National Institute of Standards & Technology

Report of Investigation

Reference Material 8605 Molybdenum Ore GBW 07238

Hubei Geological Research Laboratory

This Reference Material (RM) is a molybdenum ore mined from a skarn molybdenum deposit, then prepared and certified by the Hubei Geological Research Laboratory (HGRL) in China which is the sole authority for the information provided in this report including reference values and other technical information [1]. It is intended for use in geological and geochemical investigations, particularly in geochemical exploration programs and in studies of ore genesis, and for environmental monitoring in mining areas. Each unit of this RM consists of 100 g of ore pulverized to pass a 100 µm screen (-160 mesh).

Material Collection and Preparation: More than 350 kg of material were collected from the molybdenum skarn deposit of the Shandoazhuang ore district in Luanchuan County, Honan Province. The ore was first broken into particles of 3 cm to 5 cm size and then reduced to less than 0.83 mm size in a jaw crusher. The material was passed by a magnet to remove any iron chips, then ground to less than 0.097 mm powder in a disk pulverizer. Approximately 350 kg of the final powder, of which 99.5 % passed a 100 µm screen (-160 mesh), was blended for 10 h. Grab samples were taken for homogeneity testing by x-ray fluorescence spectrometry, and the powder was bottled in either 50 g or 100 g containers.

Analysis: The Laboratory of the Research Institute of the Ministry of Geology and Mineral Resources, its subsidiary laboratories in 12 provinces, the Department of the Nuclear Power Industry, and the Chinese Academy of Sciences collaborated in providing certification analyses for the material. Most constituents were determined by three or more independent methods of analysis. These included classical chemical methods, polarography, UV-spectrophotometry, x-ray fluorescence, inductively coupled plasma atomic emission, inductively coupled plasma mass spectrometric methods, atomic absorption spectrometry, and other methods. Reference concentration values derived from the total data set by HGRL are given in Table 1. Methods of analysis by element are given in Table 2.

Mineral Composition: In addition to chemical analyses, mineral composition was determined by heavy mineral separations, polished thin section, and polarizing microscopy at HGRL. The major ore minerals in RM 8605 are molybdenite, scheelite, chalcopyrite, pyrite, and marcasite. Major gangue minerals are garnet, diopside, vesuvianite, calcite, quartz, potash feldspar, oligoclase, and fluorite.

The material preparation and technical measurements were performed by the Hubei Geological Research Laboratory, Hubei Province, China.

The support aspects involved in the original issuance of this RM were coordinated through the NIST Standard Reference Materials Program by J.S. Kane. Revision of this report was coordinated through the NIST Standard Reference Materials Program by B.S. MacDonald.

This Report of Investigation has undergone editorial revision to reflect program and editorial changes at NIST and the Department of Commerce. No attempt was made to reevaluate the reported values or any technical data.

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Table 1. HGRL Reference Concentration Values[a,b]
(All analyses are based on samples dried 2 h at 105 °C)

Element	Mass Fraction (%)	Gangue Constituents	Mass Fraction (%)
Mo	1.51 ± 0.02	Al_2O_3	3.46 ± 0.14
S	1.64 ± 0.03	CaO	31.44 ± 0.28
W	0.36 ± 0.02	CO_2	(0.93)
		FeO	(2.65)
		Fe_2O_3(T)	21.34 ± 0.21
		H_2O^+	(0.23)
		K_2O	0.046 ± 0.011
		MgO	0.86 ± 0.03
		MnO	1.40 ± 0.05
		Na_2O	0.075 ± 0.031
		P_2O_5	(0.13)
		SiO_2	34.10 ± 0.17
		TiO_2	0.13 ± 0.01
		F	4.08 ± 0.13

Element	Mass Fraction (mg/kg)	Element	Mass Fraction (mg/kg)
Ag	0.09 ± 0.04	Nd	11.3 ± 1.6
As	1.6 ± 0.3	Ni	17.8 ± 1.1
Bi	2.2 ± 0.3	Pb	18.7 ± 1.9
Cd	0.12 ± 0.03	Pr	3.0 ± 0.3
Ce	20.8 ± 1.4	Re	(0.35)
Co	11.8 ± 0.9	Sb	1.2 ± 0.2
Cr	(24)	Sc	3.4 ± 0.3
Cu	93.6 ± 5.2	Se	2.1 ± 0.2
Dy	1.8 ± 0.2	Sm	2.1 ± 0.3
Er	1.0 ± 0.2	Sn	86.7 ± 3.6
Eu	0.59 ± 0.07	Tb	0.34 ± 0.03
Ga	25.1 ± 1.2	Te	0.40 ± 0.13
Gd	1.9 ± 0.3	Th	2.3 ± 0.6
Ge	19.0 ± 0.8	Tl	0.06 ± 0.03
Ho	0.36 ± 0.05	Tm	0.14 ± 0.03
In	2.9 ± 0.1	Y	11.4 ± 1.1
La	7.1 ± 0.4	Yb	1.0 ± 0.1
Li	(3.2)	Zn	65.5 ± 5.0
Lu	0.16 ± 0.03		

[a] Uncertainties are expressed as the 95 % confidence interval of the referenceconcentration value.
[b] Values in parentheses ( ) are given for information only.

Table 2. Methods of Analysis for Individual Elements

Element	Analytical Method	Element	Analytical Method
Ag	AAS, AAN, ES, ICP-AES, NAA	Al_2O_3	COL, NAA, VOL, XRF
As	AF, COL, ICP-AES, NAA, VOL	Ba	NAA
Bi	AAS, AF, COL, ES, ICP-AES, POL	CaO	AAS, NAA, VOL, XRF
Cd	AAS, AAN, ICP-AES, POL	Ce	ICP-AES, ICP-MS, NAA
Co	AAS, AAN, COL, ICP-AES, NAA, POL	Cr	AAS, COL, NAA
Cs	NAA	Cu	AAS, COL, ICP-AES, NAA, POL, VOL, XRF
Dy	ICP-AES, ICP-MS, NAA	Er	ICP-AES, ICP-MS
Eu	ICP-AES, ICP-MS, NAA	F	COL, ISE
Fe_2O_3(T)	AAS, COL, NAAA, VOL, XRF	Ga	AAN, COL, ICP-AES, POL
Gd	ICP-AES, ICP-MS, NAA	Ge	COL, POL
Ho	ICP-AES, ICP-MS, NAA	In	AAN, COL, POL
K_2O	AAS, AES, FP, NAA, XRF	La	ICP-AES, ICP-MS, NAA
Li	AAS, AES	Lu	ICP-AES, ICP-MS
MgO	AAS, NAA VOL, XRF	MnO	AAS, COL, ICP-AES, NAA, VOL, XRF
Mo	COL, ICP-AES, NAA, POL, XRF	Na_2O	AAS, AES, FP, NAA, XRF
Nd	ICP-AES, ICP-MS, NAA	Ni	AAS, AAN, ICP-AES, NAA, POL
P_2O_5	COL, XRF	Pb	AAS, AAN, ES, ICP-AES, POL, VOL, XRF
Pr	ICP-AES, ICP-MS	Rb	AAS, NAA
Re	COL, ICP-AES, POL	S	GR, ICP-AES, VOL
Sb	AF, ICP-AES, NAA	Sc	ICP-AES, NAA
Se	AAN, AF, COL, ICP-AES, NAA, POL	SiO_2	COL, GR, ICP-AES, VOL, XRF
Sm	ICP-AES, ICP-MS, NAA	Sn	AAH, COL, ES, POL
Tb	ICP-AES, ICP-MS, NAA	Te	AAN, AF, COL, ICP-AES, POL
Th	COL, ICP-AES, NAA	TiO_2	COL, ICP-AES, NAA, XRF
Tl	AAN, COL, POL	Tm	ICP-AES, ICP-MS, NAA
W	COL, ICP-AES, NAA, POL, XRF	Y	ICA-AES, ICP-MS
Yb	ICP-AES, ICP-MS, NAA	Zn	AAS, ICP-AES, NX POL, VOL, XRF

Method Abbreviations:

AAS	Atomic Absorption Spectrometry-Flame
AAN	Atomic Absorption Spectrometry-Graphite Furnace
AAH	Atomic Absorption Spectrometry-Hydride Generation
AF	Atomic Fluorescence Spectrometry
COL	Colorimetry
ES	Emission Spectrometry
FP	Flame Photometry
GR	Gravimetry
ICP-AES	Inductively Coupled Plasma-Atomic Emission Spectrometry
ICP-MS	Inductively Coupled Plasma-Mass Spectrometry
ISE	Ion Selective Electrode
NAA	Neutron Activation Analysis
POL	Polarography
XRF	X-Ray Fluorescence Spectrometry
VOL	Volumetric Analysis

REFERENCE

[1] May, W.E., Gills, T.E., Parris, R., Beck, II, C., Fassett, J.D., Gettings, R.J., Greenberg, R.D., Guenther, F.R., Kramer, G.W., MacDonald, B.S., and Wise, S.A., "Definitions of Terms and Modes Used at NIST for Value-Assignment of Reference Materials for Chemical Measurements," NIST Special Publication 260-136, (1999).

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