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Allanite Mineralization in the Unconventional Halleck Creek REE Deposit, Wyoming

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Growing technological demand and supply chain vulnerabilities have prompted a renewed effort to evaluate the United States' rare earth element (REE) resources. Several unconventional REE deposits have been identified during ongoing exploration, and advancements in metallurgical processing have broadened the feasibility of extracting REEs from previously underutilized REE minerals. The Halleck Creek deposit in southeastern Wyoming is a large, newly identified REE deposit with an estimated 2.63 billion metric tons at an average grade of 0.28 wt% total REE (TREE).

Hosted within the Mesoproterozoic Red Mountain Pluton (RMP), the Halleck Creek deposit is characterized by light REE (La-Gd) enrichment sourced primarily within allanite. Variable abundance of other REE minerals, including chevkinite and zircon, is also observed. New geochemical and textural evidence from core and surface samples reveals lithological variations across the pluton and aids in identification of mechanistic controls on the distribution of REE in the deposit. Whole rock TREE concentrations reach 1.1 wt%, and SiO_2 vs $\text{Na}_2\text{O} + \text{K}_2\text{O}$ values indicate monzogabbro to granite lithologies. Allanite is found variably dispersed across all lithologies but locally accumulates with mafic minerals (amphiboles $\pm$ clinopyroxene $\pm$ ilmenite), resulting in the highest-grade samples. LA-ICP-MS data from RMP allanite show TREE concentrations ranging between 12.4 and 20 wt%, and 51.7 to 55.7 wt% TREE for RMP chevkinite. SEM and LA-ICP-MS element mapping demonstrate key textural and geochemical variability across individual mineral grains. Together, these data enrich the ongoing characterization of the Halleck Creek deposit and enhance our understanding of the metallogeny of the RMP, revealing key geochemical and textural constraints for high-grade target exploration.