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Ferrous freudenbergite in ilmenite megacrysts: A unique paragenesis from the Dalnaya kimberlite, Yakutia

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ABSTRACT

A suite of picroilmenite megacrysts from the Dalnaya kimberlite, Siberia, was found to fall into one of two groups, the most abundant having 11–12 wt% MgO and 650–1500 ppm Nb, and the others having lower MgO (8.8–10.2 wt%) and higher Nb (1700–2700 ppm). Ferrous freudenbergite ($Na_2FeTi_7O_{16}$) crystals were found included in many of the megacrysts from the first group. The freudenbergite-bearing ilmenite megacrysts are also pervaded by micrometer-size spots that have elevated Al_2O_3 (>2 wt%), SiO_2 (>0.4 wt%), and Na_2O (>0.15 wt%) contents. The low Cr_2O_3 vs. Nb content of the second group may reflect clinopyroxene crystallization. This may be a factor influencing the lack of freudenbergite in these megacrysts.

All ferrous freudenbergite samples studied previously are manifested as metasomatic reaction mantles replacing rutile. The freudenbergite from the Dalnaya kimberlite described in this paper occurs as small (max. 150 μm × 40 μm), euhedral, prismatic inclusions in picroilmenite (11–12 wt% MgO) megacrysts, with no associated rutile. Minor-element (Cr, Al, and Mg) substitutions for Fe are more extensive than in previously studied freudenbergite, with up to 1.4 wt% Cr_2O_3, 1.9 wt% Al_2O_3, and 3.1 wt% MgO. Nb is relatively low, typically less than 0.3 wt% Nb_2O_5 with a maximum of 1.1 wt%. Reaction of some of the freudenbergite with an alkalic fluid has resulted in thin, discontinuous rims and embayments of perovskite and an unidentified hydrous calcium titanate, around most crystals. Rapid ascent from depth and shielding by ilmenite may have been contributing factors to the preservation of freudenbergite in these samples.

The significance of the euhedral nature of freudenbergite and the lack of any genetic relationship with rutile suggest that it crystallized by a process other than simple metasomatic replacement of rutile. Indeed, the freudenbergite probably crystallized directly from a Na + Ti-rich fluid infiltrating the ilmenite megacrysts. The several occurrences (Liberia, Bultfontein, and Dalnaya) of ferrous freudenbergite suggest that it may be more common in kimberlites than previously recognized.