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Uranium in Saline Lakes of Mongolia and Adjacent Areas

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1 Introduction

Increasing demand for uranium raw materials for the nuclear industry has stimulated interest in non-traditional sources, including hydromineral ones [Qin, 2009]. Those are saline lakes located in the uranium ore districts. Accumulation of uranium in such lakes results from the leaching of uranium from the rocks by surface and ground waters and its deposition in terminal basins. We have studied concentrations of uranium in saline lakes located in the uranium ore provinces of Mongolia and in adjacent areas. The lakes were hydrochemically explored during the 2007-2013 joint Russian-Mongolian field trips. About one hundred salt lakes were investigated.

The highest concentrations of uranium (up to 3 mg/l) were found in the lakes of north-western Mongolia. For comparison, concentrations of uranium in the lakes of the Chuya basin (Gorny Altai) do not exceed 0.03 mg/l and maximum concentration of uranium in the lakes of the Steppe Altai is 0.04 mg/l. In addition to uranium, the lakes water has rather high concentrations of such microelements as boron (up to 250 mg/l), bromine (1.1 g/l), lithium (100 mg/l), strontium (10 mg/l), iodine (10 mg/l), rubidium (1.3 mg/l), cesium (0.4 mg/l), and arsenic (0.8 mg/l) [Isupov, 2011, 2013].

Our obtained data on the composition of the lakes water allowed us to calculate reserves of ^{238}U and other microelements. Lake Hyargas Nuur has the greatest stock of uranium, about 6000 tons, which is priced to ca. 1 billion USD.

Figure 1 Shaazgai-Nuur Lake.

Regularities of leaching of uranium, its transportation to lakes and accumulation in water and sediments were investigated in the intermountain basin of Lake Shaazgai-Nuur locating in the southern part of the Kharkhirin Highland, north-western Mongolia (Fig. 1). The mountains around the lake are Early Carboniferous granitoid complexes: Kharkhirin and Yelinskii. The Kharkhirin

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Table 1 Forms of uranium in bottom sediments of Lake Shaazgai-Nuur , %

Forms of uranium	Sediment depth, cm (0-5)	(5-10)
Water soluble forms	17	12
Exchange forms	33	26
Carbonate forms	12	15
Hydroxide forms	34	43
Organic forms	4	4

complex is composed of subalkaline leucogranite. The Yelinskii complex consists of alkaline leucogranites (alaskite) with riebeckite, arfwedsonite, and aegirin. The complex is cut by Early-Middle Carboniferous dykes of diorite and alkaline alaskite.

The Goozhuur uranium minefield containing otenite and β-uranophane [Chistoedov, 1989] is situated to the north of the lake in the upper-stream of Khargain-Gol River. The river fed by glaciers of the Kharkhirin mountain massif is the main route of uranium accumulation into the lake. However, concentration of uranium in the up-stream river water is low ($0.8–0.9\times10^{-3}$ mg/l) which can be explained by predominance of the pure glacial waters. The concentration of uranium increases 20 times in the short way towards the lake. This increase evidences influx of the underground uranium-bearing waters to the river. Our measured concentrations of uranium in the underground waters are vary from 0.04 to 0.11 mg/l. These waters are all of alkaline soda type, which is favourable to form the uranyl-ion carbonate complexes.

The complexes, concentrating in arid zone lakes with the help of high evaporation, provide high concentrations of uranium (mg/l) and other major and trace elements. Our analyses of the Shaazgai-Nuur lake water suggest its saturation by calcite, magnesite and dolomite, and some clay minerals. These compounds absorb uranium and move it to the bottom sediment when precipitate from oversaturated solutions. We studied the distribution of uranium between the main components of the sorption complex of the bottom sediments by the method of successive chemical fractionation (Table 1).

Content of the uranium in the sediment varies from 5.2×10^{-5}g/g (depth 0-5 cm) up to 10.4×10^{-5}g/g (depth 5-10 cm), which is 50 to 100 times higher than the concentration of uranium in the lake water. Sorption of uranium occurs mainly due to the exchange forms and formation of the surface complexes. The role of the exchange processes decreases and the role of the surface complexes increases with the depth in the studied sediment interval. X-ray phase analysis of the sediments shows presence of such minerals as kaolin, montmorillonite and calcite which agrees with the proposed scheme of the uranium sorption.

The greatest uranium resources are stored in Lake Hyargas Nuur, Western Mongolia. Its volume is 66 km^3 and the catchment area 170,000 km^2. Concentration of uranium in the lake water is 0.09 mg/l. The water comes to Lake Hyargas Nuur from Lake Ayrag Nuur, which has lower uranium concentration of 0.03 mg/l. By-turn, Lake Ayrag Nuur is fed by Dzabhan-Gol River, the largest stream of Western Mongolia, and Honggui-Gol River, which uranium concentrations are 0.004 and 0.0028 mg/l, respectively. Uranium is accumulated in Lake Hyargas Nuur not only by the river inflow, but also due to the groundwater, which uranium content varies from 0.01 to 0.03 mg/l.

Thus, the soda lakes locating in the uranium-bearing provinces of Mongolia are characterized by considerably high content of uranium and are important non-traditional sources of raw uranium material.

Keywords: saline lakes, uranium, Mongolia, Chuya basin, Altai region, sorption

Acknowledgements

SB RAS Interdisciplinary Integration Projects 38 and 110, RFBR Research Project 13-05-00556, and the Tomsk State University Program to improve competitiveness.

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