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Seismic stratigraphy of Late Quaternary sediments of western Mersin Bay shelf, (NE Mediterranean Sea)

Mahmut Okyar [a,*], Mustafa Ergin [b], Graham Evans [c,d]

[a]Institute of Marine Sciences, Middle East Technical University, Erdemli, Mersin, 33731 Turkey
[b]Geological Research Center for Fluvial, Lacustrine and Marine Environments, Faculty of Engineering, Ankara University, Tandoğan, Ankara, 06100 Turkey
[c]Department of Geology, Royal School of Mines, Imperial College, London SW7 2BP, England
[d]Department of Oceanography, University of Southampton, Southampton SO9 5NH, England

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Abstract

High-resolution shallow seismic-reflection profiles obtained from the western Mersin Bay have revealed the existence of the two distinct depositional sequences (C and B) lying on a narrow and relatively steeply-sloping continental shelf which mainly receives its sediments from the ephemeral rivers. The upper Holocene sedimentary sequence (C) is characterized by stratified (simple to complex) to chaotic reflection configurations produced by the development of a prograding wedge of terrigenous sediment. Particular occurrences of slope- and front-fill facies and the lack of a sharp boundary, which has, however, been observed on the western shelf of this bay, between the Early Holocene and latest Pleistocene deposits are related to possible movement of underlying deposits due to local gravity mass movements or synsedimentary tectonics due to adjustment of the underlying evaporites in adjacent basin. The maximum thickness of the topmost sequence C is associated with the Tarsus–Seyhan delta, which lies to the northeast of the area and is prograding along the shelf. Other variations in thickness (5–40 m) of this topmost sequence are related to the variable sediment discharge along the coast, and the distance from the coast. It is at a maximum (40 m) in the nearshore area just west of the Lamas river mouth and at a minimum (5–15 m) in the offshore area.

The lower depositional pre-Holocene sequence (B) is characterized by continuous to wavy reflection configurations and how some cyclicity, suggesting coarse, heterogeneous sediments deposited under high energy conditions (fan-deltas) of Plio-Pleistocene age.

The combined interpretation of seismic reflection profiles with the available bore-hole data reveals the existence of a widespread Miocene acoustic basement (A) off the Susanoğlu–Tırtar coasts and Karapınar–Gilindirez rivers mouths. Unusual features in some profiles suggest the escape of coastal freshwater into the accumulating sediment.

Keywords: Holocene; Late-Quaternary; shallow seismic; depositional sequence; Cilicia Basin; Mersin Bay

* Corresponding author. Fax: +90 324 521 23 27.
E-mail address: okyar@ims.metu.edu.tr (M. Okyar).

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1. Introduction

The study area, continental shelf of the Mersin Bay, is situated in the Cilicia Basin in the northeastern Mediterranean Sea. It extends seaward to depths of approximately 200 m (Fig. 1).

The shelf of Mersin Bay gradually widens, from 8.4 km near the Göksu River delta in the west to 43 km off the Seyhan River delta in the east (Fig. 1). This peculiarity reflects the greater sediment supply to the shelf from the rivers of Deliçay, Tarsus, and Seyhan in the east, in comparison to the smaller supply from the rivers of Göksu, Lamas, and other ephemeral rivers between Silifke and Mersin in the west (Figs. 1–3).

Previous singe channel high resolution seismic reflection surveys (e.g. IMS, 1986a; Bodur and Ergin, 1989; Ergin et al., 1989; Bodur and Ergin, 1992; Okyar et al., 1992) have been conducted in the nearshore waters (in depths less than 20 m) of the eastern Mersin Bay. More extensive seismic coverage, reaching up to about 200 m depth, over the shelf of the Mersin Bay includes the works of Okyar (1991) and Ergin et al. (1992). Apart from these high resolution seismic reflection surveys, detailed air-gun seismic reflection profiles with deep penetrations (up to 1200 ms TWT) were collected in the Cilicia–İskenderun Basins (Aksu et al., 1992).

Surprisingly, however, the alluvial fan-deltaic deposits on the narrow shelf of western Mersin Bay have been very poorly studied (Okyar, 1991). The aim of this paper is, therefore, to investigate the subbottom seismic stratigraphy and the distribution

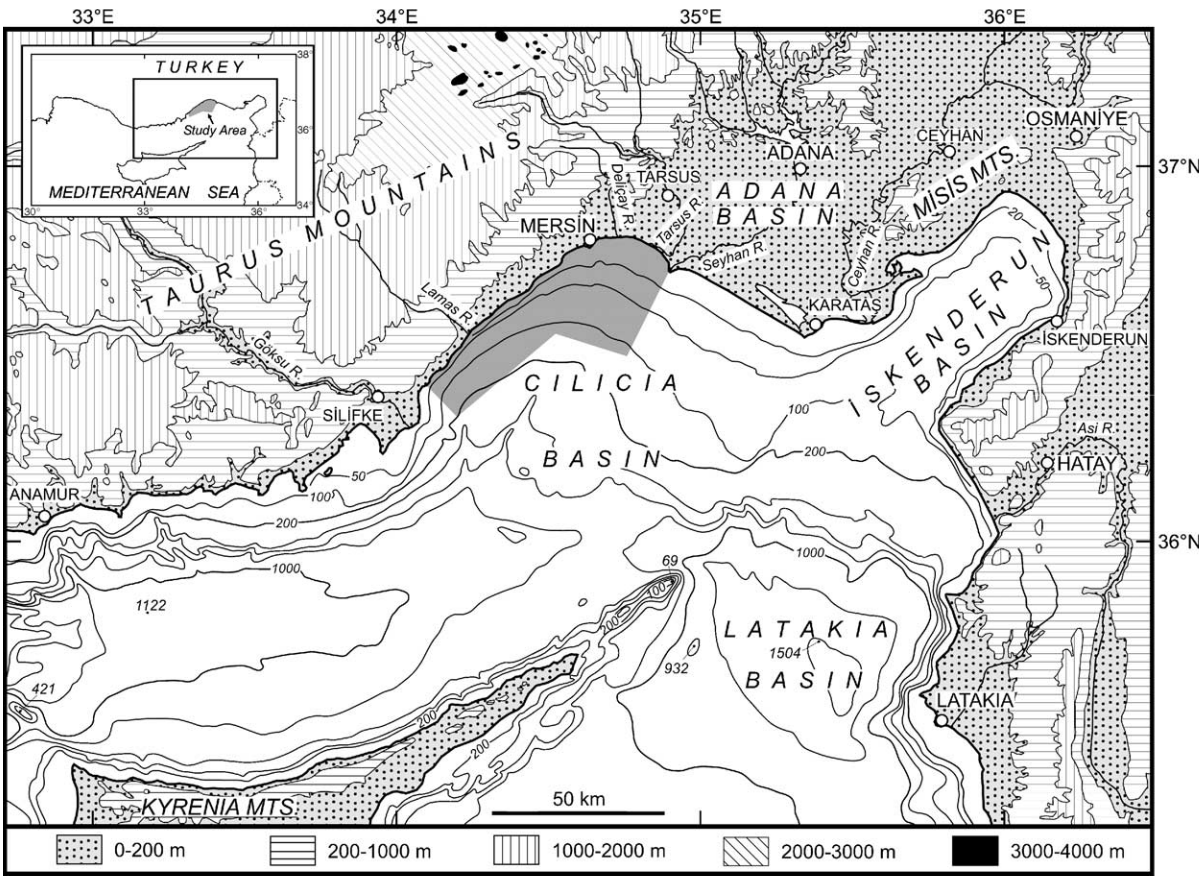

Fig. 1. Location map of the study area (grey shaded) showing the bathymetry, topography and main physiographic features of the northeastern Mediterranean region (modified from IOC, 1981). Isobaths are in metres.

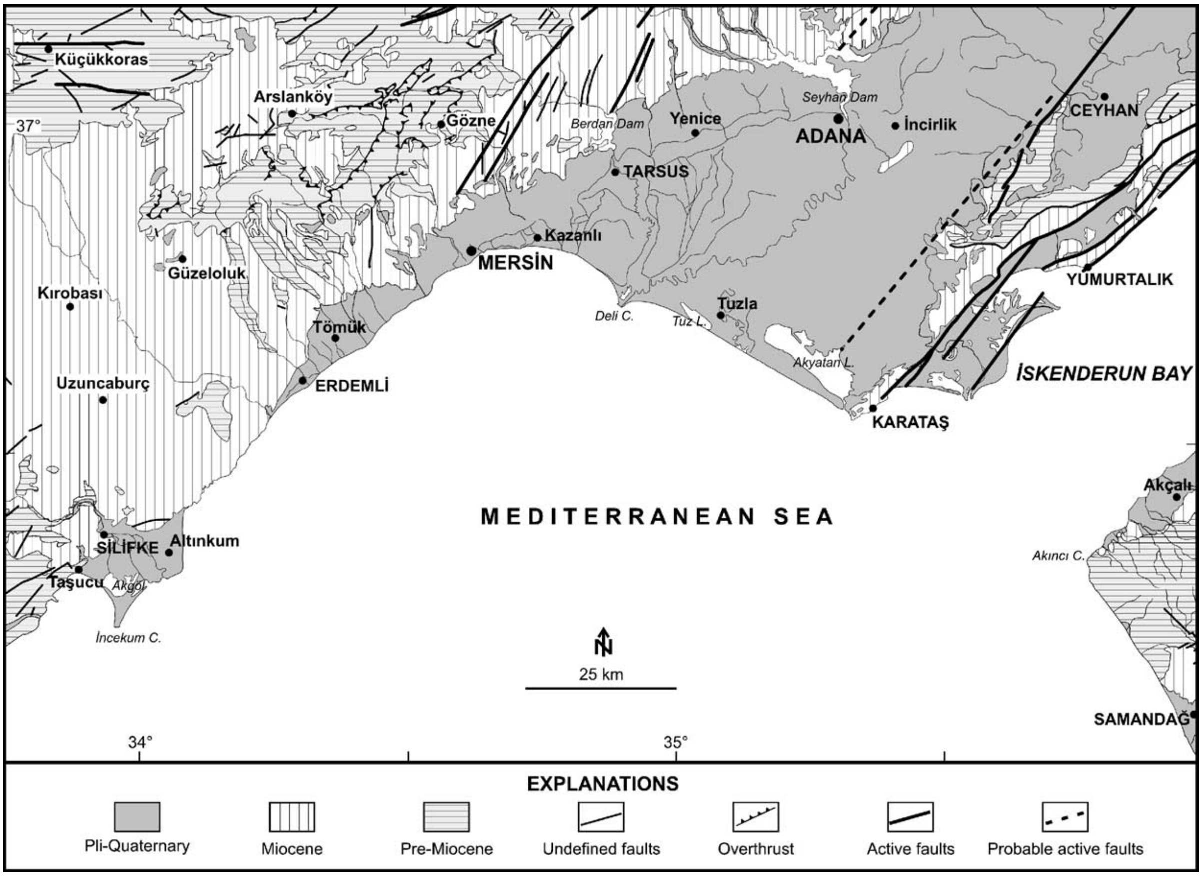

Fig. 2. Geological map of the area surrounding Mersin Bay (modified from MTA, 2002).

pattern of the related depositional sequences in response to the various topographic, hydrographic and climatic factors that prevailed during the Late Quaternary history of the Mersin Bay. Although emphasis is placed on the western part of the Mersin Bay where the narrow coastal, alluvial plain is supplied by ephemeral rivers passes southwestward into a rocky coastal area cut by numerous rivers and streams, content also includes the eastern Mersin Bay, considering previous work by Ergin et al. (1992). Therefore, this article is intended to be complimentary to those presented earlier by Aksu et al. (1992) and Ergin et al. (1992) as it contributes a new data on the seismic stratigraphic interpretation of the Late Quaternary sediments of the western Mersin Bay located in previously un-surveyed area of the Cilicia Basin.

2. Geologic and hydrographic settings

The coast of the Mersin Bay adjacent to the area under discussion may be divided into several physiographic provinces (Evans, 1971). These are (from southwest to the northeast): the fluvio-deltaic plain of the Göksu River; the rocky coast with small pockets of alluvium and pocket beaches near the mouths of small ephemeral streams of the Susanoğlu–Erdemli stretch; the narrow alluvial Mersin plain composed of small coalescing alluvial fans fed by several mainly ephemeral streams, the largest of which is the Deliçay; and the wide, fluvio-deltaic plain of the combined Tarsus, Seyhan and Ceyhan rivers (Figs. 2 and 3).

The shelf of the Mersin Bay occupies the northwestern flank of the contiguous onshore Adana Basin–offshore Cilicia Basin (Fig. 1). These two basins lie

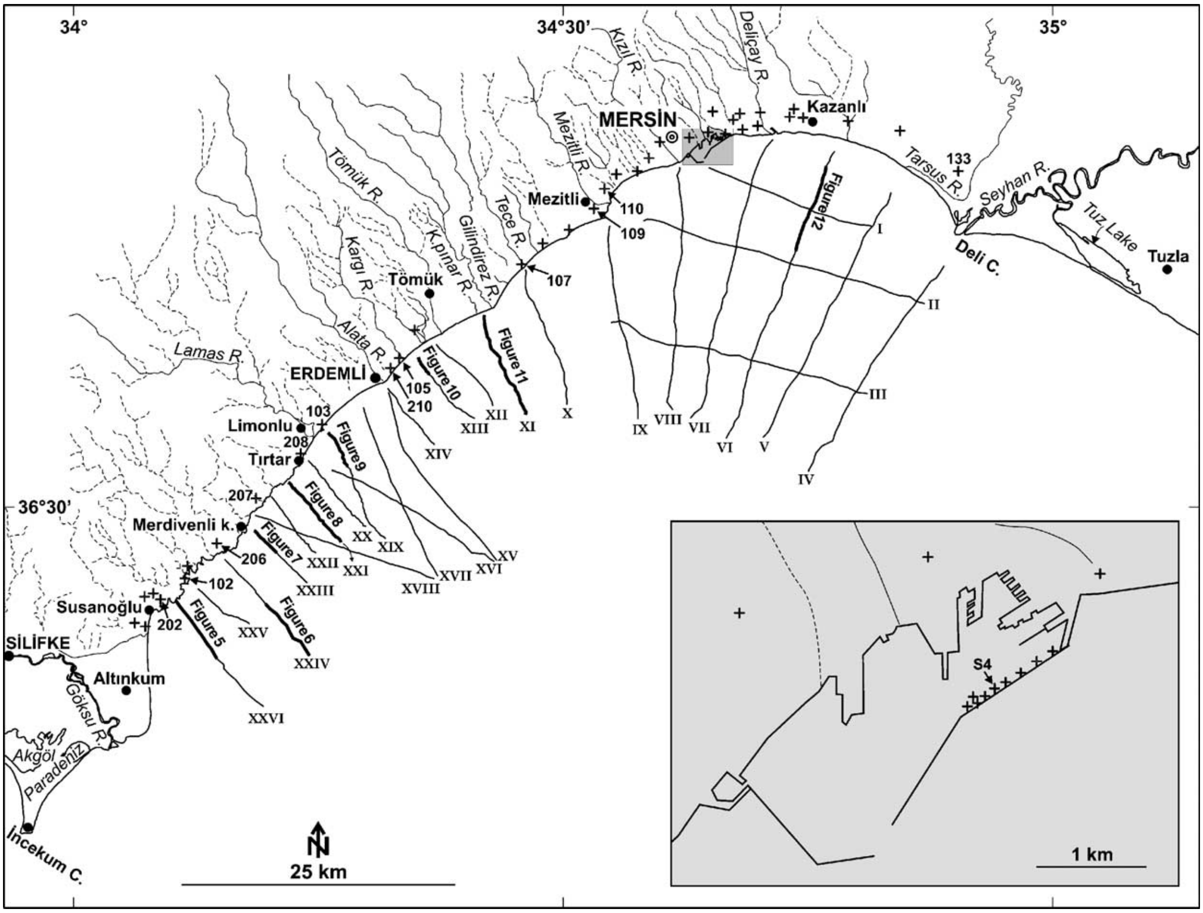

Fig. 3. Location map of the seismic survey lines (I–XXVI). The seismic reflection profiles discussed in the text are given in solid lines (Figs. 5–12); and the seismic reflection profiles used in previous publication by Ergin et al. (1992) are numbered with I–XI. Borehole locations are marked with plus signs. The numbers (202, 102,133, S4, etc) denote the location of lithological logs from the boreholes discussed in the text (see also Fig. 4). Also shown in an inset are the locations of offshore boreholes.

just to the north of the boundary of the Eurasian and Africa plates (McKenzie, 1970). The geology of the adjacent coastal region of the area (Fig. 2) is dominated by Plio-Quaternary deposits overlying the Late Tertiary [mainly Neogene (Miocene)] limestones, marls, sandstones and conglomerates (DSİ, 1978; and unpublished data). The Plio-Quaternary deposits are characterized by terrace deposits, alluvium, slope debris, alluvial fans and travertine.

The Plio-Quaternary deposits on the coastal plain show considerable variations in thickness. They are greater than 1 km in the wells drilled in the vicinity of the Seyhan River (e.g. Schmidt, 1961). The minimum thickness of these deposits is found along the south-western coast, where Miocene limestones commonly crop-out (Figs. 3 and 4). Extending southward, below the Mediterranean Sea, the Plio-Quaternary sequences range in thickness from 250 m (on the shelf/upper slope beyond the shelf platform; Fig. 1, cf. Stanley, 1977) to 1–2 km (Stanley, 1977; Woodside, 1977; Özhan, 1988).

Surface sediments of Mersin Bay are composed of a narrow belt of coarse sediment which quickly passes seawards largely into mud which locally has high proportions of biogenic constituents (Shaw and Bush, 1978; Ediger, 1991).

Mersin Bay is characterized by a general cyclonic circulation of a dominant westerly flowing shelf current

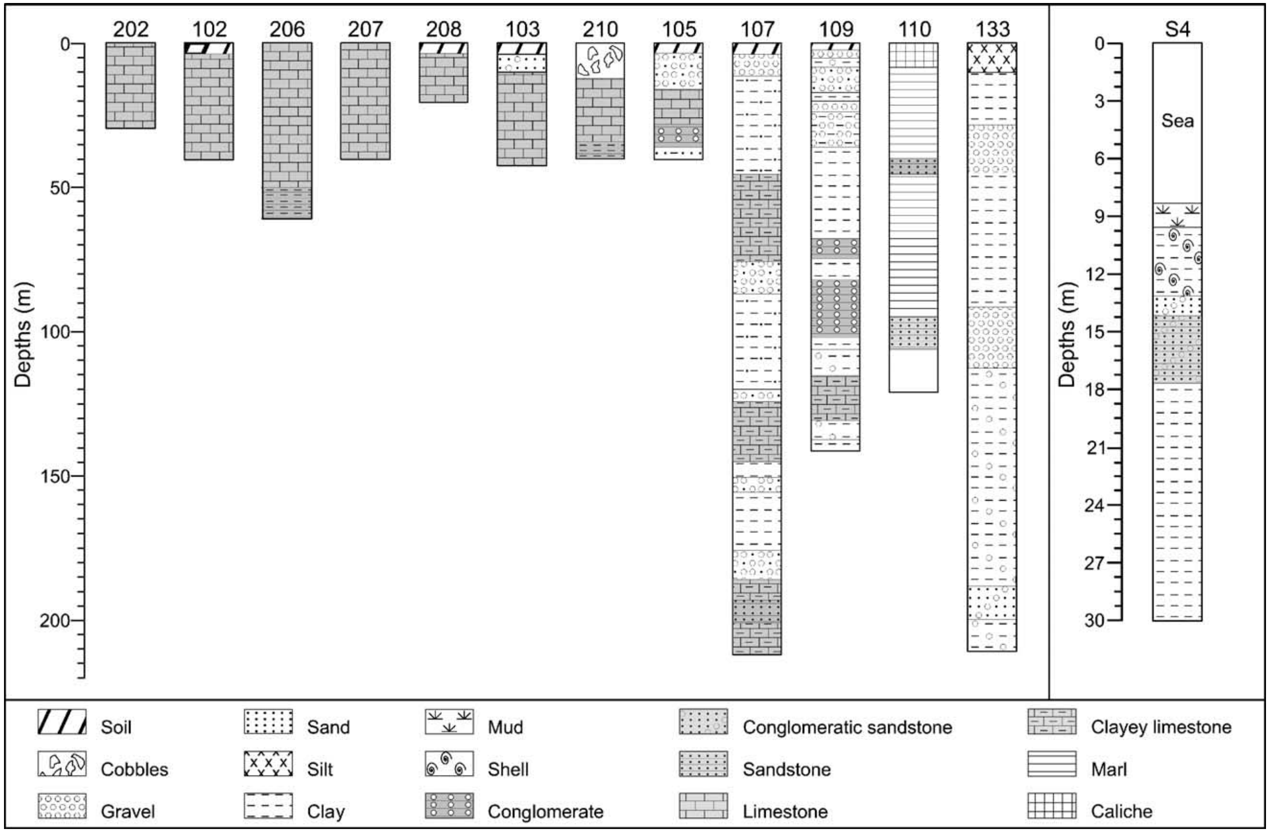

Fig. 4. Lithological logs of the boreholes (see Fig. 3 for location).

system (Lacombe and Tchernia, 1972; Ünlüata et al., 1978). However, several minor anticyclonic and cyclonic circulation systems, which may extend to the shelf edge, are produced by local winds and coastal morphology (Collins and Banner, 1979). The near-surface current velocities vary between 10 and 30 cm/sec, although much greater fluctuations occur (3–57 cm/sec) under changing hydrographic conditions (IMS, 1986b). Tidal range variations are in the order of 65 to 90 cm (Bal and Demirkol, 1987/1988). Wave action is limited in summer, but in winter waves with heights of 1–2 m are common especially under the influence of southwest and sometimes southeast winds.

3. Materials and methods

The seismic data used in this work were collected during four cruises of the "R/V Lamas" and "R/V Erdemli" of the Institute of Marine Sciences between the years of 1985 and 1989. An "EG and G" Uniboom high-resolution reflection-profiling system was utilized to investigate the sub-bottom stratigraphy of the area. The sound source with a power output of 300 J was maintained throughout the surveys. The source signals (400 Hz-14 kHz) were received by a streamer with frequency band of 400 Hz-5 kHz. Approximately, 404 km of continuous seismic profiles were collected along the 26 cruise lines of which three were parallel to the shore, whilst the others were perpendicular to the shore (Fig. 3). Positions were determined using a Del Norte Trisponder system with a positional accuracy of +3.0 m.

Numerous general lithological logs from a total of 105 boreholes (i.e. Figs. 3 and 4) which were drilled by several state (KHGM, 1989; DSİ, 1990) and private (YÜKSEL Building, 1988; TEKAR, 1988; TEMEL Investigation, 1985, Mersin Soda Sanayi, 1985) institutions for various hydrogeological, coastal and harbour engineering surveys were also available for consultation in this work.

Recognition of the depositional sequences and the interpretation of data is based on seismic stratigraphic analysis methods outlined by Mitchum et al. (1977a), Vail et al. (1977), Brown and Fisher (1979), Badley (1985) and Boggs (1987). The term "depositional sequence" used here is defined as a stratigraphic unit that is composed of a relatively conformable succession of genetically related strata bounded at its top and base by unconformities or their correlative conformities (Mitchum et al., 1977b).

Depth conversions from time sections were made using a sound velocity of 1500 m/s for water and 1600 m/s for sediments.

4. Results and discussion

4.1. Coastal-plain (onshore) and offshore lithofacies

Based on the information obtained from boreholes drilled along the coast of Mersin Bay (Figs. 3 and 4), considerable variations were observed in the thickness of the Plio-Quaternary sediments which overlie the Miocene limestones and marls.

In the most southwestern part of the coastal zone, between Susanoğlu and Tırtar, Miocene limestones are widely exposed at the surface to form a cliffed coastline (Holes 202, 206 and 207) and here, the Plio-Quaternary sequences are no more than 5 m in thickness (Holes 102 and 208).

Further northeast, where a series of alluvial fans form the coastal plain from Tırtar to Tece, the Plio-Quaternary sequences tends to thicken in Holes 103 (9 m), 210 (12 m), 105 (15 m), and 107 (43 m). In particular, Hole 109 which is situated close to the bed of the River Mezitli, exhibits much thicker sediments of Plio-Quaternary age (up to 113 m). Alternating coarse and fine deposits in this hole suggest marked fluctuations in the types and amounts of sediment supply, as is common in many alluvial fan-delta regimes (e.g. Reineck and Singh, 1975; Collinson, 1978; Hallam, 1981). Brown-coloured clay intervals, reported from Hole 109, probably indicate the effects of subaerial deposition or later subaerial weathering (Okyar, 1991). In Hole 110, a little further away from the Mezitli river bed, the sequence is almost entirely marl of Miocene age which forms a basement to thin Plio-Quaternary sediments. The Plio-Quaternary sediments attain their maximum thicknesses on the fluvio-deltaic plain of Çukurova (Tarsus–Seyhan–Ceyhan delta complex): at Hole 133, the Plio-Quaternary sequence is thicker than 212 m.

Lithological data obtained from the 10 boreholes which were drilled offshore (TEKAR, 1988), near the town of Mersin (at water depths between 6.3 and 9.0 m) have provided some useful evidence of depositional environmental changes in the area (Figs. 3 and 4). It is seen that the upper 1.5 m of the sediment found in the borehole S4 (Fig. 4) are comprised of the contemporary mud, greenish gray to grayish olive in colour. Between the depths of 9.6 and 13.2 m shelly, stiff clay sequences appear which are brown in colour. Because of their such physical appearances these deposits must once have been subjected to subaerial weathering (palaeo-soils), affected by the lowering of sea level during the Late Quaternary, whereas the presence of shells reflects marine depositional conditions. Clay sequences are underlain by the gravelly sand sequences (1 m thick). From the base of these sequences down to 17.7 m depth, conglomeratic sandstone sequences appear. Further downhole, stiff clay sequences, reddish to brown in colour, appear (Fig. 4).

4.2. Subbottom stratigraphy

High-resolution seismic reflection profiles show the presence of the two distinctive depositional sequences (C and B) (Figs. 5–12) underlain by a third sequence (A) which appears to form the acoustic basement and was only observed off the western rocky Susanoğlu–Tırtar coast and off the mouths of the Karapınar and Gilindirez Rivers (Fig. 11). When projected onshore, from its most landward position on

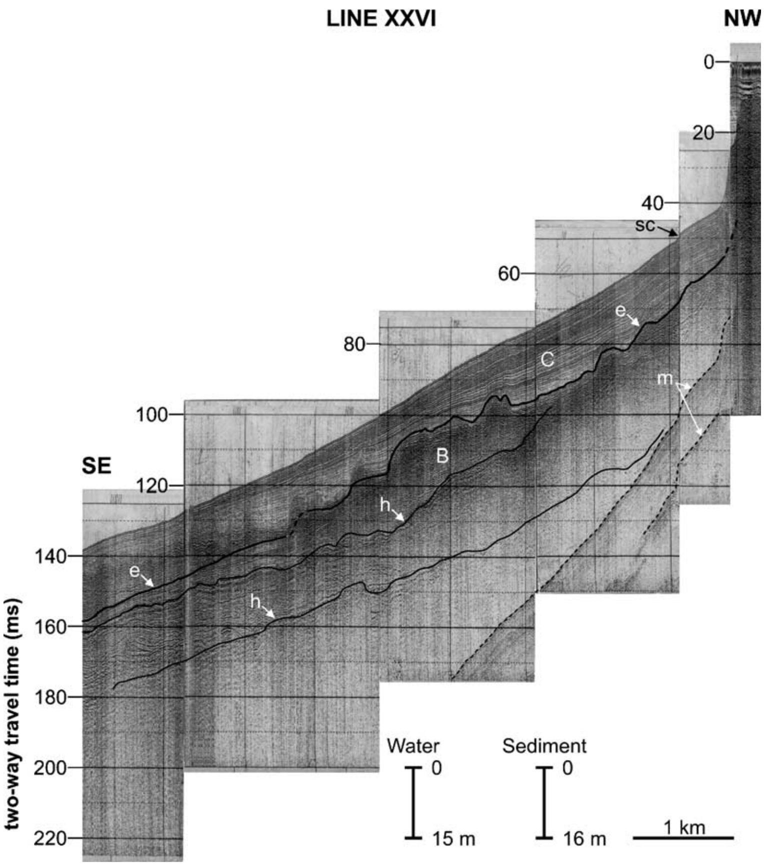

Fig. 5. High-resolution seismic profile showing the seaward prograding pattern of sequence (C). The chaotic reflection configurations and some cyclic sedimentation patterns (h) are prominent within the pre-Holocene sequence (B). Note the opaque zone at the boundary of sequences C and B. e = approximate pre-Holocene erosional surface; sc = erosional-, or fault-scarp; m = multiples. Location of erosional-, or fault-scarp (sc) is shown in the inset of Fig. 13. For location of all profiles, see Fig. 3.

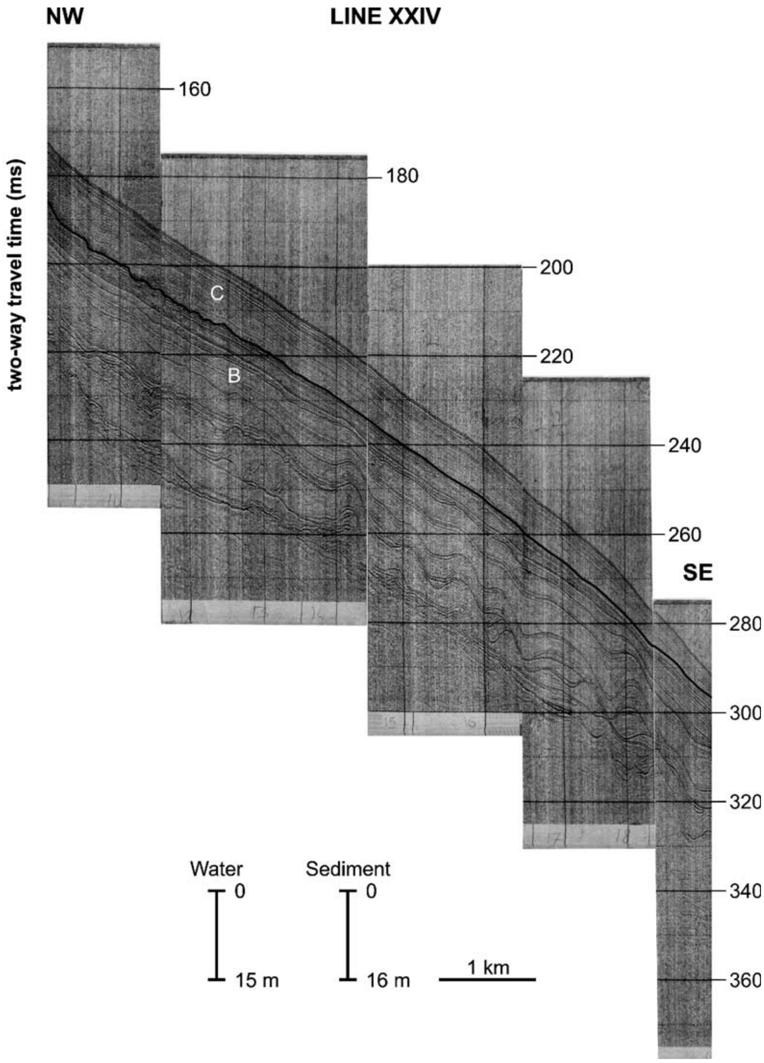

Fig. 6. High-resolution seismic profile showing the seaward thinning of Holocene sequence (C). Note the undulated/wavy reflection configuration and the associated cyclic sequences within the pre-Holocene sequence (B).

the seismic profiles, the acoustic basement (reflector A) seems to correspond to the Miocene limestones which crop-out on the adjacent coast, or the caliche capping which is found on the limestone and later Tertiary deposits throughout the coastal area (Ternek, 1957).

4.2.1. Depositional sequence C

Depositional sequence C forms the upper sedimentary unit and its top forms the present sea floor. This sequence displays a wide variety of reflection configurations (from simple- to complex-stratified, to chaotic) observed in variable external forms on most of the seismic profiles (Figs. 5–11).

Sediments of sequence C deposited off the indented and steep coast of Susanoğlu–Tırtar (Figs. 5, 7 and 8), the mouths of Lamas (Fig. 9), Gilindirez–Karapınar (Fig. 11), and off Kazanlı (Fig. 12) show a typical seaward-prograding clinoform pattern, commonly interpreted as a response to coastal progradation ("offlap reflections" of Brown and Fisher, 1979).

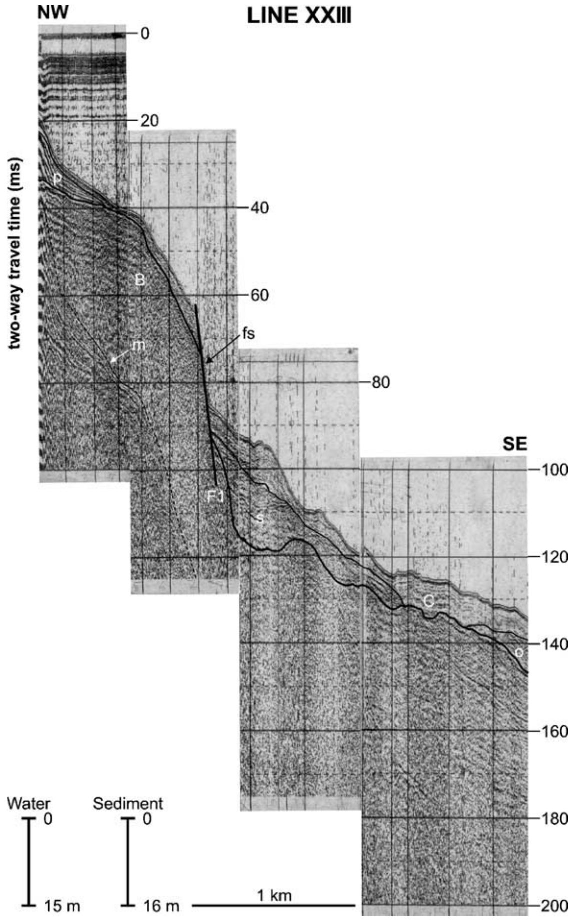

Fig. 7. High-resolution seismic profile showing coastal progradation (p) with slumps along a fault scarp or drowned cliffline. C = Holocene sequence; B; pre-Holocene sequence; fs = fault scarp produced by normal faulting F1; s = slope front fill; o = onlap fill; m = multiple. Irregularities on the shelf surface may be drowned littoral deposits or else slump masses from scarp. Location of fault (F1) line is shown in the inset of Fig. 13.

The depositional sequence C of the narrow western shelf of the Mersin Bay (i.e. seaward extension of the alluvial plain-deltaic associations along the Susanoğlu–Mersin coast) is characterized by laterally-grading facies, from progradational updip near shore to steep-slope, front-fill and with some possible mass transport downdip, which may be due to syn-sedimentary faulting or to the initial steepness of the drowned topography. This prograding sequence (C), especially off the Susanoğlu–Tırtar coasts (Figs. 7 and 8), and the mouths of the Gilindirez–Karapınar rivers (Fig. 11) grades basinward into contemporaneous slope facies. Here, rapid development of the coastal progradational wedge, which was probably fed by fan-deltas, are commonly represented by offlap-reflectors. Reflections characterizing the progradational facies have typically complex (sigmoid, oblique) stratified configurations updip, to simple stratified (parallel/divergent), hummocky, chaotic to reflection-free configurations downdip (Figs. 5, 7, 8, 9, and 11).

By contrast, the depositional sequence C in the eastern shelf area of the Mersin Bay (i.e. in front of the fluvio-deltaic plain of the Çukurova) is noticeably characterized by relative laterally uniform reflection configurations. The parallel/divergent to sigmoidal configurations of coastal-nearshore-progradation facies are common. These, parallel arrangements suggest uniform areal rates of deposition, whilst divergent arrangements suggest areal variations in the rate of deposition. Sigmoid configurations usually denote slowly prograding shelf systems (Mitchum et al., 1977a; Brown and Fisher, 1979).

It thus appears that significant differences exist between the sequences of the eastern and western parts of Mersin Bay with respect to the configurations of the basin morphology, the rate of sedimentation, the supply of sediments, and the intensity of hydrodynamic processes. Of these, changes of coastal morphology and sediment supply are believed to be most important (Ergin et al., 1992). However, from the seismic data, we interpreted two active normal faults (F1 and F2), aligning approximately NE–SW direction that step down to the SE, cutting the depositional sequence C (Figs. 7 and 8). These faults also cut the upper sections of the underlying sequence B. Fault F1 (Fig. 7) reaching to the sea floor has a vertical displacement of about 15 m, based on the fault scarp of it. However, no thickness variation were observed on both sides of fault F1, but instead has led to deformation on the sea floor and in the internal layering of sequence C. Developed slump facies in front of this fault imply that faulting was associated with sediment slumping (Fig. 7). Other fault (F2) has a vertical displacement of about 5 m and is covered by the upper depositional sequence C (Fig. 8), which is about 5 m thicker on the downthrown than the upthrown side of the fault. These findings indicate that the tectonism can also be another factor controlling the deposition and deformation of sediments. However, this effect appears to be local considering

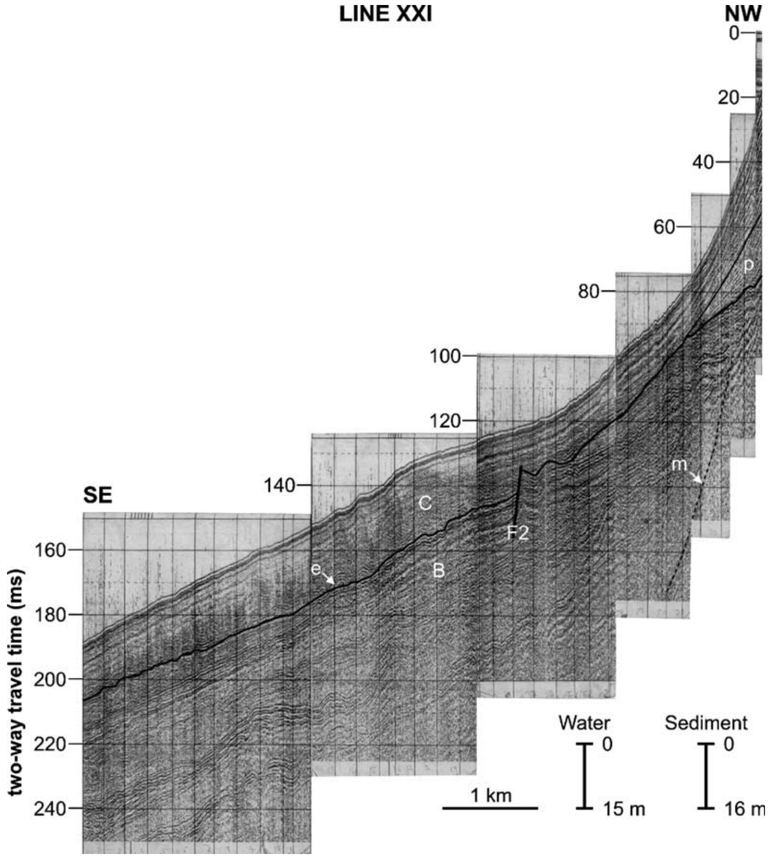

Fig. 8. High-resolution seismic profile showing coastal progradation (p). Note considerable internal irregularity in (B). e = approximate boundary between the sequences of (C) and (B); F2 = normal faulting; m = multiple. Location of fault (F2) line is shown in the inset of Fig. 13.

the number of faults that were determined from only two seismic profiles (Figs. 7 and 8).

The pattern of distribution of the external geometry of reflection configuration of sequence C revealed significant differences between the western and eastern shelves of Mersin Bay. Sequence C of the eastern shelf can often be readily divided into two units (Unit 1 and Unit 2; i.e. Fig. 12) whilst this distinction is impossible to make in the profiles of the narrow western shelf (i.e. Figs. 5–11). This appears to be the result of distinct topographic characteristics in each of the two areas: the relatively wide and stable surface of the eastern shelf, where fairly uniform rates of deposition have occurred; and a relatively narrow and steeper western shelf, due to either gravity of syn-sedimentary movements or to differential loading of the underlying Messinian evaporites in the adjacent Cilicia Basin and shelf edge to the Seyhan delta (Evans et al., 1978; Aksu et al., 1992).

Some acoustically opaque zones observed at or near the lower boundary of sequence C (i.e. Fig. 5). They occur in isolated areas and sometimes can be traced over a distance of several kilometres. These are possibly due to entrapped gas bubbles produced by the degradation of organic matter (cf. Stefanon et al., 1981; Park and Yoo, 1988; Okyar and Ediger, 1999) or, more likely in this area, are due to the upward movement of land-derived ground water into the near-shore sediments. This water emerges as small springs on the coast and in shallow bays (e.g. Narlıkuyu between Tırtar and Susanoğlu). Alternatively, it is also possible that they are side-echoes reflected from a buried karstic former land surface or merely a direct reflection from such a surface.

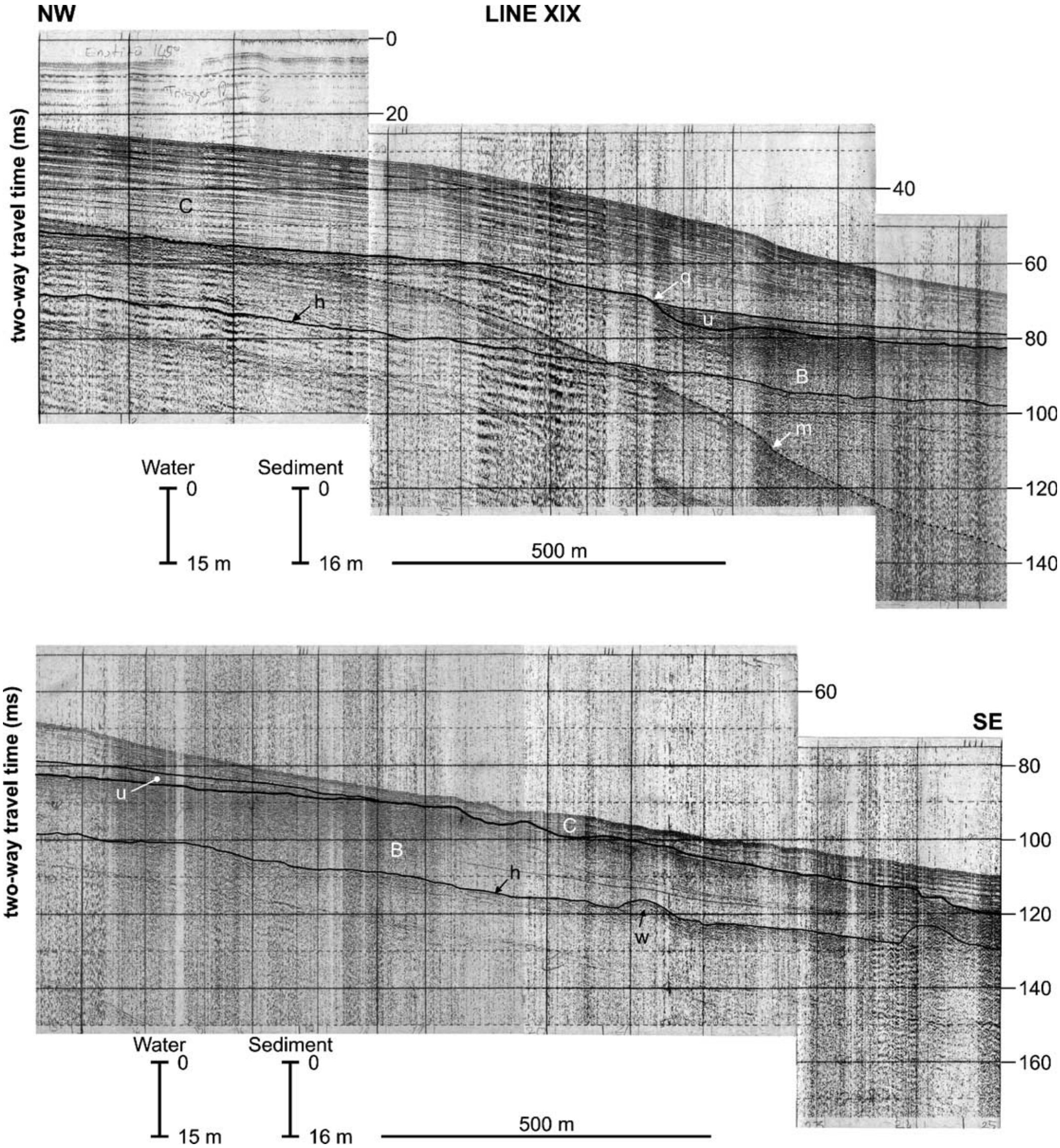

Fig. 9. High-resolution seismic profile showing coastal progradation of Holocene sequence (C). Parallel to sigmoidal and discontinuous to semi-transparent reflection configurations are prominent within sequence (C). q = erosional (wave-cut ?) platform; u = transgressive onlap fill; B = pre-Holocene sequence; m = multiple. Note possible old submarine ridge/barrier system (w) with a sediment wedge (C) thickening in both the landward and seaward directions. h = discontinuity indicating possible cyclic sedimentation ?.

The contact between sequence C and sequence B is interpreted to be the Late Pleistocene–Early Holocene erosional–depositional surfaces formed during the last fall of sea level (Würmian regression; − 100 to − 125 m between 20,000 and 18,000 years BP; Clark et al., 1978; Coutellier and Stanley, 1987) and is equivalent to the pre-Holocene reflector "R" buried under the sediments of the post-glacial (Flandrian) transgression found in eastern Mersin Bay around the Tarsus–Seyhan delta (Okyar, 1991; Ergin et al., 1992). Based on stratigraphic correlation of radiocarbon-dated sediments from major lobes of Nile Delta (Coutellier and Stanley, 1987), and seismic and sediment budget

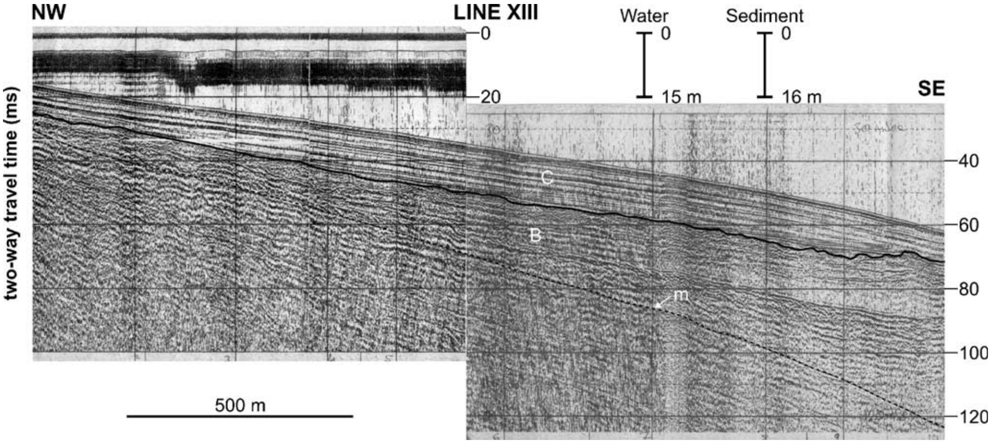

Fig. 10. High-resolution seismic profile showing seaward-dipping and sheet-like coastal prodelta/shelf facies (C) with high-continuity parallel reflection configurations. The underlying pre-Holocene sequence (B) is marked by irregular reflection configurations. m = multiple.

calculation data from Seyhan and Ceyhan deltas (Aksu et al., 1992), we may suggest that the sequence C identified on the seismic profiles of this study mostly corresponds to the Holocene sediments, as was also described in a previous work of Ergin et al. (1992).

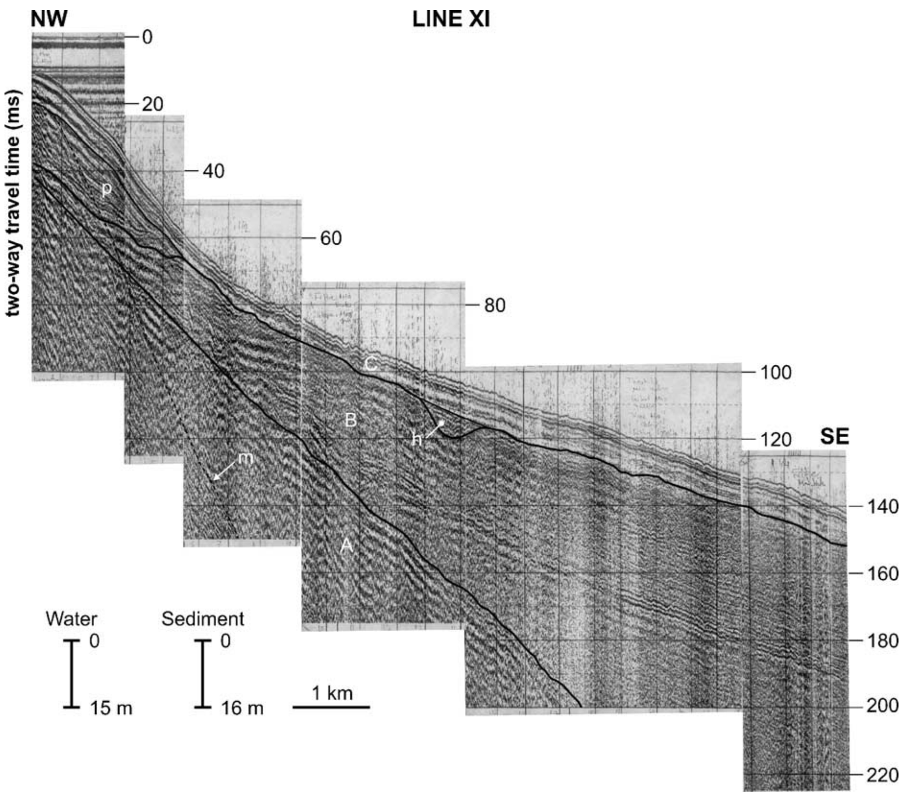

Fig. 11. High-resolution seismic profile showing coastal progradation (p) of sequence C with the downslope irregularities or possibly minor erosional scours. A = pre-Plio-Quaternary basement; h = channel fill; C = Holocene sequence; B = Plio-Pleistocene sequence; m = multiple.

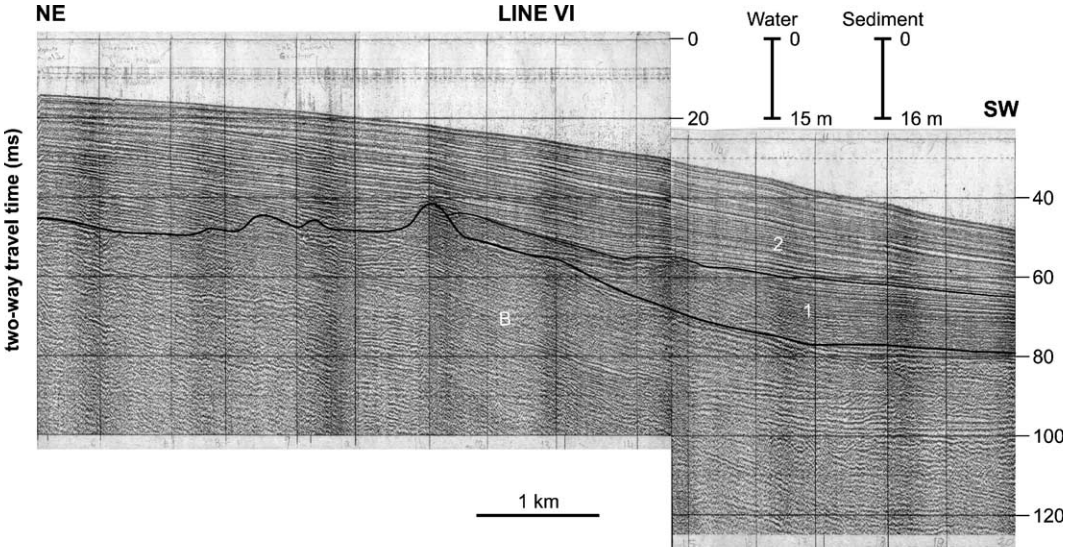

Fig. 12. High-resolution seismic profile showing typical seaward prograding pattern of Holocene deltaic sequence (1 and 2) of C above pre-Holocene sequence (B).

4.2.2. Depositional sequence B

The depositional sequence B underlies the sequence C and is marked by continuous to wavy stratal configurations and locally by chaotic configurations (Figs. 5, 7–12). Sometimes it is rather difficult to recognize a sharp boundary between the sequences B and C, in contrast to the eastern shelf of the Mersin Bay, where well-developed boundaries and related unconformities can be recognized, which give clear evidence of deposition of Holocene transgressional sequences above the pre-Holocene, erosional surfaces (i.e. Fig. 12). In the west, the latest Pleistocene and its terminal erosional surfaces (cf. Van Andel and Sachs, 1964; Stefanon, 1985; Kindinger, 1988; Park and Yoo, 1988; Okyar, 1991; Ergin et al., 1992), seem to have been blurred by the movement of the overlying Holocene deposits because of gravitational or mass movements due to local fault movements or due to deposition adjacent to steep slopes.

Depositional sequence B also exhibits some cyclic sedimentation on some seismic profiles (Figs. 5, 6 and 9) which are bounded by similar surface to that of Late Glacial/Early Holocene erosional surface. They are presumably related to climatic fluctuations and oscillating sea-level changes in the Pleistocene (e.g. Vail et al., 1977; Aksu et al., 1987; Ergin et al., 1992) but unfortunately the data available on the present profiles are not sufficient to analyze these in detail.

The undulated/wavy reflections observed within sequence B, particularly off the Merdivenlikuyu coast (Fig. 6), may be the manifestation of the highly variable alluvial fan type sedimentation or more likely have been caused by syn-sedimentary tectonic processes.

Apart from this, the upper parts of sequence B seem to be deformed in some places where the faults have occurred (Figs. 7 and 8).

4.2.3. Acoustic basement

The surface of the acoustic basement characterized by strong (high-amplitude) reflections (Ringis, 1986), is clearly seen below the sediments of sequence B in some seismic profiles, e.g. off the Karapınar and Gilindirez river mouths (Fig. 11). The available borehole data from the adjacent coast (Hole 107), suggest that this basement reflector, corresponds to the surface of the Miocene limestone and marl which crop-out on the coast (Okyar, 1991).

Although not substantiated by borehole data it seems likely that the same acoustic basement is present on the other seismic profiles (Figs. 5, 7 and 8) from the offshore area between Susanoğlu and Tırtar where Miocene limestones crop out on the adjacent coast to form cliffs. Here, the seismic sections exhibit very weak (low amplitude) reflections. Perhaps deep weathering of the underlying bedrock surface may lessen the acoustic impedance contrast between the weathered bedrock and the overlying sediment, and hence produces a very weak (low-amplitude) reflections masked by noise or multiples (Ringis, 1986). Indeed, in many road-cuts on the adjacent land the Miocene limestone can be seen to be irregular and covered with a cover of "Terra rosa", superficial soil of highly variable thickness, containing fragments of the underlying Miocene limestone.

4.3. Thickness distribution of depositional sequence C

The total thickness of the depositional sequence C, which was interpreted to represent Holocene sediments, has been calculated and an isopach map has been prepared (Fig. 13).

The sequence C is well developed in the northeast of the area due to the progradation along the shelf of the sediments of the Seyhan–Tarsus–Ceyhan delta. It reaches a thickness of 35 m at a distance of about 7.2 km from the mouth of the Seyhan River and gradually thins (10 m) along the shelf to the southwest and towards the coast near Mezitli (Fig. 13). We interpreted this pattern of thinning as indication that the sediment

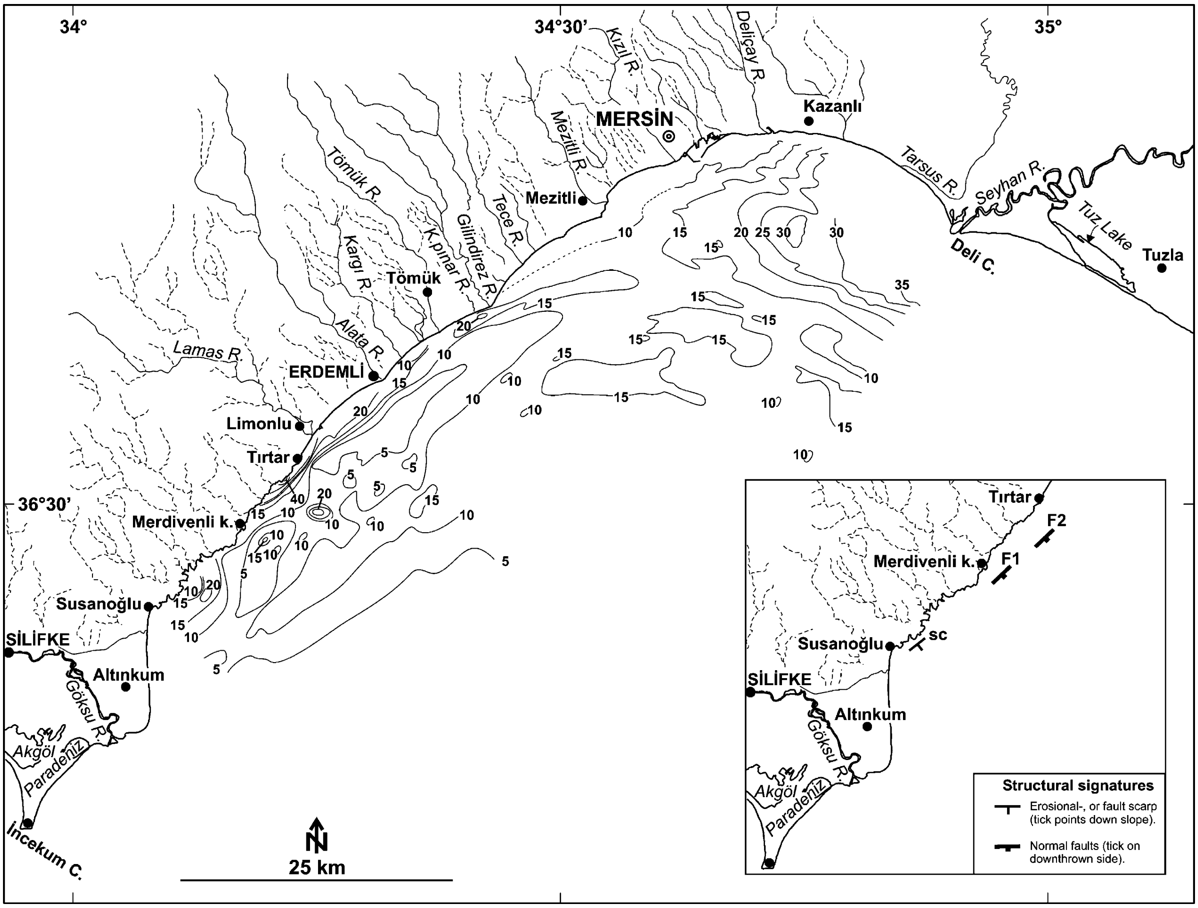

Fig. 13. Isopach map of sequence C (contours are in metres). Note the prograding wedge extending along the shelf from the Tarsus–Seyhan delta and the coastal wedges between Mersin and Tırtar. Further west the sediment cover is thinner due to only a small number of small streams which bring very little sediment to this part of the coast. The sediment load of the Göksu River is diverted away to the southwest by the prevailing current system so has little effect on the shelf to the northeast. Lower right inset shows the location of structural features of erosional-, or fault-scarp (sc) and normal faults (F1, F2), interpreted from seismic profiles in Figs. 5, 7 and 8, respectively.

transportation from the main rivers, Seyhan, Tarsus and Deliçay, appears to have occurred in southwest direction, parallel to the main current of the north-eastern Mediterranean. This picture also suggests that the progradation of the Tarsus–Seyhan delta along the shelf has formed in the same direction (Okyar, 1991). The importance of the sediment supply by the ephemeral rivers between Mersin and Tırtar point, to the west of the mouth of the Lamas river is shown by the well developed nearshore sedimentary wedge along this coast. This is approximately 10 to 25 m thick, off the mouths of the rivers Gilindirez, Karapınar, Tömük, Kargıcak, Alata and Lamas, while in nearshore waters off Tırtar just to the west of the mouth of the Lamas river, it attains a thickness of up to 40 m and further offshore ranges from 5 to 15 m in thickness.

Further to the west, between Tırtar point and the Göksu Delta, the low rates of sediment supply from the adjacent land, due to the paucity of sediment run-off from the Miocene limestones, is reflected by the small thicknesses of sequence C. Hence the isopach map faithfully records the changing pattern of the source: major perennial rivers; ephemeral small rivers flowing over areas of mixed lithology; and very small ephemeral rivers flowing over limestones.

If 10,000 years BP is taken as the approximate boundary of the latest Pleistocene–earliest Holocene (e.g. Coutellier and Stanley, 1987; Ergin et al., 1992), a 40 m maximum thickness of sequence C corresponds to a sedimentation rate of 0.4 cm/year during the Holocene in the western shelf of the Mersin Bay.

5. Conclusions

The seismic facies interpretations obtained in this study, from western Mersin Bay, suggest that the following conclusions may be drawn.

At least two major depositional sequences (B and C) are present on the narrow and relatively steeply-sloping shelf of western Mersin Bay. The seaward-dipping reflection configurations with variable geometry, continuity and amplitude of seismic facies in this part of the bay suggest a combination of a variety of depositional processes known from the present day depositional environments under the influences of coastal and shelf morphology, marine hydrodynamics, and the areally variable terrigenous input.

The topmost and youngest sequence (C) accumulated under present day conditions and represents a sequence of deposits which have accumulated on a shelf dominated by a southwesterly flowing shore-parallel current. Sediment transportation to the south-west from the main rivers, Seyhan, Tarsus and Deliçay, has resulted in the formation of a prodeltaic wedge off the Tarsus–Seyhan delta in the eastern part of the Mersin Bay. To the southwest, along the shoreline between Mersin and Tırtar, the ephemeral lateral supply from a series of small rivers have formed a coastal plain formed of merged alluvial-fan deltas and have caused the coast to prograde to form a nearshore prograding wedge which is >10 m thick near the coast at most locations and is best developed between the mouth of the Alata and Lamas rivers (the most persistently flowing rivers, along the coastline between Mersin and Tırtar). The southwest flowing currents have extended this coastal wedge to the southwest to the mouth of the Lamas River. Generally, the coastal rivers between Tırtar and the Göksu produce only a sparse supply of sediment except near the close proximity of the Göksu delta. Consequently, the nearshore prograding wedge is not found and scarps and other features in the underlying units are covered by a veener of sediment. It thus appears that the greater sediment supply from the rivers of Deliçay, Tarsus, and Seyhan contribute to the development of deltaic progradation, as evidenced by wide shelf area in the eastern Mersin Bay. On the contrary, western Mersin Bay characterised by a narrow and relatively steeply sloping shelf receives the little sediment supply from the ephemeral rivers and this seems to be acting as a primary control on the formation of coastal progradational wedge.

In some cases, an underlying transgressive onlapping sequence (Unit 2) has been revealed which presumably formed during the beginning of the Holocene sequences.

In many areas, there is a clear and sharp boundary between C and B, but elsewhere, this is lacking. This suggests that the irregular surface of separation between these two sequences is complicated by processes of gravity mass movements due to the steep gradient of the nearshore shelf and the spasmodic supply from ephemeral rivers or by syn-sedimentary tectonic movements produced by movement of underlying Messinian evaporate (Evans et al., 1978). Sequence B shows considerable internal variability and appear to represent a series of alluvial fan and fan-delta deposits developed during the last low period of sea-level of the Late Pleistocene.

The apparent presence of several depositional cycles within sequence B is presumably the result of climatic fluctuations and related oscillating sea-level changes during the Pleistocene. The acoustic basement appears to be the surface of the Miocene limestones and marls which are widely distributed on the adjacent coast. Apparent irregularities in places may be due to escape of water or gas, more likely the former, from the fractured Miocene limestones as freshwater springs are abundant on this coast.

The maximum thickness of sequence C yields a sedimentation rate of 0,4 cm/year during the Holocene in the western shelf of the Mersin Bay.

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