Effects of heavy mineral processing on stream waters in Malaysia as indicated by REE patterns, Pb and Fe isotopes

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The processing of igneous and placer type rare earth element (REE) deposits may generate radioactive wastes as well as acid drainage due to their high content of radioactive elements (e.g. Th, U) and the use of acids to decompose REE-bearing minerals. Therefore, appropriate indicators must be established to assess the environmental impacts of REE extraction. In this study, we collected water and sediment samples from Kinta River as well as two of its tributaries near Ipoh city, Malaysia, where heavy minerals (e.g., ilmenite, monazite) are processed. We analyzed the dissolved concentration of major and trace elements, as well as Fe and Pb isotope ratios.

Major element concentrations in the water samples indicate that they are mainly controlled by the underlying lithology: limestone or granite. However, water samples from a tributary near an ilmenite processing plant and water leaked from the tailings pond show very low pH (2.4–6.0), high Cl (900–6800 ppm) and Fe (82–2000 ppm) concentrations. The samples are also characterized by high REE (<31 ppm), Th (<340 ppb), U (<870 ppb). The REE patterns and Pb isotope ratios of the tributary water samples resemble those of water leaked from the tailings pond. In this tributary, the Fe isotope ratios decrease downstream, which can be explained by Rayleigh fractionation due to the oxidative precipitation of iron hydroxides. These data suggest that the high concentrations of the above elements are due to the heavy mineral processing operations nearby. Therefore, they may be used as indicators of environmental impact. Although the concentrations of REE, Th and U decrease downstream, the removal efficiency of these elements decrease in the order of Th>U>REE. The results of geochemical modeling suggest that Th may be removed by precipitation with increasing pH while U may be up taken by iron hydroxides precipitated from the stream water.