THE SECTOR OF FLUVIAL LIMANS IN THE SOUTHWEST OF DOBRUDJA – GENESIS, MORPHOGRAPHIC AND MORPHOMETRIC FEATURES

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ABSTRACT. - The sector of fluvial limans in the southwest of Dobrudja – genesis, morphographic and morphometric features. The fluvial limans in the southwest of Dobrudja are the most typical forms of this kind found exclusively on the Romanian territory. Based on the morphometric records and on the interpretation of the geological deposits, the aim of this study is the genetic exploration of the lake within the southwest of Dobrudja. Throughout time, they have been interpreted as fluvio–maritime or even fluvio–lacustrine limans. The altimetric and granulometric records and their shape include them in the category of typical fluvial limans. Their subsequent evolution has led to significant clogging and to a decrease in the depth, caused by the strong erosion specific to excessive continental climate and to inadequate farming. The most interesting erosion processes – concerning the current shore – are governed by suffusion and lake erosion (through waves). The superficial deposits – loess and of a loessoid type – have a NW–SE wind-driven nature, just like those in Bulgaria; this is why they have managed to create accumulation levels included in the category of “constructed rasa”.

Keywords: fluvial limans, genesis, current geomorphologic processes, loessoid deposits, suffusion

1.INTRODUCTION

As these fluviatile limans were interpreted to have other origins along time, we have tried, by offering geomorphologic proof, to demonstrate that their origin is not marine or lacustrine, but purely fluviatile. This thing is important for the continuity of the fluviatile life within this aquatic biotope. At the same time, special attention was given to the evolution of the lacustrine cuvette through the geomorphologic processes occurring here and influencing water quality.

Only the big size and the economically important lakes were considered: Bugeac (Gârlita), Oltina, Dunăreni (Mârleanu) and Vederoasa. Bugeac Lake, also known as Gârlita, Oltina lake included another enclosure known as Iortmac, Dunareni lake, known as Mârleanu, has in its upstream cuvette a small size lake known as Beilic and Vederoasa lake has, in its north-eastern sector another small size cuvette known as Baciu. For a good correlation with data previously obtained and a full analysis of morphological traits (morphography and morphometry)

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in specific lakes, wide-ranging international and national sources have been consulted: Banu,1966; Basarabeanu, 1969; Conea, 1970; Coteţ, 1966, 1969, 1978; Dumitrescu-Aldem, 1911; Gâştescu, 1959, 1971; Iancu and Iana, 1969; Ionesi, 1994; Popovici et al., 1984; Romanescu et al., 2010; Rozycki, 1967; Tufescu, 1966.

2.GEOGRAPHIC LOCATION AND LIMITS

The Danubian fluvial limans in Dobrudja occupy its southwest side and they are situated between the State border with Bulgaria (to the south) and the locality of Cernavodă (to the north). The most important such forms are represented by the limans of Bugeac (Gârliţa), Oltina, Dunăreni (Mârleanu), Vederoasa, Baciu, and Cochirleni (Fig. 1).

3.METHODOLOGY

The purpose of this study was to interpret the old hypotheses and to adjust them to a new vision on the genesis and evolution of fluvial limans in the southwest of Dobrudja. In order to support these interpretations, a correlation was attempted between measurements and detailed analyses on the morphometry, on the origin of terraces and of – lake or fluvial – levelling stages, on the origin of the loess or loessoid deposits, through a granulometric and mineralogy analysis, as well as by mapping the highly-erodible slopes (mostly the ones affected by suffusion and by the action of lake waters, etc). The data were obtained through measurements on the topographic maps, on the satellite images, on orthophotograms, as well as through field measurements, using the total station and the GPS. The granulometric and mineralogical analyses took place in the laboratories of the Faculty of Geography and Geology in Iași. All the data obtained in the field and in the laboratory have been confronted with those within the specialized literature (extremely rich otherwise, but still waiting certain confirmations or closures for various overall interpretations).

Fig. 1. ***Geographic location of the four fluvial limans in the southwestern sector of Dobrudja***

4.RESULTS

4.1.Geologic features and their implications on the genesis and evolution of lake basins

From a structural perspective, Dobrudja is divided into three morpho–tectonic units: Northern Dobrudja, Central Dobrudja, and Southern Dobrudja. The three sectors are separated by the faults of Peceneaga–Camena and Capidava–Ovidiu. Unlike the two orogenetic units in the north, Southern Dobrudja has a plateau-specific relief, with quasi–horizontal surfaces, with a foundation down to over 1,000 m, made of green schists, folded during the New Assyntian and the Old Caledonian orogenies. The Upper mid-Jurassic and Lower Cretaceous are present through formations jammed among large folds. There are also a series of angular discordances between various structures, because of the pre-Austrian, Austrian, and Laramian movements. Starting with the Sarmatian, raising movements of Southern Dobrudja were registered; at the end of the period, the entire region was above the sea level.

Southern Dobrudja – part of the Moesian Platform – had a geologic evolution similar to the one of the Walachian Platform. The differences reside only in the lack of certain formations and the presence of others. As for the tectonic aspect, it represents an elevated compartment, which allows the unveiling of older deposits, starting with Eo-Cretaceous. The platform of Southern Dobrudja is situated between the Massif of Central Dobrudja to the north, the Walachian Platform to the west, the platform area of the Black Sea to the east, and the State border with Bulgaria to the south. The delimitation of the Walachian Platform from the Platform of Southern Dobrudja occurs along a fracture parallel with the Danube (Ionesi, 1994).

The foundation represents an elevated area in the direction of the Capidava–Ovidiu fault. It is compartmented into blocks falling westward. The most significantly elevated sector is represented by the Palazu block. The rocks belong to three distinct groups, separated through discordances (Ionesi, 1994).

a. The Ovidiu group starts from -950 m, at the level of the Palazu Mare point and from -1,750 m at the level of Cocoşu. This group contains microcline granite gneisses, crossed by pegmatite lodes, open on a 600 m-thick surface. The absolute age of 1,670–1,850 million years is believed to reflect the metamorphism age for the new group of Palazu. The gneisses in Southern Dobrudja bear striking similarities to those within the foundation of the Moldavian Platform, which denotes that – during the first stage – the Moesian Platform was embedded in the East European Platform.

b. The Palazu group is discordantly shaped on top of the granite gneisses, and the thickness ranges between 500 and 1,100 m. Two formations emerged: the first is lower, made of amphibolites (quartz–amphibolites, amphibolic and pyroxenic mica schists with or without garnets, and rarer limestones, dolomites with silicates, siliconites), bearing ironstones. The upper formation is made of mica schists with andalusite, almandine, and sillimanite. This group is equivalent to the one of Krivoi Rog, as it was metamorphosed during the Svecokarelian orogeny. The retromorphism is significantly more recent, probably contemporary with the green schists specific to Central Dobrudja.

c. The Cocoşu formation contains ankimetamorphic schists discordantly distributed on top of the Palazu group, represented by volcano–sedimentary rocks. Within the base, it contains spilites and pyroclastics, associated with arkosic sandstones, while in the upper side it includes epiclastic rocks (sandstones, micro-conglomerates, greyish–purple siltite). The presence of basic volcanites suggests the beginning of a sedimentation cycle that would correspond to the one of green schists. South from the Capidava–Ovidiu fault, no green schists were identified, and their presence in the foundation is no more than an assumption. Folding and the incipient metamorphism of the Cocoşu formation occurred before Upper Cambrian, during the late Assyntian or early Caledonian movements.

The deposits accumulated during the platform stage (Palaeozoic, Mesozoic, and Cenozoic) represent the *cover*. Within it, several sedimentation cycles are worth mentioning: Cambrian–Westphalian, Permian–Triassic, Upper Bathonian–Campanian–Lower Maastrichtian, Eocene–Oligocene, and Upper Badenian–Romanian. On top of the cover – as the last layer – the Quaternary is identified. The stratigraphic particularities and its character of elevated sector compared to the Walachian Platform give a certain individuality to the Platform of Southern Dobrudja. There were also interruptions in the major sedimentation cycles. In this sense, it is worth mentioning the following cycles:

-Cambrian–Westphalian – it includes the Cambrian, Middle and Upper Silurian, Devonian (without the Famennian) and the Carboniferous (without the Stephanian) (Ionesi, 1994). There has also been an interruption in the sedimentation during the Lower Silurian (Llandoverian) and another one during the Lower Tournaisian–Visean. The most important: the 523 m-thick Mangalia sandstone formation; the Ţăndărei clay formation, between 11 and 495 m thick, which belongs to Wenlockian–Emsian; the Smirna (Eifelian) formation, made of quartz sandstone with intercalations of siltites and clays, around 180 m thick; the Călăraşi formation (Givetian, Frasnian, Lower Famennian, Upper Visean) closes the sequence of the first sedimentation cycle and it is made of limestones and dolomites, 1,227 m thick; the south-specific Vlaşin formation (Namurian–Westphalian), with epiclastic rocks and thin intercalations of cobble, 285 m.

-The 36 m-thick Permian–Triassic comprises epiclastic deposits such as breccias, conglomerates associated with sandstones. During the accumulation of the Alexandria formation, the Southern Dobrudja sector rose above the sea level, which led to the erosion of the Permian deposits. The Upper Bathonian–Campanian comprises the Jurassic and the Cretaceous. Because of erosion, only a few remains were identified out of the Jurassic formations that had probably covered vast lands in Central and North Dobrudja. In Southern Dobrudja, newer deposits – from the Cretaceous to the Mio-Pliocene – cover the Jurassic formations. All of the older formations than the Jurassic ones are compartmented into five distinct blocks, geologically characterized by four crustal fractures fields, all of which pre-Jurassic, continuing both westward and north-westward – in the Romanian Plain and in Moldavia – and in the continental platform of the Black Sea. By identifying the four – almost parallel, which suggests they belong to a system of pre-Jurassic transformation faults – Dobrudja fields of crustal fractures, the first steps were made towards setting a frame for the pre-Jurassic events in Dobrudja.

Jurassic deposits are present throughout the entire Southern Dobrudja, but they were covered by more recent formations (Cretaceous and Cenozoic). From a stratigraphic perspective, for most of Southern Dobrudja, Jurassic is represented by the Upper Bathonian–Kimmeridgian interval. The consecutive cycles are Bathonian–Callovian, Oxfordian, and Kimmeridgian. The Cretaceous deposits developed on the tributary valleys of the Danube, as well as on its right slope. During the Cretaceous, several sedimentation interruptions occurred, corresponding to parts of layers or even to sub-layers. From a stratigraphic standpoint, there is evidence for the presence of Middle and Upper Berriasian, Valanginian, Barremian, Aptian, Albian, Cenomanian (without the base), Middle Turonian, Santonian, Campanian, and even Lower Maastrichtian. Depending on the sedimentation evolution, the accumulated deposits are grouped into several formations, as follows: Middle Berriasian–Valanginian, Barremian, Aptian, Clansayesian–Albian, Cenomanian, Turonian, and Santonian-Campanian.

The layers of the Eocene–Oligocene are widespread and highly fossiliferous; they contain nummulites, assilines, operculines, discocyclines, bivalves, echinoids, etc. During the Upper Badenian–Romanian, the last sedimentation cycle began and it ended during the Lower Romanian. In this sense, it is worth mentioning the Upper Badenian, Sarmatian, Upper Voklhynian, Bessarabian, Chersonian, Pontian, Dacian, and Romanian. The Quaternary covers the previous formations. On top of the Sarmatian or of older limestones, there are greenish and reddish clays and siltites, with calcareous concretions or –locally – with crystals and gypsum crystal aggregates. These deposits represent alteration residual products (paleosols) formed on land, but the presence of gypsum denotes at least that it accumulated in swampy areas. They present a thickness of 5 m and on top of them, there are loessoid deposits attaining a thickness of 40 m, which contain 2–7 tile-coloured levels, slightly more clayish, represented by paleosols. In the loessoid deposits, remains of *Mammuthus primigenius* and *Coelodonta antiquitatis* have been discovered. Loess – wind-generated, for the most, but not exclusively – was accumulated during the glacial stages of Middle and Upper Pleistocene (Ionesi, 1994).

From a tectonic perspective, Southern Dobrudja passed from the stage of geosyncline to the one of platform stability before the Upper Cambrian, following the Late Assyntian or Early Caledonian movements. The structural disposition of the basement is not fully known. One could not ascertain whether there are green schists south from the Capidava–Ovidiu fault. The lack of cover-like Palaeozoic formations in Central Dobrudja denotes either the functionality as a block elevated during this era, or a geosyncline evolution, if one accepts the presence of a furrowed ankimetamorphic Palaeozoic. The Capidava–Ovidiu fault also continues on the continental platform of the Black Sea; from there, offshore, it generally had a W–E orientation. Through it, Southern Dobrudja had direct contact with the North Dobrudja Orogene. In this case, the disappearance of the Central Dobrudja Massif is the result of tectonic covering, which also denotes the importance of the fault. A similar phenomenon may have occurred west from the Danube, in the foundation of the Walachian Platform. There is no doubt concerning the repeated activation of this fault during the platform stage, and its reflexion in the cover manifested differently, depending on the magnitude of the oscillation registered by the two neighbouring compartments and on the pressures generated between them. During the first stage, Southern Dobrudja was pushed towards Central Dobrudja; however, afterwards, given the raise of Central Dobrudja, the situation probably changed because the elevated compartment bent over the sunken one. The Capidava–Ovidiu fault was activated during the Palaeozoic, the Mesozoic, and Cenozoic. By all appearances, the transgressions from the Lutetian, the Upper Badenian, and the Bessarabian did not occur beyond the Capidava–Ovidiu fault.

The platform stage – begun during the Cambrian – presented oscillations on the vertical, which determined the great sedimentation cycles, as well as temporary interruptions. At the level of the entire cover – including Cenozoic –, there is evidence of mild plicative deformations and discordances, which generated tangential pressures. The Southern Dobrudja Platform also manifested overturning movements, mostly at the beginning of the Chersonian, when the waters took over the eastern half, while the western one remained above the sea level. A similar movement (but the other way around) occurred during the Upper Pontian, when the western part sunk and the persisting waters penetrated to the Upper Dacian.

Quaternary is the most important one from a tectonic perspective, because it left a legacy containing the most important features of the current landforms. During the Pleistocene, the most significant sea oscillations took place, leading to widening or limiting effects on the land, to the emergence of limans, and to their transformation into lakes. Transgressions are correlated with the cataglacial periods and regressions with the anaglacial ones.

4.2.Genesis of the fluvial limans in the southwest of Dobrudja

The Romanian (Levantine) lake within the current Romanian Plain played an important role in the initial sculpting of the gulf–sized depressions where the fluvial limans were later placed. The idea that the fluvial valleys in the southwest of Dobrudja deepened during the Dacian regression and that they were dammed during the Walachian (Fanagorian) transgression is a interpretation (Banu, 1966; Gâştescu, 1971). If these valleys had been dammed during the Fanagorian (Walachian) transgression, they would have constituted fluvio–marine or fluvio–lacustrine, but not fluvial limans. There is no doubt that this transgression during the period of the climatic optimum (5,000–6,000 years BP) did not exceed the current one by more than 3–5 m. In this case, considering such amplitude, it could not have had any influence within the Romanian Plain.

The lake units situated to the left and to the right of Dobrudja have evolved separately, given their distinct basic levels: to the east – the Black Sea oscillations, to the west – the Danube oscillations (following the disappearance of the Romanian lake). The spasmodic character of Danube waters caused the damming of fluvial valleys. The fluvial ridges – just as their shape shows – appeared during the high waters of the Danube. These ridges are better developed upstream (on the left of the liman valleys) and less developed downstream (on their right). The coarser materials denote that they were elevated during high waters, mostly those over 7 hydrogrades. Therefore, these fluvial ridges are flooded above seven hydrogrades. When there are very high waters, the Danube can break the liman basins even today. The same goes for the lake waters: during significantly heavy rains, they could penetrate the main hydrographic artery if this ridge were not supra-elevated by the road cut that connects the towns of Cernavodă and Ostrov.

The fact that these relatively small valleys have big mouths denotes that they evolved as gulfs of the Romanian (Levantine) lake. The most important record is represented by the existence of the terrace, which extends to Ostrov and Cernavodă, sometimes well structured, while other times just as shoulders. Gh.M. Murgoci (1907) mentions it for the first time, without presenting its nature; subsequently, C. Brătescu (1938) and P. Coteţ (1966) underline it and make a detailed analysis in this sense. Coteţ pinpoints that it extends under the shape of shoulders all the way to Hârşova. This terrace can be interpreted as an aeolian constructed rasa (glacial loess accumulation with paleosols intertwines).

The withdrawing of the Romanian (Levantine) lake was accompanied by the deepening of the valleys in the calcareous rocks specific to the southwest sector of Dobrudja. Loess and loessoid deposits are more recent – Pleistocene – and they were deposited during the glacial periods. A superficial erosive process causes the current appearance of the valleys – wide, flat-bottomed. These valleys are practically buried in their own alluvia; their average aggradation rate is very intense, considering the existence of an arid temperate–continental climate and of a soil lacking an arbustive level. In this case, the superficial erosion is high and the aggradation accelerated because of human intervention. By their initial sizes, the following water surfaces are worth mentioning among the limans of southwest Dobrudja: Bugeac (Gârliţa) 13.86 km^2, Oltina 30.36 km^2, Dunăreni (Mârleanu) 10.22 km^2, Vederoasa, Baciu and Cochirleni 2.68 km^2.

5.CONCLUSIONS

Geology – mostly the geologic structure and the tectonic movements – has influenced the current modelling of the landforms and it has led to the emergence of valleys instead of faults or micro-faults or in the areas where the rock was less tough. The valleys on which the fluvio–marine limans were formed inherited old gulf-like mouths in the ancient Romanian lake within the Romanian Plain. The fluvial waters closed them during the floods, thus turning them into fluvial limans. The detailed morphology – with higher heights in the left (downstream from the

Danube) and lower heights in the right (upstream from the Danube) – bears testimony of this origin. The mouths could not have been dammed by the Fanagorian transgression (5,000–6,000 years BP), during the climatic optimum, because in the Black Sea the level it was never more than 3–5 m higher than the current one. Though considered a Romanian (Levantine) terrace, this relatively smooth surface is covered by loess and loessoid deposits, which could create vast slightly horizontal lands (in this case seen as aeolian constructed rasas). The significant soil suffusion and degradation processes specific to the Dobrudja border accelerate the rapid evolution of the liman valleys.

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