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ACCEPTED MANUSCRIPT

Rare Earth Elements in Tributaries of Lake Baikal (Siberia, Russia)

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Abstract

REE dissolved in waters from sixty five sampled tributaries of Lake Baikal show diversity in abundances (∑REE = 0.02 – 2.16 μg/L) and distribution patterns ($[La/Yb]_N$ = 0.20-5.58; $[La/Tb]_N$ = 0.30-2.59). Total REE contents vary seasonally and yearly, while REE patterns remain generally similar. The REE patterns in stream waters correlate with those in the drained rocks and hence, seem to be predominantly controlled by watershed lithology. Rivers having small watersheds around Lake Baikal belong to six lithological provinces with different stream-water REE patterns: the Olkha plateau and the ranges of Primorsky, Baikalsky, Barguzin, Ulan-Burgassy, and Khamar-Daban. The Khamar-Daban province, in turn, is lithologically heterogeneous and comprises four subprovinces with different respective patterns of dissolved REE. Rock-water interaction in subsurface aquifers that feed the Baikal inlets provides much stronger lithological control of REE than the weak interaction of short and rapid streams with rocks on the surface. REE fractionation in stream waters show negative Ce anomalies in almost all samples (Ce_{anom} = 0.12-0.97), except for those of large rivers (Selenga, Turka, Barguzin, Upper Angara, and Kichera). The reason is that the great length, relatively slow current, and the presence of streambed fine alluvium make the water chemistry more uniform and the REE patterns less dependent on local variations in watershed lithology. The sampled tributaries represent a range of physico-chemical and geomorphological conditions which can be used as reference for calibrations in future studies of sediment sources and, possibly, as a valuable tool for mineral exploration.

Key words: rare earth elements (REE), stream waters chemistry, watershed lithology, Lake Baikal, Siberia, Russia

Highlights:

REE dissolved in waters from sixty five sampled tributaries of Lake Baikal show large differences in abundances (∑REE = 0.02 – 2.16 μg/L) and distribution patterns ($[La/Yb]_N$ = 0.20-5.58; $[La/Tb]_N$ = 0.30-2.59).

The REE patterns in stream waters apparently depend on watershed lithology.

Six lithological provinces with different stream-water REE patterns have been distinguished.

REE patterns in stream waters all contain negative Ce anomalies (Ce_{anom} = 0.12-0.97), in contrast to patterns found in the large tributaries (Selenga, Turka, Barguzin, Upper Angara, and Kichera).

1. Introduction

Rare earth elements (REE), with their unique chemical properties as a group, have been extensively used as powerful tracers of fundamental geochemical processes in surficial and subsurface waters (Dia et al.,2000; Elderfield, 1990; Goldstein and Jacobsen, 1988; Johannesson et al., 1997; Meybeck, 1987; Négrel et al., 1993; Noack et al., 2014; Sholkovitz, 1995; Sholkovitz et al., 1999; Smedley, 1991; Stille et al., 2006). There are three main criteria for REE suitability as geochemical tracers: (i) their absolute abundances (ii) the degree of fractionation (e.g. $[La/Tb]_N$ and $[La/Yb]_N$ ratios), and (iii) anomalies in normalised REE patterns. The latter mainly refers to the cerium anomaly

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