Ferrotochilinite, $6\text{FeS} \cdot 5\text{Fe(OH)}_2$, a New Mineral from the Oktyabr’sky Deposit, Noril’sk District, Siberia, Russia

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Abstract—A new mineral, ferrotochilinite, ideally $6\text{FeS} \cdot 5\text{Fe(OH)}_2$, was found at the Oktyabr’sky Mine, Oktyabr’skoe Cu–Ni deposit, Noril’sk, Krasnoyarsk Krai, Siberia, Russia. It is associated with ferrovalleriite, magnetite and Fe-rich, chlorite-like phyllosilicate in the cavities of pentlandite–moovihoekite–cubanite ore with subordinate magnetite and chalcopyrite. Ferrotochilinite occurs as flattened on [001], prismatic to elongated lamellar crystals up to 0.1 $\times$ 0.5 $\times$ 3.2 mm, typically split and curved. Aggregates (up to 6.5 mm in size) are fanlike, rosette-like, or chaotic. Ferrotochilinite is dark bronze. The streak is black. The luster is moderately flexible, inelastic. $D_{\text{calc}} = 3.467 \text{ g/cm}^3$. In reflected light, ferrotochilinite is gray, with the hue changing from pale beige to bluish; bireflectance is distinct. Anisotropy is distinct, with gray bluish to yellowish beige rotation colors. No internal reflections. Reflectance values $[\% (\lambda, \text{nm})]$: 11.6$–$11.4 (470), 11.2$–$12.4 (546), 11.1$–$13.6 (589), 11.0$–$15.5 (650). The IR spectrum shows the presence of (OH) groups bonded with Fe and the absence of H$_2$O molecules. Chemical composition (wt %; electron probe; H content is calculated): 61.92 Fe, 0.03 Ni, 0.09 Cu, 19.45 S, 16.3 O, 1.03 $\Sigma$ (Mg 0.01Fe 10.96Ni 0.005Cu 0.015S 6(OH) 0.07 = (Fe 5.98Cu 0.015Ni 0.005) 3$\Sigma$ 6S 6(OH) 9.80Fe 10.96Ni 0.005Cu 0.015S 6(OH) 0.07). Ferrotochilinite is monoclinic, space group is $C2/m$, $Cm$ or $C2$, the unit-cell dimensions are: $a = 5.463(5)$, $b = 15.865(17)$, $c = 10.825(12)$ Å, $\beta = 93.7(1)^\circ$, $V = 936(3)$ Å$^3$, $Z = 2$. The strongest reflections in the X-ray powder diffraction pattern ($d$, Å—$l(hkI)$ are: 10.83$–$13[001], 5.392$–$100[002], 3.281$–$7[023], 2.777$–$7[150], 2.696$–$12[004], 2.524$–$12[221, 202], 2.152$–$8[134, 153], 1.837$–$11[135, 173]). Ferrotochilinite is a structural analog of tochilinite, with Fe$^{2+}$ instead of Mg in the hydroxide part. The type specimen is deposited in Fersman Mineralogical Museum of Russian Academy of Sciences, Moscow.

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INTRODUCTION

T tochilinite, a hybrid, layered hydroxide–sulfide with the idealized formula $6\text{FeS} \cdot 5\text{Mg(OH)}_2$, was described as a new mineral species in 1971. It was found in veins of serpentine and calcite, cutting ultramafic rocks of the Nizhnii Mamon Cu–Ni deposit in the Voronezh oblast, central Russia (Organova et al., 1971). Further investigations revealed that tochilinite is abundant in the low-temperature assemblages related to ultramafic rocks, kimberlite, carbon-
where the sulfide and hydroxide sublattice occur in one crystal (Evans and Allmann, 1968), the structure of tochilinite can be described in the unique lattice common of mackinawite and brucite modules. As was shown by an investigation of material from various locations, tochilinite has a significant number of structural varieties, which are slightly different in proportions of sulfide and hydroxide constituents and in the cation composition of the brucite packet. The commensurate varieties are more frequent in nature, though misfit varieties were also identified (Organova et al., 1989).

The tochilinite-type phases from meteorites, primarily from carbonaceous chondrites, should be noted separately. Initially, they were described either without a name or were conditionally called PCP (poorly characterized phases) (Barber et al., 1983; Tomeoka and Buseck, 1983); later on, they were proved to belong to the tochilinite structural type (Mackinnon and Zolensky, 1984). The interest in these phases arose owing to the suggestion to use them as indicators for reconstructing conditions of comparatively low-temperature alteration of meteorite matter (Zolensky and Mackinnon, 1984; Barber, 1985; Gooding and Zolensky, 1987; Browning and Bourcier, 1996). The meteoritic “tochilinite” studied in these papers is distinguished by the prevalence of Fe over Mg (up to 2 mm) of another hydroxide—sulfide, ferrovalle-

Organova et al. (1988) and Organova (1989) reported the absence or paucity of Fe in its brucite modules relative to Mg and frequently to Al. According to our data, tochilinite is not a rare mineral at the Noril’sk deposits, although its ferrous analog has so far been found in a singular place.

G.N. Plesin collected the specimens with ferro-
tochilinite in 2002 in shaft no. 1 (panel 5, belt 102) at the Oktjabr’sky Mine. The mineral fills fractures and small caverns in the massive pentlandite—mooihoekite–cubanite ore with subordinate magnetite and chalcopyrite. Ferrotochilinite overlies tiny spherical crystals of pale green lamellar crystals of Fe-rich and almost Mg- and Al-free chlorite-type phyllosilicate, coating the walls of cavities; less frequently, it overgrows rosette-shaped clusters of hexagonal lamellar crystals (up to 2 mm) of a singular place. Organic mineralization as low-temperature hydro-
thermal.

Ferrotochilinite occurs as flattened parallel to [001] prismatic to elongated lamellar crystals. Rare striation across elongation is usual on the pinacoidal faces {001}, which are the major habit form. Most crystals are rectangular and lath-shaped (Fig. 1a); less frequently, they have pointed tops and look like a sword (Fig. 1b). Many individuals are substantially split. The open-work skeletal forms are occasional (Fig. 1c). The crystals of ferrotochilinite are usually fractured and frequently curved, sometimes undula-
tory like climbing ribbons. The mineral individuals are not longer than 1.5 mm, but they occasionally reach 3.2 mm in length. They are up to 0.5 mm in width, up to 0.1 mm in thickness, and are often transformed into bunches, rosettes, and fan-shaped and chaotic aggregates (Fig. 2) reaching 6.5 mm across.

Ferrotochilinite that was altered to a variable degree and partly or completely transformed into red aggregates of iron hydroxides and sulfates (Fig. 3) was found in some cavities.

Note that complete pseudomorphs of iron hydrox-
ides with lath- and sword-shaped crystals of an un-
denitied mineral were found in a similar setting in many other places at the Oktjabr’sky Mine. Ferro-
tochilinite most likely was a primary mineral phase.

OCCURRENCE AND GENERAL
CHARACTERIZATION

In the 1970s, Genkin identified tochilinite in the Cu—Ni deposits of the Noril’sk district for the first