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Some geochemical and mineralogical characteristics of Urmia Lake deposits

Certaines caractéristiques géochimiques et minéralogiques des dépôts de lac Urmia

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ABSTRACT

Some geochemical and mineralogical characteristics of selected soil samples, exhumed from the Urmia Lake deposits by drilling, were studied. The geotechnical investigation at the Urmia Lake bridge site, were conducted from December 2002 to September 2003. Four boreholes were drilled up to 100 meters from the lakebed, and the exhumed soil samples were tested for soil mechanical and geotechnical characteristics. Fifteen core samples from two boreholes were selected and their pore water was squeezed using the pneumatic soil pore water squeeze apparatus. The squeezed pore water samples were analyzed for chloride, sodium, and calcium concentrations, and pH, salinity and electrical conductivity. The Urmia Lake water was sampled and tested for the same parameters. The resulted values from the lake water and boreholes pore water samples were plotted against bore holes depth. The resulted chloride and sodium concentration profiles were almost uniform against soil depth, but the calcium concentrations showed a gradual increase against boreholes depth. The pH, salinity and electrical conductivity values in the pore water samples were almost uniform against boreholes depth. The pore water values in the lake bed deposits were consistent with the lake water values for the same chemical parameters. This is believed to be due to the long term sedimentation and diffusion in a saline environment.

Four soil samples from two boreholes were selected for the complete mineralogical analysis. The samples were analyzed by XRF and XRD methods and the percentages of the dominated minerals in each soil sample were determined. The Silica mineral (SiO_2) dominated in all soil samples.

RÉSUMÉ

Certaines caractéristiques géochimiques et minéralogiques des échantillons choisis de sol, exhumées des dépôts de lac Urmia par le forage, ont été étudiées (Badv, 2003). La recherche géotechnique à l'emplacement de pont de lac Urmia, ont été conduites de décembre 2002 à septembre 2003 (Mandro Geotechnical Co., 2003). Quatre forages ont été forés jusqu'à 100 mètres de basan du lac, et les échantillons exhumés de sol ont été examinés pour des caractéristiques mécaniques et géotechniques de sol. Quinze échantillons de noyau provenant de deux forages ont été choisis et leur eau interstitielle a été serrée à l'aide de l'appareillage pneumatique de compression d'eau interstitielle de sol. Les échantillons serrés d'eau interstitielle ont été analysés le chlorure, le sodium, et les concentrations en calcium, et le pH, la salinité et la conductivité électrique. L'eau de lac Urmia a été prélevée et examinée pour les mêmes paramètres. Les valeurs résultées des échantillons de l'eau de lac et d'eau interstitielle de forages ont été tracées contre la profondeur de trous d'alésage. Les profils résultés de concentration en chlorure et en sodium étaient presque uniformes contre la profondeur de sol, mais les concentrations en calcium ont montré une augmentation progressive contre la profondeur de forages. Les valeurs de pH, de salinité et de conductivité électrique dans les échantillons d'eau interstitielle étaient presque uniformes contre la profondeur de forages. Les valeurs d'eau interstitielle dans les dépôts de lit de lac étaient conformées aux valeurs de l'eau de lac pour les mêmes paramètres chimiques. On pense que ceci est dû à la sédimentation et à la diffusion à long terme dans un environnement salin.

Quatre échantillons de sol provenant de deux forages ont été choisis pour l'analyse minéralogique complète. Les échantillons ont été analysés par XRF et des méthodes de XRD et les pourcentages des minerais dominés dans chaque échantillon de sol ont été déterminés. Le minerai de silice (SiO2) a dominé dans tous les échantillons de sol.

1 INTRODUCTION

The purpose of this investigation was to examine the geo-chemical characteristics of some soil samples exhumed from the Urmia Lake deposits by drilling. The field works of the geotechnical investigation at the site of the Urmia Lake Bridge, were conducted by Mandro Consulting Engineers (Mandro, 2003). Four boreholes were drilled by Mandro up to 100 m from the lakebed, and were tested for soil mechanical and geotechnical characteristics.

The general geology and description of the site, and the soil mechanical and geotechnical characteristics of the Urmia Lake deposits, could be found in Mandro Interim Report No. M-1568 (Mandro, 2003).

The scope of this report is to present: (1) some chemical characteristics of the pore-water samples extracted from selected soil samples in boreholes No. BH-1, BH-2, and BH-3 of the Urmia Lake Bridge site, (2) the qualitative and quantitative mineralogical characteristics of four soil samples from boreholes No. BH-2 and BH-3 of the Urmia Lake Bridge site (Badv, 2003). Figure 1 shows the schematic cross-sectional view of the boreholes BH-1, BH-2, and BH-3 and the elevations of the soil samples in the boreholes, selected and taken from the core-boxes for the purpose of this investigation. Since a limited geo-chemical investigation is requested by the client, 20 soil samples were selected for the pore-water extraction and limited chemical analysis (BH-1, BH-2, and BH-3 samples, see Figure 1), and 4 soil samples were selected for

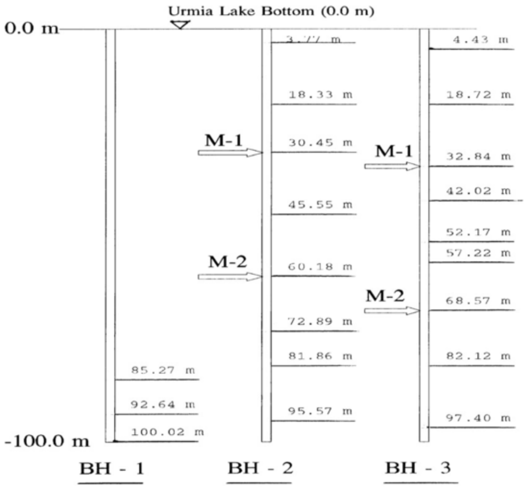

Figure 1. Cross-sectional view of the location of the soil samples tested for geo-chemical analysis (arrows refer to the location of the soil samples tested for mineralogical analysis).

the mineralogical analysis (two samples from BH-2 and two samples from BH-3, see the elevations shown by M-1 and M-2 in Figure 1).

2 PRELIMINARY FIELD AND LABORATORY WORKS

The available core-boxes from BH-1 were limited to the deeper locations but all the core-boxes from BH-2 and BH-3 were available at Mandro site. The twenty selected soil samples were distributed in three boreholes as follows: three soil samples from BH-1, eight soil samples from BH-2, and nine soil samples from BH-3 (Figure 1). The soil samples were taken from the core-boxes, rapped in a tight plastic sheet and transported to the laboratory. The water contents of the samples were measured using the samples from the core of each sample. Figure 2 shows the variations of the water contents against borehole depths in BH-2 and BH-3 samples.

The pore water samples were squeezed from the soil samples using the Pneumatic Soil Pore Water Squeeze Apparatus. This apparatus is designed so that a maximum hydraulic pressure of 600 kPa can be exerted to the clayey sample which is installed in a stainless steel cylinder having a piston on top and a porous plate and a filter paper at the bottom of the soil. The squeezed pore water passes through the filter paper and is collected in a 5 mL glass bottle. For a clayey soil with moisture content of 13% or greater, a minimum of 60 grams of soil is required to produce about 3 mL of pore-water within 2.5 to 4 hours of squeezing. The rate of increase of the applied pressure on the soil sample is controlled by an Automatic Speed Controller which is an auxiliary part of the equipment. The time required to reach to the maximum pressure depends on the soil type and it may range from 2.5 hours to 4 hours.

By several squeezing on each soil sample, sufficient pore-water samples were obtained for chemical analysis, to be discussed in the following section.

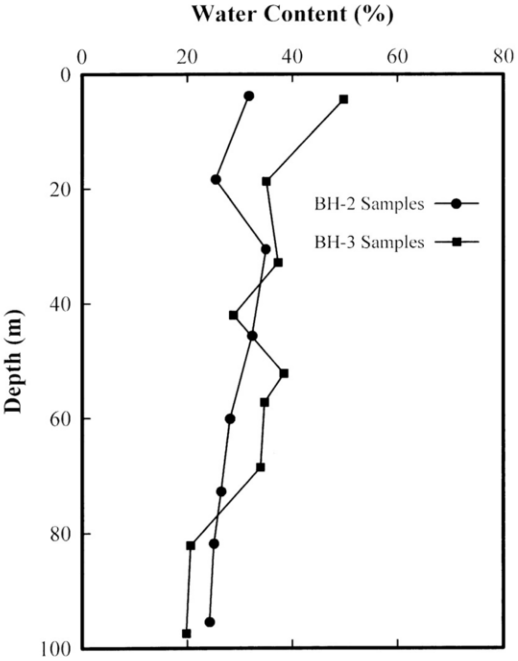

Figure 2. Water contents versus depth, in BH-2 and BH-3 soil samples

3 CHEMICAL ANALYSIS ON PORE-WATER AND LAKE-WATER SAMPLES

The pore-water and lake-water samples were analyzed for some chemical parameters. The parameters were as follows: (1) chloride, (2) sodium, (3) calcium, (4) pH, (5) salinity, and (6) conductivity. The chloride, sodium, and calcium concentrations in the samples were measured using a pH/ION meter and the ion-selective electrodes. The pH values were measured using the pH/ION meter and a pH electrode. The salinity, conductivity, and temperature of the pore-water and lake-water samples were measured using a conductivity-meter. The apparatus has the capability of measuring the conductivity, salinity and the temperature, using a combination electrode. In the chemical analysis the pore-water solutions were diluted to bring the concentrations to the range of the standard solutions concentrations, where appropriate (except for the conductivity and pH measurements in which the original samples were used). All tests were performed at the room temperature of 26.3±0.3 °C.

The concentrations of the chloride and sodium ions are expressed in g/l and plotted against boreholes depth as shown in Figure 3. As shown in the figure, the chloride and sodium concentrations are almost uniform against depth in both BH-2 and BH-3 pore-water samples. The concentrations of the calcium ion are expressed in mg/l and are shown in Figure 4. As shown in the figure the calcium concentrations show a gradual increase against depth in both BH-2 and BH-3 pore-water samples. In all figures the appropriate ion concentrations in the lake-water are plotted in depth zero. As shown in Figures 3 to 4, the pore-water concentrations in the vicinity of the lake-bed, are consistent with the lake-water concentrations.

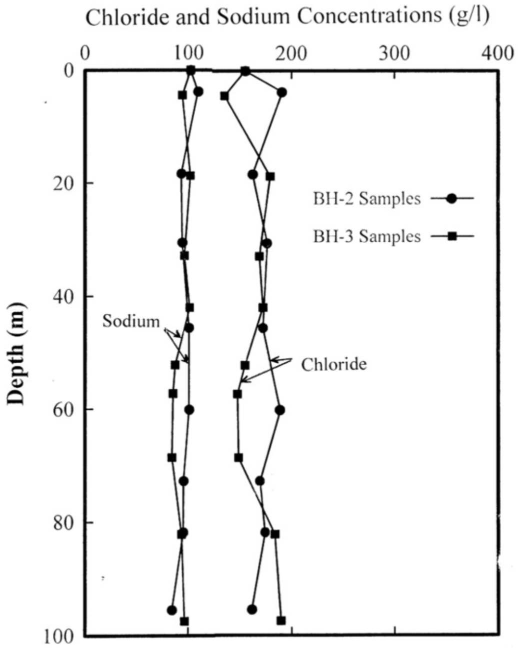

Figure 3. Chloride and Sodium concentrations in pore-water versus bore-hole depth, in BH-2 and BH-3 soil samples

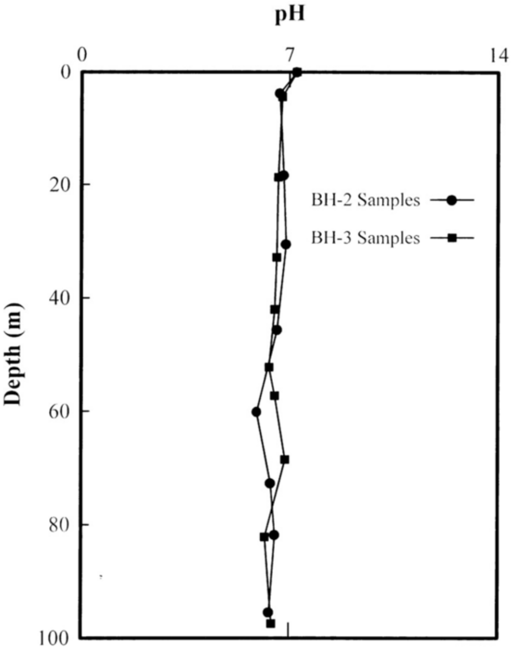

Figure 5. pH values in pore-water versus bore-hole depth, in BH-2 and BH-3 soil samples

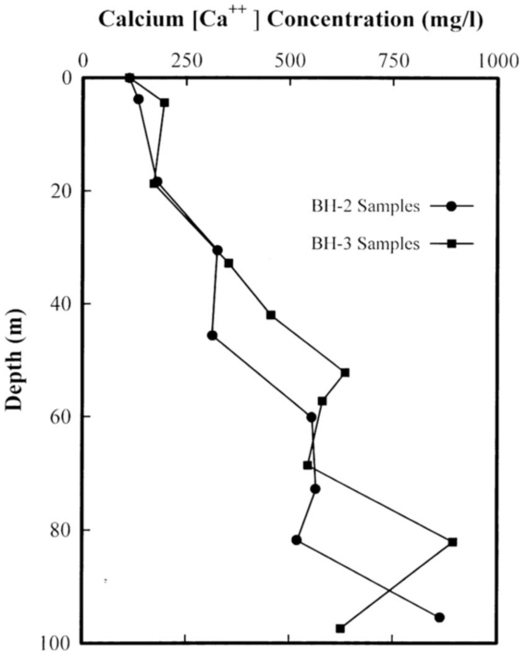

Figure 4. Calcium concentrations in pore-water versus bore-hole depth, in BH-2 and BH-3 soil samples

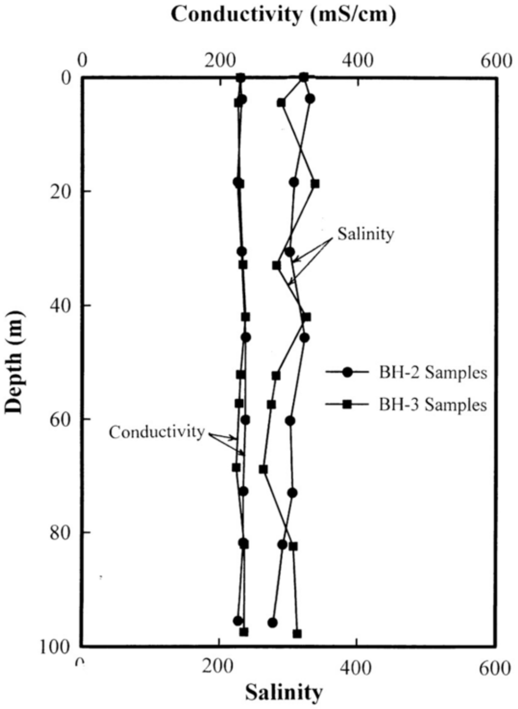

Figure 6. Salinity and conductivity values in pore-water versus bore-hole depth, in BH-2 and BH-3 soil samples

The variations of the pH values against depth are shown in Figure 5. Figure 6 shows the variations of salinity and conductivity values against depth. As shown in the figures, the pH, salinity and conductivity values in the pore-water samples are almost uniform against soil depth. The pH, salinity, and conductivity values for the lake-water samples are shown in depth zero of the figures and are consistent with the soil pore-water values.

The practical salinity (S) of a pore-water sample is defined in terms of the ratio of the electrical conductivity of the sample to that of a standard potassium chloride solution (0.01 mol/l KCl, the calibration solution) (Culkin, 1979, Lewis, 1980). The temperature compensation is automatically done by the measuring instrument using a temperature sensor in the combination electrode. The measuring instrument records the actual conductivity and temperature, converts it to the reference temperature (25 ^{o}C) using temperature compensation function and displays the conductivity at the reference temperature. A cell constant is used in the measuring instrument and is determined using a calibration solution of 0.01 mol/l KCl with a known conductivity.

Table 1. The results of the XRF analysis on the soil samples in bore-holes No. BH-2 and BH-3

Parameter	Bore Hole Number			
	BH-2		BH-3	
	Depth (m)		Depth (m)	
	30.48	60.18	32.84	68.57
SiO_2 (%)	40.98	38.68	35.25	35.35
Al_2O_3 (%)	7.46	9.74	8.50	8.47
Fe_2O_3 (%)	5.26	6.06	4.94	5.49
CaO (%)	10.99	12.08	15.01	15.22
Na_2O (%)	6.59	2.56	2.13	3.25
MgO (%)	4.46	4.58	4.66	4.44
K_2O (%)	2.18	1.84	1.50	1.69
TiO_2 (%)	0.490	0.630	0.506	0.549
MnO (%)	0.073	0.107	0.085	0.091
P_2O_5 (%)	0.095	0.127	0.107	0.105
SO_3 (%)	0.430	0.600	2.92	0.370
Cl (%)	6.54	1.89	2.12	2.95
Rb (ppm)	63	66	54	57
Sr (ppm)	362	466	604	728
V (ppm)	68	68	56	55
W (ppm)	<1	<1	<1	<1
Y (ppm)	16	16	14	15
Zr (ppm)	96	111	95	100
Zn (ppm)	73	80	59	78
Mo (ppm)	<1	<1	<1	<1
Ba (ppm)	190	263	191	231
Ce (ppm)	11	19	22	15
Co (ppm)	8	10	9	9
Cr (ppm)	70	81	58	66
Cu (ppm)	13	12	8	11
Nb (ppm)	8	9	10	10
Ni (ppm)	117	90	87	83
Pb (ppm)	13	20	7	25
U (ppm)	4	1	3	3
Th (ppm)	4	4	6	7

4 MINERALOGICAL ANALYSIS ON SELECTED SAMPLES

Four soil samples from BH-2 and BH-3 were selected for the complete mineralogical analysis. The elevations of the samples are shown in Figure 1 as M-1 and M-2. The samples were analyzed by XRF and XRD methods. The results of the XRF analysis are shown in Table 1. The results of the XRD analysis are not shown here and the reader is referred to Badv (2003). As shown in Table 1, the Silica mineral (SiO_2) dominates in all soil samples.

5 SUMMARY AND CONCLUSION

The borehole samples from Urmia Lake deposits at Urmia Lake bridge site were tested for some geochemical and mineralogical characteristics. The squeezed soil pore water and the lake water samples were analyzed for chloride, sodium, calcium, pH, salinity, and electrical conductivity. The plotted parameter values against borehole depths were almost uniform and were consistent with the lake water parameter values for chloride, sodium, pH, salinity, and electrical conductivity. Calcium showed a gradual increase of concentration against borehole depth.

The mineralogical analysis on four selected soil samples from the boreholes showed that the dominant mineral is Silica.

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