

Difference in the partition behaviors and speciation between scandium and other rare earth elements in nickel laterite ore deposits

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Scandium (Sc) is a critical metal with wide applications in modern industrial applications. Consequently, the enrichment of Sc at earth surface has been of great interest in resource geology. It has been reported that laterite enriched with nickel (Ni laterite) contained significant amounts of Sc (about 80-100 ppm). The vertical profile of Ni laterite mainly consists of bed rock, saprolite, and limonite layers from bottom to the top. Generally speaking, Ni remobilized downward during weathering processes leads to the enrichment of Ni in the saprolite layer, while maximum Sc enrichment is found in the limonite layer mainly consisting of goethite. However, distribution and speciation of Sc in the limonite layer are not clear at present, which was examined by μ -XRF mapping and X-ray absorption fine structure (XAFS) spectroscopy in this study. In addition, similar information such as abundances and speciation was obtained also for other rare earth elements including yttrium (REY) to compare geochemical behaviors between Sc and REY.

Micro-XRF analysis revealed that Sc and Y are distributed to goethite in the limonite layer. Sequential extraction revealed that Sc remains in the residual phase which goethite is still present even after the treatments by reducing agents and aqua regia. XANES and EXAFS analyses for Sc in the limonite layer and its comparison with synthetic samples of Sc coprecipitated with goethite and Sc adsorbed on goethite revealed that Sc was incorporated within the goethite structure replacing Fe^{3+} site. This result is reasonable considering the similar ionic radii (6 coordination number) of Sc^{3+} (0.75 Å) and Fe^{3+} (0.65 Å). On the contrary, EXAFS for the Y samples synthesized similarly to Sc showed that Y cannot be incorporated within the goethite structure, possibly due to its large size (ionic radius of Y^{3+} : 0.90 Å) compared with Fe^{3+} . The sequential extraction showed that most of Y was present as ion-exchangeable species or Y in amorphous Fe and Mn oxides, which are consistent with the fact that Y is mainly present as adsorbed species on goethite. These results clearly explain fractionation of REY and Sc in limonite layer, with steep increase from Yb^{3+} to Sc^{3+} when we plot Sc at right of Lu in REY pattern.

The high concentration of Sc in Ni laterite is caused by (i) high concentration of Sc in the original rock (peridotite) and (ii) effective fixation of Sc^{3+} within goethite by substitution of Fe^{3+} site by Sc^{3+} during intense weathering to form laterite.

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