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MECHANISMS OF SEDIMENT TRANSPORT AND DEPOSITION IN SLOPES OFF CHIOS AND LESVOS ISLANDS, E.AEGEAN SEA

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ABSTRACT

High resolution 3.5 kHz profiles, side-scan sonar records and selected sediment cores were assessed to study the mechanisms of sediment transport and deposition in the slopes off Chios I. and Lesvos I., and area seismically and neotectonically very active.

Slumps, mudflows, turbidity flows and collapse structures were observed in the tectonically controlled and seismically influenced slopes off S. Lesvos I. and N.W. Chios I. Resuspension, erosion and bedload transport by strong bottom currents in the upper slope of S.W. Chios I., is evidenced by characteristic sand ribbons parallel to the isobaths. In the basins and the slope off N. and W. Chios I. hemipelagic deposition predominates with accumulation rates of 7 -11 cm/1000 yrs and 3 - 5 cm/1000 yrs respectively. During low sea-level stand turbidity flows were more active and coupled with hemipelagic deposition were the principal depositional mechanism of slope to basin sedimentation processes.

INTRODUCTION

The continental slopes covers almost the 10-15% of the earth surface and are the principal pathway of terigenous sediments towards the deeper basins.They react either as region of permanent or temporal sediment deposition during their downslope transport. Mass movements are the main downslope sedimentological processes triggered by a) earth movements (seismic-neotectonic activity), b) erosion and resuspension (bottom currents, internal waves), c) overloading due to rapid sedimentation, d) gases in sediments etc.The mass transport processes include rockfalls and slides (elastic transport mechanisms), debris, grain and mud flows in which transport is dominated by plastic behavior and liquified, fluidized and turbidity flows that display internal viscous mechanical behavior (Nardin et al., 1979).The relation of these processes with the hemipelagic sedimentation have been studied in

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detail particularly for the N.E.Mediterranean sea (cf.Stanley, 1985), where various models has been proposed.

The area under ivestigation is located in the eastern Aegean sea and incorporates the region west from Chios I.and the area between N.Chios I.and Lesvos I. (Fig. 1). The bottom morphology is characterized by two elongate independent basins (west from Chios I.and south from Lesvos I.), precipitous slopes off south Lesvos I., low angle and even slopes north of Chios I. and relatively steep slopes west of Chios I. that leads to a NW-SE trend submarine valley. This valley is conected with the west Chios basin after an E-W shift of his axis. Another E-W submarine valley, across the slope off Izmir Bay, leads to the south Lesvos I. The study area is seismotectonically very active, since is located in possible Aegean microplate boundaries (McKenzie, 1978; Dewey and Sengor, 1979).

There have not been many studies on sedimentary processes in the eastern Aegean sea . Aksu and Piper (1983) and Aksu et al., (1987) was studied the late Quaternary grouth of Gediz and Bakircay deltas relativelly to tectonics and sea level changes, east of the investigated area.

The purpose of this paper is to examine the variability of mechanisms in slope to basin sedimentation processes in the seismoteconically active region of the E.Aegean sea.

METHODS

The area was surveyed with the R/V AEGAIO using a 3.5 kHz pinger and a 100 kHz side-scan sonar of O.R.E. (Fig. 1). The position of the R/V Aegaio was carried out by G.P.S. Six selected sediment cores was recovered by a 3 m long gravity corer of BENTHOS INSTR. for detailed sedimentological analysis. Although the number of cores is rather small the coring sites is regarded to relfect representative sedimentary conditions over a greater area, since they were selected after detailed inspection of the 3.5 kHz and side-scan records. Grain size and carbonate content analysis were carried out by pipette and gasometric methods, respectively, while organic carbon were determined by the method of Gaudette et al., (1974). Smear slides of the coarse fraction was prepared and observed through a binocular microscope in order to determine the possible detrital origin of the grains.

RESULTS AND DISCUSSION

Area West of Chios I.

The detailed study of the high resolution 3.5 kHz and side-scan profiles, revealed diverse sediment transport and erosion processes across and along W. Chios I. slope.

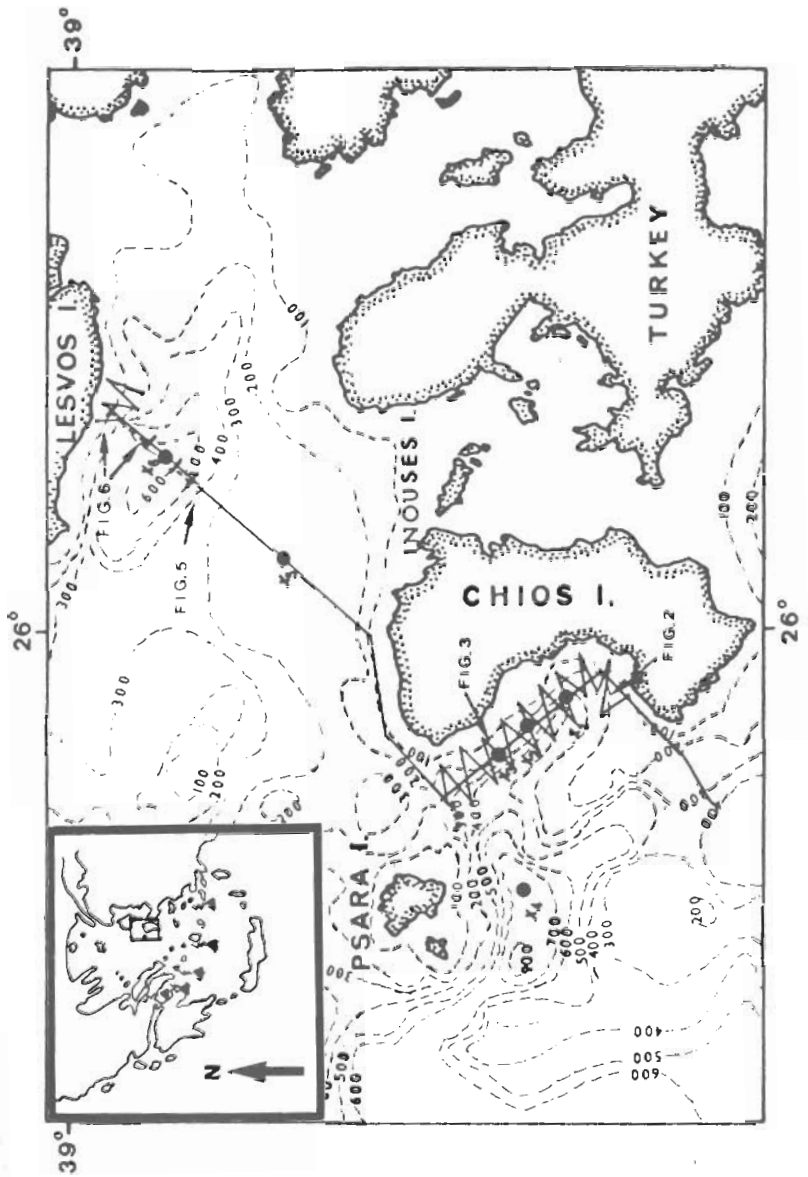

Fig 1: Sketch map of the area under investigation with 3.5 khz and side-scan sonar tracks (solid lines) and core locations.

The southern part of the slope is characterized by a series of well defined sand ribbons (Fig. 2) that strikes almost parallel to the isobaths from 130 m to over 300 m depth and along a distance of about 5 km. These sea-bed erosional linations reflect the net bedload transport of the relatively coarse grained (sand-silt) material from strong unidirectional currents with velocities up to 1m/sec (Belderson et al., 1982). Strong currents in the Aegean sea, are produced under exceptionally intense stormy conditions and the passage of barometric pressures (Kardaras pers. commun.). These currents, in the S.W. Chios slope, could be accelerated locally, due to "Bernoulli effects" from bottom physiography (shallowing, valley morphology, etc), reaching very high near-bed velocities. The ultimate result is the resuspension and the winnowing away of the finer fraction (fine silt - clay) and the bedload transport of the coarser (silt - sand) along the slope. This process display a semicircular zonoidal distribution following the isobaths and decreasing gradually in their intensity

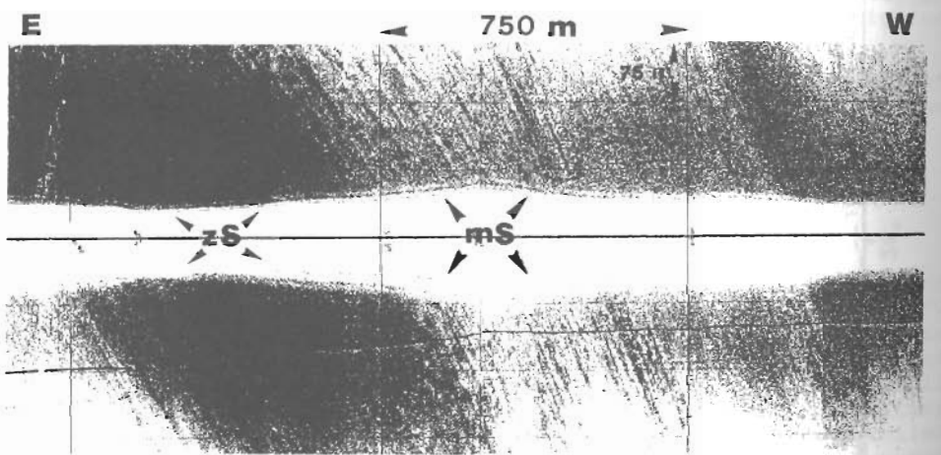

Fig. 2: Characteristic sand ribbons in the S.W. Chios slope. Areas of intense reflection (dark shaded) with silty sand (zS) cover and relatively weaker reflections with muddy sand (mS) are also indicated.

castwards. Towards the same direction the bottom texture changes from silty sand to sandy mud and mud in the area before reaching core site X1.

The central and north part of the W. Chios I. slope is covered by mud and, as evidenced by 3.5 kHz profiles and side-scan sonographs, is very much affected by sediment mass movements (Fig. 3). Elliptical sulmping (SL) with diameter up to 50 m can be recognized from the sonographs parallel to the isobaths (Fig. 3A). In the 3.5 kHz profiles the slumps appeared as a 10 - 15 m elevation of sea-bed, with characteristic internal plastic deformation, that is indicated by the chaotic character of the seismic reflections and the mounted topography of the sea-bottom (Fig. 3B,C). Erosional channels appeared in the central W. Chios slope and basin, with estimated mean sedimentation

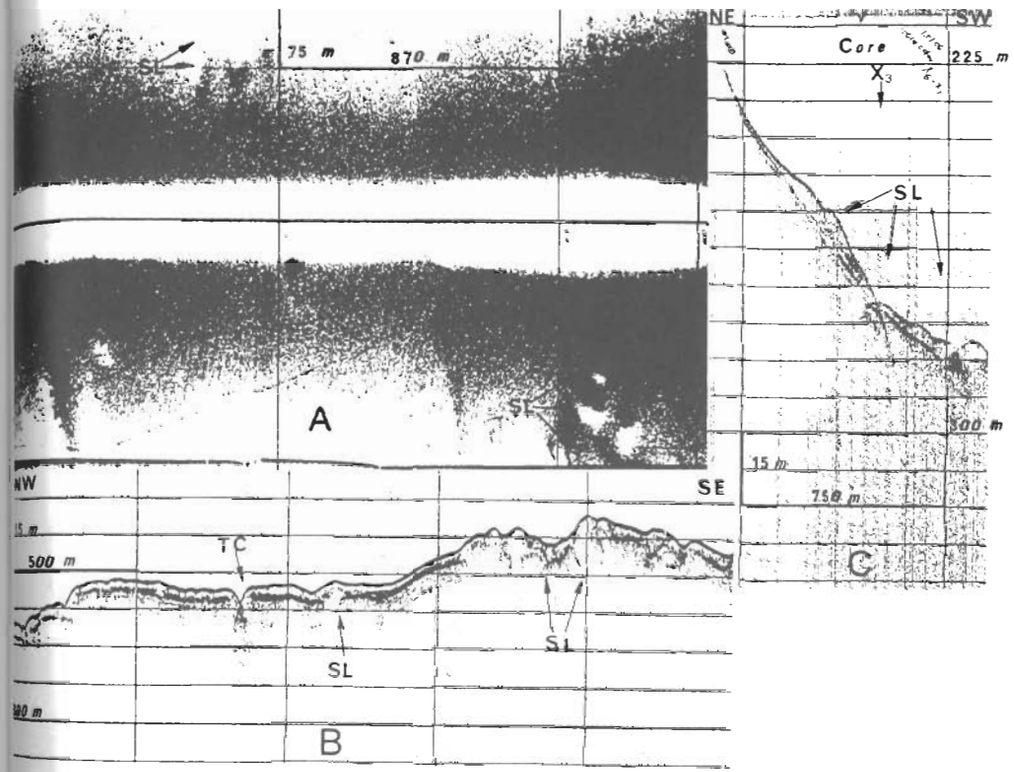

Fig. 3: Slumping (SL) and channels of possible turbidity currents (TC) along the slope (A, B). Profile (C) indicates slumping across the slope (cross section of A,B) and approximate position of core X3.

profiles along the slope (TC, Fig. 3B). These channels are indicators of downslope turbidity flows related, possibly, with the slumping processes (partial sediment dissolution and fluidization).

The results of the selected cores not only were in accordance with the already observed processes but also provided information about the Holocene and Late-Pleistocene downslope processes. In particular the core X3 from the slumped area (Fig. 3C) displayed clearly sandy turbidites with two redeposited (from resuspension) sapropelic horizons (1.2% Corg) indicating probably contemporaneous turbidity flows within slumping processes. The cores X1, X2 from the slope and X4 from the basin showed the complete Holocene sediment (sequences) facies from the sapropelic S1 (0.9 - 1.3% Corg) that have been deposited about 9 - 7.000 yrs B.P. (c.f. Ryan, 1972), to the hemipelagic mud (H.L.) above and finally to the top the (recent) oxidized layer (O.L) (Fig. 4). This implies undisturbed hemipelagic sedimentation during the Holocene in the central W. Chios slope and basin, with estimated mean sedimentation

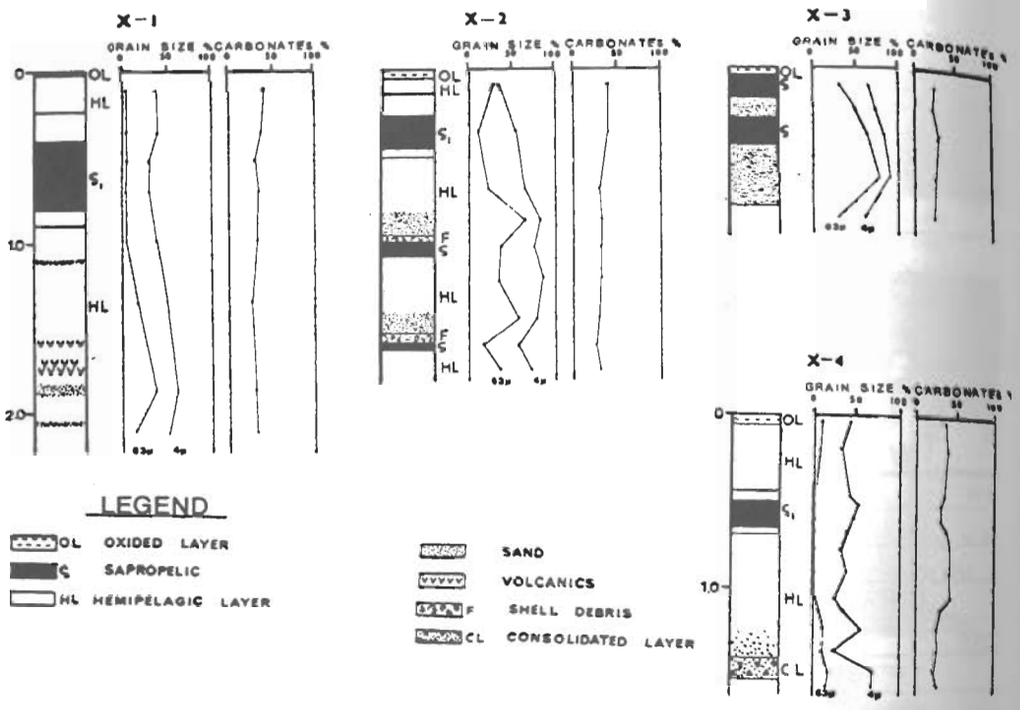

Fig. 4: Sediment facies, grain size analysis and carbonate content along the cores from W. Chios slope (X1, X2, X3) and W. Chios basin (X4).

rates of 3 - 5 cm/1000 yrs in the slope and about 7 cm/1000 yrs within the basin. These relatively low values are very much comparable with the sedimentation rates observed in S. Aegean sea and Hellenic trench (Stanley, 1985). To the contrary, earlier, during Late Pleistocene turbidity flows are evidenced by the significant downcore increase of detrital sand and silt horizons to the cores X1, X2, X4, although they are coupled by hemipelagic mud deposition (Fig. 4). Especially the core X2 display a series of different complicated turbiditic events two similar complicated turbidites with redeposited sapropelic sandy mud in the base, shell debris and detrital sand in the top. The relatively consolidated layer (C.L.) consisted from inorganic sandy silt, towards the bottom of the core X4 (W. Chios basin) could be the end member of a turbidity flow (distal turbidite) From these results the effect of Late-Pleistocene sea-level changes to slope and basin sedimentation processes were significant and determinative. Strong bottom currents and wave activity were affected the sea-bed deeper, due to low sea-level stand during late glacial period and together with seismic activity, were initiated turbidity flows to the lower W. Chios slope and basin.

Area between Chios I. and Lesvos I.

The submarine morphology consists of an extensive, even and low gradient slope off N. Chios I. and an elongated basin with precipitous slope off S. Lesvos I. The morphology and the 3.5 kHz profile between the two islands indicates a semi-graben (or half-graben structure) with the master fault to be the very steep slope off S. Lesvos I.

The slope off N. Chios I., although relatively even, was displayed intense neotectonic activity with numerous reverse faults of small through, indicating a compressional rather than extensional regime in the area. Towards the basin, the elevated sea bottom revealed an intensively compressed zone of 3 - 4 km that have been uplifted 30 - 50 m (Fig. 5). Within this zone reverse faulting (R.F.) with through up to 15 m and deformation of Late Quaternary subbottom layers due to stretching (haotic subbottom reflections) are indicative of the compression and the uplift of the pre-Quaternary bedrock. The reverse faults are extended, as well, into the basin, off S. Lesvos I. as figured in the sonographs of the muddy bottom (Fig. 6).

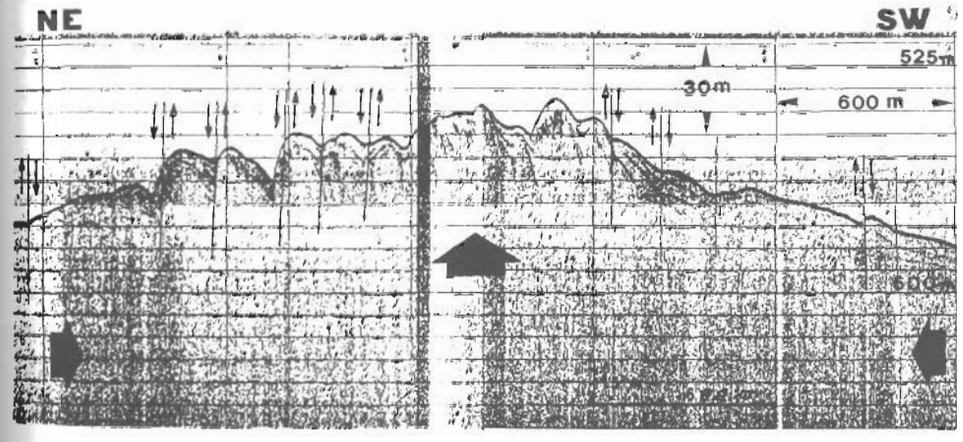

Fig. 5: 3.5 kHz profile between Chios I. and Lesvos I. displaying a compressional zone with reverse faulting and bedrock uplift.

Side-scan sonar images from the precititous slope off S. Lesvos I. revealed the very complicated character of mass movement processes (Fig. 6). A variety of deformational processes such as collapse structures, mudflows, rotational slumps etc. that are difficult to differentiated was simply reffered as slumps (SL.). These phenomena are assosiated with a downslope series of listric gravity faults (L.F.), that was recognized in 3.5 kHz profiles. The strong reflections within the sonographs (darker areas) indicates coarser material (muddy sand or sandy mud) that can be traced down to the base of the slope and partly to the [illegible] This implies transportation and deposition of

sand-sized material by downslope turbidity flows but with relatively limitted aerial extention into the basin.

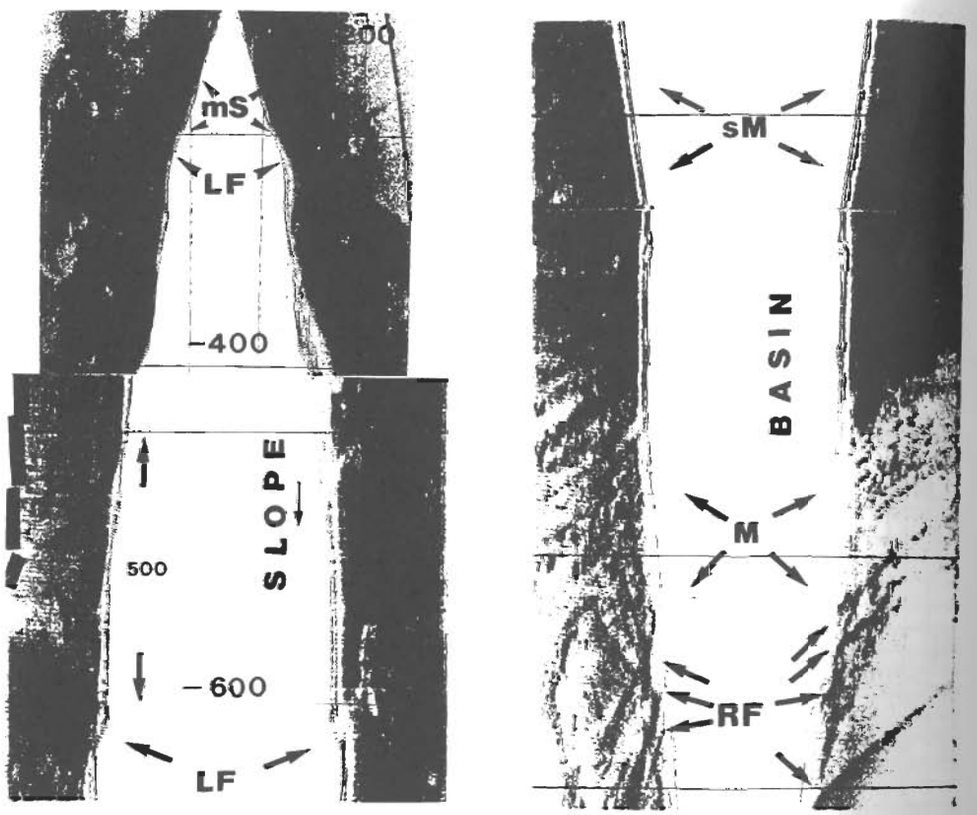

Fig. 6: Intense complicated slumping phenomena assosiated possible gravity grouth faulting (L.F.) across S. Lesvos slope changing to reverse faults (R.F.) into the basin.

The core X6 from the basin confirmed the localized extention of the turbidites to the base of the slope, since it consists entirely from successive hemipelagic layers (Fig. 7). The complete Holocene sedimentary sequence (Sapropelic S1 (1.1% Corg), Hemipelagic mud, oxidized layer) implies continuous and undisturbed hemipelagic sedimentation with mean sedimentation rates of 11 cm/1000 yrs. Taking in account these small rates of deposition, it has to be concluded that the area does not receive significant amounts of suspended sediment from rivers discharging in the eastern located Izmir and Candarli bays. Probably the majority of the suspended sediment is trapped within these bays something that were observed, as well, in the N.W. Aegean Sea (Lykousis and Chronis, 1989). The shallower core X5 from the N. Chios slope display a gradual increase of silt fraction downcore of the lower

section (second half), which together with the small turbiditic event (consolidated horizon - C.L.), is expected to be the influence of the lowering of sea-level and the related increase of detrital supply. Mean sedimentation rates were estimated, from the upper Holocene hemipelagic sediment sequence, to be 4 cm/1000 yrs.

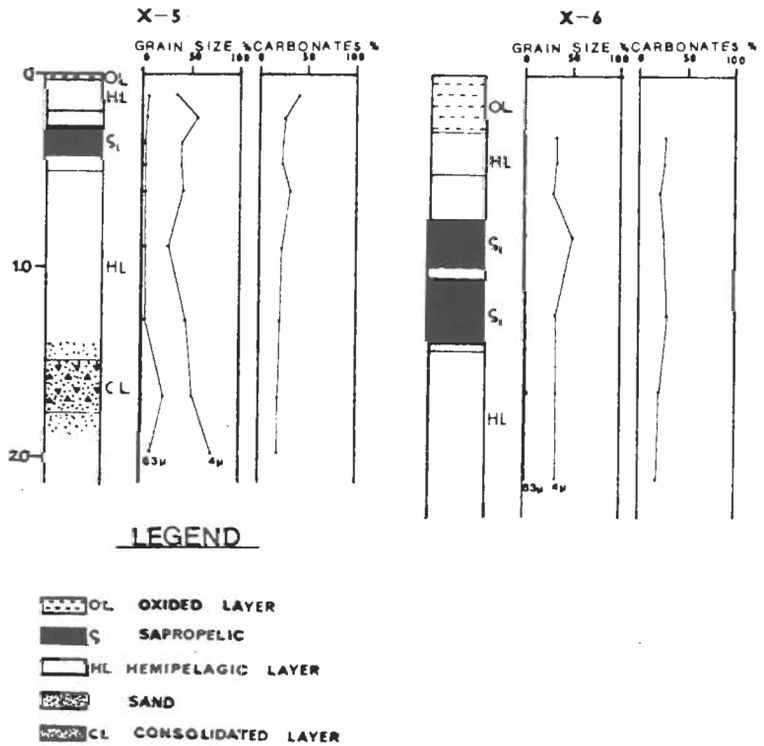

Fig. 7: Sediment facies, grain size analysis and carbonate content along the cores from N. Chios slope (X5) and S. Lesvos basin (X6).

CONCLUSIONS

A variety of sediment transport processes and depositional mechanisms in space and time were observed in the slopes off Chios I. and S. Lesvos I.

Slumps, mudflows, collapse structures and turbidity flows assosiated with listric gravity faults were the dominant processes in the precipitous slope off S. Lesvos I. Slumping with turbidity flows

were observed, as well, in the N.W. Chios slope that were triggered by seismic activity. Erosional features, as sand ribbons in the S. Chios upper slope are witness of sediment resuspension and bedload transport of sand and silt sized material parallel to the isobaths. Hemipelagic settling with accumulation rates of 7 - 11 cm/1000 yrs within the basins and 3 - 5 cm/1000 yrs in the slopes, that were not affected by gravitational precesses, is the main sediment depositional process during the Holocene within these regions. During lower sea-level stand (glacial period - Late Pleistocene) turbidity flows and erosional processes coupled with hemipelagic deposition should be the predominant mechanism of slope to basin sedimentation.

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