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POSTAL ADDRESS

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F O R E W A R D

The Bulletin of the Mineral Research and Exploration Institute has now, with this issue, been published for the hundredth time. This can be seen as a great attainment particularly in view of the limited number of publications of similar scope in Turkey and the respect the Bulletin has acquired amongst earth-scientists.

The purpose of publishing the Bulletin was stated as follows in the first issue which came out soon after the founding of the Institute in 1936:

«The tasks of creating a mining industry and of providing it with the necessary information must be carried out simultaneously in order to establish a systematical mineral exploration and exploitation work. The publications in this field in our country are unfortunately very scarce or almost absent as compared with those of the western countries and even the neighbouring Balkan countries. The Institute considers the filling of this gap as one of its prime tasks.»

«Bulletin of the Mineral Research and Exploration Institute aimed at «gathering scientific information to result from mineral exploration», «publishing the exploration work carried out in Turkey», «publisizing the technical and scientific research conducted by native or foreign scientists in Turkey and gaining recognition in the academic world» and following the progress made in world mining. Inspite of all the difficulties of the last five decades, the Bulletin has succeeded publication and now reached its hundredth edition.

Since its publication, the number of printed copies of the Bulletin has grown from a few hundred to the present three thousand. A foreign edition of the Bulletin has accompanied the Turkish edition since 1954. Expect for the period during the Second World War, the Bulletin has continuously been sent to 230 different establishments abroad for the purpose of exchange. This has been an enormous help in setting up the Institute's Library which is the richest of its kind in the country.

The Bulletin, however, went through some notable changes with respect to form and content in the course of reaching its hundredth issue. The Bulletin was published quarterly in the period 1936-1942, after which it appeared twice a year. While the earlier issues were largely concerned with the technological progress in the mining world and the international mining market, the later issues progressively published more research articles. A distinct shift in the subjects covered by the Bulletin is also apparent. Papers on general geology and mining geology gained importance in the period following the earlier issues. The policy of the Institute, adapted soon after the founding, to educate and finance the education of scientific and technical personnel bore its fruits in the 1950's which reflected itself in the Bulletin. These were the years when Turkish scientists and engineers contributed increasingly more research papers to the Bulletin alongside foreign workers.

The 1960's are the years when many papers concerned with basic geological investigations and the related mineral exploration in addition to other subjects of interest constituted the content of the Bulletin. For instance, of the 198 articles published in the period 1960-1970, 64 deal with various topics of general geology, 27 with palaeontology, 25 with petrology, 9 each with coal-geology and palinology, 7, with geophysics, 5 each with drilling geothermal energy, petroleum geology and economics, 4 with mathematics, 3 with geomorphology and 2 each with technology and chemistry.

The aim of the Bulletin and the regulations related to its format were revised during the second half of the 1970's in order to meet the demands of the growing scientific and technical research activities and to attain a faster spread of information. The Bulletin then emphasized the relevance of publishing the research and application studies in earth-sciences--carried out within the framework of the Institute and stressed the importance of maintaining the high quality of the publication both in form and content and its role in the exchange with foreign publications.

We all share the responsibility to sustain and improve the present status of the Bulletin which was the first of its kind in Turkey and set an example for the later publications in its field.

I would like to take this opportunity to thank, on behalf of those aware of the significance of the Bulletin, all the authors who supported the Bulletin with their articles since the first issue, the readers who improved the quality by constructive criticism and all the personnel involved with editing and publishing the Bulletin.

STRATIGRAPHY OF THE CRETACEOUS IN THE EREĞLİ AREA, ZONGULDAK

Orhan KAYA*; Atife DİZER**; İzver TANSEL** and Engin MERİÇ***

ABSTRACT.— The Ereğli area comprises a marine sedimentary sequence ranging from Aptian to Ypresian in age and unconformably overlying the Carboniferous rocks. The sequence is about 1900 m thick, and is divided by several sfratigraphic breaks. Aptian-Cenomanian consists of limestones and epiclastic rocks; Santonian-Middle Campanian consists of volcaniclastic rocks and pelagic limy mudrocks; Upper Campanian -Maastrichtian consists of epiclastic rocks and minor limestone; Lower-Upper Paleocene consists primarily of limy mudrocks. The boundary between the Cretaceous and Paleocene systems is a bio-and lithostratigraphic continuity.

INTRODUCTION

In Northwest Turkey, the most complete Cretaceous rock sequence of the Pontides is exposed in the Ereğli area (Fig. 1), where the pioneer regional study was made by Tokay in 1952. Altınlı (1951), Ketin and Gümüş (1963), and Bürkan and others (1982) have investigated the stratigraphy and structure of the Cretaceous rocks in the Ereğli and contiguous areas. A new lithostratigraphic interpretation of the Cretaceous rocks in the report area, on the basis of 1:25 000 scaled mapping, is introduced by Kaya (1982).

The symbols used in the graphic presentations are explained in Fig. 2. The terminologies used herein for sandstones and mudrocks follow those of Folk (1968) and Lundegard and Samuels (1980), respectively. The term «limy» is applied to rocks with high carbonate content, which in the field have a deceptive appearance of a carbonate rock. The rock unit names adapted from the earlier work have been capitalized.

STRATIGRAPHY

The order of the rock succession in the Ereğli area is given in Fig. 3. The areal distributions and contact relations of the rock units are demonstrated in Fig. 4A, B. The Cretaceous stratigraphy of the report area has a certain integrity with the Yığılca area lying to the south, and some of the rock-unit names used here originate from the latter (Fig. 5). The descriptions of the Carboniferous rock-units have not been included here.

İnaltı limestone

The İnaltı limestone was designated by Ketin and Gümüş (1963) for a sequence of gray limestones with interlayers of limestone pebble conglomerates and minor limy mudstones. In the report area two reference sections have been established, which supply stratigraphic details. The limestone pebble conglomerate dominating the lowermost section of the İnaltı is exposed at map coordinate 75.35:77.70, wherfe it unconformably rests on the Carboniferous rocks. The other reference section of the higher, predominantly limestone part of the İnaltı is exposed between map coordinates 75.40: 79.05 and 75.31:79.22.

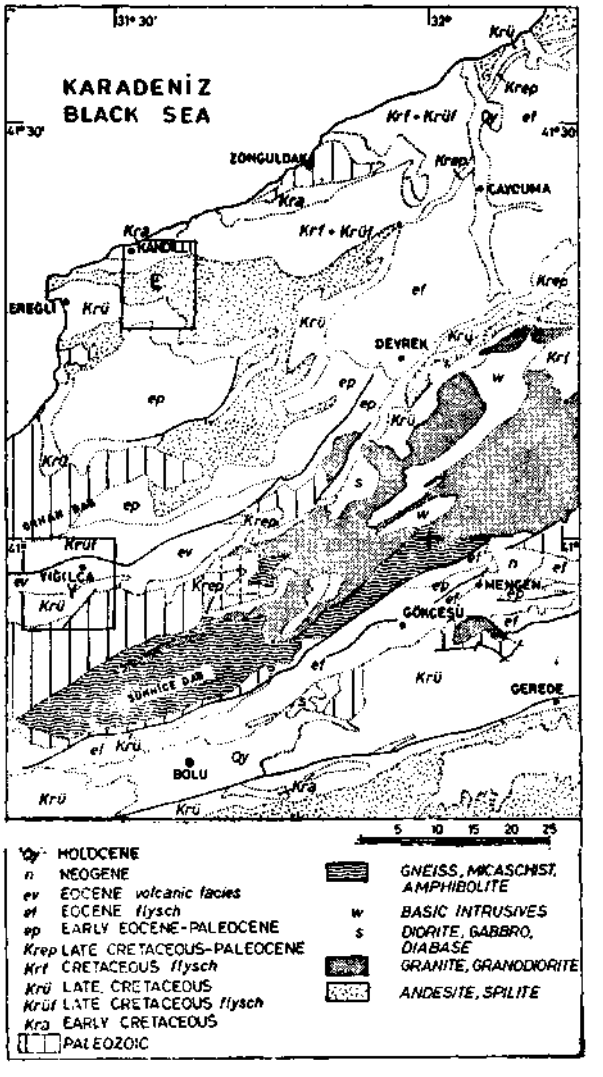

Fig. 1 - Sketch map (MTA, 1964) showing the report area and distribution of Cretaceous rocks in relation to other stratigraphic units.

The limestones are light to medium gray, medium to very thick-bedded, and include moderately recrystallized skeletal - micrites. *Requienia* coquinite, *Orbitolina* banks and *Orbitolina-bearing* limy mudstones, and limy epiclastic sandstones occur as sporadic interlayers in the limestone dominating upper part of the İnaltı. The limestone pebble conglomerates are, in part, poorly indurated, thick-bedded to massive and grain-supported. The clasts are rounded, sorted in size, and include uniformly Jurassic and Early Cretaceous limestones. Matrix is of small volume, and consists of very fine-grained versions of the pebbles. Pale red pebbly and sandy mudstones occur as interlayers in the conglomerate dominating part of the formation.

The İnaltı limestone unconformably rest on the Carboniferous rocks. The basal beds are mostly limestone-pebble conglomerates (81.40:80.73; 74.98:78.15). However, at 75.36:77.73 (a former

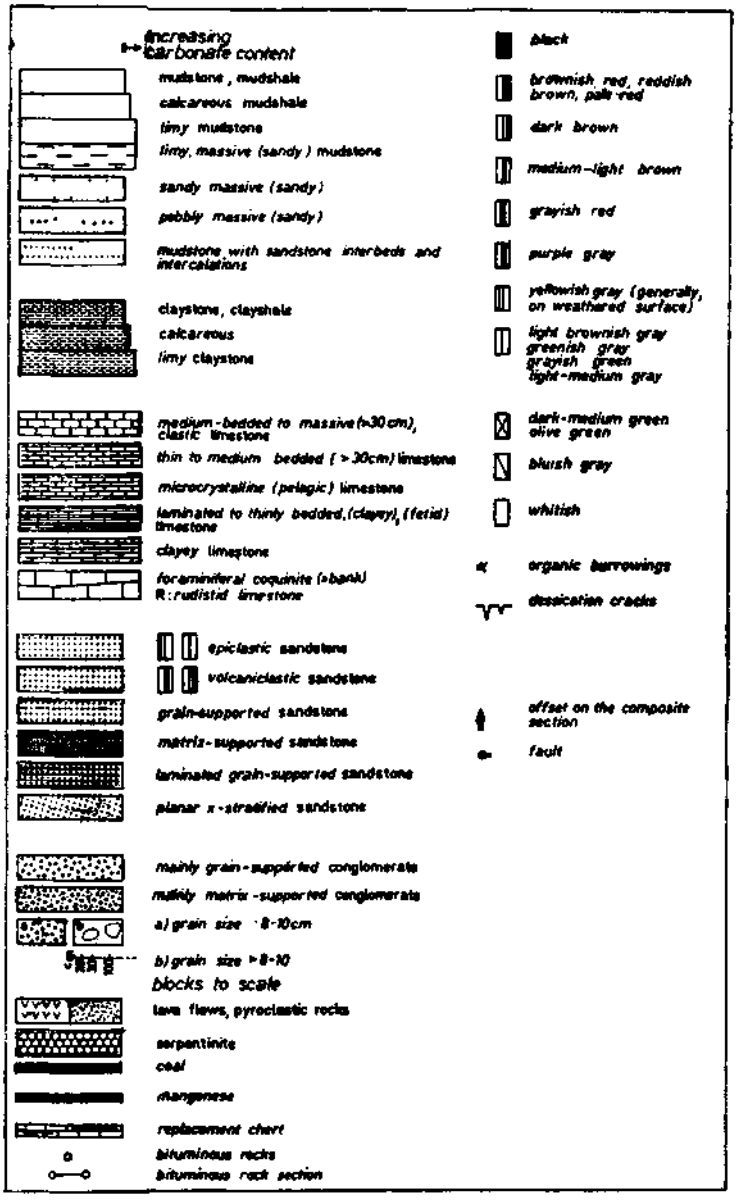

Fig. 2 - Symbols for lithology and color, used for the graphical presentations.

ditch for water pipes in the Railway Station) the basal beds are mudstones and pebbly mudstones (Fig. 6A).

Tokay (1952) recorded the ages of Barremian and Aptian for the lower and upper parts of the İnaltı limestone. The recently recognized *Orbitolina kurdica* Henson, *0.* cf. *texana* (Roemer), O. cf. *discoidea* Grass, and *Choffatella* cf. *decipiens* Schlumberger in the *Orbitolina* banks indicate an Aptian age for the greater part of the İnaltı.

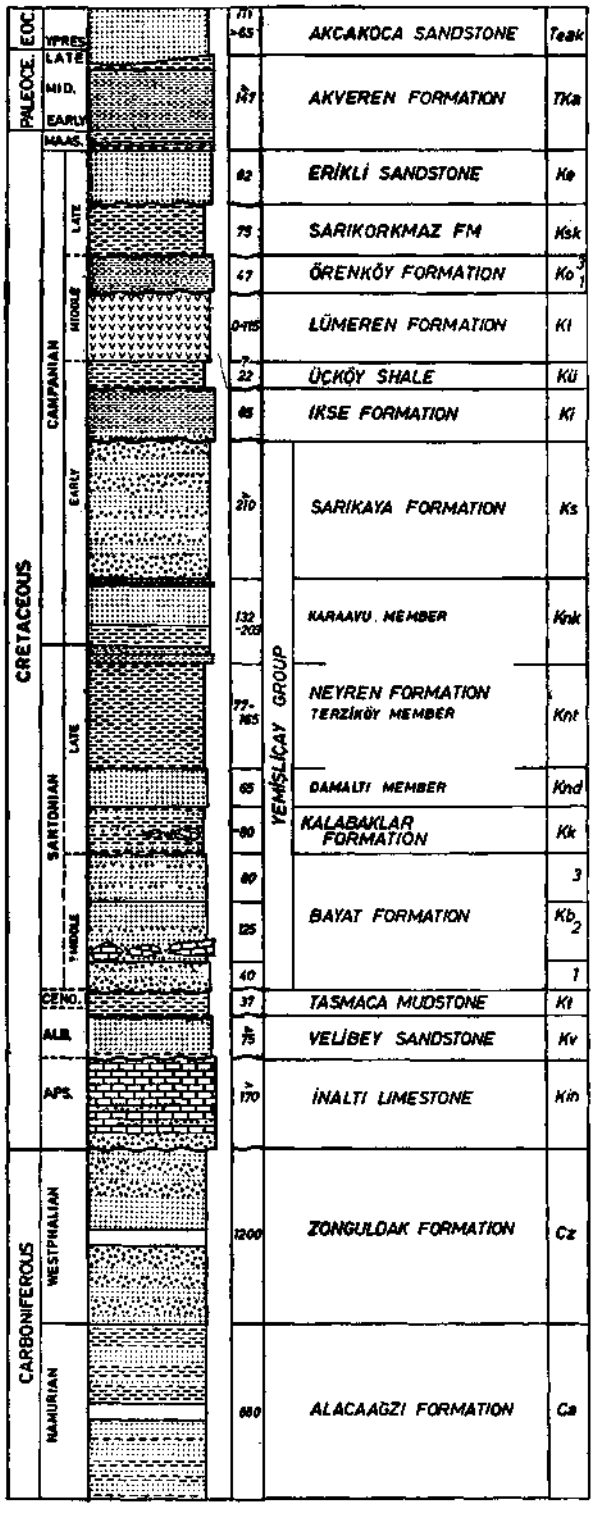

Fig. 3 – Columnar section showing rock units that occur in the study area.

Velibey sandstone

The name Velibey sandstone is used by Altınlı (1951) and Tokay (1952) for exposures of quartzose sandstones and quartz granule conglomerates overlying the İnaltı limestone. In the report area the Velibey sandstone is divisible into three parts: in ascending order, a basal mudstone, a lower massive coarse-grained sandstone, and an upper thinly bedded fine-grained, in part glauconitic sandstone. The reference section of the basal mudstone is at 76.25:78.30. The reference sections for the lower sandstone part of the Velibey are at 76.15:78.15, 74.88:77.49, and between 79.23:79.60 and 79.95:79.85. Those of the upper sandstone part are at 76.85:78.17, 77.25:77.95, and between 77.57:78.30 and 77.55:78.10.

The mudstone is medium gray, moderately indurated, massive, sandy and slightly calcareous, and contains abundant finely macerated coalified plant fragments. The sandstones are light gray, grain-supported quartzarenites and sublitharenites. Minor clay gives the sandstones the characteristic grayish yellow color on the weathered surface. The most widespread late diagenetic silica cementation is developed along the joints and the diffuse boundaries of the bedding. The sandstones in the lower part of the Velibey are thick-bedded to massive, coarse to very coarse-grained and carbonate-cemented. They commonly contain typically white, rounded quartz granules either as floating grains or as stringers of conglomerates. The sandstones in the upper part of the Velibey are primarily thinly bedded, fine to medium-grained and silica-cemented. Interlayers of glauconite-rich quartzose litharenites occur in increasingly large amounts in the upper part of the formation.

The contact betweeen the Velibey sandstone and the underlying İnaltı limestone is not exposed. At 81.20:80.19 the lowermost beds of the Velibey sandstone contain molds of dissolved angular pebbles of limestone. At 74.88:77.49 the covered contact interval is only about 4 m thick, but indicates a slight structural unconformity. Because the moderately weathered out mudrocks float in the covered interval, the contact is suggested to be an unconformity.

No identifiable fossil material is found in the Velibey sandstone. Tokay (1952) on the basis of an ammonite fragment assigns an Aptia-n age to the Velibey. However, due to its unconformable position on the Aptian İnaltı limestone, an Albian can be assumed for the Velibey.

Tasmaca mudstone

The name Tasmaca mudstone was applied to a homogeneous bluish gray mudstone unit by Saner (1980) to replace Tokay's (1952) designation of the «blue marls». The reference outcrops of the Tasmaca mudstone are exposed around 80.60:79.75 and 76.70:77.85.

The mudstone is moderately consolidated, poorly stratified to unsorted, variably fine sandy and micaceous, and in part calcareous.

The contact between the Tasmaca mudstone and the underlying Velibey sandstone is not exposed. At 79.77:79.55 a nearly 2 m thick sandy limestone bed probably defines the lower boundary of the Tasmaca (Fig. 6C).

No fossil material is recognized in the Tasmaca mudstone. Tokay (1952), on the basis of ammonite evidence, assigns an Albian and a Cenomanian age for the lower and upper parts of the formation, respectively.

Yemişliçay group

A complex Late Cretaceous stratigraphic sequence consisting primarily of volcaniclastic rocks of mafic rock derivation, and subordinately of mafic lava flows, pelagic limy mudrocks and lime-

stones, and epiclastic rocks at the lowermost part, is widely distributed throughout the Pontides. The sequence is, in part, lithically equivalent with Tokay's (1952) «Turonian-Coniasian volcanic flysch», and Ketin and Gümüş's (1963) «Yemişliçay formation». Although the name Yemişliçay is well established for this sequence, it is here raised to group status to permit additional subdivisions into formations and members that apparently facilitate descriptions, mapping works and correlations. A thin section of epiclastic rocks underlying the mainly volcaniclastic sequence is here included with the Yemişliçay group, as is accepted by Ketin and Gümüş, (1963). The base of the highermost limy mudrock and epiclastic units is suggested to be the upper limit of the Yemişliçay group, as in the work of Tokay (1952).

The Yemişliçay group is divisible into four formations: in ascending order, the Bayat, Kalabaklar, Neyren and Sarıkaya formations. The Bayat formation consists of epiclastic sandstones and conglomerates. The Kalabaklar consists of mudrocks with minor interlayers of epiclastic and volcaniclast sandstones. The Neyren formation consists of volcaniclastic sandstones, mudrocks, limy clayshale and claystone, and micrit limestone. The Sarıkaya formation is a thick sequence of volcaniclastic conglomerates, sandstones, mudrocks, and minor mafic volcanic rocks.

Bayat formation

The name Bayat formation is here applied to a heterogeneous sequence of epiclastic and volcaniclastic sandstones and conglomerates, with minor block-sized epiclasts. It lithically corresponds to the «Cenomanian Wild-flysch» unit defined by Altınlı (1951) and Tokay (1952). The Bayat formation is divisible into three parts: in ascending order, (1) calcareous epiclastic sandstone-conglomerate, (2) epiclastic sandstone-conglomerate, and (3) volcaniclastic sandstone-conglomerate. The partial composite type section of the Bayat formation is exposed between 81.50:79.72 and 81.86:79.40, to the north of Bayat Köyü. The reference sections for the lower, middle and upper parts of the Bayat are, in the same order, at 79.72:79.25, between 79.57:78.78 and 79.45:78.80, and 81.62: 79.70 and 81.47:79.40 (Fig. 6C, D).

In the lower and middle parts of the formation the sandstones are medium gray on fresh surfaces, grayish yellow when weathered, thinly bedded to massive, fine to coarse-grained and variably calcareous grain-supported litharenites. They contain floating pebbles, and thin lenses and stringers of conglomerates. Thickly bedded to massive interlayers of conglomerates are grain- and sand matrix-supported. The constituents are subround to round and moderately sorted in size, and include vein quartz, lithic and quartzose sandstones, mudstones, minor granitoid and metamorphic rocks. The vein quartz pebbles are most strikingly well-rounded and highly polished, and seem to be the product of the recycled Carboniferous conglomerates. Locally they contain large blocks derived from the İnaltı limestone (81.27:79.65, 78.93:78.20) and the Velibey Sandstone (81.41:79.27, 79.73: 78.92). The volcaniclastic sandstones in the upper part of the Bayat weather brownish gray, and are massive, medium to very coarse-grained, grain-supported litharenites. They contain occasional thin beds and lenses of epiclastic conglomerate, floating limestone pebbles derived from the İnaltı limestone (81.30:78.95).

The contact between the Bayat formation and the underlying Tasmaca mudstone is in most places (80.55:79.76) structurally conformable and abrupt (Fig. 6F). Locally (80.47:79.62) it is defined by large-scale cross-stratified conglomerates and pebbly sandstones with large clasts derived from the Tasmaca mudstone (79.75:79.28), as much as 65 cm in size, on the irregular erosional surface of the Tasmaca, suggesting a disconformity (Fig. 6E).

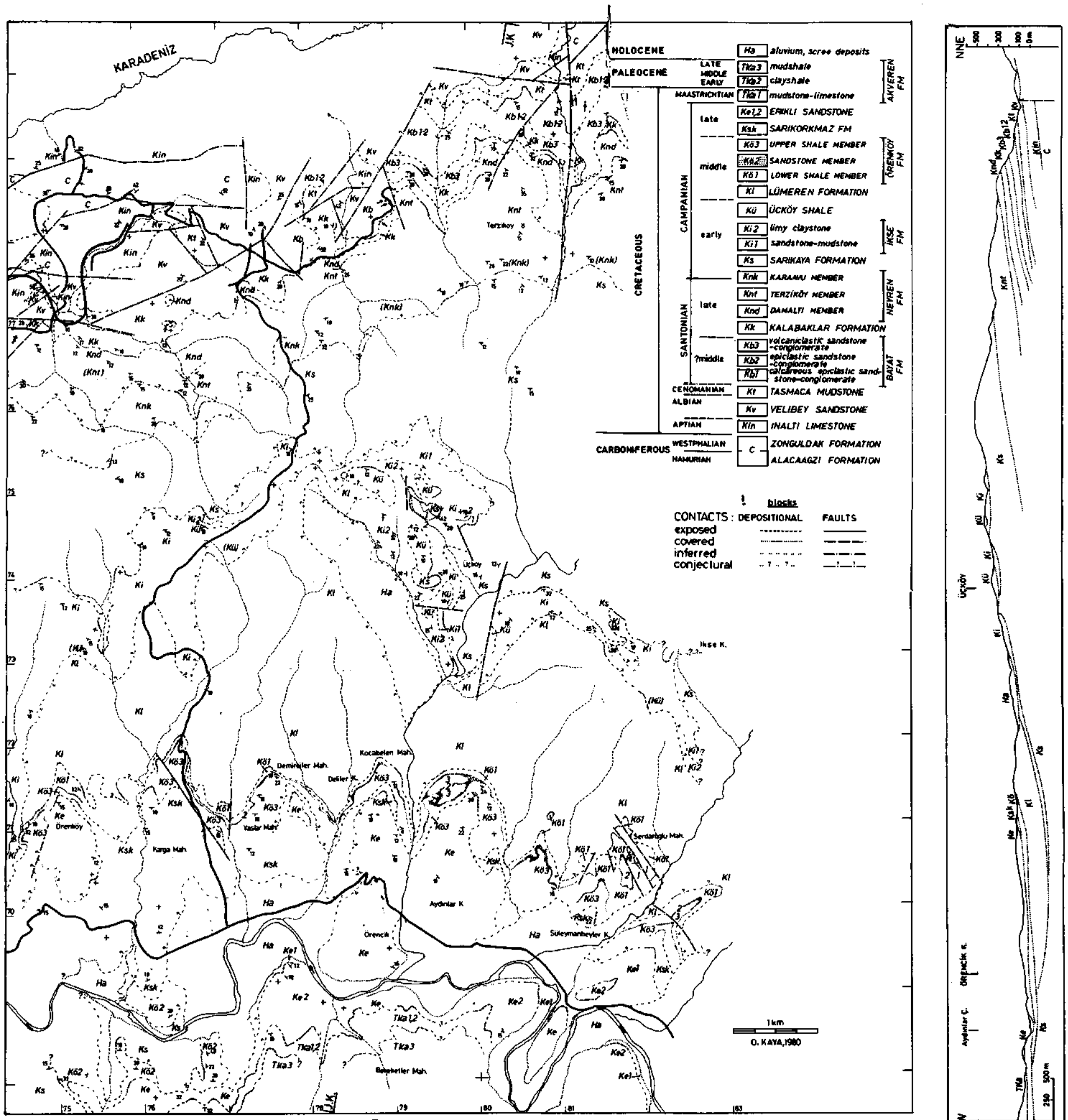

Fig. 4 - Geologic map (A) and north-south cross-section (B) of the Ereğli area.

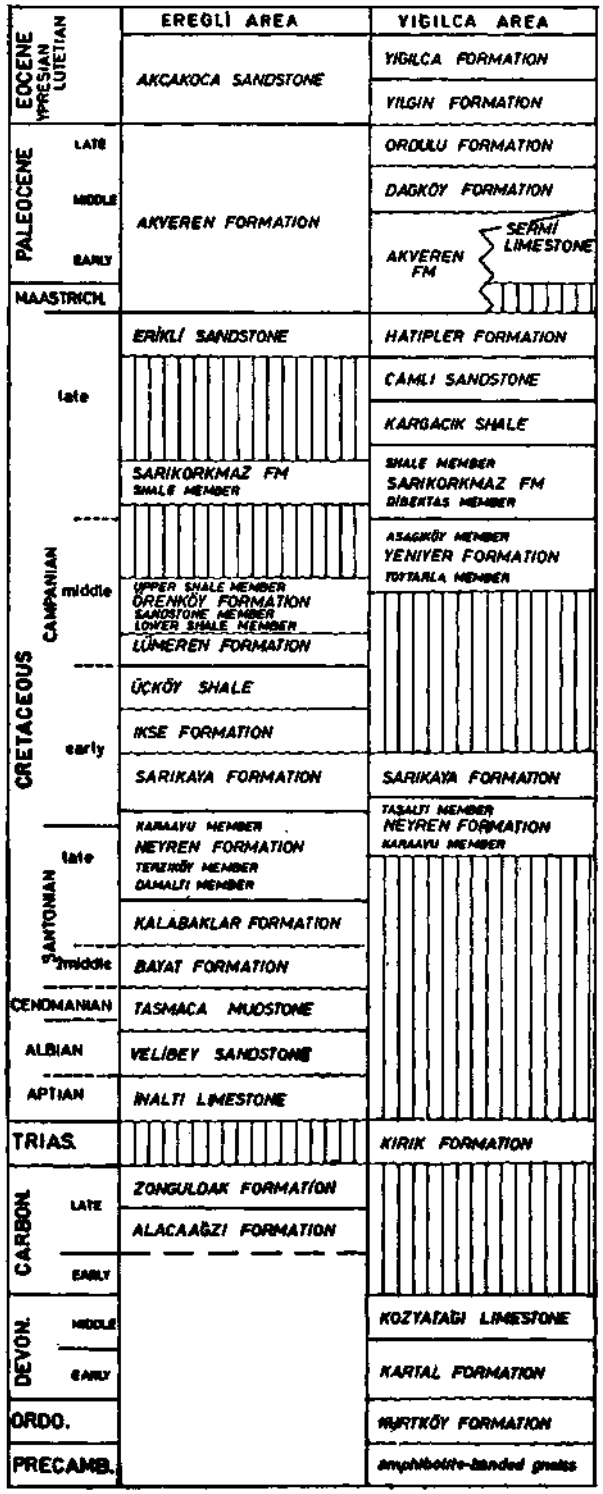

Fig. 5 - Rocks, and time unit correlations between the Ereğli area and southerly-lying Yığılca (Kaya ,1982) area.

The Bayat formation is unfossiliferous. Because abundant blocks derived from the older units and earliest volcaniclastic materials made their first appearance in the Bayat Formation, its lower contact is probably the reflection of a significant tectonic event and time gap. A probable Middle Santonian age is tentatively assigned to the Bayat, on the basis of the superjacent Karaavu member of the Neyren formation.

Kalabaklar formation

The Kalabaklar formation was named by Saner (1980) for a shaly mudrock sequence with interlayers of primarily epiclastic sandstone and conglomerate with sporadic blocks. The reference sections for the lower and upper parts of the Kalabaklar formation are between 77.60:77.76 and 77.78:77.73, and at 78.65:77.90, respectively.

The mudrocks are primarily greenish gray and patchily reddish gray, moderately indurated, thick-bedded to massive mudstones and claystones, displaying a shaly weathering tendency. The epiclastic sandstones, which occur sporadically in the upper part of the formation, are gray, thinly bedded, fine-grained calcareous turbidite litharenites. The thicker beds of the sandstones are coarse-grained, pebbly and interlayered with epiclastic granule conglomerates (77.65:77.72). Thin beds of volcaniclastic sandstones occur in the uppermost part of the Kalabaklar. The conglomerates are gray, poorly indurated, thickly bedded to massive, grain-supported, and include primarily vein quartz, limestone from the İnaltı, sandstones and mudrocks. Large blocks of limestones and limestone pebble conglomerates of the İnaltı limestone locally incorporate into the conglomerates.

The contact between the Kalabaklar formation and the underlying volcaniclastic upper part of the Bayat formation (80.98:79.00) is defined by the reworked Bayat material in the Kalabaklar (Fig. 6H). The contact with the epiclastic part of the Bayat formation (75.45:78.80) is abrupt. Because the contact between the Kalabaklar formation and the Velibey sandstone (75.43:77.11) is a clear-cut angular unconformity (Fig. 6G), the structurally conformable contacts with the Bayat formation are explainable as unconformities rather than being related to a facies change in the Bayat.

No fossils have been found in the Kalabaklar formation. According to the conformably succeeding Karaavu member of the Neyren formation a late Santonian age can tentatively be suggested for the Kalabaklar.

Neyren formation

The name Neyren formation is here applied to a heterogeneous sequence consisting of volcaniclastic sandstones of mafic rock origin, mudstones, limy claystone, micritic limestone, and mafic tuff. The Neyren formation is divisible into four formal members displaying internal lateral changes, and intergrading to each other; in ascending order, (1) Damaltı member consisting uniformly of volcaniclastic sandstone, (2) Terziköy member consisting of mudrocks, (3) Karaavu member representing a succession of volcaniclastic sandstone, limy mudrocks and micritic limestones, and tuff, (4) Taşaltı member consisting primarily of mudrocks. The latter is restricted to the Yığılca area (Fig.5). The partial composite type section of the formation is exposed between 77.73:76.78 and 77.85: 76.49.

According to the microforaminiferal evidence from its Karaavu member, the Neyren formation spans a late Santonian age.

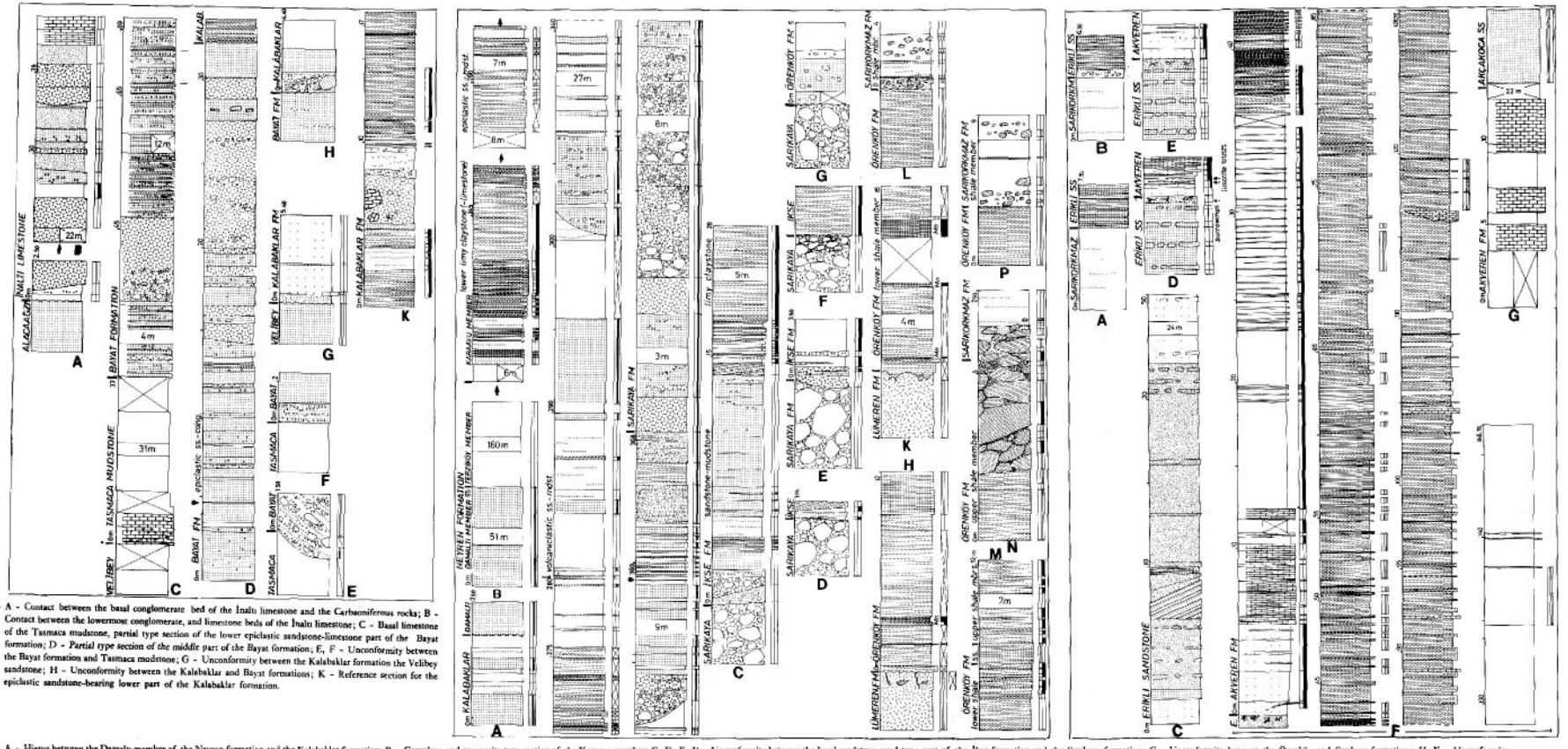

Fig. 6 - A - Contact between the basal conglomerate bed of the İnaltı limestone and the Carbaoniferous rocks; B - Contact between the lowermost conglomerate, and limestone beds of the İnaltı limestone; C - Basal limestone of the Tasmaca mudstone, partial type section of the lower epiclastic sandstone-limestone part of the Bayat formation; D - *Partial type section of the middle part of the Bayat formation*; E, F - Unconformity between the Bayat formation and Tasmaca mudstone; G - Unconformity between the Kalabaklar formation the Velibey sandstone; H - Unconformity between the Kalabaklar and Bayat formations; K - Reference section for the epiclastic sandstone-bearing lower part of the Kalabaklar formation.

Fig. 7 - A - Hiatus between the Damalı member of the Neyren formation and the Kalabaklar formation; B - Complete and composite type section of the Karaavu member; C, D, E, F - Unconformity between the basal sandstone-mudstone part of the İkse formation and the Sarıkaya formation; G - Unconformity between the Örenköy and Sarıkaya formations; H, K - Unconformity between the lower shale member of the Örenköy formation and the lavas of the Lümeren formation; reference section for the lower shale member of the Örenköy formation; L - Unconformity between the Sarıkorkmaz and Örenköy formations; M - Contact relations between the lower shale, sandstone and upper shale members of the Örenköy formation; N - Type section of the megabreccia of the Örenköy formation; N, P - Unconformity between the Sarıkorkmaz and Örenköy formations.

Fig. 8 - A, B - Low-angle unconformity between the Erikli and Sarıkorkmaz formations; C - Partial reference section of the Erikli formation; D, E - Abrupt contact between the Akveren and Erikli formations corresponding to an abrupt lithotope shift; F - Complete and composite reference section for the Akveren formation; G - Covered contact interval between the Akçakoca sandstone and the Akveren formation.

Damaltı member. — The name Damaltı member is here used for a massive volcaniclastic sandstone unit. The type section is exposed between 79.27:78.14 and 79.27:78.60, on the northern slope of the Damaltı tepe.

The volcaniclastic sandstone is brownish gray weathering, moderately consolidated, massive, medium to coarse-grained and grain-supported litharenite, and shows large scale exfoliation structures. Occasional thick lenses of matrix-supported conglomerate and pebbly mudstone occur in the middle and upper parts of the Damaltı. The constituents are angular to round with little sorting in size, and include mostly intraformational clasts of volcaniclastic sandstones, mudrocks and green cherty claystones, up to small block in size. Limestone clasts from the İnaltı are not uncommon.

The contact between the Damaltı member of the Neyren formation and the underlying Kalabaklar formation is gradational (76.42:76.77, 77.30:77.50, 81.07:78.85). The contact locally (77.78: 77.44) may have a deceptive appearance of an angular unconformity owing to synsedimentary deformations (Fig. 7A).

Except for unidentifiable plant remnants, the Damaltı member is free of fossils.

Terziköy member. — The name Terziköy member is here applied to a mudrock sequence with minor volcaniclastic sandstone. The partial composite type section of the member is exposed between 77.73:76.78 and 77.85:76.49 around Terziköy.

The mudrocks are bluish gray on fresh surfaces, greenish gray and locally reddish gray when weathered, moderately indurated, and include mud-and clayshales. Occasional interlayers of volcaniclastic sandstones are lithically equivalent with those of the Damaltı member.

The contact between the Terziköy and Damaltı members is everywhere gradational (81.85: 78.90, 79.52:78.32, 76.57:76.38).

The Terziköy member is unfossiliferous.

Karaavu member. — The name Karaavu member is here applied to a heterogeneous sequence of red and purple gray limy claystone, gray mudshale, volcaniclastic sandstones, minor epiclastic sandstone, and tuff. The Karaavu is divisible into four parts; in ascending order, (1) lower limy claystone (-limestone), (2) epiclastic sandstone - mudstone, (3) upper limy claystone-limestone (in the Yığılca area: Kaya and others, in prep.), and (4) volcaniclastic sandstone-mudstone. The complete type section of the member is exposed between 77.73:76.78 and 77.85:76.49, to the east of the Karaavu Dere, on the road cuttings. The reference section for the lower limy claystone (-limestone) is at 76.79:75.53 (Fig. 7B). It corresponds to Saner's (1980) «Başköy clayey limestone member of the Yemişliçay formation».

The limy claystones and interlayering clayshales are pale red through purplish gray to greenish gray, and when weathered they lose their limestone appearance. Epiclastic sandstones are light gray, laminated, fine to medium-grained, grain-supported feidspathic litharenites. Interlayered claystones are olive gray. In the volcaniclastic sandstone-mudstone part of the member, the sandstones are greenish gray, mostly upward-fining, fine to medium-grained, grain-supported litharenites. Thickly bedded sandstones are interlayered with thin beds of volcaniclastic conglomerates, and occasionally with channel-filling volcaniclastic pebbly sandstones. The latter additionally contain clasts of green cherty claystone, and limestone derived from the İnaltı limestone. Mudstones are olive gray to brownish gray. Mafic tuffs are greenish gray, medium to coarse-grained, and weather into small nodules up to 3 cm in size.

The contact between the Karaavu and Terziköy members is defined by the base of the lower limy claystone (-limestone), and is gradational (76.75:75.99, 76.50:76.21).

The lower limy claystone (-limestone) part of the Karaavu member carries *Globotruncana coronata* Bolli, *G. lapperenti* Brotzen, G. cf. *imbricata* Mornod, and *Rotalipora* sp., indicating the turn of late Santonian/Campanian. In the Yığılca area this part of the member contains a more rich microfauna supporting this age assignment.

Sarıkaya formation

The Sarıkaya formation was designated by Karya (1982) for a thick sequence of volcaniclastic conglomerates, sandstones and mudrocks, all being of mafic rock derivation, and minor mafic tuff and epiclastic sandstones, typically exposed in the Yığılca area. In the study area a partial reference section of its lower part is exposed between 77.85:76.49 and 78.60:75.75 (Fig., 7B).

The conglomerates are brownish gray, thickly bedded to massive, grain-supported, and are generally devoid of internal organization. Individual layers commonly occur as large scale cut-and-fill structures. The clast are mainly pebble-sized, subround to round with little sorting in size, and include primarily mafic volcanic rocks. The sandstones which occur as thick sets of beds interlayering with conglomerates, are lithically fine-grained versions of the latter. They are thin to thick-bedded, fine to very coarse-grained, grain-supported litharenites and feldspathic litharenites. The mudrocks occur in minor amounts in association with the sandstone sections. They weather brownish gray and locally reddish gray. The mafic tuffs occur in trace amounts.

The structurally conformable contact between the Sarıkaya formation and the underlying Neyren formation is gradational in respect to sandstones, and abrupt in respect to conglomerates and mudrocks (Fig. 7B). It is placed on the uppermost mudrock bed of the Karaavu member of the Neyren formation (79.90:77.37, 79.67:77.23, 77.83:76.49, 75.67:75.35).

The Sarıkaya formation is everywhere unfossiliferous. On the basis of its gradational contact with the Karaavu member an early Campanian age can be tentatively suggested.

İkse formation

The name İkse formation is here used for a red limy claystone unit with volcaniclastic rocks at the base, following the designation «marnocalcaire d'İkse» of Tokay (1952). The formation is divisible into two parts; a basal volcaniclastic sandstone-mudstone, and an upper limy claystone. The complete type section of the sandstone-mudstone is at 80.77:73.77 (Fig. 7C), and the reference sections at 82.60:72.00 and 79.76:72.90. The partial type section of the limy claystone is at 78.78: 75.27, and the reference sections at 82.62:71.60, 74.45:71.00 and 79.67:72.90.

The limy mudstones are reddish gray to brownish red, well indurated, and weather pale red to pink. The weathered out rocks have a shaly disposition. The basal elastics are greenish gray, thin to medium-bedded volcaniclastic litharenites, grain-supported pebble conglomerates, and pale red to greenish gray mudstones.

The basal sandstone-mudstone part of the İkse formation includes recycled material of the underlying Sarıkaya formation at 80.77:73.77 (Fig. 7C), 75.72:74.03 (Fig. 7D), 76.03:74.35, and 75.53:73.42. The conglomerate and pale red mudstone dominating basal sections are at 76.82: 74.70 (Fig. 7E), 79.76:72.90, 72.62:74.82, and 80.00:74.61. The contact between the basal clastic and limy claystone parts of the formation is either abrupt (76.03:74.35) or gradational (76.82:74.70, 75.72:74,03). Intraformational sandstone chips in the pale mudstones grading upward into the limy claystones, are not uncommon (75.53:73.42). At 79.50:73.95 (Fig. 7F) and 81.77:73.20, where the basal sandstone-mudstone part of the İkse formation is missing, the limy claystone directly rests

on the Sarıkaya formation. An unconformity between the İkse and Sarıkaya formations is suggested because (1) the basal sandstone-mudstone shows a strong variation in lithology and thickness over remarkably short distances, (2) it has locally conspicuous large-scaled cross-stratification, (3) the limy claystone fills up the open spaces, either fractures or interstices of the regolithic material, of the Sarıkaya formation, (4) in the latter case, the contact is locally defined by Fe-Mn oxide and hydroxide incrustations, (5) the İkse formation constitutes an onlap sequence, and (6) the Sarıkaya presents buried hill features both in the field and on the map (79.50:74.75, 79.40:73.80).

The limy claystones contain *Globotnmcana lapparenti* Brotzen and *G. linneiana* (d'Orbigny), which may indicate an early Campanian age with respect to the stratigraphic position of the İkse formation.

Üçköy shale. — The name Üçköy shale is here applied to a thinly bedded green mudrock unit. The type section is exposed at 78.78:75.27.

The mudrocks are dark green to olive gray, locally reddish gray, moderately indurated mudshales, clayshales and claystones fine-grained volcaniclastic sandstones occur as sporadic thin interlayers. The mudrocks and sandstones weather dark brown to yellowish gray.

The contact between the Üçköy shale and the underlying. İkse formation is structurally conformable, and abrupt (78.78:75.25, 78.17:75.27). Although the contact is not well exposed, the map evidence indicates that locally the Üçköy unconformably rests on the Sarıkaya formation (79.42: 71.00). There, the missing İkse formation suggests that the İkse and Üçköy formations together constitute an onlap sequence.

The Üçköy shale does not bear an organic element. According to its conformable stratigraphic position on the İkse, an early Campanian age can be assumed.

Lumeren formation

The name Lumeren is here applied to an intermediate volcanic rocks assemblage consisting primarily of lava flows. It corresponds to Tokay's (1952) «andesite and basalt, representing the closure of the Cretaceous volcanism». The partial type section of the Lumeren is exposed between 76.82:72.76 and 76.55:72.30.

The lower contact of the Lumeren formation is nowhere exposed. However, the map distribution of it suggests the overlying position of the Lumeren formation on the Üçköy shale.

A middle Campanian age is assumed for the Lumeren.

Örenköy formation

The name Örenköy formation is here used for a red and green clayshale sequence with minor volcaniclastic sandstone and manganese beds at the base. The Örenköy formation probably corresponds to Tokay's «Kale beds». The formation is divisible into three informal members; in ascending order, (1) lower shale member, (2) volcaniclastic sandstone member, (2) upper shale member. The complete type section of the Örenköy formation-is exposed between 75.03:71.80 and 75.00:71.42.

The Örenköy formation unconformably rests on the Lumeren İkse and Sarıkaya formations.

The formation is of Middle Campanian age.

Lower shale member. — The lower shale member consists of gray clay shale, (sedimentary) manganese and manganiferous shale. The partial type section is exposed at 82.07:70.42, and the reference section at 80.75.:70.80 (Fig. 7H).

The clay shales are generally grayish greern, moderately indurated and slightly calcareous, and laterally change into red clay shales (76.96:71.27, 71.45:75.40). Manganese occurs as several beds in the lower part of the member. The thickest bed is about 120 cm (81.82:70.60). The total thickness shows a general decrease from east to west, up to 20 cm.

The contact between the lower shale member of the Örenköy formation and the Lümeren formation is a clear-cut unconformity. The green shales directly rest on the weathered out lavas of the Lümeren, and penetrate into the fissures of the latter, in the form of neptunian dykes, as deep as 4 m. The infillings contain floating clasts of the Lümeren. Almost everywhere, near the trace of the contact, the infillings of the fissures connect with irregular masses of green opal. These features are best exposed at 79.15:71.59 (Fig. 7H), 81.86:70.57 (Fig. 7K), 81.83:70.90, 77.52:71.73, 76.90:71.23, and 76.50:72.13. The shales directly resting on the Lümeren lavas are silicified, and contain clasts from the Lümeren. The lower shale member unconformably overlies the İkse formation at 74.95:71.97 and the Sarıkaya formation at 74.98:68.00 (Fig. 7G) and 76.69:68.15.

Sandstone member. — The member consisting of volcamiclastic sandstone serves as a horizont-marker in the middle part of the Örenköy. The type section is exposed at 76.50:71.62 (Fig. 7M), and the reference sections at 79.76:71.35 and 80.81:70.60.

The sandstone is yellowish gray weathering, moderately indurated, thinly bedded, medium to coarse-grained volcaniclastic litharenite.

The contact between the sandstone member and the underlying lower shale member is gradational at 76.50:71.62 (Fig. 7M).

Upper shale member. — The upper shale member consists of pale red and brownish gray clay shales. The member can be divided into three parts: red shale, gray shale and sedimentary megabreccia. The type section of the red shale is exposed at 76.67:71.42, and the reference section at 80.07:71.32. The type section of the gray shale is situated at 75.25:71.37, and the reference section at 78.97:71.32. The type section of the megabreccia is at 75.25:71.38 (Fig. 7N).

The red shales constitute the greater part of the member, and are moderately indurated, homogeneous, calcareous clayshales. The gray shales weather light brownish gray, and are moderately indurated and thinly bedded. They contain thin interlayers of pale red claystone and limy claystone. The sedimentary megabreccia is about 450 cm thick, and consists of closely packed small blocks of intraformational origin. The blocks are subround to round, and include the claystones, limy claystones and shales typical of the Örenköy. The matrix is composed of the coarse sand-sized versions of the blocks.

The contact between the upper shale member and the sandstone member is structurally conformable and abrupt (Fig. 7M).

In the gray shale part of the member, the limy claystones bear *Globotruucana ventricosa* White, *G. tricarıı ata* (Quereau), G. *coronata* Bolli, G. *linneiana* (d'Orbigny) and G. *lapperenti* Brotzen, indicating an Early Campanian or probable Middle Campanian age. *Praeglobotruncana* sp., *Heterohelix* sp., *Hedbergella* sp. and *Pseudotextnlaria* sp. associate the *Globotruncana* assemblage.

Sarıkorkmaz formation

The name «Sarıkorkmaz» was originally used by Tokay (1952), who described it as consisting of shales with minor sandstones. In this report, the Sarıkorkmaz formation is designated for a sequence of gray mudshales with sporadic interlayers of lithic sandstones, occasional floating blocks

of volcanic rocks, and sedimentary megabreccia at the base, and the type section is designated in the Yığılca area. The Sarıkorkmaz formation is divisible into a formal Dibektaşı member, which consists of sedimentary megabreccia and is restricted to the Yığılca area (Fig. 5), and an upper informal shale member.

The contact between the Sarıkorkmaz and Örenköy formations is a disconformity.

The age of the Sarıkorkmaz is possibly Late Campanian.

Shale member. — The shale member consisting of mudshales with minor interbeds of lithic sandstone, represents the main body of the Sarıkorkmaz formation, particularly in the report area. Nearly complete type section is exposed between 77.80:71.42 and 77.75:71.10, and the partial reference section between 76.17:70.07 and 75.50:70.10.

The shales are medium gray, moderately indurated, thickly bedded to massive, light brownish gray weathering mudshales and clayshales. The sandstones are thin to thick-bedded epiclastic litharenites. Sporadic floating clasts of the Örenköy-type limy claystone up to 80 cm in size (77.90:71.19, 77.90:71.36, 76.12:71.20), and of the Lümeren volcanic rocks up to 175 cm (82.18:69.30) occur sporadically in the member.

The contact between the shale member of the Sarıkorkmaz and the underlying upper shale member of the Örenköy formations is everywhere abrupt, and is apparently a structural conformity. Because at 78.92:71.40 (Fig. 7L) and 80.00:71.22 the sandstones, and at 77.90:71.36 (Fig. 7P) and 76.12:71.51 the pebbly to blocky mudstones, all reflecting a derivation from the underlying Örenköy formation, define the base of the Sarıkorkmazlar, a disconformity is suggested. At 75.25: 71.38 (Fig. 7N) the basal 30 to 40 cm thick blocky conglomerate on the megabreccia of the Örenkoy, appears to be the recycled material of the latter, as distinguished by high content of matrix, in the form of grain-supported sandstone, and by abundant volcanic rock pebbles.

The shale member contains *Stegastergillieroni* De Loriol indicating a Campanian age. On the basis of its stratigraphic position the shale member can be assigned a Late Campanian age.

Erikli sandstone

The name Erikli sandstone is here applied to sequence of calcareous to limy sandstones, mudstones and sandy limestones. The Erikli sandstone is the facies equivalent of Tokay's (1952) «base des marnocalcaires d'Alaplı» to the west of the report area. The partial type section of the Erikli sandstone is situated between 77.65:69.38 and 77.78:69.20, and the reference sections at 78.27:69.75, 78.95:63.32, and 80.65:69.00. The Erikli is divisible into a lower mudstone-sandstone, and an upper sandstone part.

The mudstone-sandstone part of the Erikli sandstone consists primarily of sandy mudstones and matrix-supported sandstones, showing all gradational rock types. In the sandstone part of the formation, the sandstones are medium gray to greenish gray, medium to coarse-grained, and yellowish gray weathering grain-supported litharenites. Essentially, less calcareous and bioclastic litharenites up to 120 cm thick alternate with highly calcareous and bioclastic litharenites and sandy limestones up to 40 cm thick, the latter having a large-scale nodular appearance on the weathered out sections. The lower part of the sandstone has conspicuous and areally persistent large-scale planar cross-bedding with a height up to 10 m artel with a general south-southeastward inclination.

The contact between the Erikli sandstone and Sarıkorkmaz formation is a disconformity at 75.45:70.42 (Fig. 8A). Locally (75.36:71.12) pebbly and sandy mudstones at the base of the

Erikli contain limy claystones derived from the Örenköy (Fig. 8B). At 75.00:71.40, the Erikli sandstone directly rests on the Sarıkorkmaz formation.

The upper beds of the Erikli sandstone contain a prolific macrofauna. Echinoderms *Echinocorys conicus* Agassis, *E. ovatus* Leske, and *Micraster cortestudinarium* Gold, indicate a Campanian age. Ammonite *Eupachydiscus levyi* (Gross.) indicates a Middle Campanian age. Nevertheless, the stratigraphic position of the Erikli is suggestive of a Late Campanian age.

Akveren formation

The name Akveren formation is applied by Ketin and Gümüş (1963) for a sequence of «interbedded limestone and marl, and minor lava flows, tuffs and sandstones. In the report area, the Akveren formation consists of calcareous to limy mudrocks, poorly-calcareous shales and minor lithic sandstones, and corresponds to Tokay's (1952) «marnocalcaire d'Alaplı». The Akveren is divisible into three parts; in ascending order, mudstone-limestone, clayshale and mudshale. The nearly complete composite reference section is compiled from 77.67:68.42, and between 79.12:68.76 and 79.25: 68.57 (Fig. 8F).

In the mudstone-limestone part of the Akveren, the mudstones are pale red, reddish gray, variably calcareous and locally sandy. *Inoceramus* fragments and occasionally complete shells, up to 30 cm in one dimension, are typical constituents. Limestones are light to medium gray and fine-grained, and contain thin and uneven interbeds of calcareous mudstones. In the clayshale part of the formation, the shales are greenish gray, brownish gray, poorly calcareous clay-and mudshales, and contain laterally discontinuous limy mudstones, limy claystones, allodapic limestones and sporadic micritic limestones. In the upper mudshale part of the Akveren, the shales are greenish, brownish and pinkish gray mud- and clayshales, and contain occasional interlayers of thinly bedded allodapic limestones, sandy allodapic limestones and minor epiclastic litharenite.

The Akveren formation everywhere rests in structural conformity on the Erikli sandstone, and there is an apparent gradation between the red sandy mudstone of the Akveren and the matrix (mud)-supported litharenites of the Erikli. However, the abrupt extinction of the burrowings and the large-scale nodular appearance, along with the presence of frequent limonite-covered smooth planes in the contact interval, as exposed at 77.87:68.52 (Fig. 8D) and 80.03:68.83 (Fig. 8E), suggest that a rapid lithotope shift has accompanied the transitional deposition.

Dizer (1971), has established the following biostratigraphic zones to the west of Ereğli, however also applicable to the report area; in ascending order, Late Maastrichtian *Globotruncana contusa,* Early Paleocene *Globogerina daubjergensis, Globorotalia compressa,* Middle Paleocene *Globorotalia pseudomenardii* and Late Paleocene *Globorotalia velascoensis* zones. Outside the map area (in G25-a2 sheet, at 00.40:40.07, 03.12:39.68, 03.42:40.53, 03.97:41.02; in F26-d4, 34.45:44.35 — Fig. 8G), the microfauna of the uppermost beds of the Akveren is indicative of a turn from Late Paleocene to Eocene: *Nummiilites solitarius* de la Harpe, *N.* sp. (gr. *N. planulatus), Discocyclina seuneusi* Douvillei, *D.* sp. (gr. *D. nummnlitica), Aheolina* sp. (gr. *A. sicida)* and *Asterocyclina* sp. (gr. *A. teramelle).*

Ak9akoca sandstone

The name Ak9akoca sandstone is here suggested for a sequence of epiclastic sandstones, and minor volcaniclastic sandstones and mudrocks. The Akcakoca sandstone is exposed in outside aress.

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