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Chemical Composition of Some Saline Lakes in the Tuva Region (Russia)

Yulia KOPYLOVA¹, Natalia GUSEVA¹, Choyganmaa OYDUP² and Anastasia SHESTAKOVA¹

¹ Institute of Natural Resources, Tomsk Polytechnic University, Tomsk, 634050, Russia;

² Tuva Institute for Exploration of Natural Resources of the Siberian Branch of the RAS, Kyzyl, 667007, Russia

1 Introduction

Salt lakes are very interesting natural objects which can be found in different places in the world. Russia is not an exception. Climate conditions are various in Russia, but the climate is not very hot. In Russia there are a lot of places where salt lakes are spread. One of them is the Tuva region where lakes with different compositions are located in the small intermountainous basins. These lakes have been known for a long time (Levchenko, 1935, Pinneker, 1968) but they have not been studied carefully yet.

2 Study site and methods

Mostly the lakes are situated in the Tuvinskaya, the Turano-Uyukskaya and the Ubsunurskaya basins. The position of sampling lakes is shown below (Fig. 1).

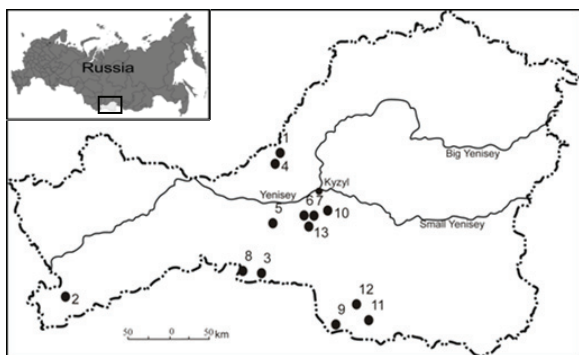


Fig. 1. Scheme of salt lakes location in the Tuva region.

1 – Kisloye lake; 2 – Ak-Khol lake; 3 – Amtaygyn lake; 4 – Beloye lake; 5 – Kak lake; 6 – Gryazevoye lake; 7 – Khadyne lake; 8 – Ubsu-Nur lake; 9 – Shara-Nur lake; 10 – Cheder lake; 11 – Bay-Khol lake; 12 – Dus-Khol-Samalgatay lake; 13 – Dus-Khol-Svatikovo lake.

These lakes are of diverse sizes. The largest lakes are the Ubsu-Nur and the Khadyne, their water-surface areas are more than 20 km². The Cheder, the Shara-Nur, the

Kak, the Bay-Khol and the Beloye have water-surface areas from 1 to 10 km². The water-surface areas of Dus-Khol-Samalgatay lake and Dus-Khol-Svatikovo lake are less than 1 km².

Water samples were taken in the summer period of 2012-2013. The water samples were collected in 1-liter cleaned bottles. The pH, temperature and Eh values were measured using a water test *in situ*. The water samples were investigated by the following methods: titrimetric (HCO₃⁻, CO₃²⁻, Cl⁻, Ca²⁺, Mg²⁺), turbidimetric (SO₄²⁻), inductively coupled plasma mass spectrometry (Na⁺, K⁺).

3 Results and discussion

All the lakes were divided into two groups according to the ratio (HCO₃+CO₃+SO₄)/(Ca+Mg) (in equivalent form). This ratio can be more or less 1.

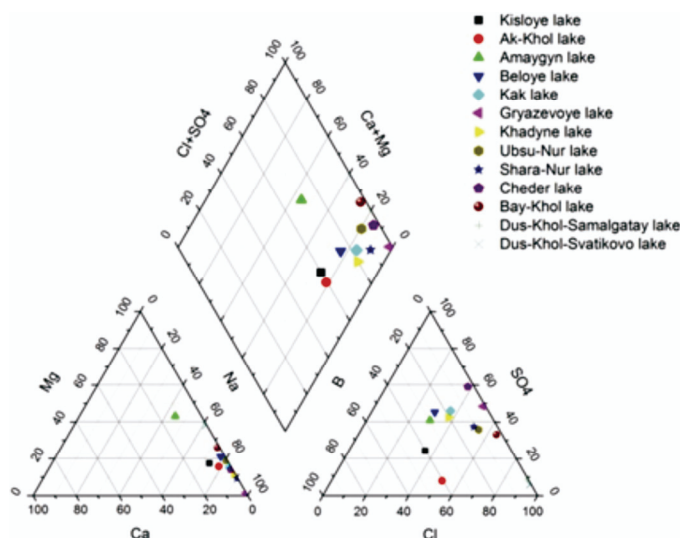


Fig. 2. Piper diagram with the chemical composition data of some saline lakes in the Tuva region.

The most spread lakes are the lakes having this ratio more than 1. There are 10 lakes of this type such as the

* Corresponding author. E-mail: stysha@sibmail.com

Kisloye, the Ak-Khol, the Amtaygyn, the Beloye, the Kak, the Gryazevoye, the Khadyne, the Ubsu-Nur, the Shara-Nur, the Cheder. The waters of these lakes are alkalinity; pH varies from 7.8 to 9.5, the mean value is 8.8. The waters of the lakes are distinct by their TDS ranged from 1.3 to 217 g/l. The ionic composition of these lakes is various (Fig. 2). Sulphate is the major anion in the chemical composition of lakes where TDS is less than 14 g/l. The exception is two lakes, the Kisloye and the Ak-Khol, having hydrocarbonate and chloride as the main anion respectively.

Chloride is the main anion in the chemical composition of the lakes where TDS is more than 14 g/l. The exception is Gryazevoye lake which contains chloride and sulfate in the equal ratio.

The cationic composition of the studied lakes is not so various than the anionic one. Sodium is the dominating cation in waters of these lakes, whereas the Amtaygyn also contains magnesium and sodium in equal proportions.

Specific features of these lakes are their connection with the river activity. The Beloye and Kisloye have connection with fresh water of the Uyk River. Similarly the Khadyne River falls into Khadyne lake. A few rivers flow into Ubsu-Nur lake. The largest among them is the Tes-Khem river. Amtaygyn lake is connected with the Khulu river during high water level in the lake.

The second type of lakes is characterized by the ratio $(\text{HCO}_3 + \text{CO}_3 + \text{SO}_4)/(\text{Ca} + \text{Mg})$ less than 1. In this group those lakes are the Bay-Khol, the Dus-Khol-Samalgatay, the Dus-Khol-Svatikovo.

TDS of these lakes ranges from 28 to 302 g/l. The highest TDS 302 g/l is observed in the Dus-Khol-Samalgatay. The lakes are not so alkalinity as lakes of the first type, their pH is less than 8.8.

Chloride is the main anion in the chemical composition of Dus-Khol-Samalgatay lake and Dus-Khol-Svatikovo lake, contents of which are 91-93 %. Anionic composition of the Bay-Khol is presented by sulphate (33 %) and chloride (64 %). Sodium is the dominating cation in the waters of these lakes.

Chemical composition of all studied lakes is conditioned by different processes such as microbiological, water-rock interaction and evaporation (Drever, 1982).

The microbiological processes are noted to play a significant part in the chemical composition formation of these lakes. High content of sulphate in the studied waters can be conditioned by sulfate-reduction processes.

Low content of calcium and high content of magnesium in waters of Cheder, Dus-Khol-Samalgatay and Dus-Khol-Svatikovo lakes is due to widely spread mafic and ultramafic rocks in the catchment basins of these lakes.

Evaporation plays a significant part in water enrichment in sodium and chloride in the studied lakes. This process is not as intensive in Tuva region as, for example, in Africa and Australia and etc.

Besides the above mentioned, the reason of the high chloride and sodium content in Dus-Khol-Samalgatay lake is an additional source of these chemical components. This source can be the salt of nearest mineral salt deposit. There is such a type of the deposit near Dus-Khol-Samalgatay lake named the Dus-Khol deposit of chloride sodium.

4 Conclusion

Tuva is one of the regions, where lakes with different compositions are located in the small intermountainous basins. In present research we investigated 13 lakes such as Kisloye lake, Ak-Khol lake, Amtaygyn lake, Beloye lake, Kak lake, Gryazevoye lake, Khadyne lake, Ubsu-Nur lake, Shara-Nur lake, Cheder lake, Bay-Khol lake, Dus-Khol-Samalgatay lake, Dus-Khol-Svatikovo lake. Chemical composition of these lakes differs. TDS ranged from 1.3 to 302 g/l. pH varies from 7.5 to 9.5. Using ratio $(\text{HCO}_3 + \text{CO}_3 + \text{SO}_4)/(\text{Ca} + \text{Mg})$ all the lakes were divided into two types. The first type is more spread and includes 10 lakes. These lakes are characterized by high pH, sulphate, sodium and rarer magnesium concentrations. Their average TDS is 35 g/l. Some lakes are connected with rivers all the time, whereas other lakes periodically.

The second type includes only 3 lakes. TDS of these lakes is much higher. The mean value of TDS is 164 g/l. pH is less 8.8. The main ions are chloride and sodium. The water interaction with salt (sodium chloride) and evaporation play a significant part in chemical composition formation of these lakes.

Key words: saline lakes, chemical composition, Tuva region, water-rock interaction, microbiological processes, evaporation.

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