

Geochronologic Data Infrastructure for Critical Mineral Systems: The USGS Geochron Database and a National Coverage Gap Analysis

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Mineral deposits form within narrow windows of geologic time. Understanding when systems were active is as fundamental to mineral exploration and resource assessment as knowing where they occur. The mineral systems concept recognizes four key components: lithospheric architecture, transient favorable geodynamics, fertility, and preservation. Each has an essential temporal dimension that only geochronology can directly constrain. Yet geochronologic data have historically been scattered across publications, agency reports, and laboratory archives, limiting their utility at the regional scales relevant to exploration targeting and national resource assessment.

The USGS Geochron Database (doi:10.5066/P9RZNPIF) addresses this problem by providing open access to over 200,000 isotopic age measurements from more than 35,000 samples compiled from USGS and cooperating state geological surveys. This standardized, queryable archive integrates geochronological and thermochronological methods, ranging from Quaternary techniques like radiocarbon and luminescence to long-lived isotopic systems including U-Th-Pb, Sm-Nd, Rb-Sr, Lu-Hf, Re-Os, and ⁴⁰Ar/³⁹Ar.

We present the first systematic assessment of U.S. geochronologic data coverage for critical mineral systems, evaluating spatial and temporal data availability relative to diagnostic age windows for deposit types including porphyry copper, sediment-hosted copper, and rare earth element systems. Results identify specific regions where geochronologic data are sparse relative to known or suspected mineral potential. These gaps represent both a limitation on current exploration confidence and a data-driven basis for prioritizing future sampling. As exploration increasingly targets covered terranes and greater depths where deposit-scale footprints are not visible, this national geochronologic dataset serves as an essential geoscientific framework for both human and AI-assisted targeting workflows.