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ENVIRONMENTAL SYNERGY IN THE ROMANIAN PLAIN (TO THE EAST OF OLT RIVER)

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Abstract: The objective of the study is the detection of areas and the functioning mechanisms of the oropedo-hydro-geographic and hydrogeologic systems within the Romanian Plain. Geological conditions, especially the hydrogeological ones (groundwater depth and flow) largely influence superficial and underground drainage system. The influence of groundwater dynamics in the padding interfluvial microrelief in direct connection with the thick of loess deposits, is a conditional variable in the occurrence and development of microdepressions towards drainage systems. The analysis of data shows a discrepancy between the supply of the maximum piezometric levels and rainfall, so the groundwater level oscillations are influenced by overlapping rainfall in previous years. To highlight the close link that exists between the microforms of relief and soil covering there have been made correlations between reappearance of padding soils with the distribution of compaction microdepressions. The large arteries assert the direction drainage of the groundwater and the groundwater depth climbs as it bears away from the hydrographic arteries; it results that density relief's fragmentation is directly proportional with the increasing of the groundwater depth.

Key words: Romanian Plain, environment synergy, pading microrelief, geomorphological processes.

1. Introduction

Romanian Plain (Lower Danube) is located in the central-south-east of Europe, the connection with the Black Sea being realized via the Danube River. It corresponds with the accumulation basin within the Carpathian-Balkan mountain arch, being a Quaternary fluvial-lake plane (Fig. 1). Subaerial modeling took place in distinct phases, which imposed various relief, manifested by individualization of several genetic types of plains.

The orogen units situated to the north (Carpathians and Subcarpathians) and the south (Balkans) of that depression influenced the hydrogeological regime of the field by the type of the deposits accumulated in the immediate connection units (gravel of Candesti, gravel of Fratesti), by the position and by the relative high flow of the phreatic water. This is reflected in the high density of drainage network of some sectors of plain (Grecu et al. 2006, 2007). To the south, the Danube, individualized in different stages of time, along with the withdrawal of Pleistocene Lake by E and NE, has contributed to the genetic variety of plain and imposed the general orientation of the hydrographic network (Valsan,1916; Cotet, 1976; Posea, 2002). Also, the Danube river is a major factor in the dynamics of the rivers: the small, young, indigenous to the plain ones (Mostistea, Calmatui), and those allochthonous that cross the plain (Olt, Arges, Ialomita, Buzau).

The neotectonics, manifested in the north-east through movements of different intensities or local

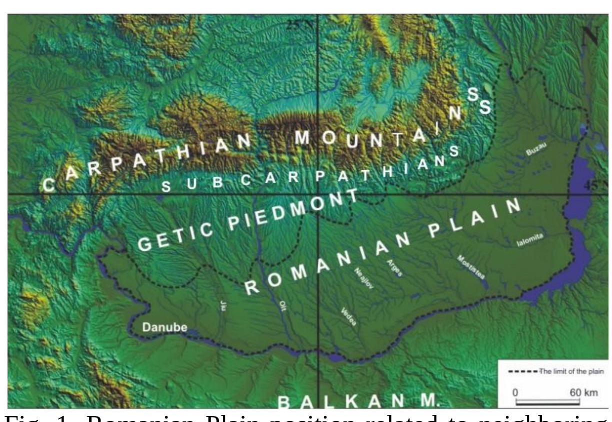

Fig. 1. Romanian Plain position related to neighboring units.

subsidence, is reflected in the morphohydrographic dynamics of the plain as convergence area of the network basins and small depths of the groundwater (0-2 m).

The anthropogenic intervention led to extensive changes in dynamics and drainage regime of the rivers, as well as in the interfluvial hydrophreatic system dynamics (through irrigation), something which is not subject to this study river-interfluve synergism.

Due to these factors, within the Romanian Plain (to the east of Olt River) have been identified the following types of areas according to the interdependent relationships between environmental factors, especially according to:

1. Sectors with high density of river network (between Olt and Arges) imposed by rich aquifers of piedmont deposits.
2. Areas with low density of river network but with common down-sagging processes (Ciornuleasa Field, Burnazul Field);
3. Interfluves with microdepresions of down-sagging and pipping, some of them lacustrine (Baragan Ialomita);
4. Sectors with typical landforms of the Bend glacis.
5. Lower Siret Plain - specific subsidence river-beds forms.

2. Objectives, materials and methods

The main objective of this study is the detection of areas and the functioning mechanisms of the oro-pedo-hydro-geographic and hydrogeologic systems within the Romanian Plain (to the east of the Olt River). Analytical approach focuses both on the indicator elements (morphometric, morfographic, pedological) and the factor elements (geological data, hydrogeological, climatic, hydrological). Based on field mapping, synthesis reveals specific forms of relief. Conception and systemic approach is supported by the geomorphological one, by the observations and by mapping field.

2.1. Sources and materials

Thematic maps at different scales:

- Hydrogeological map, scale 1:1000000, Liteanu E. 1969;
- Geological map, scale 1:200 000, State Committee of Geology
- Soil Map, scale 1:200 000, L- 35- XXXIV, Calarasi, Institutul Geologic, Comitetul Geologic, Bucuresti
- Topographic maps (scale 1:100000, 1:50000, 1:25000), orthophotomaps (scale 1:5000).
- Data recorded at weather and hydrometric stations;
- Groundwater measurements in wells and field observations (2004-2009).
- ArcGis-ArcMap/Gis, 70 Stereograph projection, Datum S_42 ROMANIA, SRTM (Shuttle Radar Topography Mission) or Corine Land Cover.

3. Results

3.1. Geological and hydrogeological features

Geological conditions, especially the hydrogeological ones (groundwater depth and flow) largely influence superficial and underground drainage system. Deposits characteristic to the central sector of the Romanian Plain (between Olt and Arges) are composed of porous permeable rock, respectively Pleistocene gravel and sand (Fig. 2). Candesti layers, characteristic to the Getic Piedmont, continue on relatively small areas in the field, especially at the contact Piedmont-plain. They are river-lake deposits, composed of stacks of tens of meters of gravel in alternation with marl-clays and sands (Fig. 3). In Piedmont, the groundwater is located at more than 50 m depth, due to gravel. Groundwater drainage to the contact with the plain and within the plain leads to psephitic deposits saturation. Aquifers layers appear as springs that feed rivers in the plains (Liteanu and coord. 1969) (Fig. 2).

Fratesti layers to the south of the alignment Pitesti-Slătioarele, are found in loessic deposits at depths of 20-25 m (Bandrabur 1968). The groundwaters at these depths have free hydrostatic level and flowing from northwest to southeast is consistent with the hydrographic network (within the plain between Olt and Arges).

To the east of Mostistea sands with middle granulation appear, the hydrostatic level ranging between 5 and 20 m being influenced by the presence of sandy clays intercalated in the sands complex (low flow, below 1 l/s) (Fig. 2).

In the Central Bărăgan the Sands of Mostiştea composed of fine sands, pass in clay sands on the east and northeast. They have been encountered in wells in the south of the interfluves Ialomita - Calmatui. Region's counterpane is made of loamy textured deposits with different percentage of sand (loess and loessic deposits), in the southern half of the region and deposits with texture ranging from

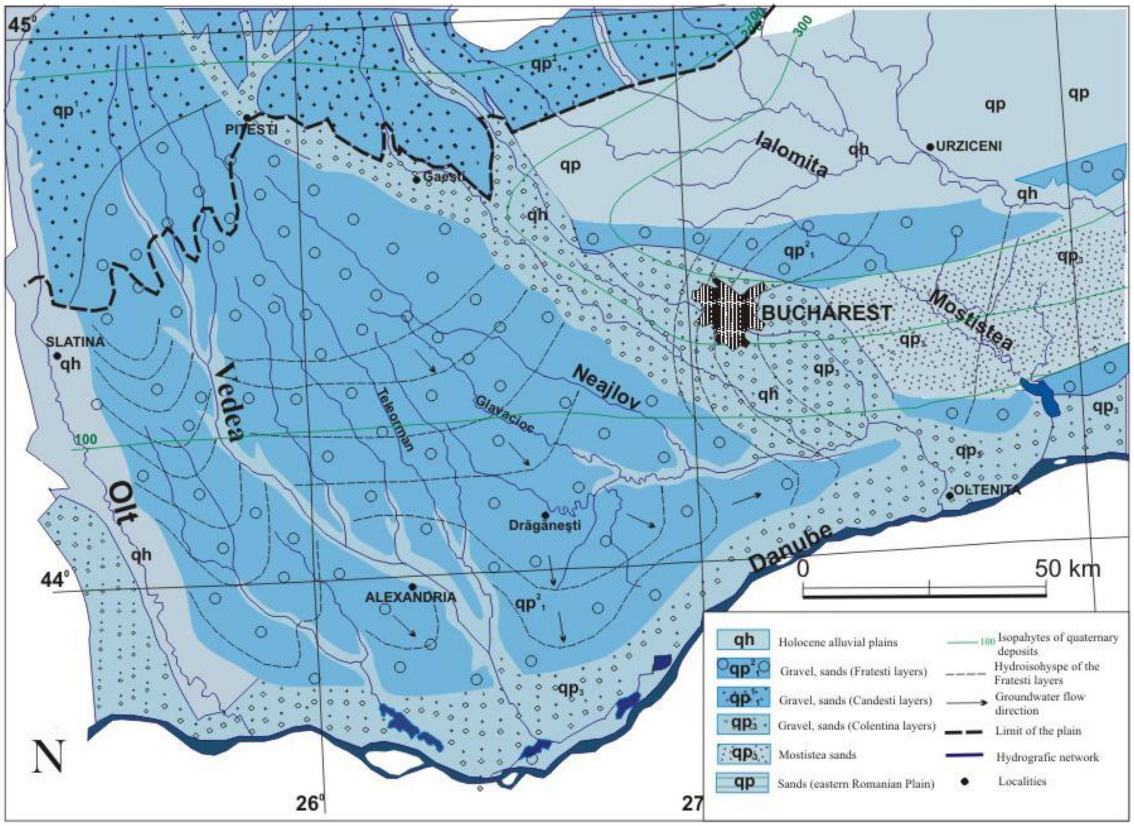

Fig. 2. Romanian Plain to the east of the Olt river. Hydrogeological map (after the *Hydrogeological map*, 1:1000000, E. Liteanu et. all, 1969).

sandy clay to loamy sand and sand (loessic deposits and sand) in the southern part (Tenu et al. 1989) (fig. 4). Under these conditions, the rivers feeding are done in moderate proportions from ground, but considerable for a flat unit. This presents significant variations from west to east (20-25% for Vedea and Neajlov, 15% for Mosti-stea). Rivers in the central plains (Vedea, Neajlov) are characterized by a dense network of drainage (4-6 km/km2). In the eastern sector, however, presents reduced network density (in the Mostistea basin is 0.14 km/km2) (Grecu et al., 2009b).

The hydrographic network is conditioned by geological structure of the Quaternary formations of the plains. The general inclination of the piezometric slope is strongly related to individualization of the hydrographic network: from north to south in the central and east-west (towards the Danube) and even from southwest to northeast in the eastern sector. In periods with excess moisture the levels of groundwater in the northeastern plain grow up near the surface causing flooding in appreciable areas, both in the valley along the corridors and on interfluves (Gastescu et al., 1979; Bogdan, 1979).

Types of groundwater regime in the East Romanian Plain:

¬ fluvial type in river flood-plains, with large amplitudes in normal years and very high in rainy years, returning every year at the same minimum level;

¬ piedmont type in piedmont plains, with large amplitudes (1-3 m) and annual return of the minimum levels around the same level as determined by high permeability of the covering deposits and a good drainage;

¬ divagation plains type, with medium amplitudes (0.5-1 m, rarely 2-2.5 m), with a slight increase of the minimum level in rainy years;

¬ Central Bărăgan type, met in Central Bărăgan, NW of South Bărăgan and in South Bărăgan, west of Ianca Valley, with average annual amplitudes of 0.5-1.5 m and a continued increase of the minimum level in consecutive rainy years, growth that exceed a little the range rainy years;

¬ South Bărăgan type, with a continuous increasing level without annual swings or with very small oscillations, growth that exceeds a lot the rainy consecutive years intervals; this can be meet also in the eastern part of the North Bărăgan.

Fig. 3. Gravels of Candesti in an opening at Milcoiu on the left slope of Topolog (foto 2009).

3.2. The morphology of the drainage network

The inter rivers Olt-Arges is fragmented by a rich local hydrographic network, tributary to Arges, Olt, and Vedea (partially native river, with springs in the Getic Piedmont) (Fig. 5). The rivers have their source in alluvial deposits (alluvial cones of the large rivers, at the exit of the Piedmont or Sub-carpathians). For the rivers in the upper sectors of the confluence report presents high values (6.63), leading to a high magnitude in the Horton-Strahler scheme (5,6,7), atypical situation for river plain. For example, in the superior sector, Neajlov, of order 4, is made in terms of number of river segments (I_N = 105%), but under-realized from the length of river segments point of view (I_L = 59%) and also from the average length of river segments point of view (I_l = 56%) (Grecu et al.2009b).

The sub-realization of the lengths sum gives the torrential character of the rivers' segments, most of which are segments of order 1 and 2, respectively glens and gullies, with average lengths between 1 and 4 km, with intermittent flow, whose occurrence is mainly due to geological substrate (sedimentary deposits, friable, poorly consolidated: sand and gravel terrace of Arges - T_2, T_3, loessic deposits, loess) and to modeling processes (rain wash, pouring, down-sagging and pipping).

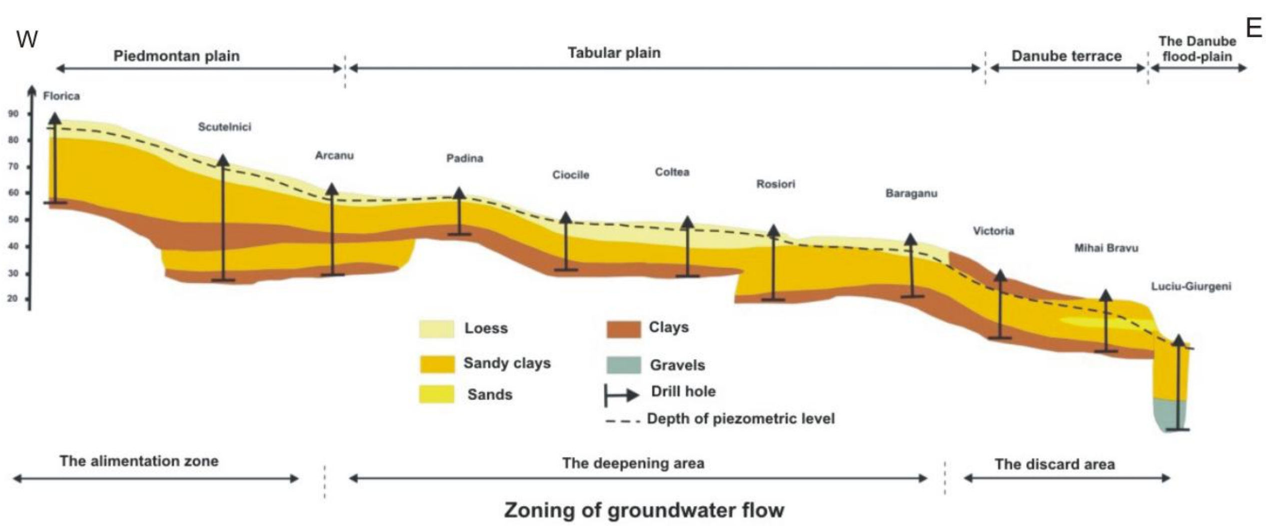

Fig. 4. Hydrogeological transverse profile in the Central Bărăgan Plain on the direction W-E (after Tenu S., Frugina E., 1989).

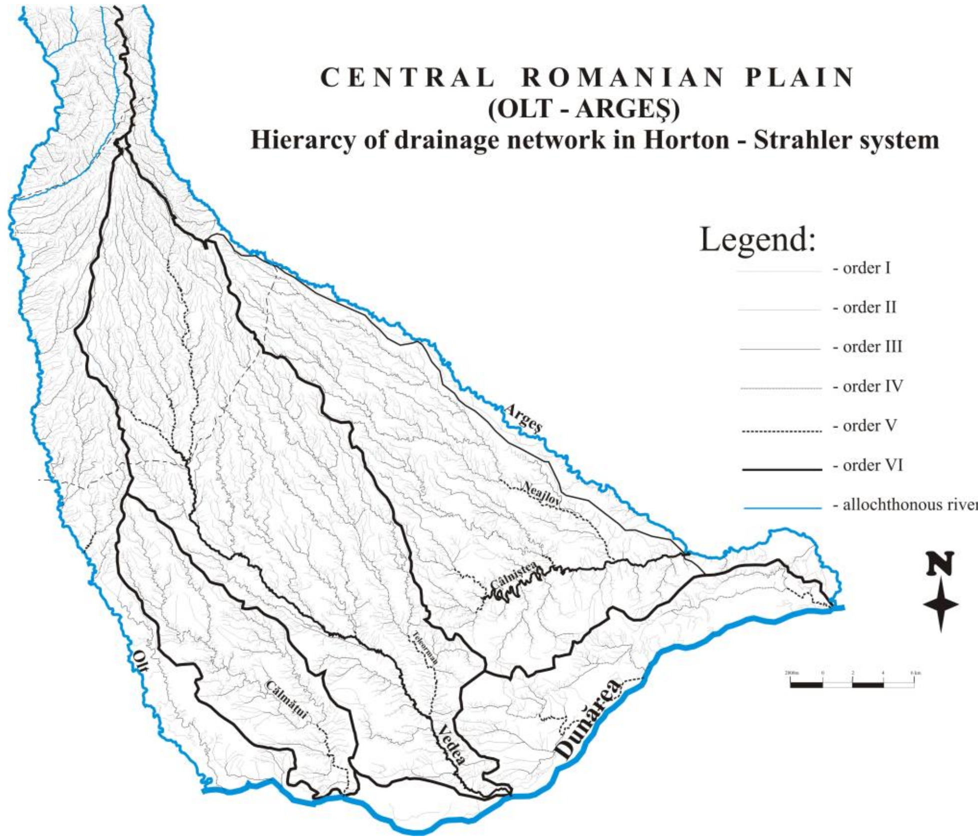

Fig. 5. Olt-Arges sector. The chain of the hydrographic network on Horton-Strahler system it can be observed the high density of the drainage network.

As it regards Cotmeana River a tributary of Vedea in the superior course) with spings in the Piedmont, it should be assessed as a contact river, the medium and the inferior sectors belonging to the plain. On entering the plain, in the basin Cotmeana can be observed a line of springs, making the largest partial confluence report $R_{C_3} = 7.4$.

3.3. The pading microrelief

The influence of groundwater dynamics in the pading microrelief on the fields (inter rivers), in direct connection with the thick of loessic deposits, is a conditional variable in the occurrence and development of microdepressions towards drainage systems.

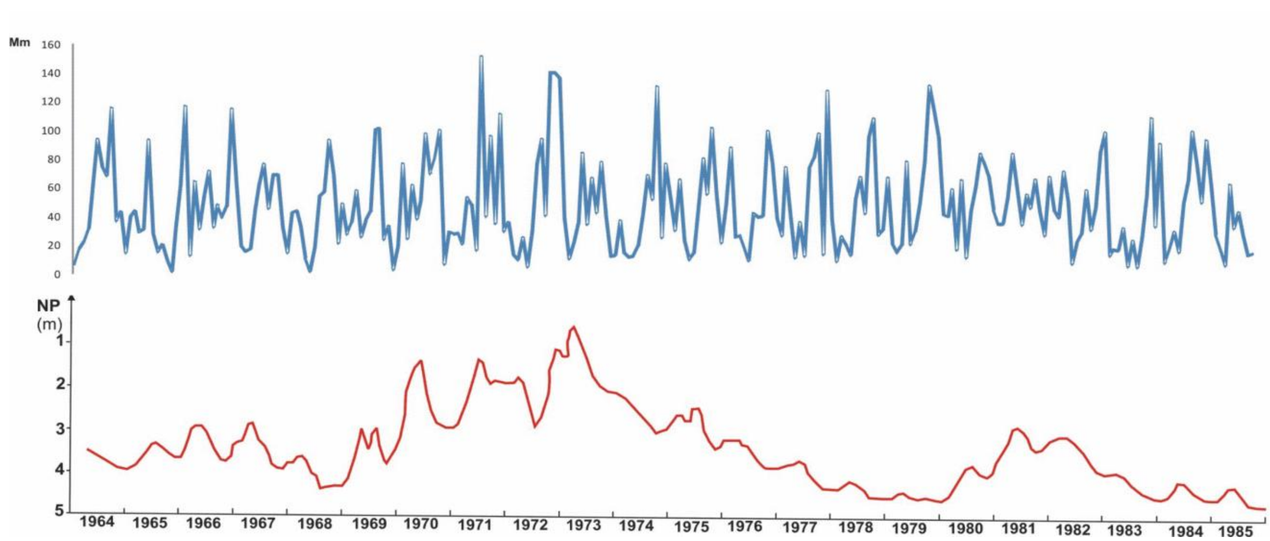

Fig. 6. Relationship between changes in the piezometric level in Grindu area (source's datas Tenu S., Frugina E., 1989) and average monthly rainfall values (station Urziceni) (source data: ANM).

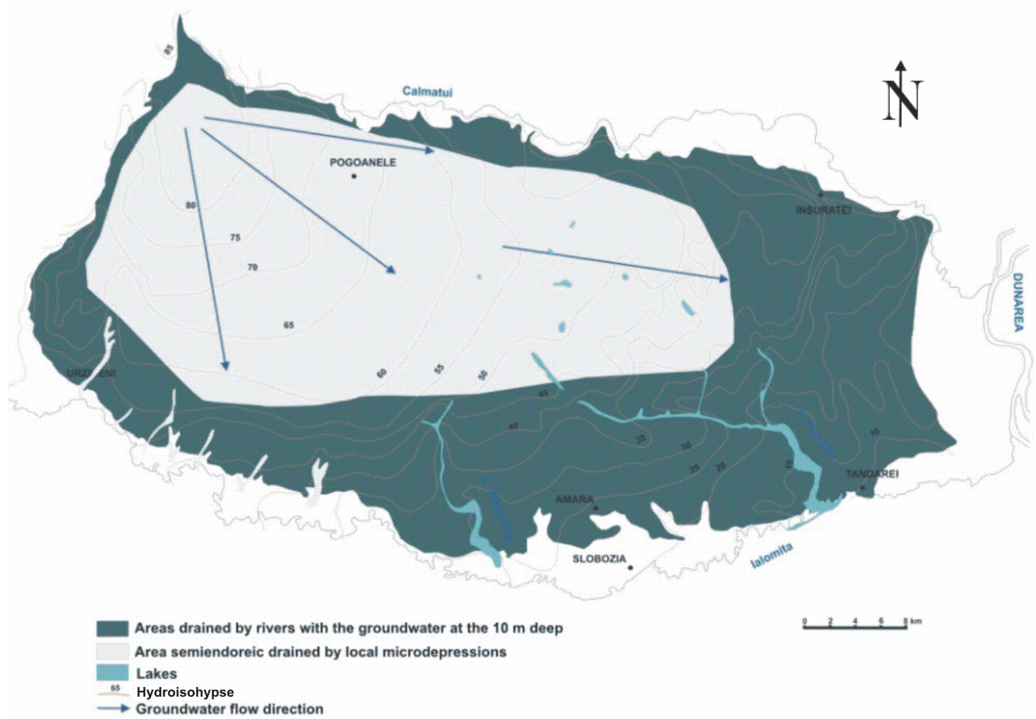

Fig. 7. The general direction of the groundwater flux within Central Baragan (after Florea N., 1976, with modifications and completions based on researches in the field)

In the Central Bărăgan, for example, the main feature of the groundwater system is the very slow horizontal flow, which favours the growth of the salts and raising the hydrostatic level (Florea 1970). The phreatic water is found below the surface of 2-5 m in the central part of the plain, while in the northern, eastern and southern falls to 5-10 m depth, even 15 m, due to the action of draining of Ialomita, Calmatui and Dunarea rivers . The hydroisohypses have general West-East direction, with a slight orientation towards South-East due to strong action of drainage of Ialomița. The cuvettes and the drowned rivers work as natural drains, collecting groundwaters from a small area, water gradually evaporates, increasing the salt concentration of lakes.

The analysis of data shows a discrepancy between production of the maxims piezometric levels and rainfall, so the groundwater level oscillations are influenced by overlapping rainfall in previous years (Fig. 6). The large and sudden level variations of the rivers and the high rainfall determine high variations of the subteran drainage, that draw te sagging of the deposits from above. The general direction of groundwater flow is from NW to the south and east, from intense supply areas in the northwestern and central towards unloading areas. Groundwater flow follows, in general, the direction of decreasing energy relief. In western Central Baragan the underground flow is radial, the download being toward Ialomița, Sărata and Călmățui and in east flow gradually becomes a west-east direction, towards the Danube (Fig. 7).

The high loessic deposit thickness and the great depth of groundwater have led to the apparition of microdepressions with small areas and circular forms, without irregularities (low sinuosity coefficient). The ratio between length and width exceeds the value 2, and the general orientation complies with the general direction of the wind direction and the isopahcytes. Depending on the particular morphohydrogeological features, in the Central Bărăgan (Fig. 8) were identified:

- ***microdepressions with vertical circulation of the water*** (water aquifers at great depth -10-15 m and great thick of loess), circular or elongated, occur in the southern plains, between the valleys Strachina and Fundata. In these depressions the groundwater flow is predominantly downward, the carbonates and the soluble salts are washed from the soil, and the main consequence are the reducing of the total mass of the material and the particles' compacting;

¬ ***interdunes microdepressions*** (at the contact between loess and sand), with excess moisture and accumulation of salts; the low depth situated

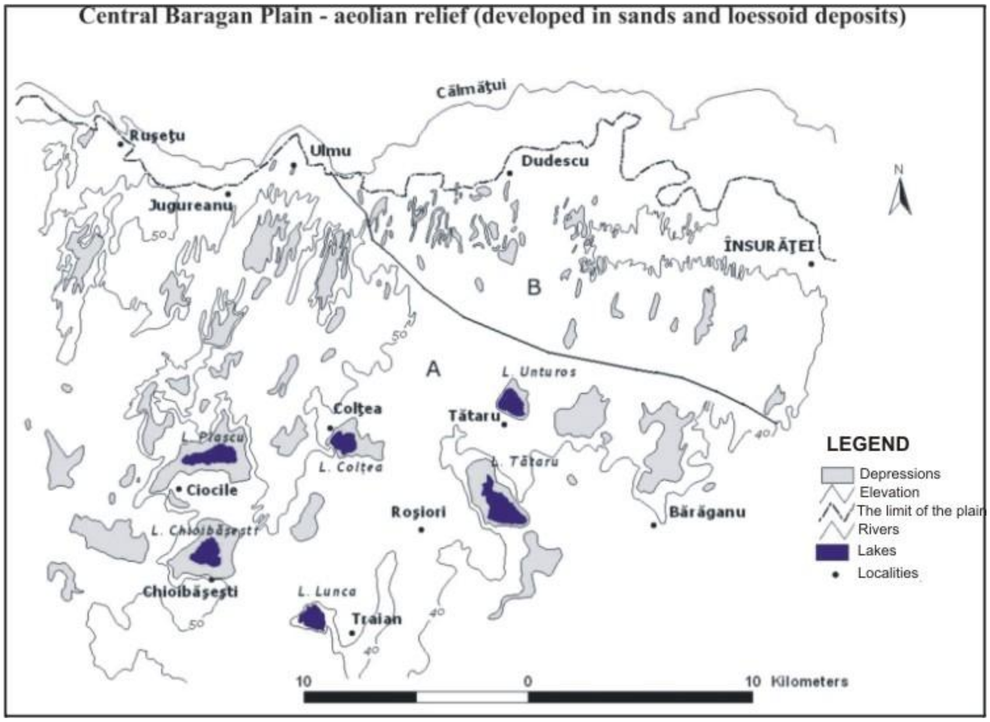

Fig. 8. Central Baragan Plain. Eolian relief (developed on sands and loessic deposits) (after *Topographic map* 1:25 000, *Ortophotoplans* 1: 5 000 and researches in the field).

groundwater intersects the bottom of the depressions, where temporary lakes can even install and water flow is predominantly upward; in dry periods, slightly mineralized groundwater that rises to the surface by capillarity evaporates and contained salts precipitate out, forming crusts of salts;

¬ ***microdepressions with groundwater at 0-3 m, with lakes***. They have large areas and depths of 5 meters and they are situated in the perimeter Tătaru-Ciocile-Traian. Due to large depth in rainy periods the groundwater level rises above the bottom of the depressions, forming lakes (Tataru, Ciocile, Plascu, Chioibăşeşti);

¬ ***low depression areas, with groundwater at 5 m***, that appear in the west of the plain, the area Brădeanu-Glodeanu Sărat-Florica, and in the center, in the area Scutelnici-Cocora-Padina. They have depths of several tens of cm, and during periods of excess moisture can turn into swamps.

¬ ***microdepressions at the contact between terrace and field,*** developed mainly at the contact with the Danube terrace.

¬ ***microdepressions at the contact between terrace and flood-plain***, very numerous, whose development was influenced by human activities (creating holes for exploitation of sand and clay).

¬ ***microdepressions formed at the confluence between the secondary valleys with Ialomita (lake cuvettes)***, formed by sluicing the discharge with materials submitted by Ialomita, behind which formed lakes (drowned rivers). In these valleys there were built human dams for use in agriculture.

3.4. Oropedogeomorphologic report

The correlation between the edaphic and morphologic element may be an important variable in identifying the stage of development, age and current dynamics of the relief interfluves forms. The depressions' microrelief creates conditions for diversifying the edaphic covering where the genetic area type is the chernozem. The great quantity of water that accumulates in depressions, due to internal and external drainage, causes a dampening more pronounced here than on tabular relief and the appearance of eluvium soils (Ghita, 2009).

To highlight the close link that exists between the microforms of relief and edaphic covering there have been made correlations between reappearance of padding soils (cambic and argillic chernozems in paddings and padinies, respectively cambic and phreatic-wet argillic chernozems in paddings and

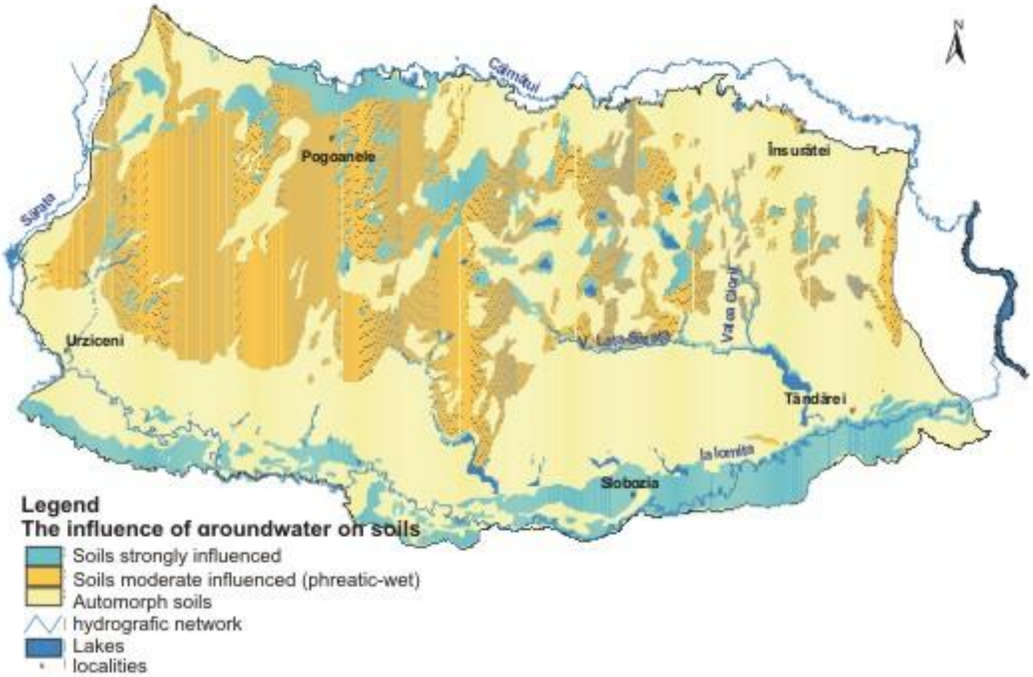

Fig. 9. Central Baragan Plain. Oropedologic relations (after *Topographic map* 1:25 000, *Soil map* 1:200 000, *Calarasi*, and researches in the field).

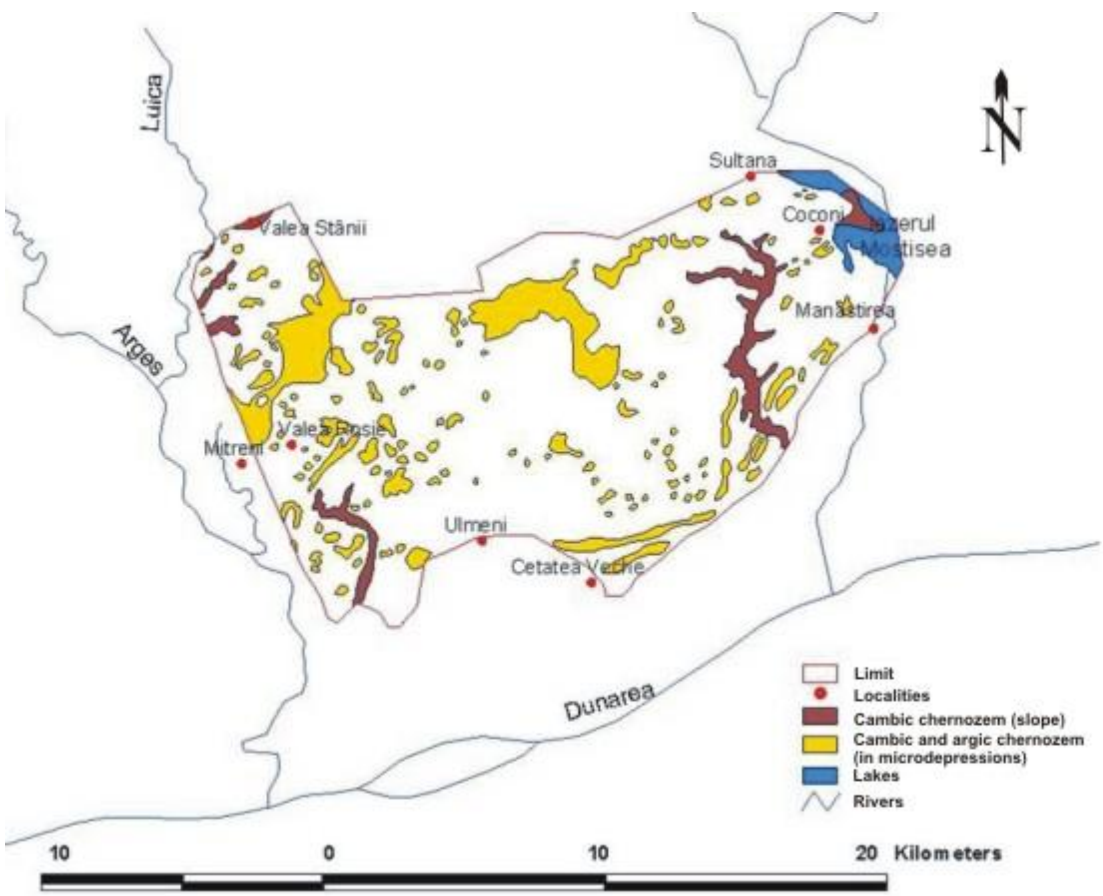

Fig. 10. The Sector Mostiştea-Ulmeni (Arges-Mostistea intefluve). Oropedologic relations (after *Topographic map* 1:25 000, *Soil map* 1:200 000, *Calarasi*, and researches in the field).

padinies and tableland, that chernozems argiloiluviale bill and phreatic-wet, in Crovurilor and tableland) (Fig. 9, 10) with the distribution of compaction microdepressions (Florea et.al. 1959; Florea 1970, Florea, Vespremeanu, 1999).

Thus, the upward movement of water from the profound layers towards the surface, rarely occurs, in short periods of the year, or not at all; therefore, no longer soluble salts are transported to surface by capillary rise of the water. In this way, the carbonates (hardly soluble salts) are at a greater depth as the depression is deeper and provides conditions for accumulation of water here in larger quantities and thus a worsening aerohydric regime, with negative consequences on fertility soil (Chitu, 1975). Parallel to the process of eluviation and podzolization of the soils from padings, there is also a compaction of the mineral material.

4. Conclusions

It can be ascertain the poly-and multi-genetic feature of the padings, the final causal process constituting the compaction in deposits with high porosity.

- In areas with the deep groundwater chemical compaction prevails due calcium carbonate dissolution (eg the central part of Ialomita Baragan, Mostistea Baragan);

-Where groundwater is near the surface, the slope changes of leakage (surface and groundwater) the compaction due hydrodynamic pipping dominates (eg Ialomita Baragan, the northern part);

- The large and sudden variations in level of rivers determine the groeth of the underground drainage and in its turn it determines the pipping of the above deposits. This is the case of the padings and padinies aligned along some glens (eg Mostistea Baragan);

- The large arteries assert the direction drainage of the groundwater and the groundwater depth climbs as it bears away from the hydrographic arteries; it results that density relief's fragmentation is directly proportional with the increasing of the groundwater depth (ex semiendoreic areas of Central Baragan, Mostistea Baragan);

- Groundwater near the surface contributes to the increasing of the intensity of compaction processes (by decreasing the porosity of loessoic deposits), and also to the emergence of numerous springs that influence the high density of river network (the Romanian Plain between Olt and Arges);

- The indicator elements of changes occurred in relief are soils. The soils from the areas with paddings are diversified in small spaces, although it's a plain unit;

- Local peculiarities are due to synergetic relationships between groundwater and the hydrographic network, and between them and the interfluvial dynamics, in addition with the type of rivers feeding: pluvial-nival and underground;

- On a relatively small area there is a great diversity of these relationships that are connected by the general palaeogeographic evolution of the region (Grecu et al. 2009).

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