NEW GEOLOGICAL OBSERVATIONS IN THE AREA WEST OF ANTALYA BAY

Fuat BAYKAL and Adnan KALAFATÇIOĞLU

Istanbul University, Institute of Geology

Mineral Research and Exploration Institute of Turkey

ABSTRACT. — A study of the Permian-Mesozoic limestone series, which were previously called the *comprehensive series,* occurring in the area under investigation, showed that the limestone series belong to various facies, and the detailed chrono-stratigraphy of the area was established based on the fossil content determined through studying the formations in respect to the rock-stratigraphy units.

The Permian limestones and dolomites, Triassic sandstones, radiolarites and pelagic limestone formations, Liassic reef limestones, Dogger oolitic limestones, Malm dolomite and limestone formations, Lower Cretaceous limestones, Upper Cretaceous limestone and dolomite formations, occurring in the western part of the Antalya Bay, were studied and the fact that the above-mentioned formations formed various nappes in the area was investigated.

The tectonic units, i.e. anticlines and synclines, characterized by overthrusts, thrusts and imbricated structures, form a successive sequence and the general strike of these units is nearly parallel to the western coastal line of the Antalya Bay. Based on the nappes observed in the western (Elmalı area) and northeastern (Hadım) parts of the area, it was suggested that the thrusts as well as imbricated patterns show nappe structure.

Two structure zones striking ESE and WSW are observed south of Anatolids, i.e. in the area that also covers the Antalya Bay. This is in conformity with the main Alpidic structure and the structure of the Taurus Range is in conformity with the marginal folding pattern of Dinaric-Hellenic. The fact that the reverse, that is the northern direction is dominant in the vicinity of Antalya Bay area, is hard to accept.

INTRODUCTION

The area under investigation extends between 36°45'00"-36°52'30" longitudes and 30°22'33"-30°37'30" latitudes; it covers the western parts of Antalya Bay in Southern Anatolia.

We wish to thank Assoc. Prof. Dr. Sadrettin Alpan, General Director of the M.T.A. Institute, for facilitating the present work. Our grateful thanks are also due to Dr. G. Elgin, who conducted the petrographic determinations, and to Dr. Ü. Özdemir, N. Karacabey, M. Serdaroğlu, S. Freneix, E. Öngüç, F. Armağan, B. Sözeri, E. Çatal, who carried out the paleontological investigations.

GEOGRAPHICAL LOCATION AND MORPHOLOGY

The area, which was investigated during the summer of 1971, is located west of the Antalya Bay. It is mountainous, with peaks reaching up to 2650 meters in height. The area covers approximately 285 square km.

The area under investigation is bounded-by the western coast of the Antalya Bay in the east, Çakırlar village-Çağlarca-Geyikyeri localities in the north, Kabaardıç village-Karçukuru-Dolabanlı Tepe in the west, and Damlarcaini-Çobanlar village in the south (Fig. 1).

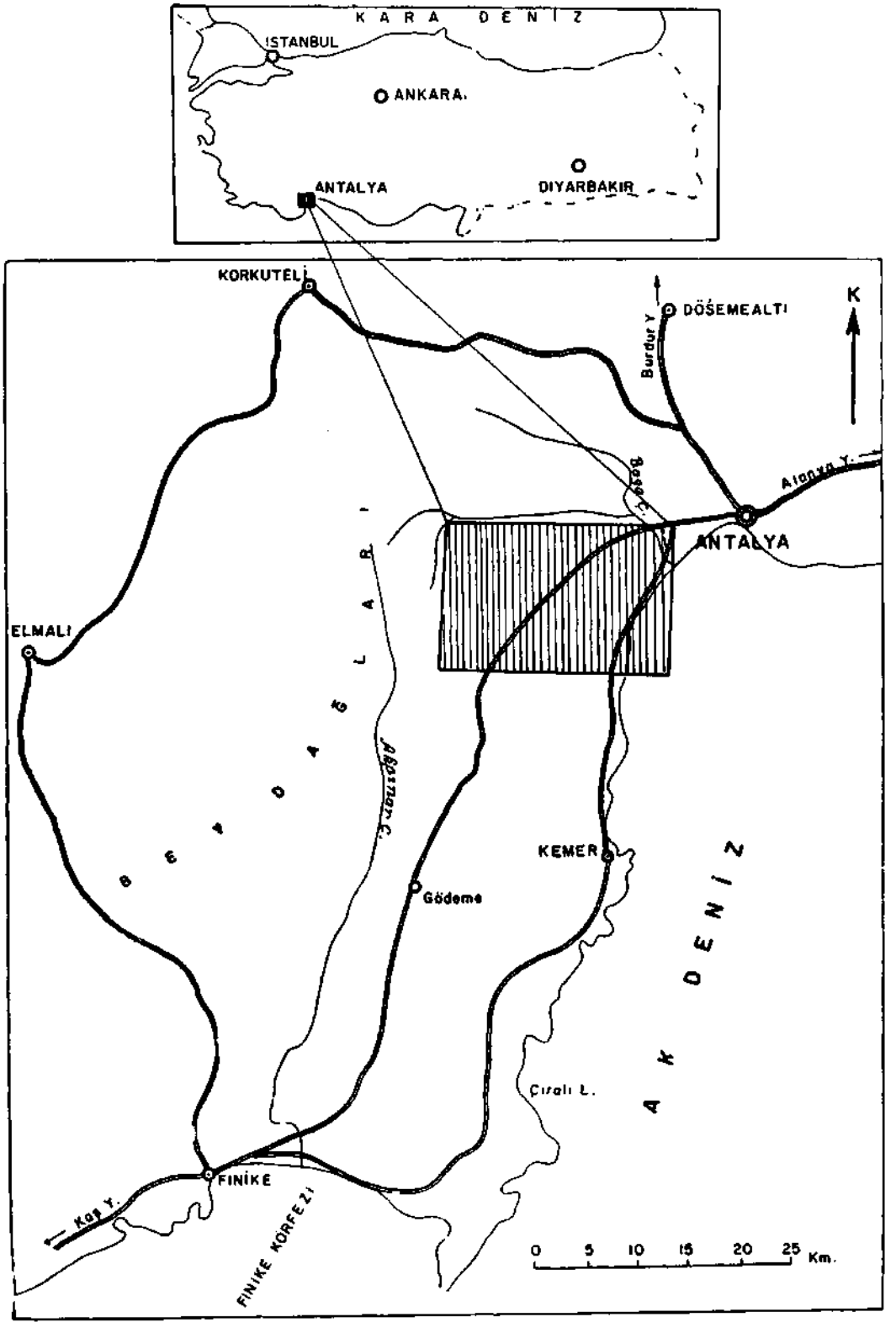

Fig. 1 - Geographic location map of the investigated area.

The highest mountains in the area are Girevit Mt. (911 m), Şalbalı Mt. (1651 m), Eşikyelesi peak (1321 m) on the Karıncalı Mt., Kocaboğaz peak (1915 m) on the Sivri Mt., Karadağ (1960 m), Ziyaret Tepe (2472 m) on the Eren Mt. and Bereket Mt. (2648 m). Other steep and rocky peaks are also present in the area. Since these mountains start at the sea level, they usually have a rather disturbed morphology. These mountains are parallel to the western coastal line of the Antalya Bay. The mountainous character of the area and the rather recent morphology caused the formation of hanging valleys.

The area under investigation belongs to the Iranids, which is one of the tectonic units of Turkey. The Paleozoic and particularly the Permo-Carboniferous beds are well-developed west of Antalya, as is the case in the Iranids located north of Syria. Transgressive character is observed in the Triassic and other periods of Mesozoic, while ophiolitic extrusives took place during Triassic. Another typical feature of this tectonic unit is the imbricated structure.

The area under investigation represents the rather pinched Iranid section located south of the A-shaped Taurus belt.

This part, which reaches a maximum height of 2650 meters above the sea level in the northern direction, is very mountainous. In general, it represents a typical alpine morphology. Narrow and deep valleys are observed between the steep slopes. Thus the area is rather inaccessible.

According to previous studies, the area consists of monotonous and thick Mesozoic formations. These formations were generally mapped as comprehensive series. During the recent studies, as well as during the field trips, it was determined that the following periods were represented in the comprehensive series, based on the lithological and paleontological data.

STRATIGRAPHY

A. PALEOZOIC

Permian

The oldest formations occurring in the region are Permian. Permian formations are exposed along the western coastal line, at Dinek Çeşmesi, south of Gedeller, west of Sivridağ, and east of Erendağ Some small exposures caused by tectonic stresses are also observed on the northern slope of the Gökdere.

The outcrops observed at Eren and Sivridağ were also caused by faulting. Permian beds occurring in the Dinek Çeşmesi area, which is bounded on the north and south by faults, show gradual transition into Triassic beds on the western side, whereas in the east, that is along the coast, these beds are cut by topography.

The following fossils were identified in the Permian beds, which start with black-colored limestone: Frondicularia, Geinitzina, *Mizzia velebitana* Schubert.

The Permo-Carboniferous formation, which in its upper part is dolomitic in character, shows gradual transition into Triassic beds (Fig. 2).

The outcrops observed at Gedeller consist of the same type of limestones and are overlain unconformably by Triassic sediments and Jurassic formations. In this part of the area Permian fossils such as Gymnocodium and Stafiella (Upper Permian) were found.

The following fossils were found in the Permian outcrops west of Sivridağ: Pseudofusulina, Schwagerina, Polydiexodina, Robulus, Ammbdiscus (Lower-Middle-Upper Permian).

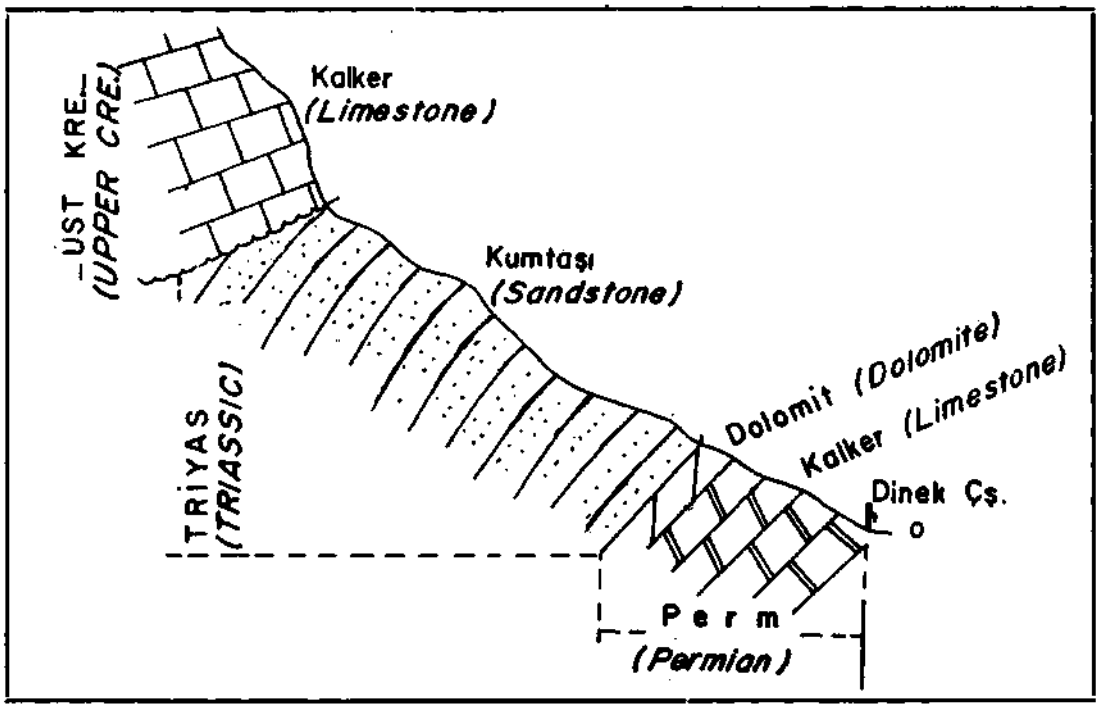

Fig. 2 - Schematic cross-section showing relation among Permian - Triassic and Upper Cretaceous formations in western Dinek Çeşmesi area.

In the eastern part of Erendağ, another Permian outcrop overlain by Jurassic beds and thrusted onto the Triassic is observed. The thrusting process, observed in this area, took place in the WNW-ESE direction (Fig. 3).

B. MESOZOIC

1. Triassic

Mesozoic formations occurring in the region could only be distinguished lately, and the Triassic, Jurassic and Cretaceous formations, which were called the *comprehensive series,* were studied as a whole and were mapped as one unit. Recent studies, however, provided detailed information on the area under investigation.

Triassic is generally represented by rhythmical formations and consists of alternating sandstone, clayey schist, limestone and radiolarite beds. Previously this lithological unit was ascribed to Upper Cretaceous (Blumenthal, Colin, Holzer). However, studies carried out recently showed the presence of fossils such as Halobia and Daonella, which prove definitely a Triassic age for this series.

Due to the fact that various lithosomes present in the Triassic formations show lateral and vertical transition, it was hard to investigate and map these formations.

Limestones and radiolarites contain abundant Halobia, *Daonella indica* Bittner and Ammonites. Based on this fossil content, it was proved that Ladinian stage is present in the region. The lower non-fossiliferous series is also ascribed to Lower Triassic. In the previous paragraphs of this article the gradual transition of the dolomitic levels of Permian age into Triassic was mentioned.

Contained in the sandy levels of the Triassic formations, Myophoria and in the clayey levels Modiola were identified. Abundant Radiolaria, Nodosaria, Algae and sponge spicules occur in the limestone. It is also interesting to note that silica nodules and layers are also present in this limestone.

Locally marine sills and plant fragments occur in the sandstone. In some localities, limestone wedges and lenses occur in cherts, whereas in some outcrops chert lenses occur in the limestone. The fact that small serpentine outcrops occur locally in the Triassic formations indicates that ophiolitic intrusions took place during Triassic period.

2. Jurassic

Lower (Liassic), Middle (Dogger) and Upper (Malm) Jurassic is represented in the area.

a. Liassic. — Liassic formations are exposed west of Antalya Bay. Liassic beds, which are generally characterized by light gray or white color, form steep cliffs sometimes several hundred meters thick. They consist of well-bedded layers showing biohermal, biostromal, pelletic, biomicritic and algal characters. Contained in these limestones, which usually show isopic sedimentation, intraformational rocks are also present.

Corals such as Montlivaultia, Thecosmilia, etc., and microorganisms such as *Vidalina martana* Farinacci, *Involutina turgida* Kristan, *In. liassica* Jones, *In.* cf. *tumida* Kristan-Tollman, *In. sinuosa* Weynschenk, *Trocholina permodiscoides* Oberhauser, Glomospira, Solenopora and Gastropods are present in this formation, and this fossil content indicates that the limestone series in question is Rhetian-Hettangian in age.

b. Dogger. — In the area under investigation typical Dogger fossils are rarely observed. Only *Meyendorffina bathonica* Aurouze-Bijon was observed in the bedded and partially oolitic limestones overlying conformably the Liassic limestones of Bereket Mt. Furthermore, *Protopenoroplis striata* ,Weyn. is found in some oolitic levels, and these, together with the fact that Juras-

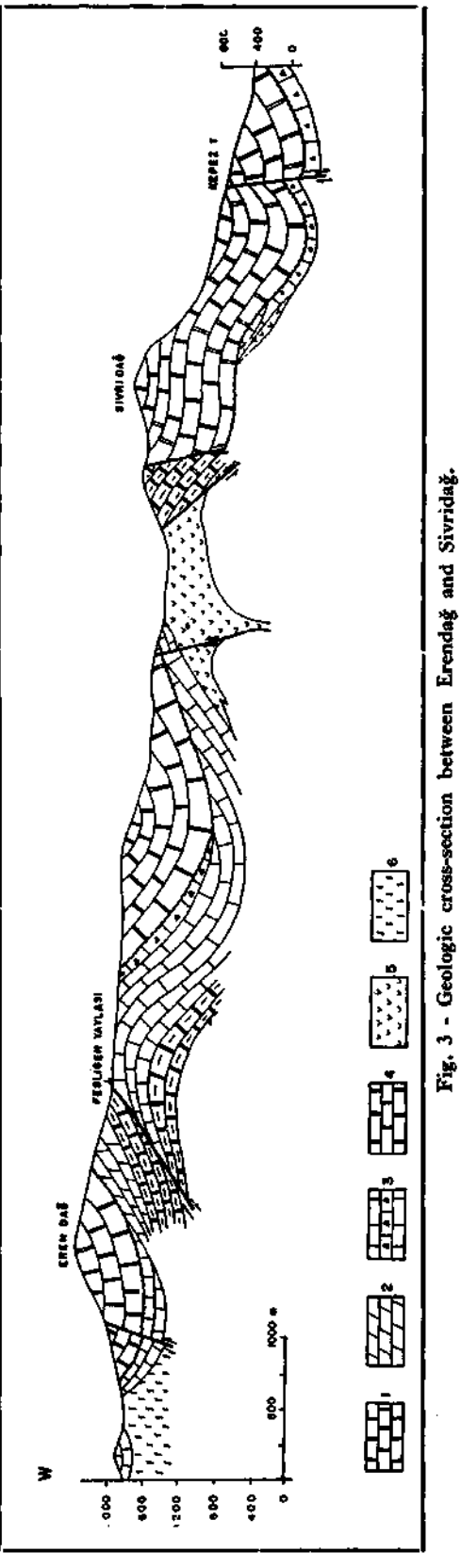

Fig. 3 - Geologic cross-section between Erendağ and Sivridağ.

1 - Permian limestone; 2 - Permian dolomite; 3 - Triassic limestone, radiolarite; 4 - Liassic limestone; 5 - Alpine ophiolite effusive; 6 - Serpantine peridotite.

sic formations as a whole have a total thickness of 1500 meters, suggest that Dogger is also represented in these formations.

c. Malm. — It is represented by dolomite, biomicritic limestones and dark to gray-colored limestones. Secondary crystallization is observed in these limestones. Joints as well as uniform stratification are found in the beds. Malm limestones, which are as much as 1 meter thick, contain *Kilianina blancheti* Pfender, *Pseudocydammina* cf. *lituus* Yokoyama, *Clypeina jurassica* Favre and Valvulinellidae as well as Ostracods. Based on this, Upper Jurassic age is assigned to this limestone series. Further to the south, white to light-colored limestones overlying the Triassic beds on Dünek Tepe contain *Calpionella alpina* Lor., *Calpionella elliptica* Cad., Pseudocydammina and Textularidae. Based on this fauna it was understood that the Upper Jurassic or the base of the Cretaceous formations is represented in this area.

3. Cretaceous

Outcrops of Cretaceous formations consist of white-colored reef limestones in the lower part, light-colored massive limestones in the middle part, and dolomitic limestones in the upper part. Reef limestones represent Lower Cretaceous, whereas the other two levels represent Upper Cretaceous.

a. Lower Cretaceous. — Lower Cretaceous formations are exposed in the Dünek Tepe area, located south of our region. Corals and fossils such as Orbitolina, Pseudocyclammina, Neotrocholina are found in an outcrop which consists of biomicritic and thick layers. Based on the fact that the Cretaceous formations occurring in the area rest upon the Jurassic and Triassic beds, it may easily be assumed that the formations show transgression characteristics.

b. Upper Cretaceous. — Compared to Jurassic formations, Upper Cretaceous formations are exposed in a limited area. This is probably due to erosion processes which followed the end of Mesozoic.

The Upper Cretaceous outcrops, plotted on the geological map of the area, are concentrated in the eastern part of the region.

Rudistids, Actaeonella, Nerinea, Algae and corals are identified in the lower levels of the Upper Cretaceous, which was deposited after the Austric movements, which in turn affected the Lower Cretaceous formations. Based on this fact, the limestones described above were assumed to have been formed in a reef environment. These organisms were identified within the massive limestones overlying the Jurassic in the vicinity of İnburnu area. Microorganisms such as *Dicyclina* cf. *schlumbergeri* Mun.-Chal., *Cuneolina pavonia* d'Orbigny, Pseudocydammina and Pseudolituonella were also found. Based on this fossil content Cenomanian age is assigned to the above-mentioned series.

Dolomites and dolomitic limestones of Upper Cretaceous age occurring at Şalbalı Mt. overlie the Jurassic formations (Malm), and this in turn indicates that the Upper Cretaceous limestones are transgressive.

Dicyclina, Cuneolina and Opthalmidiidae were identified in the thin sections of the Rudistid-bearing limestones occurring south of Gedeller. Based on this fauna, these limestones are assigned Lower Senonian (Cenomanian-Santonian) age.

C. NEOCENE

Neogene formations do not play an important role in this area, as is also the case in the Iranids. Nummulitic formations are not observed throughout the region. It is highly probable that the area was affected by the epirogenic or orogenic movements which took place during this period. However, some outcrops located in the area are probably of Neogene age, although it is not proved paleontologically. It is interesting to note that the stratified polymictic conglomerates occurring on the northeastern slopes of Bereketdağı and east of Karıncalıdağı are similar to the Neogene and particularly to the Pliocene formations observed in the various parts of Turkey.

In fact, these formations are younger compared to the fossiliferous Miocene marine formations situated outside of our region.

D. QUATERNARY

Following the Cenozoic movements, which affected the area under investigation, the morphological framework of the region was formed, and this in turn was followed by the formation of deep and narrow valleys. As a result, loosely cemented or uncemented debris were deposited at the bottom of these valleys or at the foot of the steep cliffs.

For instance, the maximum thickness of the debris is observed at the mouth of the valleys, reaching their basal level. For instance, at the mouth of Çandır Bay, which opens into the Antalya Plain, alluvium and debris with a maximum thickness of more than 50 meters and attaining some 2 km in width are observed.

Moreover, the presence of alluvial fans and talus along the margins of the valleys and at the foot of steep cliffs prevents access to the higher areas.

REGIONAL TECTONICS

Tectonics in the region which covers the area under investigation is very interesting. If we trace a line from Antalya Bay to the north towards Hoyran Lake, it will be observed that on both sides of this line strong alpidic movements took place during Eocene and Miocene; these movements are mostly to the south. Movements trending in the SE direction were observed in the east, while in the west they assume a SW direction. Locally, movements trending northward are also observed. The structural pattern of these movements is indicated by the surface tectonics (imbricated structures, fractures and overthrusting). In some areas these movements were not strong enough to affect the structural framework of the region. However, strong movements, which usually took place after Lower Miocene, affected large areas and caused the Mesozoic and Eocene beds to overlap onto the Miocene formations. This is best seen in the Korkuteli-Elmalı-Kaş region; in this area, Eocene flysch is thrust onto Miocene beds, whereas the Mesozoic (Liassic-Dogger, Malm, Cretaceous) is thrust in the SW direction on the Eocene formations. On the other hand, the Beydağları formation, which was thought to be autochthonous (Upper Cretaceous-Eocene), was thrust in the western direction with the Upper Cretaceous overthrusted onto Eocene or both formations overthrusted onto Miocene.

Further to the west, in the vicinity of Muğla, the same type of movements have a southern trend.

E. Parejas reports that the thrusting took place towards Central Turkey, to the north of the area between Afyon and Dinar. Strong tectonic movements affecting the eastern part of the Antalya Bay, occurred following the Eocene and the folding, and the formation of imbricated structures terminated before Miocene.

The allochthonous and autochthonous series occurring in these regions are of various ages and show various facies. Detailed and local information to explain the differences in the strike of these movements is still lacking, but, based on the studies carried out up-to-date, it may be thought that the overthrusting processes occurred at different times (during Savic, Steiric, Attic and Rhodanic phases). Recent activities, i.e. fracture blocks (occurring during Pliocene and Quaternary), caused formation of the present morphology.

The tectonic structure of the area under investigation is as follows: The steep and accidental topography of the region —Lycia of the Antiquity—gives the impression that the tectonic structure of the area is also very complex. Prior to the detailed investigations, many foreign geologists working in this area have arrived at the same conclusion. But close examination and detailed investigation of the region showed that the area in question was not complicated and that the tectonic units, i.e. anticlines and synclines, formed a sequence which is sub-parallel to the western coastal line of the Antalya Bay. The succession of the beds as well as the dips and the facies, the folding axes and the strikes, clearly indicate that the tectonics of the area is, in fact, characterized by simple overthrusting. Even nappes and double nappes do not occur in the area.

The area under investigation belongs to the Iranid tectonic unit of Turkey. But due to the fact that the area is located very close to the Taurid belt and is pinched, it is almost impossible to distinguish the two units. The tectonic units occurring in the area, i.e. anticlines and synclines, are either parallel to the Antalya Bay, or have an eastern strike in relation to the coastal line and, as a result, the ends of the folds observed in this area are sharply cut. Thus it may be concluded that the western edge of the Antalya Bay corresponds to a major fault.

The major tectonic units striking SSW-NNE or SW-NE are described below:

1. Karıncalıdağ syncline: South of the syncline, consisting of Jurassic formations, the western slopes of a broken and subsided anticline are observed.

2. Gökdere anticline: The oldest Permian formation occurring SE of the Gedeller village outcropped along the axis strike. The sinking of the northeastern end of the anticline caused the formation of the Gökdere valley. A thrust plate, approximately 4 km long and 1 km wide, is present southeast of the Gökdere village. In this area, the Triassic beds were pushed over Upper Cretaceous beds at an angle of 30-55°.

3. Şalbalı-Girevit fault zone: The compressional stresses caused the dissection of this zone—which in fact corresponds to a syncline—into major and minor faults and thus the tectonic rocks occurring in this belt were formed. The slickensides and an important amount of talus can be observed here even from great distances.

4. Folds occurring between Şalbalı-Cumayanı area: Several short but frequent anticlines and synclines occur in this zone. Following the strike-slip in the folding, the two main synclines, separated in the south by a short anticline, were drawn closer and extended at Girevit Mt. Further to the south, these two synclines diverged like a fan and an anticline was formed between them. On the other hand, the fact that two synclines occurred closely at the Girevit Mt. indicates that an important stress took place in the area.

5. Intrusive belt of Çandır-Sivridağ: This belt, which consists of basic and ultrabasic rocks, such as gabbro, serpentine, peridotite, follows the axes of the folding; that is, this intrusive belt

extends parallelly to the folding. Sedimentary formations occurring on the banks of Çandır Çay indicate that the Çandır-Sivridağ intrusive belt corresponds to an anticline.

6. Extrusive belt of Dolabanlı Tepe-Karcıbayırı: Pillow lava, tuff and Triassic platy limestone beds also occur in this belt, which consists of basalt, diabase and spilites. It is interesting to note that the belt in question also extends parallelly to the sedimentary folds occurring in the area.

7. Thrust plate of Erendağ-Fesliğen Yaylası: The zone is located at the northwestern end of the area under investigation. Fusulinid-bearing Permian limestones were thrust over the Triassic beds on the NW slopes of the Fesligen anticline. The thrust plate, which extends for some 4-5 km, has an amplitude of 1 km. The area which is located west of the Antalya Bay, of which detailed stratigraphic and tectonic information is given above, is characterized by parallel folds that are also in conformity with the western coastal line of the bay. Magmatic contours extending parallelly to the folds are also observed.

The area was affected by compressional stresses having a NW-SE strike. As a result, various faults extending perpendicularly to the strike of this compressional stress were formed. Furthermore, Gökdere village thrust plate to the east and Erendağ thrust plate to the NW were also formed. Faulting resulted in the formation of imbricated structures and this in turn is one of the characteristic features of the area.

The most important factor here is that no Upper Cretaceous limestones were observed underlying the Triassic formations, which were called the lower Antalya nappe. Triassic formations here are underlain by Permian beds or ophiolites. This fact necessitates a closer investigation of the area, since it was previously assumed that the Triassic beds occurring in the region formed a nappe.

Taking into consideration that the thrusting process at Karıncalıdağ is related to the Upper Cretaceous beds, it may be assumed that these movements took place in the post-Cretaceous age. However, in our country, the major orogenic movements are known to have taken place following the Laramian, during the Anatolian (Ante-Lutetian) and Tauric (Young Styric) phases. Based on this, it would be logical to think that paroxysmal phases of the Lycian movement took place during the orogenic phases described above.

Manuscript received October 19, 1972

Translated by: Filtz E. Dikmen

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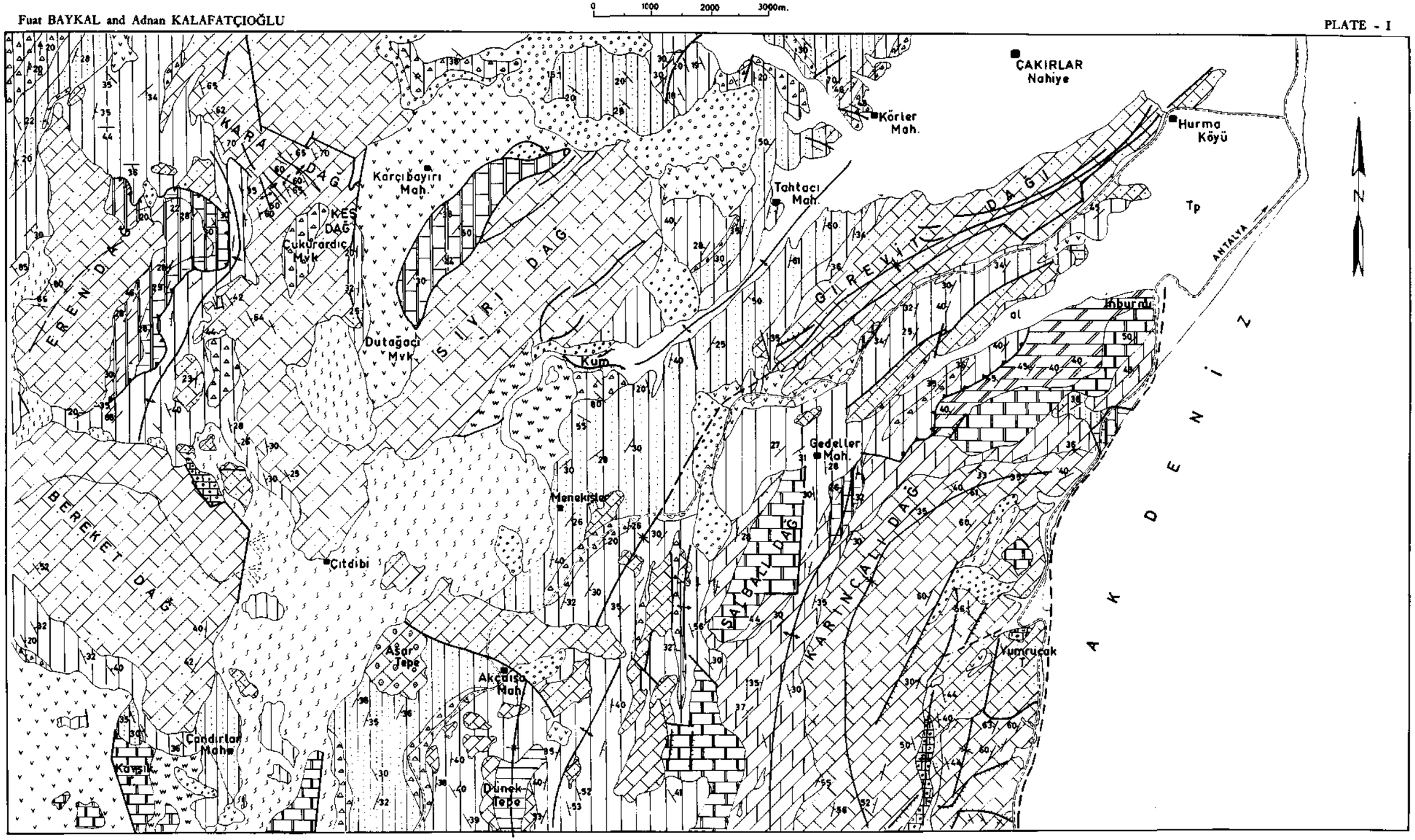

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GEOLOGIC MAP OF THE WESTERN ANTALYA BAY

1 - Alluvium; 2 - Terrace; 3 - Earth; 4 - Quaternary conglomerate; 5 - Pliocene conglomerate; 6 - Upper Cretaceous dolomite; 7 - Upper Cretaceous limestone; 8 - Lower Cretaceous limestone; 9 - Malm limestone and dolomite; 10 - Malm dolomite; 11 - Dogger oolithic limestone; 12 - Liassic reef limestone; 13 - Triassic, platy limestones; 14 - Triassic chert and radiolarite; 15 - Triassic sandstones; 16 - Permian dolomites; 17 - Permian limestones; 18 - Triassic ophiolite (effusive rocks); 19 - Triassic, ophiolite (intrusive rocks); 20 - Fault; 21 - Thrust, imbricated structure.