Morphometrical Analysis of Microdepressions in the Central Baragan Plain (Romania)

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Key words: plain, loess, microdepressions, morphometry.

Abstarct. In the Eastern part of the Romanian Plain, covered with loess or loess deposits, negative microforms (microdepressions) are developing, known in literature as „crovuri", but they also have local given names like "gavane" or "padine".
From geomorphological point of view, "crovurile" are depressions, (ease subsidences) in loess or loess deposits covered plains, having circular or ellipsoidal shape, with diameters from few meters to 1-2 km, and a depth of 1-3 m.
In the Central Baragan Plain a number of 387 microdepressions with a medium density of 0.11 depr/km^2, that covers about 5% from plain's surface, it has been determined on topographic maps on scale of 1:50.000.
Parameters like surface (S), Perimeter (P), lenght (L), width (l), have been calculated as weell as microdepression's alignment and different coefficients (indicators of shape).
The microdepressions are concentrated especially in the central-north part of the plain with NNE-SSV and NE-SV alignment.
The investigation shown big differences between the microdepressions from the north side (which overlaps to the Holocene sands area) and those from the Central part of the plain; the first ones have smaller dimenssions, are elongate and a bit sinous, and the latter have bigger dimessions (surface, depth) and round sinous shapes. Also, in the Northern part, the number and density of microdepressions have bigger values.

Introduction

In Romania, microdepressions from the loess covered regions, especially in the Romanian Plain, are described in literature as "crovuri". The studies over these relief forms are focused on two important aspects: 1) morphologically and morphometric description and 2) their genesis.

First references on these microdepressions in the Romanian literature belongs to Murgoci which mentioned with „Câmpia Română şi Balta Dunării" paper (1907), the term "crov" to describe the depressions on plain's surface "caughted between pre-historic dunes". In 1908, in „Raport asupra lucrărilor făcute de secţia agrogeologică în anul 1906-1907", Murgoci says that within the central part of plains in Romanian Plain emerge „ vârtoape, dolii sau crovuri" whose origin can be multiple, because of, and especially because of the existence of some preloessic, as well of soil and subsoil subsidence because of water.

In 1916, G. Vâlsan describes the "crovuri" morphology in Romanian Plain as „light depressions", with a diameter from scores of meters to 2-3 km, at a depth of 5-6 m, whose origin is the subsidence process, influenced by wind.

An important role in "crovuri" studies also has Morariu who sustained, within his paper, issued in 1945, regarding the crovuri from Banat, that the emergence of "crovuri" can be referable to the subsidence process and wind, plus the pre-existing relief morphology and the influence of anthropic activity (Surdeanu, 2003).

If morphometrical description is clear, the "crovuri" genesis is still an open problem. Nowadays, we consider that their emergence is connected with the accumulance and dulnes of water from rainfall, salt dissolution from loess and re-setting of particles, having as a result a smaller volume of the sediment and the issue of an perceptible subsidence of the surface.

As far as the subsidence accentuates, more water gets into intensifying the carbonates solution from loess, as well as material's settle and the microdepression is developing in depth and surface.

This type of microdepressions have also been identified in Europe in loess covered regions, and were named "closed depressions". Their genesis is

related to natural processes (dissolution in subsurface horizon) and anthropogen interventions (digging).

2. The study area

The Central Baragan Plain is also known as the Calmatuiului Plain or the Ialomitei Baragan, considered in geographical litterature the most untypical tabular plain, having a lacustrine or fluvial-lacustrine origin.

The Central Baragan Plain is situated in the south-east part of the country, in the eastern part of the Eastern Romanian Plain and it is overlapp on the Ialomita-Calmatui interfluve.

The meadows of these two rivers represent the plain's southern and northern limits. The other two limits are the Sarata Valley, on the western side and the Danube to the East.

It has a surface of around 3370 km^2 and a light rectangular shape, with a lengt of 90 km and the width of 40 km.

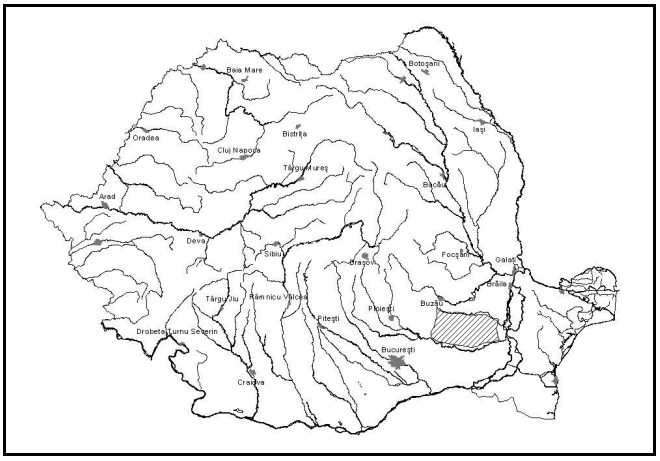

Fig. 1 **Geographical setting of the study area**

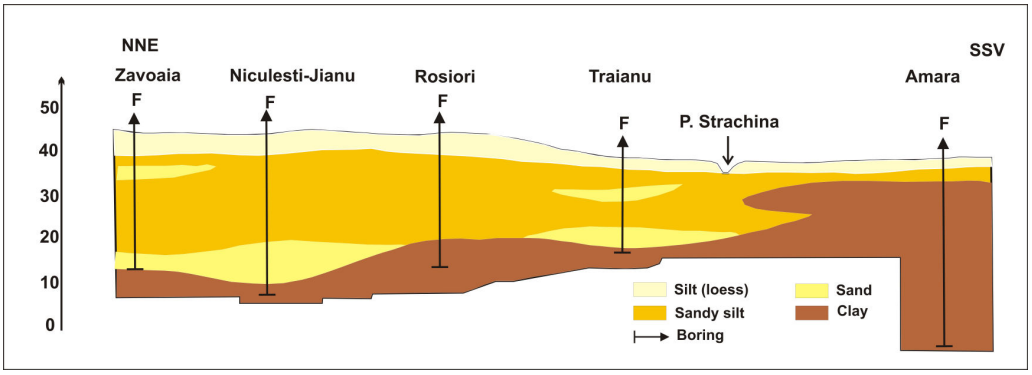

Fig. 2 **Lithological cross-section** (NNE-SSV) **in the Central Baragan Plain**

From the lithological point of view, Central Baragan Plain is made of loess and loessoid deposits which are staying on clay and are covered, in the northern part of the plain, with Holocene sand deposits. The loess deposits who cover all Baragan Plain are named ”the Baragan loess” (Grecu, Demeter, 1997) because their particularity: enrichment in coarser particles which caused material compactation and microdepression forming.

According to the existing litterature (Ana Conea, Nadia Ghitulescu, P. Vasilescu, 1963), within the Central Baragan Plain from the north to the south occurs the following types of superficial deposits: clayey sands with intercalated fine and mobile sand zones, in the northern part of interfluve clay-sand deposits with different percentages of rough sand, on the northern half of interfluve and on the eastern part on the terrace level; silt deposits with diferent percentages of coarse sand, on the southern half of the plain.

The thickness of the loess deposits, grows from the west to East, from 5 to 30 meters northern

from Murgeanca village, and decreases again to the east, to 15 meters; the biggest thickness's in the Nasul Mare - Nasul Mic (20-30 m) zone, and on the interfluve center (Căldărăşti – E Scutelnici – Colelia – Padina zone). Their thickness decreases to 5 meters. In the rest part of the plain the thickess of loessoid deposits is between these two values.

The climate is continental-mild with excessive influences with a big degree of continental weather caracterized by: medium annual temperature with a value under 10.5^0 C in the western half (10.4^0 C at Armăşeşti) and more than this value in the eastern half (10.5^0 C at Griviţa, 10.6^0 C at Mărculeşti). The medium monthly temperatures vary from 22.4^0 C to Armăşeşti and 22.7^0 C to Griviţa for July. And between -3.1^0 C to Armăşeşti and -3.2^0 C to Griviţa for January. Medium annual rainfall is between 450 and 500 mm (478 mm to Grindu, 493 mm to Ciochina, 456 mm to Slobozia).

The natural spontaneous vegetation of the Central Baragan Plain is specific to the steppe area, in the Eastern part and forest steppe in the Western one; The natural vegetation areas has been replaced by agricultural land.

Due to the big homogenity of lithological conditions, the soil cover of the Central Baragan Plain has a small diversification. On the interfluve the cernozems are dominat (calcaric, cambic, gleiyc), which make gleysols, solonchacks, solonetz associations in the central part of interfluve (where the freatic water is situated at small depths, having an influence on soil profile) and with psalmosols (on the right part of the Calmatui river). In the Ialomita and Danube Floodplain predominant are fluvisols (eutric, ethnic) and in Calmatui Floodplain, solonchacks şi solonetz. The texture of the upper soil horizons is mostly loamy and clayey-loamy (in the western part, in the cambic chernozems area).

3. Methodology

Topographical basis started from the topographic maps on 1:50,000 scale since 1970. They have been georeferencied and digitalized with Global Maper and Arcview software and the graph were drawn in Word Excel.

We have mesured the following parameters: surface, perimeter, lenght, width, azimuth and there were calculated more coefficients, indicators of microdepressions shape, whose formulae are shown in table 1. The formulae for circularity and elongation index, that makes refference to the circle shape, as well as the one of form factor, rapported to the square's form have been taken from the morphometrical analysis of hydrographical basins. The sinuosity coefficient has been calculated as a report between the circle's perimeter that has the same surface as the deprssion and the depression's perimeter, having 1 as a refference value, adequately to the circle shape. The non-correspondant values has been eliminated from the analysis.

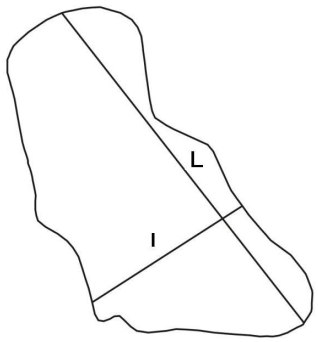

Fig. 3 **Lenght and width measurements**

Tabel 1. **Formulas of the calculated coefficients**

Coefficient	Formula
repport L/l	R = L/l repport between the depressions lenghts of main axis and minor axis
Circularrity repport	Rc = Sd/Sc, repport between depressions' surface and circle's surface with the diameter equal with main axislenght; it is reported to value of 1, adequate to the circle.
Elongation repport	Ra = Dc/Ld, repport between circle's diameter that has the same surface as the basin and the depressions' major axis lenght; it has values between 0.67 and 1.27 for elongated depressions and more that 1.27 for the round ones.
Shape factor	Ff = Sd/L², repport between depressions' surface and the quadratic lenght of main axis, reported to the square's shape, and his guiding mark value is 1.
Sinousity coefficient	Ks = Pc/Pd, repport between circle's perimeter that has the same surface as the depression and depression's perimeter; reported to the circle;s shape, with guiding mark value 1

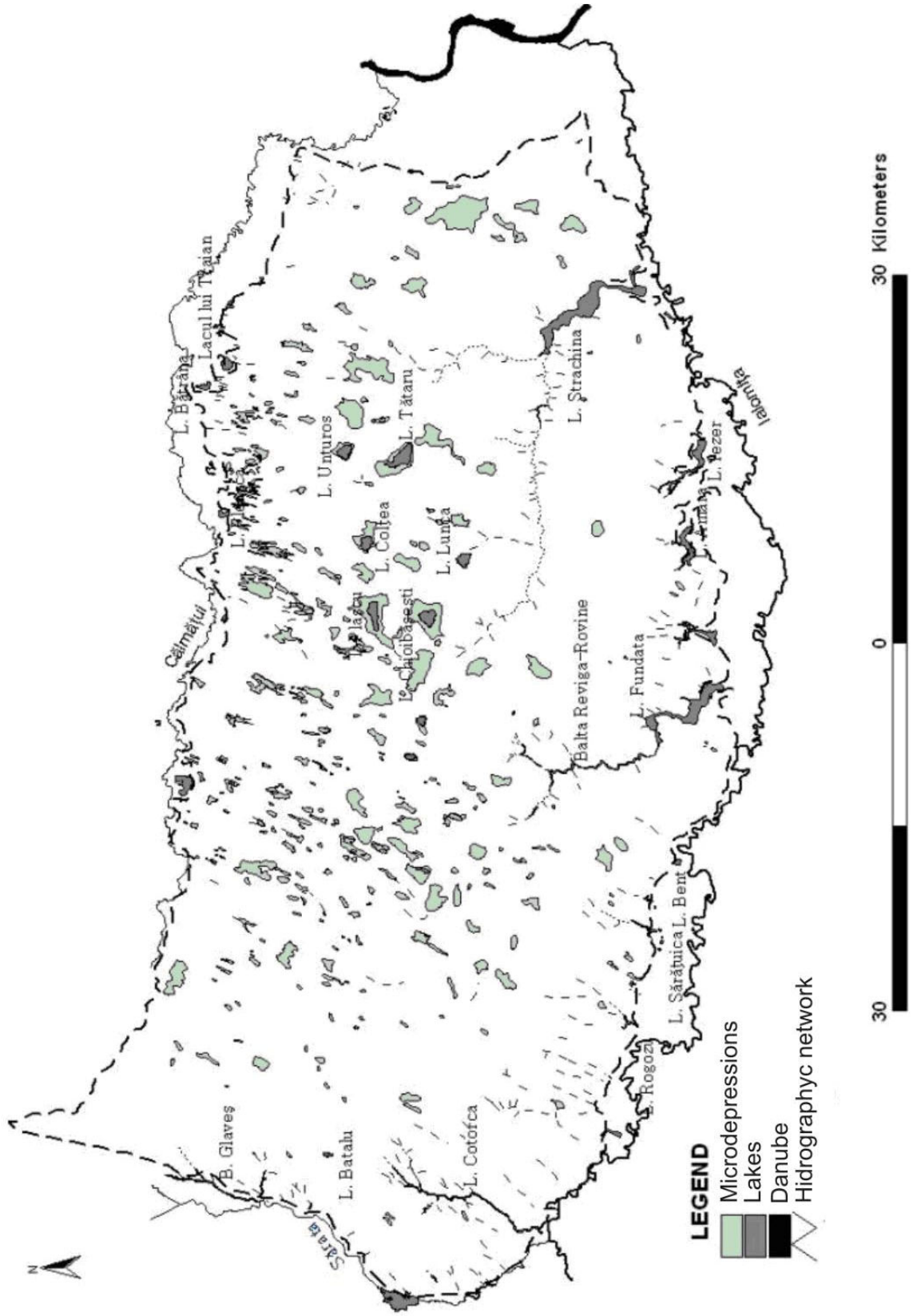

Fig. 4 **Microdepressions in the Central Baragan Plain**

4. Results

The microdepressions from the Central Baragan Plain covers a surface of 170 km^2, (about 5% from plain's surface). We mapped 387 microdepressions, with a medium surface of 0.34 km^2, with a medium density of 0.11 depr/km^2.

Microdepressions are spreaded mostly in the northern and central part of the plain and on Danube terraces and have a smaller frequency in the western and southern outsides.

Biggest densities are seen in Ulmu-Zăvoaia and Pogoanele-Călădărăşti areas, connected by holocenic sand deposits.

4.1.Orientation

Microdepressions predominant orientation is NNE-SSV (57%), followed by NE-SV (18%) direction and N-S (10%). These three directions hold together 85% from microdepressions total (see chart 3). The smallest percentages are detained by (1%), NV-SE şi ENE-VSV orientations, both with 2% şi VNV-ESE, with 3%. (fig. 5).

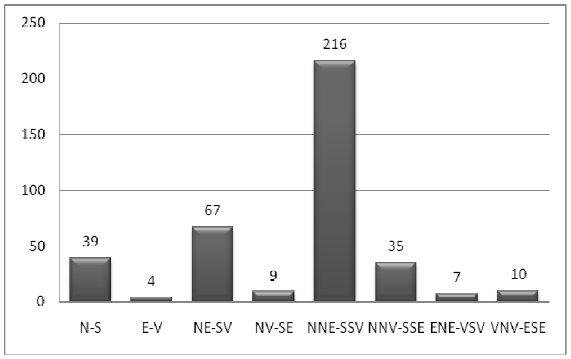

Fig. 5. **Microdepressions orientation**

Tabel 2 **Medium maximum and minimum values, of analised parameters and guiding marks**

Indicator	S (kmp)	P (km)	L (m)	l (m)	Rc	Ra	Ff	Ks	L/l
media	0.34	2.45	935.98	384.32	0.60	0.61	0.31	0.76	2.87
max	2.82	12.47	3652.31	1762.03	0.96	0.95	0.71	0.98	12.95
min	0.01	0.38	148.91	67.10	0.01	0.25	0.05	0.1	0.96

4.2. Surface

The average surface of microdepressions is around 0.34 km^2 (table 2), with a 77% balance under the medium value (microdepressions with a smaller surface, other than 0.5 km^2 hold a balance of 73% - see graphic 4). Microdepressions have bigger surfaces developped in the central part of the plain, where the water is at 3-5 meter depth or under 3 meters, so in most of them in the rainy periods the water stagnates as temporary lakes. The best known and largest lakes are Tătaru, Colţea, Plaşcu, Chioibăşeşti, but these are dry areas during summer.

The medium value for microdepressions **perimeter** is 2.45 km, frequently seen are microdepressions from the 1-5 km interval (65%), followed by the 5-10 km interval ones; microdepressions with the biggest values, over 10 km, are rerely seen (3%). The perimeter is directly corelated with the microdepressions' surface, the repport is 0.86. (fig. 7).

The main axis lenght is about 935.98 m. The extreme values, less than 500 m and more than 2000 m have a percentage of 30%, respectively of 10%, and the middle values, of 500-1000 m and 1000-2000 m sums together 60% of the total number (fig. 6). Microdepressions' lenght values are directly correlated with the surface (R = 0,86) and the width (R = 0,80) (Fig. 7).

Microdepressions' width values (minor axis lenght) is 384,32 meters, the distance 100-500 m is the most frecquent seen (70%). Extreme values under 100 m and over 1000 have 6%, respectively 10% from microdepressions' total. The width varries directly and very tight with the surface, the corellation report is 0,90.

The **depth** varries between 0.30-0.60 cm, for small surface microdepressions, and 4-7 m, for bigger microdepressions, which have temporary lakes inside, such as Tataru Lake (fig. 8), Plascu Lake, Coltea Lake, Chioibasesti Lake.

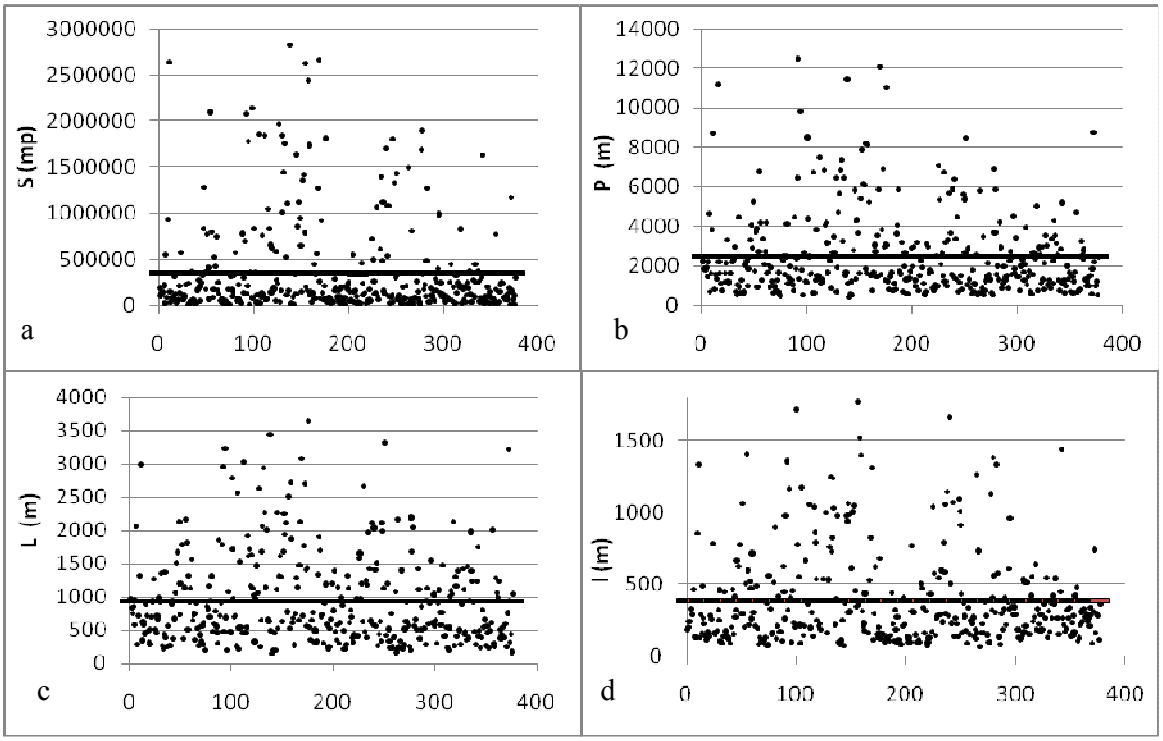

Fig. 6. **Main microdepressions' parameters:** a) Surface, b)Perimeter, c) main axis lenght, d) minor axis lenght

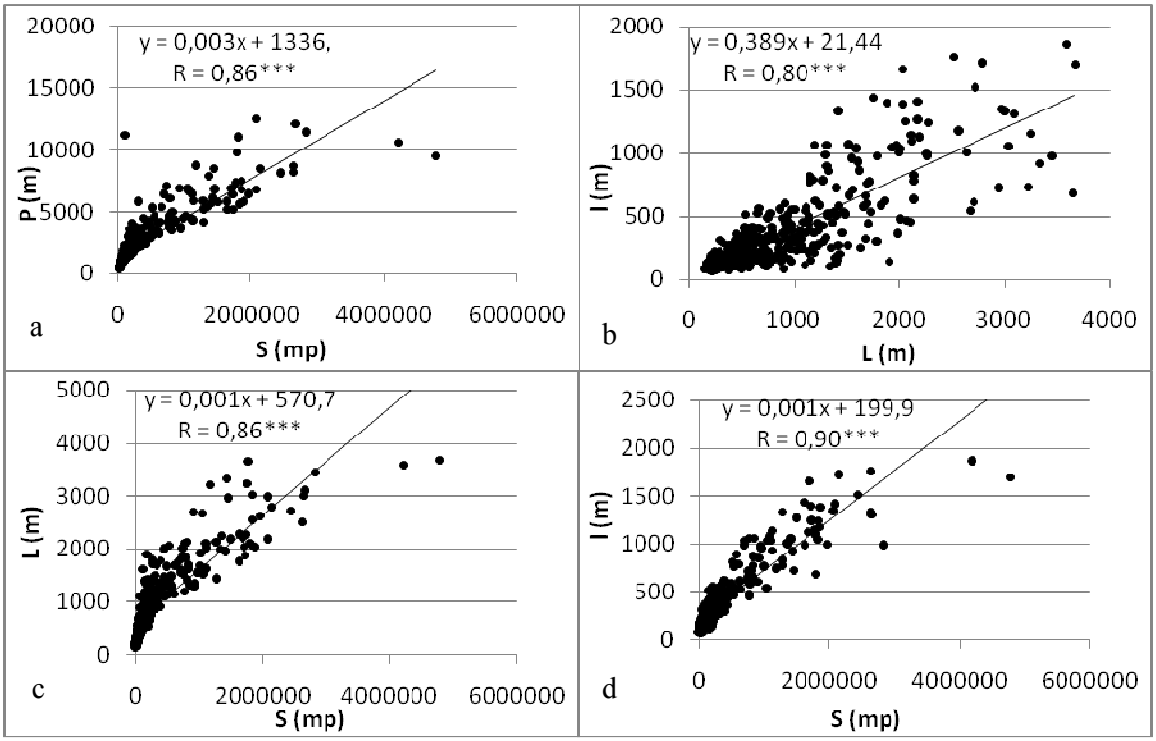

Fig. 7. **Correlation graphic**: a) Surface -perimeter correlation; b) Lenght-width correlation; c) Surface- lenght correlation; d) Surface - width correlation

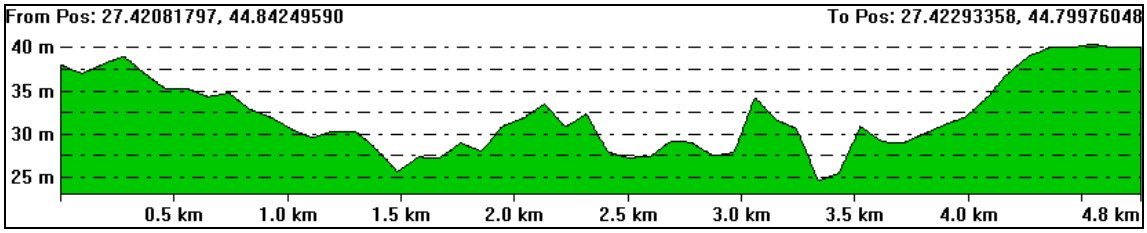

Fig. 8 **Longitudinal section through Tataru Lake** (NNV-SSE)

4.3.Microdepressions' shape

To analize microdepressions' shape there have been calculated indexes (table 1), reported to circles form, respectively to the value of 1. So, the values close to 1 indicates the similarity of a microdepression shape to the geometrical form that is related to (circle or square) and values close to 0 indicate an elongated shape (fig. 9).

Circularity report, which refferes to circle's shape has values between 0.01 and 0.96, and 69% of microdepressions are higher than 0.5. The biggest values of circularity ratio, show, consequently, circular shapes, ang are seen in small surface microdepressons' case. Small values and elongated shapes also have the microdepressions situated in the northern part of the plain.

The elongation ratio varies between 0.25 and 0.95. Microdepressions from the 0.67-1 interval, have elongated shapes, and represents 55,4%. The rest of them are under 0.67.

The shape factor which refers to square shape, has values situated between 0.05 and 0.71, with 93,5% of values under 0.5. So, their shape is different from a square shape, meaning elongated.

The sinousity coefficient, which is reported to the shape of circle too, is between 0.1 and 0.98, with a 94% percent over 0.5, which shows that microdepressions' shape is slightly sinous.

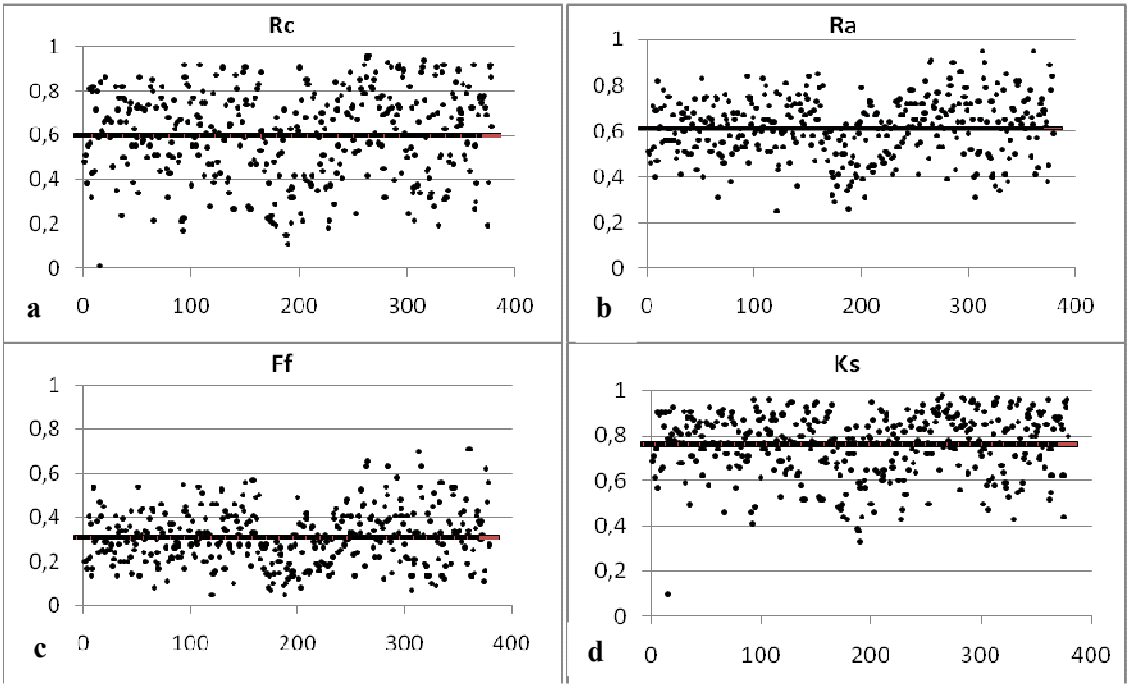

Fig. 9. **Graphical representation of shape indicators**: a) circularity report; b) raportul elongation report; c) shape factor; d) sinousity report

The lenght-width report is between 0.96-12.95, with a medium value of 2,87. 65% from the cases corespond to the medium value. (Fig. 10). The biggest values correspond, generally, to the interdune microdepressions, developed on north side plain's holocenic sands, which are extremelly elongated.

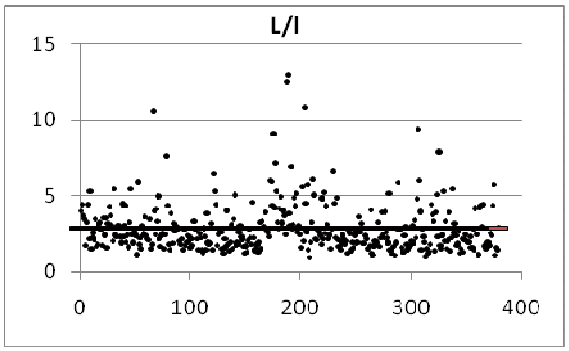

Fig. 10. **Lenght-width report** (L/l)

5. Conclusions

Both dimensions and microdepressions' shape are, mostly, determinated by lithological strata properties. Freatic water and wind also influence their orientation and distribution.

Most of the microdepressions are distributed in the north and the central part of the plain and have a smaller frequence in southern and western sides. Biggest density are found in Ulmu-Zavoaia and Pogoanele-Călărăşti areas, connected by Holocenic sands deposits.

Microdepressions' predominant orientation is NNE to SSV (57%), followed by NE-SV (18%) and N-S (10%)orientations, same as predominat winds.

There are differences between the Northern part microdepressions (superposed to the Holocenic sands deposits area) and those in the central part of the plain. The first ones generally have smaller dimensions, are more elongated and less sinuous, and the latter have bigger dimenssions (surface, depth) and round shapes. Also, in the Northern part, microdepressions' number and density have bigger values.

Generally, microdepressions with small surfaces, under 0.05 km^2 (27%) have almost circular shapes and are not sinuous. The other with bigger surfaces, over 1 km^2 (16%) have complex shapes and a big degree of sinuosity. Elongated shapes, but not sinous, features inter dune microdepressions developed on the northern side of the plain. Their lenght/width report is bigger than 2.

BIBLIOGRAPHY

FLOREA, N. (1970), Campia cu crovuri, un stadiu de evolutie al campiilor loessice, *Studii tehnice si economice*, C, nr. 16, *Studii Pedologice*.Bucuresti, pp. 339-353.

GRECU, FLORINA, DEMETER T., (1997), *Geografia formaţiunilor superficiale*, Ed. Universităţii, Bucureşti, 150 p..

GRECU, FLORINA, PALMENTOLA, G.(2003), *Geomorfologie dinamică*, Ed. Tehnică, Bucureşti, 392 p.

HYATT, J.A., JACOBS, P.M, 1996, Distribution and morphology of sinkholes triggered gy flooding following Tropical Storm Alberto at Albany, Georgia, USA, *Geomorphology*, 17, pp.305-316.

GILLIJNS, KATLEEN, POESEN, J., DECKERS J., 2004, On the characteristics and origin of closed depressions in loess-derived soils in Europe—a case study from central Belgium, *Catena*, Volume 60, Issue 1, pp. 43-58.

MORARIU T. (1946), Câteva consideraţiuni geomorfologice asupra crovurilor din Banat, *Revista Geografică*, anul II, fasc. I-IV, 1945, Bucureşti, pp. 37- 50.

MORARIU T., TUFESCU V. (1964), Procese de modelare în formaţiunile loessoide din sudul Câmpiei Române şi Dobrogea, *SUBB-GG*, I,Cluj, pp. 69 -84.

MURGOCI GH., PROTOPOPESCU-PACHE EM., ENCULESCU P. (1908), Raport asupra lucrărilor făcute de secţia agrogeologică în anul 1906-1907, *An. Inst. Geol*, I, Bucureşti.

TUFESCU V. (1966), *Modelarea naturală a reliefului şi eroziunea accelerată*, Ed. Academiei, Bucureşti, 618 p.

VĂLSAN G. (1917), Influenţe climatice în morfologia Câmpiei Române, D.d.S. Inst. Geol., VII (1915-1916), Bucureşti.

*** (2005), *Geografia României, vol. V (Câmpia Română, Dunărea, Podişul Dobrogei, Litoralul românesc al Mării Negre şi Platforma Continentală)*, Ed. Academiei , Bucureşti, 968 p.

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