

MAZZETTIITE, $\text{Ag}_3\text{HgPbSbTe}_5$, A NEW MINERAL SPECIES FROM FINDLEY GULCH, SAGUACHE COUNTY, COLORADO, USA

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ABSTRACT

Mazzettiite, ideally $\text{Ag}_3\text{HgPbSbTe}_5$, is a new mineral species from Findley Gulch, Saguache County, Colorado. It occurs as anhedral to subhedral grains up to 200 μm across, closely associated with altaite together with galena in a gangue of quartz. Mazzettiite is opaque with a metallic luster and a black streak. It is brittle; the Vickers hardness (VHN_{25}) is 101 kg/mm^2 (range: 96–106) (Mohs hardness of $\sim 3\text{--}3\frac{1}{2}$). The density could not be measured because of the small grain-size [density (calc.) = 9.04 g/cm^3]. In reflected light, mazzettiite is light grey, weakly to moderately birefractant, and weakly pleochroic from slightly greenish grey to a slightly darker bluish grey. Under crossed polars, it is moderately anisotropic, without characteristic rotation-tints. Internal reflections are absent. Reflectance percentages in the range 400–700 nm are tabulated, with values for the four COM wavelengths interpolated. The values for R_{\min} and R_{\max} are 45.6, 46.1% (470 nm), 46.1, 46.6% (546 nm), 46.3, 47.0% (589 nm), and 46.4, 47.1% (650 nm), respectively. The unit-cell parameters of mazzettiite were derived by comparison with petrovicite, $\text{Cu}_3\text{HgPbBiSe}_5$, to which it shows strong similarities, both from a chemical and a structural point of view. Mazzettiite is orthorhombic, space group $Pna2_1$ or $Pnam$, with a 16.495(6), b 14.762(7), c 4.506(2) Å, $V = 1097.2(8)$ Å³, $Z = 4$. The strongest seven powder-diffraction lines [d in Å (I/I_0)(hkl)] are: 3.65(60)(330), 3.26(50)(131), 3.17(60)(430), 3.01(100)(520), 2.754(60)(440), 2.137(50)(122), and 1.806(55)(561). A mean of 20 electron-microprobe analyses gave Ag 21.6(3), Hg 13.6(2), Pb 14.1(3), Sb 8.1(1), Te 42.7(3), total 100.1 wt.%, corresponding, on the basis of a total of 11 atoms, to $\text{Ag}_{2.99}\text{Hg}_{1.01}\text{Pb}_{1.02}\text{Sb}_{0.99}\text{Te}_{4.99}$. Requirements of the ideal formula are: Ag 21.70, Hg 13.45, Pb 13.90, Sb 8.16, Te 42.79. The new mineral and mineral name have been approved by the IMA Commission on New Minerals and Mineral Names (2004–03). It is named after Giuseppe Mazzetti, curator-in-chief of the Mineralogy Section of the Museo di Storia Naturale, Università di Firenze.

Keywords: mazzettiite, new mineral species, telluride, Findley Gulch, Colorado.

SOMMAIRE

La mazzettiite, de formule idéale $\text{Ag}_3\text{HgPbSbTe}_5$, est une nouvelle espèce minérale provenant de Findley Gulch, comté de Saguache, au Colorado. Elle se présente en grains xénomorphes à subidiomorphes atteignant 200 μm de diamètre, étroitement associée à l'altaïte et à la galène dans une gangue de quartz. La mazzettiite est opaque, avec un éclat métallique et une rayure noire. Elle est cassante; la dureté de Vickers (VHN_{25}) est 101 kg/mm^2 (intervalle: 96–106), ce qui correspond à une dureté de Mohs d'environ 3 ou $3\frac{1}{2}$. A cause de la taille des grains, la densité n'a pas pu être mesurée [densité (calc.) = 9.04 g/cm^3]. En lumière réfléchie, la mazzettiite est gris pâle, faiblement à modérément biréfléchante, et faiblement pléochroïque de gris verdâtre pâle à gris bleuâtre légèrement plus foncé. En lumière polarisée, le minéral est légèrement anisotrope, sans teintes de rotation caractéristiques. Aucune réflexion interne n'est manifestée. Les valeurs de réflectance ont été établies dans l'intervalle 400–700 nm, et les valeurs de R_{\min} et R_{\max} aux quatre longueurs d'onde standards (COM) ont été interpolées: 45.6, 46.1% (470 nm), 46.1, 46.6% (546 nm), 46.3, 47.0% (589 nm), et 46.4, 47.1% (650 nm), respectivement. Les paramètres réticulaires de la mazzettiite ont été dérivés par comparaison avec la petrovicite, $\text{Cu}_3\text{HgPbBiSe}_5$, à laquelle elle manifeste de fortes ressemblances, tant du point de vue chimique que structural. La mazzettiite est orthorhombique, groupe spatial $Pna2_1$ ou $Pnam$, a 16.495(6), b 14.762(7), c 4.506(2) Å, $V = 1097.2(8)$ Å³, $Z = 4$. Les sept raies les plus intenses du spectre de diffraction (méthode des poudres) [d en Å (I/I_0)(hkl)] sont: 3.65(60)(330), 3.26(50)(131), 3.17(60)(430), 3.01(100)(520), 2.754(60)(440), 2.137(50)(122), et 1.806(55)(561). Vingt analyses à la microsonde électronique ont donné, en moyenne, Ag 21.6(3), Hg 13.6(2), Pb 14.1(3), Sb 8.1(1), Te 42.7(3), pour un total de 100.1% (poids), ce qui correspond, sur une base de onze atomes, à $\text{Ag}_{2.99}\text{Hg}_{1.01}\text{Pb}_{1.02}\text{Sb}_{0.99}\text{Te}_{4.99}$. La formule idéale requiert Ag 21.70, Hg 13.45, Pb 13.90, Sb 8.16, Te 42.79%. La nouvelle espèce et son nom ont été approuvés par la Commission des Minéraux Nouveaux et des Noms de Minéraux de l'IMA (2004–03). Le nom choisi honore Giuseppe Mazzetti, conservateur-en-chef de la section de minéralogie du Museo di Storia Naturale, Università di Firenze.

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Mots-clés: mazzettiite, nouvelle espèce minérale, tellurure, Findley Gulch, Colorado.

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INTRODUCTION

Mazzettiite, $\text{Ag}_3\text{HgPbSbTe}_5$, was discovered in a sample from the Mineralogical Collection of the Institut royal des Sciences naturelles de Belgique, Bruxelles (Belgium), kindly provided by Michel Deliens, where it had been misidentified as empressite (AgTe). The rock sample containing the new species was bought by the Institut royal des Sciences naturelles de Belgique from Georges Vanacker, a French mineral collector, in 1991. The specimen was labeled "empressite, Findley Gulch, Colorado". Findley Gulch forms part of the Bonanza mining district, Saguache County, Colorado, USA, at the extreme eastern end of the San Juan Mountains, south of Poncha Pass, 20 km from the Empress Josephine mine. Geological and metallogenetic data concerning this mining district were first reported by Burbank (1932). More recently, several works dealing with the geological characterization of the Bonanza mining district have been published (Lipman *et al.* 1970, Bruns *et al.* 1971, Varga & Smith 1984, Cande & Kent 1995).

We have named the new mineral *mazzettiite* in honor of Giuseppe Mazzetti (1942–2003), curator in chief of the Mineralogy Section of the Museo di Storia Naturale, Università di Firenze. His research included both experimental and systematic mineralogy, as well as the reconstruction of the history of our collections. Type material is housed in the mineralogical collection of the Museo di Storia Naturale, Università di Firenze, under

catalogue number 2951/I. Cotype material is deposited in the Mineralogical Collection of the Institut royal des Sciences naturelles de Belgique, under catalogue number V/876. The new mineral and mineral name have been approved by the IMA Commission on New Minerals and Mineral Names (2004–03).

OCCURRENCE AND PHYSICAL PROPERTIES

Mazzettiite occurs as anhedral to subhedral grains up to 200 μm in length associated with coarse crystals of altaite (Fig. 1). The grains exhibit a subhedral to anhedral morphology, and are without inclusions or intergrowths with other minerals. Contacts between mazzettiite and altaite are usually sharp (Fig. 1). Other minerals spatially associated with mazzettiite are galena and quartz.

Mazzettiite is opaque with a metallic luster and shows a black streak. It is brittle and devoid of cleavage. Unfortunately, the density could not be measured because of the small grain-size [density (calc.) = 9.04 g/cm^3]. The micro-indentation measurements carried out with a VHN load of 25 g gave a mean value of 101 kg/mm^2 (range: 96–106), corresponding to a Mohs hardness of about 3 or 3½.

In plane-polarized reflected light, mazzettiite is light grey, weakly to moderately bireflectant and weakly pleochroic from slightly greenish grey to a slightly darker bluish grey. Between crossed polars, the mineral is moderately anisotropic, without characteristic rota-

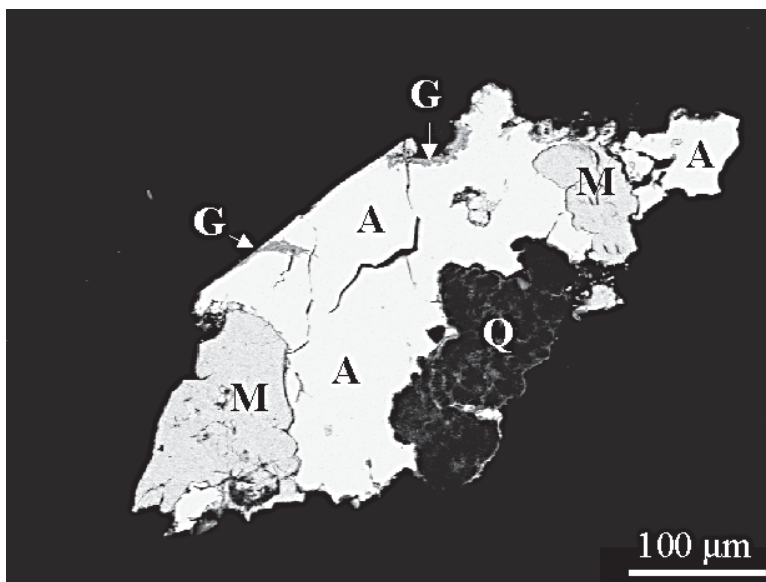


FIG. 1. Back-scattered electron photograph (SEM) of mazzettiite (M), associated with altaite (A), galena (G) and quartz (Q).

tion-tints. Internal reflections are absent. No evidence of growth zonation or twinning was observed. Mazzettiite has a much lower reflectance than altaite.

Reflectance measurements were performed in air by means of a MPM-200 Zeiss microphotometer equipped with a MSP-20 system processor on a Zeiss Axioplan ore microscope. Filament temperature was approximately 3350 K. Readings were taken for specimen and standard (SiC) maintained under the same focus conditions. The diameter of the measurement area was 0.1 mm. Reflectance values for R_{\min} and R_{\max} , in the range 400–700 nm with a step of 20 nm, are reported in Table 1. In Figure 2, the reflectance values obtained for mazzettiite have been plotted together with those measured by Johan *et al.* (1976) for petrovicite, $\text{Cu}_3\text{HgPbBiSe}_5$, an isotypic mineral (see below).

CHEMICAL COMPOSITION

A preliminary chemical analysis using a scanning electron microscope equipped with energy-dispersion spectrometry, performed on the same fragment as used for the X-ray study, did not indicate the presence of elements ($Z > 9$) other than Pb, Ag, Hg, Sb and Te. The chemical composition was then determined using wavelength-dispersion spectrometry (WDS) by means of a JEOL JXA-8600 electron microprobe. Major and minor elements were determined at an accelerating voltage of 20 kV and a beam current of 40 nA, with 30 s counting time. For the WDS analyses, the following lines were used: $\text{PbM}\alpha$, $\text{AgL}\alpha$, $\text{HgM}\beta$, $\text{SbL}\beta$, $\text{TeL}\alpha$. The

estimated analytical precision (in wt.%) is: ± 0.30 for Pb, Ag and Te, ± 0.20 for Hg, and ± 0.10 for Sb. The following standards were employed: galena (Pb), pure Ag (Ag), synthetic Sb_2Te_3 (Sb, Te) and cinnabar (Hg). The crystal fragment was found to be homogeneous within analytical error. The average chemical composition (20 analyses on different spots of the same grain), together with ranges of concentration of elements, is reported in Table 2. On the basis of 11 atoms, the empirical formula of mazzettiite is $\text{Ag}_{2.99}\text{Hg}_{1.01}\text{Pb}_{1.02}\text{Sb}_{0.99}\text{Te}_{4.99}$, ideally $\text{Ag}_3\text{HgPbSbTe}_5$. The ideal formula requirements are: Ag 21.70, Hg 13.45, Pb 13.90, Sb 8.16, Te 42.79 wt.%.

TABLE 1. REFLECTANCE OF MAZZETTIITE MEASURED IN AIR

λ (nm)	R_{\min} (%)	R_{\max} (%)	λ (nm)	R_{\min} (%)	R_{\max} (%)
400	45.1	45.4	560	46.2	46.6
420	45.2	45.7	580	46.3	47.0
440	45.4	45.9	589	46.3	47.0
460	45.6	46.1	600	46.4	47.0
470	45.6	46.1	620	46.4	47.1
480	45.9	46.3	640	46.5	47.2
500	45.9	46.4	650	46.4	47.1
520	46.0	46.4	660	46.3	47.0
540	46.0	46.5	680	46.2	46.9
546	46.1	46.6	700	46.0	46.8

The four COM wavelengths at 470, 546, 589 and 650 nm (in bold) were calculated by interpolation.

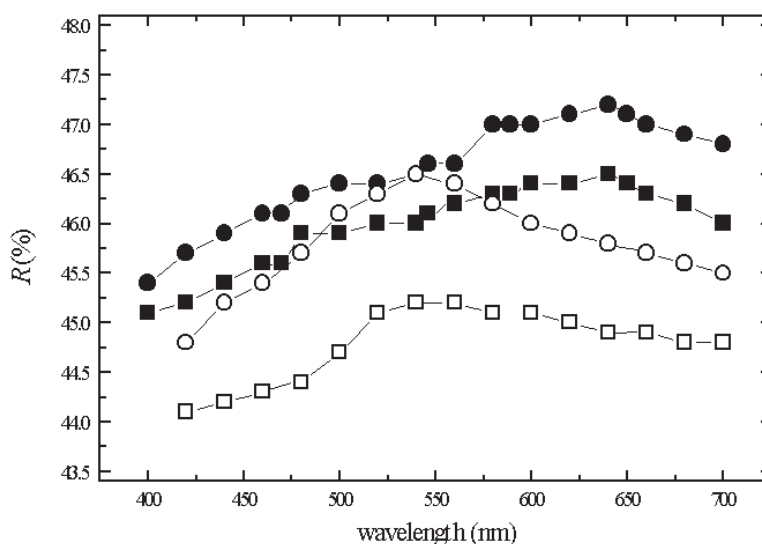


FIG. 2. Reflectivity curves for mazzettiite in air. Open symbols refer to petrovicite (Johan *et al.* 1976), filled symbols refer to mazzettiite (this study). Circles and squares refer to R_{\max} and R_{\min} values, respectively.

TABLE 2. CHEMICAL COMPOSITION OF MAZZETTIITE

	wt%	range	at. %	atom ratio
Pb	14.12	13.59 – 14.27	6.82	1.02
Ag	21.60	21.41 – 21.90	20.02	2.99
Hg	13.58	13.32 – 13.65	6.77	1.01
Sb	8.07	8.00 – 8.31	6.63	0.99
Te	42.68	42.56 – 42.97	33.45	4.99
Total	100.05			

X-RAY CRYSTALLOGRAPHY

Three fragments, dug out of a polished section, were checked by rotation and Weissenberg film techniques and with a Nonius CAD4 four-circle diffractometer. The fragments gave extremely broad X-ray-diffraction profiles, thus indicating the powder-diffraction approach as the only possible means of X-ray investigation. Fully indexed X-ray powder data (Ni-filtered $\text{CuK}\alpha$) obtained with a 114.6 mm Gandolfi camera are presented in Table 3. The intensities were measured with an automated densitometer. The unit-cell parameters were derived by means of the program TREOR (Werner *et al.* 1985) and by comparison with the mineral petrovicite, $\text{Cu}_3\text{HgPbBiSe}_5$ (Johan *et al.* 1976), which shows strong similarities with mazzettiite, both from a chemical and a crystallographic point of view. Mazzettiite is orthorhombic, with the following refined unit-cell parameters, based on 36 reflections between 5.50 and 1.562 Å: a 16.495(6), b 14.762(7), c 4.506(2) Å, $V = 1097.2(8)$ Å³, $Z = 4$ and $a : b : c = 1.1174 : 1 : 0.3052$. Systematic absences noted in the observed reflections ($0kl: k + l = 2n$; $h0l: h = 2n$; $h00: h = 2n$; $0k0: k = 2n$; $00l: l = 2n$) are consistent with the space groups $Pna2_1$ and $Pnma$ (as standard).

CONCLUSIONS

As already outlined, the strong similarities between mazzettiite, $\text{Ag}_3\text{HgPbSbTe}_5$, and petrovicite, $\text{Cu}_3\text{HgPbBiSe}_5$ (Johan *et al.* 1976), led us to suppose that mazzettiite is the Ag–Sb–Te-dominant analogue of petrovicite. The two minerals show a very similar powder-diffraction pattern and, consequently, very similar unit-cell parameters [*i.e.*, a 16.176(5), b 14.684(5), c 4.331(3) Å, $V = 1028.7(8)$ Å³, $Z = 4$, for petrovicite (Johan *et al.* 1976)].

One of the difficulties encountered with the description of such a complex metallic mineral, for which a complete crystal-structure characterization is not possible because of small size of crystals, complex twinning and intergrowths, is the valence state of the elements. On the basis of the formula $\text{Ag}_3\text{HgPbSbTe}_5$ for mazzettiite, the formal charge balance is assumed

TABLE 3. X-RAY POWDER-DIFFRACTION PATTERN FOR MAZZETTIITE

hkl	d_{meas}	d_{calc}	hkl	hkl	d_{meas}	d_{calc}	hkl	hkl
15	5.50	5.500	2 2 0	30	2.254	2.253	0 0 2	
30	4.41	4.409	3 2 0	5	2.174	2.173	2 0 2	
15	4.12	4.124	4 0 0	15	2.158	2.155	0 2 2	
60	3.65	3.667	3 3 0	50	2.137	2.137	1 2 2	
40	3.60	3.600	4 2 0	15	2.085	2.089	2 6 1	
20	3.38	3.369	2 4 0	35	2.060	2.062	8 0 0	
50	3.26	3.258	1 3 1	20	2.012	2.012	6 5 0	
60	3.17	3.161	4 3 0	25	1.984	1.988	2 3 2	
100	3.01	3.012	5 2 0	30	1.975	1.977	5 5 1	
15	2.909	2.906	1 5 0	15	1.923	1.923	0 4 2	
15	2.814	2.813	1 4 1	30	1.846	1.845	0 8 0	
60	2.754	2.750	4 4 0	20	1.834	1.833	6 6 0	
10	2.618	2.620	5 1 1	55	1.806	1.807	5 6 1	
20	2.577	2.576	6 2 0	20	1.754	1.752	8 3 1	
10	2.459	2.460	5 4 0	15	1.690	1.690	8 5 0	
15	2.404	2.401	4 5 0	20	1.651	1.649	10 0 0	
25	2.367	2.366	2 5 1	5	1.606	1.605	9 3 1	
45	2.316	2.318	6 1 1	5	1.562	1.564	10 3 0	

The pattern is indexed by analogy with that of petrovicite. The strongest seven lines are indicated in bold.

by considering the normal valence-states of the elements: Ag^+ , Hg^{2+} , Pb^{2+} , Sb^{3+} , and Te^{2-} . If we apply these valence states also to petrovicite, we find that the charge balance makes sense only if we consider Cu as monovalent, *i.e.*, $[\text{Cu}_3\text{HgPbBi}]^{+10.00}[\text{Se}_5]^{-10.00}$. However, a full structural study remains to be done on both minerals, pending the availability of more suitable crystals, and discussions about charge balance, degree of metallic bonding and possible structural models are premature.

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