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Geochemical and mineralogical constraints on the distribution and enrichment of the rare earth elements during pedogenesis and tropical weathering

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Current European manufacturing relies heavily on imports from the USA & China for unprocessed rare earth elements (REEs) and rare earth oxides (REOs). It has been suggested that the EU holds viable reserves of REEs that, with adequate research, could satisfy 10% of EU industrial demand, by the recycling of mine waste from bauxite production (red muds) alone (Deady, E. (BGS), 2014). Focus has been turned to the potential for Mount Weld type laterite deposits being exploited in the EU, but limited exploration and understanding of EU laterite (& paleo laterite) formations currently makes them unattractive to investment.

Although previously researched, the full range of factors influencing the transition of rare earth (primarily lanthanide series, Y & Sc) elements between mineral and clay phases in allochthonous soils, saprolites and laterites is not fully understood, especially in present and Paleo-European environments (Herrington, Boni, Skarpelis, & Large, 2007) (Deady, E. (BGS), 2014) but several deposits globally are suggested to have formed at economically viable concentrations due to this secondary remobilisation & transition from mineral to clay phase and subsequent seasonal leaching and evaporation system, to form depositional buffer zones other than the soil base. (Hoatson, Jaireth, & Miezitis, 2011) (Berger, Janots, Gnos, Frei, & Bernier, 2014).

This project intends to use new techniques in sequential extractions, ICP-MS, Quantitative XRD & SEM analysis to expand current knowledge around lateritic & allochtonous ore forming, & weathering processes. Heavy REE content and mineralogical variations in clays will be examined, with examples from a selection of profiles across Southern Europe (and potentially paleo soils from Scandinavia) to define the main influencing factors on REE concentration. Are the specific sites enriched simply by the nature of their source rock (protolith), by the soil formation (pedogenesis), or by biogenic & meteorological factors?

These results will then be applied in targeted, environmentally focused exploration projects, and perhaps enhance techniques used industrially for the extraction of HREEs, for less environmentally damaging production in sensitive areas (with current research sites within national parks in Italy and Portugal; and in areas where it is believed more attention should be paid to environmental preservation, including Central Turkey and Southern China).

It is hypothesised that: HREE content in tropical laterite formations is due primarily to the source rock's mineralogy, although it's distribution is a result of slower genesis and leaching as opposed to more common biogenetic pedogenesis. It is suggested this distribution initially forms banded horizontal enrichment zones according to protolith, but eventual separation of heavy and light REEs is controlled by clay-surface (the protolith's weathering style), solvent type, fluctuation and availability. It may be found, as in Fe-Ni laterite resources globally (Herrington, Boni, Skarpelis, & Large, 2007) (Eliopoulos, 2000), that high initial bedrock concentrations of REEs are not necessarily required if prolonged weathering continues to concentrate these elements/minerals over longer periods (although this has been found inversely in certain Turkish bauxites (Karadag˘, Peli, Ary, & Ayhan, 2008)).

Regardless of eventual concentrations, identifying the argillic phase and the time scales required for clay REE hosting clay formation may broaden the European search for supergene enrichments to REE hosting marine shales, mineral sands and other sedimentary formations that have been long-term- weathered without major displacement.