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Geochemical Evaluation Sediments and Water of Shurabil Lake, Northwest of Iran

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ABSTRACT: Shurabil Lake, situated in south west of Ardebil City (Northwest of Iran) with 2 km distance from city centre, is one of the natural and continental lakes in Iran. It was created as a result of Shurabil fault activity within the limy hillocks in early Quaternary. This is the type of pluvial lake and has been formed along with argillite interlayers on the synclinal bed with limy-marl basement rock. The samples taken from sediments deposited on the surface of the lakebed and investigation of the results from granulometry and chemical analyses indicate that these sediments are actually limy sands carried into the lake as a result of erosion of marls in surrounding hills. On the western coast of the lake, the above mentioned sediments are characterized with clayey sand texture, while towards the eastern side as the presence of clastic materials decreases and granules within the sediments get finer, the texture becomes silty. Lakebed sediments with PH>7, contain 3 – 12% of organic material. The presence of salts, especially calcium carbonate and magnesium in abundance within the clastic materials carried into the lake, has caused the lake water to be excessively saline and being called Shurabil which means "Brine Lake". The studies show that deep into the floor of the lake, on the clastic sediments, a sludge-like thin layer with black color have been formed by the biochemical deposits. Up until the time when the water of Balkhlou-chay River didn't introduce into the lake and prior to the biological and chemical changes of lake's water, this sediment had been deposited in significant thickness on the entire lakebed and even around it and due to the presence of abundant salts, local people used it as the therapeutic sludge for treatment of some diseases.
Keywords: *Shurabil; Salty Lake; sediments; Ardebil; Therapeutic sludge; Quaternary.*

INTRODUCTION

In the beginning of the Quaternary, after orogenic movements of the middle Miocene (which caused folding of shallow deposits and emerging a vast area of Iran from water), a low land formed in deep zones located between sedimentary high lands of Miocene in south west part of Ardebil Province and developed due to the activities of Fault Shurabil in detrital marl and clay deposits (Darvishzadeh, 2004). Quaternary heavy rain falls and accumulation of water in this low land resulted in formation a permanent lake in this area – called Shurabil due to its high salinity.

Hence, Shurabil is categorized into continental lakes. This lake is classified as rainfall lakes that their chemical and sedimentary properties are highly affected by climate and type of deposited sediments and the quality of water could be defined along with some physical and environmental characteristics (Amirbeigy,2004; Homayoonzad et al, 2008). Over the past years, this lake has been among 9 lakes with the highest salinity; since its too much salinity led to the development of a white thin strip on its surface. However, through the last decade with transferring of Balkhlou-Chaye River to the lake, its salinity has considerably decreased and its ecosystem changed (Mehdizadeh, 1993).

Although Shurabil was famous for its high salinity and medical, therapeutic sludge, but all performed researches are confined to limnologic and chemical studies and there is scanty information about its geology and sedimentology. The only studies during the last years are those directed by Hydroproject Company of Russia - operated on sections of sediments around the lake. These studies imply the presence of clay-carbonate bedrock with sandstone and diatomite interlaminates and laminates of organic materials at the bottom of the lake (Mehdizadeh, 1993). Marl and carbonate rocks, carbonate sandstones, and argillite clays with age of Neogene were detected by Geological and Mining Exploration experts of Iran. In this research, there has been an effort to gather some information through the water and deposit sampling from the lake bottom

about geology and sedimentology of deposits (particularly biochemical ones which are famous by native people for their therapeutic traits).

The study area

Shurabil Lake is a saltwater continental lake which is located as a low land between low hills in North West of Iran, 2 *km* from South West of Ardebil (48˚15□/48˚17□ E - 38˚12□/38˚17□ N) (Fig. 1).

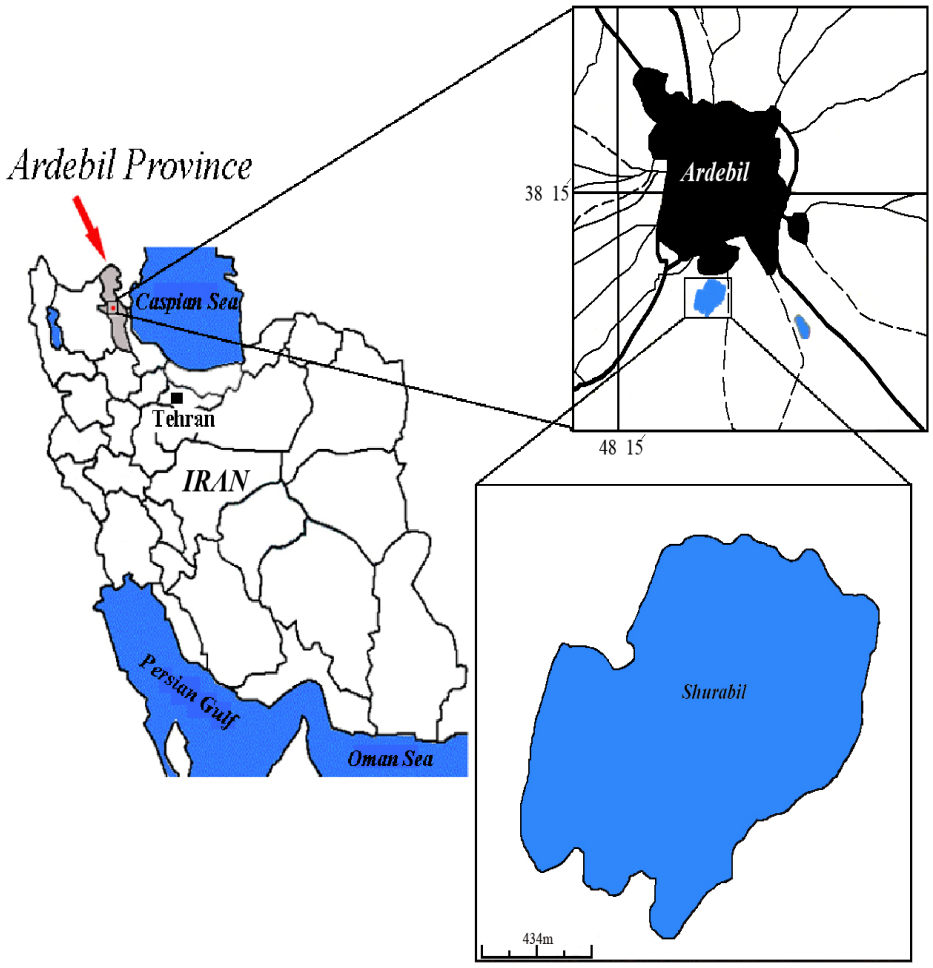

Figure 1. The Geographic location of Shurabil Lake

It is located in a higher position than Ardebil and its altitude is 1365 *m*. Its surface is about 1.70 km^2 and at the deepest points in the south west part of the lake, is 8.07 *m*. In this lake, the volume of water is 2.2 million m^3 which increases up to 14 million m^3 by conduction of Balkhlou-Chaye water to the lake through the channel. At this condition, water depth can even reach up to 10 *m*.

METHOD OF STUDY

In this research, to study the sediment of Shurabil Lake bed with consideration to type of Lake bottom sediment and difficulty of its sampling, the samples were collected in 13 selected points from surface sediment at the lake bottom up to 30 *cm*. To determine the water quality, the lake water samples were also collected as well as sediments (Fig. 2).

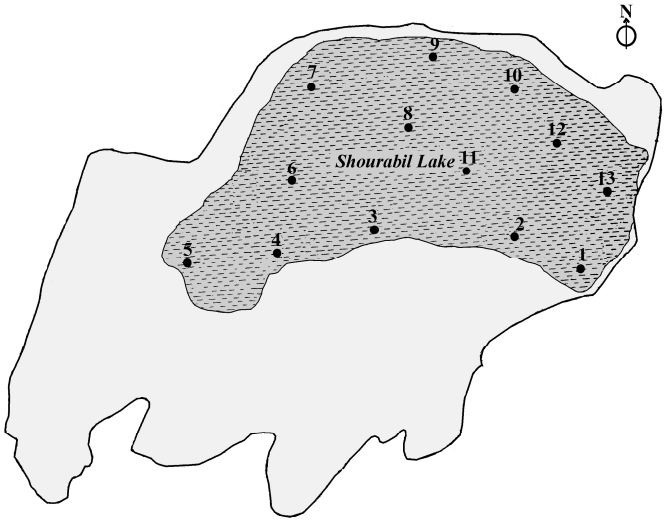

Figure 2. The location of sediments and water sampling points of Shurabil Lake bottom

Ec and pH of the water in sampling site and pH of the wet sedimentary samples were measured. For determination of chemical composition and the amount of salts in the lake water, water samples analysis were performed by chemistry laboratory of Ardebil Province Regional Water Co. Required sedimentary analysises, to determine the sedimentary type and texture of the samples, were performed by sedimentology laboratory of Payame Nour University of Ardebil. For determination of de sedimentary texture, moving sieve and pipette method were applied (aflaki, 1989). Also, titration method was applied for measuring the rate of calcium carbonate ratio in lake bottom sediments. The ratio of sediments organic material was measured by oven method, burning 1*gr* of fine-grained sediment at temperature of 450 ℃ for 4 *h* (Karbassi, 1990).

DISCUSSION

Geological Characteristics of Shurabil Lake

According to the studies of Geological and Mining Exploration of Iran, sediments around the lake are carbonate-marl type with argillite interlaminations which deposited in Neogen and were folded by orogenic movements of the middle Miocene at NW-SE direction. Hence, the low hills with smooth dip developed. Concurrent to sediment folding, Fault Shurabil also created between formed hills.

Activities of Fault Shurabil have led to formation of a fairly wide low land in carbonate-marl sediments of the area. Because of the temperate climates of Ardebil Province in the Quaternary time and due to increase of precipitations and heavy rainfalls in that time, the water obtained from rainfalls and snow melting accumulated in developed low lands and caused to gradual creation of Shurabil Lake. As it is seen in figure 3, the morphology of Shurabil Lake is an asymmetric syncline with NW-SE dip. The deepest part of the lake is located close to its eastern part.

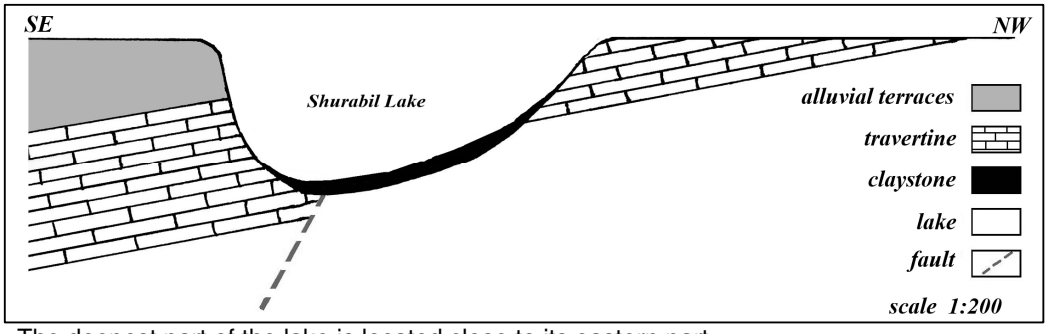

Figure 3. Map of Shurabil Lake morphology and constituting sediments of its bottom.

Sedimentary Characteristics of Shurabil Lake

Regarding the mode of Shurabil Lake development and according to Richard Selly, the sediments deposited at rain lakes bottom are influenced by existed stones around the lake (Amini and Okhravi, 2002). Introducing the detritus sediment of sedimentary hills around Shurabil Lake (which are clay, marl and sometimes sand type) into the lake has led to deposition of diatomite-bearing sandstones layers with carbonate shale on carbonate-marl bedrock of the lake.

The results obtained from grain size analysis of samples gathered from Shurabil Lake bottom show that deposited sediments at the west part of the lake are fairly coarse and have sand-clay texture while at the eastern part, the texture changes to sand-silt due to increase of introduced detritus sediments to the lake.

The presence of carbonate sediments around the lake which is a hallmark of the lakes in temperate climates (Mousavi Harami, 1998), caused a considerable amount of salts particularly calcium bicarbonate and magnesium bicarbonate, to be carried into the lake and deposited along with other detrital sediments. Thus, the results obtained from chemical analysis of the lake bed sedimentary samples imply the presence of a high ratio of calcium carbonate (66 to 81 %) in these sediments. At deeper parts of the lake, these carbonate sediments can be observed as alternative layers of marl with thin laminations of organic materials (Fig. 4). Ratio of the measured organic materials in the sediments in this part of the lake can even exceed to 12% (Table 1).

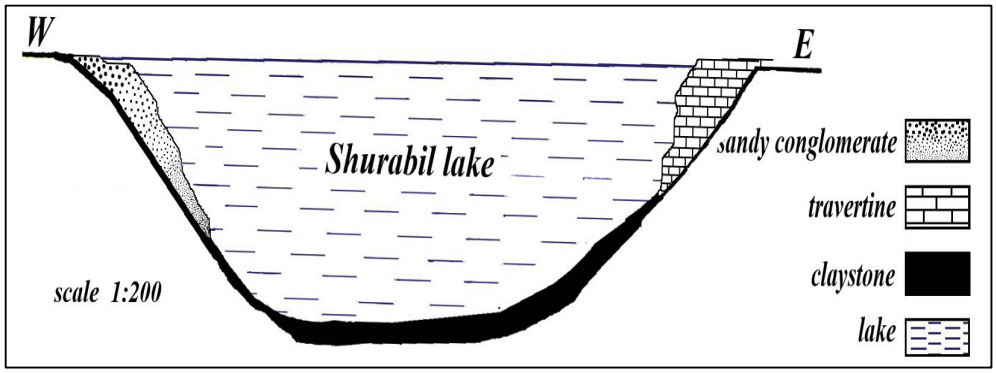

Figure 4. The mode of sediments deposition in Shurabil Lake

Table 1. The results obtained from analysis of Shurabil Lake bed

Sample	Depth(m)	Sand%	Silt%	Clay%	%OC	%$CaCO_3$	pH
1	7.22	90	6	4	6	72	9.00
2	7.40	89	5	6	4	70	9.10
3	4.30	91	1	8	4	70	9.14
4	4.30	92	6	2	3	68	8.40
5	4.50	94	2	4	4	66	7.95
6	4.55	90	7	3	4	68	8.10
7	7.30	89	10	1	5	71	9.07
8	6.40	82	11	7	10	69	7.90
9	6.10	83	12	5	9	68	7.28
10	7.30	80	10	10	8	67	7.14
11	7.50	81	6	13	12	76	7.40
12	7.40	81	8	11	12	74	7.68
13	7.30	53	43	4	3	81	8.67

Since carried detrital materials into the lake had mostly originated from carbonate sediments erosion related to Miocene period, the salt existed in them causes water saltiness of Shurabil Lake. The results obtained from chemical analysis of the collected water samples from Shurabil Lake suggest that water type of the lake is chloro-sodic (Table 2). Also, it was found that adding of Balkhlou-Chaye River water to the lake during the last decade has considerably changed its chemical composition, yet there is a high rate of Solphate ions in Shurabil water and the molar ratio of magnesium to calcium is 5 to 35 (Fig. 5).

Table 2. The results of chemical analysis of Shurabil Lake water at sampling points and sampling average in 1999 (amount of ions is meq/l).

Sample	Na^{2+}	Mg^{2+}	Ca^{2+}	SO_4^-	Cl^-	HCO_3^-	pH	TDS	Ec	SAR
5	14.9	4.50	3	7.90	8.20	3.50	8.13	1365	1950	7.69
6	15.90	2.70	2.30	9.40	8.10	3.60	8.25	1470	2100	10.10
7	14.80	2.80	2.60	8.00	8.50	3.90	7.84	1421	2030	9.01
11	7.10	2.20	2.10	3.50	4.50	3.60	7.25	805	1150	4.84
13	7.10	2.40	2.30	5.70	3.10	3.20	8.11	833	1320	4.84
1999	109	35.50	5.50	71	95	5.50	8.04	8780	1570	24.10

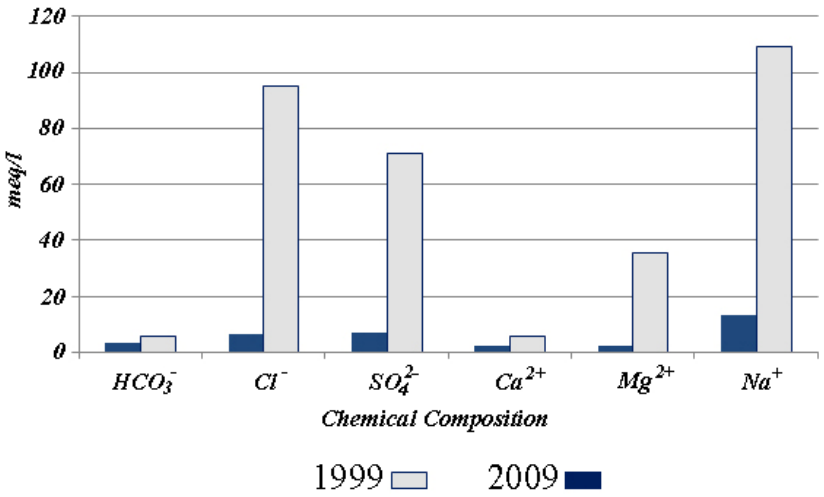

Figure 5. The chemical composition of Shurabil Lake water

With increasing the temperature and evaporation rate during the warm months of the year, which is followed by an increase in water salinity, the evaporative sediments are dominant deposited sediments at the west bank of the lake. The sediments are gypsum and anhydrite types (Motamed, 1999) which deposited on mud cracks were developed by water withdrawal, same as the other sediments deposited in salty lakes which are in form of a closed basin.

In eastern and central part of the lake, where detrital deposits do not considerably introduce into the lake, the chemical and biochemical sediments can develop. Since the type of these deposits depends on the climatic condition, water chemistry, and flooding plot of the area (Mousavi Harami, 1998), the chemical deposits of the lake bottom are mostly a composition of carbonate type; and fairly thick sedimentary beds have performed in deep parts of the lake. Lack of oxygen in underlying layers (Hypolimnion section) of deep part of the lake has led to creation the thin laminates through the deposition of organic materials in interlayer mode inside the carbonate deposits, as well as creation of a thin film of clay similar to black sludge layer on carbonate sediments of the lake bottom. Before conducting Balkhlou-Chaye River water into the lake and changing the chemical and biochemical conditions of the water, this thin slimy layer had a larger expansion. Not only the layer was expanding on all surface of the lake bottom, but also it had a considerable thickness at the lake shores. The presence of salt and other organic materials in these sediments has contributed to local people for using this therapeutic sludge to cure the Rheumatic pains.

CONCLUSION

Shurabil Lake is a tectonic sink developed from Shurabil fault activities in the beginning of the Quaternary period. The lake involves carbonate-clay bedrocks and is surrounded by carbonate-clay sediments with interlaminations of argillite clay. Through these low-dip layers (about 10 °) at NW-SE, these sediments have developed the low hills around the lake. In fact, these layers are the main constituents of the lake bedrock. Changes in the lake depth imply the presence of an asymmetric syncline with NW-SE depth. Detrital deposits on carbonate bedrock of the lake in west bank, where a great deal of detrital grains are carried into the lake, have sand-clay texture. However, this texture changes to clay and finally to sand-silt at eastern bank.

The presence of carbonate sediments around the lake, which is a characteristic of temperate regions, contributes to transfer a high amount of salts, namely calcium carbonate and magnesium carbonate, into the lake and the development of fairly thick carbonate sediments with some organic interlaminations in deep parts of the lake. Biochemical sediments have developed a thin black sludge

layer on these carbonate and marl sediments. Before conducting the Balkhlou-Chaye River water to the lake, the layer had a larger expansion and was used as medical sludge by local people.

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