YECORAITE $Fe_3Bi_5(TeO_3)(TeO_4)_2O_9$, nH_2O

A NEW MINERAL FROM SONORA, MEXICO

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RESUMEN

Este nuevo mineral se localizó en la mina de San Martín de Porres, cerca de Yecora, Sonora. Ocurre junto con óxidos de hierro y calcopirita, tetradimita y pirita en vetas de cuarzo. Análisis químico clásico y por microsonda indican - As_2O_5 0.96, Fe_2O_3 10.45, TeO_2 7.65, TeO_3 16.83, Bi_2O_3 55.37, H_2O 8.06, total 99.32%, que corresponde a la fórmula $Fe_3Bi_5(TeO_3)(TeO_4)_2O_9 \cdot nH_2O$ (aprox. 9). El registro de difracción sugiere simetria alta, siendo las tres líneas más intensas - 5.45(4), 3.212(7) y 2.743(10). El color es naranja a amarillo, H 3, G 5.59, brillo resinoso. Yecoraite es uniaxica positiva, ω 1.812 y ε 1.824. El nuevo mineral y su nombre han - sido aprobados por la Comisión de Nuevos Minerales y Nombres Minerales de la International Mineralogical Association.

ABSTRACT

This new mineral was found at the San Martin de Porres mine, very near Yecora, Sonora. It occurs with iron oxides - and chalcopyrite, tetradymite and pyrite in vein quartz. Classical chemical analysis and electron microprobe analysis gave: As_2O_5 0.96, Fe_2O_3 10.45; TeO_2 7.65; TeO_3 16.83; Bi_2O_3 55.37;- H_2O 8.06; total 99.32%; this leads to $Fe_3Bi_5(TeO_3)(TeO_4)_2O_9 \cdot nH_2O$ (n about 9). The diffraction powder pattern suggests - high symmetry and the three strongest lines are: 5.45 (4), - 3.212 (7), 2.743 (10). The color is orange to yellow, H = 3, G = 5.59, luster pitchy. Yecoraite is uniaxial positive with

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ω = 1.812 and ε = 1.824.

The new mineral and name have been approved by the Commission on New Minerals and Mineral Names of the IMA.

OCCURENCE

Samples of the mineral were first provided by Rudy Coronado, late of Moctezuma, Sonora. He reported that the mine is a quartz vein deposit in granitic rocks very close to the main highway just West of Yecora, Sonora.

Thin sections of ore show coarse sodic plagioclase, - microcline and muscovite, floating in an abundance of equally coarse quartz. Textures indicate that quartz veins carrying ores are of late magmatic age, developing in fractures zones in a quartz monzonite host as it cooled.

The sulfides in the vein matter are very coarse grained, including cubes of pyrite 10-15 mm in size and later equally coarse chalcopyrite and tetradymite. Sphalerite is rela- -- tively rare.

Oxidation begins with films of covellite developing on pyrite and chalcopyrite, followed by simple leaching of all sulfides. The result is a porous boxworks with voids filmed by goethite and little else. Yecoraite joins goethite in - - samples where tetradymite was abundant and was seldom seen in

specimens without some relict tetradymite in them.

Two other tellurites/tellurates of Bi and Fe were found in addition to yecoraite but both in quantities far too small to characterize. By contrast, yecoraite is quite abundant for a new mineral

During the study, Richard V. Gaines kindly provided ore samples and concentrates from the same locality. His gravity concentrate consisted largely of yecoraite and tetradymite -- but was unfortunately contaminated with thallium (Clerici solution) and could not be used for chemical analysis. Dr. Gaines also provided a specimen of montanite (with a Genth's label) to use for comparison purposes.

PHYSICAL PROPERTIES

Yecoraite occurs as pitchy or resinous masses attached to or mantling tetradymite, even invading it along cleavage surfaces. The masses sometimes have smooth surfaces, sometimes have highly irregular or pitted, cavernous surfaces.

The purest material is orange to yellow and "chinese yellow" (RHS 20B/20C) is typical. The color inclines to dull browns with some admixture of goethite. No crystals were -- found and masses exhibit conchoidal fracture.

The Mohs hardness is 3 and the specific gravity determined by Berman balance is 5.59 $\pm$ .11, averaged from three

trials in toluene using a 7.80 mg sample. No fluorescence is visible with long or short ultra-violet wavelengths.

CHEMISTRY

Early attempts at analysis by wet methods were - - - hampered by lack of pure material and difficulties in con-- trolling the oxidation state in solutions. The wet method did show Te^{+4}/Te^{+6} equals 1/2 using the HBr method.

Analyses were performed with an electron microprobe, using pure Fe, As, Bi and Te as standards. In the following results (average of 20 analyses), iron was considered as -- Fe_2O_3 and tellurium (18.55%) was separated in TeO_2 and TeO_3 according to the Te^{+4}/Te^{+6} ratio given by wet method. Water was determined in closed tube as 8.06 $\pm$ 0.72% (using samples of 1-1.5 mg) based on three trials.

	1	2		3
As_2O_5	0.96			
Fe_2O_3	10.45	11.53	Fe^{+3}	2.73
Bi_2O_3	55.37	56.08	Bi^{+3}	4.96
TeO_2	7.65	7.68	Te^{+4}	1
TeO_3	16.83	16.91	Te^{+6}	2
H_2O	8.06	7.80	H_2	9.33
	99.32	100.00		

1 - Observed composition. Analysts: M. Duggan and R. Giraud.

2 - Theoretical composition for $Fe_3Bi_5(TeO_3)(TeO_4)_2O_9 \cdot 9H_2O$.

3 - Molecular ratios.

The mineral fuses easily to a red glass and begins to evolve TeO_2 shortly after the loss of water. It is readily soluble in cold 16% HCl or 10% HNO_3.

We were concerned about the relation of yecoraite to montanite at the onset of this study. Montanite (as provided by R. Gaines) closely resembles it physically and optically, and shows the same easy solubility in cold acids. Wet chemical analysis of a large pure sample (1.257 mg; analyst: M. Duggan) gave Bi_2O_3 67.0%; TeO_3 23.5%; H_2O 5.86% (balance is SiO_2), verifying the formula $Bi_2TeO_6 \cdot 2H_2O$. The specific gravity is - also distinctly higher: 6.2 ± 0.15.

OPTICAL PROPERTIES

Optical examination of yecoraite reveals that it is fibrous, the fibers being length slow and showing parallel - extinction; these seldom exceed 5 microns in length and are typically matted in a disorganized fashion so that even fiber-axis X-ray study was ruled out.

The indices of refraction (white light) are $\omega = 1.812$

and $\varepsilon = 1.824$, and the fibers are presumed to be uniaxial positive.

X-RAY STUDY

The X-ray powder pattern is very simple and the data are shown together with those of montanite in the following table. Lines are broad or diffuse due to the minute grain size of both minerals used for this study.

Montanite		Yecoraite	
d	I/I	d	I/I
3.513	10	5.45	4
3.206	3	3.722	4
2.952	1	3.212	7
2.800	3	2.962	4
2.605	5	2.743	10
2.380	1/2	1.940	3
2.172	1/2	1.625	3
2.088	1		
2.028	1		
1.906	4		
1.724	2b		
1.630	1/2		
1.503	1b		

(radiation Cr K α , 114 mm diameter camera)

Because neither mineral offers hope of single crystals to study, efforts were made to index the patterns by the Ito method. Cells for both were easily found, either tetragonal or hexagonal, simply because the patterns offer few lines, - hence many solutions. In the case of yecoraite however, no

cell could be found that matches the density and mole weight. The correct cell must be very large, with stringent extinction rules.

ADDENDA AND ACKNOWLEDGEMENTS

About a dozen specimens comprising some tens of milligrams are known and a type specimen has been provided to the British Museum (Natural History). The sample used for the microprobe analysis is kept in the mineralogical colection of the Paris School of Mines.

We are grateful to Sr. R. Coronado and to Dr. R. Gaines for obtaining specimens used in this study. We thank Marjorie Duggan for her help in the difficult analytical process in the early stages of the study and Roger Giraud for the microprobe analysis.