ECOHYDROLOGICAL APPLICATIONS IN SOUTHEASTERN ROMANIA WETLANDS BASED ON A MAGNETO-LITHOLOGICAL TOOL

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Abstract. Modern sediments have been sampled from the most important wetlands in the southeastern Romania, *i.e.* Danube Delta, Razim (Razelm) – Sinoie Lagoonal Complex and the Black Sea Littoral Zone. Composite models are illustrated and the correlations between the magnetic susceptibility (**MS**; **k**) values and the main lithological components (*i.e.* total organic matter/**TOM**, carbonate/**CAR** and mineral-siliciclastic/**SIL**, respectively) are analysed. The quality of proxy environmental parameter of the magnetic susceptibility to reveal distinguishing features for different lithological characters is discussed. Besides, the data show the connection with the distinct position of the lakes related to the fluvial supplies, to the hydrodynamic context or to the specific source-areas. Moreover, it is analysed how the changes of the ecohydrological conditions in the Western Meşteru – Fortuna Depression (by digging a new canal) or along a Danube Delta distributary (by cutting-off its meanders) are reflected by the enviromagnetic fingerprints recovered from the bottom sediments.

Key words: magnetic susceptibility, lake sediment, lithological components, environmental magnetism, ecohydrology, Danube Delta, Razim (Razelm) – Sinoie Lagoonal Complex, Black Sea Littoral Zone, wetland.

1. INTRODUCTION

The lake sediments have played a determinant role and have stimulated the start concerning the development of the *environmental magnetism* (Thompson *et al.*, 1975, 1980, Oldfield *et al.*, 1978, Verosub & Roberts, 1995, Dekkers, 1997, Evans & Heller, 2003).

The study of the modern sediments from three main aquatic areas of Romania, *i.e.* *Danube Delta* (DD), *Razim* (*Razelm*) *– Sinoie Lagoonal Complex (RSLC)* and the *Black Sea Littoral Zone (BSLZ)* (Fig. 1), is based on an integrated petromagnetic and lithological approach, resulting in a magnetic susceptibility (**MS**) characterisation of the different sedimentary environments from deltaic, lagoonal and littoral lakes. Besides, two cases from Danube Delta were chosen in order to exemplify the capability for ecohydrological applications of this enviromagnetic tool, which use magnetic susceptibility measurements on bottom sediments.

Based on the **MS** (**k**) values and the lithological components (*i.e.* total organic matter/**TOM**, carbonates/**CAR** and mineral-siliciclastic fraction/**SIL**), a number of magneto-lithological models are carried out for several important lacustrine ecosystems located in the most important wetlands of southeastern Romania (Fig. 1). Results obtained on bottom sediment collections taken from the Puiu – Roşu – Roşuleţ zone (DD) in 2006 and 2009 cruises, and from the Razelm and Goloviţa area (RSLC) and the Taşaul Lake (BSLZ) in 2007 cruises (Fig. 1) are presented; very good correlations were shown by **k** *vs* **TOM**, **k** *vs* (**TOM+CAR**) and **k** *vs* **SIL** (negative – in the first two cases, positive – in the third one).

For other cases, the reader is referred to Rădan & Rădan, 2007, 2009, 2010a,b, Rădan & Rădan, 2007b,d, in Rădan, 2008, Rădan *et al.*, 2008.

Fig. 1 Aquatic areas in the southeastern Romania and location of the investigated wetlands.
Note: **1** and **3** (marked by yellow rectangles) – deltaic lakes under attention in the paper.

2. LOGISTICS, MATERIALS AND METHODS

There is a huge magnetic susceptibility data bank for the southeastern Romania wetlands, which was achieved during more than three decades. This is based on ca 2500 **MS** measurements on bottom sediments sampled in the *Danube Delta* and around 1750 **k** values for recent sediments from the *Razim – Sinoie Lagoonal Complex,* to which about 150 **MS** values obtained for modern sediments sampled from the *Black Sea Littoral Zone*, in 2007 and 2008, must be added (Rădan & Rădan 2006; Rădan & Rădan 2007a,b, in Rădan, 2008). The data that are analysed herein are mainly based on the collections taken during the cruises performed in the 2006 – 2009 period.

The field campaigns have been performed on board of the fluvial research vessel "*Istros*" (Fig. 2a) and the motor-boat "*Măriuca*" (Fig. 2b), the latter being used in the lakes where the depths were very low (*e.g.* lower than 1.50 m).

To locate the sampling points, a high precision was ensured by "*Simrad*" radar, GPS and echosounder equipments, and by "*Magellan – Meridian Color*" portable GPS and "*Eagle – Cuda-168*" echosounder, respectively (Fig. 3).

The stations were located to allow for an uniform network of sediment sampling points within the lacustrine areas (two examples, in Fig. 4).

The sampling of bottom sediments was carried out using "*Van Veen*"-type grabs (Fig. 5a), which allowed to take relatively undisturbed (at the upper part) "sediment packets" (Fig. 5b). Besides, in 2009, a number of short sediment cores (less than 56 cm long) were taken from all the four main lakes of the lagoonal complex. In 2010, another 8 cores (up to maximum 57 cm) were sampled with the Hydro-Bios corer from 6 lakes of the Danube Delta.

A macroscopic description of the lithological constitution of the bottom sediments (Fig. 5b) was performed on board of the research vessels. The different levels identified within the "sediment packets" were marked "a", "b", "c" *etc*., and material from each sediment level was collected for different laboratory analyses, *e.g*. the magnetic susceptibility (**MS**) and the lithological components (*i.e. total organic matter/**TOM**, carbo-*

Fig. 2 Research vessels used in the cruises in various lakes. **a)** Fluvial research vessel "*Istros*"; **b)** Motor-boat "*Măriuca*" (for shallow lakes).

Fig. 3 Equipments used for location of the sampling stations and for water depth and temperature measurements. **a)** "*Simrad*" Radar-GPS-Echo-sounder equipment; **b)** "*Eagle-Cuda-168*" echosounder.

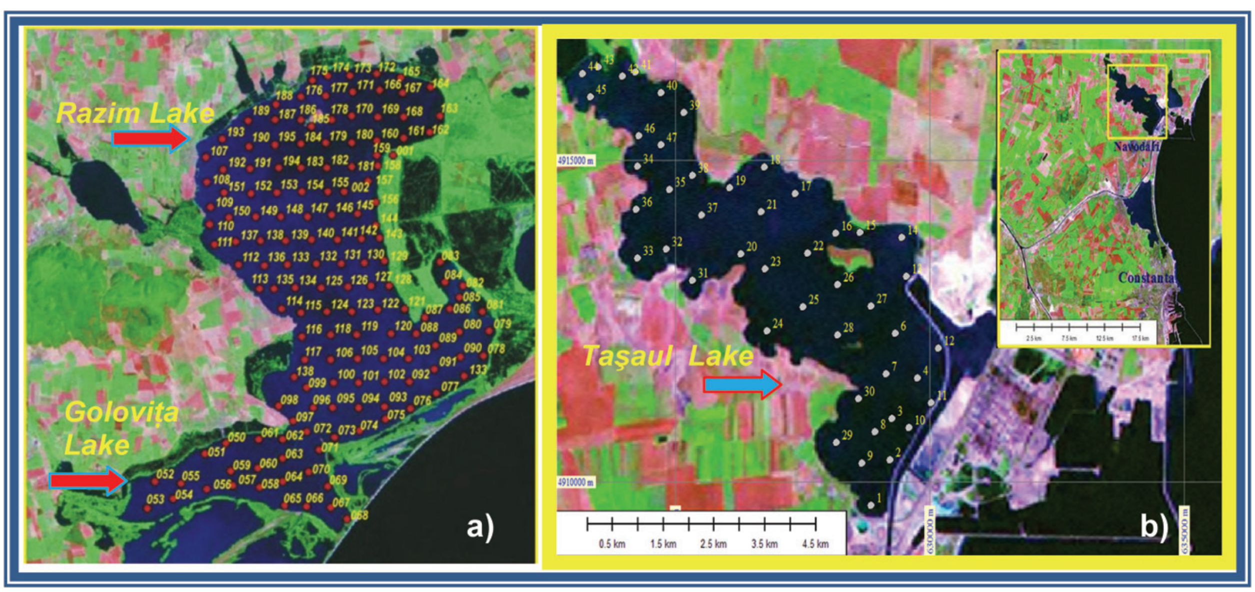


Fig. 4 Distribution of the sampling stations for bottom sediments; examples: **a)** Razim and Goloviţa Lakes (Razim – Sinoie Lagoonal Complex); **b)** Taşaul Lake (Black Sea Littoral Zone).

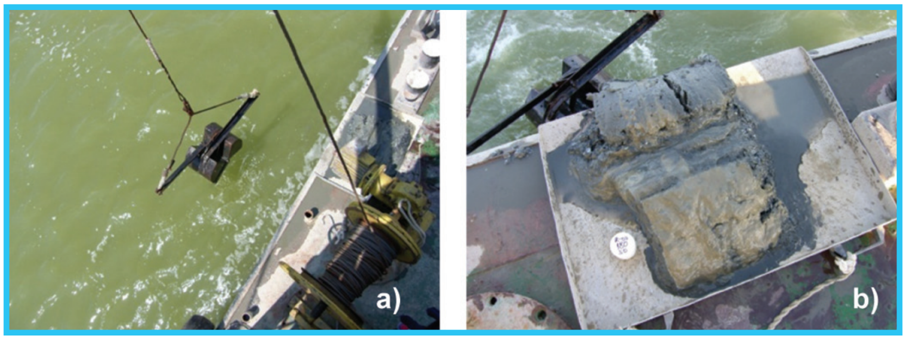


Fig. 5 Equipment used for sediment sampling. **a)** "*Van Veen*"-type grab sampler; **b)** "Bottom sediment packet" sampled by using a high capacity "*Van Veen*"-type grab (an example from the Razim Lake).

*nate/**CAR*** and *mineral-siliciclastic/**SIL** fractions*). Ternary diagrams were drawn up to show the lithological classification of the bottom sediments.

The **MS** parameter was measured with a Kappabridge KLY-2 instrument in the laboratory of rock-magnetism and palaeomagnetism of the Geological Institute of Romania. The lithological components were determined in the geochemical laboratory of the Faculty of Geology and Geophysics, the University of Bucharest. To calibrate the lake sediments, a "Magnetic Susceptibility (**k**) Scale" (Rădan & Rădan, 2007; Fig. 6) was used. Numerous **MS** patterns were performed to analyse the characteristic magnetic signatures of the various sedimentary environments.

Several correlation coefficients (**r**) were calculated, *e.g.* related to **k** *vs* **TOM**, **k** *vs* **CAR**, **k** *vs* (**TOM**+**CAR**) and **k** *vs* **SIL**. Graphical correlation was also taken into consideration to show and interpret the connection between the enviromagnetic parameter and the lithological characters. A scale to evaluate the size of the correlation was used (Fig. 7).

A number of composite magneto-lithological models were carried out on the basis of the magnetic susceptibility values (**k**) and the contents of the lithological components (*i.e.* **TOM**, **CAR**, **SIL**) obtained for the lake sediments.

3. RESULTS AND DISCUSSION. ECOHYDROLOGICAL APPLICATIONS

The specific enviromagnetic fingerprints recovered from the lake sediments are emphasised by various integrated **k-TOM-CAR-SIL** models. The established correlations between the magnetic susceptibility (**MS**; **k**) and the lithological components of the lake sediments favour the use of this enviromagnetic tool to carry out ecohydrological applications. Two cases from the Danube Delta are analysed in the second part of this chapter.

3.1. Correlation between the enviromagnetic parameter MS and the lithological components of the lake sediments as a support for ecohydrological applications

Integrated magnetic susceptibility and lithological data obtained for a series of representative lakes from the three above mentioned wetlands are further analysed.

3.1.1. Deltaic wetlands

The main lakes from four zones of the Danube Delta (**1**, **2**, **3**, **4**, in Fig. 1) were in attention for our complex study in 2006. Several **MS-**lithological patterns that illustrate the various cases of the "dynamic", "confined" and "intermediate" deltaic environments located in the *Fluvial Delta Plain* and *Fluvio-Marine Delta Plain* are given in three recently published papers (Rădan & Rădan 2009, 2010a,b).

A conclusion of the previous studies was that the models associated with 10 deltaic lakes located within four DD depressions emphasise the allochthonous sedimentation, predominantly siliciclastic in the lacustrine ecosystems that are directly influenced by the River Danube, comparing with the dominantly autochthonous sedimentation in the distal zones, where the organic component is mostly present.

Four deltaic areas were investigated. The case of the Puiu – Roşu – Roşuleț zone (Fig. 8a), situated in the Lumina – Roşu Depression (**3**, in Fig. 1), is here presented, the lake sediments being sampled not only in 2006, but in May 2009, as well.

The magnetic susceptibility and the lithological models resulting from the investigation of the bottom sediments sampled in the 2006 cruise (Fig. 8b,c) reveal the predominance of the lower classes **I**+**II** (83%) (according to the **k** scale fom Fig. 6; also, in Rădan & Rădan, 2007), and of the organic and carbonate components (**TOM**+**CAR** contents; 64.3%), respectively; the remaining percents belong to the intermediary class **III** (17%), and to the mineral fraction (**SIL** content; 35.7%), respectively. A strong negative correlation (**r** = - 0.8502), according to the scale from Fig. 7, was shown by **k** *vs* (**TOM**+**CAR**), and a strong positive correlation (**r** = 0.8502) for **k** *vs* **SIL** (Fig. 8d).

Magnetic susceptibility (MS; k) scale (× 10E-06 SI)		
Vd	> 1000	Coarse silts and sands
Vc	675 ÷ 1000	
Vb	575 ÷ 675	
Va	275 ÷ 575	
IV	175 ÷ 275	
III	75 ÷ 175	Clayey fine up to siltic sediments
II	10 ÷ 75	Fine sediments, usually rich in organic matter and / or carbonates
I	< 10	

Fig. 6 Magnetic susceptibility (**k**) scale used to calibrate the lake sediments and to correlate with their lithological characters.

Correlation coefficients (r)	
0.65 ÷ 1.00	Strong positive correlation
0.32 ÷ 0.64	Moderate positive correlation
0.00 ÷ 0.31	No correlation – Weak positive correlation
0.00 ÷ (- 0.31)	No correlation – Weak negative correlation
(- 0.32) ÷ (- 0.64)	Moderate negative correlation
(- 0.65) ÷ (- 1.00)	Strong negative correlation

Fig. 7 The scale used to evaluate the size of the correlation (**r**) between the enviromagnetic parameter (**k**) and the lithological components (**TOM**, **CAR** and **SIL**) related to the bottom sediments.

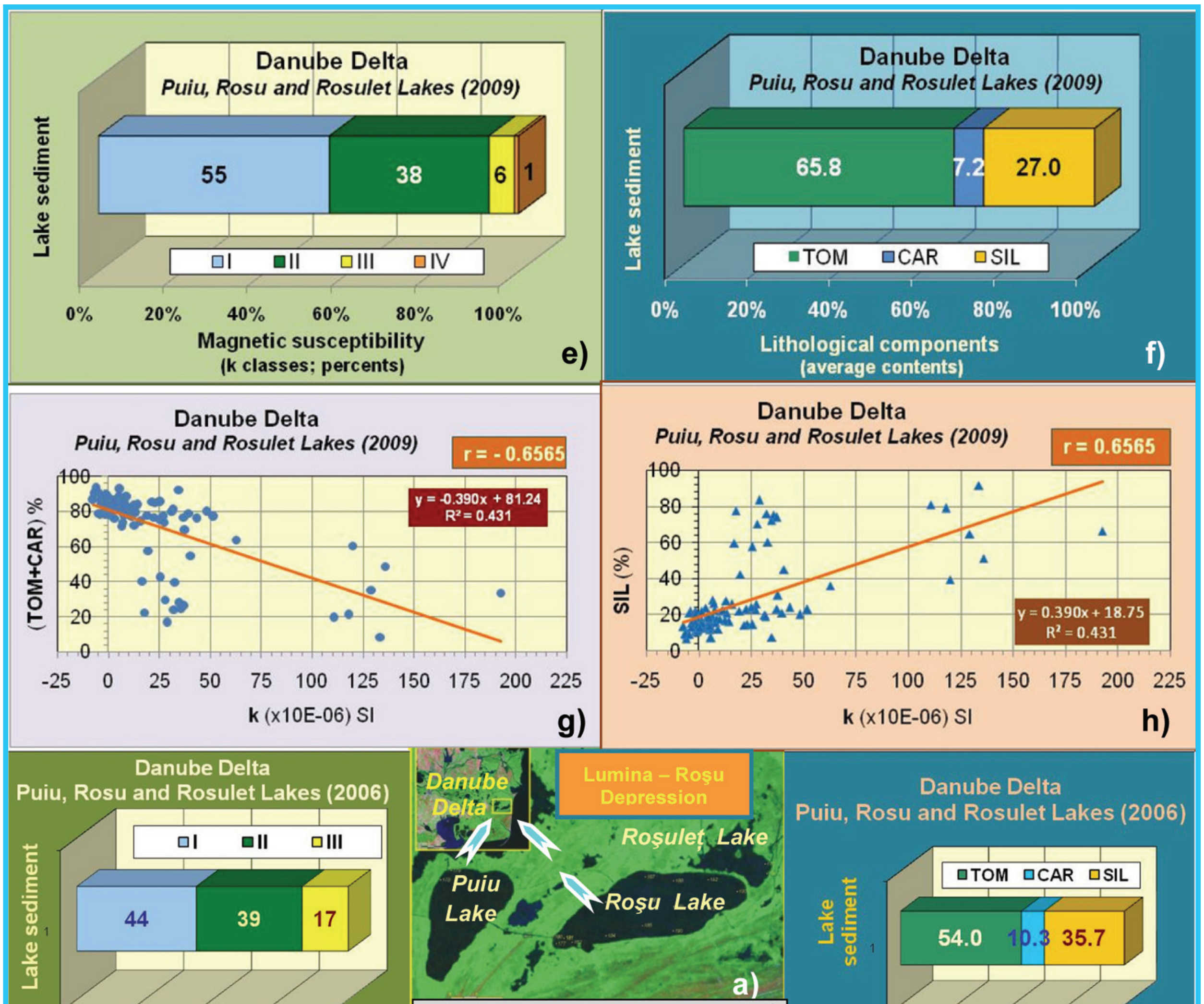
The **MS**-lithological results obtained for the bottom sediments sampled in the 2009 cruise (Fig. 8e,f,g,h) confirm the above mentioned data (related to the 2006 cruise): the clear predominance of the lower **k** classes **I**+**II** (93%; Fig. 8e), and of the (**TOM**+**CAR**) contents (73%; Fig. 8f), respectively; the remaining percents belong to **k** classes **III**+**IV** (*i.e.* 6%+1%), and to the **SIL** component content (27%), respectively. A strong negative correlation (according to the scale from Fig. 7) was shown by **k** *vs* (**TOM**+**CAR**), and a strong positive correlation for **k** *vs* **SIL** (Fig. 8d,g,h).

Higher percentages were obtained for the **MS** values correlated to the classes **III** or (**III**+**IV**) and for the **SIL** component content recorded for the lake sediments sampled in 2006 as compared with the data (**k**; **SIL**) achieved for the sediment samples collected in 2009 (Fig. 8b,c,e,f). This result is explained by the different hydrological regime (and its influence on the sedimentary environments) relating to the two campaigns. In the spring 2006, due to the existing floods (at the same time, a very high flow of the Danube River), the detrital material discharge increased, so that the **SIL** content is higher (35.7%; Fig. 8c) than in 2009 (27%; Fig. 8f), and consequently, the **k** values assigned to the class **III** represent a higher percentage (17%; Fig. 8b) than of the **MS** values assigned to classes **III**+**IV** (7%; Fig. 8e) measured on the bottom sediments sampled in 2009.

So, the magnetic susceptibility fingerprints recovered from bottom sediments sampled in various lakes of the Danube Delta show suitable capabilities of this enviromagnetic tool for ecohydrological applications.

3.1.2. Lagoonal wetlands

In fact, the Razim (Razelm) – Sinoie Lagoonal Complex was the first aquatic area of Romania in which the capabilities of the magnetic susceptibility (**MS**) relating to the study of the lake sediments have been tested (*e.g.* Mihăilescu *et al.*, 1983). The **MS** data bank comprises around 1750 **k** values measured on bottom sediment samples (cores included) collected from all the 4 main lakes of the lagoonal area (*i.e.* *Razim/Razelm*, *Golovița*, *Zmeica* and *Sinoie lakes*; Fig. 1). The data base was achieved during more than three decades and can be systematised relating to three important time periods in which the sediment samples were taken and investigated:



Cruise	k/ (TOM+CAR)	k/SIL
2006	- 0.8502	0.8502
2009	- 0.6565	0.6565

Fig. 8 Magneto-lithological model for bottom sediments sampled from three lakes (*i.e.* Puiu, Roşu and Roşuleţ) in the Fluvio-Marine Delta Plain (Danube Delta; **3**, in Fig. 1), showing the correlation between the enviromagnetic parameter **k** and the lithological components (**TOM**, **CAR**, **SIL**).

1976 – 1978, 2002 – 2004, and 2007 – 2010. The lake sediments were calibrated to **k** scale (Fig. 6).

Here, the cases of the *Razim (Razelm) L.* and *Goloviţa L.* are briefly presented. Among a series of factors, the variations of the magnetic susceptibility are controlled by the sediment grain size, generally coarser than in the Danube Delta lakes; they are also influenced by the less significant contents of organic material and carbonates (excepting the *Zmeica Lake* case). At the lagoonal complex scale, an increasing weight of the sediments calibrated to **k** class **II** is noticed, in the direction *Razim L.* → *Goloviţa L.*, accompanied by a corresponding decrease of the contribution of the **k** classes **III**, **IV** and $\mathbf{V_a}$, in agreement with the lithological composition variations; the lake sediments are predominantly of mineral or mineral-organic type, rarely organic-mineral in the *Razim L.*, and of organic-mineral type, subordinately organic-mineral, in the *Goloviţa L.* (see the ternary diagrams in Fig. 9).

A general model for the *Razim (Razelm) – Sinoie Lagoonal Complex*, referring to all the four lakes and covering the time intervals 1976 – 1978 and 2002 – 2004 is presented by Rădan & Rădan (2007d, in Rădan 2008); for *Razim* and *Goloviţa lakes* only, the results for the sediments sampled in 2007 are added as well.

As we have mentioned before, the present paper is focused on examples from the *Razim* and *Goloviţa lakes* (**6** and **7**, in Fig. 1). Some results based on magnetic susceptibility and lithological data obtained for modern sediments sampled during the 2007 cruise are presented in Figs. 9 and 10. Besides, in Fig. 9 are illustrated the **k** classes to which were calibrated the *Goloviţa Lake* sediments sampled at a 30 years

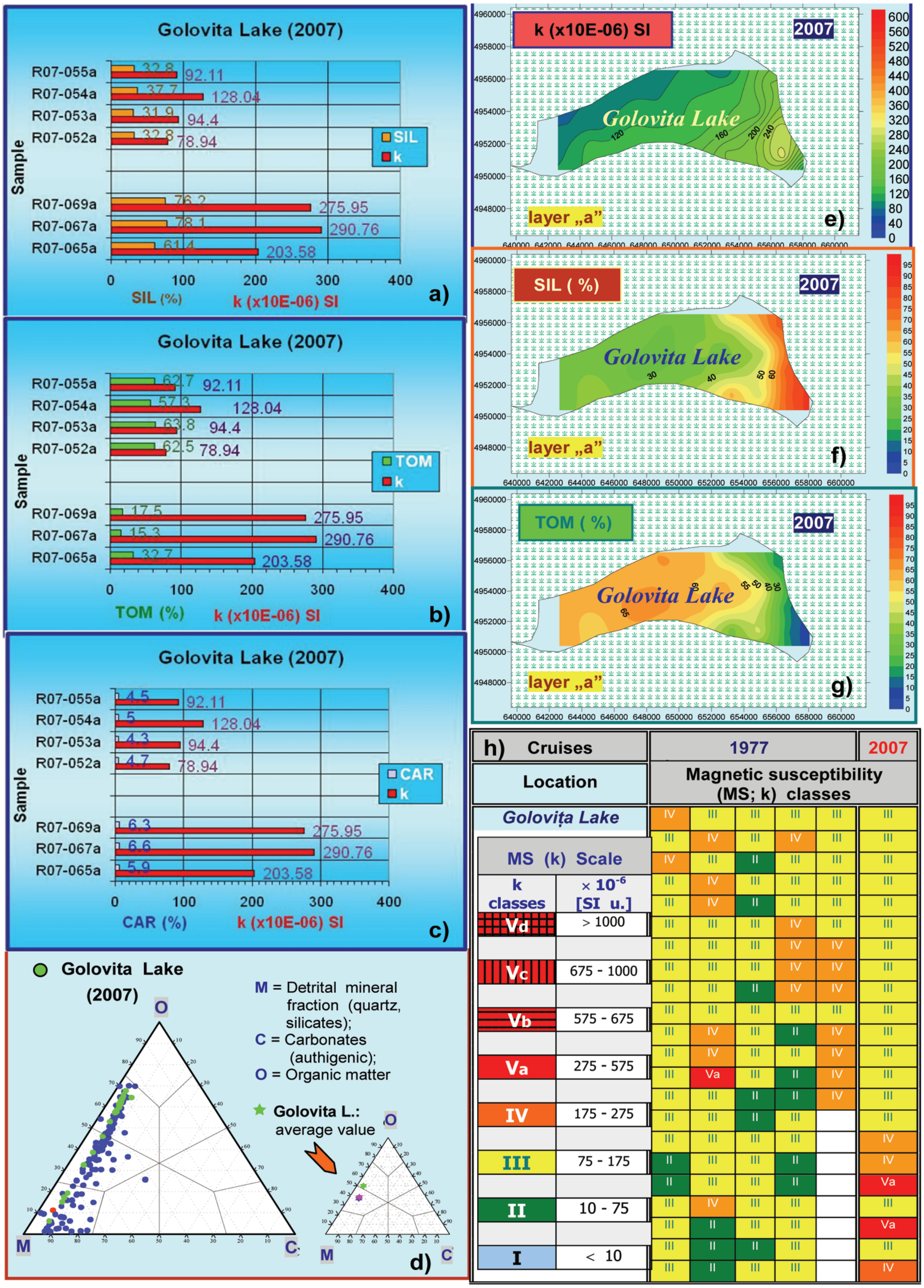


Fig. 9 Magneto-lithological model for bottom sediments sampled from Goloviţa Lake, located in the Razim – Sinoie Lagoonal Complex (**7**, in Fig. 1).

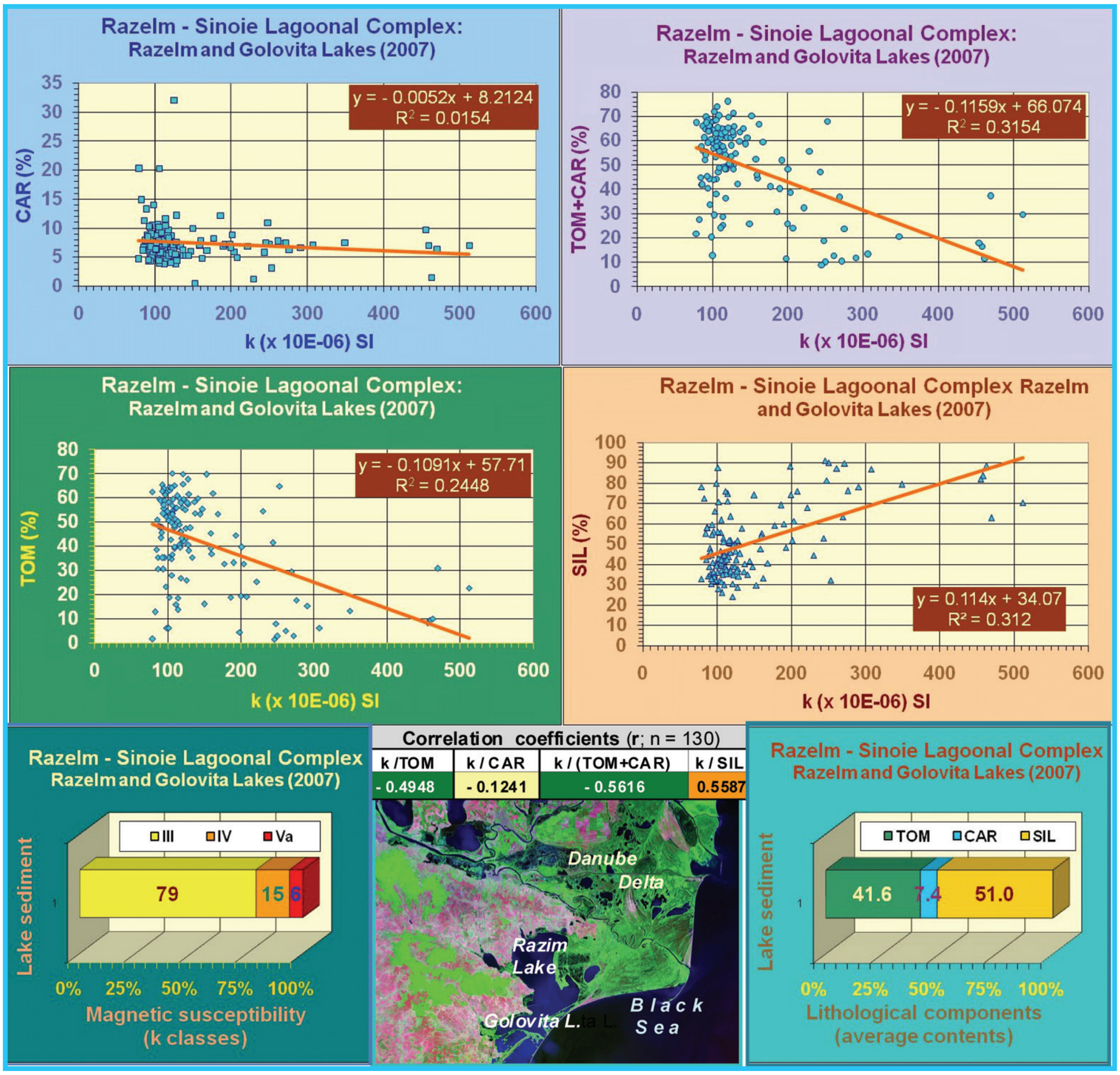


Fig. 10 Magneto-lithological model for bottom sediments sampled from two lakes of the Razim – Sinoie Lagoonal Complex (*i.e.* Razim and Golovița; **6**,**7**, in Fig. 1), showing the correlations between the enviromagnetic parameter **k** and the lithological components (**TOM**, **CAR**, **SIL**).

time interval (1977, and 2007, respectively; a larger collection was taken in the first cruise). As regards the latter campaign (2007), the **MS**-lithological cartographic models illustrated in Fig. 9 for the *Golovița Lake* reflect the coincidence between the sedimentation zones characterised by high **k** values and the areas outlined as dominantly siliciclastic. For example, the prolongation into the underwater area of an important sand ridge (*i.e. Lupilor Ridge*), which separates the southern lakes (*Sinoie* and *Zmeica*) of the lagoonal complex (Fig. 1), is pointed out by a zone of maximum values in the "Golovița" magnetic susceptibility map, particularly located in its eastern-southeastern part (Fig. 9e). This result confirms the clear **MS** anomaly that was mapped on the basis of the large collection of sediment samples taken for the first time from *Golovița Lake*, in 1977 (Mihăilescu *et al.*, 1983; also, Rădan & Rădan 2007d, in Rădan, 2008, where another image version of the "Golovița – Razim" **MS** map is illustrated).

Additionally, the lithological composition of the recent sediments sampled during the 2007 cruise is here presented. A maximum anomaly is outlined in the mineral-siliciclastic content (**SIL**) map, in the same eastern-southeastern area of the *Golovița Lake* (Fig. 9f). That explains the higher **k** values measured on the bottom sediments sampled in the specified zone. Correspondingly, a minimum anomaly is shown by the Total Organic Matter content (**TOM**) map in the same sector (Fig. 9g). For similar patterns carried out for the *Razim Lake*, the reader is referred to Rădan *et al.*, 2008; Rădan & Rădan, 2007d, in Rădan 2008; Rădan & Rădan, 2010b.

With regard to these two lakes (*Razim* and *Goloviţa*), a composite magneto-lithological model shows the explicit (graphical) correlation between the magnetic susceptibility **k** and the lithological components **TOM** (organic matter), **CAR** (carbonates) and **SIL** (mineral-siliciclastic content) (Fig. 10). Concerning the magnetic susceptibility (**MS**), the sediment samples are calibrated to **k** class **III** (79%), class **IV** (15%) and $\mathbf{V_a}$ (6%) (**MS** scale, inserted in Fig. 9), while the lithological components show contents of 41.6%, 7.4% and 51.0% for **TOM**, **CAR** and **SIL**, respectively. According to the scale from Fig. 7, the coefficients **r** suggest moderate negative correlations for **k** *vs* **TOM** and **k** *vs* (**TOM**+**CAR**), and a moderate positive correlation for **k** *vs* **SIL** (Fig. 10).

3.1.3. Littoral wetlands

The modern sediments of four lakes from the *Black Sea Littoral Zone* (Fig. 1) were investigated with regard to the magnetic susceptibility and the lithological composition, namely *Taşaul*, *Siutghiol*, *Techirghiol* and *Mangalia*. Some results achieved for the bottom sediments sampled from the first one during the 2007 cruise are here briefly presented as an example.

The particularities of the genesis and the aquatic environment evolution characteristics stand for the *Taşaul L.* (**8**, in Fig. 1) to be considered as representative for this last category of wetlands (*i.e. littoral*) under attention in the paper.

The total organic material (**TOM**), showing an average content of 62.7%, is the principal lithological component of the *Taşaul Lake* sediments. The carbonates (most probably of biochemical origin) have not an important contribution (4% average content). The siliciclastic component (**SIL**) content values are placed within a large definition range, but the average is relatively low (33.3%), confirming the predominance of rich in organic matter muds. The areal distribution of the **TOM** and **SIL** contents is shown in the corresponding maps in Fig. 11f,g, next to the magnetic susceptibility (**k**) map illustrated in Fig. 11e. The ternary diagram (Fig. 11j) points out the net preponderance of the organic component, followed by the siliciclastic one and the carbonate fraction, the latter with

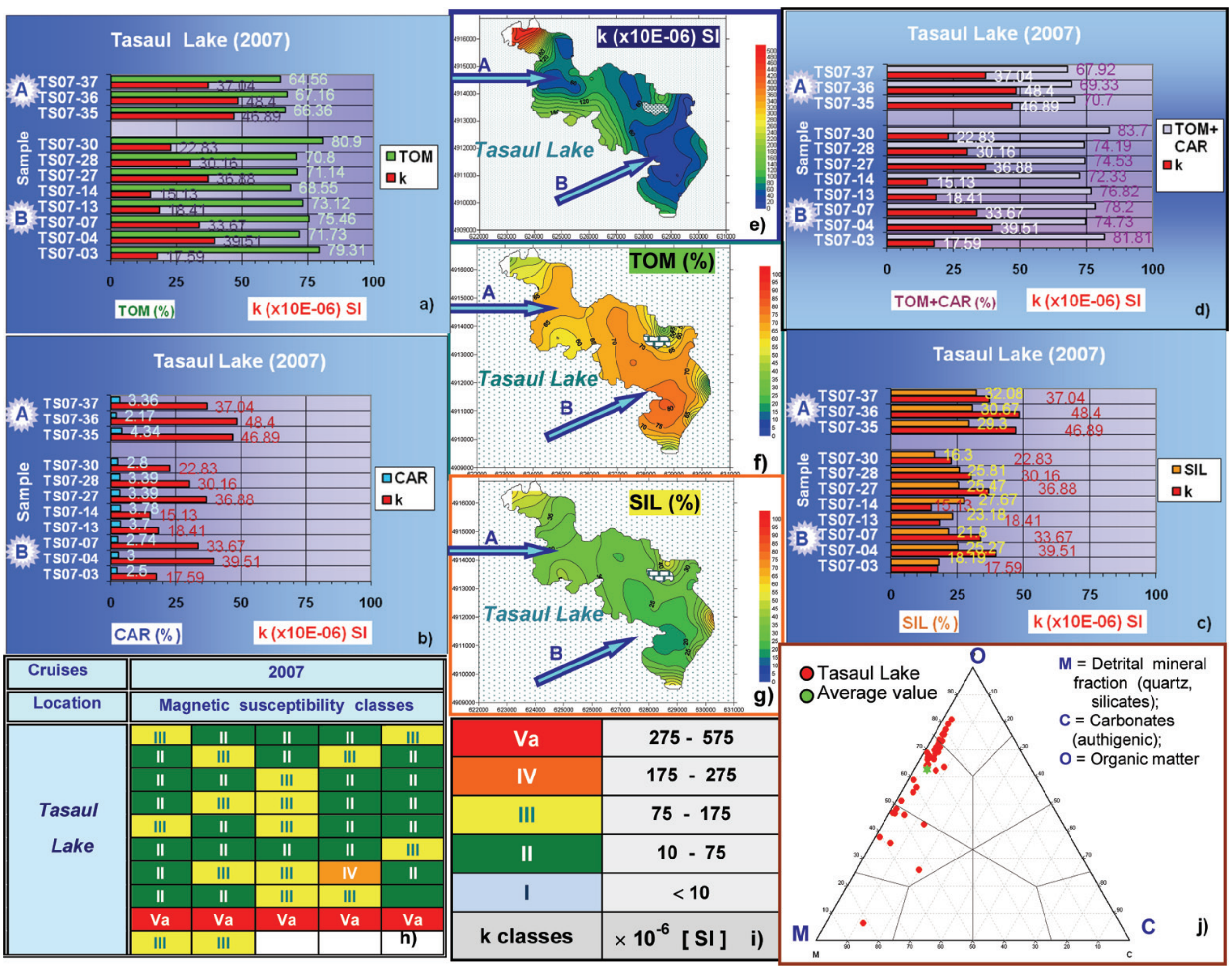


Fig. 11 Magneto-lithological model for bottom sediments sampled in the Taşaul Lake. *Note*: The arrows **A** and **B** show two zones of minimum values revealed by the magnetic susceptibility (**k**) map chosen for correlation with the (spatial) coincident sectors from the **TOM** and **SIL** lithological maps. A parralel model relating to the zones of maximum values outlined in these maps is given in Rădan *et al.*, 2008. For further explanations, see text.

a small contribution. The most sediment samples belong to the organic-mineral muds; in the second position are placed the organic muds, followed by the mineral-organic muds. A sample only belongs to the mineral, net siliciclastic sediments (Fig. 11j).

The calibration to the magnetic susceptibility scale, which was carried out for the bottom sediments sampled in the *Taşaul Lake* in 2007, points out the predominance of the **k** class **II** (53%), followed by the class **III** (34%), $\mathbf{V_a}$ (11%) and **IV** (2%) (Fig. 11h). The **MS** results are in agreement with the above mentioned lithological data. Actually, the lowest **k** values (zones shown by the arrows **A** and **B** in Fig. 11) were provided by the samples collected from the places where the organic rich sediments are deposited (Fig. 11e,f); an important maximum **k** regime was particularly mapped within the river (Casimcea) discharge zone, well shown by the detrital component map (Fig. 11g).

3.2. Ecohydrological applications of the enviromagnetic tool in the Danube Delta

Firstly, a case study concerning some lakes from the *Fluvial Delta Plain* is analysed, followed up by a test carried out in a fluvial-deltaic area, particularly relating to a meandering distributary of the *Danube Delta*.

3.2.1. Changes of the ecohydrological conditions in the Western Meşteru – Fortuna Depression and their enviromagnetic fingerprints recovered from bottom sediments

Thus, the deltaic areas of the *Danube Delta* are undergoing the cumulative effects of the human interventions on the *Danube* flow regime, the anthropogenic activities carried out around them and the interventions taking place even inside of these aquatic systems.

The case study under attention in the present paper concerns the latter situation. The area anthropogenically stressed is located within the western part of the north fluvial delta plain, between *Chilia* and *Tulcea & Sulina Branches* (Fig. 12).

This zone became strongly affected by the *Danube* water supply since 1983, when a short *canal* cut between the *Tulcea* and *Chilia Branches* was completed (*i.e. Cn. "Mila 36"*, shown by red arrows in Fig. 12b,c).

The influence of the anthropogenic activities on the sedimentary environments and ecosystems from the western zone of the *Meşteru – Fortuna Depression* is reflected by the changes in the hydrologic system dynamics, as well as by the modifications (*i.e.* lithological, mineralogical and geochemical) in the quality of sediments that are deposited in this area. The example of the *Lungu* and *Meşteru Lakes* is the clearest in

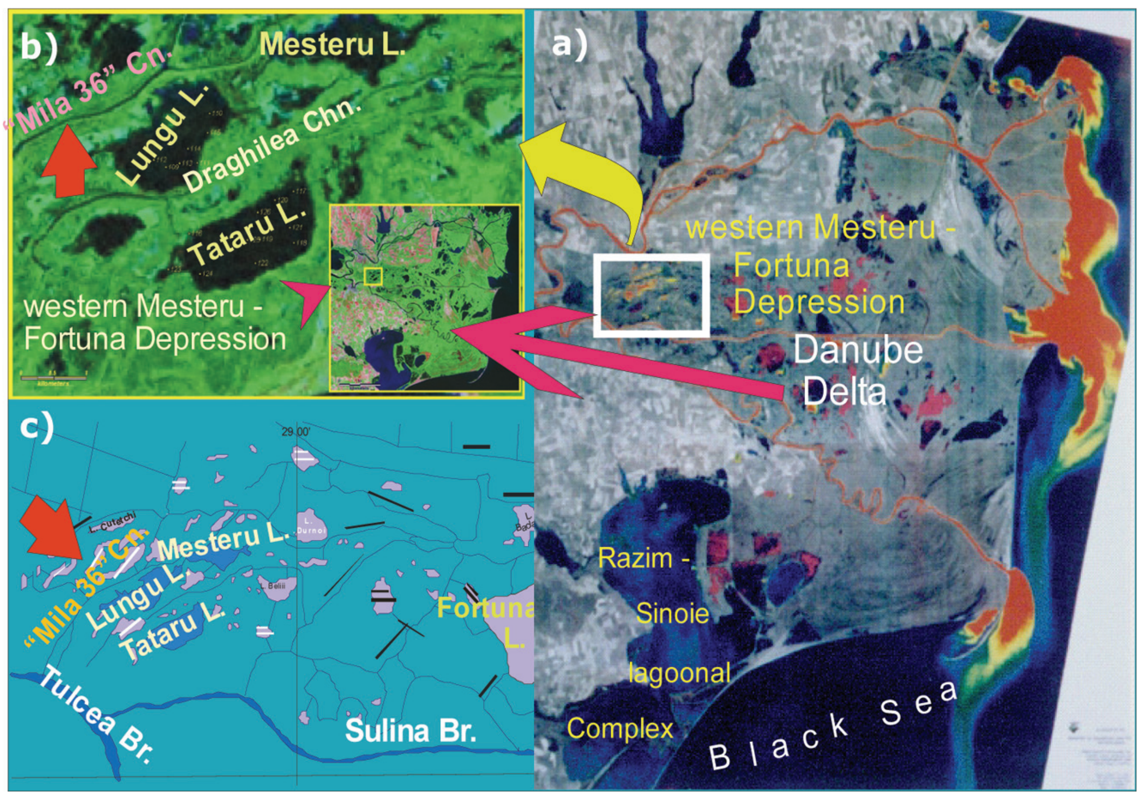


Fig. 12 Location of the Canal "Mila 36" within the Western Meşteru – Fortuna Depression. **a)** location of the western Meşteru Depression within the Danube Delta; **b)** location of the "Mila 36" Canal related to the Lungu, Meşteru and Tătaru Lakes; **c)** location of the "Mila 36" Canal related to the above mentioned lakes and to the Tulcea Br. and Sulina Br. (*i.e.* Danube Delta branches).

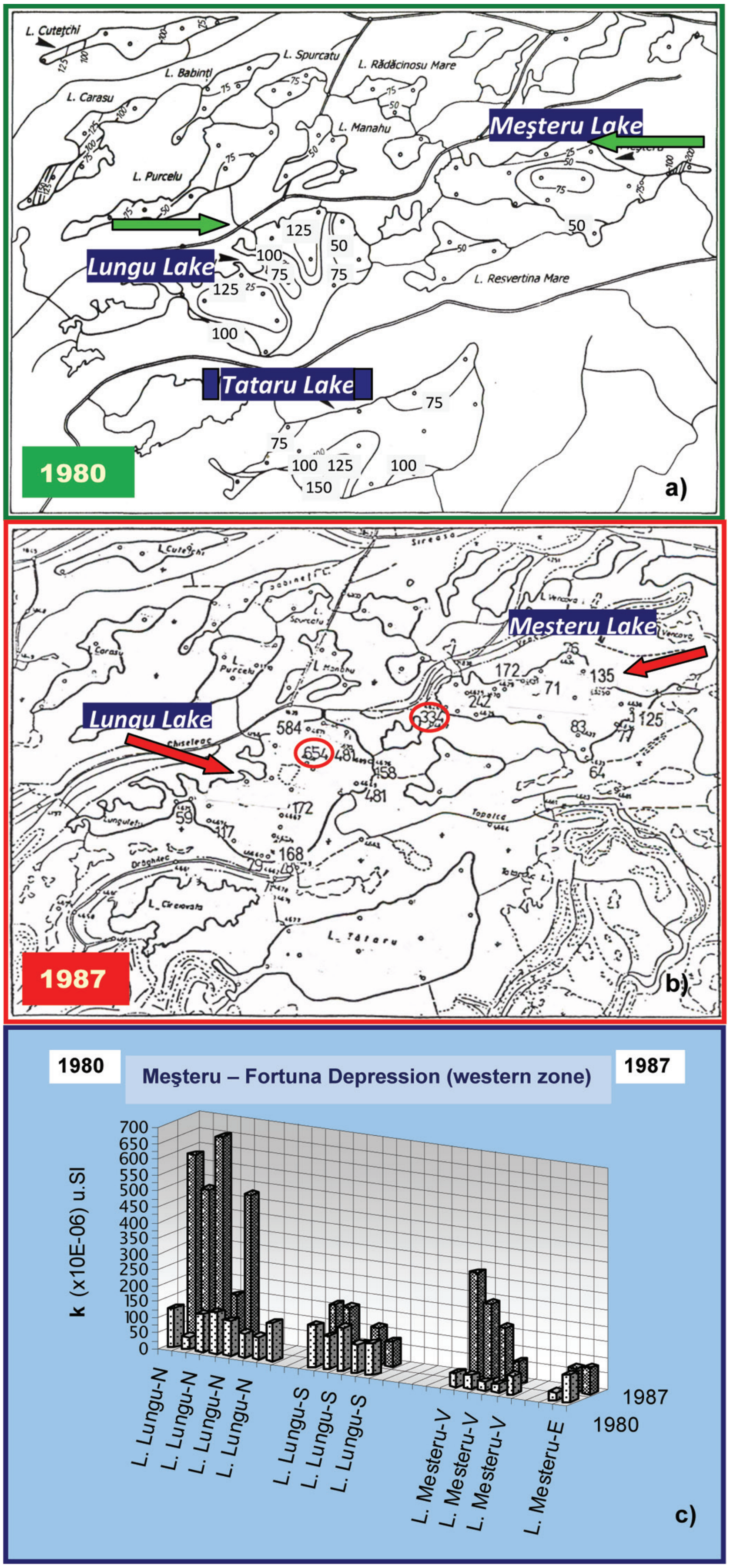


Fig. 13 Magnetic susceptibility (**MS; k**) patterns showing the **MS** distribution in two main lakes from the Western Meşteru – Fortuna Depression. **a) k** map (1980 cruise); **b) k** map (1987 cruise). *Note*: the **MS** values must be multiplied by 10^{-6} (SI); **c) k** values for sediments sampled in the Lungu L. (northern and southern zones) and Meşteru L. (western and eastern zones) before (*i.e.* in 1980) and after (*i.e.* 1987) the human intervention in the area (hydrotechnical works).

this respect. These lakes are the most affected, the high sedimentation rate leading to a rapid filling-up with sediments, particularly in the northern and western sector, respectively, of the two lakes. The changes are well reflected by the enviromagnetic parameter **MS** proving its capability for ecohydrological applications.

The magnetic susceptibility measured on bottom sediment samples collected from the *Lungu* and *Meşteru Lakes* during the 1980 cruise (Fig. 13a,c) showed **k** values as high as 137x10^{-6} SI (with an exception, locally explained). The sediments sampled in the two lakes during the 1987 cruise, that is after the "*Mila 36*" *Canal* was dug up (in 1982-1983), yielded **k** values up tu 654x10^{-6} SI for the *Lungu L.*, and up to 334x10^{-6} SI for the *Meşteru* L. (marked by red ovals in Fig. 13b; see, also, Fig. 13c).

A confirmation of the modified magnetic signatures, in keeping with the changes of the ecohydrological conditions followed up by those of the sedimentary environments, resulted from the **MS** monitoring cruises carried out during 1992-1997, as well as from the expedition organised in 2006 in the *Lungu L.* (and also in *Tătaru L.*; Fig. 14). Consequently, according to the **k** Scale, the **MS** signatures identified in 1980 in the *Lungu* and *Meşteru Lakes* are characterised by **k** classes **II** and **III** (with the exception above mentioned, *i.e.* a **k** value assigned to class **IV**) (Fig. 14a$_4$,b$_4$).

As concerns the 1987-1997 period, the **MS** calibration of the sediments shows obvious changes. Thus, for the *Lungu L.* (closer to the "*Mila 36*" *Cn.* inflow mouth; see Fig. 12b,c), 60% of the **k** values are defined by high **k** classes (**IV**, **V$_a$**, **V$_b$**), while 40% by the classes **II** and **III** (Fig. 14a$_2$; see also Fig. 14a$_4$). In 2006, the sampling stations were placed in the eastern – south-eastern part of the *Lungu Lake*, an area less exposed to the fluvial inflow than the northern one (see Fig. 12b,c); the **k** values are defined between 78.22x10^{-6} – 226.34x10^{-6} SI (assigned to **k** classes **III** and **IV**; Fig. 14a$_1$). With regard to the *Meşteru L.* (1987-1996), the percentages are equally attributed to the classes **II** and **III** (50%) and to the higher classes **IV**

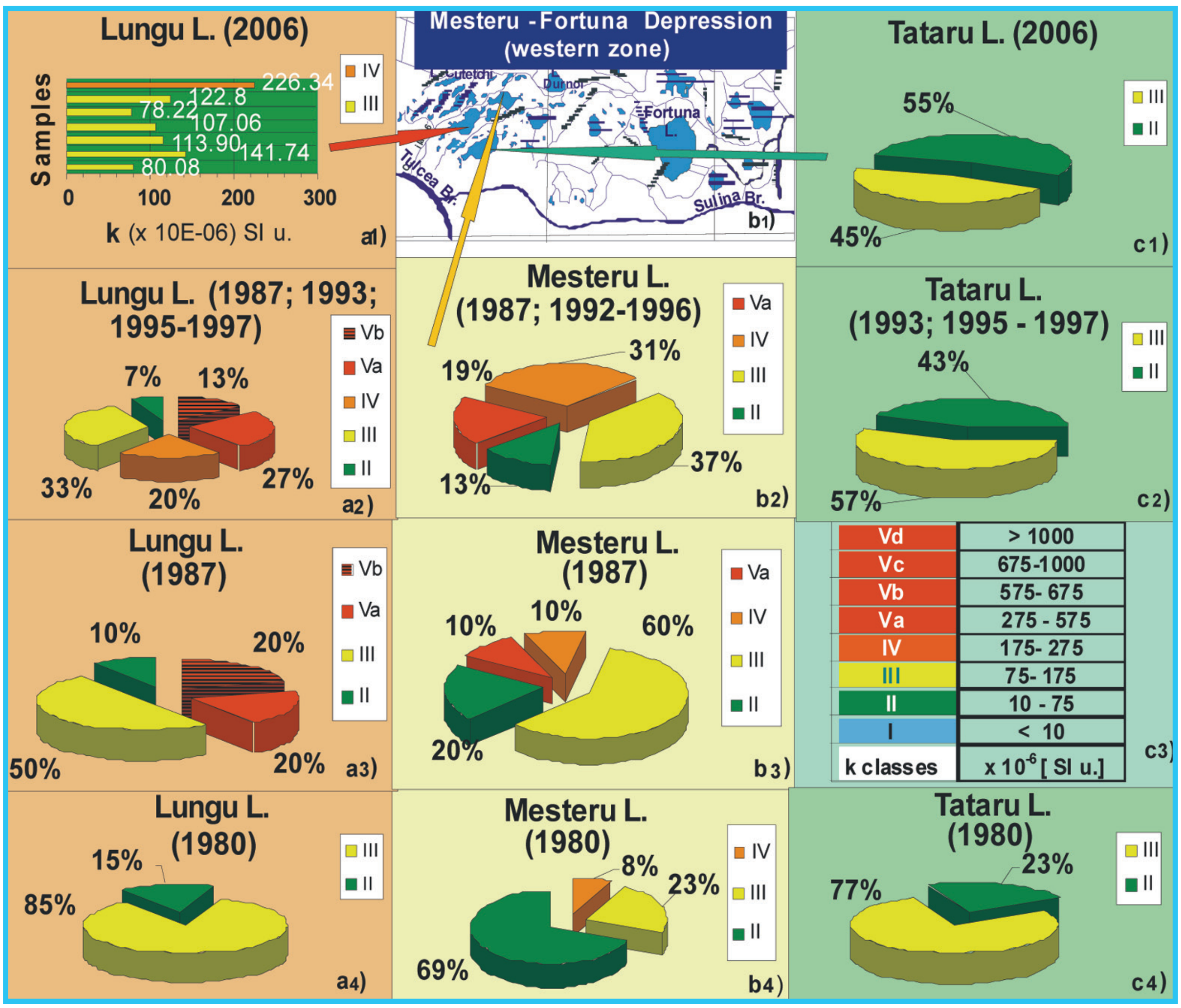


Fig. 14 Magnetic susceptibility of the sediments sampled in the Lungu, Meşteru and Tătaru lakes, in the 1980-2006 time span.

and $\mathbf{V_a}$ (50%; Fig. 14b$_2$; see also Figs. 14b$_4$ and 13a,c to compare with the data obtained in the first cruise-1980).

This indicates that the deltaic environments of the *Lungu* and *Meşteru Lakes* are under anthropogenic pressure, induced by the hydrotechnical works, relating to the "*Mila 36*" *Canal* (shown by red arrows in Fig. 12b,c), dug up between the *Tulcea* and *Chilia Branches*, for economical reasons.

The *sedimentary environments* from the both lakes before digging the *Canal* "*Mila 36*" (*i.e*. before 1982-1983) and afterwards were characterised by means of **MS** measurements made on bottom sediments, and consequently differentiated. In the latter case, the *sedimentary environments* were modified as a reply to the intervention of the anthropogenic activities inside the deltaic ecosystems. The "*magnetic susceptibility fingerprint*" identified in the bottom sediments sampled from the *Lungu L*. and *Meşteru L*., in 1980, is defined by **k** values placed totally and up to 92%, respectively, within the classes **II** and **III** of the **MS** scale (Fig. 14a$_4$,b$_4$).

According to the environmental changes in the area caused by the digging of the "*Mila 36*" *C*., resulting in a modification of the ecohydrological context as well, the **MS** fingerprint suffered an essential transformation. In the *sedimentary environments* of the two lakes, which became "*dynamic*" due to the intense Danubian supplies, in the bottom sediments sampled in 1987 and in different phases in the time period 1992-1997, an enhanced **MS** fingerprint was deciphered, which is defined by **k** values belonging to the *classes* **IV** and **V** of the **MS** scale from Fig. 6 (also, Fig. 14c$_3$).

The third lake under **MS** monitoring, *i.e*. the *Tătaru L*. (Fig. 12b,c), has not undergone important changes after the severe modification of the ecohydrological conditions in the area; its spatial position (relating to the *Lungu L*. and the *Draghilea Chn*.; Fig. 12b,c) made possible a double protection against the direct Danubian supplies. The magnetic signatures identified in the *Tătaru L*. sediments in 1980, 1993-1997 and 2006 keep the same characteristics; they are calibrated to **k** classes **II** and **III** [100%; Fig. 14c$_4$,c$_2$, c$_1$; see also the **k** map related to the first cruise-1980 (Fig. 13a)]. However, a transfer of the class **III** percentage weight towards the class **II** is noticed, which could reflect a slight increase of the organic matter content within the sediments during 26 years. This is the case of an "intermediary" type aquatic environment.

The ternary diagram from Fig. 15, showing the lithological classification of the sediments sampled in the *Lungu* and *Tătaru Lakes* in 2006, points out the distinguishing features recorded for the two lakes due to their different positions related to the fluvial supplies. The differences existent with regard to the lithological composition are clearly reflected by the enviromagnetic parameter (**MS**).

We finish the presentation of this case study on the ecohydrological applications of the environmental magnetism tool with a pattern showing the synoptic images of the

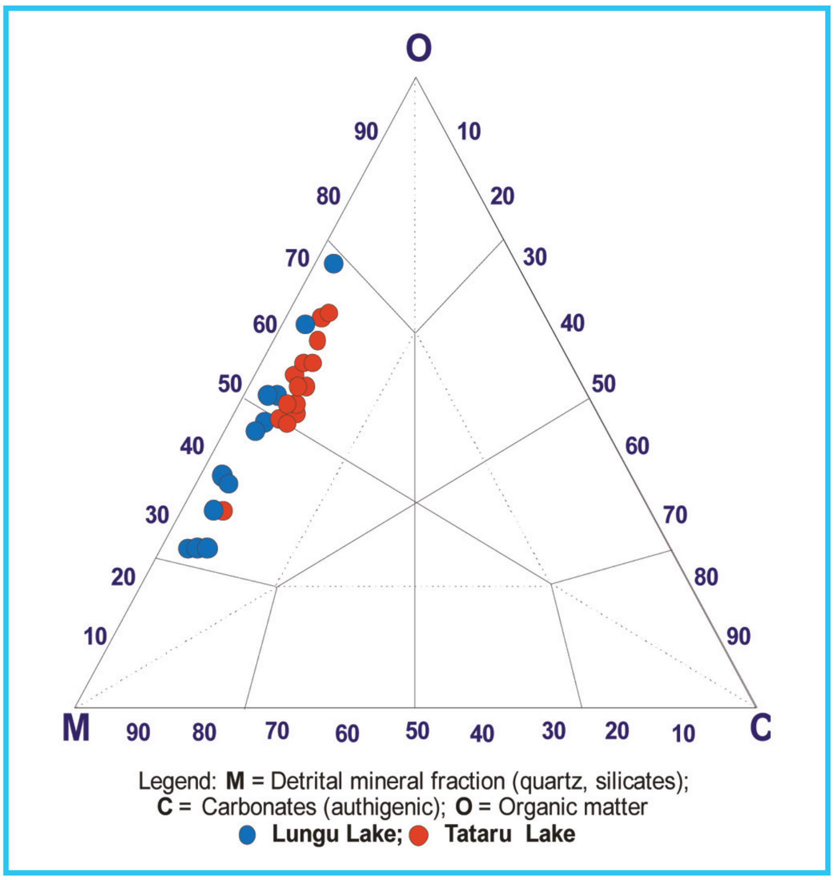


Fig. 15 Lithology of recent sediments sampled in 2006 from the Tătaru and Lungu lakes, with and without protection, respectively, related to the *Canal* "*Mila 36*", which changed the ecohydrological conditions within the aquatic environments in the Western Meşteru – Fortuna Depression.

MS fingerprints identified within the lake sediments of the Western Meşteru – Fortuna Depression for 3 intervals: 1980 (Fig. 16a) – before the intervention of the human activities on the aquatic ecosystems; afterwards, between 1987-1997 (Fig. 16b), and in 2006 (Fig. 16c), respectively. The **k** maps are based on the average **MS** values calculated for all the samples measured for each lake, and are coloured according to **k** scale from Fig. 6.

After the *“Mila 36” C.* was dug up, the intensities of the **MS** fingerprints were modified, showing *dynamic sedimentary environments*, directly controlled by the riverine supplies. In the *Lungu* and *Meşteru* lake sediments, the intensity is increasing by two **k** classes (from **III** to $\mathbf{V_a}$, and from **II** to **IV**, respectively; Fig. 16a,b), while in the *Tătaru Lake* it keeps the same (calibrated to class **III**; Fig. 16a,b,c) (some explanations were previously presented).

Another ecohydrological application of the enviromagnetic tool regards one of the Danube Delta Branches.

3.2.2. Modifications of the ecohydrological regime within the fluvial-deltaic aquatic environments: cutting-off the meanders of the Sf. Gheorghe Danube distributary; sedimentogenetic and enviromagnetic consequences

The Sf. Gheorghe Branch (**5**, in Fig. 1), characterised by a very sinuous, meander belt water flow, suffered important modifications. The human intervention by cutting-off 6 loops in order to improve the navigation conditions, the distance between Tulcea and Sf. Gheorghe localities being shortened from 108 km to 70 km, resulted in the discharge growth, by increasing the slope. The intervention on the hydrological regime, followed up by the changes of the environmental conditions in the aquatic ecosystems, influences also the sedimentary environments by lithological, mineralogical and geochemical modifications. More details regarding the dynamic morphology and the hydrosedimentary behaviour of this important delta meandering distributary could be found in a recently published book (Tiron, 2010); the role of the meander cut-offs canals and their effects on the sediment fluxes are particularly analysed.

In this context, it is very interesting and useful to test and evaluate the capability of the magnetic susceptibility technique as an enviromagnetic tool to be used for ecohydrological applications. This study is based on the data provided by two cruises organised in some sectors of the “free meandering segment” (km 90 – km 22). The two sampling campaigns were carried out in different environmental conditions: the first one – during a period with an extremely low-water level of the *Danube River* at the end of summer – beginning of autumn 2003, and the second one – during the high-water level in the spring 2004.

The first investigated fluvial-deltaic profile includes the most important meander of the *Sf. Gheorghe Branch* (**A**, in Fig. 17; between the former km 85 – km 65). Another sector which was investigated is located downstream, between km 38 – km 29 (**B**, in Fig.17). The sediments from the latter zone were sampled during the first cruise only (in 2003). The meander cutting intervention resulted in decreasing the water and sediment circulation on the loops, leading to some silting up processes, which mainly occur at the upstream meander ends. The cut-off meanders are going to become “oxbow” type lakes (similar to the *Erenciuc* and *Belciug lakes* from the *Danube Delta*).

The Danube bottom sediments are usually coarser, being represented by sands, deposited in fluvial conditions. The lithological analysis of the sediments from the meanders of the *Sf. Gheorghe Branch* emphasises a series of modifications of the general pattern, which clearly reflect the human impact on the river watercourse. Thus, on the first meander, the sediments sampled at the km 85 (Fig. 17: **A**), upstream of the cut (*DD03-93 – DD03-95*), consist in sands, which is a normal situation for the principal watercourse of the *Danube*. The

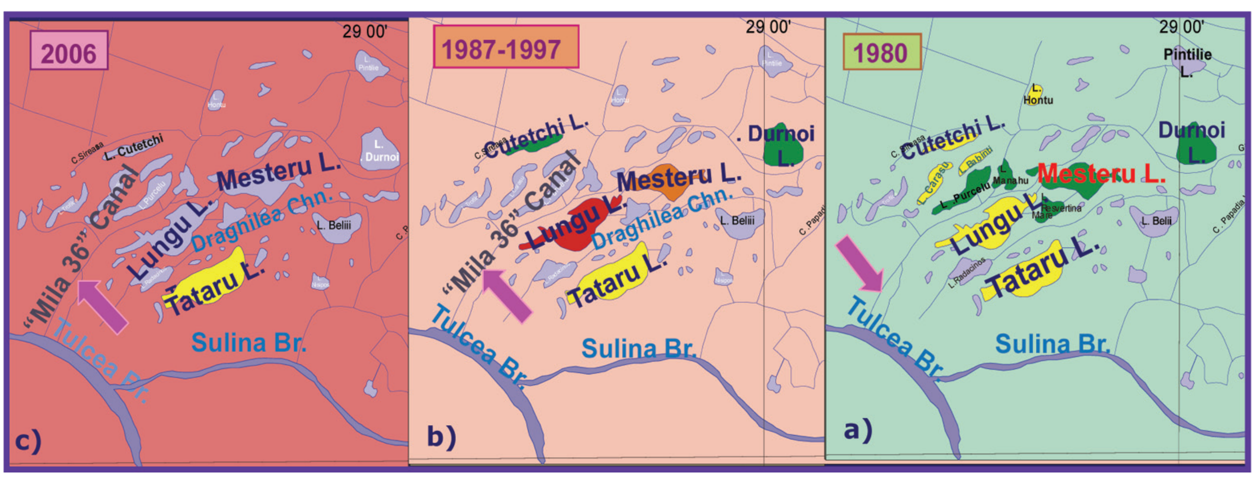


Fig. 16 Synoptic maps with the intensities of the magnetic susceptibility fingerprints (calibrated to the **k** scale from Fig. 6) identified in the lake sediments sampled in the Western Meşteru – Fortuna Depression, in two periods with different ecohydrological conditions in the area (see the text).

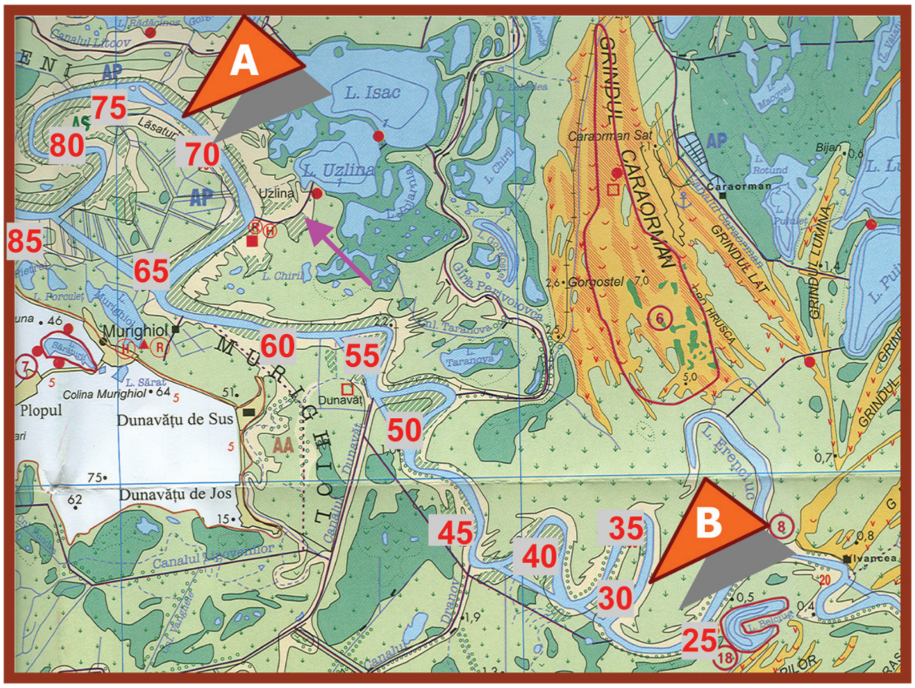


Fig. 17 Meanders of the Sf. Gheorghe Danube distributary. **A** - main meander: km 85 – km 65; **B** – second meander investigated: km 38 – km 29 (fragment from the "Danube Delta touristic map"; Gâştescu, 2004).

associated fauna is represented by living specimen or shells of *Dreissena, Corbicula, Cepaea, Theodoxus, Hydrobia*. Downstream, at the middle of the canal which shortens the meander (sample *DD03-96*), the erosion process is stronger than the deposition one, so that at the bottom appear only the old compacted clayey-siltic deposits, in which the waters continue to dig up, deepening the canal. Even downstream, at the km 64, immediately after the canal end (samples *DD03-97 – DD03-99*), the sediments are quite heterogeneous, reflecting both the material washed from the canal basement (fragments and pebbles of compacted clay) and the normal fluviatile sediment (*i.e.* sand), transported from upstream of cut. As regards the left bank, the sediments are associated with a muddy matrix. The fauna is reduced, dominated by *Dreissena,* at which scarce *Cepaea* şi *Planorbis* specimens are added.

The magnetic susceptibility corespondingly reflects the lithological observations above specified. Thus, the **k** values measured for the *DD03-93 – DD03-95* samples (sands) are the highest among the 16 samples which were measured in the stations placed on the main meander, being calibrated to the **k** classes $\mathbf{V_d}$, $\mathbf{V_c}$ and $\mathbf{V_a}$ (see the **k** scale in Fig. 6). Actually, *DD03-93* and *DD03-95* are the only samples collected from the entire profile (the two meanders) which showed **k** values calibrated to the classes $\mathbf{V_d}$ and $\mathbf{V_c}$: 1761.18×10^{-6} SI, and 760.48×10^{-6} SI, respectively (Table 1).

On the other hand, for the *DD03-96* sample, collected from the clayey-siltic deposits, a smaller **k** value was recorded, assigned to class **IV** (201.55×10^{-6} SI; Table 1). If we analyse the composition of the cut meander sediments, upstream downstream, we observe a clear trend towards a finner grain size, according to decreasing of the transport agent power. The upstream sediments, even they are already muds, have an important sandy component (*DD03-92 – DD03-88*). An exception is the sample *DD03-91*, collected at km 63, where a non-deposition zone appears, with a basement consisting of clay in the right bank which is exposed to the erosion. The mentioned sample is characterised by a magnetic susceptibility assigned to class **III**, namely 142.18×10^{-6} SI (Table 1).

Downstream, the dominant sediments are the organic mineral muds (*DD03-87 – DD03-84*), gray-blackish, with bioturbations, similar to those from some lakes inside the delta. The fauna gets lacustrine trends as well, by the abundance of the *Unio*, *Anodonta* and *Viviparus* specimens, next to the previously mentioned genera relating to the branch.

The magnetic susceptibility reflects well the trend of sediments to pass towards a finner grain size, upstream downstream. Even the **MS** is defined within the class $\mathbf{V_a}$ only, the samples *DD03-92 – DD03-88* (excepted *DD03-91*, above explained), which were collected upstream, are characterised by higher **k** values (*i.e.* 286.15×10^{-6} – 415.61×10^{-6} SI, with the average value $\mathbf{k_m}$ = 360.71×10^{-6} SI) than the samples that were taken downstream (*i.e. DD03-87 – DD03-84*), for which the **MS** interval is 278.18×10^{-6} – 336.33×10^{-6}, with $\mathbf{k_m}$ = 296.05×10^{-6} SI (Table 1).

The study carried out in the main meander area in the second phase, in 2004, showed again that the measured **k**

Table 1. Values of the magnetic susceptibility (**k**), correlated to the **k** scale classes, for bottom sediments sampled from two cut meanders (**A** and **B**, in Fig. 17) of the Sf. Gheorghe Branch, during the 2003 cruise.

Location (km)	Sample	Magnetic susceptibility k [× 10^{-6} SI]	k Scale
Sf. Gheorghe Branch (meanders)			
km 29	DD 03-100	206.04	IV
≈ km 30	DD 03-101	369.93	Va
≈ km 34	DD 03-102	302.86	Va
≈ km 37	DD 03-103	350.17	Va
km 38.1	DD 03-104	196.97	IV
km 64 (immediately after the canal end ; see Fig. 17)	DD 03-97	408.13	Va
	DD 03-98	338.54	Va
	DD 03-99	324.96	Va
km 65 (Sf. Gheorghe Branch)	DD 03-84	285.43	Va
	DD 03-85	278.18	Va
	DD 03-86	284.24	Va
≈ km 70	DD 03-87	336.33	Va
km 75	DD 03-88	415.61	Va
	DD 03-89	370.08	Va
	DD 03-90	286.15	Va
≈ km 81	DD 03-91	142.18	III
	DD 03-92	370.98	Va
≈ km 85 (Sf. Gheorghe Branch)	DD 03-93	1761.18	Vd
	DD 03-94	542.81	Va
	DD 03-95	760.48	Vc
½ cut (middle of the canal ; between km 85 and km 65)	DD 03-96	201.55	IV

Table 2. Values of the magnetic susceptibility (**k**), correlated to the **k** scale classes, for bottom sediments sampled from the main meander cut-off of the Sf. Gheorghe Branch, during the 2004 cruise.

Location (km)	Sample	Magnetic susceptibility k [× 10^{-6} SI]	k Scale
Sf. Gheorghe Branch (main meander)			
km 66+700	DD 04-12a	237.08	IV
	DD 04-13a	246.52	IV
	DD 04-13b	279.39	Va
	DD 04-14a	243.64	IV
	DD 04-14b	245.39	IV
km 70	DD 04-15	253.14	IV
	DD 04-16	327.64	Va
	DD 04-17a	303.89	Va
km 75	DD 04-18a	382.14	Va
	DD 04-18b	361.64	Va
	DD 04-19a	360.64	Va
	DD 04-19b	433.64	Va
	DD 04-20a	388.89	Va
	DD 04-20b	438.89	Va
km 78+900	DD 04-21a	343.89	Va
	DD 04-21b	157.27	III
	DD 04-22	406.89	Va
	DD 04-23a	379.14	Va
	DD 04-23b	355.39	Va
km 85 (Sf. Gheorghe Br.)	DD 04-24	129.64	III
	DD 04-25	865.64	Vc
	DD 04-26	339.52	Va

values are within the normal limits for the Danubian sediments (generally, higher than 200×10^{-6} SI) and does not record spectacular variations (Table 2). The downstream sediments are situated within the class **IV** of the **k** scale from Fig. 6 (with an exception, a value assigned to class $\mathbf{V_a}$, but very close to the higher limit of the class **IV**). The sediments from the median sector and from the upstream zone are grouped within the classes $\mathbf{V_a}$ and $\mathbf{V_c}$ (with two exceptions in class **III**). It is clearly observed an increasing trend of the magnetic susceptibility values (Table 2) from downstream (*DD04-12*; **k** = 237.08×10^{-6} SI) upstream (*DD04-025*, with **k** = 865.64×10^{-6} SI; *DD04-026*, with **k** = 339.52×10^{-6} SI), according to the increase of the sediment grain size (with some exceptions, easily to be explained).

Thus, the samples *DD04-21b* (**k** = 157.27×10^{-6} SI; Table 2) and *DD04-24* (**k** = 129.64×10^{-6} SI) show lower **MS** values within a zone defined by high susceptibilities. The first sample is a finner mud (sediment layer ″b″), representing an older mud, which was previously deposited relating to the sand from the sediment layer ″a″ (probably, during a period characterised by low waters and powerless water-courses). The second sample (*i.e*. *DD04-24*) is a more special sediment, namely fluffy clay pebbles, deposited in a zone with strong water flow, where the sand was washed. Instead, the highest **k** value which was recorded for the sample *DD04-13b* (**k** = 279.39×10^{-6} SI; Table 2), and also the quite high level of the susceptibilities measured on all the samples collected downstream could indicate a pollution trend within the sediments from the meander downstream, in the sector where the fine sediments are accumulated. As this zone is the most exposed to the anthropogenic pressure, taking into consideration the close touristic facilities and the associated intensive traffic, a contamination of the sediments, which is reflected by the high values of the magnetic susceptibility, is not excluded.

This situation was remarked in the previous cruise, as well (in 2003), so that the use of other analysis techniques, *e.g*. for heavy metals, is recommended in order to confirm the metalic pollution trends of the fine sediments from the meander sector situated between the mouth of the *Uzlina Channel* (shown by a purple arrow, in Fig. 17) and the km 64.

As regards the second meander, which was investigated in 2003 only (**B**, in Fig. 17; samples *DD03* -100 – *DD03-104*, in Table 1), there can be noticed the same trends of passing from coarser sediments, *i.e*. muddy sands and sandy muds (samples *DD03-102 – DD03-104*) towards finner sediments, *i.e*. siltic muds (*DD03-101*). The fauna is poorly represented. Here, also, at the downstream end of the cut, on the branch, it appears a sector with a strong erosion, with a basement consisting of clay (*DD03-100*); this sample records a lower value of the magnetic susceptibility (**k** = 206.04×10^{-6} SI), assigned to class **IV** (Table 1).

The magnetic susceptibility data which were obtained on the fluvial-deltaic profiles carried out in two sectors of the ″free meandering segment″ along the *Sf. Gheorghe Branch*, namely between km 85 – km 65 and km 38 – km 29 (Fig. 17), where the meanders were cut-off, can be also analysed by means of the patterns from Fig. 18. To the pie-diagram with the **MS** data associated with the two meanders (Fig. 18b; see also Tables 1 and 2), two synoptical pie-diagrams are added (Fig. 18a,c): the first (Fig. 18a) is based on the **k** values measured for the bottom sediments sampled during 15 phases of the geoecological monitoring carried out between 1992 – 1998, 2003 and 2004-campaigns I and II; the second (Fig. 18c) is based on the same data as previously mentioned to which the **k** values measured on the sediments sampled from the two meanders in 2003 and 2004 (2003-M and 2004-M, in Fig. 18c) were added.

The **k** values are predominantly situated within the higher classes **V** and **IV** in all the studied cases. Thus, with regard to the sediments sampled from the two meanders (**A**, **B**, in Fig. 17), in 2003 and 2004, the **k** classes $\mathbf{V_d}$, $\mathbf{V_c}$, $\mathbf{V_a}$ and **IV** are defined by 94% of the **MS** values, the remaining 6% being the susceptibilities assigned to class **III** (Fig. 18b). We remark that no monitoring sampling station was located within the former km 85 – km 65 and km 38 – km 29. In the pie-diagram from Fig. 18a, it can be noticed that 83% of the magnetic susceptibilities are assigned to class **V** (all the 4 sub-classes $\mathbf{V_a}$, $\mathbf{V_b}$, $\mathbf{V_c}$ and $\mathbf{V_d}$; see the **k** scale in Fig. 6); the remaining are correlated to class **IV** (14%) and **III** (3%). In the pie-diagram from Fig. 18c, 79% of samples show susceptibilities assigned to class **V** (all the 4 sub-classes), 17% – to class **IV** and 4% – to class **III**. It is noticed a slight decreasing of the weight of the **k** values situated within the class **V**, and correspondingly, a transfer of 3% towards the class **IV** and 1% towards the class **III**. Therefore, the decreasing trend of the weight of the subclasses $\mathbf{V_a}$, $\mathbf{V_b}$, $\mathbf{V_c}$, $\mathbf{V_d}$ and the increasing trend of the percentages associated with the classes **IV** and **III** – aspect which was above argued – are in agreement with the hydrosedimentary processes taking place on the cut meander streams.

Finally, in the synoptic model from Fig. 19, the much higher intensities determined for the magnetic fingerprints of the fluvial-deltaic environments of the *Danube Branches* (*i.e*. *Chilia*, *Tulcea*, *Sulina*, *Sf. Gheorghe distributaries*), as compared with those detected in the lake sediments (*e.g*. Fig. 8, Fig. 14; also, Rădan & Rădan, 2009), are remarked. The most samples, collected from the bottom sediments of the *Danube Delta distributaries*, during two time intervals (1992 – 1998 and 2003/2004 – 2007), recorded magnetic susceptibilities assigned to the highest classes ($\mathbf{V_a}$, $\mathbf{V_b}$, $\mathbf{V_c}$, $\mathbf{V_d}$), namely 84% – *Chilia Branch*, 75% – *Tulcea Br*., 54% – *Sulina Br*., 83% – *Sf. Gheorghe Branch*. No **MS** values were assigned to the lower classes **I** and **II** (Fig. 19), which is a normal situation, taking into consideration that the sediments of the *Danube Delta Branches* consist of sands, primarily, with a variable grain size. Hence, the capability of the commented enviromagnetic tool to differentiate lacustrine-deltaic and fluvial-deltaic sedimentary environments is easily inferred. Besides, in the synoptic model (Fig. 19-B), the influence of cutting-off a branch meander (of the *Sf. Gheorghe distributary*; Fig. 17 and Fig. 19 –

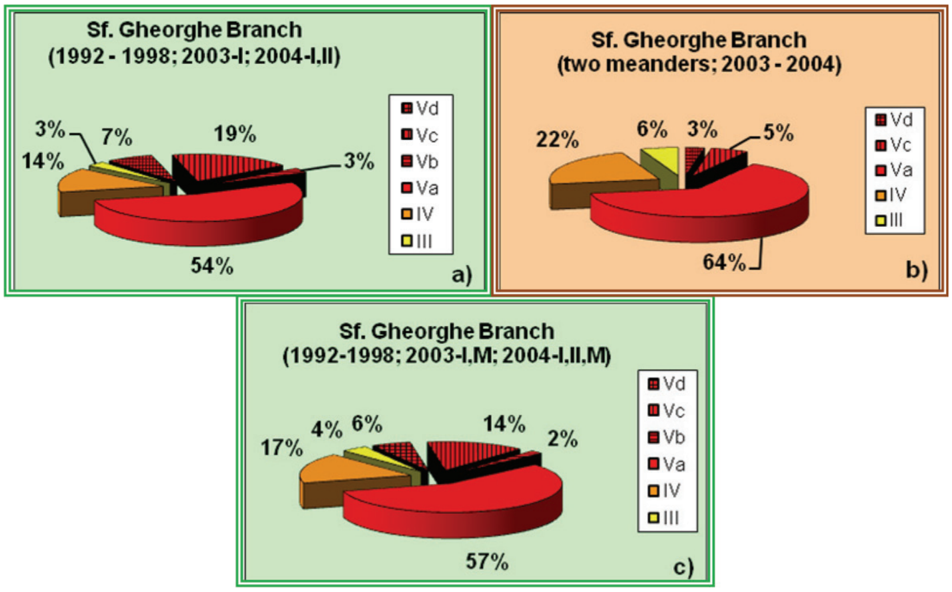


Fig. 18 Pie-diagrams showing the percentage distribution of the magnetic susceptibility values (**k**) for bottom sediments of the Sf. Gheorghe Branch, related to 3 cases: **a)** samples collected from stations located along the entire Danube distributary [geoecological monitoring (1992 -1998), 2003 and 2004 cruises]; **b)** samples collected from two meanders (**A** and **B**, in Fig. 17), in 2003 and 2004; **c)** samples collected from stations located along the entire Danube distributary (1992 - 2004, data for meanders included).

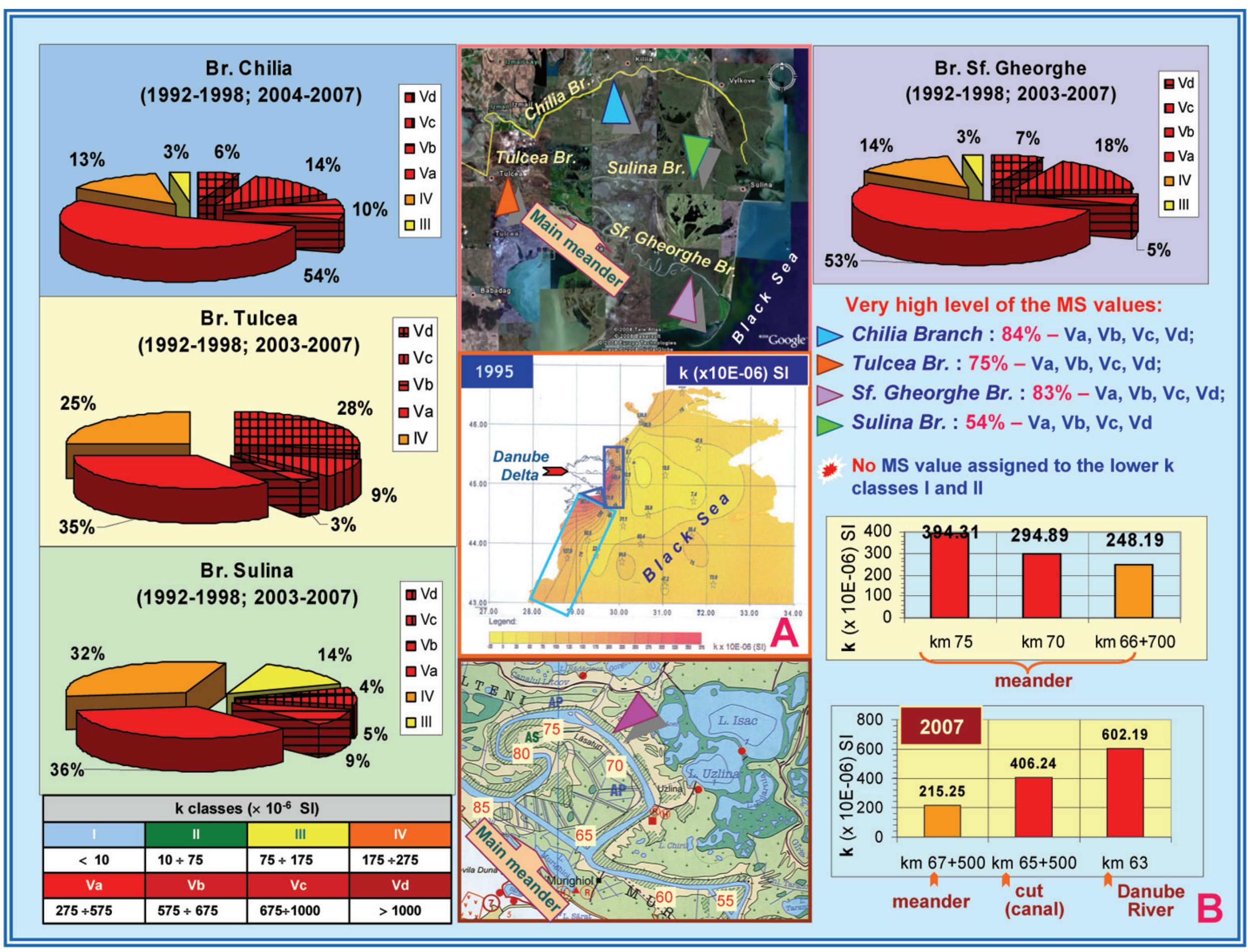


Fig. 19 A synoptic model showing the magnetic susceptibility (**MS**) characterisation of the bottom sediments of the Danube Delta distributaries and an ecohydrological application of the enviromagnetic tool related to the Sf. Gheorghe Branch meanders case.

middle-up and middle-down) on the **MS** signatures is shown (**B**, down-right corner). The magnetic susceptibility values were obtained on a sediment collection sampled in the 2007 cruise; these results must be added to the previously presented data pertaining to the 2003 and 2004 cruises as proofs of the abilities of the enviromagnetic tool for ecohydrological applications.

In conclusion, by silting up processes, which mainly occur at the upstream and downstream meander ends, these zones are going to become ″oxbow″-type lakes. The decreasing trend of the sediment grain size, upstream downstream, wich is consistent with the transport force decrease, could result in decreasing of the magnetic susceptibility percentages assigned to the higher **k** classes ($\mathbf{V_a}$ – $\mathbf{V_d}$), which characterise the coarser sediments (*i.e.* sands), and in increasing of the percentages of the **k** classes **III** and **IV**, to which the finer sediments (*e.g*. mineral muds, clayey muds, coarse siltic muds) are calibrated. Discussing in an ecohydrological context, it can be mentioned that as opposed to the cruise from the autumn 2003, when the low waters were also associated with a lower speed of the Danube watercourse, during the spring 2004 cruise there were high waters, the water flow speed was higher, and generaly, the deposited superficial sediments were coarser. The decreasing trend of the grain size of the sediments upstream downstream remains very pronounced, and the evolution of the modified distributary towards an ″oxbow″-type lake is imminent.

In addition to these data, in the synoptic model from Fig. 19, the influence of the *Danube River* discharge in the *Northwestern Black Se*a is shown by the maximum **k** anomalies (marked by two blue rectangles; Fig. 19-A). As regards the *Black Sea Littoral Zone*, particularly concerning the lakes located in that area, some integrated enviromagnetic and lithological data pertaining to the most representative of them were presented in the Chapter 3.1.3.

4. CONCLUSIONS

The magnetic susceptibility (**MS**) results which were presented – independently or integrated with lithological data – with regard to the bottom sediments sampled from some representative lakes and a delta meandering distributary, located in three important southeastern Romania wetlands (*i.e*. *Danube Delta*, *Razelm – Sinoie Lagoonal Complex* and the *Black Sea Littoral Zone*), demonstrate the capability of the petromagnetic parameter (**k**; **MS**) to decipher sedimentogenetic, environmental and geoecological contexts. Moreover, the composite models, shortly commented in the paper, argue that the magnetic susceptibility is a sensitive proxy parameter for characterising the lithology of the sedimentary environments from deltaic, lagoonal and littoral wetlands. For example, related to the deltaic lakes, the models emphasise the specific enviromagnetic fingerprints that characterise the allochthonous and autochthonous sedimentation, respectively. As regards the lagoonal and the littoral lakes, the coincidence between the sedimentary areas characterised by higher **MS** values and those defined as dominantly siliciclastic or by low **MS** intensity fingerprints and those rich in organic matter, respectively, is well reflected by corresponding anomalies of maximum and minimum values of the various parameters pertaining to the specific (**k**, **SIL**, **TOM**) maps; the previous results are confirmed (*e.g*. Rădan & Rădan, 2007; Rădan & Rădan, 2007d, in Rădan, 2008; Rădan *et al.,* 2008).

By measuring the magnetic susceptibility in laboratory, well-defined **MS** fingerprints can be recovered from the recent sediments. They are associated with different lithological characteristics, making possible some connections with the distinct positions of the lakes related to the fluvial supplies, the hydrodynamic context or specific source-areas. Therewith, the (**k**) magnetic signatures detected within the lake sediments sampled at different time intervals – during more than 3 decades – can be reliable proofs for the evaluation of the changes that were produced within the aquatic ecosystems as a result of the impact of the human activities in the area.

Besides, the two particulary cases regarding the effects of the human intervention on the deltaic and fluvial-deltaic ecosystems (Danube Delta), which were analysed in the paper, show that the modifications of the hydrological regime induce changes of the sedimentary environments, and consequently, modifications of the magnetic susceptibility signatures. Therefore, the case of digging a new canal (*i.e*. *Cn.* ″*Mila 36*″) between the *Tulcea* and *Chilia Branches*, in the western zone of the *Meşteru – Fortuna Depression*, and the case of cutting-off the meanders of the *Sf. Gheorghe Danube distributary* prove the capability for ecohydrological applications of the enviromagnetic tool, which is based on magnetic susceptibility measurements on bottom sediments. As concerns the first case, the *Lungu* and *Meşteru Lakes* are the most affected, the high sedimentation rate leading to a rapid filling-up with sediments, particularly in their northern and western sector, respectively. With regard to the latter case, some hydrobiological consequences were shown by comparing the fauna identified in the upstream sectors of the cut-off meanders of the *Sf. Gheorghe Danube distributary* with the fauna detected in the downstream zones, which get lacustrine trends (they are going to become "oxbow"-type lakes).

The data presented in the paper for the modern sediments sampled from deltaic, lagoonal and littoral lakes, some of them representing parts of ″case-studies″ or ″history cases″, contribute to the development of the enviromagnetic archives recovered from ones of the most important wetlands of Romania.

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