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PETROGRAPHY AND ORIGIN OF DOLOMITES OF YANIKTEPE FORMATION (UPPER CRETACEOUS) IN GÜRÜN AUTOCHTHONOUS, EASTERN TAURUS TURKEY

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ABSTRACT.- The purpose of this study was to reveal the petrography and origin of the Upper Cretaceous dolomites in the Gürün autochthonous in eastern Taurus The Upper Cretaceous (Upper Santonian-Campanian) dolomites in the Gürün autochthonous belong to the Yanıktepe formation and are restricted to outcrops near Salyurt Yaylası, southern slope of Kavunağılı Tepe and Toycu Tepe The Yanıktepe formation is represented by the interfingering limestone and dolomite fades, which can be identified in the field The limestones are massive and exhibit texture of wackestone that contains foraminifera-macro shells (rudist). The dolomites formed as a result of dolomitization of foraminifera-macro shell-bearing wackestones. Three types of texture can be petrographically identified in these dolomites Type: Clear dolomite crystals, Type 2: Filthy (blurry) dolomite crystals, Type 3: Zoned dolomite crystals Of these, Type 1 is euhedral and subhedral, and very fine-to fine-grained; Type 2 anhedral and subhedral, and fine-to medium-grained; Type 3 subhedral and euhedral, and fine-to medium-grained These data support that the Upper Cretaceous dolomites in the study area could have been formed at two different stages, early and late diagenetic The early diagenetic dolomites (Type 1 and Type 2) are likely to form as a result of structural changes that occurred concurrently with sedimentation in the basin during the Upper Cretaceous The sea water fresh water mixing zones over uplifted submarine masses (rudist-bearing limestones) are probably the most favoured environments for dolomitization The late diagenetic ones (Type 3 texture) are wholly tectonically controlled and correspond to the dolomites which are controlled by fractures associated with nappe tectonics in the region

INTRODUCTION

The occurrence of dolomite is rather complicated and problematic matter. Different models have been established for dolomitization, and many theories have been put forward on this subject. These were separately evaluated and discussed by Hardie(1986).

Dolomitization may occur at two stages, early and late diagenetic stages. The early diagenetic dolomites form concurrently with deposition or immediately after this process and reflect the conditions of environment in which they occur. Evaporitic dolomites (Deffeyes et al., 1964; Illing et al., 1965; Behrens and Land, 1972; Patterson and Kinsman, 1982), mixing water dolomites (Hanshaw et al., 1971) and marine dolomites (Land, 1985) are examples for this type. Evaporitic dolomites occur widespread in supra-tidal environments (sabkha) characterized by excessive evaporation under con" tinental climatic conditions. They can be found in a mineral association of gypsum-anhydrite dolomite or can form as cavity dolomites by leaching of evaporites (Illing et al., 1965). Mixing water dolomites (sea water-fresh water) have been formerly proposed as a theorical model (Dorag type dolomitization: Badiozamani, 1973) and afterwards modern and tossil examples of this type have been identified. This type is mostly used to explain the dolomitization of platform-type limestones that are not accompanied by evaporites. In addition to these, some workers put forward that high Mg rate required for the formation of thick and massive platform dolomites is directly supplied from sea water and established a dolomitization model by sea water (Varol and Magaritz, 1992).

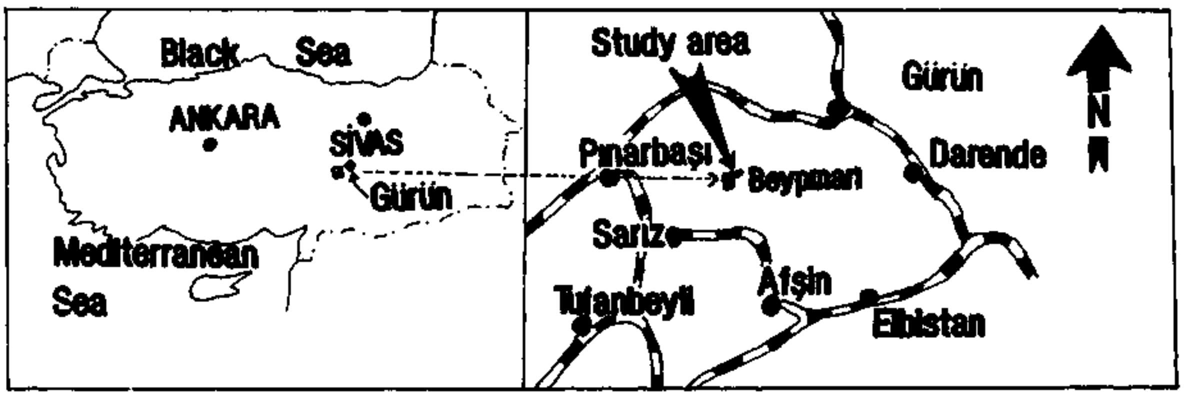
Dolomitization by Mg-rich waters percolating through stylolites and micro fractures which were developed at epigenetic stage or during burial dolomitization (Zenger, 1983). Mg-bearing solutions removed from shales during burial process (Mc Harque and Price, 1982) and Mg-rich solutions of hydrothermal origin (Matsumoto et al., 1988; Radke and Mathis, 1980) can cause dolomitization in adjacent limestones. Among all these dolomitization mechanisms, the dolomites of Upper Devonian, Upper Permian, Upper Triassic and Middle Jurassic-Cenomanian age defined by Atabey (1993) in the study area as well as the Upper Cretaceous (Upper Santonian-Campanian) dolomites whose petrographic features will be described in detail are of the some type and included in the dolomite group without evaporites. The Upper Cretaceous dolomites that were aimed in this study exhibit textural features which reflect the effects of mixing water during the early diagenetic stage and effects of Mg-bearing waters percolating through the fracture systems and burial effects during the late diagenetic stage.

The geology, petrography and geochemistry of dolomite were evaluated together in order to elucidate the above mentioned mechanisms that resulted in the formation of dolomites. The geochemical studies based on stable isotopes (O^{18}, C^{13}) are underway. In this study, the emphasis will be placed on the geology and petrography of the Upper Cretaceous dolomites that crop out to the 30 km W of Gürün (SW Sivas) (Fig. 1). For this purpose, a detailed study was carried out near Salyurt Yaylası, southern slope of Kavunağılı Tepe and Toycu Tepe (K37-c_1 and c_2 sheets) where the dolomites are best exposed (Fig. 2A). The petrological microscopic and scanning electron microscopic (SEM) studies were made on thin section specimens. Additional, a dyeing technique which employs a mixture of alizarine Red-S and potasium ferrocyanide was utilized for calcite and dolomite tests on thin sections (Dickson, 1965).

Using field and laboratory data, a mechanism for dolomitization was proposed and a model was established.

YANIKTEPE FORMATION

The study area which is situated in the Gürün autochthonous, Eastern Taurus is characterized by a thick sedimentary sequence ranging in age from Paleozoic to Tertiary. The dolomites belong to a unit called the Yanıktepe formation in this sequence. The Yanıktepe formation crops out over an extensive area that covers K37-c_1, c_2, c_3 and c_4 sheets. It is typically exposed near Salyurt Yaylası and southern slope of Kavunağılı Tepe in the west of Beypınarı village (K37-c_1 sheet), near Toycu Tepe, between Camiliyurt and Yolgeçen villages, near Bölücek Tepe (K37-c_2 and c_3 sheets), and to the northwest of Arpaçukuru village (K37-c_4 sheet). The dolomite formations are restricted to small outcrops of this unit in K37-c_1 and c_2 sheets. As a seen from figure 2A, the Yanıktepe formation is bounded by the Soğanlı allocthonous rock units in the north (Tekeli et al., 1983). Here, the outcrops were intensely affected by the Upper Cretaceous and post-Lutetian tectonisms.



The Yanıktepe formation consists of limestone and dolomite. At Bölücek Tepe (K37-c_2 sheet), it unconformably overlies the Yüceyurt formation of Middle Jurassic-Cenomanian age, which consists of limestone and dolomitic limestone. From

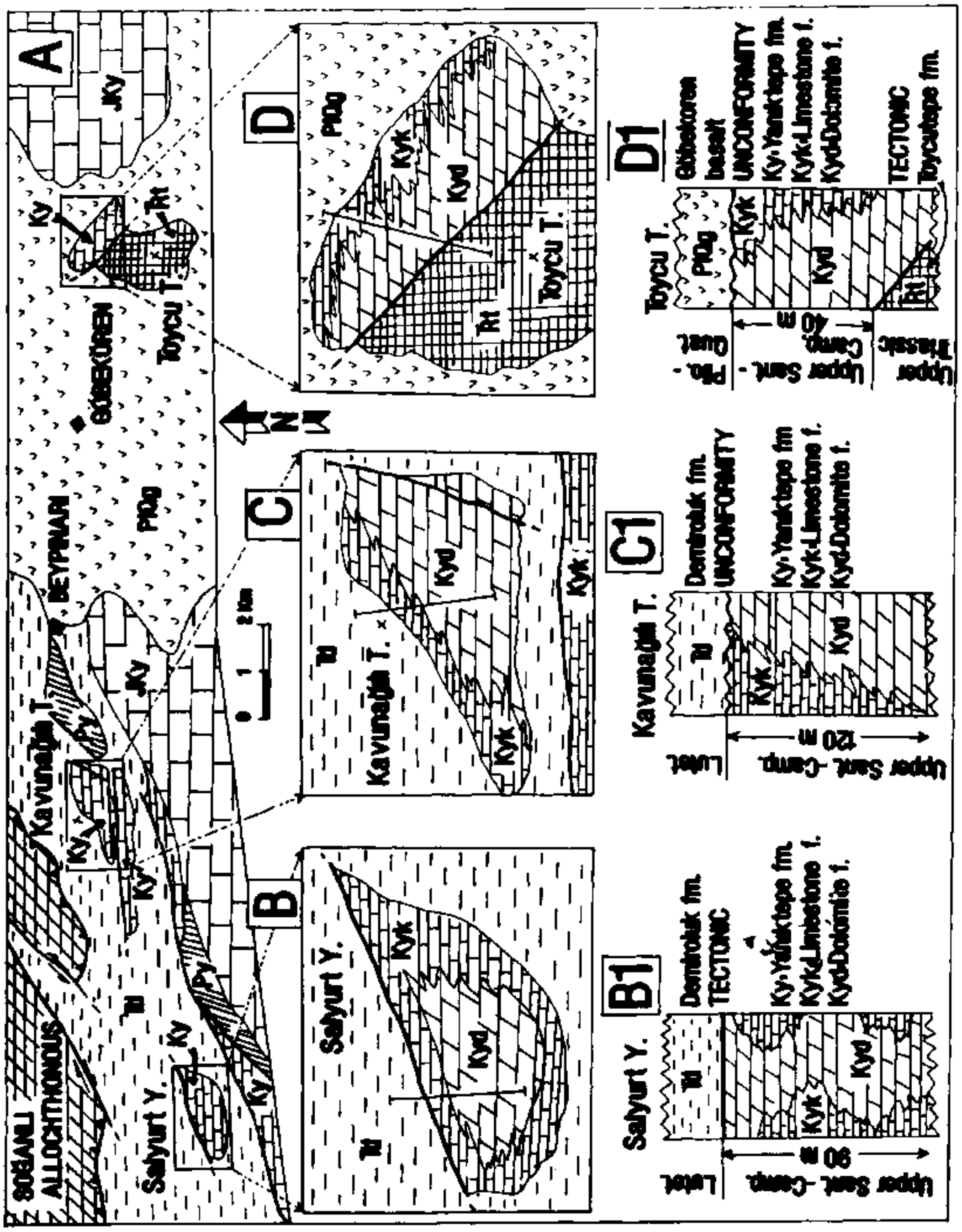


Fig. 2- A: Field view of Upper Cretaceous dolomites and their relationship with other units. Py-Yiğiltepe fm. (Upper Permian); TRt- Toycutepe fm. (Upper Triassic), JKy-Yüceyurt fm. (Dogger-Cenomanian); Ky- Yanıktepe fm. (Upper Santonian-Campanian); Td-Demiroluk fm. (Lutetian); PlQg-Göbekören basalt (Pliocene-Quaternary), B, C and D-Yanıktepe fm. facies; Kyk- Limestone facies, Kyd-Dolomite facies, B1, C1 and D1-Columnar sections.

the base upward, it consists of conglomerate breccia, massive and thickly bedded rudist-bearing limestone, and semi-pelagic and pelagic sequenses (Atabey, 1993). It is overlain by the pelagic rocks that constitute the Upper Campanian-Maestrichtian Akdere formation. Near Beypınarı village (Fig 2A), the appearance is different from the southern part. Here, the Yanıktepe formation is represented by only horizons of rudist-bearing limestone, and dolomite. It is surrounded by the Tertiary

Fig. 3- Field view of dolomites yellowish, pinkish and light gray colored, form highrelief topography, overlying by Tertiary unit (Demiroluk fm.: Td). Kyk-Limestone fades, Kyd-Dolomite facies, 3 km west of Beypınarı village, south slope of Kavunağılı Tepe.

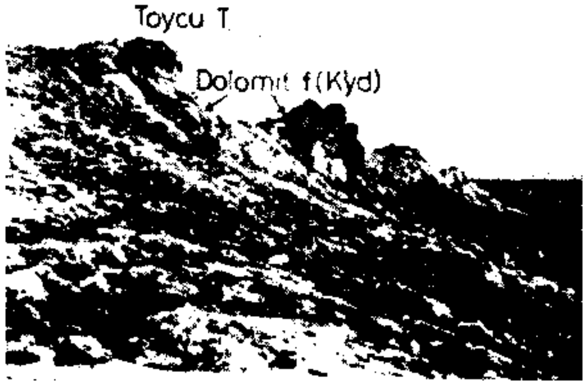


Fig. 4- Field view of pinkish, light colored dolomite forming high-relief topography with respect to limestones. Faulted contact with Upper Triassic unit (TRti) and (Toycutepe fm.). Kyd-Dolomite, 1 km east of Göbekören village, Toycu Tepe.

unit (Demiroluk fm.) and in part covered by this unit near Salyurt Yaylası and southern slope of Kavunağılı Tepe (Fig. 3). At Toycu Tepe, its contact with the underlying Upper Triassic rock unit (Toycutepe fm.) is a fault, and it is in part covered by the Göbekören basalt (Fig. 2A and 4).

The fossils identified from the limestones and pelagic rocks of the Yanıktepe formation are *Aeolisaccus kotori Radocic, Rotalia aff. skourensis Pfender, Siderolites vidali Schlumberger, Globotruncana stuartiformis Dalbienz, Globotruncana bulloides Vogler and Hippurites* sp. all of which represent a time span of Upper Santonian-Campanian.

According to the sections shown in figures 2B1, C1 and D1, the total thickness of levels of limestone and dolomite was estimated to be approximately 90 m, near Salyurt Yayla, 120 m at southern slope of Kavunağılı Tepe, and 40 m near Toycu Tepe, respectively. The thicknesses are not certain due to a variety of faults which the dolomites are found, limestone and dolomite facies (Fig. 2B, C and D).

Limestone facies

It is light gray and pinkish gray in a appearrance. It is massive and thickly bedded. Its thickness is variable, 60 m near Salyurt Yayla, 70 m at southern slope of Kavunağılı Tepe and 30 m at Toycu Tepe (Fig. 2A). The limestones interfinger with the dolomites laterally. This interfingering is locally interrupted by faults.

It exhibits a texture of foraminiferous wackestone-packestone, macro shell-bearing (rudist-bearing) mudstone-wackestone under the microscope. In this mudstone texture, rudist shells that are locally rounded and floating are observed. The mudstone-wackestone texture laterally grades into foraminifera-pellet and macro shell-bearing wackestone-packstone mud-supported texture reflects back-reef shelf lagoon in which relatively low energy conditions prevail (Flügel, 1982), while packstone texture characterizes reef environments in which medium-high energy conditions prevail.

Dolomite facles.

It differs markediy from the limestone facies in that its color is whitish, pinkish, and yellowish white and it forms high reliefs (Fig. 3 and 4). It is massive and fractured and displays a sugary texture. It is locally brecciated dissolution hallows and cavities developed on rock surfaces. Its thickness was measured to be 30 m near Salyurt Yayla, 50 m at southern slope of Kavunağılı Tepe and 10 m at Toycu Tepe (Fig. 2 B1, C1 and D1). The most important feature of dolomites is that they laterally in-

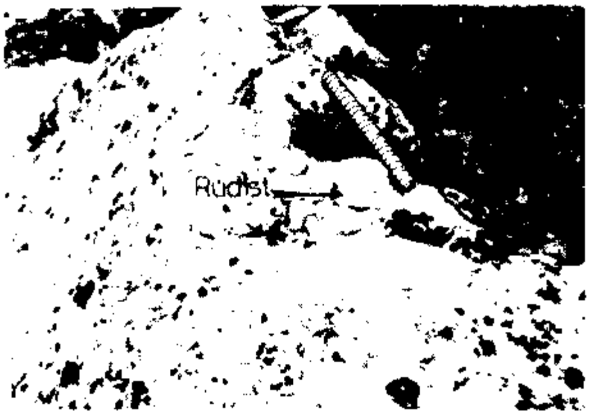


Fig. 5- Close-up view of yellowish, pinkish gray colored dolomite rock. Dolomitized rudist and cast fragments observed within it (arrow), 3 km west of Beypınarı village, south slope of Kavunağılı Tepe.

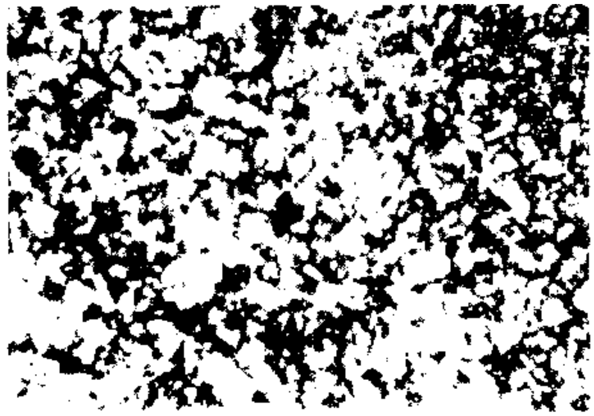


Fig. 6- Euhedral and regular sided fresh dolomite crystals (Type 1). Lime mud in the rock causa cloudy structure. Intercrystal areas filled with calcite (black areas). X63

terfinger with limestones. Some relics of undolomitized limestone are locally observed within dolomites and at boundaries with limestones. The dolomites were formed as a result of partial dolpmitization of foraminifera-macro shell-bearing (rudist-bearing) mudstone-wackestone-packstone, as a evidenced by dolomitized complete rudist shells in dolomite (Fig. 5).

PETROGRAPHY

The Upper Cretaceous dolomites in the study area petrographically differ from the dolomites of Upper Devonian, Upper Permian, Upper Triassic and Dogger age. Three types of dolomite crystal were identified on the basis of textural changes, internal structure and crystal shape. Type 1, clear dolomite crystals, Type 2, filthy (blurry) dolomite crystals, Type 3, zoned dolomite crystals.

Clear dolomite crystals (Type 1)

These are mostly light colored and represented by a dolosparitic mosaic. Dolomite crystals are euhedral and subhedral, very fine-to fine-grained (0.10-0.15 mm). The crystal boundaries are well-developed. They have a character similar to limpid dolomite crystal type defined by Folk and Land (1975). Interlocking is poorly-developed in crystals. This resulted in high porosity. Intergranular spaces are filled with calcite matrix (black areas in Fig. 6). This type of dolomites are best seer near Salyurt Yayla and at southern slope of Kavu nağılı Tepe.

Filthy (blurry) dolomite crystals (Type 2)

These are dark gray, subhedral and anheoral (Fig. 7). They are fine-to medium-grained (C.15-0.34 mm). Although they are usually disseminated,

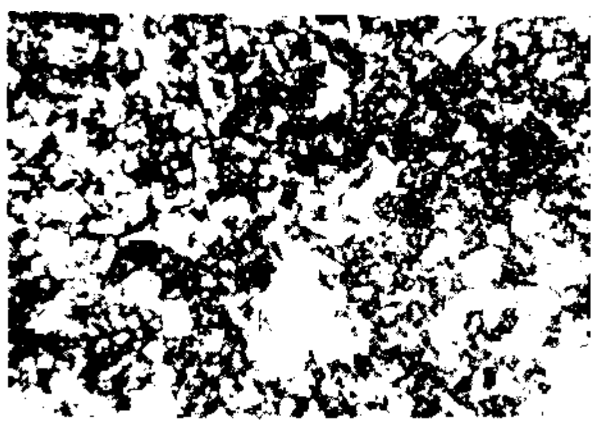


Fig. 7- Dirty (cloudy) appearance dolomite crystalls (Type 2). Some crystalls one euhodral (D), some are anhedral and dirty. This dirty ap pearance formed by lime mud escaped from dolomitization. Calcite filling in intergrain (K). Within the rock ooid or fossil-like structures are present, X63

they locally form interlocked aggregates. Large spaces are present between grains. These spaces are filled with calcite (black areas). Porosity is medium-to high. The crystals become more filthy (blurry) from the center outward This filthiness is caused by relics of undolomitized lime mud. As a result, the rock grained a cloudy appearrance.

This type of dolomites crop out at Toycu Tepe and at southern slope of Kavunağılı Tepe.

Zoned dolomite crystals (Type 3)

These dolomites are light gray and light colored. The crystals are anhedral and rarely euhedral

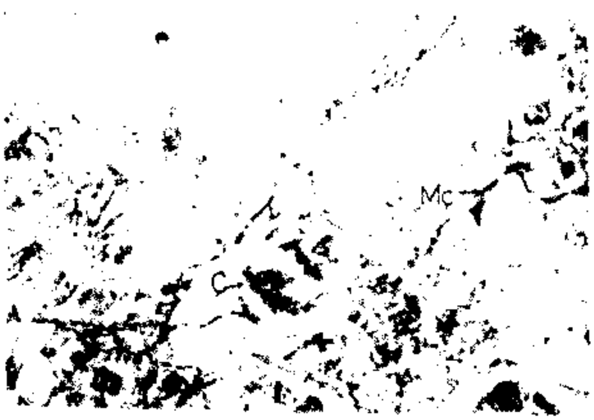


Fig. 8- Zoned dolomite crystalls (Type 3). There are euhedral-subhedral and partly anhedral with cloudy center (B) fresh framework (Ç) dolomite crystalls. Crystalls are sutured. Sometimes rudist cast or allochem like structures observed (Al). Dolomite crystalls cut by late stage fracture and microfractures (Mç) and there are filled with calcite cement (Ç), X63.

(Gregg and Sibley, 1984). They are fine-to medium-grained (0.24-0.37 mm). The crystal boundaries are regular and found in contact with each other (Fig. 8). Porosity is extremely low or undeveloped. The dolomite crystal are intersected by fractures and micro-fractures. These micro-fractures are filled with calcite (black areas along fractures). Fossil shells or allochem-like structures are locally seen in the rock. This type of dolomites are usually found at Toycu Tepe.

SCANNING ELECTRON MICROSCOPE (SEM)

The dolomites where crystal types were petrographically defined above, exhibit similar textural features in scanning electron microscopic (SEM) images The SEM images (664 and 665) of the sample 905 collected from a dolomite outcrop near Salyurt Yayla are given in figures 9 and 10. The image 661 belonging to the same sampie (Fig. 9) indicates an euhodral clear dolomite crystal (Type 1: Limpid dolomite) The intergranular spaces that are not filled with dolomite are ahundant. The im-

Fig. 9- Fresh dolomite crystalls (Type 1) SEM view. Euhedral regular sided, intergrain areas not filled with dolomite cement. Sample no: 905 from Salyurt Yaylası.

Fig. 10 Fresh dolomite crystalls (Type 1) SEM view. Euhedral and anhedral crystalls. Grains are in contact with each other, porosity decreased. Sample no: 905 from Salyurt Yaylası.

age 665 shows that euhedral crystals as well as subhedral crystals are found (Fig. 10). The crystals are found in contact with each other. As a result, the porosity is poorly developed relative to that in the image 664. A partial dissolution started in dolomite crystals. Consequently, they were replaced by calcite. Figures 11 and 12 show the SEM images of a sample (images 666 and 667), taken from the southern siope of Kavunağılı Tepe. These images belong to filthy (Type 2) dolomite crystals. The leaflike structures in figure 11 are undolomitized rudist sheis. Figure 12 (image 667) shows a subhedral crystal type and dissolution cavities. Both images have filthy and blurry appearrance. The presence of undolomitized areas and formation of dolomicrites which represent the early stage of dolomitization caused this filthiness. The SEM images (images 662 and 663) of dolomite sample (sample 905) collected horn Salyurt Yaylası are given in figures 13 and 14. These images belong to zoned dolomite crystals (Type 3). The crystals tend to grow inward into the center of hollows. Figure 13

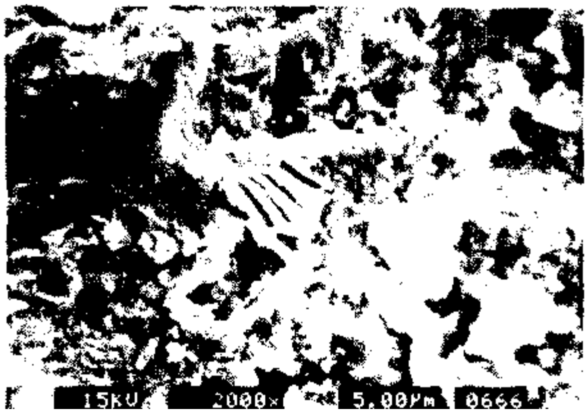


Fig. 11- Dirty (cloudy) appearance dolomite crysialls (Type *2)* SEM view Crystal shape and dimension is not clear. The leave-like structures are rudist casts escaped from dolomitization. Sampie no: 560 from south slope of Kavunağılı Tepe.

Fig. 12- Dirty-appearance dolomite crystalls (Type 2) SEM view. Partly euhedral and anhedral dolo mite crystalls with dissolve surfaces.

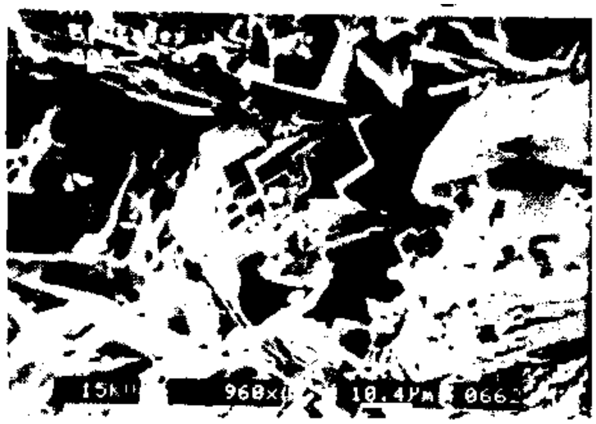


Fig. 13- Zoned growth dolomite crystalls (Type 3) SEM view. Increasing growth tendency toward empty center, Euhedral and regular sided. Sample no: 905 from Salyurt Yaylası.

Fig. 14- Zoned growth dolomite crystalls (Type 3) SEM view. Increasing growth tendency toward empty crystall center. Anhedral and subhedral crystalls with dissolve surfaces Sample no: 905 from Salyurt Yaylası.

shows euhedral, regular sided dolomite crystals, whereas figure 14 shows anhedral and subhedral dolomite crystals. Dissolution seems to have started in these crystals indicates a multi-stage crystallization rather than a single-stage one.

DISCUSSION and CONCLUSIONS

The Upper Cretaceous Yanıktepe formation that belongs to the Gürün autochthonous in Eastern Taurus is represented by limestone and dolomite fades. These facies laterally interfinger with each other. The dolomites formed by dolomitization of limestone facies which consists of foraminifera- and macro sholl-bearing (rudist-bearing) mudstone-wackestone-packstone. This is well documented by the presence of dclomitized complete rudist shells in dolomite rocks and of relics of undolomitized limestone in the field.

Having regard the facies features, crystal shapes and texture features of dolomites it is suggested that dolomitization has taken place at early and late diagenetic phases. The apsence of evapcrite minerals from the collected samples is not reconciled with the model of dolomitization which takes place in evaporitic supra tidal environments, discussed by Illing et al., (1965) and Patterson and Kinsman (1982). Thin section studies reveal that no evaporite minerals formed and no hollows which may be developed by leaching of evaporite minerals as *a* result of influx of fresh water, are found. The formation model of the Upper Cretaceous dolomites generally fits the model of dolomitization by mixing water, common in reef facies. The Yanıktepe formation is locally composed of rudist-bearing reefs. These rudistiferous reef facies lie on active continental slopes. This activity provided favorable conditions for mixing of fresh water-sea water. It is most likely that a contemperanous fault tectonics that had been active throughout the Upper Cretaceous played a role on this process. The areas that became shallower during sea level fluctuations (probably short lived lowering and raising of sea level) triggered by fault tectonics concurrent with deposition, were invoded by fresh water. This fresh water was mixed with sea water to make brackish water favorable for dolomitization. The ground water which, becomes brackish by this process can cause dolomitization. At the beginning, dolomitization has rapidly taken place in Mg-rich terrains of back-reef shelf lagoon and resulted in the formation of clear dolomite crystals (Type 1). The limestones remained undolomitized when Mg supply was occasionally interrupted and as a result, cloudy textures developed. The solutions which give rise to dolomitization can hardly replace the fossil shells such as rudist and foraminifera at early stages (Sibley, 1980,1982). At more advanced stages, these fossil shells dissolve and Ca deficiency in dolomitizing solutions is compensated in this way. The balancing Mg/Ca ratio (approximately 1/1) results in the formation of dolomite crystals having cloudy centers and ciear rims (Type 2), as evidenced by our samples. This type of dolomite crystals discussed here reflect feeding from a local source. This local source can have been originated by dissolution of rudist shells by fresh water effect. Zoned dolomite crystals (Type 3) developed along fractures at late diagenetic stage. The solutions which have arisen possibly recrystallization of early formed dolomites along fractures or in open spaces. The dolomite matrix filling the dissolution spaces resulted in the formation of zoned dolomite crystals (Type 3) in these parts. The trace element analyses on collected samples yielded Sr values between 60 and 90 ppm. These low Sr values has taken place in dolomites in the study area.

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