Continental Shelf Research 29 (2009) 2045–2060

Contents lists available at ScienceDirect

Continental Shelf Research

journal homepage: www.elsevier.com/locate/csr

Origin and distribution of the terrigenous component of the unconsolidated surface sediment of the Aegean floor: A synthesis

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ARTICLE INFO

Article history:
Received 5 February 2008
Received in revised form
3 October 2008
Accepted 24 November 2008
Available online 9 December 2008

Keywords:
Riverine sediment flux
Sedimentary texture
Clay minerals
Aeolian input
Suspended matter
NE Mediterranean

ABSTRACT

The Aegean Sea covers an area of some $160 \times 10^3\,km^2$ and receives the water/sediment fluxes from a mountainous drainage basin of $>200 \times 10^3\,km^2$. On the basis of its morphodynamic characteristics, the Aegean Basin could be divided into: (1) the North Aegean Sea, an elongated region (trending between N50° and N70°) including the extensive northern shelves and the Deep Aegean Trough; (2) the Central Aegean, which includes: the Cyclades Plateau, a relatively shallow (average depth <350 m) submerged platform, surrounded by small basins (up to 1000 m depth), including also the relatively extended eastern shelf of Asia Minor, and (3) the Southern Aegean Sea, located southwards of the Hellenic volcanic arc, which presents the characteristics of a true back-arc basin (the Cretan Sea).

The surficial unconsolidated sediments of the north Aegean floor are dominated by the terrigenous component (from 50% up to >90%) due to the large terrigenous riverine fluxes. The South Aegean presents high percentages (>50%) of biogenic material, due to the small terrigenous inputs and despite the fact that it is more oligotrophic than the North Aegean. The Central Aegean presents a transitional character with the terrigenous influxes being imported along its eastern part and quantitatively being in between those of the North and South Aegean Sea sub-regions.

The coarse-grained materials in shallow (shelf) areas are attributed to 'relict' deposits, while those in large water depths are almost exclusively biogenic products. The offshore distribution of the fine-grained terrigenous material is dominated by the overall circulation pattern, while meso-scale eddies may, locally, either enhance (anticyclones) or reduce (cyclones) settling rates. Moreover, the spatial distribution of the predominant clay minerals (illite and smectite) and of kaolinite and chlorite is governed by the lithology and proximity to land source areas, the water circulation and the processes of differential settling and flocculation.

Overall, the North Aegean is characterised by sedimentation processes similar to those of a 'continental margin', primarily neritic and secondarily hemipelagic, the Central Aegean region mostly by hemipelagic and the South Aegean, behaving more like an 'oceanic margin', mostly by pelagic processes.

1. Introduction

The Aegean Sea constitutes the NE part of the eastern Mediterranean basin, lying in between the Turkish coastline to the west, the Greek mainland to the north and west and bounded to the south by the island of Crete (Fig. 1). It covers an area of approximately $160 \times 10^3\,km^2$. To the northeast, it is connected to the Sea of Marmara and to the Black Sea through the Strait of Dardanelles (62 km long, 0.45–7.4 km wide and of an average depth of 55 m) and the Bosporus Strait. To the south it exchanges water masses with the Mediterranean Sea through the Cretan passages. Thus, to the southwest, it is connected to the Ionian Sea through: (i) the Strait of Antikithira, between Crete and Antikithira Island (32 km wide and 700 m deep); (ii) the Strait of Kithira, between the islands of Antikithira and Kithira (33 km wide and 160 m deep), and (iii) the Strait of Elaphonissos, between the Kithira Isl. and the SE end of Peloponessos (11 km wide and 180 m deep). To the southeast, it joins the Levantine Sea via (i) the Kasos Strait, between Crete and the adjacent islands of Kasos and Karpathos (67 km wide and >1000 m deep); (ii) the Karpathos Strait, between the islands of Karpathos and Rhodos (43 km wide and 850 m deep); and (iii) the Rhodos Strait, between the Rhodos Isl. and Turkey (17 km wide and 350 m deep) (Fig. 1).

The Aegean Sea is an epicontinental (Stanley and Perissoratis, 1977) microtidal (Tsimplis, 1994) marine basin characterised further by a complex topographical structure; it consists of an

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doi:10.1016/j.csr.2008.11.010

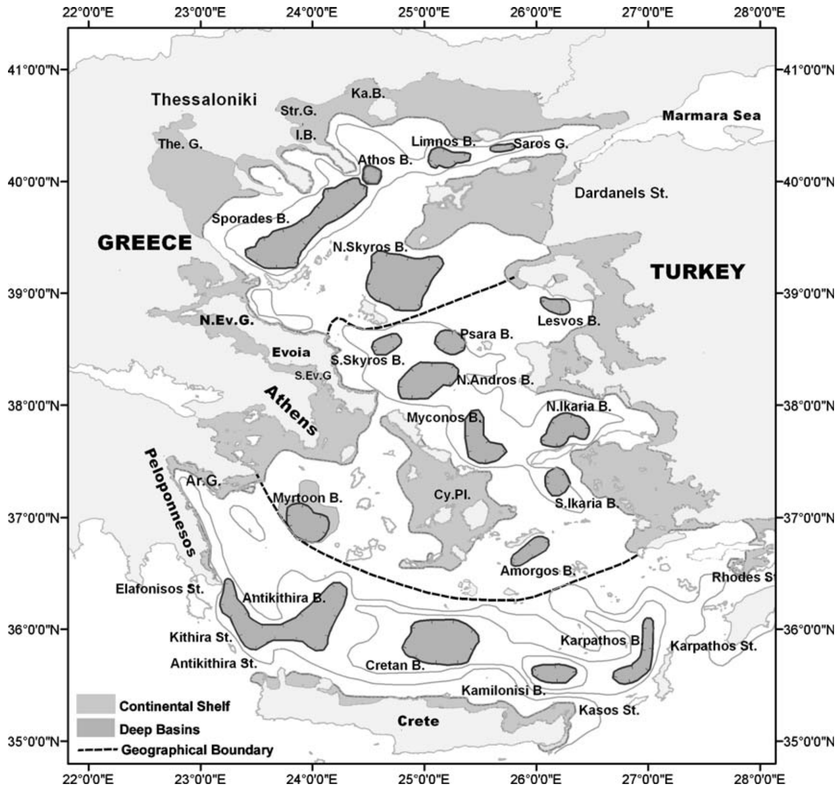

Fig. 1. Bathymetry of the Aegean Sea (Key. B: basin; St.: strait; G: gulf; The.: Thermaikos; Ev.: Evoikos; Cy: Cyclades; Pl: plateau; N: north; S: south; -----: boundary between north, central and south Aegean Sea).

irregular bathymetry (maximum water depth 2561 m), a multifarious coastline and incorporates more than 2000 small and large islands (Fig. 1). Its continental shelf is broad (25–95 km) along its northern and eastern coast, with a rather smooth morphology and a distinct shelf break lying in water depths from 120 to 140 m (Perissoratis and Conispoliatis, 2003); its formation is related to the seaward extension of Quaternary coastal alluvial plains, where large rivers (e.g. Aliakmon, Axios, Strimonas, Nestos and Evros (Meriç)) debouche large quantities of terrigenous sediment (see also Section 4.1). Relatively narrow shelves (<10 km) dominate most of the western margin of the Aegean Sea, with their shelf breaks controlled primarily by major faults and being in between 130–150 m of depth and associated usually with very steep (1:20) slopes (Aksu et al., 1995a).

The climate in the Aegean Sea is of the "Mediterranean" type with two distinct periods: November to March, which is cool and rainy and (ii) May to September, which is hot and rather dry. October and April, the intermediate months between these two distinctive periods, have a transitional character representing also the short-lasting seasons of autumn and spring. Mean monthly air temperatures vary from 5 to 26.5 °C, whilst annual levels of rainfall hardly exceed 500 mm. The annual variation in the wind field is dominated by the persistence of the northerly winds, presenting a double maximum: the first during the winter period (December–February) and the second (known also as the "Etesians") during the summer period (July–August) (Poulos et al., 1996).

The water budget of the Aegean Sea, on an annual basis, is negative as the amount of evaporation ($E = 1280$ mm) exceeds the sum of precipitation ($P = 500$ mm) and river runoff ($R \approx 110$ mm). However, it becomes positive (>1000 mm) if the net Black Sea inflow (BS $\approx$ 1670 mm) is included (Poulos et al., 1996; Bethoux and Gentili, 1994). This excess of water is involved in the exchange of water masses through the Cretan passages, where the total inflow and outflow through all the straits varies between ~2 and ~3.5 Sv (1 Sv = 10^6 m^3/a) (Kontoyiannis et al., 1999). The same authors have found that the net surficial inflow from the eastern straits (through the Karpathos and Rhodes strait) accounts for 60–80% of the total inflow (~2 Sv) and is balanced basically by a net outflow (0.8–2.5 Sv) in the western straits (Kithira and Antikithira); this is imposed by the general circulation pattern of the eastern Mediterranean Sea being a few orders of magnitude greater than the water budget constituents.

Over the past decades, a large number of sedimentological studies have been published concerning mostly the processes of sedimentation taking place within the Aegean basin, with the emphasis being placed upon the continental shelf, and in particular, the major gulfs, bays and river-delta mouth areas (e.g. Thermaikos, Kavala, Alexandroupolis, Izmir, Kusadasi, Ermaios), and the deep basins (e.g. North Aegean Through, Sporades, Chios, Cretan, etc.). These studies may be distinguished further into those refering to the stratigraphy, palaeogeography and related mechanisms of sediment deposition during (primarily) the upper Quaternary, such as those produced by Lykousis et al. (1995), Stanley and Perissoratis (1977), Collins et al. (1981), Van Andel and Lianos (1984), Aksu et al. (1987), Perissoratis et al. (1987a, b), Perissoratis and van Andel (1988), Perissoratis and Mitropoulos (1989), Piper and Perissoratis (1991), van Andel et al. (1990), Perissoratis and van Andel (1991), Perissoratis and Piper (1992), van Andel et al. (1993), Aksu et al. (1995a, b), Perissoratis and Papadopoulos (1999), Geraga et al. (2000), Perissoratis and Conispoliatis (2003), Piper and Perissoratis (2003), Roussakis et al. (2004), Anastasakis et al. (2006), van Andel and Perissoratis (2006), Ergin et al. (2007), Anastasakis (2007), and those refering to the characteristics (origin and distribution) of surficial seabed sediments (i.e. granulometry, clay mineralogy) in association with the prevailing processes of dispersion and settling of suspended particulate matter, i.e. Lykousis et al. (1981), Conispoliatis (1984, 1987),