Ca-Al-silicate inclusions in natural moissanite (SiC)

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ABSTRACT

Hundred-micrometer-sized calcium-aluminum-silicates (CAS) inclusions occur in moissanite-4H, moissanite-15R, and moissanite-6H from Turkey. These inclusions commonly consist of tabular exsolution lamellae of two different minerals. By combined electron microprobe and Raman spectroscopy analysis, at least eight different, essentially Mg- and Fe-free Ca-Al-silicate or Al-silicate phases have been discerned. The most common phase is dmisteinbergite, a hexagonal modification of CaAlSi2O6, occurring in association with lamellae of Ca3–x(Al,Si)6+xO14, or Ca1–x(Al,Si)3+xO6 compositions. All three phases contain significant amounts of BaO (up to 2 mol% of celsian component in dmisteinbergite), SrO, SO3, and light rare earth elements (LREE). In particular, Ca3–x(Al,Si)6+xO14 contains up to 2.1 wt% of LREE, 3.9 wt% of F, and significant traces of Cl, while it is also associated to osbornite (TiN). Pure gheleinite, CaAlSiO4, and three additional compositions, namely CaAl2SiO7, Ca1–x(Al,Si)3+xO6, and Ca3–x(Al,Si)6+xO14 have been found, either occurring as single grains or forming exsolution lamellae. They also contain significant amounts of BaO, SrO, SO3, and LREE. One last intriguing phase is composed in average of 65.9 wt% SiO2, 17.4% Al2O3, 3.0% alkalis, 6.0% BaO, 2.0% CaO+MgO, 0.9% ZrO2, and up to 0.5% LREE. Dmisteinbergite and gheleinite show Raman peaks in very good agreement with literature data, Ca3–x(Al,Si)6+xO14 shows main Raman modes at 416 and 1009 cm–1 while Ca1–x(Al,Si)3+xO6 has a strong peak at 553 cm–1. CaAl4–xSixO7 shows a weak Raman pattern, while Ca1–x(Al,Si)3+xO6 has no detectable Raman modes. Since the association moissanite-CAS is thermodynamically not stable at ambient pressure and moissanite crystals hosting the CAS phases have δ13C values typical of deep-mantle origin, we interpret the CAS inclusions as partially retrogressed HP minerals. Striking analogies exist between observed CAS compositions and experimentally obtained HP-HT mineralogy. For instance, Ca3–x(Al,Si)6+xO14 has been found, either occurring as single grains or forming exsolution lamellae.

Keywords: Moissanite, dmisteinbergite, gheleinite, unknown CAS mineral, Raman spectra, mineral composition

INTRODUCTION

The natural occurrence of moissanite, natural α-silicon carbide, under terrestrial conditions was vigorously debated until the end of the 1980s. Milton and Vitaliano (1984) critically but correctly proposed a series of six independent criteria to discern natural moissanite occurrences from synthetic SiC contamination. Extensive field researches in the last three decades fulfilled most of these criteria. The first one concerned the finding of moissanite as inclusions in other minerals. In fact, moissanite crystals were reported included in diamonds and carbonados from kimberlites and lamproites from many continental cratons in Russia (Yakutia; Marshintsev 1990), China (Fuxian; Leung 1990), U.S.A. (Colorado; McCammon et al. 1997; Otter and Gurney 1986, 1989), South Africa (Monastery Mine; Moore et al. 1986; Moore and Gurney 1989; Koffiefontein mine, Klein-BenDavid et al. 2007), Central Africa (De et al. 1998), Australia (Argyle lamproite; Jaques et al. 1989), and Brazil (Sao Luis River placers; Wilding et al. 1991; Svisero 1995; De et al. 1998; Kaminsky 2012). Moissanite was also reported included in garnets from a Chinese retrogressive eclogite (Qi et al. 2007). These authors show excellent thin section microphotographs of a dozen of moissanite crystals included, along with coesite and rutile, in pyrope. In serpentinite from the Chinese Dabie Mountains, Xu et al. (2008) present thin section microphotographs of moissanite crystals associated to rutile and baddeleyite. Moreover, moissanite was also reported as inclusions in olivine from the diamondiferous Karashoho pipe from the Bukantau mountains from Uzbekistan (Golovko and Kaminsky 2010), and in garnets from felsic granulites from the Moldanubian Zone of the Bohemian Massif (Perraki and Faryad 2014). These latter authors also show thin section microphotographs where moissanite is unequivocally contained within the hosting mineral. Finally, from the Luobusa ophiolite, Tibet, Robinson et al. (2015) and Liang et al. (2014) reported moissanite in olivine from peridotite, and in Cr-spinel from dunite, respectively. Euhedral, unbroken crystals, the second criterion, have been reported from Fuxian (Leung et al. 1990; Leung 1990), Turkey (Di Pierro et al. 2003), and Yakutia (Shiryaev et al. 2011), while abundant silicon and...