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Nature and origin of sapropels in the Quarternary sediments of the Cilician Basin, NE. Mediterranean

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ABSTRACT: *Dark, finely laminated, organic-rich sapropelic horizons are the most striking features of the Cilician Basin sediments as revealed by the radiographic and geochemical investigations. TOC of these horizons occur in the range of 0.8-1.52%, is lower than the previously reported values of TOC from the S1 sapropels in the Mediterranean Basin. AOM are intensely degraded except in one core, where partially preserved AOM are observed. Terresterial OM are comparatively preserved. The degraded nature of OM suggests that the condition for OM preservation is not favourable. However, the fine lamination and absence of benthic organisms are the evidence in favour of anoxic conditions leading to the ormation of sapropelic horizons. The idea that anoxia favouring the OM preservation is the cause of sapropelic formation is not supported in present work. These layers are presumed to have been formed during Post-Glacial climatic warming as a result of high input of terresterial OM and increased bilogical productivity.*

Abbreviations: Organic matter (OM), Amorphous organic matter (AOM), Terresterial organic matter (TOM), Total organic carbon (TOC), Pleistocene-Holocene Sapropels of the Mediterranean (SI).

INTRODUCTION

The Cilician Basin is a part of of the North Eastern Mediterranean located between Cyprus and Turkish Coasts (Fig. 1a). The Adana Basin infilled with Neogene Quaternary deposits is the onshore extension of this basin and together they form the combined Cilician Adana Basin (Evans et al., 1978). The sources of the terresterial sediments into Cilician Basin are the perennial and seasonal rivers that drains the Cyprus and Turkish coastal areas in the hinterland (Evans, 1971; Shaw, 1978; Shaw & Bush, 1978; Ali, 1992). Detailed radiographic and geochemical analyses of the sediments from piston and gravity reveals the occurence of sapropelic layers within the Basin, which are characteristically very similar to S1 sapropels of other workers.

The term sapropel was defined by Kidd et al. (1978) as dark, finely laminated discrete layers containing more than 2% (by weight) organic carbon. These layers are generally more than 1cm thick and form in open marine pelagic sediments. The term saprolpelic layers on the other hand, is used for a similar layer having a range of organic carbon contents varying between 0.5 and 2% by weight.

The so called sapropels were first discovered and reported from the Quaternary sediments of eastern Mediterranean by Kullenberg

(1952), Olaussons (1961) and Ryan (1972). These layers are believed to have formed by the preservation of organic matter under stagnation and bottom-water anoxic conditions. Based on the radiographic, geochemical and micropaleontological studies of the sediments the present study also deals with the origin and distribution of the sapropels in the Cilician Basin, to confirm the existing ideas regarding their origin.

METHOD OF STUDY

Piston and gravity cores samples were collected from the Cilician Basin during three cruises in the summers of 1972, 1974 and 1977 on RSS "Shakleton" (Fig. 1b). All cores were sealed on collection, wraped in polythene film and kept in cool-cabinet at 5°C to prevent contamination or dessication. X-ray radiographs of selected cores were taken using a Faxitron, an X-ray machine (see Hamblin, 1962; Calvert & Veever, 1962; Bouma, 1964C and Coleman, 1966). Four cores bearing sapropelic layers, labelled SH/2035, SH/166, SH/170 and SH/182 were geochemically analysed employing the following techniques:

a) Total organic carbon (TOC) analyses were performed on Perkin-Elmer 240 elemental analyser.

b) Acid maceration method was employed using 10% HCl (to remove inorganic carbon) and later 60% HF (to remove silicates). The residue left organic matter (OM) was later used for petrographic study.

Micropaleontological investigation of the sapropelic sediments was carried out using the percentages of planktonic and benthonic foraminifers in size fraction >250 microns (see Buckley et al., 1982; Buckley & Johnson, 1988).

RESULTS

Radiographic study of the sediment cores form the Cilician Basin reveals the presence of dark, finelly laminated, non- bioturbated, organic-rich horizons (Fig. 2). These horizons display sharp contacts with the sediments above and below and are similar to the S1 sapropels layers of the previous workers, reported from Eastern Mediterranean sediments. Visual examination of the Cilician Basin sediment shows that the S1 sapropelic layers are not black, but are dark grey to olive green muddy sediments. The layers normally do not occur in a single horizon, but are split-up into more than one horizon by a layer of uniform light olive grey laminated and non-laminated mud. The same type of sequence is known from eastern Mediterranean (Kidd et al., 1978). The radiographic study shows that cores containing these layers are confined to water depth greater than 400m (see Fig.1b) within the Cilician Basin, shallower than the previously reported horizons in the Mediterranean Basins (Shaw & Evans, 1984; Ali, 1992).

The TOC concentration in the non-sapropelic sediments of Cilician Basin varies from 0.25 to 0.6%, with a higher values (0.8-1.52%), being observed only in the sapropelic layers (Fig. 3). The TOC is lower than the Late Pleistocene sapropels of the Ionian and Lavant Basins (see Kullenberg, 1952; Stanley & Maldonado, 1979) implying a comparatively less favourable conditions for the development of sapropelic sediments. These organic rich horizons according to the definition of Kidd et al. 1978, should be categorised as sapropelic rather than sapropels. The organic carbon profiles in the sapropelic layers, shown in Fig. 3, indicate the establishment of the optimum conditions producing sapropelic layers marked by a peak, followed by abrupt return to normal condition as a result of decrease in TOC above and below the sapropelic layers.

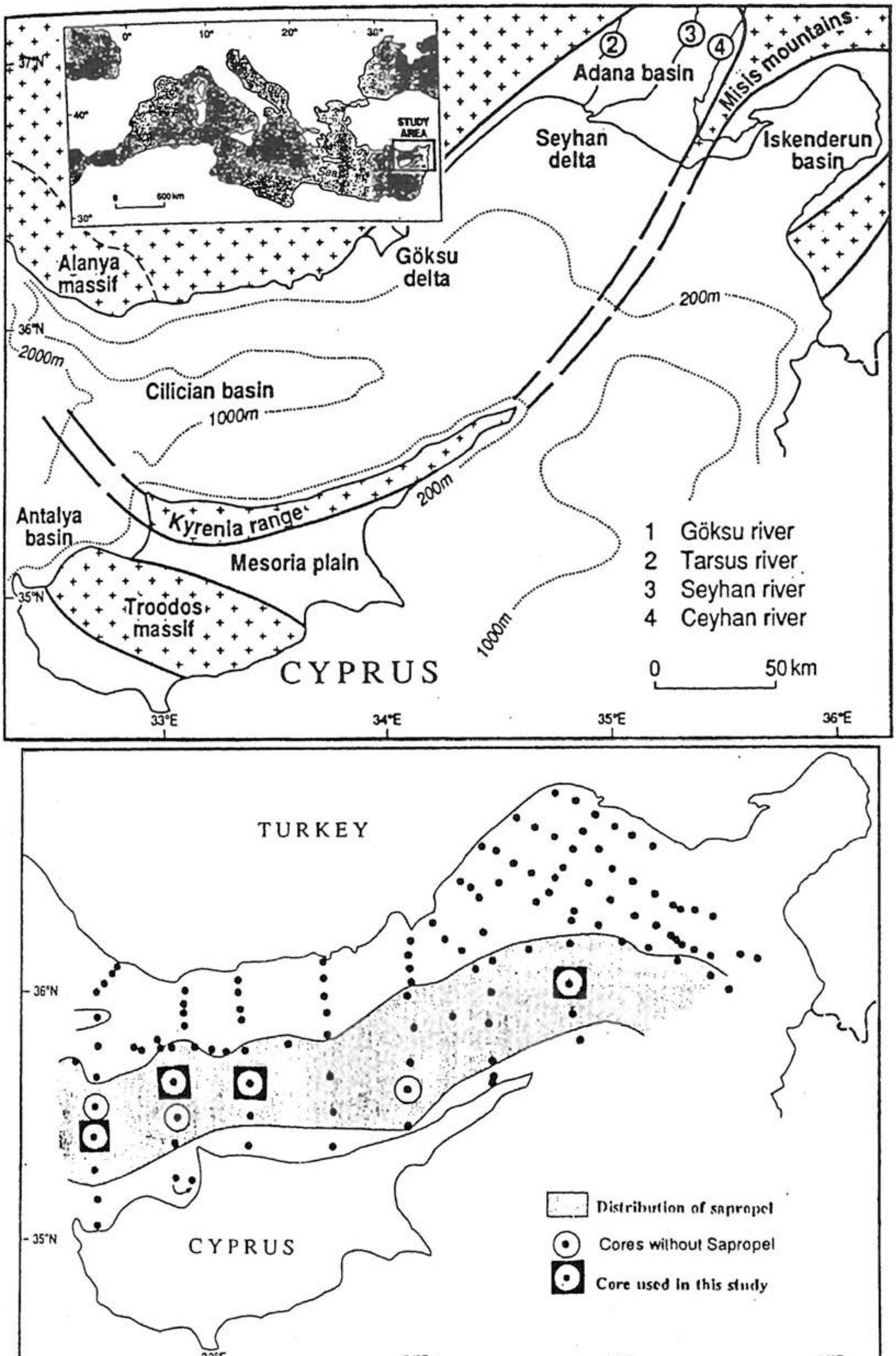

Fig. 1a. Location of the study area (top); b. distribution of sapropelic sediments in the Cilician Basin, NE Mediteranean (bottom).

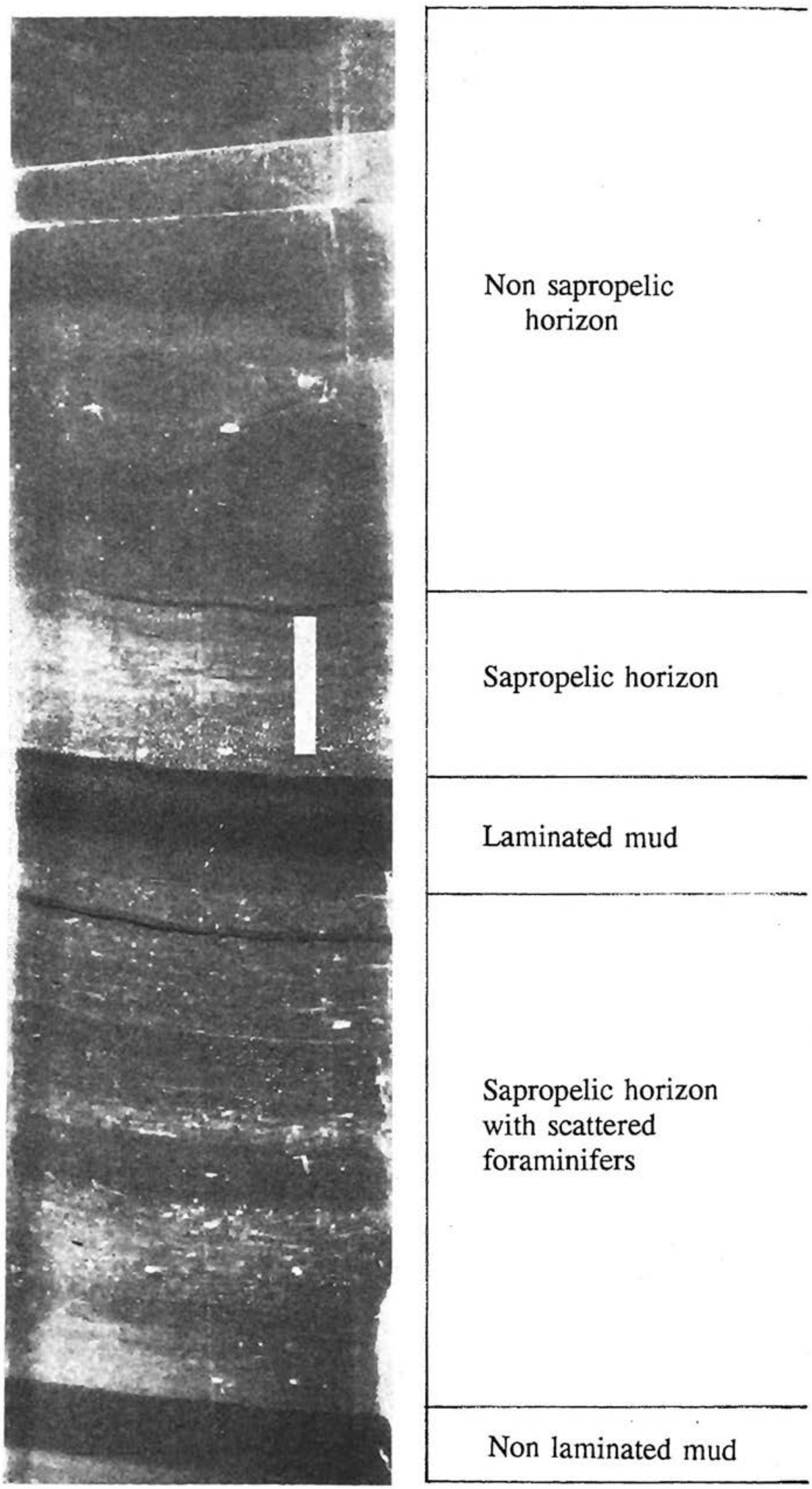

Fig. 2. Radiograph of the sediment core showing sapropelic horizons. Bar scale is 10cm.

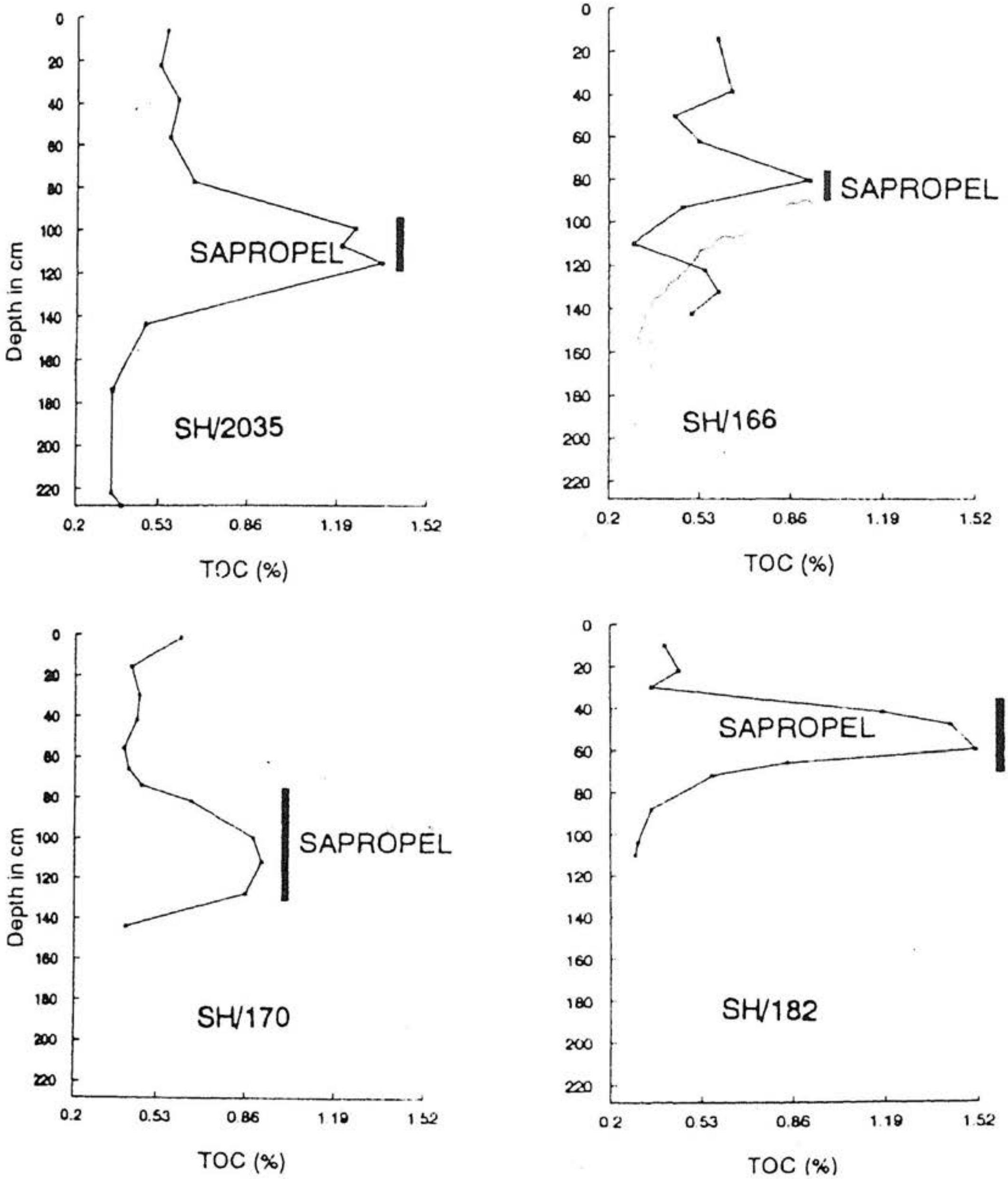

Fig. 3. Total organic carbon (TOC) in the sediment cores of the Cilician Basin.

The petrographic study of extracted OM shows that the sapropelic horizons like those of non-sapropelic are dominated by degraded AOM as revealed by the concentration of TOC. Preserved AOM was observed in only one core sample (SH/2035). This unusual occurence is believed to have resulted from high rate of sedimentation in relatively shallow parts of the basin. High contents of preserved terresterial organic matter (TOM) such as pollen, spores and plant fragments present in the sapropelic layers are attributed to the relative increase in concentration of TOC. The TOM is believed to indicate episodes of post-glacial warming resulted in high concentration of TOM as compared to non-sapropelic layers (Bates, 1982). Similar increase in TOM have been reported from the sapropels and sapropelic layers of various parts of the eastern Mediterranean (Ryan, 1972; Sigl et al., 1978).

Paleontological evidence show that the sapropelic sediments of the Cilician Basin were deposited between 9000-6800 yrs B.P. during post glacial climate warming. The changes in climatic conditions are marked by abrupt increase in the concentration of warm water planktonic foraminiferal species, *Globigerinoides Ruber* and the entire absence of benthic foraminifers from the sediments.

DISCUSSION

The formation of sapropels and sapropelic layers has been attributed to the preservation of OM during period of stagnation under anaerobic conditions. (Kullenberg, 1952; Olausson, 1961; Ryan & Cita, 1977; Cita & Grigni, 1982; Shaw & Evans, 1984). However, from the petrographic study there is very little evidence that there was any preferential preservation of OM as revealed by the low TOC contents of the sapropelic sediments. The dominantly degraded nature of the AOM within both the sapropelic and non-sapropelic sediments alike suggest that these organic rich horizons were not necessarily the result of bottom water anoxia, but could be deposited in an oxygenated environment. Similar observations were made by Calvert (1990) on the Holocene sapropels which are regarded as formed under oxygenated conditions. This imply that the organic richness of the sapropelic horizon may not be due to the enhanced preservation of OM during anoxic events as reported previously. However the fine lamination (as observed in the radiographic study) and the complete absence of benthic foraminifers favour bottom anoxia. A possible explanation for the organic richness of these horizons could be that they were deposited in period of high productivity caused by increased availability of nutrient salts introduced during an increase input of fresh water from the land via rivers that drains the hinterland. This increase would also explain the relatively high concentration of pollen, spores and plant fragments in these horizons (see Bates, 1982; Shaw & Evans, 1984; Ali, 1992). It is believed that TOM was brought into the Cilcian Basin by sediment-laden rivers which originated as a consequence of post-glacial climatic warming.

CONCLUSION

The sapropelic sediments like many other S1 sapropels of the eastern Mediterranean, were deposited during post-glacial climatic warming (9000-6800 yrs B.P) as a result of high input of TOM and increased biological activity produced by the nutrient rich fresh water. The increased river runoff supplied increased amount of land-derived OM such as pollens, spores and plant debris. The low salinity nutrient-rich waters formed a layer over the denser and more saline waters of the eastern Mediterranean, inhibiting the circulation of oxygen in deeper parts of the basin. The oxygen already present was consumed partly by aerobic microbes and partly by oxidation of OM. This created an oxygen deficient environment, marked by the presence of fine lamination and absence of benthic organisms in sapropelic horizons. The existing idea of total preservation of OM under anoxic conditions leads to the formation of sapropel, is not supported by the present observations on the nature of the OM seen in the sapropelic horizons.

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REFRENCES

Ali, Z., 1991. Nature and source of organic matter in the Cilician Basin, NE Mediterranean (abstract), In: BSRG. Conf. Proc. Edinburgh, U.K.

Ali, Z., 1992. Recent sedimentology of the Cilician Basin north eastern Mediterranean. Unpubl. Ph.D thesis, Imperial College London.

Bates, C. D., 1982. Pollen stratigraphy from deep sea cores in Cilician Basin, north eastern Mediterranean. Unpubl. Ph.D thesis, Cambridge Univ., Cambridge.

Buckley, H. A., Johnson, L. C., Shackleton, N. J. & Blow, K. A., 1982. Late glacial to Recent cores from the eastern Mediterranean. Deep-Sea Research, 29, 739-766.

Buckley, H. A. & Johnson, L. C., 1988. Late Pleistocene to Recent sediments deposition in the central and western Mediterranean. Deep-Sea Research, 35, 749-766.

Bouma, A. H., 1964. Notes on X-ray interpretation of marine Sediments: Mar. Geol. 2, 278-307.

Calvert, S. E., & Veever, J. J., 1962. Minor structures of unconsolidated marine sediments revealed by X-radiography. Sedimtology, 1, 296-301.

Calvert, S. E., 1990. Geochemistry and origin of Holocene sapropels in the Black Sea, In: Facets of modern biogeochemistry (V. Ittekkot, ed.). Springer-Verlag, Berlin, 327-353.

Cita, M. B., & Grignani, D., 1982. Nature and origin of Late Neogene Mediterranean sapropels. In: The nature and origin of Cretaceous carbon-rich facies (Schlanger S.O. & Cita, M. B., eds.). London, Academic Press, 165-196.

Evans, G., 1971. The Recent sedimentation of Turkey, adjacent Mediterranean and Black Sea: a review. In: Geology and history of Turkey (Campbell, C.V. ed.). Pet. Expl. Soc., Libya, 385-406.

Evans, G., Morgan, P., Evans, W. E., Evans, T. R. & Woodside, J. M., 1978. Faulting and halokinetic in north eastern Mediterranean between Cyprus and Turkey, Geology, 6, 392-396.

Hamblin, W. K. 1962. X-ray radiography in the study of structures in homogeneous sediments. Jour. Sed. Pet., 32, 201-210.

Kidd, R. B. & Ryan, W. B. F., 1978. Stratigraphy of eastern Mediterranean sapropels sequences recovered during DSDP Leg 42A and their paleoenvironmental significance. In: Initial Reports of DSDP (K. J. Hsu & Montadertetal, L. eds.). US Govt. Printing off., Washington D.C. 42, 421-443.

Kullenberg, B., 1952. On the salinity of the water contained in marine sediments, Medd. Oceanogr. Inst. Goteborg 21, 1-38.

Olausson, E., 1961. Studies of deep sea cores. Rep. Swed. Deep-Sea Exped., 1947-48, 8 (4).

Ryan, W. B. F., & Cita, M. B., 1977. Ignorance concerning episodes of oceanwide stagnation. Mar. Geol. 23, 197-215.

Ryan, W. B. F., 1972. Stratigraphy of Late Quaternary sediments in the eastern Mediterranean. In: The Mediterranean Sea: a natural sedimentation laboratory (D.J.Stanley, ed.). Dowden, Hutchinson and Ross, Stroudsburg, 149-170.

Shaw, H. F., 1978. The clay mineralogy of the recent surface sediments of the Cilician Basin, north eastern Mediterranean. Mar. Geol. 26, M51-M58.

Shaw, H. F., & Bush, P. R., 1978. The mineralogy and geochemistary of the recent surface sediments of the Cilician Basin, north eastern Mediterranean. Mar. Geol. 27, 115-136.

Shaw, H. F., & Evans, G., 1984. The nature, distribution and origin of sapropelic layers in the sediments of Cilician Basin north eastern Mediterranean. Mar. Geol. 61, 1-12.

Sigl, W., Chamley, H., Fabricius, S., D'Argoin, G. C., & Muller, J.,1978. Sedimentological and environmental conditions of sapropels. In: Initial Reports of the DSDP (K. J. Hsu & L. Montadert, eds.), 42, US Govt. Printing off., Washington, D.C., 445-465.

Stanley, D. J. & Maldonado, A.,1979. Lavantine Sea Nile Cone lithostratigraphic evolution: Quantitative analysis and correlation with paleoclimatic and eustatic oscillations in the Late Quaternary. Sed. Geol., 23, 37-65.