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Apatite recorded multiple W–Sn–Nb–Ta mineralization in the Limu greisen–type deposits, Nanling Metallognic Belt, South China

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The chemical composition of apatite in magmatic–thermal deposits is influenced by both the crystallization differentiation of parent magmas and the associated hydrothermal fluids [1]. Apatite thus serves as a critical indicator for understanding geological processes, though interpretation criteria remain unclear. To address this, we studied the Limu W–Sn–Nb–Ta greisen–type deposit in South China through field surveys, mineralogical, geochemical, and chronological analyses. Our goal was to test for multiple W–Sn–Nb–Ta mineralizations and establish discrimination models for Nb–Ta mineralization linked to multi–stage hydrothermal fluids. The Limu pluton (230–200 Ma) is an ultra–felsic, peraluminous S–type granite with distinct geochemical signatures in W, Sn, Nb, and Ta mineralization [2]. We categorized the apatite at Limu into three types: (Ia) microporous granular fluor–hydroxyapatite, (Ib) vein–like fluor–hydroxyapatite, and (II) idiomorphic Sr–rich fluor–hydroxyapatite. Chondrite–normalized rare earth element (REE) patterns of apatite show δCe ratios ranging from 1.08 to 1.96, δEu ratios between 0.01 and 0.31, and Sr/Y ratios of 0.28 for Ia–apatite, 12.27 for Ib–apatite, and 12750.87 for II–apatite, all indicative of typical S–type granite characteristics. The δCe and δEu ratios indicate a strongly oxidizing environment in the Limu greisen, while fluctuations in the Sr/Y ratio reflect evolved hydrothermal processes linked to sedimentary rock remelting [3]. Notably, the Ib–apatite in greisen exhibits a well–preserved closed system, yielding an age of 78.0 ± 1.8 Ma, significantly younger than the youngest granite with a crystallization age of approximately 200 Ma. This suggests that W–Sn–Nb–Ta mineralization occurred through tectonic processes over a multi–stage timeframe, spanning from 230 Ma magmatism to 78 Ma hydrothermal activities [4]. Therefore, the Limu apatite records multiple episodes of W–Sn–Nb–Ta mineralization and remobilization associated with a complexity of magmatic–hydrothermal events.

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