A MAGNETIC SUSCEPTIBILITY SCALE FOR LAKE SEDIMENTS; INFERENCES FROM THE DANUBE DELTA AND THE RAZIM – SINOIE LAGOONAL COMPLEX (ROMANIA)

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Abstract: The magnetic susceptibility (MS) research carried out in Romania, since 1977, on thousands of bottom sediment samples collected from various environments of the Danube River – Danube Delta – Black Sea geosystem, have demonstrated that the MS (k) values mainly reflect the lithological variations of the deposits. On the other hand, the results have shown that the k values can reveal the metallic contamination levels in the finer sediments; the most important of these are clearly evidenced by high magnetic susceptibilities. Taking into consideration the noticeable connections between the MS values and the lithological characteristics of the bottom sediment samples, a data sorting based on several susceptibility classes was quite feasible. It must be emphasized that for the Danube Delta and the Razim – Sinoie Lagoonal Complex (RSLC) area, more than 2000 k values have been measured and analysed. Five MS (k) categories related to certain lithological types of bottom sediments have been identified, the last one (Vth class) being subdivided into 4 sub-classes: Va, Vb, Vc and Vd. They subsequently became "magnetic susceptibility classes". The version in use of the scale extends between k values lower than $10x10^{-6}$ SI u. (negative values included) and k values higher than $1000x10^{-6}$ SI u. The lower classes (*i.e.* I and II) correspond to the fine sediments, usually rich in organic material and/or carbonates, the intermediate class III is characteristic for the fine clayey up to silty sediments, and the higher classes (*i.e.* IV and V) are commonly recorded for the coarser silts and sands. A series of examples are given in the paper, where the patterns integrate – through the MS classes – all the k values that have been used for the MS characterisation of the bottom sediments in the Danube Delta, its main branches, as well as in the RSLC. A comparative analysis of the percentage weight distribution of the MS values that characterise the sedimentary deposits from the deltaic, fluvial-deltaic and the lagoonal aquatic environments is done. The presented cases exemplify the way the elaborated and experimented "k scale" works. The correlation to the Environment Quality Scale is pointed out. To conclude, the Danube Delta lake sediments provided a high resolution enviromagnetic instrument, a Magnetic Susceptibility Scale with a genuine lithological support.

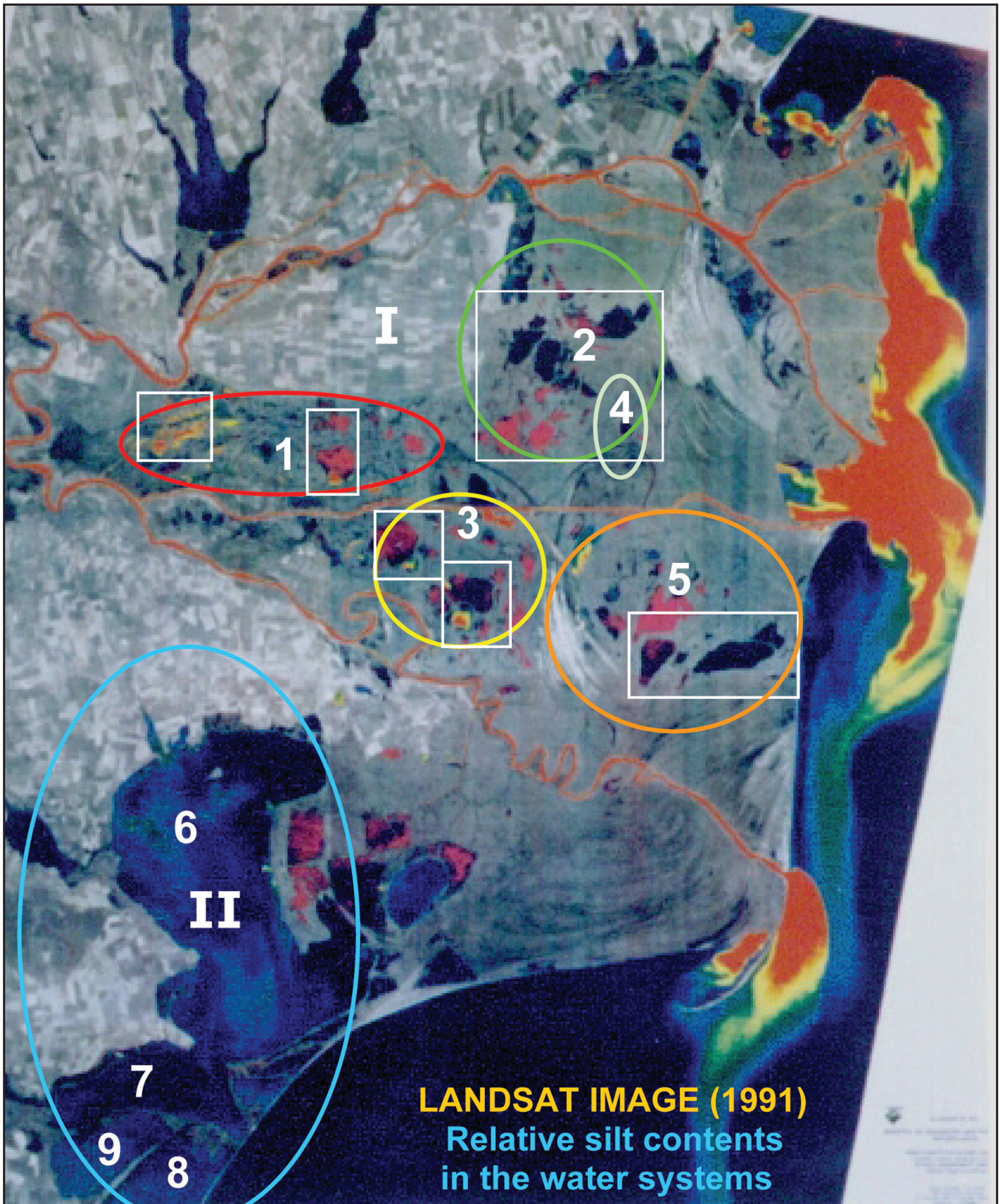
Keywords: magnetic susceptibility scale, lithology, bottom sediment, environmental magnetism, environment quality scale, Danube Delta (Romania)

1. INTRODUCTION. STUDY AREAS

An original Magnetic Susceptibility (**MS**) Scale has been conceived by the authors in order to characterise the sediments and to compare different deltaic-lacustrine environments.

The last version of the scale extends between **k** values lower than $10x10^{-6}$ SI u. (negative values included) and **k** values higher than $1000x10^{-6}$ SI u. The Magnetic Susceptibility Scale (**MSS** or "**k** Scale") was established using more than 2000 sediment samples collected from the Danube Delta and the Razim (Razelm) – Sinoie Lagoonal Complex (RSLC). Consequently, the **MS** scale has a "genuine" lithological support and it is based on thousands of sub-samples collected from the lakes of 5 Danube Delta depressions, from its main branches, as well as from the 4 main lakes of the Razim - Sinoie Lagoonal Complex (Fig. 1; see also Fig.12).

A very large number of **MS** patterns resulted from the huge data bank; most of the models use the **k** classes to which the sediments were calibrated. The long time period (*i.e.* 3 decades) covered by magnetic susceptibility measurements made feasible composite patterns to be performed for the same aquatic area, and equally for different "moments" of



Legend. I. Danube Delta – **a)** Fluvial Delta Plain: **1.** Mesteru - Fortuna Depression; **2.** Matita - Merhei Depression; **3.** Gorgova - Uzlina Depression; **b)** Marine Delta Plain: **4.** Raducu - Raduculet Depression; **5.** Lumina – Rosu Depression; **II.** Razim – Sinoie Lagoonal Complex – **6.** Razim Lake; **7.** Golovita Lake; **8.** Sinoie Lake; **9.** Zmeica Lake.

Characteristic ecosystems of the Danube Delta under magnetic susceptibility monitoring (1992 – 2006)

Fig. 1 Danube Delta and Razim (Razelm) – Sinoie Lagoonal Complex. Location of the study areas the investigation. These patterns were further used to compare the **MS** data obtained on bottom sediments collected in successive phases, from the same zones, within a long interval. Therefore, a "back-monitoring process" was carried out, making possible the detection of some changes within the submerged environments, due to the human activities with negative impact on the deltaic, deltaic-fluvial and lagoonal ecosystems. Based on the **k** scale, the intensity of the enviromagnetic fingerprints of the natural and anthropogenic pressure on Danube Delta ecosystems is evaluated.

The results can be correlated to the data obtained by using the "Sediment Quality Scale", based on the average heavy metal contents (according to *Turekian and Wedepohl*, 1961 and *Naffrechoux*, 1992) and the "Environment Quality Scale" with the normative definitions of the ecological status classification (Fig. 3).

2. MATERIALS AND METHODS. THE MAGNETIC SUSCEPTIBILITY SCALE

The environmental magnetism research carried out in Romania benefits from the **MS** measurements (by KLY Kappabridges) on thousands of bottom sediment samples collected from various environments of the Danube River – Danube Delta – Black Sea geosystem.

The acquired data demonstrated that the **MS** (**k**) values mainly reflect the lithological variations of the deposits. On the other hand, the results showed that the **k** values can reveal the metallic contamination in the finer sediments; the heavy metal contents are clearly evidenced by higher magnetic susceptibilities.

Taking into consideration the noticeable connections between the **MS** values and the lithological characteristics of the bottom sediment samples (which were first completed aboard the ship and which were later confirmed by the granulometric and mineralogical analyses), a data sorting based on several susceptibility classes was possible. It must be emphasised that for the Danube Delta and the RSLC area, more than 2000 **k** values were measured and analysed.

In a first stage, three **MS** (**k**) categories related to certain lithological types of bottom sediments have been identified. They subsequently became "magnetic susceptibility classes". Particularly, the first two "basal classes" were defined by **k** values lower than 10×10^{-6} SI, and between 10×10^{-6} – 75×10^{-6} SI u., respectively; another class ("upper"), generated by elevated **MS** values, has initially been suggested by **k** values higher than 200×10^{-6} – 300×10^{-6} SI u. (*Rădan et al*., 1997b). Subsequently, 5 "magnetic susceptibility classes" have been established (Fig. 2a) in order to perform a better correlation to the existing environment quality classification.

The first application of the "**k** scale" (Fig. 2a) was used to the calibration of the bottom sediments that were investigated in the framework of the geo-ecological monitoring phases carried out in the Danube Delta and the RSLC during 1992–1997.

When the enviromagnetic method was applied to the main Danube Delta Branches, the use of the "**k** scale" from Fig. 2a to calibrating the fluvial-deltaic sedimentary environments, which are defined by sandy deposits with variable grain size, led to the necessity of subdividing the last ("upper") class (**V**; Fig. 2a) into 4 sub-classes: **Va**, **Vb**, **Vc** and **Vd** (Fig. 2b).

a)

MAGNETIC SUSCEPTIBILITY SCALE (MS; k)

k classes	k [SI u.]
V	$> 275\times10^{-6}$
IV	$175\times10^{-6} \div 275\times10^{-6}$
III	$75\times10^{-6} \div 175\times10^{-6}$
II	$10\times10^{-6} \div 75\times10^{-6}$
I	$< 10\times10^{-6}$

b)

MAGNETIC SUSCEPTIBILITY SCALE (MS; k)

k classes	k [SI u.]
Vd	$> 1000\times10^{-6}$
Vc	$675\times10^{-6} \div 1000\times10^{-6}$
Vb	$575\times10^{-6} \div 675\times10^{-6}$
Va	$275\times10^{-6} \div 575\times10^{-6}$
IV	$175\times10^{-6} \div 275\times10^{-6}$
III	$75\times10^{-6} \div 175\times10^{-6}$
II	$10\times10^{-6} \div 75\times10^{-6}$
I	$< 10\times10^{-6}$

Fig. 2 Magnetic Susceptibility Scale (**k** Scale): a) first version; b) version in use

The lower **k** classes (*i.e.* **I** and **II**) correspond to the fine sediments, usually rich in organic material and/or carbonates; the intermediate class **III** is characteristic for the fine clayey up to silty sediments; the higher classes (*i.e.* **IV** and **V**) are commonly recorded for the coarser silts and sands. In the case of a lake protected from the direct Danubian sedimentary influx, the **k** classes **I** and **II** correlate to the "high" and "good" quality categories of the "Scale with the normative definitions of the ecological status classification" ("**EQ** Scale"; Fig. 3); when the lake is under anthropogenic pressure (*e.g.*, a canal is cut in the area, therefore the lake undergoes an intensive process of filling up with sediments), the **k** class **III** corresponds to the "moderate" quality, and the classes **IV** and **V** (*i.e.* **Va**, **Vb**, **Vc**, **Vd**) to the "poor" and "bad" qualities shown by the "**EQ** Scale" (Fig. 3).

Normative Definitions of Ecological Status Classification		
(nearly) totally undisturbed	high	OK
slight alterations	good	
moderate alterations	moderate	Restoration needed
major alterations	poor	
severe alterations	bad	

Fig. 3 Environment Quality Scale (**EQ** Scale)

3. RESULTS AND DISCUSSION. APPLICATIONS OF THE MAGNETIC SUSCEPTIBILITY SCALE

The study is focussed on sediments of standing water bodies – the lakes. With regard to the running waters (i.e. channels, canals and Danube Branches), only the main distributaries of the Danube Delta are taken into consideration in this paper.

In relation to their position to Danubian inputs, some of the delta lakes are to a certain extent protected from the direct Danube influence, others are more or less directly influenced by the riverine supplies. The first category is characterised by relatively stagnant conditions and a reduced water circulation, while the second one is represented by quite dynamic environments, with active change of water and sediment quality. A third intermediate category can be considered as well.

The magnetic susceptibility study of the lake sediments, based on the calibration to the "**MS** (**k**) scale" (Fig. 2b) resulted in recovering different "magnetic fingerprints" for various sedimentary environments. Some examples are further presented.

3.1. Confined deltaic environments

The simplest cases identified are related to more or less stagnant sedimentation environments, protected or located far from the main fluvial influx points, where only insignificant changes have occurred for a long period of time; for instance, the Lakes Baclanesti (Eastern Mesteru – Fortuna Depression; Fig. 1 and Fig. 4a,b1,b2), Matita (Fig. 5a1-a3), Poludionca (Fig. 5b1, b3), Merhei (Fig. 5c1-c3), Babina, Trei Ozere, Bogdaproste (Matita – Merhei Depression; Fig. 1 and Fig. 5b2), Isacova (Gorgova – Uzlina Depression; Fig. 1 and Fig. 7c1-c3), Raducu (Raducu – Raduculet Depression; Fig. 1 and Fig. 6a,b,c,d), Rosu (Fig. 8c1-c3) and Rosulet (Fig. 8d1-d3) (Lumina – Rosu Depression; Fig. 1 and Fig. 8a).

The intensity of the magnetic susceptibility fingerprints is calibrated to the **k** classes **I** and **II**, except for several samples collected from the supply channels' mouths (*e.g.* in the Lakes Matita, Isacova, Rosu). In these lakes, the sediments are characterised by muds with a very loose structure, fluffy, porous, non-cohesive, rich in fine vegetal material; sometimes, they are predominantly carbonatic-organic and contain shell fragments (Fig. 9A,B). As regards the sediments from the supply channels' mouths, they are represented by coarser muds; e.g. in the Rosu L. case, at the input area of the Puiu – Rosu Channel, the small "delta" consisting of coarse muds and sandy deposits provided a magnetic signature with an intensity predominantly assigned to the class **III** of the "**k** scale".

The **MS** characterisation shows that the sedimentary environments in the confined aquatic systems remained totally or nearly undisturbed, or underwent only slight alterations (cf. Fig. 4 – Fig. 8 and the "**EQ** Scale" from Fig. 3).

3.2. Dynamic deltaic environments

The second case is represented by dynamic environments, with active change of water and sediment supply. The lakes are connected by relatively short channels/canals to the main Danube Delta Branches or are placed close to the influx points of the master channels/canals.

For example, the Fortuna (Fig. 4a,c1,c2) and Uzlina Lakes (Fig. 7b1-b3); there is also the case of the Lungu (Fig. 10b1-b3) and Mesteru Lakes (Fig. 10c1-c3), but only after the "Mila 36" Canal (indicated by arrow, in Fig. 11b) was cut (in 1982-1983). The intensity of the **MS** fingerprints is calibrated to the intermediate class (*i.e.* **III**), and mainly to higher **k** classes **IV** and **V** (cf. Fig. 11 for the Fortuna, Lungu and Mesteru Lakes). In these cases, the sediments are represented by mineral muds (Fig.9A), usually with a fluid, oxidised layer at the upper part.

Most representative is the Fortuna Lake, located in the Eastern Mesteru – Fortuna Depression (Fig. 1 and Fig. 11). The significant liquid and solid supply, which is provided by the short connecting canal to the Danube River, has resulted in a small "delta" in the Southern part of the Fortuna L.; this is associated with an underwater discharge area covering almost half of the lake. The magnetic susceptibility map (based on samples collected in 1980) points out the presence and extension of the

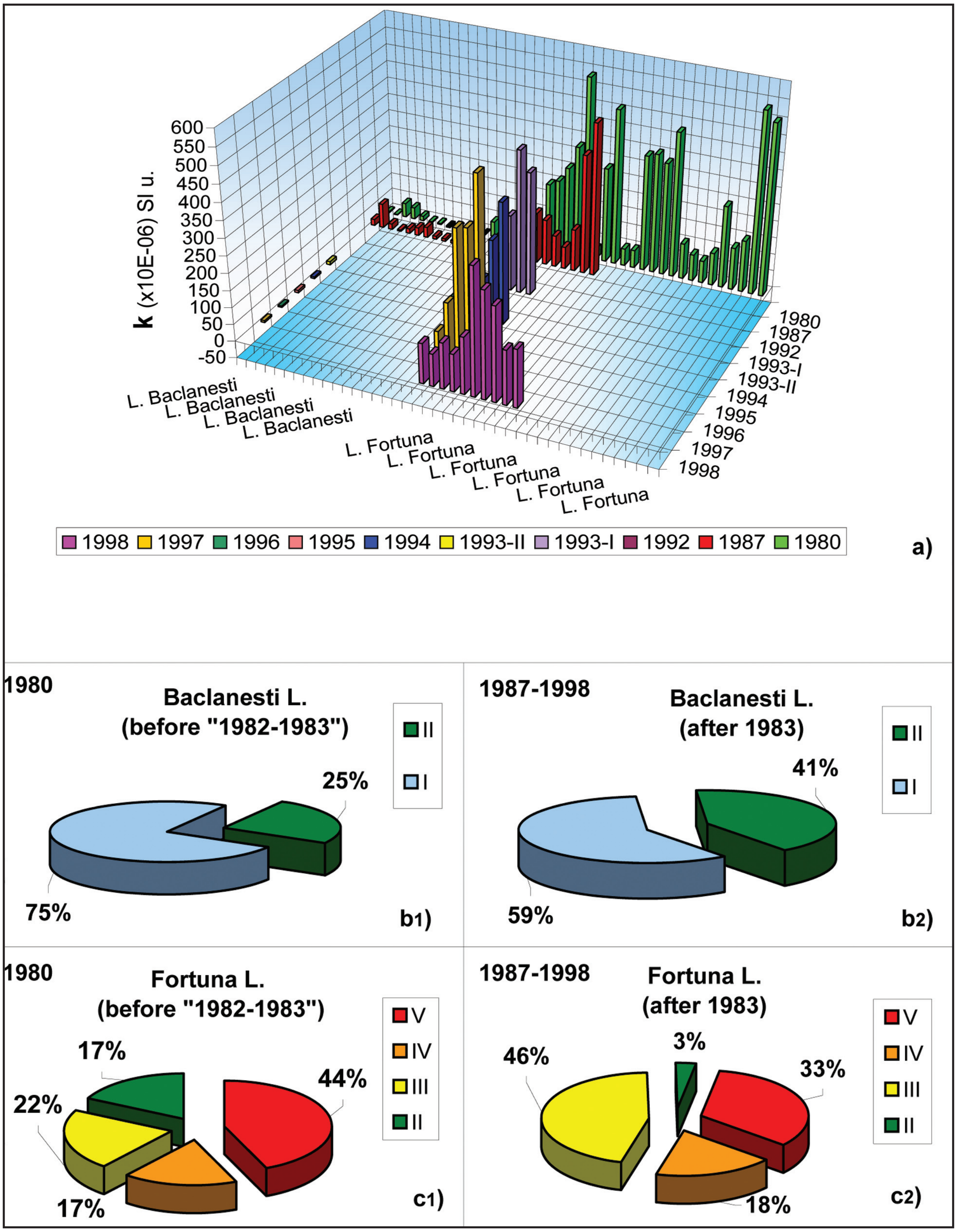


Fig. 4 Magnetic susceptibility (**MS**) of the sediments sampled in two lakes located in different positions as regards the Danubian inputs (Eastern Mesteru – Fortuna Depression). **a)** pattern based on the **MS** values measured on bottom sediments sampled in 10 cruises, during 1980 – 1998; **b1**, **b2)** distribution of the **MS** values correlated to **k** scale for a lake characterised by a confined deltaic environment; **c1**, **c2)** distribution of the MS values correlated to **k** scale for a lake characterised by a dynamic deltaic environment. Note: "1982-1983" – time of the intervention of the anthropogenic activities in the Western Mesteru – Fortuna Depression („Mila 36" Canal)

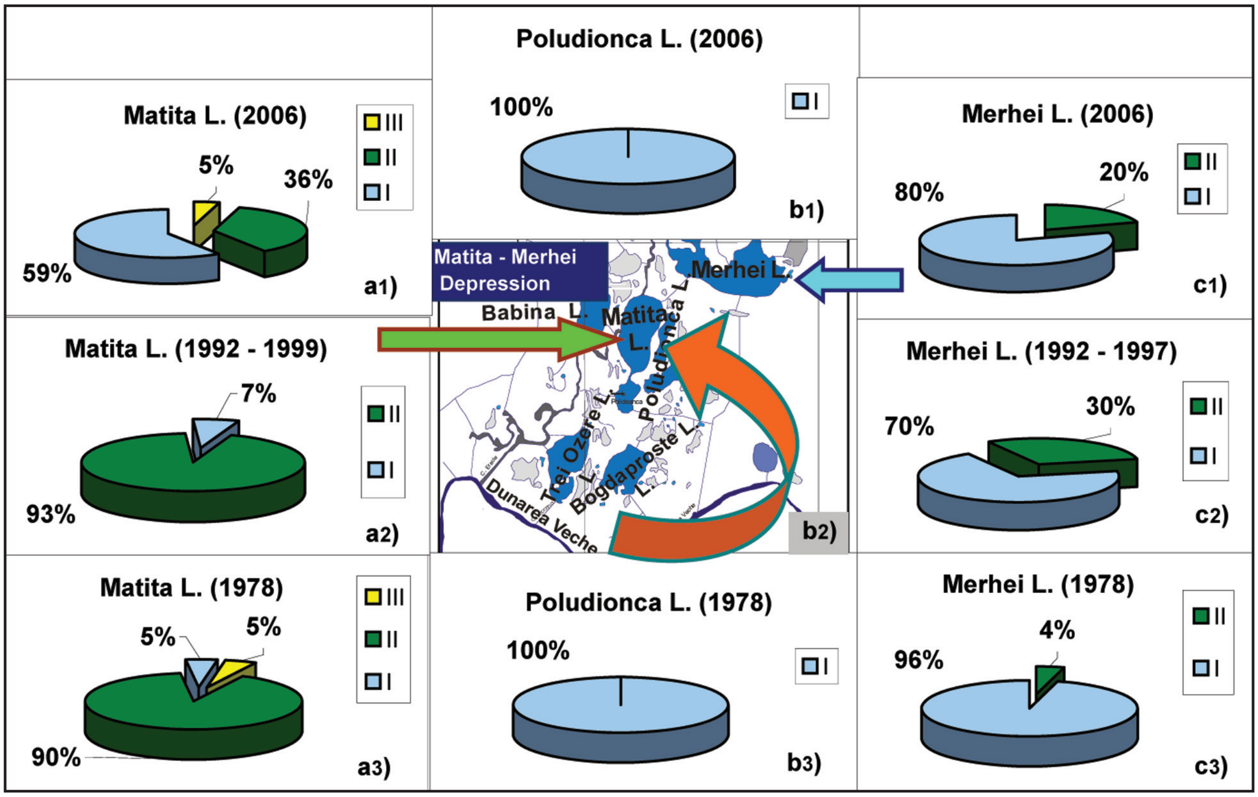


Fig. 5 Distribution of the magnetic susceptibility values correlated to **k** scale for sediments sampled in three lakes (**a1- a3, b1, b3,** and **c1-c3**) located far from the main fluvial inflow mouths (Matita - Merhei Depression – **b2**)

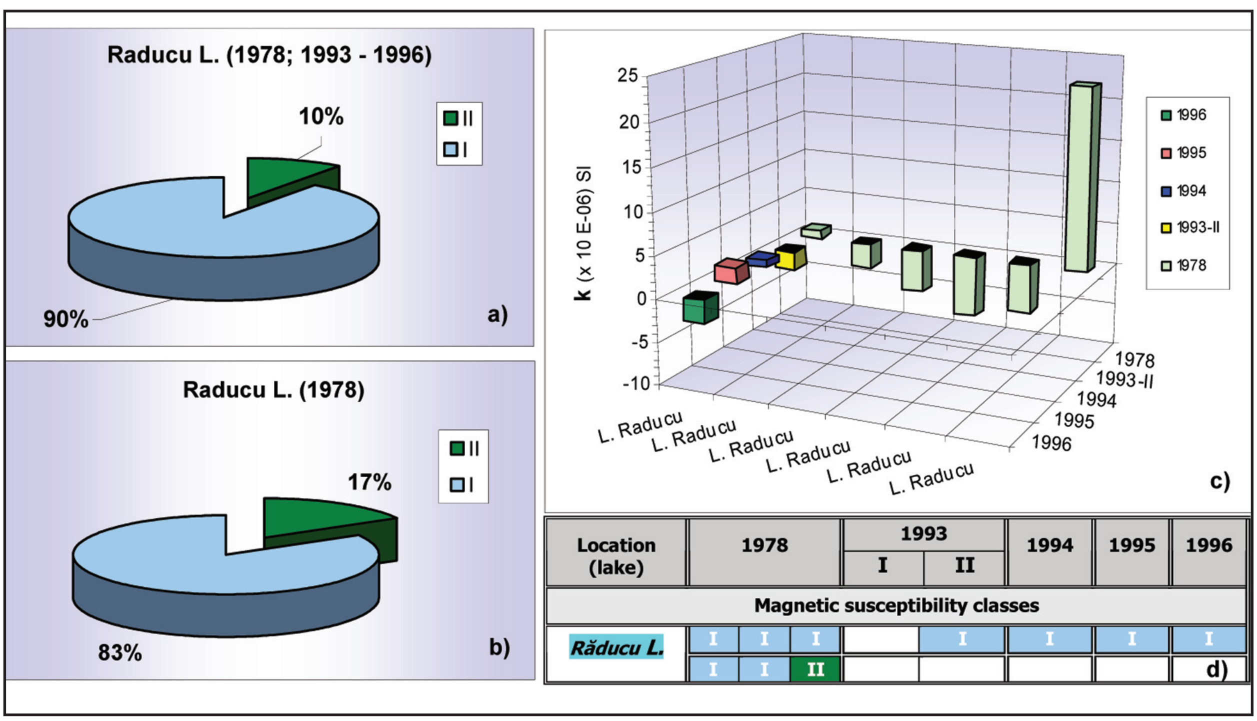


Fig. 6 Magnetic susceptibility of the sediments sampled in a lake protected from the direct Danubian sedimentary influx (Raducu - Raduculet Depression)

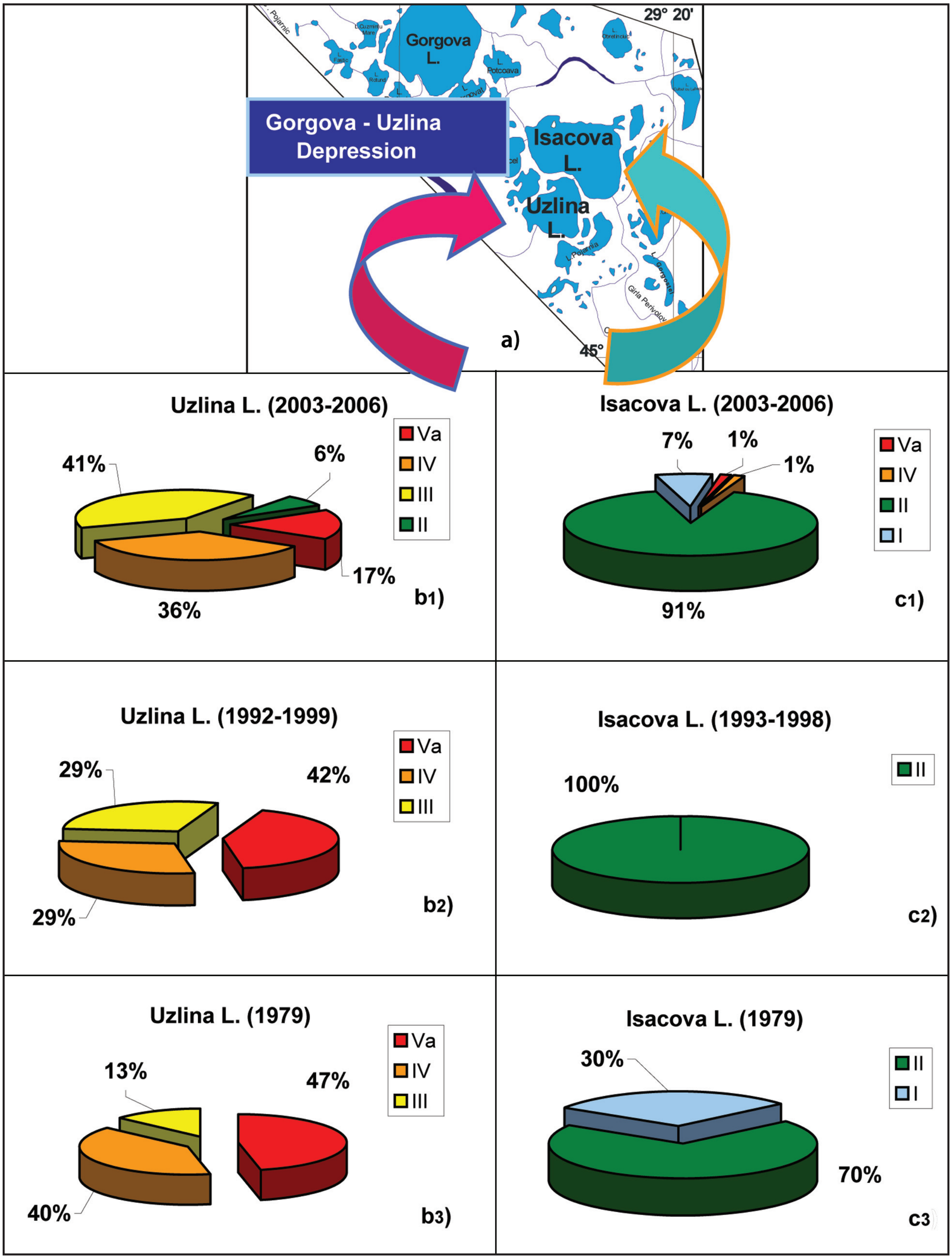


Fig. 7 Magnetic susceptibility characterisation based on the **k** scale for sediments sampled in a "couple of lakes" (Gorgova - Uzlina Depression - **a**). **b1-b3)** Uzlina Lake, connected by a short canal to the Danube River (a lake characterised by a dynamic environment); **c1-c3)** Isacova Lake (a lake characterised by a confined environment), coupled with the Uzlina L. (which works as a buffer interface between the Danube supplies and the Isacova L.)

underwater alluvial fan (*Radan et al.,* 1999); the intermediate (**III**) to high **k** classes (**IV** and **Va**) to which the sediments sampled in 9 subsequent cruises (1987–1998) were predominantly calibrated confirm the first results (Fig. 4 c1,c2).

A special case was analysed in the western part of the Mesteru - Fortuna Depression. The magnetic susceptibility signature identified in the bottom sediments sampled in the Lungu and Mesteru Lakes in 1980 was mainly characterised by **k** values assigned to **MS** classes **II** and **III** (Fig. 10b3 and c3, respectively). Therefore, the initial environments could be included in the intermediate category, like in the Tataru Lake (Fig. 10d1-d3). The latter is located southward of Lungu L. and Draghilea C., which offer a double protection against the direct Danubian supplies the Tataru L. A similar intermediate position has the Puiu Lake in the Lumina – Rosu Depression (*cf.* Fig. 8 a,b1-b3). After the "Mila 36" Canal was dug up in the area (1983), the **MS** characterisation of the lake sediments points out **k** values mainly assigned to higher **k** classes (**IV** and **Va**, even **Vb**), for the Lungu L. (closer to the "M.36" C. inflow mouth), and to the intermediate (**III**) and high classes (**IV** and **Va**), for the Mesteru L. (Fig. 10b1,b2 and Fig. 10c1,c2, respectively).

According to the environmental changes induced by the "Mila 36" C., the **MS** fingerprints detected in the bottom sediments were modified (the intensities of the magnetic fingerprints, in Fig. 11a,b), showing dynamic sedimentary environments, directly controlled by the riverine supplies. It is worth seeing the good correlation between these data and the "**EQ** Scale" from Fig. 3.

The **MS** classes assigned to the sediments from these main lakes from both the Eastern and the Western Mesteru – Fortuna Depression demonstrate that in the Fortuna Lake (see Fig. 4c1,c2) the silting up process is not triggered by the "Mila 36" Canal, dug up in 1982-1983, as in the case of the Mesteru and Lungu Lakes (Fig. 10). The silting up process in the Fortuna L. is caused by the solid supplies entering through a short canal from the Sulina Branch (Cranjala C.).

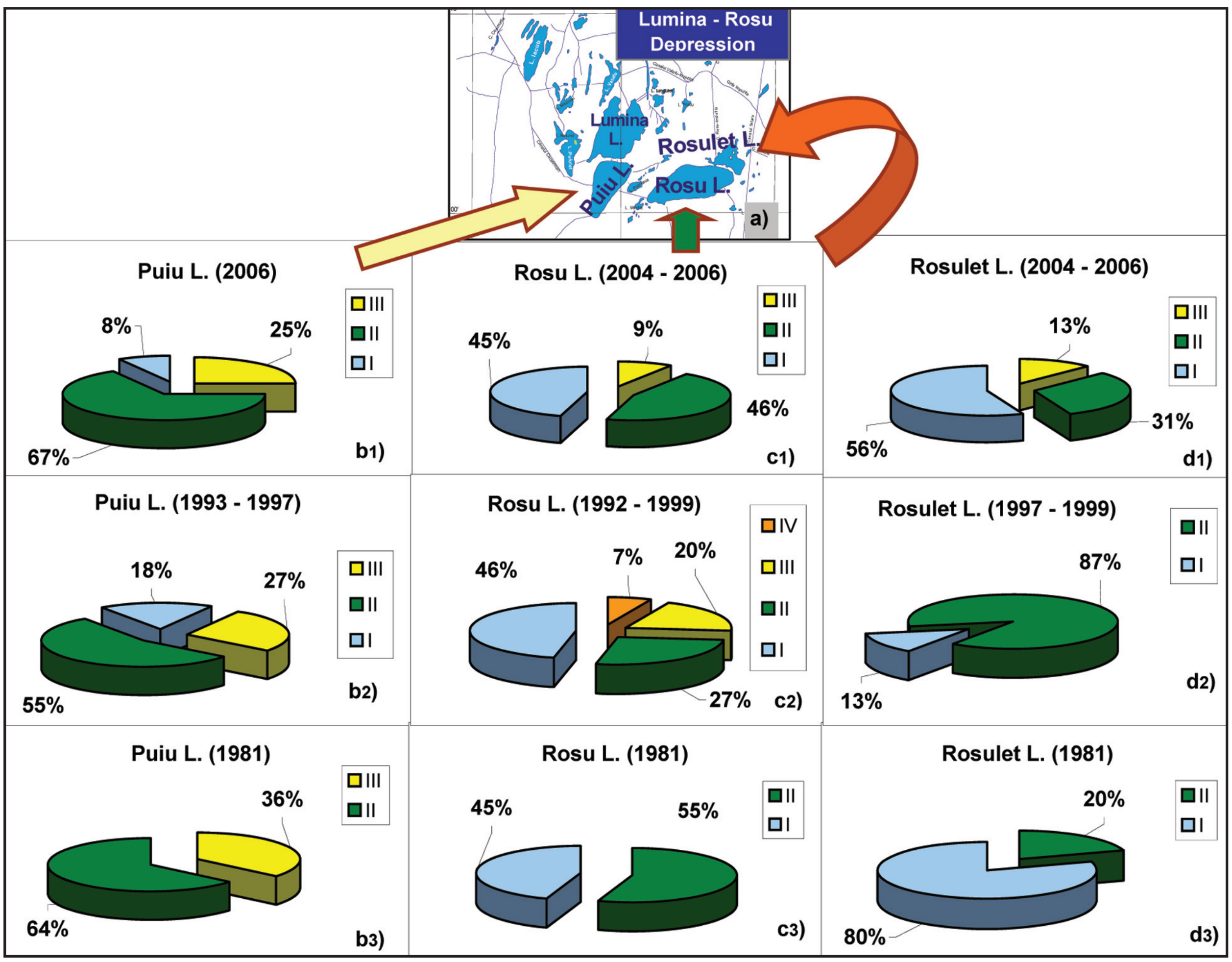


Fig. 8 Magnetic susceptibility characterisation based on the **k** scale for sediments sampled in three lakes successively placed along a main water flowing way, at its downstream end (Lumina - Rosu Depression - **a**). **b1-b3)** a lake defined by an intermediate category environment (in between dynamic and confined environments, characterised by an attenuated fluvial supply influence); **c1-c3), d1-d3)** two lakes characterised by more or less stagnant sedimentation environments

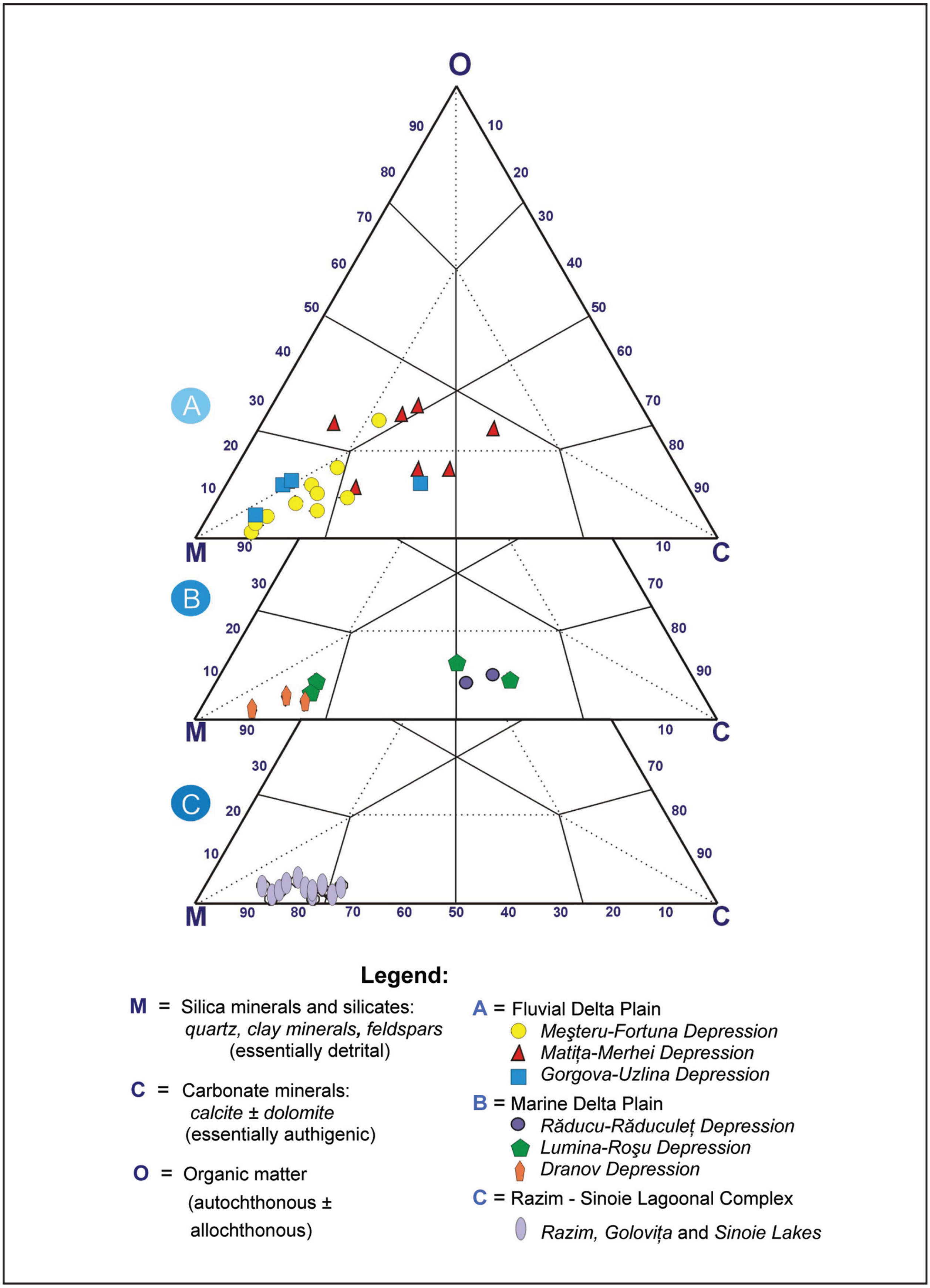


Fig. 9 Lithology of the modern sediments in Danube Delta and Razim – Sinoie Lagoonal Complex

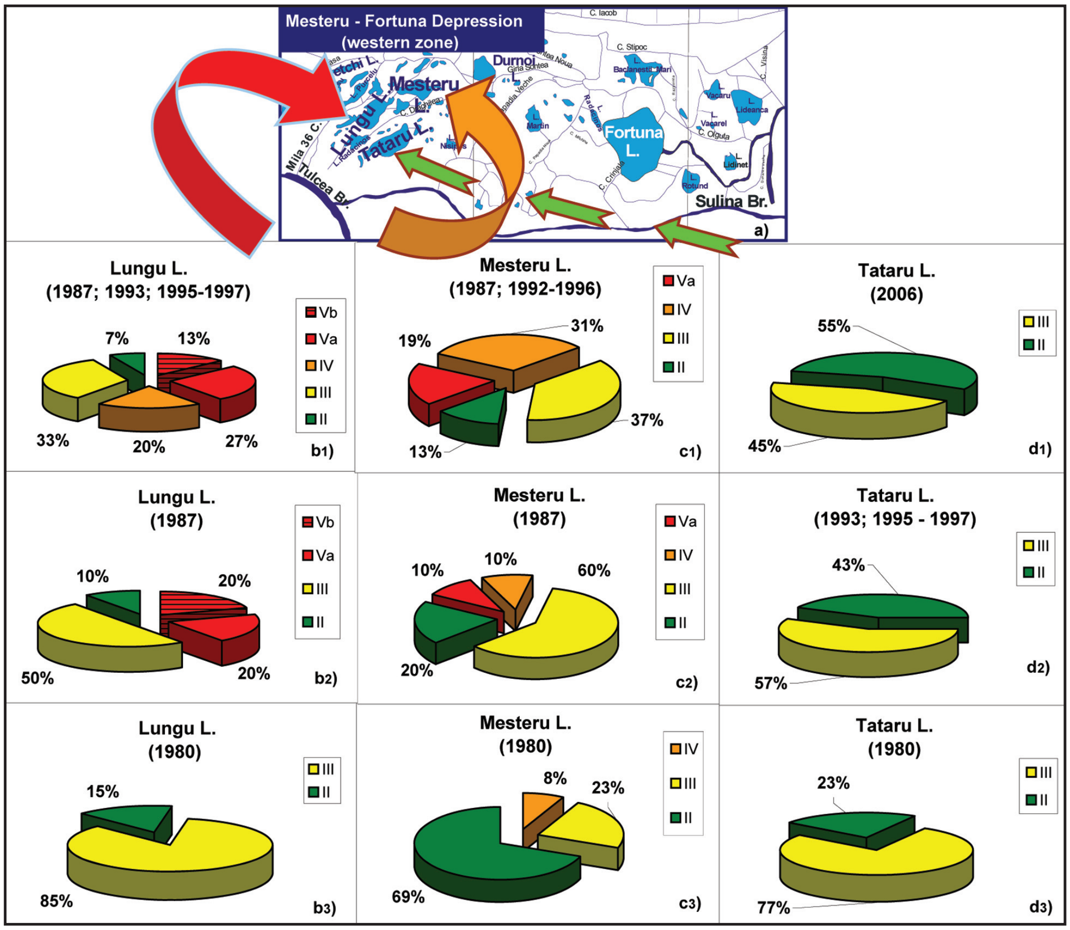


Fig. 10 Magnetic susceptibility characterisation based on the **k** scale for sediments sampled in lakes located in an area under anthropogenic pressure (Western Mesteru – Fortuna Depression – **a**). **b1-b3)** and **c1-c3**) – two lakes affected by the anthropogenic pressure, after the „Mila 36" Canal was cut (in 1982-1983); **d1-d3**) a lake characterised by an intermediate category environment both before and after cutting the Canal in the area

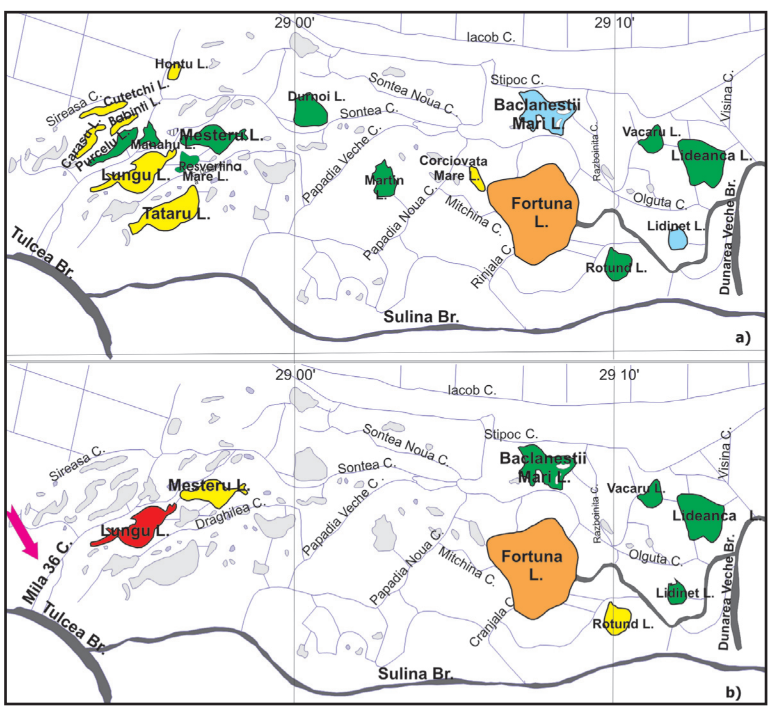


Fig. 11 Magnetic susceptibility fingerprint intensity identified within the sediments sampled in the lakes from the Mesteru – Fortuna Depression, before **(a)** and after **(b)** the human intervention in its Western part. **a)** 1980; **b)** 1987. Note: The **k** maps are based on the average **MS** values calculated for all the samples measured for each lake, and are coloured according to **k** scale from Fig. 2b

3.3. Fluvial – deltaic environments: The Danube Delta Branches

The sediments of the Danube Delta Branches consist of sands, primarily, with a variable grain size. The **MS** signatures are significantly different from those identified for the Danube Delta lakes (Fig. 12f, as compared with Fig.12 a,b,c,d,e).

The most **k** values (95%) are assigned to upper **k** classes **IV** and **V** (*i.e.*, **Va**, **Vb**, **Vc** and **Vd**), while the remaining 5% is covered by the class **III**. The percentages for the **k** classes **IV** and **V** related to the sediments from the lakes of the 5 investigated depressions (Fig.1 and Fig.12) are as follows: 38% – Mesteru–Fortuna D., 0% – Matita–Merhei D., 0% – Raducu–Raduculet D., 34% – Gorgova–Uzlina D. and 9% – Lumina–Rosu D. (Fig. 12a,b,c,d,e). No **k** value corresponding to the **MS** classes **I** and **II** was measured for the sediments of the DD Branches, while 69 % of the samples collected from the bottom sediments of the Danube Delta lakes were calibrated to these lower classes of the **k** scale (*Radan and Radan*, 2006b). The percentages for the classes **I** and **II** related to the five depressions investigated are as follows: 33% – Mesteru–Fortuna Depression, 93% – Matita–Merhei D., 100% – Raducu–Raduculet D., 48% – Gorgova–Uzlina D. and 67% – Lumina–Rosu D., respectively (Fig. 12a,b,c,d,e). On the other hand, while 77% of the **MS** values measured on the sediments sampled in the DD Branches are assigned to class **V**, only 6.2% of the **k** values are placed within this high class related to the sediments of the DD lakes.

The calibration of the Danube Delta bottom sediments to the Magnetic Susceptibility Scale revealed two main aspects (Fig. 12): a) the differentiation of the sedimentation environments located in the DD Branches (which belong to the fluvial – deltaic ecosystems) *vs* each of the 5 DD depressionary areas (which belong to the deltaic – lacustrine ecosystems) ; b) the differentiation of the aquatic environments that are « more or less directly influenced by riverine supplies » (*e.g.*, lakes from Mesteru–Fortuna D. and Gorgova–Uzlina D.) *vs* the « environments that are located far from main fluvial influx points » (*e.g.* lakes in the Matita–Merhei D. and Raducu–Raduculet D.).

Therefore, the various categories of submerged sedimentary environments – with a different lithological support – are accordingly expressed by the **MS** rock magnetic parameter. The sediments of the DD lakes are clayey or even sandy muds, predominantly consisting of essentially detrital allochthonous silica minerals and silicates (quartz, clay minerals, feldspars), but also organic and/or carbonatic muds, rich in authigenic components, while the sediments of the DD Branches are usually fine or intermediate, sometimes coarse sands. The differences that exist between the lithology/ mineralogy of the bottom sediments sampled in the Danube Delta lakes, and in the Danube Delta Branches, respectively, the later belonging much more to the fluvial environment than to the deltaic one, are clearly reflected by the high level of the **k** values measured on the samples collected from the DD Branches: the magnetic susceptibilities are predominantly (namely 77%) assigned to **k** sub-classes **Va, Vb, Vc, Vd** of the **MSS** (Fig. 2b and Fig. 12f).

3.4. Lagoonal environments: The Razim – Sinoie Complex

The sediments sampled in the main lakes of the Razim – Sinoie Lagoonal Complex are calibrated to classes **II** – **V**, predominantly to **k** class **III** (64%). The variations of the magnetic parameter are especially controlled by the sediment grain size, generally coarser than in the Danube Delta lakes, and influenced by the less significant organic and carbonate contents (except for the Zmeica Lake) (Fig.9C and Fig. 12g,h,i,j).

There is a decreasing trend of **MS** values southwards [Razelm (**R**) ➘ Golovita (**G**) ➘ Sinoie (**S**) ➘ Zmeica (**Z**)], associated with the increasing trend of finer sediments occurrence.

Therefore, the first research in the lagoonal complex, in 1976–1978, showed an increasing of the percentage of the sediments calibrated to the class **II** of the **MSS**, in the direction Razelm (4%) ➚ Golovita (16%) ➚ Sinoie (43%) ➚ Zmeica (51%), accompanied by a decreasing of the percentage of the classes **III** [*i.e.* **R** (72 %) ➘ **G** (63%) ➘ **S** (53%) ➘ **Z** (47%)] and **IV**+ **V** [**R** (24 %) ➘ **G** (21%) ➘ **S** (4%) ➘ **Z** (2%)] in the same direction (*Radan and Radan*, 2004, 2005). The Zmeica Lake is ranked after the Sinoie Lake due to its more isolated character, favourable to the occurrence of the finer sediments.

It is worth emphasising that after more than 25 years (2002 – 2004) the general trend in the direction Razelm ➲ Golovita ➲ Sinoie ➲ Zmeica is kept up (Fig. 12g,h,i,j), with slightly different percentages of the **k** classes: **II** [**R** (2%) ➚ **G** (17%) ➚ **S** (44%) ➚ **Z** (58%), **III** [**R** (75 %) ➘ **G** (65%) ➘ **S** (52%) ➘ **Z** (42%)], and **IV**+ **V** [**R** (23 %) ➘ **G** (18%) ➘ **S** (4%) ➘ **Z** (0%)].

Based on the percentage of the **k** classes calculated for both periods, i.e. (1976–1978) and (2002–2004), for the CLRS lakes put together, it is possible to evaluate the evolution trends of the rock magnetic parameter and of the sedimentologic parameters. So, for the first time interval, the general percentage related to the **k** classes is as follows: **II** = 20%, **III** = 63%, **IV** + **V** = 17%. For the more recent interval, the distribution is as follows: **II** = 19%, **III** = 66% and **IV** + **V** = 15%. Consequently, it should be noticed that the differences that occur after ca 27 years are not very important: the marginal classes **II** and **IV** + **V** lost 1%, and 2%, respectively. Those percentages will be found within class **III**, which gains 3 %. These differences could suggest an increasing trend of the siltic fraction percentage in the constitution of the superficial sediments to the prejudice of the finer – clayey – fraction. The later is removed from the system by repeated suspension of the upper part of the bottom sediments, followed by a differentiated transport and sedimentation, and by decreasing of the coarser material influx. This process takes place in the context of diminishing the Danube solid discharge and reducing the supply of the banks and of the sandy bottom in the sand

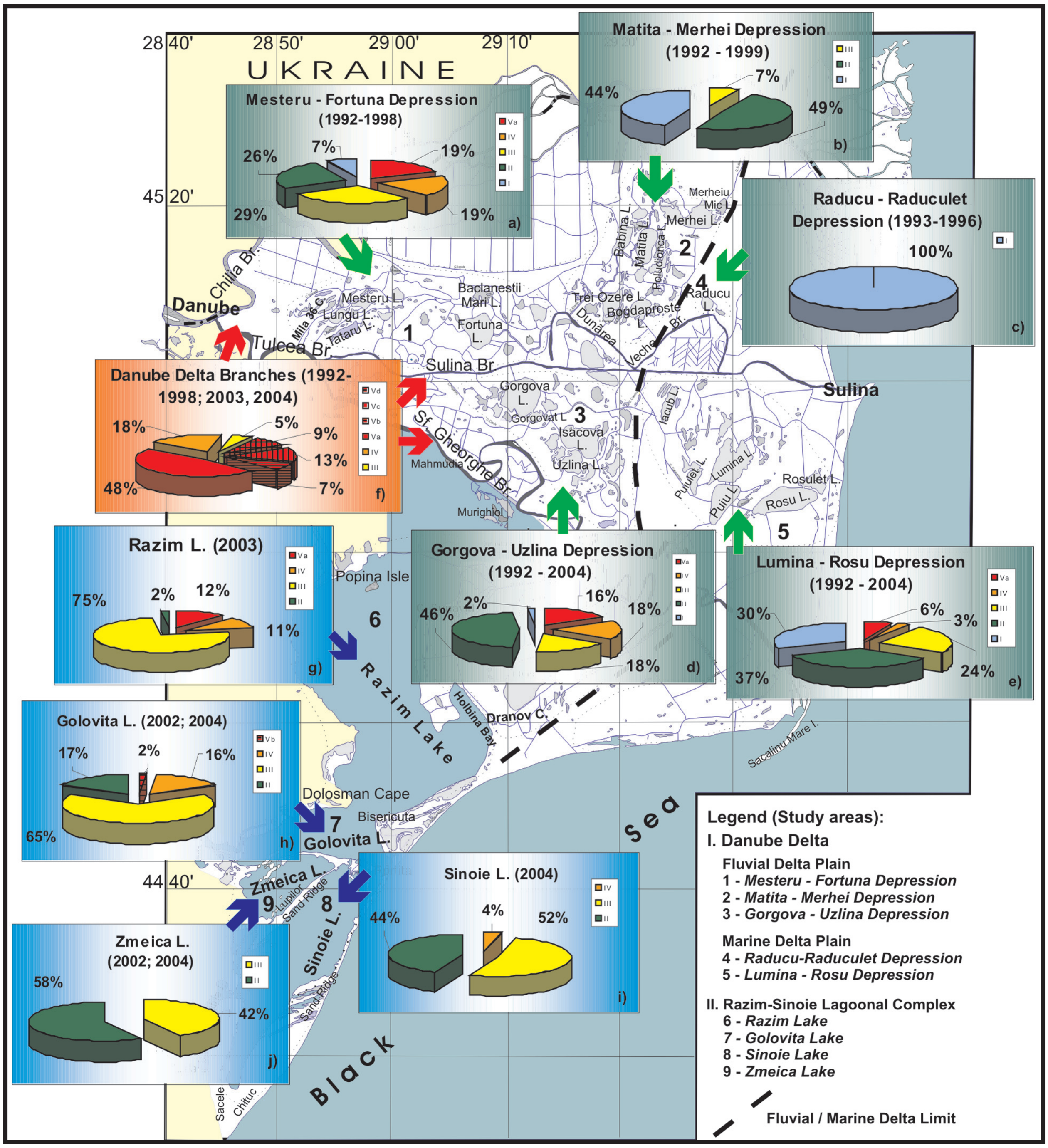


Fig. 12 Magnetic susceptibility characterisation based on the **k** scale for the sediments of the Danube Delta (DD) lakes, Danube Branches and the Razim - Sinoie Lagoonal Complex (RSLC) (1992-2004). **a)** Mesteru – Fortuna Depression (DD); **b)** Matita – Merhei Depression (DD); **c)** Raducu – Raduculet Depression (DD); **d)** Gorgova – Uzlina Depression (DD); **e)** Lumina – Rosu Depression (DD); **f)** Danube Delta Branches; **g)** Razim Lake (RSLC); **h)** Golovita Lake (RSLC); **i)** Sinoie Lake (RSLC); **j)** Zmeica Lake (RSLC)

ridge areas, as a consequence of silting up with finer material, which, nevertheless, remains a dominant process.

This dynamic sedimentogenetic interpretation, based on the **k** classes, is equally an argument for the good resolution of the Magnetic Susceptibility Scale (**MSS**) presented in the paper.

4. CONCLUDING REMARKS

A comparative analysis of the percentage distribution of more than 2000 **k** values correlated to 5 classes of a Magnetic Susceptibility Scale (**MSS**) led to the characterisation of the sedimentary deposits from various deltaic, fluvial-deltaic and lagoonal aquatic environments in the Danube Delta (DD) and

Razim – Sinoie Lagoonal Complex (RSLC) (see also *Radan and Radan*, 2006b).

With regard to the sediments of the Danube Delta lakes, the **k** classes **I** and **II** record the highest percentage (*i.e.* 69%), while the upper **k** classes **IV** and **V** – the lowest (11%).

Related to the Danube Delta Branches, the upper **k** classes **IV** and **V** record, together, 95%, the remaining percentage being covered by the **k** class **III**.

As concerns the lakes of the Razim – Sinoie Lagoonal Complex, the **k** values assigned to the class **III** record the highest percentage (64%), while the lower classes (only **k** class **II**, in this case) equally share the remaining percentages (36%) with the upper classes (**IV** and **V**).

An additional proof of the environmental capabilities of the Magnetic Susceptibiliy Scale that was applied to calibrating the sediments of the Danube Delta and of the Razim – Sinoie Lagoonal Complex was provided by comparing a Landsat image (recorded in 1991 and presented in Fig.1) with a set of magnetic susceptibility patterns. These are based on the colours that are characteristic for the **k** classes of the **MSS** (*Radan and Radan*, 2004), and which were carried out for collections of samples taken in the 1992–2004 time span or related to two time intervals (*i.e.* before and after the intervention of major anthropogenic work in the area).

The allochthonous inputs, of Danubian origin, which generate the gradual silting up of the lakes that are under their close influence, are visible on the satellite images and they are very well reflected by the **MS** patterns, based on the **k** classes (upper classes, in this case); and, more importantly, this was confirmed by the direct investigation of the sediments by using sedimentological, mineralogical and geochemical methods. Similar to this, but referring to the lower classes **I** and **II**, is the case of the distal lakes, more confined, with reduced direct riverine supplies, characterised by fine sediments (organic and carbonatic).

All the analysed cases demonstrate that the elaborated and experimented "**k** scale" works well. The correlation to the Scale with the normative definitions of the ecological status classification ("**EQ** Scale") equally supports this statement. The "**MS** Scale" shows, also, a significant correlation to the scale based on the average heavy metal contents, previously used for the evaluation of the sediment quality in the Danube Delta water system (*e.g., Radan et al.*, 1997a, *Radan and Radan*, 2004).

Therefore, the Magnetic Susceptibility Scale herein described proved the ability to differentiate depositional areas that were or were not exposed to riverine influences, which were naturally and/or anthropogenically induced. The **MSS** was successfully tested in various zones of the Danube Delta and Razim – Sinoie Lagoonal Complex.

To conclude, the DD and RSLC lake sediments provided a high resolution enviromagnetic instrument, a Magnetic Susceptibility Scale with a genuine lithological support.

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