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TRACE FOSIL ASSOCIATIONS AND PALAEOENVIRONMENTAL INTERPRETATION OF THE LATE EOCENE UNITS (SW-THRACE)

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ABSTRACT.- The Late Eocene deep marine fan sequence exposed in the northeast of the Saros Bay and around Korudağ, Keşan, Yenimuhacir regions consists of several facies associations such as middle and outer fan, slope, prodelta. From the study area, as a part of the observations, 4 measured sections involving Korudağ, Keşan, Yenimuhacir Formations were taken and the mid and outer fan facies association deposits were found to be more common than the others. The middle fan association was divided into two sub-associations: distribution channels and interchannel areas. 19 ichnogenus were identified in the deep sea fan deposits. From these ichnogenus: *Ophiomorpha* isp, *Ophiomorpha annulata, Ophiomorpha rudis, Thalassinoides* isp, *Planolites* isp, *Halopoa annulata, Rutichnius* isp, *Chondrites* isp, *Scolicia vertebralis, Scolicia strozzii, Scolicia prisca, Scolicia plana, Nereites irregularis, Helminthoidichnites* isp, *Helminthopsis* isp, *Cosmorhaphe* isp, and *Paleodictyon strozzi* helped to distinguish the mid fan-distal of the mid fan Korudağ Formation, *Ophiomorpha* isp, *Ophiomorpha annulata, Ophiomorpha rudis, Thalassinoides* isp, *Planolites* isp, *Halopoa annulata Zoophycos* isp, helped to distinguish inner fan Keşan formation and the *Lockeia* isp, ve *Planolites* isp. helped to distinguish the deltaic Yenimuhacir formation. The abundance and diversity of trace fossils found in the study area increase in the middle fan interchannel and channel margin sediments. On the other hand, in the outer fan and slope facies associations, the abundance and diversity of trace fossils are lower. Distribution and relative abundance of the trace fossils are compared with the interpretations of depositional environment and trace fossils associations were found to be related to the various parts of deep sea fan model.

Key words: Deep sea fan, Late Eocene, Trace Fossils, Thrace

INTRODUCTION

The research area is located northeast of the Saros bay and around Korudağ, Keşan, Yenimuhacir regions (Figure 1). There have been many published data which are related to especially oil and coal mining exploration around research area. The basin has different occurring between the area which has been showed by various geologist (Druit, 1961; Sfondrini, 1961; Saltık and Saka, 1972; Saltık, 1974; Önem, 1974; Doust and Arıkan 1974; Toker and Erkan 1985; Sümengen and Terlemez, 1991; Yaltırak, 1995; Demircan and Uchman, 2006). In this study the trace fossils in late Eocene deposits have been recognized and identified for the first time.

Trace fossils or ichnofossils are dwelling, feeding, crawling and other structures made by living organism in or on a substrate (Crimes et. al., 1981). According to Seilacher, (1964), 1967), the diversity of marine fossil groups related to water depth recurred throughout Phanerozoic time. Each assemblages was named after a characteristic trace fosil and they are, in order of increasing water depth: *Skolithos* zone (mainly litoral zone), *Cruziana zone,* (litoral zone to wave base), *Zoophycos* zone (wave base, turbidite depositional zone and slope), *Nereites* zone (deep water turbidite zone). Even though this classification seemed very useful, later studies showed that, trace fosil distribution is related to many factors, including substrate type, energy conditions, food availability, and preservation conditions, rather than bathymetry (Crimes, 1970, 1975; Frey and Howard, 1970). *Zoophycos* assemblage is questioned because of being in different marine environments but *Skolithos* and *Cruzina* assemblages are generally repre-

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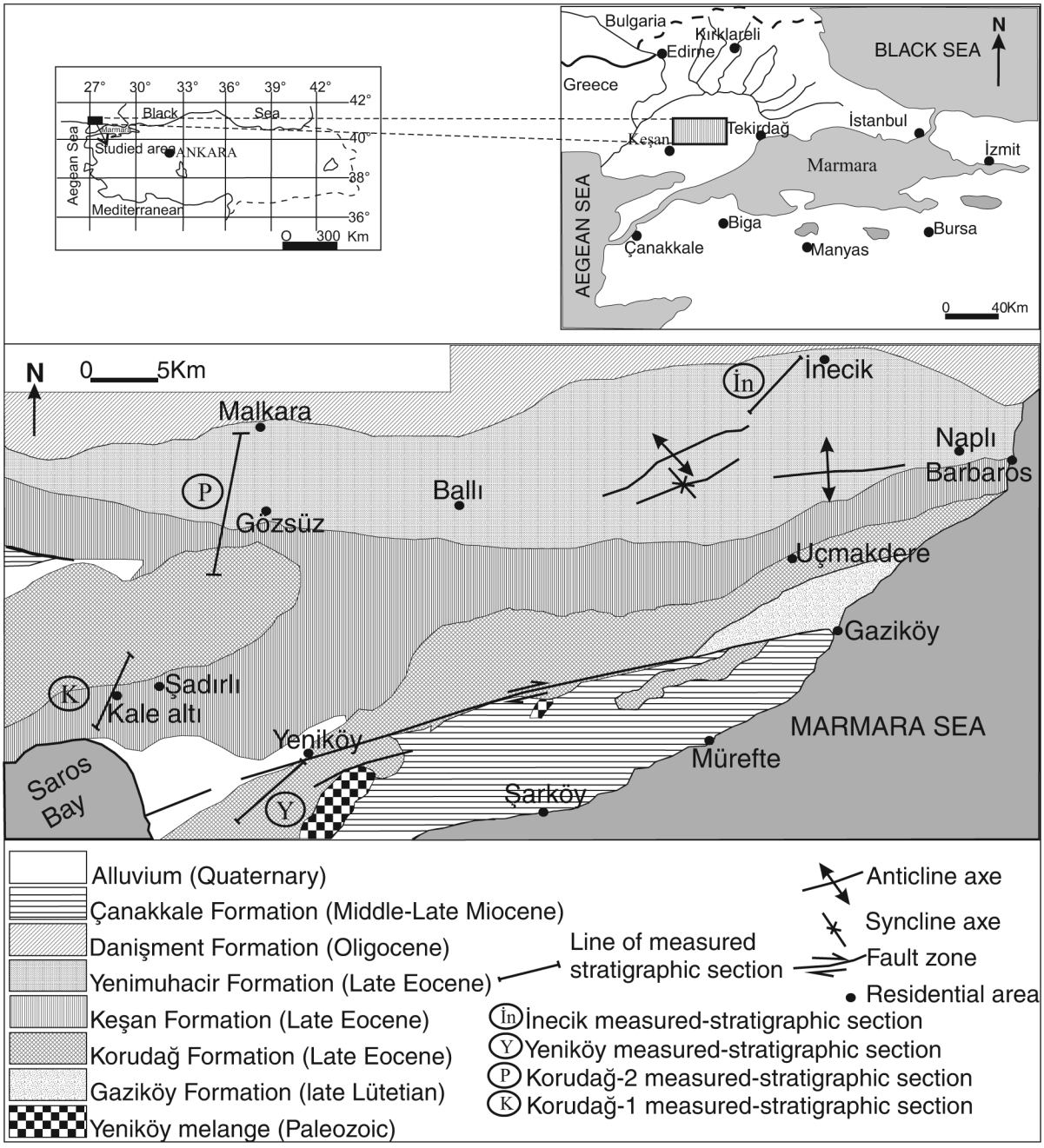


Figure 1- Location map (modified by Sümengen and Terlemez,1991)

sent the shallow marine on the other hand there is a common sense that *Nereites* assemblage indicates the deep marine environment (Seilacher, 1967; Crimes, 1970, 1975).

The aim of this study is to examine the ichnological properties of Late Eocene deep marine fan facies associations which are seen around Korudağ, Keşan and Yenimuhacir regions.

MATERIAL AND METHOD

The material for tis study, from the study area, as a part of the observations, 4 measured sections involving Late Eocene aged Korudağ, Keşan, Yenimuhacir formations were taken. The samples taking in the study area based on lithology changing. Identifications were made in the field from bedding surfaces, on parting surface and in vertical sections, and checked using collected material, photographs and sketches. Also, all specimens are taken in the field were correlated by literature (Table 1).

GEOLOGICAL SETTING

Considering Thrace Basin as a whole, the basement is mainly consists of Istranca massive metamorphites on the northeast of study area. Tertiary sediments which are not very thick are located on the south of bloc. However, Tertiary sediments more than 7000 m. thickness was measured on the southwest of the study area. The relation of Eocene and Miocene is very clear and all facies belonging to Eocene and Miocene are easily noticeable. Ergene Basin is in the middle section and mainly younger (?Pliocene) sediments are exposed in this region (Sümengen

Table 1- Position of the stratigrafic sections in the study area.

Quandrangle	The name of the stratlgrafic section	Start point (x,y) high (z)	End point (x, y) high (z)	Thickness (m.)
Bandırma G18-d1	Yeniköy	x 50 5000 y 45 01000 z 330 m	x 510900; y 4507000 z 290 m	460
ÇanakkaleG17-c1	Korudağ-1	x 48 2500 y 45 04600 z 90 m	x 481900 y 45 06500 z 300	310
Çanakkale G17-c1 (start point) Bandırma G18-a2 (end point)	Korudağ -2	x 48 1900; y 45 06500; z 300	x 51 1000; y 45 25800; z 270	335
BandırmaG18-b1 (start point) Bandırma G18-b2 (end point)	İnecik	x 52 4000 y 45 30320 z 200	x 542000 y 45 37000 z 50	250

and Terlemez 1991). The oldest unit in the area is the ophiolitic complex which forms the base of the basin called Yenikoy complex (Şentürk and Okay 1984). A series of Eocene-Oligocene (?) facies overlies the ofiolitic complex. These facies from bottom to top are; Late Lutetian age Gazikoy Formation, Late Eocene age Korudağ, Keşan, Yenimucahir Formations and Oligocene age Danişment Formation (Figure 2). There is an unconfirmity below Miocene age sediments. These sediments are called as Middle-Late Miocene Çanakkale Formation.

One of the most important tectonic structure in the study area is the N 70 E Saros gulf-Gazikoy Fault which is still active. This fault is a part of Northern Anatolian Fault System (Sümengen and et. al., 1987). Although, between Gaziköy and Saroz bay, at the northern parts of the fault was not considerably effected by tectonic processing, reverse and thrust faults are observed at the south (Sümengen and et. al., 1987).

SEDIMENTOLOGY

Four measured sections were taken at the investigated area (Yeniköy, Korudağ-1, Korudağ-2 and İnecik), and have been detailed in 4 main facies association as their litology changing. These are: prodelta, slope, middle and lower fan deposits.

Middle Fan Facies Association

Middle fan facies associations are common in the study area. They are seen as distributary channel fill and interchannel deposits at the Korudağ-1, Korudağ-2 measured sections (Figure 3, 4 Keşan formation).

a) Distributary channel fill deposits.- The channel deposits are characterized by coarse grained conglomerates at the base of the channel and continue thinning and fining upward. Trace fossils characterized by high energy are common.

b) Interchannel deposits.- They are represented by a sequence of thin bedded turbiditic sandstones with mudstones. Also, increase in the number of trace fossils and diversity is observed in these deposits.

Lower Fan Facies Association

It is a common facies association in the study area where it is seen at the Korudağ-1, Korudağ-2 and Yeniköy measured sections (Figure 5, Korudağ Formation). The unit is composed of thin bedded, fine grained sandstones with mudstone intercalations, and medium bedded, medium grained turbiditic sandstones. These two facies associations are observed to be vertically thickening and coarsening upward series that depend on grain size and bed thickness. Big and small scale loading, flute marks and groove marks are seen at the bottom of sandstone beds.

Slope Deposits

They represent a transition between Korudağ-1 and Korudağ-2 measured sections (Figure 3, 4 Keşan Formation). Sometimes, slump structure and shallower channel between middle fan and transitions levels are observed. Also, thicker sandstone beds include endichnial *Zoophycos* ichnospecies.

Prodeltaic deposits

They are observed at Korudağ-2 and Yeniköy measured sections (Figure 6, Yenimuhacır Formation). Generally, they consists of thin bedded, fine grained sandstone, alternated massive mudstone, and sandy, gravelly channel filled deposits. Sandstones are fine grained and, thin bedded with sharp contact at the bottom while ripple marks are observed on the bed surface. Bed thickness is laterally continuous and displays lenses form. Small scale cross beds and ripple lamination is common in sandstones, however, sandstone thickness is small scaled, and thickness continuously upwards. It also contains plant material and Bivalvia fraction.

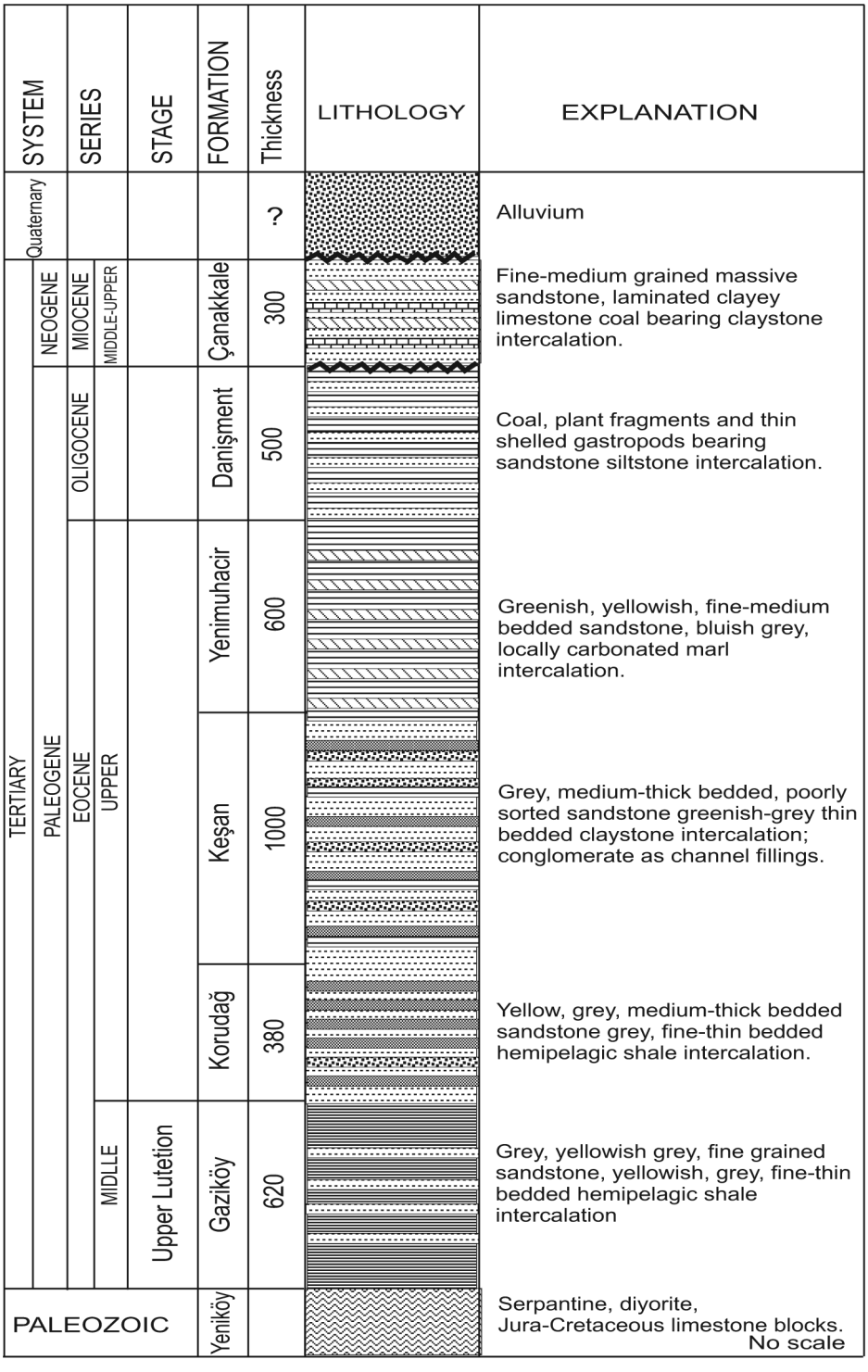


Figure 2- Generalized columnar section of the studied area (modified by Sümengen and Terlemez, 1991).

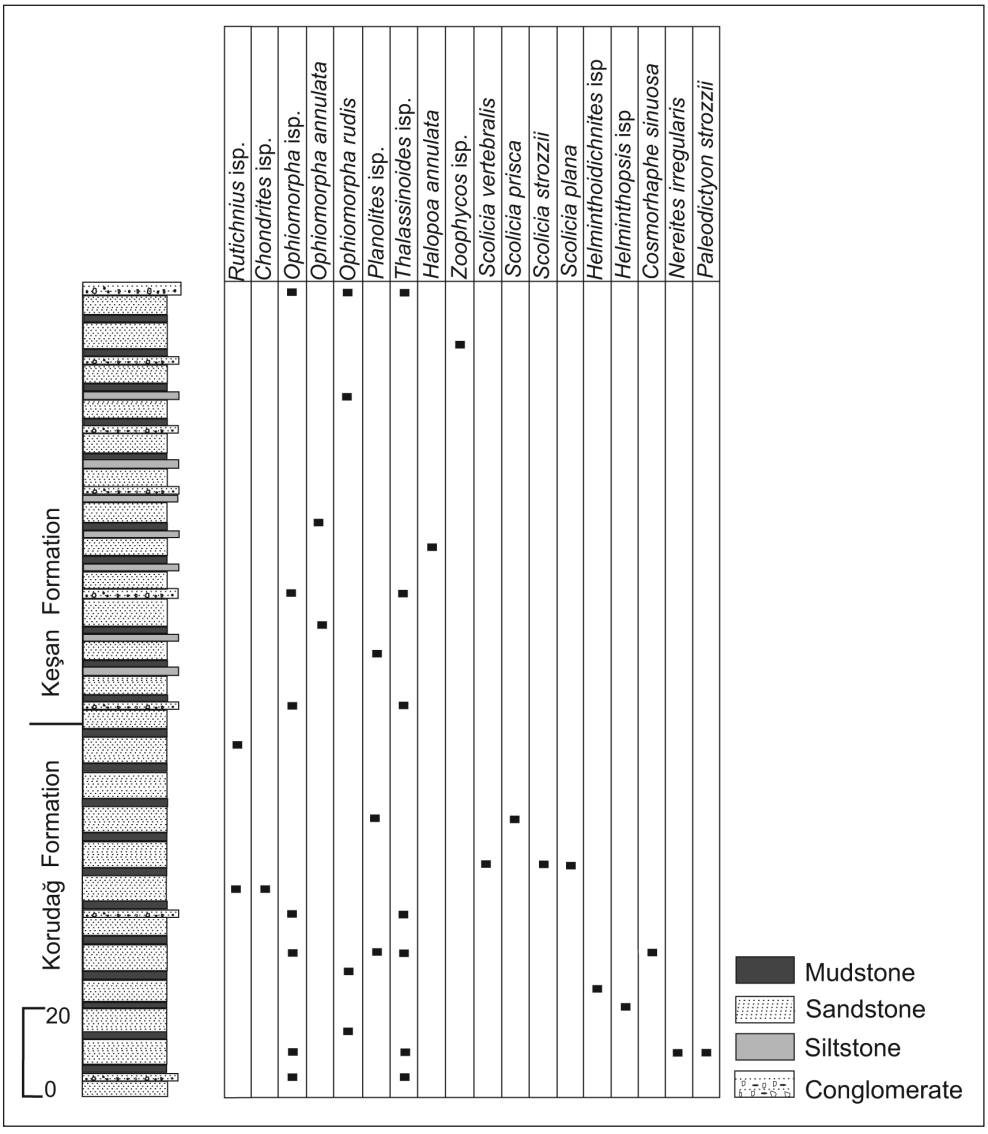


Figure 3- Korudağ-1 measured stratigrafic section

TRACE FOSSILS

From bottom to top, it is observed Late Eocene aged in Korudağ, Keşan, Yenimuhacır Formations. Most of trace fossils are middle fan, interchannel and outer fan deposits. Taxonomic description is prepared according to morphological groups distinguished by Hantzchel (1975), Ksiazkiewicz (1977), Seilacher (1977), Fillion and Pickerill (1990), Crimes and Crossley (1991) and Uchman (1998).

Simple and branched structure

This group embraces relatively small, rarely branched, horizontal or oblique burrows.

Planolites isp. (Plate 1, Figure 1).- *Planolites* isp., is straight, slightly curved and semi-relief,

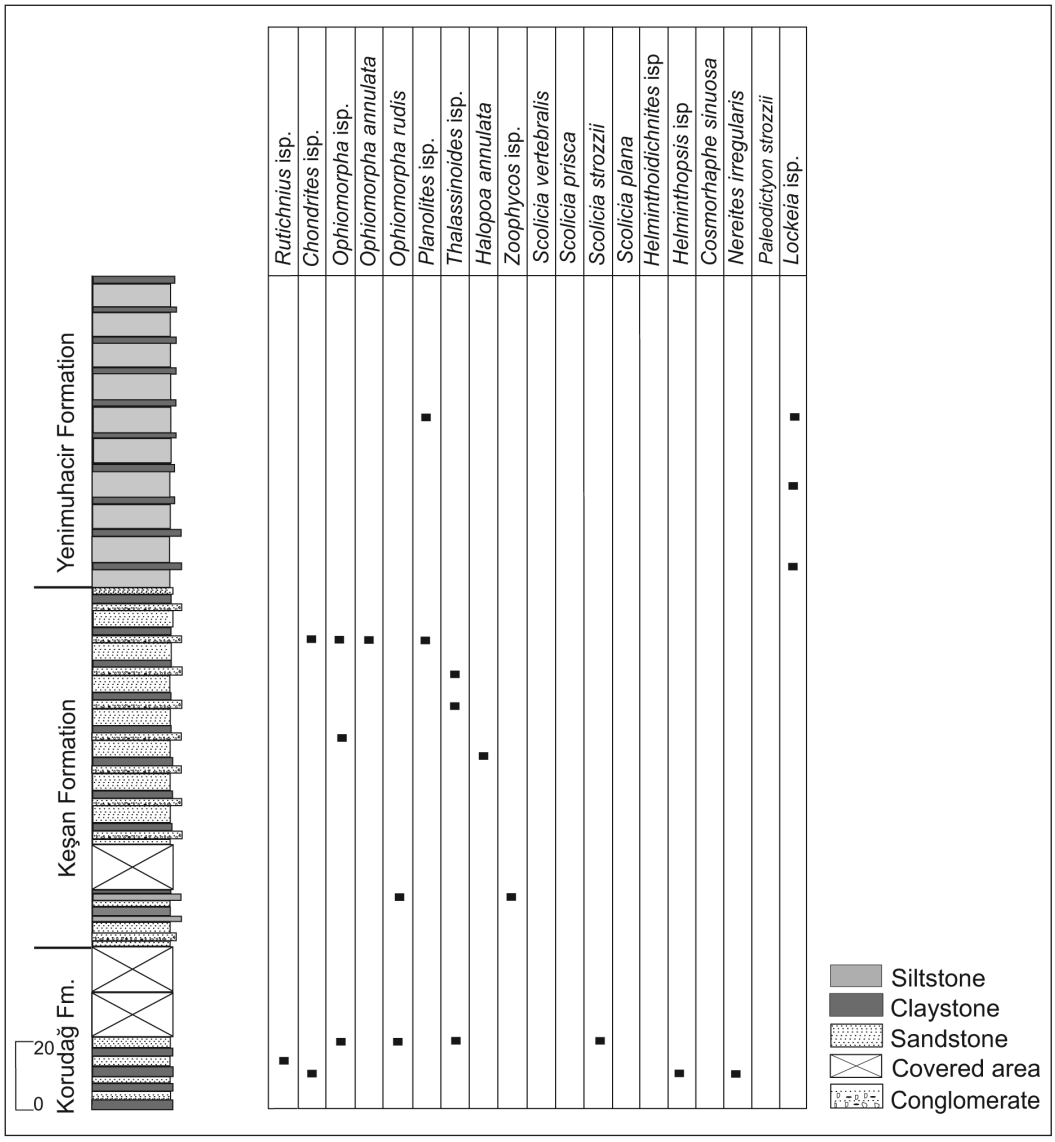


Figure 4- Korudağ-2 measured stratigrafic section

hypichial ridges. They are found as cylindrical tubes. The ridges are 2-4 mm wide. They are observed (İnecik, Korudağ-1 and Yeniköy measured sections) as facies breaking forms in the study area.

Planolites are common from Precambrian to today (Hantzschel, 1975).

Ophiomorpha isp.- They are observed in fine grained turbiditic sandstones as endichnial and hypichnial. Full relief, and wall structure is observed. The forms determined in the field (Korudağ-1, Korudağ-2 and Yeniköy measured sections) have 10 mm diameter and 49 mm length. *Ophiomorpha* is similar to *Thalassinoides* when it is in lateral or vertical forms (Kern and

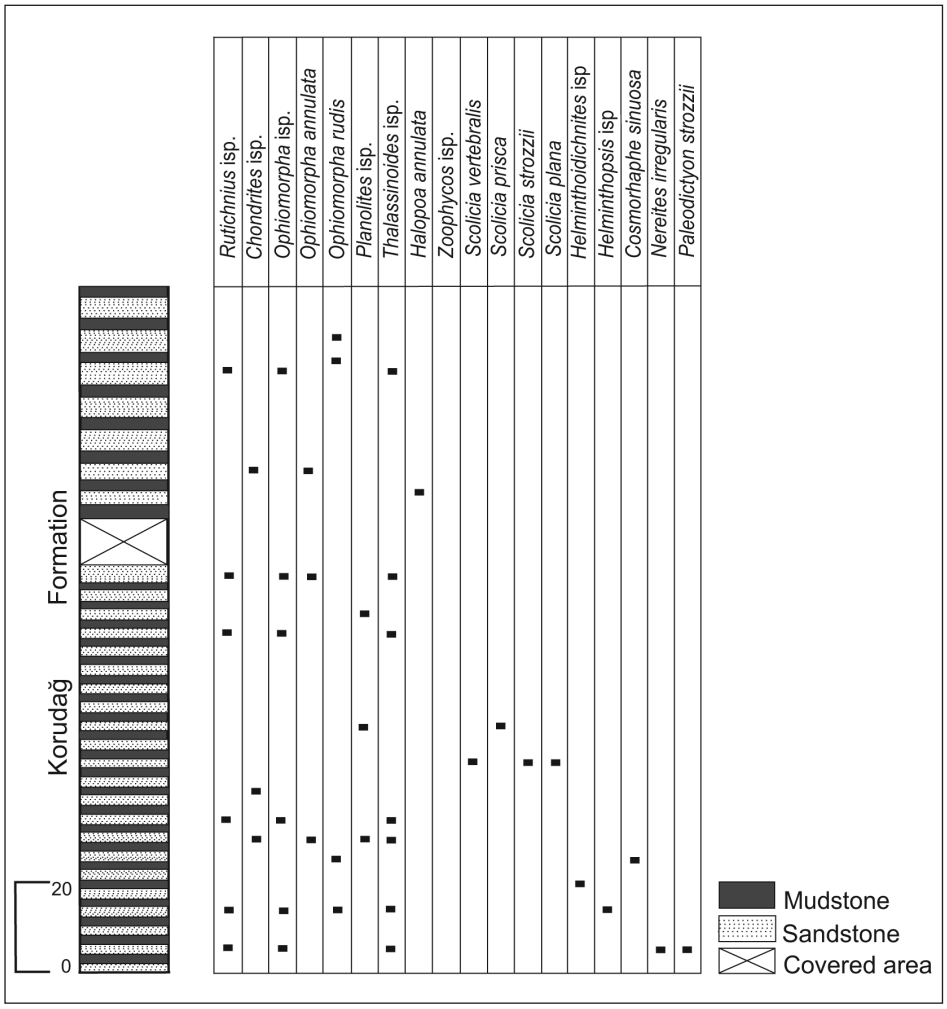


Figure 5- Yeniköy measured stratigrafic section

Warme, 1974). *Sabularia rudis* (Ksiazkiewicz, 1977) including the holotype, also strongly resembles *Ophiomorpha* (Uchman, 1991*a*) and may be regarded as a synonym of the latter. *Thalassinoides, Spongeliomorpha* and *Gyrolithes* are known to be the system of burrows formed by the same trace makers in different positions (Kennedy, 1967; Fürsich, 1973; Bromley and Frey, 1974).

Ophiomopha rudis (Ksiazkiewicz 1977) (Plate 1, Figure 2).- They are preserved as vertical to subvertical cylindrical, walled or unwalled, sand-filled, rarely branched tunnels (Korudağ-1, Korudağ-2 and Yeniköy measured sections). The diameters of the tubes are 2.5-2.6 mm and 34.5 cm. long.

Ophiomopha annulata (Ksiazkiewicz, 1977) (Plate 1, Figures 3, 4).- They embrace mainly horizontal and elongate pellets, cylindrical burrows. They are observed as exichnial cylindrical lined burrows (Korudağ-1, Korudağ-2 and Yeniköy measured sections). They are 2-4 mm in diameter.

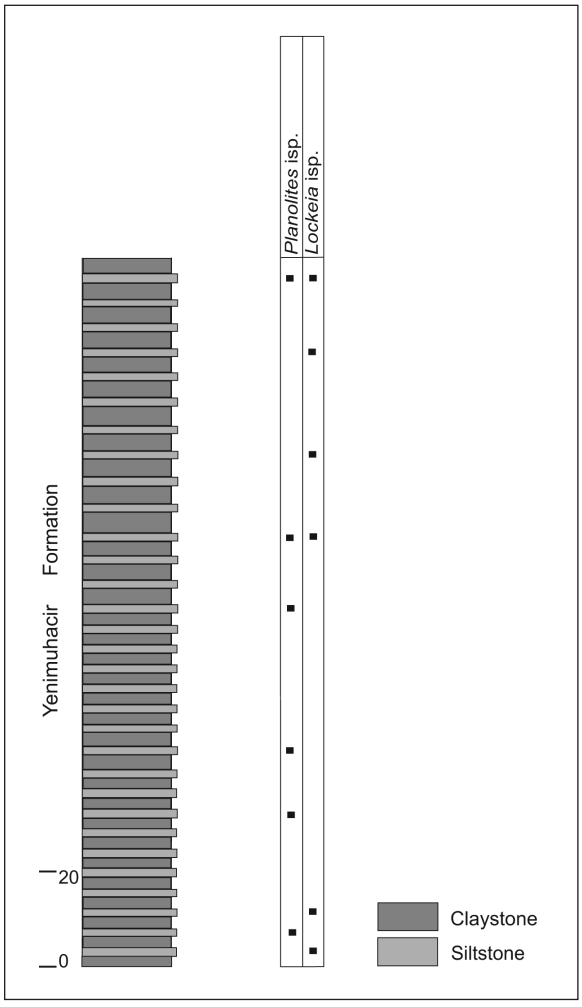


Figure 6- İnecik measured stratigrafic section

Thalassinoides Ehrenberg 1944 (Plate 1, figure 5).- They form the three-dimensional burrow system. They show branching from Y-shape to T-shape (Korudağ-1, Korudağ-2 and Yeniköy measured sections). They are typical to shallow-marine environments, and are formed by Crustaceans (Frey et. al., 1984). *Thalassinoides* is a facies breaking trace fossil. Origin and palaeoenvironmental meaning of *Thalassinoides* were summarized by Ekdale (1992). According to Föllmi and Grimm (1990) the *Thalassinoides* were formed by Crustaceans are produced burrow under anoxic conditions and can survive in turbidity currents.

Besides being widespread in Mesozoic and Cenozoic occurrences, *Thalassinoides* are common in Paleozoic shallow marine environments (Palmer, 1978; Archer and Maples, 1984; Sheehan and Schiefelbein, 1984; Stanistreet, 1989; Kulkov, 1991).

Halopoa annulata Uchman 1999 (Plate 1, Figure 6).- They are observed as straight, unbranched, and hypichnial traces (Korudağ-1 and Korudağ-2 measured sections). They don't have any secondary coming-out parts in the study area. The middle hand is 2 mm in diameter and contains 2-3 wrinkles. *Fucusopsis annulata* which contains *Halopoa* Torell (Uchman, 1998) was defined by Ksiazkiewicz (1970).

Chondrites isp. (Plate 2, Figure 1).- They appear in the form of small, branching, downward penetrating, and markedly flattened tunnels (Korudağ-1, Korudağ-2, and Yeniköy measured sections). The burrow is 0.5 mm in diameter.

Chondrites isp, is a feeding trace of an unknown trace maker. This trace fossil has a high degree of branching, and at the same time, this kind of fossil is probably constructed by endobentic deposit feeding (Bromley and Ekdale, 1984). *Chondrites* occurs independent from facies (Crimes, 1977) and significantly it is formed hypichially, and under anaerobic conditions as a chemo symbiotic organism (Bromley and Ekdale, 1984).

Rutichnus isp. (Plate 2, Figure 2).- They are branching, walled, meniscate traces. A branched structure can be produced by a deposit feeder, backing up or reversing as horizontal or oblique (Korudağ-1, Korudağ-2 and Yeniköy measured sections).

It mainly indicates shallow marine deposits (D' Alessandro et. al., 1987).

Circular structure

Lockeia isp. James 1879.- Generally, It is almond shaped or heart shaped outline with, smooth margin, preserved commonly as hypichnial mounds (İnecik measured section). Lockeia isp. is commonly interpreted as Bivalve resting trace (Seilacher, and Seilacher 1994) occuring from Cambrian to the recent, and seen nonmarine and deltaic environment.

Spreiten structure

This group consists of typically helicoidal lining and three dimensional spreite structures (Hantzschel, 1975).

Zoophycos Massalongo 1855 (Plate 2, Figure 3).- It is observed as spreiten structures which are endichnial to epichnial in fine grained turbiditic sandstone (Korudağ-1 and Korudağ-2 measured sections). The spreite lamellae are 1-5 mm wide and consists of numerous small, more or less 'U' or 'J' shaped protrusive burrows. The structure is bordered by a marginal tunnel, which is 5 mm wide. Different ichnogenera and/or species have been defined as *Zoophycos* (Hantzschel, 1975). Recently, many special studies have been made about the members of Zoophycos group (Bromley, 1991; Wetzel, 1992; Gaillard and Olivero, 1993; Olivero, 1994; Uchman and Demircan, 1999). There is a real necessity to re-observe this group.

Zoophycos is generally accepted as the traces left by unknown deposit feeding organisms. Organisms producing these traces can be sipunculoids (Wetzel and Werner, 1981), polychaete annelid, artropod (Ekdale and Lewis, 1991*a*, and *b*) and hemicordates. According to Kotake (1989, 1991*a*), *Zoophycos* are formed by surface ingestors of organic detritus, but still the organisms which are forming these traces are unclear.

Winding and meandering structure

This term was used firstly by Hantzschel (1975). These bilobate and trilobate tube forms were formed by echinoid burrows in Mesozoic and Senozoic (Smith and Crimes, 1983). All members of this group were included in the ichnogenus *Scolicia* by Seilacher (1986).

Scolicia vertebralis Ksiazkiewicz 1970 (Plate 2, Figure 4, 5).- They are observed as epichnial two or three lobed, winding and meandering traces in medium-grained turbiditic sandstones (Korudağ-1 and Yeniköy measured sections). The furrow is very narrow 10 mm in width, and 5 mm in depth. The side lobes consist of asymmetric ribs that are 1.5 mm in width. They are less common than *Scolia plana* and *Scolicia prisca* (Ksiazkiewicz 1970, 1977).

Scolicia prisca De Quatrafages 1849 (Plate 2, Figure 6).- They are observed as epichnial, three lobed, winding trace fossils in medium-grained turbiditic sandstones (Korudağ-1 and Yeniköy measured sections). The furrow is 10 mm in width and 3.5 mm in depth. The median lobe is the lower ridge on the floor of the furrow. It is 6 mm in width. The side lobes have assymetric ribs. The ribs are nearly 2 mm in width.

The parallel strings structure is formed by drainage of spatangoid echinoids. The asymmetric thicker ribs on both sides are remnants of backfill menisci. This ichnotaxon is generally observed in the middle part of turbidites at the transition from sandstone to mudstone. The lower part of the burrow is preserved. The upper part, making up backfill structures, remains usually at the top of the shaley levels of the turbidites (Ksiazkiewicz 1970, 1977).

Scolicia strozzii (Savi and Meneghini 1850) (Plate 3, Figure 1).- They are observed as hypichnical, having bilobate ridge with median groove in fine grained turbiditic sandstone (Korudağ-1, Korudağ-2 and Yeniköy measured sections). The ridge is 13 mm in width, and 1.5-2 mm in height. The median groove is narrow and shallow.

This ichnotaxon is a cast of the furrow formed after erosion of the *Scolicia* burrow. Height, depth of the median ridge, and wide of the trace depend on small differences in depth of burrowing, depth and strength of erosion, and properties of substrate. If the burrow is cut by erosion in the central part, its cast gets higher and wider, the sides of the ridge become gentler, and the median groove seems to be narrower. If erosion cuts the base of the burrow, its cast gets lower, the median groove becomes shallow and wide, and the prominent part of the ridge becomes narrow. However, some differences in burrow shapes depend on biological factors. Preservation factors seem to dominate the shape of the ridge. In the past, such criteria were used for distinguishing taxa of *Taphrhelminthopsis.*

Ksiazkiewicz (1977) differentiated these forms by their meandering structures; 1) gently winding, usually single *Taphrhelminthopsis vagans*, 2) usually gregariously occurring *Taphrhelminthopsis auricularis,* and 3) tightly meandering *Taphrhelminthoida.* The first form corresponds to locomotion activity (repichnia), and the latter to feeding activity (pascichnia) (e.g. Ksiazkiewicz, 1977; plate 17, figure2: Crimes, 1977; plate 6b). However, some transitional forms occur among them *Scolicia prisca* and *Subphyllochorda* (*Scolicia* isp.) commonly display meanders, which may be preserved as *Taphrhelminthopsis* or *Taphrhelminthoida* (=*Scolicia strazzii*). The tendency to meandering depends on the nutrient content of the substrate. Thus, differentiating between meandering and non-meandering forms is problematic at the species level.

Scolicia strozzii was produced at shallow tiers as indicated by the co-occurrence of *Paleodictyon strozzii*. Its Mesozoic-Cenozoic producers (*spantangoid echinoids*) can not be excluded. The Paleozoic forms are probably casts of washed out burrows of *Cruziana* and *Curvolithus*. There are no diagnostic features, which allow Paleozoic and past Paleozoic forms.

Scolicia plana Ksiazkiewicz 1970.- They are three lobed, winding and meandering, and hypichnial trace fossil in fine-grained turbiditic sandstone (Korudağ-1 and Yeniköy measured sections). The furrow is 9 mm in width, and side lobes are covered with ribs which are 1.5 mm in width. The narrow side lobes are 2.6 mm in width.

They are typical for Mesozoic and Cenozoic deposits (Ksiazkiewicz, 1977).

Nereites irregularis (Schafhäutl 1851) (Plate 3, Figure 2).- They are observed as meandering to winding, epichnial and/or endichnial trace fossils in fine-grained turbiditic sandstone. (Korudağ-1, Korudağ-2 and Yeniköy measured sections). The thickness of meander formed by *Nereites* is 3.5-4 mm. The list of ichnotaxa including Nereites was offered by Uchman (1995).

Nereites ırregularis was observed in deep sea environments in the begining of the Mesozoic (Yang, 1986) to Miocene (Uchman, 1995) and ?Quaternary (Ekdale and Lewis, 1991*b*)

Helminthoidichnites isp. (Plate 3, Figure 3).- They are traces having irregular winding with rarely ridges on both parting surfaces and on the upper parting surface or grooves on the lower parting surface (Korudağ-1 and Yeniköy measured sections). They are similar to *Gordia*, but *Helminthoidichnites* displays only occasional loops, whereas Gordio Emmons' (1844) loops are the most characteristic feature. However, these trace fossils were produced by the same tracemarker. They were probably been produced by insect larvae (Hoffman, 1990). *Helminthoidichnites* spreads form marine to nonmarine environment.

Helminthopsis Heer 1877 (Plate 3, Figure 4).- They are observed as hypichnial, convex, loosely meandering, smooth, string-like, no branched forms in fine-grained turbiditic sandstone (Korudağ-1, Korudağ-2 and Yeniköy measured sec-

tions). The string is 3.5-4 mm in width. Examination of the type material related to *Helminthopsis* has revealed that the type species *Helminthopsis magna* is in fact *Taphrhelminthopsis* Sacco, and that *Helminthopsis labyrintica* (Heer, 1877) is identical to *Spirocosmorhaphe* Seilacher. These types of traces are probably produced by polychaetes or pripulid (Ksiazkiewicz, 1977; Fillón and Pickerill, 1990).

Helminthopsis occurs in the time interval ranging between the Cambrian (Crimes, 1987) to the Recent (Swinbanks and Murray, 1981; Wetzel, 1983*a, b*).

Cosmorhaphe sinuosa (Azpeitia Moros 1933) (Plate 3, Figure 5).- It is a hypichnial, convex, meandering string in fine-grained turbiditic sandstone (Korudağ-1 and Yeniköy measured sections). It is preserved in semi-relief. The string is 2 mm in width. The meanders are 10-15 mm in width.

Cosmorhaphe isp. is a graphoglyptid burrow, common in flysch deposits since the Ordovician (Häntzschel, 1975). Fossil forms have been present since the Cambrian (Narbonne et al., 1987).

Networks

Paleodictyon (Glenodictyum) strozzii Meneghini, 1850 (Plate 3, Figure 6).- They form a hypichnial semi-relief, network in fine-grained turbiditic sandstone (Korudağ-1, Korudağ-2 and Yeniköy measured sections). The net is 2-5 mm in size and 1 mm in string diameter. The nets forming the trace are quite regular.

ENVIRONMENTAL DISTRIBUTION OF TRACE FOSSILS

From the study area, 4 measured sections involving Korudağ, Keşan, Yenimuhacir formations were taken. Although Korudağ and Keşan formations have various trace fossils, Yenimuhacır formation has rarely. Environmental distribution of trace fossils depending on facies association in the measured sections are shown in table 2, 3, 4. Ichnogenus and/or species were tried to be given as environmental indicators forming the ichnofacies. Generally simple structures show shallow water trace fossils while mixing, meandering and network structures indicate deep water trace fossils.

DISCUSSION

Working on distribution of trace fossils in the submarine fan and evaluating the submarine through the different part of submarine is more accurate than evaluating it through their preservation factor and source. (Crimes et. al, 1981). For example; since main channel fill of inner fan and distributary channel of the mid fan deposits is mostly conglomerate, trace fossils were not observed. Shallow water trace fossils such as *Ophiomorpha* isp, *Thalassinoides* isp. which occur in vertical and horizontal position at the coarse sandy level and especially loose meandering forms of the trace fossils which is eroded by turbidity current, do not have the chance to preserve of their vertical and horizontal forms. (Crimes, 1977; Crimes et. al., 1981: McCann and Pickerill, 1988). The facies that have the most trace fossils and diversity are mostly middle fan interchannel and fan fridge deposits. In these deposits, especially meandering, network and radial trace fossils which are parallel to the bedding, show abundance and diversity. At the same time, these forms indicate deep water (Crimes et. al., 1981).

Demircan and Toker (2003) in their submarine fan research around Adana, Southern Turkey observed that the diversity of the organisms at the inner fan is sparse and not many traces were observed at this part on the other hand, in the middle fan this diversity increases and the highest level of the organisms were observed at the outer fan.

Sander and Hessler (1969) indicated the variations in ichnofauna in modern seas which

Table 2- Environmental distribution of trace fossils in Korudağ Formation

shows higher diversity on the continental slope than the shelf shows a gradual decrease with depths under 2000 m.

Boreen and James (1995) explained that deeper part of the shelf facies in Tertiary limestone in Southeast Avustralia has *Scolicia* isp, *Planolites* isp, and *Helminthopsis* isp forms, and especially *Scolicia* isp, is common.

According to Howell et. al., (1996), at shoreface deposits which is very common at the Hammer group in England, Ophiomorpha isp. forms are abundant.

Distribution of the trace fossils, which were observed at the submarine fan deposits at the outcrops of Korudağ, Keşan and Yenimuhacir Formations, in the study area, change according

Table 3- Environmental distribution of trace fossils in Keşan formation

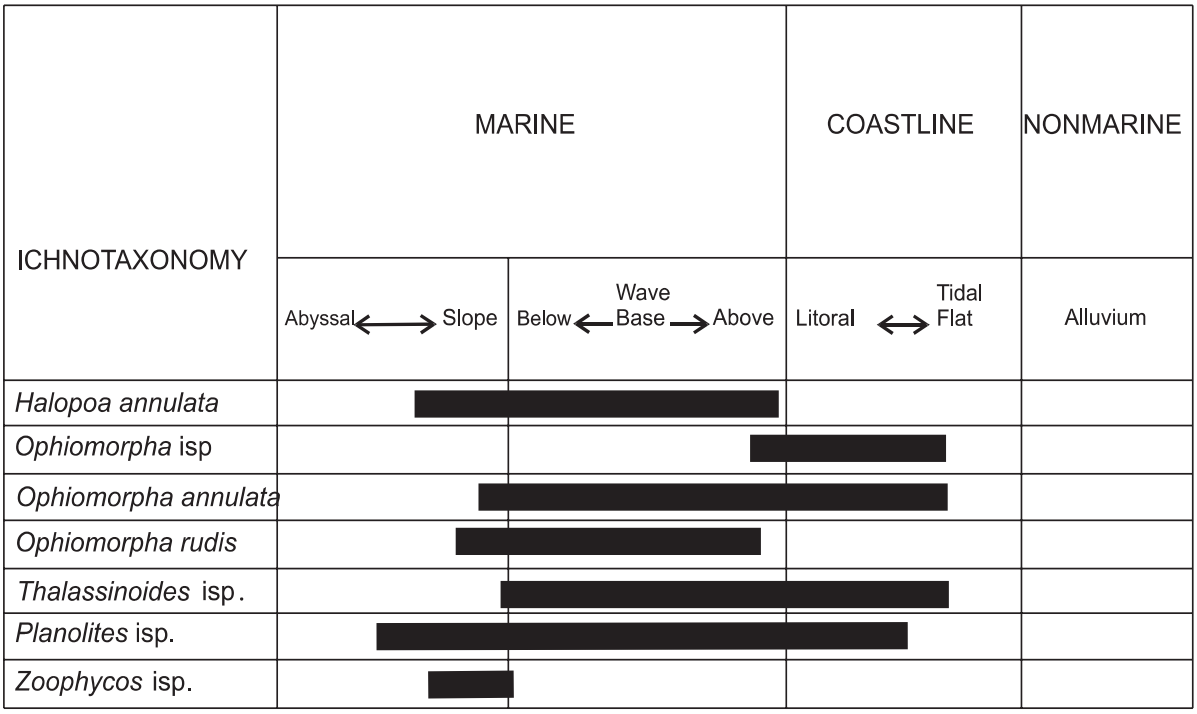
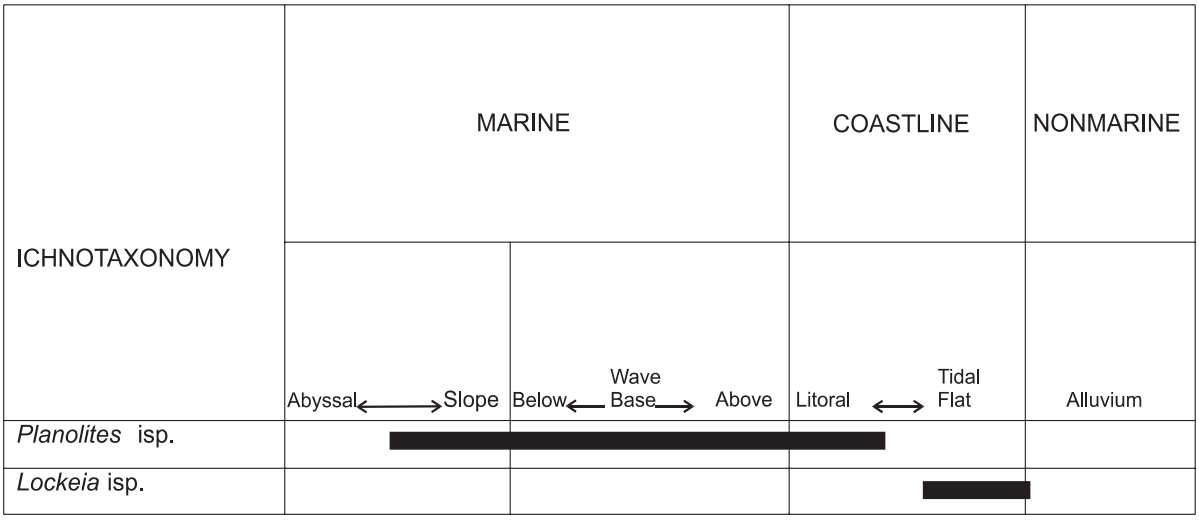


Table 4- Environmental distribution of trace fossils in Yenimuhacır formation



to their position in the fan system. In the research area Keşan Formation which was formed in the slope deposits, the facies breaking forms observes. Addition to facies breaking forms, it contains shallow trace fossils such as *Ophiomorpha* isp. and *Thalassinoides* isp. The unit also contains crawling trace fossils (*Scolicia* isp, etc.) which are common. In the deposits which are belong to Korudağ formation, has especially meandering, network and radial trace fossils. These forms indicate deep water. Although Korudağ and Keşan formations have various trace fossils, Yenimuhacır formation has rarely. At the same time, at the study area, lateral and vertical distribution of the trace fossils at the middle fan is higher than the ones abundant in the outer fan.

RESULTS

Five groups (simple and branched structures, circular structure, spreiten structure, winding and meandering structures and networks) and 19 ichnofossils (*Ophiomorpha* isp, *Ophiomorpha annulata, Ophiomorpha rudis, Thalassinoides* isp, *Planolites* isp, *Halopoa annulata, Rutichnius* isp, *Chondrites* isp, *Scolicia vertebralis, Scolicia strozzii, Scolicia prisca, Scolicia plana, Nereites irregularis, Helminthopsis* isp, *Cosmorhaphe* isp, *Helminthoidichnites* isp, *Paleodictyon strozzii Zoophycos* isp, *Lockeia* isp,) depending on their morphology at northeastern of Saros bay and around Korudağ, Keşan, Yenimuhacir regions in Late Eocene deposits were identified. As a result, inner fan is represented by Keşan formation which is composed of simple structures (*Ophiomorpha* isp, *Ophiomorpha annulata, Ophiomorpha rudis, Thalassinoides* isp, *Planolites* isp, *Halopoa annulata, Zoophycos* isp,), while Korudağ formation is characterized as a middle fan and distal of middle fan which has lamell and meandering structures (*Ophiomorpha* isp, *Ophiomorpha annulata, Ophiomorpha rudis, Thalassinoides* isp, *Planolites* isp, *Halopoa annulata, Rutichnius* isp, *Chondrites* isp, *Scolicia vertebralis, Scolicia strozzii, Scolicia prisca, Scolicia plana, Nereites irregularis, Helminthoidichnites* isp, *Helminthopsis* isp, *Cosmorhaphe* isp, and *Paleodictyon strozzi*), and Yenimuhacır formation shows deltaic features which has simple and circular structure (*Lockeia* isp., *Planolites* isp.,). It indicates Cruziana ichnofacies which is represented by normal salinity, temperature varies seasonally. According to the data, inner fan has normal salinity; temperature varies seasonally, contains high oxygen, bottom is stable except during the storms and is represented by *Skolithos-Cruziana* ichnofacies and eutrophic conditions. The middle fan has low oxygen, except the turbidite sedimantation the conditions are same as the inner fan and is represented by mixed ichnoassemblages *Skolithos-Cruziana* ichnofacies and *Nereites* ichnofacies which show eutrophic-oligotrophic conditions. Outer fan is described by high diversity in ichnofossils, low or no oxygen, turbidite sedimentation and totally oligotrophic conditions in *Nereites* ichnofacies.

ACKNOWLEDGEMENTS

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PLATES

PLATE I

Figure 1- *Planolites* isp.
Endichnial full-relief in fine grained sandstone.
İnecik (Delta)-Korudağ-1 (Middle fan)- Yeniköy (Outer fan).

Figure 2- *Ophiomorpha rudis*
Endichnial full-relief in medium-fine grained sandstone.
Korudağ-1 (Slope)- Korudağ-2 (Middle fan-Outer fan)
Yeniköy (Outer fan).

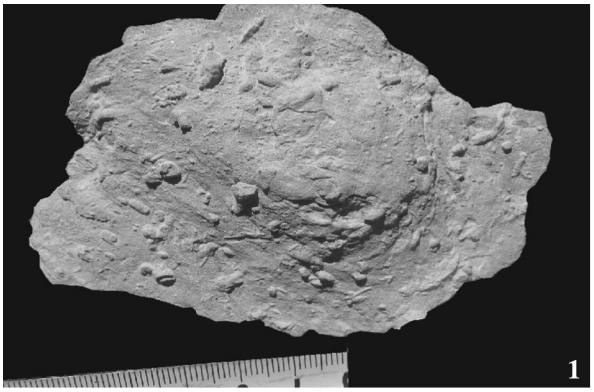
Figure 3- *Ophiomorpha annulata*
Exichnial semi-relief in medium-fine grained sandstone.
Korudağ-1 (Slope)- Korudağ-2 (Middle fan-Outer fan)
Yeniköy (Outer fan).

Figure 4- *Ophiomorpha annulata*
Exichnial semi-relief in medium-fine grained sandstone.
Korudağ-1 (Slope)- Korudağ-2 (Middle fan-Outer fan)
Yeniköy (Outer fan).

Figure 5- *Thallasinoides* isp.
Exichnial semi-relief in medium grained sandstone.
Korudağ-1 (Slope)-Korudağ-2 (Middle fan-Outer fan)
Yeniköy (Fan fridge).

Figure 6- *Halopoa annulata*
Hypichnial semi-relief in medium grained sandstone.
Korudağ-1 (Slope)-Korudağ-2 (Middle fan).

PLATE - I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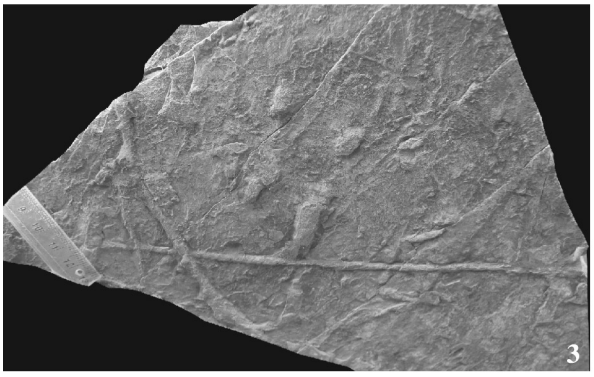
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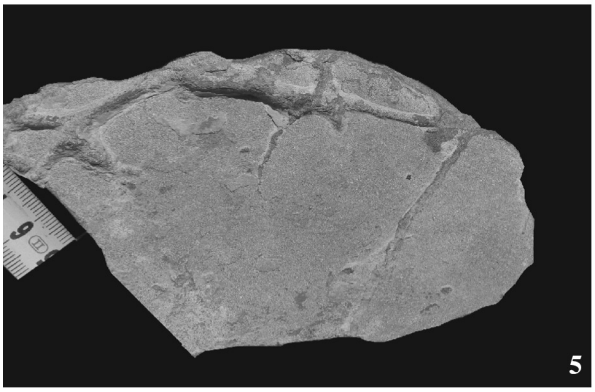
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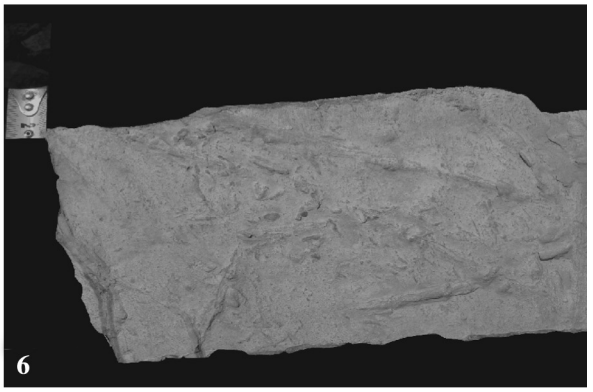
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PLATE II

Figure 1- *Chondrites* isp.
Endichnial full-relief in medium-fine grained sandstone.
Korudağ-1 (Slope-Outer fan)-Korudağ-2 (Middle fan-Outer fan)
Yeniköy (Outer fan).

Figure 2- *Rutichnius* isp.
Hypichnial full-relief in medium grained sandstone.
Korudağ-1 (Slope-Outer fan)-Korudağ-2 (Middle fan-Outer fan)
Yeniköy (Outer fan).

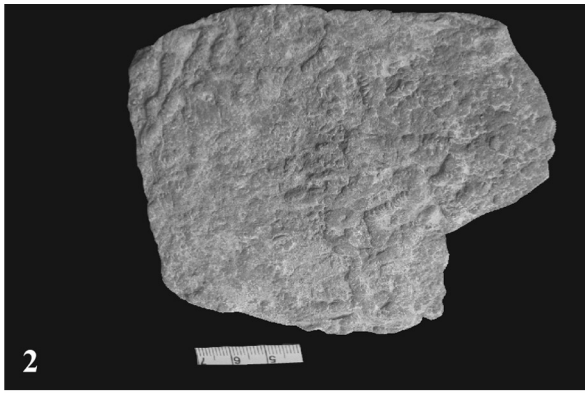
Figure 3- *Zoophycos* isp.
Endichnial semi-relief in medium-fine grained sandstone.
Korudağ-1 (Slope)-Korudağ-2 (Middle fan)

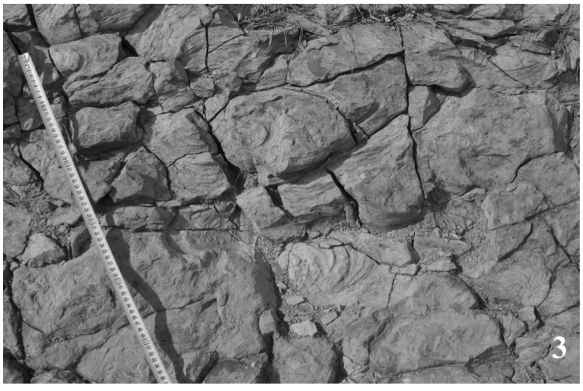
Figure 4- *Scolicia vertebralis.*
Exichnial semi-relief in fine grained sandstone.
Korudağ-1 (Distal of Middle fan-Outer fan)-Yeniköy (Outer fan).

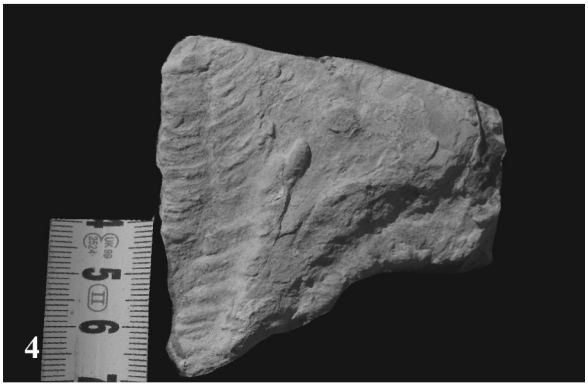
Figure 5- *Scolicia vertebralis.*
Exichnial semi-relief in fine grained sandstone.
Korudağ-1 (Distal of Middle fan-Outer fan)-Yeniköy (Outer fan).

Figure 6- *Scolicia prisca.*
Exichnial full-relief in fine grained sandstone.
Korudağ-1 (Distal of Middle fan-Outer fan)-Yeniköy (Outer fan).

PLATE - II







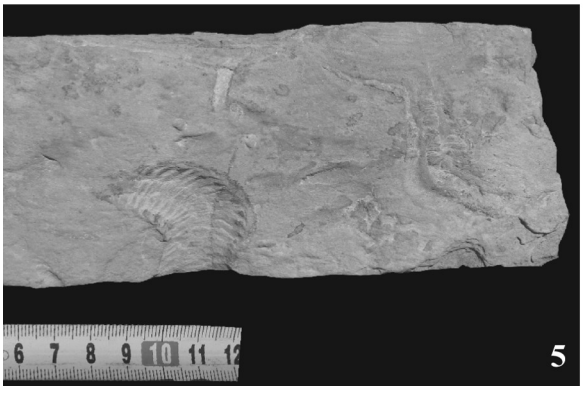


PLATE III

Figure 1- *Scolicia strozzii.*
Hypichnial semi-relief in fine grained sandstone.
Korudağ-1 (Distal of Middle fan-Outer fan)-Korudağ-2 (Middle-Outer fan)
Yeniköy (Outer fan).

Figure 2- *Nereites irregularis.*
Epichnial semi-relief in fine grained sandstone.
Korudağ-1 (Distal of Middle fan -Outer fan)-Korudağ-2 (Middle-Outer fan)
Yeniköy (Outer fan).

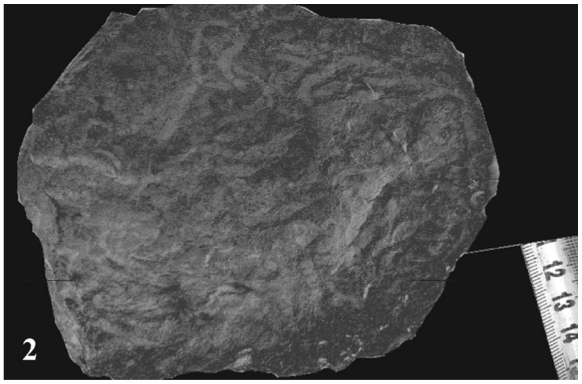
Figure 3- *Helminthoidichnites* isp.
Hypichnial semi-relief in fine grained sandstone.
Korudağ-1 (Distal of Middle fan-Outer fan)-Yeniköy (Outer fan).

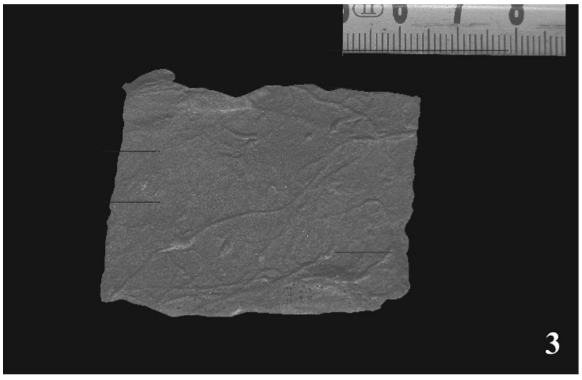
Figure 4- *Helminthopsis* isp.
Hypichnial semi-relief in fine grained sandstone.
Korudağ-1 (Distal of Middle fan -Outer fan)-Korudağ-2 (Middle-Outer fan)
Yeniköy (Outer fan).

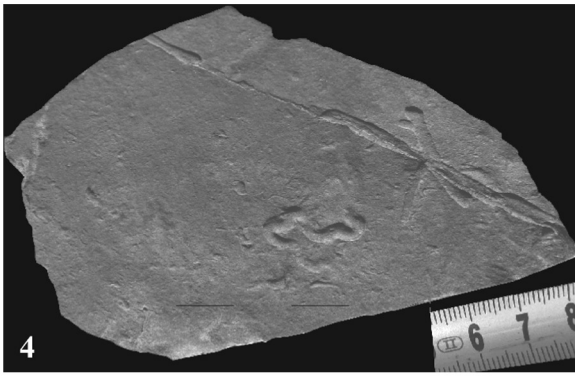
Figure 5- *Cosmorhaphe sinuosa.*
Hypichnial semi-relief in fine grained sandstone.
Korudağ-1 (Distal of Middle fan-Outer fan)-Yeniköy (Outer fan).

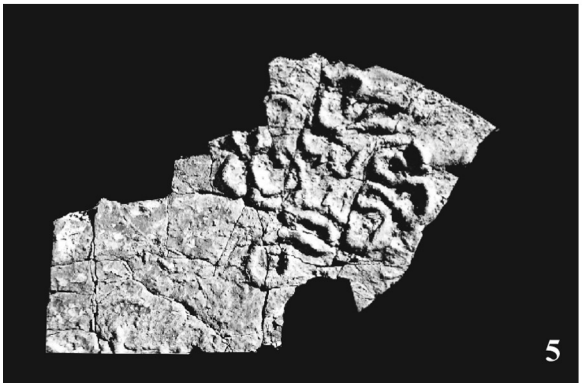
Figure 6- *Paleodictyon strozzii.*
Hypichnial semi-relief in fine grained sandstone.
Korudağ-1 (Distal of Middle fan -Outer fan)-Korudağ-2 (Middle-Outer fan)
Yeniköy (Outer fan).

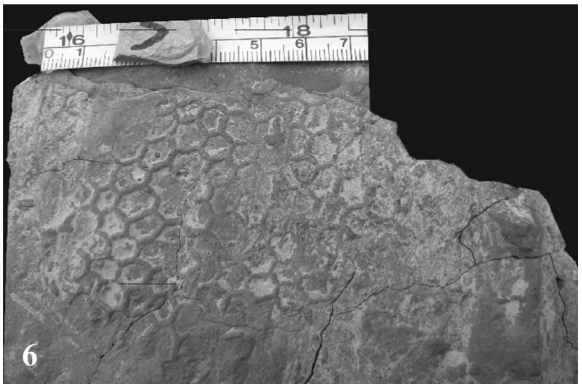
PLATE - III











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