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

Chi Ma[1*] and Alan E. Rubin[2]. [1]Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, CA 91125, USA; [2]Deptartment of Earth, Planetary, and Space Sciences, University of California, Los Angeles, CA 90095, USA; [*]email: chima@caltech.edu.

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* $CrNb_2Se_4$-Cr_3S_4-type structure. Synthetic $FeCr_2S_4$ and $(Fe_{0.6}Cr_{0.4})Cr_2S_4$ 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 ~10-20-μm-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 $Fe_{0.99}Mn_{0.04}Ca_{0.01}Cr_{1.99}S_{3.98}$. The ideal formula is $FeCr_2S_4$. EBSD analysis reveals that zolenskyite has the *C2/m* $CrNb_2Se_4$-Cr_3S_4-type structure of synthetic $FeCr_2S_4$ [1], showing a = 12.84(1) Å, b = 3.44(1) Å, c = 5.94(1) Å, β = 117(1)°, V = 234(6) Å^3 and Z = 2. All of the $FeCr_2S_4$ we found in the Indarch matrix is zolenskyite. Daubréelite (cubic $FeCr_2S_4$) was found only in one sulfide-rich patch within a porphyritic pyroxene chondrule [4]. Whereas the daubréelite 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 daubréelite. Some previous reports of daubréelite in enstatite chondrites may be zolenskyite. Experiments show that daubréelite 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 daubréelite 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 ($K_6(Fe,Cu,Ni)_{25}S_{26}Cl$) [7]; such processes may also have moderately altered zolenskyite in Indarch. Annealing of the Indarch whole-rock to ~640ºC [8] obliterated evidence of brecciation.

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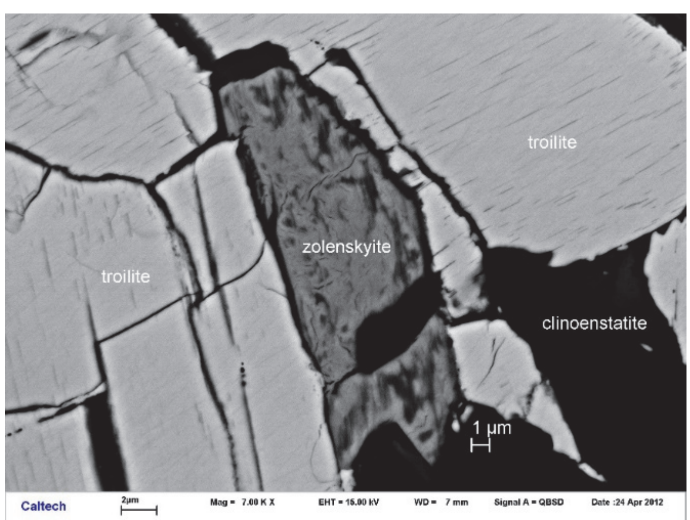

Fig. 1. Back-scatter electron image showing zolenskyite in the Indarch matrix in section ICM6.