

SEG 2022 Conference: Minerals For Our Future

Metallogeny and Exploration Strategy for Alkaline Volcanic Rocks Hosting World Class Be-U-F Mineralization at Spor Mountain, Utah, U.S.A.

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New geochemical data for the Spor Mountain Formation (SMF) shed light on the metallogeny of rocks hosting the largest known deposit of beryllium in the world. The deposit and hostrocks (a lower Be-U-F-rich tuff and upper topaz-rich rhyolite) are part of an extensive sequence of Miocene-to-Oligocene alkalic rhyolitic tuffs and lavas occurring near the boundary between thicker and thinner crust. A broader understanding of the genesis of SMF is critical for evaluating regional and global exploration strategies for volcanic-hosted Be.

Key attributes of SMF include a magmatic Be-U-F enrichment stage from melting of continental lithosphere and later hydrothermal/metasomatic Be-enrichment stages. The magmatic stage is characterized by distinctive elemental (Be, REE, Y, Ti, by SHRIMP) contents in zircon. In post-magmatic stages, F-rich fluids reacted with tuff, altering glass and carbonate detritus to clay-rich sequences (primarily montmorillonite) containing high-grade (bertrandite + fluorite + opal) mineralization. The SMF shows contrasting behavior of Nb and Ta reflecting effects of prolonged fractional crystallization (e.g., large Eu anomalies) and pervasive hydrothermal alteration by F-rich aqueous fluids. A shared source and evolution for rhyolite and tuff are indicated by (1) regular, stacked subparallel, chondrite-normalized REE patterns, (2) overlapping sub-vertical arrays for Pb isotopes ($^{207}\text{Pb}/^{204}\text{Pb} \sim 15.60\text{-}15.70$ at $^{206}\text{Pb}/^{204}\text{Pb} \sim 18.60$), and (3) negative values of ϵ_{Nd} (average ~ -8.0). Pb isotopic ratios for SMF do not match slopes, initial isotope values, nor basement ages for precious/base-metal districts in Utah. Crustal ages from Nd isotopes (average $T_{\text{DM}} \sim 2.2$ Ga) are older than basement ages obtained by Pb isotopes. Rare-metal indices of granite-related mineralization (e.g., Nb/Ta, Zr/Hf) show SMF values overlap fields for globally-distributed Be-bearing granitic/rhyolitic deposits, for example, the Ermakovka F-Be deposit (Russia) and Baiyanghe Be-U deposit (China); however, none of these deposits match the mineralogy, geologic setting, or rare metal chemistry of the Spor Mountain system.