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Chemical Composition and Hydromineral Resources of Salt Lakes in the North-West Mongolia

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Abstract

Data are presented concerning the macro- and microcomponent composition of the salt lakes of the North-West Mongolia. The evaluation of Li, U-238, B, Br, Sr, Rb content was performed for several lakes of the North-West Mongolia. It was demonstrated that the concentration of U-238 in lake waters can reach 1 mg/L, Li – 50 mg/L, Br – 460 mg/L, B – 100 mg/L. By the example of the Shaazgay Nuur Lake we estimated a daily intake of macro- and microcomponents at the expense of water flowing into the Hargayn Gol River. It was demonstrated that the complex processing of hydromineral raw from the lakes of the North-West Mongolia requires for purifying them from uranium.

Key words: chemical composition, mineralized water, the lakes of Mongolia, lithium, uranium

INTRODUCTION

The chemical composition and hydromineral resources of salt lakes in the North-West Mongolia for quite a long time were studied by Russian and Mongolian researchers, being systematically and in detail considered in the literature [1–3]. The main attention was paid to the macrocomponent composition (Na, K, Ca, Mg, Cl, SO_4, *etc.*) of lake water. The microcomponent composition was poorly studied [2]. At the same time, the study of lake microcomponents is required for to create a more complete picture of hydromineral resources inherent in salt lakes, as well as the assessment environmental risks in water resource management for this region of Mongolia, which just became a major goal of this work.

EXPERIMENTAL

The study of the lakes was carried in the course the Russian-Mongolian hydrochemical expeditions in 2008–2009. The sampling points and their coordinates are presented in Fig. 1 and Table 1. The sampling of lake water was made, as usual, at a depth of 30–40 cm. The water sampled was filtered through membrane filters

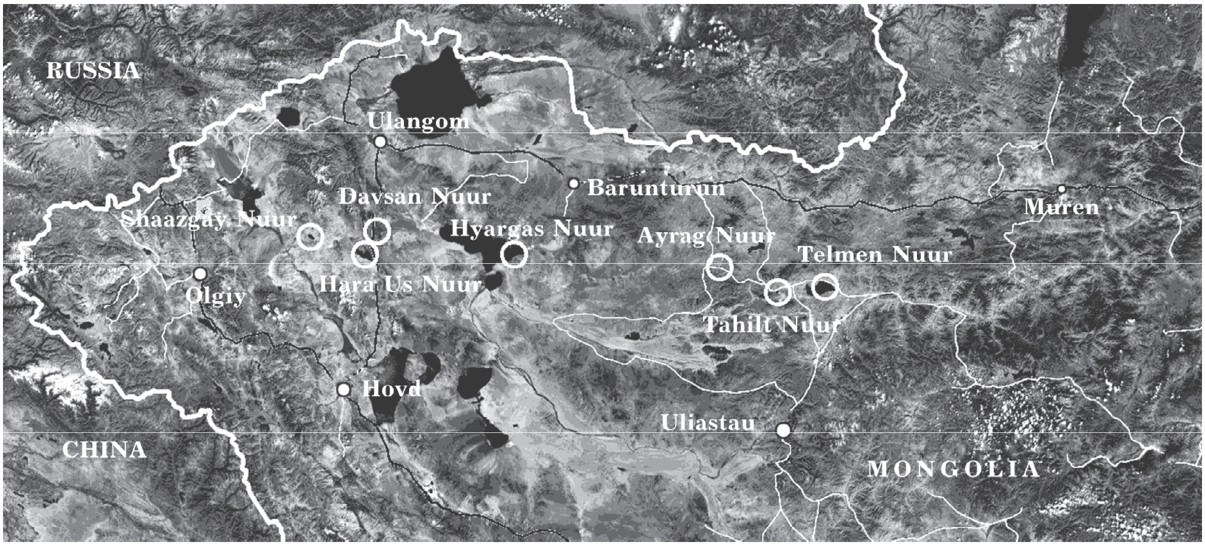

Fig. 1. Overview sampling point map of the expedition in the territory of the North-West Mongolia, 2009.

TABLE 1

Brief information concerning the water sampling points of the North-West Mongolia

Point No.	Subject of investigation	Coordinates	Height, m	Water surface area, km^2	Average depth, m
1	Hargayn Gol River, 2009	N 49°21′17.4″ E 91°16′39.3″	1830	ND	ND
2	The same	N 49°17′28.5″ E 91°16′24.4″	1737	ND	ND
3	Shaazgay Nuur Lake, 2009	N 49°14"43.4″ E 91°17′17.9″	1703	8.3 [1]	1.6 [1]
4	The same	N 49°13′30.7″ E 91°19′02.2″	1701	8.3 [1]	1.6 [1]
5	«	100 m from point No. 4	1699	8.3 [1]	1.6 [1]
6	«	The same	1699	8.3 [1]	1.6 [1]
7	«	«	1699	8.3 [1]	1.6 [1]
8	«	N 49°14′34.6″ E 91°14′27.6″	1699	8.3 [1]	1.6 [1]
9	«	N 49°13′09.7″ E 91°16′46.5″	1699	8.3 [1]	1.6 [1]
10	Shaazgay Nuur Lake, 2008	N 49°14′35.7″ E 91°14′26.2″	1699	8.3 [1]	1.6 [1]
11	Davsan Nuur Lake, 2009	N 49°13′44.8″ E 92°03′07.0″	1515	1.3	ND
12	The same, 2008	N 49°13′38.2″ E 92°03′01.5″	1515	1.3	ND
13	Hara Us Nuur Lake, 2009	N 49°04′13.8″ E 91°53′42.0″	1577	62.7 [1]	5 [1]
14	Suuzh Nuur Lake, 2009	N 49°10′18.9″ E 92°06′11.7″	1553	0.5	ND
15	Hyargas Nuur Lake, 2009	N 49°06′02.9″ E 93°45′07.2″	1027	1407 [1]	19 [1]
16	Ayrag Nuur Lake, 2009	N 49°00′13.2″ E 96°05′44.2″	1770	1.9 [1]	0.6 [1]
17	Tahilt Nuur Lake, 2009	N 48°49′13.8″ E 96°48′39.9″	1833	5.1 [1]	1.8 [1]
18	Telmen Nuur Lake, 2009	N 48°53′10.1″ E 97°17′54.5″	1796	194 [1]	12 [1]
19	Ureg Nuur Lake, 2008	N 50°05′13.0″ E 91°04′27.6″	1425	238 [1]	12 [1]
20	Baga Nuur Lake, 2008	N 49°30′22.4″ E 90°48′02.5″	1547	0.5	ND
21	Bor Hag Nuur Lake, 2008	N 49°07′42.5″ E 91°24′27.8″	1603	0.5	ND

Notes. 1. Point No. 5 is located at a depth of 6 m, point No. 6 – at a depth of 3 m, and point No. 7 – on the surface. 2. ND – not determined.

with a pore size equal to 0.45 μm to be collected in plastic bottles with the volume capacity of 0.5 L for analyzing macrocomponents; for analyzing microcomponents, water was collected in polypropylene bottles with the volume capacity of 250 mL. All the bottles were previously prepared in accordance with the regulations on preparing containers before sampling to prevent contamination. The samples for analyzing the microcomponents were acidified with high purity grade nitric acid up to pH value equal to 1–2. The measurement of pH under field conditions was carried out with the help of a pHep type pH meter. Simultaneously, using a GPS navigator, we determined certain sampling locations (the accuracy of determining the coordinates of sampling ranged within 6–10 m). Data concerning the water surface area and the average depth of the most of the lakes were taken from [1]; for the remaining lakes the estimation of water surface area was carried out basing on of field observations. The chemical analysis of the samples was carried out under laboratory conditions at the Institute of Solid State Chemistry and Mechanochemistry of the SB RAS (Novosibirsk) and at the Scientific Education and Production Center "Water" (at the Tomsk Polytechnic University).

The content of silicon, carbonate, bicarbonate, chloride and sulphate ions was determined by standard methods for saline water [4]. The content of carbonate and bicarbonate ions was determined under field conditions *via* acid-base titration. The silicon content was determined using a colorimetric method; the content of chloride ions was determined using argentometry. In order to determine the content of sulphate ions we use a gravimetric method based

TABLE 2

Content of macrocomponents and the mineralization level (M^*) in saline waters of lakes North-West Mongolia and the Hargayn Gol River, mg/L

Sample No.	Subject of investigation	pH	Na	K	Ca	Mg	Cl	HCO_3^-	CO_3^{2-}	SO_4^{2-}	M^*
1	Hargayn Gol River	8.6	37.0	1.2	16	2.4	25	96	–	10.0	188
2	The same	8.2	36.0	1.2	20	4.9	30	116	–	7.36	215
3	Shaazgay Nuur Lake, 2009	9.3	4300	55	8.0	17.1	4900	2200	280	280	12 500
4	The same	9.4	4100	41	8.0	17.1	4500	2070	490	485	11 900
5	«	9.4	4800	25	8.0	14.6	5300	2500	260	260	13 500
6	«	9.4	4800	25	4.0	17.1	5300	2300	597	597	13 600
7	«	9.4	4990	25	12	13.4	5680	2270	550	550	14 200
8	«	9.4	6100	23	6.0	11.0	7380	2530	480	475	17 100
9	«	9.4	4200	59	8.0	14.6	4510	2190	574	627	12 200
	Average	9.4	4800	36	7.7	15.0	5380	2290	460	470	13 560
10	Shaazgay Nuur Lake, 2008	9.3	4200	40	16	9.8	4260	2300	540	580	11 950
11	Davsan Nuur Lake, 2009	8.5	3000	58	20	590	5430	290	120	1120	10 660
12	The same, 2008	7.4	53 100	945	130	15 800	10 000	ND	ND	39 000	>209 500
13	Hara Us Nuur Lake, 2009	9.0	1600	31	15	61	1540	1400	93	380	5080
14	Suuzh Nuur Lake, 2009	8.6	4300	240	60	1090	4970	960	36	6140	17 740
15	Hyargas Nuur Lake, 2009	9.1	1900	190	9.0	170	1880	1800	400	1030	7480
16	Ayrag Nuur Lake, 2009	9.1	8500	87	16	240	7530	1670	340	6880	25 200
17	Tahilt Nuur Lake, 2009	8.9	960	28	37	190	1300	660	24	560	3780
18	Telmen Nuur Lake, 2009	8.9	1900	60	10	370	2310	1100	160	1470	7390
19	Ureg Nuur Lake, 2008	8.8	810	50	8.8	422	640	ND	ND	1290	>3220
20	Baga Nuur Lake, 2008	8.0	1300	75	4.8	90	1400	ND	ND	390	>3300
21	Bor Hag Nuur Lake, 2008	7.7	7600	307	100	626	6300	ND	ND	4800	>19 740

Note. ND – not determined.

on the deposition of barium sulphate. The content of Li, Na, K, Ca, Mg, Sr was measured by means of Saturn-2 M and Varian 280 FS AA spectrometers, in emission and absorption modes, depending on an element under determination. Trace element composition was determined using an Agilent 7500a mass spectrometer with inductively coupled plasma (ICP), as well as by means of ICP (iCAP 6300 Duo unit for atomic emission spectroscopy (Thermo Scientific). For analysis, we used deionised water taken from Direct-Q 3 UV apparatus (Millipore) with a resistivity of 18.2 MOhm · cm at 25 °C. As the reference solution and the solution for adjusting the mass spectrometer we used a 2 % solution of HNO_3, containing 10 ppb Li, Co, Ce, Y, Tl (Tuning Solution), from Agilent.

In some cases, alongside with water sampling conducted the selection of bottom sediments.

The X-ray analysis of the solid phases was carried out using a DRON-4 diffractometer, CuK_α radiation, registration rate being of 2°/min, the registration angle being within the range $2\theta = 5-70°$. The analysis of the phase composition was based on Search Match program. The coefficient of correlation was performed using Origin 6.0 software.

RESULTS AND DISCUSSION

According to the chemical composition, slightly alkaline and alkaline, low- and medium-mineralized waters are observed to prevail in the territory of the North-West Mongolia (Table 2). The mineralization level of lake water ranges mainly between 1 and 25 g/L at pH 7.8–9.4. The exception is the Davsan Nuur Lake, whose salinity 2008 exceeded 200 g/L. The content of carbonate ions varies within the range of 23–600 mg/L, whereas that of hydrocarbonates ranges within 580–2500 mg/L. The dominant cation is Sodium is a prevailing cation; in some cases, the saline water exhibits an increased content of magnesium.

In the limnological aspect, usually there are four types of lakes: carbonate (soda) lakes, sodium sulphate lakes, magnesium sulphate lakes, chloride lakes [5]. Russian researchers in the field of lake waters consider a hydrochemical classification by Kurnakov–Valyashko to be generally recognized, which classification is based on a combination of the major cations of natural waters with the major anions. For this purpose, researchers use special water metamorphization coefficients (K_n^*):

$$K_1^* = E_{CO_3^{2-}} + E_{HCO_3^-} / E_{Ca^{2+}} + E_{Mg^{2+}}$$
$$K_2^* = E_{CO_3^{2-}} + E_{HCO_3^-} + E_{SO_4^{2-}} / E_{Ca^{2+}} + E_{Mg^{2+}}$$
$$K_3^* = E_{CO_3^{2-}} + E_{HCO_3^-} + E_{SO_4^{2-}} / E_{Ca^{2+}}$$
$$K_4^* = E_{CO_3^{2-}} + E_{HCO_3^-} / E_{Ca^{2+}}$$

where E_i is the number of gram-equivalents for the i-th ion.

The values of these coefficients we calculated for some lakes are presented in Table 3. As it can be seen, the lakes under study mainly belong to a carbonate (soda) type.

For the most of lakes, there is the following range of element content observed (mg/L): Li 0.9–3.5, Sr 0.4–5.0, Si 0–6.5, B 0.6–12, Br 1–28, U-238 0.01–1.1, Rb 0.001–0.015 (Table 4). The content of other elements varies in

TABLE 3

Hydrochemical types of lake water in the North-West Mongolia

Sample No.	Lakes	K_1	K_2	K_3	K_4	Hydrochemical type
3	Shaazgay Nuur Lake	25.8	29.0	132.2	117.5	Carbonate (Soda)
11	Davsan Nuur Lake	0.2	0.7	15.8	5.0	Sulphate-magnesium
13	Hara Us Nuur Lake	4.2	5.5	44.1	33.3	Carbonate (Soda)
14	Suuzh Nuur Lake	0.2	1.5	48.1	5.5	Sulphate-sodium
15	Hyargas Nuur Lake	1.5	2.4	128.5	80.9	Carbonate (Soda)
16	Ayrag Nuur Lake	2.0	10.7	225.1	42.1	Carbonate (Soda)
17	Tahilt Nuur Lake	0.6	1.3	12.4	6.1	Sulphate-sodium
32	Telmen Nuur Lake	0.7	1.7	102.4	41.1	Sulphate-sodium

TABLE 4

Content of microcomponents in the saline lake waters of the North-West Mongolia and the Hargayn Gol River, mg/L

Point No.	Subject of investigation	B	Br	Li	Rb	Si	Sr	U-238
1	Hargayn Gol River, 2009	0.092	0.16	0.11	0.015	7.0	0.047	0.01
2	The same	0.15	0.16	0.10	0.0012	7.5	0.19	0.03
3	Shaazgay Nuur Lake, 2009	10.0	12.0	0.86	0.0059	5.3	0.49	1.00
4	The same	11.0	12.0	0.91	0.0061	5.1	0.32	1.10
5	«	10.0	12.0	0.88	0.0081	6.3	0.40	1.10
6	«	10.0	12.0	0.90	0.0100	6.8	0.51	1.10
7	«	10.0	12.0	0.85	0.0066	5.9	0.34	1.0
8	«	9.9	11.0	0.85	0.0077	5.2	0.460	1.0
9	«	9.9	12.0	0.85	0.007	4.3	0.53	1.0
	Average	10.0	11.9	0.87	0.0073	5.6	0.4	1.04
10	Shaazgay Nuur Lake, 2008	7.5	12	0.75	0.0028	8.3	0.4	0.67
11	Davsan Nuur Lake, 2009	12.0	28	2.9	0.004	3.3	1.7	0.013
12	The same, 2008	100	460	52.7±4.0	ND	ND	3.7	ND
13	Hara Us Nuur Lake, 2009	3.6	2.9	1.2	0.001	3.6	1.7	0.07
14	Suuzh Nuur Lake, 2009	13.0	21	1.8	0.022	4.9	3.5	0.05
15	Hyargas Nuur Lake, 2009	3.7	3.6	0.36	0.021	0.2	1.2	0.09
16	Ayrag Nuur Lake, 2009	5.4	27.0	2.0	0.02	0.9	1.2	0.095
17	Tahilt Nuur Lake, 2009	0.66	2.6	0.47	0.006	4.1	2.0	0.02
18	Telmen Nuur Lake, 2009	1.6	ND	0.43	ND	0.15	1.8	0.02
19	Uregei Nuur Lake, 2008	0.61	1.1	0.066	0.0047	0.006	1.0	0.026
20	Baga Nuur Lake, 2008	5.6	3.2	3.50	0.0014	6.5	5.0	0.13
21	Bor Hag Nuur Lake, 2008	4.0	31	1.47	ND	<0.009	8.0	0.42

Note. ND – not determined.

the following range, μg/L: Ba $n100-n10$, Fe $n100-n$, Mo $n10$, Al, Zn, V $n10-n$, Mn $n10-n0.1$, Se, Ag, Pb n, Ti $n-n0.1$. The remaining elements analyzed (Cr, Cu, *etc.*) are present in the amounts lower than $n0.1$ μg/L (Table 5). It should be noted that there is a high content of arsenic, whose content in the waters of the Shaazgay Nuur Lake amounts up to 250 μg/L.

The results of comparative analysis for lake water salinity and the content of macro- and microcomponents indicate that there is a correlation between these values exhibited. With increasing the salinity, all the lakes demonstrate a proportional increase in the content of sodium, chloride and sulphate ions (Fig. 2). The Pearson's correlation coefficient for them is equal to 0.966, 0.919 and 0.857, respectively. A somewhat worse correlation with salinity is exhibited by the content of magnesium (0.339) and bicarbonate ions (0.224). Even lower corre-

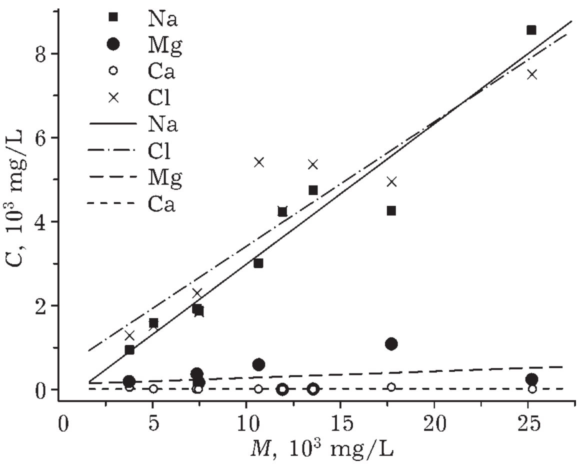

Fig. 2. Correlation between the mineralization level (salinity) (M) and the concentration (C) of macrocomponents (Na, Mg, Ca, Cl) in the lake water of the North-West Mongolia.

TABLE 5

Content of microcomponents in the saline lake waters of the North-West Mongolia and the Hargayn Gol River, μg/L

Point No.	Subject of investigation	Ag	Al	As	Ba	Cr	Cu	Fe	Mn	Mo	Pb	Se	Ti	V	Zn
1	Hargayn Gol River, 2009	0.8	7	2.0	7.0	0.5	0.4	20	0.6	7.0	6.0	1.0	1.0	2.0	8.0
2	The same	2	7	0.0	8.0	0.5	0.4	9	0.5	9.0	4.0	5.0	0.3	2.5	7.0
3	Shaazgay Nuur Lake, 2009	1	14	245	16	0.8	0.6	27	2.0	61.0	2.0	5.0	3.0	6.0	7.5
4	The same	5	14	246	20	0.4	0.5	146	3.0	74.0	2.0	5.0	3.0	4.0	12
5	«	2	12	245	17	0.7	0.5	22	5.0	65.0	3.0	6.0	2.0	5.0	7.0
6	«	3	10	243	17	0.5	2	36	2.0	60.0	4.0	4.0	2.5	4.0	9.0
7	«	1	11	246	13	0.5	0.4	13	6.0	65.0	2.5	6.0	2.0	4.0	8.0
8	«	2	12	245	18	0.7	0.5	28	15.0	61.0	3.0	7.0	3.0	5.0	16
9	«	6.5	11.0	246	12	0.7	0.5	17	5.0	64.0	1.0	6.5	2.0	5.0	5.0
	Average	2.9	12.0	245	16.1	0.7	0.71	41	5.4	64.2	2.5	5.6	2.5	4.7	9.2
10	Shaazgay Nuur Lake, 2008	ND	ND	240	20	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
11	The Davsan Nuur Lake, 2009	1.0	15.0	32	44	0.5	0.3	8.0	17.0	30.0	1.5	5.0	0.3	8.0	7.0
12	The same, 2008	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
13	Hara Us Nuur Lake, 2009	2.0	36.0	93	190	0.5	0.6	57	2.0	39.0	3.0	6.0	0.8	7.0	6.0
14	Suuzh Nuur Lake, 2009	3.0	18.0	10	27	0.7	1	10	5.0	96	3.0	7.5	0.3	3.0	17
15	Hyargas Nuur Lake, 2009	2.0	11.0	34	36	0.3	0.4	9	0.4	75.0	0.0	7.0	0.4	14	10
16	Ayrag Nuur Lake, 2009	2.0	14.0	9.0	15.0	0.3	0.4	15.0	0.8	88.0	1.0	6.0	0.6	0.9	12
17	Tahilt Nuur Lake, 2009	4.0	20.0	7.0	62	0.4	0.3	136	4.0	30.0	2.0	4.0	0.8	6.5	7.0
18	Telmen Nuur Lake, 2009	2.0	1.4	7.0	18	0	0	7	0.4	27.0	0	6.0	0.6	3.0	10
19	Uregei Nuur Lake, 2008	ND	ND	20	17	ND	ND	ND	ND	19	ND	ND	ND	ND	ND
20	Baga Nuur Lake, 2008	ND	ND	70	43.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
21	Bor Hag Nuur Lake, 2008	ND	ND	54	150	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Note. ND – not determined.

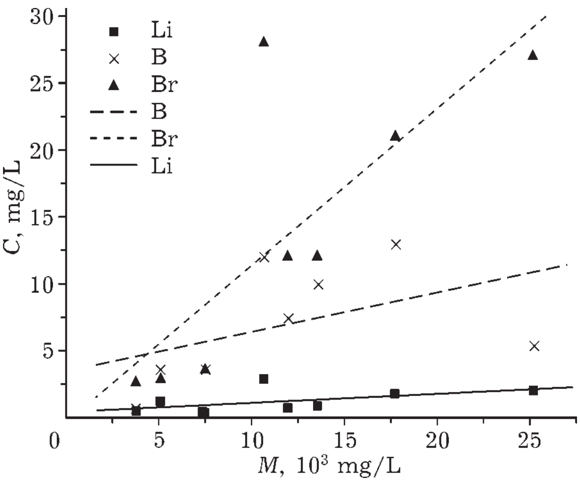

Fig. 3. Correlation between the mineralization level (salinity) (M) and the concentration (C) of microcomponents (Li, B, Br) in the lake water of the North-West Mongolia.

lation coefficient (0.191) was observed for calcium, which could be caused by the formation of poorly soluble calcium carbonate (calcite) and, to all appearance, dolomite in carbonate-bicarbonate lake waters. The presence of these minerals is demonstrated by X-ray diffraction data for the bottom sediments of the lakes.

Among the microcomponents, the greatest correlation coefficient is observed for bromine (0.784) (Fig. 3). For lithium and boron, the correlation coefficient is lower (0.523 and 0.469, respectively). The uranium content is weakly correlated with the total mineralization of lake water (0.158), a higher correlation coefficient is observed between the concentration of uranium and hydrocarbonates species in the lake water (0.738) (Fig. 4). The increased level of uranium in lake water containing a significant amount of hydrocarbonate/carbonate ions could be connected with the formation of different of uranyl complexes $UO_2(CO_3)_2^{2-}$,

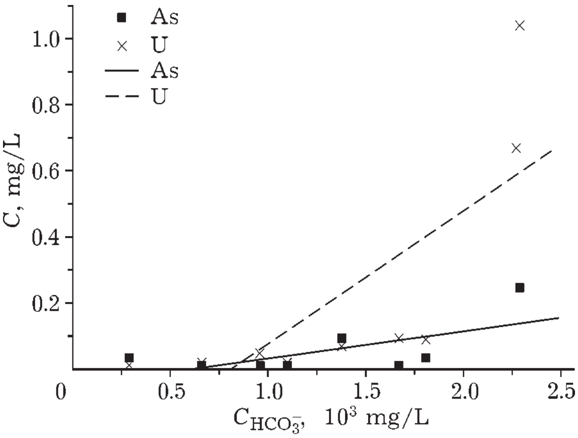

Fig. 4. Correlation between the concentration of hydrocarbonates ions and the content of U-238 and As in lake waters of the North-West Mongolia.

$UO_2(CO_3)_3^{4-}$, $UO_2(CO_3)^0$, and so on under these conditions [6]. These complex anions tend to form highly soluble compound with most cations of lake waters, to provide the accumulation of high uranium concentrations. The behaviour of arsenic is similar to the behaviour of uranium: its concentration in the lake water is weakly correlated with salinity (−0.026), however there is a much more high correlation level with the concentration of hydrogen ions (0.647) (see Fig. 4). Finally, there is a high correlation level between the concentrations of uranium and arsenic in the lake water (0.942).

The analytical data concerning the chemical composition of lake water with river feeding (the Shaazgay Nuur Lake, the Hara Us Nuur Lake, the Hyargas Nuur Lake), indicate that the annual change in the concentration of macro- and microcomponents (measured at the same time of a year) are relatively small being equal to about several dozen percent (Table 6). At the same time, for the lakes with no permanent river feeding, the changes in the chemical composition could be much greater. Thus, the concentration of macro- (K, Na, Mg, Cl, SO_4^{2-}) and microcomponents (Li, Br, B), belonging to the highly soluble salts (chloride, sulphate, bromide, borate) in the lake water of the Davsan Nuur Lake in 2008 was significantly higher than the concentration of the mentioned components in this lake in 2009 (see Table 6).

Most large and medium-sized lakes in the northwest Mongolia (the Achit Nuur Lake, the Ureg Nuur Lake, the Hyargas Nuur Lake, the Hara Us Nuur Lake, the Shaazgay Nuur Lake, *etc.*) have a river feeding, so we measured the intake of macro- and microcomponents with river water. For these purposes, we have chosen the Shaazgay Nuur Lake located within an intermountain depression. From the northern part of the lake there is Hargayn Gol River flowing therein which is formed in the moun-

TABLE 6

Annual changes in the composition of some lakes of the North-West Mongolia, mg/L

Years	Li	Na	K	Ca	Mg	Cl	SO_4^{2-}	B	Br
				Hyargas Nuur Lake					
2009 (July)	0.36	1880	190	8.4	280				
2008 (July)	0.20	1930	219	32	226				
2007 (August)	0.30	1940	200	37	300				
				Shaazgay Nuur Lake					
2009 (July)	0.87	4170	59	8.0	14				
2008 (July)	0.75	4240	40	16.0	10				
2007 (August)	0.79	4110	60	6.0	13				
				Hara Us Nuur Lake					
2009 (July)	1.256	1585	31	15	61				
2008 (July)	1.00	1115	24	7	44				
2007 (August)	1.00	1190	40	19	76				
				Davsan Nuur Lake					
2009 (July)	2.9	3020	58	20	510	5430	1120	12.0	28
2008 (July)	53	53 100	945	130	15 800	100 000	39 000	100	460

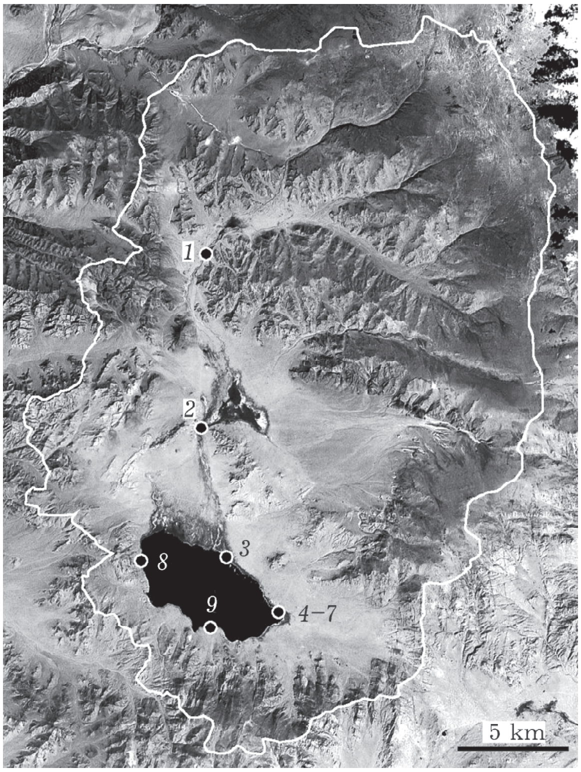

Fig. 5. Map of sampling points on the Shaazgay Nuur Lake.

tain range Harhira located just north of the lake (Fig. 5).

Water surface area is equal to 8.3 km^2, the volume amounting to 0.01 km^3 [1]. Choosing the Shaazgay Nuur Lake as a subject of investigation is caused by several factors: a high content of microcomponents (Li, B, Br, U-238) therein, a good accessibility of the lake and river shoreline, which allowed us to sample water almost anywhere in the lake. Figure 5 demonstrates the sampling points at the Shaazgay Nuur Lake and the Hargayn Gol River.

The data obtained (see Tables 2, 4) suggest that the content of macro- (Na, K, Mg, HCO_3, CO_3) and microcomponents (Li, U-238, B, Si, Sr) is varied at different points on the lake surface. This could be connected with the features of mixing river and lake water: higher component concentration values can be observed seen in the distance from the mouth of Hargayn Gol River. The analysis of water in depth demonstrates that the mineralization level with the depth of sampling decreases, which, to all appearance, could be associated with the evaporation of surface water layers.

As one could see from Table 2, despite a relatively low salinity of the river water (0.2 g/L), a high content of lithium and uranium is ob served therein, the sources of those, to all appearance, are connected with the rocks of catchment area. The average coefficient of concentrating the elements in the lake water compared to the river water is equal to: 130 for Na, 30 for K, 160 for Cl, 9 for Li, 80 for B, 75 for Br, 50 for U. A significant difference in the values of this coefficient for the elements under investigation indicate the fact that their formation results not only from the evaporation of water in the lake. For a number of elements there are additional sources caused by their influx with groundwater; for other elements such factor is determined by the interaction of lake water with rocks. Some elements, as against, is precipitated at the bottom of the lake in the form of various minerals [6, 7]. All of these phenomena will be the subject of our investigations in the near future. This would help us to better define the ore-generating potential of the Mongolian lakes. In this paper, we present the preliminary results of this evaluation, using only surface water.

The estimate of the daily intake of lithium, uranium and other components in the lake water, based on the concentrations of these elements and the volume flow rate value at the point No. 2 ($\omega = 0.15$ m^3/s), is equal to, kg: Li 1.3, Na 300, K 8, Mg 63, B 2, Br 2, U-238 0.65, Sr 2.6, Rb 0.016. For a more accurate evaluation of the intake of the elements in lake water with river water one needs data concerning the flow velocity of the river and the composition of its water during the hydrological period.

Basing on the data concerning the chemical composition of lake water and the information on the volume of lakes available from the literature [1], a preliminary estimate of the Li, B, Br, Rb, Sr, U-238 and As resources in a number of lakes in the North-West Mongolia with river feeding (Table 7). It is seen that the largest volumes of hydromineral resources are concentrated in the Hyargas Nuur Lake.

Existing industrial methods for processing saline lake water, located in the arid zone, are based on the helioconcetration of hydromineral resources with the first stage isolation of salts those often are presented by NaCl, Na_2SO_4,

TABLE 7

Ore-generation potential of the lakes of the North-West Mongolia, 2009

Lakes	Volume, km^3	Content, mg/L/Resources, t						
		Li	Rb	B	Sr	Br	U-238	As
Uregei Nuur Lake	6.4	0.066/450	0.0047/30	0.61/3900	1.0/6390	1.1/7000	0.026/166	n/d
Hyargas Nuur Lake	66	0.3/19 800	0.0155/1023	$3.7/2.4 \cdot 10^5$	1.2/79 200	$3.6/2.4 \cdot 10^5$	0.09/5940	0.034/2240
Hara Us Nuur Lake	0.3	1.00/300	0.0010/0.3	1.6/480	1.7/510	2.900/870	0.07/21	0.093/28
Shaazgay Nuur Lake	0.01	0.8/8	0.0028/0.03	7.5/75	0.4/4	12.0/120	1.0/10	0.25/2.5
Telmen Nuur Lake	2.7	0.43/1160	no data/–	1.6/4320	1.8/4860	no data/no data	0.02/54	0.007/19
Davsan Nuur Lake*	0.0002	50/10	no data/–	100/20	3.7/0.74	460/92	n/d	no data/no data

Note. n/d – not detected.

*Investigations were carried out in 2008.

Na_2CO_3, *etc.* [8]. The choice of methods for further extracting the microcomponents (Li, B, Br, Sr), whose concentration after salt precipitation exhibits a substantial increase, depending on the nature of a particular element, its concentration, and salt background. With a low content of magnesium and alkaline earth metals (Ca, Sr, Ba) in concentrated lake waters, these components of the lake waters are removed in the form of soluble compounds (magnesium hydroxide, calcium, barium and strontium carbonate). Lithium carbonate can be isolated in the course of processing purified lake water with sodium carbonate.

With a high concentration of alkaline-earth metal cations, the isolation of lithium in the form of lithium carbonate inappropriate, and in order to isolate it, in some cases one could use selective sorption methods [9, 10].

It should be noted that saline lake waters of the North-West Mongolia are remarkable for a high concentration of U-238. In this context, in order to extract the elements from the waters of this type one should adjust existing halurgical methods taking into account the fact that hydromineral resources should be purified from uranium.

A great number of methods are known concerning the isolation of uranium from aqueous solutions (water, salt water, and salt water lakes). Thus, we might note the works concerning an application of strongly basic anion exchange resins such as Ionac A-651, Purolite A-520 E, Amberlite IRA 910 [11, 12]. The isolation of uranium could be realized using its sorption on highly dispersed aluminum [12] and iron [13] hydroxide, and cerium oxide. Choosing the method for the extraction of uranium from saline lake waters of the North-West Mongolia would be determined by the macro- and microcomponent composition of water and the concentration of uranium, which requires for a separate study.

CONCLUSION

The results of studying the microcomponent water composition of saline lakes in the North-West Mongolia indicate an elevated content of lithium, bromine, uranium, boron and arsenic therein in some cases. It was revealed that the content of macrocomponents (Na, Cl, SO_4^{2-}) and microcomponents (Li, B, Br) is correlated with the salinity of lake water, whereas the content of U-238 and As correlates with the concentration of hydrogen ions. The content of microelements (Li, B, Br, Rb, Sr, U-238, As) in the water of some salt lakes of the northwest Mongolia was estimated. It is demonstrated that the greatest resources of microcomponents are concentrated in the Hyargas Nuur Lake water. By the example of the Shaazgay Nuur Lake, a preliminary estimation of the daily intake of micro- and macrocomponents into lake water with river water. The extraction of microcomponents from lake waters in the northwest Mongolia could be based on the existing schemes for processing hydromineral raw material, but owing to a high content of uranium in the lake waters these schemes require for modifying.

A high content of arsenic and uranium in water discovered for the first time in some salt lakes of the northwest Mongolia is important for the assessment of environmental risks concerning the use of water resources of these lakes, especially for livestock breeding, and requires for a separate investigation.

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