Rare earth element enrichment in the Precambrian-Cambrian marine phosphate deposits in South China: A trace element and isotope perspective

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Rare earth elements (REE) are critical metals that are important for high-tech industry, and almost 90% of REE resources are produced in China in the past decades, with the most important supply from the carbonatites (e.g. LREE, Bayan Obo) and the granite weathering crusts (e.g. HREE, South China). There are widespread occurrences of marine phosphate deposits in the Neoproterozoic to early Cambrian sequences in South China, and high abundance of REE has been found in these rocks, which may serve as a possible new source of rare earth elements in particular the HREE (for example, Y_2O_3 reserve in the Zhijin phosphate deposit of Guizhou Province reaches up to 1.24 Mt, which constitutes 35.33% of ∑REE). In order to reveal the REE and P enrichment mechanism and formation condition of these phosphate deposits, we carried out a detailed mineralogical, geochemical and isotope investigation for the phosphate rocks and minerals from both the Ediacaran Doushantuo Formation and the Early Cambrian Niutitang (Gezhongwu) Formation in South China. In general the phosphate phases show either a MREE enriched hat shaped or a seawater-like shale-normalized pattern, and LA-ICP-MS analysis reveals an increase in total REE contents (∑REE) from the grain core to the rim. The REE characteristics reflect an early diagenetic enrichment process. The negative Ce anomaly and the redox-sensitive trace metals indicate an oxic bottom water condition, and the positive Eu anomaly and O-Nd-Mo-Os isotopes reflect involvement of hydrothermal fluids during the phosphogenesis.