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THE FORMATION OF FISSURE RIDGE TYPE LAMINATED TRAVERTINE-TUFA DEPOSITS MICROSCOPICAL CHARACTERISTICS AND DIAGENESIS, KIRŞEHİR CENTRAL ANATOLIA

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ABSTRACT.- At Kırşehir center, in Kuşdili and Kayabaşı, along NE-SW directed extensional fracture, there is a fissure ridge type-travertine-tufa deposits. Travertine-tufa ridge is appoximately 800 m in length and 10-30 m in width. The hot-water saturated with calcium bicarbonate and minerals are enhensed from fissures and have caused to deposit yellow orange, brown and cream colored travertine in the walls of fissures as well as along the both sides. On the walls of the fissure, parallel to the fissure, compact and hard, laminated and thin bedded travertine crusts were deposited. However, in the both sides of the ridge, consistent with the slopes, the bedded crusts being porous, spongy tufas were deposites as well. Milimeter and Centimeter sized microscopic structures, similar to shrubs, are commonly found in this hot water originated travertine-tufas. These are; 1-Dendritic structures and, 2-Crystal bunches. Dendritic structures own micritic aggregate, shrub bunch, reed bunch and small twig shapes. There are calcite crystallisations among the twigs. But the crystal bunches are knife-shaped, large crystals and fibrous ray crystal structures. Dendritic structures have developed in the laminated crust and microterrace pools, located on both slopes of the fissure. On the other hand, the crystal bunches are common on the parallel-laminated crusts deposited an developed chemically. Super crystals were developed on the prismatic crystals, that were also developed along c-axes of the fibrous crystals.

INTRODUCTION

Travertines are calcium carbonate precipitations developed from organic and inorganic processes in karstic, hydrothermal springs, small rivers and swamps. They are spongy, compact and indicate crystal structures in different colors. They are named as calcitic tufa, calc tufa, sinter crust and plant tufa. However, there are characteristic features which make differency between tufa and travertine. Pedley (1990) used to define the tufa as high porous, spongy, paper-leaved and woody texture cool-fresh water carbonate deposits. In contrast, He defined the travertine as extremely well-lithified, spari calcite textured, diagenetic old calcerous tufa deposit.

The research works have been carried out about the classification formational environment, origin and diagenesis of the travertine and tufas (Julia, 1983; Chafetz and Folk, 1984; Pedley, 1990; Ford and Pedley, 1996; Pentecost, 1990; Evams, 1999; Chafetz and Guidry, 1999; Guo and Riding, 1994, 1998). In Türkiye, such a study like occurrence, age, microorganism effects and depositional kinetics of travertines have been concentrated on Pamukkale (Denizli) travertines (Pentecost et al., 1997; Altunel and Hancock, 1993; Ekmekçi et al., 1995; Altunel, 1996). Moreover, the characteristics of within-travertine pisolites in Mut (İçel) and petrography of travertines in Sıcakçermik (Sivas) areas were conducted by Atabey (2002) and Tekin et al., (2000) respectively. The tufa deposits are subdivided into two classes, namely, autochthonous-and clastic-originated by Pedley (1990). Chafetz and Folk (1984) distinguished five classes of travertine accumulations. These are, 1-Lake deposits, 2-Mounds and cones, 3-Terraced mounds, 4-Fissure ridges, 5-Waterfall deposits.

The fissure ridge-type travertine of this classification is found in Kırşehir (Fig. 1 and Plate-I, fig. 1). The formation of fissure ridge-type travertine has previously been investigated at Pamukkale (Altunel, 1996). In Kırşehir, at Kuşdili and Kayabaşı localities, fissure ridge-type travertine deposits formed along a N-S directed fracture (Fig. 2). For the purpose of hot water supply, the drilling facilities by MTA have been carried out and the characteristics of the hot water were given (Özmutaf and Didik, 1992; Didik and Tekin, 1995).

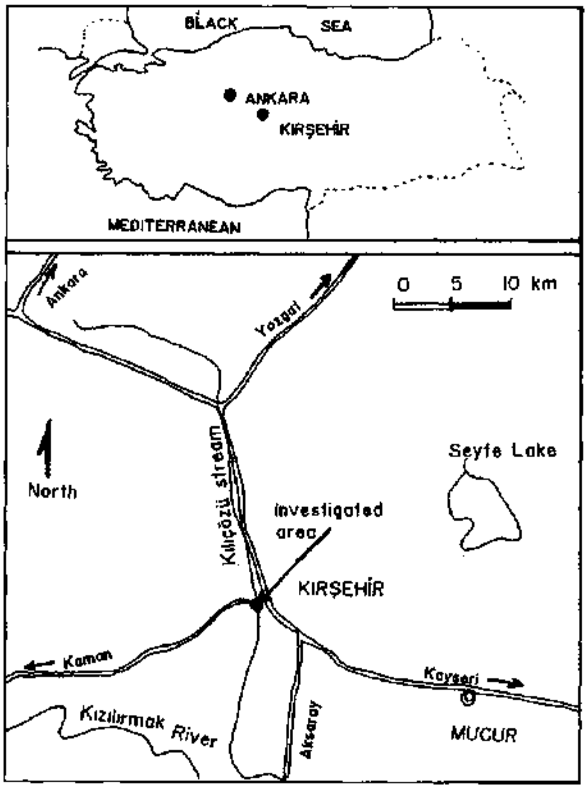


Fig. 1- Location map.

Based upon the microscopic characteristics of the samples taken from the travertines, it is observed that the structures are of two types, dendritic shape and crystal bunches. The purpose of this study is to present the properties, formation and diagenesis of these structures and their role in the formation of travertihe-tufa deposition.

In consistency with the purpose of study, systematic samples were collected from different parts of travertine-tufa mass, in the order from fissure ridge outward. These samples have been examined under Polarization Microscope and Scanning Electron Microscope (SEM), including x-ray analysis. The drilling locations have been correlated to establish the relationship between spring water and travertine deposit.

GENERAL GEOLOGY

Fissure ridge-type travertine accumulated at intersection points of the northeast-southwest and eastwest trending faults in southern part of Kırşehir massif. The Kırşehir metamorphic rock units consisting of Paleozoic age marble and schists are exposed at north, east and southwest of Kırşehir (Fig. 3). At southwest of Kırşehir, the Late Cretaceous Baranadağ granodiorite and Early Eocene conglomerate, sandstone and limestone of Baraklı formation are exposed (Kara, 1991) in the

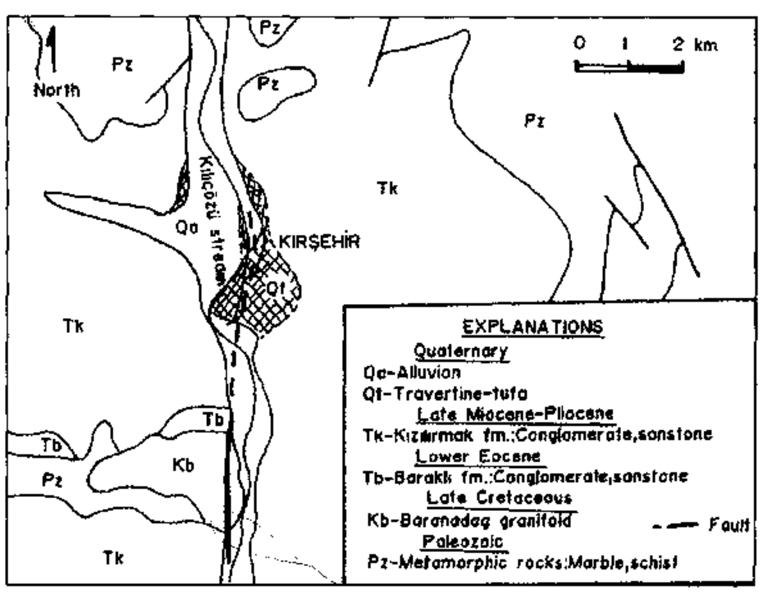


Fig. 2- Map indicating the setting of travertine-tufa mass. (Modified from Kara, 1991).

area to the west of Kılıçözü stream. These units are overlain by Late Miocene-Pliocene Kızılırmak formation, composed of conglomerate, sandstone, mudstone and tuffite (Fig. 2 and 3) (Kara, 1991). The alluvium sediments are present along Kılıçözü stream. Travertine is Quaternary ?-Recent in age, overlying the Kızılırmak formation and it is formed around the fault located along Kılıçözü stream. As it is shown on the drillings facilitied by MTA (inturn 1, 6, 7, 5, 4, 3 and 8 numbered drillings), the thickness of travertine and late Miocene-Pliocene unit, consequently depth to the metamorphic unit as source rock are changed. At number 1, the travertine is 46 m and late Miocene-Pliocene unit is 175 m in thickness. These thickness values are 28 m and 20 m at number 6, 22 m and 26 m at number 7, 38 m and 15 m at number 5, 18 m and 55 m at number 4, 10 m and 118 m at 3, and 10 m and 87 m at drilling number 8, respectively. Consequently, it is deduced that, a downthrown block side is present between 1 and 6, and 4 and 3, whereas at 6, 7, 5 and 4, the metamorphic basement was uplifted.

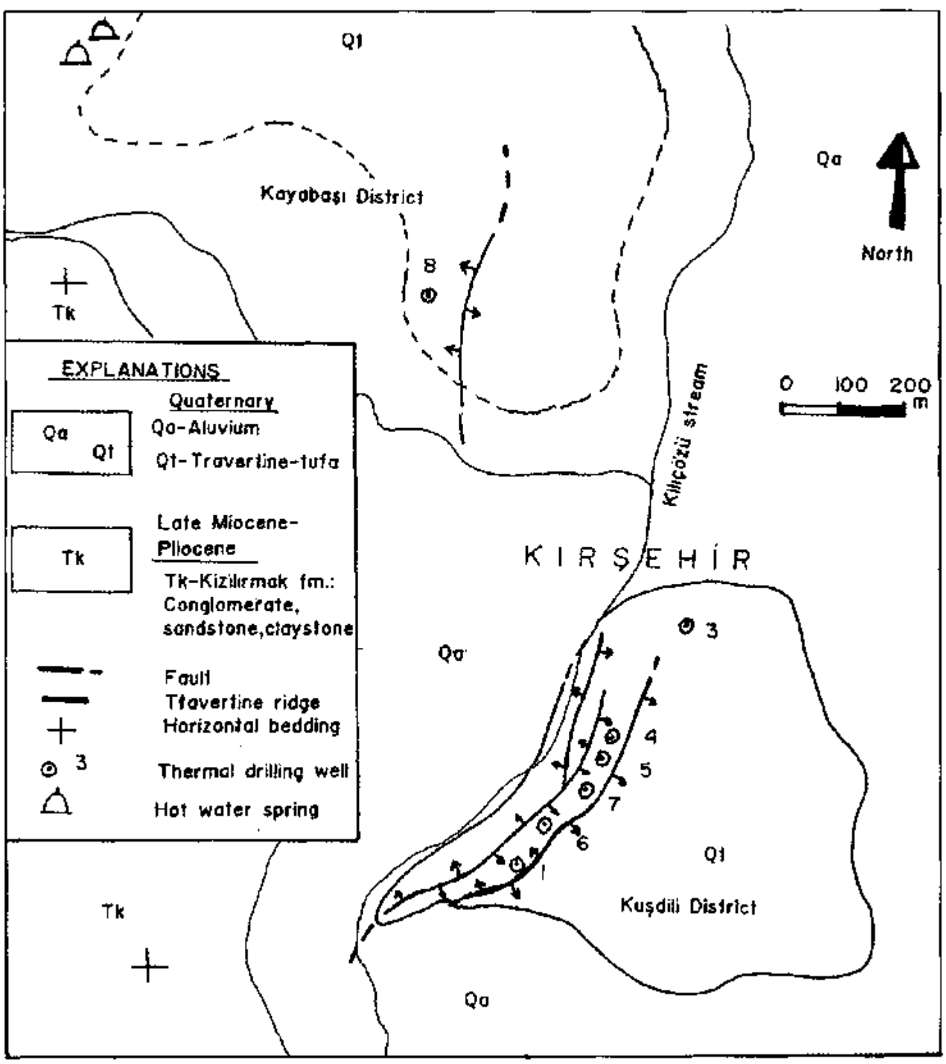


Fig. 3- Geological map

CHARACTERISTICS OF TRAVERTINE-TUFA DEPOSITS

The ridge-type travertine-tufa deposits are located in Kuşdili and Kayabaşı districts at Kırşehir center along a northeast-southwest trending fissure fracture. The ridge is approximately 800 m in length, 10-30 m in width and 2-4 m in height. The travertine-tufa rocks due to the effect of mineral-saturated hot groundwater are reddish, brown, yellow, blue, green, orange, beige, white and blackish in color (Plate-I, fig. 1). There is a fissure at the center of travertine ridge and parallel to this fissure, laminated, thin-bedded, hard and compact crystalline crusts are present (Plate-I, figs. 2, 3). At both slopes of fissure microterrace pools tufas are deposited. Within the tufas, round, ellipsoidal and composite tube-shaped, calcite-filled gas cavities are present (Plate-II, fig. 1).

MICROSCOPICAL CHARACTERISTICS OF DENDRITIC STRUCTURES AND CRYSTAL BUNCHES

Based on the samples collected from hot water originated Kırşehir travertine-tufa deposits, there are shrub-like structures changing from milimeter to centimeter in scale. These are 1-Dendritic structures and 2-Crystal bunches. The widely occurrence of these dendritic structures in hot water travertines has been assigned in studies by Chafetz and Folk (1984), Chafetz and Guidry (1999) in Italy. As a result of x-ray analyses of samples, together with aragonite and calcite crystal structure, iodine, phosphate, iron, chlorine, borax and sodium carbonate has been detected.

Dendritic structures

The dendritic structures are extensively developed within the yellow, brown, green, blue, reddish, beige colored, laminated and thin-bedded travertine crusts and microterrace pools at both slopes of the ridge, and within the porous, spongy tufa. They are changing from 3 mm to 3-4 cm and characterized 6y dark color, mottled and micritic aggregate-shaped (Plate-II, fig. 2), herbage-shaped (Plate-II, fig. 3), asicular redd-shaped (Plate-II, fig. 4), woody plant overgrowth on crust surface and small twig-shaped (Plate-II, fig. 5). The dendrites similar to reed, feather shaped ones have been interpreted by Weijermers et al. (1986) that were originated from *Bryum* cf. (algae) in Spain travertines. In interareas of dendrites there is light-colored spari-calcite, in other areas, they are yellow and brown-colored due to limonitization, iron and phosphate content. In the dendrites of short herbage bunch, the micritic aggregate-shaped ones are in medium-coarse grained calcite crystall, whereas the woody, tree twig-shaped ones are overgrowth on laminated crust surface and within bed calcite crystalls (Plate-II, fig. 6). Jones and Renaut (1995) is their study in Kenya, defined the dendrite structures as non-crystal asicular dendrites.

Crystal bunches

Crystal bunches are mostly found in fissure-parallel laminated travertine crusts and in thin-bedded, laminated crusts at both slopes of the ridge. The crystal bunches, unlike the dendrites, similar to reed bunches are fan, ray-shaped and longer in length. The reed bunch-like ones are in 5-8 cm in length and fan in shape (Plate-III, fig. 1). The area among twigs is spari-calcite. The ray, fibrous crystal bunches (Plate-III, fig. 2) and fan-shaped crystal bunches are also present (Plate-III, fig. 3). Jones and Renaut (1995) defined the similar crystal bunches as scandulitic dentrites in Kenya.

FORMATION AND DIAGENESIS

A close relationship is present between the thickness of basement marble mass and thickness or depositional rate of travertine-tufa. Based on the drilling data, the thickness of travertine and depth to the marble is different.

The bicarbonate-saturated hot-water originated from massive and thick marble basement rock has caused the thick travertine deposition.

The fissures-parallel hard and compact, laminated and thin-bedded travertine crusts have developed with the lower hydrostatic pressure and decreasing water content. In contrast, the porous tufa has been deposited at higher hydrostatic pressure, much water content, turbulant and during sudden CO_2 loss. Dentdritic structures have been formed in microterrace pools at suitable environment. As it is seen from the scanning electron microscopic view, they are the calcitized algae filaments (Plate-IV, figs. 1, 2, 3). These filaments, formed from carbonate crystalls, are a green type of algae which are *Schzotrix* cf. and *Bryum* cf. (Nevbahar Atabey, personal communication). The algae survive by feeding with CO_2 present in the calcium bicarbonate-rich hot groundwater. Later the calcite crystalls increased at periphery of algae filaments and carbonate deposition occurred. The filament has a tube at its center and knife-shaped calcite crystalls are formed at inner and outer part of this tube. At a later diagenetic stage, this type formations are caused the development of dentritic and crystal bunch shape structures. After completion of each calcium carbonate structure, suitable to the second, third and there after laminated crust structures, the bedded shape dendritic and crystal bunch structure layers formed (Fig. 4)

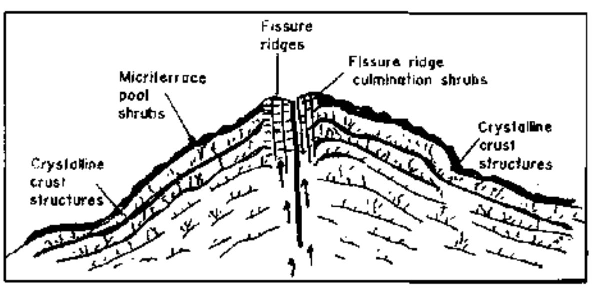
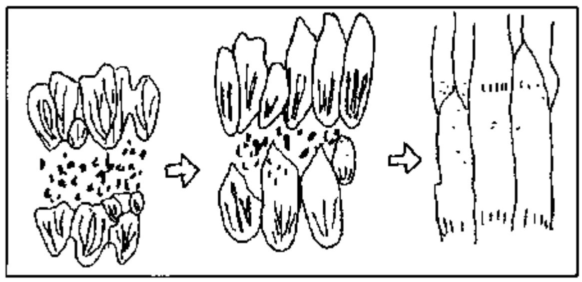


Fig. 4- The model depicting the formation of dendritic and crystal bunch-structured crusts.

(Plate-IV, figs. 4, 5). This layered structure has formed as a result of neomorphism according to Love and Chafetz (1988). The neomorphism takes place in such processes; first overgrowth of crystalls on dendrites, later along their c-axes the overgrowing of these crystalls in the form of columnar crystalls (Figs. 5, 6). There after, as it is seen from Plate-IV, figs. 5 and 6, the bedded and inclusion-type crystal structures are formed at progressive stage of diagenesis. Jones and Kahle



Şek. 5- Asicular, fibrous, coarse prismatic and uneven crystal formation (From (Braithwaite, 1979).

(1986, 1993), examined the crystal shrub structures formed by the calcitization of algae filaments. Furthermore, they pointed out that; the secondary twigs orthogonally cutting the first asicular crystalls and the third-order twigs cutting the secondary asicular crystalls were developed. Pentecost (1990) interpreted the formation of hot water originated dendritic structures, as the overgrowth of preferred crystalls on sharpened top part of mounds of microstructures. The calcitized bunches are arranged in a pattern parallel to laminated crusts. When viewed under the microscope, on the early formed coarse crystalls, fibrous, small, ray crystalls, that also developed along c-axes of the fibrous crystalls (Fig. 6). The deposits precipitated from mineral-rich hot water at slope of travertine ridge are in different colors (Plate-IV, fig. 6). This is due to oxidation and evaporation processes.

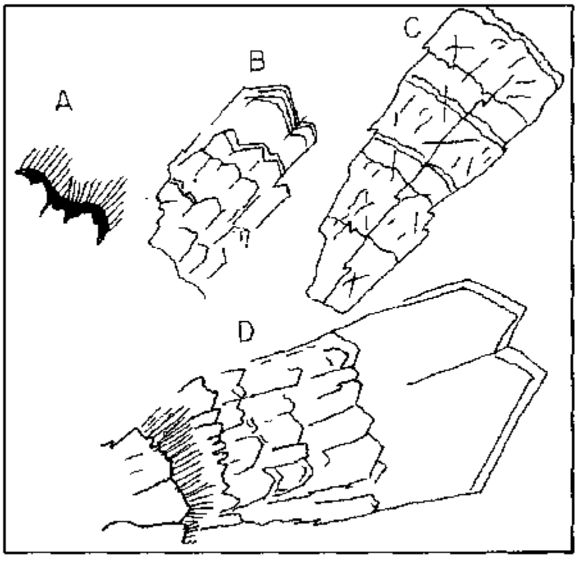


Fig. 6- The formation of coarse, columnar crystalls by neomorphism (From Love and Chafetz, 1988)

DISCUSSION AND CONCLUSION

The Kırşehir travertine-tufa has been deposited by the precipitation of calcium carbonate developed due to mineral-rich and calcium bicarbonate-saturated hot groundwater, reached at ground surface and loss of its CO_2 content. However, green algae species *Schrotrixsp.,* has played an active role during formation of Kırşehir travertine-tufa deposits. Especially, the slow rate of decreasing amount of CO_2 dissolved in microterrace pools has caused algae to use and deposite the carbonates. This also has made suitable conditions for feeding green algae to form the dendritic structures developed at both slopes of the ridge. Dendrites have relatively formed in horizontal areas and microterrace pools. Guo and Riding (1992, 1998), in their studies, assigned the neccessity of low-slope surfaces for microorganism activity. The crystal bunches have developed in fissure-parallel laminated crusts and those at both slopes of the ridge. The algae activity in Kırşehir travertine-tufa deposits led to the formation of dendrites. Guo and Riding (1994), in their study about hot-water travertines in Italy, considered these structures as microbial originated. Pentecost (1990) pointed out a cyanobacteria origin for the hot-water travertine shrubs in Wyoming. USA, also Chafetz and Folk (1984) agreed with the bacterial origin. Based on the x-ray analyses, phosphate, iodine, chlorine, borax and sodium carbonate in Kırşehir travertine-tufa deposits might have been developed from basement and surrounding rocks. The dominant tufa deposits formed at both slopes of travertine-tufa mass indicate high hydrostatic pressure, great groundwater discharge and sudden CO_2 loss. The bedded crusts within the fissure of the ridge, depict the low hydrostatic pressure, less groundwater dischange and slow loss of CO_2. The lower content of water caused the slow rate of deposition and the complete depleted water with time made carbonate deposition within the fissure at the center of the travertine-tufa mass.

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PLATES

PLATE-I

Fig. 1- View to the eastern flank of travertine-tufa mass. Kuşdili district.

Fig. 1-2- The ridge of travertine-tufa mass and central fissure (y), ridge slope (Y) and fissure-parallel laminated and thin-bedded travertine crust structures (Tk).

Fig. 4- The microterrace pools developed at travertine ridge slope

Fig. 1

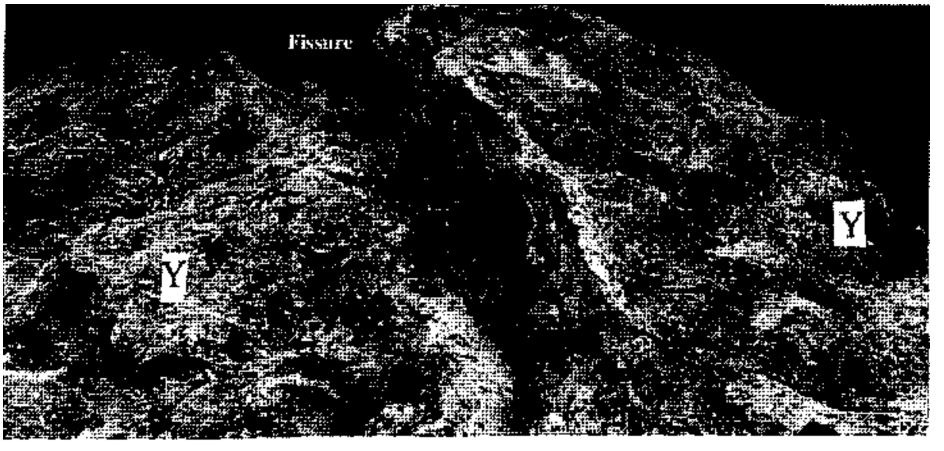


Fig. 2

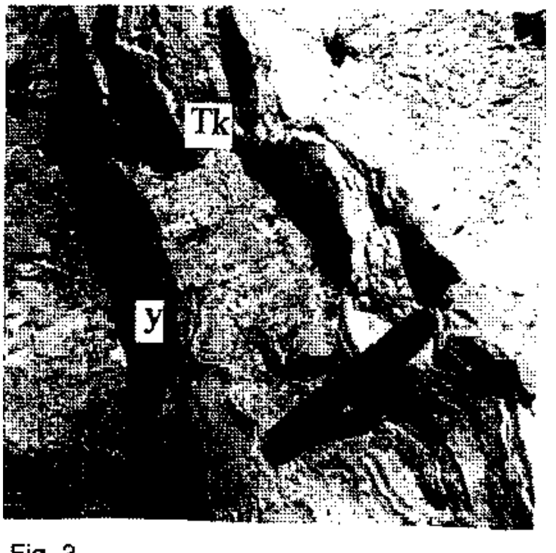


Fig. 3

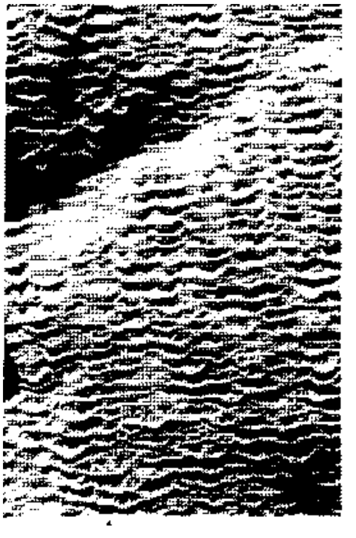


Fig. 4

PLATE-II

Fig. 1- The composite tube (Bt) and laminated crust (Lk) developed in tufa deposit formed at slope of travertine-tufa mass.

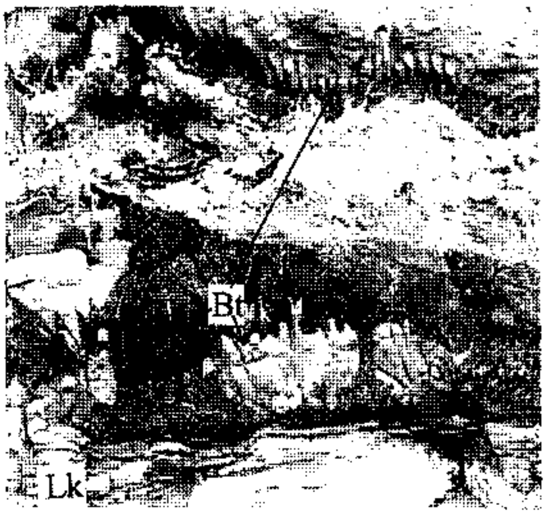
Fig. 2- Microscopic view of the mottled (B) and micritic aggregate (Ma) dendritic structures (6X).

Fig. 3- Microscopic view of the herbage-shaped dendritic structures (09) (6X).

Fig. 4- Microscopic view of the feather-shaped dendritic structures (6X)

Fig. 5- Small tree twig-shaped (aç) dendritic structures overgrown on laminated crust surface (6X)

Fig. 6- Microscopic view of small tree twig (Ad) and micritic aggregate (Ma) dendritic structures (6X)



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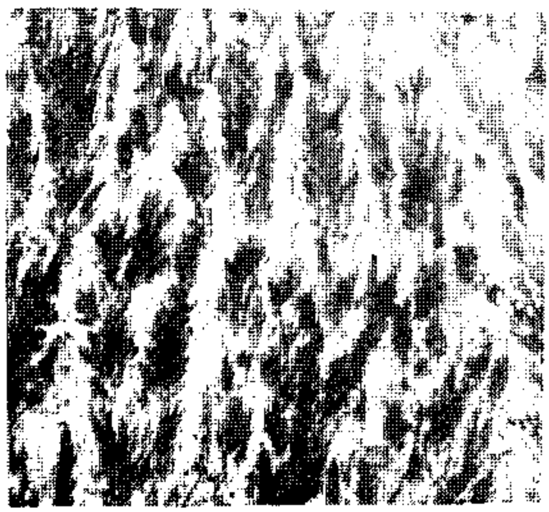
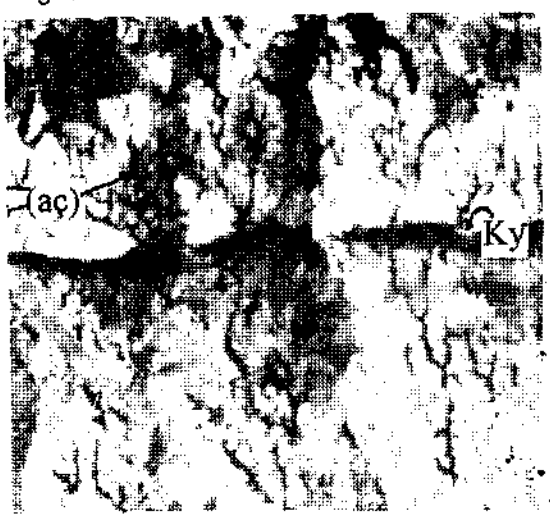


Fig. 4



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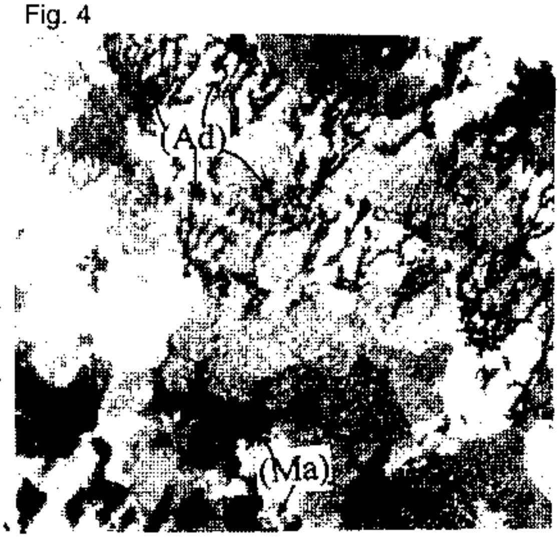


Fig. 6

PLATE-III

Fig. 1- Microscopic view of the fan-shaped crystal bunch (6X)

Fig. 2- Microscopic view of the ray, fibrous crystal bunch (6X)

Şek. 3- Microscopic view of the fan-shaped, ray crystal bunch (6X)


Fig. 1


Fig. 2


Fig. 3

PLATE-IV

Figs. 1-2-3- SEM view of the calcitized algae filaments (Af).

Fig. 4- Prismatic crystalls (Pk) overgrown fibrous crystalls (K) that overgrown laminated crust (Lk)

Fig. 5- Microscopic view of the fibrous (L), prismatic (P) crystalls (6X)

Fig. 6- Different coloration developed due to • different mineral content in hot groundwater

Fig. 1

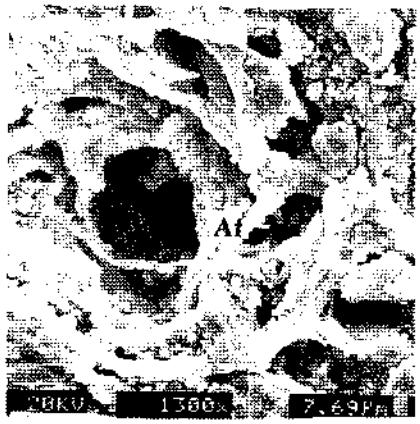


Fig. 2

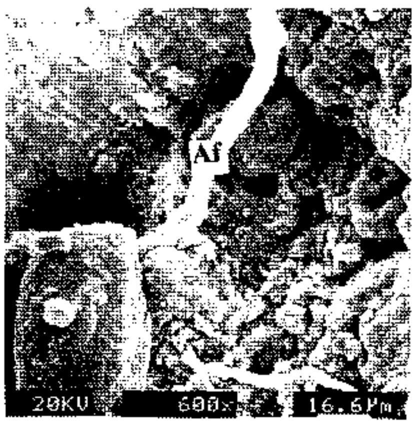
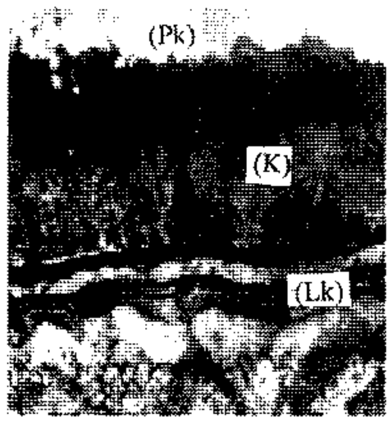


Fig. 3



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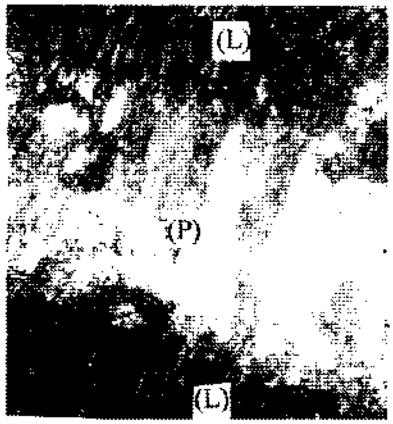

Fig. 5


Fig. 6

GEOCHEMICAL CHARACTERISTICS AND ORIGIN OF BARITE DEPOSITS BETWEEN ŞARKİKARAAĞAÇ (ISPARTA) AND HÜYÜK (KONYA)

Oya CENGİZ* and Mustafa KUŞÇU*

ABSTRACT.- Barite deposits in the region of Şarkikaraağaç and Hüyük which are generally located in the form of veins, lenses and layers along the contacts of these units and the schists showing an extensive distribution within the same formation found within recrystallized Çaltepe limestone and dolomite, Çavuştepe calcschists of the Cambrian-Devonian age Sultandede formation are epigenetic in character. According to the results of chemical analysis of barite mineralization in the region, the presence of trace elements such as Pb, Zn, Cu, Cd, Ni, Co, Ag, Sb are locally identified in low values within barites of the region. Especially, in some trace elements such as Pb, Zn, Cu, Cd, Ag and As show an increase towards from Hüyük region to Çarıksaraylar area. When the results of chemical analysis of barite samples evaluated statistically, the presence of high correlation between Ba-Pb, Ba-Ag. Pb-Ag, and Al_2O_3-K_2O element pairs and mediumgrade correlation between Ba-Sr, Pb-Cu, Zn-Cd, CaO-Fe_2O_3, CaO-SiO_2, SiO_2-Al_2O_3, CO- MgO, Fe_2O_3-Al_2O_3, Fe_2O_3, Fe_2O_3-Na_2O, MgO-K_2O element pairs of barite ores have been determined. The deposition forms of the barites in the investigated area, paragenesis, wall rock alteration, the high amount of trace elements, high Ba/Sr ratio, SrO values over 1.5 %, 180°-360°C homogenisation temperatures of the two-phase (liquid+gas) fluid inclusions, +30.15 ‰ and +13.9 ‰ ^{34}S isotope ratio in galena and barites, and 434°C high formation temperature indicate a hydrothermal origin of barite deposits in the region.

SEDIMENTOLOGY OF OYLAT CAVE SEDIMENTARY ROCKS İNEGÖL (BURSA)

Eşref ATABEY**; Lütfi NAZİK** and Koray TÖRK**

ABSTRACT.- Oylat cave is located at 17 km southeast of the İnegöl (Bursa) in the exit of Oylat River canyon. Oylat cave has been developed at the intersection of two fault zones striking along WNW-ESE and NE-SW directions in recrystalized limestone unit of Permian-Triassic age. Clastics and carbonate sediments are in the Oylat cave developet due to karstification. The cave, presenting multi-stage development character can be divided into three sections. In the third section karst breccias, siltstone and mudstone, in the second section the great rimstone pools and flowstones had grown. In the first division at the end of the cave huge rock fragments due to the collapsing of roof, karst breccia, stalactite, stalacmite, soda straws, flowstones and cave pearls (pisolites) had grown. Moreever, in this part, a sedimentary sequence formed by a alteration of conglomerate, sandstone, siltstone and mudstone crops out. The clastic sediments in the Oylat cave is deposited from the sediments carried by surficial water entering the cave system, and flowstones, rimstones, cave pearls have been formed by the dripping from the cave roof, whereas rimstones pools were formed by the steadly flowing intra cave river.

POST STACK SEISMIC ATTRIBUTE ANALYSIS

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ABSTRACT.- Hydrocarbon accumulations sometimes have effects on seismic data which can be used to indicate suitable worthy accumulations of hydrocarbon areas. The most prominent of these effects in increase in amplitude. Hydrocarbon accumulations may produce sufficent changes in amplitude however changes in acoustic impedance can be caused by various reasons. To get more information possible from the seismic data, impedance comparison and examination of all the properties constitutes the basic idea of seismic attribute analysis. From the analysis of seismic data by the amplitude information which has a primordial importance and other factors to be taken into cosideration are called seicmic attributes which are used to get contribution to interpretation and to make detailed analysis. The most useful attributes are amplitude, phase, frequency, polarity and velocity. Depending on the problem to be solved, seismic attributes can be obtained from instantaneous analysis, lateral continuity relationship and large variety of seismic data. In this work, several post stack seismic attributes is defined and how they can be used to get opportunities for interpretation is examined. After the application of migration, seismic attribute analysis is applied to two dimensional seismic data in Trakya region and provide the opportunity for comparison between seismic subsurface characteristics. With the comparison of conventional sections by the information of seismic attributes, it is observed that attributes can be used to enhance the interpretation.

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