Reference Material Certificate

Basalt Hosted Gold, Platinum and Palladium

IMS-349

Table 1: IMS-349 Certified Values

Analyte	unit	Certified Value (*y*)	Standard Deviation (s)		95% Confidence Interval (*CI*)		u_{CRM}^	*k*#	U_{CRM}~	No. of Labs (ISO/IEC 17025)	No. Samples
			1 SD	1 SD Within Lab	lower	upper					
Au	mg/t	82	3.0	2.3	80	85	2.9	2	5.8	12	60
Pt	mg/t	25	0.8	0.7	25	25	1.4	2	2.7	11	55
Pd	mg/t	26	1.0	0.7	25	27	1.4	2	2.7	11	55

Note 1. SI units equivalent: 1 ppb, parts per billion ≡ milligrams per ton ≡ mg/t ≡ ug/kg ≡ 0.001 parts per million ≡ 0.001 g/t
Note 2. The number of decimal places quoted does not imply accuracy of the certified value to this level but are given to minimise rounding errors when calculating 2SD and 3SD.
^ Standard uncertainty.
# Coverage Factor.
~ Expanded Uncertainty.

Table 2: IMS-349 Informational Values

Analyte	XRF Value (wt.%)
Al_2O_3	13.88
BaO	0.02
CaO	7.69
Cr_2O_3	0.03
Fe_2O_3	16.85
K_2O	0.48
MgO	4.43

Analyte	XRF Value (wt.%)
MnO	0.2
Na_2O	2.43
P_2O_5	0.179
SO_3	0.19
SiO_2	50.7
TiO_2	1.69
LOI1000	1.02

Material and Method of Preparation

IMS-349 is manufactured from a pulverised (95%< 105µm) basalt rock spiked with gold (Au), platinum (Pt) and palladium (Pd). The blended materials underwent a multi-stage homogenisation process and were discharged into storage drums. During the discharge the material was sub-sampled at regular intervals from which homogeneity and characterisation samples were drawn.

The samples taken were randomised before being submitted to independent ISO/IEC 17025 accredited laboratories for homogeneity and inter-laboratory round-robin testing.

Multi-element results provide valuable analytical information to assist laboratories in selecting the optimal procedure when performing a digest and analysis of the reference material. A single sample was analysed by both lithium-borate fusion with x-ray fluorescence spectrometry (XRF) determination. The multi-elemental analysis results presented in Table 2 are for informational purpose only.

Homogeneity Analysis

A homogeneity study was undertaken in accordance with ISO Guide 35:2017 and ISO17034:2016 using systematically selected samples to be representative of the entire batch. The sample identifiers were randomised to ensure different production order and laboratory analytical order. These samples were submitted to a single laboratory for multiple analysis in a single batch under repeatable conditions.

Homogeneity analysis was performed for Au using instrument neutron activation analysis (INAA) with an aliquot mass significantly below common practice for gold and platinum group elemental analysis. The reduced aliquot mass method is used to test material homogeneity by amplifying the volume-variance effect of small masses, whilst using an analytical method with suitable measurement uncertainty.

The reduced aliquot INAA results have been scaled to equivalent 25g variance by using the method of Ingamells and Switzer (1973).

The homogeneity study results were reviewed, and the material was deemed suitable for progressing to the inter-laboratory round-robin stage. A summary of the study results is presented in Table 3.

Table 3: IMS-349 Au Homogeneity Study Results

Analytical Method	INAA (Au)
Aliquot mass (g)	1
Number of Samples Submitted	20
Number of Samples tested	20
Total Samples in Analysis	20
No. Determinations per sample	2
Number of technically invalid	0
Mean concentration (Au mg/t)	77
1g INAA Material Standard Deviation (Au mg/t)	9.7
25g Material Standard Deviation equivalent (Au mg/t)	1.9
1g INAA Relative Standard Deviation	12.7%
25g Relative Standard Deviation	2.5%

Material Characterisation and Certification Methodology

A total of 60 x 100g samples were selected for inter-laboratory round-robin analysis, 5 samples were provided to 12 laboratories. Laboratories analysed samples via lead collection fire-assay digestion followed by either ICP-OES or ICP-MS finish. All laboratories returned results in this round.

The process of characterisation was undertaken in accordance with ISO Guide 35:2017 and ISO17034:2016 following examination of grouped laboratory results for potential technical failures by way of comparison with the established CRM submitted for analysis with the candidate material. Where required, further investigation of outliers was conducted. Laboratory results deemed technical outliers were removed from the analysis pool prior to the determination of statistical parameters. The certifying officer, in some cases, may use their judgment in identifying or eliminating outliers outside of these statistical parameters.

- Certified value was determined by average of laboratory averages for analytes with no outlier laboratory results, or median of laboratory medians for those with outlier laboratory results.
- Standard deviation (s) is the measure of spread of analyte determinations and includes inter-laboratory bias, method uncertainty, and material homogeneity uncertainty. Approximately 95% of determinations using the same analytical method are expected to be between two standard deviations either side of the certified value. The standard deviation is calculated from the validated laboratory group data less outlier laboratory and individual determinations.
- Confidence Interval (*CI*) is an estimate of the true (unknowable) analyte concentration in the material at the 95% confidence interval. For example, a 95% *CI* could be interpreted as there is a 0.95 probability that the true value is between certified value ± *CI*. The narrower the interval, the more precise the certified value. The 95% *CI* should not be used for determination of quality control gates.
- Standard Uncertainty (u_{CRM}) is the sum of variance from characterisation, homogeneity, and stability studies. The uncertainty of characterisation is derived from the standard deviation of average of laboratory averages divided by the square root of the number of laboratories. Uncertainty of material homogeneity (u_{hom}) is the sum of ANOVA within and between sample uncertainty derived from the homogeneity study in accordance with ISO Guide 35. The uncertainty of homogeneity for gold was applied to platinum and palladium. An allowance for stability has been included in accordance with ISO Guide 35.
- Coverage Factor (*k*) is the students t-distribution value for two tailed test at 95%.
- Expanded Uncertainty (U_{CRM}) is the product of coverage factor and standard uncertainty, and represents the 95% confidence interval of the true unknowable analyte concentration of the batch combined with the bias from individual samples.

Participating laboratories

Samples were sent to 11 participating laboratories which are listed in Table 4, along with nominal sample mass and analysis method. The laboratories are presented in alphabetical order, and are not related to the laboratory number identified in Appendix 1.

Table 4: Participating Laboratories

Laboratory Name	Location	Mass (g)	Analysis method
Activation Laboratories Ltd	Ancaster, Ontario	30	Fire Assay ICP-MS (1C-Research)
ALS Geochemistry	Malaga, Western Australia	30	Fire Assay ICP-MS (PGM-ICP23)
ALS Geochemistry	North Vancouver, British Columbia	30	Fire Assay ICP-OES (PGM-ICP23)
ALS Geochemistry	Edenvale, South Africa	50	Fire Assay ICP-OES (PGM-ICP24)
ALS OMAC Laboratories Ltd	Loughrea, Co. Galway	50	Fire Assay ICP-OES (PGM-ICP24)
Bureau Veritas	Wingfield, South Australia	40	Fire Assay ICP-OES (FA002)
Intertek	Townsville, Queensland	25	Fire Assay ICP-MS (FA25/MS)
Intertek	Wingfield, South Australia	25	Fire Assay ICP-MS (FA25/MS)
Intertek Genalysis	Maddington, Western Australia	25	Fire Assay ICP-MS (FA25/MS)
Jinning	Maddington, Western Australia	30	Fire Assay ICP-OES (FA30I)
MSA Labs	Langley, British Columbia	30	Fire Assay ICP-OES (FAS113)
SGS Geochemistry	Perth Airport, Western Australia	50	Fire Assay ICP-MS (GE_FAM50V10)

Preparer and Supplier of Certified Reference Material

This certified reference material, IMS-349, was prepared and certified by:

Independent Mineral Standards Pty Ltd
16 Durham Rd
Bayswater, WA 6053
Australia
Ph: +61 8 6155 7616
imstandards.com.au

The material is available in sealed 1kg PET heat sealed jars, or 60g and 100g aluminised plastic foils.

Minimum Sample Mass

This reference material has been certified using 25g to 50g aliquots for fire assay. Homogeneity has been undertaken with reduced mass aliquots which have subsequently been normalised to 25g aliquot equivalents.

Uncertainty and homogeneity statements relating to this are only applicable if a minimum of 25g sample mass is used.

Intended Use

The pulverised reference material is intended for monitoring and testing the accuracy and precision of lead collection fire-assay analysis for gold, platinum and palladium. This intended use may include a quality control program within a minerals or mine site laboratory.

The estimate of material and measurement uncertainties reported in this certificate are the product of the participating laboratories, not any individual laboratory. Commercial laboratories typically have different measurement uncertainties to site-based laboratories. Application of the grouped uncertainties reported in this certificate to a specific laboratory for ongoing QC may lead to many false reports of out-of-control processes, or alternatively non reporting of out-of-control processes.

It is recommended that the centre line and control limits of a Shewhart chart used for ongoing monitoring of a particular laboratory are derived from averaged values and variation from replicate analysis of this CRM after removal of outliers.

Period of Validity

This Certificate is valid 10 years from the date of original issue.

Commutability

This pulverised reference material is not commutable to any other analytical methods than as stated by its intended use.

Metrological Traceability

Metrological traceability of the assigned values and their uncertainties has been established through an unbroken chain to the SI unit kilogram for Certified Values in Table 1. This is achieved through the use of accredited ISO17025 assay laboratories during homogeneity, characterisation and stability studies.

An insufficient number of samples and or independent laboratories have been used to establish metrological traceability for the informational values in Table 2. The values are presented to inform users of nature of the material matrix.

Stability and Storage Instructions

Jars should be stored in a cool dry location, and mixed by shaking the sealed container before opening for first use. Once opened it is recommended to re-seal opened jars when not in use. The long-term storage of this product is monitored, and purchasers will be notified if changes are observed during the period of validity of the product.

Instructions for Correct Use

The certified values derived from fire-assay digestion and analysis is based on the concentration level in the packaged state, and no further drying is required before weighing and analysis.

Legal Notice

Independent Mineral Standards Pty Ltd has prepared and statistically evaluated the property values of this reference material to the best of its ability. The purchaser by receipt hereof releases and indemnifies Independent Mineral Standards Pty Ltd from and against all liability and costs from the use of this material and information.

Certifying Officer

Dr. John Carter, General Manager - ISO17034:2016 authorised signatory

Certification Date

21-Mar-2024

References

ISO Guide 35:2017, Reference materials – General and statistical principles for certification.

ISO17034:2016, General Requirements for the competence of reference material producers.

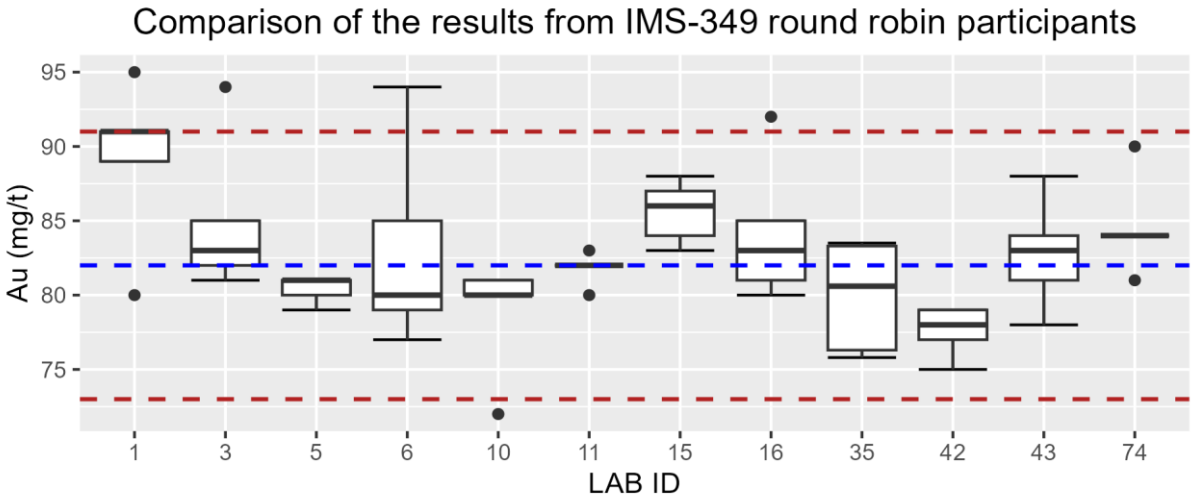
Version History

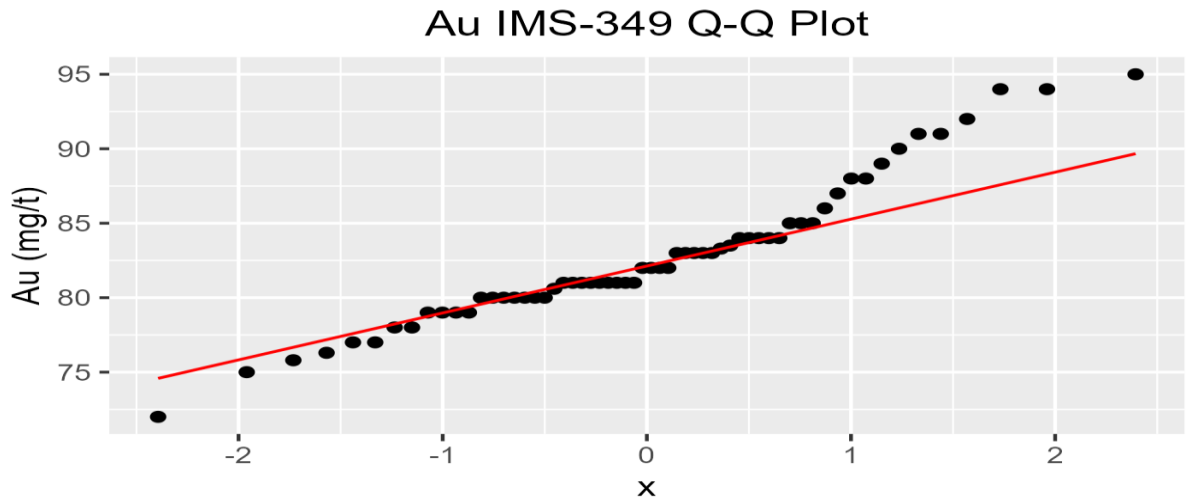
Batch #	Document Version	Date	Modification
IMS-349	R0	21 /03/2024	Initial Document

Appendix 1

Tabulated and graphical presentation of certification data.

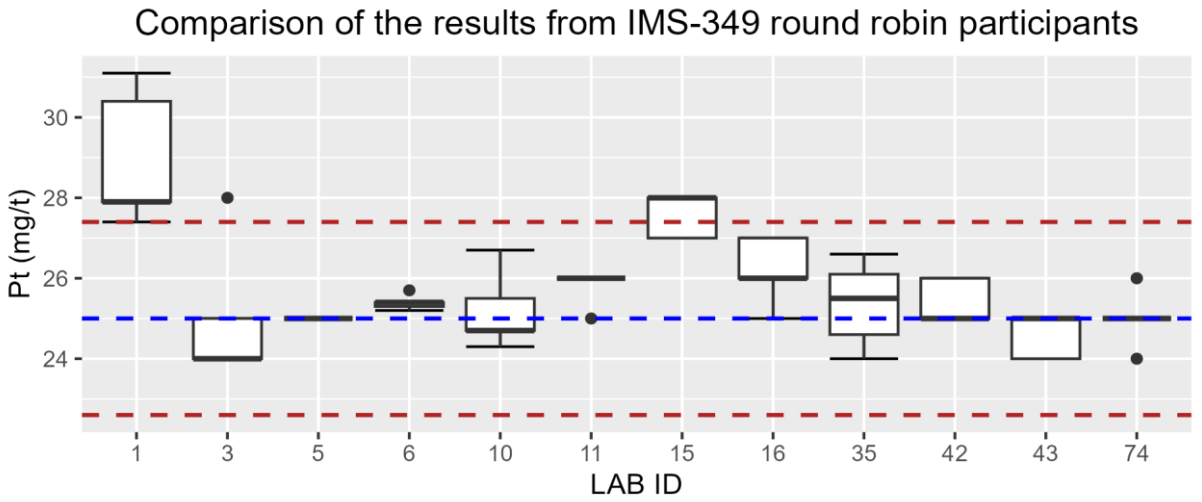
		Laboratory ID											
Au Determination	1	3	5	6	10	11	15	16	35	42	43	74	Overall
1	91	81	81	80	80	82	83	92	75.8	79	88	84	
2	95	82	79	77	81	82	86	81	83.3	78	84	90	
3	91	94	81	85	80	83	88	85	83.5	79	78	84	
4	89	85	81	79	81	82	84	83	80.6	77	83	81	
5	80	83	80	94	72	80	87	80	76.3	75	81	84	
Count	0	4	5	4	4	5	5	4	5	5	5	4	50
Min	-	81	79	77	80	80	83	80	76	75	78	81	75
Max	-	85	81	85	81	83	88	85	84	79	88	84	88
Median	-	82	81	80	80	82	86	82	81	78	83	84	82
Mean	-	83	80	80	80	82	86	82	80	78	83	83	82
Std Dev	-	1.7	0.9	3.4	0.6	1.1	2.1	2.2	3.7	1.7	3.7	1.5	3.0
Coeff. Variation	-	2.06	1.11	4.24	0.72	1.34	2.42	2.7	4.63	2.16	4.47	1.8	3.64
Dev. From Cert Mean	-	1.47	-1.42	-1.6	-1.29	0.3	4.96	0.85	-2.03	-4.85	1.53	2.08	-
95% Confidence Interval	-	-	-	-	-	-	-	-	-	-	-	-	1.4
SD Within Labs	-	-	-	-	-	-	-	-	-	-	-	-	2.3
SD Between Labs	-	-	-	-	-	-	-	-	-	-	-	-	4.7
M-Score	3.37	0.2	0.6	0.99	0.99	0.2	1.39	0.2	0.75	1.79	0.2	0.6	4
Z-Score													3

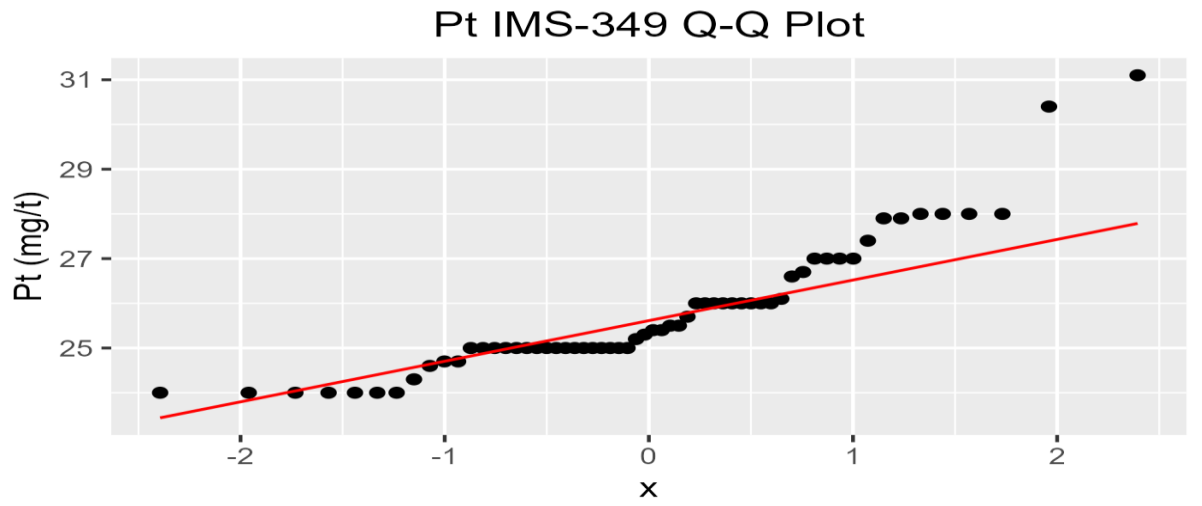

Comparison of the results from IMS-349 round robin participants
Au (mg/t)
95
90
85
80
75
1
3
5
6
10
11
15
16
35
42
43
74
LAB ID


Au IMS-349 Q-Q Plot
Au (mg/t)
95
90
85
80
75
-2
-1
0
1
2
x

Tabulated and graphical presentation of certification data.

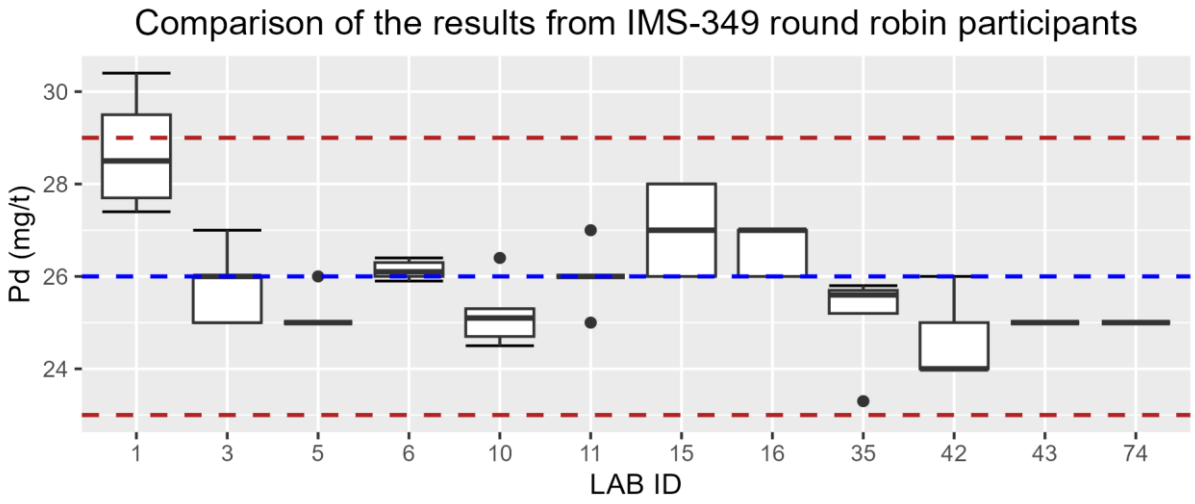
		Laboratory ID											
Pt Determination	1	3	5	6	10	11	15	16	35	42	43	74	Overall
1	31.1	24	25	25.4	24.7	26	27	27	24	26	25	26	
2	30.4	25	25	25.4	24.3	25	27	27	24.6	25	24	25	
3	27.9	24	25	25.3	26.7	26	28	26	25.5	26	25	25	
4	27.9	28	25	25.2	25.5	26	28	26	26.1	25	25	24	
5	27.4	24	25	25.7	24.7	26	28	25	26.6	25	24	25	
Count	0	4	5	5	5	5	0	5	5	5	5	5	49
Min	-	24	25	25	24	25	-	25	24	25	24	24	24
Max	-	25	25	26	27	26	-	27	27	26	25	26	27
Median	-	24	25	25	25	26	-	26	26	25	25	25	25
Mean	-	24	25	25	25	26	-	26	25	25	25	25	25
Std Dev	-	0.5	0	0.2	1	0.4	-	0.8	1.1	0.5	0.5	0.7	0.8
Coeff. Variation	-	2.06	0	0.74	3.79	1.73	-	3.19	4.2	2.16	2.23	2.83	3.14
Dev. From Cert Mean	-	-3.84	-0.87	0.72	-0.15	2.3	-	3.89	0.56	0.72	-2.45	-0.87	-
95% Confidence Interval	-	-	-	-	-	-	-	-	-	-	-	-	0.4
SD Within Labs	-	-	-	-	-	-	-	-	-	-	-	-	0.7
SD Between Labs	-	-	-	-	-	-	-	-	-	-	-	-	1.2
M-Score	4.55	2.02	0.34	0.34	0.84	1.35	4.72	1.35	0.51	0.34	0.34	0.34	4
Z-Score													3

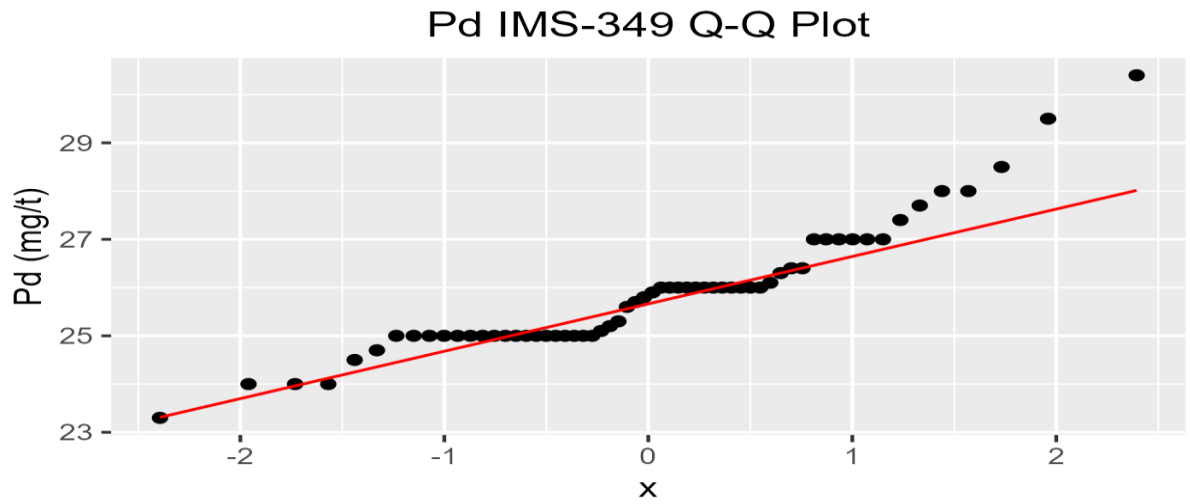

Comparison of the results from IMS-349 round robin participants
Pt (mg/t)
30
28
26
24
1
3
5
6
10
11
15
16
35
42
43
74
LAB ID


Pt IMS-349 Q-Q Plot
Pt (mg/t)
31
29
27
25
-2
-1
0
1
2
x

Tabulated and graphical presentation of certification data.

		Laboratory ID											
Pd Determination	1	3	5	6	10	11	15	16	35	42	43	74	Overall
1	30.4	25	25	26.4	24.5	27	26	27	25.2	25	25	25	
2	29.5	26	25	26	25.3	26	26	27	25.8	26	25	25	
3	28.5	26	25	26.1	26.4	26	28	26	25.7	24	25	25	
4	27.7	27	25	25.9	25.1	25	27	26	25.6	24	25	25	
5	27.4	25	26	26.3	24.7	26	28	27	23.3	24	25	25	
Count	0	5	5	5	5	5	5	5	5	5	5	5	55
Min	-	25	25	26	24	25	26	26	23	24	25	25	23
Max	-	27	26	26	26	27	28	27	26	26	25	25	28
Median	-	26	25	26	25	26	27	27	26	24	25	25	26
Mean	-	26	25	26	25	26	27	27	25	25	25	25	26
Std Dev	-	0.8	0.4	0.2	0.7	0.7	1	0.5	1	0.9	0	0	1.0
Coeff. Variation	-	3.24	1.77	0.79	2.94	2.72	3.7	2.06	4.15	3.64	0	0	3.73
Dev. From Cert Mean	-	0.76	-1.58	2.09	-1.58	1.54	5.45	3.88	-1.9	-3.93	-2.36	-2.36	-
95% Confidence Interval	-	-	-	-	-	-	-	-	-	-	-	-	0.5
SD Within Labs	-	-	-	-	-	-	-	-	-	-	-	-	0.7
SD Between Labs	-	-	-	-	-	-	-	-	-	-	-	-	1.7
M-Score	2.28	0.17	0.67	0.25	0.59	0.17	1.01	1.01	0.17	1.52	0.67	0.67	4
Z-Score													3


Comparison of the results from IMS-349 round robin participants
Pd (mg/t)
30
28
26
24
1
3
5
6
10
11
15
16
35
42
43
74
LAB ID


Pd IMS-349 Q-Q Plot
Pd (mg/t)
29
27
25
23
-2
-1
0
1
2
x

Appendix 2

Tabulated and graphical presentation of homogeneity data.

Replicate No.	1	2	3	4	5	6	7	8	9	10
1	81	78	78	78	75	79	79	77	80	76
2	79	73	77	77	78	74	79	73	76	74

Replicate No.	11	12	13	14	15	16	17	18	19	20
1	74	75	75	77	81	74	74	75	80	78
2	78	79	73	77	77	74	80	71	80	76