Sources of rare earths and prospects for a viable REE deposit in river sediments of Kerala, southwest India

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Studies on rare earth elements (REEs) of river sediments from Kerala, India indicate that the average total REE (ΣREE) of clay and silt-sized fractions is much higher than in Post-Archaean average Australian Shale (PAAS). Peak high ΣREE for the clay fraction is found in the rivers of central Kerala and, for the silt fraction, it is in south and central Kerala. ΣREE shows a moderate to strong correlation with Mn and P and, no correlation with Al, Fe and Ti in both size fractions. ΣREE also shows no correlation with heavy metals in the clay fraction but a strong correlation in silt fraction. PAAS-normalized REE shows MREE-enrichment in almost all the samples. Further, LREE-enriched and HREE-depleted REE patterns are characteristic of sediments from south and central Kerala, and HREE-enriched or flat REE patterns are characteristic of sediments from north Kerala. Weak positive or weak negative Ce anomalies are characteristic of the sediments. The Eu anomaly is negative in a few silt fractions from south Kerala and positive in all other sediments. Sm/Nd ratios are high in the clay fraction and decrease with increasing ΣREE for the sediments of central Kerala. REE enrichment and REE patterns are related to the felsic component and heavy mineral content in the sediments of south Kerala, adsorbed REE associated with the weathering products of laterites in the sediments of central Kerala, and the dominance of mafic component in the sediments of north Kerala. The river sediments of central Kerala may serve as a viable REE deposit because of their high REE content, inexpensive mining, easy recovery and extraction of REE. Only 21 out of 41 rivers of Kerala were analysed in this study. Detailed exploration in other rivers may expand and confirm the potential REE deposits and their economic viability. This REE deposit is different from the placer sand deposits on the beaches of south Kerala.

Keywords: Clay and silt fractions, Kerala, laterite, rare earth elements, river sediments.

RARE EARTH ELEMENTS (REEs) are a coherent group of elements widely used as tracers to understand better the geological evolution of the continental crust, provenance, palaeoclimate and palaeoceanography, geochemical and sedimentary processes associated with weathering, erosion, transport and deposition of sediments in the riverine, estuarine and marine systems, and diagenesis[1–14]. Chemical weathering of rocks is an important process, wherein mobile REEs are removed, and immobile REEs are enriched with the weathering products[15]. REEs thus are not only fractionated but also concentrated into REE deposits during lateritization of bedrocks[16–18]. Cocker[19] reported higher REE content in weathering profiles and laterites than in parent rocks. REE content was four times higher in the laterites than in granites from the Riau Islands, Indonesia[20]. Moreover, sedimentary REE deposits related to the chemical weathering of rocks, known as Ion-Adsorption-type Deposits (IADs), have been reported[21–25] and mined in South China[22,23].

The Kerala region is located in the southwestern part of peninsular India, and its landscape is covered by thick laterites. Bauxites have also been reported (Figure 1). At least 41 west-flowing, rainfed, minor and medium rivers drain the landscape of Kerala, bringing sediments from bedrock and laterites[26]. The river sediments are expected to contain weathering products of rocks and laterites, further modified by erosion and sorting processes which occurred during transport from the source to the sink site. The purpose of this study is to determine: (a) the REE sources in the clay and silt-sized fractions of sediments in the rivers of Kerala and the factors controlling their distribution and (b) indicate a viable REE deposit in the river sediments. This REE deposit is similar to IAD, being reported from the laterite soils of India. It is different from the placer mineral deposits in the beaches of south Kerala[27].

REE distribution in the Vembanad estuary, coastal and shelf region of Kerala and impact of rare earth mining