Mineral Res. Expl. Bull., 140, 35-53, 2010

ACTUAL BLOEDITE MINERAL PRECIPITATION IN A SEASONAL LAKE IN ÇANKIRI-ÇORUM BASIN

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ABSTRACT - Bloedite ($Na_2Mg(SO_4)_2.4H_2O$) which is an economically important sodium sulfate mineral currently precipitates through evaporation in Lake İshaklı, a small seasonal lake (playa lake) situated to the north of İshaklı Village (Bayat - Çorum) in Çankırı-Çorum Basin. Lake İshaklı, in which actual bloedite precipitation has been determined for the first time by this work in Turkey, extends in East-West direction and covers an area of approximately 220.000 m^2. During winter and spring months it becomes a lake with a depth of more than 2 m. However, during hot periods when evaporation becomes effective, the lake dries up and is covered with a white mineral crust. Mineralogical determinations, chemical analyses and SEM examinations were carried out on the representative samples taken from conspicuous zonings in the lake. According to the results of the analysis, it has been determined that the predominant mineral in the area is bloedite; however, thenardite (Na_2SO_4), very little halite (NaCl) and gypsum ($CaSO_4.2H_2O$) accompany this precipitation. The sodium sulfate crustification (bloedite + thenardite), which reaches an average thicknes of 3 cm over an evaporation area of approximately 187.500 m^2 in Lake İshaklı, has economical potential with its proven reserve of about 12.500 tons.

Key words: Bloedite, actual evaporite precipitation, playa lake, Çankırı-Çorum Basin

INTRODUCTION

Lake İshaklı, a playa lake in which actual bloedite precipitation has been determined for the first time in Turkey, is situated to the north of İshaklı Village, Bayat township, Çorum province (Figure 1 a,b,c). Lake water is very saline and its maximum depth exceeds 2 m in rainy seasons (Figure 2). During hot periods when evaporation is effective this pond dries up and it is covered with a mineral crust (bloedite + thenardite) that reaches a maximum thickness of 10 cm in the middle of the lake and has an average thickness of 3 cm over an evaporation area of about 187,500 m^2 (Figure 3).

Although there exists no specific source to feed the lake during evaporation periods, it is thought that there may be a source at the bottom to feed the lake.

With the thought that this actual mineralization formed at the surface might be indicative of a buried Na-sulfate deposition in the area, a core hole of 966.45 m depth was drilled at the west shore of Lake İshaklı. During this drilling work a total of 592 m halite (NaCl) mineral was cut in the salt dome after 225 m depth. No clear evidence of bloedite-thenardite association was observed. This current bloedite-thenardite formation, determined in a small, playa type lake in Çankırı-Çorum Basin may be fed by a buried fossil Na-sulfate deposit precipitated earlier in the evaporitic environment. Nevertheless, when one considers that the ophiolitic rocks lying at the base of the basin are rich in magnesium, the gypsums are rich in sulfate and volcanics are rich in sodium and these might feed the groundwater, it is also possible that this mineralization takes place as a result of surface evaporation and temperature variations following this ionic equilibrium.

This work has been prepared based on the preliminary findings of the data obtained in the field and in the laboratory. It will be possible to explain the origin and formation of this precipitation by means of the new data to be obtained

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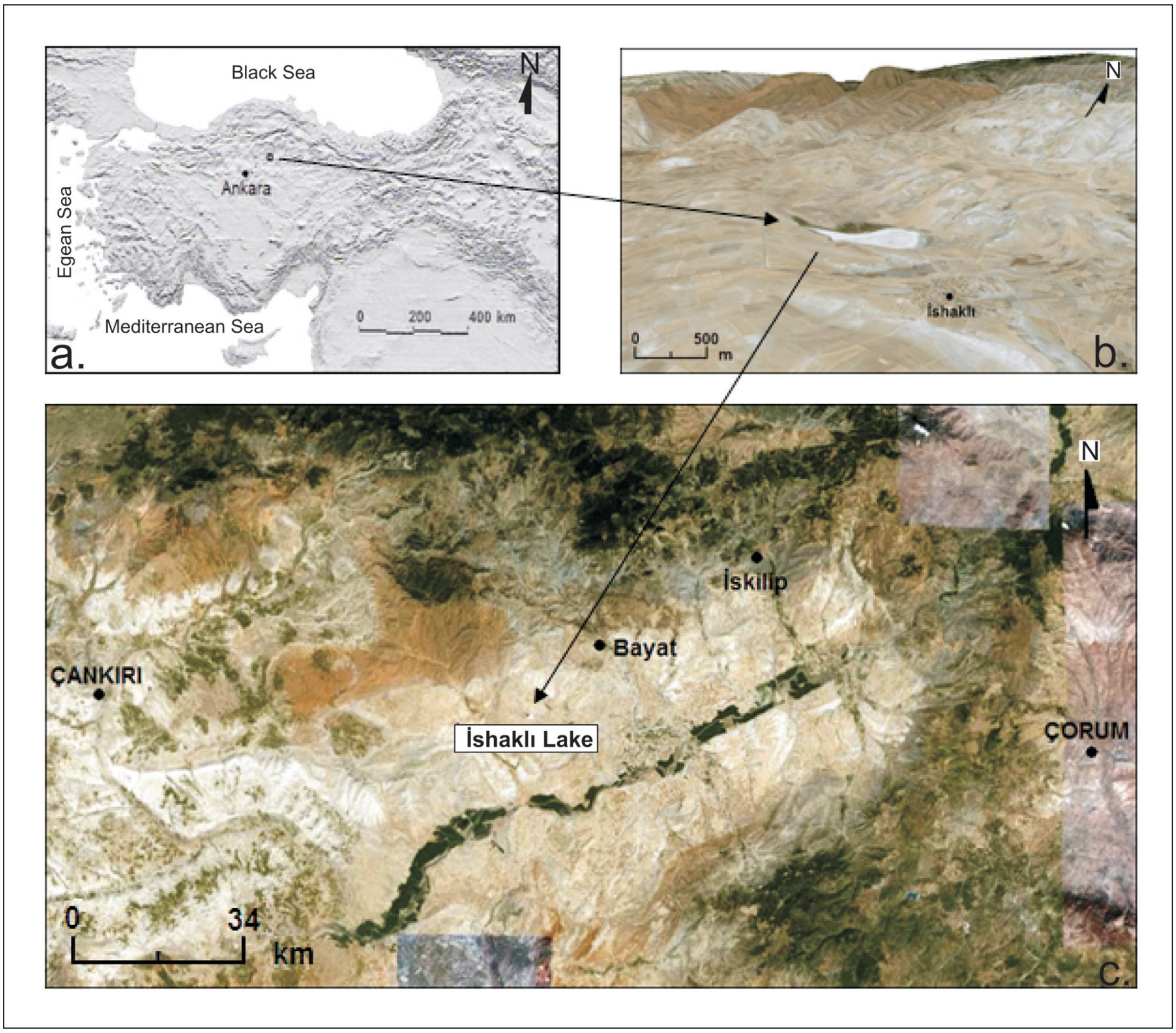


Figure 1- a,b,c: Location map of İshaklı Lake (image taken from "Google Earth).

from the works which are being carried out and which will be carried out in the basin.

In addition, it is another matter requiring detailed data to explain the relationship of the ionic concentration feeding this current formation with the thick halite mineral zone which was cut during the drilling beneath the playa lake.

The aim of this study is to state the existence of this actual mineralization which has been determined for the first time in Çankırı-Çorum basin, and by opening up for discussion the origin of the occurrence and the system of precipitation, to contribute to the production of new indicators to be used in the exploration for Na-sulfate in this basin or in Turkey.

Although Na-sulfate forms numerous minerals in the nature, the most important Na-sulfate minerals, from the standpoint of economy and mineability, are mirabilite $(Na_2SO_4).10H_2O$, the-

Figure 2- İshaklı Lake, rainy season (November-April).

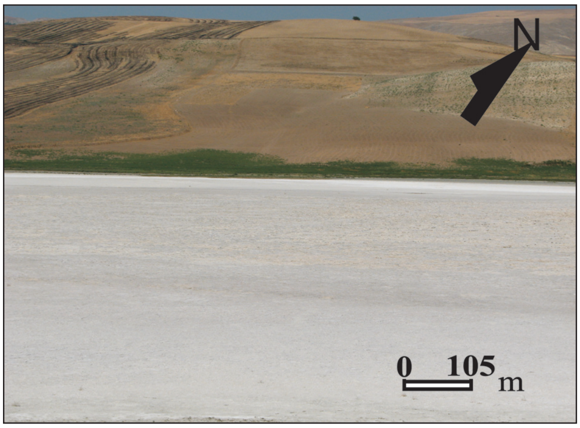


Figure 3- İshaklı Lake, dry season (May-October).

nardite (Na_2SO_4), glauberite ($Na_2Ca(SO_4)_2$) and bloedite ($Na_2Mg(SO_4)_2.4H_2O$). Na-sulfate minerals are minerals that have hardnesses of around 2-3, colorless in pure state transparent, readily soluble in water, having bitter and salty taste, having densities of around 1.49-2.8 gr/cm^3, formed in evaporitic terrestrial environments and that cannot be preserved under atmospheric conditions.

Na-sulfate is obtained in our country as in other countries of the world, primarily from alkaline lakes having saline and brackish waters, from buried solid sedimentary deposits and from chemical processes as a byproduct (synthetically).

In the our country 99% of the natural Na-sulfate produced is obtained from alkaline lakes having saline and brackish waters, and the remaining 1% from buried solid sedimentary deposits (Türkel and Ertok, 2001).

The most important production sites for Na-sulfate in Turkey are: Acıgöl (Denizli); Tersakan, Bolluk (Konya) alkaline lakes (Figure 4). From these lakes, sulfate minerals such as mirabilite (glauber's salt) and thenardite are produced (Gündoğan, 1994).

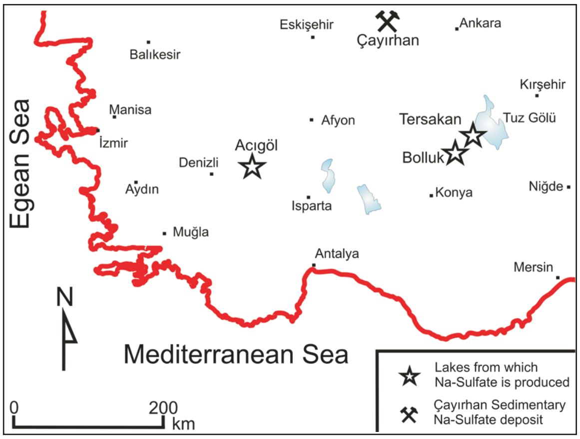


Figure 4 - Locations of Na-sulfate production in Turkey.

Apart from these, Çayırhan (Ankara) deposit in Beypazarı Basin is an example of buried sedimentary Na-sulfate deposits which are scarce in the world (Çelik et al., 1987).

Çayırhan deposit in Beypazarı Basin takes place in the Kirmir Formation by intercalating with, gypsum-bearing evaporite levels, which is of Upper Miocene age and deposited in playa lake environment. Within this deposit Na-sulfate exists as glauberite and thenardite (Helvacı et al.,1989). It has been observed that Na-sulfate occurrences in the formation are mostly composed of idiomorphic glauberite minerals and the thenardite minerals among them which bind the glauberite minerals by replacement and/or cementation (Gündoğan 2000; Gündoğan and Helvacı, 2001). In Çankırı-Çorum and Beypazarı basins of Central Anatolia there exist evaporitic formations deposited in playa lake environment during Miocene and contain Na-sulfate. The presence of Na-sulfate in Çankırı-Çorum basin was first determined by Gündoğan (2000). He states that the peculiar textures observed in pseudomorphic secondary gypsums, formed as a result of the alteration of glauberites observed in some levels within the Upper Miocene Bozkır Formation which have got the properties to be used as key indicators in the exploration for Na-sulfate and points to the importance of petrographical studies.

In addition to these formations, Oligocene Upper Evaporite Formation in Valence Basin of France (Dromart and Dumas, 1997) and Folces gypsum formation in Ebro Basin of Spain (Salvany, 1997) contain glauberite.

Depositions similar to Upper Miocene Çayırhan Na-sulfate (thenardite-glauberite) mine are observed in the world in Lower Miocene Calatayud gypsums in Calatayud Basin (Orti and Rosell, 2000) and in Lower Miocene saline unit in Madrid- Tajo Basin (Ordonez and Garcia del Cura, 1994) in Spain. In addition, in Spain's Ebro Basin, Lower Miocene Lering gypsum formation (Salvany and Orti, 1994) and Zaragoza gypsum formation (Salvany et al., 2007) contain glauberite.

REGIONAL LOCATION AND PREVIOUS WORKS

The study area is situated in Çankırı-Çorum Basin which is one of the largest sedimentary basins of Turkey. This basin lies approximately between longitudes 33.5°- 35° east and latitudes 39.5°- 41° north in Central Anatolia (Figure 5).

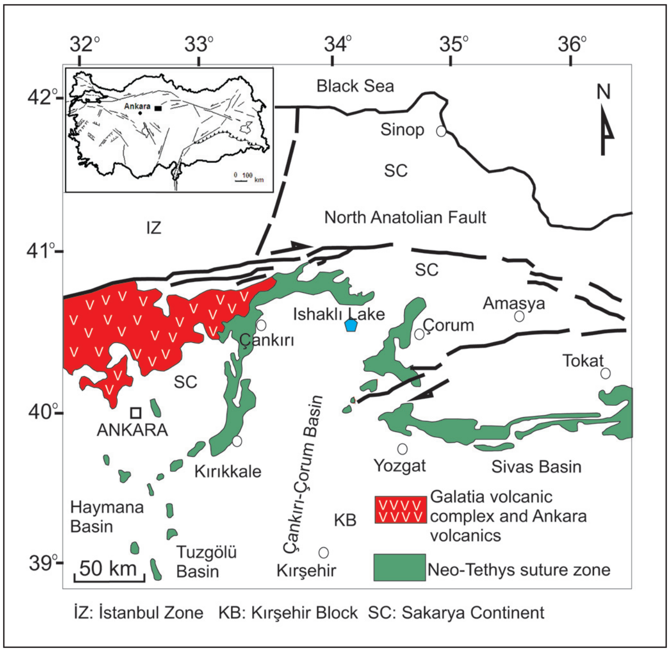


Figure 5- Simplified geological map of Çankırı-Çorum basin (Karadenizli et al., 2004).

Çankırı-Çorum Basin is surrounded in the west by Elmadağ-Eldivan mountain, in the north by Ilgaz mountains, and in the east by Köse mountain (Tüysüz and Dellaloğlu,1992). Exist there are thick deposits of rock salt (halite) within this evaporitic basin which were deposited during various evaporitic periods and which are still being exploited.

In the fieldwork and drilling, performed in the vicinity of İshaklı Lake, it has been observed that this playa lake overlies the Plio-Quaternary Değim Formation deposited in the environment of alluvial fan which constitutes the covering unit of the Çankırı-Çorum Basin. Underlying this covering unit is the Upper Miocene-Pliocene Bozkır Formation which is the first evaporitic unit of the basin, deposited in lacustrine environment and composed of gypsum- claystone succession (Figure 6).

Previous works about Çankırı-Çorum Basin include some works on Tertiary geology and stratigraphy by Birgili et al. (1975), Akyürek et al. (1982), Yoldaş (1982) and Hakyemez et al. (1986). In addition to these works, Koçyiğit (1991) and Kaymakçı (2000) established new findings regarding the tectonics and the stratigraphy of the basin.

Seyitoğlu et al. (1997, 2001) introduced the fault systems effective in the tectonics of the

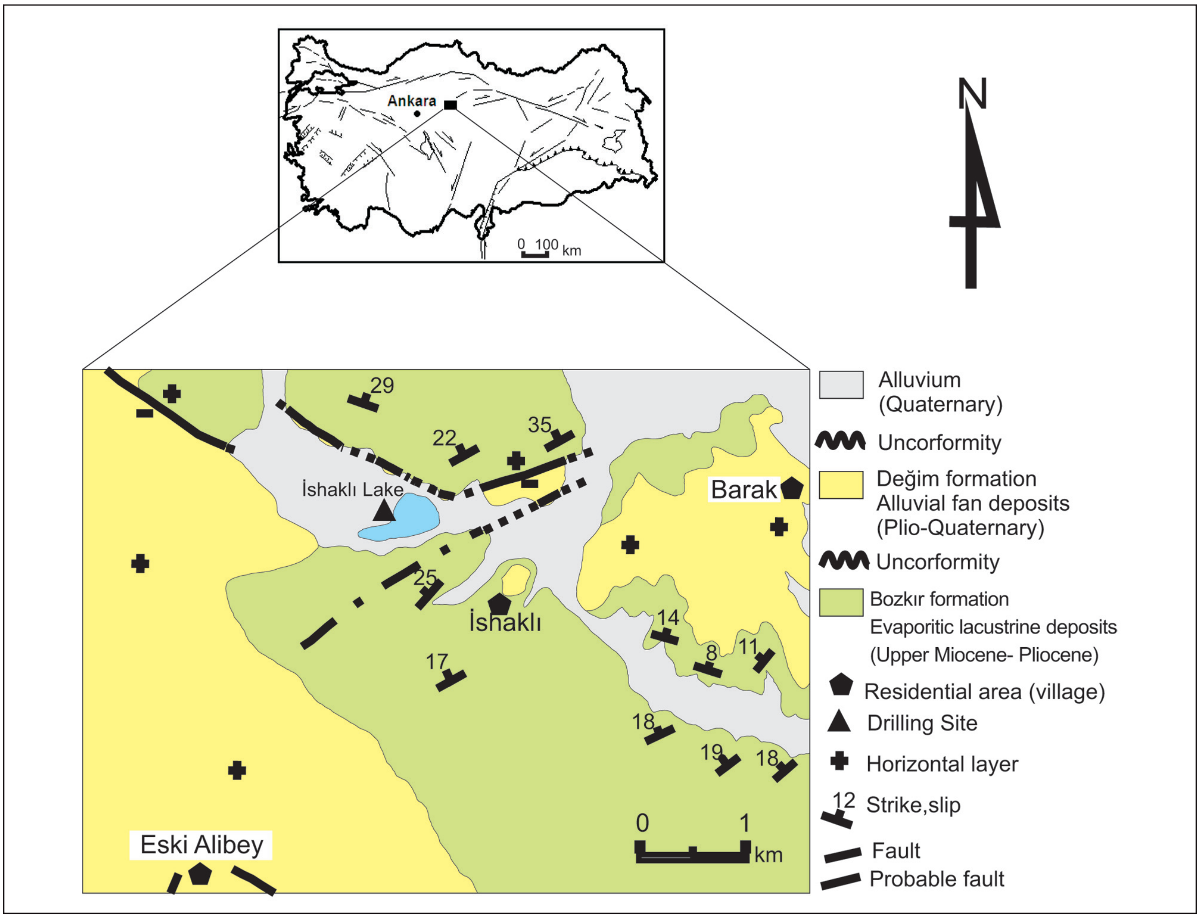


Figure 6- Geological map of the near vicinity of İshaklı Lake (modified after Aziz, 1972).

basin and the rockfall sediments developed under their control. There are also some studies carried out by Ergun (1977), Karadenizli and Kazancı (2000), Karadenizli (1999), Karadenizli et al. (2004), Gündoğan (2000), Gündoğan and Helvacı (2001), Varol et al. (2002) regarding the evaporite stratigraphy in the region.

In addition, General Directorate of MTA has been conducting an exploration work with drilling for industrial raw materials since 2006.

TECTONIC SETTING

Çankırı - Çorum Basin, which is one of the most important Tertiary basins of the Central Anatolia, is located within the Anatolide Tectonic Unit, in a complex region formed by Sakarya and Kırşehir Continents and Ankara - Erzincan Suture. The units at the bottom of the basin are made up of units belonging to Sakarya, Kırşehir Continents and İzmir - Ankara - Erzincan Suture zone. While the basin is surrounded from the north and west by an ophiolithic melange, from the south by Kırşehir Massif bounds the basin from the south. It is observed that it has a narrow connection with Haymana-Polatlı and Tuz Gölü Basins in the southwest.

The northern branch of the Neothetys (İzmir-Ankara - Erzincan Ocean) began to be depleted under Sakarya Continent with a northward subduction in Early Cretaceous; Sakarya and Kırşehir Continents were closed by Tokat and Galatia Massifs in Late Cretaceous and the Neothetys, the northern flank of which was closed in Late Cretaceous-Upper Eocene, created a complex tectonic model (Şengör and Yılmaz,1981). The regions subjected to sqeeze between irregular plates are named as Central Anatolian Basin (Görür et al., 1984). The Central Anatolian Basin is composed of Çankırı - Çorum, Tuz gölü, Haymana-Polatlı, Beypazarı and Sivas Basins (Birgili et al., 1975; Görür et al., 1984). All these basins are defined as depression basins between rising plates.

GENERAL GEOLOGY

It is known that there exists a sediment infill which continued from Paleocene to Pliocene; Paleogene rocks are marine, and Neogene rocks are composed of terrestrial, clastic and evaporitic rocks.

The basement of the Çankırı - Çorum Basin is composed of ophiolites of Mesozoic age. Paleocene - Eocene flysch unconformably overlies these. This flysch is composed of evenly stratified sandstone-shale succession and these are cut by Eocene volcanites of basaltic origin (Bayat formation). Oligo-Miocene sediments overlies all these units. In the basin there is a very thick sedimentary sequence continuing from Late Cretaceous to Pliocene without interruption. The part of this sequence up to Oligocene was deposited in marine environment, and the post - Oligocene rock units were deposited in terrestrial environment.

Evaporitic units of the Tertiary Çankırı - Çorum basin were formed during four different geologic times. During Late Eocene, when the first evaporite deposition took place (Kocaçay formation), marine environment was dominant. In the evaporite depositions during Oligocene (İncik formation), Miocene (Bayındır formation) and Upper Miocene-Pliocene (Bozkır formation) lacustrine environment was completely dominant.

All rock units in the basin are unconformably overlain by Değim formation of Plio-Quaternary age deposited in fluvial and fan environment.

METHODOLOGY

In this field, which was discovered as a result of the works carried out wihin the scope of a project implemented by the General Directorate of MTA, revision of the geological map (scale: 1/25000) stratigraphic section preparation, intense field observations were carried out and in order to check the presence of a buried deposition, a reconnaissance core drill of 966.45 m was bored.

For mineralogical examinations, the map of the conspicuous zonings observed in the lake area were made and ten different representative samples were collected in (A-A') direction (Figure7). On these samples, XRD and chemical anayses were performed; SEM examinations were carried out to determine mineral relations.

Mineralogical analyses were realized using Philips PW XRD equipment in the laboratory of MTA's MAT Department. Diffractograms were obtained using Cu-K radiation, 2,5°-70° and 2θ. During chemical analyses samples were dried at 105°C. Analyses were performed using XRF equipment, IQ+program, again in MTA's laboratory.

During SEM examinations, from 4 selected samples (B4-B7-B9-B10), under FEI Quanta 400 MK2 model scanning electron microscobe, a total of 18 secondary electron detector (SE) images and 7 adet EDS (Energy Dispersive X Ray Spectrometer) point analysis results were obtained. EDS point analysis results are semi-quantitative elemental and oxide analysis results obtained using EDAX Genesis XM4I model EDS detector. Elemental point analyses were carried out under the detector conditions of kV: 25.00 Tilt: 0.00 Take-off: 34.94 AmpT: 102.4 Det Type: SUTW, Sapphire Res: 130.54 Lsec:10.

MINERALOGY

In the İshaklı playa lake, four different mineralogical zones were distinguished using the "google earth" image of the region and field observations (Figure 7). These zones are, starting from the outermost; 1. zone: gypsum+calcite zone, 2. zone: gypsum + calcite + bloedite zone, 3. zone: bloedite + gypsum zone and 4. zone: bloedite + thenardite zone. By XRD examinations of the representative samples taken from these zones approximately in the east - west direction (A-A'), mineralogical contents of these zones were determined and by XRF analysis, the

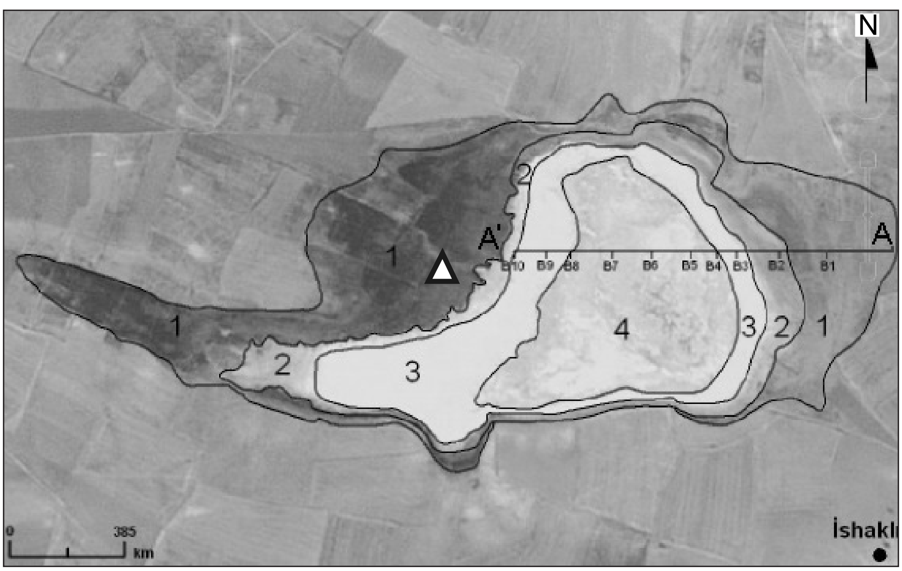


Figure 7- The map showing the zoning in İshaklı Pond (image taken from "Google Earth") A-A': sampling direction, 1: gypsum + calcite zone, 2: gypsum + calcite + bloedite zone, 3: bloedite + gypsum zone, 4: bloedite + thenardite zone Δ : Drilling location.

chemical analyses of the same samples were made and basic oxide percentages were determined (Table-1). In addition, SEM examinations were carried out in order to understand the micromorphologies and relations of the minerals.

According to the results of the analyses, mineralogical and chemical variations in the zones are clearly observed. In figure 7, in the samples taken in A-A' direction, towards the bloedite-thenardite zone, a net increase in the proportions of Na_2O and SO_3, and a net decrease in the proportions of Al_2O3, SiO_2, CaO_3 and Fe_2O3 is observed. MgO percentage varies between 4.9-8.7 in all the zones, and Cl persentage in all of the zones is constant and 0.02, which is very low. this shows that the think halite (NaCl) mineral, cut during the drilling, has almost no effect on the mineral formation at the surface

1. Zone: Gypsum + Calcite Zone

This zone, represented by green clays, corresponds to the lake's flood plain and has a length of approximately 215 m in (A-A') direction in figure 7 (Figure 8). In the samples taken from this zone gypsum, calcite, quartz, amorphous substance and very little anhydride have been determined. (Figure 9). In addition, it has been determined that the sample is rich in MgO, SO_3, Fe_2O_3 and CaO (Table-2).

2. Zone: Gypsum+Calcite+Bloedite Zone

It is the zone in which mineralization is weak and in the form of "efflorescence" (Figure 10). Its length is around 80 m along A-A' direction. In XRD analysis of the representative sample taken to determine the mineralogical composition of this zone gypsum, calcite, amorphous substance, bloedite, quartz and very little thenardite

Table 1- Results of analyses of the distinguished zones (oxide values are given as weight %).

Sample No	Na_2O	MgO	Al_2O_3	SiO_2	CaO	Fe_2O_3	SO_3	Cl	A.K.	XRD mineralogical composition	Zones
B1	1,2	5,7	7,0	24,9	17,1	6,0	15,7	0,02	19,50	Gypsum,Calcite,Quartz, Amorphous substance, very very little Anhydride	Gypsum-Calcite zone
B2	6,7	4,9	3,0	10,8	14,7	3,0	21,3	0,02	34,00	Gypsum,Calcite, Amorphous sustance, **Bloedite,** Quartz, very little Thenardite	Gypsum-Calcite-Bloedite Zone
B3	13,0	8,0	0,6	2,2	6,3	2,1	36,4	0,02	30,75	**Bloedite**,Gypsum,little **Thenardite**,very little Halite	Bloedite - Gypsum Zone
B4	23.3	7.4	0,1	0.4	1.3	0,1	50.1	0.02	17,10	**Bloedite, Thenardite**, Halite, very little Gypsum	Bloedite - Thenardite Zone
B5	27.5	5.7	<0.1	0.1	0.5	0,1	52.4	0.02	13,50	**Thenardite, Bloedite**,little Halite	
B6	21.0	8.7	0.3	1.1	5.4	0,2	49.1	0.02	13,85	**Bloedite**, Halite, **Thenardite**, little Gypsum	
B7	23.2	7.7	0.3	0.8	3.3	0,1	52.4	0.02	12,00	**Thenardite, Bloedite,** very very little Halite	
B8	29.9	6.2	0.1	0.3	0.2	0,1	53.2	0.02	9,95	**Thenardite,Bloedite**, little Halite	
B9	24.7	6.7	0.1	0.3	1.8	0,1	50.3	0.02	15.80	**Bloedite, Thenardite**, Halite, little Gypsum	Bloedite - Gypsum zone
B10	26.1	5.7	0.1	0.6	1.4	0,2	47.1	0.02	18.65	**Thenardite,Bloedite** little Gypsum,little Halite	

Table 2- Chemical analysis of Sample B1 (oxide values are given as weight %).

Sample No:	Na_2O	MgO	Al_2O_3	SiO_2	K_2O	CaO	Fe_2O_3	SO_3	Cl	MnO	P_2O_5	TiO_2	SrO	LOI
B1	1,2	5,7	7,0	24,9	1,0	17,1	6,0	15,7	0,02	0,2	0,1	0,5	0,49	19,50

have been determined (Figure 11). Results of the sample's chemical analysis are given in table 3.

3. Zone: Bloedite + Gypsum Zone

It is the zone in which mineralization begins to intensify in a rough and foamlike "efflorescent" appearance and a mineral crust with an average thickness of 3-5 cm is observed (Figure 12 a,b). This zone has an approximate length of 93 m at the east side of the pond, along A-A' direction. In the XRD analysis of the sample taken from this zone plenty of bloedite, gypsum, little thenardite, very little feldspar and trace amount of halite have been determined (Figure 13). The result of the chemical analysis clearly shows the increase in the proportions of Na_2O, MgO and SO_3 and the decrease in the proportion of CaO (Table-4).

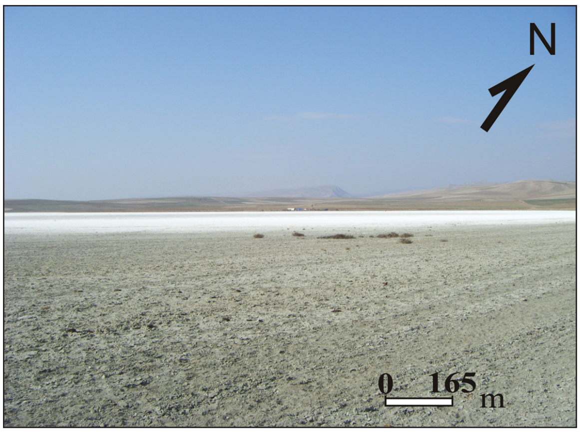


Figure 8- Gypsum+calcite zone at the lakeflat.

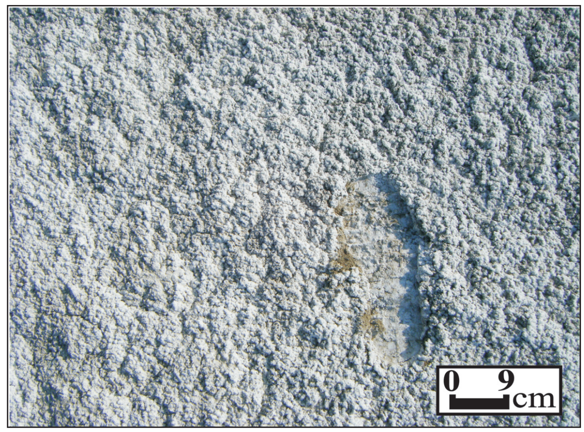


Figure10 - Weak, efflorescence mineralization surface representing gypsum + calcite+bloedite zone.

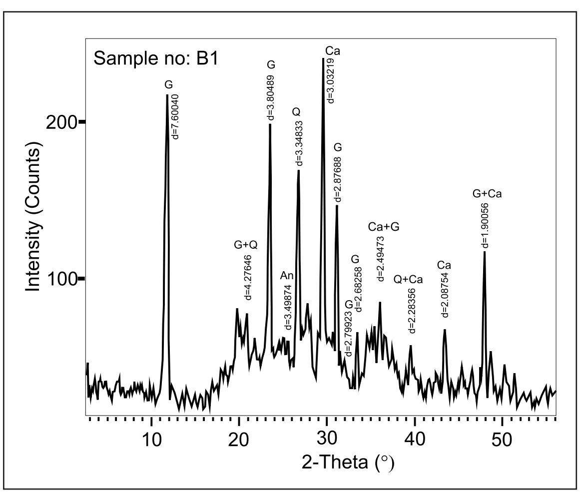


Figure 9- XRD diffractogram of Sample B1; G:Gypsum, Q: Quartz, Ca: Calcite, An: Anhydride.

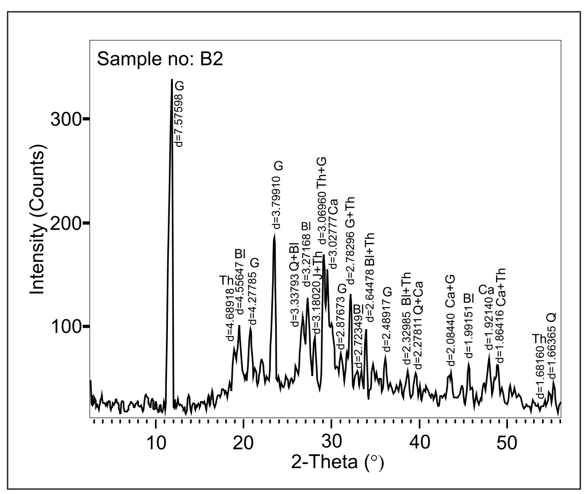


Figure11- XRD diffractogram of Sample B2 G:gypsum, Bl:bloedite, Th:thenardite, Q:quartz, Ca:calcite.

Table 3- Chemical analysis of Sample B2 (oxide values are given as weight %).

Sample No:	Na_2O	MgO	Al_2O_3	SiO_2	K_2O	CaO	Fe_2O_3	SO_3	Cl	MnO	P_2O_5	TiO_2	SrO	LOI
B2	6,7	4,9	3,0	10,8	0,5	14,7	3,0	21,3	0,02	0,1	0,1	0,5	0,33	34,00

Table 4 - Chemical analysis of Sample B3 (Oxide values are given as weight %).

Sample No	Na_2O	MgO	Al_2O_3	SiO_2	K_2O	CaO	Fe_2O_3	SO_3	Cl	MnO	P_2O_5	TiO_2	SrO	LOI
B3	13,0	8,0	0,6	2,2	0,2	6,3	2,1	36,4	0,02	<0,1	0,1	<0,1	0,20	30,75

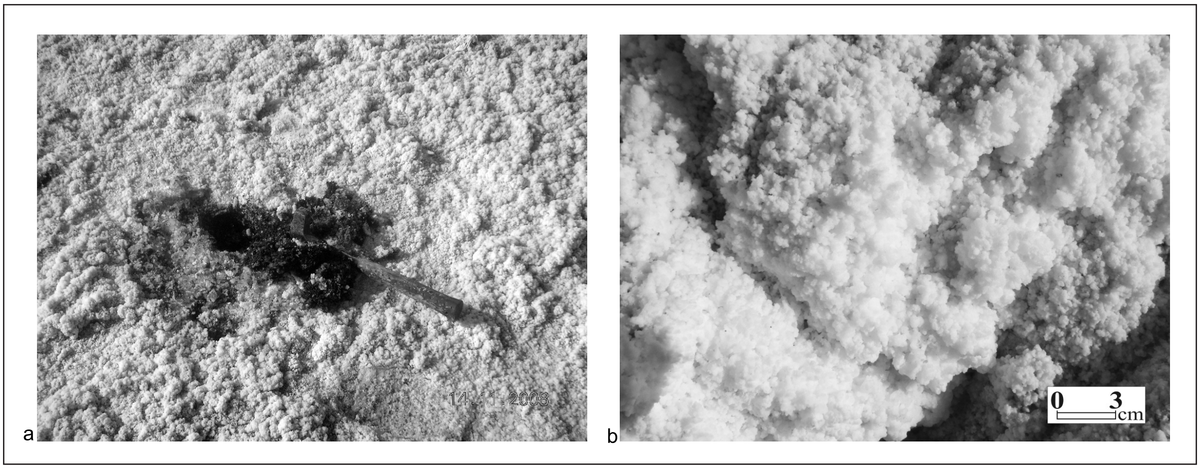


Figure 12- Foamlike "efflorescence" mineralization surface representing bloedite + gypsum zone a: general view b: detailed view.

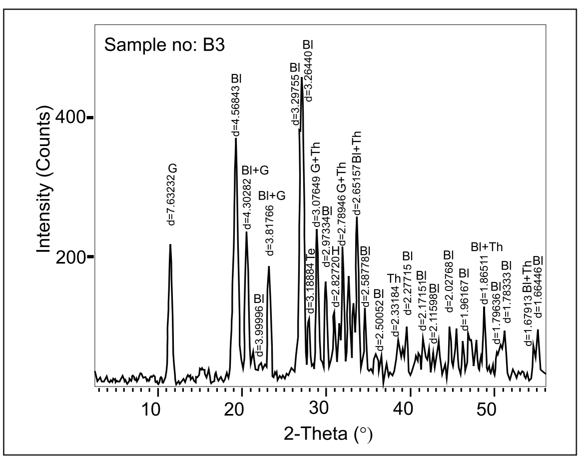


Figure 13- XRD diffractogram of Sample B3; G:gypsum, Bl: bloedite Th:thenardite, H:halite.

4. Zone: Bloedite + Thenardite Zone

This zone is represented by bloedite-thenardite assocation and has the thickest mineralization with a crust thickness of 5-10 cm (Figure 14 a,b). It has a length of about 285 m along A-A' direction. The plants growing in this salty zone intensifing in mid-lake accelerate evaporation and by absorbing salty water feed the precipitation (Figure 15 a, b). In this zone are abundantly present tepee structures (Figure 16 a,b), rodlike bloedite crystals (Figure 17), polygonal desiccation cracks (Figure 18) and bloedite crystals within the brecciated structure developed under the influence of desiccation (Figure 19). XRD analyses of the representative samples of this zone, B4, B5, B6, B7, B8 show bloedite-thenardite association and very little halite and very little gypsum (Figure 20a, b, c,d, e). And the results of the chemical analyses support this association (Table 5).

In the XRD analyses performed on the representative samples B9 and B10 corresponding to

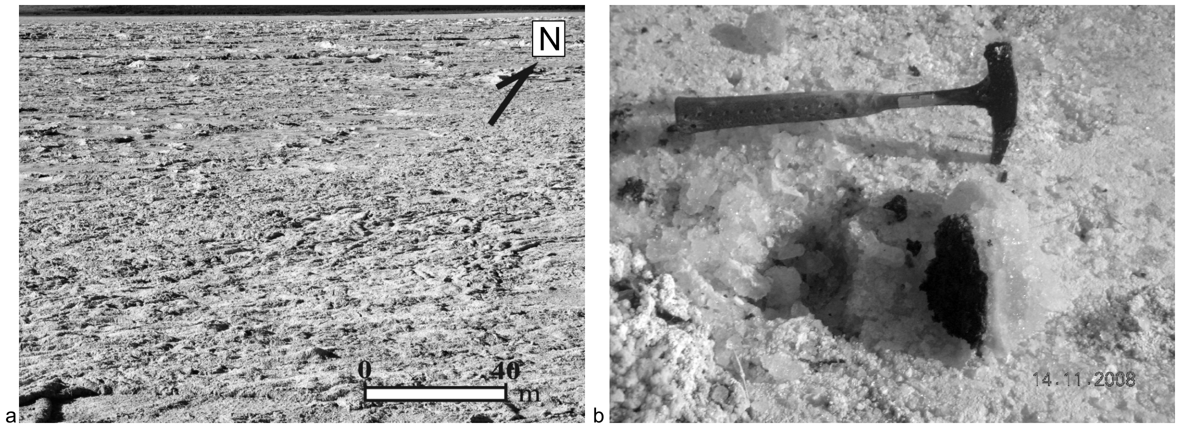


Figure 14- Large-scale desiccation cracks and crustifications observed in bloedite-thenardite zone.

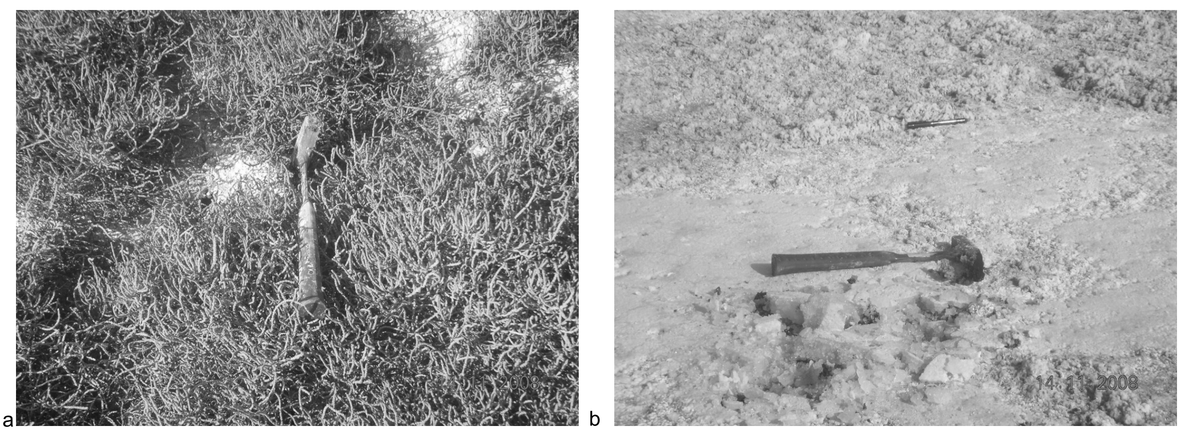


Figure 15- a: General view of the haloduric plants at lake shore, b: plant remains completetly covered by bloedite mineral in mid-lake.

Table 5- Chemical analyses of Samples B4, B5, B6, B7, B8 (Oxide values are given as weight %).

Sample No	Na_2O	MgO	Al_2O_3	SiO_2	K_2O	CaO	Fe_2O_3	SO_3	Cl	MnO	P_2O_5	TiO_2	SrO	LOI
B4	23.3	7.4	0,1	0.4	0,1	1.3	0,1	50.1	0.02	<0,1	<0,1	<0,1	0,04	17,10
B5	27.5	5.7	<0.1	0.1	<0.1	0.5	0,1	52.4	0.02	<0,1	<0,1	<0,1	0,03	13,50
B6	21.0	8.7	0.3	1.1	0.1	5.4	0,2	49.1	0.02	<0,1	<0,1	<0,1	0,16	13,85
B7	23.2	7.7	0.3	0.8	<0.1	3.3	0,1	52.4	0.02	<0,1	<0,1	<0,1	0,13	12,00
B8	29.9	6.2	0.1	0.3	<0.1	0.2	0,1	53.2	0.02	<0,1	<0,1	<0,1	0,01	9,95

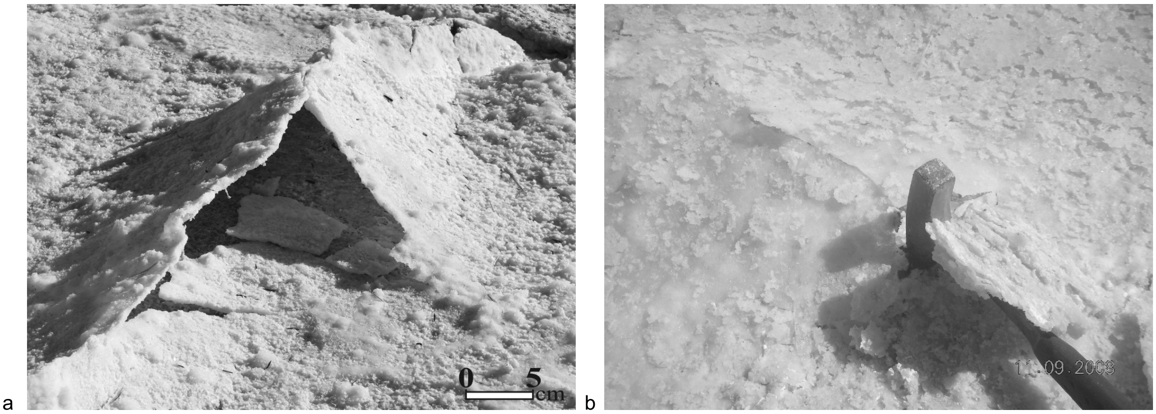


Figure 16- Tepee structures a: well-developed, b:weak.

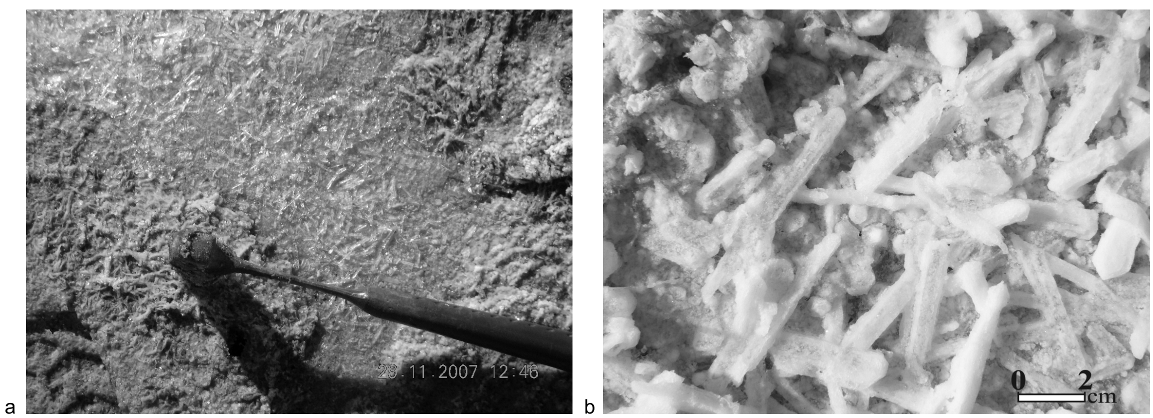


Figure 17- Rodlike bloedite crystals a: general view b: detailed view.

Figure 18- Mid-lake polygonal desiccation cracks.

Figure19- Bloedite crystals within brecciated structure developed under the influence of desiccation.

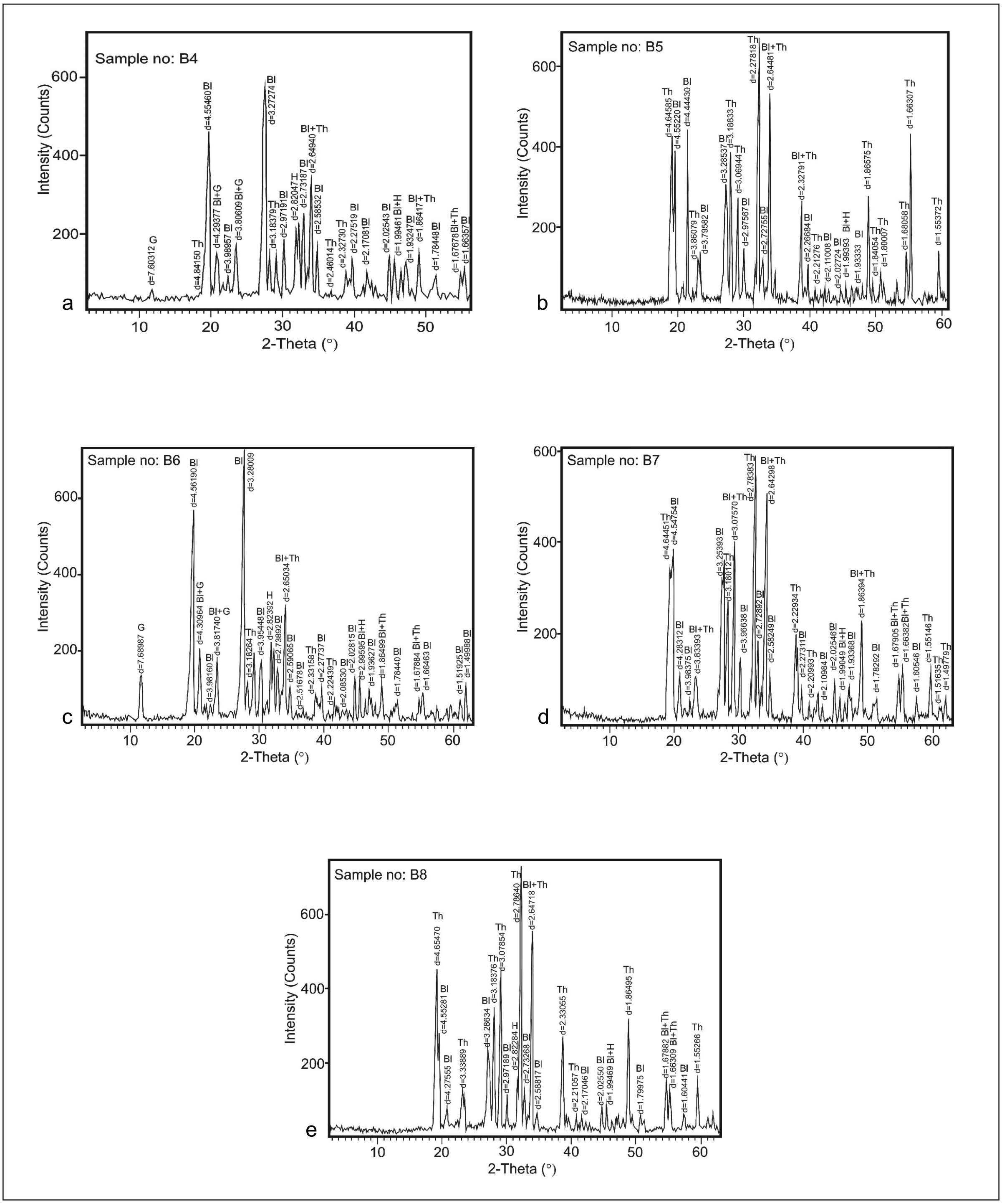


Figure 20- XRD diffractograms of the samples taken from Bloedite+Thenardite zone; G:gypsum, Bl:bloedite, H:halite, Th:thenardite, a:sample B4, b:sample B5, c:sample B6, d:sample B7, e:sample B8.

the bloedite - gypsum zone lying to the west of İshaklı playa lake bloedite, thenardite, halite and very little gypsum have been determined (Figure 21 a,b). And the chemical analyses of these samples show high proportions of Na_2O and SO_3 (Table 6).

The fact that the bloedite + gypsum zone lying to the west of İshaklı playa lake contains higher proportions of Na_2O and SO_3 compared to the zone lying to the east of the lake, according to the results of the analyses, and the mineralization seems to be thicker in the west side compared to the east side makes one think that feeding from the west might be more effective in the lake.

Through SEM examinations the mineralogical relation of the bloedite-thenardite association determined by XRD analyses was tried to be defined. Besides, by performing EDS point analyses on the crystals (Figure 22 b, d, f), (Figure 23 b), different forms of the minerals were defined. It has been observed that thenardite minerals, seen as rodlike and zoned (Figure 23 a, c) have grown on semi-idiomorphic, tabular bloedite crystals (Figure 22 a, c, e) and crystallized after bloedite (Figure 24 a, b).

CONCLUSIONS

In Turkey, the existence of actual precipitation of bloedite, which is an economically important Na-sulfate mineral, has been determined for the

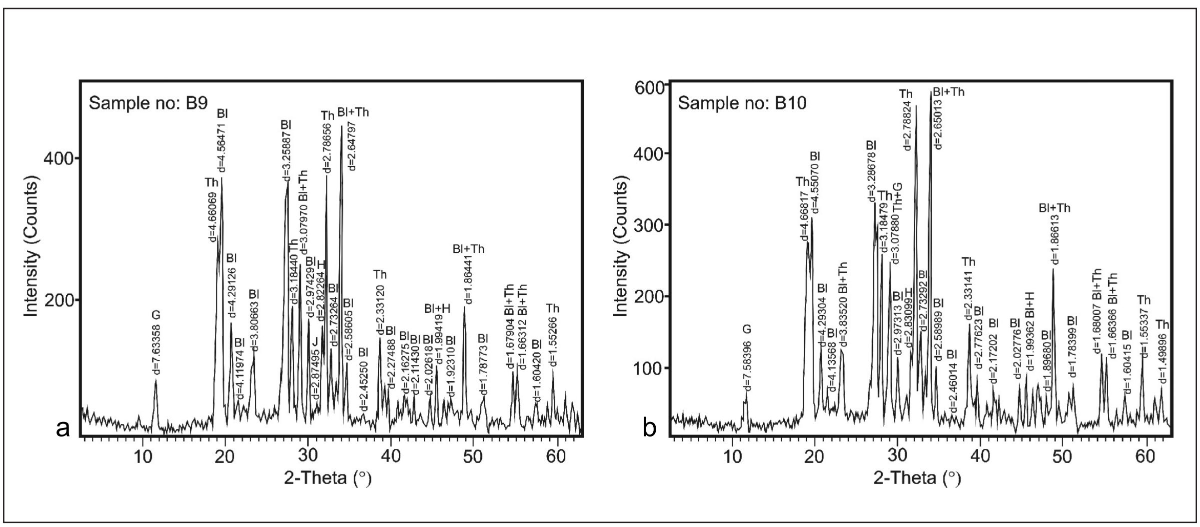


Figure 21 - XRD diffractograms of Samples B9 and B10; G: gypsum, Bl: bloedite, H: halite Th: thenardite a: Sample B9, b: Sample B10.

Table 6- Chemical analyses of Samples B9 and B10 (Oxide values are given as weight %).

Sample No	Na_2O	MgO	Al_2O_3	SiO_2	K_2O	CaO	Fe_2O_3	SO_3	Cl	MnO	P_2O_5	TiO_2	SrO	L O I
B9	24.7	6.7	0.1	0.3	0,1	1.8	0,1	50.3	0.02	<0,1	<0,1	<0,1	0,05	15.80
B10	26.1	5.7	0.1	0.6	0.1	1.4	0,2	47.1	0.02	<0,1	<0,1	<0,1	0,05	18.65

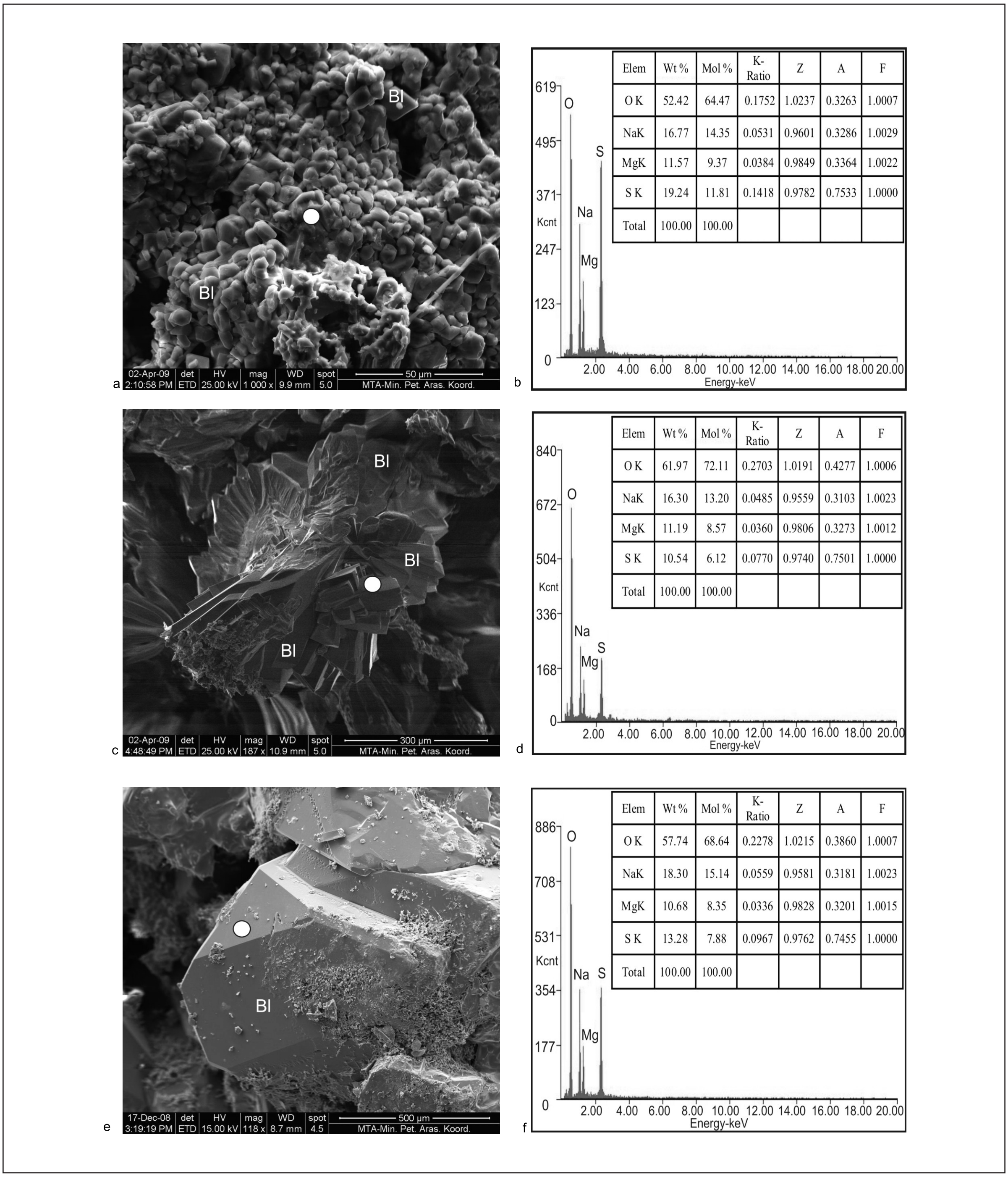
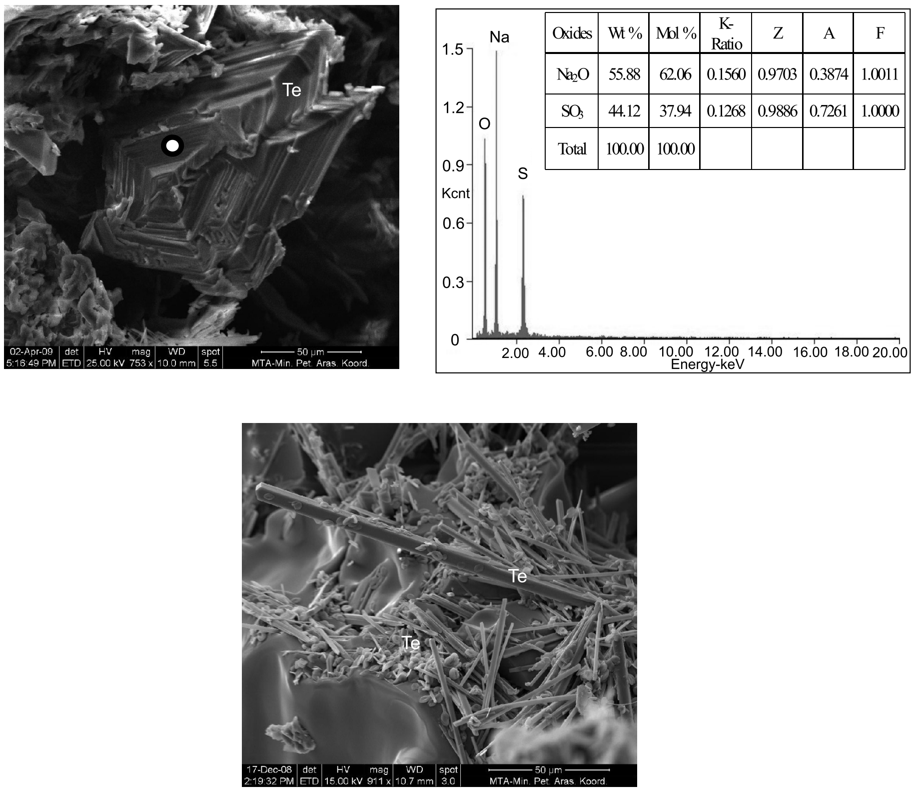


Figure 22- Bloedite crystals a: Blodite mineral associaton (B4), b:EDS point analysis done on bloedite crystal (B4), c: Tabular bloedite crystal (B7), d: EDS point analysis done on tabular crystal (B7), e: Semi-idiomorphic bloedite crystal (B10), f: EDS point analysis done on semi-idiomorphic bloedite crystal (B10), (O: EDS analysis measurement point on the crystal).



Oxides	Wt %	Mol %	K-Ratio	Z	A	F
Na_2O	55.88	62.06	0.1560	0.9703	0.3874	1.0011
SO_3	44.12	37.94	0.1268	0.9886	0.7261	1.0000
Total	100.00	100.00				

Figure 23- Thenardite crystals a: thenardite crystals in zoned structure (B9), b: EDS point analysis done on thenardite crystal in zoned structure (B9), c: rodlike thenardite crystals (B9).

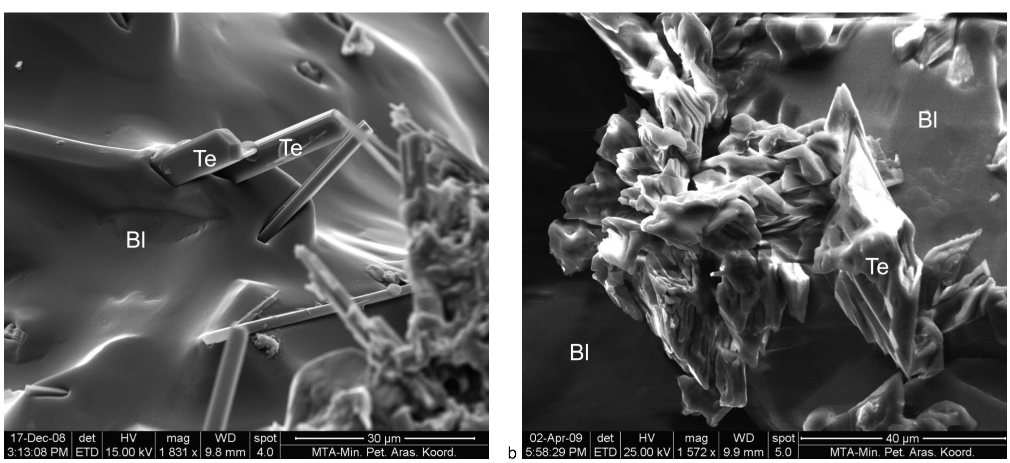


Figure 24- Thenardite crystals on bloedite crystal a: rodlike thenardite crystal (B9), b: disc-shaped thenardite crystal (B9).

first time in İshaklı playa lake in Çankırı-Çorum Basin. Through analyses it has been determined that thenardite, very little halite and gypsum accompany this occurrence.

According to the mineralogical zone map of the İshaklı playa lake, lake area has been divided into four different zones. These are from the outermost to the innermost: 1. zone: gypsum+ calcite zone, 2. zone: gypsum + calcite + bloedite zonu, 3. zone: bloedite + gypsum zone and 4. zone: bloedite + thenardite zone. According to the results of the analyses of the samples taken from these zones, the fact that the bloedite-gypsum zone mineralization lying to the west of the lake is thicker and contains higher proportions of Na_2O and SO_3 makes one think that feeding from the west side of the lake might be more effective.

During SEM examinations it has been clearly determined that in the bloedite-thenardite association thenardite mineral grows on bloedite crystals and crystallizes after bloedite.

In the core drilling performed in the gypsum-calcite zone forming the mudflat of the lake, a halite layer of 592 m in total has been cut. Although no net evidence of bloedite - thenardite association has been observed, detailed analyses and drillings have been continuing.

This mineralization, currently formed through evaporation of lake water, corresponds to a proven economical reserve of around 125,000 tons (bloedite+thenardite) with an average mineral thickness of 3 cm over a pond area of about 187,500 m^2. However, after harvesting this precipitated reserve, the duration and thickness of the new precipitation should be observed. Only after these data have been obtained, it will be possible to decide whether the field is economic in terms of Na-sulfate or not.

More detailed works are needed in order to determine whether this surface mineralization is fed by a buried deposit or it develops through the process of evaporation at the surface which follows the ionic enrichment (Na,Mg) in the ground water.

Besides, the reason why the very thick halite (NaCl) mineralization cut in the basin does not accompany this actual precipitation should be searched. In addition, detailed data should be produced taking into consideration such factors as the origin of the chemistry of ground water feeding the system, actual tectonics and hydrogeology.

ACKNOWLEDGMENTS

This work includes some data obtained within the scope of Central Anatolian Industrial Raw Materials Exploration Project conducted by the General Directorate of the Mineral Research and Exploration (MTA). I would like to express my thanks to Prof. Dr. Baki Varol (Ankara University) for his contributions to the field and office works, to İnciser Girgin (MTA) and Okan Zimitoğlu (MTA) for their contributions to XRD and SEM examinations, to Haşim Ağrılı (MTA) for his encouragement and to M. Ali Yastı (MTA) for his help in drawings.

Manuscript received April 8, 2009

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