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THE EVOLUTION OF THE FLUVIATILE NETWORK
OF THE DANUBE DELTA IN PLEISTOCENE
AND HOLOCENE TIMES

The Danube Delta ($45^{\circ}22'$ — $44^{\circ}24'N$ and $24^{\circ}14'$ — $29^{\circ}46'E$) is a Holocene terminal plain which lies in a region of high tectonic mobility (Predobrogean Depression) being generally characterized by strong subsidence movements and sediment accumulations (Patrulius, *et. al.* 1974). Geomorphologically, the Danube Delta is bordered to the north by the Bugeac Platform and to the south by the Northern Dobrogean Hills. The actual hydrographic drainage of the Danube Delta is formed of the river Danube, together with its tributaries and the systems of the lakes Ialpuș, Katlabuh and Kitaj to the north. To the south, the following rivers: Taița, Telita, Slava, Hamangia and Nuntași flow into the Razelm Lake.

The Quaternary deposits of the Predobrogean Depression cover a large area modelled by an ancient hydrographic network (Mihăilescu, Rogojină 1984) i.e. the ancient valleys of the Danube and the ancient systems of the lakes Ialpuș, Katlabuh and Kitaj. The shape of this ancient hydrographic network was considered by Rogojină, Mihăilescu (1987) to be a result of the presence of numerous channel systems, with a single major collector branch (proto-Danube?) situated in the northern part of Dobrogea and continuing eastward.

The possible existence of a major branch (proto-Danube) in the Early Quaternary represents a still unsolved problem which can raise numerous discussions. The Lower Pleistocene gravel and boulder deposits Liteanu, Pricăjan, Baltac (1961) suggesting terraces or alluvial fans gradually controlled the general direction of the collecting valleys from NW—SE (pre-Lower Pleistocene) to W—E (post-Lower Pleistocene) (Rogojină, Mihăilescu 1987). Above the basal deposits a layer of loess covers both the northern half and the southernmost part of the Danube Delta. Holocene deposits, mostly of a marine origin, lie directly on the loesslike beds there (Mihăilescu *et al.* 1983).

In the fills of the fossil valleys different levels and lenticular formations of sands and silts among lateral variations of marine deposits

were found during the drilling operations, to overlie the Early Pleistocene gravels (Liteanu, Pricăjan, Baltac 1961; Liteanu, Pricăjan 1963). A few peat lenses were also identified at different levels. All deposits were regarded by different authors to be either Upper Pleistocene (Mutihac, Bandrabur 1967) or Holocene in age (Panin 1974).

The molluscan fauna (*Gastropoda* and *Bivalvia*) of the Early Quaternary deposits is less diverse, and the lack of datings make any correlation difficult. Therefore, it seems that either the loesslike deposits were formed in this area and then were removed or that the areno-siltic material which filled the ancient valleys is synchronous with the loesslike deposits.

By the end of the Upper Pleistocene and in the Early Holocene (10 800—7500 yr B.P., acc. Panin *et al.* 1983) the "initial sand spit" (Vîlsan 1934) was formed and it lay on loesslike deposits. It was the first structure which closed the "Danube Gulf". The initial sand spit appears to be a sand belt which divides the ancient Danube Gulf into two parts: a fluvio-lacustrine area in the west and a fluvio-marine area in the east. Therefore the Delta front, i.e. the mouth of the proto-Danube was situated more to the west than the actual limit and about 50 m lower than the present Black Sea level. Sediments accumulated in the western part of the littoral bars and in the actual area of the Razelm Lake (Mihăilescu, Rogojină 1984). It seems that the Ialpug-Sireasa valley crossed the actual Chilia valley and continued through the paleo-channels Litcov and Dunavăț toward the Razelm depression or Razelm Gulf (Mihăilescu 1986). The presence of loesslike deposits of the Stipoc formation directed the water flow towards the south and then to the south-east. On the other hand, the waters draining the Katlabuh and Kitaj basins flowed between the Izmail and Stipoc formations.

The shape of littoral bars of the Sf. Gheorghe Delta I (9000—7200 yr B.P., acc. to Panin *et al.* 1983), as well as the morphological aspects of the Sf. Gheorghe limb (Panin 1974; Mihăilescu, Rogojină 1984) seem to represent the first deltaic formation, also being visible on the surface geologic maps.

The absolute ages of the initial spit (Noakes, Herz 1983) and the deposits of Sf. Gheorghe Delta I were estimated at between 10 000 and 7500 yr B.P. and at 9000 and 7300 yr B.P. respectively (Panin *et al.* 1983). It is obvious that at least some of these deposits are synchronous. This can be explained in two ways:

a) the initial spit and the Sf. Gheorghe Delta I were a single formation,

b) a part of the molluscs analysed by ^{14}C became reworked. This accounts for two heterochronous formations.

The latter possibility was mentioned by Panin *et al.* (1983), but it is extremely difficult to make a time connection between the age of the initial spit and the age of the molluscs of this formation. This hypothesis raises some problems with respect to possible fauna reworking.

During the formation of the Sulina Delta (7200—2500 yr B.P., acc. to Panin *et al.* 1983) the Black Sea level at first rose from -10 m to $+5$ m and then decreased to -5 m. This period must be divided in to two sequences of events:

— Delta Sulina I, from 7200 to 3500 yr B.P. (Atlantic-Lower Subboreal). The Black Sea level rose from -10 m to $+5$ m and a part of the delta was flooded by marine waters.

— Delta Sulina II of Upper Subboreal age (3500—2500 yr B.P.) when the Black Sea level fell from $+5$ m to -5 m; lagoons turned into freshwater lakes, new channels were cut and the old ones were reactivated.

Morpho-hydrologically the period of Delta Sulina I may be characterized as follows:

a. The waters of the proto-Danube were mostly collected by the Sulina paleo-limb and subsidiarily by both the Sf. Gheorghe paleo-limb (Panin 1974) and the Chilia-Sireasa paleo-limb.

b. In the north-eastern part of the Sulina paleo-limb a lagoon (Mațița) was formed (5610 to 3400 yr B.P.) having direct connections with the Black Sea, between the northernmost part of the littoral bars and the Bugeac Platform.

c. By the end of this period, the Pardina-Katlabuh-Kitaj depression was flooded by marine water (the sea level rose from 0 m to $+5$ m), showing a direct link to the Mațița lagoon* and the Black Sea (through the Chilia Vache strait). The confluence of rivers Katlabuh, Kitaj and Sofian was in this area.

d. Till the Mid-Subboreal (end of the Old Black Sea period) the southern part of the Danube Delta, i.e. the southern area of the present Razelm-Sinoe lagoon complex was a marine environment.

The period of Delta Sulina II may be characterized as follows:

a. As the sea level continued its slow fall to -5 m, a high amount of sediments was transported by the Dunavăț and Dranov channels, and these sediments accumulated to form beaches in the southern part of the Danube Delta. This deposition at first formed the Coșna Delta (3550—2550 yr B.P., acc. to Panin *et al.* 1983) and then the littoral bar Grindul Lupilor (2740—2080 yr B.P., also see Panin *et al.* 1983). The Dobrogean rivers Taița, Telița and Agighiol behind the Coșna Delta

* The fauna yielded by these freshwater deposits was collected and identified by Luciana Artin (Panin *et al.* 1986).

the Razelm lagoon started to form also by contributed to the formation of the Coşna Delta.

b. According to Panin (1983), at the beginning of this period Lake Thiagola already drained the Katlabuh and Kitaj valleys.

c. The Pardina-Katlabuh-Kitaj lagoon underwent marked changes, gradually becoming a freshwater lake. Concurrently with the decrease of the Black Sea level, the rivers Katlabuh, Kitaj and Sofian formed new beds towards the Chilia strait. Subsequently the sinuous part of the Chilia limb would formed along one of these beds.

d. About 3500 yr B.P. (Upper Subboreal) the Matiţa lagoon had no direct connection with the Black Sea, gradually becoming a freshwater lake. As the sea level reached -5 m, the fluvial waters from the north-western part of the Danube Delta cut a new channel (Lopatna) which became the major collector of this area.

During the last 2500 years, with the rise of the Black Sea level the Danube Delta has gradually changed to attain its actual configuration:

a. The Chilia limb becomes the most important channel of the Danube Delta. It is formed of at least three segments of different ages. At present the channel is composed of two parts: a free meandering channel (km 70—116) and a sinuous channel (km 30—70) apparently meandering (Mihăilescu, Rogojină 1984).

Both the flow and the sediment discharge of the Danube were mainly directed to the Chilia limb which started to form a delta (Chilia Delta — 2900 yr B.P. until the present time, acc. to Panin *et al.* 1983), and subsidiarily to the Sulina limb and the Sf. Gheorghe limb which also started to form a delta (St. Gheorghe II Delta — 2500 yr B.P. until the present time, acc. to Panin *et al.* 1983).

b. The Pardina-Katlabuh-Kitaj depression became divided into three parts by a wandering zone: a southern part — the Pardina sector with numerous sinuous channels and two lacustrine areas in the northern part, i. e. the Katlabuh and Kitaj sectors.

c. As the sea level rose to the present one, the delta fronts of Sulina and Coşna became eroded. At the same time, the Sulina paleolimb started to meander and became partially abandoned. The upper part of the Sulina limb migrates towards the north.

d. During the Subatlantic another delta was formed in the southern part of the Danube Delta (Sinoe Delta, after Panin 1974). In our opinion, it was due to the two Dobrogean rivers Hamangia and Slava, its front zone being, however, rapidly eroded. The Sinoe gulf was closed to become a lagoon.

There is an obvious difference between the field data on the Danube Delta (Panin 1972, 1974; Panin *et al.* 1983; Mihăilescu *et al.* 1983; Mihăilescu, Rogojină 1984; Mihăilescu 1986) and those inferred from the study of the Black Sea with respect to the evo-

lutionary stages of the former (Degens, Ross 1972; Paliska, Degens in: Schroder 1978). The main differences are related to:

— Fauna of the initial sand spit deposits (at present at 0 m level). The age of these deposits was estimated at between 10 000 and 7500 yr B.P. At that time, the Black Sea level was estimated to be much lower than the actual level, at about —30 to —60 m.

— The same discordance was observed with respect to the Delta Sf. Gheorghe I formation (c. 9000—7300 yr B.P.) at a very low level of the Black Sea, i.e. —30 to —10 m, compared to the actual level.

All of these data suggest a possible rise of the Danube Delta platform during the Upper Pleistocene and the Early Holocene. Thus, we can explain why there is a perfect concordance between the stratigraphical, paleontological and radiocarbon data and the results of the Black Sea investigations for the same period including the last 7000 years.

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