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REE concentration processes in ion adsorption deposits: Evidence from Madagascar and China.

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Lateritic clay deposits, where the rare earth elements (REE) occur adsorbed to clay mineral surfaces, are the world's dominant supply of heavy REE (Gd-Lu). These deposits are currently only mined in China where there is a reported heavy REE enrichment, but other deposits are currently under exploration in Brazil, the Philippines and Madagascar. Concentration of REE within IADs has been proposed to be a dominantly supergene process, where easily degradable REE-minerals (e.g. REE-fluorcarbonates) break down and release REE that are then adsorbed to clay minerals resulting in HREE enrichment. Here we present data from the Ambohimirahavavy Complex, Madagascar, and compare them to data from mineralised profiles in China, with the aim of further constraining the formation and REE enrichment processes in ion adsorption deposits. Bulk rock total REE contents from Madagascar vary from 400-5000ppm, with the HREE varying from 10 to 20% of the TREE. Ammonium Sulphate leaches (designed to remove clay-adsorbed REE) of laterite show leachable TREE from 130-500ppm, with no preferential HREE adsorption. Within the sequential extraction procedure the reducible fraction (hydroxylammonium chloride leach) showed the highest REE, but this is largely attributable to Ce4+ in oxide layers. Analysis of laterite profiles show that the REE distribution is heterogeneous, with control from both bedrock heterogeneity, and the hydrological variation between pedolith and saprolith. Similar patterns are seen in Chinese profiles from Jiangxi province. X-ray diffraction shows the clay fraction in all sites is dominated by kaolinite and halloysite. These data are consistent with experimental data which show that kaolinite is only HREE selective in high ionic strength solutions (Coppin et al., 2002), and suggest that HREE enrichment in lateritic deposits may be a function of exceptional bed rock conditions. Petrographic investigation of the Zhaibei granite, immediately underlying HREE enriched weathering profiles in Jiangxi province has identified the presence of HREE-enriched secondary phases associated with carbonate-rich areas (Xu et al., In press). Neodymium isotope data from primary granitic minerals (εNd(t)=-11.5$\pm$0.5) contrasts dramatically with data from HREE-enriched minerals (εNd(t)=0.9$\pm$0.8) indicating that pre-weathering metasomatism from fluids derived from outside the granite system may be critical in the HREE enrichment process of mineralised laterites. This may be important in determining the viability of ion adsorption deposits as HREE resources.

Coppin et al. (2002) Sorption of lanthanides on smectite and kaolinite. Chem. Geol. 182, 57-68
Xu et al., (In press) Origin of heavy rare earth mineralization in South China. Nature Comms.