Certificate of Analysis

Certified Reference Material: LBMA AuRM3

Trace Elements in High Purity Gold

General information

The London Bullion Market Association (LBMA) promotes quality and good practice in the area of gold and silver refining and trade. The production and sale of the reference materials referred to herein represent part of this effort. In 2009, the LBMA developed sets of gold and silver reference materials (AuRM1 & 2 and AgRM1 & 2). The new reference material, AuRM3, was produced by the Gulidov Krasnoyarsk Non-Ferrous Metals Plant ("Krastsvetmet"), Russia, under the guidance of a Steering Committee. The chosen composition reflects the needs expressed by LBMA accredited refiners.

The following table lists the elements for which certified values have been established with expanded uncertainty ($U_{CRM} = ku_c$, where u_c is the combined standard uncertainty calculated according to the ISO Guide [1] and k=2 is the coverage factor).

Element Concentrations, mg/kg

Ag	4456 ± 95
Cu	317 ± 11
Fe	21.0 ± 2.3
In	15.4 ± 1.2
Ir	6.3 ± 1.8
Ni	13.4 ± 1.0
Pb	23.6 ± 2.2
Pd	25.8 ± 2.5
Pt	25.4 ± 1.6
Sn	12.2 ± 0.7
Ti	7.8 ± 1.3
Zn	12.6 ± 1.5

Manufacture of the reference material

The reference material was produced by melting high-purity gold with master alloys in order to include trace impurities of a number of elements as shown in the table. The target level of each element was agreed upon by the Steering Committee. After casting in a vertical graphite mould designed for rapid cooling, the ingot was rolled to a thickness of 6 mm. The surfaces at the top and bottom faces were removed using a milling machine. The ingot was cut into individual pieces and machined to produce disks of 30 mm diameter and 5 mm thickness with a weight of approximately 66.7 g.

Homogeneity

Samples were cut from the rolled ingot according to a grid pattern. Two sets of nine pieces were selected systematically from the grid pattern which encompassed 3 samples from each of 3 evenly spaced rows of cut pieces. The samples were chosen to cover the edges and the middle of the rolled ingot. Samples were analysed at the top, bottom, and at three intermediate depths for each of the elements in a random order. Concentration data were obtained by two different laboratories: using spark optical emission spectrometry. Results from these tests were evaluated using ANOVA and found to be satisfactory.

Quantitative analysis of trace elements

Shavings from the milling of the disks were acid washed in 50% HCl, rinsed several times with distilled deionised water, and then dried in a clean hood. Portions of the shavings (25 g) of each reference material were distributed to 12 laboratories for analysis. Each participant laboratory was requested to perform their trace elements determination on at least 5 sub samples. All the laboratories determined the trace element concentrations by inductively coupled plasma optical emission spectrometry of the solutions prepared from the shavings.

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Instructions for the storage, handling and correct use of the reference material

Keep the materials in a box to avoid exposure to industrial environment. Metallic dusts or vapour may deposit on the surface. In case of doubt, clean with ethanol, then high-purity water. If not sufficient, it is recommended that possible surface contamination be removed by placing the sample in hot 18 % HCl for approx. 10 minutes, followed by rinsing with high purity water. Once impacts of a spark spectrometer cover the surface, remove about 50 micrometers by milling or polishing.

Hazardous information:

There are no hazards associated with this material.

Intended use

The reference material is intended to be used for the validation of instrumental methods for determining the concentration of trace metallic impurities in gold, such as X-ray fluorescence and optical emission spectrometry, using spark or inductively coupled plasmas (the latter by taking shavings from the materials).

Traceability

The results in this certificate are traceable to the SI through gravimetrically prepared standards of established purity and international measurement intercomparisons.

Date of certification: 21.5.2014

Expiration date of the certificate: 31.12.2024 . This gold reference material and its certified property values are expected to remain unchanged for more than 50 years, but new analytical techniques or instruments with better characteristics of accuracy and precision are likely to appear as laboratory equipment is renewed. Accordingly, analyses may be performed again by some of the laboratories.

Acknowledgements

The following laboratories participated in the analysis of the reference material:

Allgemeine Gold und Silber, Germany	PAMP, Switzerland
Argor Heraeus, Switzerland	Perth Mint, Australia
Aurubis, Germany	Rand Refinery, South Africa
Japan Mint, Japan	Royal Canadian Mint, Canada
Krastsvetmet, Russia	Tanaka Kikinzoku Kogyo, Japan
Metalor Technologies, Switzerland	Umicore Precious Metals Refining, Belgium

For the LBMA:

Stewart Murray, Good Delivery Consultant

Steering Committee members:

Great Wall Gold and Silver Refinery, China Chen Jie	Royal Canadian Mint, Canada Dr. Michael Hinds (Chair)
Metalor Technologies, Switzerland Dr. Jonathan J. Jodry	Tanaka Kikinzoku Kogyo, Japan Nobuyasu Ezawa and Hitoshi Kosai
Rand Refinery Ltd., South Africa Neil Harby and Madeleine Theron	Umicore, Belgium Dr. Dirk Hofmans

References

[1] Guide to Expression of Uncertainty in Measurement, ISBN 92-67-10188-9, 1st ed. ISO, Geneva, Switzerland (1993).

Disclaimer

The LBMA, the Steering Committee, the manufacturer and the laboratories involved in the chemical analysis of the reference material have used their best endeavours to ensure that the reference material is homogeneous in respect of the contained elements and that their concentrations are accurately determined.

However, all assayers will recognize that there can be no absolute guarantees in relation to these parameters. For example, it cannot be ruled out totally that the reference material may contain extraneous inclusions (though such foreign bodies would be readily detected by the using laboratory). In addition, minor deviations from complete homogeneity which are not detected by the homogeneity testing are conceivable.

London, May, 2014