Mapping mineral systems to bolster predictive analyses of critical mineral potential for the United States of America

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Mineral systems are a wholistic geologic framework that relates coeval and cogenetic mineral deposits to their formation in geotectonic environments. A mineral system may generate multiple deposit types, and a single deposit type may form in multiple mineral systems – demonstrating the many to many relationships intrinsically associated with ore deposits and systems. The utility of mineral systems is that they represent geologic frameworks with regional-scale footprints contrasting with the relatively small footprints of deposits or districts. Mineral systems relate precious and base metals to critical minerals commonly found as co- or by-products.

One common schema for mineral systems describes the tectonic setting in which they form, such as convergent, divergent, and passive settings. Each tectonic setting may have multiple geotectonic stages (e.g. subduction, orogenesis, post-orogenic collapse) and settings (continental arc, island arc). Mineral systems can be broken down into various constituent components that include: 1) triggers, 2) drivers, 3) component sources, 4) transport, 5) trap, 6) and preservation. Each component can be mapped using defined geologic criteria, representing prospectivity for deposits based on the presence of portions of the system at different scales and temporal parts of the overall system.

Developing mappable criteria forms the linkage between the theoretical system and the application to resource assessments and mineral exploration. Mappable criteria involve identification of the important geologic feature(s) for each component of the system, how it can be mapped, and what datasets can be used to map the system. The U.S. Geological Survey is currently developing mappable criteria for 24 mineral systems prioritized by their importance as domestic sources of critical mineral resources. Mapping mineral systems by their fundamental components can elucidate prospectivity for concealed deposits by highlighting the presence of important system-scale components in areas that lack outcropping deposit or district-scale features – enhancing exploration and land management decisions.