

Mappable Criteria of Rare Metal-Bearing Peraluminous Granite-Related Mineral Systems

Joshua Rosera¹, George Case², Christopher Holm-Denoma³, Niki Wintzer⁴, Dalton McCaffrey⁵, Kelsey Crocker⁴, Lucas Evart⁴, Joshua Coyn⁴

¹U.S. Geological Survey, Geology, Energy & Minerals Science Center, Reston, USA, ²U.S. Geological Survey, Alaska Science Center, Anchorage, USA, ³U.S. Geological Survey, Geology, Geophysics, and Geochemistry Science Center, Denver, USA, ⁴U.S. Geological Survey, Geology, Minerals, Energy, and Geophysics Science Center, Spokane, USA, ⁵U.S. Geological Survey, National Minerals Information Center, Las Vegas, USA

Peraluminous granite-related mineral systems produce rare metal (RM) granite and pegmatite deposits that are among the primary sources of the critical commodities Li, Sn, W, Cs, Ta, and Rb. We present mappable criteria for these systems, based on their salient geologic characteristics, that aid efficient assessment and exploration. Defining features of these systems are their association with collisional tectonic settings and chemically evolved, peraluminous, and reduced igneous compositions thought to be derived from crustal melting and/or fractionation from peraluminous granitic magmas. Source rocks for these magmas are clay-rich metasedimentary rocks or possibly metaigneous rocks. Melting of these rocks is driven by crustal thickening, orogenic collapse, or shear heating. Debate continues over the relative importance of magmatic fractionation versus primary metal and/or flux enrichment of the crustal source. In the middle-upper crust of orogenic hinterlands, structural zones localize and transport melts into mineralogically zoned Li-Cs-Ta-Sn pegmatite districts. At upper crustal levels, separation of melt and fluid phases forms RM granite complexes characterized by zonation from moderately evolved ilmenite-series biotite granites into smaller, highly evolved, albite and Li-mica granites with apical Sn ± W greisen ± proximal skarn. Distal polymetallic vein or epithermal deposits are enriched in Sn, As, Sb, Pb, and Zn. More than half of RM pegmatite resources are related to Archean and Proterozoic orogens, whereas RM granite resources are prevalent in Phanerozoic orogens. Important mappable criteria are derived from: lithotectonic maps and geochronology data that define permissive orogens and plutonic suites; geologic and metamorphic maps that identify amphibolite facies source rocks or precursor granites; structural and geophysical maps that delineate potential conduits; and geochemical indicators of strongly peraluminous and evolved magmas such as high Rb/ Sr, low K/Rb, Nb/Ta, and elevated rare metal abundances. Shallow RM granite complexes can be mapped via aeromagnetic and gravity surveys.