# SEDIMENT, ORGANIC CARBON AND CARBONATE MASS ACCUMULATION RATES ON THE WESTERN CONTINENTAL MARGIN OF THE BLACK SEA

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**Abstract**

Mass accumulation rates (MAR) based on $^{210}$Pb dating were determined in cores BS-9 and BS-15 located on the western continental margin of the Black Sea in water depths of 600 and 1319 m. The total MAR for these sites is 171.5 and 71.3 g m$^{-2}$ yr$^{-1}$, respectively. The average MARs of total organic carbon (TOC) and carbonate during the last 125 yr in Core BS-15 are 0.75 and 11.85 g m$^{-2}$ yr$^{-1}$, whereas the corresponding values for the Core BS-9 are 0.39 and 6.21 g m$^{-2}$ yr$^{-1}$. The average total MAR values for the last 125 yr are considerably higher than those for the last 2000 years, computed from published $^{14}$C ages, suggesting that the sedimentation rate has considerably increased in recent times.

*Key-words: Black Sea; Accumlation rates, Holocene sediment, Organic Carbon; Carbonate.*

## Introduction

The Black Sea is the largest modern anoxic basin of the world with a maximum depth of 2250 m. It has a pycnocline at a depth of about 100-150 m, separating aerated brackish waters (*18 ‰) from anaerobic, $H_2S$-rich more saline waters (*22.5 ‰). The Black Sea Holocene sediments consist of three units. These from top to base are a laminated coccolith marl (unit 1), a micro-laminated organic-rich sapropel (unit 2) and a lacustrine lutite unit (unit 3). Based on modern AMS $^{14}$C datings of numerous core samples from various parts of the basin, the calibrated ages of 2720 and 7900 yr BP were assigned to the unit 1/unit 2 and unit2/unit 3 boundaries, respectively [1]. Later, the same boundaries were dated at 2000 and 7800 yr [2]. In this paper, we study the mass accumulation rates of total sediment ($MAR_{SED}$), total organic carbon (TOC) and total carbonate in the Holocene sediment section in two cores located on the western continental margin of the Black Sea (Fig. 1). The study is based on $^{210}$Pb dating and TOC and total carbonate analyses of the core samples. The chronology determined by $^{210}$Pb dating is compared with the published $^{14}$C data for the unit 1/unit 2 boundary and both the 210Pband 14C chronologies are used to compute the MARs of TOC ($MAR_{TOC}$) and carbonate ($MAR_{CaCO3}$) for the upper parts of units 1 and 2.

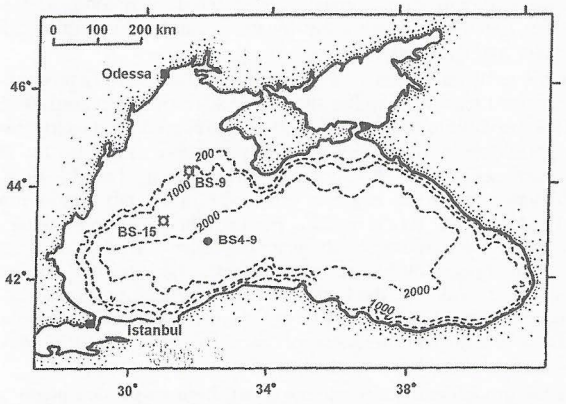


**Figure 1. Location of studied cores. Isobaths are in metres. The location of Core BS4-9 studied by Calvert *et al.* [3] and Buesseler and Benitez [4] is also shown.**

## Methodology

The Cores BS-9 (44°28.118'N, 31°15.178'E, 600 m depth) and BS-15 (: 43°29.094'N, 30°42.367'E, 1319 m depth) were recovered during the IAEA sponsored RADEUX 1998 expedition in the western Black Sea (Fig.1). Undisturbed cores with an intact fluff layer were obtained using a MARK II 400 multicorer. The cores were sliced into 1-cm-thick sections.

Porosity was determined from the water content after correction for the presence of salt. The $^{210}$Pb activity was determined by measurement of the $^{210}$Po by low-level alpha counting after a total acid digestion and silver disc plating. In this method a secular equilibrium (reached in two years) between $^{210}$Pb and its daughter product $^{210}$Po was assumed. Sediment accumulation rates were determined from the unsupported or excess $^{210}$Pb. Supported levels of $^{210}$Pb were assumed to be equal to the downcore asymptote. The mean value is subtracted from the total activity of each sample to arrive at the unsupported level. The average supported activity of $^{210}$Pb in Cores BS-9 and BS-15 were 38 Bq/kg and 30 Bq/kg, respectively. In the absence of bioturbation and assuming that both the flux of $^{210}$Pb ($F_{Pb\text{-}210}$ in Bq cm$^{-2}$ yr$^{-1}$) to the sediment/water interface and the sediment accumulation rate (MAR in g cm$^{-2}$ yr$^{-1}$) have remained constant (i.e., constant flux-constant MAR model), there is the following relationship between the excess $^{210}$Pb activity $A_{Pb\text{-}210}$(m) and the mass-depth (m; g.cm$^{-2}$):

$$A_{Pb-210}(t) = \frac{F_{Pb-210}}{MAR} .e^{-\lambda m/MAR} = A_0 e^{-}$$

where $\lambda$ = radioactive decay constant for $^{210}$Pb (0.693/22.26 yr). A semi-logarithmic plot of excess $^{210}$Pb activity versus m gives a straight line with a slope = - $\lambda$/MAR and intercept Y= $F_{Pb\text{-}210}$/MAR.

TOC was analyzed in acidified sediment samples using a CHN elemental analyzer. Total carbonate contents were determined by a gasometric-volumetric method. The precision of these methods is better than 10% at 95% significance level. MAR (g m$^{-2}$ yr$^{-1}$) is calculated for total sediment, TOC (wt %) and carbonate (wt %) using

MAR= TOC (or $CaCO_3$) / 100 x SR x (1-$\rho$)-(1.02 x $\Phi$ / 100) (2)

where SR = sedimentation rate (cm/kyr), $\Phi$ = porosity (%), $\rho$ = bulk density (g/cm$^3$).

## Results and Discussion

The excess $^{210}$Pb data for Cores BS-9 and BS-15 follow smoothly decreasing exponential curves for the upper 3-9 cm. Using equation 1, we found sedimentation rates of 72 cm kyr$^{-1}$ ($MAR_{SED}$ = 171.5 g m$^{-2}$ yr$^{-1}$) and 24 cm.ky$^{-1}$ ($MAR_{SED}$ = 71.25 g m$^{-2}$ yr$^{-1}$) in Cores BS-9 and BS-15, respectively. The sedimentation rate at Site BS-9 is thus about 3 times higher than at Site B-15. The high sedimentation rate at the former site is in line with its location being closer to the sediment source than Site BS-15 on the Danube submarine fan. Considering that the corrected AMS $^{14}$C age for the unit 1/unit 2 boundary is ≈2000 yr [2] and assuming a linear sedimentation rate between the core top and the unit 1/unit 2 boundary, sedimentation rates for unit 1 in Cores BS-9 and BS-15 would be 25 and 16.3 cm kyr$^{-1}$, respectively. These rates averaged over 2000 yr are therefore about 1.5 to 3 times lower than those for the last 125 yr determined from the $^{210}$Pb data. This suggests that the sediment accumulation rates have not been constant in the last 2000 years and that they significantly increased probably in the last 1000 years as a result of man's impact. Previously using several AMS $^{14}$C datings, Calvert et al. [3] calculated a $MAR_{SED}$ value of 38.7 g m$^{-2}$ yr$^{-1}$ in a core in 2087-m water depth in central part of the western Black Sea. However, based on $^{210}$Pb data in the same core Buesseler and Benitez [4] determined a $MAR_{SED}$ value of 69±3 g m$^{-2}$ yr$^{-1}$, again suggesting a major increase in sedimentation rate in recent times. This last value is comparable with the $MAR_{SED}$ value of 71.25 g m$^{-2}$ yr$^{-1}$ found by us at Site BS-15. The average $MAR_{TOC}$ and $MAR_{CaCO3}$ in the upper 3 cm of the Core BS-15 representing the last 125 yr are 11.85 and 0.75 g m$^{-2}$ yr$^{-1}$, respectively, whereas the corresponding $MAR_{TOC}$ and $MAR_{CaCO3}$ values in Core BS-9 are 6.21 and 0.39 g m$^{-2}$ yr$^{-1}$. Subtracting the $MAR_{TOC}$ and $MAR_{CaCO3}$ from the $MAR_{SED}$, we estimate that Site BS-9 has received 2.7 times more siliciclastic material than that has Site BS-15. Assuming that at Site BS-15 the top of sapropel unit (unit 2) has the same linear sedimentation rate as unit 1 (i.e., 16.3 cm kyr$^{-1}$), the average $MAR_{TOC}$ and $MAR_{CaCO3}$ in the upper part of unit 2 are found to be 3.86 and 0.93 g m$^{-2}$ yr$^{-1}$. The $MAR_{TOC}$ in the sapropel unit is about 25% higher and the $MAR_{CaCO3}$ is 3 times lower than those in the upper part of unit 1. The high $MAR_{CaCO3}$ in unit 1 is essentially caused by the coccolithophore *E. Huxleyi*, which usually blooms during the summer and autumn forming the white laminae.

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