

THE DANUBE DELTA – CHRONOLOGY OF LOBES AND RATES OF SEDIMENT DEPOSITION

Nicolae PANIN, Gabriel ION, Elena ION

National Institute of Marine Geology and Geo-ecology (GEOECOMAR)

Abstract. An attempt of evaluation of the Danube River paleo sediment discharge and of the littoral drift fluxes along the delta front is presented. The computations suggest that during the last 12 k yr. the total amount of sediments forming the main lobes of the Danube Delta (the coastal sandy progradational sheet) is of approximately 23 billion m³ of which about 95 billion m³ are of Danubian origin with an average annual sediment discharge of ca. 80 million m³. These figures are of the same order of values as the Danube sediment discharge in the period before damming in 1970 and 1983. The figures obtained for the paleo littoral drift fluxes are also consistent with the present-day ones.

Key words: chronology, sediment discharge, drift fluxes, Danube Delta

The Danube Delta edifice comprises a sequence of detritic deposits of tens to 300-400 m thickness formed mainly during the upper Pleistocene (Karangatian, Surozhian, Neoeuxinian) and Holocene. The deltaic conditions occurred here, probably during the Quaternary, when the Danube started flowing into the Black Sea basin.

The Holocene evolution of the Delta includes the

following main phases (N. Panin *et al.*, 1983; N. Panin, 1989, 1997) (Fig.1, Table 1): (1) the formation of the Letea-Caraorman initial spit and of the “Danube Blocked Delta”, 11,700-7500 yr. BP; (2) the St. George I Delta, 9000-7200 years BP; (3) the Sulina Delta, 7200-2000 years BP; (4) the St. George II and Kilia Deltas, 2800 years BP to present and (5) the Cosna-Sinoie Delta, 3500-1500 years BP.

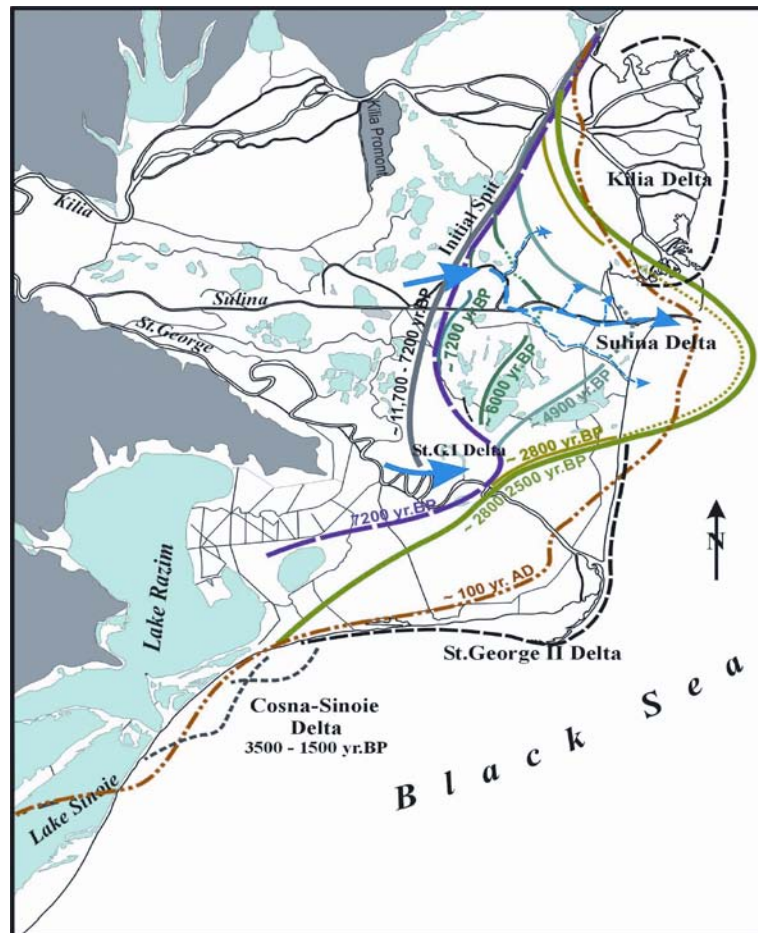


Fig. 1 The Danube Delta Evolution during the Holocene and Correspondent Coastline Position Changes (after Panin, 1997) 1: Initial Spit 11.7-7.5 K yr.BP; 2: St. George I Delta 9.0-7.2 Kyr.BP; 3: Sulina Delta 7.2-2.0 K yr.BP; 4: Coastline position at ~ 100 yr AD; 5: St.George II Delta and Kilia Delta 2.8 K yr.BP-Present; 6: Cosna-Sinoie Delta 3.5-1.5 K yr.BP

The Danube Delta marine plain displays two types of coastal deposits: (1) marine littoral deposits of type "a", formed by longshore drift from the north (from mouths of the Southern Bug, Dniester and Dnieper rivers) and (2) littoral deposits of type "b", of Danube origin (Fig. 2).

The structure of the Danube Delta was deciphered by interpreting the data from bore-holes of over hundred meters deep (Figs. 3, 4) (Liteanu et al., 1961, 1963; Panin, 1972). Unfortunately high resolution seismic data from the Danube Prodelta and Delta

Front zone are not available. The only data available for this zone are the 3.5 kHz sub-bottom profiler in quite dense network of lines. The penetration in the Prodelta and Delta-Front areas is limited by the presence of gases in sediments and this limited penetration doesn't allow the recognising the MFS. This surface was recognised on land based on the data from bore-holes; thus the progradational beach ridge sandy deposits that form different delta lobes during the Holocene high stand were defined.

Table 1 Danube Delta Lobe Chronology

No.	Main lobe	Relative dating	Absolute dating years BP	Number of channels	Number of mouths	Progradation speed
1	Initial Spit	1	11,700 - 7200	1	1	
1	Blocked Delta	1	11,700 - 7200	1	1	
2	St. George I Delta	2	~9000 - 7200	1	1	3-5 m/yr
3	Sulina	3	~7200 - 2 000	1	1	3-5 m/yr
3a	Sulina Delta – phase 1	3a	7200	1	1	6-9 m/yr
3b	Sulina Delta – phase 2	3b	~ 6000	3	3	
3c	Sulina Delta – phase 3	3c	~ 4900	5	5	
3d	Sulina Delta – phase 4	3d	~ 2800 - 2000	2	2	
4	Cosna – Sinoie Delta		3500 - 1500	1	1	?
5a	Kilia Delta	4	2500 - present	1 to 19	1 to 19	8-10 m/yr
5b	St. George II Delta	4	~ 2800 - present	1 to 3	1 to 3	8-9 m/yr

The evaluation of the past Danube River sediment supply, of its contribution to the delta progradation and of the littoral plaeo-drift fluxes are calculated taking into consideration the volumes of different lobes and the origins of sediments (types "a" and "b" and type "r" – sediments reworked from the eroded part different lobes).

The volume of sediments forming different delta lobes was estimated taking into consideration the area of lobes and the thickness of the coastal sandy progradational sheet (Fig. 5).

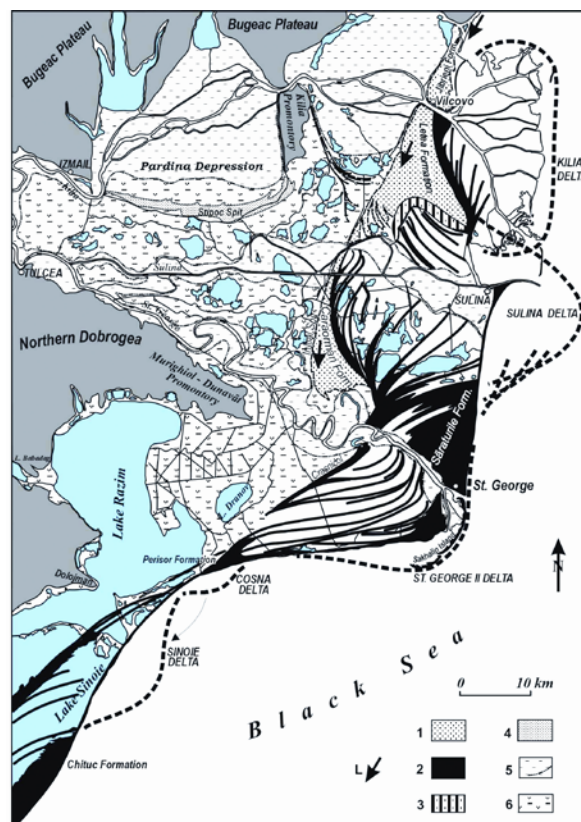


Fig. 2 Areal Distribution of the Main Types of Deposits within the Danube Delta Territory (after Panin 1989).

1: marine littoral deposits of type "a", formed by the littoral drift from the rivers Dniester and Dnieper mouths; 2: marine littoral deposits of type "b", of Danubian origin; 3: deposits of littoral diffusion, formed by mixing of "a" and "b" types; 4: lacustrine littoral deposits; 5: fluvial meander belt deposits; 6: interdistributary depression deposits; L: direction of the longshore sediment drift.

The volumes mentioned above represent the coastal sandy deposits supplied by the littoral drift from different sources (Ukrainian river-borne type “a” deposits, Danube-borne type “b” deposits and reworked by the coastal erosion type “r” deposits). To those volumes one should add the Cosna-Sinoie Delta sediments supplied by a secondary distributary, namely Dunavatz. The Cosna-Sinoie Delta volume of sediments could be roughly estimated at about 2-2.5 billion m³ of sediments. Consequently, the total quantity of sediments forming the main lobes of the Danube Delta amounts to approximately 23 billion m³.

The estimations of the paleo-littoral drift fluxes are given below (Table 3).

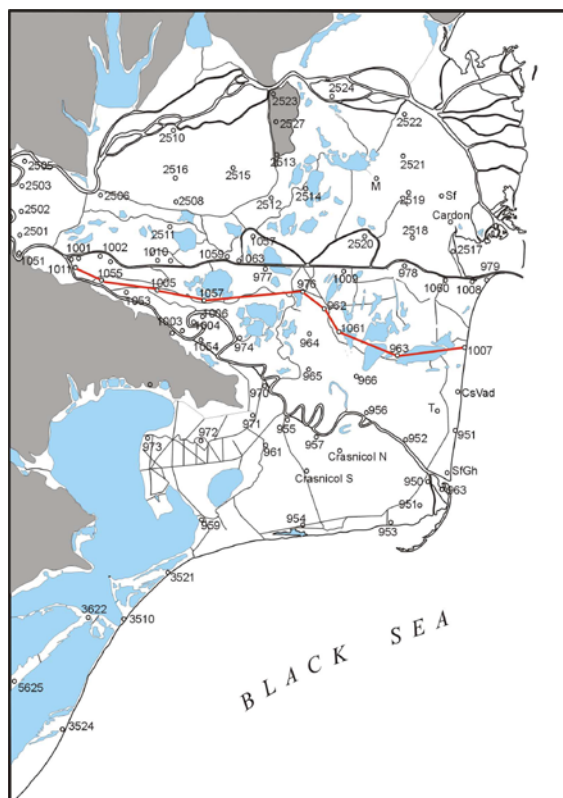


Fig. 3 Location of Bore-Holes within the Danube Delta Territory and of the Geological Section through the Delta.

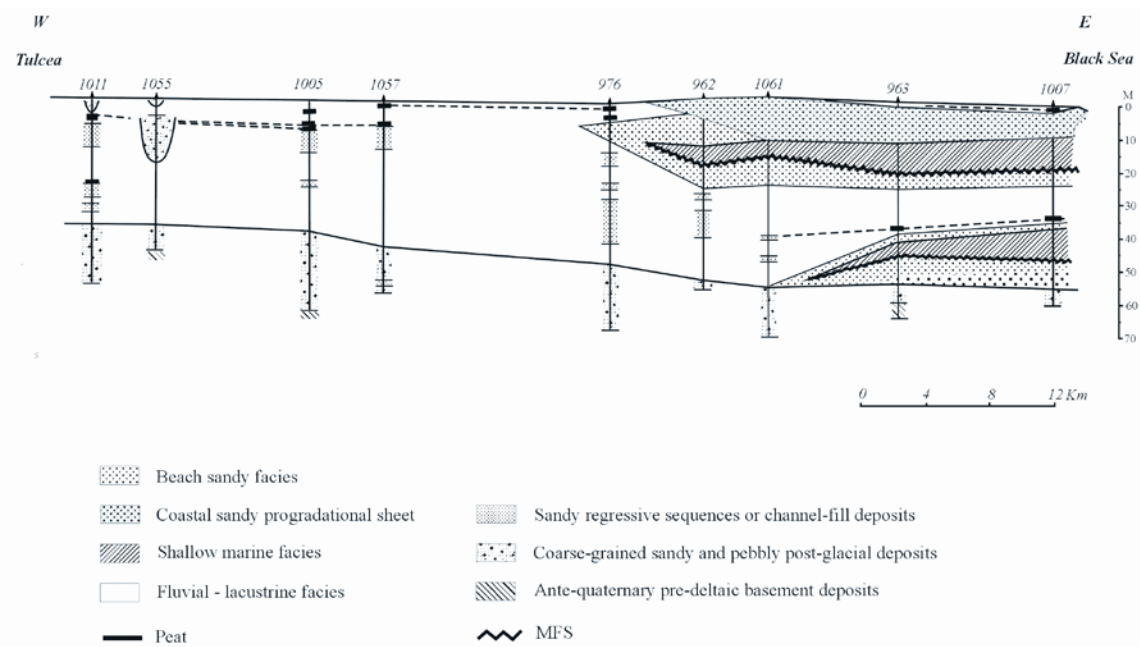


Fig. 4 Geological Section of the Danube Delta Oriented West-East.

The Danube-borne sandy coastal sediments represent mostly the sediments trapped in the

mouth-bar zone, reworked and redistributed long-shore on the delta front area.

Table 2 The Danube Delta lobes - the volume of deposits mobilised in different lobes

Lobe name and their time of development	Total Volume of deposits m ³	Volume of types "a" or "r" deposits (m ³)	Volume of type "b" deposits (m ³)	General average rate of deposition (m ³ /yr)	Rate of deposition for Danubian sediments (m ³ /yr)
St. George I/ 2200 yr.	2,105,342,923	"a"-1,262,603,707	842,739,216	956,974	383,063
Sulina Delta/ 4500 yr.	9,236,857,413	"a"-1,797,681,322	7,439,176,091	2,052,635	1,653,150
St. George II/2800 yr.	5,294,475,401	"r"-1,271,199,243	4,023,276,158	1,890,884	1,436,884
Kilia/ 2500 yr.	3,982,737,489	-	3,982,737,489	1,593,095	1,593,095
Total (without the Cosna-Sinoie Delta)	20,619,413,226				

Table 3 Estimated average paleo-fluxes of the littoral drift during different phases of delta development

Fluxes of littoral drift (m ³ /yr) For type "a" or "r" deposits	St. George I Delta ("a")	Sulina Delta ("a")	St. George II Delta ("r")
	~574,000 m ³ /yr	~400,000m ³ /yr	~454,000 m ³ /yr

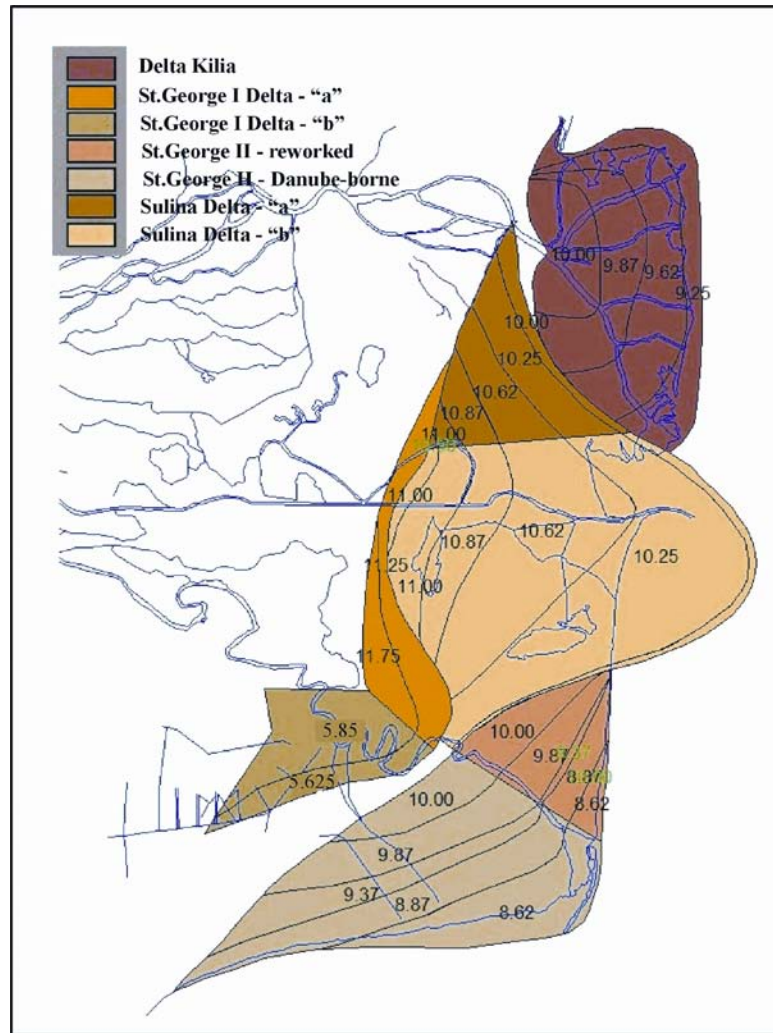


Fig. 5 Main Lobes of the Danube Delta – their Surface and the Thickness of the Coastal Sandy Progradational Deposits Forming these Lobes.

Considering that the mouth bar deposits represent only ~ 20 % of the total sediment discharge of the river, one could approximate the total sediment supply for about 12 k yr. to about 95 billion cubic meters and the average annual sediment discharge to about 80

million cubic meters. These figures are of the same order of values as the Danube sediment discharge in the period before damming (1970,1983) (Almazov *et al.*, 1963; Bondar *et al.*, 1991, 2000).

REFERENCES

- ALMAZOV A.A., BONDAR C., DIAONU C., GHEDERIM VETURIA, MIHAILOV A.N., MITA P., NICHIFOROV I.D., RAI I.A., RODIONOV N.A., STANESCU S., STANESCU V., VAGHIN N.F. , 1963, Zona de vărsare a Dunării. Monografie hidrologică. Ed. Tehnică, București, 396 p.
- BONDAR C., STATE I., CERNEA D., HARABAGIU ELENA , 1991, Water flow and sediment transport of the Danube at its outlet into the Black Sea. *Meteorology and Hydrology*, **21**, 1, 21-25, București.
- BONDAR C., PANIN N., 2000, The Danube Delta Hydrologic Database and Modelling, *GeoEcoMarina*, **5-6**, 5-53, Bucharest.
- LITEANU E., PRICĂJAN A., BALTAC G., 1961, Transgresiunile cuaternare ale Mării Negre pe teritoriul Deltei Dunării. *Studii si Cercetări Geologice*, **6**, 4, 743-762, București.
- LITEANU E., PRICĂJAN A., 1963, Alcătuirea geologică a Deltei Dunării. *Hidrobiologia*, **IV**, 57-82, București.
- PANIN N., 1972, Histoire Quaternaire du Delta du Danube. Essai d'interprétation des facies des dépôts deltaïques. *Cercet. Marine IRCM*, **4**, 5-15, București-Constanța.
- PANIN N., 1989, Danube Delta. Genesis, evolution and sedimentology. *Révue Roumaine Géologie, Géophysique, Géographie, Série Géographie*, **33**, 25-36, București.
- PANIN N., 1997, On the Geomorphologic and Geologic Evolution of the River Danube-Black Sea Interaction Zone. *Geo-Eco-Marina*, **2**, 31-40, București.
- PANIN N., PANIN STEFANA, HERZ N., NOAKES J.E., 1983, Radiocarbon dating of Danube Delta deposits. *Quaternary Research*, **19**, 249-255, Washington.