, dust masks, gloves and laboratory coats.

Minimum Sample Size:

- Multi-element Iron Ore Suite – XRF fused disc analysis 0.7g
- LOI – 1g

Analysis Validity:

The property values for RRM Fe-122 Certified Reference Material remain valid provided that good laboratory practice is observed during handling and storage.

The material is in fine powder form and may be hygroscopic in nature.

Stability and storage:

This CRM is considered to have long-term stability under normal storage conditions. The CRM is available in different packaging and mass lots. When considering the lot size and said the ISO 16042, which recommends that the total contents of the container holding the CRM prior to its first use be divided in two portions that match the intended test portions.

Traceability:

The characterization of this material has been achieved by inter-laboratory study, each laboratory using an appropriate analytical method. These methods are calibrated against and analysed against high purity materials and appropriate Certified Reference Materials.

Additional Information:

Additional information on material RRM Fe-122 is available on request and includes the following:

- Data Tables
- Statistical Tables
- Particle Size Analysis Data
- Quantitative X-Ray Diffraction Analysis Report
- FTIR Spectral Data
- VNIR-SWIR Spectral Data
- Sorption Testing Data

Revisions:

This certificate is version 0.00 for the material RRM-Fe-122; and is intended to be a 'live document' intended to reflect progress in analytical chemistry. In that, any significant new data and information could be added at any time to ensure the currency and relevance of the certification. Any revisions to this Certificate of Analysis will be made available via the company website www.resourcereferencematerials.com

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Prepared and Supplied:

Certified Reference Material RRM Fe-122 has been prepared, certified and is supplied by;

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36 Michelson Road
Anderbolt, Boksburg
South Africa, 1459
E-Mail: info@resourcereferencematerials.com

Approved on behalf of Resource Reference Materials (Pty) Ltd:

6th June 2017

Name	*C.S. van der Linde*
Position	*Managing Director*

References:

ISO 17034:2016 General requirements for the competence of reference material producers
DRAFT ISO GUIDE 35:2016 Reference materials — Guidance for the characterization and the assessment of the homogeneity and stability of the material
ISO 5725-2:1994 Accuracy (trueness and precision) of measurement methods and results - Part 2: Basic method for the determination of repeatability and reproducibility of a standard measurement method
ISO 2596:2006 Iron ores — Determination of hygroscopic moisture in analytical samples — Gravimetric, Karl Fischer and mass-loss methods
ISO 11536:2015 Iron ores — Determination of loss on ignition — Gravimetric method
ISO 9516-1:2003 Iron ores — Determination of various elements by X-ray fluorescence spectrometry — Part 1: Comprehensive procedure
ISO 2597: 2006 part 3 Iron ores — Determination of hygroscopic moisture in analytical samples — Gravimetric, Karl Fischer and mass-loss methods

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