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STRATIGRAPHY OF THE UPPER CRETACEOUS AND PALEOGENE IN YIĞILCA-BOLU (NW TURKEY)

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Orhan KAYA*; Atife DİZER**; İzver TANSEL** and Sacit ÖZER*

ABSTRACT. — The post-Triassic rocks of the Yığılca area extend in age from late Santonian/early Campanian to Ypresian or probably Lutetian, and constitute a marine sequence intervened by submarine and subaerial unconformities. The sequence is represented primarily by volcaniclastic sandstone and conglomerate, derived from a provenance of mafic volcanic rocks, and subordinately by epiclastic sandstone. The Cretaceous and Paleogene rocks of the Yığılca area have a marked lithic and sequential similarity to those in the northerly-lying Ereğli area. The Cretaceous is suggested to have been deposited by the progressive onlap of an apparently southward transgressing sea. The coeval but differing rocks of the uppermost Cretaceous and Paleogene in the Yığılca, and southerly-lying Bolu and Mengen areas, suggests a structural divide to the south of the Yığılca area, formed by the latest Cretaceous. The totally 200 m thick Cretaceous olistostromal interval of the Yığılca sequence, which has a 4 m thick correlative in the Ereğli sequence, has apparently a significant bearing on the stratigraphy of the so-called «Ankara melange». The areal structure is characterized by a southward recumbent syncline whose northern limb is thrusted on the southern. High-angle faults are suggested to be originally shear fractures related to a nearly northeast-trending horizontal acute bisector, and later to have acted as extensional. High-angle faults postdate the thrust, and both are probably post-Lutetian in age.

INTRODUCTION

The map area is situated in G26-b2 and b1 sheets of 1:25,000 scale (Fig. 1). The pioneer regional work was done by Blumenthal (1948). Batum (1968), Görmüş (1980, 1982*a*, *b*), Bürkan and others (1982) and Kaya (1982) have studied the map and surrounding areas.

The geology of the Yığılca area has a significant bearing on the understanding of the north-south stratigraphic variations in the Cretaceous and Paleogene sequences of the western parts of northern Anatolia.

The symbols used in the graphic presentations are explained in Figure 2. The terminologies used herein for sandstones and mudrocks follow the classifications of Gilbert (1954: in Williams and others, 1954), and Lundegard and Samuels (1980), respectively. The term «limy» is used to qualify the clastic rocks with high carbonate content, which may have the deceptive appearance of a carbonate rock in the field.

O. Kaya is responsible for the field data and text. A. Dizer, İ. Tansel and S. Özer contributed by studying the benthic and pelagic foraminifers, and rudistids.

STRATIGRAPHY

The generalized rock succession of the Yığılca area is given in Figure 3. The age of the poorly fossiliferous or non-fossiliferous units, and classification of some rock units with poorly exposed contact relationships are based on the correlations with the northerly-lying Ereğli area (Fig. 4). The geologic map and representative cross-sections are given in Figure 5 a,b. The Paleozoic and older rocks (Kaya, 1982) have not been dealt with in this study.

* Dokuz Eylül Üniversitesi, Jeoloji Mühendisliği Bölümü, İzmir-Turkey.
** İstanbul Üniversitesi, Jeoloji Mühendisliği Bölümü, İstanbul-Turkey.

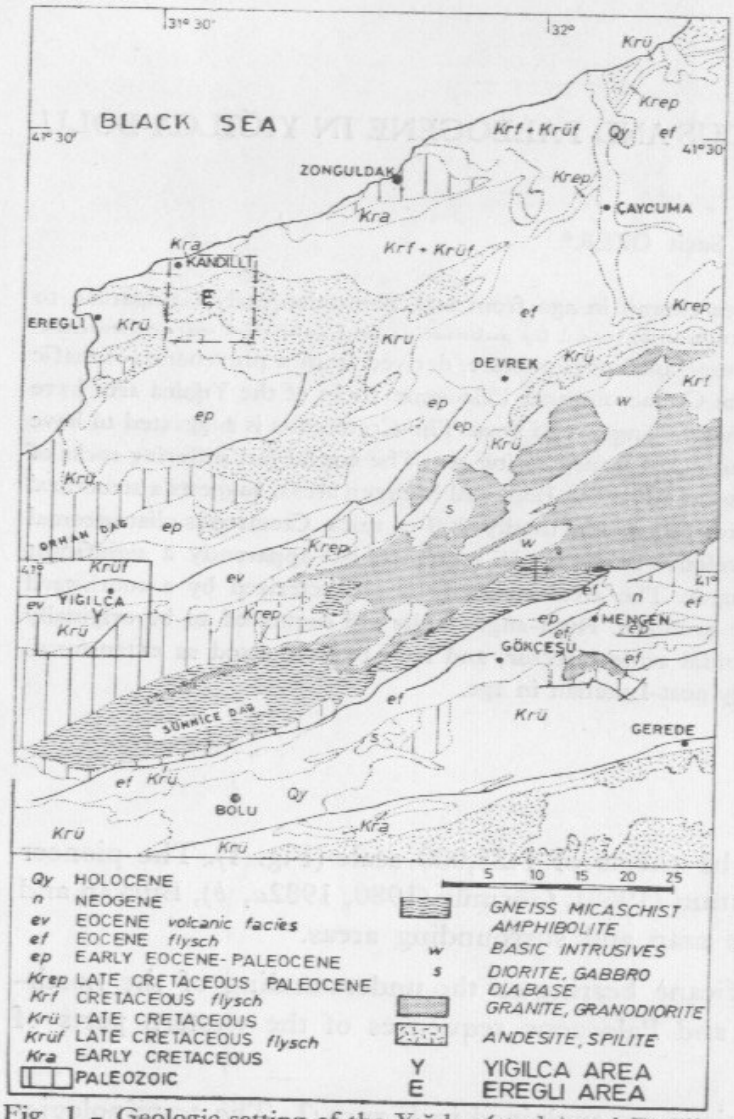

Fig. 1 – Geologic setting of the Yığılca (study) and Ereğli (reference) : areas in 1:500, 000 scale geologic map of Turkey (Zonguldak sheet).

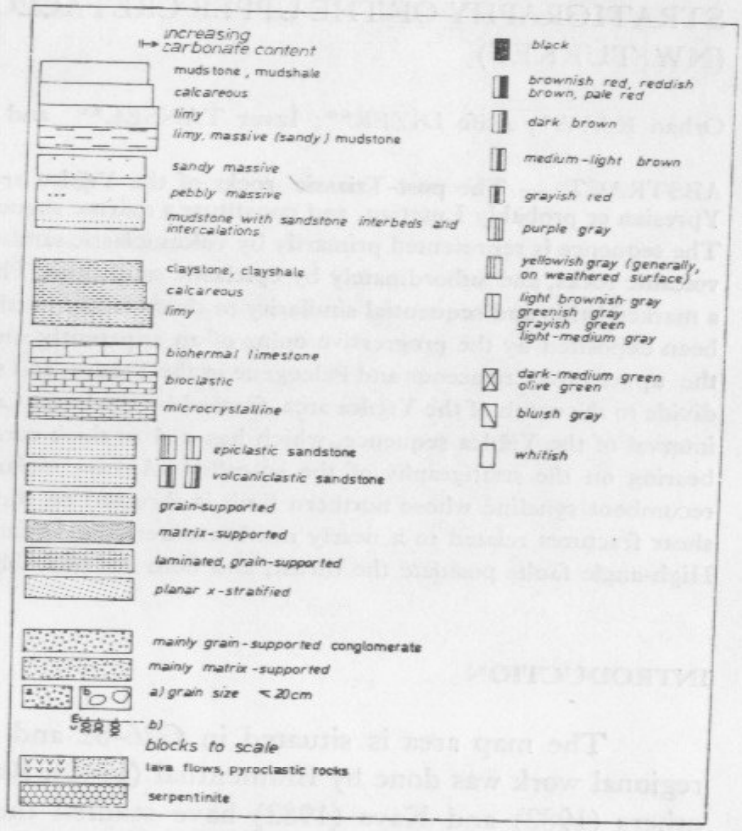

Fig. 2 – Symbols for rock types and colors.

Kırık formation

The name Kırık formation is here applied to a sequence of red beds consisting of slate, slaty lithic sandstone and conglomerate. The partial type section is exposed between 66.00:29.55 and 65.90:27.75. Reference sections are situated at 63.50:31.23 and 67.85:30.17. The Kırık formation corresponds to Görmüş's (1982*a*) probably late Devonian «Değirmendere formation».

The slate is purplish red to reddish brown, moderately indurated, thinly bedded, and originally mudshale and clayshale. The slaty sandstone is fine-grained quartzose lithic arenite, and lithic wacke. The basal conglomerate (69.47:31.73) is primarily gray, poorly stratified, and is divisible into three parts. The bottom part is poorly consolidated and matrix-supported lithic conglomerate. The constituents are angular to subround and with little sorting in size, and include shale, sandstone and limestone of Devonian age. The middle and thicker part of the basal conglomerate is well consolidated, massive and carbonate-cemented limestone-pebble conglomerate. The clasts are round to

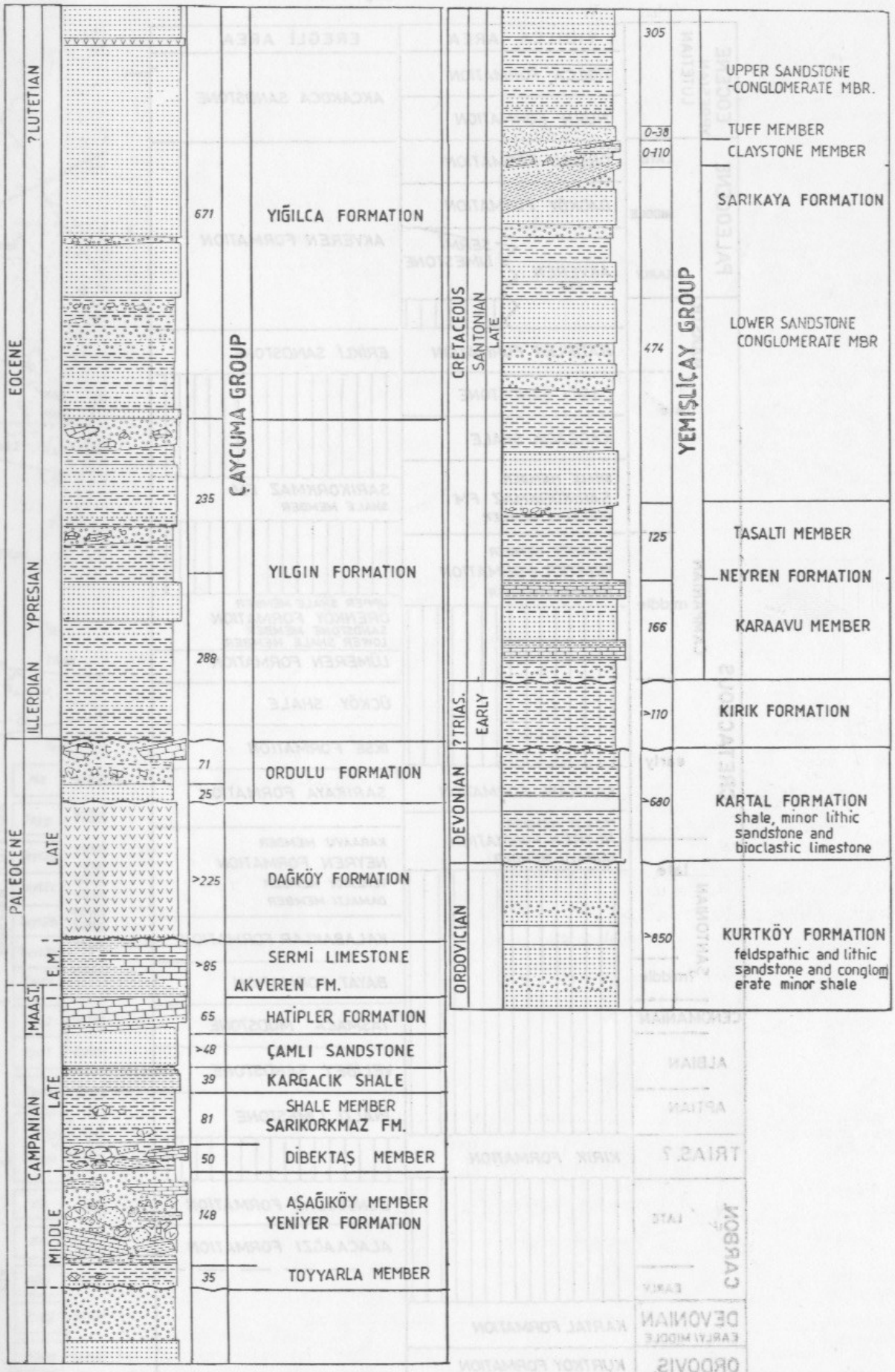

Fig. 3 - Generalized rock succession of the Yığılca area. The Peleozoic and older rocks (Kaya, 1982) have not been dealt with in this study.

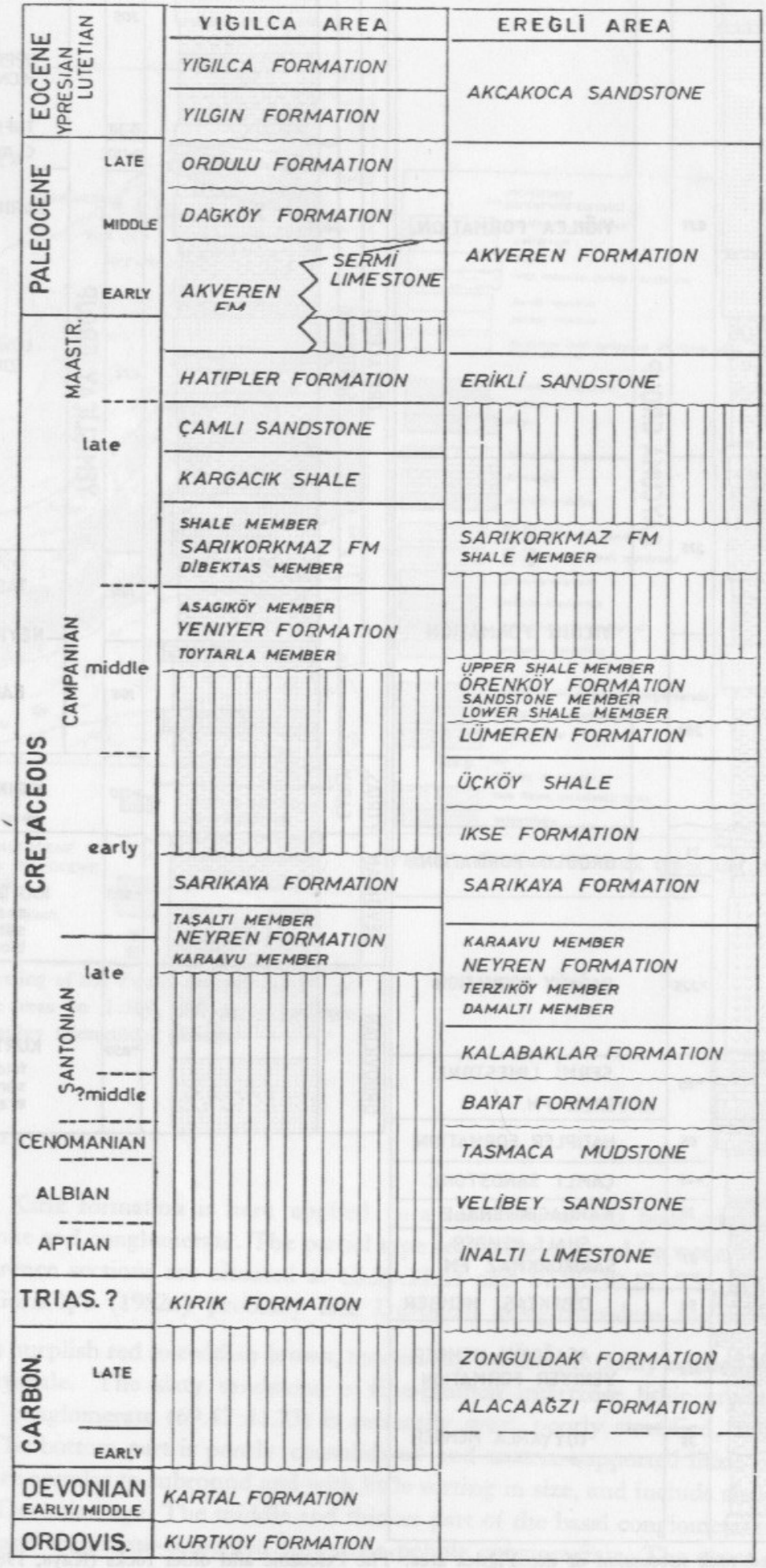

Fig. 4 - Correlation of the rocks units of the Yığılca and Ereğli areas. The Ereğli succession is from Kaya and others (1984*c*).

subround, moderately sorted in size, and include mainly Devonian limestone up to 35 cm in size. The upper part is poorly to moderately indurated and grain-supported lithic conglomerate. The constituents include mainly Devonian rocks, minor volcanic rocks, chert and vein quartz. A widely extending lenticular bed of conglomerate exists in the apparently middle part of the formation. It is up to 8 m thick, gray, in places well indurated, massive, grain-supported and carbonate-cemented limestone-pebble conglomerate. The clasts include dark gray Devonian limestone, white marble, light gray and brownish gray bioclastic limestone. The grains and carbonate cement are pervasively recrystallized. Thin interlayers of brownish gray, fine pebbly clayey limestone occur in the lower part of the conglomerate.

The basal conglomerate of the Kırık formation rests directly on the Lower Devonian rocks. The unconformity is well exposed at the locality 69.49:31.65. Deformed contacts occur at 67.90:30.13 and 69.07:31.50. The slate, which makes up the bulk of the formation, lies conformably and abruptly on the basal conglomerate.

The Kırık formation is barren of fossils. It underlies the late Santonian and overlies the Middle Devonian strata. Because the Kırık formation is in part lithically comparable with the probably Permian to early Triassic rocks in İstanbul (Asserato, 1972), it is tentatively suggested to be early Triassic in age (Kaya, in prep.). A lithic correlation with the late Devonian rocks of the İstanbul area (Kaya, 1973), as considered by Görmüş (1982*a*), is not adequate.

YEMİŞLİÇAY GROUP

The name Yemişliçay group has been applied by Kaya and others (1984*c*) to a heterogeneous assemblage consisting primarily of volcaniclastic sandstone and conglomerate. It contains subordinate but significant amounts of mafic tuff, blockstone, agglomerate, lava, pelagic limy mudrocks and limestone. The assemblage which is characterized by volcaniclastic rocks, contains minor epiclastic rocks at the basal part. The Yemişliçay group corresponds to Ketin and Gümüş's (1963) Senomanian-Campanian «Yemişliçay formation», and Tokay's (1952) Turonian-Coniacian «volcanic flysch».

The Yemişliçay group is divisible into four formations: in ascending order, (1) The Bayat formation consisting of epiclastic and volcaniclastic sandstones; (2) The Kalabaklar formation consisting of mudrocks and mainly epiclastic sandstone; (3) The Neyren formation consisting of volcaniclastic sandstone, mudrocks, and minor limy claystone and microcrystalline limestone; (4) The Sarıkaya formation consisting of volcaniclastic conglomerate, sandstone, mudrocks, and minor mafic tuff. The Bayat and Kalabaklar formations are restricted to the Ereğli area. The Neyren and Sarıkaya formations are widely exposed in the study area.

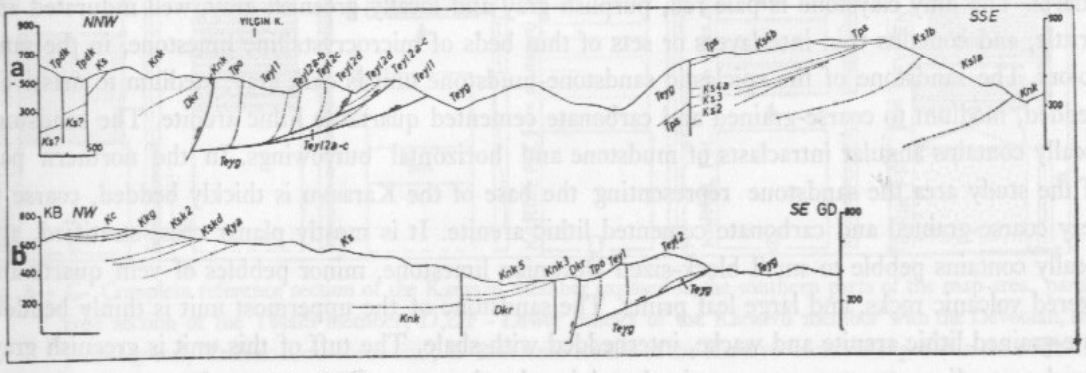

Fig. 5b - Cross-sections of the Yığılca area.

The entire Yemişliçay group is suggested to extend in age from probable Middle Santonian to early Campanian (Kaya and others, 1984*c*).

Neyren formation

The Neyren formation was designated by Kaya and others (1984*c*) for a heterogeneous sequence consisting primarily of volcaniclastic sandstone, mudrocks, and minor but stratigraphically significant limy claystone, microcrystalline limestone and mafic tuff. The type section is situated in Ereğli. The formation is divided into four formal members: in ascending order, (1) The Damaltı member consisting of volcaniclastic sandstone; (2) The Terziköy member consisting of mudrocks with local thin interlayers of volcaniclastic sandstone; (3) The Karaavu member consisting mainly of volcaniclastic sandstone, mudrocks, and minor limy claystone and microcrystalline limestone, and (4) The Taşaltı member consisting primarily of mudrocks. The Damaltı and Terziköy members are confined to the Ereğli area. The Karaavu member is widely exposed in the Ereğli and Yığılca areas. The Taşaltı is restricted to the Yığılca area. The Karaavu and Taşaltı members correspond to parts of Görmüş's (1982*a*) «Hızardere formation of Senonian-Campanian-Maastrichtian and partly Turonian age».

The uppermost part of the Neyren formation contains pelagic foraminifers indicating the turn in age from late Santonian to early Campanian. Accordingly, the main bulk of the formation appears to be late Santonian in age.

Karaavu member. — The name Karaavu member was designated by Kaya and others (1984*c*) for a heterogeneous sequence of volcaniclastic sandstone, mudrocks, and minor limy claystone, microcrystalline limestone, epiclastic sandstone and mafic tuff. The type section was established in the Ereğli area. In the map area, for practical field purposes, the Karaavu can be divided into 5 units: in ascending order, (1) mudstone-conglomerate, (2) lower limy claystone (-limestone), (3) epiclastic sandstone-mudstone, and (4) upper limy claystone-limestone. The type sections of this units are exposed, in the same order, at 62.50:31.85, 64.70:30.58, 64.70:30.60 and 64.98:30.52 (Fig. 6C). In the northernmost part of the map area the Karaavu member is mainly represented by a (5) thinly interbedded epiclastic sandstone-shale unit typically exposed between 62.97:37.55 and 62.80:38.15.

In the mudstone-conglomerate unit of the member, the mudstone is greenish gray, and contains sporadic thin interlayers of turbiditic lithic arenite. The conglomerate is up to 9 m in thickness, laterally discontinuous, moderately indurated, matrix-supported and polymictic. The clasts are angular to subrounded, poorly sorted in size, and include Kırık rocks, which are up to 60 cm in size, Paleozoic limestone and mudrocks, probably Mesozoic microcrystalline limestone and lithic arenite and vein quartz. The limy claystone is pale red, purplish gray and locally greenish gray, well indurated and brittle, and contains thin interlayers or sets of thin beds of microcrystalline limestone, in the same colors. The sandstone of the epiclastic sandstone-mudstone unit is dark gray, medium to massively bedded, medium to coarse-grained and carbonate cemented quartzose lithic arenite. The sandstone locally contains angular intraclasts of mudstone and horizontal burrowings. In the northern part of the study area the sandstone representing the base of the Karaavu is thickly bedded, coarse to very coarse-grained and carbonate cemented lithic arenite. It is mostly planar cross-stratified, and locally contains pebble to small block-sized Devonian limestone, minor pebbles of vein quartz and altered volcanic rocks, and large leaf prints. The sandstone of the uppermost unit is thinly bedded, fine-grained lithic arenite and wacke, interbedded with shale. The tuff of this unit is greenish gray, massive, medium to very coarse-grained and is related to a mafic source rock.

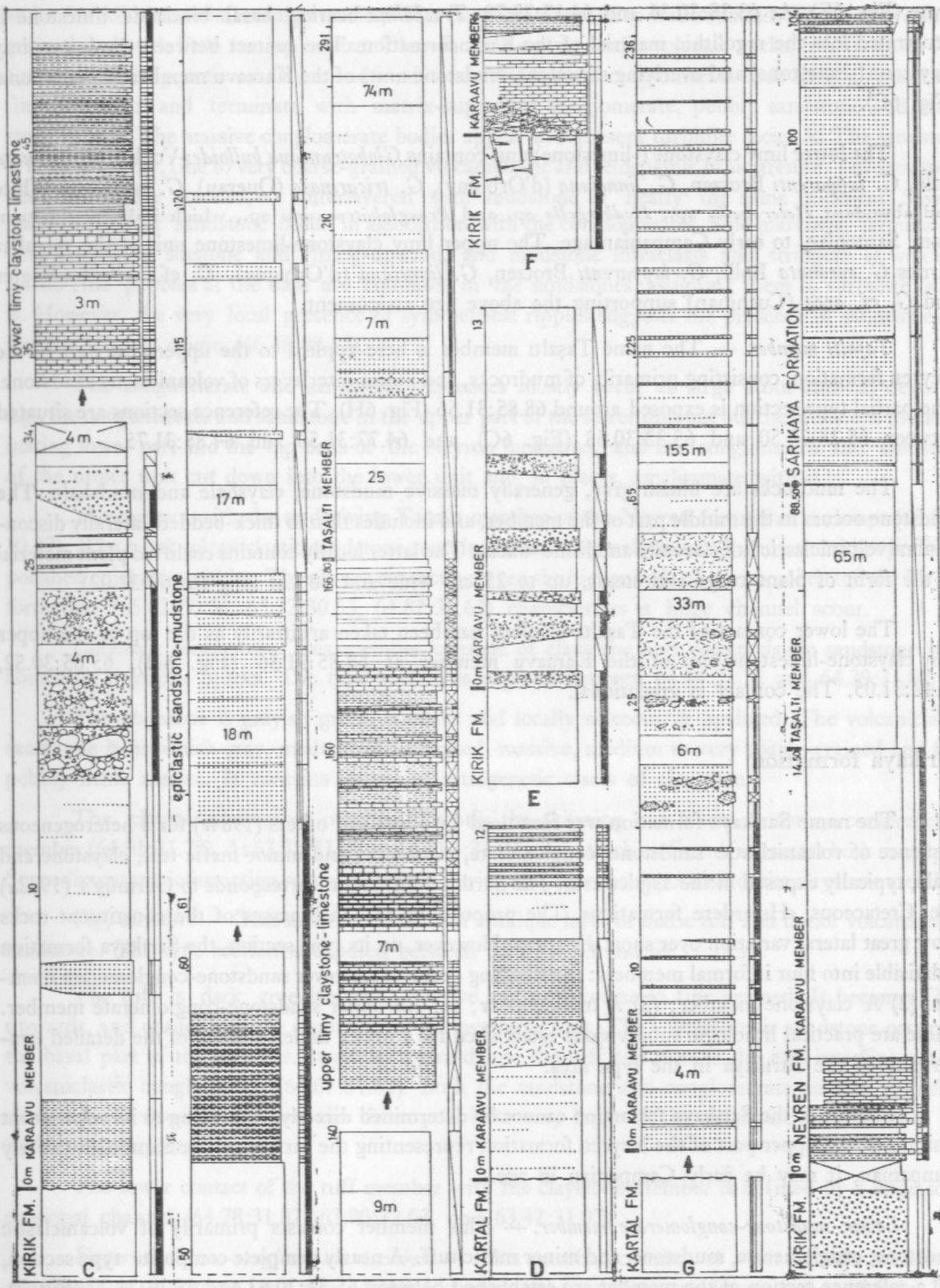

Fig. 6 - C- Complete reference section of the Karaavu member exposed in the southern parts of the map area, partial type section of the Taşaltı member; D,E,F - Lower contact of the Karaavu member with the Devonian, and probably early Triassic Kırık formation; G-Reference section of the Karaavu member exposed in the northernmost part of the study area.

The contact between the lower limy claystone (-limestone) unit of the Karaavu member and the Kırık formation is an unconformity. At 62.40:31.88 it is defined by basal mudshale and conglomerate (Fig. 6E). At 63.38:30.36 and 64.17:29.78 *Trocholina*-bearing basal bioclastic limestone is penetrated into the regolithic material of the Kırık formation. The contact between the lower limy claystone (-limestone) and overlying sandstone-mudstone units of the Karaavu member is gradational (Fig. 6C).

The lower limy claystone (-limestone) unit contains *Globotruncana bulloides* Vogler, *G. coronata* Bolli, *G. lapparenti* Brotzen, *G. linneiana* (d'Orbigny), *G. tricarinata* (Querau), *G. ventricosa* White and abundant *Heterohelix* sp., *Hedbergella* sp. and *Praeglobotruncana* sp., which indicate the turn from Santonian to early Campanian age. The upper limy claystone-limestone unit of the member carries *G. coronata* Bolli, *G. lapparenti* Brotzen, *G. linneiana* (d'Orbigny), *G.* cf. *bulloides* Vogler and *G.* cf. *area* (Cushman) supporting the above age assignment.

Taşaltı member. — The name Taşaltı member is here applied to the uppermost part of the Neyren formation, consisting primarily of mudrocks, and minor interlayers of volcaniclastic sandstone. The partial type section is exposed around 68.85:31.56 (Fig. 6H). The reference sections are situated between 65.28:30.50 and 65.32:30.63 (Fig. 6C), and 64.77:31.50 and 64.85:31.75.

The mudrocks are bluish gray, generally massive mudstone, clayshale and mudshale. The sandstone occurs in the middle part of the member, and includes thin to thick-bedded, laterally discontinuous volcaniclastic lithic arenite and lithic wacke. The latter locally contains coalified plant material in the form of plant twigs and stems, up to 25 cm wide and 60 cm long (64.69:31.02).

The lower contact of the Taşaltı member has been taken arbitrarily as the top of the upper limy claystone-limestone unit of the Karaavu member at 68.85:31.56 (Fig. 6H), 65.05:30.52, 64.42:31.05. The contact is gradational.

Sarıkaya formation

The name Sarıkaya formation was first used by Kaya and others (1984*c*) for a heterogeneous sequence of volcaniclastic sandstone, conglomerate, mudstone, and minor mafic tuff, claystone and shale, typically exposed in the Yığılca area. The Sarıkaya formation corresponds to Görmüş's (1982*a*) late Cretaceous «Hızardere formation». The proportions and thicknesses of the constituent rocks show great lateral variation over short distances. However, on its type section, the Sarıkaya formation is divisible into four informal members: in ascending order, (1) A lower sandstone-conglomerate member; (2) A claystone member; (3) A tuff member; (4) An upper sandstone-conglomerate member. These are practical lithologic subdivisions established for a better understanding of the detailed stratigraphy of the Sarıkaya in the type area.

The age of the Sarıkaya formation cannot be determined directly. According to its superjacent position on the upper part of the Neyren formation representing the turn from late Santonian to early Campanian, it may be early Campanian in age.

Lower sandstone-conglomerate member. — This member consists primarily of volcaniclastic sandstone, conglomerate, mudstone, and minor mafic tuff. A nearly complete composite type section, and a reference section of the member are established between 65.32:30.63 and 65.39:31.27 (Fig. 7), and between 68.83:31.56 and 68.35:31.97, respectively. On its composite type section the member is divisible into two units: a lower volcaniclastic conglomerate-sandstone-mudstone and an upper volcaniclastic sandstone-conglomerate-mudstone unit.

The conglomerate is mainly brownish gray, very thick-bedded to massive, grain-supported and without fabric elements. Locally, it is scour channel filling up to tens of meters in thickness and a few kilometers in lateral extension. The clasts are rounded to well rounded, fine to very coarse-grained and with little sorting in size. They include mainly mafic volcanic rocks, locally up to 7 m across, and intragenetic mudstone and sandstone. Many of the conglomerate beds show a remarkable fining-upward and terminate with matrix-supported conglomerate, pebbly sandstone and mudstone in turn. The massive conglomerate bodies appear to represent turbidite facies A. The sandstone is brownish gray, fine to very coarse-grained volcaniclastic and feldspathic lithic arenite. The sandstone beds are either stacked, or interlayered with mudstone of nearly the same thickness. Several massive beds of sandstone occur in association with the conglomerates. Sole markings, termination with laminated siltstone and fining-upward, and mudstone intraclasts and stringers of volcaniclastic fine pebbles at the base are common in the sandstones, assigning them to turbidite facies B. However, the very local presence of symmetrical ripples suggests the presence of sandstones of traction current origin (66.48:30.57).

The conglomerate and sandstone sequences mostly occur as large scour-and-fill deposits; e.g., the conglomerate and sandstone in the upper part of the lower unit cut out the mudstone predominating lower part and the top beds of the Neyren formation, and the conglomerate and sandstone of the upper unit cut down into the lower unit and, in places, amalgamate with it.

The contact with the underlying Taşaltı member of the Neyren formation is abrupt (65.57:-30.27). The basal volcaniclastic sandstone contains remarkably well rounded, and sometimes perfectly polished epiclastic pebbles. The abrupt contact between the higher beds of the member and the Neyren formation (65.62:30.50, 65.32:30.63, 64.82:31.63) characterizes a huge channel scour.

Claystone member. — This member consists of claystone and volcaniclastic sandstone with abundant claystone blocks. The type section is exposed between 64.44:31.52 and 64.39:31.88.

The claystone is grayish green, massive and locally siliceous or opalized. The volcaniclastic sandstone is brownish gray, moderately indurated, massive, medium to very coarse-grained and fine pebbly lithic arenite. It contains abundant intragenetic clasts of claystone.

The claystone member overlies abruptly the thinning out lower sandstone-conglomerate member (64.91:31.72). At 63.78:31.93 and 63.52:31.93 a 2 m thick mafic tuff separates both members. Synsedimentary deformation occurred before, during and after the deposition of the claystone member.

Tuff member. — This member consists of a unique layer of mafic tuff and minor volcaniclastic sandstone. The type section is exposed between 63.75:32.03 and 64.35:32.17.

The tuff is dark greenish gray, massive and very coarse to fine-grained. It becomes finer upwards, and grades into the mudstone of the overlying unit. The volcaniclastic sandstone occurs at the basal part of the member. It grades upward into the tuff and toward the east into fine pebbly volcaniclastic conglomerate (64.67:31.82). Both the sandstone and conglomerate contain abundant clasts of claystone, varying in size from pebble to very large block, which are derived from the underlying claystone member.

The lower contact of the tuff member with the claystone member is defined by a large-scale erosional channel (64.78:31.87, 63.90:32.03, and 63.42:31.97).

Upper sandstone-conglomerate member. — This member consists of volcaniclastic sandstone, conglomerate, mudstone, and subordinate but significant epiclastic sandstone and mudshale. The type and reference sections are exposed between 65.27:31.73 and 65.80:32.05 (Fig. 7), and 66.55: 32.50 and 66.85:32.53, respectively. The member can be divided into three units: (1) Lower epiclastic sandstone-shale; (2) Volcaniclastic sandstone-mudstone; (3) Upper epiclastic sandstone-shale.

The volcaniclastic conglomerate, sandstone and mudstone are lithically identical to those in the lower parts of the Sarıkaya formation. The epiclastic sandstone, which weathers yellowish gray, is thinly bedded turbiditic lithic arenite interlayered with thicker mudshale.

The member overlies gradationally the tuff member (64.85:31.96). The contact interval is represented by the continuous upward diminution in the grain size of the underlying tuff (Fig.7).

Yeniyer formation

The name Yeniyer formation is here used for a heterogeneous sequence of gray and red mudshale and clayshale, with floating or intimately admixed blocks. The Yeniyer formation corresponds to a section of Görmüş's (1982*a*) «Hızardere formation» of late Cretaceous age. Partial type section of the formation is situated between 62.82:38.64 and 62.40:39.12. The formation is divided into two formal members: a lower Toytarla member consisting mainly of gray mudshale with minor blocks, and an upper Aşağıköy member consisting of mudshale and clayshale, with abundant blocks.

The Yeniyer formation is barren of fossils. According to its stratigraphic position a Middle Campanian age can be suggested.

Toytarla member. — The name Toytarla member is here applied to a sequence consisting primarily of greenish gray mudshale with floating blocks, and minor sandstone, at the base. The type and reference sections of the member are located at 62.75:39.42, and 62.82:38.75, respectively.

The mudshale is in part slightly calcareous, and contains sporadic thin interbeds of turbiditic (Ta-Tb) lithic arenite. In its lower part the basal sandstone is gray, poorly stratified and coarse-grained lithic arenite (62.75:39.45). It is carbonate cemented, without sorting in size, and made up primarily of volcanic rocks and limestone. The lowermost beds contain bioclastic sandy limestone as lenses and intraclastic angular to rounded pebbles, and mafic volcaniclastic pebbles and cobbles. The upper part of the basal sandstone consists of slightly calcareous lithic wacke and sandy musdstone. All of the lower beds of the member contain abundant prisms of broken Inoceramus and rudist shells. In places, the lower part of the member contains isolated or intimately admixed blocks including pink to pale red microcrystalline limestone and limy claystone, gray microcrystalline limestone, and volcaniclastic conglomerate (62.82:38.64).

The basal sandstone (with mafic volcaniclastic pebbles, cobbles and abundant Inoceramus rudist fragments) of the Toytarla member overlies unconformably the Sarıkaya formation (62.75: 39.42, 61.99:40.5, and less distinctly 63.17:39.52). Gray mudshale (61.30:39.00) and a row of limestone blocks (62.82:38.64) locally define the unconformity.

The extrabasinal red micritic limestone blocks contain *Globotruncana lapparenti* Brotzen, *G. linneiana* (d'Orbigny), *G. coronata* Bolli, and acoompanying *Hedbergella* sp., *Heterohelix* sp. and *Praeglobotruncana* sp., indicating a late Santonian-early Campanian age. They are possibly derived from İkse formation lying in the Ereğli area. Accordingly, a Middle Campanian age can tentatively be suggested for the Toytarla member.

Aşağıköy member. — The Aşağıköy member is here named for a poorly stratified red shale and pebbly mudstone with isolated and intimately admixed blocks (olistostrome). The type section of the member is exposed between 60.38:39.05 and 60.35:39.36 (Fig. 8N).

The olistostrome is of debris-flow depositional origin. The mudrocks constituting the matrix are brownish red clayshale and sandy to fine pebbly mudstone. The blocks are upto several hundred meters across and, most commonly, intimately admixed. They include pink to pale red massive micro-

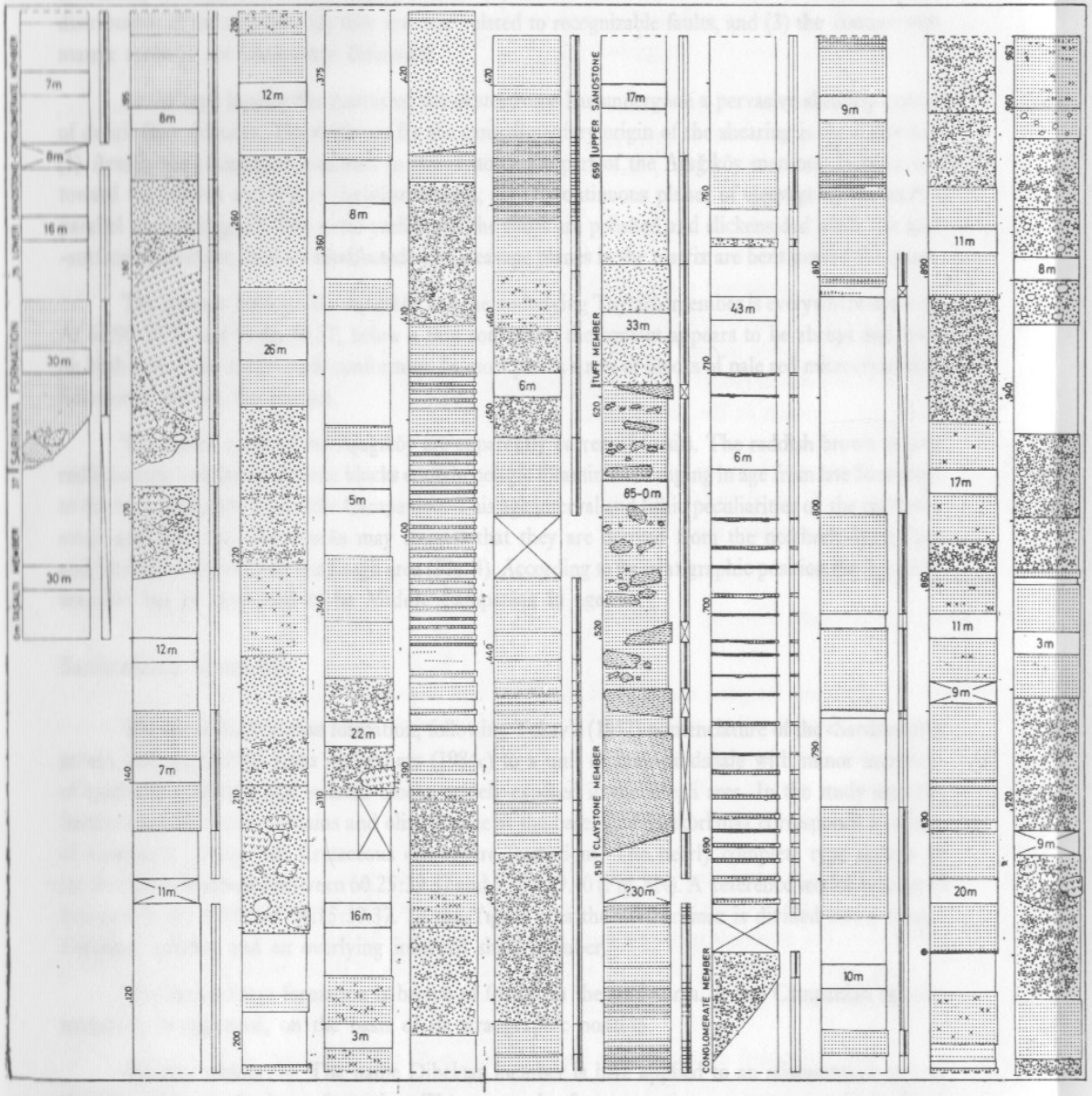

Fig. 7 - Partial composite type section of the Sarıkaya formation.

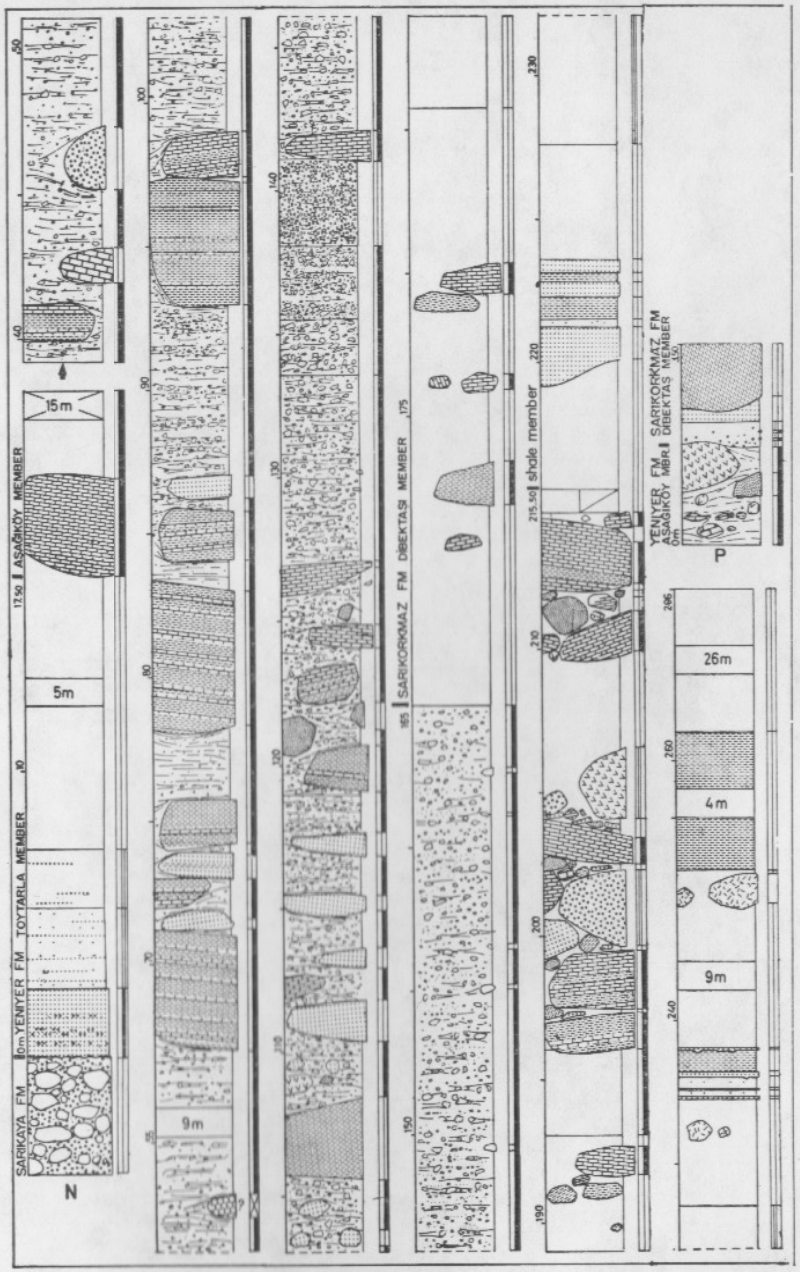

Fig. 8 - N - Complete type section of the Toytarla member, partial type section of the Aşağıköy member, nearly complete type section of the Sarıkorkmaz formation; P - Unconformity between the Sarıkorkmaz and Yeniyer formations.

crystalline limestone, pale red to brownish red thinly interbedded limestone and limy claystone, gray to red lithic wacke and mudstone, greenish gray thick-bedded and coarse-grained lithic arenite with thin interbeds of pale red mudstone, gray recrystallized limestone of probably Paleozoic age, epiclastic rounded pebble conglomerate, volcaniclastic rocks lithically similar to those of the Sarıkaya formation and manganiferous rocks (Atabek, 1940) which might have been derived from the Örenköy formation in the Ereğli area (Fig. 4). The serpentinetes, which indicate a derivation from the ultramafic tectonites, are suggested to be blocks, because (1) their occurrence in the area is confined to the distribution of the member, (2) they are not related to recognizable faults, and (3) the contact with matrix rocks is not intensively deformed.

At the type locality the matrix of the olistostrome has undergone a pervasive shearing typical of debris flow deposits. The evidence for the synsedimentary origin of the shearing is the following: (1) Areally the shearing is confined to the olistostrome part of the Aşağıköy member. It fades out toward the bottom and top of the olistostrome; (2) Discontinuous planes of cleavage in the matrix parallel the bedding; (3) The outer surfaces of the clasts are polished and slickensided while the near -surface parts of the clast are unaffected. The cleavage planes in the matrix are bent toward the clasts.

The contact between the Aşağıköy and the underlying Toytarla member is everywhere covered. At 61.90:38.35 and 61.66:38.37, below a thin soil cover, the contact appears to be abrupt and beds on both sides show a structural conformity. In most places a row of blocks of pale red microcrystalline limestones defines the contact.

The matrix rocks of the Aşağıköy are apparently barren of fossils. The reddish brown to pale red limestone and limy claystone blocks contain pelagic foraminifers ranging in age from late Santonian to the turn from early to Middle Campanian. This age interval and lithic peculiarities of the red limestone and limy claystone blocks may suggest that they are derived from the northerly-lying İkse and Örenköy formations of the Ereğli area (Fig. 4). According to its stratigraphic position the Aşağıköy member can be suggested to be Middle Campanian in age.

Sarıkorkmaz formation

The name Sarıkorkmaz formation, following Tokay's (1952) nomenclature of the «Sarıkorkmaz series», was applied by Kaya and others (1984*c*) to a unit of gray mudshale with minor interbeds of epiclastic sandstone and isolated blocks, widely exposed in the Ereğli area. In the study area the Sarıkorkmaz formation contains and olistostrome at the base. The Sarıkorkmaz corresponds to a part of Görmüş's (1982*a*) late Cretaceous «Hızardere formation». The nearly complete type section of the formation is exposed between 60.25:39.37 and 55.82:39.40 (Fig. 8N). A reference section is situated between 56.65:38.88 and 56.15:39.37. In the Yığılca area the Sarıkorkmaz is divided into a formal Dibektaş member and an overlying informal shale member.

The Sarıkorkmaz formation is barren of fossils, in the study area. A late Campanian age can tentatively be suggested, on the basis of its stratigraphic position.

Dibektaş member. — The name Dibektaş member is here applied to an olistostromal unit at the base of the Sarıkorkmaz formation. The type and reference section are exposed at 60.25:39.37 (Fig. 8N), and 56.65: 35.87 and 60.00:38.65, respectively.

The olistostrome is a nonstratified, chaotic unit consisting of closely packed to matrix-supported, angular to subrounded blocks. The matrix is gray mudstone and lithic wacke. The clasts are round to subrounded, and range in size from pebble to large block up to 10 m on one axis. They include primarily brownish red to pale red limy claystone and limestone, which are lithically similar to those

of the Örenköy and İkse formations of the Ereğli area (Fig. 4), gray sandstone with different textural and diagenetic grades, and volcanic rocks derived from the Sarıkaya and Lümerli formations, the latter being confined to the Ereğli area.

The contact between the Dibektaş member and the underlying Aşağıköy member of the Yeniyer formation is everywhere abrupt. At 56.65:35.88 the basal lithic wacke contains angular fine pebbles of red mudstone derived from the Aşağıköy. Across the contact, the composition and size of the coarse clasts show an abrupt change, and the shearing typical of the Aşağıköy matrix material disappears.

Shale member. — The shale member, which represents the bulk of the Sarıkorkmaz formation, consists of mudshale with sporadic epiclastic sandstone interlayers. The type and reference sections are exposed between 60.18:39.17 and 59.97:39.43, and at the surroundings of 56.20:35.90 and 57.25:37.32, respectively.

The mudshale is medium gray, thickly bedded to massive, and weathers light brownish gray. The epiclastic sandstone occurs as thin to thick-bedded channel-fills at wide intervals. Thinly bedded sandstone represents Ta and Tb Bouma divisions. In the lower part of the member the mudshale contains widely isolated blocks of red and gray limy clayshale and claystone up to 80 cm in size, and lava blocks (60.03:39.20, 57.48:38.27), as much as 175 cm in diameter, derived from the Lümeren formation in the Ereğli area.

The contact between the shale member and the matrix rocks of the Dibektaş member is gradational (56.80:37.65, 60.20:39.40). At 60.25:39.37 gray mudshale with floating blocks overlies abruptly the Aşağıköy member (Fig. 8P).

Kargacık shale

The name Kargacık shale is here used for a unit of primarily reddish gray, thinly bedded to laminated, limy clayshale and mudshale. The Kargacık shale corresponds to a part of Görmüş's (1982*a*) late Cretaceous «Hızardere formation». The complete type section is exposed at 57.20:37.18. The reference sections for the lowermost and uppermost parts of the Kargacık are situated at 56.12:36.00 (Fig. 9B) and 59.37:40.02 (Fig. 9D), respectively.

The clayshale and mudshale are reddish gray, grayish brown, pale red, thinly bedded to laminated and calcareous to limy. The main body consists of rhythmically interbedded carbonate-poor and rich layers. The mudshale is predominant in the lower part of the Kargacık. The upper part is represented mainly by fucoidal clay shale with sporadic interlayers of thinly bedded fine-grained lithic arenite and mudshale.

The gradational contact of the Kargacık shale with the underlying shale member of the Sarıkorkmaz formation is well exposed at 56.15:35.97 (Fig. 9B), 57.10:37.10, 59.35:40.02. The contact interval consists of a sequence of thinly interlayered red and gray claystone, mudstone and sandstone. At 55.62:37.08 the Kargacık shale overlies unconformably the Sarıkaya formation, with a nearly 35 cm thick greenish gray mudstone (Fig. 9A).

The Kargacık shale is barren of identifiable fossils. A late Campanian age can be suggested depending on its stratigraphic position.

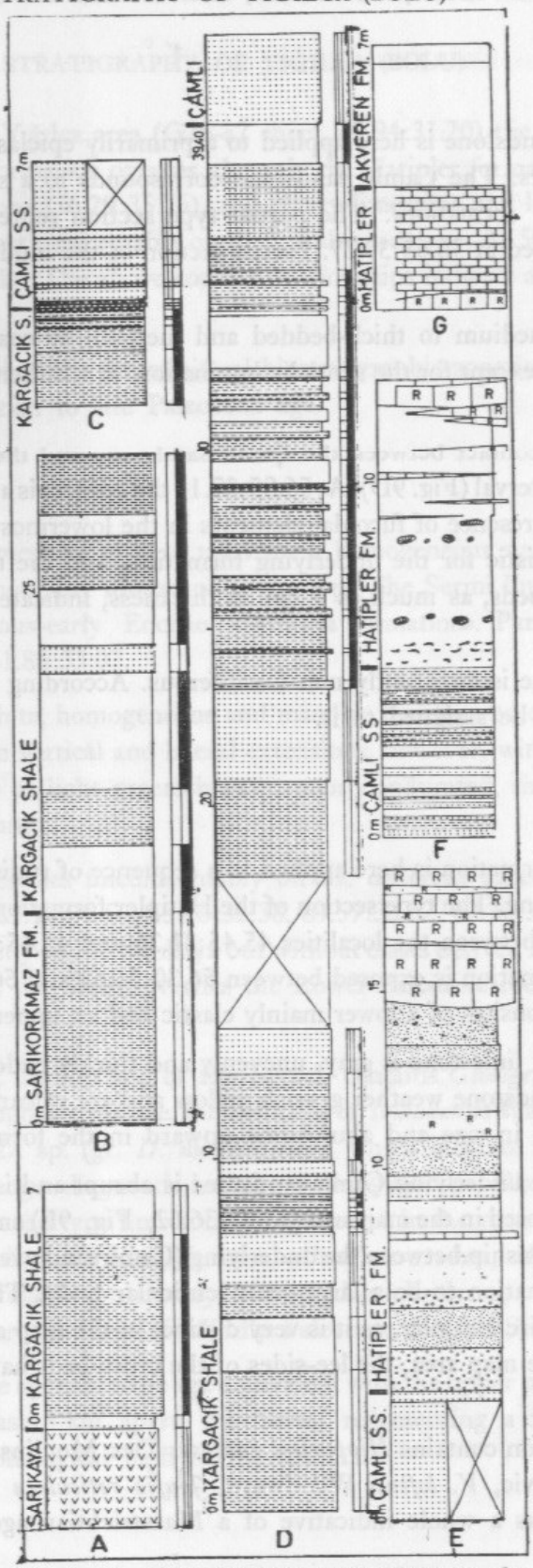

Fig. 9 - A- Unconformable contact between the Kargacık shale and Sarıkaya formation; B- Reference section for the lower part of the Kargacık shale, and its gradational contact with the Sarıkorkmaz formation; C- Gradational contact between the Çamlı sandstone and Kargacık shale; D- Reference section for the upper part of the Kargacık shale; E,F- Gradational contact between the Hatipler formation and Çamlı sandstone; G- The abrupt but conformable contact between the Akveren and Hatipler formations, which is suggested to represent a hiatus related to an abrupt lateral shift of lithotope.

Çamlı sandstone

The name Çamlı sandstone is here applied to a primarily epiclastic sandstone sequence with minor mudstone interlayers. The Çamlı sandstone corresponds to a section of Görmüş's (1982*a*) late Cretaceous «Hızardere formation». The partial type section representing the main sandstone body of the Çamlı is exposed at 56.68:37.27. Partial section of the mudstone rich upper part of the Çamlı is at 57.15:37.13.

The sandstone is medium to thick-bedded and medium to coarse-grained quartzose lithic arenite that is structureless except for the sporadic lamination. It weathers characteristically yellowish gray to grayish orange.

At 56.15:35.98 the contact between the Çamlı sandstone and the underlying Kargacık shale is gradational over a wide interval (Fig. 9D). At 56.85:37.14 the contact is abrupt in respect to sandstone and red shale. There, the presence of fucoidal elements in the lowermost thin sandstone beds of the Çamlı, which are characteristic for the underlying formation, and the termination of the Kargacık with a few gray claystone beds, as much as 6 cm in thickness, indicate an interbedded gradational contact (Fig. 9C).

The Çamlı sandstone is apparently non-fossiliferous. According to its stratigraphic position a late Campanian age can be assigned to it.

Hatipler formation

The name Hatipler formation is here applied to a sequence of rudistid-bearing limestone, and mudrocks and lithic sandstone. The type section of the Hatipler formation is situated outside the map area, in the G26-a2 sheet, between the localities 45.45:31.36 and 45.45:31.20. In the map area the reference section of the formation is exposed between 56.30:36.63 and 56.30:36.73 (Fig. 9E). In the type locality the Hatipler consists of a lower mainly clastic and an upper mainly carbonate part.

The rudistid-bearing limestone is gray, unevenly and thickly bedded and fragmental detrital. The mudrock and lithic sandstone weather grayish yellow and are calcareous to limy. The rudistids are reworked, and decrease in size and abundance upward in the formation.

The contact with the underlying Çamlı sandstone is abrupt and is suggestive of a submarine stratigraphic break. It is exposed in the map area (55.82:36.62, Fig. 9E) and type locality (45.94:31.20, Fig. 9F). The contact relationship between the underlying (Çamlı) and overlying (Akveren) formations indicates the Hatipler formation to be a large-scale lenticular body. The large-scale cross-bedded internal structure of the entire Hatipler, as it is very distinct in the map area, supports the lenticular shape of the Hatipler. In the map area, the lee-sides of the cross-beds have an inclination up to 30°, apparently toward the west.

The Hatipler formation contains *Hippurites radiosus* Des Moulins, *H. colliciatus* Woodward, *Vaccinites ultimus* Milovanovic, *V. loftusi* Woodward, *Joufia reticulata* Boehm, *Radiolites* sp. and *Biradiolites* sp., which are as a whole indicative of a Maastrichtian age.

Akveren formation

The name Akveren formation was used by Ketin and Gümüş (1963) for the sequence of «interlayered clayey limestone-marl, and minor lava, tuff and sandstone». In the study and surrounding areas the Akveren formation consists of greenish gray limy claystone, mudstone, and sporadic allodapic limestone. Görmüş (1982) considered the Akveren rocks as the late Cretaceous-early Eocene «Sarıkaya formation» which is herein called the Sermi limestone.

To the west of the Yığılca area (G26-a2 sheet, 49.94:31.20) the massive, calcareous to limy mudstone of the Akveren formation overlies abruptly the Hatipler formation. In the Yığılca area the basal massive sandy limestone (56.29:35.25), and clayey limestone and limy mudstone (57.05:37.07) of the Akveren formation rest conformably on the Çamlı sandstone. At 56.40:34.09 the Akveren rests on the Lower Paleozoic rocks. The above contact relationships indicate an apparent southward onlap of the Akveren formation.

Dizer (1971) established the foraminiferal biostratigraphic zonation in the Akveren formation, and proposed a Maastrichtian to late Paleocene age.

Sermi limestone

The name Sermi limestone is here used for a homogeneous unit of bioclastic and patchily coralgal limestone, and minor limy mudstone at the top. The Sermi limestone corresponds to Görmüş's (1982) late Cretaceous-early Eocene «Sarıkaya formation». Partial type section is exposed between 61.80:32.87 and 61.80:33.07.

The limestone is white, homogeneous and massive. Small-sized coralgal buildups and related bioclastic limestone recur in vertical and lateral extensions, however, without a distinct stratification. A very restricted exposure of light greenish gray, poorly indurated, thinly bedded limy mudstone occurs at the top of the unit.

The Sermi limestone lies unconformably on the different parts of the Sarıkaya formation (66.80:32.65, 67.40:31.40, 65.10:31.57, 65.00:32.38, 69.57:33.62, 62.20:32.30). At many localities the Sermi limestone rests directly on the Sarıkaya but without clasts derived from the latter. In the outside area (G27-a1, 82.75:35.50) the Sermi overlies the Lower Paleozoic rocks, with basal clastics up to 80 cm thick.

The limy mudstone, the top bed of the Sermi, contains *Globigerina triloculinoides* Plummer, *Neodiscocyclina barkeri* Waughan and Cole, *Ranikothalia* cf. *soldadensis* Waughan and Cole, *Discocyclina* sp. (gr. *D. seuneusi*) and *D.* sp. (gr. *D. nummulitica*), which indicate a late Paleocene age. Other foraminifers which are not age diagnostic include *Globorotalia* sp., *Globigerina* sp., *Planorbulina* sp. and *Asterigerina* sp. The Sermi type limestone blocks found in the younger detrital units (e.g. Yılgın formation) carry *Planorbulina cretacea* Marsson, *Alveolina ovulum*, *Miscellanea* sp., *Glomalveolina* sp., *Lockhartia* sp., *Globorotalia* sp., *Discocyclina* sp., *Distichoplax* sp. and *Asterocyclina* sp., which as a whole indicate a lower age limit of Middle Paleocene for the Sermi.

The Sermi limestone appears to be age equivalent with the upper part of the Akveren formation. Both formations lie at least 5 km apart, the Sermi representing a compound carbonate buildup developed on a paleomorphological high to the south.

Dağköy formation

The name Dağköy formation is here applied to a homogenous unit of massive subaerial lavas of intermediate composition. The Dağköy formation corresponds to Görmüş's (1982*a*) «Keltepe volcanics» of Neogene age.

The lower contact and the underlying unit (s) are not exposed. The well exposed unconformity between the Dağköy and the overlying earliest Eocene Yılgın formation indicates the Dağköy formation to be pre-Eocene in age. The volcaniclastic rocks of the Ordulu formation lithically correspond to the volcanics of the Dağköy formation. A Paleocene age for the Dağköy can tentatively be suggested.

ÇAYCUMA GROUP

The name Çaycuma group is applied by Kaya and others (1984*c*) to a sequence of epiclastic and volcaniclastic rocks, and minor volcanic rocks. Broadly, it corresponds to the «Çaycuma formation» of Saner and others (1979). The group is divided into four formations: in ascending order,

1. The Ordulu formation consisting of volcaniclastic conglomerate;

2. The Akçakoca sandstone consisting primarily of epiclastic sandstone, and being confined to the coastal parts of the Black Sea;

3. The Yılgın formation, the time-equivalent of the Akçakoca sandstone in the study and surrounding areas, consisting of mudrocks, epiclastic sandstone and minor volcaniclastic sandstone;

4. The Yığılca formation consisting uniformly of volcaniclastic sandstone, conglomerate and minor mafic lava. In the study area the Akçakoca sandstone is not exposed.

Ordulu formation

The name Ordulu formation is here applied to a blocky unit consisting primarily of volcaniclastic rocks, and epiclastic sandstone and mudstone at the base. The Ordulu formation corresponds to a part of Görmüş's (1982*a*) late Cretaceous «Hızardere formation». The Ordulu is divisible into a lower epiclastic sandstone and an upper volcaniclastic conglomerate unit. The complete type section of the formation is situated between 63.12:36.67 and 63.17:36.35 (Fig. 10A). Reference sections are exposed between 62.46:36.13 and 62.46:35.95, and 64.80:37.37 and 64.81:37.11.

The volcaniclastic rocks are dark greenish gray to reddish gray, poorly consolidated, poorly stratified conglomerate and very coarse-grained, fine pebbly sandstone. The clasts include primarily intermediate volcanic rocks. They are angular and with no sorting in size. Their size varies from fine pebble to cobble, althouhg large blocks up to 150 cm in diameter are also common. The upper half the volcaniclastic unit is finer grained than the lower. The epiclastic basal sandstone unit consists primarily of sandstone, pebbly sandstone and mudstone. The sandstone is greenish gray, poorly to moderately indurated, thin-bedded to massive, fine- to very coarse-grained feldspathic lithic arenite and lithic wacke. Thinly bedded sandstones interbedded with mudshale represent facies C to E. Massive beds contain swirls and stringers of volcaniclastic and/or epiclastic rounded pebbles, up to 8 cm in diameter. From base to top the volcaniclastic clasts replace the epiclastic material in both percentage and size. In the uppermost part of the unit floating blocks of mafic volcanic rocks, up to 250 m on one dimension, occur sporadically. The blocks include limestone, limy mudstone, and mudstone, up to 250 m in length and 75 m in width, and ranging in age from probably late Cretaceous to Paleogene. Locally exposed matrix rocks are typically yellowish gray weathering mudshale with thin interbeds of sandstone (64.80:37.24).

The Ordulu formation rests unconformably on the Karaavu member of the Neyren formation (62.46:36.13, 62.90:36.48). The missing older Paleocene and Cretaceous rocks indicate a deep-reaching unconformity (Fig. 10A). The contact between the volcaniclastic bulk of the formation and the lower sandstone unit is conformable (63.10:36.65; 62.45:36.07; and 62.93:36.43). It is abrupt with respect to epiclastic clasts, but gradational with respect to volcaniclastic constituents. At the locality 62.48:36.07 the basal volcaniclastic conglomerate bed contains mudstone fragments derived from the sandstone unit that may reflect a short hiatus.

The Ordulu formation is barren of fossils. The limestone blocks, lithically similar to the Sermi limestone, contain *Globogerina* sp., *Globorotalia* sp. and *Discorbis* sp., which may suggest a latest Paleocene age for the Ordulu.

Yılgın formation

The name Yılgın formation is here used for a sequence consisting primarily of shale and typically yellowish gray weathering lithic sandstone, which show interlayering at all scales, and minor volcaniclastic sandstone and conglomerate. It corresponds, in parts, to Görmüş's (1982*a*) Middle Eocene «Alaptura formation» and late Cretaceous «Hızardere formation». The Yılgın is divisible into two units: a lower shale-epiclastic sandstone, and an upper volcaniclastic and epiclastic sandstone-shale unit. The latter can further be divided into four parts, for practical field purposes (Fig. 5A). The complete type section of the lower unit is exposed between 64.86:37.10 and 65.36:36.85, and that of the upper unit between 66.54:37.30 and 66.80:37.10 (Fig. 10C).

The shale is greenish gray, thinly bedded to massive, yellowish gray weathering mudshale and clayshale. The epiclastic sandstone is yellowish gray weathering, thin to thick-bedded lithic arenite of turbidite facies B to D. The volcaniclastic sandstone is brownish gray, medium to coarse-grained feldispathic lithic arenite with a salt-and-pepper appearance. It locally shows sedimentary structures implying a turbidity origin. The conglomerate is laterally discontinuous, matrix and grain-supported, poorly sorted in size, and is internally unorganized. It has an overall gradation into blocky pebbly mudstone. The clasts range from fine pebble to large block in size. Extragenetic clasts are mafic volcanic and related volcaniclastic rocks, Sermi-type limestone, late Cretaceous limestone and Ordovician sandstone. Intragenetic clasts are foraminiferal sandy limestone and limy mudstone, which are mostly tabular in shape. The matrix rocks include feldispathic and volcaniclastic lithic arenite, sandy and finely pebbly mudstone and lithic wacke. Synsedimentary folding, faulting and distruption in the conglomerate and underlying strata are common. The conglomerate and pebbly mudstone are debris-flow deposits scouring and filling the channels.

The lower epiclastic part of the Yılgın formation overlies abruptly the volcaniclastic conglomerate unit of the Ordulu formation (62.46:35.98, 63.17:36.35, 64.81:37.11; in the same order Figs. 10A, 10B, 10C). Widespread limestone penetrations into fissures of the Ordulu volcaniclastic rocks in the form of neptunian dykes (64.81:37.11) indicate the contact to be an unconformity (Fig. 10C). Because the yellowish gray weathering shale typical of the Yılgın formation occurs as early as in the underlying Ordulu formation, the contact suggests a limestone deposition and subsequent erosion, within a short duration. The epiclastic unit of the Yılgın formation overlies unconformably the Dağköy formation consisting of volcanic rocks (66.35:37.52, 67.36:37.24). The contact between the epiclastic and epiclastic-volcaniclastic units of the Yılgın formation is conformable. It is abrupt with respect to the first occurrence of volcaniclastic sandstone, brownish red mudstone (65.35:36.84, 62.40:35.73, 65.06:35.85) and conglomerate (64.10:35.15) in the upper unit.

The bulk rocks of the Yılgın formation are barren of fossils. The intragenetic pebbles and small blocks of limestone and limy mudstone in the conglomerate (66.62:35.97, 66.70:35.95, 66.80:36.50, 66.70:36.47) contain *Nummulites* cf. *planulatus* (Lamarck), *N.* cf. *solitarius* de la Harpe, *Discocylina* sp. (gr. *D. archiaci*), which indicate an early Ypresian age. The limestone penetrations into the fissures of the Ordulu rocks contain *Globorotalia* sp. supporting a post-Paleocene age.

Yığılca formation

The name Yığılca formation is here applied to a thick sequence of typically brownish gray weathering volcaniclastic sandstone, conglomerate, tuff, mudrocks and minor basaltic lava. The Yığılca formation corresponds to Görmüş's (1982*a*) «Melendere formation» of early Eocene age. The formation, with little change in the lithology of the strata, is extensively widespread in and outside

the study area. The partial composite type section is compiled between 68.62:33.98 and 68.72:34.50, 67.60:35.23 and 67.33:35.98, and 68.95:36.96 and 68.82:37.16, which represents the middle, upper, and uppermost parts of the formation, respectively (Fig. 11).

The sandstone is primarily a feldispathic lithic arenite of the salt-and-pepper type, containing dark volcaniclastic fragments, feldspar and quartz. It is thin-bedded to massive, and in part, interbedded with mudstone. Many of the very thick bedded to massive sandstones, in the lower part of the Yığılca, contain stringers of fine volcaniclastic pebbles. Nearly all of the sandstones show fining upward, and in part grade into mudstone. Most peculiarly the sandstone exfoliates with large ellipsoidal or spheroidal cores, sometimes up to a radius of several meters .The light brownish gray weathering mudstone contains interlayers of subfeldspathic arenite. The olive gray to greenish gray weathering shale occurs in the lowermost part of the formation, on the Sermi limestone. Some of the thick mudstone beds contain floating pebbles of limestone of the Sermi-type, and most commonly, intrabasinal mudstone. The conglomerate is poorly indurated, poorly stratified, and matrix and grain-supported. The constituents include almost entirely mafic lavas of a large variety of lithology. However, mudstone, volcaniclastic sandstone and limestone of the Sermi-type are locally abundant. Large detrital calcite crystal and chlorite-muscovite-schist occur locally. Most clasts are subangular to round and up to 16 cm in diameter, although the size varies from fine pebble to large cobble. Blocks of Sermi-type limestone occur locally. Many of the conglomerate beds are widespread channel fills, in some of which synsedimentary deformation is prevalent. They contain mudstone, shale and volcaniclastic sandstone fragments up to 6 m in size, as intragenetic products.

The contact between the Yığılca and the underlying Yılgın formations is conformable. It is abrupt with respect to the disappearance of epiclastic turbiditic (Ta-Tc) sandstone, thick sections of interbedded sandstone and mudstone, and yellowish gray and reddish weathering mudstones of the Yılgın (Fig. 10C). In most places the contact is defined by the lowermost massive volcaniclastic sandstone bed and/or block-bearing conglomerate of the Yığılca formation (62.97:35.10; 66.76:37.12). The lower contact of the Yığılca formation with the underlying Sermi limestone is well exposed at the locality 68.62:33.93. There, it is a sharp mudshale-on-limestone break, and the limestone pebbles and blocks of the Sermi-type first occur about 26 m above the contact. A similar but less well exposed contact is at 61.94:33.03. The contact is considered to be an erosional unconformity, because the detritus of the Sermi limestone occur abundantly in the lower part of the Yığılca, and the Ordulu and Yılgın formations are missing.

No fossil material was obtained from the Yığılca formation, so the age of the beds connot be determined directly. An Ypresian and/or Lutetian age can tentatively be placed on the Yığılca formation by the fact that the Sermi-type limestone pebbles and blocks contain (*Planorbulina cretacea* (Marsson), *Miscellanea* sp. and *Verneuillina* sp., indicating a Middle to late Paleocene age.

AREAL STRUCTURE

The structure defining the distribution of the Cretaceous and Paleogene rock units includes the following major elements, in order of their relative age (Fig. 5a, b):

1. The Yığılca thrust fault extends nearly east-west, and dips northward with an angle of 30° to 40°. It apparently coincides with the axial plane of a southward recumbent syncline, bringing the northern limb onto the southern (i.e., in places it has brought the Yılgın rocks on the Yığılca, the older parts of the Yığılca on the younger parts).

2. High-angle faults have deformed the Paleozoic to Paleogene rocks into numerous blocks, on various scales. The fault planes are either not exposed or poorly exposed, and movement (s) on

them are not recognizable. However, the conjugate vertical sets of the faults are suggested to have been originally shear fractures related to a northeast-trending, horizontal acute bisector, which later acted as extensional. The original shear fractures postdate the Yığılca thrust fault, and both are probably post-Lutetian in age.

INTERPRETATIONS

The comparison of the Cretaceous and Paleogene sequences of the Yığılca area with those of the northerly lying Ereğli (Kaya and others, 1984*c*), and the southerly-lying Bolu and Mengen areas (Kaya and Dizer, 1984*a*, *b*) indicates the following stratigraphic and structural significance of the relevent rock units:

1. The lower part of the Ereğli Cretaceous sequence, the İnaltı limestone to Terziköy member of the Neyren formation in vertical extent, is missing in the Yığılca area. The Neyren formation was deposited by the progressive onlap of an apparently southward transgressive sea.

2. The Yemişliçay group is a primarily volcanogenic sequence with minor epiclastic constituents at the top and base. The ash-fall deposits are very subordinate (totally about 150 m) and lava-flows are absent. The predominating volcaniclastic sandstone and conglomerate imply reworking of loose pyroclastic ejecta of subaerial explosive volcanic eruptions, variably mixed with fine epiclastic debris, under unconfined mass flow depositional mechanisms. Large leaf prints and large-scale planar cross-stratification (Karaavu member), coalified plant fragments in non-turbiditic sandstone (Taşaltı member), symmetrical ripple marks (lower sandstone-conglomerate member of the Sarıkaya formation), and the progressive onlap of the entire group imply a broad shelf environment adjoining a subaerial volcanic apron.

3. The upper part of the Cretaceous sequence in the Ereğli area, the İkse to Örenköy formations in vertical extent, is not represented in the Yığılca area. The pebble to large block-sized clasts derived from this part of the Ereğli Cretaceous occur in the olistostromes of the Yığılca sequence (i.e., Aşağıköy member of the Yeniyer formation and Dibektaş member of the Sarıkorkmaz formation). The totally 200 m thick olistostromal interval of the Yığılca sequence has a 4 m thick lithic correlative in the Örenköy formation in the Ereğli area (Kaya and others, 1984c, Fig. 7N). Because the olistostromal interval of the Yığılca sequence contains blocks of serpentinite and has a certain time equivalency with a part of the «Ankara melange» of Bailey and McCallien (1954), it may have important structural and stratigraphic bearings on the understanding of the so-called «melange» (Kaya, in prep.).

4. The Maastrichtian Hatipler formation is primarily a rudistid bank, a large-scale cross-stratified lenticular body recurring toward the west. The Hatipler and the correlative carbonate buildups of organic detritus, in the other parts of northwestern and northern Anatolia (e.g. the lower part of the Erikli formation in the Ereğli area), overlie the older rocks with either submarine or subaerial stratigraphic break. In the Yığılca area the massive sandy limestone (56.29:35.25), classed as the basal beds of the Akveren, appears to represent the coeval filling of the areas between the banks.

5. As is the general case throughout nortwhestern Anatolia, the Akveren formation overlies conformably and abruptly the Maastrichtian Hatipler formation and the older Çamlı sandstone, and laps onto the basement. The overall abrupt basal boundary appears to be related to a strong shift of facies.

6. The Sermi limestone appears to be the marginal coralgal buildup corresponding to the upper part of the Akveren onlapping onto a paleomorphological high of the basement rocks, in the southern part of the Yığılca.

7. The Maastrichtian to Eocene sequence of the Yığılca area, extending from the Hatipler to the Yığılca formation, is lithically and sequentially comparable with the Ereğli area rather than the southerly-lying Bolu and Mengen areas. The marked contrast with the Bolu and Mengen sequences may suggest either a structural separation of a previous basin, occurring as late as during the earliest Maastrichtian, or a post-Eocene crustal shortening. The available evidence may support the alternative interpretation of a structural separation (Kaya, in prep.).

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