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

SIMONPIETRO DI PIERRO[1,*] AND EDWIN GNOS[2]

[1]UMR CNRS 5570, Laboratoire de Sciences de la Terre, ENS Lyon, France
[2]Natural History Museum of Geneva, route de Malagnou 1, CP 6434, 1211 Geneve 6, Switzerland

ABSTRACT

Hundred-micrometer-sized calcium-aluminum-silicates (CAS) inclusions occur in moissanite-4*H*, moissanite-15*R*, and moissanite-6*H* 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 $CaAl_2Si_2O_8$, occurring in association with lamellae of $Ca_x(Al,Si)_{1-x}O_3$ or $Ca_{1-x}(Al,Si)_{2+x}O_5$ compositions. All three phases contain significant amounts of BaO (up to 2 mol% of celsiane component in dmisteinbergite), SrO, SO_3, and light rare earth elements (LREE). In particular, $Ca_{1-x}(Al,Si)_{2+x}O_5$ 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 ghelenite, $Ca_2Al_2SiO_7$, and three additional compositions, namely $CaAl_{4-x}Si_xO_7$, $Ca_{1-x}(Al,Si)_{3+x}O_6$, and $Ca_{3-x}(Al,Si)_{6+x}O_{14}$ have been found, either occurring as single grains or forming exsolution lamellae. They also contain significant amounts of BaO, SrO, SO_3, and LREE. One last intriguing phase is composed in average of 65.9 wt% SiO_2, 17.4% Al_2O_3, 3.0% alkalis, 6.0% BaO, 2.0% CaO+MgO, 0.9% ZrO_2, and up to 0.5% LREE. Dmisteinbergite and ghelenite show Raman peaks in very good agreement with literature data, $Ca_x(Al,Si)_{1-x}O_3$ shows main Raman modes at 416 and 1009 cm^{-1}, $Ca_{1-x}(Al,Si)_{3+x}O_6$ at 531 and 1579 cm^{-1} while $Ca_{3-x}(Al,Si)_{6+x}O_{14}$ has a strong peak at 553 cm^{-1}. $CaAl_{4-x}Si_xO_7$ shows a weak Raman pattern, while $Ca_{1-x}(Al,Si)_{2+x}O_5$ 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 $\delta^{13}C$ 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, $Ca_x(Al,Si)_{1-x}O_3$ contains up to 25 mol% of Al_2O_3, which is considered as the upper limit of alumina solubility in Ca-perovskite. The study confirms that CAS phases are an important mantle depository for large ion lithophile elements (LILE) and LREE.

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