

BLACK SEA COAST LINE CHANGES IN THE LAST 10,000 YEARS A NEW ATTEMPT AT IDENTIFYING THE DANUBE MOUTHS AS DESCRIBED BY THE ANCIENTS

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1. INTRODUCTION

The western and north-western coasts of the Black Sea were undoubtedly the most convenient ways of communication between the peoples from south-eastern and eastern Europe and those from the Mediterranean Basin, especially the Greeks and Romans.

Which were the changes undergone by these coasts during the Holocene and which were the ways followed by the ancients in their attempts at expansion and knowing the world?

The evolution of the Black Sea coast starting from Constanța, and especially from the Midia Cape, northward, was influenced, besides eustatic processes, by the development of the Danube Delta. Thus, the investigation of the Delta furnishes us valuable information for the reconstitution of the coast line in this area.

Without giving a historical description of the investigations carried out in the region, we just mention as highly representative for the study of the Danube Delta, the works of Antipa (1914), Brătescu (1921), de Martonne (1931), Vilsan (1934), Slanar (1945), Pfannensiel (1950), Zenkovich (1956, 1960), Liteanu, Pricăjan and Baltac (1961, 1963), Petrescu (1957, 1975), Banu and Rudescu (1965), Almazov et al. (1963). In the light of present-day data we may state that the main trends of the Holocene evolution of the Danube Delta have been identified by Zenkovich (1956). The studies of Banu and Rudescu (1965), Coteț (1960), Grumăzescu (1961) and Almazov et al. (1963) are further steps in clearing up this question.

The following chapters are meant to offer a brief account of the results of geological and sedimentological studies carried out by the author of this paper together with Ștefana Panin, Dan Jipa, Nicolae Mihăilescu, Silviu Rădan and Luciana Artin, as well as of an ample programme of scientific collaboration between the above-mentioned researchers and Prof. Norman Herz and John Noakes from the University of Georgia, U.S.A. The aim of the programme was the radiocarbon dating of the Danube Delta deposits. The results of these studies point to a new interpretation of the paleogeography of the Black Sea north-western area during the Holocene.

2. FACTORS INFLUENCING THE MAJOR COAST LINE CHANGES

The sea and ocean coast changes during the Quaternary were considerable being determined especially by sea level oscillations. The Black Sea level generally followed the oscillation in the World Ocean level. According to the latest data, from marine geological investigations and from the study of "Glomar Challenger" drillings, the Riss-Würm interglacial, when the Black Sea level was higher than the present one, was followed by: (1) a lowering of the level up to almost - 100 m during the Lower Würm; (2) a rise of the level to nearly 0 m, during the Würm interglacial (40,000 - 25,000 years B.P.); (3) another lowering of the sea level to - 80 m, during the Upper Würm (the minimum level was recorded around 18,000 y.B.P.) and (4) since the interval 15,000-12,000 y.B.P., a continuous rise until present times. In the Holo-

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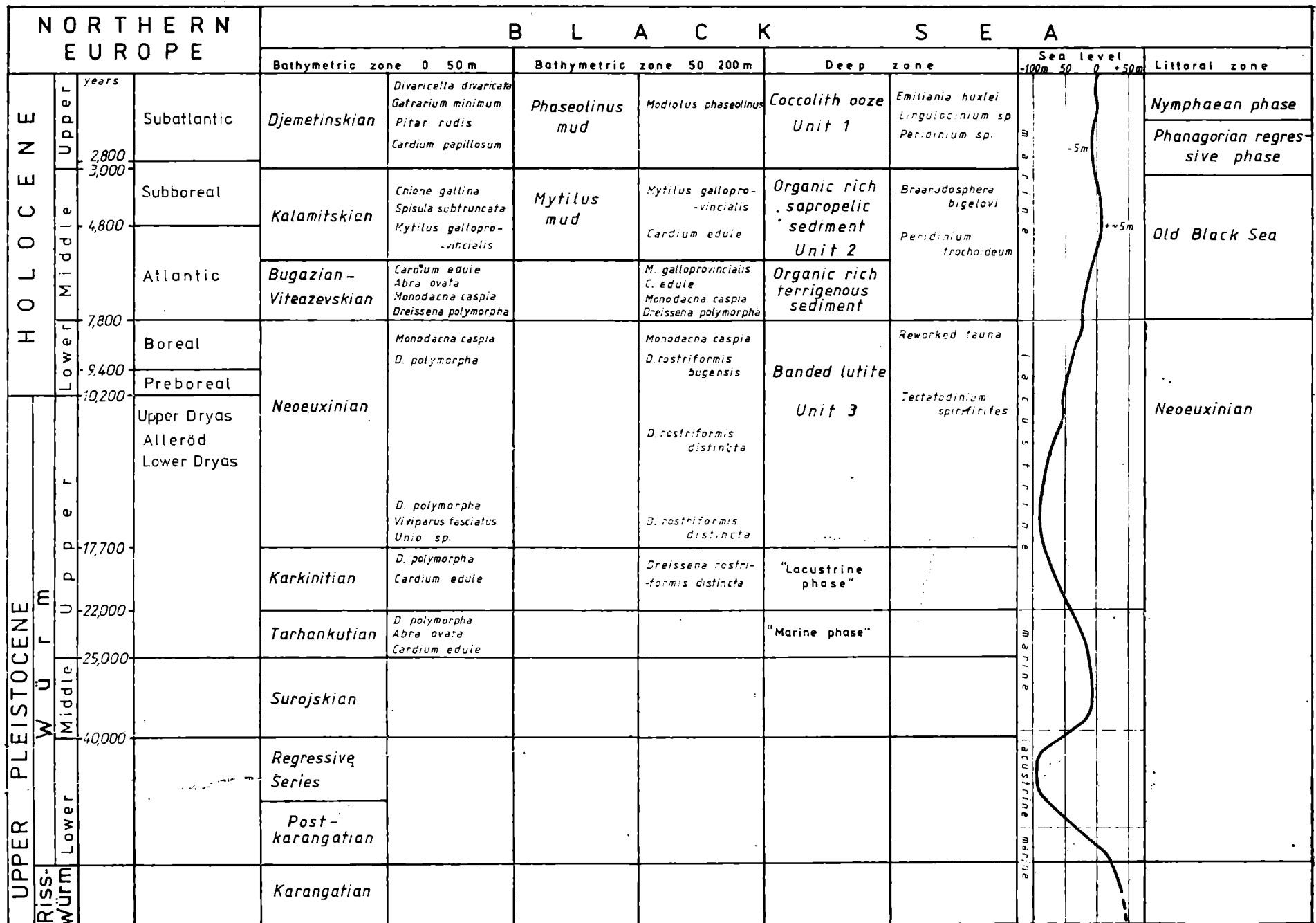


Fig. 1 — Sea level changes and biostratigraphic scheme of the Black Sea deposits during the Upper Quaternary (after Šcerbakov et al., 1979, Fedorov, 1972, and Degens and Ross, 1972).

cene, there also occurred variations in the sea level whose amplitude was not higher than $\pm 5-7$ m (Fig. 1) (Degens and Ross, 1972; Šcerbakov et al., 1979; Fedorov, 1959, 1972; Silik, 1975, etc.).

In the north-western area of the Black Sea, the changes were also influenced by the great amounts of sediments brought by the big rivers flowing into the sea (the Dnieper, the Dniester, the Bug and the Danube), as well as by regional subsidence, particularly active in the Danube Delta.

The interaction of the above-mentioned phenomena defined the position of the coast line at different moments of its evolution.

3. MAIN FEATURES OF THE HOLOCENE EVOLUTION OF THE DANUBE DELTA

The changes of the sea coast as well as the evolution of the Danube Delta in the last 10,000 years, have been revealed by studying the geological-geomorphological structure of the Delta (Figs. 2 and 5). In view of stating the age of different development stages, more than 130 radiocarbon datings have been made in collaboration with N. Herz and J. Noakes (Panin et al., 1983).

During the Old Stage of the Black Sea, 10,000–8,000 y.B.P., there was formed at the mouth of the so-called "Danube Gulf", a spit called the "Letea-Caraorman initial spit". This was formed with support points at predeltaic relief relics built up of loessoid deposits. This is the stage of "blocked delta" when delta was forming inside a lagoon behind the initial spit. This stands for the boundary between the two big delta subdivisions: the fluvial delta, to the west, and the fluvial-marine delta, to the east.

Between the southern end of the initial spit and the Murighiol-Dunavăț Promontory there was a passage through which the first arm of the Danube, St. George, flew into the sea. It is here that the first delta of the Danube was formed — "the St. George I Delta". The evolution of this delta occurred within the interval 8,900–7,200 y.B.P.

During the next stage, characterised by the clogging of the St. George arm which could no longer receive the entire Danube flow, a new arm developed — Sulina arm. This one advanced into the sea and formed its own delta — "the Sulina Delta". The growth of the Sulina Delta quite slow at first and then more and more rapid, took place during the interval 7,200–2,000 y.B.P. Its rapid growth and maximum advancement into the sea (the delta front exceeded the present-day coast by 10–15 km) coincided with the Phanagorian regression. At certain times of development the delta was lobate in shape and exhibited 3–5 distributaries of the Sulina main arm (Fig. 4). Concomitantly the southern part of the delta included a secondary delta, called "Coșna" (Panin, 1974).

The following stage (the interval 2,000 y.B.P. — present time) coincides with the present raising of the sea. The clogging of the Sulina arm has generated new and important water ways for the river flow to the sea: the Chilia arm developed to the north, while to the south St. George arm was reactivated. Both arms built up their own deltas — the "Chilia Delta" and the "St. George II Delta". During the same phase, the insufficient sediments supply and the slow, but continuous rising of the sea level have determined the erosion of the Sulina Delta.

To the south of the delta, there stands out another secondary delta, called the "Sinoe Delta". The Coșna and Sinoe deltas are but different evolution stages of the southernmost secondary delta of the Danube delta system, generated by a less important distributary of the river — the Dunavăț arm.

4. AN ATTEMPT AT IDENTIFYING THE DANUBE MOUTHS, AS DESCRIBED BY ANCIENT GEOGRAPHERS

Any scientist wants, at a certain moment, to get involved in elucidating the information inherited from the Ancients. Our interest is polarised by the information regarding the Pontus Euxinus, its coasts and the Danube Delta. At present, we have new data which make possible the study of this matter on more reliable scientific grounds. We are now going to present the main ancient sources regarding the Danube Delta.

The first information on the Danube river is provided by Herodotus in his Histories. According to Herodotus, the springs of the river Istros are "on the land of Celts, near Pyrene town, and it flows cutting the middle of Europe through ... The Istros finishes by flowing into the

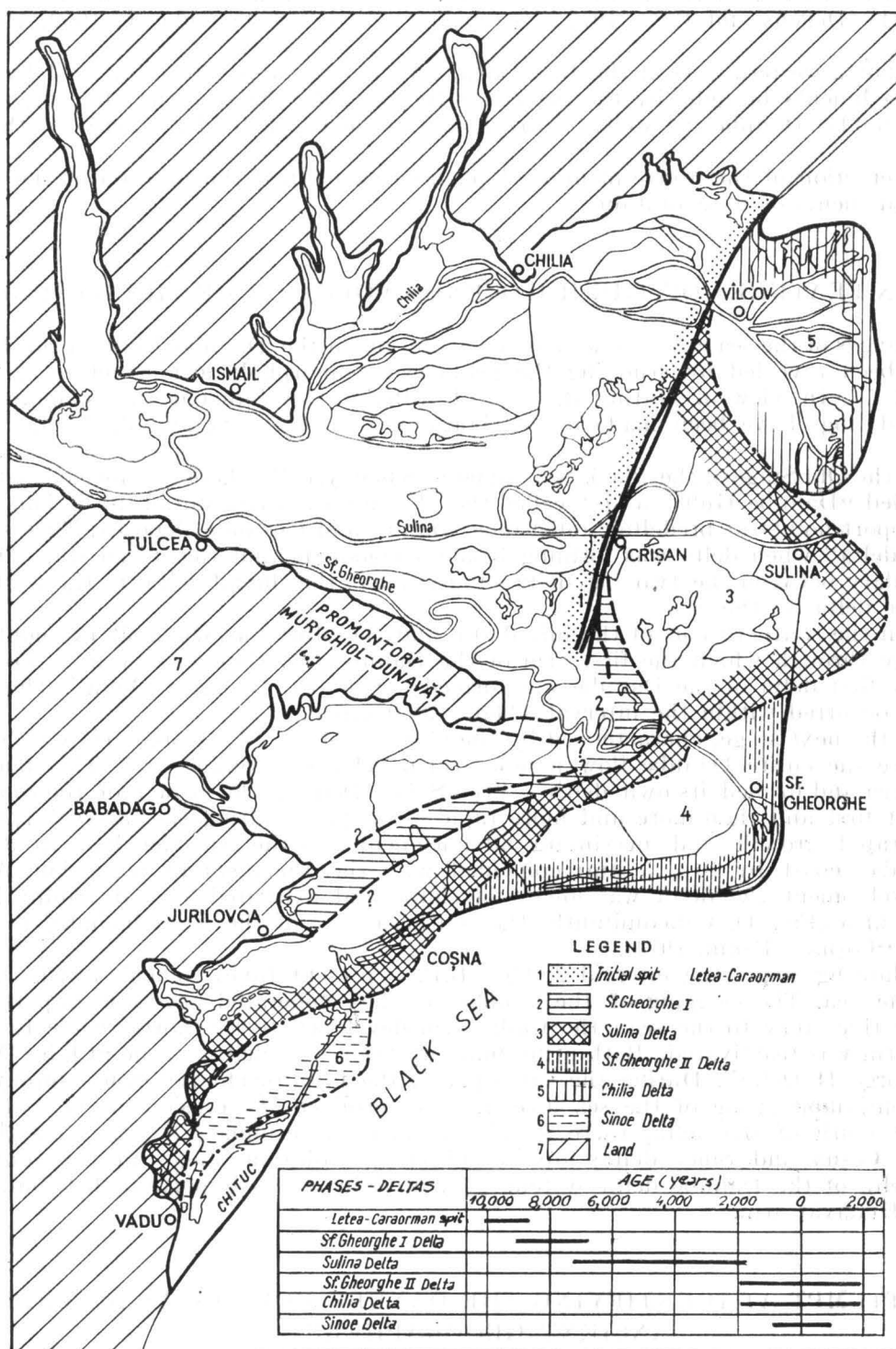


Fig. 2. — Danube Delta evolution phases during the Holocene (after Panin, 1974)

Legend: 1. Letea—Caraorman initial spit; 2. St. George I Delta; 3. Sulina Delta; 4. St. George II Delta; 5. Chilia Delta; 6. Sinoe Delta; 7. Land.



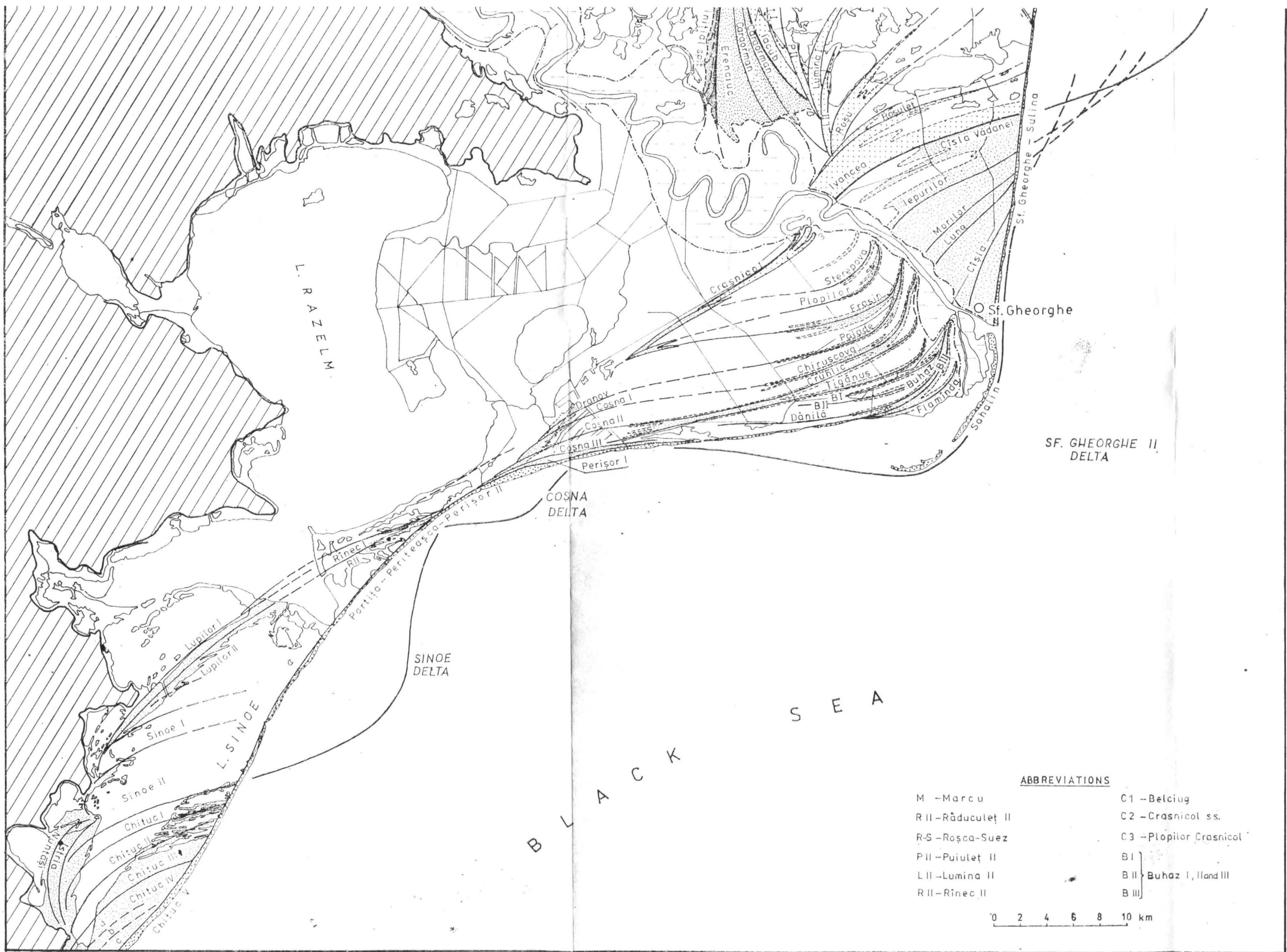
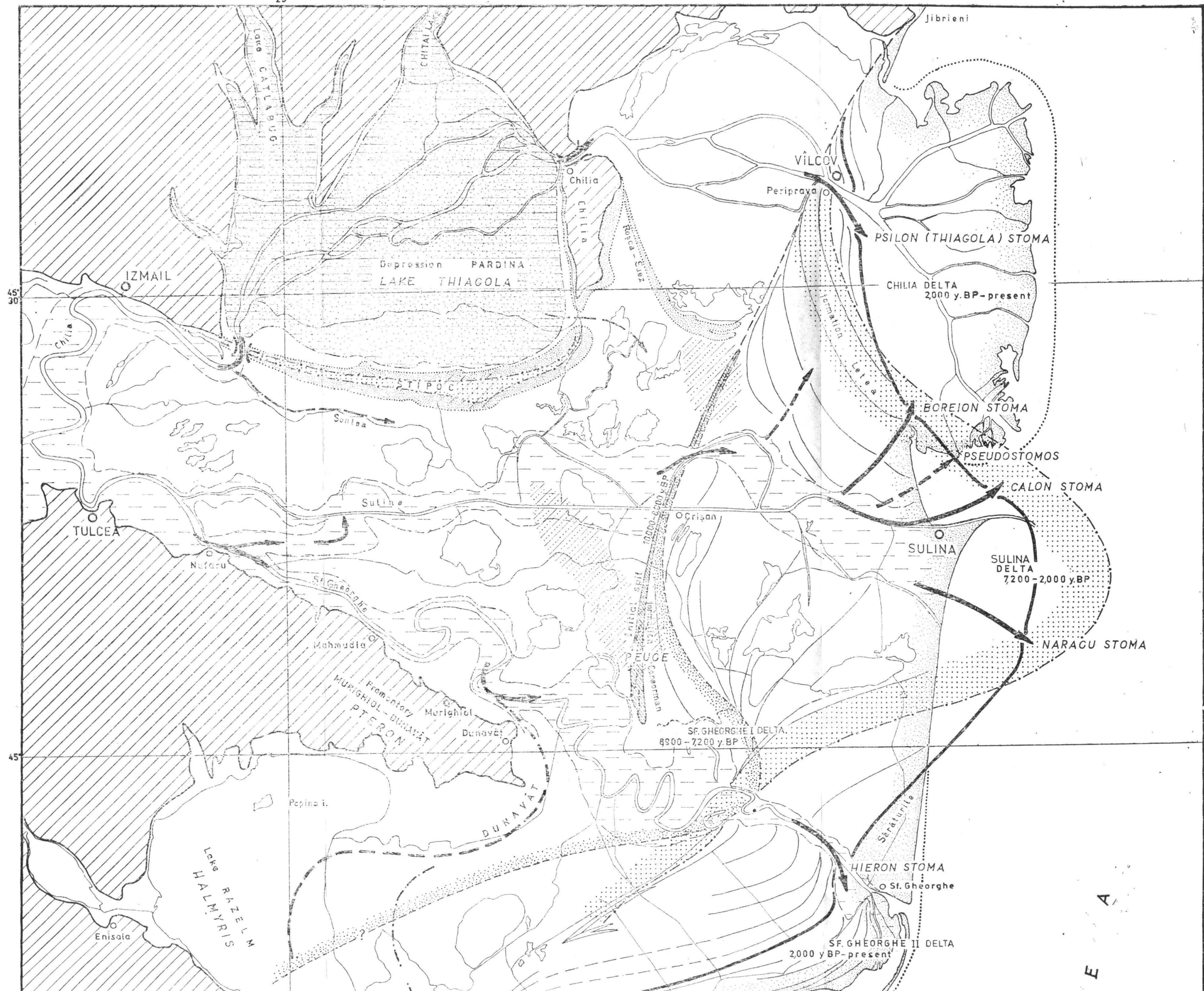


Fig. 3. — The Danube Delta geomorphological-sedimentological structure. The map outlines the main sets of beach ridges and the phases of delta evolution during the Quaternary.



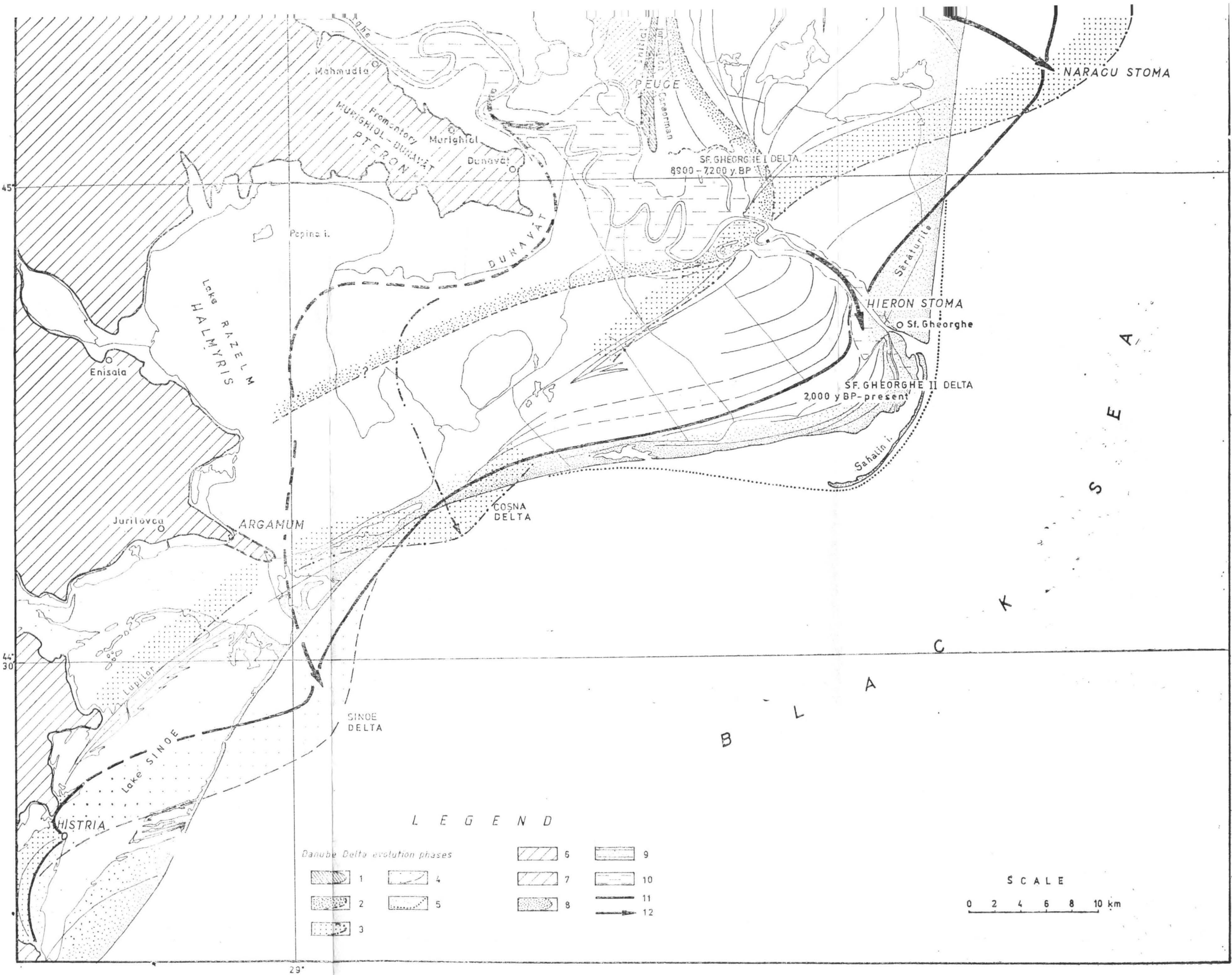


Fig. 6. — Paleogeographic reconstruction of the Danube delta area. The map shows the coast line in the first century A. D. and the Danube distributaries mouths at that time.

Legend: Danube Delta evolution phases: 1. Letea-Caraorman initial spit; 1. St. George I Delta; 3. Sulina and Cosna Deltas; 4. Sinoe Delta; 5. Chilia and St. George II Deltas; 6. Dry land; 7. Predeltaic relief relics; 8. Lacustrine spit; 9. Thiagola lake; 10. Divagation zone; 11. Sea shore line in the first century A. D. after C 14 dating; 12. Danube distributaries mouths.

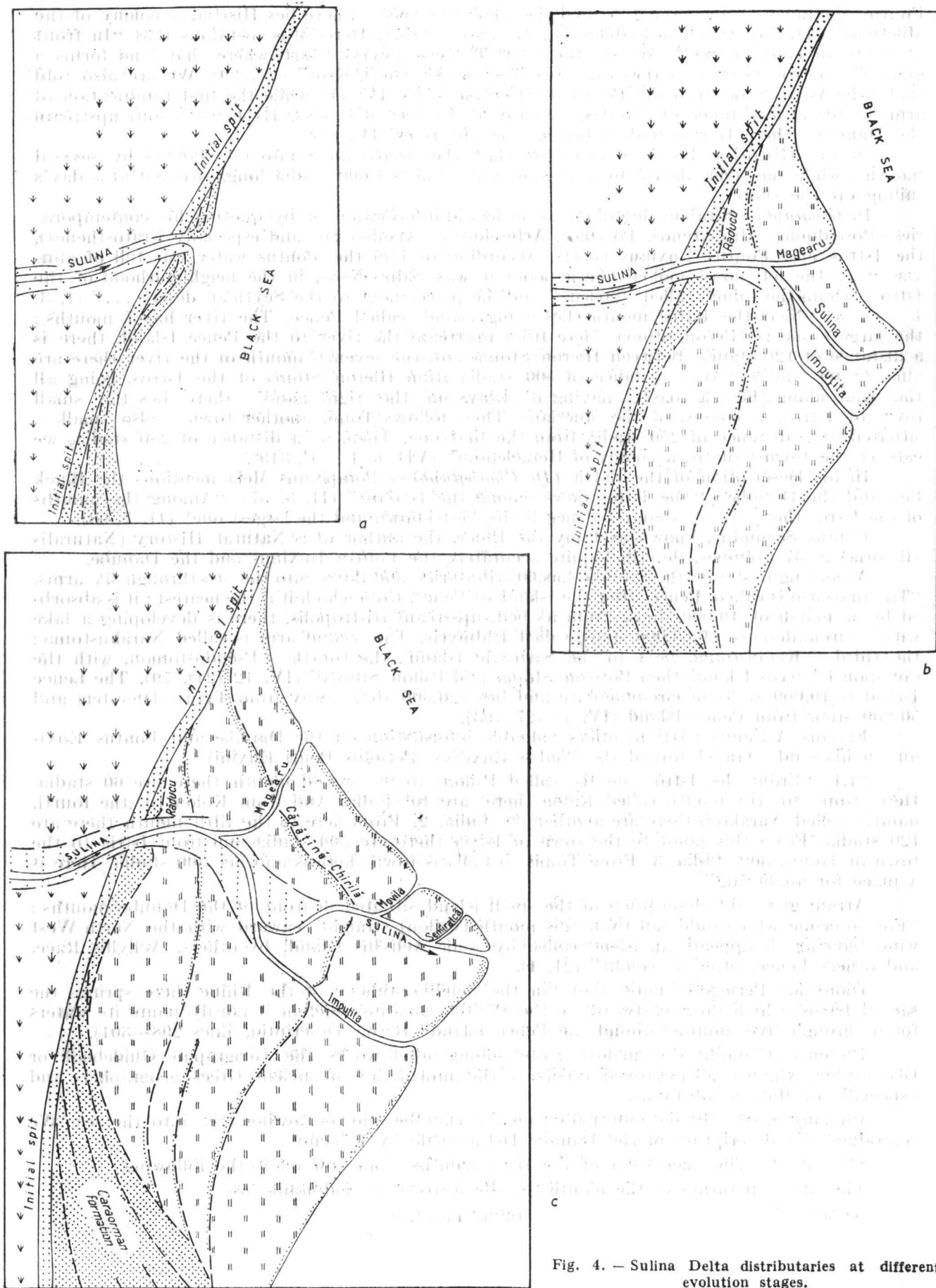


Fig. 4. — Sulina Delta distributaries at different evolution stages.

Pontus Euxinus — after having crossed the whole Europe — where lies Histria, a colony of the Milesians" (II, 33). When describing Thracia and Scythia, Herodotus mentions that "In front of Scythian land, towards the sea, there lies Thracia. Scythia starts where that land forms a gulf. The Istros flows into the sea, streaming to the South-East" (IV, 99). We are also told that "the Istros flows into the Pontus by five mouths (IV, 47) while the first ramification of arms occurs at a distance of two days' sailing (of the fleet of Darius, Hystaspes's son) upstream the Danube. There Darius built a bridge over the river (IV, 89).

In his Histories Polybius mentions that the Istros flows into the Pontus by several mouths, while the river alluvia form a sand bank almost 1,000 stadia long, situated at a day's sailing off the shore.

In *Geographia* Strabon describes, by using old information or by quoting his contemporaries (Poseidonios, Hipparchos, Polybios, Artemidorus, Apollodorus and especially Eratosthenes), the Istros and Pontus Euxinus coasts. According to him the Pontus water was full of alluvia. "... the left coast looked like a pool: it was Salmydesos, in the neighbourhood of the Istros, whom the sailors called "breasts" and the places next to the Scythian desert ... " (I, 3, 4 — C. 50). Near the Istros mouths lies a big island, called Peuce. The river has 7 mouths: the largest one is Hieron Stoma. Here from upstream the river to the Peuce Island, there is a distance of 120 stadia. Between Hieron Stoma and the seventh mouth of the river there are almost 300 stadia. "At a distance of 500 stadia from Hieron Stoma of the Istros, going all the time along the sea coast — having it always on the right hand — there lies the small town of Istros, a colony of the Milesians. Then follows Tomi, another town — also small — situated at a distance of 250 stadia from the first one. Then, at a distance of 280 stadia, we can see the town Callatis, a colony of Heracleoton" (VII, 6, 1 — C. 319).

In his Description of the Earth (*De Chorographia*) Pomponius Mela mentions the Black Sea and the Danube: "The Istros flows among the Istrians" (II, 3, 57). "Among the mouths of the Istros there are six islands: Peuce is the best-known and the largest one" (II, 7, 98).

Plinius Secundus, known as Pliny the Elder, the author of a Natural History (*Naturalis Historia*) in 37 volumes, describes quite accurately the Pontus Euxinus and the Danube.

According to Pliny, the Danube has 60 tributaries and flows into the sea through six arms. "The first arm is called Peuce, after the Island of Peuce, from which it is the nearest; it is absorbed by a marsh of 19,000 steps. From its bed, upstream Histropolis, there is developing a lake with a circumference of 63,000 steps, called Halmyris. The second arm is called Narakustoma; the third — Kalonstoma, next to the Sarmatic Island; the fourth — Pseudostomon, with the Conopon Diabasis Island, then Boreion Stoma and Pylon Stoma" (IV, 12 (24), 79). The Leuce Island is 10,000 steps in circumference and lies 120,000 steps away from Tyras (Dniester) and 50,000 steps from Peuce Island (IV, 13 (27), 93).

Flavius Arrianus (Arrian) offers valuable information on the Danube and Pontus Euxinus in his study Travel Round the Pontus Euxinus (*Periplus Ponti Euxini*):

24.1. "From the Istros mouth, called Pylon, to its second mouth there are 60 stadia. Here from to the mouth called Kalon there are 40 stadia. And from Kalon to the fourth mouth, called Narakon, there are another 60 stadia. 2. From here to the fifth mouth there are 120 stadia. From this point to the town of Istria there are 500 stadia and from Istria to the town of Tomis, 300 stadia. 3. From Tomis to Callatis town there is another 300 stadia. Here is a place for anchoring".

Arrian gives the description of the small island situated in front of the Danube mouths: "For someone who would sail from this mouth (Pylon) straight seaward with the North-West wind blowing, it appears an island called by some Achyllis Island, by others, Achyllis Race, and others Leuce, after its colour" (21, 1).

Dionysios Periegetes notes that "in the neighbourhood of the Rhine there springs the sacred Istros, which flows eastwards to the Pontus Euxinus wherein it noisily pours its waters foam through five mouths around the Peuce Island" (*Orbis Descriptio*, lines 298—301).

Ptolemy (Claudios Ptolemaios) wrote among other works the Geographic Guidebook or *Geographia*, which is an improved version of the information of ancient Greek geographers and especially of Marinus of Tyros.

Ptolemy gave valuable information on the Danube and its flowing area into the sea. We reproduce the description of the Danube Delta made by Ptolemy:

III, 10, 2 "The succession of the river mouths from now on is the following:

The first separation of the mouths at the fortress Noviodunum has

54°50'

46°30' degrees

while there from, the southernmost arm which surrounds the island called Peuce and has the position :

55°20'	46°30'
flows into the Pontus through Hieron Stoma (Sacred Mouth) or Peuce, being at :	
56°	46°15'
The northernmost part is divided into two and is situated at	
55°	46°45'
The northern part of this separation is divided in its turn into two at the position	
55°30'	47°
Then the southern part of this separation stops its course just before flowing into the Pontus. The northernmost arm which forms a pool called Thiagola, which lies at	
55°40'	47°15'
flows into the Pontus through the mouth called also Thiagola or Psilon, situated at	
56°15'	47°

The southern part of the second division is, in its turn, divided into two at the position

55°20'	46°45'
The northern part of this separation flows into the Pontus through the mouth called Boreic, situated at	
56°20'	46°50' degrees
and the southern arm is also divided into two at the position	
55°40'	46°30'

The southernmost arm of this separation flows into the Pontus through the mouth called Narakion, situated at

56°10'	46°20'
The northern arm is also divided into two at the position	
56°	46°40'

The northernmost arm of this separation flows into the sea through Pseudostomos mouth, which lies at

56°15'	46°40'
The southernmost arm flows through the mouth called Kalon, situated at	
56°15'	46°30'."

And farther :

III, 10, 3 "... The position of this coast is the following. After Hieron Stoma of the river Istros

Pteron Promontory	56°20'	46°
The town of Istros	55°40'	46°
Tomi	55°	45°50'
Callatis	54°40'	45°30'
Dionysopolis	54°20'	45°15'
Tiristis Promontory	55°	45°10'
Odessos	54°50'	45°
The mouth of the river Panyosos	54°45'	44°50'
Mesembria	55°	44°40' "

In view of a better understanding of the rather confusing description of the Danube Delta, we have outlined the Danube arms and the localities Istros, Tomi and Callatis (Fig. 5).

Although there are other studies which round up the image of this region in ancient times (such as Pseudo-Scymnos, Pausanias, Maximus of Tyr, Claudius Aelianus, Solinus, Dexippos, Tabula Peutingeriana, etc.), we confine ourselves to the information given above regarding the Danube and its Delta.

Briefly, between the 5th century B.C. and the 2nd century A.D., the Danube Delta exhibited five (after Herodotus and Arrianus), six (after Ptolemy) or seven (after Strabo) arms. According to Pliny, the delta had six arms, while the seventh flowed into a marsh and then into a lake — Halmyris.

The main arms, from South to North, were : Hieron or Peuce Stoma (Sacred Mouth), Naraku or Narakion Stoma (Narrow Mouth), Kalon Stoma (Nice Mouth), Pseudostomon (False Mouth), Boreion Stoma (Northern Mouth) and Thiagola or Psilon Stoma (Barren Arm, without willows). The distances between the mouths were the following : between Psilon Stoma and

Boreion Stoma — 60 stadia, between Boreion and Kalon Stoma — 40 stadia, between Kalon and Naraku Stoma — 60 stadia, between Naraku Stoma and Hieron Stoma — 120 stadia. Between Hieron Stoma and the town of Histria there were 500 stadia according to Arrianus and Strabo or 425 stadia according to Ptolemy. The Peuce Island lay at 120 stadia upstream the mouth of the Sacred Arm (Hieron). The Leuce Island lay at 50,000 steps off Peuce. Between Histria and Tomis there was a distance of 300 stadia, according to Arrianus, or 250 stadia

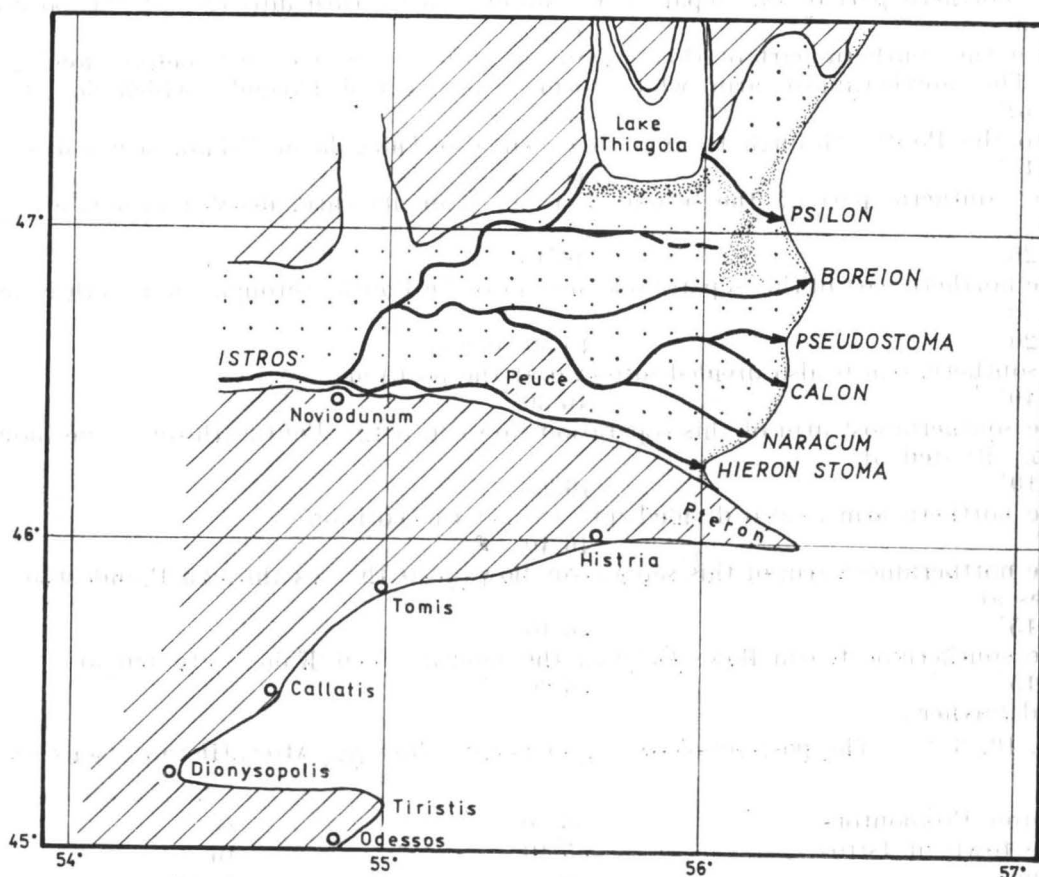


Fig. 5. — The Danube Delta, its distributaries and the Black Sea coast line after Ptolemy.

according to Strabo, whereas between Tomis and Callatis — 300 stadia (Arrianus) or 280 stadia (Strabo). Ptolemy mentioned that South of Hieron Stoma there lay the Pteron Promontory and the northernmost arm of the Danube flew formerly into Lake Thiagola and then into the sea; according to Herodotus, Strabo and Pliny, South of Hieron Stoma there lay a gulf, several pools or marshes and lake Halmyris, while Polybius and Strabo noted that on their way from Histria northwards, the ancient ships come across numerous obstacles, sand banks.

The geological and geomorphological reconstruction (Fig. 3) as well as the radiocarbon datings (Fig. 6) demonstrate that between the 5th century B.C. and the 2nd century A.D. the Danube Delta passed through the final stage of the "Sulina Delta" phase. Within the studied interval, there existed the following arms (from South to North):

(a) St. George, which was initially (during the "St. George I Delta" phase) the only arm of the Danube flowing into the sea and then underwent the clogging stage and implicitly got a diminished significance, got reactivated and generated its own delta — "St. George II Delta". The St. George arm has generated a secondary arm which flows southwards into the Razelm Lake — the Dunavăț arm.

(b) The main arm of the Sulina Delta was the Sulina arm. To the South there was a secondary distributary — Imputita arm, and to the North there occurred, given the evolution

stage, one, two or three secondary distributaries. During the studied interval, there occurred only one active secondary northern arm (we called it Movilă arm). The two others (Semiratca and Măgearu arms) were already clogged (Fig. 4).

(c) North of the Sulina Delta, the Chilia arm started advancing to the sea and generating its own delta. During this stage, the Chilia Delta was of cusped type, with a single distributary.

So the geological reconstruction of the ancient delta involve six active distributaries and two already clogged.

Now we are able to join many predecessors (Ionescu, 1909; Brătescu, 1912; Lepși, 1942; Petrescu, 1957; Iliescu et al., 1964; Popescu-Spineni, 1978 and many others) trying to identify the Danube mouths as described by the Ancients. Our reconstruction leads us to following correspondence with the geographic data and the Danube distributaries provided by the Ancients (Fig. 6).

Hieron Stoma corresponds to the St. George arm; the secondary distributary of Hieron arm, which flew into a lake corresponds to the Dunavăț; Lake Halmyris is the present-day Lake Razelm; Naraku Stoma corresponds to the Impuțita arm; Kalon Stoma is the present-day Sulina arm; Pseudostomos corresponds to the clogged secondary distributary North of Sulina, called the Semiratca arm (Fig. 4); Boreion Stoma is the only active distributary during the studied interval, lying North of Sulina and belonging to the Sulina Delta (called by us Movilă arm, Fig. 4); Psilon or Thiagola Stoma corresponds to the Chilia arm.

Peuce Island probably corresponds to the Caraorman accumulative formation to which were added the predeltaic relief relics where the initial spit formed. The Leuce Island seems to correspond to the Snake Island (Insula Șerpilor), and the way followed by the ships when the North-West wind blew, started from Psilon Stoma and reached Leuce.

Lake Thiagola, crossed by the northernmost arm of the Danube on its way to the sea, corresponds to the Pardina Depression, which at that time was covered by a lake that collected the rivers Catalbug and Chitai and which constituted a sort of lagoon delimited from the delta area by the Stipoc lacustrine spit and the Chilia Promontory.

The Pteron Promontory, described by Ptolemy, is the Murighiol-Dunavăț Promontory, and the "breasts" or bars mentioned by Polybius and Strabo, seem to correspond to the secondary Coșna-Sinoe Delta.

It is suprising how well the real distances between the different reconstituted elements are corresponding to those provided by the Ancients (Arrianus, Strabo, Ptolemy, Pliny) (see Table 1). Our calculations used the following values: Roman stadium — 185 m, Phileterian stadium — 211 m, step (pasus) — 1,4815 m.

Table 1

Correspondence between the distances given by the Ancients and those obtained by paleogeographic reconstruction

Described segments	Distances given by the Ancients								Real distances resulted from paleogeographic reconstruction
	Arrianus		Strabo		Ptolemy		Plinius		
	s/p	km r/ph	s/p	km r/ph	s/p	km r/ph	s/p	km r/ph	
Psilon — Boreion	60 s	11.1/12.7	—	—	—	—	—	—	13.0
Boreion — Kalon	40 s	7.4/8.5	—	—	—	—	—	—	8.5
Kalon — Narakum	60 s	11.1/12.7	—	—	—	—	—	—	13.0
Narakum — Hieron	120 s	22.2/25.3	—	—	—	—	—	—	25.0
Hieron — Istria	500 s	92.0/105.0	500 s	92.0/105.0	425 s	78.6/89.7	—	—	80.0
Hieron — Peuce	—	—	120 s	22.2/25.3	—	—	—	—	23.0
Istria — Tomis	300 s	55.5/63.3	250 s	46.2/52.7	—	—	—	—	50.0
Tomis — Callatis	300 s	55.5/63.3	280 s	51.8/59.1	—	—	—	—	45.0
Peuce — Leuce	—	—	—	—	—	—	50.000 p	74.0	70.0
Circumference of Lake Halmyris	—	—	—	—	—	—	63.000 p	93.0	95.0

Legend: s — stadium; p — step (pasus) = 1.4815 m; km r — transformation, having in view the value of 185 m of the Roman stadium; km ph — transformation, having in view the value of 211 m of the Phileterian stadium.

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