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REE Mineralization in the Yushishan Nb-Ta-REE deposit (South Qilian, NW China): Constraints from calcite, allanite and monazite geochemistry

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REE Mineralization in the Yushishan Nb-Ta-REE deposit (South Qilian, NW China): Constraints from calcite, allanite and monazite geochemistry.

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The Yushishan Nb-Ta-REE deposit, situated at the intersection of the Altyn-Tagh fault and Qilian block, records a complex history of multiphase tectonic-magmatic-metamorphic evolution. This deposit, hosted in leptynite with associated alkaline rock dikes (aegirine-augite syenite and syenite), reveals critical insights into rare earth element (REE) enrichment processes. Three calcite types were identified: **Type I:** Anhedral grains intergrown with aegirine-augite in syenite; **Type II:** Subhedral crystals crosscutting allanite in syenite; **Type III**: Veins transecting allanite in mineralized leptynite. Geochemical analyses demonstrate that all calcites exhibit Yb/La ratios (0.033–29.93) diagnostic of hydrothermal origins. Their $\delta^{13}C_{PDB}$ values (–3.6‰ to –0.9‰) overlap with mantle-derived carbon signatures (–5‰ to –8‰). Strontium isotopes further distinguish genetic environments: calcites in alkaline veins show $^{87}Sr/^{86}Sr$ = 0.70863–0.72159, while Type III calcite in leptynite displays elevated ratios (0.7216–0.7468), reflecting contamination by host-rock materials.

Monazite from granitic mylonite and mineralized leptynite exhibits low Th concentrations (9,752–33,499 ppm), consistent with hydrothermal formation. U-Pb geochronology yields concordant ages: monazite $^{208}Pb/^{232}Th$ weighted ages of 491 ± 6 Ma and 492 ± 3 Ma, and allanite Tera-Wasserburg lower intercept age of 491 ± 30 Ma. Monazite $\varepsilon_{Nd}(t)$ values (–0.5 to 0.28) align with those of alkaline dikes (–0.78 to –0.09), confirming a shared magmatic source.

These results collectively establish that REE mineralization at Yushishan originated from ~490 Ma alkaline magmatism, which supplied both heat and ore-forming fluids to the leptynite-hosted system. Calcite and monazite geochemistry thus provides robust constraints for tracing fluid-rock interactions and metallogenic processes in similar REE-bearing systems.