

DISCOVERY OF ZOLENSKYITE (FeCr_2S_4), A NEW SULFIDE MINERAL IN THE INDARCH ENSTATITE CHONDRITE.

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Introduction: During a nanomineralogy investigation of the Indarch EH4 enstatite chondrite, a new sulfide mineral, monoclinic FeCr_2S_4 , named “zolenskyite”, was discovered in the matrix. It has a $C2/m$ $\text{CrNb}_2\text{Se}_4\text{-Cr}_3\text{S}_4$ -type structure. Synthetic FeCr_2S_4 and $(\text{Fe}_{0.6}\text{Cr}_{0.4})\text{Cr}_2\text{S}_4$ with the monoclinic structure have been reported [1,2]. Presented here is the first natural occurrence of this phase as a new mineral in a chondritic meteorite. A field-emission analytical scanning electron microscope, electron back-scatter diffraction (EBSD) and electron probe microanalyzer (EPMA) were used to characterize its composition and structure and associated phases. The new mineral has been approved by the IMA-CNMNC (IMA 2020-070) [3]. The mineral name honors Michael E. Zolensky, an esteemed cosmochemist and mineralogist at NASA’s Johnson Space Center, for his contributions to research on extraterrestrial materials, including enstatite chondrites. A full paper on zolenskyite is under revision for *American Mineralogist* [4].

Occurrence, Chemistry, and Crystallography: Zolenskyite occurs as euhedral-subhedral single $\sim 10\text{-}20\text{-}\mu\text{m}$ -size crystals, associated with troilite, clinoenstatite and tridymite in the Indarch matrix (Fig. 1). The chemical composition of zolenskyite determined by EPMA is (wt%): S 43.85, Cr 35.53, Fe 18.94, Mn 0.68, Ca 0.13, total 99.13, showing an empirical formula of $\text{Fe}_{0.99}\text{Mn}_{0.04}\text{Ca}_{0.01}\text{Cr}_{1.99}\text{S}_{3.98}$. The ideal formula is FeCr_2S_4 . EBSD analysis reveals that zolenskyite has the $C2/m$ $\text{CrNb}_2\text{Se}_4\text{-Cr}_3\text{S}_4$ -type structure of synthetic FeCr_2S_4 [1], showing $a = 12.84(1)\text{ \AA}$, $b = 3.44(1)\text{ \AA}$, $c = 5.94(1)\text{ \AA}$, $\beta = 117(1)^\circ$, $V = 234(6)\text{ \AA}^3$ and $Z = 2$. All of the FeCr_2S_4 we found in the Indarch matrix is zolenskyite. Daubr elilite (cubic FeCr_2S_4) was found only in one sulfide-rich patch within a porphyritic pyroxene chondrule [4]. Whereas the daubr elilite grain in the chondrule is homogeneous and unaltered, all zolenskyite grains in the matrix appear moderately altered (Fig. 1).

Origin and Significance: Zolenskyite (FeCr_2S_4) is the Fe-analog of brezinaite (Cr_3S_4) or the Cr-analog of heideite (ideally FeTi_2S_4), joining the wilkmanite group. Zolenskyite is a monoclinic polymorph of daubr elilite. Some previous reports of daubr elilite in enstatite chondrites may be zolenskyite. Experiments show that daubr elilite can transform into zolenskyite at high pressures and moderate temperatures (e.g., 5.5 GPa, 520°C; 3 GPa, 200°C) [1], such as pertained in highly shocked EH6 chondrites [5]. Zolenskyite may have formed from daubr elilite in these regions, later to be incorporated into Indarch as aberrant grains during small-scale impact events [6]. Alkali metasomatic processes in EH3-chondrite matrices produced djerfisherite ($\text{K}_6(\text{Fe,Cu,Ni})_{25}\text{S}_{26}\text{Cl}$) [7]; such processes may also have moderately altered zolenskyite in Indarch. Annealing of the Indarch whole-rock to $\sim 640^\circ\text{C}$ [8] obliterated evidence of brecciation.

References: [1] Tressler R.E. et al. (1968) *J. Am. Cer. Soc.* 51:648–651. [2] Lutz H.D. et al. (1983) *Mat. Res. Bul.* 18:1383–1389. [3] Ma C. (2021) *Eur. J. Mineral.* 33, CNMNC Newslet. No. 59. [4] Ma C. and Rubin A.E. (2022) *Am. Mineral.*, DOI:10.2138/am-2022-8094. [5] Rubin A.E. and Wasson J.T. (2011) *GCA* 75:3757-3780. [6] Rubin A.E. (1990) *GCA* 54:1217-1232. [7] El Goresy A. et al. (1988) *Symp. Ant. Met.* 1:65-101. [8] Huss G.R. and Lewis R.S. (1994) *Meteoritics* 29:811-829.

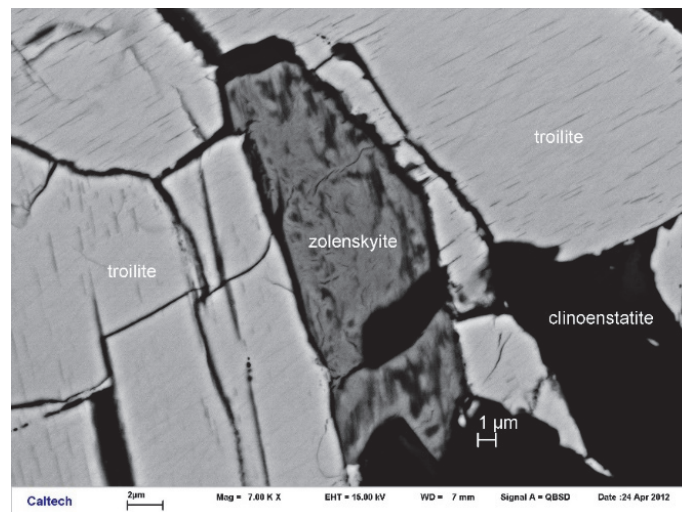


Fig. 1. Back-scatter electron image showing zolenskyite in the Indarch matrix in section ICM6.