# MIGRATION PATTERN OF CHEMICAL ELEMENTS IN SALINE LAKES OF KULUNDA PLAIN (ALTAI REGION) BASED ON CHEMICAL TYPE

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Analysis of chemical element migration patterns in natural water is a very important aspect in water study. Saline lakes are of a great interest for scientists because of high chemical element's content. This fact makes them a potential source of hydro minerals.

Objects of the study are saline lakes located in Kulundinskaya plain of Altai territory (Fig.).

The territory is covered with many mineralized basinal lakes as it is located in forest steppe and steppe zones.

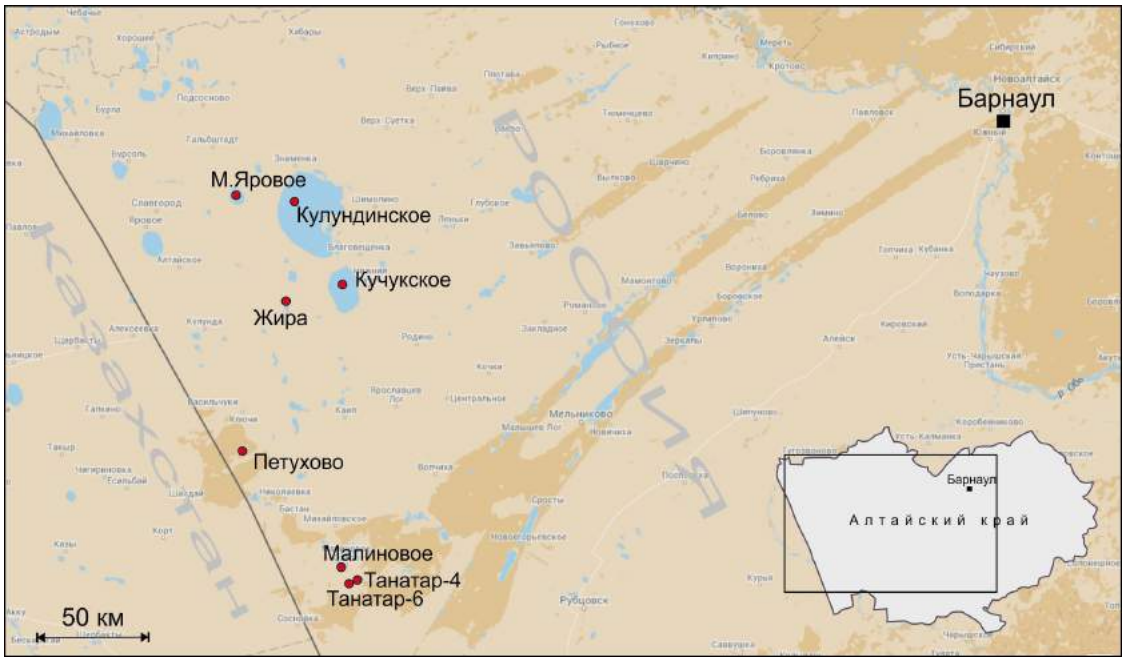


***Fig. Map-layout of sampling point***

Used data were obtained in the expedition in 2015. Chemical composition analysis was made in the Fundamental Research Laboratory of Hydrogeochemistry of Education and Research Centre "Water" (Tomsk Polytechnic University, Russia).

All calculations of chemical elements migration forms were made using Visual MINTEQ 3.1 software. Modeling temperature was 25°C and pressure - 0.1 MPa.

As input information for analysis, we used macro and micro water component composition taking into account hydrogen ion concentration (pH), electro-hydraulic potential (Eh) and organic content.

According to the total salt content the study lakes are brine and saline. Chemical composition of water is presented in Table 1. The minimum value of pH is typical for the most saline water. Chloride is a predominate anion for the most of the lakes. Its content changes from 0.6 to 170 g/l.

Concentration of carbonates and hydrogen carbonates varies from 0.07 to 25 g/l. Sodium is prevalent among other cations. The value reaches 120 g/l.

The concentration of magnesium varies between 0.07-7 g/l. Content of calcium and potassium is up to 3-4 g/l in certain cases.

***Table 1***

***Macrocomponent composition saline lakes of Kulunda Plains, Altay Region***

| Name of the lake | | Tanatar-4 | Tanatar-6 | Petuhovo | Zhira | Kulundin-skoe | Small Yarovoe | Kuchuk-skoe | Malino-voe |
|---|---|---|---|---|---|---|---|---|---|
| № п/п / Units | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| pH | | 9.3 | 9.8 | 9.8 | 8.8 | 8.3 | 7.7 | 7.6 | 7.7 |
| Eh | | 245 | 228 | -200 | 212 | 261 | 238 | 258 | 48 |
| $CO_3^{2-}$ | | 534 | 15300 | 17850 | 29 | 12 | n/d* | n/d | n/d |
| $HCO_3$ | | 2104 | 6558 | 7472 | 46 | 1372 | 537 | 595 | 702 |
| $SO_4^{2-}$ | | 120 | 2663 | 1398 | 8384 | 23860 | 9660 | 41030 | 34300 |
| $Cl^-$ | | 590 | 10570 | 10300 | 17990 | 59320 | 132760 | 146130 | 177120 |
| $Ca^{2+}$ | | 6 | 12 | 5 | 17 | 77 | 166 | 393 | 160 |
| $Mg^{2+}$ | | 31 | 7 | 31 | 1098 | 3185 | 7049 | 7057 | 5300 |
| $Na^+$ | | 1335 | 16044 | 16560 | 13371 | 43175 | 75549 | 98307 | 121121 |
| $K^+$ | mg/l | 22 | 135 | 207 | 48 | 235 | 89 | 456 | 316 |
| Br | | 2 | 40 | 41 | 28 | 138 | 298 | 285 | 222 |
| Mn | | 0.010 | 0.001 | 0.002 | 0.008 | 0.007 | 0.44 | 0.285 | 0.118 |
| As | | 0.02 | 0.36 | 0.54 | 0.01 | 0.15 | 0.07 | 0.11 | 0.20 |
| B | | 3 | 37 | 103 | 10 | 26 | 18 | 43 | 59 |
| Si | | 4.5 | 5.4 | 1.8 | 1.7 | 0.6 | 1.4 | 1.8 | 2.6 |
| Fe | | 0.13 | 0.35 | 0.65 | 0.03 | 0.13 | 0.07 | 0.45 | 0.08 |
| Al | | 0.10 | 0.09 | 0.05 | 0.03 | 0.08 | 0.07 | 0.73 | 0.07 |
| FA* | | 25.7 | 23.8 | 15.7 | 8.4 | 10.9 | 3.9 | 19.7 | 10.6 |
| HA* | | n/d | 2.1 | 1.1 | n/d | 0.7 | 0.8 | n/d. | n/d |
| DOC | | 50 | 111 | 60 | 34 | 70 | 131 | 134 | 212 |
| M.* | g/l | 5 | 51 | 54 | 41 | 131 | 226 | 294 | 339 |

*Note: M.* - general mineralization, n/d – not detected, FA, HA – fulvic and humic acid, DOC - Dissolved Organic Compounds.*

A hydro chemical characteristic of the lakes is strongly required in studying elements migration pattern. Based on the classification of salt waters presented in [1] and considering some aspects in [2], we distinguished two chemical types of lakes. Tnatar-4, Tanatar-6, Petuhovo are carbonate (soda) lakes. In this type of water carbonates are predominate anion, pH of water is above 9.0. Chloride type lakes include by Zhira, Kulundinskoe, Small Yarovoe, Kuchukskoe, Malinovoe. Chloride type in comparison with soda one is characterized by a higher salinity (41 – 339 g/l), but has smaller values of pH (7.6 – 8.8). Sodium prevails among cations. The patterns of element migration in both types of lake are shown in Table 2.

***Table 2***

***Major migration pattern of elements in saline lakes located in Kulundin plate of Altai region (%)***

| Patterns of migration | 1* | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| $Ca^{+2}$ | 70.1 | 35.4 | 35.5 | 47.9 | 18.8 | 10.4 | 5.6 | 4.5 |
| $CaCl^+$ | 1.2 | 7.0 | 6.9 | 16.1 | 34.3 | 74.8 | 55.5 | 64.5 |
| $CaSO_4$ | 3.1 | 8.9 | 4.6 | 35.5 | 44.4 | 13.8 | 38.1 | 30.0 |
| $CaHCO_3^+$ | 16.1 | 43.1 | 49.2 | 0.2 | 2.2 | 0.9 | 0.7 | 0.8 |
| $Mg^{+2}$ | 72.5 | 37.2 | 38.2 | 47.0 | 17.1 | 7.4 | 4.5 | 3.4 |
| $MgCl^+$ | 2.0 | 11.7 | 11.7 | 25.0 | 49.3 | 84.2 | 70.7 | 77.8 |
| $MgSO_4$ | 2.5 | 7.4 | 3.9 | 27.6 | 31.9 | 7.8 | 24.3 | 18.1 |
| $MgHCO_3^+$ | 13.4 | 36.5 | 42.7 | 0.1 | 1.6 | 0.5 | 0.4 | 0.5 |
| $Na^+$ | 97.5 | 85.9 | 86.1 | 85.2 | 68.3 | 56.0 | 50.4 | 47.3 |
| NaCl | 0.5 | 5.3 | 5.2 | 9.0 | 22.5 | 41.7 | 41.6 | 46.8 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| $NaSO_4^-$ | 0.2 | 2.0 | 1.0 | 5.8 | 8.9 | 2.2 | 7.9 | 5.8 |
| K+1 | 98.8 | 91.5 | 92.9 | 83.8 | 66.8 | 55.7 | 49.4 | 46.6 |
| KCl | 0.5 | 5.7 | 5.6 | 8.9 | 22.0 | 41.5 | 40.7 | 46.0 |
| $KSO_4^-$ | 0.3 | 2.7 | 1.4 | 7.3 | 11.2 | 2.8 | 9.9 | 7.4 |
| $Br^-$ | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| $Mn^{+3}$ | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| FA2-Fe | 100 | 100 | 99.9 | 100 | 100 | 100 | 100 | 100 |
| FA2-Al | 99.6 | 99.8 | 99.7 | 99.9 | 99.9 | 100 | 93.8 | 100 |
| $H_4SiO_4$ | 99.8 | 99.3 | 99.5 | 98.4 | 98.2 | 99.5 | 99.0 | 99.3 |
| $H_3BO_3$ | 99.2 | 98.7 | 98.6 | 98.6 | 97.6 | 96.5 | 96.2 | 95.9 |
| $H_3AsO_3$ | 99.2 | 99.0 | 99.0 | 99.0 | 98.9 | 99.0 | 99.0 | 99.0 |

*Note: * - the number of sample is given according to table 1, FA1-Me, FA2-Me - Organically complexed Me to dissolved fulvic acid. Sites 1 and 2 refer to carboxylic and phenolic functional groups, respectively.*

Every type is characterized by unique chemical elements behavior, but there are some characteristics in common. For example, such elements as Si, B, As migrates in the form of $H_kMeO_n^{m-}$ion; Br and Mn only in ionic form. Organic complex is predominant form for Al and Fe. Content of dissolved organic matter increases with the growth in total mineralization in a lake.

As for the major cations, ionic pattern of migration reduces with increase of mineralization, while complexes with the predominant anion increase. Thus, content of cations with carbonate ion increases in soda lakes. Content of complexes such as $CaHCO_3$ and $MgHCO_3$ increases up to 40% of the general mineralization in water, while Na, K continue accumulating in water solution. In chloride type of lakes, which are characterized by high salinity, the proportion of complexes with chloride ion is more than 50% in most cases.

Therefore, in the territory of the Kulunda Plain (Altai Territory) chloride type of lakes develop, the predominant forms of migration are the complexes containing chloride ion.

**References**

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## EPR STUDY OF HYDROCARBON GENERATION POTENTIAL OF ORGANIC-RICH DOMANIC ROCKS

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Semiluki (domanic) sediments are widespread in the Volga-Urals Basin and stratigraphically confined to the Upper Devonian Frasnian stage [8, 5, 10, 6]. Domanic sediments are composed of bituminous siliceous-carbonate rocks with a small argillaceous admixture (5.9-13.6 %). The rocks are black and dark brown due to the high organic matter content (18-20%) [6]. Domanic sediments are analogous to oil shale. The increasing interest in them in recent years conditioned by the possibility of oil shale extraction [8, 13, 1]. A distinctive feature is that rocks along with light oil contain the organic matter as a component of rock, called kerogen [8, 12, 2].

The aim of the work was to study the characteristics of the composition and structure of the mineral matrix, bitumen and kerogen, as well as the conversion of kerogen and rocks in the pyrolytic laboratory experiments using EPR spectroscopy. The objects of investigations were core materials, selected from the Domanic sediments from Berezovskaya area Romashkinskoye field. According to thermal analysis results, the substance of organic matter in the sample 1 is 35.48 %, and in the second sample is 13.36 %.

There are different methods of studying Domanic rocks to assess the prospects of the liquid hydrocarbons generation depending on the composition of organic matter in rocks and its thermal stability [11]. The special place among these methods takes the electron paramagnetic resonance (EPR) [7, 4, 3]. One of the traditional objects of EPR researches are stable free radicals – particles containing one or more unpaired electrons, so-called paramagnetic centers. Free radicals reflect the composition of carbonate and sulfate components (calcite and dolomite), show presence of organic matter, indicate ferruginization and other features of rocks composition [4, 3]. Registration of the EPR spectra of the initial rocks samples and thermally activated in the pyrolysis process was conducted on CMS-8400 X-band spectrometer at a