# ENVIRONMENTAL MAGNETISM IN THE NORTHWESTERN BLACK SEA; NEW RESULTS

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**Abstract.** During two research cruises performed in the northwestern Black Sea in 1995 and 1997, samples of bottom sediments (clayey, silty and sandy muds, shelly muds, muddy coquina a.o.) have been collected for magnetic susceptibility (***MS***) study. To determine ***MS***, a Kappabridge KLY-2 has been used. The ***k*** values are ranged between $1.2 \cdot 10^{-6}$SIu. and $448.1 \cdot 10^{-6}$SIu. (1995 phase) and $-4.4 \cdot 10^{-6} \div 438.3 \cdot 10^{-6}$SIu. (1997 phase), respectively. This paper is dealing with the ***MS*** results obtained on samples collected during the 1997 cruise. The ***MS*** map shows a clear anomalous zone (with a maximum ***k*** contour of $400 \cdot 10^{-6}$SIu.) which is coincident with the area directly influenced by the Danube River sediment discharge (particularly, *Danube delta front* and *Danube prodelta* areas, as well as the *area under the influence of the Danube originated sediment flux*). On the other hand, within the *sediment starved external shelf* area, the ***k*** values show an extensive minimum zone (***k*** contours of $25 \cdot 10^{-6}$SIu. and $50 \cdot 10^{-6}$SIu.; minimum $k_{mean}$ value of $7.4 \cdot 10^{-6}$SIu.). So, the areal distribution pattern of the magnetic susceptibility measured on bottom sediments provide clear (geo)physical arguments supporting the main sedimentary environments described by Panin et al. (1999) in the northwestern Black Sea. It is thus confirmed the ability of the environmental magnetism tool used to reflect the principal characteristics of the sedimentary mechanism acting in the river – sea system. Actually, these results are extending the data obtained by the magnetic susceptibility monitoring which has been successfully applied since 1992 in the Danube River - Danube Delta system.

**Key words**: environmental magnetism, magnetic susceptibility, bottom sediment, sedimentary environments, sedimentary processes, Danube River influenced area, northwestern Black Sea.

## INTRODUCTION

Magnetic susceptibility (***MS***) measurements on recent bottom sediment samples collected from the Danube Delta lakes and from the Romanian segment of the River Danube have been made since 1977 (lacustrine sediments) and, respectively, 1981 (fluviatile sediments). The results of these investigations provided interesting and promising results from the perspective of sedimentological and environmental significances (Rădan et al., 1981; S.C. Rădan, in Mihăilescu et al., 1983; Rădan et al., 1993 a.o.). The monitoring program initiated in 1992 allowed to perform seasonal assessments which provided a huge quantity of data, contributing to a better knowledge of the connection between the magnetic properties and various lithologic and chemical parameters of the studied fresh water sediments. The last results obtained for River Danube and Danube Delta sediments pointed out the importance of the ***MS*** studies for geo-ecological evaluation of aquatic ecosystems (Rădan et al., 1996a,b,c, 1998a a.o.).

Magnetic susceptibilimetry has been only recently applied in the marine area, occasioned by the 1995 cruise, leg 2 of the R/V *"Prof. Vodyanitskiy"*, carried out in the north-western part of the Black Sea, in the framework of the EROS-2000 programme. The interpretation of these primary results represents a first application of the rock magnetic method in this terminal sector of the *River Danube* (**RD**) – *Danube Delta* (**DD**) – *Black Sea* (**BS**) macrosystem. Some short remarks on the environmental significance of the contour map achieved on the basis of ***MS*** measurements performed on bottom sediments were included in an extended abstract in which the entire **RD-DD-northwestern BS** system was taken into consideration (Rădan et al., 1998b). Consequently, the spatial extending of the magnetic susceptibilimetry technique application and its conceptual-interpretative implications have become feasible.

A second collection of bottom sediment samples, specially taken for ***MS*** study, has been obtained during the EROS-21 Black Sea 1997 cruise, leg 2, of R/V *"Prof. Vodyanitskiy"*, performed in the same area of the Black Sea. The results are presented in this paper.

## METHODS

The bottom sediments have been collected from different stations of a net covering a large sector of the north-western Black Sea area (Fig. 1), using a box-corer and/or a multicorer, which permited practically a continuous sampling of a sequence, up to 60 cm thick, of recent deposits. The sediment samples measured for ***MS*** consist in clayey to coarse silty or even sandy muds, grey, yellowish, brownish, or blackish in colour, sometimes very rich in organic matter, carbonatic coccolith ooze, sapropelic muds, shelly muds, muddy coquina, and occasionally sands.

The magnetic properties have been measured on a KLY-2 Kappabridge in the palaeomagnetic - rock magnetic laboratory of the Geological Institute of Romania. The magnetic susceptibility value (***k***), expressed in $10^{-6}$SIu, was calculated for each $1.2 \cdot 10^{-6} \div 448.1 \cdot 10^{-6}$SIu. (Rădan et al., 1998b). The range limits correspond to muds very rich in shells, and to coarse silty muds, respectively.

As regards the 1997 investigation phase, 209 sediment subsamples provided by 24 sampling

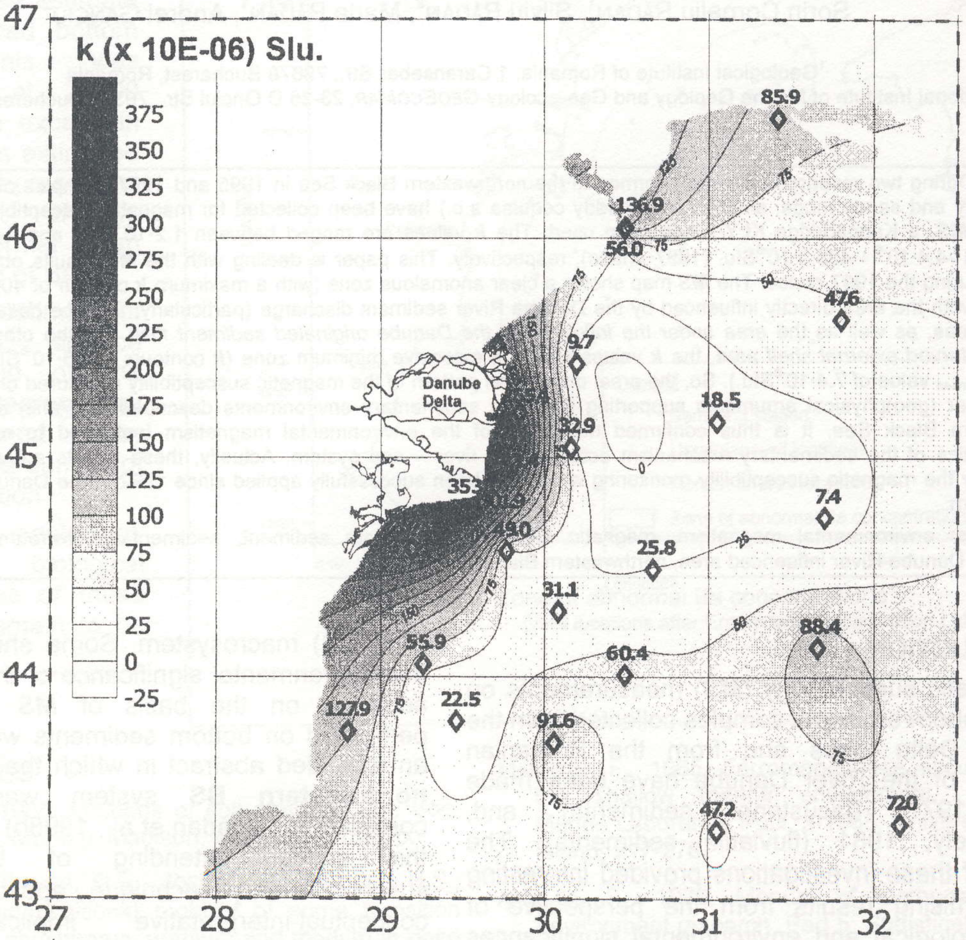


**Fig. 1** Magnetic susceptibility map for bottom sediments sampled in the northwestern Black Sea (Cruise - 1997, Leg.2)

Legend: 136.9 ◇ sampling station and the magnetic susceptibility (k) mean value

—150— k contour

*Note.* The k values must be multiplied by $10^{-6}$ (SIu.). The k contour interval is $25 \times 10^{-6}$ SIu.

sediment sample not neglecting the ***MS*** of the cylindrical measuring vessel used (diamagnetic material – negative ***k*** value). The high sensitivity of the instrument ($4 \cdot 10^{-8}$SIu.), the accuracy and the use of a calibration standard of susceptibility offer feasibility to the ***MS*** data. An average ***k*** value was computed for each location, considering all ***MS*** measurements on subsamples collected from the same multicorer or box core. These mean values have been used to build the ***k*** contour map for the upper part of the modern sediments of the north-western part of the Black Sea (Fig. 1).

## RESULTS AND DISCUSSION

The ***k*** values recorded for 25 surficial sediment samples obtained from 25 stations of the 1995 research phase are situated within the interval

stations were measured for magnetic susceptibility, the ***k*** values varying between $-4.4 \cdot 10^{-6}$ and $438.3 \cdot 10^{-6}$SIu. In this last case, a few cores (up to 55 cm long) were sampled and measured in detail (on 2 cm thick slices) in order to investigate the ***MS*** vertical distribution. Significant variations of the rock magnetic parameter have been recorded along some of the cores picked up from the abyssal zone, controlled by the microlayered sediment lithology of the two units pierced: coccolithic and sapropelic. The pattern of the ***MS*** areal distribution, configured by the map with ***k*** contours based on measurements performed on the collection of bottom sediments sampled during the 1997 Black Sea cruise (Fig. 1), shows a very good correlation with the disposition of the main

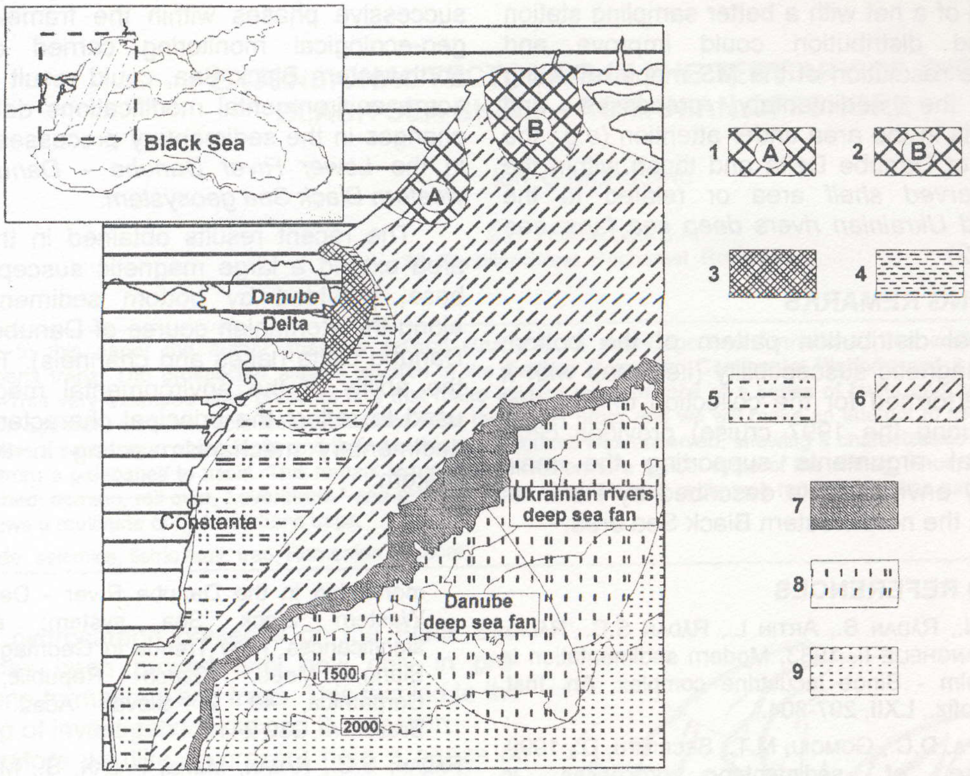


**Fig. 2.** Main sedimentary environments in the northwestern Black Sea area.
1-2. Areas under the influence of the Ukrainian rivers (Dnieper and Dniester) sediment discharge.
3. Danube Delta front area. 4. Danube prodelta area. 5-6. Western Black Sea shelf areas. (5-area under the influence of the Danube originated sediment flux; 6-sediment starved area). 7. Shelfbreak and uppermost continental slope zone. 8. Deep sea fan area. 9. Deep sea floor area.
(after Panin et al., 1999)

sedimentary environments described by Panin et al. (1999) in the same area (Fig. 2).

Thus, the ***MS*** map indicates a clear anomalous (maximum) zone (limited by a ***k*** contour of $400{\cdot}10^{-6}$ Slu.) which is coincident with the *area under the influence of the Danube river sediment discharge*, particularly the *Danube Delta front* and the *Danube prodelta* areas being suggestively revealed (Figs. 1 and 2). The ***MS*** map is consistent as a whole with the existence of two main areas characterized by different depositional processes remarked by Panin et al. (1999) on the *Romanian Black Sea shelf*: the *Danube sediment fed internal shelf* and the *sediment starved external shelf*.

The first area consists in a shallow marine zone which receives detrital sediments supplied by the Danube River; the clayey and silty sediment flux drifts southward toward the Bulgarian shelf, keeping closer to the shoreline (Panin et al., 1999; Fig.2). This area is expressively reflected by the ***k*** contours (lower limit, $75{\cdot}10^{-6}$Slu.; Fig. 1).

In the second above mentioned area, practically deprived of clastic material, the sediments are represented by a condensed deposit of biogenic origin corresponding to *Mytilus* and/or *Phaseolinus* mud zones, where the upper part of the sedimentary sequence consists usually of coquina accumulation (Fig. 2). Consequently, the ***k*** values show an extensive minimum zone (***k*** contours of $25{\cdot}10^{-6}$Slu. and $50{\cdot}10^{-6}$Slu.; minimum $k_{mean}$ value of $7.4{\cdot}10^{-6}$Slu.; Fig. 1).

The *Danube deep sea fan* area (Fig. 2) is also suggested by the ***k*** contours (in the ***MS*** map; Fig. 1).

As regards the *areas under the influence of the Ukrainian rivers (Dniester and Dnieper,* respectively) *sediment discharge* (Fig. 2), they are not reflected by clear individual **k** anomalous zones in the magnetic susceptibility map (Fig. 1). At present, according to the same authors (Panin et al., 1999), these main rivers north of Danube Delta are no significant sediment suppliers for the northwestern Black Sea shelf; their sedimentary load is discharged into lagoons, separated by beach barriers from the Black Sea. However, a higher **k** value can be noticed in the ***MS*** map for the sediment sampled in the *area under the influence of the Dnieper river sediment discharge* ($136.9{\cdot}10^{-6}$Slu.; Figs. 1 and 2).

The *Ukrainian rivers deep sea fan* area (Fig. 2) seems to be shown by a slightly higher ***k*** value ($88.4\times10^{-6}$Slu.; Fig. 1).

In this respect, it must be pointed out that the carrying out of a net with a better sampling station density and distribution could improve and enhance the resolution of the ***MS*** maps reflecting in detail the sedimentary processes and environments in the area under attention (e.g., the zone north of Danube Delta and those within the *sediment-starved shelf* area or related to the *Danube and Ukrainian rivers deep sea fans*; see Figs. 1 and 2).

## CONCLUDING REMARKS

The areal distribution pattern of the bottom sediment magnetic susceptibility (i.e., map with ***k*** contours performed for the collection of samples obtained during the 1997 cruise) provides clear (geo)physical arguments supporting the main sedimentary environments described by Panin et al. (1999) in the northwestern Black Sea area.

The comparison of such images, obtained in successive phases within the framework of the geo-ecological monitoring carried out in the northwestern Black Sea, could result in revealing some environmental modifications determined by changes in the sedimentary processes developing in the *Lower River Danube – Danube Delta – western Black Sea geosystem*.

The recent results obtained in this research area extend a large magnetic susceptibility data-base, provided by bottom sediments sampled along the Romanian course of Danube and within Danube Delta (lakes and channels). They confirm the ability of the environmental magnetism tool used to reflect the principal characteristics of the sedimentary mechanism acting in the river-sea system.

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