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Characteristics of djerfisherite from fluid-rich, metasomatized alkaline intrusive environments and anhydrous enstatite chondrites and achondrites

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Abstract

Djerfisherite is a K-Cl-bearing sulfide that is present in both ultra-reduced extraterrestrial enstatite meteorites (enstatite chondrites or achondrites) and reduced terrestrial alkaline intrusions, kimberlites, ore deposits, and skarns. Major element chemistry of two terrestrial occurrences of djerfisherite (from the Ilímaussaq and Khibina alkaline igneous suites) and three extraterrestrial examples of djerfisherite have been determined and combined with petrographic characterization and element mapping to unravel three discrete modes of djerfisherite formation. High Fe/Cu is characteristic of extraterrestrial djerfisherite and low Fe/Cu is typical of terrestrial djerfisherite. Ilímaussaq djerfisherite, which has high-Fe contents (~55 wt%) is the exception. Low Ni contents are typical of terrestrial djerfisherite due to preferential incorporation of Fe and/or Cu over Ni, but Ni contents of up to 2.2 wt% are measured in extraterrestrial djerfisherite. Extensive interchange between K and Na is evident in extraterrestrial samples, though Na is limited (<0.15 wt%) in terrestrial djerfisherite. We propose three setting-dependent mechanisms of djerfisherite formation: primitive djerfisherite as a product of nebula condensation in the unequilibrated E chondrites; formation by extensive K-metasomatism in Khibina djerfisherite; and as a product of primary "unmixing" due to silicate-sulfide immiscibility for Ilímaussaq djerfisherite. There are several important reasons why a deeper understanding of the petrogenesis of this rare and unusual mineral is valuable: (1) its anomalously high K-contents make it a potential target for Ar-Ar geochronology to constrain the timing of metasomatic alteration; (2) typically high Cl-contents (~1.1 wt%) mean it can be used as a valuable tracer of fluid evolution during metasomatic alteration; and (3) it may be a potential source of K and magmatic Cl in the sub-continental lithospheric mantle (SCLM), which has implications for metal solubility and the generation of ore deposits.

Keywords: Djerfisherite, metasomatism, alkaline intrusions, E-chondrites, sulfide immiscibility, halogen