Buseckite, (Fe,Zn,Mn)S, a new mineral from the Zakłodzie meteorite

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ABSTRACT

Buseckite (IMA 2011-070), (Fe,Zn,Mn)S, is the Fe-dominant analog of wurtzite, a new member of the wurtzite group discovered in Zakłodzie, and an ungrouped enstatite-rich achondrite. The type material occurs as single-crystal grains (4–20 µm in size) in contact with two or more of enstatite, plagioclase, troilite, tridymite, quartz, and sinoite. Low-Ni iron, martensitic iron, schreibersite, keilite, cristobalite, and graphite, which are also present in the type sample, are not observed to be in contact with buseckite. Buseckite is black under diffuse illumination and nearly opaque grayish brown in transmitted light. The mean chemical composition of buseckite, as determined by electron microprobe analysis of the type material, is (wt%) S 35.84, Fe 28.68, Zn 23.54, Mn 10.04, Mg 1.18, sum 99.28, leading to an empirical formula calculated on the basis of 2 atoms of (Fe₀.₉₈Zn₀.₁₂Mn₀.₃₈Mg₀.₃₄)₀.₉₉S₁.₈₁. Electron backscatter diffraction patterns of buseckite are a good match to that of synthetic (Zn₀.₅₆Fe₀.₄₄)S with the P6mc wurtzite-type structure, showing a = 3.8357 Å, c = 6.3002 Å, V = 80.27 Å³, and Z = 2. Buseckite is likely derived from the breakdown of high-temperature pyrrhotite to form troilite and buseckite following the solidification of sulfide-rich liquids produced during impact melting of an enstatite-rich rock.

Keywords: Buseckite, (Fe,Zn,Mn)S, new mineral, wurtzite group, sinoite, Zakłodzie meteorite, estatite achondrite

INTRODUCTION

The Zakłodzie meteorite, which is a moderately weathered find discovered near the village of Zakłodzie, Poland, is an ungrouped enstatite-rich achondrite that has been ascribed to an impact melt (e.g., Keil 2010) and to internal melting within the parent body (Przylibski et al. 2005). During a nano-mineralogy investigation of this meteorite, a new Fe-dominant monosulfide mineral, (Fe,Zn,Mn)S with a P6mc wurtzite-type structure, was identified and named “buseckite.” Field-emission scanning electron microscope, electron-backscatter diffraction (EBSD), electron microprobe, and micro-Raman spectroscopic analyses were used to characterize its composition and structure and those of associated minerals. All of the minerals in this study were identified structurally with EBSD and/or Raman. (Fe,Zn,Mn)S phases similar in composition to buseckite were previously found through electron microprobe analysis of sulfides in the Yilmia EL6 chondrite (Buseck and Holdsworth 1972), the Grein 002 EL4/5 chondrite (Patzer et al. 2004), and the Zakłodzie achondrite (on a different sample; Karwowski et al. 2007). This study reports the first confirmed (Fe,Zn,Mn)S mineral with the P6mc wurtzite-type structure and considers the origin of this phase, relationships to coexisting minerals, and implications through its formation and survival for the evolution of the Zakłodzie meteorite. Preliminary results are given in Ma et al. (2012).

MINERAL NAME AND TYPE MATERIAL

The new mineral and its name have been approved by the Commission on New Minerals, Nomenclature and Classification of the International Mineralogical Association (IMA 2011-070) (Ma 2011). The name is in honor of Peter R. Buseck (b. 1935), a mineralogist at the Arizona State University, for his many contributions to mineralogy, meteorite research, and transmission electron microscopy. Two Caltech sections, ZAK-TS1 (purchased) and ZAK-TS2 (made at Caltech), taken from facing slices of the meteorite, contain the type material. ZAK-TS2, hereafter referred to as USNM 7607, has been deposited in the Smithsonian Institution’s National Museum of Natural History, Washington, D.C., and catalogued under USNM 7607.

APPEARANCE, PHYSICAL AND OPTICAL PROPERTIES

The type material appears to consist of 11 single-crystal grains scattered in USNM 7607 and ZAK-TS1 along grain boundaries between two or more of enstatite, plagioclase, quartz, and tridymite, absent other sulfides or adjacent to troilite (Figs. 1–3). One of the type grains contains euahedral sinoite (Si₃N₂O) crystals (Fig. 3a). Buseckite (Figs. 1–3) is irregular to subhedral, 4–20 µm in diameter. No forms or twinning were observed. The Zakłodzie meteorite is a modestly weathered find but each of the 11 buseckite grains that we observed is surrounded by a rim of secondary Fe oxyhydroxides, which also fill fractures that cut across the grains. Buseckite is black under diffuse illumination and nearly opaque grayish brown in transmitted light. Luster, streak, hardness, tenacity, cleavage, fracture, and optical properties, none of which were determined for buseckite because of the small grain size, are likely close to those of wurtzite (Zn,Fe)S. The density, calculated from the empirical formula, is 3.697 g/cm³. The crystal is non-fluorescent under the electron beam in an SEM.

CHEMICAL COMPOSITION

Quantitative elemental microanalyses were conducted with a JEOL 8200 electron microprobe operated at 15 kV and 10 nA in a focused beam mode. Standards for the analysis were synthesized.