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Hunting the Magmatic Processes that Lead to Granite-Related W Mineralization

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Tungsten (W) is globally considered a critical metal due to its high economic importance and limited supply. Major W resources form within magmatic-hydrothermal systems, such as greisen, skarn, and porphyry. It is broadly accepted that W mineralization associated with granites is derived from evolved volatile-rich melts that are expelled from differentiating granitic magmas. The magma must undergo high degrees of differentiation to sufficiently enrich incompatible W in the residual phase and (or) originate from partial melting of a W-rich protolith. Frequently, W orebodies are associated with other metals, including tin (Sn), molybdenum (Mo), rare metals (Li, Be, Ta, Nb), and to a lesser extent copper (Cu), gold (Au), and iron (Fe). This study investigates the association of W with different commodities and indicates that varying combinations result from distinct ore-forming processes.

Magmatic processes are recorded in the geochemistry of granitic rocks associated with W deposits. Therefore, we have compiled whole-rock geochemical data from granites associated to W deposits in 90 locations worldwide, forming a dataset with >2,600 analyses from 203 publications. Most W-related intrusions have high silica contents (>70 wt %), are peraluminous, and subalkaline. However, suites associated with Au display lower silica contents (66 ± 5 wt % SiO_2) and higher FeO total contents. Many W-Sn and W-rare metal associations share similar geochemical signatures including higher P_2O_5 and Na_2O contents and a calc-alkalic composition. W-related magmas are mostly magnesian, particularly those from W-Cu and W-Au association. Tungsten associated with Mo, Sn, Fe and rare metal displays a trend from magnesian to ferroan compositions with increasing silica contents. W-Cu, W-Au, and W-Fe associations are not highly fractionated (Rb/Sr <10) in contrast to most W-rare metal deposits. W-Sn and W-Mo display a broad range of Rb/Sr. Some Pan African and Variscan age tungsten-related intrusions hold high-fluorine concentrations (>2,500 ppm).