Dawsonite: An inclusion mineral in quartz from the Tin Mountain pegmatite, Black Hills, South Dakota

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ABSTRACT

Dawsonite —NaAl(CO3)(OH)2—was identified in primary fluid inclusions in quartz from the Li-rich Tin Mountain pegmatite, Black Hills, South Dakota, by petrography, SEM-EDS analysis, and Raman spectroscopy. This is the first report of dawsonite as an inclusion mineral in a pegmatite. The presence of dawsonite in the inclusions is evidence for the existence of carbonate ions in the complex pegmatite melt and/or exsolved magmatic fluid. The lack of dawsonite as a macroscopic mineral is attributed to its high solubility in the late pegmatite fluids and to the small fraction of carbonate ions in the melt. However, its common occurrence, along with other carbonate and borate minerals in fluid inclusions, suggests that carbonate and borate complexes play an important role in petrogenesis of pegmatites.

INTRODUCTION

Dawsonite, NaAl(CO3)(OH)2, named in 1874 after J.W. Dawson (1820–1899), a Canadian geologist, is usually a low-temperature, hydrothermal, diagenetic or authigenic mineral that forms by decomposition of aluminum silicates in the presence of carbonate/bicarbonate-rich solutions. The mineral is of some interest as a potential source of Al and in the pharmaceutical industry as an antacid. The structure of dawsonite is orthorhombic-disphenoidal (space group Imma), consisting of distorted AlO4(OH)6 and NaO4(OH)2 octahedra and CO3 groups (Corazza et al. 1977). Vibration-frequency modes of infrared and Raman spectra were reported by Serna et al. (1985). Dawsonite typically occurs in colorless to white rosettes or spherules and Raman spectra were reported by Serna et al. (1985). Dawsonite typically occurs in colorless to white rosettes or spherules of bladed to acicular fine crystals. Its recognition and identification by X-ray analysis is difficult because of the mineral’s rarity, small size (<20 μm), and brittleness (Corazza et al. 1977). Optically, dawsonite is transparent, non pleochroic, and highly birefringent: δ = 0.127, nα = 1.462, nβ = 1.537, and nγ = 1.589 (Gaines et al. 1997). It effervesces in contact with cold, concentrated HCl (Coveney and Kelly 1971).

Dawsonite occurs in: (1) hydrothermal products of weathering of igneous rocks; (2) sedimentary rocks derived from volcanics or affected by CO2-rich ± alkaline, thermal solutions; and (3) a wide variety of sedimentary rocks with no direct relationship with igneous rocks (summary in Stankevich and Batalin 1976; Corazza et al. 1977; Baker et al. 1995). Dawsonite is affiliated with various types of magmatism, including alkaline (i.e., Monteregian alkaline intrusions, Canada), felsic (ryholitic ignimbrites, Bolzano, Italy), mafic (basalts, Sollingen, Germany), and ultramafic (chromian dawsonite, serpentinite, Franciscan Complex, California; Dunning 2000).

Coveney and Kelly (1971, XRD study) and Metzger et al. (1977, SEM-EDS study) described dawsonite as an abundant daughter product in fluid inclusions in gold-quartz veins of the Oriental mine, Alleghany district, California, and interpreted it as either an equilibrium phase in the system sodic plagioclase–quartz–sodium bicarbonate-brine, or a metastable phase in the same system.

Dawsonite was synthesized from sodium carbonate/bicarbonate solutions in Al-rich environments at room temperature (Chesworth 1971; Furmakova 1981 and references therein). Optimum conditions of autoclave synthesis were: T = 175–200°C, P CO2 = 1.035 bars, and a high Na/Al atomic ratio (~43, Jackson et al. 1972). At atmospheric pressure, dawsonite dissolves incongruently in water to produce gibbsite (Furmakova 1981) and decomposes thermally at ~300°C to release CO2 (Huggins and Green 1973). The thermodynamic data for synthetic dawsonite and parameters of decomposition reactions up to 400°C, at atmospheric pressure, were tabulated by Ferrante et al. (1976). To our knowledge, there are no published studies concerning dawsonite stability at elevated pressures. We identified dawsonite during a petrographic and SEM-EDS survey of fluid and crystallized melt inclusions in the Harney Peak Granite (HPG) and associated pegmatites in the Black Hills. Its presence as an inclusion mineral within fluid inclusions in quartz from the Tin Mountain (TM) pegmatite was confirmed by laser Raman microprobe spectroscopy (LRMS).

OCCURRENCE

The TM pegmatite is an extensively studied, zoned, Li-rich pegmatite, located ~12 km southwest of the main pluton of the 1,715 Ma HPG, near the outer boundary of the pegmatite aureole (Norton and Redden 1990). It consists of a continuous, 1 to 10 m thick wall zone (albite-quartz-mica) with a very thin outer border zone, and four discontinuous, inner zones that are vertically stacked rather than concentric. The succession of zones, from top to bottom, is: 1st intermediate zone (perthite-quartz-