Rare earth elements in lacustrine sediments from the core SG-1: Implications for source area chemical weathering

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As part of the nation-level cooperation program TiP (Tibetan Plateau: Formation, Climate, Ecosystems) between China and Germany launched about five years ago, a Chinese and German research team jointly conducted a drilling campaign in the Qaidam Basin on the NE Tibetan Plateau in order to make detailed studies on sedimentologic, paleohydrologic and climatic changes in relation to drying of Asia and uplift of the Tibetan Plateau. Based on detailed magnetostratigraphy and rare earth elements (REEs) speciation investigations, we attempt to explore the proxy potential of REEs in calcareous lacustrine sediments to decipher the Quaternary chemical weathering and climate change in the western Qaidam basin, aiming at exhibiting the significant value of REEs mobility in studies of long-term chemical weathering history in the drainage area, also providing a robust base to understand the processes of Quaternary drying of the Asian inland.

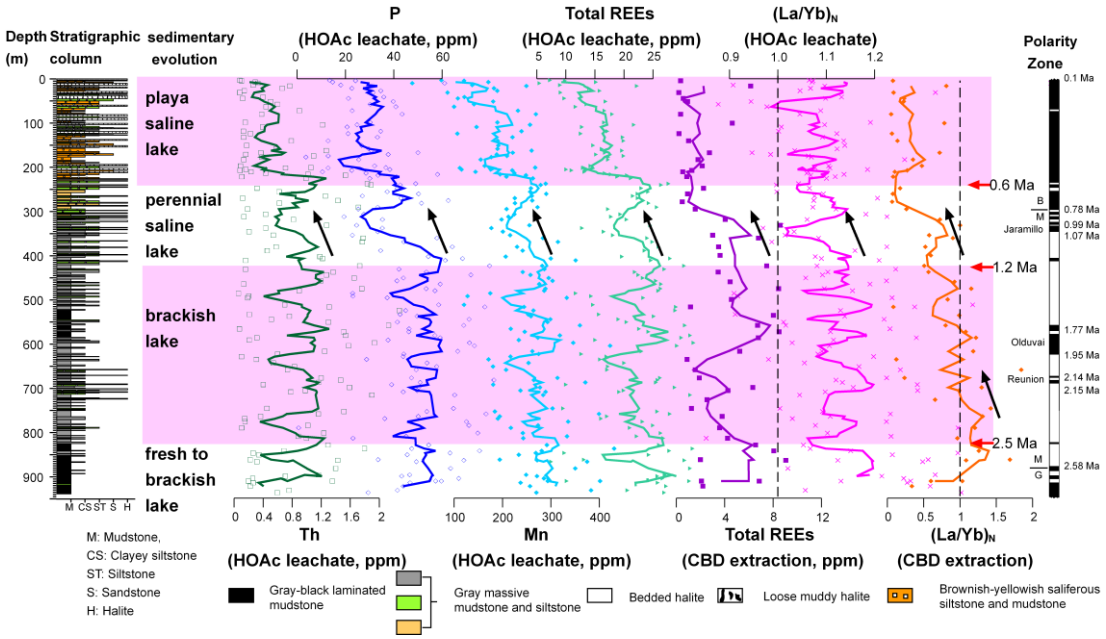

Figure 1. Depth functions of total REEs and $(La/Yb)_N$ in HOAc leachate and CBD extraction as well as the P, Th, and Mn concentrations in HOAc leachate of the SG-1 core sediments,where the subscript N indicates that values are normalized to the PAAS. The heavy solid lines show 3-point running averages. The lithologic column and stages of sedimentary evolution come from Wang et al[1]. Paleomagnetic results are based on Zhang et al. (2012)[2].

This study analyzed rare earth elements (REEs) in the calcareous lacustrine sediments from core SG-1 in the western Qaidam Basin in order to evaluate the usefulness of their abundance and fractionation in understanding chemical weathering in drainage area. We used acetic acid (HOAc) to leach the labile fraction of REEs and citrate-bicarbonate-dithionite (CBD) to extract REEs associated with Fe-Mn oxides/oxyhydroxides (Fig. 1). Four REEs phases in the core sediments were identified, including HOAc leachate, HOAc residue, CBD extraction, and the bulk phase. On average, portion of REEs in HOAc residue constitutes about 80% of the bulk phase, while those portions from HOAc leachate and CBD extraction make up 18% and 3%, respectively. The shale normalized REEs patterns of all phases show obvious middle REE enrichments, except that low REE concentrations samples in

the CBD extraction phase show heavy REE enrichments. The REE's characteristics in the HOAc residue phase, and to a lesser extent in the bulk phase, remain stable along the core, while those in HOAc leachate and CBD extraction vary dramatically. Comparing REEs abundance and fractionation in HOAc leachate and the CBD extraction phases with contents of other extracted elements, as well as contents of carbonate and Fe-Mn oxides/oxyhydroxides, demonstrates that REEs abundance and fractionation in HOAc leachate and CBD extraction phases are controlled by chemical weathering conditions in the drainage area and interactions between the dissolved and particulate fractions during transport and sedimentation. The REE abundance and the degree of fractionation of HOAc leachate and CBD extraction phases may provide sensitive proxies for the intensity of chemical weathering in the source area, which relate to the paleolake sedimentary evolution. The REE records in the core SG-1 reveal a long-term weakening of chemical weathering since 2.77 Ma in the western Qaidam Basin (Fig.2).

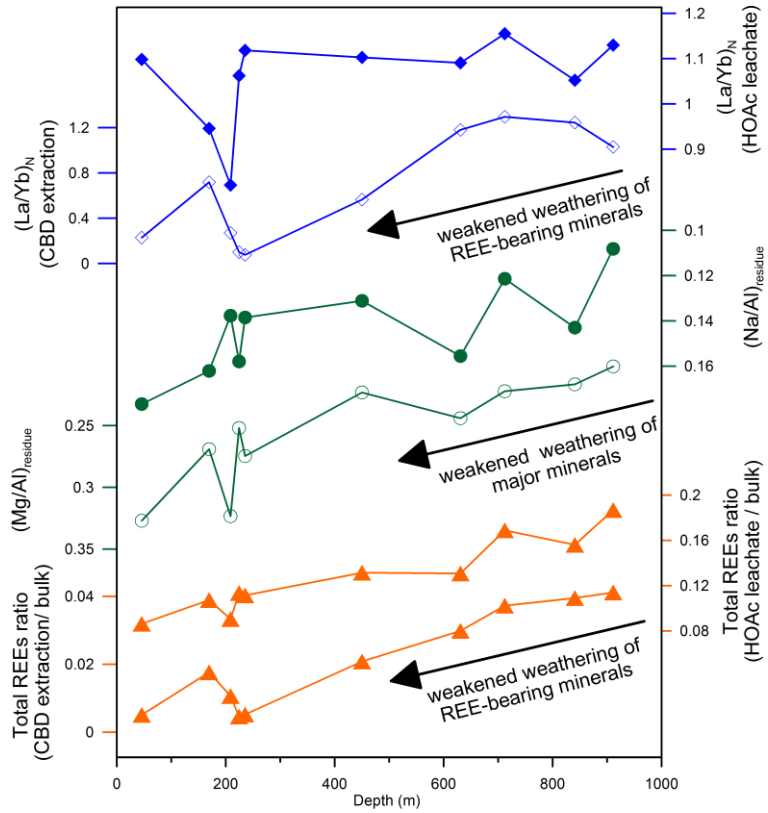

Figure 2. (a) Depth functions of Total REEs (HOAc leachate) /Total REEs (bulk) and Total REEs (CBD extraction) /Total REEs (bulk) as well as Na/Al and Mg/Al in the HOAc residue. The variations of $(La/Yb)_N$ in HOAc leachate and CBD extraction are plotted for comparison.

[1] J.Y. Wang, X. Fang, E. Appel, C. Song, Pliocene-Pleistocene climate change at the NE Tibetan Plateau deduced from lithofacies variation in the dring core SG-1, western Qaidam Basin. J. Sediment. Res. 82, 933-952 (2012).

[2] W. Zhang, E. Appel, X. Fang, C. Song. Magnetostratigraphy of deep drilling core SG-1 in the western Qaidam Basin (NE Tibetan Plateau) and its tectonic implications. Quat. Res. 78, 139-148(2012).

Key words: western Qaidam Basin, rare earth elements, chemical weathering, climate change, Quaternary