Oecologia Montana 2014,
23, 41 - 44

REPORTS

Analysis of the current salt balance of Balkhash Lake

M.A. DZHETIMOV[1], E.A. TOKPANOV[1], Sh. ZHAUKUMOVA[1] and S. TYGELBAYEV[2]
[1]Zhetysu State University named after I.Zhansugurov, 040 010 Taldykorgan, Microdistrict 4, House 68, Flat 31, Kazakhstan, e-mail: make._d_61@mail. ru.
[2]Al-Farabi National University, Almaty, Kazakhstan

Abstract. One of the largest continental salt lakes is Balkhash Lake. This article presents data of research results related to the study of main factors of the salt formation of Lake Balkhash waters in the isothermal evaporation in a carbonate crystallization stage. One of the reasons, which encourage the enhancing of the calcium carbonate settleability in the water of Balkhash Lake, is the absence of free CO_2 in water, which is relatively rarely observed in lakes. In August 2013, free CO_2 in the samples presented only in the western part of the lake was in the amount of 1.02-1.26 mg/l, and in the eastern part its concentration decreased to 0.43 mg/l. The absence of CO_2, or its low content leads to the fact that precipitated carbonates cannot transfer into hydrogen, and they remain at the bottom.

Key words: Balkhash Lake, hydrochemistry, mineralization, permanganate oxidation, metamorphism

Introduction

Questions of salt formation have not received a sufficient development in the research and project elaboration of the Ili-Balkhash Basin as well as in the issues related to defining quantitative characteristics of elements of the modern salt balance of Lake Balkhash.

The absence in literature related to a unified approach to solving the processes of sedimentation in inland water reservoirs was the reason that caused the beginning of the work on hydro chemical investigation of the water area of Balkhash Lake from the summer period of 2012 with the purpose to monitor the current salt balance of the lake.

One of the main waterways of the Balkhash Lake Basin is the Ili River. The Kapchagai Reservoir is a diversion flow built on the Ili River. In addition, the watering of developing irrigated agriculture has also significantly reduced the flow of water into Balkhash Lake. This causes an annual reduction of the lake level. In this regard the study of salt formation processes in the water of Balkhash Lake is thought to be urgent.

Material and Methods

In the period of 2012-2013, 87 water samples from 36 points standing next to each other at the distance of 2-4 km were selected from the lake. 16 samples of water were selected from the Ili River in its mouth.

The analytical work was carried out in the National Scientific Laboratory of JSC "Center of sciences of the earth, metallurgy and enrichment." The following were used for the sample analysis receive: atomic absorption spectrometer "Hitachi", model 180-50 (Japan); flame photometer PFP7 (Great Britain); optical emission spectrometer with inductively coupled plasma Optima 2000 DV (USA).

Results and Discussion

The water composition in the lake refers to the sulfate group class with a high content of sodium chloride. With increasing salinity, the lake decreased along the length of the relative abundance of the ion HCO_3^-, CO_3^{2-}, Ca^{2+}, and the ion content of Cl^-, SO_4^{2-}, Mg^{2+}, Na^+, K^+ increased (Table 1).

Comparing the values of individual chloride ion coefficients (Table 2), it is seen that there are processes in the lake, in which ions of calcium, magnesium, carbonate, bicarbonate as well as sulfate ions take a significant part (Abrosov 1983). However, processes which take place in different places of the lake are not of the same type. Metamorphic processes with the participation of carbonate, hydro carbonate ions and calcium ions leading to a calcite setting occur everywhere; processes with the participation of magnesium ions causing a magnesite setting (Bolibok-Kurnichenko and Beremzhanov 1987, Burlibayev *et al.* 2009) only in the extreme east stretch.

In the setting of water carbonates, the dissimilarity of processes occurring in the western and eastern part of the lake is viewed. In this case the analogy in changing the concentration of the amount of bicarbonates and carbonates, on the one hand, and the amount of calcium and magnesium, on the other hand, is thought to be very demonstrative.

If carbonates were not involved in the setting process, so their content as well as the content of chlorine ions would have to rise in the 8th hydrochemical area (Burle-Tube stretch) by about six times and estimate about 32.0 mmol/l. The observed carbonate content in this stretch is 10.73 mmol/l, or 21.27 mmol/l less than it would be observed in this case. Similar calculations for the amount of calcium and magnesium give 31.46 mmol/l, i.e. close figures.

Hydrochemical area	Ca^{2+}	Mg^{2+}	$Na^{+}+K^{+}$	HCO_3^{-}	CO_3^{2-}	SO_4^{2-}	Cl^{-}	∑i mg/l
	1 / z (C) mmol / L / mg / l							
1	2.2	7.8	11.8	4.6	0.8	10.6	5.8	1453
	43.4	94.4	295.7	280.7	24.0	508.8	206.0	
2	2.0	7.2	12.6	4.3	0.8	11.5	5.2	1466
	41.1	86.9	315.0	262.4	24.0	552.7	184.2	
3	1.8	10.4	18.7	4.9	1.4	16.3	7.9	2038
	36.9	126.1	467.0	300.7	43.2	783.6	281.0	
4	1.7	11.9	24.5	5.3	2.0	18.9	11.1	2471
	34.3	145.2	611.3	322.5	59.1	905.9	393.1	
Western Balkhash	1.9	9.3	16.6	4.8	1.3	14.3	7.5	1849
	38.9	113.1	414.5	291.5	37.5	687.7	266.0	
5	1.2	17.0	36.9	7.5	2.0	25.9	19.7	3615
	23.2	207.2	922.3	456.1	59.0	1247	700.4	
6	1.0	18.5	40.8	8.0	2.3	28.2	21.9	3950
	20.0	224.6	1021	485.9	68.2	1354	776.2	
7	1.0	22.8	52.4	9.6	3.4	34.8	28.4	4976
	19.8	277.2	1310	583.3	103.2	1673	1009	
8	0.7	26.8	61.6	10.8	4.2	41.0	32.1	5763
	14.2	314.0	1539	659	126.0	1971	1140	
Eastern Balkhash	1.0	21.0	47.9	8.9	3.0	32.5	15.5	4576
	19.3	255.7	1198	546	89.1	1561	906.5	
Mean value	1.5	15.2	32.2	6.9	2.1	23.4	16.5	3212
	29.1	184.4	806.5	418.7	63.3	1124	586.2	

Table 1. Average chemical composition of the Balkhash Lake water on hydrochemical areas (summer 2012).

Area	C/Cl*10^{-2}						∑/Cl^{-1}
	Ca^{2+}	Mg^{2+}	$Na^{+}+K^{+}$	HCO_3^{-}	CO_3^{2-}	SO_4^{2-}	
1	21.0	45.8	143.5	136.2	11.6	246.9	7.0
2	22.3	47.1	171.0	142.4	13.0	300.0	8.0
3	13.1	44.8	166.1	107.0	15.3	278.8	7.3
4	8.7	36.9	155.5	82.0	15.0	230.4	6.3
5	3.3	29.5	131.7	65.1	8.4	178.0	5.2
6	2.6	28.9	131.0	62.5	8.7	174.0	5.0
7	2.0	27.4	129.7	57.7	10.2	165.7	4.9
8	1.2	27.5	135.0	57.8	11.0	172.9	5.0

Table 2. Chlorine coefficients of main ions for the Balkhash Lake water (summer 2012).

If we compare the ionic composition of the water lake with the same composition, but excluding calcium and magnesium contains in it (Table 3), it can be seen that the absolute total amount of calcium and magnesium carbonates increases from 10.56 to 25.93 in the west mmol/l; in the east it increased by 2.5 times. However, their relative content in the total concentration of salts in the same direction falls in almost two. In other words, in the direction from east to west, the Balkhash water is depleted in the content of carbonate compounds and primarily of calcium as a result of setting, which is convincingly confirmed by the data in Table 3.

Note: Top figures - the observed content, lower ones-content with carbonate deduction and related calcium and magnesium.

If the calcium carbonate is present in all parts of the lake, magnesium carbonate is completely absent in the water of the western stretch, it appears only in the eastern part of the water reservoir. Here, as we approach the eastern end of the lake, the tendency to increase the content of this salt is clearly visible. All other salts (Mg $(HCO_3)_2$,

№ area	Ionic content 1/z (C), mole/l									Carbonates of Ca and Mg	Cl^-
	Cl^-	SO_4^{2-}	HCO_3^-	CO_3^{2-}	Ca^{2+}	Mg^{2+}	Na^++K^+	∑i	1/z moles/l	% from ∑and	SO_4^-
1	5.5	10.2	4.5	0.8	2.1	7.6	11.2	41.8	10.6	25.2	0.53
	5.5	10.2	-	-		4.4	11.2	31.3			
2	5.4	11.2	4.4	0.8	2.0	7.3	12.6	43.6	10.4	24.0	0.5
	5.4	11.2	-	-		4.0	12.6	33.2			
3	7.8	15.3	4.8	1.4	1.8	9.9	17.6	59.8	12.4	20.7	0,5
	7.8	15.3	-	-		5.5	17.6	46.3			
4	10.2	17.3	5.0	2.0	1.7	11.5	21.4	69.0	13.5	19.5	0.6
	10.2	17.3	-	-		6.6	21.4	55.6			
5	19.0	25.6	7.4	2.0	1.2	16.8	36.1	108.3	19.0	17.5	0.8
	19.0	25.6	-	-		8.5	36.1	89.3			
6	22.1	28.8	8.0	2.3	1.0	18.5	41.8	122.5	20.6	16.8	0.8
	22.1	28.8	-	-		9.2	41.8	101.9			
7	28.1	34.1	9.6	3.4	1.0	22.4	51.9	150.4	26.0	17.2	0.8
	28.1	34.1	-	-		10.3	51.9	124.4			
8	32.8	41.2	10.7	0.7	0.7	26.0	62.3	177.0	25.9	14.6	0.8
	32.8	41.2	-	-		15.7	62.3	152.0			

Table 3. Average ion composition of the Balkhash Lake water in its natural state deducting calcium and magnesium carbonates (summer 2013).

Hydrochemical areas	$CaCO_3$	$Ca(HCO_3)^2$	$MgCO_3$	$Mg(HCO_3)_2$	$MgSO_4$	Na_2SO_4	NaCl + KCl
1	0.8/3.6	1.4/6.3	-	3.2/14.8	4.6/20.9	6.0/27.6	5.8/26.6
2	0.8/3.6	1.3/5.7	-	3.0/13.9	4.1/18.8	7.4/33.7	5.3/24.1
3	1.4/4.6	0.4/1.3	-	4.5/14.6	5.9/19.0	10.4/33.7	8.3/26.7
4	1.7/4.5	-	0.3/0.7	5.3/13.9	6.4/16.7	12.5/32.9	1.9/31.3
Comparison Western Balkhash	1.3/4.5	0.7/2.5	-	4.1/14.6	5.2/18.7	9.0/32.6	7.5/26.9
5	1.2/2.1	-	0.8/1.4	7.5/13.6	8.8/15.9	17.2/31.2	19.7/35.8
6	1.0/1.6	-	1.3/2.1	8.0/13.2	9.3/15.3	18.9/31.2	21.9/36.3
7	1.0/1.3	-	2.5/3.2	9.6/12.5	10.8/14.2	24.0/31.5	28.4/37.3
8	0.7/0.8	-	3.5/3.9	10.8/12.2	11.5/13.1	29.5/33.4	32.1/36.4
Comparison Eastern Balkhash	1.0/1.4	-	2.0/2.9	8.9/12.8	10.1/14.4	22.4/32.1	25.5/36.5
			0.7/1.3	6.9/14.1	7.7/15.7	15.7/32.1	26.5/33.8

Table 4. Average salt composition of the Balkhash Lake water in hydrochemical areas (mmol/l, % from the amount of salts).

$MgSO_4$, Na_2SO_4, NaCl, KCl) are present in the water throughout the lake (Table 4). At the same time, their number slightly increases, particularly sharply for the sulphate and sodium chloride in the direction from west to east.

The process of setting calcium carbonate and magnesium from the Lake Balkhash water is one of the factors, which constantly decreases the salt reserve of the lake and mineralization; therefore it is included in the expenditure part of its salt balance.

As it can be seen, the water of Lake Balkhash in its water area is strongly saturated with calcium carbonate, supersaturating is unequal and grows eastward from 3.6 to 15.2 (Andasbayev and Dzhetimov 2012).

Comparing the mean values of activities, the production of Ca^{2+} and CO_3^{2-}, in the 1st and 8th hydrochemical areas we see that they practically do not change, only some increase in the value of Ca^{2+} CO_3^{2-} from the 2nd to the 6th areas as it is observed, then they decrease in the transition to 7th and 8th areas.

References

Abrosov, V.N. 1983: Lake Balhash. Nauka, Leningrad.

Andasbayev, E. and Dzhetimov, M. 2012: [Physical and chemical research of processes of salt formation in the water of Balkhash Lake.], Lazer, Taldykorgan. (in Russian).

Burlibayev, M.Zh., Dostay, Zh.D., Nikolaenko, A., Tursunov, E.A., 2009: Contemporary state of ecosystems Ili-Balkhash basin. OO «OST-XXI century", Almaty.

Bolibok-Kurnichenko, S.S., Beremzhanov, B.A., 1987: Changes in potassium at concentration of water of continental origin. *Chemistry and Chemical technology*. **16:** 28-33.