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Fluid inclusion examination of the transition from magmatic to hydrothermal conditions in pegmatites from San Diego County, California

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Abstract

Thermometric properties and compositions of fluid inclusions in quartz are used to constrain the roles that fluid-soluble elements, principally Li, B, Cl, and F, have in controlling the transition from magmatic to hydrothermal mineral paragenesis in pegmatites and to ultimately understand why some pegmatites in the San Diego County pegmatite district contain abundant, gem-quality, Li-bearing minerals in pockets, whereas others do not. In this district, lithium-cesium-tantalum type pegmatites occur in the Mesozoic Peninsular Ranges Batholith. Emplacement of the dikes occurred at low pressures (200–300 MPa) that resulted in the formation of large miarolitic cavities (pockets), some of which contain gem-quality, Li-bearing minerals. Two pegmatite suites were studied: the gem-bearing Himalaya and the more barren La Posta.

The inclusions measured in this study further underscore highly undercooled crystallization of pegmatites. Pressure-corrected homogenization temperatures (T_h) of ~400 to 515 and ~70 to 425 °C were obtained for primary inclusions in the intermediate zone and the core, respectively, of a La Posta dike. Primary inclusions in the intermediate zone and the massive quartz core of the Himalaya pegmatite have T_h ranges of ~350 to 420 and ~150 to 300 °C, respectively. The high portion of the latter temperature range is interpreted to represent the conditions that existed during the initial crystallization of minerals that line pegmatite pockets.

The most important cations in fluid inclusions in both pegmatites are Na^+, B^{3+}, and Li^+. Lithium concentrations are much higher in inclusions in the Himalaya pegmatite, up to 51 at% of all cations within the massive quartz in the core zone. In the La Posta pegmatite, few primary inclusions contain appreciable Li. The B content of inclusions in both pegmatites is high, up to 65 at% of cations. The dominant anions in the inclusions are Cl^-, F^-, and SO_4^{2-}. The data suggest that hydrothermal fluids that collected in pockets were acidic and promoted the growth of tourmaline and other minerals that are stable in acidic solutions.

In both pegmatites, Na and B dominate secondary inclusions. These inclusions reveal fluids stripped of Li and K by crystallization of lepidolite within fractures of primary minerals throughout the pegmatites, and sometimes as an alteration product in pockets. The lowering of alkali/H^+ ratios in the fluid-stabilized clays, including kaolinite, that line the walls of pockets. Coeval crystallization of terminated quartz crystals with clays is consistent with its precipitation from the fluids.

Keywords: Pegmatite; Li; B; F; San Diego County, California; pocket minerals