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A new paradigm for pegmatite formation: Generation of pegmatitic textures in a closed, isochoric system implied by the formation of miarolitic-class, segregation-type pegmatites in the Taishanmiao batholith, China

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The Taishanmiao granitic batholith, located in Henan Province, China, contains numerous small bodies exhibiting textures and mineralogy characteristic of simple quartz and alkali feldspar pegmatites. Analysis of melt (MI) and fluid inclusions (FI) in pegmatitic quartz, combined with Rhyolite-MELTS modeling of the crystallization of the granite, have been applied to develop a conceptual model of the physical and geochemical processes associated with formation of the pegmatites.

Field observations, geochemical data and results of Rhyolite-MELTS modeling indicate that the pegmatites represent the latest stage in the crystallization of the Taishanmiao granite, consistent with designation of the pegmatites as miarolitic class, segregation-type pegmatites rather than the more common intrusive-type of pegmatite. Based on the combined results of Rhyolite-MELTS prediction, the micropetrography (some inclusion assemblages consisting of only MI, while others contain coexisting MI and FI), and the relationship between halogen (F and Cl) and Na abundances in MI, the melt was probably volatile-undersaturated when pegmatites began to form, but became volatile-saturated as crystallization progressed.

We propose a closed system, isochoric model for the formation of the pegmatite. During the final stages of crystallization of the granite, small pockets of the remaining residual melt became isolated within the enclosing granite and evolved as constant mass (closed), constant volume (isochoric) systems, similar to the manner in which volatile-rich melt inclusions in igneous phenocrysts evolve during post-entrapment crystallization under isochoric conditions. As a result of the negative volume change associated with crystallization, pressure in the pegmatite initially decreases as crystals form and this leads to volatile exsolution from the melt phase. The changing PTX conditions produce a pressure-induced “liquidus deficit” that is analogous to liquidus undercooling, and results in crystal growth as required to return the system to equilibrium PTX conditions. During the evolution of this closed system, the pressure fluctuates as the system cools to maintain mass and volume balance. This behavior, in turn, leads to alternating episodes of precipitation and dissolution that serve to coarsen (ripen) the crystals to produce pegmatitic texture.