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Procedia Earth and Planetary Science 17 (2017) 128 – 131

Procedia Earth and Planetary Science

15th Water-Rock Interaction International Symposium, WRI-15

Estimation of water-rock interaction during the vertical profiles of prairie brackish lakes of the Altay region, Western Siberia: preliminary results

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Abstract

The article presents the comparative characteristic of lake water and pore water of bottom sediments of saline lakes located in the South of Western Siberia. Studied lakes are mostly Cl-Na composition and rarely Cl-HCO_3-Na. The values of pH vary from 7.6 to 9.9, TDS from 5 to 300 g/L. It is shown that redox conditions change from oxic in the upper water layer to anoxic in pore water and the bottom layer. As a result, there is dissimilarity in interaction between water layer, bottom sediment and secondary minerals caused by differences in biological and geochemical processes in these two environments. According to thermodynamic calculations, lake water is in equilibrium with calcite, quartz, kaolinite, illite, Mg-montmorillonite, barely with respect to gypsum, thenardite and halite. Simultaneous formation of evaporite minerals and bacterial mats, CH_4 and H_2S accumulation lead to microbial sediment development.

Peer-review under responsibility of the organizing committee of WRI-15

Keywords: salt lakes; Kulunda; ion composition; oxic-anoxic conditions; Phreeqc; diagenesis

1. Introduction

Saline lakes are complicated systems that can easily switch between oxic and anoxic conditions depending on external and internal conditions[1]. As an example, microbial sediments such as bacterial mats grow only in the period of brine dilution while chemical sediments (such as calcite or gypsum precipitation) appear in the dry season with a high level of evaporation. Many studies describe the peculiar properties of these two processes including microbial mat gypsification[2] and early diagenetic crystallization[3,4], which include both oxic and anoxic stages. Small inland saline lakes located in Western Siberia (Altay region, Fig. 1) are of special interest as redox processes respond quickly to seasonal fluctuations, especially winter freezing, causing unsteadiness in water salinity and temperature.

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Peer-review under responsibility of the organizing committee of WRI-15
doi:10.1016/j.proeps.2016.12.027

2. Study area and methods

The studied area forms an almost flat basin with a predominantly steppe landscape. Climatic features are frequent droughts, repeated every 3-4 years. The territory is characterized by low rainfall (240-320 mm/yr) with extremely uneven distribution in the annual cycle, and a high level of evaporation of over 600 mm/yr. Maximum precipitation occurs in July-August[5]. The Central Kulunda alluvial plain is composed of Quaternary sandy deposits with thickness of up to 1300 m. Marine sedimentary rocks in the form of gray and dark-gray clay are widespread here. Prevailing groundwater types are HCO_3, HCO_3-Cl-Ca, Ca-Na and Na[6].

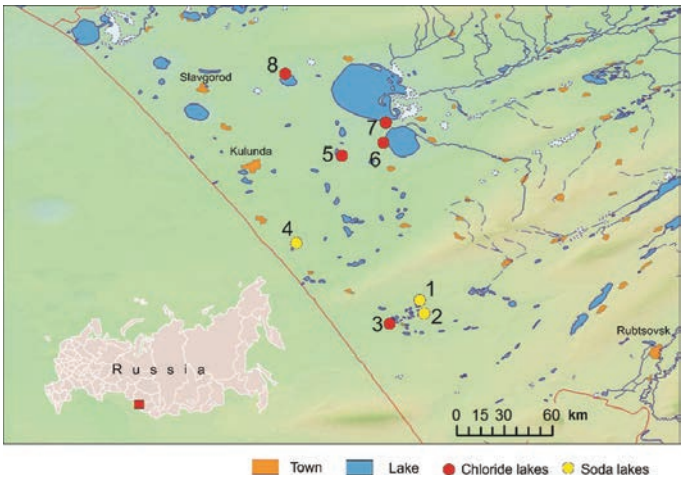

Fig. 1. Location map of studied lakes in Western Siberia

Fig. 1 shows the location of studied lakes on the territory of Kulunda steppe. All lakes were investigated in summer during daylight and all measurements were made *in situ*. The values of pH, Eh and O_2 were measured at three different points (UL – upper layer, BL – bottom layer (up to 1 m) and PW – pore waters); temperature and conductivity were estimated only in the Upper and Bottom layers (see Table 1). Collected waters were analyzed in the Institute of Natural Resources, Ecology and Cryology SB RAS using titration, photometric, atomic absorption spectroscopy (AAS) and ICP-MS methods.

3. Results and discussion

The temperature of the lakes in estimated time was about 24-28°C. As can be seen from Table 1, pH, Eh and O_2 values decrease from the upper lake layer to pore water. Apart from Raspberry, Djira and Cock lakes, all have oxygenated upper and bottom layers, while the pore water usually has anoxic conditions with the presence of H_2S. Obviously, the content of O_2 in pore water has not been detected.

The TDS of lake water varies over a very wide range from 4 (Tanatar-4 Lake) to 339 g/L (Raspberry Lake). Studied lakes can be divided into two groups by pH values. The first group has pH range of 7.6-8.2 while pH of another group reaches 9.9. These groups differ not only in pH, but also in their chemical composition. The lakes with high pH values have more substantial concentrations of HCO_3^- and CO_3^{2-} (26-51 %) in comparison with the lakes with lower pH values (0.1-2.0 %). The Cl^--ion constitutes the major anion of lakes; their chemical type is mostly Cl-Na, rarely Cl-HCO_3-Na. Only one lake (Tanatar-4) with TDS value only 5 g/L belongs to soda type of water (HCO_3-Na), but it still contains a high concentration of Cl^- (0.6 g/L). The Ca^{2+} and Mg^{2+} concentrations in the lake water vary from 0.002 to 0.75 and from 0.006 to 7 g/L, respectively. A high content of Mg usually appears in Cl-Na water with low carbonate concentration. Si values in lakes vary from 0.4 to 6.9 mg/L. However, Si content reaches 20-28 mg/L in pore water of Cock and Djira Lakes.