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Evolution of the crystallisation conditions in the Wellington Lake Pegmatite in the Pikes Peak Granite, Colorado (USA)

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Pegmatites are texturally, mineralogically, and geochemically zoned rocks that show distinctive features such as graphic granite in the wall zones, coarse-crystalline material in the centre, and unusual mineralisation sometimes of economic significance. They are usually considered to be derived from silicate melts, but a significant fluid supply is also required to reproduce their unique characteristics. These fluids are commonly enriched in flux anions such as F^-, Cl^-, CO_3^{2-}, and BO_3^{3-}. Many studies have investigated the petrogenetic processes that led to pegmatite crystallisation, yet not all aspects of pegmatite formation have been fully understood. Notably, the nature of the precipitating medium remains uncertain for the different zones of the pegmatite. In order to better understand the transition from a silicate-melt-dominated crystallisation to fluid-dominated precipitation, we aimed to produce a temperature profile across the pegmatite and its host granite. We analysed quartz crystals from the different zones of the Wellington Lake Pegmatite and the host rock, a syenogranite of the Pikes Peak Batholith, in Colorado (USA). This NYF-type pegmatite consists of a fine-grained graphic granite wall zone, a coarse-grained quartz and albite intermediate zone, and pure blocky quartz core zone with REE-dominated mineralisation including fluocerite, bastnäsite, thorite, columbite, zircon, and cassiterite. Quartz trace element data (Al, Ti, Ge) suggest that the granite crystallized over a range of conditions, with Ti-in-quartz temperatures varying from 800 to 550°C. The wall zone of the pegmatite crystallised over a more constricted range, with temperatures on the order of ~660 to 630°C, just below the experimentally determined H_2O-saturated haplogranite solidus. Finally, the intermediate and core zones of the pegmatite show much colder conditions, with fluid inclusion homogenisation temperatures calibrated for typical pegmatite pressures ranging from 450°C (for 300 MPa) or 380°C (for 200 MPa) for the intermediate zone to 380°C (for 300 MPa) or 325°C (for 200 MPa) for the core. These results suggest crystallisation from a range of conditions transitioning from hydrous silicate melt-based mineral precipitation at the high temperature end (in the core of quartz crystals in the granite) to sub-solidus Al-Si-Na-enriched fluid precipitation in the interstitial quartz of the granite and in the pegmatite. Textural and geochemical zoning in the pegmatite records the transition from near-magmatic conditions in the borders to colder and more hydrothermal conditions in the core.