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7-11 May 2018 - Antalya, TURKEY

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# ABSTRACTS AND PROCEEDINGS BOOK

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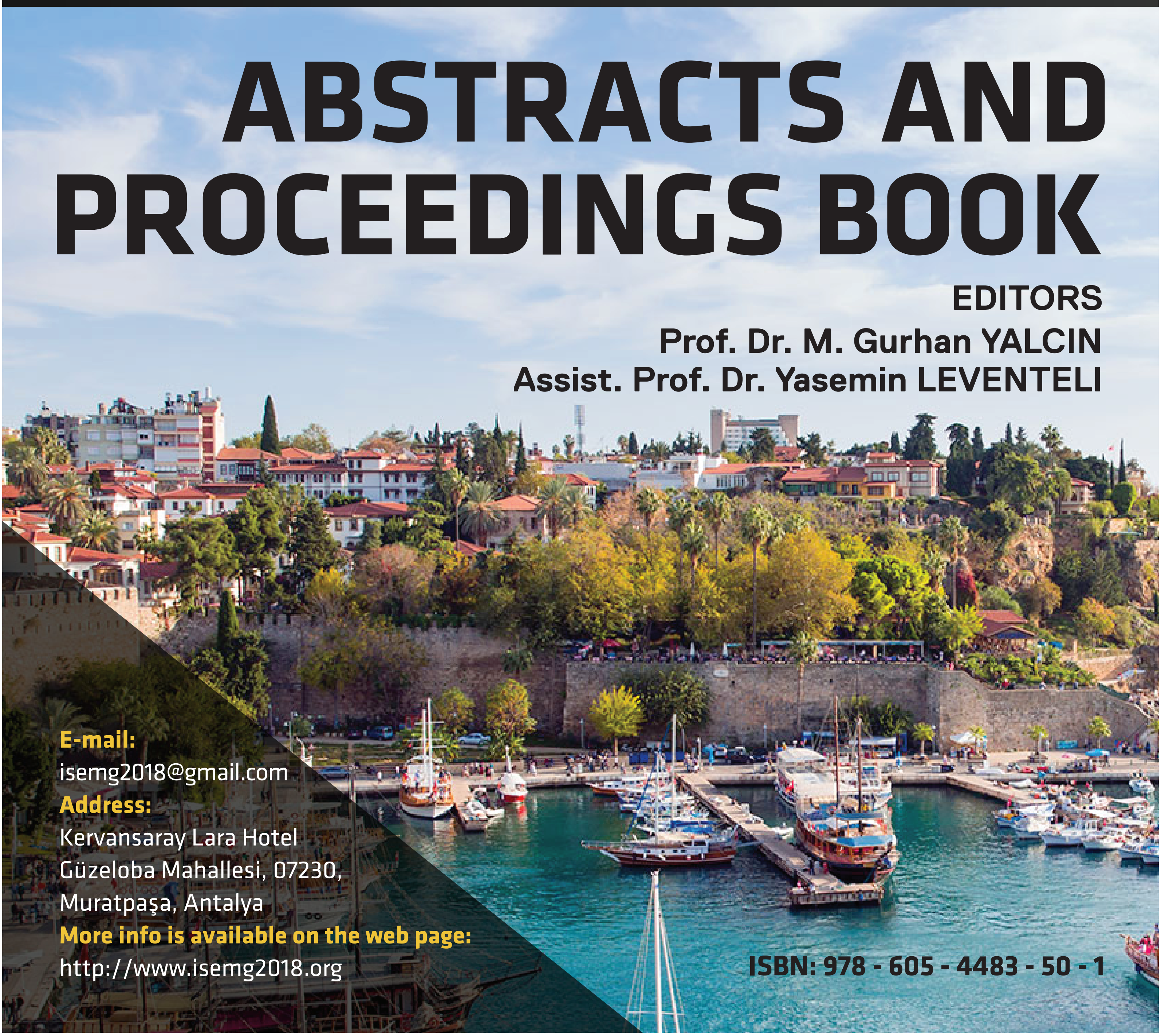

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# MINERALOGICAL CHARACTERISTICS OF NEOGENE SULPHATE MINERALS IN THE SOUTHERN OF TUZGOLU BASIN, TURKEY

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## ABSTRACT

The studied sulfate minerals are located in southern part of Tuz Gölü basin. The Na-Ca-Mg sulfate minerals determined in the basin range from the simple anhydrous salts such as anhydrite, glauberite, thenardite, to simple hydrous salts such as gypsum, eugsterite, starkeite, and also a series variably hydrated Na-Mg sulfates ranging from blöedite, mirabilite and epsomite to löweite. In this study, it has been aimed to investigate the depositional environments and syn-depositional or post-depositional properties of the sulphate minerals. Gypsum is generally the first sulfate mineral formed thermodynamically, and then the gypsum transforms to anhydrite when it just lost two mole $H_2O$. Glauberite is the next sulfate mineral either precipitated with halite or form as a reaction product with anhydrite or gypsum. Mg-sulfate minerals initially precipitate as epsomite then altered to thenardite. Syn-depositional features identified in the sulfate minerals are bed-form structures, vertically oriented euhedral crystals, detrital substrate (siliciclastic sediments), pellets and dissolution or erosion surfaces, and these fabrics have been preserved at the levels including gypsum, anhydrite and glauberite. Porphyroblast, poikilitic growth determined in the sulphate minerals are also typical features of syn-depositional crystallization. Dissolution-reprecipitation features are generally common in gypsum, anhydrite and glauberite minerals which show rounding of euhedral crystals terminations, followed by new syntaxial growth. Additionally, biological processes being syn-depositional feature lead to the form of lenticular minerals. Post-depositional features are very susceptible to alteration caused by increasing in temperature and pressure during burial. Generally, gypsum and epsomite minerals have altered when waters hydration has been released. Disruption and destruction of sedimentary structures have been observed in the levels such as mosaic textures, folds, slabs, fractures, veins. Intrasediment growth of anhydrite nodules has been also detected in all levels of the bore holes. In addition to, different types of several paedomorphic replacements such as gypsum-anhydrite, gypsum/anhydrite-glauberite and glauberite/anhydrite-halite have been determined in the sulfate minerals. Sulfate mineralogy of the Tuz Gölü basin is a key role to understand the water hydrochemistry causing precipitation, and this brine may originate from i) reprecipitation of the Eocene-Oligocene evaporates ii) also inflow of seawater (mixing with non-marine or hydrothermal inflow, and iii) de-dolomitization process.

***Keywords:*** *Sulphate minerals, Gypsum, Syn-depositional, Pos-tdepositional, Tuz Gölü*

## INTRODUCTION

The Tuz Gölü (namely Salt Lake) is located in the closed Konya basin in Central Anatolia and is a recent perennial salt lake. Middle to Upper Miocene aged pure, nearly pure soda and especially salt deposits which are third largest halite deposit in Europe found in the Konya basin. Some small ephemeral soda and salt lakes in different size are seen in the basin.
The Central Anatolian Crystalline Complex and the Kütahya - Bolkardağı metamorphic rocks form the basement of the basin. The basement rocks are unconformably overlain by the Upper Cretaceous - Quaternary sediments with a measurable thickness of 5 to 10 km from west to east. The Konya closed basin is located in central Anatolia which is the largest interior basin in eastern Mediterranean (Figure 1). Tuzgölü basin is a fore-arc basin (Görür et al. 1984), was developed on the Menderes-Taurides Platform during the Late Cretaceous-Tertiary (Okay et al. 2001). In the basin, thickness of salt (pure halite), alkali and alkali earth sulphate deposits are over than 1.250 meters in the inner portion of the basin, and probably precipitated during the event of the Messinian salinity crises (MSC). During the Messinian stage, Anatolia region was affected by a pervasive salinity crisis and evaporites in enormous dimension were precipitated, due to progressively

restriction and partly isolation of the Mediterranean Sea from the Atlantic Ocean (Hsü et al. 1973; Krijgsman et al. 1999; Vidal et al. 2002; Boulton & Robertson 2007).

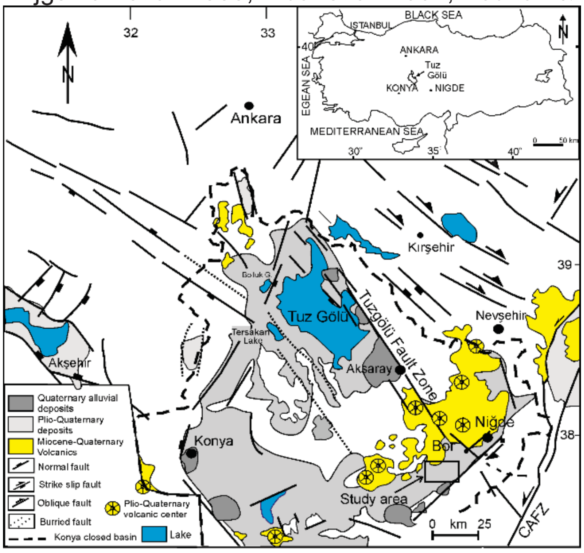


Figure 1. Location and simplified geologic of the study area (Dirik & Erol 2000).

The Messinian Salinity Crisis was especially effective in the eastern and central Mediterranean region which is also Turkey located in. In the basin, a large volume of evaporites (especially halite, Ca-Na-sulfates and partly Mg-sulfates) were precipitated, and some sedimentary structures, such as gypsum/anhydrite nodules, stramtolites were interpreted as indicators of “shallow water” conditions (Hsü et al. 1973).

Neogene sulphate mineral of the Tuz Gölü basin were not investigated in detail until today. This study aims: 1) to investigate relationships of the evaporite minerals to each other, 2) to determine transformation of the minerals to other minerals, and 3) to interpret the depositional environments and/or origin, syn-depositional or post-depositional process play role occurrence of the sulphate minerals.

## MATERIAL AND METHOD

The samples were taken from 10 drillings with depth ranging from 600 to 1700 meters. Thin section of sulfate enriched samples from the drillings were selected and mineralogic and textural properties of the minerals were investigated using Nikon Eclipse Ci Pol model microscope in thin sections.

Carbonate-rich levels were extracted from the drillings and samples pulverized for 1 min at 600 rpm in an agate mill (Fritsch Vibrating Cup Mill Pulverisette 9, Germany) to a size of 5–10 μm prior to analysis. The bulk mineralogical analysis of the samples was performed at Hacettepe University (Ankara, Turkey) on randomly oriented samples using X-ray diffraction (XRD) (Rigaku D/MAX 2200 PC, Japan), 0.5° divergence and scattering slits, 0.3 mm receiving slit, 40 kv, and 40 ma and 2°/min scanning speed from 2 to 60°2θ). Mineral percentages were determined from the powder XRD patterns with the external standard method (Brindley 1980) developed by Temel and Gündoğdu (1996) was used. The accuracy of the mineral abundance determinations was ±15%.

The morphological features of the submicroscopic of the evaporite and associated minerals and their interrelations with other minerals were determined using scanning electron microscopy (SEM). Elemental compositions were determined by energy-dispersive X-ray spectroscopy (EDS). The LEO 1430VP (Zeiss Cambridge, UK) SEM at Afyonkarahisar Kocatepe University was used to identify the mineral composition using an accelerating voltage of 15-20 kV with a beam current of 15 mA and a spot size of 5 mm. The sample was placed in a sample holder, dried at 50ºC for 1 h and coated with 5 mm of gold before EDS analysis.

**CONCLUSION**

The determined primary fabrics and structures in anhydrite and gypsum are aligned crystals, spears, euhedral habits. Secondary fabrics and structures are fibrous, nodular, entherolitic, chickenwire, ghost, spotted, bird peak, axe structures (Figure 2).


Figure 2. Some macroscopic fabrics of de evaporite minerals: a) broom-like structure globerite in the organic-rich clays, b) euhedral, spear glauberite with halite, c) slump structure (glauberite and halite), d) fibrous eugasterite in the clayey levels.

Laminated structures are very common in the study area. Laminated anhydrites, composed of nearly white anhydrite or gypsum laminate that alternate with dark gray or black laminae rich in dolomitic organic matter or clays. The thickness of laminate ranges from 2-3 mm to 1-1.5 cm. The laminations are laterally observed in all drills and indicate the evaporites precipitated in quite water either in deeper-water or shallow-water protected from strong bottom currents or wave. Light-dark color changes in these laminations annual varvs resulted from seasonal changes in water chemistry and temperature or cyclic changes. Some laminae contain halite band which are thicker than those of anhydrite laminae. Spear, nodular and fibrous structures are common morphologies of gypsum and partly anhydrite (Figure 3). Gypsum, clay and mud deposited during sedimentation, bird beak texture occur and showing medium or low organic concentration and intermediate temperature (≥35 $^{0}$C) (Cody & Cody 1988). Soft sediment deformation structures, e.g. slump may be developed at deposition shortly after or during the first stages of the sediment's consolidation. Anhydrite nodules may be grown in highly saturated and alkaline pore waters of the capillary zone (Warren 2016). These nodules partially show enterolithic, contorted fold and chicken-wire textures, which represent to supradital portion of a coastal sequence. Anhydrite nodules formed from displacive transformation of gypsum in carbonate or clay sediments. And then gypsum was transformed to anhydrite pseudomorphs by adding of $Ca^{2+}$ and $SO_4$ an external source, the grown-up anhydrite later results in segregate nodular masses.

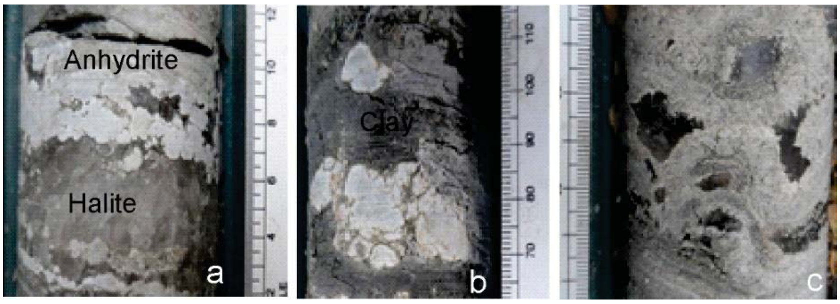


Figure 3. Some macro structures in evaporite minerals: a) enterolithic anhydite, b) nodular anhydite, c) slump structures of globerite in halite.

Fibrous gypsum grows as void filling cement or translation from anhydrite (Figure 4a). Gypsum ($CaSO_4.2H_2O$) undergone dehydration due to evaporation or diagenesis, therefore, gypsum loses two moles of $H_2O$ and it convert to anhydrite. Anhydrite ($CaSO_4$) undergone rehydration due to the getting two moles of $H_2O$ and convert to gypsum.

Hemi-bipyramidal, star-like texture was defined in gypsum indicate medium or rich organic concentration and low temperature (15 $^{o}$C) (Cody & Cody 1988) (Figure 4b). Gypsum and or anhydrite were converted to glauberite, and euhedral glauberite was observed in fibrous gypsum

(Figure 4c). Glauberite was formed secondary to the transformation from the gypsum and / or anhydride as it was primarily deposited with the increase in evaporation in the sediment basin. The primary glauberite was precipitated with an increase of Na content in the basin. Transformation/displacement was reported to be related to the interference between lake sediments from the edge zones of groundwater during early diagenesis (Salvany et al. 2007).

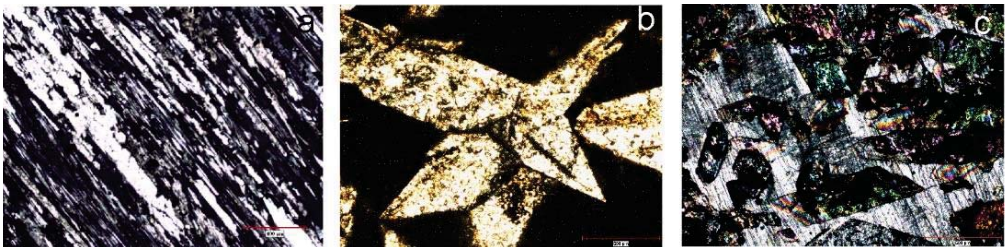


Figure 4. Some macro structures in evaporite minerals: a) fibrous gypsum, b) Hemi-bipyramidal, star-like gypsum, c) glauberite in fibrous gypsum (satin spar).

The most common sulfate minerals are gypsum, anhydrite, glauberite, starkeite, löveite, blöedite, thenardite, epsomite, and eugasterite determined by XRD in the study area (Figure 5). The thickness of gypsum increased in south of the study area. It can be interpreted that there is a water input in south of basin. In other parts of the study area, it is observed that gypsum in the upper levels and anhydrite in deeper levels which related to diagenesis, and gypsum alternate to anhydrite in deep with respect to burial. Thickness of glauberite layers are increased north and center of the study area.

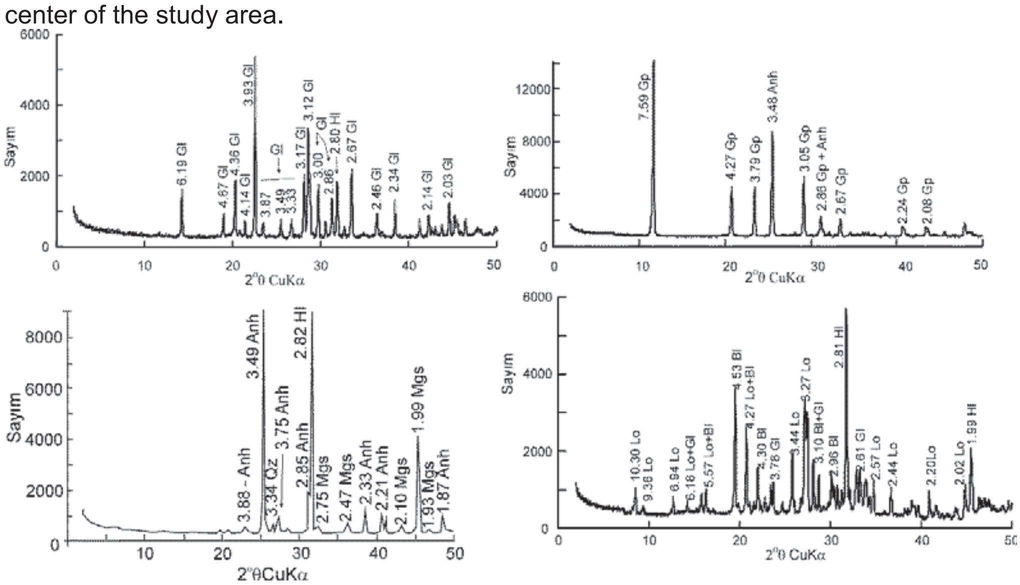


Figure 5. XRD diffractograms of some sulphate-rich samples (Anh: anhydrite, Bl: blödite, Gl: glauberite, Gp: gypsum, Hl: halite, Lo: löveite, Mgs: magnesite, Qz: quartz).

Gypsum and anhydrite are mostly found together, and transformation to glauberite was determined. Gypsum is found as fibrous (satinspar, secondary), spear or massive while anhydrite are mainly massive or rhomb/tabular shaped (Figure 6a, b). Glauberite was seen as fibrous, rod, needle shaped in especially clay enriched sediments, and spear or euhedral crystals with other evaporite minerals (Figure 6a, d). Some diatoms were determined together with needle-star shaped glauberite in organic matter-rich clayey beds (Figure 6d). And also, microbial carbonate facies was determined in the SEM observation show quite shallow environments and include rich cyanobacterians. The facies are overlain by generally sparitic cemented peloidal limestones. Additionally, dimitiyata saccula was detected in SEM. The species is the form of transition from marine to freshwater and the diatom species belonging to the Miocene (Aboal et al. 2003).

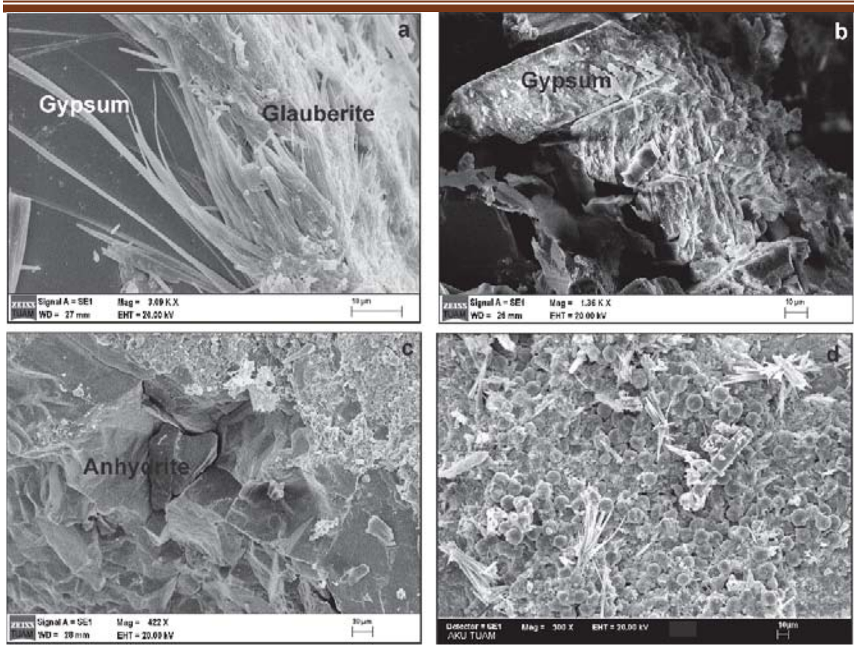

Figure 6. Microphotos of gypsum, glauberite, anhydrite and diatoms (d).

Syn-depositional and post-depositional structures were determined in the basin indicate that the evaporite sedimentation of the Tuz Gölü generally reflects shallow water environment. It has also been determined that bacterial activities were effective in the basin for mineral formation. The presence of gypsum in the upper levels and anhydrite in deeper levels related to diagenesis, and gypsum alternate to anhydrite in deep level with respect to diagenesis. Gypsum/anhydrite to glauberite transition may be related to excess of Na ions in the basin.

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