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Chemical composition and sulfur forms in saline lakes of Kulunda Plain (Russia)

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1 Introduction

On the territory Kulunda Plain, located to the south-west of the Ob' plateau, there are more than 3,000 fresh and salt lakes with water TDS range from 1 to 430 g/L. The interest in these lakes was associated mainly with the study of hydromineral resources. The massive industrial production of sodium sulphate, soda, sodium chloride was deployed based on these studies. At the same time, the salt lakes are also interesting from a geochemical perspective. In particular, for some closely spaced lakes in this region at the similar climatic conditions and modes of their water inflow is often a sharp difference in the chemical composition of the lake waters and their chemical type. In this context, the aim of this work was to investigate the lake waters macro-component composition of some salt lakes of Kulunda Plain, as well as to evaluate the role of sulfate in the chemical composition of lakes.

Kulunda Plain Lakes have isometric shape, their diameter range from 8-10 km (Bolshoe Yarovoye, Burlinskoe, etc.) up to 35 km (Kulundinskoe), the area ranges from tens to hundreds of square kilometers. Lake basins are nearly flat bowl with shallow depths (1 - 6 m). Water levels in the lakes ranging 0.4 - 1 m. The lake area is sharply reduced in dry years. Almost all lakes Kulunda are undrained. The main outflow of the lake water is going to evaporate, the value of which during the warm season is 350 - 600 mm and significantly exceeds the amount of precipitation (250 - 300 mm) [1].

The lakes were studied in July-August 2011 and 2013. Map in Fig. 1 showing the location of sampling points.

2 Chemical composition of saline lakes:

The pH of lake water is different. The highest pH values typical for soda lakes and lakes Dzhemansor, Big Topolinoe reach 9.7. Minimum values (7.8 - 7.9) were recorded in lake Malinovoe and lake Shukyrtuz. The pH dependencies of the mineralization and the amount of carbonate and bicarbonate ions are directly opposite. Thus, while increasing TDS of lake water the pH decreases, and vice versa, while increasing of the carbonate component in the waters the pH increases.

Classification of natural water is important in hydrochemical studies. Currently, there are several methods to determine chemical water type in Russia, the main of which is the classification of Kurnakova-Valyashko [2].

Learning one of adopted genetic coefficients in hydrogeology (Cl/SO_4) there were found this ratio is rarely less than one. But according to the classification of the above, the study area does not contain lakes of chloride type, and much of it is sodium-type.

In this regard, we have taken some criteria to determine the chemical type of lakes of steppe Altai. The lakes with pH > 9,0 and

$$\left(\frac{Э_{CO_3^{2-}} + Э_{HCO_3^-}}{Э_{Ca^{2+}} + Э_{Mg^{2+}}}\right) > 1$$

, where "Э" is content of ion (mEq/L), was referred to soda lakes, the lakes with pH < 9,0 and domination of chloride ion was referred to chloride lakes, the lakes with pH < 9,0 and domination of sulfate ion was referred to sulfate lakes. The sulfate lakes were not detected in the study area.

The chloride type lake is dominated in the study area on the proposed classification. These lakes are characterized by high values of the total mineralization, on average value 240 g/L. pH range from 7.8 to 8.5, in rare cases, exceed the value of 9.0 (Kulundinskoe lake, 2011.). Anion prevailing

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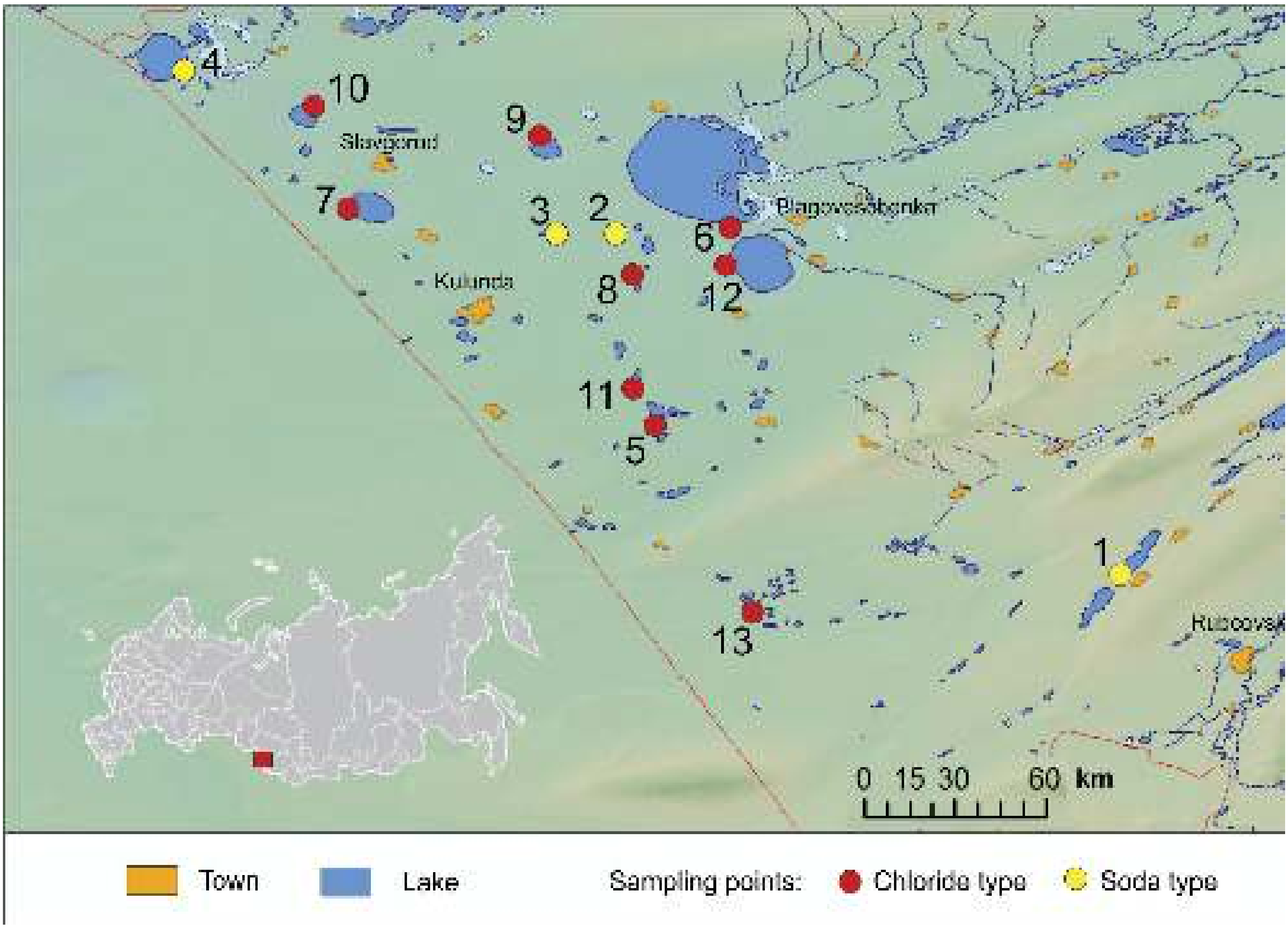

Fig.1. Schematic map of sampling points lakes of Altai Krai.

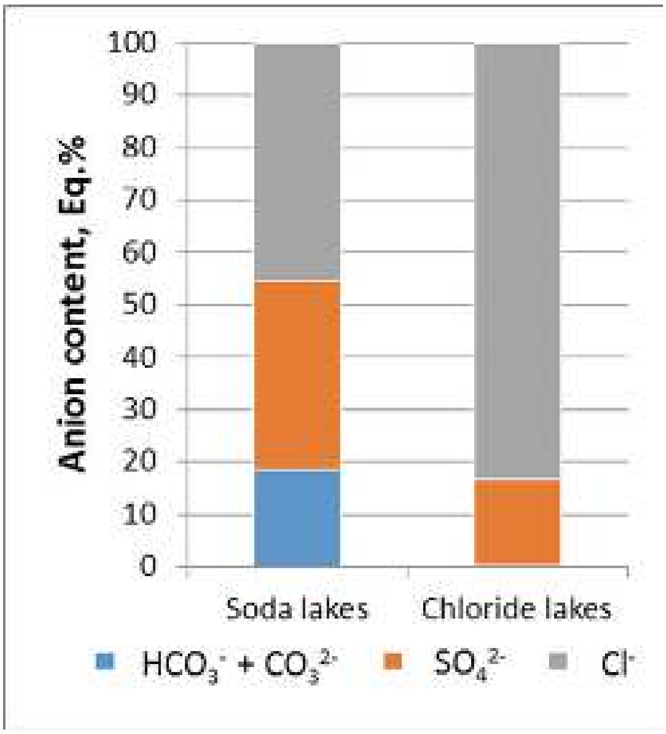

Fig. 2. The average content of anions in soda lakes and chloride types

Table 1. Reduced forms of sulfur content (mg/L) in the waters and sediments of lakes

№	ID	$S^{2-}(HS^-)$		S^0	$S^{0;4+}(S_2O_3^{2-})$
		1	2	1	1
1	Kulundinskoe	<0,001	21,7	<0,001	0,014
2	Kuchukskoe	0,005	32,2	<0,001	0,052
3	Shoshkaraly	<0,001	111,2	<0,001	<0,001
4	Dzemansor	0,012	98,2	0,009	<0,001
5	Yarovoe	<0,001	<0,001	0,026	<0,001
6	Burlinskoe	<0,001	65,4	<0,001	0,17
7	Big Topol'noe	<0,001	98,4	0,46	0,008
8	Petuhovo	0,020	125,1	<0,001	0,012
9	Kuriche	0,043	94,2	0,84	<0,001
10	Malinovoe	0,006	35,2	0,48	0,047

Note: 1 - water, 2 - sediment (100g). The limit of detection - 0,001 mg / l based on S.

in the lakes chloride type is chloride ion (70-96 eq.%), followed by the sulfate ion (3 40 eq.%). Carbonate content in the component does not exceed 1.5 eq.%.

Soda lake type, conversely, have the lower salinity waters (up to 40 g/L) and high pH (9.6 - 9.7). Carbonate component in these lakes is often dominant and the average value reaches 33 eq.% (Fig. 2).

3 Sulfur-reduction processes in saline lakes:

The main process controlling the content of H_2S in the lakes is a bacterial sulfate-reduction actively proceeding in the anaerobic zone of sediments [3]. The most intense sulfate-reduction is in Shoshkaraly, Dzhemansor, Petukhovo and Kuriche lakes judging from the contents of hydrogen sulfide in the sediments. Also, the H_2S fixed in the water layer of some lakes in the analytically determined concentrations. Due to high pH values the hydrogen sulfate is in the dissociated form mainly in the form of hydrosulfide HS^-. HS^- content does not exceed 0.043 mg/L recorded in water of Kuriche lake. In the water layer it is oxidized by bacteria or dissolved oxygen to the sulfate ion with formation of complexes: thiosulfate $S_2O_3^{2-}$ and elemental sulfur S^0 (Table 1). In the coastal zone of the Dzhemansor lake creamy white-gray incrustations are noted lying on hydrogen sulfide clay. Probably it is colloidal sulfur. No less interesting Kuchukskoe lake and Malinovoe lake are represented in terms of learning hydrochemistry of sulfur. The water of these lakes has a pink shade that gives it purple bacteria. Redox environment of lakes is firmly fixed on the positive values of the redox potential Eh waters that vary from 7 to 150 mV.

Although there is evidence of the H_2S oxidation, some sulfates can be irreversibly reduced to hydrogen sulfide reacting mainly with iron, forming amorphous troilite $FeS{\bullet}2H_2O$ and removing from the solution in the bottom sediments (presence of black clay was noted on most lakes). Also, loss is possible as a result of incomplete oxidation of hydrogen sulfide to elemental sulfur, the presence of which was recorded on a number of lakes. The process of sedimentation is not less important than the recovery of sulfur and it is associated with the saturation of water not only of sulfate minerals, but also carbonate, chloride and aluminum silicates. The water-rock interaction will be calculated at the next stage of research.

4 Conclusion

From the data obtained, the chemical composition of lakes in the Kulunda Plain is represented mainly chloride and soda types of sodium composition. Salinity lakes can reach 430 g/L, pH - 9.9. Hydrogen sulfide is securely saturated in some lakes in the water layer, where it is oxidized to form thiosulfate and elemental sulfur complexes.

Acknowledgements

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References

Hydrogeology of the USSR. Volume 17. Kemerovo region and Altay / ed. M.A. Kuznetsova, O.V. Postnikova. Moscow: Nedra, 1972. 399p. (in Russian)

Valyashko M.G. Geochemical regularities of formation potash deposits. Moscow: Moscow State University Press, 1962. 397p. (in Russian)

Global biogeochemical sulfur cycle and the impact of human activities on it / ed. G.K. Scriabin. Nauka, Moscow, 1983. 421p. (in Russian)