RELATIONSHIP BETWEEN THE MAGNETIC SUSCEPTIBILITY AND LITHOLOGICAL COMPOSITION IN SEDIMENT CORES FROM LAKES OF MATIŢA - MERHEI DEPRESSION (DANUBE DELTA, ROMANIA): TOWARDS A PROXY METHOD OF SEDIMENTOLOGICAL AND ENVIRONMENTAL FINGERPRINTING

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Abstract. In the framework of the Danube Delta geosystem spatial evolution study, new results achieved for sediment cores — this time collected from the Matiţa — Merhei Depression lakes — are added up to the data which were previously published with regard to the Meşteru — Fortuna Depression. Actually, it is the second part of the series of papers dedicated to the magneto — lithological investigation of sediment columns, taken out from various aquatic environments, in both the Fluvial and Marine Delta Plains. Vertical profiles of magnetic susceptibility (MS) and contents of siliciclastic/minerogenic/detrital fraction (SIL), total organic matter (TOM) and carbonate (CAR) are carried out for 9 cores (not longer than 55.5 cm), collected from four lakes (Babina, Matiţa, Polideanca and Bogadaplasto), a swamp (Polideanca — Lopatna) and a canal (Lopatna — Polideanca). These records are based on MS (k) measurements (with a Kappabridge KLI-2), and respectively, on lithological component contents analyses (by the ‘Loss on Ignition’/LOI method), performed on sediment samples obtained by core slicing, at 1-3 cm intervals. MS, SIL, TOM and CAR maps are carried out for surficial sediments, as well, in order to describe the magneto-lithological background which characterizes each of the lakes from where the short sediment cores were extracted. The MS calibration of the lake sediments (core and grab samples) is carried out by using a k scale with 5 classes. The correlation coefficient (r) is calculated for all 6 possible pairs of above specified parameters (SIL vs. k, TOM vs. k, CAR vs. k, SIL vs. TOM, SIL vs. CAR and TOM vs. CAR). To evaluate the correlation size, a scale with 6 steps is used. Positive/direct and negative/reversed correlations have always been obtained for SIL vs. k, and TOM vs. k, respectively. Therefore, new proofs are added to assign the magnetic parameter proxy quality as environmental and sedimentological fingerprinting tool. Another important result of the present study is the detection of some marine clays located very close below the water/sediment interface, intercepted, particularly, at the lower/basal part of two cores from the Babina Lake, two from Matiţa Lake, and another one from the Lopatna — Polideanca Canal. These marine deposits (with macroscopically identified specific fauna) are characterized by clearly different magnetic and lithological signatures (high MS values and SIL contents, low TOM contents), as compared with the fingerprints recovered from the overlying muds (sampled at the upper part of the cores). The presence of a marine episode revealed by some of the sediment cores collected from lakes of the Matiţa — Merhei Depression, which is a part of the Fluvial Delta Plain, is very interesting and can represent a contribution to the better knowledge of the deltaic system temporal and spatial evolution.

Key words: environmental magnetism, minerogenic/siliciclastic component, total organic matter component, carbonate component, lake sediments, marine clays.

1. INTRODUCTION – STUDY AREA

In a previous paper dedicated to the evaluation of relationship between the magnetic susceptibility and the lithological composition inferred from sediment cores (Rădan et al., 2013), the main lakes of Meşteru — Fortuna Depression (I, in Fig. 1) have been investigated. This depression is a deltaic unit placed in the western zone of the Danube Delta (DD) northern wing (which encompasses the area between Chilia and Sulina branches).
With a view to extending the analysis of results achieved from the integrated magneto-susceptibilimetric and lithological investigation of the cores taken out during the last five years (2010–2014) in the Danube Delta, the present paper focuses on the data obtained in the other depression situated in the northern wing, but in its central area, also in the Fluvial Delta Plain, i.e., the Matița – Merhei Depression (II, in Fig. 1).

The results provided by 9 short cores, collected in the Matița – Merhei Depression from the Babina, Matița, Polideanca and Bogdaproste lakes, as well as from the Polideanca – Lopatna Swamp and the Lopatna – Polideanca Canal (Figs. 1 and 2), which are commented in the present paper, bring new arguments on the existing correlations between the geophysical/rock-magnetic parameter (MS) and the sedimentological/LITHO ones. The vertical distribution of the magnetic susceptibility values, recorded for the sediment cores, reflects, accurately, the lithological variations, which, sometimes, are macroscopically less visible. Besides, the identification – during the process of core slicing and sediment description performed on the research vessel, right through the field trip – of some marine deposits, within several cores, is confirmed and “quantified” in laboratory; distinct MS and LITHO characteristics are decoded from the magneto-lithological signatures recovered from the sediment sample succession.

The data discussed in the paper represent a new contribution towards developing a proxy method of sedimentological and environmental fingerprinting in lake sediments, confirming the capability of the magnetic susceptibility record to be used as a proxy for the lithological composition characterization of the lake sediments.

2. LOGISTICS, MATERIALS AND METHODS

Essential data concerning the methods used to carry out an integrated magneto-lithological study of sediment cores

Fig. 1. Location of the lakes in the Danube Delta from where sediment cores were collected over the 2010 – 2014 period. I. Meșteru – Fortuna Depression: 1 – Cucuți Lake; 2 – Tătaru Lake; 3 – Băcănești Lake; 4 – Fortuna Lake; 4bis – Crângală Canal; 5 – Troflica Lake; 6 – Belaie Lake. II. Matița – Merhei Depression: 7 – Babina Lake; 8 – Matița Lake; 9 – Polideanca - Lopatna Swamp; 10 – Polideanca Lake; 11 – Bogdaproste Lake; 10bis – Lopatna - Polideanca Canal. III. Gorgova – Uzlina Depression: 12 – Gorgova Lake; 13 – Cuibedo Lake; 14 – Isacova Lake; 15 – Uzlina Lake. IV. Lumina – Roșu Depression: 16 – Lumina Lake; 17 – Puiu Lake; 18 – Roșu Lake. Notes: I – Area with published data (Rădan et al., 2013); 5, 6 – lakes from where 3 cores were collected in 2014, and consequently, are not included in the cited article; II – Area under attention in the present paper; III, IV – Deltaic areas from where the results are to be next published.
were presented in the first paper (Rădan et al., 2013) of a series of 4 articles which are intended to be published related to the four main deltaic depressions (I, II, III, IV, in Fig. 1). Consequently, some significant (new) aspects only will be here mentioned.

The field works carried out by GeoEcoMar in the framework of the Core Program, Contract no. PN 09-41 03 04, aboard the fluvial vessel "Istros" in the Danube Delta lakes have gone on with the October 2013 expedition, and two other cruises, performed in April/May, and August 2014, respectively. The investigations were focused both on the direct observations related to the water and sediments and on collecting water and sediment samples/cores for analyses in specific laboratories. In the lakes where the water depth was lower than 1.50 m, a motor-boat ("Măriuca") was used. Several physico-chemical parameters have been investigated for the surface waters, and the study of the greenhouse gas emissions in different deltaic ecosystems was performed.

The lithological and the magnetic susceptibility characterization of the lacustrine sediments represents an important objective of the respective multi-disciplinary campaigns. The detailed study of the relationship between these two distinct categories of parameters is just what this paper is dealing with.

As regards the Matița – Merhei Depression, under attention here, numerous samples from the surficial/bottom sediments have particularly been taken out (with the grab sampler) during 2010 – 2014; these gave information from the first ca. 20 cm beneath the water/sediment interface. Besides of the principal lakes of this aquatic area, i.e. Merhei, Babina, Matița, Trei Ozere, Bogdaproste, such samples have also come from several small lakes, e.g., Ciorticuț and Corciocăt, (situated north of Babina L.), Polideanca – Lapatna Swamp and Polideanca L. (south of Matița L.), and also Covăliva L. and Căzănel L. (located southwest and south, respectively, of Trei Ozere L.) (Fig. 2). Maps showing the areal distribution of the magnetic susceptibility, based on hundreds of sediment samples, taken out from all these lakes, during the above specified period, are also integrated in the paper.

The collection of 6 sediment cores (Fig. 2), extracted from the Babina L. (cores DD 10-18, DD 10-106 and DD 11-49), Matița L. (cores DD 10-01 and DD 11-01), and Bogdaproste L. (core DD 13-104), in the 2010 – 2013 period, has been completed – during the spring 2014 expedition – by taking a core (DD 14-104) from Polideanca Lake, another one (core DD 14-113) from Polideanca – Lapatna Swamp, and the core DD14-112, from the Lapatna – Polideanca Canai (Fig. 2).

Consequently, nine cores from the Matița – Merhei Depression (location in Figs. 1 and 2) have been available to be investigated for the vertical distribution of magnetic susceptibility and of three lithological components. The sediment columns (with lengths between 24 – 55.5 cm) were extracted with a Hydro-Bios type core sampler, with a transparent tube, and were sliced at 1 – 3 cm intervals, using an extruder, aboard the R/V "Istros". Some details (photos included) can be found in a paper published by Rădan et al. (2013).

The magnetic susceptibility of the samples originating from different levels along each core was measured with a KLY-2 Kappabridge (Instruction Manual for magnetic susceptibility bridge – KLY-2, Geofyzika n.p. Brno, Czechoslovakia, 1981), in the laboratory of environmental magnetism of the Geological Institute of Romania (GIR). The k values were reported to the classes of a “magnetic susceptibility scale” (Fig. 3a; Rădan & Rădan, 2007), so that a MS calibration of the cores is feasible. In this connection, some information on the sediment quality, which is generally evaluated by means of the geochemical and ecological scales, is inferred from the MS records.

As regards the determination of lithological composition variation along the sediment cores, the Loss on Ignition method (LOI) (Dean, 1974; Catianis et al., 2013) was applied, in the specific laboratory of GeoEcoMar. Therefore, the contents of three lithological components, following the order TOM (Total Organic Matter), CAR (CARbonates), and SIL (SILiciclastic/minerogenic fraction) have been determined.

Based on the achieved MS and LITHO parameters, a series of magneto-lithological models associated with each sediment core are presented, analysed and discussed (see Chapter 3). To quantify and interpret the relationship between the magnetic susceptibility calibration of the sediment cores and their lithological composition, diagrams with the graphic correlation between the two categories of parameters (MS versus LITHO), but, also, between pairs of lithological components (SIL vs. TOM; SIL vs. CAR; TOM vs. CAR) are used. The resulted correlation coefficients (r) can be reported to a scale (Fig. 3b) which makes possible the correlation size evaluation related to the enviromagnetic parameter (k) and the LITHO components; six classes are nominated between r = 1 and r = −1, covering distinct stages between "strong positive correlation" and "strong negative correlation", passing, of course, through the "no correlation" point (r = 0) (Fig. 3b). In some cases, scatter-plots which demonstrate clustering of core sediments into distinct lithogenetic groups ("muds" and "marine clays") are also illustrated.

**3. RESULTS AND DISCUSSION**

The magnetic susceptibility records, together with the vertical distribution of the lithological components contents along the sediment cores, are discussed in this chapter. In its first part, the detailed study is following the order given by the sampling-site location, from northern lakes towards the southern ones, and, at the same time, within a lake, taking into consideration the temporal criterion related to the core extraction moment/year. Synoptic MS and LITHO images, and some applications and consequences inferred from them, are presented and commented in the second part of the chapter.
3.1. Magnetic susceptibility and lithological data

The results are analysed within four subchapters, devoted to the Babina Lake, Matija Lake, Lopatna Channel – Polideanca Lake area, and, respectively, Bogdaproste Lake (Fig. 2).


Three sediment cores were collected from the Babina Lake, during 3 expeditions, carried out by GeoEcoMar Institute, in the Danube Delta, in 2010 and 2011. Therefore, the cores DD 10-18 and DD 10-106 were taken out during the expeditions performed between 16 – 30 June 2010, and 8 – 18 October 2010, respectively, while the core DD 11-49, during the campaign organized in the period 29 April – 12 May 2011 (core location in Fig. 2).

a) Core DD 10-106

The macroscopic description of this core (44.5 cm length; location in Fig. 2) correlates very well with the magnetic susceptibility vertical variation, which shows continuously increasing values from the upper part towards the base (Fig. 4a); the MS successively passes through the k class I (43 %), II (33 %) and III (24 %) (Figs. 4a-c). First time, this MS profile was presented within a paper dedicated to a brief overview of the recent sediments as environmagnetic archives, its short analysis being connected with a MS map based on the bottom sediments sampled from the Babina Lake (and Matija L.), in 1978 (Rădan & Rădan, 2011). Now, the discussion related to the core DD 10-106 is extended and diversified. Thus, the pie-chart, which synthesises the weights of the contents of LITHO components characterizing the core sediments, asserts the MS calibration: SIL (39 %), TOM (56 %), and CAR (5 %) (Fig. 4d). The MS record corresponds to the lithological composition regime: the detrital/minerogenic component (SIL) shows a trend of increasing content towards the core base, i.e., from 15.38 % (0 – 1.5 cm) to (80.93 % – 88.09 %), within the 35 cm – 44.5 cm interval below the sediment – water interface (Fig. 4b); the richest in organic substance sediments are present in the first upper 35 cm, the TOM contents ranging between 79.66 % (for the first 1.5 cm of the sediment column) and 48.59 % (for the mud sequence base, i.e., in the 33 – 35 cm depth interval; Fig. 4b). As regards the third lithological component, represented by carbonates (CAR), it is interesting to remark – even if their contents are very low – a similar vertical distribution trend with the TOM component, i.e., higher contents in the 0 – 35 cm depth interval (4.96 % – 9.48 %; Fig. 4b), and lower contents within the bottom zone of sediment column (0.99 % – 2.53 %; Fig. 4b). Actually, when is quantified the relationship between these two lithological components, that is TOM versus CAR, the correlation coefficient (r) shows a strong positive correlation, i.e., r = 0.81 (Fig. 4i). Instead, a strong negative correlation, as it is easily to be deduced from the previous comments, is revealed by the relationship between the silty fraction and carbonates (SIL vs. CAR), namely r = −0.84 (Fig. 4i). Surely, a (very) strong negative correlation is for SIL vs. TOM, with r = −0.999 (Fig. 4h).

As regards the relationships between the lithological components and the magnetic parameter, the correlation coefficients indicate – as the previous comments are suggesting by now – strong correlations in all the cases, positive for SIL vs. k (r = 0.98; Fig. 4e), and negative for TOM vs. k (r = −0.98; Fig. 4f), and CAR vs. k (r = −0.79; Fig. 4g).

The above presented quantification supports the macroscopic observations made aboard the vessel, namely a rapid transition from a silty, organic, noncohesive mud – at the upper part, towards a progressively more compact mud, with darker colour, old bioturbations, silted up, and with a Cardium fragment, at base (42.5 – 44.5 cm depth), possibly a marine clay (Fig. 4).

The line-chart carried out for the vertical variation of the magnetic susceptibility MS (Fig. 5a) and the 2D area-chart for the lithological components SIL, TOM and CAR, particularly the first two (Fig. 5b), clearly illustrate the two distinct segments of the k and LITHO profiles recorded along the sediment core.

Starting from the general correlation diagrams concerning the environmagnetic parameter MS versus the LITHO components (Figs. 4e,f,g, redrawn in Figs. 6a,d,g), we have analysed the same relationship type, but, separately, for the two parts in which the sediment column of the core DD 10-106 was divided. The results are illustrated in Figs. 6b,e,h, for the correlations SIL vs. k, TOM vs. k, and CAR vs. k, related to the “mud sequence” (0 – 35 cm depth interval), and in Figs. 6c,f,i, with regard to the possibly intercepted marine clay sediment (35 – 44.5 cm). Strong correlations are indicated by the coefficient r for muds, in the case of SIL vs. k (positive r; Fig. 6b) and TOM vs. k (negative r; Fig. 6e), and also for CAR vs. k, but concerning the marine clay horizon (positive r; Fig. 6i). Moderate correlations were obtained for the SIL vs. k case (positive r; Fig. 6c) and TOM vs. k (negative r; Fig. 6f), both relating to the marine clay horizon. The only case when a weak correlation (positive) was observed is for CAR vs. k, regarding the “mud sequence” (Fig. 6h). The scale used to evaluate the size of the correlation (r) between the lithological components SIL, TOM, CAR and the environmagnetic parameter (k) was presented in previously published papers (e.g., Rădan et al., 2013).

The magneto-lithological record recovered from the core DD 10-106 is typical for a zone in which the episodic influences are attenuated by the distance to the banks and to the supply canal mouths.

b) Core DD 10-18

The magnetic susceptibility profile recorded along the core DD 10-18 (location in Fig. 2), shows, in the first upper 18 cm (Fig. 7a), a vertical variation which is usually observed for the sediment cores collected from this type of lakes (protected from the direct fluvial influx), that is low values in the first centimeters, followed by an increasing trend towards the core base. This is the case of the previously analysed core from the Babina Lake, collected from its central part.
Fig. 2. Detailed map of the core locations in the Matiţa — Merhei Depression lakes.

Fig. 3. Scales used in the magneto-lithological study of the sediment cores. a) Magnetic susceptibility (MS; k) scale used to calibrate the lake sediments and to correlate with their lithological characters. The k values defining the MS classes must be multiplied by (10 E-06) SI. b) Scale used to evaluate the size of the correlation (r) between the enviromagnetic parameter (k) and the lithological components (SIL — siliciclastic/minerogenic/detrital fraction; TOM — total organic matter fraction; CAR — carbonate fraction).
Fig. 4. Magneto-lithological model showing the vertical distribution of the enviromagnetic parameter (MS, k) and of the lithological components (SIL, TOM, CAR), along the core DD 10-106, collected from the Babina Lake (core location in Fig. 2). a) 3D bar-chart with the vertical distribution of the magnetic susceptibility; the bars are coloured according to the k scale classes (see Fig. 3a); b) 3D 100%-stacked bar-chart with the composite vertical distribution of the three main lithological components (SIL, TOM, CAR); c) 3D pie-chart showing the MS calibration of the core sediments, according to the k classes; d) 3D pie-chart showing the lithological composition of the core sediments, based on the SIL, TOM and CAR contents; e) Diagram showing the correlation SIL versus MS (k); f) diagram showing the correlation TOM versus MS (k); g) Diagram showing the correlation CAR versus MS (k); h) Diagram showing the correlation SIL versus TOM; i) Diagram showing the correlation SIL versus CAR; j) Diagram showing the correlation TOM versus CAR.
Fig. 5. Vertical distribution of the enviromagnetic parameter values (k) and of lithological component contents (SIL, TOM, CAR) along the sediment core DD 10-106, collected from the Babina Lake. a) Line-chart showing the magnetic susceptibility vertical profile. Note: in blue, is zone with negative k values; b) Area-chart with the distribution of SIL, TOM and CAR contents along the sediment core.

(i.e., DD 10-106; Fig. 6a). Yet, the k profile of the DD 10-18 core is more complex, actually according with the vertical variation of the SIL and TOM lithological parameters (Figs. 7b,c). In Figs. 8a,b, the MS, SIL, TOM and CAR records, achieved for the sediment column of the core DD 10-18, are clearly illustrated. Its integrated magneto-lithological characterization is facilitated and argued by the strong direct and reversed correlations for SIL vs. MS, and TOM vs. MS, respectively (Figs. 7g,h). So, a large maximum zone is well defined by the k values recorded for the samples sliced from the median part of the core (with the highest k value of 102.69×10^{-6} SI; k class III), followed by a minimum zone, with its central axis (a k value of 18.5×10^{-6} SI; k class II) around the depth of 41 − 44 cm below the water/sediment interface (Fig. 7a). The 3D bar-charts with the vertical variations of the siliciclastic/minerogenic fraction (SIL; Fig. 7b) and the total organic matter (TOM; Fig. 7c) assert the magnetic susceptibility record along the core DD 10-18. In this context, the correlation diagrams from Figs. 7g,h reveal the strong positive/direct correlation for SIL versus MS (r = 0.93), and respectively, a strong reversed/negative correlation for TOM versus MS (r = -0.86). As concerns the content of carbonates (CAR), this is very low (not higher than 9.9 %), with an exception, generated by the sample collected from the depth interval 41 − 44 cm (Fig. 7d), consisting of a hard and compact soil-like sediment, showing granular to columnar structure (31.41 % carbonates); the correlation CAR versus MS is a moderate negative one (r = -0.47; Fig. 7i). When the lithological components TOM and CAR are considered together, the correlation coefficient for the relation (TOM + CAR) versus MS is increasing, becoming r = -0.93 (Fig. 7j).

The magneto-lithological data assert the macroscopic observations performed aboard, during the core slicing procedure, pointing out a peculiar pattern. The first segment from 0 to 20 cm has a normal development, similar to that of other cores, starting with a grey-brownish, non-cohesive, fluffy organic mud (first 9 cm), which becomes more dense and hard in the lower part of the interval. This mud sequence is followed downwards by compact soil-looking clayey sediment, rich in plant debris, which explains some organic matter maxima (e.g., 0 − 9 cm and 44 − 50 cm intervals; Fig. 7c) and the corresponding MS minima (Fig. 7a). This sediment could represent the partially emerged old substrate of a lake sector, close to the sea, taking into consideration the Cardiidae shells found in this deposit, atypical for the lakes included within the fluvial delta plain area. Its presence can acquire a great importance if absolute age determinations on shelly material of marine origin would be performed.
Fig. 6. Detail with the correlation of the environment parameter (MS) with the lithological components (SIL, TOM, CAR), concerning the sediment core DD 10-106 (Babina Lake). a) Correlation SIL versus k, related to the entire core (0 − 44.5 cm); b) Correlation SIL versus k, related to the "mud sequence" (0 − 35 cm); c) Correlation SIL versus k, related to the intercepted "marine sediment" (35 − 44.5 cm); d) Correlation TOM versus k, related to the entire core (0 − 44.5 cm); e) Correlation TOM versus k, related to the "mud sequence" (0 − 35 cm); f) Correlation TOM versus k, related to the intercepted "marine sediment" (35 − 44.5 cm); g) Correlation CAR versus k, related to the entire core (0 − 44.5 cm); h) Correlation CAR versus k, related to the "mud sequence" (0 − 35 cm); i) Correlation CAR versus k, related to the intercepted "marine sediment" (35 − 44.5 cm).
Fig. 7. Magneto-lithological model showing the vertical distribution of the enviromagnetic parameter (MS, k) and of the lithological components (SIL, TOM, CAR), along the core DD 10-18, collected from the Babina Lake (core location in Fig. 2).

a) 3D bar-chart with the vertical distribution of the magnetic susceptibility; the bars are coloured according to the k scale classes (see Fig. 3a); b) 3D bar-chart with the vertical distribution of the siliciclastic/minerogenic component (SIL); c) 3D bar-chart with the vertical distribution of the total organic matter component (TOM); d) 3D bar-chart with the vertical distribution of the carbonate component (CAR); e) 3D pie-chart showing the MS calibration of the core sediments, according to the k classes; f) 3D pie-chart showing the lithological composition of the core sediments, based on the SIL, TOM and CAR contents; g) Diagram showing the correlation SIL versus MS (k); f) Diagram showing the correlation TOM versus MS (k); g) Diagram showing the correlation CAR versus MS (k); h) Diagram showing the correlation SIL versus TOM; i) Diagram showing the correlation SIL versus CAR; j) Diagram showing the correlation TOM versus CAR.
The clayey substrate, with an identified marine fauna, in the Babina Lake, at west of the initial palaeo-beach sand ridge, could be older or penecontemporaneous with its formation.

c) Core DD 11-49

This sediment core was taken from the southern-central part of the Babina Lake (location in Fig. 2), during the 2011 spring campaign. The crossed sequences make this sediment core very interesting, and some considerations are hereinafter given. The upper lacustrine mud, which is fluffy, non-cohesive, containing Anodonta shell fragments, is passing, after ca. 15 cm, to a more compact mud, with a granular aspect, and then, along the following 20 cm, it is getting to a marine grey clay, rich in Cardiidae. The lithological composition of the sediment column is synthesized and quantified in Fig. 9f by means of the three main components: SIL (siliclastic fraction), TOM (organic matter) and CAR (carbonates); their weights are 59 %, 35 %, and 6 %, respectively. The downcore modification of the lithology is correspondingly recorded by the vertical variation of the LITHO components SIL and TOM, but also of the enviromagnetic parameter MS (Figs. 9b,c,a, respectively). The calibration of the core sediment to the k scale shows the predominance of the class III (64 %), followed by k class I (29 %), and class II (7 %) (Fig. 9e). This composite structure of the k classes assigned to the sediment samples extracted from the core DD 11-49, particularly classes (I + II) = 36 %, and class III = 64 %, is well correlated with the quantified lithological composition, particularly (TOM + CAR) = 41 %, and SIL content = 59 % (Fig. 9f). The integrated MS and LITHO characterization is well explained by the interception of a marine clay (Figs. 9a,b,c), which records higher magnetic susceptibility values, reaching 155.05×10⁻⁶ SI, assigned to k class III (Fig. 9a), and respectively, by the first sequence intercepted under the water/sediment interface, represented by fluffy muds, usually defined by low and very low MS values; in this case, for the first four samples, taken from the core top (0 – 11 cm), k values between 4.08×10⁻⁶ SI and 8.06×10⁻⁶ SI (attributed to class I) were measured, and for the following sample, a more compact mud (11 – 14 cm), a k value of 42.65×10⁻⁶ SI (assigned to class II) was determined (Fig. 9a). Accordingly, in the lower part of the core DD 11-49, higher contents of the siliclastic/minerogenic fraction (up to 88.34 %; Fig. 9b) were obtained, while higher organic matter contents (up to 83.07 %) were found in the core upper part (Fig. 9c). A parallel illustration of the 4 profiles recorded for the sediment core DD 11-49 is given in Fig. 10a – related to the MS enviromagnetic parameter, and in Fig. 10b – for the SIL, TOM and CAR lithological components.

The scatter-plot analysis concerning the relationship between the magnetic susceptibility (MS; k) and each of the three main lithological components (SIL, TOM, CAR) (Figs. 9g,h,i) identified within the core sediments shows clustering into the two distinct lithogenetic groups: muds and marine clays. So, the muds are defined by lower SIL, and respectively, higher TOM contents, the MS recording low k values (Figs. 9g,h), as compared with the marine clays, which are characterized by higher SIL, and respectively lower TOM contents, the MS revealing high k values (Figs. 9g,h). As regards the scatter-plot of CAR versus k (Fig. 9i), the separation of the two distinct lithological categories is marked out by the magnetic parameter (MS) only, the CAR contents determined within the muds and marine clays being placed inside of a similar variation range, i.e., 4.2 % – 6.78 % (see also Fig. 9d). There is an exception, a higher CAR content (9.21 %), which was determined for the slice cut from the 20 – 23 cm depth interval, a lumashelic grey clay, very rich in Cardiidae fragments (and a few whole shells).

To interpret relative lake-level changes, Finkenbinder et al. (2014) use the scatter-plot analysis – related to the “organic matter content” versus “magnetic susceptibility” – for a composite sediment core from the Harding Lake (central Alaska, USA), in which case is also demonstrated clustering of some lithologic units into distinct groups.

As a concluding remark at the end of the study carried out for the sediment cores collected in the Babina Lake during the 2010 and 2011 campaigns, we can mention that to set off some marine deposits very close of the actual water/sediment interface is very important for the deltaic system evolution knowledge, taking into consideration that these are located behind of the initial Jibrieni – Letea – Caraorman sand ridge, and thence, older than this one.


Two cores were collected from the central zone of the Matiţa Lake, in the years 2010 and 2011, respectively, from the sampling stations DD 10-01, and DD 11-01, respectively (location in Fig. 2).

a) Core DD 10-01

This sediment core (location in Fig. 2) has provided an interesting magneto-lithological model. The first 20 cm from the upper part are constituted of a yellowish-brown, non-cohesive organic mud, fluffy on top and more compact towards the base, where a few gastropods and depigmented and loose Dreissena shells have been found; a H₂S-like smell is characteristic. These muds are defined by low magnetic susceptibilities, but with an increasing trend towards the lower part of the upper core interval (0 – 20 cm); k values between 0.26×10⁻⁶ – 49.35×10⁻⁶ SI were measured, that is the sediment is calibrated to k classes I and II (Fig. 11a). In fact, within these 20 centimeters, the total organic matter content (TOM) decreases from 55.6 % (the highest TOM content related to the entire core) up to 16.6 % (Fig. 11e), and correspondingly, the siliclastic fraction content (SIL) increases from 34.5 % up to 70.8 % (Fig. 11b). In the following 11 centimeters (20 cm – 31 cm), where the mud becomes more compact, and the first Cardium shells (articulated valves included) occur, the k values measured on the core slices are increasing even more (79.82×10⁻⁶ – 219.63×10⁻⁶ SI), the sediment being calibrat-
ed to k classes III and IV (Fig. 11a). The lithological support related to the enviromagnetic parameter evolution is again evident: the minerogenic fraction (SIL) content increases from 75.5 % up to 84.8 % (Fig. 11b), and, correspondingly, the total organic matter (TOM) content decreases from 16.6 % up to 7.1 - 7.4 % (Fig. 11e). Further, in the following 25 centimeters, up to the core bottom, the sediments are defined by marine characteristics (light grey clayey muds, passing towards plastic clays, coarser at the core base, with Cardiidae inside). The magnetic susceptibility clearly records this lithological change, the MS measured on the sediment samples collected from this depth interval (31 − 55 cm) revealing high k values (230.32×10⁻⁶ − 285.44×10⁻⁶ SI), which are assigned to the classes IV and Va (Fig. 11a). On the other side, referring to this core lower half, the highest siliciclastic fraction (SIL) contents are ranging between 85.4 % − 90.0 % (Fig. 11b), with a mean value of 86.5%, while the lowest total organic matter (TOM) contents are defined between 4.6 % − 8.2 % (Fig. 11e), with a mean value of 6.95 %. So, the correlation of the enviromagnetic parameter with the main lithological characteristis, quantified by the (calculated) r coefficients (Figs. 11g,h), is suggested – even graphically only – by the corresponding 3D bar-charts (Fig. 11a, and Figs. 11b,e, respectively). A remark could be done on the relatively constant high and low contents determined for the SIL (Fig. 11b) and TOM (Fig. 11e) lithological components, respectively, along the specified depth interval (31 − 55 cm), where the marine clay horizon has been intercepted (Fig. 11a). The pie-charts from Figs. 11c,d help us to compare some synthesis magneto-susceptibilimetric and lithological data which characterize the DD 10-01 core sediments, resulting from the MS calibration, based on k classes, and from the LITHO composition analysis, defined by the SIL, TOM and CAR components: classes I + II = 37 %, while the contents of TOM + CAR = 26 %; classes III + IV + Va = 63 %, while SIL content = 74 %.

The cause of the discussed evolution is a diminution of the detrital supplies, associated with an increase of the primary productivity and of the eutrophication, providing more and more organic material. This decrease of the Danube
Fig. 9. Magneto-lithological model showing the vertical distribution of the eniromagnetic parameter (MS, k) and of the lithological components (SIL, TOM, CAR), along the core DD 11-49, collected from the Babina Lake (core location in Fig. 2). a) 3D bar-chart with the vertical distribution of the magnetic susceptibility; the bars are coloured according to the k scale classes (see Fig. 3a); b) 3D bar-chart with the vertical distribution of the siliciclastic/minerogenic component (SIL); c) 3D bar-chart with the vertical distribution of the total organic matter component (TOM); d) 3D bar-chart with the vertical distribution of the carbonate component (CAR); e) 3D pie-chart showing the MS calibration of the core sediments, according to the k classes; f) 3D pie-chart showing the lithological composition of the core sediments, based on the SIL, TOM and CAR contents; g) Scatter-chart of SIL versus MS (k), which shows clustering of the core sediments into two groups; h) Scatter-chart of TOM versus MS (k) (see text); i) Scatter-plot of CAR versus MS (k) (see text).
influence has also been possible in the context of the silting up of the canal inputs, which were not dredged during the last decades. The mineralization and natural trend of the organic substance decay along with increasing of the depth beneath the water/sediment interface must not be neglected.

As regards the third lithological component – the carbonates (CAR), the evolution along the sediment core (Fig. 11f) shows a relatively constant content (5.3% – 7.5%, with a mean of 6.5%), in the core lower half, as we mentioned for SIL and TOM components, as well; higher CAR contents were determined in the upper core half, with a second maximum zone around the depth of 24 – 28 cm (Fig. 11f), where the aboard macroscopic description has indicated a mud very rich in shells (Cardium, Dreissenia, Unio).

The first samples were sliced at 1 cm intervals, so that it seems the resolution of the lithological analyses has been influenced along the respective depth interval (upper 4 centimeters) because of the small available material quantity.

The scatter-plot analysis concerning the relationship between the magnetic susceptibility ($MS; k$) and each of the three main lithological components ($SIL$, $TOM$, $CAR$) (Figs. 11g,h,i) reveals clustering of the core sediments into the two groups: muds and marine clays. A general remark concerns the broader ranges in which the lithological component contents (particularly, of SIL and TOM, but also of CAR) are defined for muds, as compared with the quasi-constant (narrow) ranges characterizing the SIL and TOM contents (anyway, less narrow for CAR, as well), determined for the marine clays (Figs. 11g,h,i). Yet, as in the case of the core DD11-49 (Babina Lake; Ch. 3.1.1.c), the magnetic parameter ($MS; k$) gets on a better dissociation – inside of the scatter-plots – of core sediments into the two lithogenetic categories: the muds, defined by distinctly lower $k$ values, comparing with the (high) magnetic susceptibilities which characterize the marine clayey muds and clays (Figs. 11g,h,i).

The area-chart from Fig. 12b shows the vertical distribution composite image of the lithological components $SIL$, $TOM$ and $CAR$ (Figs. 11b,e,f). As regards the line-chart
from Fig. 12a, carried out for the downcore variation of the magnetic susceptibility $MS$ (Fig. 11a), this clearly illustrates – and asserts the above scatter-plot analysis – two distinct sequences recorded by the $k$ profile: the upper, concerning the muds, within the first 20 cm beneath the water/sediment interface, and the lower, within the following 35 cm, up to the core base, related to the marine clays.

b) Core DD 11-01

The Core DD 11-01 presents an interesting lithology, which starts with an organic, non-cohesive and fluffy mud, at the upper part, going towards the base to a darker, more compact sediment, rich in shells ($Dreissena$) and vegetal fragments, and passing, finally, to a grey marine clay, with Car-
The interception of the marine clay is clearly emphasised by all the parameters, both enviromagnetic (MS) and lithological ones (SIL, TOM); their vertical distribution along the sediment core is illustrated in Figs. 13a,b,c. The magnetic susceptibility (MS, k) record reflects, with a high accuracy, the lithological variations, data which become even more important when the respective changes are macroscopically less visible. The sediments are generally finer than those constituting the other core collected from the Matița Lake central area (i.e., DD 10-01). The most samples (48 %) are calibrated to k class II (Figs. 13a,e), a rather significant weight comes to the k classes I (19 %) and III (19 %), the rest of 14 % being attributed to class IV (Figs. 13a,e).

The increasing trend of the magnetic susceptibility values along the core DD 11-01, from top downwards, is in agreement with the sediment lithology shown by the 23 slices (the first two samples extracted at intervals of 1 cm were not measured for MS because of the low available quantity of sediment). The organic mud, non-cohesive, fluffy, and presenting a H2S smell, described along the first 10 cm of the core, is characterized by very low k values ($0.31\times10^{-6} - 2.41\times10^{-6}$ SI), assigned to class I (Figs. 13a,e). The magnetic susceptibility is continuously increasing along the following 30 cm, where a more and more compact mud (passing to a cohesive mud) was intercepted, but, anyway, keeping the measured MS values inside of the k class II ($10.19\times10^{-6} - 66.9\times10^{-6}$ SI; Figs. 13a,e). Within the 40 – 47 cm depth interval, a lighter grey mud occurs, which contains shell fragments (Cardiidae, Valvata, Dreissena), and is characterized by higher k values ($87.55\times10^{-6} - 151.65\times10^{-6}$ SI), assigned to class III. This horizon makes the transition to a grey-bluish plastic clay, with Cardiidae, which is attributed to a marine clay, and that is intercepted up to the core base, respectively 53 cm (Fig. 13a). This deposit is clearly remarked by the highest magnetic susceptibility measured for the DD 11-01 core sediments, the MS values being assigned to the k class IV ($195.3\times10^{-6} - 219.86\times10^{-6}$ SI; Figs.13a,e). It is worth mentioning that at the depth of 46 cm it was cut a sediment slice of 1 cm thickness only, the aboard macroscopic description pointing out a transition zone between the upper mud, and a light grey, plastic clay (actually, the marine clay).
The magnetic susceptibility measured on this sediment also shows a “transition value” (151.65×10^-6 SI, assigned to class III; Figs. 13a,e), which is placed between the previous “MS level” (87.55×10^-6 – 94.6×10^-6 SI; 40 – 46 cm depth interval; Fig. 13a) and the highest k values determined for the last 6 cm on the core bottom (Fig. 13a).

The vertical distribution of the lithological components, particularly concerning the siliciclastic/mineral fraction (SIL; Fig. 13b) and the total organic matter (TOM; Fig. 13c), asserts the integrated interpretation of the magnetic susceptibility core profile and of the macroscopic description. The highest SIL contents (74.13 % – 79.74 %; Fig. 13b), and, correspondingly, the lowest TOM contents (11.81 % – 16.78 %; Fig. 13c) were determined for the marine clay, while the lowest SIL, and the highest TOM contents were shown by the muds intercepted on core top (Figs. 13b,c). As regards the carbonates (CAR), the vertical distribution of their contents indicates two maximum zones (Fig. 13d), one with the apex around the 19
- 28 cm depth interval (with a maximum CAR content of 8.62 %), and the second, at the core lower part (with the highest CAR content of 12.29 % determined for the sample sliced at the 46 – 47 cm depth level). Inside of the depth intervals associated with the maximum CAR zones, the macroscopic description of the core has particularly indicated the presence of numerous shell fragments. The MS record, as well as the SIL, TOM and CAR profiles (represented by a unique area-chart) – illustrating the vertical variation of these magneto-lithological parameters along the core DD 11-01 – are given in Figures 14a and 14b.

Taking into consideration the magneto-susceptibility and lithological data achieved for the entire sediment column (53 cm length), the general correlation diagrams performed for the «MS parameter versus LITHO components» illustrate and show a strong positive/direct correlation for SIL vs. k (r = 0.98; Fig. 15a), a strong negative/reversed one for TOM vs. k (r = − 0.97; Fig. 15d), and a moderate positive correlation for CAR vs. k (r = 0.55; Fig.15g). Starting from this information, we have analysed, separately, the previous relationships for each of the two parts in which the sediment column of the core DD 11-01 was – lithologically – divided (i.e., muds and marine clay, respectively). The results relating to the "mud sequence" (2 – 46 cm depth interval) are illustrated in Figs. 15b,e,h, for the correlations SIL vs. k, TOM vs. k, and CAR vs. k, respectively, while those regarding the marine clay deposit (intercepted between 46 – 53 cm) are given in Figs.15c,f,i. Strong correlations are indicated by the coefficient r for muds, in the SIL vs. k case (r = 0.98, i.e. a positive/direct correlation; Fig. 15b) and for TOM vs. k (r = − 0.96, i.e. a negative/indirect correlation; Fig. 15e), and also in the CAR vs. k case, but concerning the marine clay horizon (r = − 0.99, i.e. a negative/reversed correlation; Fig. 15i). Relating to this marine sequence, sampled along 7 cm, at the base of the core DD 11-01, moderate positive/direct correlations were obtained for both SIL vs. k (r = 0.34; Fig. 15c) and TOM vs. k (r = 0.43; Fig. 15f). As concerns the relationship CAR vs. k, yet evaluated for the muds, sampled from the core depth interval 2 – 46 cm, the coefficient r indicated a (very) weak positive correlation (r = 0.09; Fig. 15h).

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Fig. 14. Vertical distribution of the enviromagnetic parameter values (k) and of lithological components contents (SIL, TOM, CAR) along the sediment core DD 11-01, collected from the Matiţa Lake. a) Line-chart showing the magnetic susceptibility vertical profile; b) 100% stacked area-chart with the distribution of SIL, TOM and CAR contents along the sediment core.
During the 2014 spring expedition (25 April – 7 May period), carried out in the Danube Delta, three sediment cores were collected from the Lopatna Channel – Polideanca Lake area (Fig. 2): core DD 14-113 – from the canal which connects the Lopatna Channel with the Polideanca L., and core DD 14-104 – from the Polideanca Lake central zone. The magnetic susceptibility and lithological results are further analysed.

a) Core DD 14-113

This short core, of 24 cm length, collected from a swamp situated on the canal axis which makes the connection between Lopatna Channel and Polideanca Lake (Fig. 2), penetrated a dark grey mud sequence of 22 cm thickness, containing some vegetal material, intercepting then, at the 22 – 24 cm depth level, after a net boundary, a compact “peaty” mud – a dark grey clayey-silty mud (= “lacustrine clay”).

The magnetic susceptibility measurements confirm the presence of vegetal material within all the 12 sediment slices, the MS values being correlated with the k class II (Figs. 16a,c). The MS profile is defined by k values ranging between 24.51×10^-6 – 59.47×10^-6 (Fig.16a), the two extreme values being measured on the core top (0 – 2 cm) represented by a fluid mud, containing a coarser vegetal material and, respectively, at the core base (22 – 24 cm) – a compact clayey-silty mud, with rare vegetal remains.

The lithological composition of the core DD 14-113 (Fig. 16b) supports the MS profile, particularly the above remarks. Thus, the contents of the siliclastic component (SIL) determined for the 12 sediment samples are ranging between 15.23 % – 48.17 %, values provided by the first (top) and the...
last (bottom) core samples, respectively. Complementary, the highest total organic matter (TOM) content (84.11 %) was achieved for the top mud (0 – 2 cm), containing coarser vegetal material, while the lowest TOM content (49.74 %) was provided by the “lacustrine clay”, with rare vegetal remains, intercepted at 22 – 24 cm depth. As regards the third lithological component – the carbonates (CAR), small contents (between 0.66 % – 2.1 %; Fig. 16b) characterize the core sediments; the ends of the CAR definition range were obtained for the samples collected from the same depth intervals as in the SIL and TOM component cases. The pie-chart from Fig. 16d quantifies the main characteristics of the lithological composition of the core sediments, and points out the highest content (73 %) of the TOM component, followed by the SIL (26 %) and CAR (1 %) components, respectively.

Fig. 16. Magneto-lithological model showing the vertical distribution of the enviromagnetic parameter (MS; k) and of the lithological components (SIL, TOM, CAR), along the core DD 14-113, collected from the Polideanca - Lopatna Swamp (core location in Fig. 2). a) 3D bar-chart with the vertical distribution of the magnetic susceptibility; the bars are coloured according to the k scale classes (see Fig. 3a); b) 100%-stacked bar-chart with the composite vertical distribution of the three main lithological components (SIL, TOM, CAR); c) 3D pie-chart showing the MS calibration of the core sediments, according to the k classes; d) 3D pie-chart showing the lithological composition of the core sediments, based on the SIL, TOM and CAR contents; e) Diagram showing the correlation SIL versus MS (k); f) Diagram showing the correlation TOM versus MS (k); g) Diagram showing the correlation CAR versus MS (k); h) Diagram showing the correlation SIL versus CAR; i) Diagram showing the correlation TOM versus CAR.
Actually, the correlation coefficients $r$ (Figs. 16e,f,g,h,i) assert, quantitatively, the magnetic susceptibility and lithological characterization of the core DD 14-113. As concerns the relationships between the lithological components and the enviromagnetic parameter $MS$, we can remark the strong correlation for $SIL$ versus $k$ (Fig. 16e), and $TOM$ vs. $k$ (Fig. 16f), positive/direct ($r = 0.78$), and negative/reversed ($r = −0.78$), respectively. A moderate positive correlation is shown by the $r$ coefficient for $CAR$ vs. $k$ ($r = 0.51$; Fig. 16g). It is also interesting to mention the type/size of the relationships existing between the main two lithological components, $SIL$ and $TOM$, and the carbonates ($CAR$). So, a strong direct correlation characterizes $SIL$ vs. $CAR$ ($r = 0.76$; Fig. 16h), and a strong reversed correlation is indicated by $TOM$ vs. $CAR$ ($r = −0.78$; Fig. 16i).

Finally, the vertical variation of the magnetic susceptibility related to the sediment core DD 14-113, alongside of the vertical distribution of the contents of the three lithological components, are illustrated by the line-chart (Fig. 17a), and the 2D area-chart (Fig. 17b), respectively.

b) Core DD 14-112

Located between the Polideanca − Lopatna Swamp and the Polideanca Lake, on the connection canal with the Lopatna Channel, closer of its entry mouth into the Polideanca L. (Fig. 2), the core DD 14-112 has a length of 44 cm (Fig. 18). The core sediment description made aboard the research vessel has revealed a sharp limit at cm 31 below the sediment/water interface, between an upper sequence (0 − 31 cm), consisting of blackish mud, and a lower one (31 − 44 cm), represented by a light grey clay. The mud which is rich in plant debris (fine roots, leaves and even reed fragments), non-cohesive at the upper part, becomes coarser and more cohesive at the base of the interval, and is characterized by a saprogenic or hydrogen sulfide smell. Some shells of freshwater molluscs ($Planorbis$ sp., $Valvata$ sp.) have been found within the 10 − 12 cm depth interval. The light grey clay is cohesive and softer in the upper few cms and becomes harder and more cohesive as depth increases, showing few vertical and horizontal bioturbations. Small shell fragments are present, including a $Cardium$ valve, located at the sequence top, suggesting a marine origin of the clay.

The magnetic susceptibility, measured on 15 samples collected from the upper sequence (0 − 31 cm), is ranging between $3.67\times10^{-6} – 43.56\times10^{-6}$ SI, i.e. $MS$ values assigned to $k$ classes I and II (Fig. 18a). We must add to the above general description that these muds contain various quantities of vegetal material, in some of them being identified shell fragments, too, which influence the $MS$ intensity, but within the above specified limits ($k$ class I − $k$ class II). An increasing trend is shown by the magnetic susceptibility of the sediment slices cut from the depth interval 18 − 31 cm (a dark grey mud), the clayey mud (clay) intercepted immediately after this level (i.e., at 31 − 33 cm depth) providing a $MS$ “jump” towards the $k$ class III, namely to a value of $112.0\times10^{-6}$ SI (Fig. 18a). The plastic clay, sampled up to the core bottom (a marine clay), keeps this $MS$ regime defined by the $k$ class III, the last/base
Fig. 18. Magneto-lithological model showing the vertical distribution of the enviromagnetic parameter (MS; k) and of the lithological components (SIL, TOM, CAR), along the core DD 14-112, collected from the Lopatna - Polideanca Canal (core location in Fig. 2). a) 3D bar-chart with the vertical distribution of the magnetic susceptibility; the bars are coloured according to the k scale classes (see Fig. 3a); b) 3D 100%-stacked bar-chart with the composite vertical distribution of the three main lithological components (SIL, TOM, CAR); c) 3D pie-chart showing the MS calibration of the core sediments, according to the k classes; d) 3D pie-chart showing the lithological composition of the core sediments, based on the SIL, TOM and CAR contents; e) Diagram showing the correlation SIL versus MS; f) Diagram showing the correlation TOM versus MS; g) Diagram showing the correlation CAR versus MS; h) Diagram showing the correlation SIL versus CAR; i) diagram showing the correlation TOM versus CAR; j) Diagram showing the correlation SIL versus TOM.
sediment sample reaching the highest MS value that was recorded along the whole core, namely 155.2×10⁻⁶ SI (Fig. 18a).

The lithological composition defined by the three main components SIL, TOM and CAR supports very well the magneto-susceptibility characterization of the core DD 14-112, the distribution of their contents being illustrated by the 2D area-chart from Fig. 18b. It is easily to remark the “jump” of the siliciclastic fraction/SIL (towards much higher contents) and of the total organic matter/TOM (towards much lower contents), these sharp changes appearing at the same depth level as in the MS case, i.e. beginning with the 31 – 33 cm sediment slice (Fig. 18b). Thus, if in the first 31 cm, the SIL contents are ranging between 11.11% − 35.69%, and the TOM contents between 62.65% − 88.06%, then, in the following 13 cm (31 – 44 cm depth interval), where a marine clay was intercepted, the content ranges are defined by 79.66% − 86.34% for SIL, and by 9.19% − 16.79% for TOM (Fig. 18b). It is also interesting to remark the CAR profile, which in this case – even within low contents – shows similar main characteristics: lower contents for the muds described along the upper 31 cm of the core (0.84% − 2.02%), followed by a “jump” towards higher contents, ranging between 3.55% − 5.22%, related to the marine clays, from the core lower/basal part (Fig. 18b).

The synthetic illustration of the magnetic susceptibility and lithological characterization of the core DD14-112 is given by the two pie-charts from Fig. 18c and Fig. 18d, respectively. The MS structure of the core reveals close percentages for the three k classes to which the sediments were calibrated, actually beginning with the 31 – 33 cm sediment slice (Fig. 18b). Consequently, the three main components are characterized by clearly different content distribution: SIL − 39%; TOM − 59%; CAR − 2% (Fig. 18d). Yet, this observation is changing when we compare the two categories of parameters according with the lithological/sedimentological support of the MS scale (see Rădan & Rădan, 2007, 2013). Consequently, the k classes (I + II) show, together, 71%, while the contents of (TOM + CAR), together, indicate 61%; the k class III − defined by 29%, and the SIL content − by 39% also indicate closer amounts. This grouping is based by the “genuine” lithological support of the MS scale (Rădan & Rădan, 2011, 2013), so that the lower classes (I and II) correspond to fine sediments, usually rich in organic material and/or carbonates, while the intermediate class (III) is connected with the fine clayey to silty sediments. The macroscopic description of the core DD 14-112 indicates a very good agreement with the lithological support of the MS scale. Moreover, the quantification of the relationships existing between the enviromagnetic parameter (MS) and the lithological components, illustrated in Figs. 18e,f,g, confirms the parallel observations which were above commented. There were calculated (very) strong correlation coefficients (r) in all the cases: SIL versus k (r = 0.97; Fig. 18e); TOM versus k (r = −0.97); CAR versus k (r = 0.97). In all three cases, the r size is very close of the upper boundary (i.e., 1.00) of the range within which the strong correlation is defined (see, e.g., Rădan & Rădan, 2013). We have to remark the result obtained for carbonates, which usually, in other cases of investigated cores/bottom sediments, showed reversed correlations with the MS. In our foregoing comment, it was revealed the similar behaviour and trends of the SIL and CAR components along the core, although these are distinctly defined, namely by high, and much lower contents, respectively (see Fig.18b). In fact, the correlation coefficient calculated for SIL versus CAR confirms these remarks: r = 0.94 (Fig. 18h), that is a (very) strong positive/direct correlation. A similar result is obtained for TOM versus CAR, but the correlation is a (very) strong negative/reversed one: r = −0.95 (Fig. 18i). Certainly, for SIL vs. TOM, a very strong reversed correlation is shown by r, which is almost 1 (respectively, r = −0.99; Fig. 18j).

Starting from the magneto-susceptibility and lithological data recorded for the entire sediment column (44 cm length), which were above discussed in detail, we analyse further, separately, the respective relationships for each of the two parts in which the sediment column of the core DD 14-112 was lithologicaly divided: muds, and marine clays (a net boundary between them was identified). The general correlation diagrams, performed for the «LITHO components versus MS parameter» related to the entire core, are given again, in Figs. 19a,d,g, yet, with some additional elements, which regard the marking of the two zones associated with the two sediment categories composing the core. The results relating to the “mud sequence” (0 – 31 cm) are illustrated in Figs. 19b,e,h, for the correlations SIL vs. k, TOM vs. k, and CAR vs. k, respectively, and the data regarding the marine clay unit (31 – 44 cm) are represented in Figs.19c,f,i. As concerns the muds, the r coefficient indicates a strong positive/direct correlation in the case of SIL vs. k (r = 0.81; Fig. 19b), a strong negative/reversed one for TOM vs. k (r = −0.81; Fig. 19e), and a moderate positive correlation for CAR vs. k (r = 0.53; Fig. 19h). In respect of the marine clay horizon, sampled along 13 cm, towards the base of the core DD 14-112 (31 – 44 cm depth interval), moderate correlations were obtained for both SIL vs. k (r = 0.33; Fig. 19c), and TOM vs. k (r = −0.47; Fig. 19f), positive/direct in the first mentioned case, and negative/reversed, in the second one. Related to the relationship CAR vs. k, analysed in the case of the marine clay, the r coefficient shows a strong positive/direct correlation (r = 0.90; Fig. 19i), a result which makes interesting, again, the discussion around the carbonates which are present inside of this core.

Finally, in Figs. 20a,b, the MS, SIL, TOM and CAR profiles are illustrated for the whole sediment core DD 14-112, by means of a line-chart, for the enviromagnetic parameter (k) vertical variation (Fig. 20a), and a 2D area-chart, for the simultaneous/composite illustration of the vertical distribution of the three lithological components (Fig. 20b).

c) Core DD 14-104

This core was collected from the central zone of the Poli- deanca Lake (Fig. 2) and points out an interesting vertical var-
iation of the sequences which were penetrated up to 44 cm below the water/sediment interface. The first 10 cm consist of typical mud for the Polideanca Lake (i.e., a fluffy, non-cohesive sediment, with H₂S smell). The magnetic susceptibility measurements show low but positive $k$ values (assigned to $k$ class I), increasing from $0.07 \times 10^{-6}$ SI for the core top (0–2 cm) up to $2.58 \times 10^{-6}$ SI for the sample collected from the 8–10 cm depth level (Fig. 21a). The siliciclastic component (SIL) asserts this trend and its low definition range, showing contents of 9.70 % up to 13.99 % (Fig. 21b). Complementary, high contents were obtained for the organic matter (TOM), namely 88.49 % for the core top (Fig. 21b), decreasing then up to 83.43 % for the sample sliced at the depth interval 8–10 cm. Downwards, along the following 30 cm, the presence of the vegetal material – finely triturated, or as fragments – becomes more and more important, getting up to a peat-like sediment, very rich in organic material. The enviromagnetic parameter MS confirms this composition particularity of the sediment sequence, and records very low and negative $k$ values (of course, attributed to $k$ class I), ranging between $−6.51 \times 10^{-6}$ SI and $0.05 \times 10^{-6}$ SI. The presence of some shell fragments, observed within this sediment sequence, could influence even more the very low level of the MS intensity. Further, it follows a stepwise transition towards a coarse siliciclastic sediment. Within the peaty horizon occurs a clayey-silty micaceous material, its presence increasing towards the core base. The magnetic susceptibility is fingerprinting this special composition of the sediment at the core bottom, and the $k$ values measured on the last two sediment slices (40–44 cm) towards the base show the highest intensity recorded along the core DD 14-104, namely $6.99 \times 10^{-6}$ SI (i.e., $k$ class I) and $12.40 \times 10^{-6}$ SI (i.e., $k$ class II) (Fig. 21a). The siliciclastic and the total organic material components, SIL and TOM, respectively, support these MS fingerprints, indicating the highest.

Fig. 19. Detail with the correlation of the enviromagnetic parameter (MS) with the lithological components (SIL, TOM, CAR), concerning the sediment core DD 14-112 (Lopatna - Polideanca Canal), in the context of the “marine clay” horizon interception at its basal part. a) Correlation SIL versus $k$, related to the entire core (0 – 44 cm); b) Correlation SIL versus $k$, related to the “mud sequence” (0 – 31 cm); c) Correlation SIL versus $k$, related to the intercepted “marine clay sequence” (31 – 44 cm); d) Correlation TOM versus $k$, related to the entire core (0 – 44 cm); e) Correlation TOM versus $k$, related to the “mud sequence” (0 – 31 cm); f) Correlation TOM versus $k$, related to the intercepted “marine clay sequence” (31 – 44 cm); g) Correlation CAR versus $k$, related to the entire core (0 – 44 cm); h) Correlation CAR versus $k$, related to the “mud sequence” (0 – 31 cm); i) Correlation CAR versus $k$, related to the intercepted “marine clay sequence” (31 – 44 cm).
contents (30.21 % and 33.3 %, for SIL), and, complementary, the lowest ones (63.85 % and 62.18 %, for TOM), respectively (Fig. 21b). As regards the third lithological component, the carbonates (CAR), the contents are ranging between 0.91 % − 5.93 % (Fig. 21b), the highest values being determined for the same two bottom slices, cut at the core base (40 − 44 cm depth interval beneath the water/sediment interface).

The MS and LITHO data, above commented, and illustrated in Figs. 21a,b, are synthetised by the pie-charts from Figs. 21c,d. Thus, concerning the enviromagnetic parameter MS (Fig. 21c), 5 % only are assigned to k class II, the remaining 95 % being attributed to class I (k values lower than $10 \times 10^{-6}$ SI; see Rădan & Rădan, 2007, 2013). This magnetic characteristics is supported by the lithological composition of the core sediments, the synoptic image from Fig. 21d showing the highest average content is determined for the total organic matter component (85 %), to which there can be added 2 percents provided by carbonates. The siliciclastic component holds 13 % only within the core lithological composition (Fig. 21d), in agreement with the very low weight of the k class II, a MS range ($10 \times 10^{-6}$ SI − $75 \times 10^{-6}$ SI; Rădan & Rădan, 2007, 2013) to which 5 % of samples only were calibrated (Fig. 21c).

The magneto-lithological data obtained for the core DD 14-104 can be remarked for the very good correlations between the magneto-susceptibility and each of the three lithological components, as well as with regard to the correlations related to the pairs of LITHO components. So, the $r$ coefficient calculated for SIL versus $k$ is 0.83 (Fig. 21e), showing a strong positive correlation. Correspondingly, for TOM vs. $k$ is indicated a negative correlation, also a strong one, as $r = −0.84$ (Fig. 21f). Even for CAR vs. $k$, the $r$ coefficient shows a strong correlation, a positive one ($r = 0.80$; Fig. 21g), as in the case of the siliciclastic component. Strong negative correlations define the cases SIL vs. TOM ($r = −0.996$; Fig. 21h), and TOM vs. CAR ($r = −0.86$; Fig. 21i), while for SIL vs. CAR, a strong positive correlation ($r = 0.81$; Fig. 21j) is shown by the $r$ coefficient.

A parallel view of the profiles recorded for the four parameters − MS, SIL, TOM, CAR − is offered by the line-chart from Fig. 22a, showing the downcore magneto-susceptibility vertical variation, and by Fig. 22b, in which the three profiles SIL, TOM, CAR are simultaneously drawn; the area-chart makes possible to display the parallel and therewith integrated vertical distribution of the lithological components, within

**Fig. 20.** Vertical distribution of the enviromagnetic parameter values ($k$) and of lithological components contents (SIL, TOM, CAR), along the sediment core DD 14-112, collected from the Lopatna - Polideanca Canal. a) Line-chart showing the magnetic susceptibility vertical profile; b) 100% stacked area-chart with the distribution of SIL, TOM and CAR contents along the sediment core.
Fig. 21. Magneto-lithological model showing the vertical distribution of the environmentally magnetic parameter (MS; k) and of the lithological components (SIL, TOM, CAR), along the core DD 14-104, collected from the Polideanca Lake (core location in Fig. 2). a) 3D bar-chart with the vertical distribution of the magnetic susceptibility; the bars are coloured according to the k scale classes (see Fig. 3a); b) 3D 100%-stacked bar-chart with the composite vertical distribution of the three main lithological components (SIL, TOM, CAR); c) 3D pie-chart showing the MS calibration of the core sediments, according to the k classes; d) 3D pie-chart showing the lithological composition of the core sediments, based on the SIL, TOM and CAR contents; e) Diagram showing the correlation SIL versus MS (k); f) Diagram showing the correlation TOM versus MS (k); g) Diagram showing the correlation CAR versus MS (k); h) Diagram showing the correlation SIL versus TOM; i) Diagram showing the correlation TOM versus CAR; j) Diagram showing the correlation SIL versus CAR.
a total area of 100 percents. This composite image could be seen as a corresponding LITHO background for the pie-chart from Fig. 21d, where the percentages of SIL, TOM and CAR contents are indicated, synoptically, for all the 22 samples sliced from the sediment column, which actually support the three LITHO profiles. The dominance of the organic matter is evident (85 %), followed by the siliciclastic fraction, but at a much lower level (13 %), and, finally, the carbonates, at an extremely low level (2 %). The macroscopic description of the core, particularly the complex analysis from the beginning of this section (3.1.3.c) – the presence of a peaty material within the core sediment being a significant element – is correspondingly asserted by the above remarks.

3.1.4. Bogdaproste Lake (2013)
Core DD 13-104

One sediment core only, namely DD 13-104, was collected from the Bogdaproste Lake (location in Fig. 2), during the 2013 spring expedition, carried out in the 16 – 29 April time interval.

The recovered sediment column, thick of 48 cm, includes three sequences, with a stepwise transition from a lithology to another (Fig. 23). The magneto-susceptibility and the lithological signature clearly reveal the gradual transition from the upper sequence (0 – 18 cm), consisting of dark grey to brown-greenish organic muds, loose, non-cohesive, rich in plant fragments and finely triturated vegetal material, with scarce small shell fragments, to a middle one (18 – 36 cm), represented by a dark brown, coarse peat deposit, containing rare shell fragments and minor but increasing downward amounts of coarse silt material that change the peat into a peaty mud which becomes more plastic and cohesive along the last 4 cm towards the base interval. The last unit (36 – 48 cm) starts with a grey, clayey, plastic, cohesive mud, with small fragments of reed and irregular enclaves of dark brown muddy peat, which changes to a more compact and coarse mud, with lower plasticity, containing small reed and peat fragments and quite frequent marine shells (Cardiidae and Corbula).
Fig. 23. Magneto-lithological model showing the vertical distribution of the environmagnetic parameter (MS, k) and of the lithological components (SIL, TOM, CAR), along the core DD 13-104, collected from the Bogdaproste Lake (core location in Fig. 2). a) 3D bar-chart with the vertical distribution of the magnetic susceptibility; the bars are coloured according to the k scale classes (see Fig. 3a); b) 3D bar-chart with the vertical distribution of the siliciclastic/minerogenic component (SIL); c) 3D bar-chart with the vertical distribution of the total organic matter component (TOM); d) 3D bar-chart with the vertical distribution of the carbonate component (CAR); e) 3D pie-chart showing the MS calibration of the core sediments, according to the k classes; f) 3D pie-chart showing the lithological composition of the core sediments, based on the SIL, TOM and CAR contents; g) Diagram showing the correlation SIL versus MS (k); h) Diagram showing the correlation TOM versus MS (k); i) Diagram showing the correlation CAR versus MS (k).
The upper vegetal organic mud sequence (0 – 18 cm) is characterized by very low MS values, ranging from \(-4.63\times10^{-4}\) Si up to 1.85x\(10^{-3}\) Si, eight of nine values being negative (Fig. 23a); all are assigned to k class I. The mineralogic/siliciclastic component (SIL), and complementary, the total organic matter (TOM), support these magnetic fingerprints, the SIL and TOM contents ranging between 12.63 % – 21.65 % (Fig. 23b), and 72.46 % – 82.97 % (Fig. 23c), respectively. As regards the carbonates (CAR), they are present inside of these organic vegetal muds within a range with very close limits, i.e., 4.39 % – 5.79 % (Fig. 23d); the shell fragments found within the samples collected from the sediment column across this depth interval (0 – 18 cm) could influence the level of the CAR contents.

Passing to the middle sequence, the dark-brown, non-cohesive coarse peat, which occurs downwards along the core up to the depth level 30 – 32 cm, where the peat becomes finer, the macroscopic description mentions some reed leaves inside, but also some silty to finely sandy grains. The magnetic susceptibility reflects very well the macroscopic lithological records and a continuous increasing, from the k value of 3.4x\(10^{-4}\) Si (class I), measured on the slice from 18 – 20 cm depth interval, up to 47.11x\(10^{-5}\) Si (k class II), on the sample sliced at 28 – 30 cm depth (Fig. 23a). The lithological analyses confirm the MS behaviour: the siliciclastic component (SIL) content increases from 25.59 % (for the 18 – 20 cm sample) up to 43.81 % (for the 28 – 30 cm sample) (Fig. 23b), while the total organic matter (TOM) content decreases from 70.28 % up to 54.36 % (Fig. 23c), along the respective depth interval (18 – 30 cm). The transition zone – it has already been revealed, at the beginning of this section, the existence of a stepwise passing from the middle sequence towards the lower one – is going on up to the depth interval 34 – 36 cm; the MS signature records an intensity which is increasing up to 69.1x\(10^{-5}\) Si (Fig. 23a). Along this depth interval (30 – 36 cm), the sediment becomes a peaty mud, more cohesive, containing some coarse silt or fine sand, but also some enclaves of compact clayey mud within the end sample of this sequence. The SIL contents are also increasing, ranging between 56.29 % – 82.84 % (Fig. 23b), and the TOM contents are decreasing, from 41.67 % up to 16.56 % (Fig. 23c).

The lowest sequence, which starts at the 36 cm depth, up to the base, the clayey mud being the main sediment core constituent, shows a different regime – comparing with the higher sequences – with regard to the MS and the main LITHO parameters. The k values "jump" to the class III, along the depth interval 36 – 48 cm (core bottom), the MS measurements showing a range with very close limits, namely 89.45x\(10^{-6}\)Si – 99.20x\(10^{-6}\)Si (Fig. 23a). The siliciclastic component asserts the MS signature, the SIL contents being placed within a very narrow interval, and defined by high value ends: 84.64 % – 91.35 % (Fig. 23b). Certainly, the total organic matter component (TOM) consolidates this distinct regime, revealing very low contents, placed between 3.89 % – 9.28 % (Fig. 23c). In this case, the range of values is very narrow, too, but opposite – as intensity – to those of the MS and SIL signatures. The TOM component records a very low level of contents, a situation which is in agreement with the macroscopic description of the samples sliced from the lowest part of the core. The highest k values and SIL contents – referring to the entire sediment column recovered from the core DD 13-104 – were determined along this depth interval (36 – 48 cm), within which the TOM component has revealed the lowest contents (Figs. 23a,b,c).

In this context, referring to the sediment composition towards the core base, we must add the clayey muds become more silty, coarser, a lithological constitution which explains the MS, SIL, and oppositely, the TOM signatures.

As concerns the evolution of carbonates within the whole core, their contents are ranging between 1.4 % – 6.88 % (Fig. 23d). The CAR signature marks a slightly constant level of the contents, and at the same time higher (4.39 % – 5.79 %), for the samples collected from the upper sequence, followed by a minimum anomaly (1.4 % – 2.27 %), which is defined within the transition zone and the lower sequence. The lowest CAT contents were recorded for samples collected from the transition sediment sequence, the minimum axis being located around the middle of the core. The lower sequence is defined by higher CAR contents (2.27 % – 6.88 %), placed on the lower increasing branch of the CAR minimum anomaly (Fig. 23d). As we mentioned before, several Cardiidaeae and Corbula shells and shell fragments have been observed along this interval.

The results of the magneto-lithological analysis of the sediment core DD 13-104, above discussed, are synthesised by means of the pie-charts from Fig. 23e – for the MS data, and in Fig. 23f – for the LITHO data. The structure of the MS pie-chart clearly reflects the core lithological constitution: an upper sequence (0 –18 cm) – with all 9 slices defined by negative values only, calibrated to k class I; a transition sediment sequence, of similar thickness (18 – 36 cm) – calibrated to k class I (first two samples), and to k class II (the following 7 slices; 29 %); a lower sequence, less thick (36 – 48 cm) – calibrated to k class III (25 %). As regards the k class I, to which 11 sediment slices are assigned, this holds 46 % of the pie-chart structure (Fig. 23e). The LITHO pie-chart (Fig. 23f) supports, in a great measure, the predominance of the lower k classes (I + II), i.e. 75 %, the TOM +CAR contents totalling 54 %; the remaining 46 % are covered by the SIL contents.

The relationships between the MS enviromagnetic parameter and the main lithological components SIL and TOM are illustrated in Figs. 23g,h. For both cases, i.e., SIL vs. k, and TOM vs. k, the r coefficient shows strong correlations, positive/reversed (r = 0.98; Fig. 23g), and negative/reversed (r = − 0.98; Fig. 23h), respectively. These results represent the quantification of the MS and LITHO characterization of the sediment column which has just been presented above. Instead, the r coefficient calculated for CAR vs. k shows a weak negative correlation (r = − 0.17; Fig. 23i; Table 1), indicating a low level of the connection of carbonates with the envi-
magnetic parameter $\text{MS}$ (if it is taken into consideration the whole sediment column). The diagram from Fig. 23i could suggest a composite trend line, which might be possible because of the different sediment sequences within the core constitution. A test regarding the calculation of the $r$ coefficient related to the relationship $\text{CAR} \text{ vs. } k$, analysed for each of the 3 parts (Table 1) in which the core was divided, as it has been above discussed, shows a moderate positive correlation in the case of the “upper sequence” ($0 – 18 \text{ cm}; r = 0.32$), a strong negative correlation relating to the “transition zone” (as in the $\text{CAR} \text{ vs. } k$ case), so that it could be considered the carbonates are not connected with the detrital fraction. On the other side, for $\text{TOM} \text{ vs. } \text{CAR}$, relating to the same “sediment sequence” (a coarse peat passing then into a peaty mud), a strong positive correlation is shown by the $r$ coefficient ($r = 0.72$; Table 1), an argument for the

<table>
<thead>
<tr>
<th>Lake/ Core code</th>
<th>Sediment column</th>
<th>Depth level (cm)</th>
<th>$\text{Correlation coefficient (r)}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bogdaproste DD 13-104</td>
<td>Entire core</td>
<td>$0 – 48$</td>
<td>0.10</td>
</tr>
<tr>
<td></td>
<td>$0 – 18$</td>
<td>0.32</td>
<td>0.79</td>
</tr>
<tr>
<td></td>
<td>Transition sediment packet</td>
<td>$18 – 36$</td>
<td>-0.75</td>
</tr>
<tr>
<td></td>
<td>Lower/basal sequence</td>
<td>$36 – 48$</td>
<td>0.28</td>
</tr>
</tbody>
</table>

Table 1. Detail with the correlation of the carbonate component ($\text{CAR}$) with the enviromagnetic parameter ($\text{MS}; k$) and the other two main lithological components ($\text{SIL}, \text{TOM}$), related to the principal sequences identified within the sediment core DD 13-104, collected from the Bogdaproste Lake. Legend: The circles are coloured according to the scale used to evaluate the size of the correlation ($r$) (see Fig. 3b).

Fig. 24. Vertical distribution of the enviromagnetic parameter values ($k$) and of lithological components contents ($\text{SIL, TOM, CAR}$), along the sediment core DD 13-104, collected from the Bogdaproste Lake. a) Line-chart showing the magnetic susceptibility vertical profile; b) 100% stacked area-chart with the distribution of $\text{SIL, TOM and CAR}$ contents along the sediment core.
direct connection of the carbonates with the organic material. Opposite data are obtained for the “upper sequence” of the core (Table 1), i.e., a strong positive correlation for SIL vs. CAR \((r = 0.79)\), and a strong negative correlation for TOM vs. CAR \((r = -0.84)\), results which could argue the detrital origin of the carbonates related to this sediment horizon. As regards the “lower sequence” \((36 – 48 \text{ cm})\; a\; clayey\; mud,\; becoming\; more\; silty\; downwards\; (the\; core\; bottom)\), a weak negative correlation is found for TOM vs. CAR \((r = 0.13)\) (Table 1). As a moderate negative correlation defines SIL vs. CAR \((r = -0.51)\), it can be considered the carbonates, in the “lower sequence”, generally, are bearing no relation to the siliciclastic fraction or to the organic material, the main lithological components.

The magnetic susceptibility (MS) vertical profile is illustrated in Fig. 24a, and next is given a composite image (Fig. 24b) for the vertical variation of the three lithological components – SIL, TOM, and CAR. It can be easily remarked the similarity between the MS and SIL signatures, the TOM record representing a “negative/mirror counterpart” of the other two images. The core sediments are passing from the organic vegetal muds – at the upper part, towards the mineral muds – at the lower part.

The magneto-lithological parameters reflect these two opposite categories of muds, by distinct intensities:

- **at the upper part:** very low \(k\) values – an average of \((-3.02)\times10^{-6} \text{ Si/k class I} \), confirmed by very low SIL contents – an average of 16.40 %, as a response to the very high TOM contents – an average of 78.65 %
- **at the lower part:** higher MS values – an average of 94.34\times10^{-6} \text{ Si/k class III} \), very high SIL contents – an average of 89.58 %, and, as a “negative/mirror counterpart”, very low TOM contents – an average of 6.06 %.

It is also very interesting to observe that beginning with the depth level 38 cm, from where the sediment slice no. 20 was taken, therefore, within the “lower sequence”, it has been identified a marine fauna (e.g., Cardiliidae, Corbulida), in situ, not-transported (Corbulia, with both valves connected). This faunistic content of the clayey muds shows the existence of a marine episode at west of the Letaa – Caraoman initial spit, in a zone, which, at present, is part of the Fluvial Delta Plain, suggesting an age corresponding to either an earlier period of the initial spit formation, or slightly afterwards, in an incipient phase, when the Danube bay blocking had not been settled into shape. Certainly, an absolute age analysis, supported by the fauna which was identified within this core, could help to clarify some aspects of the controversy relating to the age of the different events which led to the deltaic edifice building up.

3.2. SYNOPSIS OF MAGNETO-SUSCEPTIBILITY AND LITHOLOGICAL DATA PROVIDED BY SEDIMENT CORE INVESTIGATION

The nine cores analysed in the present paper were collected from an aquatic unit, which has been chosen – among others – as a representative monitoring area in the Danube Delta. So, in several expeditions carried out within the period under our attention (2010 – 2014), the bottom sediments of the Matita – Merhei Depression (M. – M. D.) lakes were investigated by different methods, in the field and in laboratory. The material needed for analyses has firstly been taken with “Van Veen” grab samplers; a number of cores were also extracted from a series of lakes.

3.2.1. A general magneto-lithological background, based on a short analysis of the MS and LITHO characteristics of the surficial sediments

As a magneto-lithological background, supported by several MS and LITHO maps and diagrams, general considerations on the surficial sediments from this deltaic area will be further presented.

Thus, in Fig. 25 and Fig. 26, the MS maps (a), as well as the SIL (b), TOM (c), and CAR (d) maps are illustrated for the bottom sediments sampled in the northern and southern halves of the M. – M. D., respectively. Also, a synoptic image of the magnetic susceptibility calibration of these lake sediments is represented in Fig. 27, by using MS cubes which are coloured according to the \(k\) classes of the MS scale (Fig. 3a) and are located in the sampling stations from each lake/channel which were investigated during the last five years. A pie-chart, with the \(k\) classes to which the surficial sediments were calibrated, is associated to each lake investigated in the M. – M. D. (Fig. 27). As regards the lithological composition of the bottom sediments, a pie-chart with the content weights of the main LITHO components (i.e., SIL, TOM and CAR) is placed close to each MS pie-chart, and both of them are associated with each lake from this representative monitoring deltaic area (Fig. 27).

All these maps and diagrams show the most significant magneto-lithological characteristics of the M. – M. D. lacustrine sediments. It is easily to note their dominant feature, namely the calibration to the lowest \(k\) class (values under \(10x10^{-6} \text{ Si}\), negative ones included), i.e. class I (Fig. 27), which, according to MS scale (Fig. 3a), is assigned to the “fine sediments, rich in organic matter and/or carbonates”. The MS areal distribution provided by the \(k\) maps reflects the same particular remark, only at some of the entry mouths of the canals into the lakes being observed small MS anomalies (Fig. 25a and Fig. 26a). Therewith, in Fig. 27, these zones are marked out by the presence of some green cubes (\(k\) class II), or yellow cubes (\(k\) class III); the \(k\) class II is associated with the same sediment-type as the \(k\) class I, but with a slightly higher magnetic susceptibility (values ranging between \(10x10^{-6} – 75x10^{-6} \text{ Si}\)), while the \(k\) class III (values which range between \(75x10^{-6} – 175x10^{+6} \text{ Si}\)) is assigned to “clayey, fine up to silty sediments” (Fig. 3a).

Related to the main 5 lakes of the M. – M. D., i.e., Merhei, Babina, Matita, Trei Ozere and Bogdaproste lakes, the \(k\) class I percentages are ranging from 68 % – for Bogdaproste Lake surficial sediments up to 84 % – Bogdaproste L., 88% – Matita L., 95% – Trei Ozere L., and 96% – Merhei L. (Fig. 27).
Fig. 25. Areal distribution of the environmental parameter (MS) values ($k_{\text{MS}}$) and of the lithological component ($\text{SIL}$, $\text{TOM}$, $\text{CAR}$) contents, determined for the surficial sediments collected with a grab-sampler in the lakes from the northern half of Matița − Merhei Depression, over the period 2010 − 2014. 

a) Magnetic susceptibility ($\text{MS}$) maps.

Note: The $k_{\text{MS}}$ contour lines are expressed in $10^{-6}$ SI and the colored shading is according to the five classes of $\text{MS}$ scale (see Fig. 3a);

b) Siliciclastic/minerogenic/detrital component ($\text{SIL}$) maps;

c) Total organic matter component ($\text{TOM}$) maps;

d) Carbonate component ($\text{CAR}$) maps.

Note: The $\text{SIL}$, $\text{TOM}$ and $\text{CAR}$ contour lines are expressed in percents (%).
Fig. 26. Areal distribution of the enviromagnetic parameter (MS) values ($k$) and of the lithological component (SIL, TOM, CAR) contents, determined for the surficial sediments collected with a grab-sampler in the lakes from southern half of Matița – Merhei Depression, over the period 2010 – 2014. a) Magnetic susceptibility (MS) maps. Note: The $k$ (MS) contour lines are expressed in $10^{-6}$ SI and the coloured shading is according to the five classes of MS scale (see Fig. 3a); b) Siliciclastic/minerogenic/detrital component (SIL) maps; c) Total organic matter component (TOM) maps; d) Carbonate component (CAR) maps. Note: The SIL, TOM and CAR contour lines are expressed in percents (%).
Fig. 27. Synoptic image with the 3D pie-charts showing the MS calibration (by using the k scale classes) and the lithological composition (based on the contents of SIL, TOM and CAR components) of the surficial sediments sampled in the lakes, some swamps and canals from the Matiţa – Merhei Depression, over the period 2010 – 2014.
Correspondingly, the total organic matter (TOM) contents record very high percentages, ranging from 67 % – in the Babina L. up to 83 % – in the Merhei L. (Fig. 27). The MS, SIL, TOM and CAR maps (Fig. 25, Fig. 26) confirm these remarks. Therefore, these maps point out – by the areal distribution of the magnetic (a) and lithological (b,c,d) parameters, respectively – low k value contours (Fig. 25a, Fig. 26a), connected to the lowest MS scale part (i.e., associated with the blue colour; Fig. 3a), and, respectively, high TOM content contours (connected with the upper LITHO scale part, i.e. associated with the red colour) (Fig. 25c, Fig. 26c). Complementary, the characteristics of the TOM maps are presented “in mirror counterpart” by the SIL maps (Fig. 25b, Fig. 26b), which suggest comparative features with the MS maps.

All these data reflect the affluence of the organic matter of autochthonous origin within the surficial sediments of the main M. – M. D. lakes, which is mainly generated by the decay of phytoplankton, zooplankton and macrophyte vegetation, as a consequence of the protection conditions characterizing these lakes in relation to the direct fluvial supplies. In the Merhei L., where the lowest k values (most of them, negative; Fig. 25a), the highest TOM contents (Fig. 25c), and, complementary, the lowest SIL contents (Fig. 25b, Fig. 27) were determined, the great majority of the sediments are placed inside of the organic muds category. A small k and SIL maximum anomaly, and a TOM minimum one, respectively, can be observed in the northeastern part of the Merheiul Mic Lake, at the entry mouth zone of the Sulimancu Canal (Figs. 25a,b,c), where mineral-organic muds were sampled; this canal is flowing close along the Letea Sand Beach ridges, from where some siliciclastic (sandy and silty) material could be washed-out. Small anomalies are also illustrated by the MS, SIL and TOM maps in the other four M. – M. D. main lakes (Figs. 25a,b,c, Figs. 26a,b,c), located at the entry mouths of some canals, as well. Yet, slightly more extended anomaly zones are illustrated by the MS maps carried out for the Babina L. (at the entry mouth area of the Râďăcinoasele Canal; Fig. 25a), Trei Ozere (at the mouth of a short canal coming from the Lopatna Channel, and extended, possibly due to some emerged zones, in the northern lake area; Fig. 26a), and Bogdaproste L. (in southwest, at the mouth of the connection canal with the Trei Ozere L.; Fig. 26a).

As regards the carbonates, they do not have an important contribution to the lithological composition of the surficial sediments; excepting the CAR content (higher than 10 %) provided by a sample taken from the northeastern Babina Lake, the carbonates present within the sediments from the 5 main lakes record lower contents, all the maps showing CAR content contours not higher than 5 % (Fig. 25d, Fig. 26d). They generally have a biochemical origin, with a few exceptions, probably explained by a local contribution of a finely triturated – by fragmentation and leaching – shelly material.

Passing now to the other (smaller) lakes of the Motija – Merhei Depression, i.e. Polideanca, Covaliova and Căzănel, which actually have recently been investigated (during the 2014 spring expedition), we mention a general characteristic, namely the bottom sediments are calibrated to the same three k classes, I, II and III, but with some differences related to the size of their percentages (Fig. 27).

The lower k classes I and II define, particularly, the bottom sediments of Polideanca and Covaliova lakes; the predominance of the lowest k class I is clearly observed (79 %, and 72 %, respectively), 21 % belonging to k class II in both lakes. This MS calibration (Fig. 27), as well as the TOM and SIL average contents, defined by 78 % and 18 %, respectively, in the Polideanca L. case (Fig. 27), and by 82 % and 15 %, respectively, in the Covaliova L. case (Fig. 27), indicate the prevalence of the organic matter within the bottom sediments, as it has previously been revealed with regard to the 5 main lakes of the deltaic area under attention. The sediments are mainly placed within the category of organic and organic-mineral muds, the mineral-organic ones being subordinated to them.

Yet, a MS anomaly is observed at the mouth of the canal which makes the connection of the Polideanca L. with the Lopatna Channel (Fig. 25a), where sediments with a higher minerogenic material content are transported from this canal, which was dredged some time ago. In the SIL and TOM maps, this zone is also evident, but the anomalies, of maximum (Fig. 25b) and minimum (Fig. 25c), respectively, are less strongly marked out by content contour lines. Besides, it is worth to remark the presence of a marine fauna (e.g., Cardiidae, Corbula) within the sediments sampled in the lake western extremity (at the Lopatna – Polideanca Canal mouth), probably reworked from the underlying horizon, as a consequence of digging works necessary to the canal deepening. Moreover, we remember the core DD 14-112 (see Ch. 3.1.3.b), extracted from the above mentioned canal, just before entering into the Polideanca L. (Fig. 2), and the marine clay horizon intercepted within the 31 – 44 cm depth interval. The magneto-lithological characteristics of this sediment sequence were presented and analysed in the cited chapter.

In addition, in the Covaliova Lake, in its western extremity, just at the mouth of the canal which makes the connection with the Oracle Can. (Fig. 26a), the MS map remarks a k anomaly, mainly generated by the sample of coarse mud with some fine sand traces (station DD 14-62), which provides the highest magnetic susceptibility (i.e., 139.45×10^-6 SI, correlated with the MS class III). This is supported by some k values associated with the class II, recorded in the neighbouring stations, so that a MS positive anomaly is clearly evidenced in the lake western area (Fig. 26a). Correspondingly, there can be observed a (maximum) SIL anomaly around the same sampling station (Fig. 26b), where the highest minerogenic material content (i.e., 33.24 %) – related to the sediments of this lake – was determined, and, respectively, a (minimum) TOM anomaly (Fig. 26c), mainly defined by the lowest organic substance content (i.e., 64.14 %) recorded in the above nominated station (DD 14-62).
Fig. 28. Synoptic image with the magnetic susceptibility (MS) records obtained for five sediment cores collected from the Babina and Matița lakes, in 2010 and 2011. Legend. The red points located on the map within the lakes and along some canals indicate the grab sampling stations (over the period 2010 – 2014). The coloured cylinders mark the collecting sites for the sediment cores.
As regards the third small lake, i.e. Căzănel, investigated in the southern extremity of the Matiţa – Merhei Depression, situated closely south of Trei Ozere Lake (Fig. 2, Fig. 26), the surficial sediments are a bit more various, due to the Căzănel Canal intervention in the southern area.

Consequently, the areal distribution of the enviromagnetic parameter (MS) measured on the collected samples (Fig. 26a) reveals the influence of the mentioned canal, which makes the connection with the Old Danube Branch, and contributes with an important siliciclastic fraction (SIL) to the lithological composition of the lake sediments. This minerogenic contribution is gradually diminished from the canal entry mouth towards the northern lake extremity, the SIL contents decreasing along this direction, from 41.04 %, in station DD 14-73, to 13.02 %, in station DD 14-79 (Fig. 26b). This trend is even better reflected by the MS contour lines (Fig. 26a), the k map showing the decreasing gradient from the k class III (a value of 164.04×10^6 SI, in the station DD 14-73), to which the coarse silty (possibly a bit sandy) muds, from the canal mouth, are calibrated, passing then through the class II (k values of maximum 57.03×10^6 SI, measured on the muds from the central lake zone), and reaching the class I, in the station DD 14-79, in the northern lake extremity, where for the sampled fluffy, non-cohesive muds a k value of 2.47×10^6 SI, only, was recorded. This variation of the lithological characteristics of the bottom sediments, from the entry mouth canal (placed in south) up to the Căzănel Lake northern extremity, is also well reflected by the TOM contour lines of the organic matter content map (Fig. 26c). Therefore, the TOM contents are gradually increasing from 55.97 % (in south) up to 83.72 % (in north), i.e. from the TOM contour line of 60 % up to the TOM contour line of 80 % (Fig. 26c).

The distribution of the magnetic susceptibility classes to which the bottom sediments of the Căzănel Lake are calibrated, i.e. the significant majority is defined by the k classes I and II (14% + 72%), which are specific to the organic sediments, is well reflected by the lithological model, which shows the highest weight (76 %) for the TOM component, to which an average content of 2 % is added by the carbonate component (CAR) (Fig. 27). The remaining 22 % are allocated to the detrital/siliciclastic fraction (SIL), a level comparable with the percentage determined for the k class III (14 %) (Fig. 27), a situation in agreement with the magento-lithological scale (Fig. 3a). Actually, the r coefficients calculated for SIL vs. k, and TOM vs. k, related to the surficial sediments sampled in the Căzănel L., show (very) strong correlations (see the scale in Fig. 3b), positive, and negative, respectively: r = 0.99, r = − 0.98. This asserts, again, the quality of proxy parameter of the magnetic susceptibility for the lithological characterization of the lake sediments.

As concerns the other LITHO component – the carbonates –, the CAR contents are lower than 5 % for the sediments investigated in all these three small lakes (Fig. 25d, Fig. 26d), namely Polideanca (4 %), Covaliova (3 %) and Căzănel (4 %) (Fig. 27).

3.2.2. Synoptic images of the MS and LITHO signatures recovered from sediment cores in the Matiţa – Merhei Depression

A magneto-lithological data base is now constituted by integrating the MS and LITHO signatures recovered from nine cores collected from the lacustrine sediments of five lakes from the Matiţa – Mehei Depression (Fig. 1, Fig. 2). To illustrate together the recorded vertical magnetic susceptibility profiles, we formally divided the M. – M. D. area into the northern and southern halves. Therefore, relating to the first, the three cores from the Babina Lake (i.e., DD 10-106, DD 10-18, DD 11-49) and the two cores from the Matiţa Lake (i.e., DD 10-01, DD 11-01) have provided the MS records from Fig. 28. As regards the second zone, the southern half, in Fig. 30 are redrawn the MS records for the three cores collected along a West – East profile, starting from the Lapotna – Polideanca Swamp (DD 14-113), continuing the canal course which connects the Lapotna Channel with the Polideanca L. (core DD 14-112), and finally entering into the central area of this lake (core DD 14-104). Besides, in this synoptic image, is illustrated the MS profile carried out for the core DD 13-104, collected from the Bogdaproste Lake central zone. Following the same scenario, the associated lithological signatures, expressed by composite images which integrate the three main LITHO components (SIL, TOM, CAR), are also illustrated for the sediment cores taken from the M. – M. D. northern and southern halves, in Fig. 29 and Fig. 31, respectively.

Details, supported by various diagrams and extended analyses and comments, were presented in the subchapters 3.1.1 ÷ 3.1.4. Some general observations, based on these synoptic images, are feasible. They can be applied in the future – together with new data – to approach various stratigraphic, sedimentogenetic, mineralogical and ecological studies within the Danube Delta. As concerns the use of the downcore MS records in lacustrine stratigraphy, we mention, e.g., Trodahl (2010), who emphasizes the necessity of additional information – provided by grain size and charcoal analyses, as well as radiocarbon dating – to get clarification with regard to the ambiguity associated with matching magnetic susceptibility peaks identified in the MS profiles along two sediment cores extracted from the Lake Wairarapa (New Zealand).

The connections between the magnetic susceptibility proxy parameter and the lithological composition of the lake sediments from the Danube Delta have proved to be of great interest. In Table 2, the r coefficients calculated for four cores are synthesized (the five cores in which marine deposits were detected are not included in the Table 2), assessing all the possible correlations related to the four (magnetic and lithological) parameters (MS, SIL, TOM and CAR). Firstly, we remark 3 pairs of parameters for which the r coefficient shows strong correlations in all these cases: SIL vs. k (positive;
Fig. 29. Synoptic image with the composite lithological (SIL, TOM, CAR) records obtained for five sediment cores collected from the Babina and Matiţa lakes, in 2010 and 2011. Legend. The red points located on the map within the lakes and along some canals indicate the grab sampling stations (over the period 2010 – 2014). The coloured cylinders mark the collecting sites for the sediment cores.
Fig. 30. Synoptic image with the magnetic susceptibility (MS) records obtained for four sediment cores collected from the Polideanca and Bogdaproste lakes, the Polideanca - Lopatna swamp and the Lopatna - Polideanca canal, in 2013 and 2014. The red points located on the map within the lakes and along some canals indicate the grab sampling stations (over the period 2010 – 2014). The coloured cylinders mark the collecting sites for the sediment cores.
Fig. 31. Synoptic image with the composite lithological (SIL, TOM, CAR) records obtained for four sediment cores collected from the Polideanca and Bogdaproste lakes, the Polideanca - Lopatna swamp, and the Lopatna - Polideanca canal, in 2013 and 2014. Legend. The red points located on the map within the lakes and along some canals indicate the grab sampling stations (over the period 2010 – 2014). The coloured cylinders mark the collecting sites for the sediment cores.
was in our attention above, and in which case the sediment column begins with organic muds, continues downwards with a sequence of coarse peat and peaty muds, to finish at its base within a horizon of mineral muds (clayey-silty muds) with a marine fauna. The data commented in the mentioned chapter remark the possible complex character of such an integrated approach, and the necessity to investigate the lithological, faunistic and enviromagnetic particularities of each of the distinct sediment sequences crossed even by the short cores.

4. Conclusions

In the context of the study of Danube Delta geosystem spatial evolution, the present paper continues the work dedicated to the data base achievement, involving magneto-lithological models carried out for sediment cores collected from lakes, swamps and canals in various sedimentary environments. Consequently, the results analysed in the previous chapters for the cores taken out from 4 lakes, a swamp and a canal in the Mația – Merhei Depression are to add up the data which were published for the cores collected from 4 lakes and a channel of the Meșteru – Fortuna Depression (Rădăn et al., 2013), also situated in the Fluvial Delta Plain, in the Danube Delta northern wing (but in its western area). This succession of the studied deltaic areas, from north southwards and from west eastwards, brings very interesting data; the Meșteru – Fortuna Depression lakes are directly influenced by the Danube supplies (particularly, through the Mila 36 and Crânlăș canals), while the Mația – Merhei Depression lakes are located far from the main Danube Delta distributaries, and are protected from the direct fluvial influx, and, therefore, they are not significantly affected by the riverine inputs. Yet, a parallel analysis of the magneto-lithological models associated with the cores collected from these two depressions with distinctly different characteristics will be performed when the study will be finished, that is the results achieved for the cores extracted in the other two main Delta depressions (Gogova – Uzlină and Lumina – Roșu) will be published, as well.
The lithological data reflect the important supply of organic matter of autochthonous origin within the surficial sediments of the principal Matita – Mehei Depression lakes, mainly generated by phytoplankton, zooplankton and macrophyte vegetation decay as a consequence of the confined conditions characterizing this deltaic area in relation to the direct fluvial influxes. Magnetic susceptibility (MS) maps, as well as siliciclastic/minerogenic (SIL), total organic matter (TOM), and carbonate (CAR) component maps were carried out for the surficial sediments, in order to describe the magneto-lithological background which characterizes each of the investigated lakes. The dominant feature was the calibration of the bottom sediments to the lowest k class (i.e., values under \(10 \times 10^{-6} \text{SI} \), negative ones included), and II (k values ranging between \(10 \times 10^{-6} - 75 \times 10^{-6} \text{SI} \), to which the "fine sediments, rich in organic matter and/or carbonates", are usually included. Only at some of the entry mouths of the canals into the lakes were observed small MS anomalies (some of them reaching the k class III, i.e., MS values within \(75 \times 10^{-6} - 175 \times 10^{-6} \text{SI} \) interval), assigned to "clayey, fine up to silty sediments". The SIL and TOM maps offer a coincident support for the MS areal distribution analysed in the first. The first lithological component follows the same variation type/intensity (defined by the SIL content contour lines, i.e., gradient, maximum/minimum anomalies) with the MS magnetic parameter, while the second LITHO component (TOM) follows, precisely, the SIL (and MS) areal variation pattern, but as seen "in mirror", as regards the anomaly/gradient "trend sign". These clearly opposite "images" which concern SIL vs. MS related to TOM vs. MS (and SIL vs. TOM) are confirmed by the magneto-lithological models carried out for all the sediment cores investigated; the relationships are quantified by the r coefficients which were calculated for all possible correlations between the four investigated parameters (the third analysed lithological parameter is added, i.e., the carbonates/CAR). The surficial sediments showed low CAR contents (lower than 10 %, with an exception only, given by a sample from the Babina L.), the 5 % content contour lines being the highest ones within the CAR maps.

The sedimentation environments from the Matita – Mehei Depression are well characterized by specific magnetic susceptibility (MS) fingerprints, recovered from the sediments of the investigated lakes. The cores, even their lengths did not exceed 55.5 cm (Core DD 10-18, Babina Lake), the shortest being of 24 cm (Core DD 14-113, Lapotna – Polideanca Swamp), have offered interesting specific MS, SIL, TOM and CAR signatures, associated with the crossed sediment sequences. The vertical distribution of the k values reflects, accurately, the lithological variations, in some cases being revealed details which sometimes are macroscopically less visible.

The proxy quality of lithological index assigned to the magnetic susceptibility, which was discussed in the paper devoted to the Meșteru – Fortuna Depression (Rădan et al., 2013), is again demonstrated, this time by the MS – LITHO models carried out for the cores collected in the Matita– Mehei Depression. The r correlation coefficients, calculated for all 6 possible combinations related to the MS, SIL, TOM, and CAR parameters, quantitatively argue the availability shown by the MS enviromagnetic quantity as a proxy lithological indicator. Not lastly, they attest the reliability of the "Magneto-Susceptiblrimetric technique" and "Loss on Ignition method", which were applied in the specialized laboratories from GIR and GeoEcoMar, respectively. In some cases, the deviation from the correlation lines (shown, especially, by the scatter-plots SIL vs. MS and TOM vs. MS) imposed the reanalysis of certain samples, and higher r coefficients resulted, being confirmed the benefit of this methodology. An improvement of the correlations related to the lithological components (SIL vs. TOM, SIL vs. CAR, and TOM vs. CAR) has been recorded, as well.

This integrated magneto-lithological study, carried out on sediment cores taken during the last five years from the Matita – Mehei Depression, has also resulted in the detection of some marine deposits located very close to the water/sediment interface. Particularly, two cores from the Babina Lake, two from Matita Lake, and another one from the Lapotna – Polideanca Canal crossed marine clays. The intensity of the MS fingerprint associated with the marine clays is clearly higher than that of the muds which occur in the upper part of these cores. So, if the muds are correlated with the k class I, possibly with the class II (i.e., MS values not higher than \(75 \times 10^{-6} \text{SI} \)), the marine deposits are calibrated to k class III, and sometimes to class IV (e.g., the case of the core DD 11-01, collected from the Matita Lake, for which k values of \(195.3 \times 10^{-6} - 219.86 \times 10^{-6} \text{SI} \) were recorded). The siliciclastic/minerogenic (SIL) component supports this distinct magnetic characteristics, showing high SIL contents, as well (ranging between 74.13 % − 88.34 %); complementary, the organic fraction is defined by low TOM contents (within the range 6.48 % − 19.56 %). A detailed analysis of the MS and LITHO data, associated with these five cores in which some marine clays were intercepted, has been performed, by dividing the respective extracted sediment columns into two main parts: upper (and median/central) – the muds, and lower – the marine clays. In three of these cases, the correlation coefficients (e.g., related to SIL vs. k and TOM vs. k) were calculated for each of their distinct lithological parts; for the other two cores, a scatter-plot analysis was carried out, which indicated clustering of the core sediments into two groups, assigned to muds, and marine clayey muds/ clays, respectively. This approach will be further applied to similar cases from lakes investigated in the other Danube Delta depressions, and some more conclusions will be drawn at the end.

Anyway, we can mention that the identification within the Fluvial Delta Plain of some marine deposits very close to the actual water/sediment interface is very important for the
deltaic system evolution knowledge, taking into consideration that these are located behind of the initial Jibrieni – Letea – Caraorman sand ridge, and thence older than this one. The presence of the marine fauna (e.g., Cardiidae) inside of certain studied cores, at a low depth, corresponds either the former period of the initial belt, or slightly afterwards, related to an incipient phase, when the Danube bay blocking had not been settled into shape.

Certainly, an absolute age analysis, supported by the identified fauna within the respective cores, could help to clarify some aspects of the controversy relating to the development in time of the different events which led to the deltaic edifice building up.

Another important new direction – possibly to be initiated by the synoptic images which present together the profiles with the vertical distribution of the magnetic susceptibility recorded along each sediment core – is the stratigraphy of the recent sediment sequences. Even the studied cores are short, being not longer than 55.5 cm, some distinct features are seen in the most of them. The 2D area-charts with the vertical distribution of the three main lithological components, particularly the SIL and TOM diagrams, analysed in detail, but in the same time in connection with the MS profiles and other known parameters, are of use in testing the capabilities of the investigated cores for stratigraphic applications in deltaic environments. The multi-proxy study, supported by the lithological, sedimentological, mineralogical, faunistic data, as well as grain size analyses, radiocarbon dating, and other complementary information, could generate interesting applications in the future, particularly in a stratigraphic context.

Besides, the high correlation coefficients which characterize the relationships concerning the susceptibility (MS) and the siliciclastic/detrital material (SIL), which is present, in more or less quantity, within the sediment core composition, can constitute arguments towards the proxy quality assignment of the magnetic parameter as sedimentological and environmental fingerprinting tool, one of the main objectives towards which the paper has been directed just from beginning.

REFERENCES


