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Stratigraphic Controls on Heavy Rare Earth Enrichment in the Phosphoria Formation of Southwest Montana

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The Phosphoria Formation in the western United States has produced phosphorous products for over a century from various mines in Idaho, Utah, and Montana.

Modern, comprehensive, whole-rock assays, have shown that some phosphorite strata in this formation are enriched in rare earth elements (REEs). The degree of enrichment varies from about 200 to 3500 ppm total elemental REE (including Y). The exact grade can vary depending on the specific bed, and the location of the measured stratigraphic section. Regardless of the specific grade, ~45% of the REEs are heavy: Tb, Dy, Er, Ho, Tm, Yb, Lu, and Y.

The REEs are locked in the phosphorous ore mineral francolite (biogenic, impurity-rich, apatite) on a substitutional basis. Automated SEM-EDS and LA-ICP-MS analyses show that there are no other REE-bearing phases of note in the phosphorite. Phosphate phases are needed to host the REEs, but the relationship between P and REEs varies.

The current processing of most phosphorite in the USA involves digestion of the REE-bearing phases. Some of the processed ore may contain REE grades at levels worthwhile to consider the recovery of them as a byproduct.

As there are no domestic heavy REE projects near production in the USA, consideration of these byproducts may present an opportunity to resolve eight of the 60 critical minerals listed as of 2025.