LATE NEOGENE - QUATERNARY EVOLUTION OF DACIAN BASIN (ROMANIA). AN ANALYSIS OF SEDIMENT THICKNESS PATTERN

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Abstract: During the Pliocene within the Paratethyan Dacian Basin two sediment accumulation area functioned, acting as two large sedimentary fans. Their development was controlled by the sediment supply rate of the two northern, Carpathian source-areas. Comparatively small amounts of sediment came from two southern source-areas. The eastern Dacian Basin fan grew up through aggradation, showing progradation activity at his western extremity. Since Lower Pontian the western fan represents a retrograding unit, practically disappearing during the Quaternary. Starting from the Upper Dacian time the important sediment influx led to the filling up of the Dacian Basin Lake. The development of the two sediment fans continued even after the change from lacustrine to fluvial environment.

Key words: sediment thickness, source-area, sedimentary fan, sediment influx, accommodation, lacustrine environment, fluvial environment, progradation, retrogradation, aggradation.

1.INTRODUCTION

The sediment thickness distribution represents an important potential for revealing some of the large scale genetic trends of the Dacian Basin. This is especially important as most of the Late Neogene - Early Quaternary sediment filling of the Dacian Basin is only accessible through drillings and mining works.

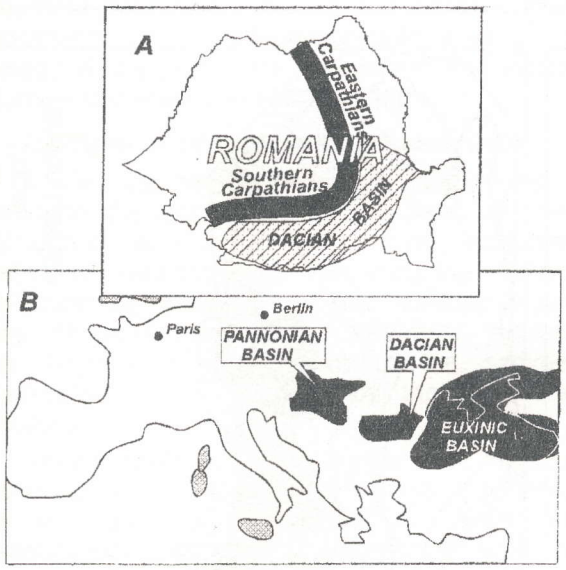

Fig.1. Dacian Basin sediments in Romania (A) and in Europe (B).

Dacian Basin setting

The Dacian Basin is part of the Paratethys realm, which separated itself from Tethys during the Middle Miocene.

The Dacian Basin sediments cover most of the southern and eastern territory of Romania (Fig.1A). Its area is confined between the Southern and Eastern Carpathians and the present-day lower course of the Danube River.

Table 1. Chronostratigraphic units used for the Dacian Basin deposits. Modified, from Papaianopol et al. (1995)

M. Y.	CHRONSTRATIGRAPHIC UNITS	
1.8	QUATERNARY	HOLOCEN
		PLEISTOCEN
	PLIOCENE	ROMANIAN
		DACIAN
5	UPPER MIOCENE	PONTIAN
		MEOTIAN

Located between the Pannonian Basin (Central Paratethys) and the Euxinic Basin (Eastern Paratethys) (Fig.1B), the Dacian Basin alternatively acted as a communication area and a closed basin.

The Dacian Basin appears as a large lake, with the size of a small interior sea. Brackish and fresh water episodes occurred during the Dacian Basin evolution (Papaianopol et al., 1995).

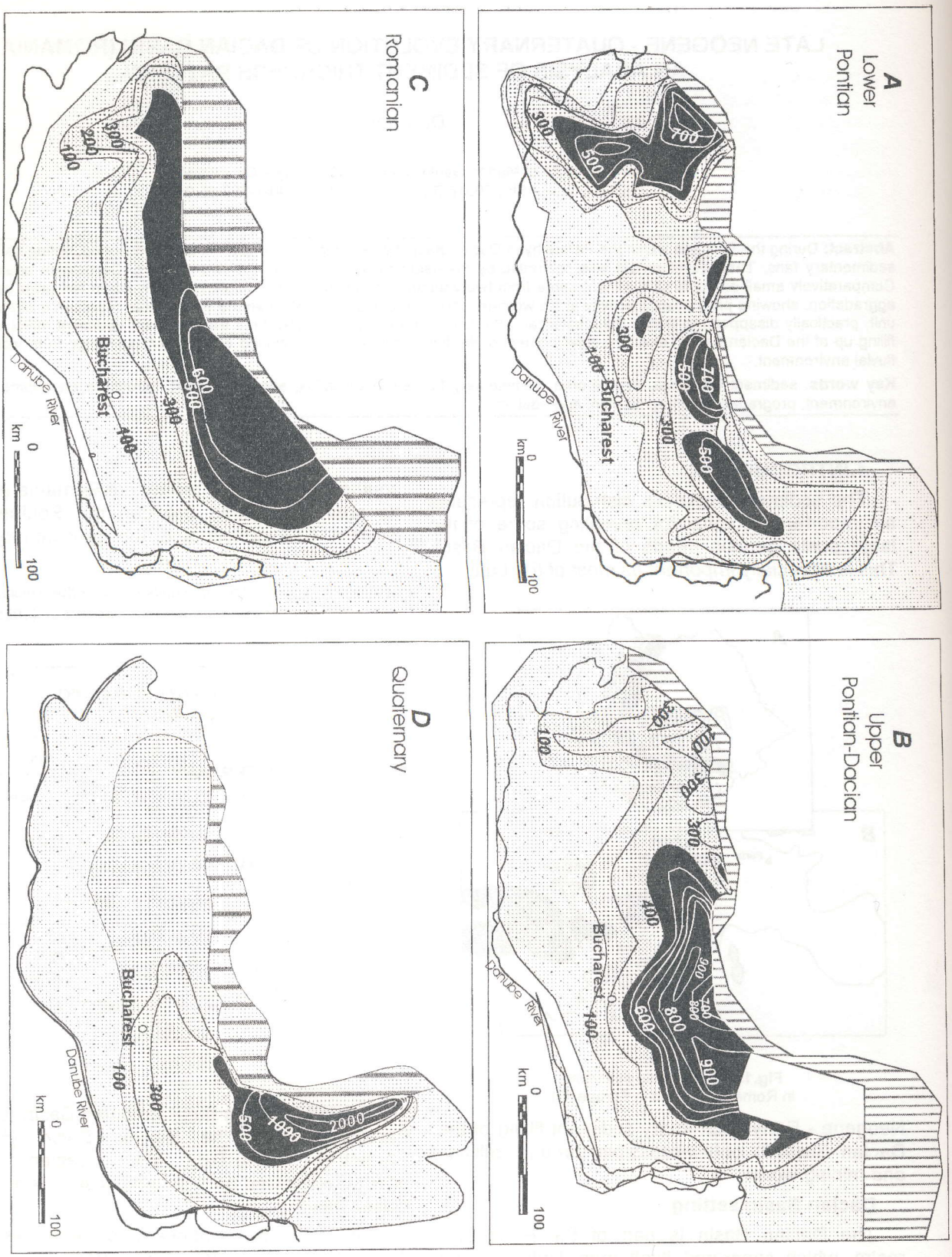

Fig. 2 Evolution of the Dacian Basin sediment thickness pattern.
Isopach maps simplified after Saulea et al., 1969 (A, B and C) and Ghenea et al.,1971 (D).

100 isopach lines (thickness in meters). proximal zone with eroded Dacian Basin sediments

The fresh water environment dominates the final stages of the basin evolution.

The chronostratigraphic upper Neogene units used for the Dacian Basin deposits are shown in table 1.

Sources of sediment thickness data

Based on borehole data, several lithofacial, paleogeographic maps or atlases (Ghenea et al., 1971; Hamor, 1988; Hristescu et al., 1964; Saulea et al., 1969) present data picturing the sediment thickness distribution of the Dacian Basin (Neogene to Quaternary).

For the genetic interpretation of the Late Neogene Dacian Basin this paper relies mainly on the isopach maps included in the Neogene lithofacial atlas of Romania prepared by Saulea et al. (1969). Some thickness data from Hristescu et al. (1964) maps were also utilized. These additional data come from the northernmost Dacian Basin area, which is not entirely covered by some of the Saulea et al. (1969) isopach maps.

The isopach lines drawn up on the Quaternary map of Ghenea et al. (1971) represented the only available sediment thickness distribution picture for the Quaternary development of the Dacian Basin.

The configuration of the Late Neogene southern boundary of the Dacian Basin is drawn according to the paleogeographic atlas of the Neogene deposits from the central and eastern Europe (Marinescu, in Hamor, 1988).

Confidence of sediment thickness data.

There are quite restricted possibilities to evaluate the confidence of the used sediment thickness data. An informative confidence estimation was made by comparing the sediment thickness distribution on all the available isopach and lithofacial maps. This comparison indicated the large scale agreement of the sediment thickness images provided by the used data sources.

Smaller scale discrepancies are to be remarked between the Neogene isopach maps of Hristescu et al., 1964 and Saulea et al., 1989. The reconciliation of these differences was not possible, as the primary data are not available. We presume that the stratigraphic interpretation of the borehole data is the reason of the disagreements.

In accordance with the above discussed thickness data confidence, the investigation exposed in the present paper aimed only at the large scale genetic characters of the Dacian Basin.

2. SEDIMENT ACCUMULATION AREAS

The isopach maps prepared for the Lower Pontian (Fig.2A), Upper Pontian-Dacian (Fig.2B) and Romanian (Fig.2C) time intervals point out the existence of two major sedimentation areas of the Dacian Basin (Fig.3). These areas are individualized by sediment thickness patterns consisting of concentric isopach lines, with one or more than one maximal thickness cores.

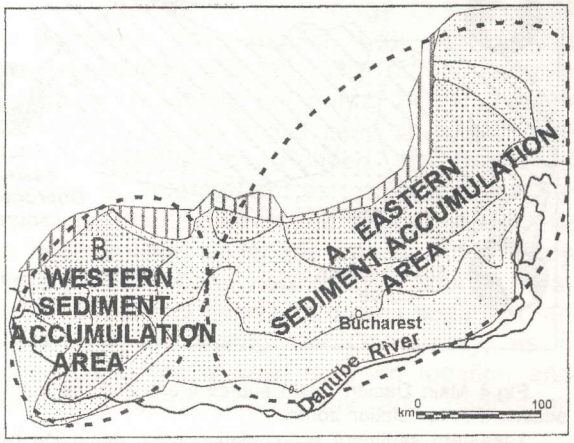

Fig.3 Main sediment accumulation areas of the Dacian Basin. Danube River and Bucharest location are shown as geographic reference features.

The *eastern sediment accumulation area* is the most extensive of the Upper Neogene areal constituents of the Dacian Basin. This unit extends from the northeastern extreme to the central-western part of the basin (Fig.3A).

The *western sediment accumulation area* is situated in the occidental part of the Dacian Basin (Fig.3B). This area is considerably smaller, representing about one third of the eastern area surface.

Both eastern and western areas display maximal sediment thickness in the northern part, close to the contact with the Carpathian zone (Fig.2). Southward of the Carpathians the sediment thickness decreases continuously. The sediment accumulation disappears marking the southern limit of the Dacian Basin, along a line roughly following the present course of the Lower Danube River.

3. SOURCE - AREAS

The Pliocene - Quaternary source-areas of the Dacian Basin have been identified on the base of sediment thickness distribution and sediment lithology.

Northern source-areas

The most important feature indicating source-areas location is the fact that the sediment thickness is always maximal in the proximity of the Carpathian zone. Moreover the sediment thickness invariably decreases away from the Carpathians.

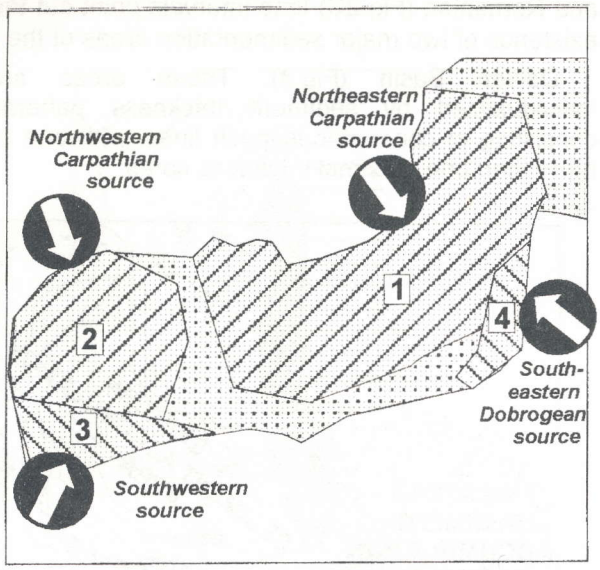

Fig.4 Main Dacian Basin source-areas and the controlled sediment accumulation zones.

1=eastern sediment accumulation area, controlled by the supply rate of the northeastern source-area. 2=western sediment accumulation area, under the influence of the northwestern Carpathian source-area. 3=zone controlled by the southwestern source-area. 4=zone controlled by the southeastern, Dobrogean source-area.

This indicates the northern, Carpathian provenance of the most Dacian Basin sediments. The Carpathian area acted as a major sediment source-area during all the Pontian - Quaternary investigated time interval.

The sediment thickness pattern evidences two independent sediment accumulation areas within the Dacian Basin (Fig.3). Both of the two sediment areas are thickest in the northern part and thinning out southward. This is a strong indication that two sediment sources acted simultaneously within the Carpathian zone: the northeastern Carpathian source-area and the northwestern Carpathian source-area (Fig.4).

Southern source-areas

Local accumulation of relatively coarser grained sediments have been evidenced in the southwestern and the southeastern extremities of the Dacian Basin. The coarser grained accumulations are clearly shown on the lithofacial maps of Saulea et al. (1969) and on the paleogeographic maps prepared by Marinescu (in Hamor, 1988). The areal distribution of these accumulations is restricted and their sediment thickness is relatively small. These lithofacial data indicate that a part of the sedimentary material came from areas located south of the Dacian Basin.

According to the location of the coarser grained accumulations two southern source-area have been active (Fig.4). The Dobrogean area supplied sediment to the southeastern extremity of the Dacian Basin. The two southern sediment sources acted as separate dryland areas. As the paleogeographic reconstruction points out (Saulea et al., 1969) sometimes they were part of the same dryland zone, covering all the area south of the Dacian Basin.

4. EVOLUTION OF SOURCE-AREAS AND SEDIMENT ACCUMULATION ZONES

Sediment thickness and its distribution pattern are the most significant criteria used in this paper to analyse the evolution of the sediment accumulations and their supplying sources.

As already discussed, on the basis of the sediment thickness distribution two main sediment accumulation zones have been distinguished within the Dacian Basin (Fig.3). Moreover, the polar character of the sediment thickness pattern demonstrate that each sediment accumulation area is controlled by a certain source-area (Fig.4). Taking advantage of this situation, it was possible to evidence the evolution of the source-areas activity as it is reflected by the sediment thickness distribution.

Northeastern source-area - eastern accumulation area.

From the sediment thickness viewpoint the eastern sediment accumulation area is characterized by the concentric arrangement of the isopach lines, determining the fan shape of the large sedimentary pile (Fig.5).

Within the eastern sediment accumulation area the maximal thickness zone maintained approximately the same position during the Upper Pontian to Romanian time interval (Fig.2). This indicates that the northeastern source-area was stable and the supplied sediment used the same funneling way all through the mentioned time interval. The nucleus of the maximal sediment thickness shows a different areal location during the Quaternary (Ghenea et al., 1971), occurring towards the north of the basin.

There are divergent data on the subject of the important sediment accumulation zone located in the northern part of the Dacian Basin. Hristescu et al. (1964) isopach maps indicate very high thickness values for the Pliocene sediments from the northern Dacian Basin zone (Pontian = 1200m; Dacian =1500m; Romanian=3000m). In contrast, Saulea at al. (1969) significantly did not extend their Pliocene isopach maps over the same northern area; probably mistrusting the available stratigraphic data. More recent data from Marinescu (in Hamor, 1988) mention again very thick Meotian (800 m) and Romanian (2000 m) sediments in the northern part of the Dacian Basin. Taking into consideration the above presented

data, it appears that the most active sediment source was located in the northern part of the Dacian Basin during all its Sarmatian - Quaternary development period. The northeastern Carpathian source supplied sedimentary material along a large zone extending from the northern to the center of the Dacian Basin.

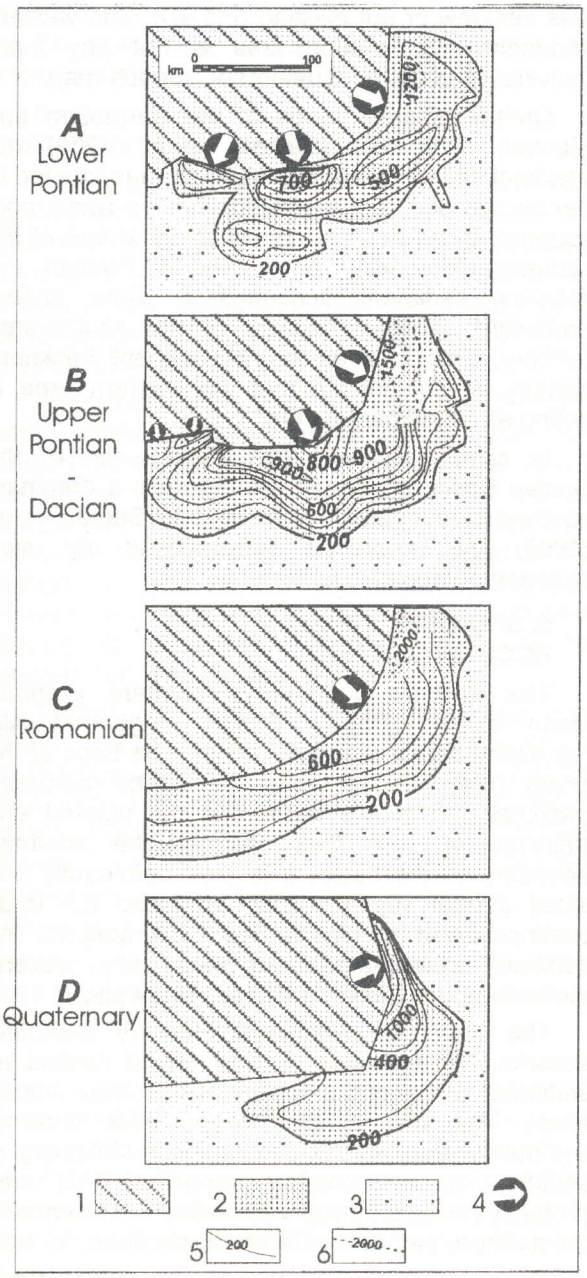

Fig.5 Evolution of the sediment accumulation and sediment supply within the eastern area of the Dacian Basin.
1-Source area. 2-Main sediment accumulation area (sediments thicker than 200 m). 3-Area with thinner than 200 m sediments. 4-Main sediment supply zone, within the northeastern Carpathian source area. 5-Isopach lines (sediment thickness in meters); simplified from Saulea et al., 1969 (Pontian to Romanian) and Ghenea et al., 1971 (Quaternary). 6-Additional sediment thickness information, from Hristescu et al., 1964.

The 200 m isopach line was selected in this study to represent the frontal zone of the large sediment fan making up the eastern accumulation area. Following the morphologic evolution of this frontal zone it is to be remarked that the Lower Pontian frontal zone was rather deeply undulated (Fig.5A). During the next time period (Upper Pontian - Dacian) the morphology of the frontal zone becomes more regular, with smaller and wider undulations (Fig.5B). The frontal zone is significantly smoothing out during the Romanian time (Fig.5C). As the frontal zone does not show important shifting, its Pontian to Romanian evolution is interpreted as representing the morphologic maturation of the aggrading eastern area sediment fan under the intense and steady sediment influx of the northeastern source area. The frontal zone of the eastern area sediment fan is quite different during the Quaternary, as it stepped back into a new, northern location and shows a different morphology and orientation (Fig.5D).

The growing morphological maturation of the eastern sediment fan is also shown by the evolution of the maximal sediment accumulation sites. The structure of the maximal thickness zone is quite complex for the Lower Pontian sediment accumulation (Fig.7A). This maximal accumulation zone becomes simpler and more concentrated during the Upper Pontian - Dacian time period (Fig.7B). Since the Romanian time (including the Quaternary) there is only one maximal thickness core (Fig.7C, D).

The maximal sediment thickness in the eastern accumulation area was regarded as a rough estimation of the northeastern source-area supply rate magnitude. According to this criteria during the Pliocene the northeastern source-area constantly provided high amounts of sedimentary material over a zone with large areal extension. Since the Quaternary the very high sediment supply rate concentrated in the northern part of the Dacian Basin.

Northwestern source-area - western accumulation area

With modest development, the western sediment accumulation area of the Dacian Basin is first individualized during the Middle and Upper Sarmatian. The western area reached its most important development during the Meotian and Lower Pontian (Fig.6A). The large accumulation area accommodated up to 800 m thick sediments, revealing the intense activity of the northeastern, Carpathian source-area. The sediment supply activity of the northwestern source-area significantly diminished during the upper Pontian-Dacian time interval. Most of the sediments

generated by this source-area are thinner than 200 m and accumulated within a smaller area. (Fig.6B).

In contrast with the Sarmatian-Dacian interval during the Romanian time the sediment thickness distribution of the western accumulation area is not any more distinct versus the similar distribution in the eastern accumulation area (Fig.6C). The sediment thickness is higher in comparison with the Upper Pontian-Dacian interval, but the supplying source cannot be differentiated based on the sediment thickness pattern.

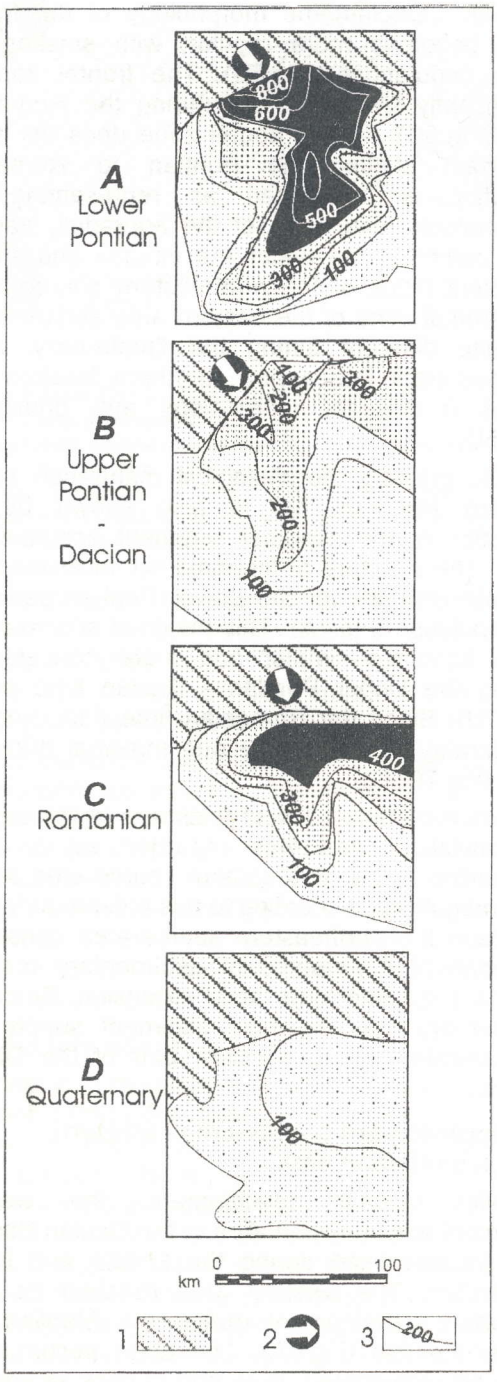

Fig.6 Evolution of the sediment accumulation within western area of the Dacian Basin.
1-Source area. 2-Main sediment supply zone, within the northeastern Carpathian source area. 3-Isopach lines (sediment thickness in meters); simplified from Saulea et al., 1969 (Pontian to Romanian) and Ghenea et al., 1971 (Quaternary).

The Quaternary sediment thickness pattern in the western Dacian Basin indicates that the supplying activity of the northwestern source-area was very low or not existing (Fig.6D). The western sediment accumulation area is not any more individualized on the Quaternary isopach map.

On the isopach maps of the Sarmatian and Meotian sediments (Saulea et al. 1969) the maximal sediment accumulation zone is located in the central part of the western Dacian Basin unit; suggesting the depressional, basinal shape of the sedimentation area. Since Upper Pontian the maximal sediment accumulation zone shifted northward, in the proximity of the source-area territory. This is a piedmont sediment thickness pattern, which indicate that the western area is acting as a sedimentary fan.

In comparison with the eastern fan of the Dacian Basin, the western fan shows a dominant southward elongation. According to Saulea et al. (1969) this character is imposed by syn-sedimentary tectonic factors.

5. SEDIMENT INFLUX VERSUS ACCOMMODATION

The Pliocene-Quaternary sediment accumulation of the Dacian Basin is geometrically represented by a triangular prism. The base of the prism (maximal thickness) is in the northern, proximal part of the basin and the pointed end (minimal or zero thickness) at the southern boundary of the basin. It is the dominantly one sided detrital supply, which produced the large scale shape of the Dacian Basin sediment fill. The southern source-areas supplied only several percents of the Dacian Basin sediment pile.

The important Pontian-Quaternary sediment accumulation indicates the active and continuous sediment supply of the uplifting Carpathian source-areas. The accumulation of the thick proximal sediments required the continuous maintaining of sediment accommodation capacity. This was probably realized through the active subsidence of the northern part of the Dacian Basin floor.

The paleo-environmental analysis carried out in the northern littoral zone of the Dacian Basin (Jipa, 1995; Jipa, 1997) pointed out the offshore and littoral (beach and deltaic) lacustrine sedimentation during the Pontian and Lower Dacian times. Fluvial sedimentation is gradually replacing the lacustrine environment starting from the upper part of the Dacian time. This environmental evolution suggests the growing lack of balance between the

sediment influx and the accommodation. Since Late Dacian the available accommodation space is exceeded by the sediment influx. The Dacian Lake is filling up and the sediment accumulation becomes fluvial.

6. MAIN SEDIMENTARY ENVIRONMENTAL FEATURES

Sedimentary fans

The piedmont accumulation represents the most important sedimentary feature of the

Dacian Basin all through the Pontian to Quaternary time.

During the Pontian - Lower Dacian lacustrine sedimentation the sediment thickness pattern points out the existence of two large subaquatic sedimentary fans. Prograding beach and deltaic environments dominated the fans sedimentary development; the mass transport processes playing a subordinate role (Jipa, 1995).

After the filling up of the lake the piedmont sedimentation goes on in the eastern area. The eastern accumulation zone develops as an alluvial fan. It is the steady activity of the eastern Carpathian source-area which imposed the continuation of the piedmont, fan-like accumulation pattern in spite of the important environmental change (from subaquatic, lacustrine to subaerial, fluvial). At least from the Quaternary time the western fan is not active any more.

Taking into account the predominant finer grained sedimentation, as well as the development of the coal generating facies, it appears that the Romanian time alluvial fan was relatively flat. It was crossed by low energy, meandering rivers with levees and flood plains covered by abundant vegetation.

The existence of very thick and coarser grained sediments within a more restricted accumulation area suggests that during the Quaternary the slope of the alluvial fan is steeper.

A large area in the southern part of the Dacian Basin consists of thin sediments. This area is interpreted as representing the *sedimentary plain* developed as the southern, distal component of the fan units. This area could have also acted as the restricted lacustrine environment during the last retreat phase of the Paratethys Dacian Lake.

Paleo - Lower Danube River

The activity within the large alluvial fan area existing during the terminal Neogene and Quaternary Dacian Basin implies the activity of extensive fluvial networks shifting on the fan surface. It is logical to suppose that the water discharge of these rivers was collected by a larger river. It is most probable that, due to the upper and middle fan slope, this larger river was flowing at the southern periphery of the alluvial fan system; at the margin of the alluvial plain or within this area. Such a large river can be considered the ancestor of the present day Lower Danube River. The location of the paleo-river mouth is still uncertain.

7. PROGRADATION, RETROGRADATION, AGGRADATION

The interval between the 100 m and 200 m isopach lines was selected in figure no. 7 to mark the frontal zone of the sedimentary fan system in the Dacian Basin. The overlapping of the frontal zone for three succeeding time intervals makes evident some of the dynamics of the sedimentary fans. From this viewpoint the eastern and the western fans are again different.

The western fan

The time sequence image (Fig.7) of the western fan frontal zone shows a definite retrogradation of this unit during the Pliocene. After an irregular areal expansion from Upper Sarmation to Lower Pontian the western area is decreasing. Until the Romanian time the frontal zone of the western fan is stepping back.

The eastern fan

Within the eastern fan unit the migration of the frontal zone is not homogeneous. The areal distribution of the central and eastern part of this fan unit was essentially stable during the Upper Neogene. Within this area the frontal zone shows only local outward and inward lateral movements (Fig.7). It appears then that this central and eastern part of the fan evolved through a dominant aggradational process. This allowed the morphological maturation of the eastern fan, as discussed in chapter 4.

In the western part of the eastern fan the sequential location of the frontal zone shows the lateral outgrowing of the fan (Fig.7). This part of the eastern fan is actively prograding towards south-east.

The Quaternary sediment thickness image (Fig.2D, 5D) shows a drastic retrogradation of the eastern fan frontal zone.

The sediment thickness distribution of the Dacian Basin during the Pontian to Quaternary interval was investigated using existing isopach maps.

According to the sediment thickness distribution two important sediment accumulation areas acted simultaneously and independently within the Upper Neogen Dacian Basin. The two sediment accumulations appear as large fans.

The development of the fans was controlled by the sediment supply coming from two Carpathian source-areas. The northeastern Carpathian source supplied sedimentary material along a zone

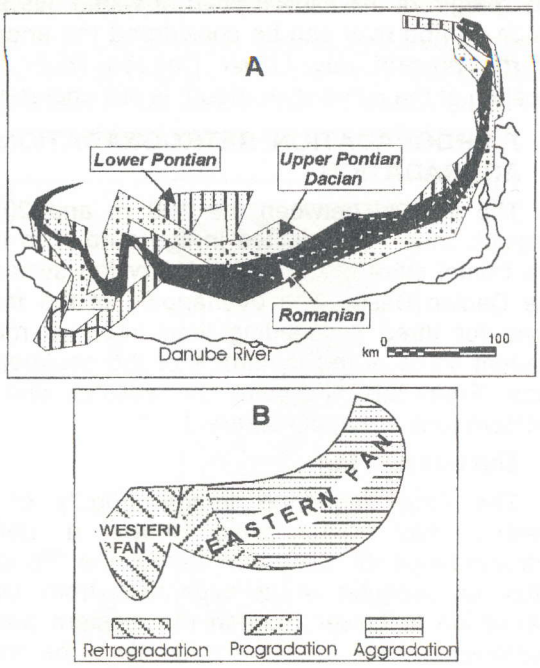

Fig.7 Frontal zone dynamics within the sediment fan system of the upper Neogene Dacian Basin. The frontal zone is represented by the areal distribution of the 100 to 200 m sediment thickness interval.

extending from the northern to the central parts of the Dacian Basin edge. Two additional small source-areas provided clastic material from areas located south of the Dacian Basin.

Reflecting the trend of the northwestern Carpathian source-area, after Lower Pontian to Romanian the western sediment accumulation area retrograded and disappeared during the Quaternary.

Supported by a continuously active northeastern Carpathian source-area the eastern sediment accumulation area developed into a growing up large sediment fan. After a long phase (Upper Sarmatian to Romanian) of western progradation the eastern fan abruptly retrograded during the Quaternary; the western area becoming a continuation of the eastern sediment accumulation area.

The western accumulation area accommodates the thickest sediment pile during Meotian and Lower Pontian.

The steady sediment influx led to the filling up of the Dacian Basin Lake starting from the upper Dacian time.

The sediment fan accumulation (subaquatic and afterward subaerial) persisted during the whole Pontian - Quaternary time period, in spite of the environmental change.

REFERENCES

GHENEA,C., BANDRABUR, T., MIHĂILĂ, N., GHENEA, A., GIURGEA, P., 1971, Atlas géologique. Echelle 1/1.000.000. Carte du Quaternaire. Institut Géologique. Bucarest.

HAMOR, G. (ed.), 1988, Neogene paleogeographic atlas of Central and Eastern Europe. Hungarian Geological Institute, Budapest.

HRISTESCU et al., 1964, Atlasul hărtilor litologo-paleogeografice ale sedimentarului din R.P.R. Ministerul Industriei Petrolului si Chimiei. Intreprinderea de Laboratoare Geologice. Tema 121 B. Bucuresti.

JIPA, D.C., 1995, Upper Neogene evolution of sedimentary environments in the littoral zone of Dacic Basin. Romanian Journal of Stratigraphy, 76/7: 131-132. Abstract. Bucharest.

JIPA, D.C., 1997, Paleoenvironmental criteria in fluvio-lacustrine deposits (Late Neogene, Dacian Basin, Romania). 18th IAS Regional European Meeting of Sedimentology. Abstracts. Heidelberg.

PAPAIANOPOL, I., JIPA, D., MARINESCU, F., ŢICLEANU N., MACALET, R.,1995, Upper Neogene from the Dacian Basin. Guide to excursion B2 (post-congress). Romanian Journal of Stratigraphy. 76/1, 43 p. Bucharest.

SAULEA, E., POPESCU, I., SĂNDULESCU, J., 1969, Atlas lithofacial. VI - Neogene. 1:200.000. Institut Géologique. Bucharest