

**FEATURES OF MACRO AND MICRO STRUCTURES DETERMINED IN  
HALITE AND GLAUBERITE DEPOSITS, IN TUZGÖLÜ BASIN (TURKEY)**

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**ABSTRACT**

The study area is located in the southern part of the Tuz Gölü in Central Anatolia. Many evaporate minerals e.g. halite, glauberite, gypsum/anhydrite, dolomite and partially calcite, magnesite and bloedite were determined in the Neogene aged evaporitic deposits. Many macro and micro structures were observed in ten cores which of depth range from 655 to 1400 m. Halite mineral is found in three forms in the samples: 1) filling the gaps between the sulfate minerals (matrix), 2) in the massive structure, 3) in the large crystal structure in the mosaic. In the specimens studied, the glauberite mineral is found in two different forms, one being deposited in layers in shallow environments and the other being in the form crystallites with other evaporate minerals in deep. Glauberite crystals are found in macro and microscopic dimensions, especially in the form of banded and random aggregates in the form of spear or partially equilateral quadrangular mosaic and semi-euhedral crystals intercalated with halite and partially anhydrite minerals. Gypsum mineral is found especially in shallow and / or stagnant water as euhedral crystals and can be converted into anhydrite mineral in a very short time due to the change of solution chemistry and diagenesis. Anhydrite minerals usually exhibit banded structures, while single ordered large crystals have also been found.

**Keywords:** Evaporite, halite, glauberite, Tuzgölü, Turkey

**INTRODUCTION**

Bedded ancient evaporates are frequently formed from Na, Ca, Mg, Cl, CO<sub>3</sub>, and SO<sub>4</sub> in varied proportions, with most of them having been precipitated in continental, tectonically active, arid lacustrine environments. In this study area, huge thicknesses of salt and soda were deposited during Miocene period. The Tuz Gölü Basin is located in the south-eastern part of Central Anatolia (Figure 1).

Although the recent evaporites are widespread in the region, all sequence of the Miocene evaporites are not observed on the outcrop. Therefore, no information is available on the vertical and lateral distribution of evaporites. Additionally, macroscopic and microsocial features of the evaporates were not determined in detail nowadays. The investigation area is the important inner basins located in the Central Anatolian bordered to the north of the Taurus Mountains and Salt Lake on the southwest. The basin is the Turkey's most

important salt and soda deposits. Therefore, a number of studies have been carried out in the study area for various purposes ([1], [2], [3], [4], [5], [6] and [7]).

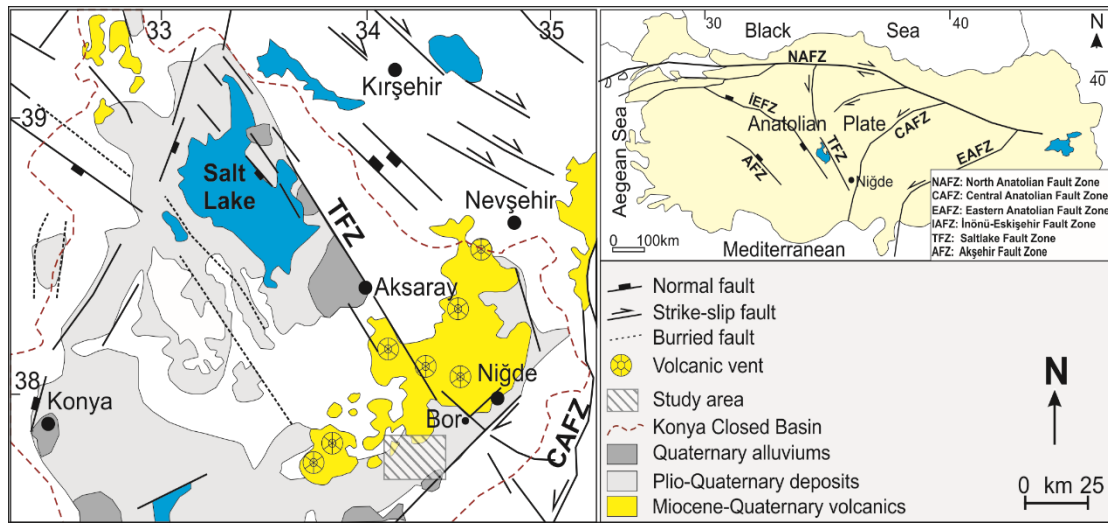


Figure 1. Simplified geology (after [8]) and location maps of study area.

## GEOLOGY

The study area is located in the southern part of the Tuz Gölü. The basement rocks of the study area consist of Paleozoic metamorphic (metaschist, metacarbonate, quartzite, calc-schists and coarse crystalline white marbles etc.) of the Niğde massive and Upper Cretaceous ultrabasic rocks. The basement unit is overlain unconformably by the Paleocene-Eocene-aged marine volcanoclastic rocks. During the period, the basin displayed as inner shallow marine characteristics, whereas during the Miocene-Pliocene it was a closed lake. During Upper Miocene-Pliocene-Quaternary volcanism activated in the basin, and formed from mainly tuff, andesitic-basaltic volcanic and volcanoclastic rocks (Figure 1). The volcanic rocks are generally observed in upper level of the basin sediments and intercalated mainly with detrital sediments.

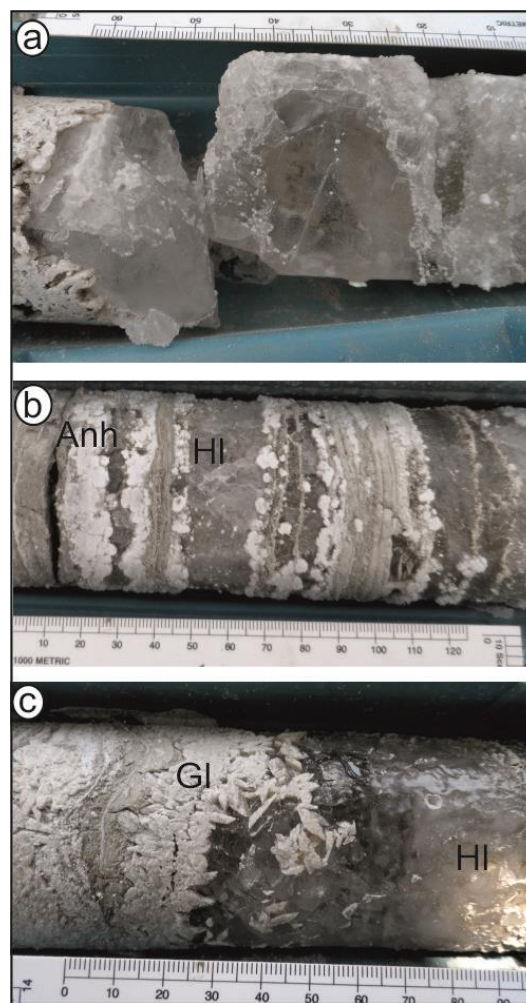
The most important tectonic lines in the region are right lateral Salt Lake fault extending in N-NW direction and the S-SW trending Ecemiş fault along the eastern boundary of the Lake Tuzgölü that borders of the inner basin. The basement of the basin is represented by Paleozoic aged rocks which consists of gneiss, quartzite, calc-schists and coarse crystalline white marbles. The basement unit is overlain unconformably by the Paleocene-Eocene-aged units consists of basaltic pillow lava, graded, bedded detrital sediments and volcanoclastics. The basin was an inner shallow marine character in the Paleocene-Eocene period while it was a closed lake in the Miocene-Pliocene.

## RESULTS

The evaporite minerals detected in the study area are formed from the sulphate group minerals (gypsum, anhydrite, glauberite and partially bloedite, epsomite, loweite), carbonate minerals (dolomite and partially magnesite), and chloride group (halite and rarely polyhalite). In optical microscopic examinations, distribution of these minerals in the formation, their frequency was determined, their textural properties and their conversion to each other were evaluated whether they were primary or secondary.

Halite mineral is found in three forms in the samples: 1) filling the gaps between the sulphate minerals (matrix), 2) in the massive structure, 3) in the large crystal structure in

the mosaic (Figure 2). The chevron halide texture observed is observed in both macro and micro dimensions and indicates that the mineral firstly collapses rapidly in shallow environments during the first sedimentation. Growth traces are observed in darker coloured halite with increasing amount of liquid inclusion in the growth traces of this mineral, while liquid inclusion rate is decreased in light coloured traces. In addition, the amount of fluid inclusion towards the surface from the surface decreased due to diagenesis. Fluid inclusions observed in halite minerals were observed as i) primary fluid inclusions parallel to the growth traces and ii) secondary inclusions locating perpendicular to the growth traces. Some of the inserts are round and ellipsoidal, while others are cubic. These eutectic inclusions in the salt crystals formed in the solution contact with the air, and they are formed by submerging the crystals which reach to a certain weight and size in the form of cumulate.



**Figure 2.** a) massive, coarse crystalline halite (547 m), b) pore filling halite (765.5), c) singular, spear and prismatic glauberite intercalated with halite (655.3) (Anh: anhydrite, HI: halite, GI: glauberite).

These structures, which develop simultaneously with sedimentation, are primary structures and generally exhibit a hopper structure. In some cases, this hopper (funnel) structures were also observed in the glauberite crystallites, because the solution on the surface during the formation of the glauberite at shallow depths came to the level of halite saturation. At the same time in the sedimentation environment, the concentration of the

solution at the bottom of the lake is high enough to permit layered salt crystallization, and indicates that the salt crystallization develops simultaneously on the surface and on the bottom surface. The buried cumulates were deposited with the layered halite formations in the corresponding layers. Therefore, the solution in the environment is quite saturated in the salt and shows that the formation of salt occurs on the surface and bottom of the liquid, and the depth changes about 1-2 m. Bacteria and organic materials found in the environment during sedimentation in liquid inclusions were observed as rods in these inclusions. The micro or macro cracks in the units are filled with secondary halite mineral. The dissolution surfaces observed in the halite minerals indicate that halite saturation decreases to such an extent that the salt precipitation can be achieved, and also may be indicating that there is fresh water intake in the basin. Growth and intermixing with other minerals designates that the environment conditions that cause the halite precipitation resulting in the deepening or raising of the environment have come to an end.

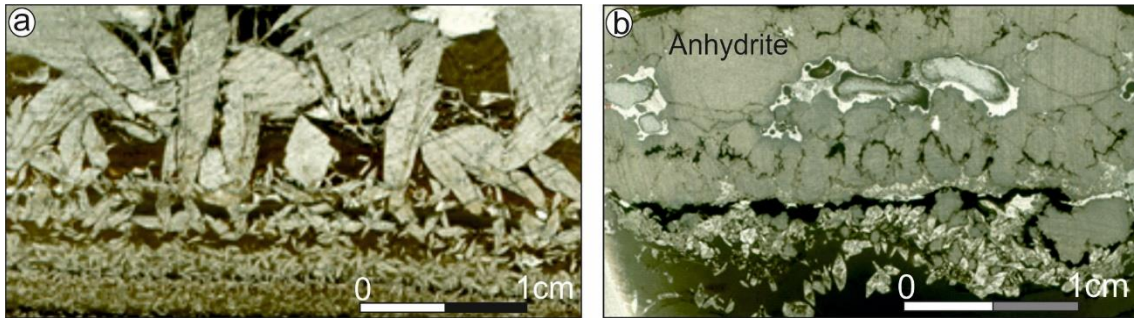
In the specimens studied, the glauberite mineral is found in two different forms, one being deposited in layers in shallow environments and the other being in the form crystallites with other evaporate minerals in deep. Glauberite crystals are found in macro and microscopic dimensions, especially in the form of banded and random aggregates in the form of spear or partially equilateral quadrangular mosaic and semi-euhedral crystals intercalated with halite and partially anhydrite minerals. In glauberites, which are usually observed as singular crystals, spear structure, isometric and prismatic crystals are rarely spindle and radial tissues are observed. Glauberite minerals showed different crystal sizes at different depths. In some beds, the sizes of the glauberite crystals are varies from 2 to 3 cm, while only a few mm in size in some depths. This change in crystal size is due to the gradual change in the environment (reduction of glauberite saturation) in the hydro-chemical/hydrological conditions. Dissolution traces were observed in some glauberites is related to the change in solution concentration. In addition, the presence of abrasive surfaces in relation to the shallowing of the environment, and to the precipitation of the crystals on the surface (vadose zone) and partly to their transportation. In the glauberite crystals intercalated with the clay units, clayey materials are penetrated in cracks and/or cleavages along the growth traces.

It has been determined that the glauberite mineral is crystallized and/or converted with other sulphate minerals (anhydrite, gypsum, bloedite, etc.) in the solution. These sulphate minerals have often been observed as inclusions in the same time. When the solubilized composition its saturation to which the glauberite could precipitate, the glauberite mineral was dissolved and transformed into another mineral (anhydrite). If the solution becomes saturated the opposite situation occurs and the existing mineral, especially anhydrite mineral, is converted into glauberite. Pseudomorphs of glauberite or anhydrite are formed depending on the change of the solution composition. Mineral inclusions detected in glauberite crystals indicate that these crystals are formed by rapid growth in shallow sections.

Gypsum mineral is found especially in shallow and / or stagnant water as euhedral crystals and can be converted into anhydrite mineral in a very short time due to the change of solution chemistry and diagenesis. For this reason, it is possible to see these two minerals together in many levels of the sequence and to find anhydrite minerals in gypsum as inclusions. Apart from this, when the gypsum mineral develops as cracked and cracked fills, it usually presents fibrous structures. In the areas, the gypsum minerals are also present in the clayey and carbonated units at the edge of the lake and generally tend to form in lenticular and bird beak constructions. Although gypsum mineralization has not

been frequently encountered in evaporation environments due to the diagenetic process cause to transformation of gypsum to anhydrite minerals. Secondary gypsum formations have exhibited different formation shapes and properties. In addition to the diagenetic transformation, the supersaturated solution was converted to halite/anhydrite minerals of the original gypsum minerals. Anhydrite minerals usually exhibit banded and enterolithic structures, while single ordered large crystals have also been found. In the cavities of these individual crystals, halite mineral is usually present as cement. The development of gypsum crystals, which exhibit a large spear structure in halite-saturated solution, indicates shallow and stagnant water environments.

In the deep sections of the sequence, the crystal size of anhydrite has become smaller and fine, and fine, small crystals were observed in the layered level in massive form. Larger crystalline gypsum occurrences are generally observed at depths of a few - <2m, while thinner crystals are observed in the millimeter-thick laminated sediments. Anhydrite nodules are very common occurrences in the studied samples, and the downward filtration of highly saturated pore water in the pores and or capillaries may be caused secondary to displacement under the upper pelagic zone on the resultant surface.



**Figure 3.** a) Prismatic, singular and spear glauberite in organic matter-rich clay, b) enterolithic anhydrite and small prismatic glauberite

#### **Acknowledge:**

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