Zinc-bearing iron-dominant member of (Fe,Zn,Mn)S solid solution from Eagle enstatite chondrite

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Introduction: Enstatite chondrites are divided into two groups based on their bulk composition: EH (high bulk iron) and EL (low bulk iron) [1 and references therein]. They formed under highly reducing conditions which are also reflected in their mineralogy [2]. Eagle meteorite belongs among enstatite chondrite of the EL group and petrologic type 6 [3]. Zinc bulk concentration in enstatite chondrites has been shown to be extremely variable among EH and EL groups and also among distinct petrologic types across the groups and simultaneously it has been observed that overall content of sphalerite as a potential main Zn carrier in these meteorites is low [4,5 and references therein]. It should be noted, however, that not only sphalerite represents zinc carrying mineral in enstatite chondrites; other Zn-bearing minerals reported from enstatite chondrites include Zn-bearing daubréelite and Fe-dominant members of (Fe,Zn,Mn)S solid solution: buseckite and rudashevskyite. Last two minerals differ mutually in their crystal structures [6; 7 and references therein]. Rudashevskyite crystalizes in sphalerite structure type (space group $F\bar{4}3m$) whereas buseckite crystalizes in würtzite structure type (space group $P6_3mc$). Here, (Fe,Zn,Mn)S phase from Eagle enstatite chondrite is presented. This mineral has not been reported from Eagle chondrite before.

Preliminary results and discussion: Next to vastly dominant almost iron-free enstatite, the studied sample of Eagle meteorite contains plagioclase, Si-bearing Fe-Ni metal and sulfides (Cr-Ti-bearing troilite, daubréelite and alabandite). Minor phases as tridymite, quartz, graphite, schreibersite and sinoite are also present. No chondrules were observed. During the detailed mineralogical investigation, few grains of (Fe,Zn,Mn)S mineral were found in a single area (approx. 400 x 400 μm^2) of Eagle sample. The mineral occurs associated with troilite grains that contain daubréelite exsolution lamellae. Chemical composition determined by electron microprobe (average of 10 analyses) of the (Fe,Zn,Mn)S mineral is (in wt%) Fe 29.97, Zn 22.98, Mn 10.31, Mg 0.42, S 35.24. Corresponding empirical formula (calculated on the basis of 2 atoms per formula unit) is $(Fe_{0.49}Zn_{0.32}Mn_{0.17}Mg_{0.02})_{\Sigma 1.00}S_{1.00}$. The presented chemical composition is very close to the composition of buseckite from Zakłodzie meteorite [7]. Consequently, it is feasible to assume that the reported (Fe,Zn,Mn)S phase corresponds to buseckite. Other features also favor the identification of the mineral as buseckite rather than rudashevskyite. In general, the würtzite-type structure is stable at higher temperatures than the sphalerite-type structure. In addition, iron and also Mn (+Mg) contents significantly lower the inversion temperature of buseckite (würtzite-type) to rudashevkyite (sphalerite-type) from approx. 1020-800°C (depending on Fe content) down to ~ 350°C (depending on Mn content) [6;7]. Published data on EL4-6 enstatite chondrites report more (Fe,Zn,Mn+Mg)S phases with relatively high Mn (+Mg) content. Taking into account relatively high formation temperatures, fast cooling rates, high Mn content and low oxygen fugacities, they probably correspond to buseckite as well [7]. However, no indication of crystal structure type is available for these minerals so far preventing their unequivocal identification.

Further mineralogical research is planned to reveal the trace element composition and more importantly the crystal structure to distinguish whether the minerals represent rudashevskyite or buseckite (EBSD and Raman microspectroscopy and if possible also the single-crystal X-ray diffraction). Note, that no complete crystal structure determination was performed for buseckite; instead only its EBSD pattern was matched to that of würtzite-structured analog.

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