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Critical metals enrichment and its controlling factors of Upper Carboniferous karst bauxite, North China Craton

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Bauxite deposits are a vital source of critical metals, which are in high demand globally. Understanding the critical metals enrichment mechanisms is key to efficient tailings purification and utilization. The North China Craton (NCC) contains one of the world's largest karst bauxite deposits, but the mechanisms driving critical metal enrichment remain unclear. We analyzed geochemical data from 20 areas within the Benxi Formation to explore the stratigraphic controls and enrichment mechanisms of critical metals.

The bauxite series of the Benxi Formation in NCC is rich in critical metals, including Li (423 ppm), B (350 ppm), ΣREE (655 ppm), Ga (36.8 ppm), and TiO2 (2.3%). The bauxite sequence is divided into five sections: ferrilite (Section A), (bauxitic) mudstone (Section B), bauxite (Section C), (bauxitic) mudstone (Section D), and dark mudstone-coal (Section E). Sections B-D represent a complete sedimentary cycle shaped by varying weathering intensities.

During periods of intense groundwater fluctuations, increased weathering and leaching processes led to the thickening of the bauxite section (Section C), causing clay minerals to transform into Al-hydroxides. This facilitated the downward migration and accumulation of REEs and B in Sections B-C. Ga primarily incorporated into Al-hydroxide via isomorphic substitution and co-deposited with stable elements like Ti in Section C. When groundwater fluctuations were minimal, weak weathering produced thinner or absent bauxite sections and more developed mudstone sections (B and D). These mudstones, rich in clay minerals, allowed Li and B to accumulate gradually.

In Section D, weak weathering and limited water mobility preserved and enriched clay minerals like cookeite, leading to Li accumulation. The enrichment of B and REE was primarily driven by adsorption and migration, with their accumulation in Sections B-C.

This study reveals the complex relationship between sedimentary environments and weathering processes in critical metal enrichment in the bauxite series of NCC. These findings offer valuable insights into metallogenic processes and provide a new pathway for the sustainable development and utilization of critical metal resources globally.

