

INTRODUCTION. STUDY AREA

The case study focusses on the environmental changes detected by magnetic susceptibility (MS) measurements carried out on the lake sediments sampled in the Mesteru - Fortuna Depression (Danube Delta/DD; Fig. 1a,b,c,d) during 1980-2006. After the "Mila36" Canal was cut (Fig. 1c,d), in 1982-1983, the dynamics of the water and sediments within the western part of the depression was strongly influenced by the very significant liquid and solide riverine supplies. The sedimentary environments from three main lakes (*i.e.* Lungu, Mesteru and Tataru; Fig. 1c,d) were investigated in 1980, 1987, 1992-1997 and 2006. The first two above mentioned lakes underwent an intensive process of filling up with sediments; the Lungu L. (Fig. 1c,d) was most exposed to the direct fluvial inflow. The magnetic signatures identified in the bottom sediments, sampled before and after the hydrotechnical work between two DD Branches was carried out, underwent obvious modifications, showing the impact of the anthropogenic pressure on the sedimentary processes taking place in the aquatic area of the western Fluvial Plain (Danube Delta).

MATERIALS AND METHODS

Magnetic susceptibility measurements were performed on hundreds of samples collected during 11 cruises, between 1980-2006. The sampling of bottom sediments was carried out using "Van Veen" grabs (Fig. 2), which allowed to take "sediment packets" (Fig. 3), undisturbed at the upper part (Fig. 4a). When the study of thicker sedimentary sequences was aimed, in order to reveal the temporal evolution of the sedimentation environments, gravitational corers were used. The MS measurements on unconsolidated sediment samples were done with (KLY) Kappabridges. An original "Magnetic Susceptibility (k) Scale" (Radan & Radan, 2004, 2006; Fig. 4a), with a genuine lithological support, based on more than 2200 k values, was used to calibrate the lake sediments of the Danube Delta. Numerous MS patterns were performed to analyse the characteristic magnetic signatures of the various sedimentary environments. A preliminary evaluation of the trace metal contamination of the DD sediments was carried out using a "Sediment Quality Scale" (Radan & Radan, 2004; Fig. 4b). The MS data were correlated to the "Ecological Quality Scale" (Fig. 4c), as well.

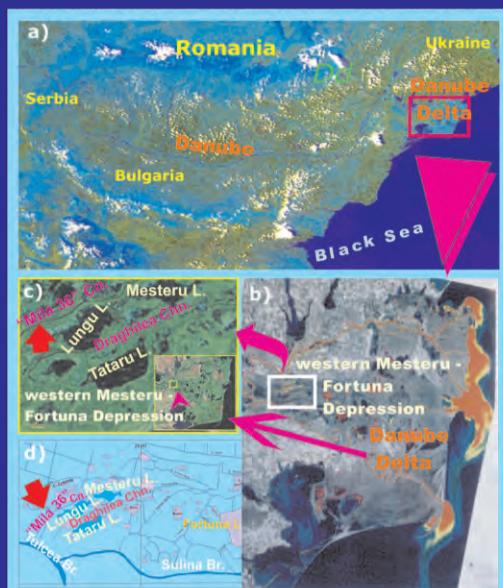


Fig. 1. Study area: western Mesteru - Fortuna Depression (Danube Delta).



Fig. 2. "Van Veen" grab sampler.



Fig. 3. Grab sampler sediment.

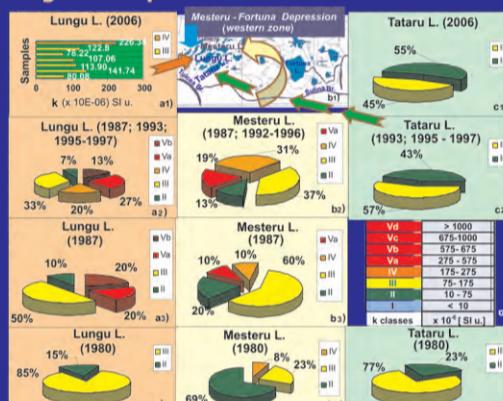


Fig. 6. Magnetic susceptibility of sediments sampled in the 1980-2006 time span.

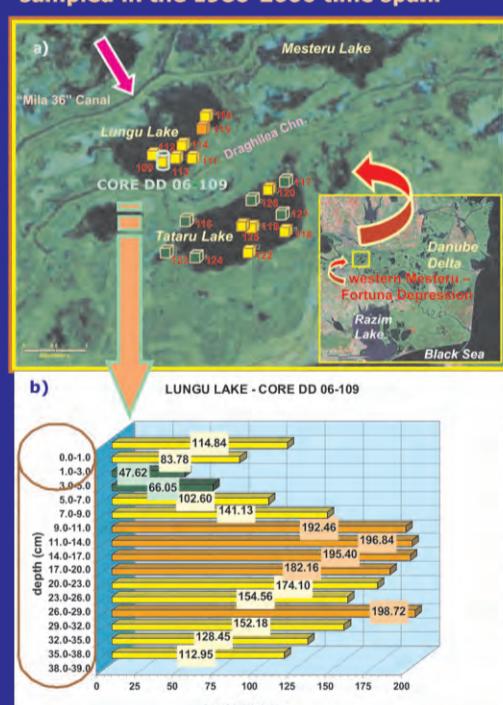


Fig. 7. Magnetic susceptibility (correlated to the k Scale) of the lake sediments (2006). a) areal distribution; b) vertical distribution.

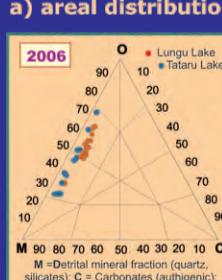


Fig. 8. Lithology of recent sediments.



Fig. 4. Scales used to characterise the sedimentary environments of the deltaic ecosystems. a) Magnetic Susceptibility (MS; k) Scale; b) Sediment Quality Scale; c) Ecological Quality Scale.

RESULTS AND DISCUSSION

○ The magnetic susceptibility measured on bottom sediment samples collected from the Lungu and Mesteru Lakes during the 1980 cruise (Fig. 5a,b) showed k values as high as 137×10^{-6} SI u. (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 to 654×10^{-6} SI u. for the Lungu L., and up to 334×10^{-6} SI u. for the Mesteru L. (Fig. 5b,c).

○ A confirmation of the modified magnetic signatures, in keeping with the sedimentary environment changes, has resulted

from the MS monitoring cruises carried out during 1992-1997, as well as from the most recent expedition, organised in 2006 in the Lungu L. (and also in Tataru L.; Fig. 6). Consequently, according to the MS Scale (see Fig. 4a), the MS signatures identified in 1980 in the Lungu and Mesteru Lakes are characterised by k classes II and III (with the above mentioned exception, *i.e.* a k value assigned to class IV) (Fig. 6a4,b4). Concerning 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. 1d), 60% of the k values are defined by high k classes (IV, Va, Vb), while 40% by the II and III classes (Fig. 6a2; see also Fig. 6a4). In 2006, the sampling stations were placed in the eastern - south-eastern part of the Lungu Lake (Fig. 7a), an area less exposed to the fluvial inflow than the northern one (see Fig. 5b,c); the k values are defined between 78.22×10^{-6} - 226.34×10^{-6} SI u. (assigned to k classes III and IV; Fig. 6a1). As regards the Mesteru L. (1987-1996), the percentages are equally attributed to the II and III classes (50%) and to the higher classes IV and Va (50%) (Fig. 6b2; see Figs. 6b4 and 5a,c to compare with the data obtained in the first cruise-1980). This indicates that the deltaic environments of the Lungu and Mesteru Lakes are under anthropogenic pressure, induced by the hydrotechnical work, relating to the "Mila 36" Canal, dug up between the Tulcea and Chilia Branches, for economical reasons; zone marked by arrows in Figs. 1c,d, 7a and 9b,c).

○ The third lake under MS monitoring, *i.e.* the Tataru L. (Figs. 1c,d and 7a), has not undergone important changes after the severe modification of the hydrological conditions in the area; its spatial position (relating to the Lungu L. and the Draghilea Chn.; Fig. 1c,d, 7a and 9b,c) made possible a double protection against the direct Danubian supplies. The magnetic signatures identified in the Tataru L. sediments in 1980, 1993-1997 and 2006 keep the same characteristics; they are calibrated to k classes II and III [100%; Fig. 6c4,c2,c1; see also the k map related to the first cruise-1980 (Fig. 5a) and the MS data with regard to the last expedition-2006 (Fig. 7a)]. However, a transfer of the III class percentage weight towards the II class 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. 8, showing the lithological classification of the sediments sampled in the Lungu and Tataru 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 with regard to the lithological composition are clearly reflected by the enviromagnetic parameter (MS).

○ An undisturbed 39 cm long core sediment taken from the Lungu Lake (Fig. 7a; location: DD 06-109) has recently been investigated. The vertical distribution of the MS values along this core is illustrated in Fig. 7b together with the calibration to the k Scale from Fig. 4a.

○ Finally, the synoptic images of the MS fingerprints identified in the lake sediments of the western Mesteru - Fortuna Depression are illustrated for 3 different periods: 1980 (Fig. 9a) - before the human intervention on the aquatic ecosystems; afterwards, between 1987-1997 (Fig. 9b), and in 2006 (Fig. 9c), 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. 4a. 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. The intensity is increasing by two k classes in the Lungu and Mesteru lake sediments (from III to Va, and from II to IV, respectively), and it keeps the same (calibrated to class III) in the Tataru Lake (some explanations were previously presented). When a lake is under anthropogenic pressure, the k class III is consistent with the "moderate quality", and the classes IV and V with the "poor" and "bad" qualities shown by the "Ecological Quality Scale" (Fig. 4c). Thus, related to the Lungu and Mesteru Lakes, it is the case: "restoration needed".

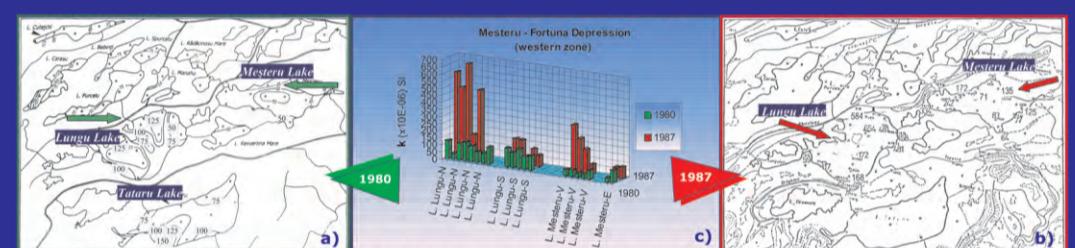


Fig. 5. Magnetic susceptibility (MS) patterns showing the MS distribution in lakes from the western Mesteru - Fortuna Depression. a) 1980 cruise (k maps); b) 1987 cruise. Note: the MS values must be multiplied by 10^{-6} [SI u.]; c) k values for sediments sampled in the Lungu L. (northern and southern sectors) and Mesteru L. (western and eastern sectors) before (1980) and after (1987) the human intervention in the area.

○ The case study analysed in the Danube Delta (Romania) clearly proves the capabilities of the magnetic susceptibility to identify present environmental changes induced by the anthropogenic pressure on the aquatic ecosystems. The magnetic signatures are recovered from the lake sediments - a high fidelity enviromagnetic archive.



Fig. 9. Magnetic susceptibility fingerprint intensity (calibrated to the k Scale) identified within the lake sediments sampled in the western Mesteru - Fortuna Depression, in 3 different periods.

CONCLUDING REMARK