

Reference Material Certificate

Crushed (<3mm) Gold Hosted Silicate Rock Chips

IMS-237

Table 1: IMS-237 Certified Values

Analyte	unit	Certified Value (y)	Standard Deviation (s)		95% Confidence Interval (CI)		u_{CRM}^{\wedge}	$k^{\#}$	U_{CRM}^{\sim}	No. of Labs (ISO/IEC 17025)	No. Samples
			1 SD	1 SD Within Lab	lower	upper					
As-received X-ray Photon Assay (500g)											
Au	g/t	2.07	0.077	0.072	2.03	2.11	0.069	2.36	0.16	7	35
Sample Preparation and Pb Fire Assay (2kg)											
Au	g/t	2.06	0.123	0.068	1.99	2.14	0.066	2	0.13	11	55

Table 2b: IMS-237 Informational Values

Analyte	unit	Certified Value (y)	Standard Deviation (s)		95% Confidence Interval (CI)		U_{CRM}^{\wedge}	$k^{\#}$	U_{CRM}^{\sim}	No. of Labs	No. Samples
			1 SD	1 SD Within Lab	lower	upper					
As-received PAL (500g)											
Au	g/t	1.57	0.056	0.053	1.56	1.62	-	-	-	7	35

The packaged CRM must not be sub-sampled prior to sample preparation for fire assay or photon assay.

Note 1. SI units equivalent: 1 ppm, parts per million \equiv grams per ton \equiv mg/kg \equiv ug/g \equiv 0.0001 wt.% \equiv 1000ppb, parts per billion

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.

\wedge Standard uncertainty.

$\#$ Coverage Factor.

\sim Expanded Uncertainty.

Material and Method of Preparation

IMS-237 is a patented product manufactured from an engineered rock, with dispersed gold embedded within the mineralogical structure. This crushed reference material was further prepared by multi-stage homogenisation and sub-sampling in rotary sample dividers. The final product was packed at nominal 500g or 2kg masses, in labelled heat-sealed bags for individual use in their entirety.

During the packaging stage samples were drawn for homogeneity and characterisation studies. The samples taken were randomised before being submitted for material characterisation 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 lithium-borate fusion with x-ray fluorescence spectrometry (XRF) determination. The multi-elemental analysis results presented in Table 3 are informational values only.

Table 3: IMS-237 Informational Values

Analyte	XRF Value (wt.%)	Analyte	XRF Value (wt.%)
Al ₂ O ₃	15.44	MnO	0.17
BaO	0.05	Na ₂ O	3.18
CaO	8.76	P ₂ O ₅	0.237
Cr ₂ O ₃	0.03	SO ₃	0.16
Fe ₂ O ₃	12.66	SiO ₂	51.65
K ₂ O	0.39	TiO ₂	1.94
MgO	4.94	LOI-1000°C	0.32

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 each method and multiple analysis in a single batch under repeatable conditions. A separate homogeneity study was conducted for sample preparation plus fire assay, and photon assay. The homogeneity studies 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 4.

Table 4: IMS-237 Homogeneity Study Results

Analytical Method	Pb Fire Assay	X-ray Photon Assay
Number of Samples Submitted	15	15
Number of Samples tested	15	15
Total Samples in Analysis	15	15
No. Determinations per sample	3	2
Number of technically invalid	0	0
Mean concentration (Au g/t)	2.14	2.10
Material Standard Deviation (Au g/t)	0.035	0.050
Relative Standard Deviation	1.65%	2.37%

Material Characterisation and Certification Methodology

For Pb collection Fire Assay, a total of 55 x 2kg samples were selected for inter-laboratory round-robin analysis, 5 samples were provided to 11 laboratories. Laboratories prepared samples by splitting, if required, followed by pulverisation and subsampling. Samples were analysed via lead collection fire-assay digestion followed by either AAS or ICP. All laboratories returned results in this round.

For Photon Assay, a total of 35 x 500g samples were selected for inter-laboratory round-robin analysis, 5 samples were provided to 7 X-ray Photon Assay instruments. No further sample preparation was performed.

For PAL, a total of 35 x 500g samples were selected for inter-laboratory round-robin analysis, 5 samples were provided to 7 laboratories. PAL is a method developed by Mineral Process Control (MPC) Pty Ltd. Samples are completely pulverised (typically to better than 90% – 75 microns) and simultaneously leached with cyanide and LeachWELL™ in less than one hour. Slurry samples are taken and the solution is analysed for gold by solvent extraction, AAS.

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 analyses with the candidate material (Fire assay and Photon Assay only). 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 lab averages for analytes with no outlier laboratory results, or median of median 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 \pm 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 and homogeneity 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. 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. The standard, nor expanded uncertainties were determined for PAL assay as a homogeneity study for this method was not conducted.

Participating laboratories

Samples were sent to the participating laboratories listed in Table 5 and 5, along with 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 5: Participating Laboratories. Pb Fire Assay

Laboratory Name	Location	Assay Mass (g)	Analysis method
ActLabs	Ancaster, Ontario	50	50g Fire Assay ICP (1C-50g)
ALS Geochemistry	Vancouver, British Columbia	50	50g Fire Assay ICP (Au-ICP22)
ALS Global	Malaga, Western Australia	50	50g Fire Assay ICP (Au-ICP22)
Bureau Veritas Minerals	Wingfield, South Australia	40	40g Fire Assay ICP (FA002)
Bureau Veritas Minerals	Canning Vale, Western Australia	40	40g Fire Assay AAS (FA001)
Intertek	Townsville, Queensland	50	50g Fire Assay ICP (FA50/OE04)
Intertek Genalysis	Maddington, Western Australia	25	25g Fire Assay ICP (FA25/OE04)
Jinning	Maddington, Western Australia	50	50g Fire Assay ICP (FA50I)
MinAnalytical Canning Vale	Canning Vale, Western Australia	50	50g Fire Assay AAS (FA50AAS)
SGS Geochemistry	Perth, Western Australia	50	50g Fire Assay AAS (FAA505)
SGS Geochemistry	Burnaby, British Columbia	50	50g Fire Assay ICP (FAI50V5)

Table 6: Participating Laboratories. Photon Assay

Laboratory Name	Location	Assay Mass (g)	Analysis method
Chrysos Corporation Limited	Urrbrae, South Australia	420 - 500	Photon Assay
Intertek Genalysis	Machine 1,2,3	420 - 500	Photon Assay (PAAU002)
MinAnalytical Canning Vale	Canning Vale, Western Australia	420 - 500	Photon Assay (Au-PA01)
MinAnalytical Kalgoorlie	Machine 1,2	420 - 500	Photon Assay (Au-PA01)

Table 6: Participating Laboratories. PAL Assay

Laboratory Name	Location	Assay Mass (g)	Analysis method
CRS Laboratories Oy	Finland	420 - 500	PAL-AAS
Galiano Gold	Ghana	420 - 500	PAL-AAS
Iamgold	Suriname	420 - 500	PAL-AAS
Intertek Calidus	Western Australia	420 - 500	PAL-AAS
Minlab AB	Sweden	420 - 500	PAL-AAS
Newmont	Suriname	420 - 500	PAL-AAS
Superior Gold	Western Australia	420 - 500	PAL-AAS

Preparer and Supplier of Certified Reference Material

This certified reference material, IMS-237, was prepared and certified by:

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

Minimum Sample Mass

The samples have been packed in nominal 500g or 2kg sealed plastic bags, and uncertainty and homogeneity statements relating to these are only applicable if the whole sample is submitted for sample preparation (if required) and subsequent analysis.

Intended Use

The crushed reference material is intended for monitoring and testing the accuracy and precision of sample preparation and sub-sampling procedures, followed by Pb collection fire-assay, Photon assay or PAL assay of gold ores. Certified and informational values are operationally defined variables obtained from a network of competent laboratories using widely accepted methods to which results obtained only by the same procedure can be compared. In the case of Fire Assay, crushed reference materials are typically used in conjunction with pulverised reference materials which monitor the analysis stage only.

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 5 years from the date of original issue.

Commutability

This 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. This is achieved through the use of accredited ISO17025 assay laboratories during homogeneity, characterisation and stability studies. Metrological traceability was not established for the PAL assay method. This method is a partial leach.

Stability and Storage Instructions

This reference material should be stored in a dry location out of direct sunlight to prevent degradation of the packaging and possible contamination of the materials. No other special storage conditions are required.

Instructions for Correct Use

The certified values are based on the concentration level in the packaged state, and no further drying is required before weighing and analysis. **The packaged CRM must be submitted to the laboratory in its entirety.**

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

Bruce Armstrong, Operations Manager - ISO17034:2016 authorised signatory

Certification Date

25 - Oct - 2022

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
IMS237	R0	30/7/22	Initial release
IMS237	R1	25/10/22	PAL informational values included
IMS237	R2	25/01/23	Correction of Table 1 95% CI header text
IMS237	R3	17/03/2023	U _{CRM} value rounded to two significant figures

Appendix 1 (Sample Preparation and Fire Assay)

Tabulated and graphical presentation of certification data.

Determination No.	Lab 1	Lab 3	Lab 5	Lab 6	Lab 10	Lab 16	Lab 19	Lab 33	Lab 35	Lab 42	Lab 71	Overall
1	2.00	2.17	1.88	2.15	1.96	2.15	2.09	1.92	2.04	1.99	2.08	
2	1.98	2.17	1.99	2.17	2.06	2.15	1.96	1.95	2.20	2.24	1.98	
3	2.06	2.20	1.96	2.20	1.95	2.16	1.88	1.96	2.12	2.22	2.05	
4	1.96	2.16	1.96	2.23	1.87	2.17	1.81	1.97	2.17	2.28	2.01	
5	2.04	2.19	1.86	2.08	1.97	2.18	1.91	1.98	2.14	2.36	2.09	
Count	5	5	5	5	5	5	5	5	5	5	5	55
Min	1.96	2.16	1.86	2.08	1.87	2.15	1.81	1.92	2.04	1.99	1.98	1.81
Max	2.06	2.2	1.99	2.23	2.06	2.18	2.09	1.98	2.2	2.36	2.09	2.36
Median	2	2.17	1.96	2.17	1.96	2.16	1.91	1.96	2.14	2.24	2.05	2.05
Mean	2.01	2.18	1.93	2.17	1.96	2.16	1.93	1.96	2.13	2.22	2.04	2.06
Std Dev	0.041	0.016	0.057	0.057	0.068	0.013	0.105	0.023	0.061	0.139	0.05	0.123
Coeff. Variation	2.07	0.75	2.93	2.61	3.45	0.6	5.42	1.18	2.86	6.29	2.44	5.96
Dev. From Cert Mean (Rel. %)	-2.64	5.61	-6.42	5.07	-4.87	4.83	-6.42	-5.16	3.46	7.52	-1	
95% Confidence Interval	-	-	-	-	-	-	-	-	-	-	-	0.075
SD Within Labs	-	-	-	-	-	-	-	-	-	-	-	0.068
SD Between Labs	-	-	-	-	-	-	-	-	-	-	-	0.248
M-Score	0.38	0.85	0.67	0.88	0.67	0.78	1.04	0.67	0.65	1.33	0	4

Appendix 1 (Photon Assay)

Tabulated and graphical presentation of certification data.

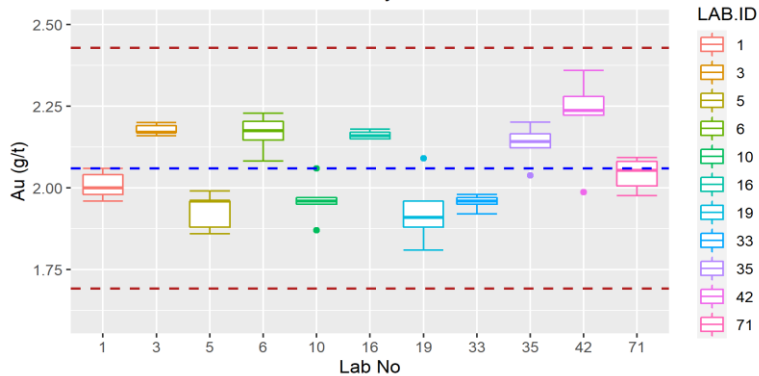
Determination No.	1	2	3	4	5	6	7	Overall
1	2.05	1.97	2.03	2.00	2.05	1.90	2.12	
2	2.12	2.01	2.00	2.16	2.11	2.01	2.06	
3	2.09	1.98	2.04	2.30	2.10	2.13	2.11	
4	2.10	2.18	2.05	2.12	2.14	1.99	2.12	
5	2.06	2.06	2.08	1.99	2.15	1.93	2.06	
Count	5	5	5	5	5	5	5	35
Min	2.05	1.97	2	1.99	2.05	1.9	2.06	1.90
Max	2.12	2.18	2.08	2.3	2.15	2.13	2.12	2.30
Median	2.09	2.01	2.04	2.12	2.11	1.99	2.11	2.09
Mean	2.08	2.04	2.04	2.11	2.11	1.99	2.09	2.07
Std Dev	0.029	0.086	0.029	0.128	0.04	0.089	0.031	0.077
Coeff. Variation	1.38	4.2	1.43	6.04	1.91	4.47	1.49	3.75
Dev. From Cert Mean (Rel. %)	0.79	-1.34	-1.34	2.24	2.05	-3.66	1.27	
95% Confidence Interval	-	-	-	-	-	-	-	0.041
SD Within Labs	-	-	-	-	-	-	-	0.072
SD Between Labs	-	-	-	-	-	-	-	0.101
M-Score	0	1.80	1.12	0.67	0.38	2.25	0.45	4

Appendix 1 (PAL Assay)

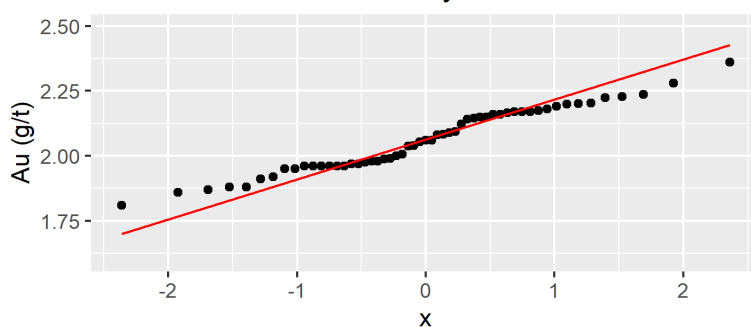
Tabulated and graphical presentation of certification data.

Determination No.	Lab 79	Lab 81	Lab 83	Lab 84	Lab 85	Lab 86	Lab 87	Overall
1	1.57	1.58	1.58	1.55	1.56	1.71	1.54	
2	1.69	1.61	1.68	1.6	1.55	1.67	1.57	
3	1.56	1.56	1.62	1.6	1.46	1.6	1.57	
4	1.55	1.51	1.59	1.68	1.64	1.62	1.58	
5	1.52	1.54	1.55	1.61	1.68	1.66	1.58	
Count	5	5	5	5	5	5	5	35
Min	1.52	1.51	1.55	1.55	1.46	1.6	1.54	1.46
Max	1.69	1.61	1.68	1.68	1.68	1.71	1.58	1.71
Median	1.56	1.56	1.59	1.6	1.56	1.66	1.57	1.57
Mean	1.58	1.56	1.61	1.61	1.58	1.65	1.57	1.59
Std Dev	0.064	0.039	0.049	0.048	0.086	0.043	0.017	0.056
Coeff. Variation	4.08	2.47	3.06	2.98	5.42	2.58	1.07	3.54
Dev. From Cert Mean (Rel. %)	-1.02	-1.95	0.8	0.91	-0.94	3.7	-1.5	
95% Confidence Interval	-	-	-	-	-	-	-	0.029
SD Within Labs	-	-	-	-	-	-	-	0.053
SD Between Labs	-	-	-	-	-	-	-	0.070
M-Score	0.64	0.52	1.01	1.3	0.67	4.33	0	4

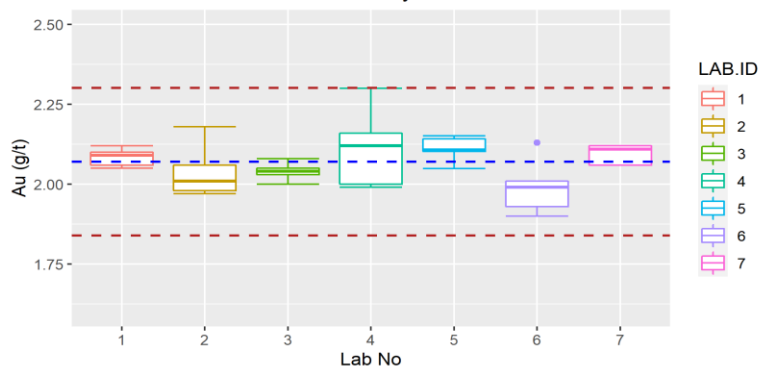
Au Fire Assay Box Plot



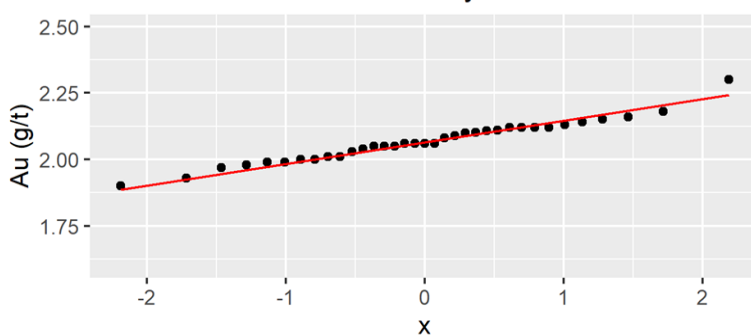
Au Fire Assay Q-Q Plot



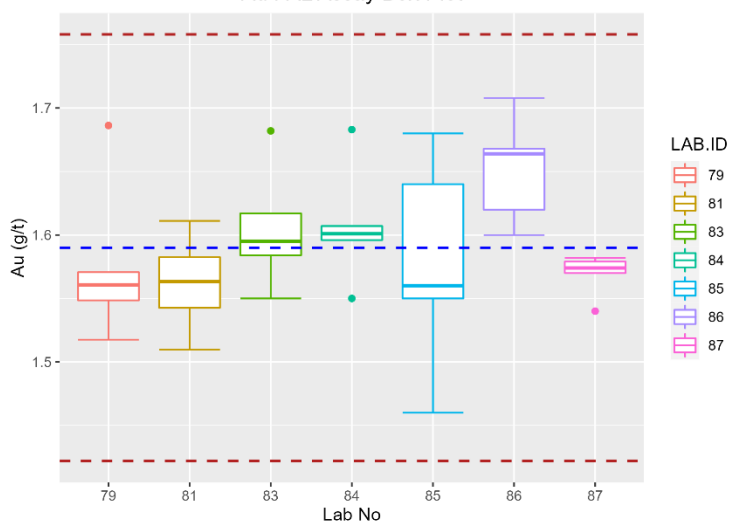
Au Photon Assay Box Plot



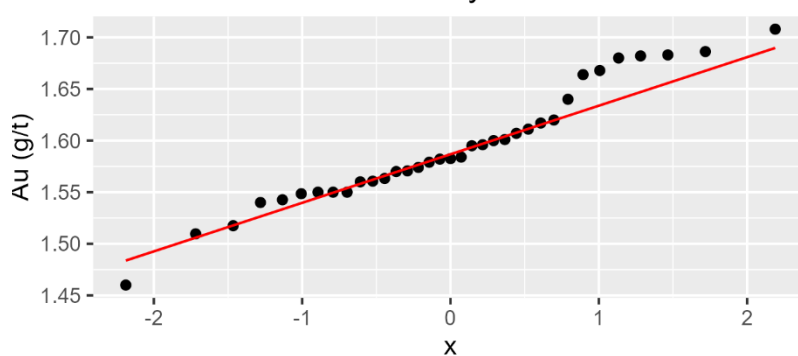
Au Photon Assay Q-Q Plot



Au PAL Assay Box Plot



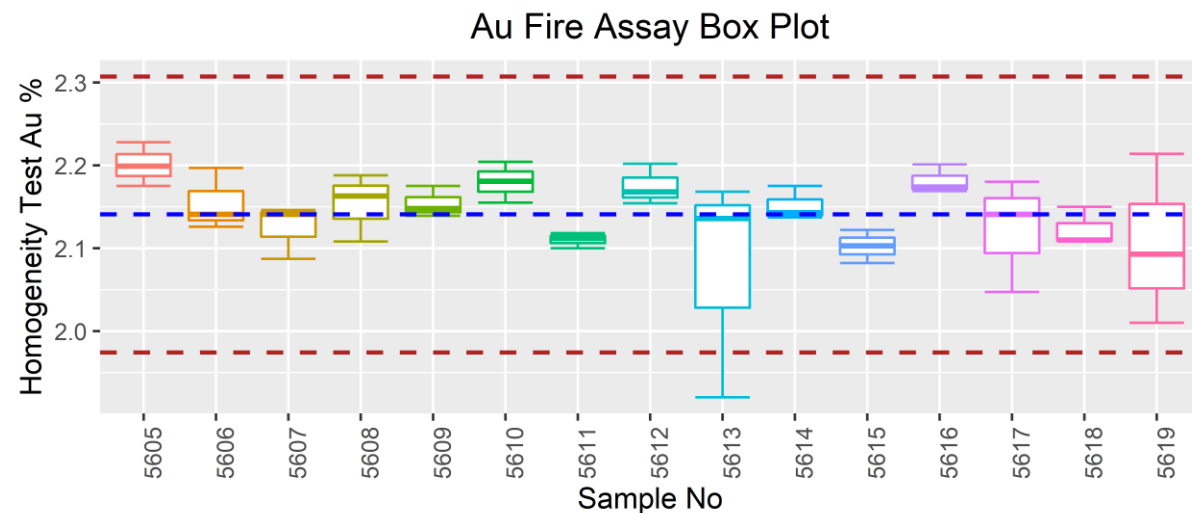
Au PAL Assay Q-Q Plot



Appendix 2 (Sample Preparation and Fire Assay)

Tabulated and graphical presentation of homogeneity data.

	Samples															
Replicate No.	5605	5606	5607	5608	5609	5610	5611	5612	5613	5614	5615	5616	5617	5618	5619	Overall
1	2.23	2.13	2.15	2.11	2.18	2.20	2.12	2.17	2.14	2.18	2.08	2.20	2.14	2.11	2.21	
2	2.20	2.20	2.09	2.16	2.14	2.16	2.10	2.20	2.17	2.14	2.10	2.17	2.05	2.15	2.09	
3	2.18	2.14	2.14	2.19	2.15	2.18	2.11	2.15	1.92	2.14	2.12	2.17	2.18	2.11	2.01	
Count	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	45
Mean	2.2	2.15	2.12	2.15	2.15	2.18	2.11	2.17	2.07	2.15	2.1	2.18	2.12	2.12	2.11	2.14
Std Dev	0.027	0.037	0.033	0.041	0.019	0.025	0.009	0.025	0.135	0.02	0.02	0.017	0.068	0.024	0.103	0.035



Appendix 2 (Photon Assay)

Tabulated and graphical presentation of homogeneity data.

	Samples															
Replicate No.	5413	5414	5415	5416	5417	5418	5419	5420	5421	5422	5423	5424	5425	5426	5427	Overall
1	2.14	2.09	1.97	2.11	2.05	2.12	2.15	2.06	2.17	2.11	2.14	2.06	2.10	2.05	2.02	
2	1.99	2.17	2.11	2.07	2.14	2.18	2.17	2.01	2.13	2.15	2.04	2.16	2.16	2.19	1.94	
Mean	2.07	2.13	2.04	2.09	2.09	2.15	2.16	2.03	2.15	2.13	2.09	2.11	2.13	2.12	1.98	2.10
Std Dev	0.107	0.053	0.098	0.026	0.064	0.045	0.01	0.039	0.026	0.026	0.073	0.074	0.041	0.1	0.054	0.050

