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Seismic stratigraphy of the southeastern Black Sea shelf from high-resolution seismic records

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Abstract

High-resolution seismic reflection profiles obtained from the shelves off the Samsun and Trabzon coasts (southeastern Black Sea) have revealed the existence of two distinct reflectors (R and T).

Reflector R forms the boundary between the upper depositional sequence A and the lower depositional sequence B. Seismo-stratigraphically, upper sequence A is characterized by stratified (simple, complex and lenticular) seismic reflection configurations which imply changing depositional systems and/or conditions, changes of source and supply of sediments due to the relative change of sea level.

Additionally, the observed onlapping pattern within this sequence denotes rising of sea level during the last post-Glacial transgression. The mounded seismic facies beyond the steep gradients on the shelf area of Trabzon imply slump masses.

The lower depositional sequence B on the Samsun and Trabzon shelves is commonly characterized by chaotic reflection configurations which are interpreted either as strata deposited in a variable, relatively high energy setting, or as initially continous strata that have been deformed. Additionally, the presence of some parallel–subparallel reflections within this sequence denotes its stratified character. The upper boundary of sequence B (reflector R) reflects a pre-Holocene unconformity, probably caused by falling sea level at the time of the Last Glacial Maximum. Additionally, toplap termination at the upper boundary of sequence B indicates a stillstand of sea level at 91 m depth during the Last Glacial Maximum. Based on borehole data, sequence B is composed of consolidated sand and gravel admixtures in the Samsun area, and basalt-agglomerate-tuff series in the Trabzon area.

Reflector T forms the boundary of a zone of anomalous reflections (acoustic turbidity, AT) that are interpreted to represent gas in the sediments of the upper depositional sequence A. The gas accumulations tend to occur in "blanket" and "curtain" forms depending on their appearances on seismic records.

1. Introduction

The Black Sea is one of the world's largest marginal seas, with an area of 432,000 km^2, a volume of 534,000 km^3 and a maximum recorded depth of 2206 m (Ross, 1977). It is located between the Palaeozoic Russian Platform to the north and the folded Alpine belts of the Crimea, Caucasus and Pontics (Karadeniz Daglarì), to the north, northeast and south, respectively (Ross, 1977).

The deep Black Sea basins have become areas of increased activity with respect to various aspects of geology (e.g., Brinkman, 1974; Ross et al., 1974a; Ross and Degens, 1974; Schrader, 1978; Degens and Stoffers, 1980; Şengör and Yılmaz, 1981; Görür, 1988; Hay et al., 1991), geophysics (e.g., Neprochnov et al., 1974; Ross et al., 1974b; Letouzey et al., 1977; Zonenshain and Le Pichon, 1986) and geochemistry (Degens and Ross, 1974; Hirst, 1974; Müller and Stoffers, 1974; Çagatay

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et al., 1987; Degens et al., 1987; Calvert et al., 1991; Murray, 1991). However, the sedimentary geology of the southern (e.g., Özhan, 1989; Yücesoy and Ergin, 1992) and southeastern (Yücesoy and Ergin, 1992) shelf regions of this sea remained poorly understood.

This paper describes the seismic facies and stratigraphy, thickness, and major sedimentary sequences for the inner part of southeastern continental shelf of the Black Sea, based on interpretation of high resolution seismic profiles, borehole and sedimentological data, as well as correlation with the onshore geology.

2. Environmental and geologic setting

The two studied areas, off Samsun and Trabzon coasts of northeastern Turkey, are situated on the southeastern shelf of the Black Sea basin (Fig. 1). The southeastern Black Sea shelf, along the Turkish coast, is narrow, rarely exceeding 20 km in width and in most areas, the shelf edge generally is delineated by the 100 m isobath (Ross et al., 1974a; Aksaray, 1978; Fig. 2). The studied shelf

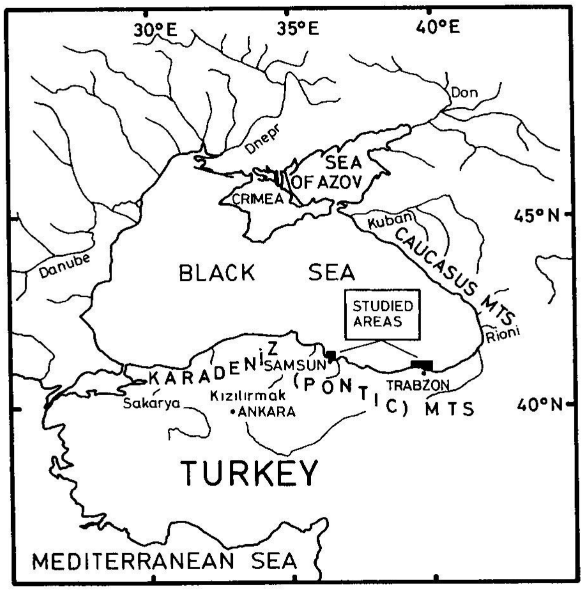

Fig. 1. Map showing the main physiographic features of the adjacent areas of the Black Sea including the seismic-surveyed marine regions, off Samsun and Trabzon coasts.

regions are bordered by a narrow coastal plain that in turn, is flanked further south by the East Pontic Mountains ("Dogu Karadeniz Dagları") with a maximum elevation of 3937 m (Fig. 2). To the north, the shelf extends down to a highly dissected slope, with a gradient typical of continental slopes (1:40) where erosion was the dominant process in the recent past, and possibly the present. In contrast to the two, large delta rivers (Kızılırmak and Yeşilırmak) of the west near Samsun (Fig. 3), the study area in the Trabzon region has numerous small, but extremely erosive rivers. The annual supply of sedimentary material to the Black Sea by all the rivers amounts to approximately 149.5×10^6 tons (Ross et al., 1978). About 11% of this amount (17×10^6 tons) comes from the rivers on the Turkish coast (Ross et al., 1978; Table 1).

Geologically, the evolution of the Black Sea basin can be considered to result from the openings of back-arc basins behind the volcanic island arcs of Pontides (Karadeniz Dagları) (Görür, 1988; Adamia et al., 1992) during three successive episodes, from Early–Middle Jurassic to Cretaceous–Early Palaeogene (Zonenshain and Le Pichon, 1986; Gealey, 1988).

The East Pontian Mountains are known to be sites of both widespread, intense submarine volcanic activity and flysh development lasting from Late Cretaceous to Eocene (Şengör and Yılmaz, 1983) and possibly to the end of the Pliocene

Table 1
River discharge into the southern Black Sea [compiled from EIE (1981, 1989) and DSI (1987)]

Rivers	Drainage area (km^2)	Average water discharge (m^3/s)	Average sediment discharge (kg/s)
Sakarya	55,322	186	37
Filyos	13,300	101	86
Yeşilırmak	35,958	178	225
Kızılırmak	75,121	183	345
İyidere	855	28	2
Fırtına	940	29	n.a
Melet	1859	27	n.a
Degirmendere	737	10	1

n.a. = no data available.

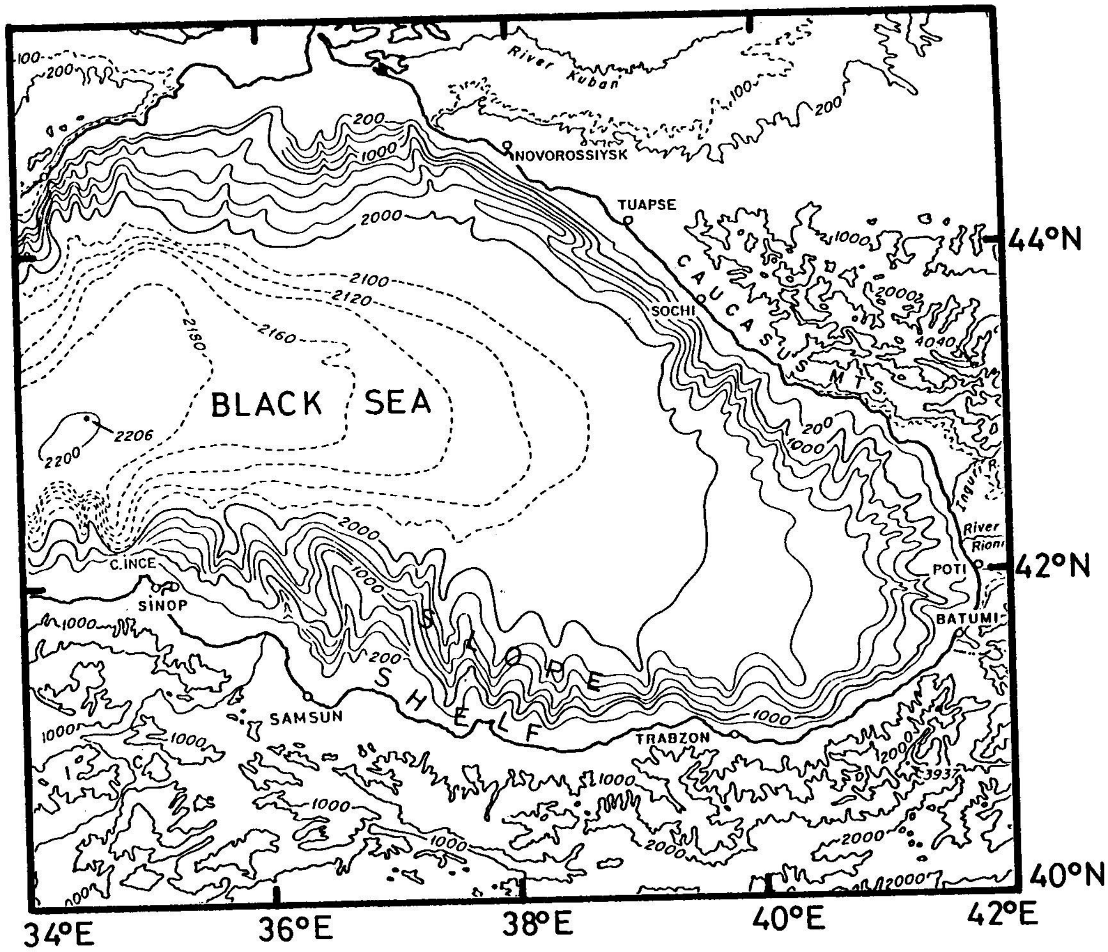

Fig. 2. Bathymetry of the eastern part of the Black Sea (contours are in meters). Note the change in contour intervals at 200 and 2000 m (modified from Ross et al., 1974a).

period (Brinkman, 1976). The Pontic Mountains, which developed at the end of the Eocene (Brinkman, 1974), have a crustal structure signature that is presently found to extend partially into the Black Sea (Shimkus and Malovitskiy, 1978), based on residual magnetic field studies (Ross et al., 1974b). In and around the study areas, between the Samsun and Trabzon coasts, volcanites (andesites, basalts, dacites), tuffs, agglomerates and flysh (limestone–marl, sandstone–siltstone) deposits are found to be predominant formations of Late Cretaceous to Eocene times (Erçin, 1971; Özkan, 1982; Karagöz, 1984; Fig. 3), possibly overlying the Palaeozoic basement (Göksu et al., 1974). A pronounced tectonic phase, starting mainly during the Plio-Pleistocene, resulted in the rapid subsidence of the deep Black Sea basins (due to isostatic adjustment of the underlying crust in response to a thick sedimentary cover) and it is still active today (Brinkman, 1974; Degens and Stoffers, 1980; Ergun et al., 1992), while along the coastal ranges (eastern Pontides) uplift and unroofing were at work. These epirogenic crustal movements, associated with uplift of East Anatolia and subsidence of West Anatolia, continued during the early Pleistocene (Letouzey et al., 1977; Shimkus and Malovitskiy, 1978). Thus, over much of the shelf, post-Eocene deposits are thin and reach a considerable thickness only in the deeper waters (Malovitskiy et al., 1976; Letouzey et al.,

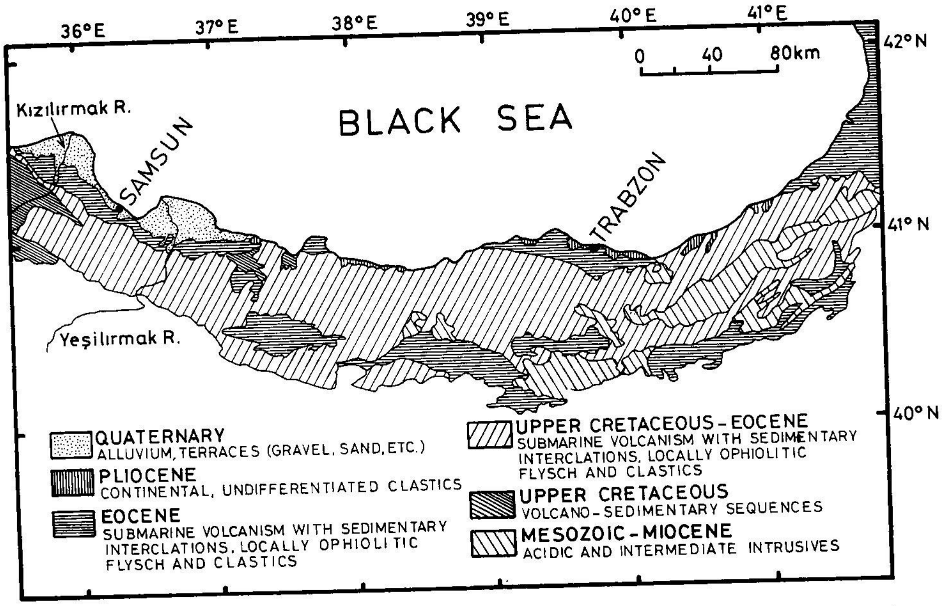

Fig. 3. Generalized geological map of the coastal hinterland of the Samsun and Trabzon regions (compiled from Gattinger et al., 1961; Göksu and Erentöz, 1962).

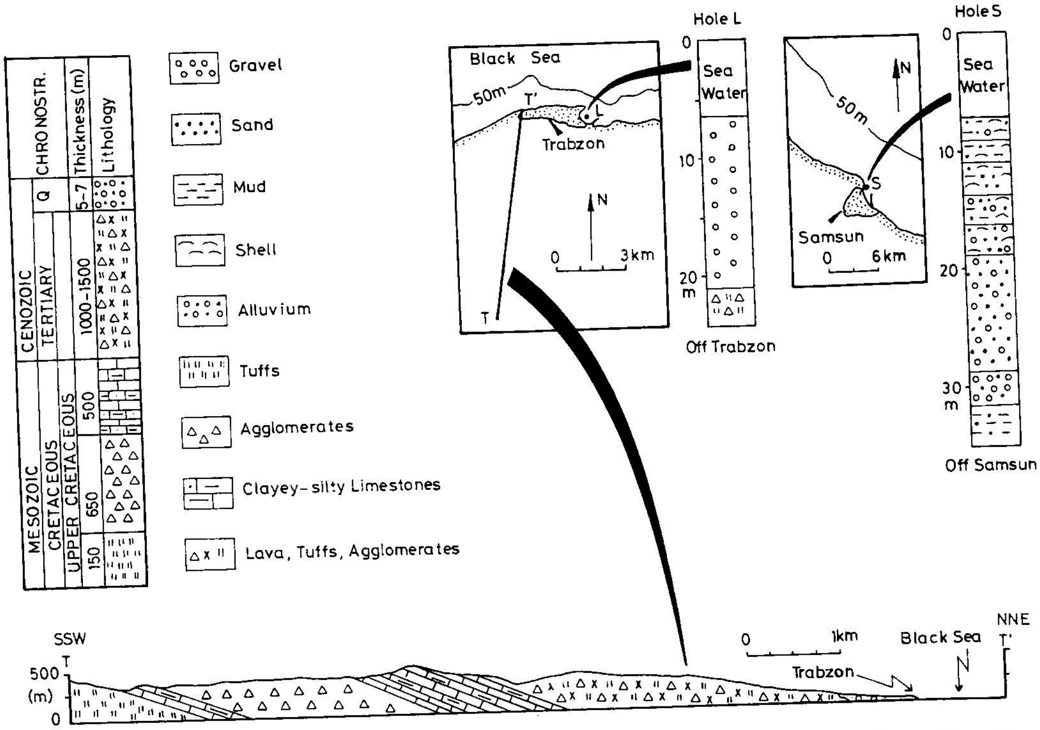

Fig. 4. Lithostratigraphy from two boreholes drilled in the vicinity of the Trabzon and Samsun harbours. Note the explanatory cross section along a SSW-NNE direction in the Trabzon area (compiled from unpublished reports of DLHİ Samsun, and TCK Trabzon, 1992).

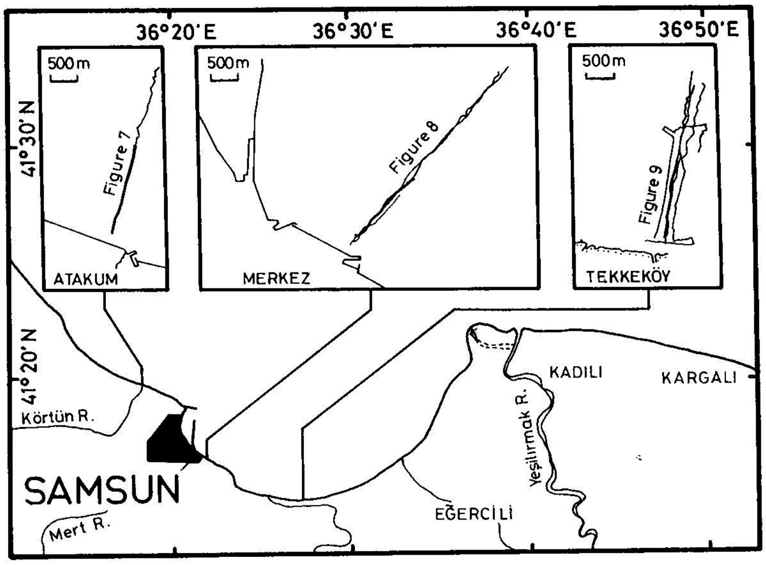

Fig. 5. Location map of the seismic reflection profiles obtained from the Atakum, Merkez and Tekkeköy regions on the shelf off Samsun. Bold lines denote the seismic reflection profiles inserted in the text.

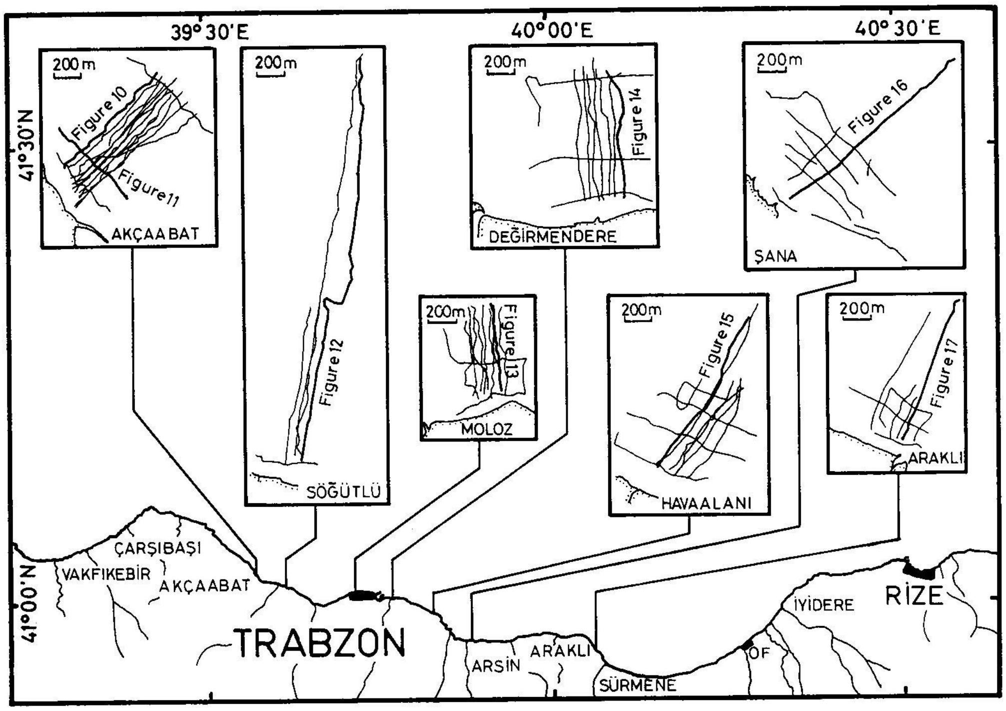

Fig. 6. Location map of the seismic reflection profiles obtained from the Akçaabat, Sögütlü, Moloz, Degirmendere, Havaalanı, Şana and Araklı regions on the shelf off Trabzon. Bold lines denote the seismic reflection profiles inserted in the text.

1977). For example, the Tertiary/Quaternary boundary is positioned in the deeper Black Sea at water depths of 2–3.5 km. Onland, this boundary is +100 to +300 m above sea level (Schrader, 1978; Degens and Stoffers, 1980; Meisner et al., 1992). Raised Plio-Quaternary terraces (with sediments usually 4–20 m thick), overlying Cretaceous–Eocene lavas and volcano-sedimentary units, imply significant uplift in the study areas, particularly in the Trabzon region where terraces are found at +5 to +300 m levels (Erçin, 1971; Özkan, 1982; Karagöz, 1984).

In the Trabzon region (Fig. 4), andesitic and basaltic lavas, tuffs and agglomerates of Late Cretaceous age reach a thickness of up to 1000 m which include 100–200 m thick flysh sequences mainly composed of greywackes, conglomerates, clays, marl and limestones. Similarly, the Eocene volcanites are found in the Trabzon area with thicknesses of up to 1000–1500 m as interbedded with flysh units (up to 300 m thick). Neogene deposits (mainly Pliocene) are widely distributed along the Trabzon coast and are composed of sandy, clayey and gravelly continental facies and marl sequences, while along the Samsun coast, Neogene conglomerates and sandstones also occur. Boreholes drilled in the offshore waters and on the coastal plain of Trabzon, close to the study area, have revealed 0–40 m thick Plio-Quaternary alluvium sequences overlying the late Tertiary basalt-agglomerate-tuff series (Fig. 4). In the Samsun region, the available borehole data seem to be insufficient to indicate any boundary between the volcanites/volcano-sedimentary units of Eocene and the overlying Quaternary series (Fig. 4). The lack of such an unconformity is probably due to increased input from the adjacent Kızılırmak and Yeşilırmak rivers which have built large alluvial

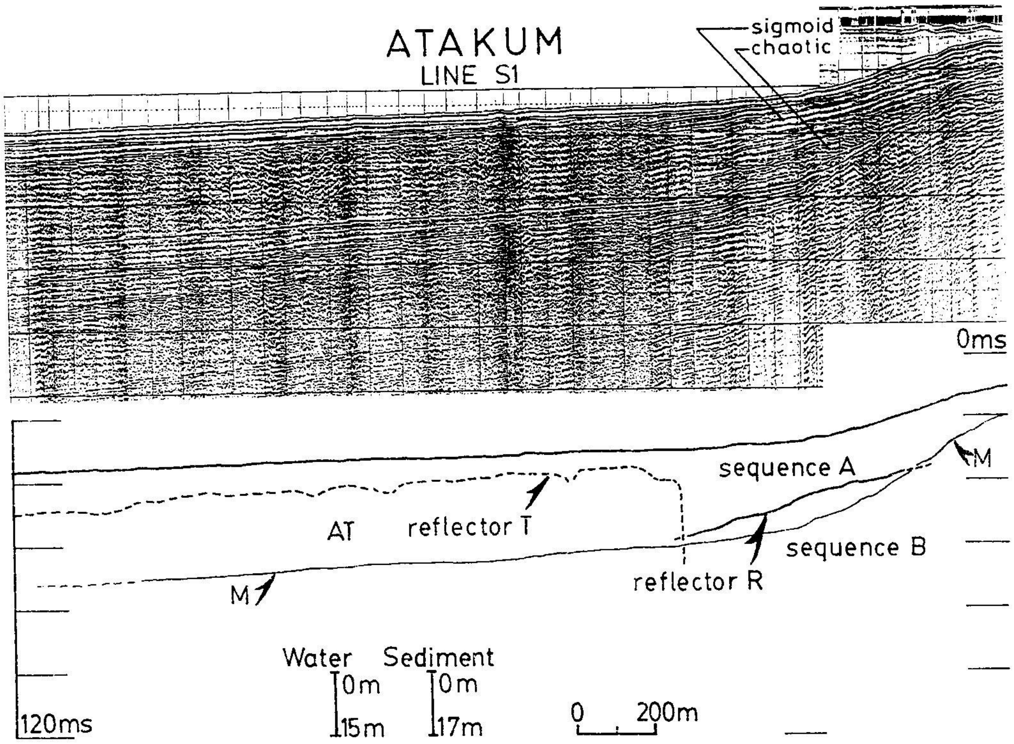

Fig. 7. High-resolution seismic profile (S1) off the Atakum coast near Samsun (location in Fig. 5). Note the reflection configurations, the prograding sigmoid nature of sequence A and the chaotic nature of sequence B. *AT*=acoustic turbidity appears as a blanket form from a water depth of 22.5 m towards the offshore; *M*=multiple.

(clays, sands and gravels) plains and deltas during the Quaternary, not only onshore but also offshore (Göksu et al., 1974).

3. Data acquisition

This study is primarily based on 95 line km high-resolution, shallow-seismic reflection profiles collected during cruises of the vessels *Temel Reis* and *Eyüpoglu* in the study area in January 1992 (Figs. 5 and 6). Ten different localities were studied. Off Samsun from west to east, these localities are Atakum, Merkez and Tekkeköy and are represented by seismic profiles S1 (Fig. 7), S2 (Fig. 8) and S3 (Fig. 9), respectively. Off the Trabzon coast the localities are Akçaabat, Sögütlü, Moloz, Degirmendere, Havaalanı, Şana and Araklı. Similarly, the seismic profiles representing these regions are designated as T1, T1-P, T2, T3, T4, T5 and T6 (Figs. 10–17).

An EG&G, broad band (400 Hz–14 kHz; 100–300 J) Uniboom seismic system was used throughout the surveys. Depth conversions from time sections were made using a sound velocity of 1500 m/s for water and 1700 m/s for the top 100 m of the sediments. The surveys were accompained by the precision depth recording (Raytheon) concurrently with the seismic profilings. Surface (0–8 cm) sediment samples were obtained with a Dietz LaFonde type grab sampler at 112 different stations and were analyzed using the standard grain-size determination methods described by Folk (1974) and Lewis (1984). Positioning was determined using a Del Norte Trisponder system. Interpretation of seismic sequences and reflection characters followed standard methods discussed by Mitchum et al. (1977), Sangree and Widmier (1977, 1979), Vail et al. (1977), Brown and Fisher (1977, 1980), Badley (1985), Boggs (1987) and Macdonald (1991). Sources of stratigraphic information were obtained from offshore and onshore

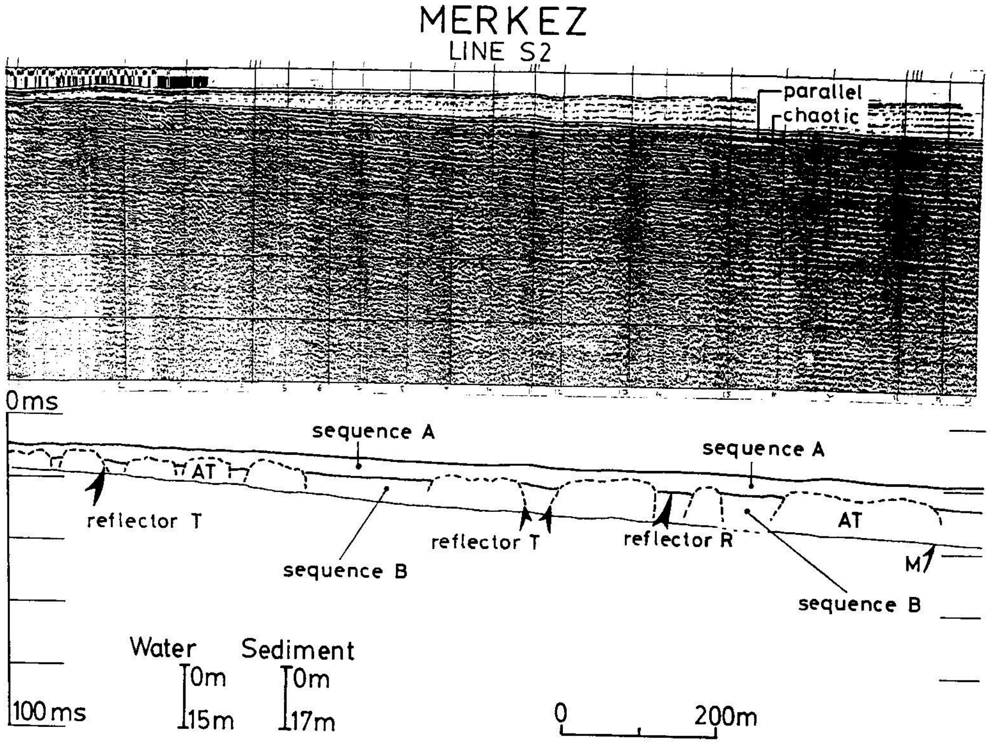

Fig. 8. High-resolution seismic profile (S2) off the Merkez coast near Samsun (location in Fig. 5). Note the reflection configurations, the parallel nature of sequence A and the chaotic nature of sequence B. *AT*=acoustic turbidity appears as curtain forms; *M*=multiple.

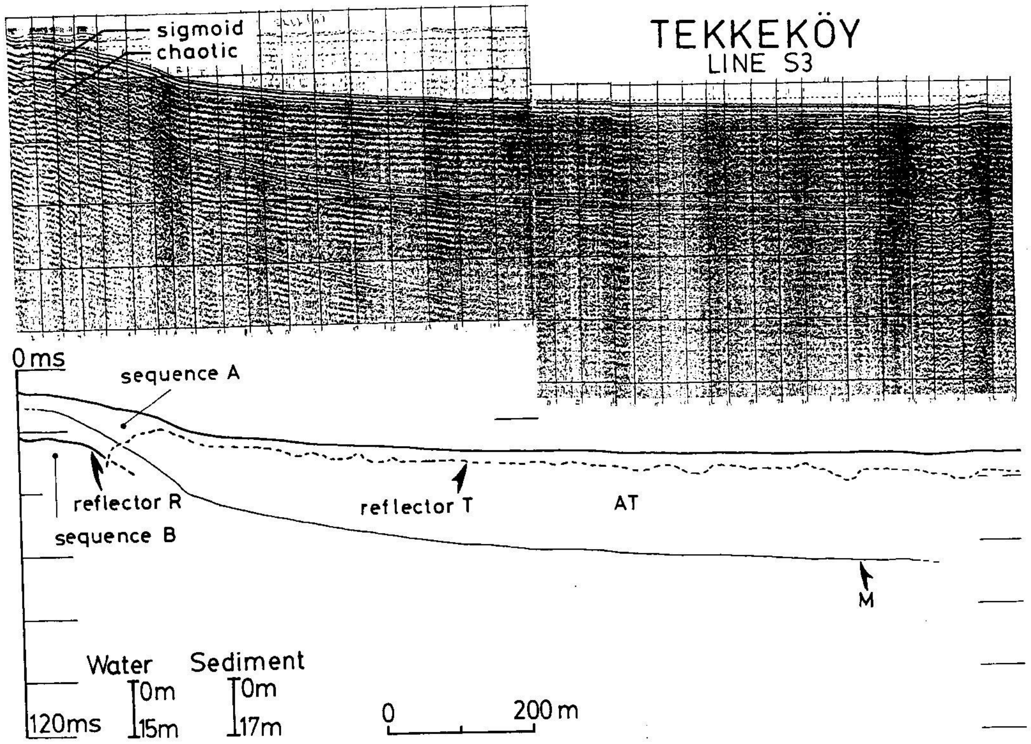

Fig. 9. High-resolution seismic profile (S3) off the Tekkeköy coast near Samsun (location in Fig. 5). Note the reflection configurations, the prograding sigmoid nature of sequence A and the chaotic nature of sequence B. *AT* = acoustic turbidity appears as a blanket form from a water depth of 7.5 m towards the offshore; *M* = multiple.

wells (Fig. 4). Correlations to boreholes are supported by other coastal well data close to the seismic surveyed track lines. To the west, at Samsun, the limitations in seismic interpretations combined with the limited well control for the coastal areas make correlations more speculative.

4. Results and discussion

4.1. Subbottom stratigraphy

High-resolution seismic reflection profiles obtained from the shelves off the Samsun (i.e. Figs. 7–9) and Trabzon (i.e. Figs. 10–17) coasts have shown that the subbottom stratigraphy is bounded by two reflectors, R and T.

Reflector R delineates the boundary between the two distinct depositional sequences A and B, which underlie the sub seafloor of the surveyed areas. Here, we define a depositional sequence as a seismic stratigraphic unit consisting of genetically related, conformable reflectors on seismic profiles; the unit is bounded at its top and base by unconformities or their correlative conformities. These units were identified by superposition and highly contrasting gross seismic reflection character of the depositional horizons.

Reflector T forms the boundary of a zone of anomalous reflections (acoustic turbidity, AT) which is interpreted to represent gas. The zone masks information in subbottom detail on many of the seismic profiles. Hence, our interpretation on depositional sequences in this text was concentrated on places where the acoustic turbidity was not present on the seismic profiles.

4.2. Sequence A

Depositional sequence A at its top is bounded by the present seafloor, and its bottom is delimited

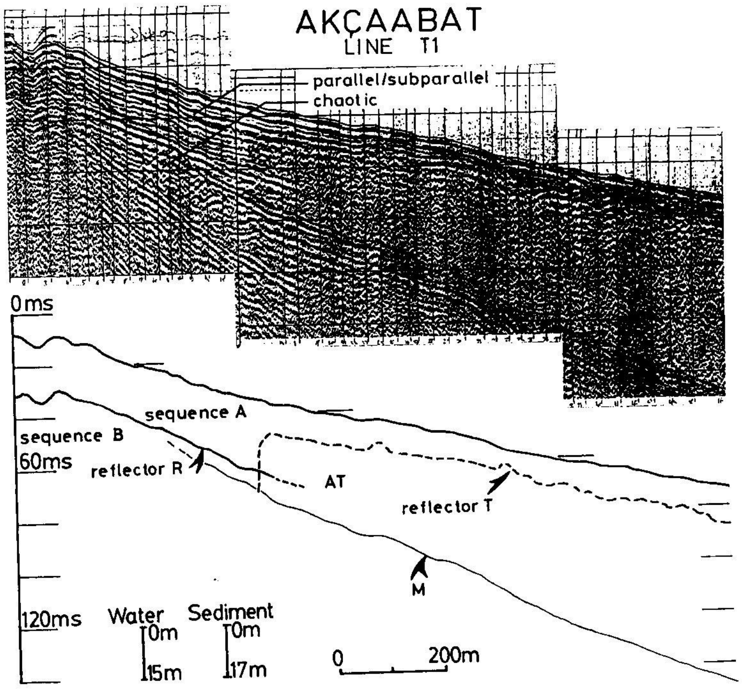

Fig. 10. High-resolution seismic profile (T1) off the Akçaabat coast near Trabzon (location in Fig. 6). Note the reflection configurations, the parallel–subparallel nature of sequence A and the chaotic nature of sequence B. *AT*=acoustic turbidity appears as a blanket form from a water depth of 26.5 m towards the offshore; *M*=multiple.

by reflector R (top of sequence B). Granulometric analysis of the surface sediments show that uppermost sequence A consists of slightly gravelly muddy sand in nearshore areas grading into mud offshore (Ergin et al., 1992a).

Sequence A exhibits simple (parallel), complex (prograding sigmoid) and lenticular stratified reflectors in the sub seafloor of Samsun area. Of these, prograding sigmoid configuration in the wedge shaped external form, which is interpreted as being of a deltaic or shallow water origin and possibly related to the high sediment input from the adjacent coastal rivers, can be observed at the nearshore sections of profiles S1 (Fig. 7) and S3 (Fig. 9). However, this peculiarity of sequence A on seismic profiles S1 and S3 is suddenly lost due to the masking effect of acoustic turbidity towards the offshore. Although masking intermittently appears along line S2 (Fig. 8), sequence A can be seen to have parallel reflection configuration having a wide-spread sheet like external form. This configuration is in response to a facies that formed under uniform rates of deposition on a uniformly subsiding shelf (cf. Brown and Fisher, 1977, 1980; Mitchum et al., 1977).

The thickness of sequence A on the Samsun shelf varies from 5 to 20 m (Figs. 7–9). Thick values appear to be associated with the prograding pattern of this sequence (shoreward section of seismic lines S1 and S3; Figs. 6 and 8).

Sequence A, in the nearshore zone off Trabzon, is commonly characterized by parallel–subparallel (T1, T1-P, T2, T4 and T5; Figs. 10–12, 14 and 15), and prograding sigmoidal (T3; Fig. 13) reflectors similar to that in Samsun. They have sheet-drape to wedge shaped external geometry. The parallel–subparallel reflectors of sequence A can be traced until the acoustic turbidity appears on seismic lines T1 (Fig. 10) and T4 (Fig. 14). However, these reflectors on seismic lines T2 and

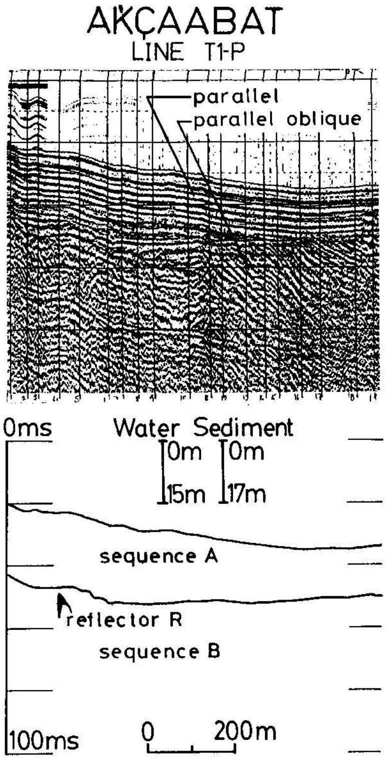

Fig. 11. High-resolution seismic profile (T1-P) oriented parallel to the coastline off Akçaabat near Trabzon (location in Fig. 6). Note the reflection configurations, the parallel of sequence A and the parallel oblique of sequence B. Note also that reflector R, cutting the stratified internal structure of the lower sequence B, represents an unconformity surface.

T5 (Figs. 12 and 15) continue after they had passed the acoustic turbidity zone. On the other hand, some chaotic patterns are also found along with the parallel–subparallel reflectors of sequence A beyond the acoustic turbidity zone on seismic lines T2 (Fig. 12). This may indicate heterogenous and coarse sediments which have accumulated in high energy settings (cf. Brown and Fisher, 1980; Mitchum et al., 1977).

On the other hand, prograding sigmoidal (T3; Fig. 13) reflectors of sequence A in the nearshore zone off Trabzon, terminate in a lenticular configurations offshore.

Other prominent characteristics off Trabzon are: the presence of a sill-like structure, the steep gradients of the continental slope and the extremely rugged bottom morphology beyond the continental slope.

The sill-like structure is located between the water depths of 30 and 45 m and has a relief of 15 m (T2; Fig. 12). On the seaward side of the structure, sequence A locally exhibits marine onlaps onto the underlying sequence B. Marine onlap may result from relative sea-level rise (Vail et al., 1977). These authors also concluded that marine onlap may occur where sea-level rise is more rapid than the rate of deposition. On the landward flank of the sill-like feature, a restricted fill seismic facies unit is present. This facies may have been deposited during a relative lowering of sea level in which the sill was exposed to erosion, and transport of debris material south.

The steep gradients of the continental slope of 12°, 15°, 13° and 14° are found on seismic profiles T2 (Fig. 12), T5 (Fig. 15), T6 (Fig. 16) and T7 (Fig. 17), respectively. Subbottom stratigraphy exhibits non-systematic reflection terminations so that reflector R has not been discriminated on the seismic profiles (Figs. 12 and 15–17).

The seafloor off Trabzon, beyond the steep gradients of the continental slope, is characterized by extremely rugged bottom morphology (Figs. 12 and 15–17). Although these irregular areas consist of parallel–subparallel and contorted internal reflectors, and reflection free, as well as side echoes, which prevent identification of reflector R on seismic profiles, their appearance is reminiscent of mounded seismic facies (conical to asymmetrical features) which characterize slump masses (Mitchum et al., 1977). Factors that contribute to the development of mounded seismic facies may include the reworking of sediments by the sliding and slumping processes along the steep gradients. Topographic studies, supplemented by sedimentary and seismic data (Ross et al., 1974b), clearly demonstrate that slumping and gravitational sliding have been and are important processes in the recent history of the Black Sea.

The thickness of sequence A in the nearshore of Trabzon varies from 20 to 8 m (Figs. 10–15). The thick values are generally observed on the eastern shelf (Figs. 10–12). The thickness of sequence A further offshore of Trabzon is generally less than 9 m (Figs. 13 and 15). Although thicknesses of up

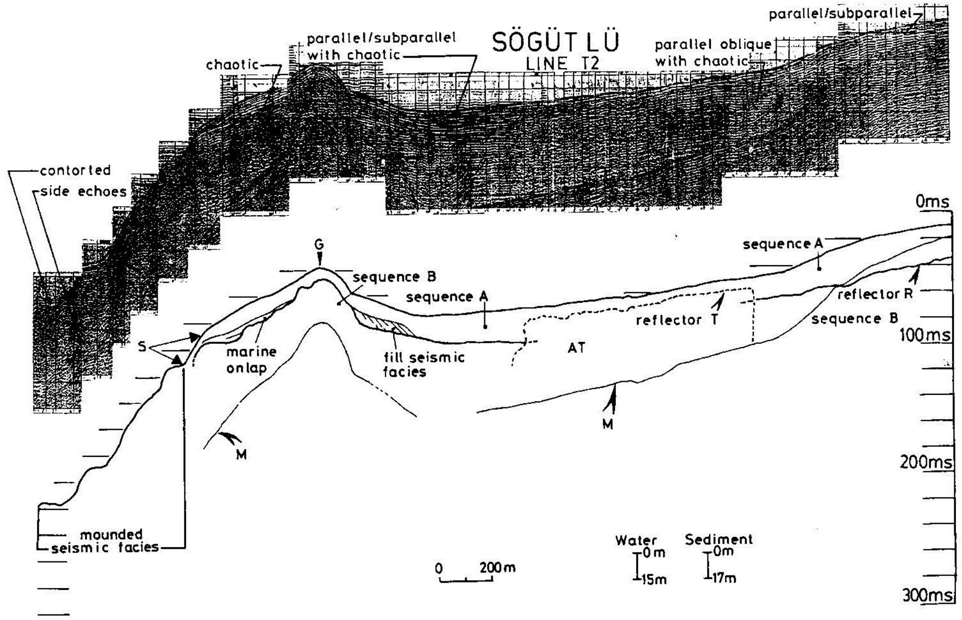

Fig. 12. High-resolution seismic profile (T2) off the Sögütlü coast near Trabzon (location in Fig. 6). Note the reflection configurations in nearshore section of profile, the parallel–subparallel of sequence A and the parallel oblique with chaotic of sequence B. Note also that reflector R represents an unconformity surface. *AT*= acoustic turbidity appears as curtain form between 36 and 52.5 m of water; *G*=the sill-like structure between 30 and 45 m of water; *S*=steep gradient (12°) between 67.5 and 82.5 m of water; *M*=multiple.

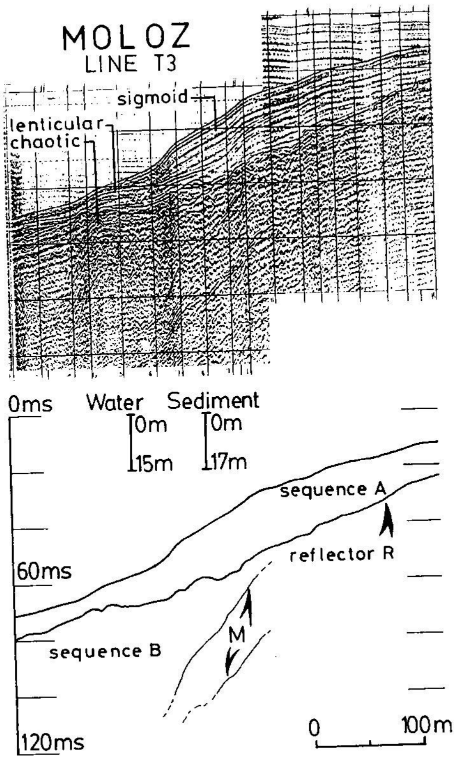

Fig. 13. High-resolution seismic profile (T3) off the Moloz coast near Trabzon (location in Fig. 6). Note the termination of reflection configurations in sequence A, from prograding sigmoid to lenticular. Sequence B displays chaotic reflection configurations. M = multiple.

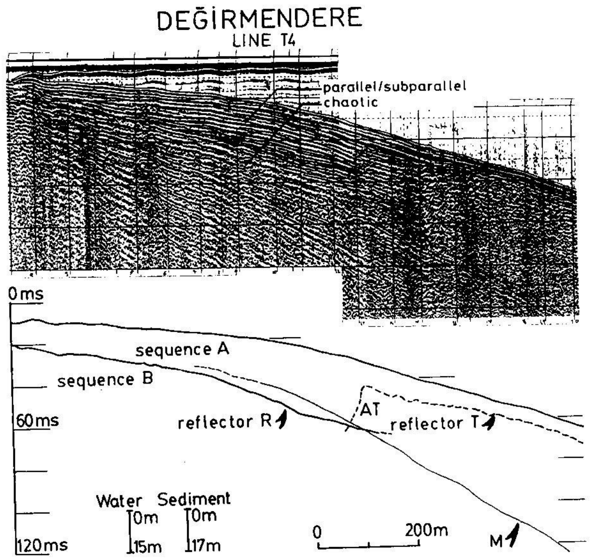

Fig. 14. High-resolution seismic profile (T4) off the Degirmendere coast near Trabzon (location in Fig. 6). Note the reflection configurations, the parallel–subparallel of sequence A and the chaotic nature of sequence B. AT = acoustic turbidity appears as a blanket form from a water depth of 24.75 m towards the offshore; M = multiple.

to 15–17 m are found locally, they suddenly thin out to 5 m towards the steep slopes.

4.3. Sequence B

Although a great part of lower sequence B underlying sequence A is masked by the acoustic turbidity zone, it is commonly characterized by chaotic reflectors which are interpreted either as strata deposited in a variable, relatively high energy setting; or as initially continous strata which have been deformed so as to disrupt continuity (Mitchum et al., 1977). Additionally, the presence of some parallel oblique reflections in some seismic profiles suggest some stratification of sequence B (cf. on shore parallel section of T1-P, nearshore section of T2 and offshore section of T6).

On these seismic profiles (Figs. 11–12 and 16) the top of sequence B, that is reflector R, represents an unconformity. Similar reflectors to R have been reported in many coastal areas, e.g. on the Korea Strait (Park and Yoo, 1988), offshore Mersin Bay (Okyar, 1991; Ergin et al., 1992b), on the Rhone continental shelf (Tesson et al., 1990), and in the North Sea (Salge and Wong, 1988), and represent the pre-Holocene surface at the time of the Last Glacial Maximum. In particular, reflector R which appears at 3 m below the present water depth of 88 m (total depth = 91 m) on seismic profile T6 (Fig. 16), exhibits a toplap termination with the seaward dipping reflectors of the underlying sequence B. This termination indicates a stillstand of sea level (Vail et al., 1977), that most probably occurred during the Last Glacial Maximum as the sea level dropped 90–140 m below the present level (e.g., Morner, 1971; Clark et al., 1978; Aksu and Piper, 1983; Coutellier and Stanley, 1987).

Based on results from boreholes (Fig. 4) close to the survey areas, we can accept with confidence that sequence B is composed of consolidated sand and gravel admixtures off Samsun, and

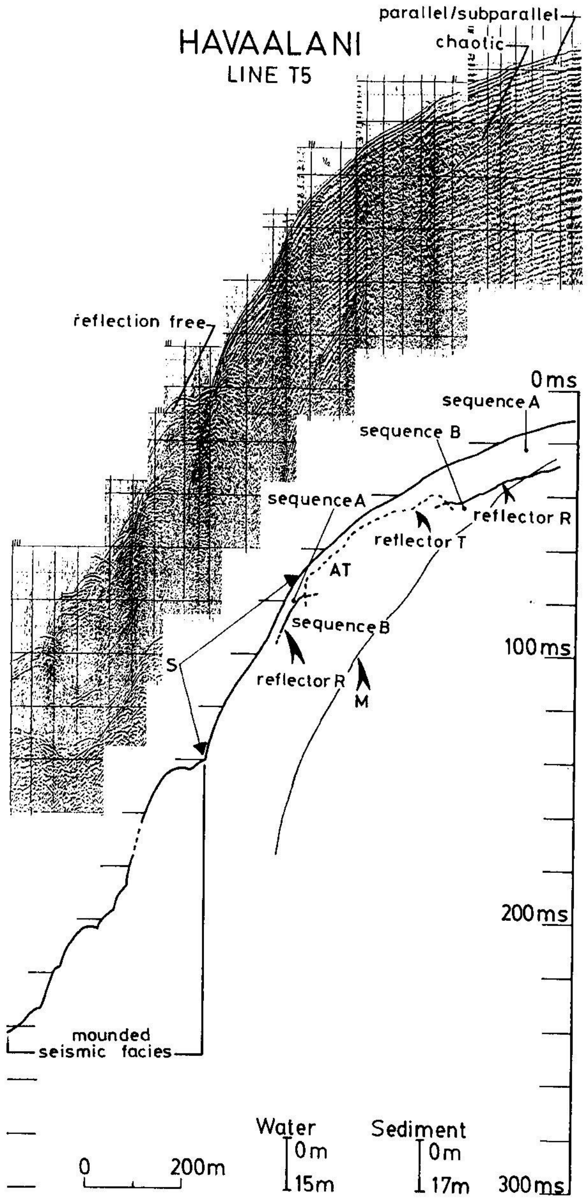

Fig. 15. High-resolution seismic profile (T5) off the Havaalanì coast near Trabzon (location in Fig. 6). Note the reflection configurations, the parallel–subparallel of sequence A and the chaotic sequence B. *AT* = acoustic turbidity appears as a curtain form between 21 and 50.3 m of water; *S* = steep gradient (15°) between 53 and 105 m of water; *M* = multiple.

basalt-agglomerate-tuff series off Trabzon. Thus, sequence B off Samsun reflects an alluvial sequence character while it represents the rock character off Trabzon.

4.4. Acoustic turbidity

Many of the high-resolution seismic profiles collected in the surveyed areas contain anomalous zones or sections that are similar to features described from other regions and are ascertained to be due to the presence of gas in the sediments (Carlson et al., 1985; Judd and Hovland, 1992; Taylor, 1992; Long, 1992; Hovland, 1992; Schubel, 1974; Korsakov et al., 1989). The term "acoustic turbidity" refers to those parts of the seismic section where subbottom detail is lost due to the effects of gas bubbles within the sediment pore space (Davis, 1992). The origin of the gas is attributed to either biogenic or thermogenic processes (or both). In both cases the gas is derived from organic material, with the biogenic process relying on bacterial activity and the thermogenic process being essentially temperature and pressure dependent (Davis, 1992).

On the records that we have examined the gas accumulations tend to occur in two main forms "blanket" and "curtain" (cf. Taylor, 1992) depending on their appearance on seismic records. The former covers a large area of the subbottom and its horizontal extent is greater than 1 km (Figs. 7, 9, 10, 14 and 16). The curtain form is characterized by an inverted "U" shape, and intermittently appears on seismic records (Figs. 8 and 12); its horizontal extent is less than 1 km. According to Taylor (1992), the mode of formation of these features is not clear. Korsakov et al. (1989), who carried out some geophysical investigations in the Black Sea, reported that the trapped gas in the upper sedimentary layers could be responsible for this.

5. Conclusions

The following points summarize the salient findings of the present study:

(1) High resolution, seismic reflection profiles reveal that subbottom stratigraphy of the shelves off Samsun and Trabzon usually consists of two sequences bounded by reflectors R and T. Reflector R, which represents the pre-Holocene surface,

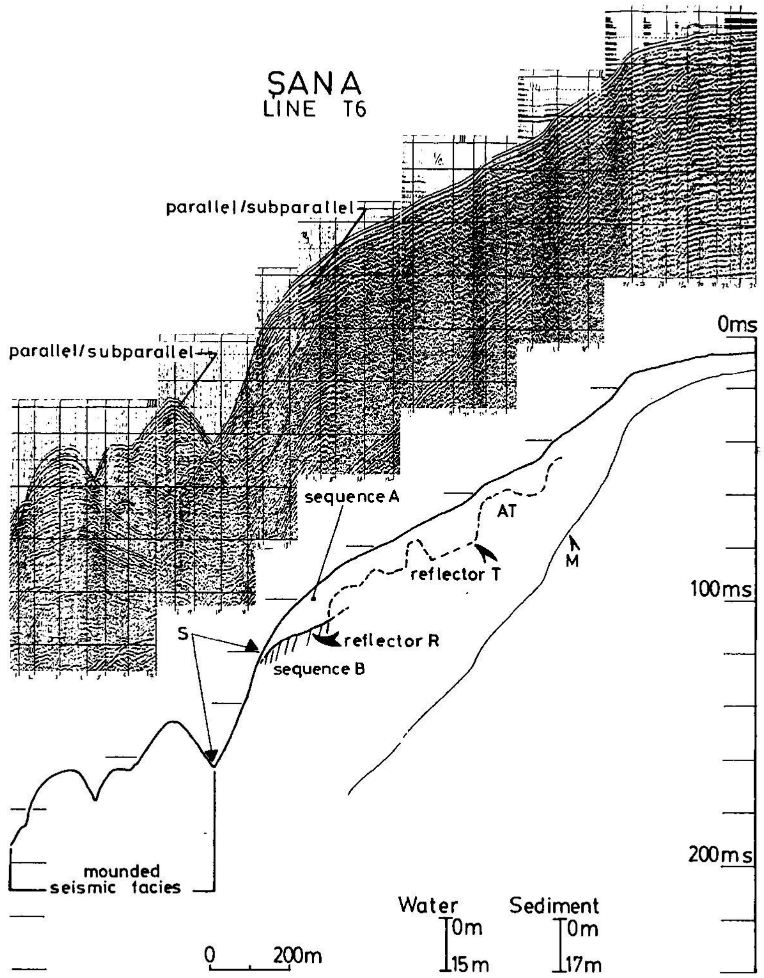

Fig. 16. High-resolution seismic profile (T6) off the Şana coast near Trabzon (location in Fig. 6). Note the acoustic turbidity (AT) as a blanket form covers a great part of the record from the nearshore towards a water depth of 68.3 m. Note that reflector R at a depth of 91 m exhibits a toplap termination with sequence B. S=steep gradient (13°) between 90 and 124 m of water; M=multiple.

delineates the boundary between depositional sequences A and B.

(2) The upper sequence A exhibits simple (parallel), complex (prograding sigmoid) and lenticular stratified reflectors. These configurations are in response to changing depositional systems and/or conditions, changes of source and supply of sediments due to fluctuations of the sea level.

(3) An onlap seismic facies within sequence A denotes rising of sea level during the last post-Glacial transgression.

(4) The Trabzon shelf extends to the slope where gradients range between 12° and 15°.

(5) Mounded seismic facies, which start immediately beyond the slope, indicate slump masses.

(6) The thickness of sequence A varies from 5 to 20 m with thick values associated with a progradational succession on the Samsun shelf, and the eastern shelf of Trabzon.

(7) The lower depositional sequence B is commonly characterized by chaotic reflectors which are interpreted either as strata deposited in a

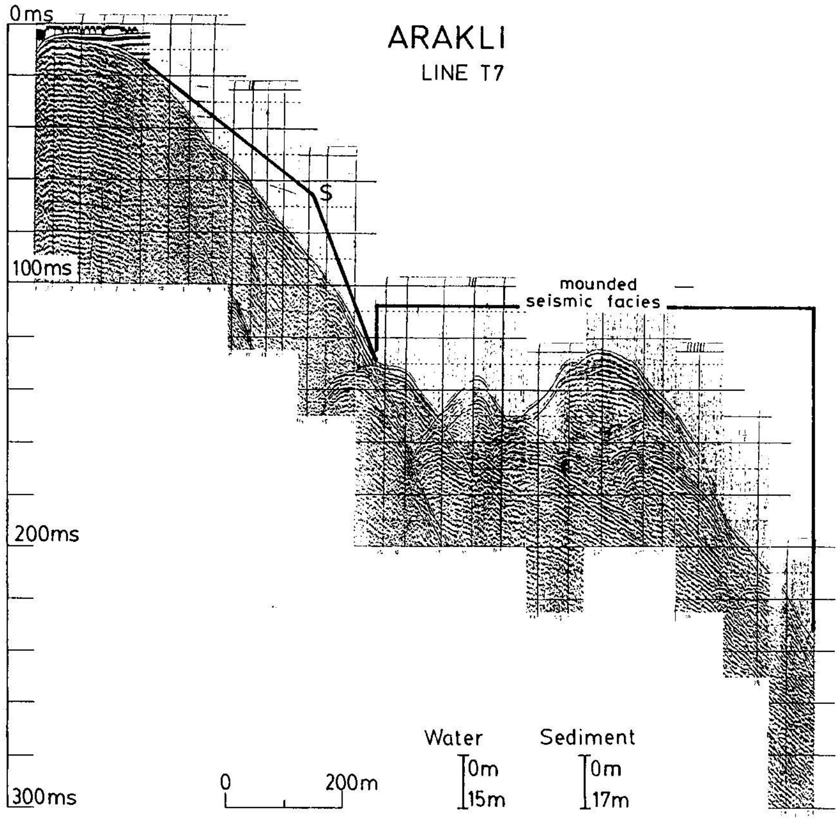

Fig. 17. High-resolution seismic profile (T7) off the Araklı coast near Trabzon (location in Fig. 6). Reflector R has not been discriminated on this profile due to non systematic reflection terminations below the surfaces of steep gradient (S = 10°) between 11 and 82.5 m of water.

variable, relatively high energy setting, or as initially continous strata that have been deformed. Additionally, the presence of some parallel–subparallel reflections within this sequence denotes its original stratified character.

(8) The upper boundary of sequence B is an erosional unconformity (reflector R), probably caused by falling sea level at the time of the Last Glacial Maximum with a toplap termination at the upper boundary of sequence B at 91 m depth indicating a stillstand of sea level during the Last Glacial Maximum.

(9) Based on borehole data, sequence B is composed of consolidated sand and gravel admixtures in Samsun area, and basalt-agglomerate-tuff series in Trabzon area.

(10) Reflector T forms the boundary of an "acoustic turbidity zone" which is interpreted to represent gas in sequence A sediments. Gas accumulations tend to occur in two main forms "blanket" and "curtain" on the seismic records.

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