BAM Bundesanstalt für Materialforschung und -prüfung

in co-operation with the Committee of Chemists of the GDMB
Gesellschaft der Metallurgen und Bergleute e.V.

Certified Reference Material

BAM-M384b

Pure Copper

Certified Values

Element	Mass fraction [1] in mg/kg	Uncertainty [2] in mg/kg
Ag	11.3	0.4
As	6.6	1.1
Bi	6.81	0.23
Cd	4.0	0.2
Co	10.4	0.5
Mg	3.3	0.5
Mn	8.1	0.9
Ni	4.7	0.6
Pb	1.6	0.4
Sb	5.8	0.4
Sn	2.1	0.4
Te	7.2	0.7
Ti	2.9	0.6
Zn	2.6	0.5
Zr	1.3	0.4

[1] Unweighted mean value of the means of accepted sets of data (consisting of at least 3 but usually 6 single results), each set being obtained by a different laboratory and/or a different method of measurement. The values are traceable to the SI (Système International d'Unités) via calibration using pure metals or substances of known stoichiometry.

[2] Estimated expanded uncertainty *U* with a coverage factor of *k*=2, corresponding to a level of confidence of approx. 95 %, as defined in the Guide to the expression of uncertainty in measurement, (GUM, ISO/IEC Guide 98-3:2008).

Sample description

The Reference Material is available in the form of discs (38 mm diameter and 30 mm height).

Indicative values

Element	Mass fraction [1] in mg/kg	Uncertainty [2] in mg/kg
Al	2.9	0.8
Cr	2.3	0.6
Fe	5.1	1.2
P	< 2	
S	3.8	1.4
Se	2.9	0.7
Si	< 2.5	

[1] Values were not certified, but given as indicative values, when the number of accepted data sets was considered to be too low (< 5) or when the uncertainty from the inter-laboratory certification was considerably larger than the expected range. The values are traceable to the SI (Système International d'Unités) via calibration using pure metals or substances of known stoichiometry.

[2] Estimated expanded uncertainty *U* with a coverage factor of $k = 2$, as defined in the Guide to the expression of uncertainty in measurement, (GUM, ISO/IEC Guide 98-3:2008).

Informative Value

One laboratory determined oxygen and found 0.15 % mass fraction.

Recommended Use

The CRM is intended for establishing or checking the calibration of optical emission and X-ray spectrometers for the analysis of samples of similar matrix composition. The minimum sample size for wet chemical analysis is 0.5 g.

Instructions for Use

Before use, the surface of the material must be prepared by milling or turning on a lathe. For wet chemical analysis chips have to be prepared by turning or milling of the sample surface.

Participating Laboratories

Allgemeine Gold- und Silberscheideanstalt, Pforzheim, Germany
Aurubis AG, Hamburg, Germany
BAM Bundesanstalt für Materialforschung und -prüfung, Berlin, Germany
Codelco, Chuquicamata, Chile
Diehl Metall Stiftung & Co KG, Röthenbach, Germany
Institut Glörfeld, Willich, Germany
Johannes Gutenberg-Universität Mainz, Institut für Kernchemie, Mainz, Germany
Montanwerke Brixlegg, Brixlegg, Austria
Outokumpu VDM, Werdohl, Germany
Umicore Precious Metals., Hobocken, Belgium
Wieland-Werke AG, Vöhringen, Germany

Means of Accepted Data Sets

Mass fraction in mg/kg

Certified values | Indicative values

Line no.	Ag	As	Bi	Cd	Co	Mg	Mn	Ni	Pb	Sb	Sn	Te	Ti	Zn	Zr	*Al*	*Cr*	Fe	*P*	*S*	*Se*	*Si*
1	10.03	5.49	---	3.73	---	---	---	3.40	1.00	---	1.48	5.98	---	1.38	0.83	*1.00*	*1.24*	*1.98*	*0.04*	*< 1*	*1.20*	*1.00*
2	10.90	5.76	6.59	3.80	---	2.50	6.28	3.54	1.23	5.46	1.78	6.30	2.53	1.50	< 1	*2.22*	*1.47*	*3.41*	*0.10*	*2.97*	*1.71*	*1.70*
3	11.00	6.00	6.67	3.88	9.34	3.00	7.10	4.16	1.37	5.50	1.88	6.44	2.68	1.75	< 1	*2.80*	*1.65*	*4.38*	*0.15*	*3.79*	*2.47*	*3.17*
4	11.06	6.05	6.69	3.89	9.60	3.15	7.25	4.50	1.44	5.57	2.03	6.48	2.82	1.80	1.00	*2.83*	*1.71*	*4.48*	*< 1*	*4.53*	*2.67*	*3.95*
5	11.18	6.60	6.75	3.93	9.87	3.18	7.64	4.65	1.55	5.68	2.17	7.50	2.84	2.41	1.23	*2.88*	*< 2*	*4.50*	*< 1*		*2.87*	
6	11.30	6.69	6.77	3.93	10.10	3.37	7.83	4.81	1.59	5.72	2.27	7.50	3.00	2.67	1.55	*3.46*	*2.17*	*4.98*	*1.65*		*2.91*	
7	11.43	7.00	6.84	3.99	10.58	3.54	8.50	4.95	1.67	5.75	2.28	7.55	3.32	2.91	1.57	*3.83*	*2.87*	*5.05*	*1.68*		*3.31*	
8	11.50	7.28	7.01	4.00	10.67	3.67	8.53	4.96	2.05	5.76	2.36	7.58	3.33	3.00	1.64	*4.18*	*2.99*	*6.48*			*3.65*	
9	11.53	7.30	7.20	4.15	10.83	3.95	8.95	4.97	2.14	6.00	2.50	7.74	---	3.02			*3.07*	*7.45*			*4.25*	
10	11.58	7.45	---	4.15	10.94		9.20	5.00	---	6.00		8.53		3.17			*3.13*	*7.96*			*4.35*	
11	11.72			---	11.20		9.86	5.18		6.04				3.31								
12	12.37				11.28			5.75		6.09												
13																						
M	11.30	6.56	6.81	4.00	10.44	3.29	8.11	4.66	1.56	5.78	2.08	7.16	2.93	2.55	1.30	*2.90*	*2.18*	*5.07*	*< 2*	*3.76*	*2.94*	*1.95*
s_M	0.56	0.71	0.21	0.14	0.68	0.45	1.09	0.68	0.37	0.23	0.33	0.81	0.31	0.66	0.34	*1.00*	*0.78*	*1.81*		*0.79*	*1.02*	*1.11*
$\bar{s}_i$	0.36	0.28	0.42	0.14	0.27	0.32	0.60	0.34	0.33	0.55	0.50	0.42	0.27	0.36	0.17	*0.41*	*0.19*	*0.88*		*0.32*	*0.30*	*0.86*

The laboratory mean values have been examined statistically to eliminate outlying values. Where a " --- " appears in the table it indicates that an outlying value has been omitted (Grubbs 95 %). A data set consists of at least 3 but usually 6 single values of one laboratory.

M : mean of laboratory means

s_M : standard deviation of laboratory means

$\bar{s}_i$: averaged repeatability standard deviation (square root of the mean of laboratory variances)

Note: "< - values" were not included into the calculation of M and s_M

Analytical Method used for Certification

Element	Line no.	Method
Ag	1, 5	GD-MS
	2, 7	INAA
	3, 4, 8, 9, 10, 11, 12	ICP-OES
	6	ICP-MS
As	1, 2	GD-MS
	3, 5, 6, 8, 9, 10	ICP-OES
	4	ICP-MS
	7	ET AAS
Bi	2, 8	GD-MS
	3, 4	ET AAS
	5, 6, 9	ICP-OES
	7	ICP-MS
Cd	1, 2, 3, 4, 5, 7, 8, 9	ICP-OES
	6	ICP-MS
	10	GD-MS
Co	3, 4, 5, 6, 8, 12	ICP-OES
	7	INAA
	9, 10	GD-MS
	11	ICP-MS
Fe	1, 2, 3, 4, 5, 6, 7	ICP-OES
	8	GD-MS
	9	ICP-MS
	10	INAA
Mg	2, 3, 4, 6, 7, 8	ICP-OES
	5	GD-MS
	9	ICP-MS
Mn	2, 3, 4, 5, 6, 7, 11	ICP-OES
	8, 9	GD-MS
	10	ICP-MS
Ni	2	ET AAS
	3, 4, 5, 7, 9, 10, 11, 12	ICP-OES
	1, 6	GD-MS
	8	ICP-MS
Pb	1, 2, 8, 9	ICP-OES
	4, 7	ET AAS
	5	ICP-MS
	3, 6	GD-MS

Element	Line no.	Method
Sb	2, 3, 7, 9, 10	ICP-OES
	3, 4	INAA
	5, 11	GD-MS
	7	ICP-MS
	12	ET AAS
Sn	1, 7	GD-MS
	2, 3, 4, 6, 8	ICP-OES
	5	ICP-MS
	9	ET AAS
Te	1, 7	GD-MS
	2, 4, 6	ICP-OES
	3	INAA
	5	ICP-MS
	8, 9	ET AAS
Ti	2, 3, 5, 6, 8	ICP-OES
	4, 7	GD-MS
Zn	1, 3, 4, 5, 10, 11	ICP-OES
	2	FAAS
	6	INAA
	7, 8	GD-MS
	9	ICP-MS
Zr	1, 2, 3, 4, 8	ICP-OES
	5, 6	GD-MS
	7	ICP-MS
Al	*1, 2, 3, 4, 5*	*ICP-OES*
	6, 7	*GD-MS*
	8	*ICP-MS*
Cr	*1, 2, 3, 4, 5, 6*	*ICP-OES*
	7, 9	*GD-MS*
	8	*INAA*
	10	*ICP-MS*
P	*1, 2*	*GD-MS*
	3	*ETV-ICP-OES*
	4, 5	*ICP-OES*
	6, 7	*Spectrophotometry*
S	*1, 3*	*ICP-OES*
	2	*GD-MS*
	4	*Combustion/iodometric titration*
Se	*1, 2, 3, 4, 9, 10*	*ICP-OES*
	5	*ET AAS*
	6, 8	*GD-MS*
	7	*INAA*
Si	*1, 3, 4*	*ICP-OES*
	2	*GD-MS*

Abbreviations: ET AAS – Electrothermal atomic absorption spectrometry
ETV-ICP-OES – Inductively coupled plasma - optical emission spectrometry plasma after electrothermal vaporisation
FAAS – Flame atomic absorption spectrometry
GD-MS – Glow discharge mass spectrometry
ICP-MS – Mass spectrometry with inductively coupled plasma
ICP-OES – Inductively coupled plasma - optical emission spectrometry
INAA – Instrumental neutron activation analysis

Transport and Storage

The material should be stored in a dry and clean environment at room temperature (approx. 20 °C). Transport under normal ambient conditions.

Technical Report

A detailed technical report describing the analysis procedures and the treatment of the analytical data used to certify BAM-M384b is available on request or can be downloaded from BAM website (www.bam.de/en/fachthemen/referenzmaterialien/index.htm).

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