A LATE NEOGENE MARKER SEQUENCE IN THE DACIAN BASIN (PARATETHYS REALM). GENETIC AND STRATIGRAPHIC SIGNIFICANCE

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Abstract: The coarsening-upward sequence (Pliocene, lower Dacian age) illustrates the final development stage of the brackish unit known as the Dacian Basin. This littoral/deltaic sequence is a marker level with basinal extent. At the beginning of the Dacian time the shoreline situated in the proximity of the Carpathian area began to migrate through progradation towards south and southeast. Finally, when migration reached the southern/southeast extremity of the basin area, the brackish-marine Dacian Basin dried up and was replaced by an area of fluvial deposition. The sea level fall that produced the subaerial exposure recognized in the north-west area of the Black Sea shelf can explain the relative fast drainage of the Dacian Basin in the first part of the Dacian time.

Key words: Dacian Basin, marker sequence, coarsening-upward sequence, basin drying-up

INTRODUCTION

This paper presents a Pliocene (early Dacian time) sequence in the Dacian Basin that has a marker character. The characters of this marker sequence provide important information regarding the significance and evolution of the Dacian Basin in its last phase as a brackish basin.

The study of the marker sequence was made using outcrop observations and well logs analysis. Direct outcrop observations provided data regarding sedimentary and paleobiological characters of the investigated sequence. These observations were made only in the area close to the Carpathians, where the upper Neogene sediments of the Dacian Basin are cropping out. In the boreholes, due to its distinctive well log signature the early Dacian age marker sequence can be noticed over most of the Dacian Basin territory. Consequently, the well log analysis represented one of the most important tools to investigate the lower Dacian coarsening-upward sequence, which constitute the objective of this work.

Dacian Basin Short Presentation

Dacian Basin is one of the low salinity marine units of the Paratethys domain. On the paleogeographic maps, the Dacian Basin appears as the westernmost component of the large Oriental Paratethys Sea (Hamor *et al.,* 1988; Popov *et al.,* 2004) (Fig. 1). In the present-day geographic picture, the Dacian Basin area is located inside the large bending of the Carpathian and Balkan mountain chains, extending eastward to the Dobrogean area and the Black Sea (Fig. 2).

Paleogeographically the Dacian Basin occurred as a distinctive brackish unit during the middle Sarmatian (s.l.) time (Saulea *et al.,* 1969). The low salinity marine state of the Dacian Basin ended during the Dacian time (Jipa, 1997; 2006). Since upper Dacian time the fluvial sediment accumulation dominated the entire Dacian Basin area (Fig. 3).

The sedimentary characters of the upper Neogene deposits from the Dacian Basin area indicate the existence of two main sedimentation environments: shallow water marine and fluvial.

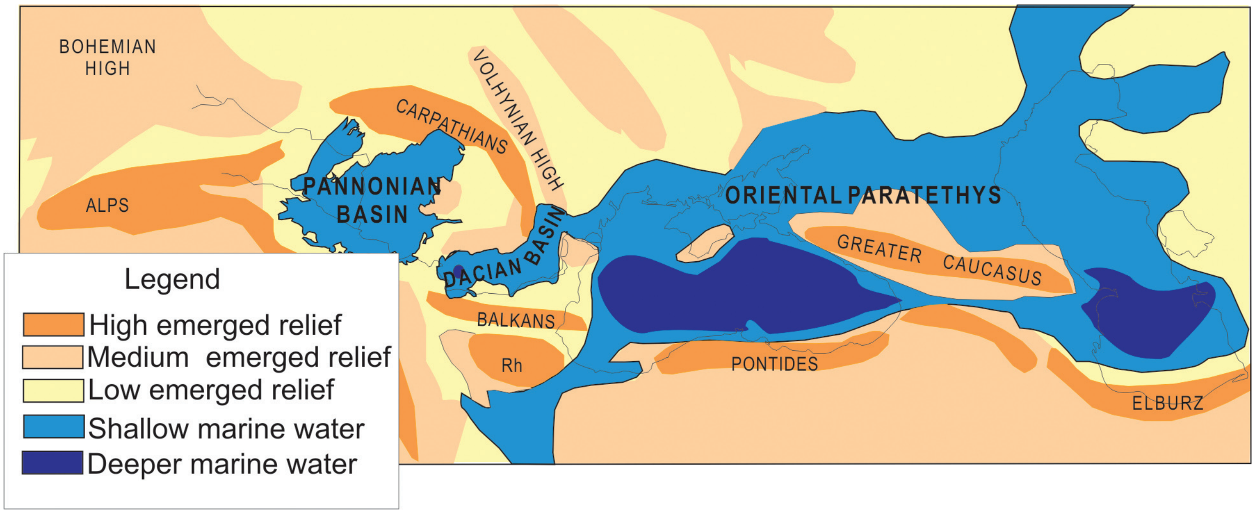


Fig. 1 Dacian Basin within the Paratethys domain during the early Pontian (6,1 - 5,7 Ma). Modified and simplified from Khondkarian *et al.* (in Popov *et al*., 2004), Saulea *et al*. (1969), and Hamor *et al*. (1988)

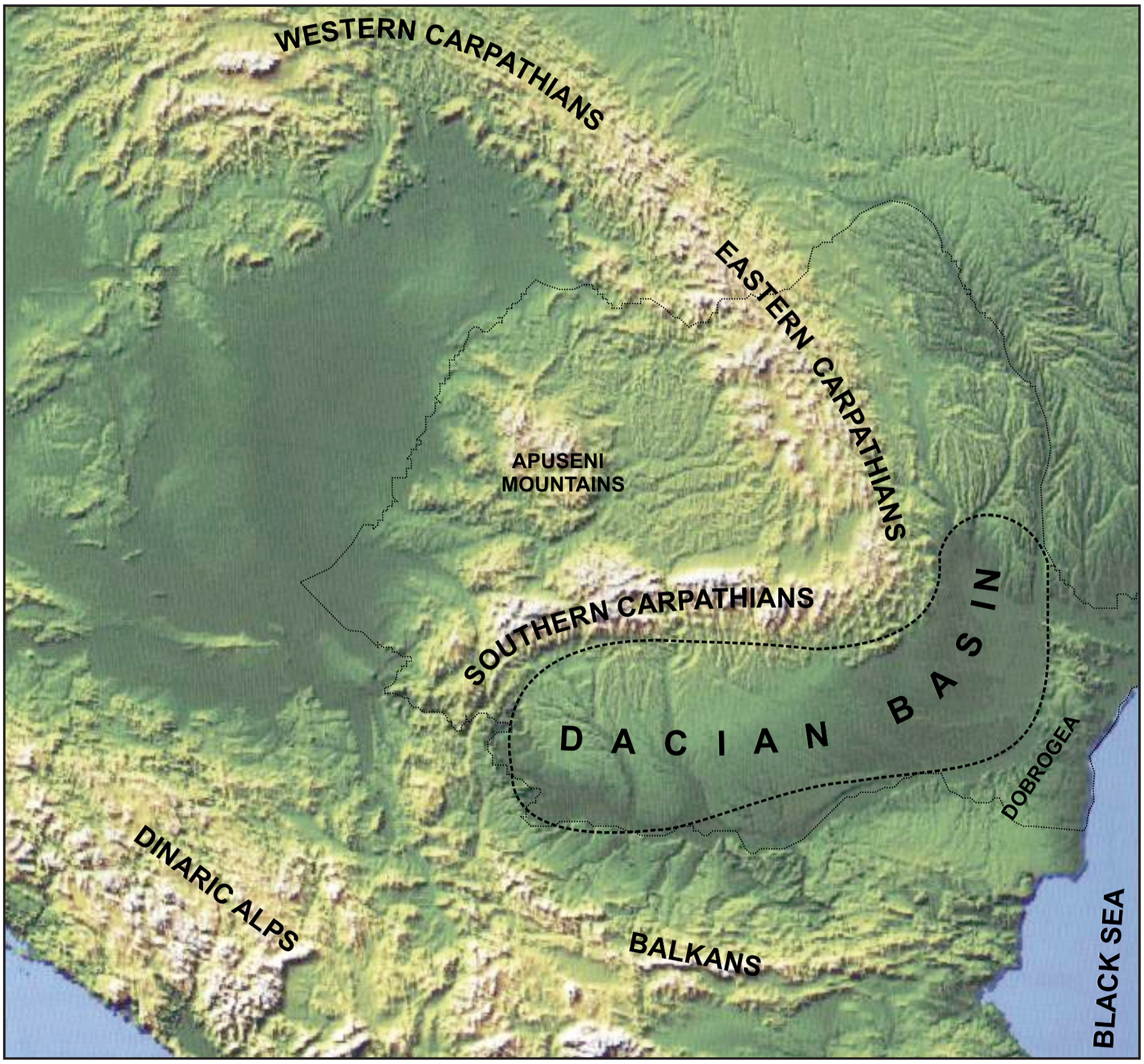


Fig. 2 Dacian Basin area on the present-day geographic image of the south-eastern Europe. The thin dotted line marks the territory of Romania

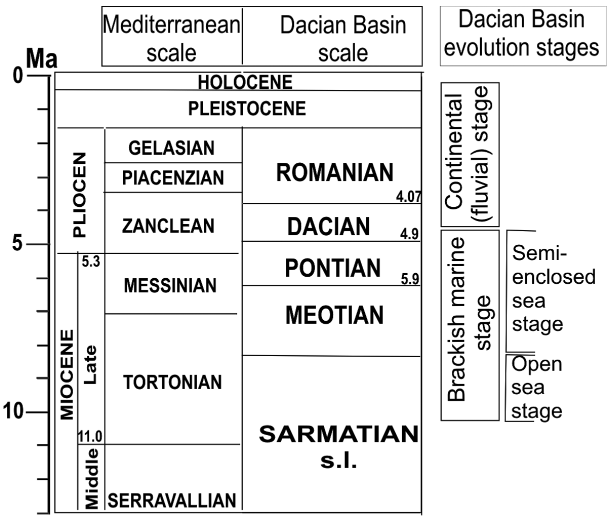


Fig. 3 The Dacian Basin stratigraphic scale (after Popov *et al.*, 2004 and Vasiliev *et al.*, 2004) and the major development phases of the Basin

Shallow water sedimentary environment of this basin is indicated by sedimentary structures produced by fair-weather waves and storms (Jipa, 2006). Frequently the predominantly sandy sequences with shallow water structures have a coarsening-upward trend (this was evident both in outcrops and in well logs), which emphasizes their prograding character. Some sandy sequences of shallow water are coarsening-upward but do not show wave or storm structures. It is considered that the coarsening-upward deposits are formed in fluvial-dominated delta environments. The muddy sequences suggest a sedimentary environment with low energy and more distal location (offshore type), but might appear also in shallow, low energy water between the fluvial deltas.

Within the brackish marine succession of the Dacian Basin deposits appear also thin or thick continental deposits. They represent minor units (meters or tens of meters thick; upper Sarmatian s.l. or upper Meotian) up to very large units (hundreds of meters thick; upper Dacian to Quaternary). These deposits occur as sandy bodies intercalated within a muddy succession. Sandy intercalations (sometimes with basal pebbles) are fining-upward units, with inclined bedding (point bar type) and current lamination, that indicate the alluvial channel filling character.

In the Dacian Basin there are two Meotian-Dacian different areas with distinct facies associations. In the western and central parts of the basin the muddy facies is dominant. The presence of sandy sediments is greater towards the northward extremity of the basin. The distinction between the two facies areas was determined by the differential influence of the two Carpathian source areas, the amount of the sediments supplied by these sources being quite different.

In the western and central areas of the Dacian Basin three major sedimentary cycles were recognized (Fig. 4A): Sarmatian (*s.l*), Meotian and Pontian-Dacian-Romanian (Jipa and Olteanu, in Jipa, 2006). Each of these cyclical sequences start with muddy transgressive offshore deposits. The upper part of the major (second order) cyclical sequences have regressive character, and consists of sandy littoral deposits, topped by fluvial deposits. These cycles, indicating low or medium sediment flux, are recognized in the westward and central part of the Dacian Basin. In the north-eastern part of the Dacian Basin, close to the main source area of the sediments, because of the high influx of clastic material, the offshore muddy sequences do not appear anymore. Because the clayey sequences (which separate the cycles) are missing, the three sedimentary cycles cannot be distinguished in the northern Dacian Basin (Focsani depression).

The most important cycle of the Dacian Basin is the one that begins with transgressive lower Pontian muddy deposits (Fig. 4B). The regressive phase of this cycle starts with a fine sand littoral sequence of lower Dacian age with coarsening up tendency. The fluvial medium Dacian - Romanian deposits, that represent the obvious part of the regressive trend, are very well represented as last term of the cyclical mega-sequence Pontian-Dacian-Romanian. These deposits represent the continental sedimentary accumulation that have been formed after the filling of the brackish-marine Dacian Basin.

SEDIMENTARY CHARACTERS OF THE LOWER DACIAN COARSENING-UPWARD SEQUENCE

Sedimentary facies in the outcrop

The lower Dacian inverse graded marker sequence crop out in the proximity of the Meridional Carpathians, on the northward frame of the Dacian Basin. The best conditions for observations of this coastal sequence were found in Bengesti (Gorj County, east of the city of Tg. Jiu) (Fig. 5) and Bobolia (Prahova county, Valea Rea point, south of Cimpina, the right bank of Prahova River) (Fig. 6).

From the lithological point of view the lower Dacian sequence is characterized by the predominance of fine/ very fine sand and silt over clay. Fine grained gravel can occur in small quantities.

The sedimentary structures observed in the lower Dacian coarsening-upward sequence are represented by different types of cross lamination. The most frequent are the small-scale asymmetrical, current ripples (Fig. 7). Rare large-scale cross lamination can be observed. At Bobolia locality outcrop (Fig. 8) the large cross laminated unit is 1.5m thick, occurring in the upper part of a sequence that is part of the lower Dacian interval.

In the outcrops from Bengeşti (Gorj county) and from Bobolia (Prahova county) the lower Dacian coarsening-upward sequence that we discuss about consists of six to ten (or more) parasequences. Each of these parasequences shows a coarsening-upward pattern, with mud at the base and sand at the upper part (Fig. 9). At Bobolia some parasequences begin with silty clay and are coarsening up to fine sand (Fig. 9c).

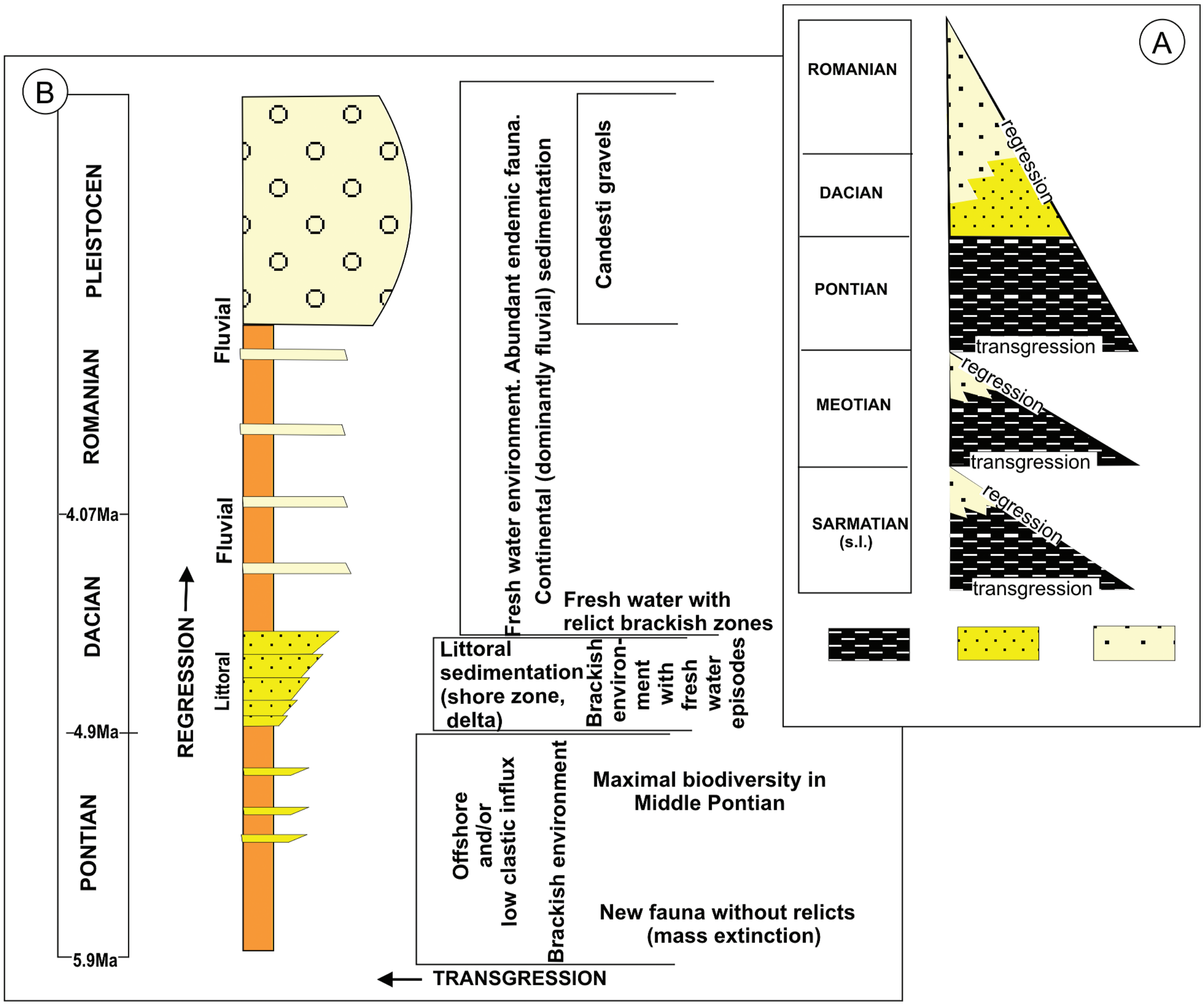


Fig. 4 The main geological cycles of the Dacian Basin development (A) and the sequence of the geological events during the Pontian -Romanian cycle (B). Partly after Jipa, Olteanu (in Jipa, 2006)

Often at the upper part of the coarsening-upward sequences, the sandy sediment becomes coarser (medium or coarse grained sand), or even including small pebbles (Fig. 9b). The upper limit of the sequences between the sand and the mud of the overlying sequence is characteristically sharp (Fig. 9).

The trace fossils have beeen examined in the sediments from Bobolia (Prahova county). The *Skolithos* biogene structures observed in the Lower Dacian age deposits are many times cut (Fig. 10A), due to frequent sedimentation discontinuities created in shallow, littoral water with high energy. Sometimes the sediments are highly biodisturbed, with many fragments of vertical and sub-vertical *Skolithos* galleries. According to the chaotic aspect of the traces, the way the galleries are cut and the aspect of the lamination at the top of the sequence the sediment might be a seismit. In the observed sediments the domichnia traces are also represented by ?*Conichnus* (Fig. 10B) and *Monocraterion* (Fig. 10C). The fossil trace remains of the Lower Dacian age sediments from Ripa Rea are similar to the paleoichnologic aspects described by Hiscott *et al.* (1984) from the Lower Cambrian fluvial to shallow marine deposits of the Bradore Formation.

In some cases the sandy sediments of the deltaic sequences are apparently homogenous, without visible sedimentary structures. This character can result from the fact that many parasequences are made of well sorted, very fine sediments. Sometimes it is obvious that the inverse graded sediments were highly bioturbated and the sedimentary structures have been partially or totally obliterated (Fig. 10D).

The lower Dacian coarsening-upward sequence displayed by well logs

The coarsening-upward shore face/deltaic lower Dacian sequence is easily distinguishable on the well logs. The electrical well logs have a funnel pattern which shows the coarsening-upward grain size trend (Jipa *et al.,* 1999) (Fig. 11).

Some well logs clearly indicate the complex structure with multi-parasequences of the lower Dacian interval discussed. There are cases when minor parasequences were not

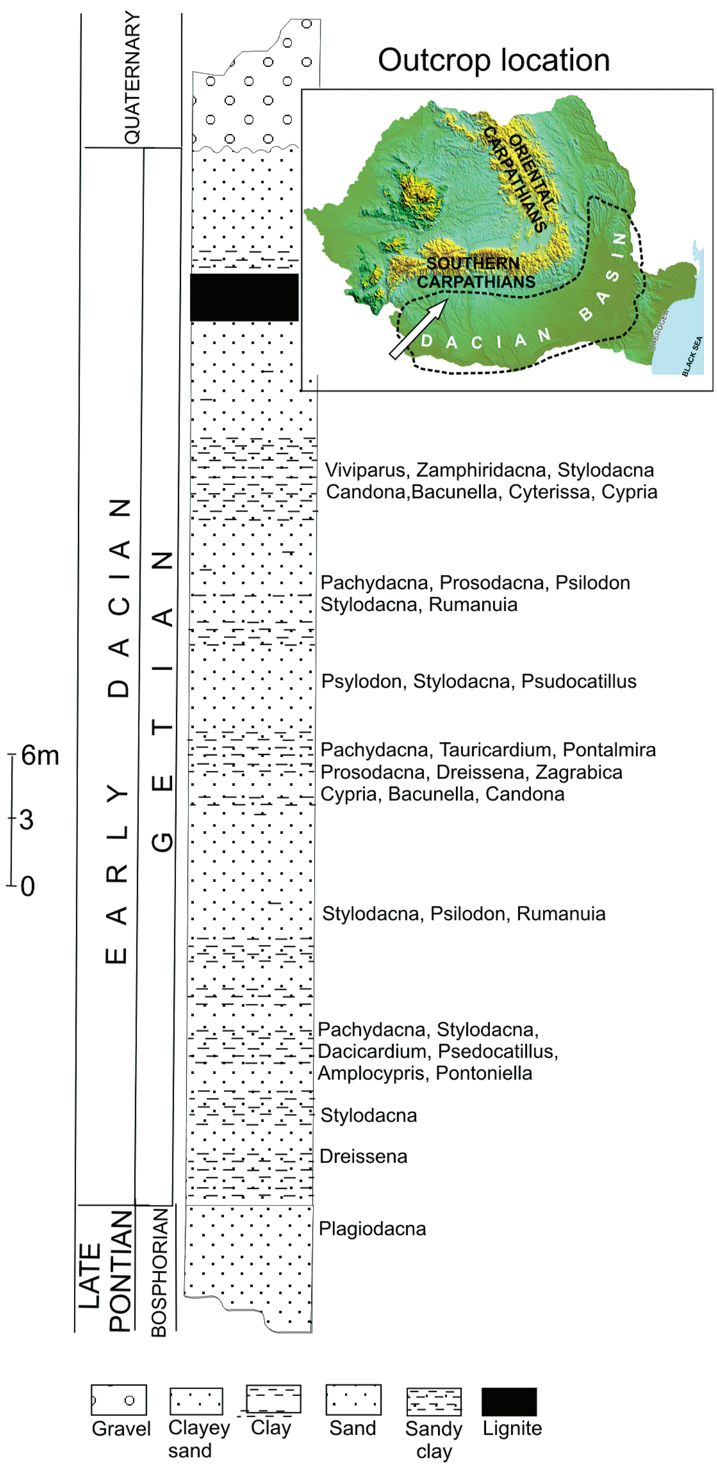


Fig. 5 Lower Dacian (Getian) sedimentary sequence at Bengeşti locality and its paleontologic record. From Papaianopol, Marinescu, Macalet (1995)

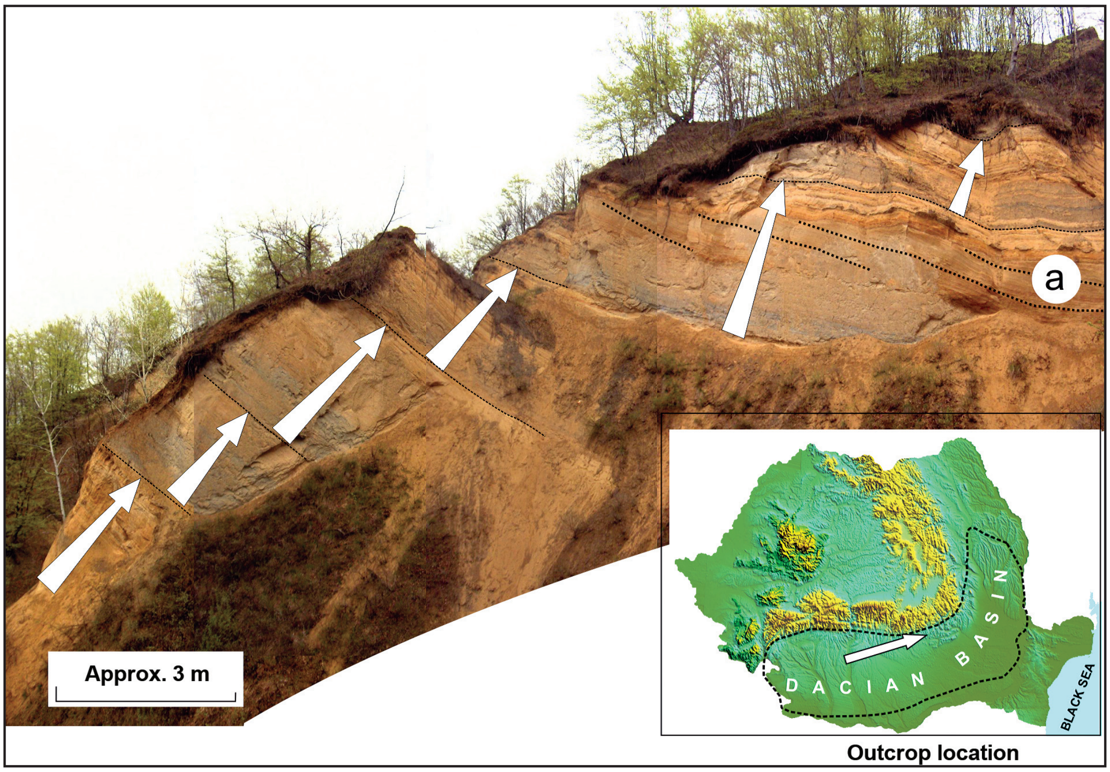


Fig. 6 Coarsening upward, parasequences (component sequences) of the lower Dacian deltaic deposits. Most of the sequences evolve from silt or sandy-silt at the base, to fine/very fine sand at the upper part (see also Fig. 9C). A= large scale cross stratified unit. Outcrop at Valea Rea, Bobolia Village, south of Campina town, on the right slope of Prahova River

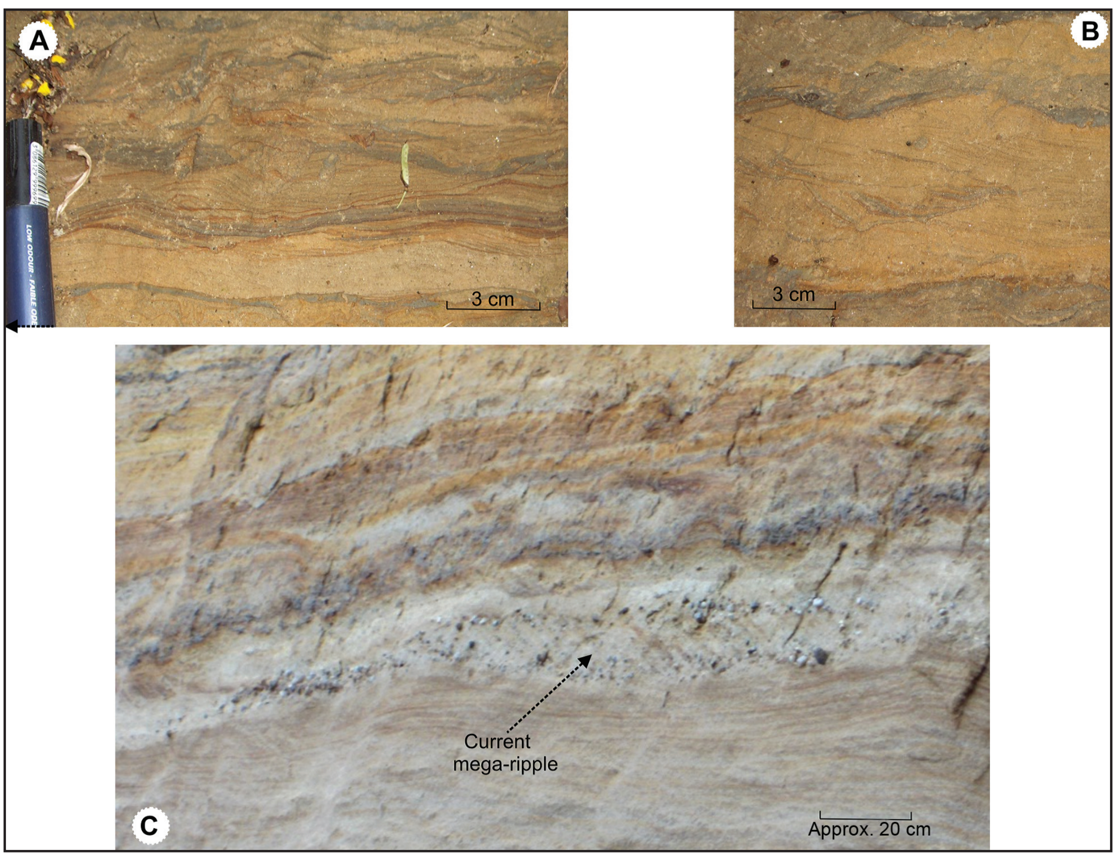


Fig. 7 Current structures in the lower Dacian deposits from Valea Rea, Bobolia Village, south of Campina town, on the right slope of Prahova River. A and B - Small scale current ripples. C - Current mega-ripple at the top of a coarsening upward sediment sequence

Fig. 8 Large scale cross-lamination at the upper part of a coarsening up component sequence. See also (A) in figure 6. Lower Dacian deposits. Outcrop at Valea Rea, Bobolia Village, south of Campina town, on the right slope of Prahova River

observed. This might be induced by the reduced thickness of the mud interbeds.

Between the coarsening upward littoral sequences observed in the outcrop and the similar sequences noticed in well log data there is a full sedimentological and stratigraphical compatibility.

The thickness of the Lower Dacian inverse graded sequence

During this study lower Dacian coarsening upward sequences were recognized in tens of wells drilled in the Dacian Basin area. The thickness of these sequences was measured only in 73 well logs, where it was possible to correctly delimit the coarsening upward interval.

Overall it was established that the thickness of the lower Dacian inverse graded sequence – measured on the well logs – appears within a limited range. The lowest thickness is 23m. The maximum thickness measured is 85m. Most of the values are in the range of 50-80m, but the thicknesses between 60-70m are the most frequent (Fig. 16).

STRATIGRAPHIC POSITION OF THE LOWER DACIAN, COARSENING UPWARD SEQUENCE

The macro-faunal study of the coarsening upward sequence, made in the outcrops from the northern part of the Dacian Basin, at the limit with the Carpathian area, show that these sediments accumulated during the lower part of the lower Dacian (Getian) time. In fact Papaianopol *et al.* (1995) described the sequence from Bengesti as the stratotype of the lower Dacian (Getian) sediments (Fig. 5). The same lower Dacian age was assigned to the sandy level overlying the Pontian clayey deposits from Piatra valley (Dimbovita county, between Tirgoviste and Pucioasa).

Relative to the position of the coal levels from Oltenia, Marinescu (2004) assign the coarsening-upward interval (which is used as a geophysical marker) in the lower part of the Getian (Fig. 12). Analyzing the paleontological and stratigraphical data connected with the Pliocene coal sequence from Oltenia, Marinescu (2004) emphasizes the following (Fig. 12):

- The coquina marker from the Dacian-Romanian coals sequence indicates that the lower Dacian (Getian)/upper

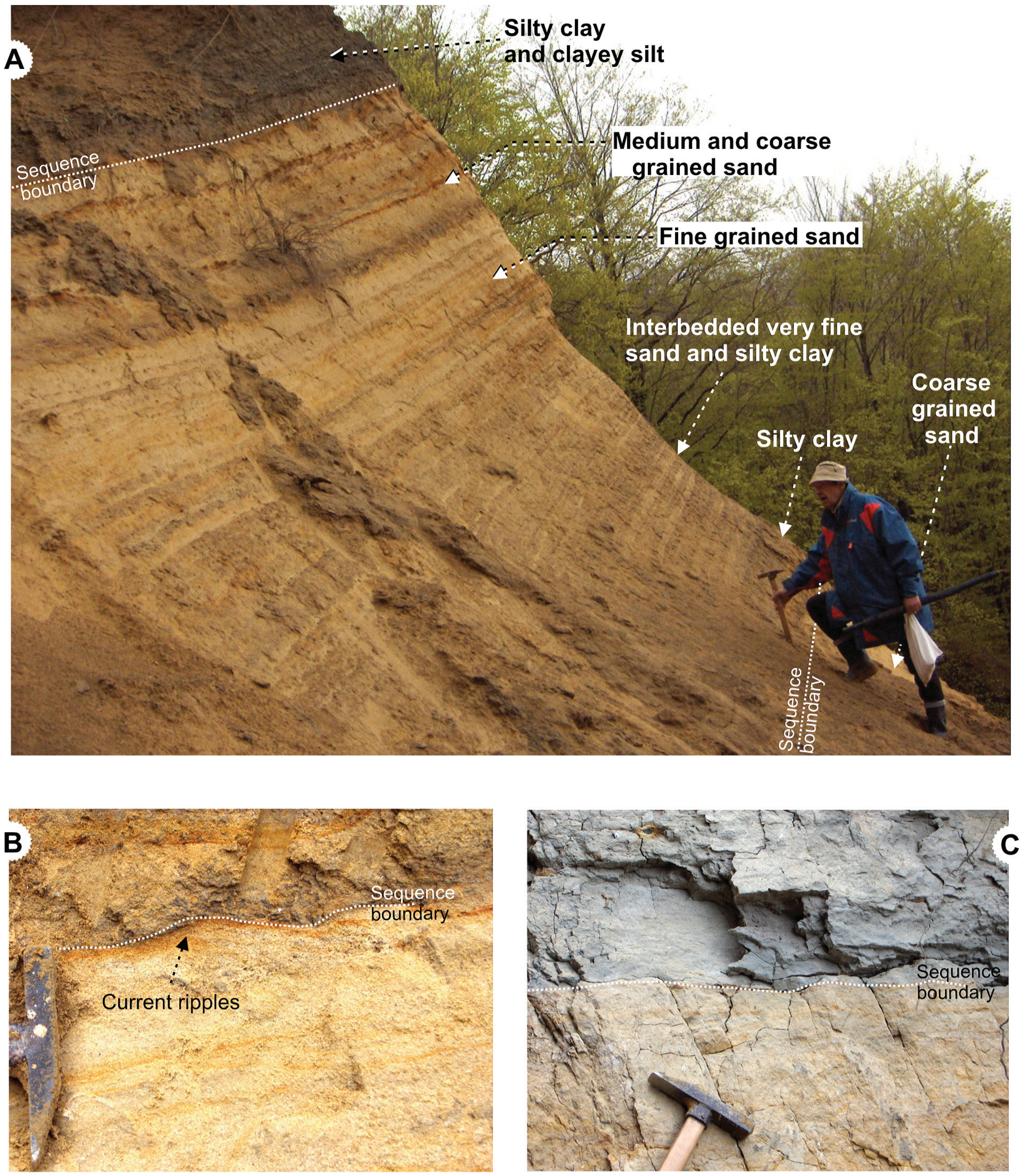


Fig. 9 Close view at the coarsening upward component sequences. A. Coarsening upward sequence, its lithologic variation and boundaries. B. Terminal, coarse grained part of a coarsening upward sequence. Current ripples at the very top of the sequence. C. Coarsening upward sequence with very fine sand at the terminal part. Lower Dacian deposits. Valea Rea, Bobolia Village, south of Campina Town, on the right slope of Prahova River

Fig. 11 The wireline signature of the coarsening upward lower Dacian interval. A - Borehole electric logs. B - sedimentary interpretation of the funnel-shaped logs. From Jipa *et al.*, 1999 ▶

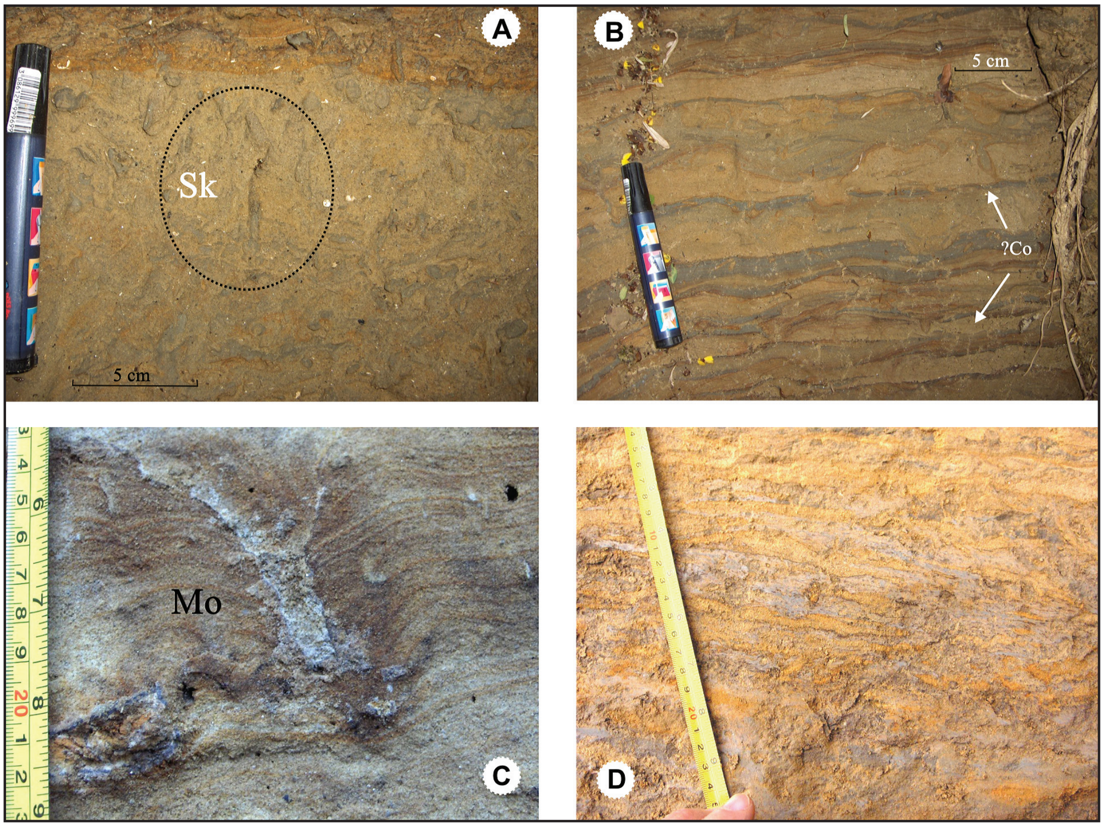
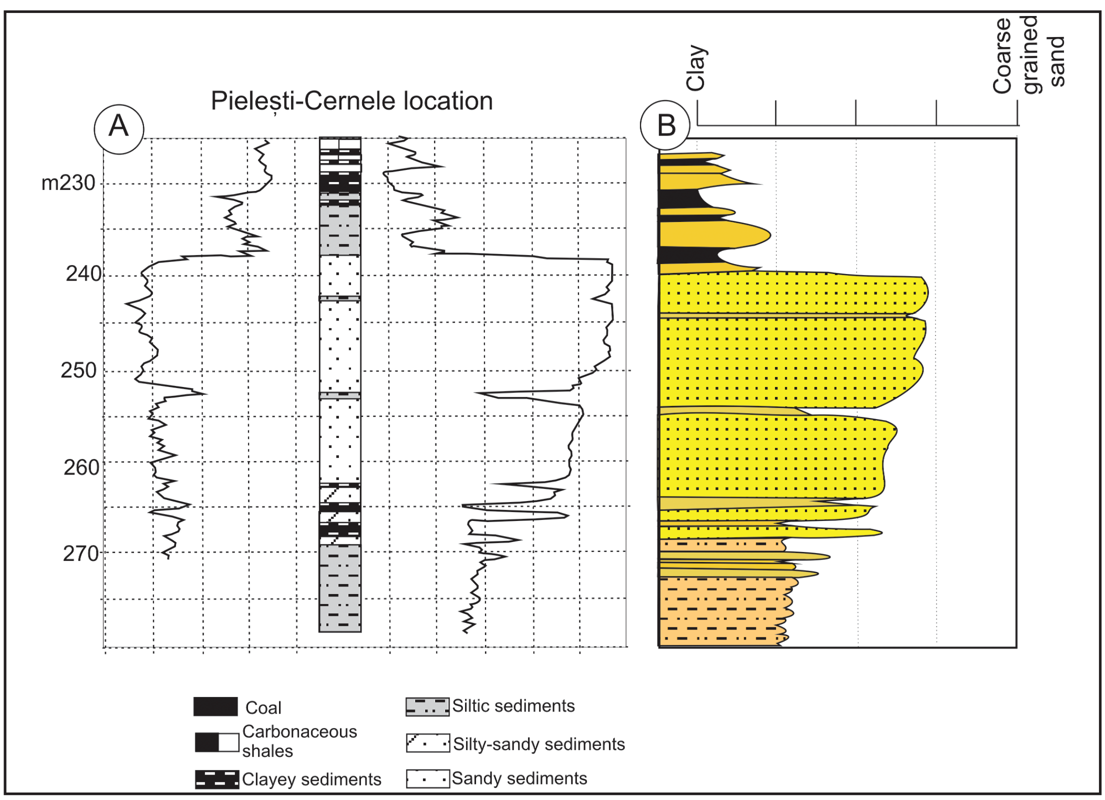


Fig. 10 Advanced bioturbation in the sandy Early Dacian deposits. Valea Rea, Bobolia Village, south of Campina town, on the right slope of Prahova River. A. *Skolithos linearis* (Sk). *B. Conichnus* (Co) (Domichnia, carnivora trophic group, anemone). *C. Monocraterion* (Mo). D. Bioturbated bedding



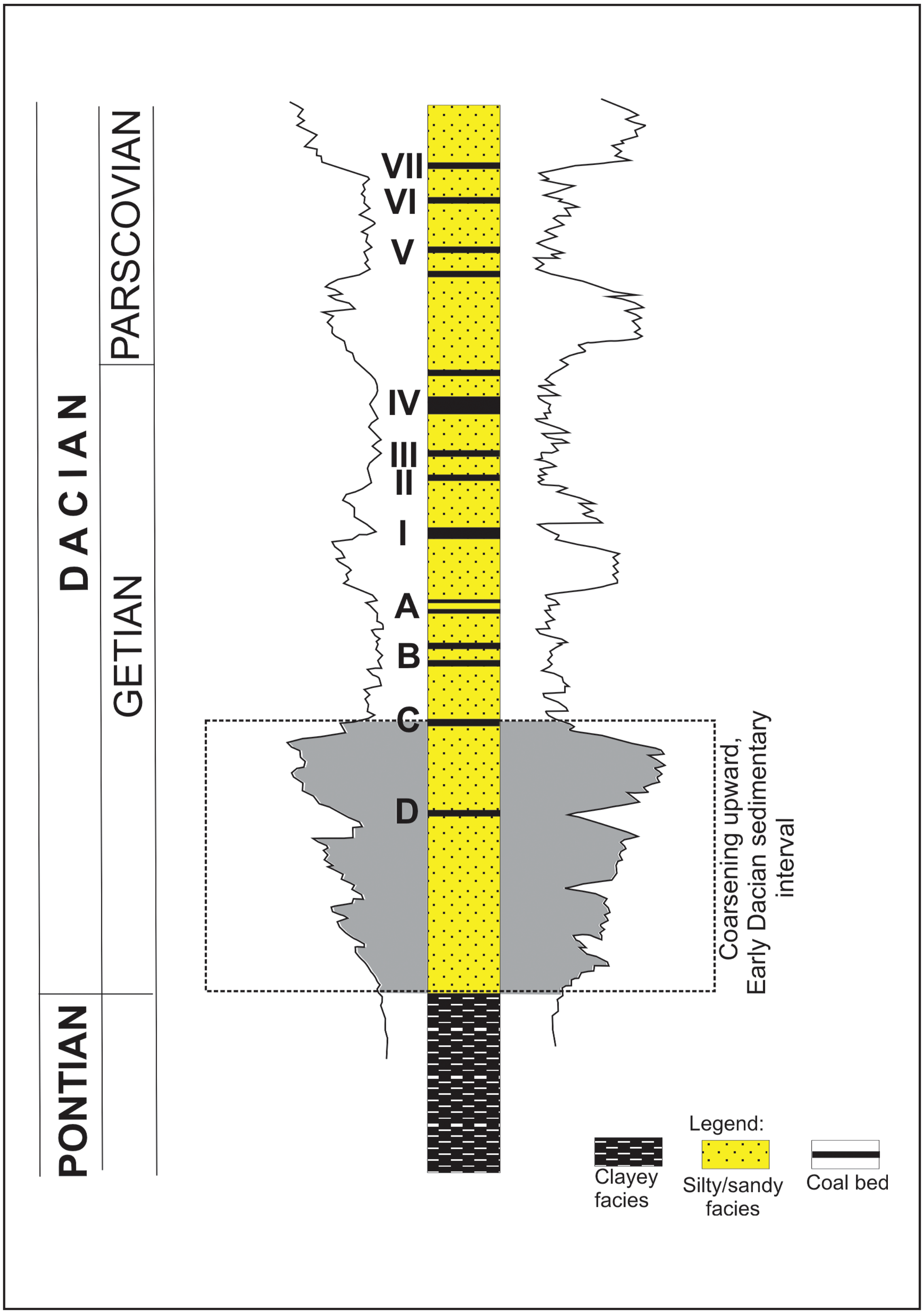


Fig. 12 The stratigraphic position of the coarsening upward, lower Dacian sedimentary interval in Oltenia coal bearing area (SW Romania). After Marinescu (2004)

Dacian (Parscovian) limit is to be traced at the level III of lignite.

- The coarsening-upward sands considered by Marinescu (2004) as "geophysical marker CN I", which constitute the study objective of the present paper, extends from the top of the Pontian deposits and the lignite layer C.

On the Luncavăţ River section, a succession of multiple coarsening upward sequences begins from the upper part of the Pontian and continues in the lower Dacian time intervals.

Paleobiological characters of the lower Dacian coarsening-upward sequence

Papaianopol *et al.* (1995) studied the fossils from the Getian stratotype sequence from Dacian Basin at Bengeşti (Valea Mare River), in the north of Oltenia, (Fig. 5). Radu Olteanu (this paper) investigated the ostracod fauna.

The Getian otracoda community found in deposits from Bengeşti consist of the following species: *Tyrrhenocythere filipescui* (Hanganu), *Loxoconcha petasa* Livental, *Amnicythere schweyeri* Olteanu, *Cytherissa bogatschovi plana* Klein, *Bacunella dorsoarcuata* (Zalany), *Caspiolla venusta* (Zalany), *Cypria tocorjescui* Hanganu, *Caspiocypris* aff *acronasuta* (Livental), *C.* aff *merculensis* Vekua, *Euxinocythere* aff *litica* (Livental), *Amplocypris* aff *odessaensis* (Ilnitkaia) and numerous specimens of tuberculates and non-tuberculates *Cyprideis*. Moluscs are exclusive Getian in age: *Stylodacna heberti, Tauricardium olteniae, Pachidacna mirabilis, Psilodon munieri.* At Bengeşti the salinity of the basin during the Pontian-Getian sedimentation can be appreciated as oligohaline (5 - 6,5‰). The fauna assemblage described at Bengeşti indicates the presence of the lower Getian, not of the entire brackish Getian.

The sediments overlying the one containing the above presented Valea Mare - Bengesti fauna is muddy, with a thickness of 4.20 m, and its fauna consists only of viviparidae *(Viviparus argesiensis, V. berbetiensis, V. muscelensis, V. monasterialis)*. Quantitative distribution of the viviparids is marked by three maximums, separated by sediment sequences with rare specimens.

In the viviparids level the ostracodes fresh water fauna consists of *Paracandona albicans* (Brady), *Darwinula stevensoni* (Brady & Robertson), *Ilyocypris* sp., *Cytherissa bogatschovi plana* Klein, *Cypria* aff *tocorjescui* Hanganu, *Amplocypris* aff *odessaensis* (Ilnitkaia), *Amplocypris* sp. A, *Bacunella djanelidzae dacica* Olteanu, *Caspiolla venusta* (Zalany), *Caspiocypris candida* Livental, *Caspiocypris* aff *filona* (Livental), *Candona* aff *neglecta* Sars, *Candoniella bengesti* Olteanu and an „explosion" of *Cyprideis* sp. 1 şi (aff *C. punctillata*), *C*. sp 2 (species with three tuberculs). The fresh water character of this level is obvious (the exclusive presence of fresh water species *Paracandona, Ilyocypris* and *Darwinula* and the lack of *Cytheridaelor* brackish euryhaline).

The Bengeşti sedimentary succession continues with sands and muds (3.8m) with an ostracode fauna dominated quantitatively by species of *Candona, Caspicypris, Amplocypris, Cytherissa* genuses. It appears that all these fossils are reworked.

The second level with viviparids (1.8 m) is ecologically identical with the first one, showing a community of fresh water ostracods (with a smaller number of species). However, molluscs are more diverse: *Zamfiridacna orientalis, Stilodacna heberti, Rumanunio rumanus* and *Hyriopsis* sp.

The coarse sand and upper pebbles on the top of the Bengesti sedimentary succesion lack fauna. They are followed by coal beds and muds.

Upper Pontian–Dacian deposits are well known from Buzau valley as well. The Bosphorian - Dacian succession in the area of Berca-Pleşcoi localities are exclusively represented by muds and fine sands in alternating decimeter-thick beds. In the muddy Pontian-Dacian sequence the fauna suggests the alternance of slightly brackish and fresh water levels. The Getian age is indficated by rare specimens of *Psilodon munieri, Pachidacna mirabilis* and fragments of *Stylodacna* sp. The fresh water levels contain fragments of *Hyriopsis* sp., *Unio* aff *rumanus* and other juvenile specimens of *Viviparus* sp. (ex. gr. *V. argensiensis*).

DISTINGUISHING FEATURES THE LOWER DACIAN COARSENING-UPWARD SEQUENCE

The lower Dacian coarsening-upward sequence is singled out by its sedimentary characters, as well as by the its position within the Pliocene sedimentary succession.

From the sedimentological point of view the lower Dacian sedimentary interval (Fig. 13 a) is identified by the following features:

- coarsening-upward trend, from mud at the base to sand on top;
- dominating fine grained sand lithofacies;
- littoral depositional environment;
- alternating brackish-marine and fresh water fauna.

The lower Dacian aged coarsening-upward sedimentary interval overlies muddy, low salinity upper Pontian deposits and is followed by a very thick upper Dacian-Romanian-Pleistocene fluvial sequence (sandy beds intercalated in muddy deposits). The contrasting facies of the three stratigraphic entities is the factor which singles out the lower Dacian sequence investigated in this paper.

The lower Dacian coarsening-upward sequence cannot be distinguished in the northern part of the Dacian Basin (Fig. 14 d). This region was under the immediate influence of an extremely active source area, which made the upper Pontian – lower Dacian deposits to show a facies with dominating sandy deposits.

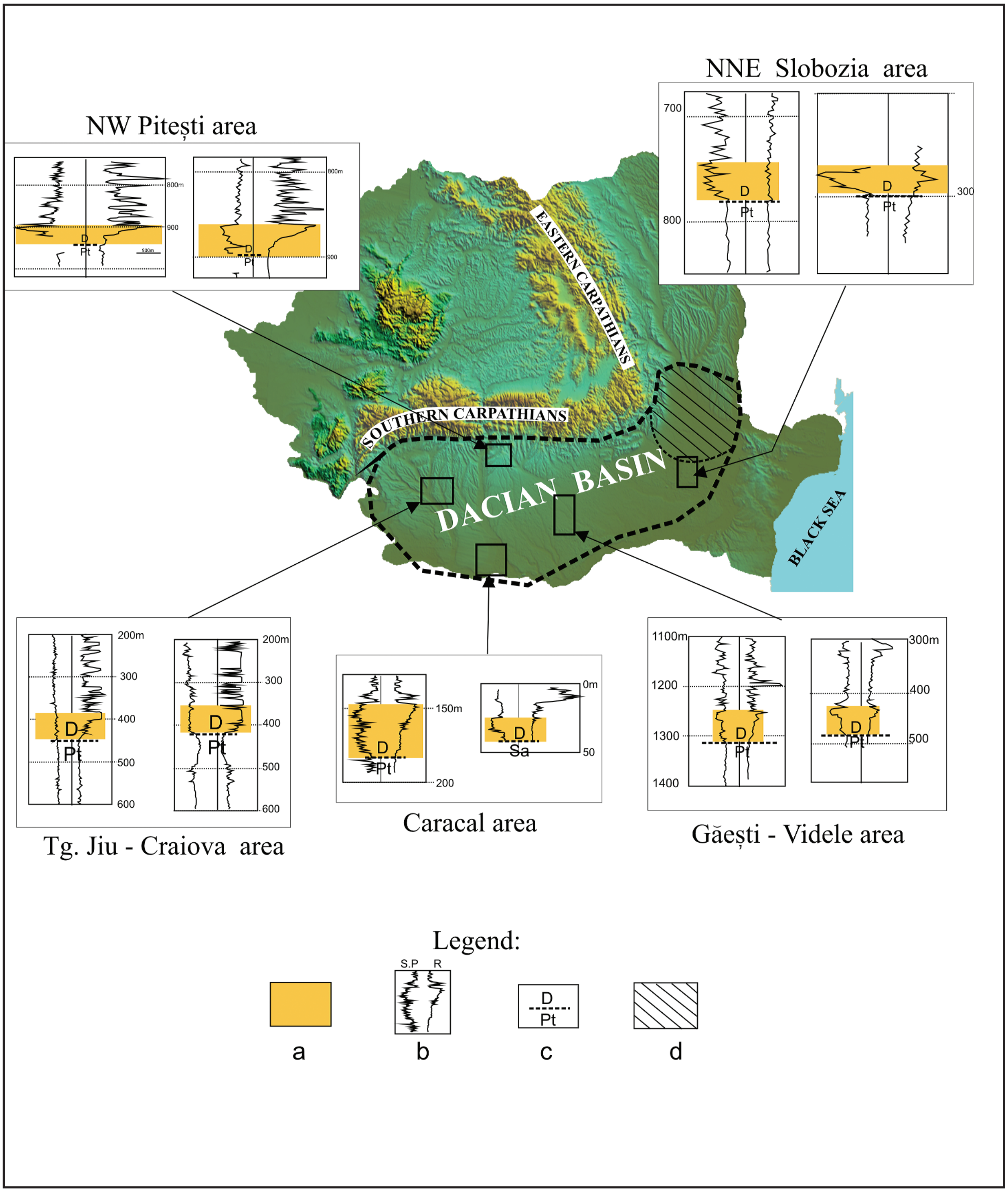


Fig. 13 Besides its log signature/coarsening upward character the lower Dacian sequence (a) is easily distinguished in the sedimentary column because it is placed in between a dominantly clayey Pontian succession (b) and an alternating sand-clay fluvial sequence (c)

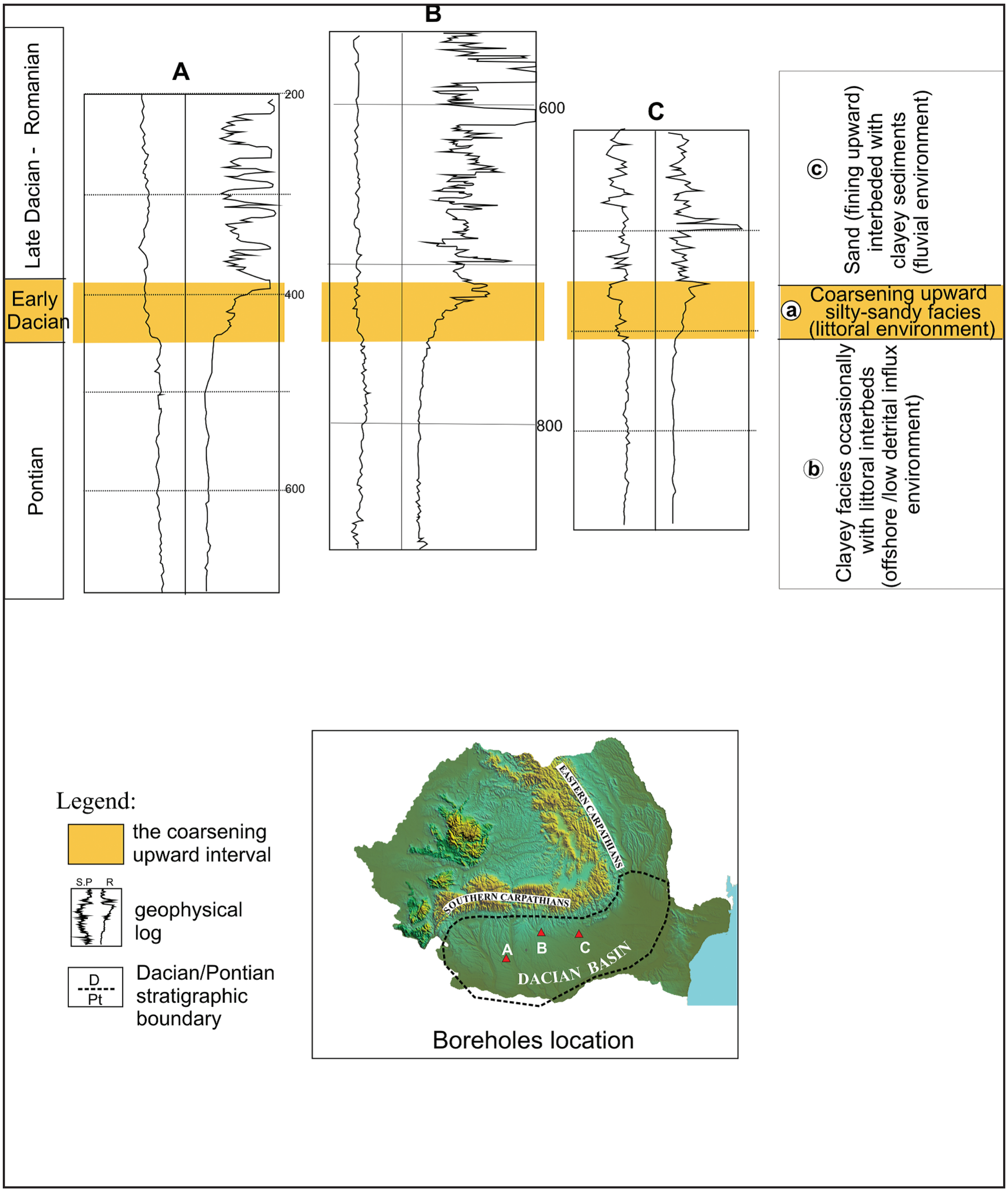


Fig. 14 Areal extension of the lower Dacian coarsening upward interval (a). The coarsening upward sequences occur at the same stratigraphic level (c) all over the Dacian Basin area, apart from the northernmost area (d). Legend: a- geophysical logs; b- Dacian/Pontian stratigraphic boundary; c-the coarsening upward interval marked by funnel-type logs; d- the northern Dacian Basin area (Focsani depression)

Areal extent of the lower Dacian coarsening-upward sequence

The cropping out area of the upper Neogene deposits from the Dacian Basin is limited, extending only along a strip localized at the base of the Carpathian Mountains. Consequently, the areal extent of the lower Dacian coarsening-upward level must be judged after information acquired from wells. The distribution of about 100 well logs that were analyzed in this study does not cover uniformly the entire area of the Dacian Basin. However their distribution is adequate enough to offer a basin-wide picture of the deposits that we study.

In the figure 14 a few well logs are presented showing that the lower Dacian coarsening-upward sequence is detectable in almost the whole area covered by the Dacian Basin. As it was mentioned previously, this lower Dacian sedimentary unit cannot be identified in the extreme north-eastern area of the basin (Fig. 14 d).

The lower Dacian coarsening-upward level can be recognized on the whole transversal length of the Dacian Basin. The affirmation is proved through the figure 15. The well logs presented in this figure show that lower Dacian coarsening-upward sequence appears continuously on the transect Jiu-Olt, from the northern part of the Dacian Basin to its southern edge.

The presented data emphasize the fact that the lower Dacian coarsening-upward level was recognized, in outcrops and in well logs on the whole area of the Dacian Basin with the exception of the northern end of the basin. Consequently it is evident that the lower Dacian coarsening-upward level is a marker level with basinal extent.

Beside the numerous cases when lower Dacian coarsening-upward sequence was recognized, there are situations when this sedimentary level was not evidenced. However the locations where it could not be established the presence of the lower Dacian inverse graded sequence are sporadic, representing less than 5% from all the analyzed localities.

SEDIMENTARY SIGNIFICANCE OF THE LOWER DACIAN MARKER SEQUENCE

Sedimentary processes in the Dacian Basin during the lower Dacian time

The lower Dacian marker sequence was studied from different perspectives: in outcrops at metric scale and from well logs at tens of meters scale. Observations made in the outcrops (Jipa, 2006) indicate the shallow water, littoral-deltaic character of the sedimentary environment of the lower Dacian sequence. The littoral Dacian Basin environment was dominated by basinal (waves, storm) or by fluvial factors. The intensity of the sediment supply was also a significant influence factor.

The lower Dacian coarsening-upward sequence analyzed in this paper appears as a deltaic accumulation, developed during moments of high fluvial discharge. Because of the intensity of the fluvial discharge, the waves and littoral currents were unable to rework the sediments in front of the delta. The coarsening-upward of this alluvial controlled accumulation underlines its prograding trend.

The deltaic character and shoreline mobility explain the presence of the brackish fauna in alternance with fresh water fauna in the sedimentary column of the sequence we are dealing with.

A very significant character of the deltaic type lower Dacian age sequence is their basin-wide extention. Development at the basinal scale implies the migration of the shoreline, from the proximal zone in the north, to the distal, marginal zone in the south.

The failure to identify the lower Dacian coarsening-upward unit in some boreholes is explicable, in the conditions of the shoreline progradation through individual deltaic bodies. These deltas could overlap, but sometimes could be apart, between them existing sediments with other shoreface characters.

The lower Dacian age marker sequence and the Dacian Basin drying-up

The lower Dacian coarsening-upward marker sequence is part of the Pontian - Romanian transgressive-regressive cycle (Fig. 4). The cycle begins with the clay dominated, brackish-marine Pontian sediments. The lower Dacian marker sequence stands for the last event with marine-brackish character. Immediately after the episode represented by this sequence, the Dacian Basin dried out and the sedimentation became fluvial (Jipa, 2006).

Sedimentary processes that contributed to the building of the lower Dacian inverse graded sequence throw light on the filling/drying up process of the marine-brackish unit known as the Dacian Basin. At the commencement of the Dacian time the shoreline situated near the Carpathian area began to migrate southward and south-eastward. The shoreline continued to migrate through progradation to the south/south-east extremity of the basin. By this migration, the area of the marine-brackish body decreased progressively, and was replaced by a continental area with fluvial sediments accumulation.

Paleontological information call attention to the fact that during the Dacian time, the fresh water fauna appeared earlier (middle part Dacian time) in the western part of the Dacian Basin (south of the Southern Carpathians). In the east (the bending area of the Romanian Carpathians) and in the north (Focsani depression; Fig. 14d) marine-brackish fauna continued to subsist till the end of the Dacian time. The longer persistence of the brackish water in the eastern and northern Dacian Basin might be explained by the following facts:

- the eastern area had direct access to the waterway connecting Dacian and Euxinian Basins (Galatzi area);
- the northern part of the Dacian Basin (also known under the name of Focsani depression) was the site of a strong subsidence process.

Global/regional control of the Dacian Basin drying up

Recent studies carried out in the northwestern part of the Black Sea produced data indicating that during the Dacian time the Black Sea depression experienced a sea level fall. Because of this event the northwestern shelf of the Black Sea Depression was subaerially exposed, being crossed by major fluvial channels. Popescu (2002) showed data on channels with a few km wide in the shelf area in front of Danube Delta that incised lower Pliocene deposits. Also in the north-western area of the Black Sea shelf Gillet (2004) recognized large erosional channels that occured only since the Dacian time (Fig. 17). This sea level fall episode represents an event that can explain the relative fast drainage of the Dacian Basin in the first part of the Dacian time.

During the geological development of the Dacian Basin there were other regressive moments of the brackish sea, marked by the fluvial sedimentation occurrence. These regressive moments can be at large scale (Sarmatian s.l. superior, Meotian superior) or at small scale (especially during the medium and upper Pontian). Such events can also be related to sea level fall episodes in the Black Sea depression. In comparison with these additional Sarmatian-Meotian-Pontian events, the Dacian time sea level fall appears more significant, generating major changes in the Dacian Basin area.

Sinchronism/diachronism of the lower Dacian marker

The coarsening-upward trend of the marker deposits points out that the basal Dacian sequence accumulated through sedimentary processes with prograding character.

The lower Dacian littoral horizon extends over most of the Dacian Basin area. As shown by the electric well logs, the coarsening-upward character of these deposits is also maintained almost over all the Basin area (Figs. 14 and 15). Consequently it appears that progradation of the deltaic early Dacian age deposits represented a significant sedimentary process, produced at the scale of the entire Dacian Basin.

The frontal migration of the Dacian age deltaic deposits, progressed from the vicinity of the Carpathian Mountains (representing the clastic material source-area) toward the south. The progradation of the Dacian sediments proceeded up to the southern limit of the Dacian Basin.

Taking into account the time required for the sediments to prograde from the Carpathian Mountains foot to the southern limit of the basin, it can be considered that the subcarpathian littoral deposits might be younger than those toward the south. So far, there are no paleontology data to corroborate the diachronicity hypothesis of the littoral accumulation during the Dacian time.

CONCLUSIONS

Observed in outcrop as well as in well logs, the lower Dacian coarsening-upwards sequence appears as a marker level that extends over the most part of the Dacian Basin. This sequence has not been identified in the northern part of the basin which corresponds to the Focsani depression.

Observations made in outcrops showed the shallow water, littoral-deltaic character of the sediments deposited during the lower Dacian time. The basin scale development of this sequence implies the shoreline migration from proximal to distal area. Deltaic character and shoreline migration explain the presence of the brackish fauna alternating with freshwater fauna in the deposits of the lower Dacian age sequence from the Dacian Basin.

Sedimentary processes that built up the lower Dacian inverse graded sequence illustrate the final stage of the brackish unit known as Dacian Basin. The present study shows that at the beginning of the Dacian time the shoreline situated in the proximity of the Carpathian area began to migrate through progradation toward south and southeast. Finally, when migration reached the southern/southeast extremity of the basin area, the brackish-marine Dacian Basin dried up and was replaced with an area of fluvial deposition.

In the western and central parts of the Dacian Basin the freshwater fauna irreversibly replaced the brackish fauna after the lower Dacian time. In the northern part of the Dacian Basin (Fig.14d) the brackish environment continued to the end of the Dacian time. This fact emphasizes the possibility that the eastern part (the area with Euxinic Basin communication) and the northern part (area with high subsidence) of the Dacian Basin might represent a slightly deeper part of the brackish Dacian Basin.

According to the data acquired in the outcropping proximal area south of the Southern Carpathians, the age of coarsening upward sequence is Getian (lower Dacian). Taking into consideration the time required for the sediments to prograde along the distance from the Carpathian Mountains foot to the southern limit of the basin, it can be estimated that the Dacian inverse graded sequence is diachronous: younger (lower Dacian) in the northern part, in subcarpathian area, and older (possibly medium or upper Dacian) toward the southern limit of the Dacian Basin.

The sea level fall that produced the subaerial exposure recognized in the north-west area of the Black Sea shelf (Popescu, 2002; Gillet, 2004) represents an event that can explain the relative fast drainage of the Dacian Basin in the first part of the Dacian time.

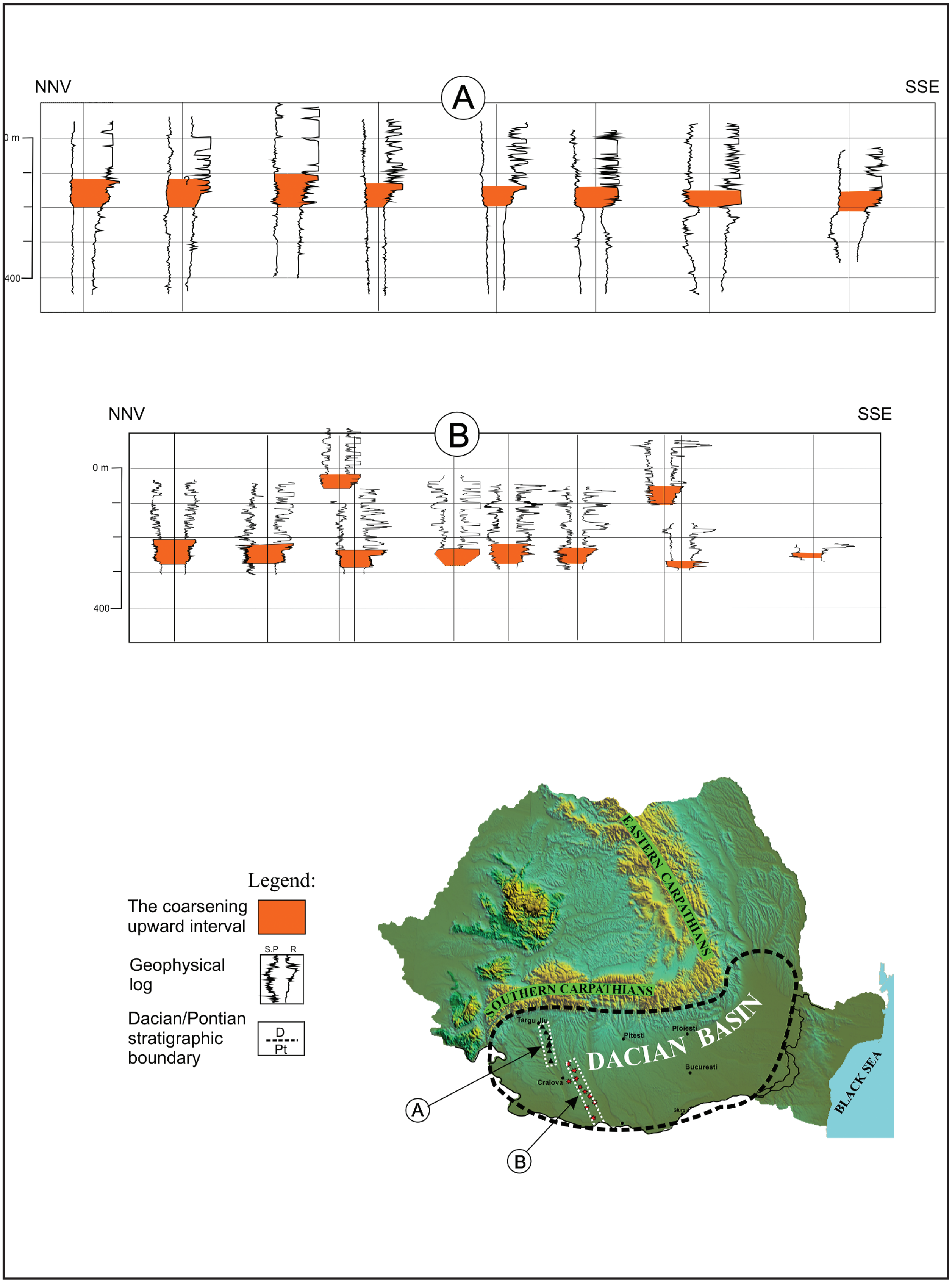


Fig. 15 The north to south extension of the lower Dacian age coarsening upward interval. The sedimentary sequence of this interval occurs from the northern, proximal part to the south, distal limit of the Dacian Basin

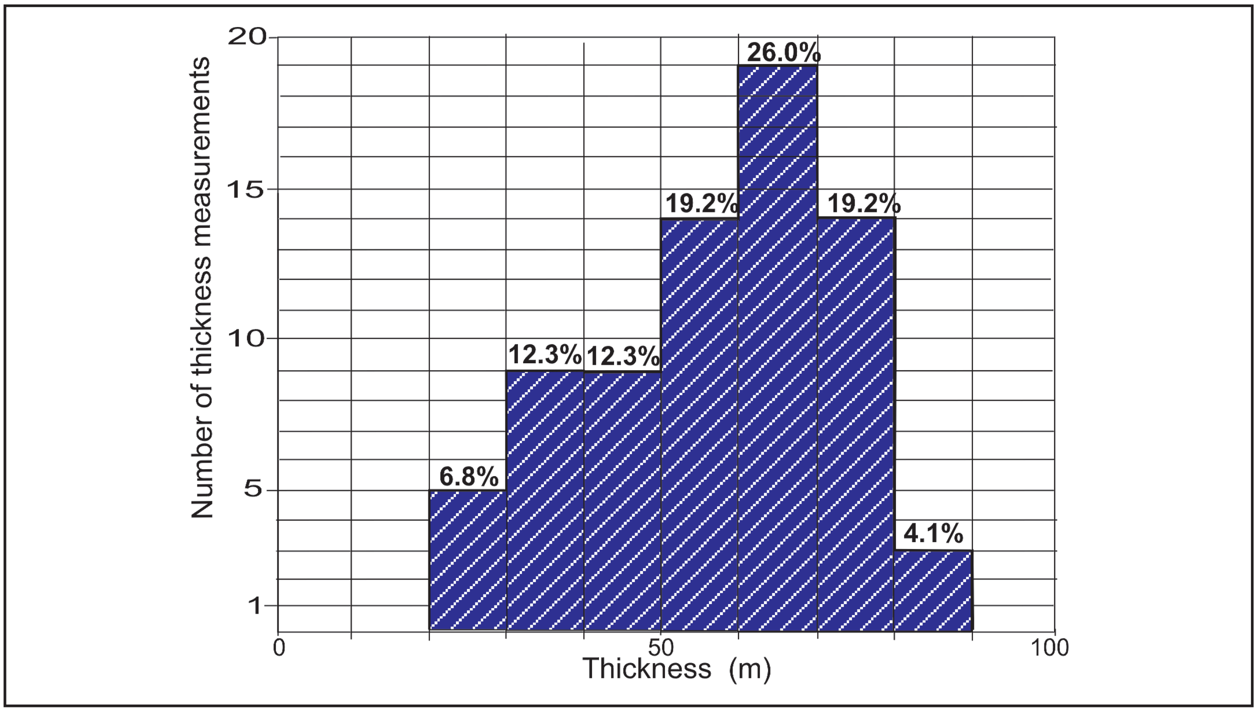


Fig. 16 Thickness values of the lower Dacian coarsening upward sedimentary sequence. The histogram is based on 73 thickness measurements

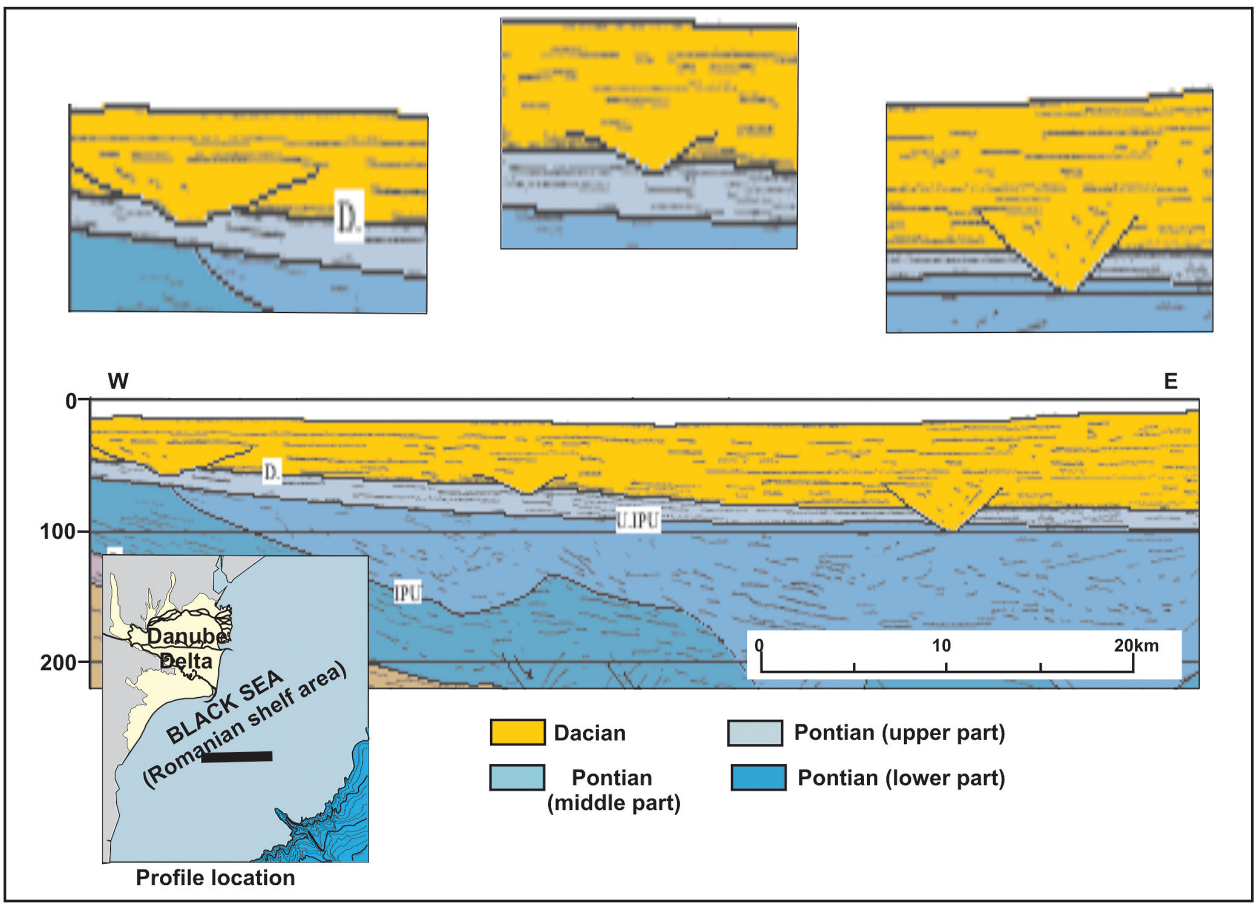


Fig. 17 Large channels occurrence in the lower part of the Dacian aged deposits. Black Sea northwestern shelf area. Modified from Gillet, 2003

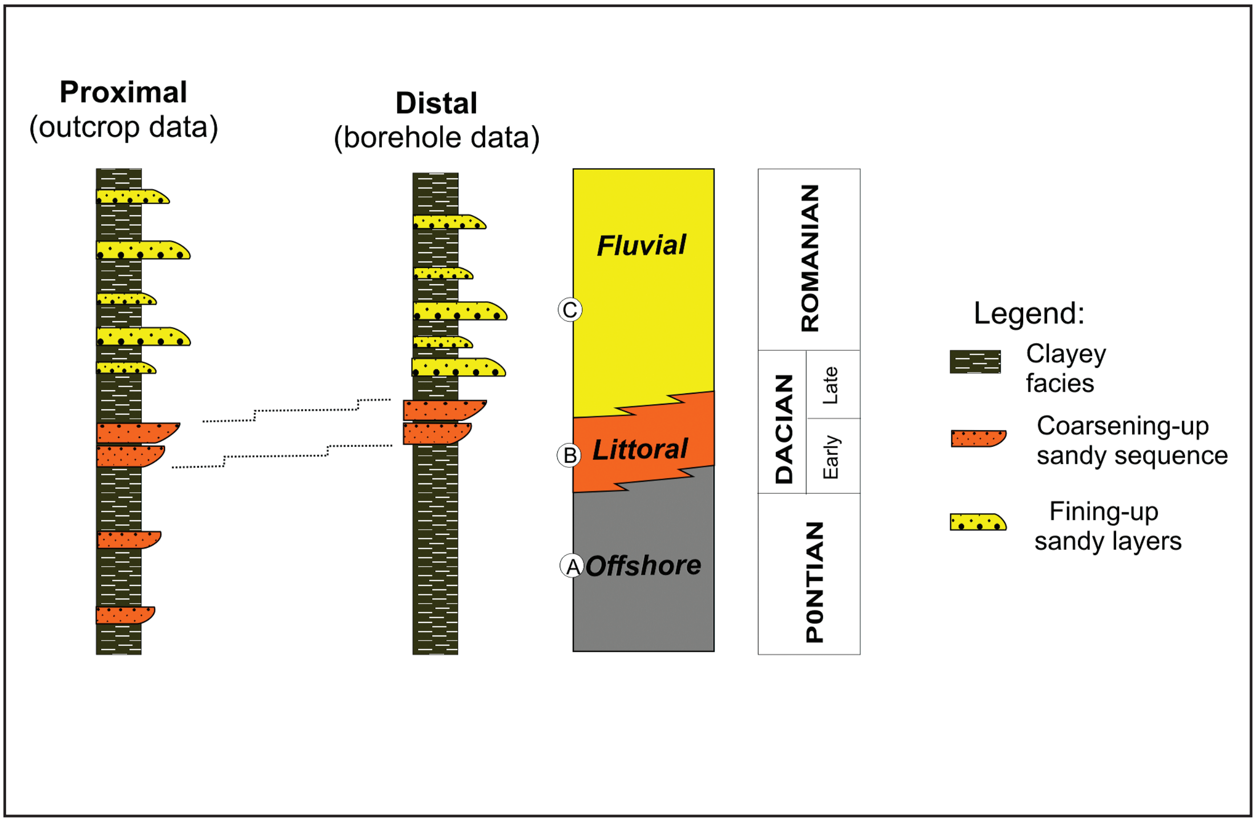


Fig. 18 Sedimentary environment evolution of the Dacian Basin. This pattern reflects the situation in the western and central parts of the Dacian Basin. Modified after Jipa *et al.,* 1999).

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