American Mineralogist, Volume 110, pages 1574–1596, 2025

Snowball quartz in highly fractionated peraluminous granites: An indicator of multiple magma degassing

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Abstract

Snowball quartz is commonly found in highly fractionated peraluminous granites that may be associated with mineralization of Ta, Nb, Li, W, Sn, and Rb. The genesis of snowball quartz has been a subject of controversy, and its genetic relationship with potential rare metal mineralization remains poorly understood. This work presents a study of the mineralogy and chemistry of quartz and plagioclase from the Yashan pluton in southern China. The Yashan pluton hosts the Yichun Ta-Nb-Li deposit and is primarily composed of two-mica granite, Li-mica granite, and topaz-lepidolite granite, which were intruded by granite dikes. The texture known as "snowball" is observed in quartz from Li-mica granite, but it is more frequently and prominently developed in quartz from topaz-lepidolite granite and granite dikes. This texture is characterized by the zonal arrangement of prismatic albite (referred to as snowball albite) within quartz phenocrysts, with the {010} face of snowball albite preferentially adhering to the crystal faces of quartz. It typically develops in specific domains of the mantle and/or rim of quartz phenocrysts, and occasionally in their cores. The snowball texture is preferentially developed on the prism faces (*m*) of quartz, as indicated by a higher abundance of snowball albites on these faces compared to others. The snowball-textured quartz domain (SBTQD) is texturally similar to other domains from the same growth zone and chemically overlaps with magmatic quartz cores or rims. The snowball albites are chemically indistinguishable from magmatic albite inclusions entrapped within quartz cores. These pieces of evidence suggest that the SBTQDs have a magmatic origin. Given the specific morphologies of snowball quartz (well development of prism faces) and albite (prismatic with a high aspect ratio of ~5–10), along with the development of sector zoning in quartz, it is proposed that the snowball quartz formed as a result of rapid growth of quartz and albite under moderate undercooling (ΔT = 50–100 °C) at near-solidus conditions, which was associated with multiple episodes of magma degassing. From the perspective of Ta-Nb mineralization, this degree of undercooling would significantly reduce the solubility of tantalite by more than 70–90%, thereby facilitating its crystallization. This process also promotes the further crystallization of already saturated columbite. Therefore, snowball quartz could serve as an exploration indicator for Ta-Nb deposits associated with highly fractionated peraluminous granites.

Keywords: Snowball quartz, Yichun 414 deposit, Yashan pluton, Ta-Nb mineralization, undercooling, magma degassing