

Binding mechanisms of Y and HREE sorption on birnessite: New insights into the formation and sustainable development of regolith-hosted REE deposits

**YUZHOU FENG^{1,2}, HUAYONG CHEN^{2,3}, YUANMING PAN^{1,*}, REZA DEEVSALAR¹, LEO KA LONG CHEUNG¹,
AYETULLAH TUNC¹, KENAN CAO¹, YUXIANG ZHU^{1,†}, RENFEI FENG⁴, MOHSEN SHAKOURI⁴,
QUNFENG XIAO⁴, NING CHEN⁴, BING XIAO^{1,2}, AND HUI ZHENG²**

¹Department of Geological Sciences, University of Saskatchewan, Saskatoon, Saskatoon S7N 5E2, Canada

²Guangzhou Institute of Geochemistry, Chinese Academy of Sciences, Guangzhou 510640, China

³University of Chinese Academy of Science, Beijing 100049, China

⁴Canadian Light Source Inc., 44 Innovation Boulevard, Saskatoon, Saskatoon S7N 2V3, Canada

ABSTRACT

Regolith-hosted rare earth element (REE) deposits are the world's primary source of heavy REEs (HREEs) critical to the global clean-energy transition. Previous studies suggested that REEs in regolith-hosted deposits are largely inherited from their parent granites. However, several HREE-dominated deposits occur in the weathering crusts of light REE (LREE)-enriched granites, where the mechanisms of REE fractionation remain poorly understood. Also, the conventional mining method of regolith-hosted REE deposits has limited efficiencies in REE recovery while causing enormous environmental contamination. Herein, we have investigated the distribution and speciation of Y and REEs in three representative regolith-hosted REE deposits (i.e., Gucheng and Shangyou, HREE-dominated; Renju, LREE-dominated) as well as Y-sorbed birnessite from batch experiments. Our results show that birnessite in all three deposits is a minor constituent but contains anomalously high concentrations of REEs and contributes to 25.3, 23.4, and 26.5% of the HREE contents of mineralized saprolites. Measured Y *K*-edge X-ray absorption spectroscopic data suggest that Y³⁺ (representing HREE³⁺) is adsorbed on birnessite as YO₈ complexes in all three deposits but via different linkages: i.e., the bidentate corner-sharing mode in the HREE-dominated deposits but a mixture of both bidentate corner-sharing and edge-sharing modes in the LREE-dominated deposit. These binding mechanisms are also observed in Y-sorbed birnessite prepared at different ionic strengths. Therefore, different binding mechanisms of Y and HREE sorption on birnessite together with its preferential adsorption of HREE not only are responsible for the formation of HREE-dominated deposits from LREE-enriched granites but have important implications for the sustainable development of regolith-hosted REE deposits.

Keywords: Regolith-hosted REE deposits, birnessite, synchrotron X-ray absorption spectroscopy, Y and HREE binding mechanisms, REE fractionation, sustainable development of critical minerals