Scientific Annals, School of Geology, Aristotle University of Thessaloniki Proceedings of the XIX CBGA Congress, Thessaloniki, Greece	Special volume 100	39-45	Thessaloniki 2010

ACCUMULATION AND DISTRIBUTION OF ORGANIC MATTER IN SEDIMENTS OF SALT-AFFECTED SHALLOW LAKES AT SZEGED, HUNGARY

Bozsó G., Pál-Molnár E.,Nyilas T., Hetényi M.

Department of Mineralogy, Geochemistry and Petrology, Faculty of Science and Informatics, University of Szeged, H-6722 Szeged, Hungary, bozso.gabor@geo.u-szeged.hu

Abstract: The primary aim of the research is to investigate the accumulation and distribution of organic material [OM] in saline shallow lacustrine sediments. This study focuses on the OM parameters of sediments at two areas with different hydrology, land use and vegetation cover. The study area is located at the Fehér Lake, Szeged (Hungary). The studied salt-affected lake system has been under intensive fish breeding from 1970. Sampling was made during the spring of 2007. In case of the profiles a 4 m deep 10 cm diameter sediment core was extracted. The OM data were measured with Rock-Eval pyrolysis, and the proportion of different OM groups was determined by the mathematical deconvolution of Rock-Eval pyrograms. It is showed that there are significant differences in OM distribution and characteristics if the different study sites are compared. In case of both profiles similar changes can be detected in the origin, quantitative and qualitative parameters of OM at depths of 15, 30, and 65-70 cm, which proves that the two sites belonged to the same depositional system, and similar changes affected them during sediment formation. Although both profiles have the same depositional environment, significant difference can be seen between the profiles. The profile 1. used to be located in coastal natural territory till 1970 and the profile 2. represents a constant water-irrigated fields. The fluctuation of F1+F2 and F3 values in Profile 1. suggests that the OM content of the marginal territory (both in its natural and present state) is determined by the alternation of dry and wet periods, sometimes with a high algae production in slack waters. Based on the quality parameters of OM, dry and wet accumulation periods can be separated, and signs of human influence can also be identified.

Key words: organic matter distribution, shallow lake, salt-affected sediment

1. Introduction

The quality and quantity of organic material [OM] preserved in sediments provide trustable information on the circumstances of accumulation, the characteristics of natural and human sources, and post-sedimentation processes influencing OM distribution (Meyers, 2003). While OM in marine sediments has implications on long term phenomenon, the quantity, quality and distribution of OM in the sediments of shallow lakes is primarily determined by short term and local processes. The preservation and transformation of OM is highly influenced by actual hydrologic, climatic and geochemical parameters (Ariztegui et al., 2001; Sebag et al., 2006). Most of the researches focus on the OM of marine and deep water lacustrine environments, the organic geochemistry of shallow, continental lakes is usually out of the scope of these studies. On the other hand due to global climate change, the area of shallow lakes and territories with water-affected soils, usually both influenced by salinization processes, is continuously increasing (Das et al., 2008; Tóth et al., 2006). As a consequence, the investigation of the organic geochemistry of these territories is getting more and more important. The extreme evaporation and hydrological conditions on saline territories can considerably affect geochemical processes (Bozsó et al., 2008), and thus the accumulation and preservation of OM.

An adequate analytical procedure for determining the quantitative and qualitative parameters of OM, influenced by the above processes, is Rock-Eval pyrolysis (Disnar et al., 2003). By the mathematic analysis of the measured pyrograms stable and unstable biopolymers (F1, F2), immature and mature refractory geopolymers (F3, F4) can easily be separated (Sebag et al., 2006), and accumulation events can also be delineated and identified in the sediment record (Hetényi et al. 2005).

The primary aims of the present research are to determine the quantity of OM in sediments of shallow lakes affected by salinization, to identify the origin of OM, to investigate the transformation processes of bio and geopolymers, and finally on the basis of the above data, to identify the depositional conditions.

2. Materials and methods

In accordance with the aims of the research the sampling sites were chosen to be at Lake Fehér near Szeged, Hungary (Fig. 1). The lake system and its environment were formed by the fluvial and aeolian accumulation processes of the Carpathian Basin (Keveiné et al., 2000). The studied lake system, with a catchment of 200 km^2 and a net area of 14 km^2, is affected by intensive fish breeding, though some areas are still considered natural and protected by the Kiskunság National Park.

Sampling was made during the spring of 2007 at four different locations with different hydrogeology and land use. Because of the lack of space only two profiles are presented in this paper.

In case of the profiles a 4 m deep 10 cm diameter sediment core was extracted. The cores were dissected into 5 cm units and dried on room temperature for 3 weeks.

2.1. Description of sampled areas

Profile 1

Control site on a saline tussocky meadow. It is the farthest from human activity. It is marshy, and inundated by water for 1-2 months during the spring period. By the 1970s the territory was at the margin of the natural lake system, since then, for almost 40 years it has been a buffer zone for the artificially created lake system too (Keveiné et al., 2000). However, conditions of hydrology and vegetation cover hardly changed.

Stratigraphy of profiles 1

The soil type along the profile is mostly sandy loess (Fig. 1) (Molnár, 1996). The ratio of the sand fraction (> 63 μm) is about 10 % in the whole depth of the profile (Fig. 2). The ratio of the aleu-

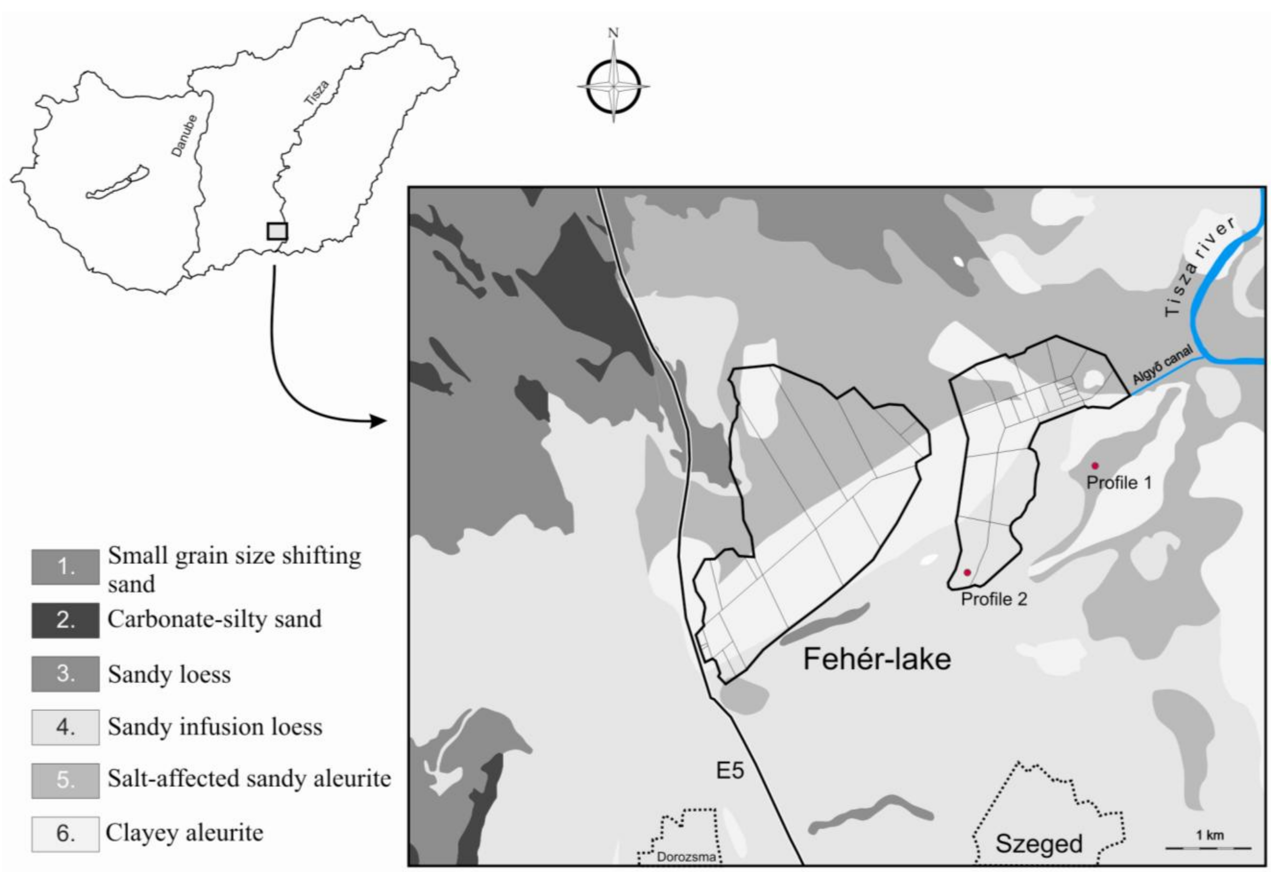

Fig. 1. Geological map of the sampling area and the location of profiles

rite fraction (63-2 μm) is the highest in the profile and with the exception of the upper 10 cm it is increasing with depth. The ratio of the clay fraction (< 2 μm) is the opposite of the aleurite fraction, it is decreasing with depth. The horizon A (from 0 cm to 30 cm) of the profile contains over 3 % of total organic carbon (TOC) that is decreasing to 0% at 100 cm. This level has a loose structure and a light brownish black color. The accumulation of salt can be founded in the depth of 50 cm. It is a level of the horizon B, too. Under this layer the carbonate starts to appear in the profile, it is indicated by the yellowish grey color of the sediment, too.

Profile 2

Directly affected by human activities. It is inundated artificially each year by 1-1.5 m water from April till October. During March-April 10-20 cm high vegetation can develop. By the 1970s this area was located in the central part of the natural lake system. Following the earthworks of the 1970s it has been used for fish breeding (Keveiné et al., 2000).

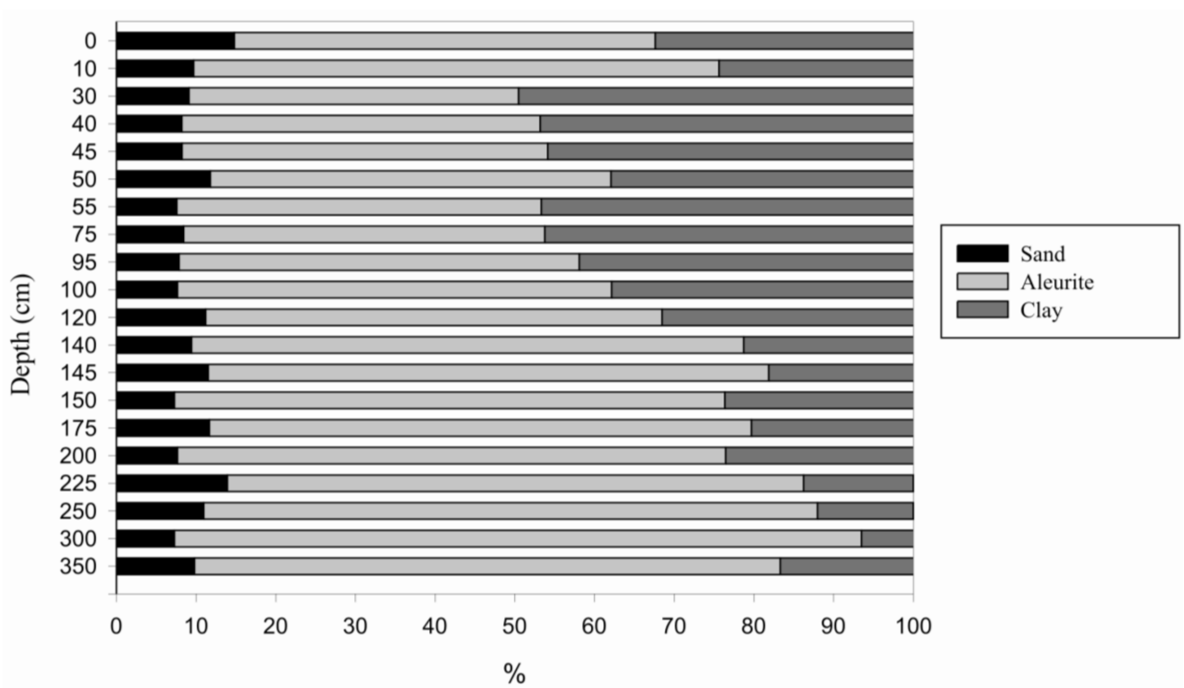

Fig. 2. Grain size distribution of profile 1.

Stratigraphy of profiles 1

The soil type along the profile is mostly sandy infusion loess (Fig. 1) (Molnár, 1996). The grain size ratios show more difficult distribution than in the case of profile 1 (Fig. 3). The ratio of the sand fraction is higher than in the first case (20-30 %), it is decreasing from the surface to 60 cm and it is apparently increased in the level of 75-95 cm. The distribution of aleurite (~ 50%) and clay (~ 20%) fraction is quite uniform. The horizon A of the profile is relatively thin (10 cm depth from the surface) and contains only about 1 % of TOC. The amount of TOC is 0% below the level of 100 cm. This level has a loose structure and a light yellowish brown color. The boundaries of horizon B and C are not distinguished because this profile looks like disturbed by the water flow.

2.2. Analytical methods

Data of the Rock-Eval pyrolysis were measured with Oil Show Analyzer: preheat for 4 minutes on 108 °C, programmed pyrolysis with a 25 °C/min ramp rate till 600 °C. Subsequently, the samples were oxidized in a constant airflow for 7 minutes on 600 °C. The proportion of different OM groups was determined by the mathematical deconvolution of Rock-Eval pyrograms (Disnar et al., 2003). In order to determine more precisely the origin of OM the C_{org}/N ratio (Meyers, 2003) was also measured in 7 samples.

3. Results and discussion

Total organic content (TOC) was measured from 160 samples concerning the two profiles. Based on the results, only the upper 100 cm section of both profiles contained an appreciable amount of OM, going deeper the concentration of OM was below

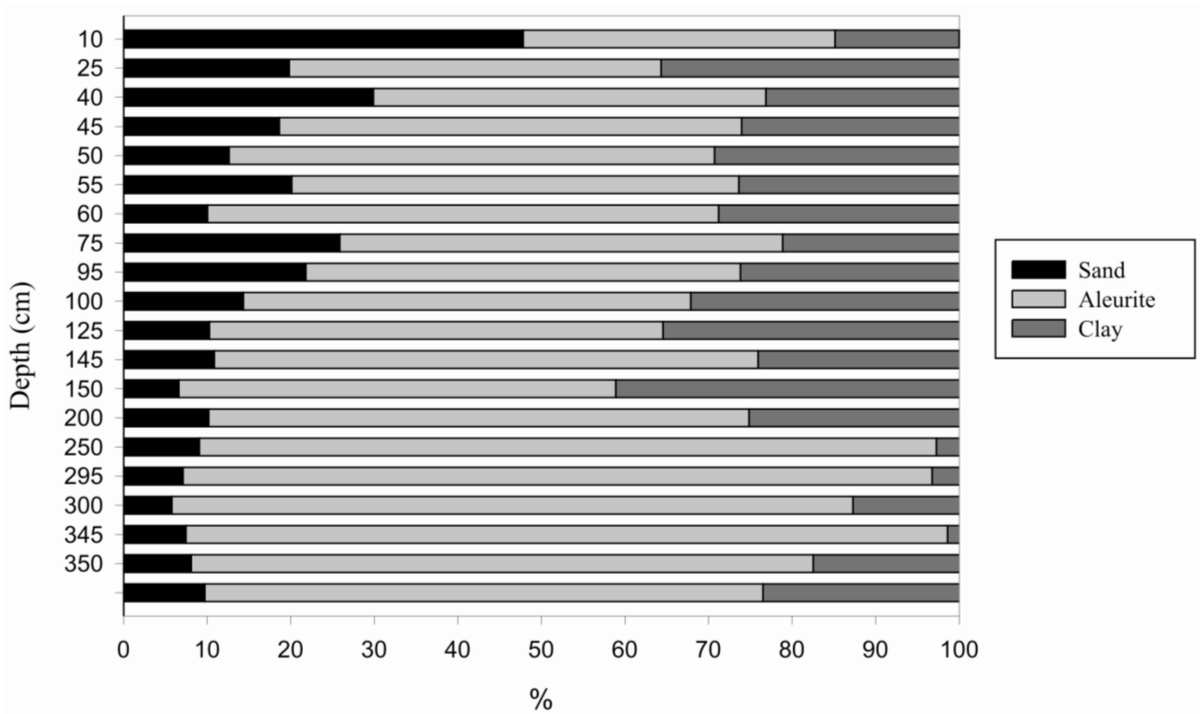

Fig. 3. Grain size distribution of profile 2.

the detection limit. As a consequence, detailed Rock-Eval analyses were only performed on the upper 100 cm layer of the profiles.

Concerning both parameters the differences between the two sites are striking (Table 1). TOC values varied between 0.2 and 2.0 % in the samples. These values are lower than usual OM concentrations measured in lake sediments (Das et al., 2008). In Prof.1 TOC values are higher and show a continuous decrease with depth (Fig. 4).

Nevertheless, the amount and distribution of TOC measured in Prof.2 are very much different (Fig. 4).

Table 1. Average values of organic carbon contents, HI and the relative contribution of major classes in the profile 1 and profile 2.

Depth (cm)	TOC (%)		HI (mgHC/gsoil)		F1 (%)		F2 (%)		F3 (%)		Corg/N	
	Prof1	Prof2	Prof1	Prof2	Prof 1	Prof 2	Prof 1	Prof 2	Prof 1	Prof 2	Prof 1	Prof 2
0	2.00	1.34	135	115	2.71	1.78	40.26	36.38	57.03	61.85		
5	2.10	1.13	135	80	4.05	4.10	35.79	39.73	60.16	56.17		
10	1.82	1.02	117	52	1.32	0.00	41.96	43.28	56.72	56.72	19.30	
15	1.09	0.83	67	49	0.00	1.51	53.63	39.42	46.37	59.07		16.10
20	1.03	0.89	64	58	1.74	3.30	49.13	38.91	49.13	57.79		
25	0.92	0.46	58	73	0.00	1.16	48.36	36.29	51.64	62.55	15.30	10.70
30	0.82	0.58	57	84	2.49	0.82	38.91	37.16	58.60	62.02		
35	0.73	0.79	60	78	3.05	0.87	50.61	36.29	46.34	62.84		
40	0.80	0.84	50	55	0.39	0.00	49.25	35.66	50.36	64.34		
45	0.67	0.43	46	79	3.62	2.70	44.43	35.28	51.95	62.02		
50	0.59	0.58	45	70	2.92	5.88	37.83	35.58	59.26	58.54		16.90
55	0.62	0.63	48	53	2.70	1.43	60.11	36.08	37.19	62.50		
60	0.53	0.58	116	67	22.52	0.89	25.85	40.72	51.62	58.40		
65	0.39	1.19	56	105	3.43	3.07	36.47	31.77	60.10	65.16		
70	0.35	1.37	45	91	1.69	3.12	35.35	30.52	62.96	66.36		13.30
75	0.29	1.13	51	74	1.76	0.00	36.36	33.97	61.88	66.03	8.80	
80	0.32	0.99	43	68	4.03	0.00	37.81	36.00	58.17	64.00		
85	0.24	0.87	79	71	8.04	0.00	47.50	35.21	44.46	64.79		
90	0.21	0.75	69	67	0.00	0.00	5.78	37.85	94.22	62.15		
95	0.20	0.60	64	60	3.97	0.00	28.35	32.43	67.68	67.57		

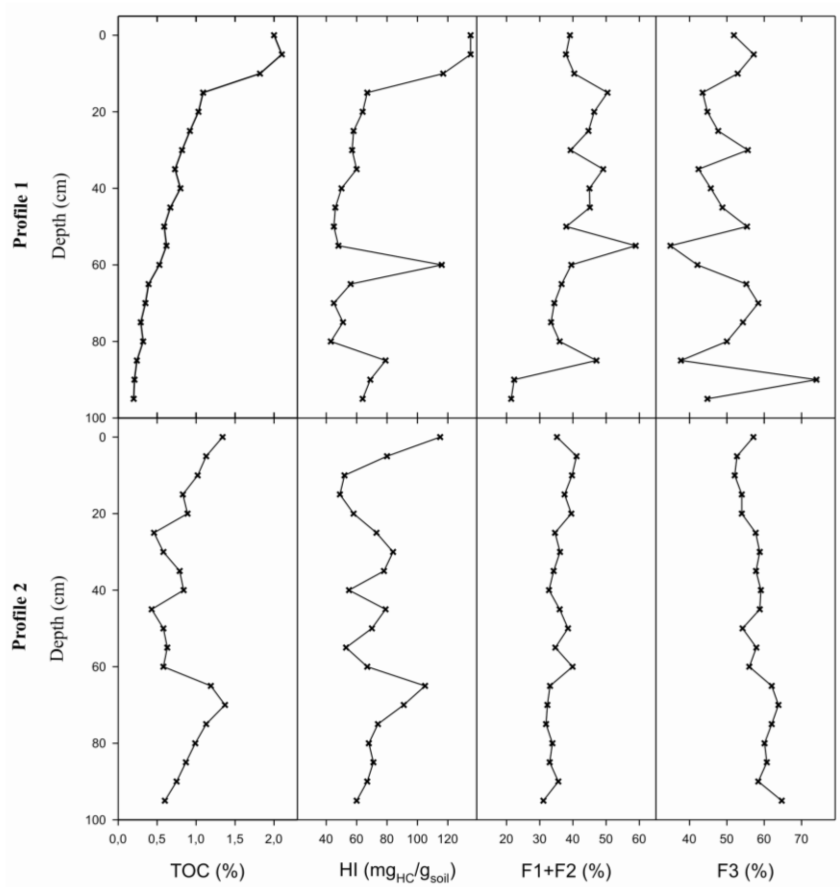

Fig. 4. TOC, HI, F1+F2, F3 values of the profiles.

TOC values are lower, and their downward change is uneven. From the surface till 60 cm with some smaller exceptions a decreasing tendency can be seen, but below 80 cm its value increases above 1 %. In both profiles the upper 15 cm has a higher TOC, which can be explained by the introduction of fish breeding in the 1970s. The distribution of Hydrogen Index (HI) is similar to that of TOC in both profiles, thus it is less even in case of the lake profile. The proportional variation of bio and geo-polymers also refers to diverse sedimentation and transformation processes. Basically, the amount of biopolymers (F1, F2) in the sediment is similar to that of immature geopolymers (F3). However, the values measured for inert geopolymers (F4) are negligible compared to the previous three parameters, thus values of polymers are represented on ternary plots (Figs. 5). On the basis of ternary plots representing the proportional distribution of bio and geopolymers, it is obvious that the values in Profile 1 can be classified into several groups (Fig. 5), while in Profile 2 they are almost entirely homogenous. These distributions and the change of F1+F2 and F3 with depth suggest that Profile 1. was periodically inundated and then desiccated in its natural state on the margin of the lake system. Both in its natural and present situation Profile 2 has been the farthest from dryland environments, therefore the accumulation and preservation of OM was more even here. This is also reinforced by C_{org}/N ratios. In Profile 1 values refer to low algae (8.8) and much higher dry land (19.3) origin of OM (Meyers, 2003), which can be another proof of temporary water cover. On the contrary, in Profile 2 C_{org}/N values mostly sign a dry-land origin, i.e. in the middle of the lake system sediments preserved the remainings of dry-land plants, transported there presumably by wind. Although the amount and maturity of OM varied over time on the basis of TOC and HI values, the dry-land supply seems to be inevitable.

4. Conclusions

In our work we mainly aimed at the characterization of OM accumulating in shallow saline lake sediments with special hydrological conditions. We also attempted to answer whether human activity can result in detectable changes in OM characteristics. In general, the OM parameters measured in the two geologically and pedologically similar

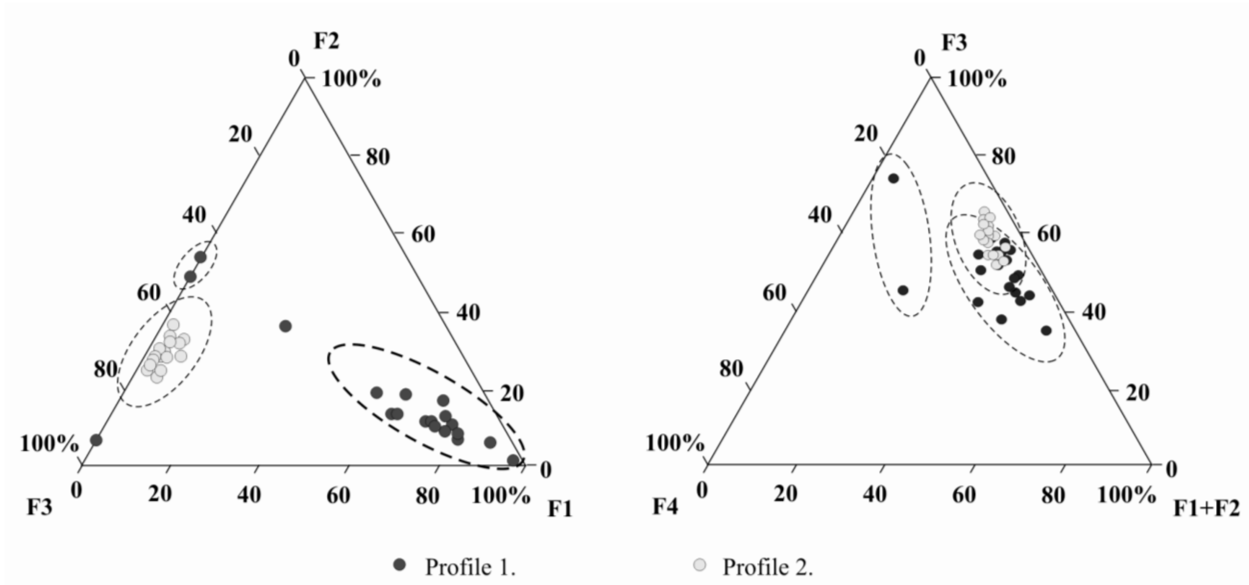

Fig. 5. Rates of F1, F2, F3, F4 fractions in the profiles.

profiles were very different, and values mainly depend on hydrological conditions and the degree of human influence. In both profiles the increased TOC above 15 cm refers to human activity. Although both profiles have the similar depositional environment, significant difference can be seen between the profiles. The profile 1 used to be located in coastal natural territory till 1970 and the profile 2 represents a constant water-irrigated fields. The TOC distribution in profile 1 corresponds well to the OM distribution in meadow soils (Dismar et al., 2003): due to permanent vegetation cover and a continuous OM supply, in the oxidative environment of the porous media the transformation of OM is even. The fluctuation of F1+F2 and F3 values in Profile 1. suggests that the OM content of the marginal territory (both in its natural and present state) is determined by the alternation of dry and wet periods, sometimes with a high algae production in slack waters (It can be seen on the increased HI in fig. 4). The variation of values in case of profile 2 refers to periodical differences in sedimentation conditions. These results are also reinforced by C_{org}/N ratios. In profile 2 F1+F2, F3 values and C_{org}/N ratios suggest that OM has always had a dry-land origin, however in terms of the quantity and maturity of OM well definable sedimentation cycles can be identified here as well. In case of profile 2 the increased amounts of TOC and HI in depth of ~30 cm and ~70 cm indicate the water covered period and the high algae production. In case of both profiles significant changes can be detected in the origin, quantitative and qualitative parameters of OM at depths of 15, 30 and 65-70 cm, which proves that the two sites belonged to the same depositional system, and similar changes affected them during sediment formation. Based on the F1, F2 and F3 values, the OM in the sediment of the study areas is primarily young and unaffected by transformation processes. The downward change of biopolymers (F1+F2) and immature geopolymers (F3) is highly variable in case of the meadow profile, while it is much more even in the lacustrine profile.

Based on the data it can be assess that the lake sediments can preserve the small changes in the OM accumulation. If the present results are compared to pH values and mineral compositions (Bozsó et al., 2008) then it turns clear that salinization processes do not have fundamental influence on the synsedimentary characteristics of OM, and preservation is more directly determined by the actual deposition and hydrological conditions.

Acknowledgements

The financial background of this work was ensured by the Hungarian National Science Found (OTKA), Grant No. T-48325.

References

Ariztegui D., Chondrogianni C., Lami A., Guilizzoni P., Lafargue E., 2001. Lacustrine organic matter and the Holocene paleoenvironmental Record of lake Albano (central Italy). J. of Paleolimnology 26, 283-292.

Bozsó G., Pál-Molnár E., Hetényi M., 2008. Relations of pH and mineral composition in saltaffected lacustrine profiles. Cereal Research Communications 36, 1463-1466.

Das B., Nordin R., Mazumder A., 2008. An alternative approach to recontructing organic matter accumulation with contrasting watershed disturban-ce histories from lake sediments. Environmental Pollution 155, 117-124.

Disnar J.R. Guillet B., Keravis D., Di-Giovanni C., Sebag D., 2003. Soil organic matter (SOM) characterization by Rock-Eval pyrolysis: scope and limitations. Organic Geochemistry 34, 327-343

Hetényi M., Nyilas T., M-Tóth T., 2005. Stepwise Rock-Eval pyrolysis as a tool for typing heterogeneous organic matter in soils. J. of Anal. Appl. Pyrolysis 74, 45-54.

Keveiné B.I., Mucsi L., Tímár B., 2000. The changes of state of the Fehér Lake at Szeged. In: Frisnyák, S. (Ed.), The historical geography of the Hungarian Great Plain. Nyíregyháza, pp. 53–66. (in Hungarian with English abstract).

Molnár B., 1996. The geological and hydrogeological characteristic of Fehér-lake at Szeged, Hungary. Hidrology Bulletin 76/5, 266-271. (in Hungarian with English abstract).

Meyers P.A., 2003. Applications of organic geochemistry to paleolimnological reconstructions: summary of examples from the Laurentian Great Lakes. Organic Geochemistry 34, 261-290.

Sebag D., Disnar J.R., Guillet B., Di Giovanni C., Verrecchia, E.P., Durand, A., 2006. Monitoring organic matter dynamics in soil profiles by Rock-Eval pyrolysis: bulk characterization and quanti-fication of degradation. European Journal of Soil Science doi: 10.1111/j.1365-2389.2005.00745.x

Tóth T., Szendrei G., 2006. Types and distribution of salt affected soils in Hungary, and the characterization of the processes of salt accumulation. Topographia Mineralogica Hungariae IX, 7-20.