Herderite from Mogok, Myanmar, and comparison with hydroxyl-herderite from Ehrenfriedersdorf, Germany

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ABSTRACT

The crystal structures of herderite, CaBePO4(3)(F) and an end-member in a solid-solution series with hydroxyl-herderite, CaBePO4(3)(OH). However, chemical verification of herderite as a species (e.g., F-dominant samples) and the conditions of its origin have always been a problem. Herderite was initially described by Haidinger (1828) from samples associated with the Sn-bearing pegmatites at Ehrenfriedersdorf in the Erzgebirge of Germany. As Grew pointed out in his review of Be minerals (Grew 2002), neither in Haidinger (1828) nor in studies since (e.g., Leavens et al. 1978; Dunn et al. 1979; King and Foor 1994) has the complete chemical composition of the sample been accurately measured; likewise F was not demonstrated as being dominant in this sample. Samples from Ehrenfriedersdorf were unavailable for study by the late-twentieth century authors noted above, and the sole analysis indicating F > OH was a measurement of only F by microprobe (and comparison with theoretical F content; Dunn and Wight 1976) on a gem of unknown provenance from Brazil. Consequently, there has been speculation (e.g., Gaines et al. 1997) that herderite, as a species in nature, distinct from hydroxyl-herderite, does not exist. With the status of herderite in doubt, paragenesis becomes somewhat of a conundrum. Hydroxyl-herderite occurs in granite pegmatites, greisens, and miarolitic cavities associated with granites and granite pegmatites (cf. Grew 2002; Černý 2002). Fluorine-rich species in miarolitic cavities associated with granites and granitic pegmatites (cf. Grew 2002; Černý 2002). Fluorine-rich species in granite pegmatites, greisens, and hydroxyl-herderite, CaBePO4(3)(OH)F(0.52), a = 9.7615(4), b = 7.6680(3), c = 4.7853(2) Å, β = 90.184(1), V = 358.18(4) Å³, P2(1)/a, and Z = 4, from the Sauberg mine, Morgenröther Zug, Ehrenfriedersdorf, Germany, have been refined to R indices of 1.7%, in both cases, using MoKα single-crystal X-ray diffraction data. Herderite from Mogok is associated with complex rare-element beryl-type granite pegmatite. Most herderite-series minerals are the product of late-stage processes in granite pegmatite evolution, typically of an exsolved fluid upon crystallization, and significant F-enrichment in these fluids appears to result in the domination of herderite over hydroxyl-herderite. Herderite is now documented from Mogok, Myanmar; Yichung, China; Brazil; and probably Erongo, Namibia. The pegmatites at Ehrenfriedersdorf, Germany have produced samples at the boundary between herderite and hydroxyl-herderite, if not possibly herderite as well.

Keywords: Herderite, hydroxyl-herderite, crystal structure, Mogok, Myanmar, Ehrenfriedersdorf, Germany

INTRODUCTION

Herderite is ideally CaBePO4(3)(F) and an end-member in a solid-solution series with hydroxyl-herderite, CaBePO4(3)(OH). However, chemical verification of herderite as a species (e.g., F-dominant samples) and the conditions of its origin have always been a problem. Herderite was initially described by Haidinger (1828) from samples associated with the Sn-bearing pegmatites at Ehrenfriedersdorf in the Erzgebirge of Germany. As Grew pointed out in his review of Be minerals (Grew 2002), neither in Haidinger (1828) nor in studies since (e.g., Leavens et al. 1978; Dunn et al. 1979; King and Foor 1994) has the complete chemical composition of the sample been accurately measured; likewise F was not demonstrated as being dominant in this sample. Samples from Ehrenfriedersdorf were unavailable for study by the late-twentieth century authors noted above, and the sole analysis indicating F > OH was a measurement of only F by microprobe (and comparison with theoretical F content; Dunn and Wight 1976) on a gem of unknown provenance from Brazil. Consequently, there has been speculation (e.g., Gaines et al. 1997) that herderite, as a species in nature, distinct from hydroxyl-herderite, does not exist. With the status of herderite in doubt, paragenesis becomes somewhat of a conundrum. Hydroxyl-herderite occurs in granite pegmatites, greisens, and miarolitic cavities associated with granites and granite pegmatites (cf. Grew 2002; Černý 2002). Fluorine-rich species in pegmatitic and miarolitic environments require some mechanism to dewater the magma or fluid and thus enhance F content.

The first author had the opportunity to visit Mogok, Myanmar, in December 1998. His fascination with the wide diversity of minerals found in the region of the Mogok Stone Tract has led to further visits to Myanmar, slow acquisition of a Mogok collection, and an investigation of the minerals and their parageneses from this famous source of rubies and other gems. Among the samples from the Mogok area acquired over the intervening years for the American Museum of Natural History (AMNH) mineral collection was a pale blue-green single crystal. XRD examination of a fragment from the crystal identified it as herderite. When a preliminary microprobe analysis of this crystal pointed to a true F-dominant herderite (>8 wt% F), we decided that further chemical and crystallographic study was needed to substantiate the specimen and the species.

EXPERIMENTAL METHODS

The Mogok herderite crystal examined here (AMNH 108370) was part of a group of specimens acquired without a specific location. However, other crystals have been identified from Sakhan Gyi (22° 53.95′ N, 96° 24′ 43″ E), a town and mining area well known for pegmatite minerals (e.g., elbaite, beryl, topaz, scheelite, cassiterite, danburite, amblygonite, and fluorite) and marble-hosted spinels that is located toward the western limit of the Mogok Stone Tract, and Pan Daw village (22° 57′ 62″ N, 96° 24′ 98″ E), near Kyauk Sin, a source of amazonite, topaz, aquamarine, cassiterite, and fluorite, in addition to the granite mineral suite (for maps see Chhibber 1934; Kammerling et al. 1994; Themelis 2007). Additional finds include diggings on Loi-Sau Mountain (ca. 22° 59′ 7″ N 96° 38′ 3″ E) near Panta-hoe village, about 16 km northeast of Mogok, from a pegmatite pocket with pink elbaite; this pegmatite also yielded jeremejevite [Al4(BO3)6F4](Kyaw Thu, personal communication). Pazun-seik (22° 57′ 72″ N, 96° 24′ 27″ E) located near Nam-peik where herderite has been recovered from open-pit mining, has also yielded beryl, cassiterite, microcline, topaz, fluorite, spessartine, and rhodochrosite as well as ruby and sapphire. All sources are associated with late pegmatites intruding the Kabaing granite (~16 Ma; Bertrand and Rangin 2003; Themelis 2007; Thu 2007) and adjacent marble units. Fragments from the base of the 2 cm long pale-green prism (011) (AMNH108370) were used in this work. In addition, fragments from a herderite specimen from the type locality in an Sn mine associated with greisens and late Variscan granites at Ehrenfriedersdorf, Sachsen, Germany, were provided...