LARGE-SCALE PROGRADATION AND SEDIMENT GRAVITY FLOW IN A DEEP-SEA BASIN: ALBIAN DEPOSITS IN THE SOUTH CARPATHIANS (IALOMIȚA-DÂMBOVIȚA AREA, ROMANIA)

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Abstract. This paper summarizes the results of a sedimentologic investigation of Albian sandstones and conglomerates from the eastern extremity of the Southern Carpathians, the area between the Ialomița and Dâmbovița rivers. Lithofacies analysis, paleotransport, provenance and paleoenvironment of these clastic sediments are the main focus of the paper. An important component of the study is the part played by Ialomița-Dâmbovița Albian sediment accumulation in the Albian sedimentary history of the Carpathian Bend zone.

Two major lithofacies occur in the Ialomița-Dâmbovița Albian sedimentary succession: medium- and coarse-grained sandstones and sandstones with conglomerate interbeds. These deposits are intercalated with a third significant lithofacies, rhythmic finer grained deposits of silty clay and silty and fine-grained sandstones.

Some of the coarser grained Albian sediments (both sandstones and conglomerates) are structureless, poorly sorted, have a relatively large amount of sandy matrix and include oversize clasts, features indicative of accumulation by sediment gravity flow. The normal graded sandstones and the conglomerates with poor sorting, abundant matrix and oversize clasts suggest sediment transport by high density turbidity currents. The accumulation of the rhythmic, alternating silty clay and silty fine-grained arenite sediments is ascribed to low density turbidity currents.

According to their relationship with the underlying, younger deposits, the monocline structure and their presence within a succession of clastic sediments forming a coarsening-upward stacking pattern, it is proposed here that the Albian deposits in the Ialomița-Dâmbovița area were involved in a very active, large-scale progradation process, with deposition occurring on the continental rise.

The Albian deposits in the Ialomița-Dâmbovița area are genetically and stratigraphically correlated with the deposits of the Babele Sandstone and the Scropoasa-Lăptici Sandstone units in the Bucegi Mountains. The Babele-Dâmbovița sedimentary basin is distinct and different from the depositional basin of the deep-water Albian conglomerate fan from the Carpathian Bend zone.

Key words: clinoform; megaclast; structureless; gravelly deep sea fan; high density turbidity currents

1. INTRODUCTION

1.1. Investigation objective

The Bucegi Mountains are remarkable for their extensive, unobstructed exposures of Albian conglomerate and sandstone deposits, which have enhanced the alpine aspect of the massif and generated great tourism potential in the area. These features have made the Bucegi Massif attractive for geological study, culminating with the book written by Patrulius (1969). In contrast to the higher Bucegi Mountains (maximum elevation 2,405 m), the area between the Ialomița and Dâmbovița rivers, where the Bucegi Albian deposits extend, reaches a maximum elevation of 1,500 m and is characterized by relief having less morphological distinction. Here, because of the dense forest, outcrops are more dispersed and poorly exposed, and the sedimentary succession is monotonous and devoid of fossil remains. Consequently, geological researchers were not attracted to this region at the southern foothills of the Leaota Mountains. However, gradually the study of the Albian deposits from the Bucegi Mountains revealed that their sedimentary history cannot be understood without comprehending the history of the synchronous deposits in the area between the Ialomița and Dâmbovița rivers.

The present paper aims to investigate the lithostratigraphic and sedimentological characteristics of the Albian detrital deposits cropping out at the foot of the Leaota Mountains. The study concentrates on their facial aspects and genetic significance. Special attention is granted to the part played by the Ialomița-Dâmbovița deposits in the general evolution of the Carpathian Bend Albian sedimentary accumulation.

1.2. Study area location

The study area is confined between the Ialomița River to the east and the Dâmbovița River to the west (Fig. 1). This area represents the southern foothills of the Leaota Mountains, and is the southwestern continuation of the Bucegi Mountains (Fig. 1b). Within the Romanian Carpathians, geographers consider the area between the Ialomița and Dâmbovița rivers as belonging to the eastern extremity of the Southern Carpathians. Geologically, this area has genetic links with the Eastern Carpathians.

From a more detailed perspective, the investigated area extends westward from the lower course of the Raciu and Doicii rivers (Fig. 1c). The western limit of the area is drawn by the localities Cetățeni and Cotenești, located in the Dâmbovița Valley.

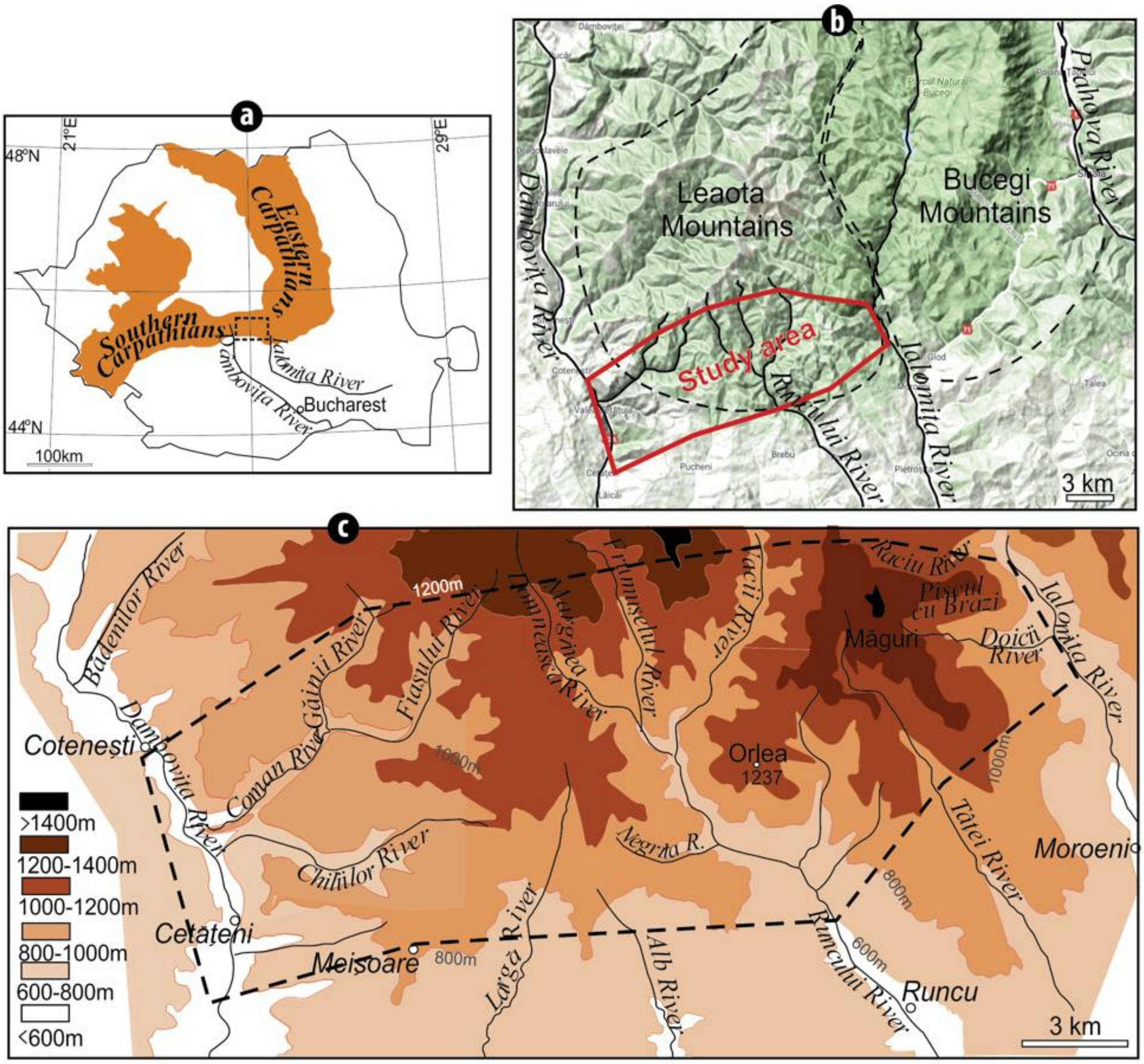


Fig. 1. Location and orography of the investigation area. The area between the Ialomița and Dâmbovița rivers is situated in the southern foothills of the Leaota Mountains and the southwestern extension of the Bucegi Mountains.

The Runcu River (also called Ialomicioara de Jos) is continued to the north by the Vacii, Frumușelu and Marginea Domnească rivers (Fig. 1c). Coman and Chiliilor rivers, Dâmbovița River tributaries, are the prominent streams in the western half of the study area (Fig. 1c). The relief is higher in the eastern part of the study area, where Raciu Mountain slightly exceeds 1,400 m in elevation, and the Orlea and Măguri mountains reach altitudes between 1,200 and 1,300 m.

2. GEOLOGICAL SETTING

2.1. Geological investigation history

Between 1920 and 1940, several studies were published on the conglomerates of the Bucegi Massif. The synchronous deposits that appear in the area between Ialomița and Dâmbovița rivers were not one of the concerns of these studies. This area was researched by G. Murgeanu in the 1930s, but the results of the study were not published.

The geological map of Romania at 1:500,000 scale, sheet 5a, (Mrazec and Macovei, 1942), provided the first modern cartographic image of the Albian deposits between the Ialomița and Dâmbovița valleys. The Geological Institute of Romania had completed drafting the 1:200,000 scale geological map of Romania by 1968. Albian deposits from the Ialomița-Dâmbovița area appeared on the 35 – Târgoviște geological map sheet with no differentiated lithological units (Institutul Geologic al României, 1968) (Fig. 2).

By the time the aforementioned maps had been published, geological knowledge of the Albian deposits exposed in the Romanian Carpathian Bend area had significantly evolved. Due to the paucity of paleontological data, for a long time the conglomerates of the Bucegi Mountains were assigned geological ages in a wide interval, between Barremian and Eocene. Beginning with Macovei and Atanasiu (1927) and Murgeanu (1934), the Aptian age of the deposits underlying the Bucegi Conglomerates had been increasingly documented. Murgeanu and Patrulius (1957) proved that Vraconian age (= latest Albian) clayey-arenitic deposits discordantly cover the sandstone and conglomerate deposits from Dâmbovița Valley. In this way, the Albian age of the Bucegi Conglomerate succession and the synchronous deposits of the southern Leaota Mountains foothills was established.

A climax in the study of the Bucegi Mountains was marked by the publication of the book written by Patrulius (1969), which is unmatched even today. The geological map drawn up by Patrulius (1969) also includes the eastern part of the Ialomița-Dâmbovița area (Fig. 3a).

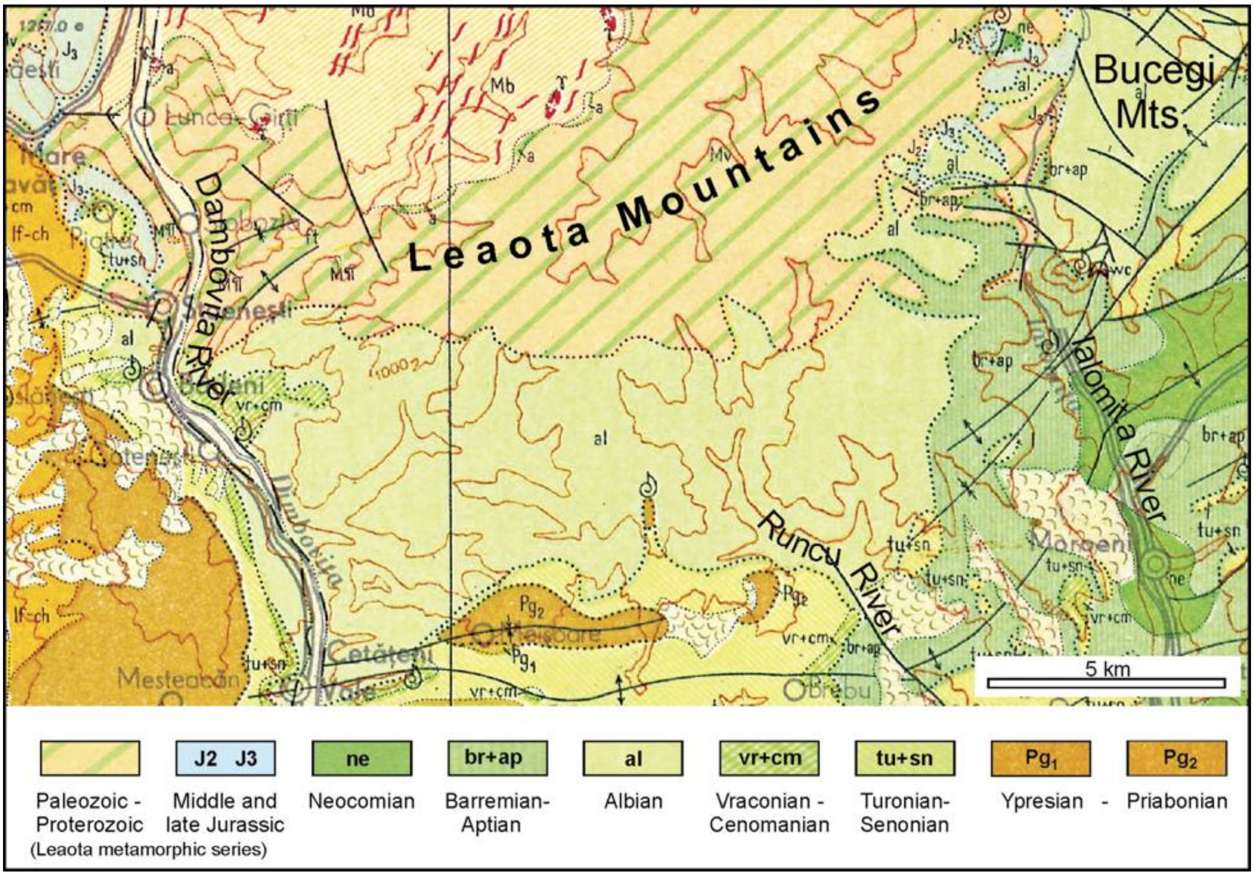


Fig. 2. Albian deposits in the Ialomița-Dâmbovița area shown on the geological map of Romania at scale 1:200,000 (sheet 35 – Târgoviște, Institutul Geologic al României, 1968).

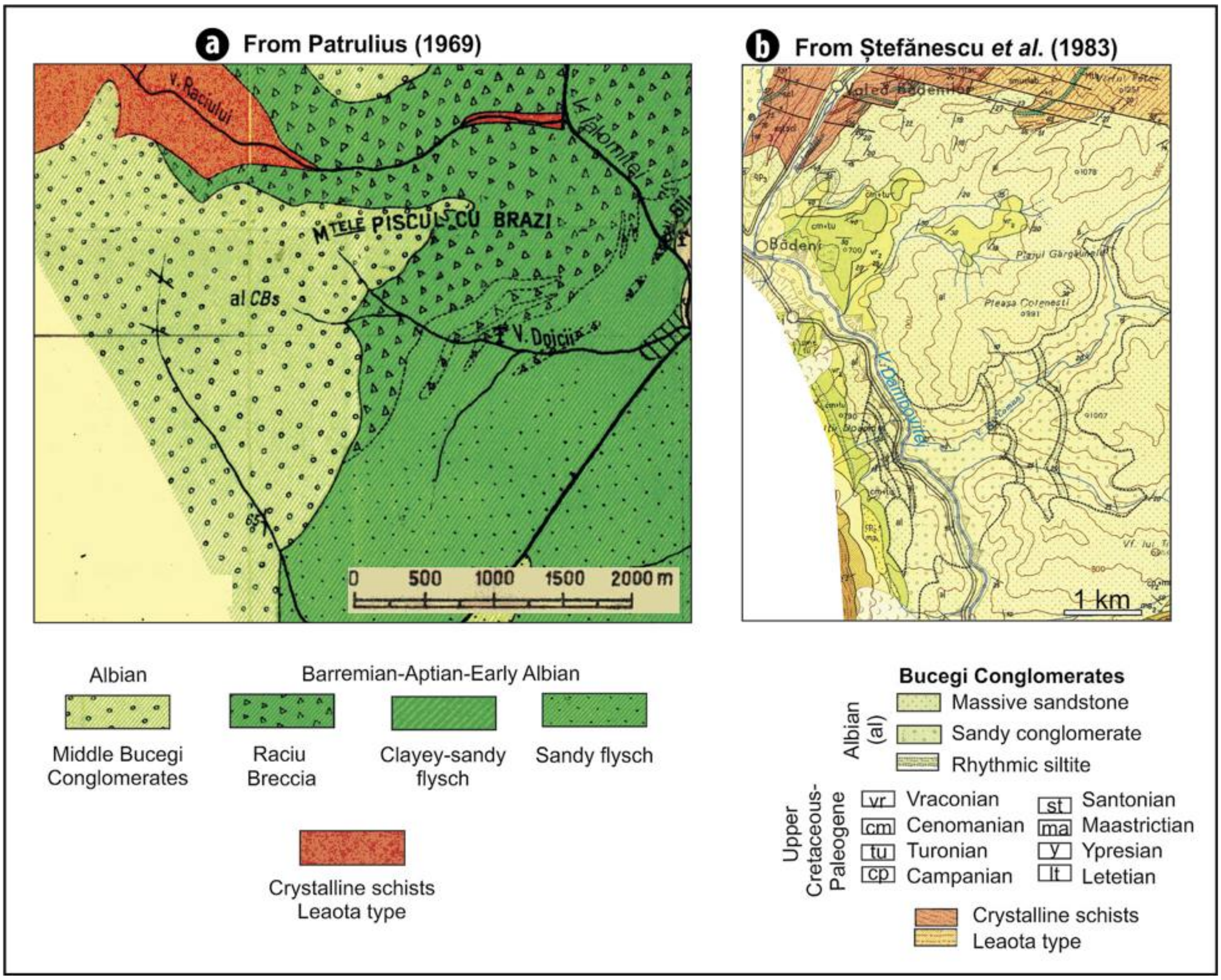


Fig. 3. Albian deposits in the Ialomiţa-Dâmboviţa area, on Patrulius (1969) map and the geological map of Romania at 1:50,000 scale (Ştefănescu *et al.*, 1983).

The first lithological description of the Ialomiţa-Dâmboviţa Albian succession was made by Murgeanu *et al.* (1963). These authors mentioned the predominance of massive sandstones with rudite intercalations, as well as the presence of the rhythmically alternating arenite and siltite units.

The Albian deposits cropping out between the Ialomiţa and Dâmboviţa rivers were included on the Geological Map of Romania at 1:50,000 scale, on sheets 128a – Câmpulung Muscel (Ştefănescu *et al.*, 1983) and 128 – Pietroşiţa (Mihăilescu *et al.*, 2020). On the Câmpulung Muscel map, Mihăilescu (in Ştefănescu *et al*., 1983) made the first lithostratigraphic subdivisions in the Albian deposits eastward of the Dâmboviţa River (Fig. 3 B). On the map, Mihăilescu outlined an area with sandy conglomerates, located on the Coman River and the Chiliilor River, intercalated with four rhythmic, silty units. Massive sandstones were mapped in the rest of the area. For the Ialomiţa-Dâmboviţa area, the Pietroşiţa map includes, with modifications, the map drawn up by Jipa (1982) (Fig. 4).

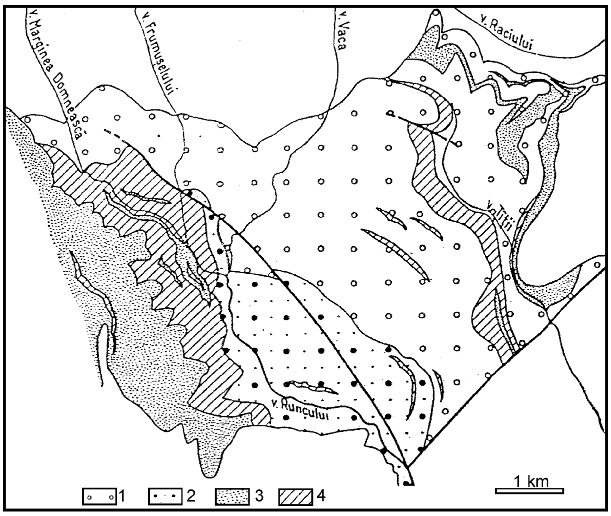


Fig. 4. Lithofacies map of the Albian deposits in the area between the Ialomiţa and Runcu rivers. From Jipa (1982). *Legend*: **1**. Conglomerate. **2**. Sandy conglomerate. **3**. Massive sandstone. **4**. Silty to fine-grained sandstones.

According to Jipa (1982, 1984), the Bucegi Conglomerates, as well as the Albian clastic accumulation between the Ialomița and Runcu rivers, evolved through large-scale progradation. This conclusion is based on the fact that successive lithostratigraphic units of the Bucegi Conglomerates, starting with the Lower Bucegi Conglomerates through to the Babele Sandstone, come into contact with the same uppermost Aptian to lowermost Albian stratigraphic unit, represented by the Raciu Breccia.

There have been a few sedimentological investigations carried out on the Albian conglomerate deposits of the Carpathian Bend area (Panin *et al.*, 1963, Mihăilescu *et al.*, 1967; Patrulius *et al.*, 1967; Mihăilescu, 1980; Jipa *et al.*, 2013; Olariu *et al.*, 2014; Jipa and Olariu, 2018), but these studies did not extend to the Ialomița-Dâmbovița area.

2.2. Stratigraphy of the Albian deposits

The geologists who studied the Albian conglomerate and sandstone deposits from the Bucegi Mountains and the Ialomița-Dâmbovița areas did not uncover stratigraphically significant fossil remains. Therefore, the age of these deposits was assigned by taking into account the biostratigraphy of the underlying and overlying deposits.

The Albian deposits from the Bucegi Mountains and the Ialomița-Dâmbovița areas occur stratigraphically between deposits of the Moroeni Formation and those of Vraconian-age (= latest Albian) (Fig. 5). The presence of the early Albian in the upper Moroeni Formation deposits was initially mentioned by Murgeanu *et al.* (1963) and Patrulius (1969) and later documented by Avram (1970) and Melinte-Dobrinescu and Jipa (2007).

In the Cotenești area, Murgeanu and Patrulius (1957) revealed the existence of fossiliferous Vraconian-Cenomanian deposits discordantly overlying the sandstones and conglomerates that are considered to be Albian today. The same stratigraphic relationships were recognized along the Glajaria River (south of the Bucegi Mountains) by Murgeanu and Patrulius (1963).

Together with the Aptian paleontological evidence found in the Moroeni Formation deposits, finding the fossiliferous Vraconian deposits from the Cotenești area represented critical data to support assigning an Albian age to the Bucegi Conglomerates, as well as to the sandy-gravelly Ialomița-Dâmbovița deposits. Since the underlying Moroeni Formation has been proven to be of early Albian age and the overlying, Vraconian (= latest Albian), the age of the ruditic and arenitic deposits from Bucegi Mountains and from the Ialomița-Dâmbovița area is (logically) at least middle Albian. Murgeanu *et al.* (1963) mentioned that these deposits belong to the middle and late Albian. The top of the Moroeni Formation has been assigned to the basal Albian, or earliest Albian, by Melinte-Dobrinescu and Jipa (2007). Taking into account these data, the Albian age of the ruditic and arenitic deposits from Bucegi Mountains and Ialomița-Dâmbovița area could also include part of the early Albian.

Although there are paleontological data revealing the earliest Albian age of the top Moroeni Formation deposits, the accurate position of the Aptian/Albian boundary in the sedimentary succession is not yet established. This is why in this paper the Raciu Breccia stratigraphic marker is mentioned as being of late Aptian to early Albian age.

The first modern paleontological and stratigraphically meaningful data regarding the Albian ruditic-arenitic deposits was presented by Melinte-Dobrinescu (in Olariu *et al.*, 2014), based on calcareous nannofossil investigations. The Albian age is supported by the presence of nannofloral assemblages with *Axopodorhabdus albianus*, recognized by Melinte-Dobrinescu in silty-clayey sediments from the Marginea Domnească River.

3. PRESENTATION OF DATA

3.1. Lithostratigraphic map of the Albian deposits between Ialomița and Dâmbovița rivers

In the area between the Ialomița and Dâmbovița rivers, three main types of lithofacies can be distinguished in the Albian deposits (Fig. 6): (i) silty and fine-grained sandstone facies, (ii) medium- and coarse-grained sandstone facies, and (iii) sandstone and conglomerate facies. The same lithofacies also appear on maps drawn up by Mihăilescu (in Ştefănescu *et al.*, 1983) and Jipa (1982).

The silty and fine-grained arenitic deposits make up several bodies of varying thickness and extent, occurring at various stratigraphic positions. The most important body of this lithofacies type occurs in the Runcu River area on some of its right-bank tributaries (Negrița River and others) and on the lower course of the Frumușelului and Marginea Domnească rivers (Fig. 6). Another important body of silty and fine-grained sandstone deposits appears in the high-relief area, southwest of Măguri Peak (Fig. 6). The strike of the two mentioned units is northwest-southeast and crossing the whole area of the Albian deposits. Numerous small, silty and fine-grained arenitic bodies are intercalated in the coarse-grained sandstone and sandstone-conglomerate facies (Fig. 6).

Two large-scale units of medium- and coarse-grained sandstone deposits are shown on the map (Fig. 6). The eastern unit extends in the area of the upper course of the western tributaries of the Runcu River. The second unit, with the largest extension of the silty and fine-grained arenitic facies, occurs southwest of the Runcu River in the upper course of the Coman and Chiliilor rivers (Fig. 6).

Three bodies of sandstone and conglomerate deposits, becoming increasingly important from east to west, are present in the Ialomița-Dâmbovița area. One of these bodies is located southwest of the Ialomița River, in the area of the Raciu and Doicii rivers (Fig. 6).

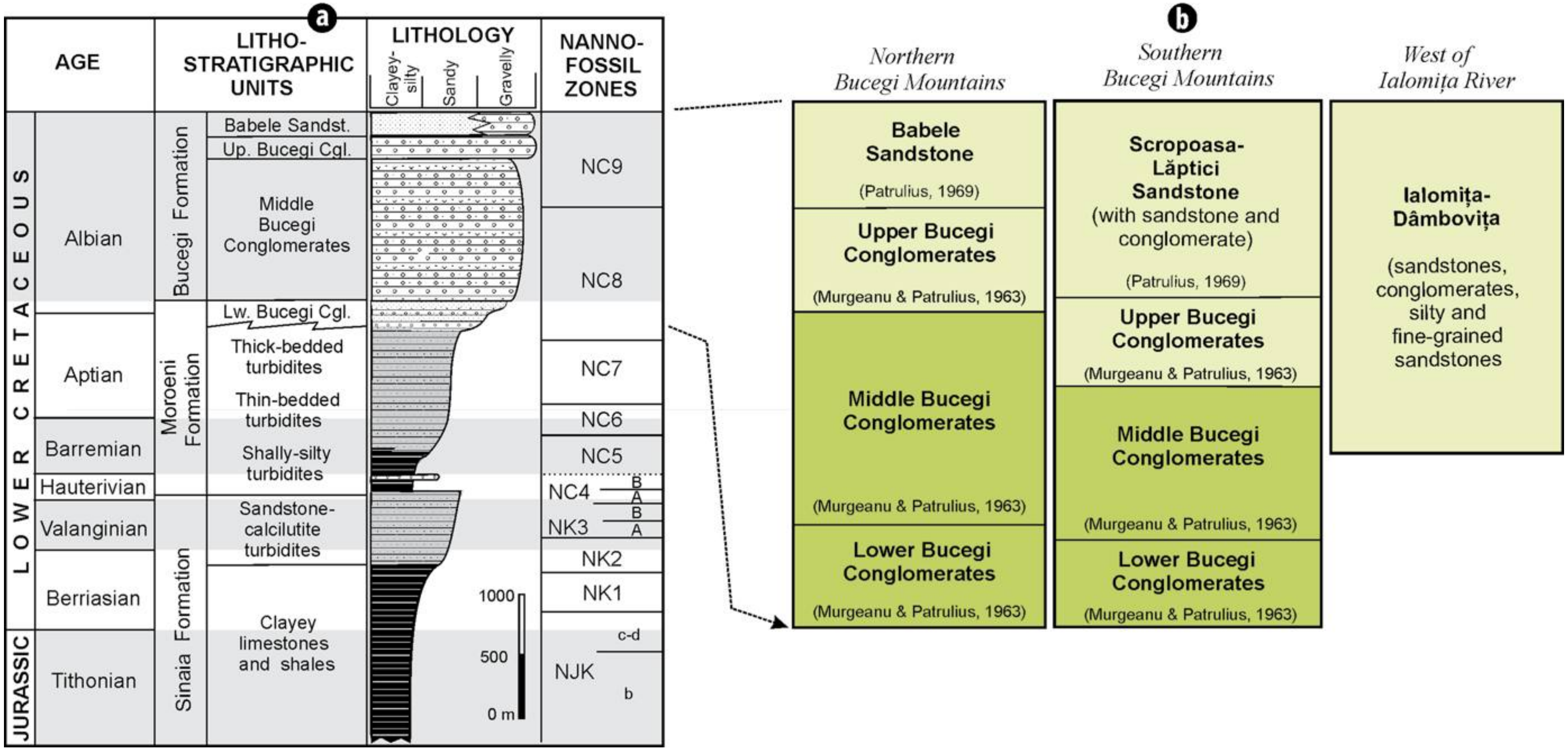


Fig. 5. Stratigraphy of the Albian deposits from the Bucegi Mountains and the Ialomița–Dâmbovița area. (**a**) Uppermost Jurassic to Lower Cretaceous succession in the Northern Bucegi zone. Nannofossil biostratigraphy after Melinte and Mutterlose (2001), Melinte-Dobrinescu and Jipa (2007), Olariu *et al*. (2014) and this paper. Note that the placement of the Aptian/Albian boundary is tentative and still under discussion. (**b**) Comparative lower Cretaceous lithostratigraphy in the Bucegi Mountains (northern and southern) and the area between the Ialomița and Dâmbovița rivers.

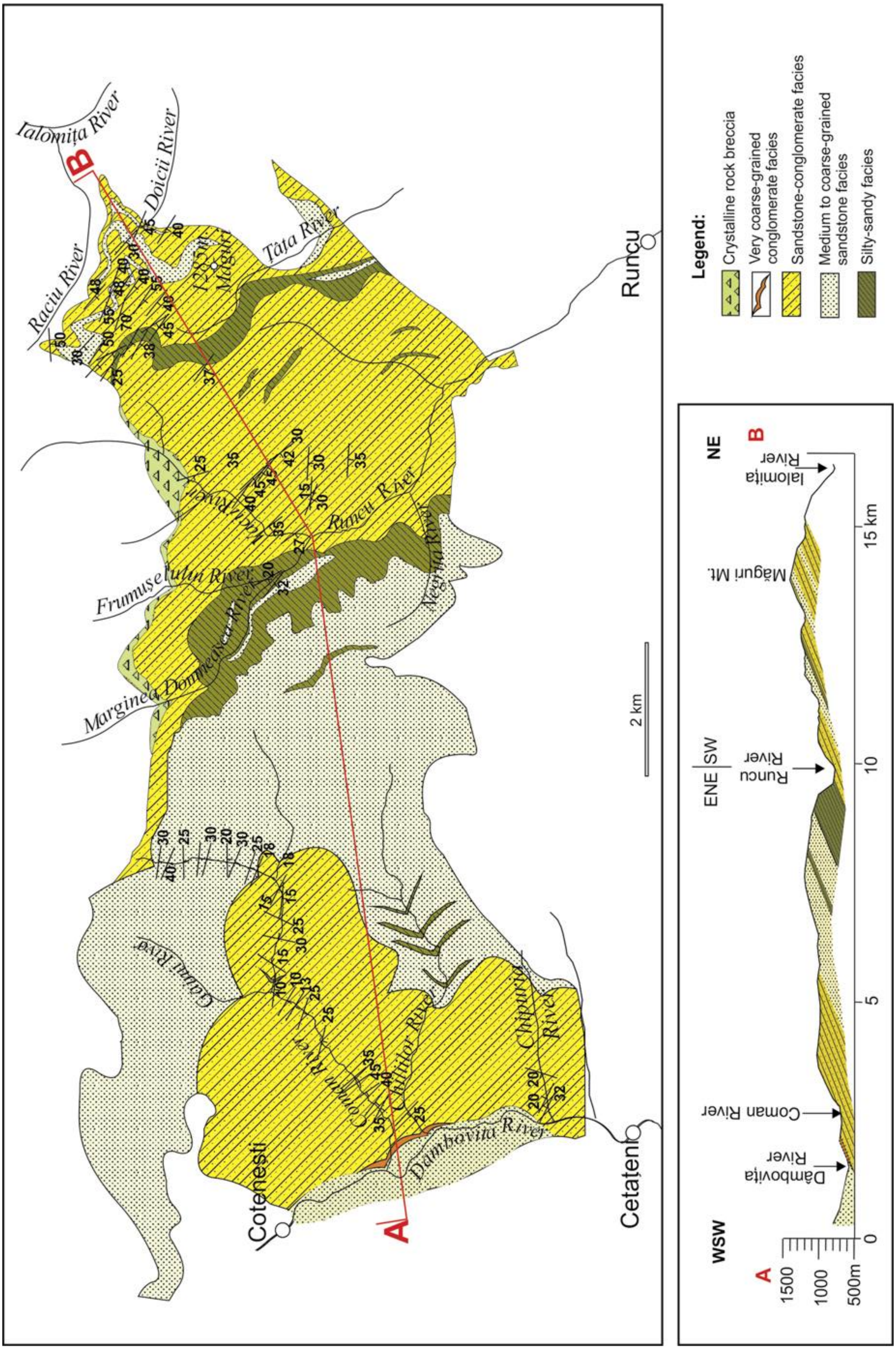


Fig. 6. Lithostratigraphy map of the Albian deposits from the area between the Ialomița and Dâmbovița rivers, showing location of geological section A–B. The geology shown between Ialomița and Runcu rivers is from Jipa (1982) with changes.

Another body of sandstones and conglomerates appears in the Runcu River area (Fig. 6), especially on the eastern side of this valley. The sandstone-conglomerate lithofacies also extends over a relatively large area on the Dâmbovița River and in the eastern area of its hydrographic network (Coman, Chiliilor, and Chipuria rivers). This is the third, western body of the sandstone and conglomerate facies (Fig. 6).

Apart from the three major lithofacies described above, two minor lithofacies also occur in the Albian deposits of the Ialomița-Dâmbovița area, and are shown on the lithofacies map (Fig. 6): very coarse-grained conglomerates and metamorphic rock breccias. The very coarse-grained conglomerates appear as a rather thin unit with restricted lateral extent at the mouths of the Coman and Chiliilor rivers (Fig. 6). The metamorphic rock breccias were noticed at the contact zone between the Albian deposits and the metamorphic basement, cropping out in good exposures in the area of the Vacii River (Fig. 6)

The lithostratigraphic map shows that the Albian deposits in the Ialomița-Dâmbovița area form a succession of different lithofacies units, with a dominant NW-SE strike and 25-30° SW dip. On the Câmpulung 1:50,000 scale map (Ștefănescu *et al.*, 1983), close to the boundary of the Leaota metamorphic series, the Albian deposits show NNE-SSW strike lines (Fig. 3). Similar strike values were measured over a limited area on the Fiasu River (Coman River west branch). Strike and dip values different from the dominant ones were recorded in several areas, but with less frequency, for example in the Chipuriei and Coman rivers (Fig. 6).

As a whole, the geological structure of the Albian deposits in the Ialomița-Dâmbovița area is that of a weakly folded monocline, with dominant NW-SE strike and SW dip.

3.2. The relationship between Raciu Breccia and Albian deposits

Raciu Breccia (or Raciu Breccia and Conglomerate; Patrulius, 1969) is a distinct lithological unit occurring in the upper part of the Moroeni Formation, sometimes even forming the upper contact of the formation. The existence, the lithological nature, the areal extent and the stratigraphic position of the Raciu Breccia were highlighted by Patrulius (1953; 1969).

The mapped outcrop area of the Raciu Breccia extends 15 km from northwest of the town of Bușteni southward to the Ialomița River (north of Moroeni) (Patrulius, 1969). In the northern part of this area, the appearance of the Raciu Breccia is continuous, whereas in the southern Bucegi Mountains, Raciu Breccia outcrops are more local in extent.

The southernmost point of the Raciu Breccia outcrop area is also where this unit is the thickest and has the highest textural and genetic variations. On the Ialomița River, downstream from the confluence with the Raciu River, the Raciu Breccia reaches a thickness of 100-120 m. At this location, medium- to coarse-grained Raciu Breccia (calcirudites with up to 5 cm clasts) with disorganized internal structure, alternate with very fine-grained Raciu Breccia calcirudite deposits (with 2-10 mm granules) (Fig. 7). Oversized metamorphic rock clasts, up to 1 m in diameter, are occasionally present (A1 in Fig. 7a).

Raciu Breccia exposures in the eastern part of the Bucegi Massif (between Bușteni and Sinaia) consist of several (usually two) units that are 10-15 m thick. The sedimentary beds consist of coarse-grained calcarenites and calcirudites, with normal grading (Fig. 8) and parallel and cross laminations. This type of Raciu Breccia represents distal sedimentary accumulation, whereas the massive calcirudites on the Ialomița River appear to represent more proximal accumulation.

Raciu Breccia has distinct sedimentary characteristics, which makes it a good marker in the Aptian-Albian lithostratigraphic succession. The calcareous character of the Raciu Breccia, demonstrated by the prevalence of limestone clasts (Fig. 9a), is singular and easily recognizable in the siliciclastic succession of the Moroeni Formation. Raciu Breccia also has Leaota-type metamorphic clasts in variable quantities, but always in a subordinate amount.

The absence of matrix is the most distinctive attribute of the Raciu Breccia. The clasts touch and interlock, thus leaving no space between them. In this case, the limestone particles are apparently welded, and only the presence of metamorphic rock particles reveals that it is not a limestone (Fig. 9a). This absence of matrix is a dominant aspect of the Raciu Breccia, but occasionally, matrix is visible (Fig. 9b).

The relationship of the Raciu Breccia marker level with the Bucegi Conglomerates, as well as with the Ialomița-Dâmbovița Albian deposits, is particularly important for the genetic interpretation of these sedimentary accumulations. In the Ialomița River area (north of Moroeni), the Patrulius (1969) Bucegi geological map shows that Raciu Breccia appears as a thick deposit that divides southward into several thinner layers (Fig. 3). Mapping by the authors confirms this observation by Patrulius and has added more details regarding the distribution of the Raciu Breccia in this area (Fig. 10). In this area, the Albian sandstone-conglomerate deposits directly overlie the massive facies of the Raciu Breccia. Downstream on the Ialomița River, the Albian coarse-grained sandstone deposits overlie, with depositional continuity, the uppermost occurrence of the Raciu Breccia (Fig. 10).

3.3. Lithofacies analysis

As mentioned above, three main lithofacies have been identified in the Albian deposits in the Ialomița-Dâmbovița area. Most of the Albian deposits are coarse-grained and belong to two coarser grained lithofacies: a medium- and coarse-grained sandstone lithofacies, and a sandstone and conglomeratic lithofacies. The finer grained Albian deposits represent the third lithofacies, a silty and fine-grained sandstone. These three lithofacies, along with very coarse-

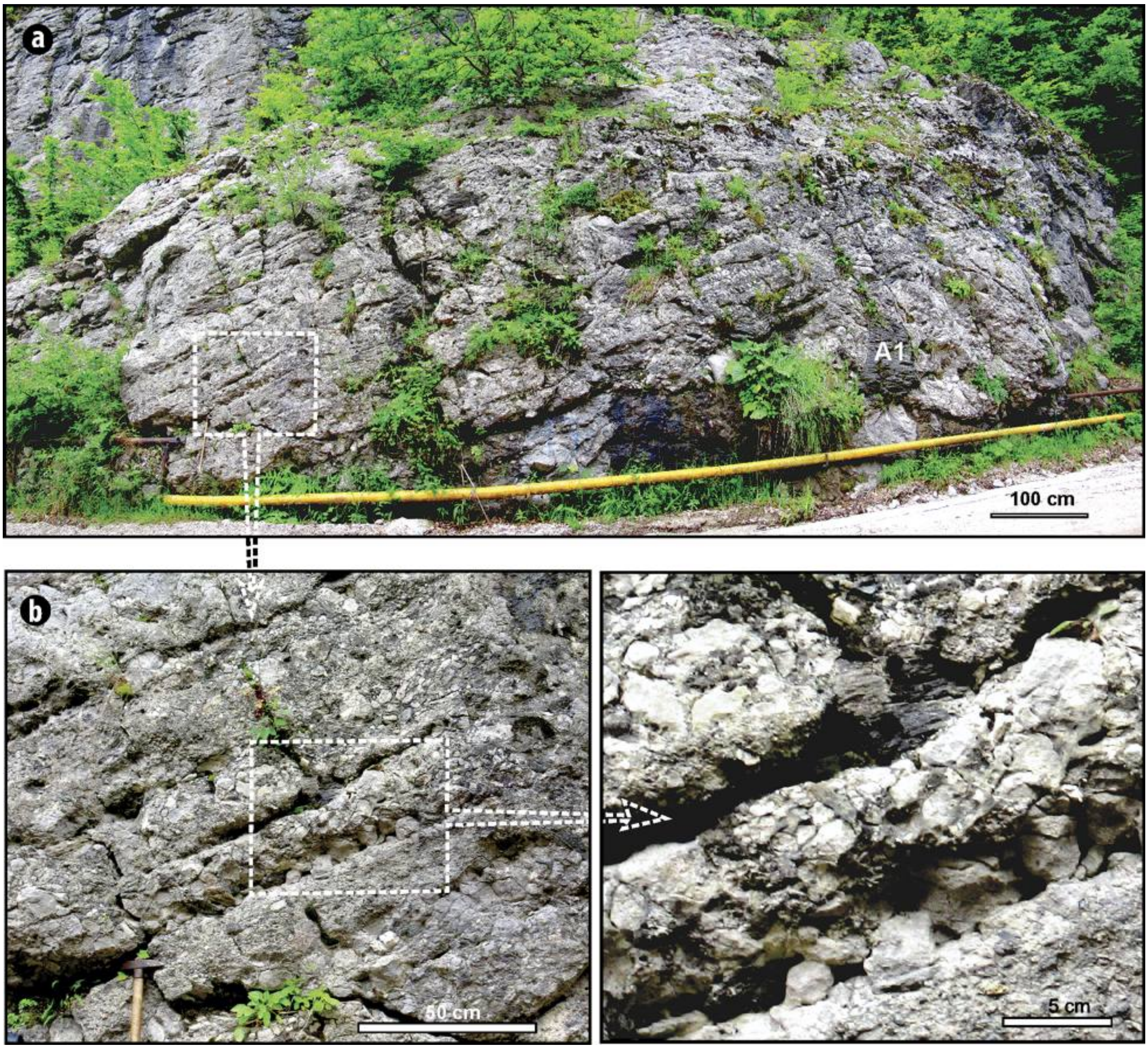


Fig. 7. Raciu Breccia from Ialomitei River (upstream of the confluence with Galmei River). (**a**) Conglomeratic (calcirudite) facies, showing an oversized metamorphic clast (A1). (**b**) Close up showing alternating medium- to coarse-grained and very fine-grained Raciu Breccia.

grained conglomerates, which form a minor but distinct lithofacies in the Ialomița-Dâmbovița area, are described below.

3.3.1. The medium- and coarse-grained sandstone lithofacies

As indicated by its designation, this sandstone facies consists of sandy deposits of coarser (medium and coarse) grain-size. Occasionally sandstones, with thicknesses of metres or tens of metres, do not show internal structures (except bedding) or significant intercalations of other lithological nature (Fig. 11). However, in many cases, there are sandstones displaying internal sedimentary organization, by way of large-scale sedimentary structures (Fig. 13). The bedding can often be evidenced by very fine-grained conglomerate interlayers.

On detailed examination, the sandstones include larger clasts several millimetres in size (Fig. 12a). The clasts are randomly oriented and dispersed and frequently made up of quartz particles (Fig. 12b). Sometimes, scattered clasts, several tens of millimetres in diameter, appear in the sandstone mass even without forming a conglomerate layer (Fig. 15).

The sandstone facies includes infrequent, very fine-grained conglomerate intercalations (Fig. 14a). The clasts of some of these conglomerate interbeds may mainly be of metamorphic origin, usually angular in shape (Figs. 14b and 15), while other conglomerate interbeds have predominantly limestone clasts with a high degree of roundness (Figs. 14c).

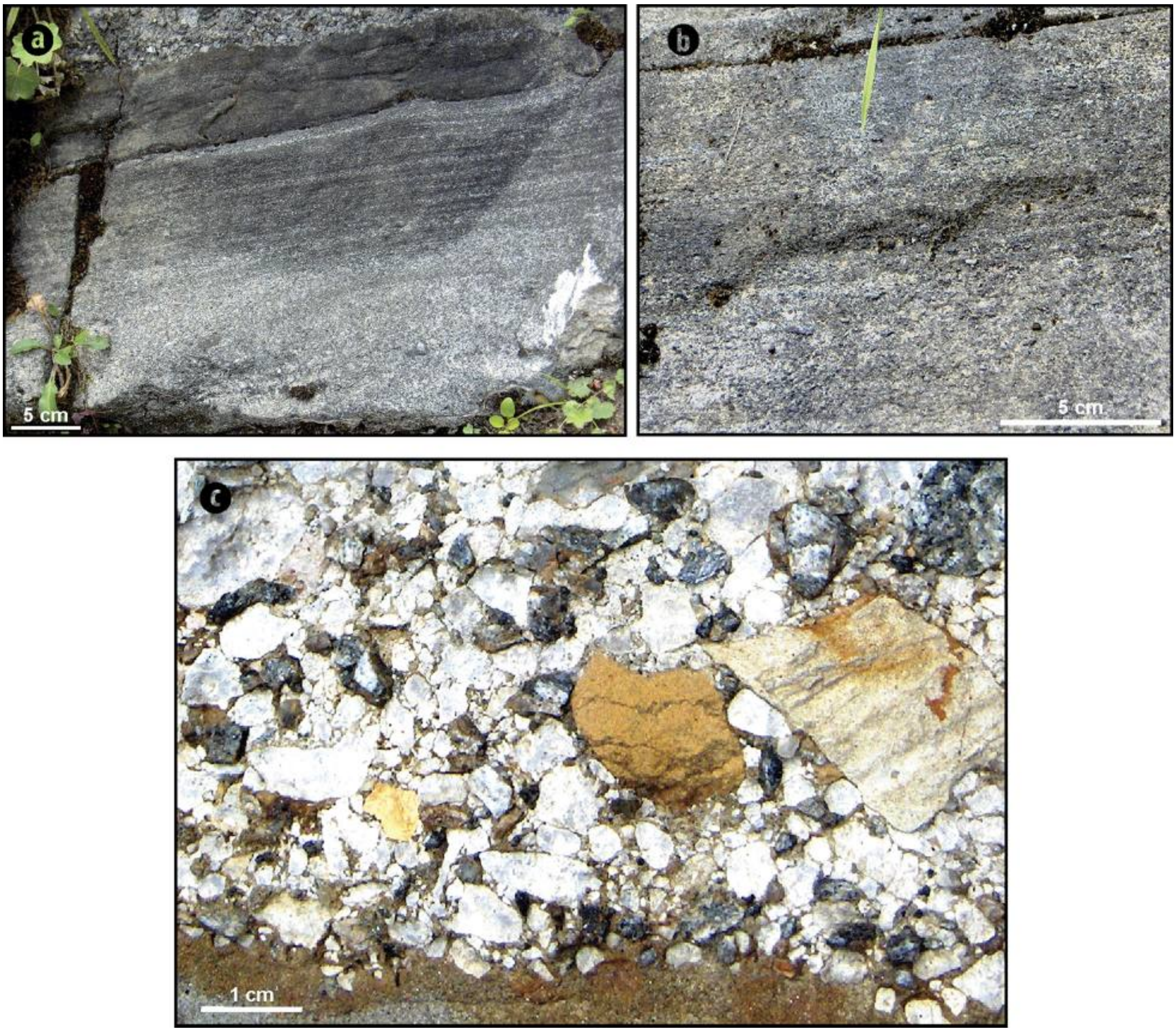


Fig. 8. Raciu Breccia with normal grading and parallel lamination. Images (**b**) and (**c**) show details from the upper and lower parts of the graded layer (**a**), respectively. Jepi River, Buşteni town.

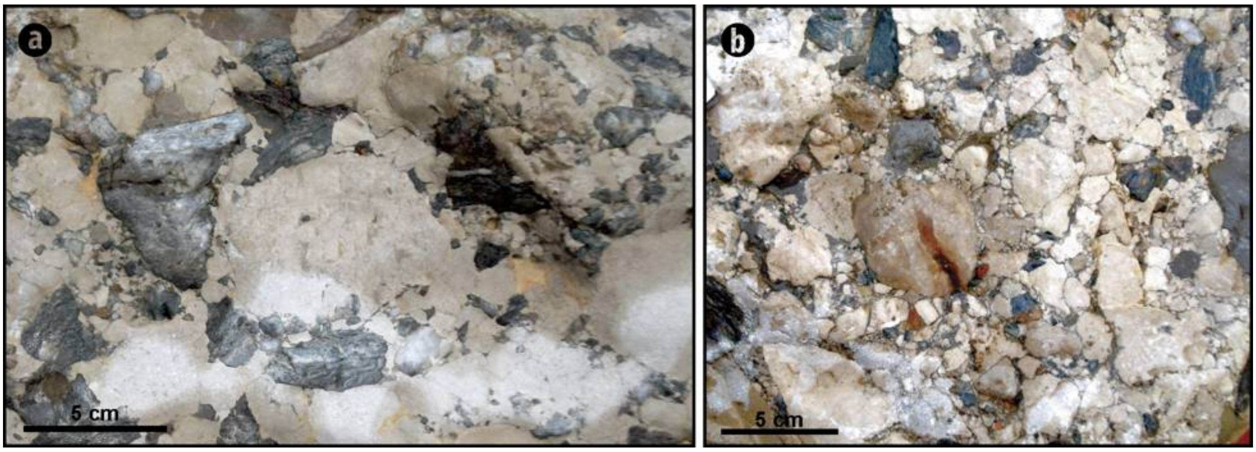
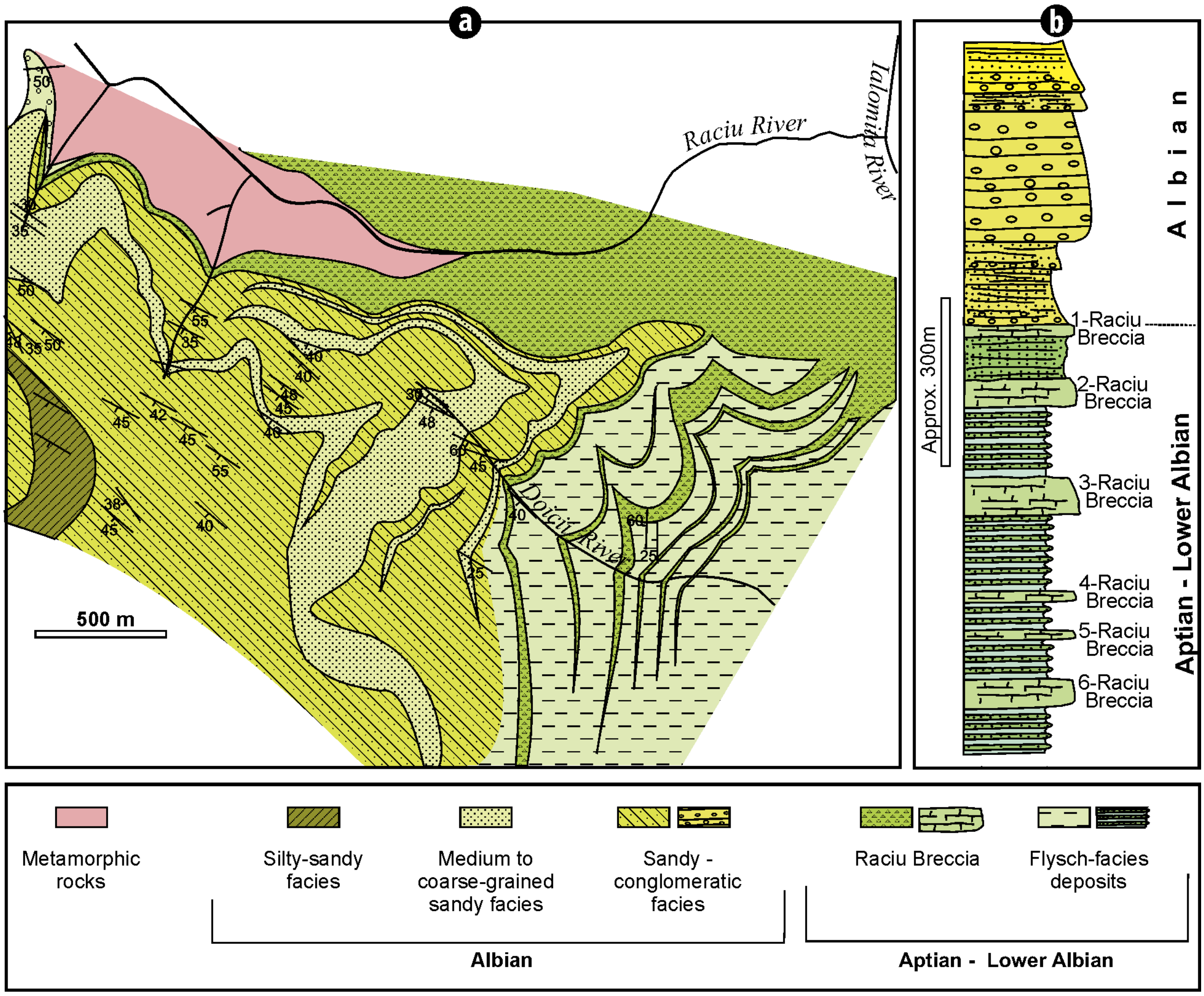


Fig. 9. Matrix in Raciu Breccia. (**a**) Raciu Breccia without matrix, with interlocked limestone clasts. (**b**) Raciu Breccia with matrix. Ialomiţa River, downstream from the confluence with Gâlmei River.



▲ **Fig. 10.** Geological map and stratigraphic section showing the relationship between the Albian deposits and the Aptian (and lower Albian) deposits in the area west of the Ialomița River (north of Moroeni).

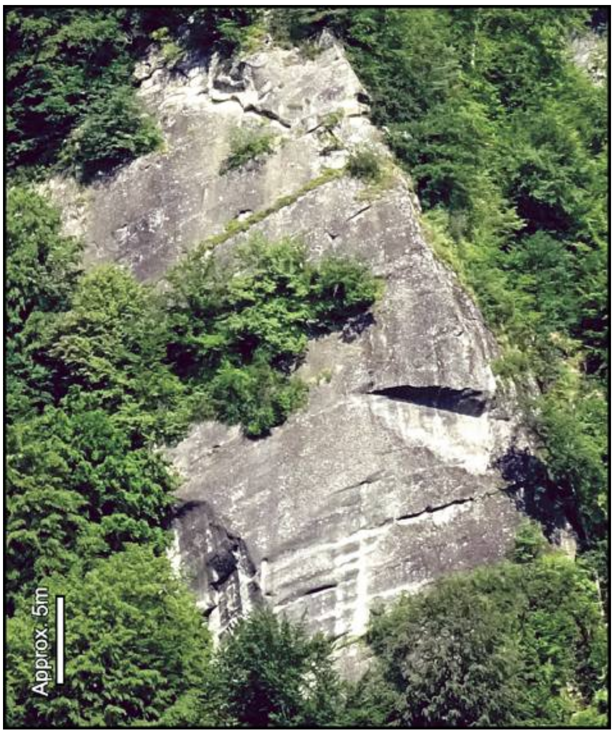


Fig. 11. The medium- and coarse-grained sandstone facies, apparently homogeneous (excepting bedding). Dâmbovița River, right bank. Cetățeni locality. ▶

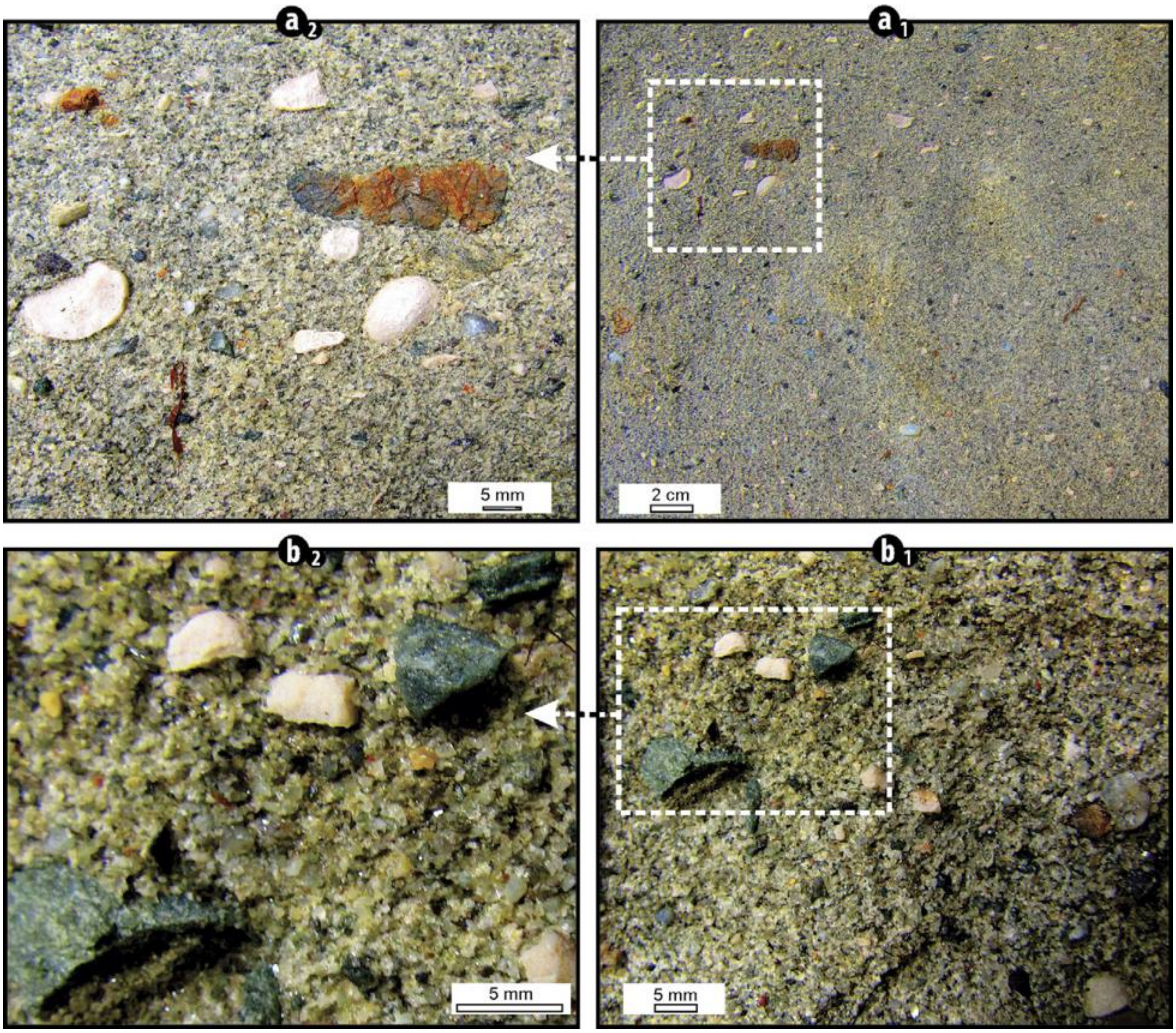


Fig. 12. Detailed view of a medium-grained sandstone. Coman River. The sandstone includes randomly oriented and dispersed larger metamorphic and calcareous clasts.

At several locations, outsize pebbles (10-30 cm) were observed floating in the homogeneous-looking sandstone (Fig. 16).

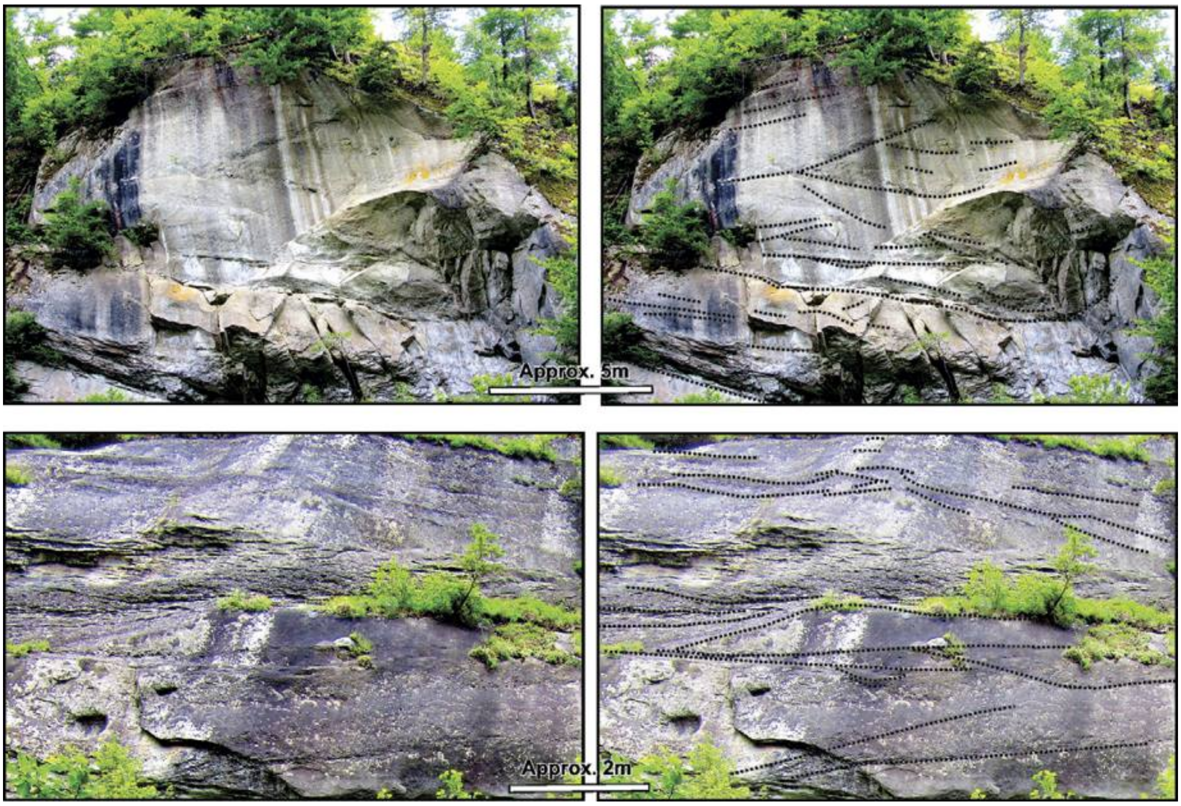
Fine-grained units are sometimes intercalated in the sandstone deposits and consist of rapidly alternating beds of clayey silt and fine-grained sandstone (Fig. 17). In many cases, the clayey silt intervals transitionally overlie medium-grained sandstones and are discontinuously overlain by conglomerates (Fig. 17).

3.3.2. Sandstone-conglomeratic lithofacies

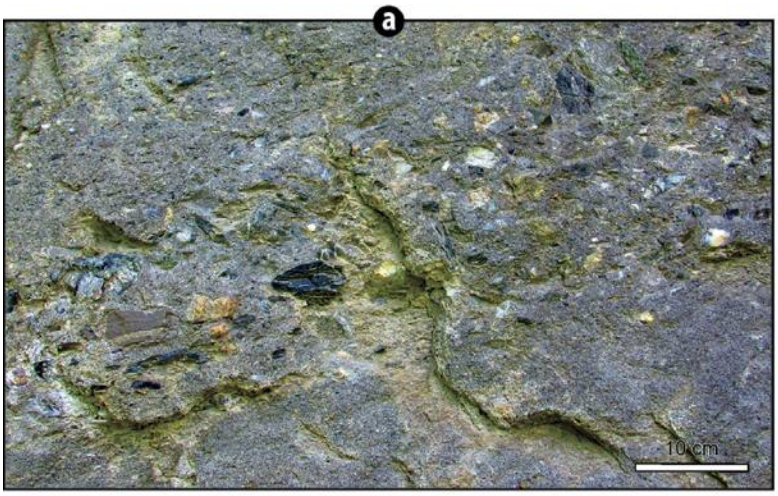
Sandstone-conglomerate facies is the name given to predominantly sandstone deposits with conglomerate interbeds. This second most important facies of the Ialomița-Dâmbovița Albian deposits includes sandstones with the same characteristics as those of the medium- and coarse-grained sandstone facies (Fig. 18).

A well exposed, thick (approximately 100 m) succession, from the north side of the Chiliilor River, shows the predominance of sandstone within the sandstone-conglomerate facies (Fig. 18). In this location, the conglomerates make up 20-25% of the entire succession. The occurrence of conglomerate interbeds is greater here than in the area of the westward-facing slope of the Runcu River.

Based on the petrography of the pebbles, the conglomerates of this facies mainly belong to two extreme categories: rudites with metamorphic rock clasts (Figs. 14b and 19a, b and c) and rudites with limestone clasts (Fig. 14c and 19d and e). Between these two categories, there are intermediary types.



▲ **Fig. 13.** Large-scale sedimentary structures in arenites of the medium- and coarse-grained sandstone facies. No small-scale, cross-laminated structures were noticed. Outcrops on Chiliilor River.



◄ **Fig. 14.** Conglomerate interbeds in the medium- and coarse-grained sandstone facies. (**a**) Very fine-grained conglomerate intercalation. Coman River. (**b**) Conglomerate with dominant metamorphic rock clasts. Coman River. (**c**) Fine-grained conglomerate with dominant limestone clasts. Chiliilor River.

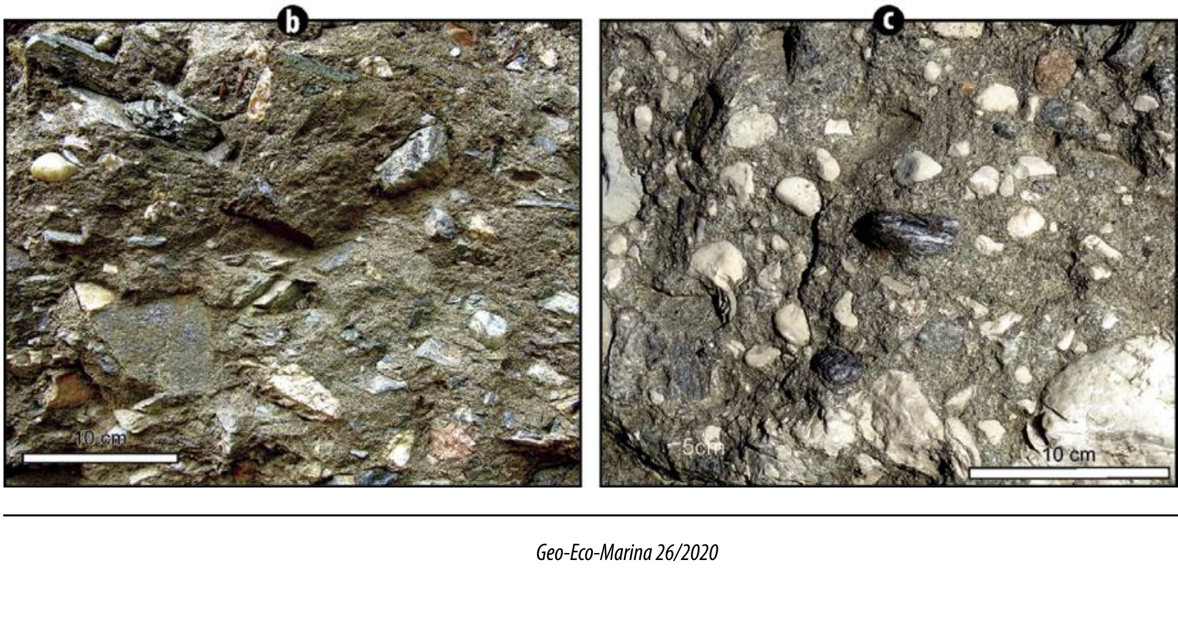


Fig. 15. Rudite clasts dispersed in medium-grained sandstone. The pebbles are poorly sorted, angular, floating in sandy material. Coman River.

Fig. 16. Oversize metamorphic clasts in homogeneous (structureless) sandstone. Coman River.

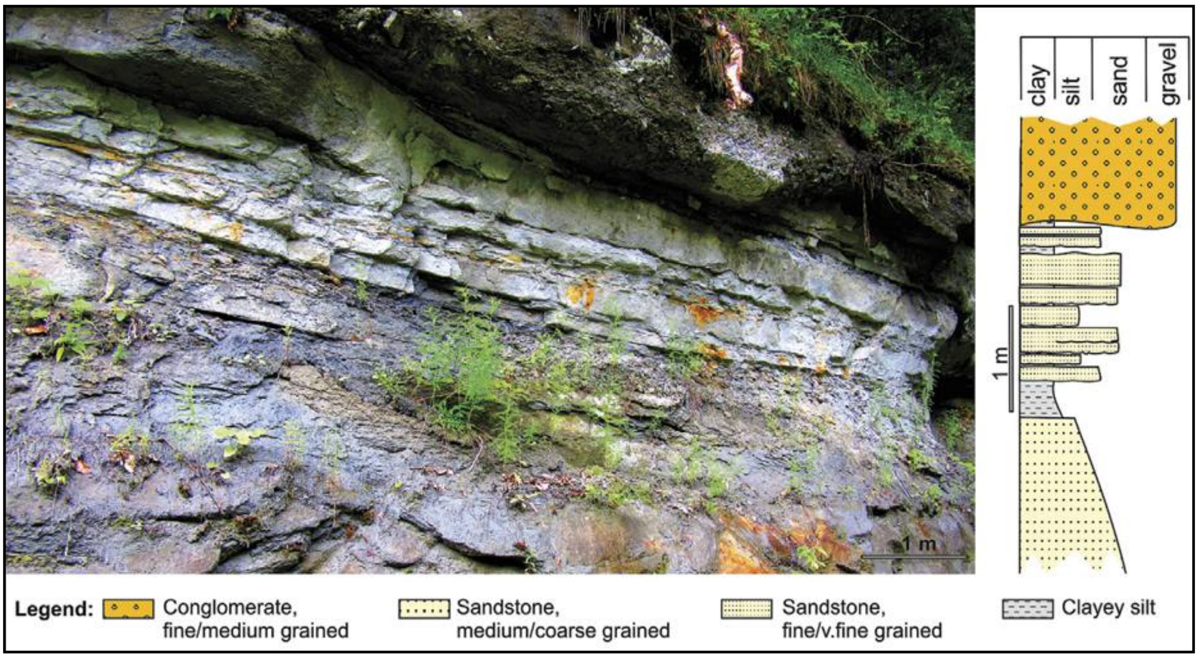


Fig. 17. Silty and fine-grained sandstone succession intercalated in the medium- and coarse-grained sandstone facies. Note the continuous passage from the underlying graded sandstone and the sharp boundary with the overlying coarse-grained sandstone and conglomerate. Coman River.

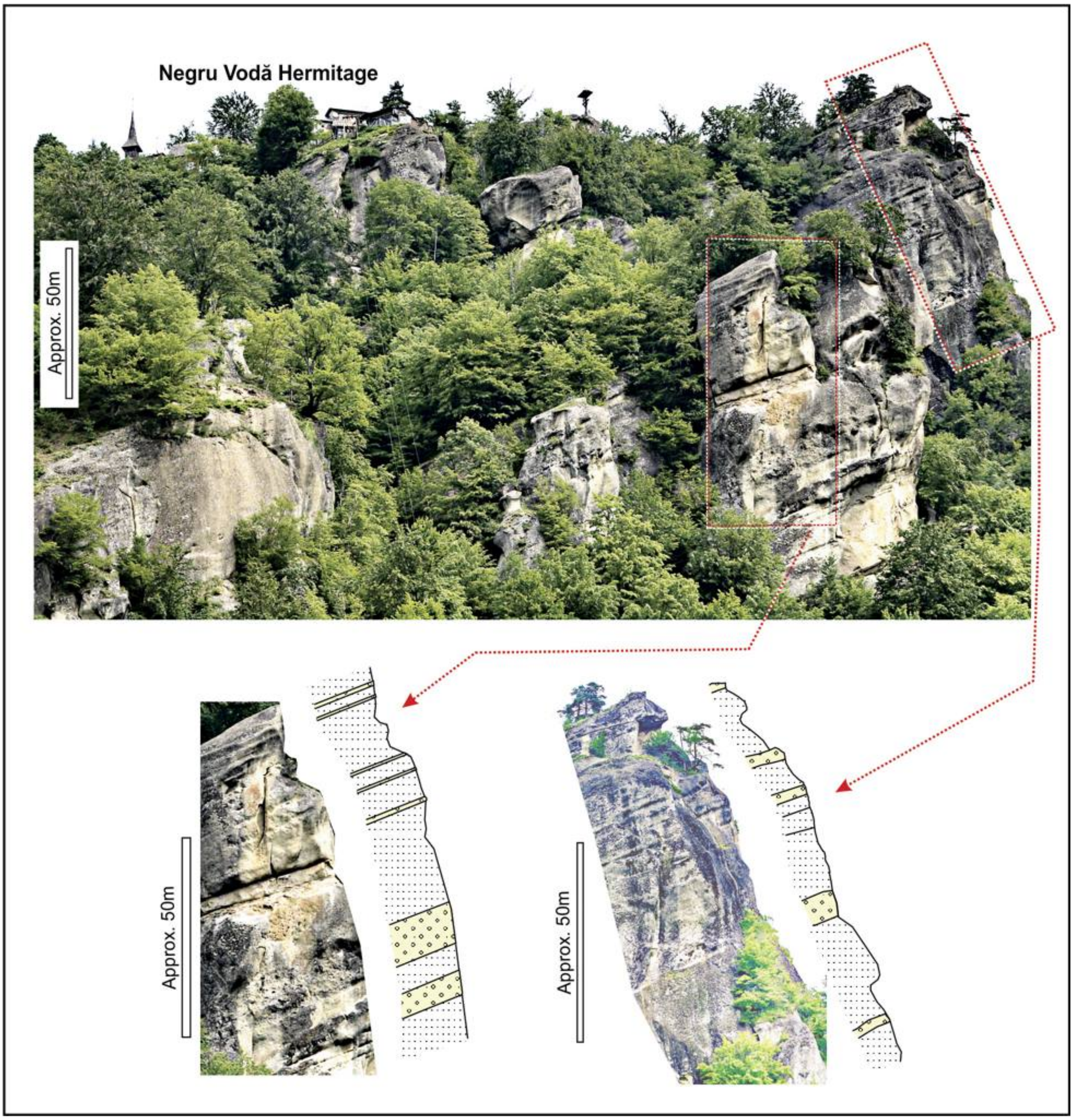


Fig. 18. The main conglomeratic interbeds in a medium- and coarse-grained sandstone succession. Large outcrop on the right bank of the Chiliilor River, under Negru Vodă Hermitage. Cetăţeni locality.

Besides the different lithologic composition of the conglomerates, pebble roundness is also different for these two kinds of conglomerates. Metamorphic rock clasts have a lower degree of roundness, primarily subangular in nature (Fig. 19a, b and c). In contrast, the limestone clasts may reach a high degree of roundness (Figs. 14c and 19d) but may also be subangular or subrounded (Fig. 19e).

Poor grain size sorting is characteristic of both these types of conglomerates, but especially of the conglomerates with metamorphic rock clasts (Fig. 19). Both categories of rudites have abundant arenite matrix. In some instances, the conglomerate clasts float in the matrix (Figs. 19a, b and d). More frequently, however, the matrix is only slightly dominant and pebbles come in contact (Figs. 19c and e).

The conglomerate units can be homogeneous, that is without noticeable organized internal structure. Disorganized fabric is manifested by the large clast size fraction and by its disordered arrangement (Fig. 19a, b, c, d and f). Some conglomerates show a certain degree of internal organization with visible pebble orientation (Fig. 19e) and even imbrications.

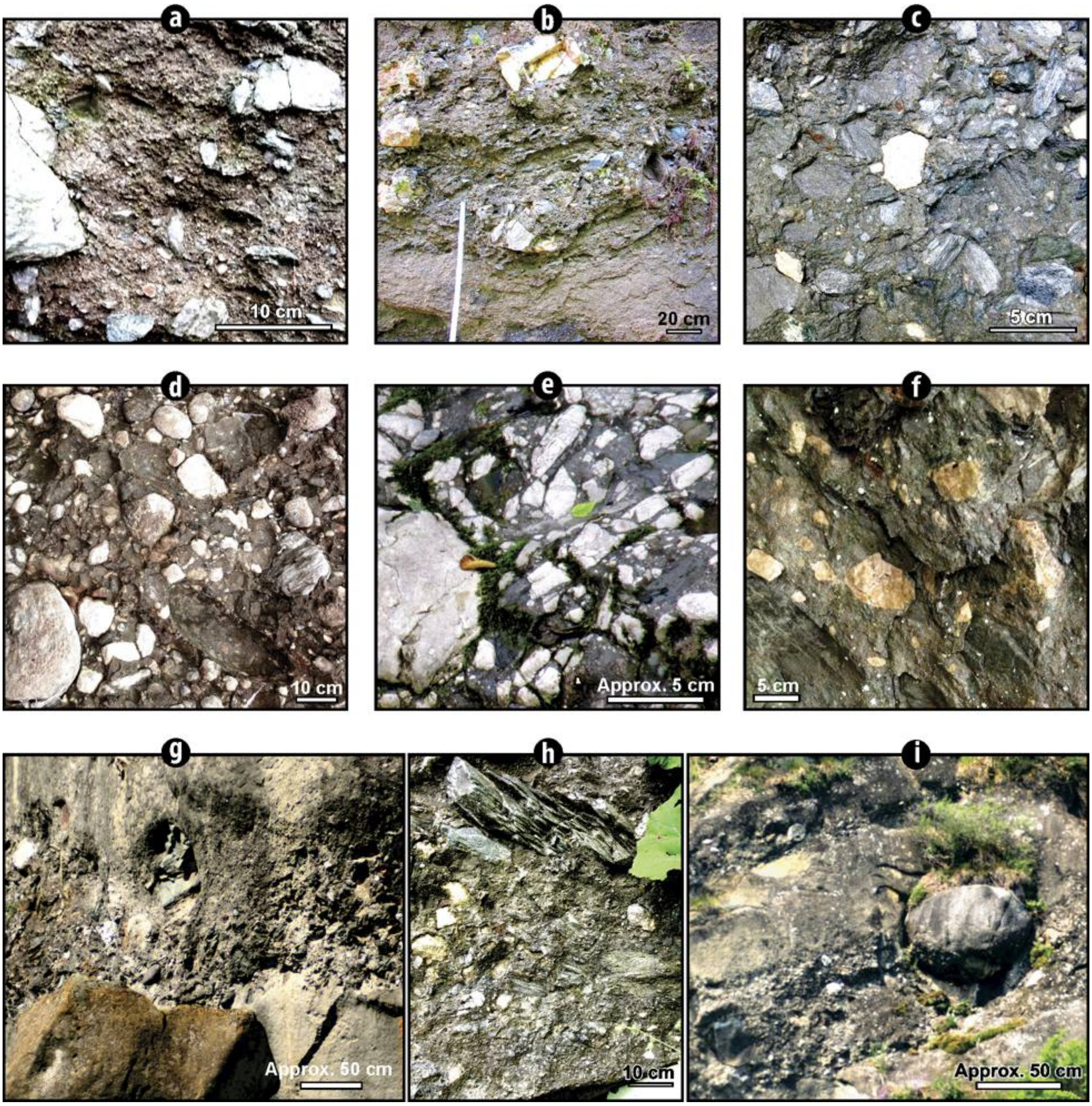


Fig. 19. Types of conglomerates in the sandstone-conglomeratic facies. (**a**), (**b**) and (**c**) Conglomerates with dominant metamorphic rock clasts. Note the subangular nature of the clasts. Vacii River, upstream from Între Văi Point. (**d**) and (**e**) Conglomerate with rounded, subrounded and subangular limestone clasts. Runcu River, Moara Dracului Point. (**f**) Limestone and metamorphic rock clasts floating in sandstone matrix. Runcu River. (**g**) Normal graded, coarse-grained conglomerate. Chiliilor River. (**h**) Conglomerate with reverse grading. (**i**) Non-graded conglomerate with a limestone megaclast. Chiliilor River.

Grading in the conglomerate units was frequently noticed. Homogeneous conglomerates with disordered fabric may be finer-grained only at the top, suggesting crude, normal grading. There are also conglomerates displaying progressive decrease in the size of the clasts and transition to the overlying sandstone (Fig. 19g). Less common are conglomerate units that are finer-grained in the lower part, suggesting reverse grading (Fig. 19h). Some conglomerate beds are homogeneous and display a sharp, nontransitional upper boundary (Fig. 19i). Exceptionally, the conglomerates show faint cross-stratification. In very seldom cases, current markings were found on the soles of some conglomerate layers.

In the succession of the sandstone-conglomeratic facies there are metres-thick sandstone units. They have all the characteristics of the arenites from the medium- and coarse-grained sandstone facies, including stratification and fine-grained conglomerate intercalations. Thin units of interbedded siltites and fine-grained sandstones are occasionally embedded in the sandstone-conglomeratic succession (Fig. 20a). Medium- to large-scale oblique bedding structures were noticed in outcrops from the lower course of the Chiliilor River (Fig. 20b). Because of the similarities between sandstones at the outcrop scale, the sandstone-conglomerate facies cannot be differentiated from the medium- and coarse-sandstone facies, unless conglomerate interbeds occur.

Trace fossils are uncommon in the deposits of the sandstone-conglomeratic facies. In an outcrop on the Coman River, a burrow that was 5 cm deep and 2.5 cm wide was observed (Fig. 21a). A winding and meandering ichnostructure similar to those reported by Uchman (1998) in flysch deposits of the Polish Carpathians, was also found on the tourist trail to the Negru Vodă Hermitage (Fig. 21b).

3.3.3. Sandstone with very coarse-grained conglomerate lithofacies

On the eastern side of the valley of the Dâmbovița River, in the area of the Coman and Chiliilor rivers, a sandy sedimentary succession with very coarse-grained conglomerates can be

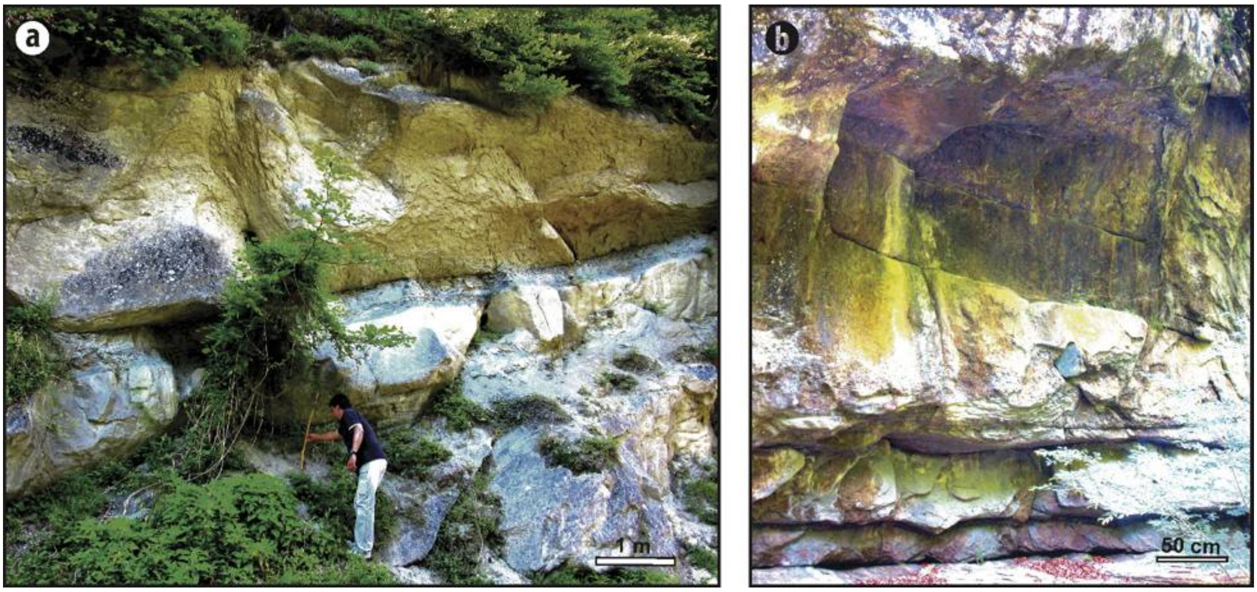


Fig. 20. Thin, finer grained sequences in the sandstone-conglomerate facies. (**a**) Intercalated silty to fine-grained sandy unit. (**b**) Very fine-grained conglomerate intercalation, hardly visible, revealing medium-scale oblique bedding. Chiliilor River, the lower course.

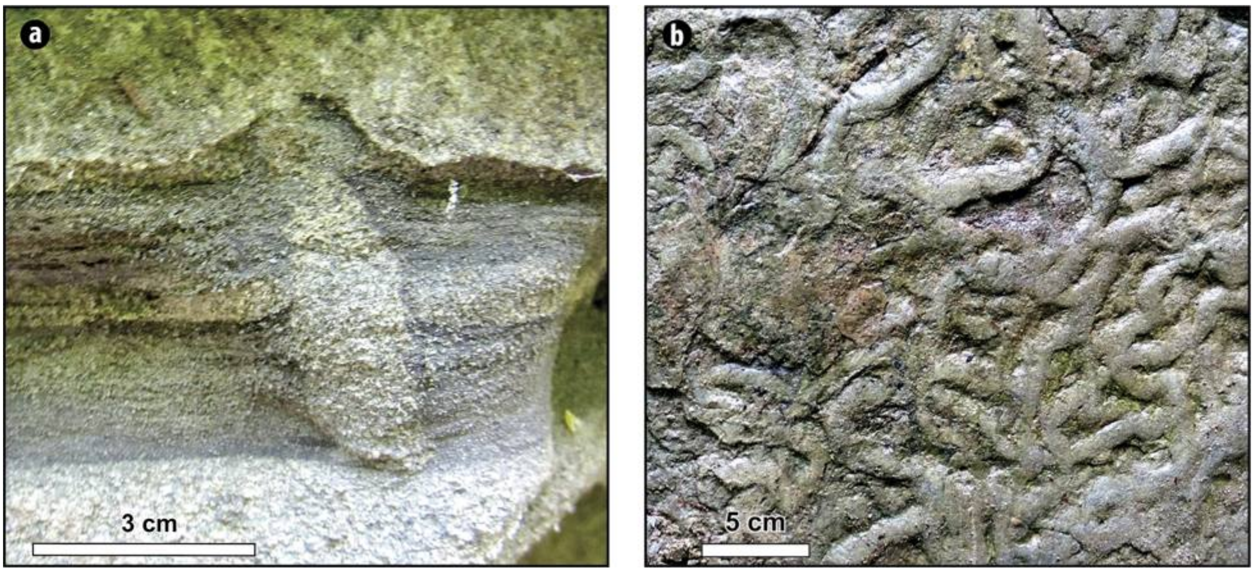


Fig. 21. Trace fossils in the sandstone-conglomeratic facies. (**a**) Burrow ichnostructure in finer grained sandstone. Coman River. (**b**) Winding ichnostructure on the bedding plane of a sandstone bed. Tourist path to the Negru Voda Hermitage.

found. This unit is several tens of metres thick and extends less than 2 km laterally along the Dâmbovița River (Fig. 6). The special features of the coarse-grained conglomerates warranted our treating this sedimentary succession as a distinct minor lithofacies.

In the large outcrop on the left side of Dâmbovița valley, at the northern periphery of the Cetățeni locality, a 30 m thick sedimentary succession includes several coarse- and very coarse-grained conglomerate interbeds (Fig. 22a to f). The first three interbeds (Fig. 22a, b and c) reveal three distinct types of coarse-grained conglomerates.

Very poorly sorted conglomerate A (Figs. 22a and 23a) has metamorphic rock and limestone clasts 20-30 cm and up to 50 cm in size. The percentage of the sandy matrix is not very high and the contact between clasts is frequent. The large metamorphic rock clasts are elongated and variously oriented, which confer on the conglomerate a pronounced, disorganized fabric. The conglomerate upper boundary is transitional to the overlying sandstone. The basal surface is sharp and nontransitional. Conglomerate A rapidly passes laterally to very fine-grained conglomerates or conglomeratic sandstones. The entire sedimentary unit is 15-20 m long and exhibits a lens-like shape.

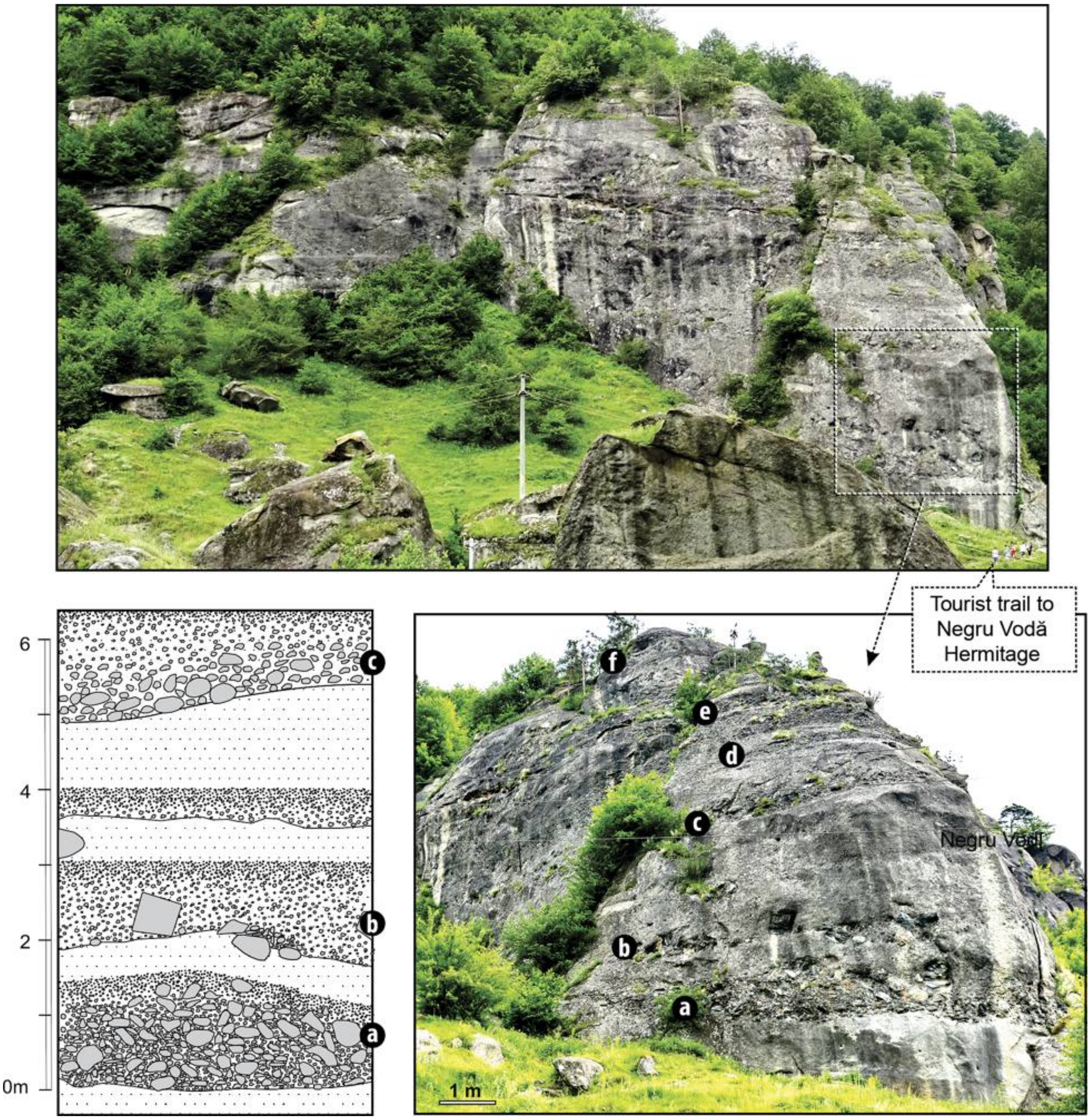


Fig. 22. Albian sandstones with intercalations of coarse- and very coarse-grained conglomerates (**a**) to (**f**). Sketch shows textural details of intercalations (**a**), (**b**) and (**c**). The conglomerate beds are intercalated in a prevailing sandstone succession. Outcrop on the western slope of Dâmbovița River, northern periphery of the Cetățeni locality.

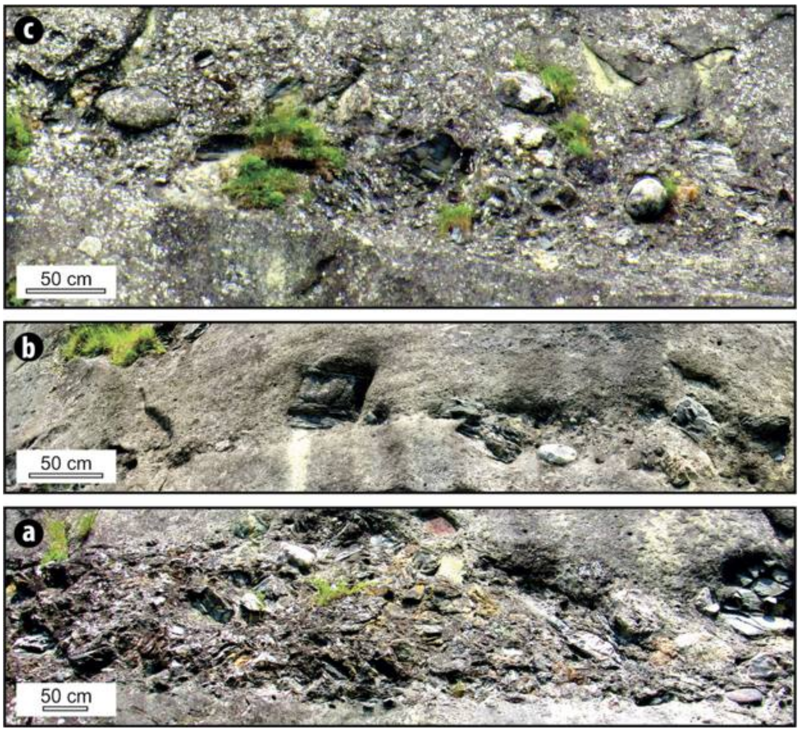


Fig. 23. Three types of coarse-grained conglomerates. See also Fig. 22. Outcrop on the western slope of Dâmbovița River, northern periphery of the Cetățeni locality.

Conglomerate B has a different character. Large clasts (10-45 cm) appear in several separate lens-like accumulations, with sharp base and transitional upper boundary. A square-shaped angular clast of 55 cm in size occurs in between the rudite lenses (Fig. 23m). The continuity of the conglomerate B layer is granted by the finer-grained conglomeratic, basal component of the unit.

The presence of organized fabric, expressed by normal grading, is shown by the conglomerate C (Figs. 22c and 23c). Larger clasts (up to 50 cm long), some of them well rounded, appear irregularly embedded in the graded layer.

Other occurrences of coarse-grained conglomerates show clasts of at least 10 cm to 15 cm in size, and of limestone and metamorphic rock composition (Fig. 24). The limestone clasts are more rounded than the metamorphic clasts, a few of them even very well rounded (Fig. 24a and b) but sometimes they are subangular (Fig. 24b and c). Oversize clasts, 90-120 cm long, occur occasionally in the uppermost part of a normal graded conglomerate ("elevated clast", after Nemec and Steel, 1984) (Fig. 23d).

The coarse-grained conglomerates discussed here have a sandy-silty matrix in variable quantity. As a whole, the sedimentary succession with coarse-grained conglomerates consists of a succession of rudites and arenites (Fig. 22), in which the arenites are predominant. Cut-and-fill structures occur in finer-grained conglomerates with sandstone intercalations (Fig. 25). The lower boundary of the graded rudite-arenite units is irregular and erosional.

3.3.4. Silty and fine-grained sandstone lithofacies

A distinct lithofacies, consisting of alternating siltstone (or silty clay) and very fine-grained sandstones, appears at various levels in the Albian deposits in the area between the Ialomița River and the Dâmbovița River. This lithofacies is called "Scropoasa-Lăptici Sandstone" in the Bucegi Mountains (Patrulius, 1969). In the Albian deposits east of Dâmbovița River, Mihăilescu (in Ștefănescu *et al.*, 1983) describes this facies as "rhythmic silt", highlighting the frequent alternation of silty clay and very fine-grained sandstone interlayers.

Most of the silty and fine-grained sandy layers occurring in this facies are 5 to 15 cm thick; however, the range in thickness is actually much wider, from a few centimetres to a few decimetres (Fig. 26). The proportion of the silty clay vs. silt and arenite in this lithofacies is usually in favour of the clayey layers (Fig. 26a), with the percentage of silty clay beds usually varying between 60 and 80% (Fig. 26b).

Normal grading is a characteristic feature of this facies. This is evident in the case of thicker layers (Fig. 27a) that have a larger grain-size range (medium sand to very fine sand and silt). There are also non-graded sandy units (Fig. 27b). Most of the silt layers frequently do not show graded bedding because of the very well sorted nature of the grains.

In the silty and fine-grained sandstone facies, lamination is common. Planar lamination is the main internal structure of the fine-grained sandstone and silt layers (Fig. 28 A and 29). In outcrops where the internal structure is well displayed, cross lamination combined with planar lamination can be observed. In the thicker, normal graded bedded sandstones, planar lamination appears in the central and top part of the

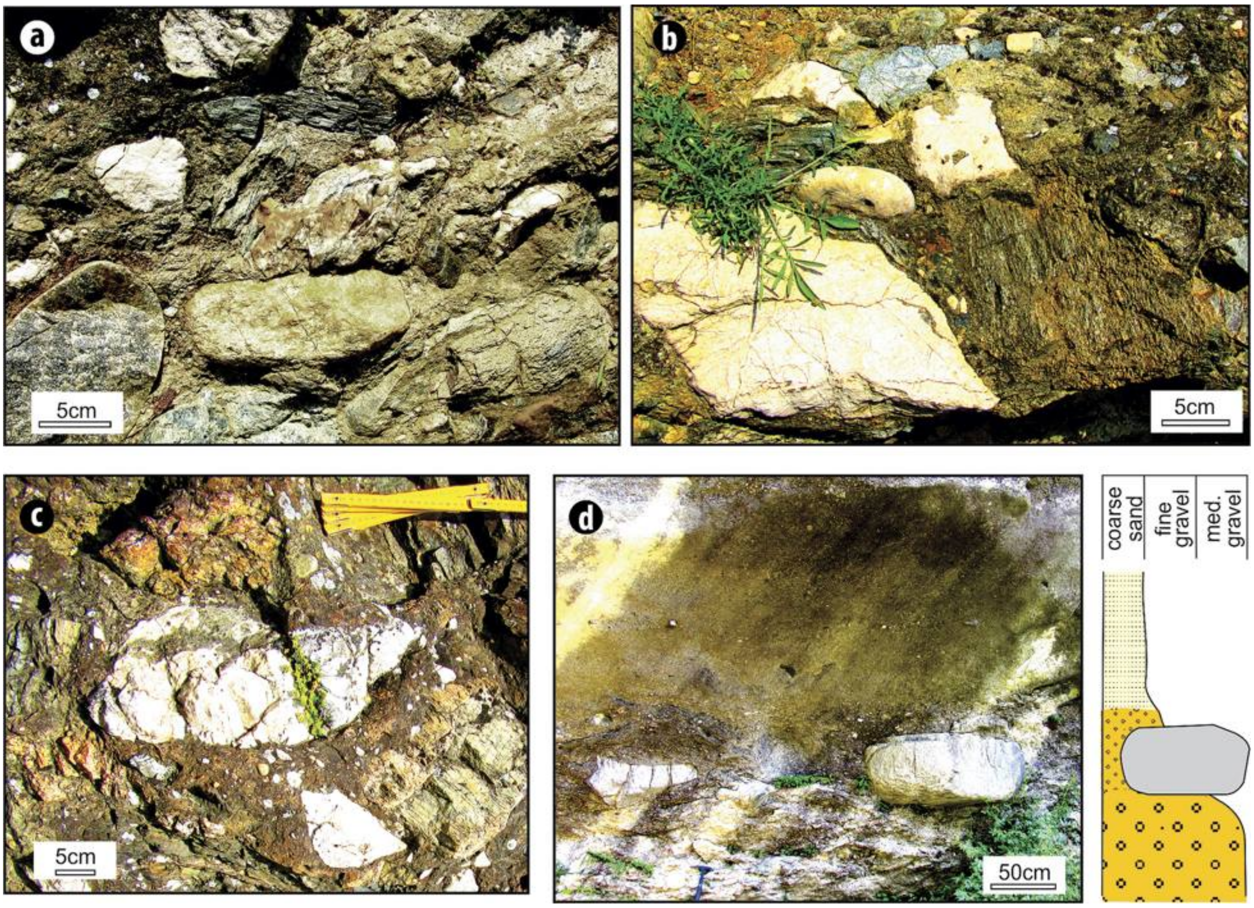


Fig. 24. Coarse-grained conglomerates, illustrating their typical textural characteristics (**a**), (**b**) and (**c**). Oversize clast in the upper part of a normal graded unit (**d**). The left side of Dâmbovița valley, Cetațeni.

Fig. 25. Normal grading and cut-and-fill structures in the very coarse-grained conglomerate lithofacies. Outcrop on the left side of Dâmbovița valley, northern periphery of the Cetațeni locality.

layer, while the basal part is either massive (structureless) or cross-laminated (Fig. 27a). Current ripples appear at the top of the sandy layers (Fig. 30a and b). Cross-laminated silty-sandstone ripples appear in thin, continuous or discontinuous layers (Fig. 28b).

Current lamination is also displayed by the silty-clay units. The ripple structure is evidenced by silt laminae (Fig. 28a) or by lens-like accumulations of silty material (Fig. 30c and d).

The basal surface of the sandstone layers may be irregular. In a few cases, on the lower surface of the sandy layers, erosion (flute casts) and traction (drag casts) sole casts have been observed.

Accumulations of coalified fossil wood (up to 5 cm in size) have rarely been observed on the stratification surface of some sand layers (Fig. 31).

Soft sediment deformation structures are present in the silty and fine-grained sandstone facies. They are expressed by the corrugation of the lamina sets (Fig. 32a and c) or by disruption of sediment layers (Fig. 32b).

3.4. Paleocurrent directions

The measurement of paleocurrent directions in the Albian deposits of the Ialomiţa-Dâmboviţa area is difficult. The numerous conglomerate units with disorganized fabric do not provide indications regarding the paleocurrent flow direction and conglomerates displaying crude cross bedding are uncommon. Sandstones and even conglomerates with sole marks generated by paleocurrents have rarely been noticed. The most reliable paleocurrent directions are provided by the silty and fine-grained sandstone facies deposits with current ripples and by a few sole cast measurements.

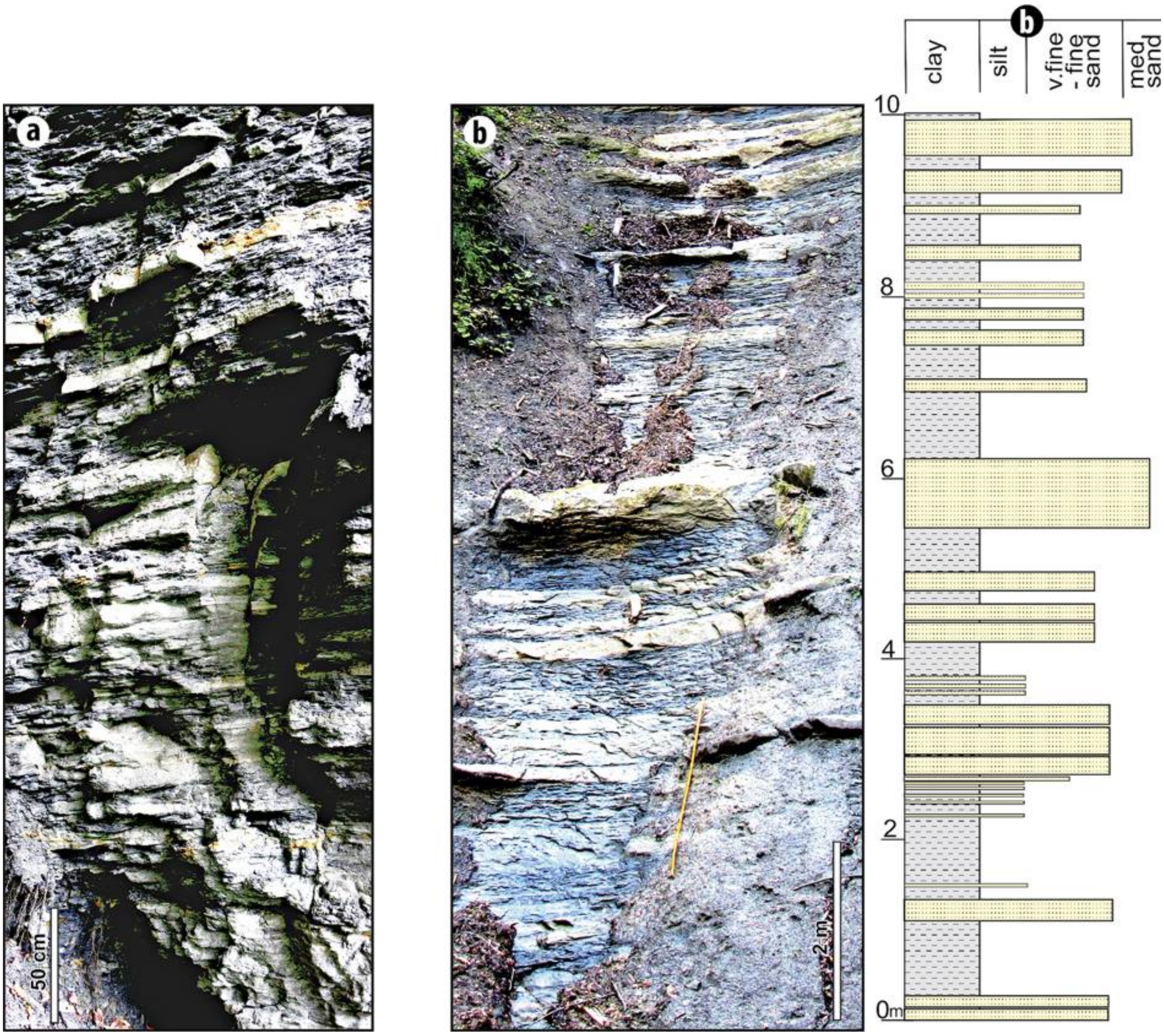


Fig. 26. Silty and fine-grained sandstone sedimentary succession. (**a**) Runcu River. (**b**) Chiliilor River, left-bank tributary. The fine-grained sandstone interbeds are more frequent in the Runcu sedimentary succession.

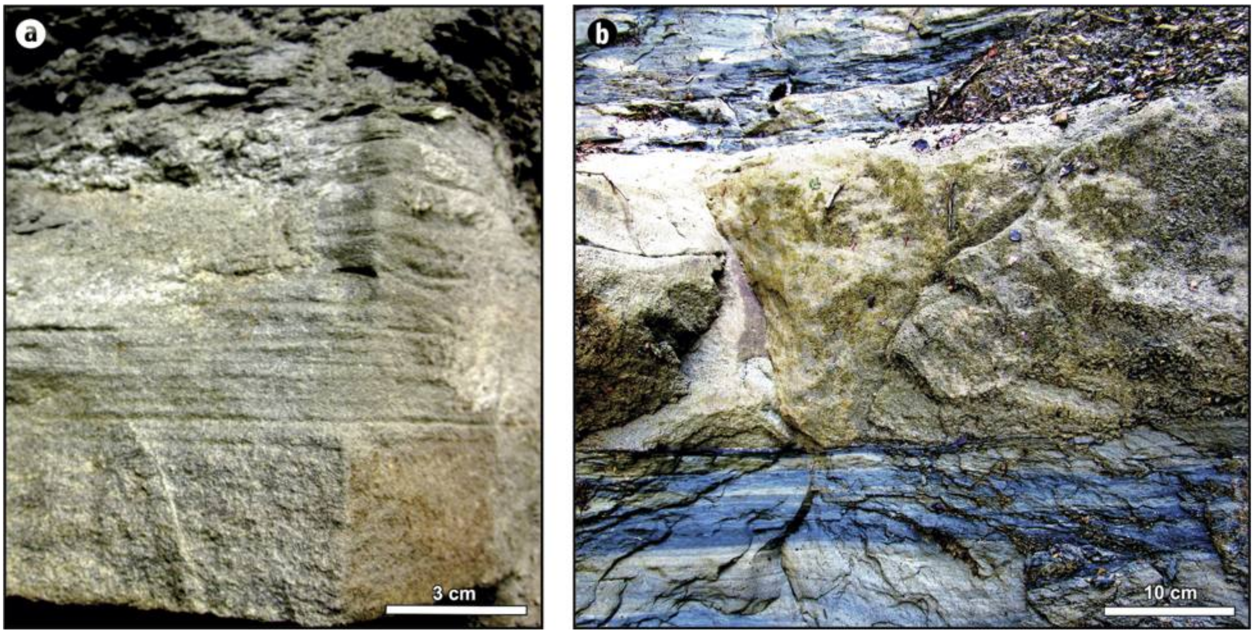


Fig. 27. Graded bedding (**a**) and lack of grading (**b**) in arenite deposits of the silty and fine-grained sandstone facies. Chilliilor River. Note the apparently structureless coarser grained lower section of the graded bed.

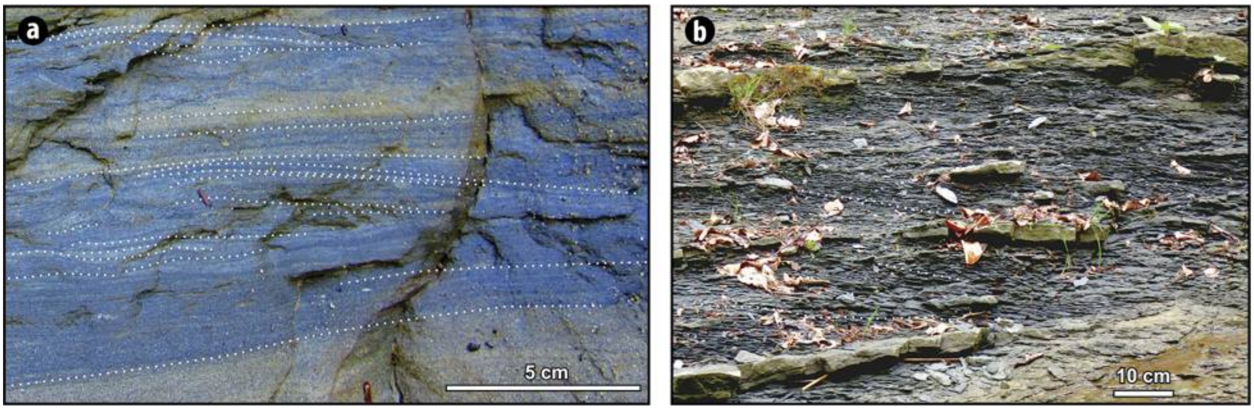
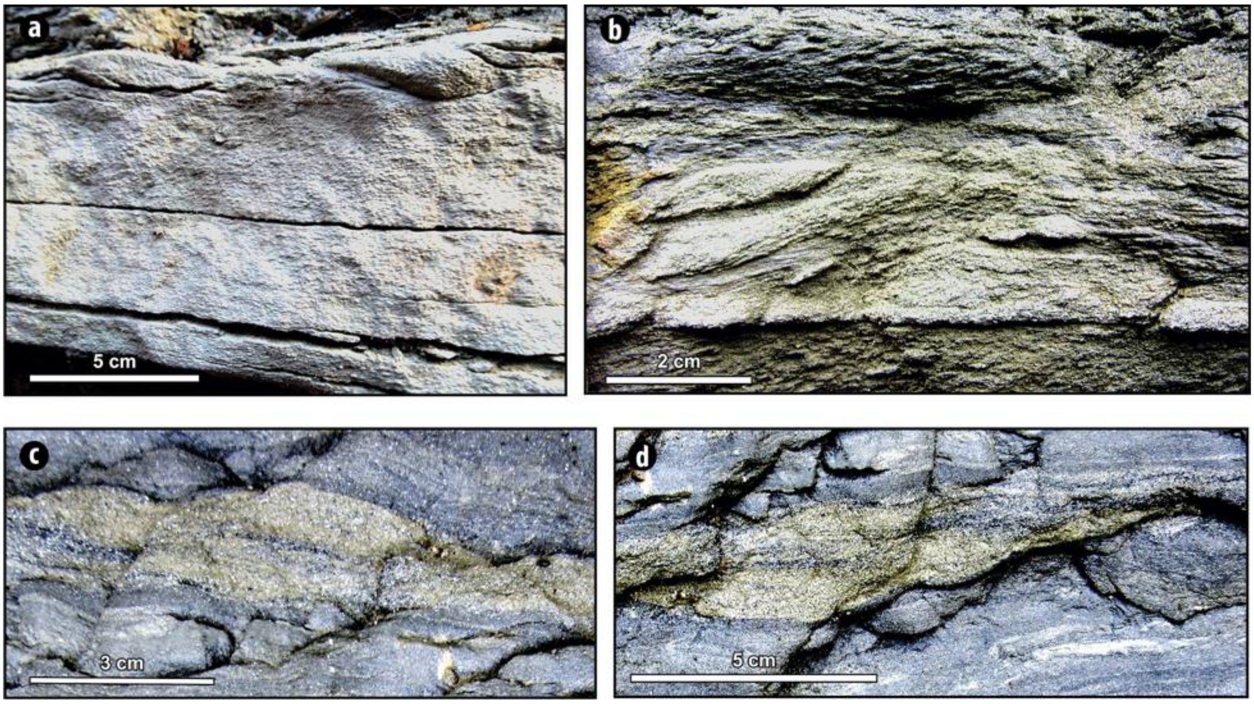


Fig. 28. Parallel and ripple-cross lamination in the deposits of the silty and fine-grained sandstone facies. Internal structure highlighted by white dotted lines. (**a**) Chiliilor River. (**b**) Marginea Domneasca River. In the (**b**) image, note the larger-scale cross-lamination (dotted lines) in the silty-clayey deposits, and small-scale cross- and ripple lamination of the fine-grained sandstone interbeds.

Fig. 29. Detail view of a planar laminated, very fine-grained sandstone layer. Chiliilor River, left-bank tributary. A vague normal grading is to be noticed.



▲ **Fig. 30.** Current ripples in silty and fine-grained sandstones. Comments in text. Runcu River. The ripples at the top of the sandstone bed are clearly visible (**a**). Two centimetres thick current ripple set in image (**b**) Complex cross-lamination developed in the silty lens-like bodies – (**c**) and (**d**).

◄ **Fig. 31.** Coalified wood fragments in fine-grained sandstone deposits. Marginea Domneasca River.

Part of the measurement data displayed by the paleocurrent direction map (Fig. 33a) has been obtained by estimating the current direction indicated by cross stratification visible in two sections. This is why some current directions (measured from coarser-grained sandstones and conglomerates) presented on the paleocurrent map only have indicative character.

Almost all the paleocurrent directions measured from the medium- and coarse-grained sandstone facies and from the sandstone-conglomeratic facies vary in a wide angular dispersion range, from southeastward to westward (Fig. 33b). Their prevailing current direction is to the southwest.

In the current rose diagram for the silty and fine-grained sandstone facies deposits (Fig. 33c), the transport directions are differently grouped. One direction cluster is similar to the current directions of the coarser-grained facies and reveals the same prevailing southwestward paleocurrent direction. The current measurements of silty and fine-grained sandstone facies deposits form a second group of directions, indicating a dominant northeastward paleocurrent flow (Fig. 33c).

4. DATA INTERPRETATION

4.1. Transport and accumulation of clastic material

4.1.1. Paleotransport of Albian gravelly sediments

The transport of rudite sediments is the most interesting and complex among the Albian deposits. The conglomerates are either massive (lack of internal organization) or show internal structure (especially graded bedding). Both

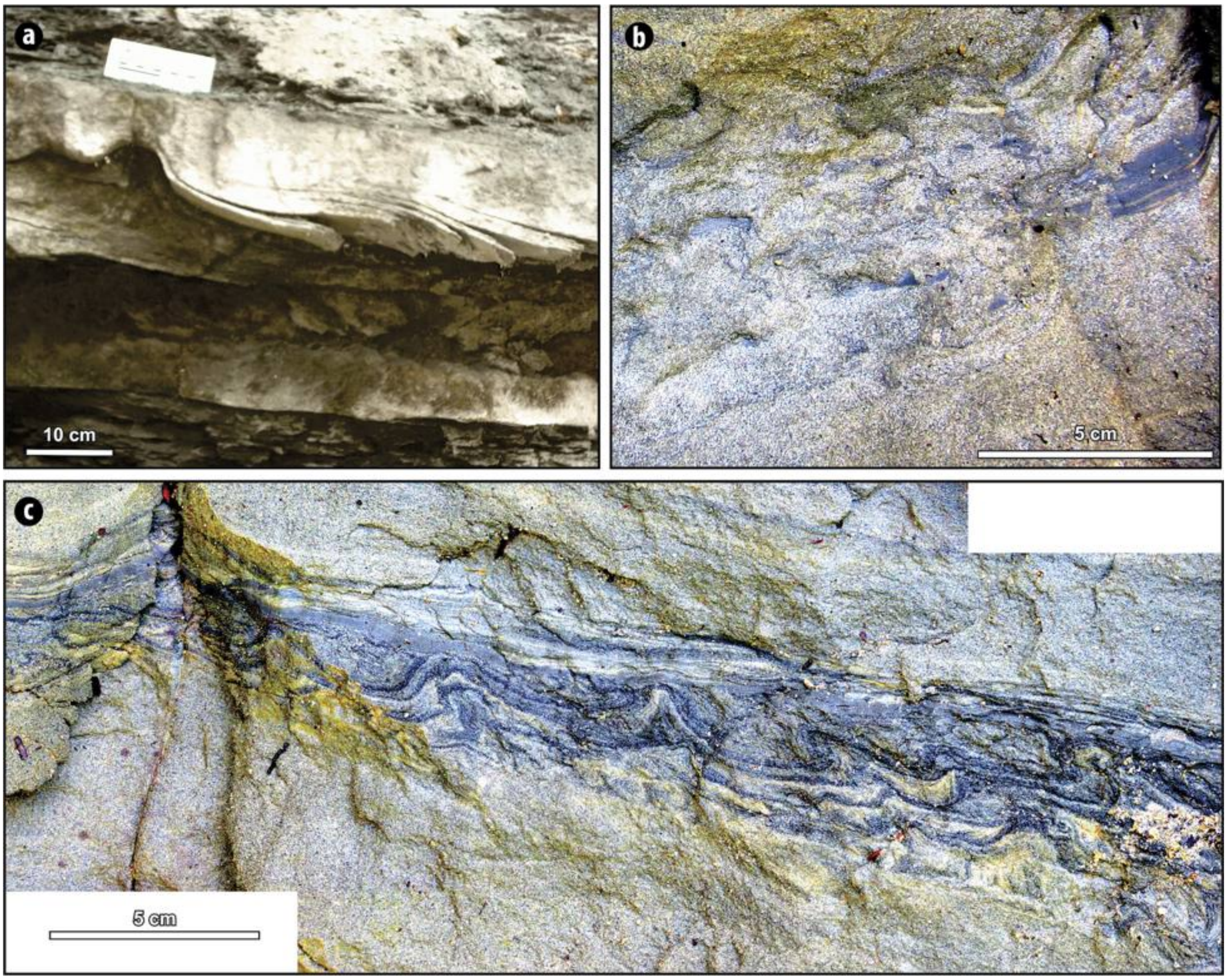


Fig. 32. Soft sediment deformation in silty and fine-grained sandstone facies deposits. Comments in text. Chiliilor River, left-bank tributary.

types of conglomerates, structureless and graded, have in common a low degree of granular sorting (Fig. 19a, b, d and e). Additionally, both types of rudite sediments include megaclasts (oversize clasts) that are much larger than the average size of the normal clasts from the hosting sandy sediments (Fig. 23b and c). The oversize clasts can reach dimensions of several tens of centimetres or even over 1 m in size (Fig. 24d).

Another feature of the Albian conglomerates is the presence of a relatively high amount of sandy (occasionally very fine-grained rudite) matrix (Fig. 34). Despite that, the large rudite fraction (with clasts 10 to 50 cm in size) is often seen in point (tangential) contact (Fig. 19a, d, e, g, h and i). Each clast may have one or two contacts. On rather rare occasions, the matrix is quantitatively dominant and the clasts are matrix-supported (Figs. 19f and 34c).

The poor size sorting, lack of internal structure and abundance of the matrix suggests that the Albian gravelly material was transported by sediment gravity flow (Middleton and Hampton, 1973), particularly by debris flows.

Apart from the massive type (with disorganized fabric), the Albian conglomerates in the Ialomiţa–Dâmboviţa area are frequently normal graded. According to Nemec and Steel (1984), the normal grading of the debris flow rudites indicates the involvement of turbulence and a reduction of the influence of dispersive pressure, the flow evolving towards high-density turbidity currents.

The type A coarse-grained conglomerate (Figs. 22a and 23a) appears in the central part of a lens-like, fine-grained conglomerate body (see section 3.3.3). These conglomerates could represent deposition of gravel sediments in the middle of a submarine channel, where the flow is intense and competent to transport large clasts. The cut-and-fill structures from the same sedimentary succession (Fig. 25) concur with this interpretation.

4.1.2. Paleotransport of the Albian medium- and coarse-grained arenite sediments

The homogeneous, Albian coarser-grained sandstones incorporate irregularly distributed larger grains and oversize clasts (Figs. 15 and 16). These features indicate sediment

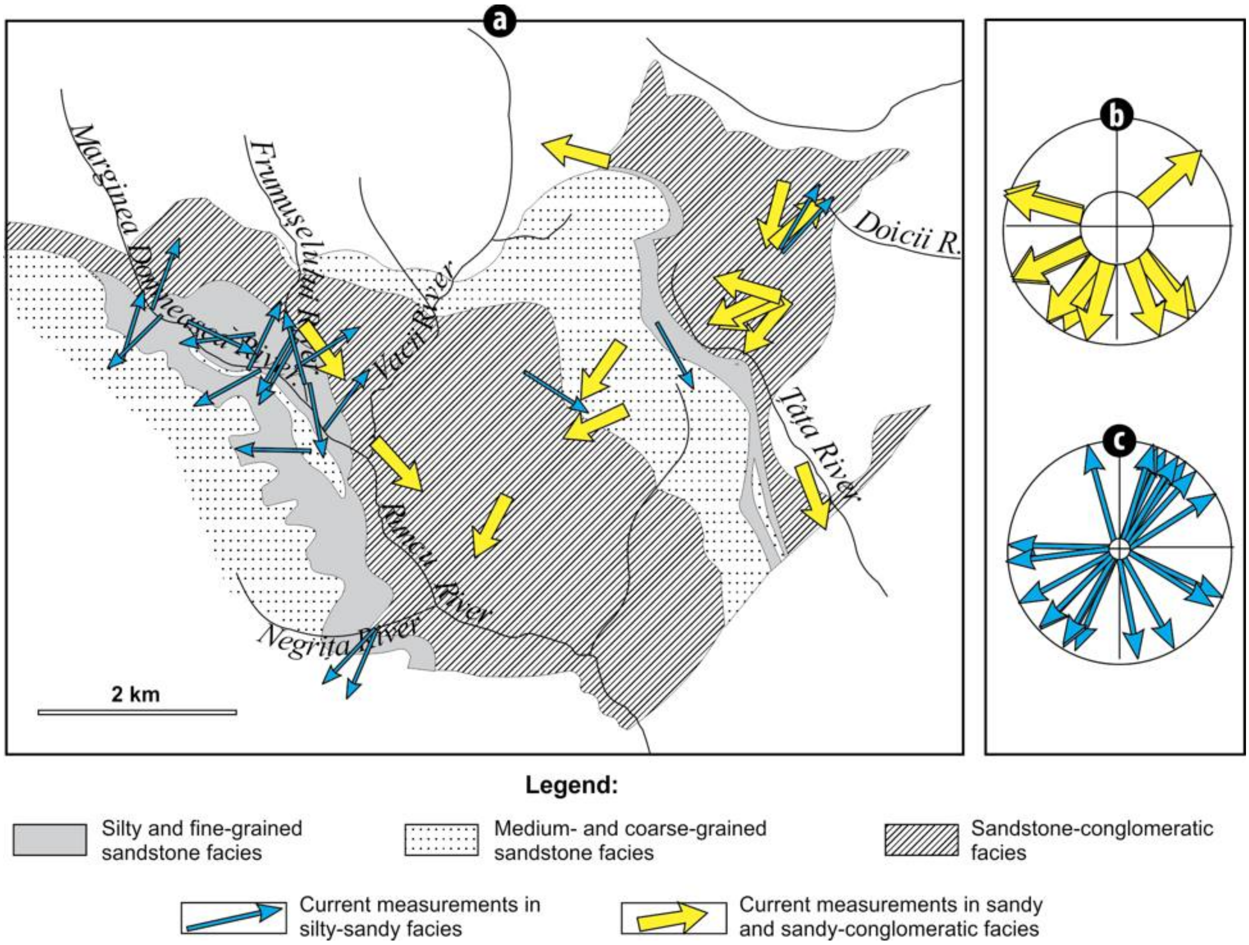


Fig. 33. Paleocurrent map and diagrams of the Albian deposits in the Ialomiţa and Runcu area. Based on Jipa (1982).

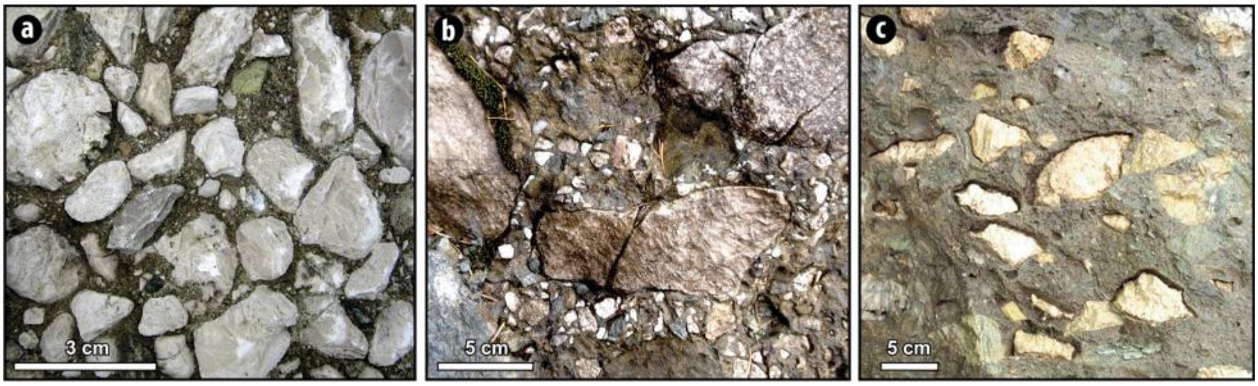


Fig. 34. Albian conglomerate matrix. (**a**) and (**b**) Conglomerates with high amount of sandy matrix. (**b**) Very fine-grained conglomerate matrix was occasionally noticed. (**c**) Matrix-supported conglomerate. Runcu River.

transport by an agent unable to separate the larger clasts from sand material, that is, by gravitational sediment flow.

Medium- to large scale inclined bedding (Fig. 13) sometimes occurs in this Albian sandstone facies. Because the large-scale inclined bedding is not accompanied by cross lamination, we assume this structure could be the result of the sediment flow's transit across the relief made by a previous sediment flow event.

In terms of sediment flow, it is more difficult to explain the planar and gently inclined laminar structures that occur in some of the sandstones (Fig. 35). These structures could be signs of tractive transport that could have acted simultaneously with the mass transport of the medium- and coarse-grained sand.

4.1.3. Paleotransport of silty and fine-grained sandstone sediments

Unlike the other Albian facies from the Ialomiţa-Dâmboviţa area, the sediments of the silty and fine-grained sandstone facies show both planar lamination (Fig. 29) and cross-lamination (current ripples) (Figs. 28a and 30a and b) as well as normal graded bedding (Fig. 27a).

According to the displayed sedimentary structures and the rapid alternation of silty-clayey and sandy-silty units, these sediments are believed to have been transported and deposited by turbidity currents. The relatively fine grain-sized sediments and the reduced thickness of the turbidites are suggestive of the low density of the transporting turbidity currents.

4.2. Provenance of the Albian detrital material

The analysis of the origin of the detrital material of the Ialomiţa-Dâmboviţa Albian sediments is based on the measured paleocurrent directions, the conglomerate clasts lithology as well as on the roundness of the large clasts.

The paleocurrent map (Fig. 33a) of the Albian deposits from the Ialomiţa-Runcu area, which is an important way of highlighting the source of the detrital material, was prepared with a small number of measurements. In addition, some measurements provide only an estimation of the current direction (see section 3.4). Therefore, for discussing the source of the detrital material we will only use the prevailing direction of the measurement clusters.

Current direction acquired from the conglomerate and medium- and coarse-grained sandstone deposits (Fig. 33b) indicate the predominance of a southwestward paleocurrent direction. This direction is parallel to the long axis of the Ialomiţa-Dâmboviţa basin area.

The paleocurrent directions measured in fine-grained, sandy and silty-sandy deposits indicate two prevailing directions. Out of the 18 measured directions, ten of them reveal an average southwestward current flow. The other eight measurements indicate a northeastward prevailing direction (Fig. 33c). Therefore, two dominant longitudinal current systems, with opposite current directions, transported the silty and fine-grained sandy sediments.

The clast lithology of the Albian conglomerates underlines two extreme types of conglomerates, those with predominantly limestone clasts, and those with metamorphic. This characteristic suggests a provenance of the detrital material that is from different areas. The conglomerates with dominant metamorphic rock clasts (Figs. 14b and 23), which are more frequent in the northern part of the Ialomiţa-Dâmboviţa area, suggest a northern origin for the clasts, from the Leaota Mountains area.

The conglomerates with predominantly limestone clasts (Figs. 14c and 19d), which seem to be more frequent in the southern part of the investigation area, suggest a different provenance for the clasts. South of the Ialomiţa-Dâmboviţa area, the geological map does not show the existence during the Albian of any emerged, sediment-supplying limestone massifs. However, upper Jurassic limestones border the western edge of the Bucegi Mountains (Fig. 36). Consequently, the rudite sediments with dominant limestone clasts could have originated from a northeastern area, probably from the Jurassic basement of the Albian Bucegi basin.

Limestone clasts also appear together with predominant metamorphic rock pebbles. Some of the limestone clasts could have come from the Dâmbovicioara Basin upper Jurassic limestones that are cropping out in the area north of the Coteneşti locality (Fig. 36).

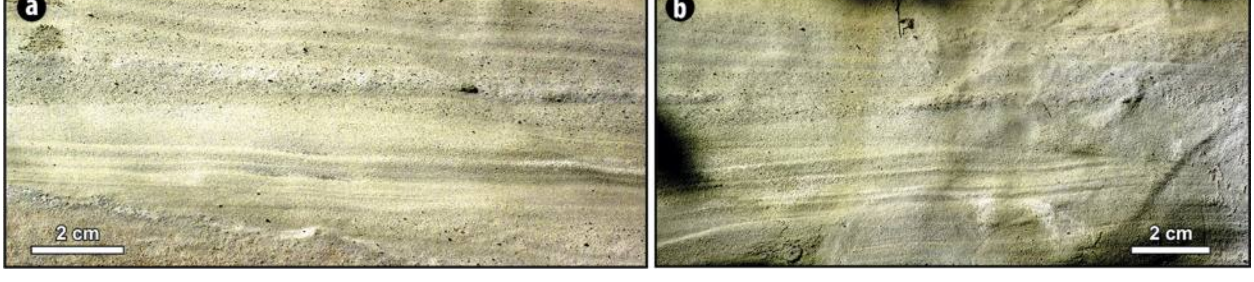


Fig. 35. Planar and low-angle cross lamination in medium-grained sandstone. The low-angle cross lamination generally occurs in relatively coarser-grained arenite sediments. Chiliilor River.

The degree of roundness of the metamorphic rock clasts is low, with most clasts being angular and subangular (Figs. 15; 19a, b, c and h), suggesting that they originated from a relatively proximal area, a source area corresponding to the Leaota Mountains area, to the north.

When limestone clasts are dominant, they show a higher degree of roundness (Fig.14c; 19d), which advocates for a longer transport distance, possibly from the Jurassic basement of the Albian Bucegi basin. It is worth mentioning that the Albian conglomerates in the Ialomiţa-Dâmboviţa area also have limestone clasts with a lower degree of rounding (Figs. 19e; 34c).

As a whole, the data we have suggests the provenance of the Albian detrital material accumulated in the Ialomiţa-Dâmboviţa basin is from the following source areas:

a. *The northern source area* corresponds to the metamorphic rocks area of the Leaota Series (Gheuca and Dinică, 1986) (Fig. 36, arrow A). Considering the high frequency of the subangular metamorphic clasts, this source area possibly provided the largest volume of Albian clastic sediments. Some of the longitudinal currents could have initially been transversal from the north and later turned to the southwest, down slope and along the axis of the basin.

b. *The western source area* is located westward of the present-day Dâmboviţa River (Fig. 36, arrow B). Revealed by northeastward paleocurrent directions (Fig. 33c), this source area supplied part of the detrital material of the turbidites in the silty and fine-grained sandstone facies. The eastward-flowing turbidity currents had been released from the western edge of the Albian basin. Upper Jurassic limestones have been mapped in the area north of Coteneşti, on the west side of the Dâmboviţa River (Fig. 36). This could represent a more proximal source area that could have supplied some of the rudite limestone clasts, possibly the less rounded ones (Fig. 36, arrow D).

c. *The northeastern source area* includes the Bucegi Mountains and the eastern Leaota Mountains area. This sediment-supplying area is mainly credited for providing part of the fine-grained material of the silty and fine-grained sandstone facies. In the Bucegi area, the similar facies ("Scropoasa-Lăptici Sandstone"; Patrulius, 1969) extends westward up to the Ialomiţa River.

The rounded limestone rudite clasts could have come from the area of the upper Jurassic limestones, which border the western edge of the Bucegi Mountains area (Fig. 36, arrow C).

4.3. Large-scale progradation of the Albian sediments

The Middle Albian extensive progradation process, which is defended in this paper as the depositional process responsible for the origin of the Albian sedimentary succession discussed herein, was common for both the Bucegi Mountains area and the Ialomiţa-Dâmboviţa area.

Albian progradation in the Bucegi Mountains. Sediment accumulation by large-scale progradation of the Albian deposits in the Bucegi Mountains is a depositional model that has been sustained for several decades now in the literature (Jipa, 1982; 1984). This concept is based on the fact that the successive lithostratigraphic horizons of the Bucegi Albian deposits overlap, and have direct contact, with the same horizon of the underlying upper Moroeni Formation (Fig. 37). These relationships are noticeable due to the presence of the Raciu Breccia marker horizon at the top of the Aptian-lower Albian succession (top of the Moroeni Formation).

Being a calcareous horizon in a succession of clay and sandstone sediments, the Raciu Breccia is easy to detect (see section 3.2.). In addition, the Raciu Breccia appears at a constant stratigraphic level (the top of the Moroeni Formation) and has been mapped for a distance of about 15 km (Patrulius, 1969).

Albian progradation in the Ialomiţa-Dâmboviţa area. The last western appearance of the Raciu Breccia is in the Ialomita River (see section 3.2.). In this area, the Ialomiţa-Dâmboviţa Albian deposits overlie the Raciu Breccia horizon (Fig. 10). For this reason, Jipa (1982) considered the Albian deposits in the Ialomiţa-Runcu area to be part of the Bucegi Albian large-scale progradational sedimentary succession (Fig. 37).

In the entire succession of the Albian deposits from the Ialomiţa-Dâmboviţa area, the beds dominantly dip southwestward (Fig. 6), showing the same structural attitude as the direction of the progradation process. Consequently, the bedding strike and dip of the Albian Ialomiţa-Dâmboviţa sediments can be regarded as primary basinward-dipping features that were, to some extent, deformed by tectonic processes. Based on this assumption, the concept of large-scale progradation can be applied to the whole Ialomiţa-Dâmboviţa Albian sedimentary succession (Fig. 38a). In this way, the image of the Albian progradation structure from the Bucegi Mountains area is completed and the structure is extended westward to the Dâmboviţa River.

In addition, the Albian deposits cropping out between the Runcu and Dâmboviţa rivers display a large-scale, coarsening-upward succession. This pattern gradually built up from silty-fine sandy deposits at the base, to sandstones with very coarse conglomerates at the top (Fig. 6). For the progradation process this is a characteristic stacking pattern.

The concept of large-scale progradation answers the problem regarding the thickness of the Ialomiţa-Dâmboviţa Albian deposits. If one considers the Albian deposits to be accumulated by aggradation (Fig. 38b), the thickness of the deposits would be in the order of several thousand metres (at least 3,500 – 4,000 m). The accumulation of such sediment volume in the relatively narrow Ialomiţa-Dâmboviţa basin would be difficult to explain.

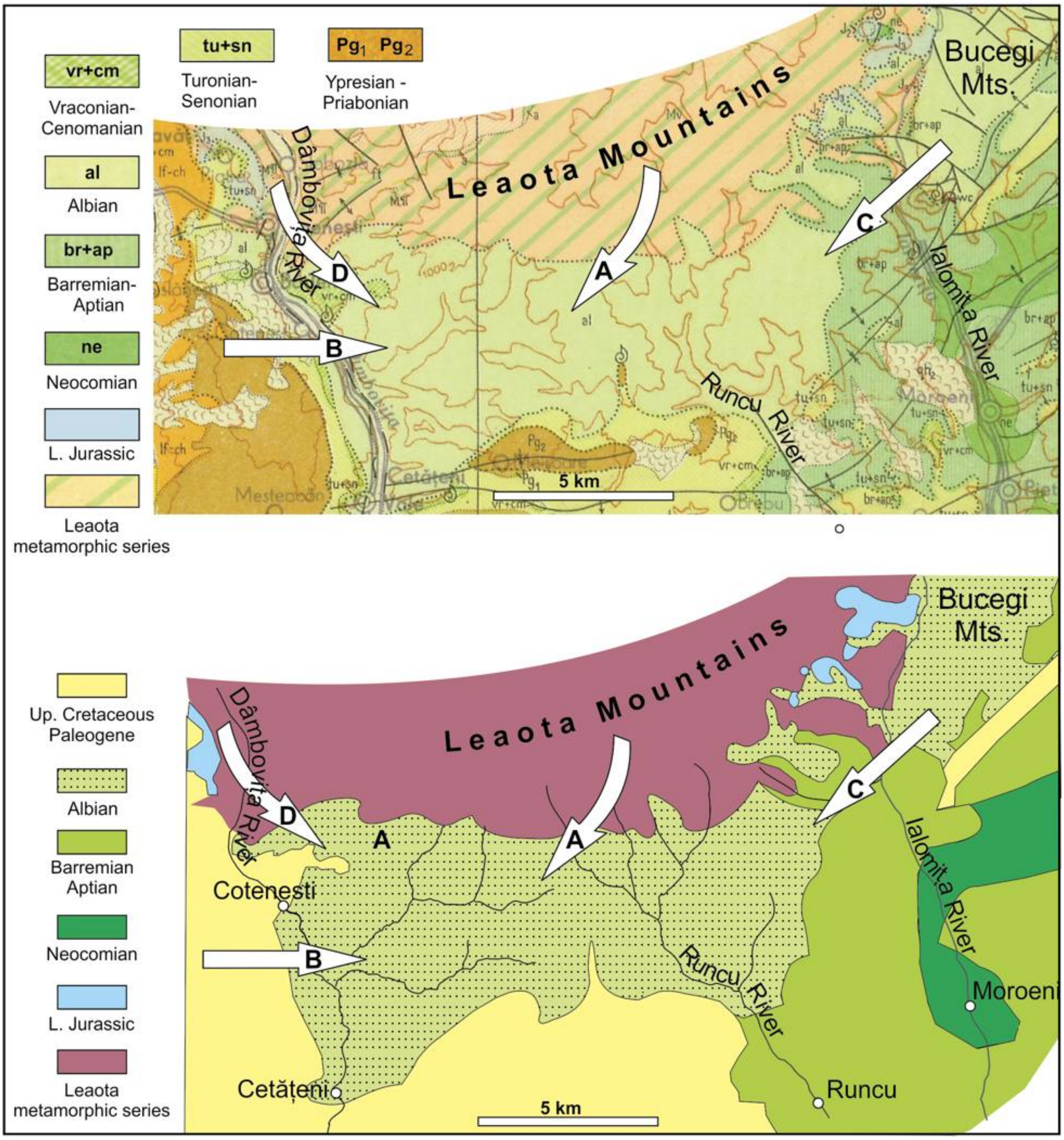


Fig. 36. Detrital material provenance of the Albian deposits from the area between the Ialomița River and the Dâmbovița River. **Arrow A**: Northern provenance (Leaota metamorphic series). **Arrow B**: Western provenance (western edge of the Albian basin). **Arrow C**: Northeastern origin (Eastern Leaota and Bucegi Mountains area). **Arrow D**: Limestone clasts from northwestern provenance. Geological map from the Geological Map of Romania, scale 1:200,000 (Institutul Geologic al Romaniei, 1968).

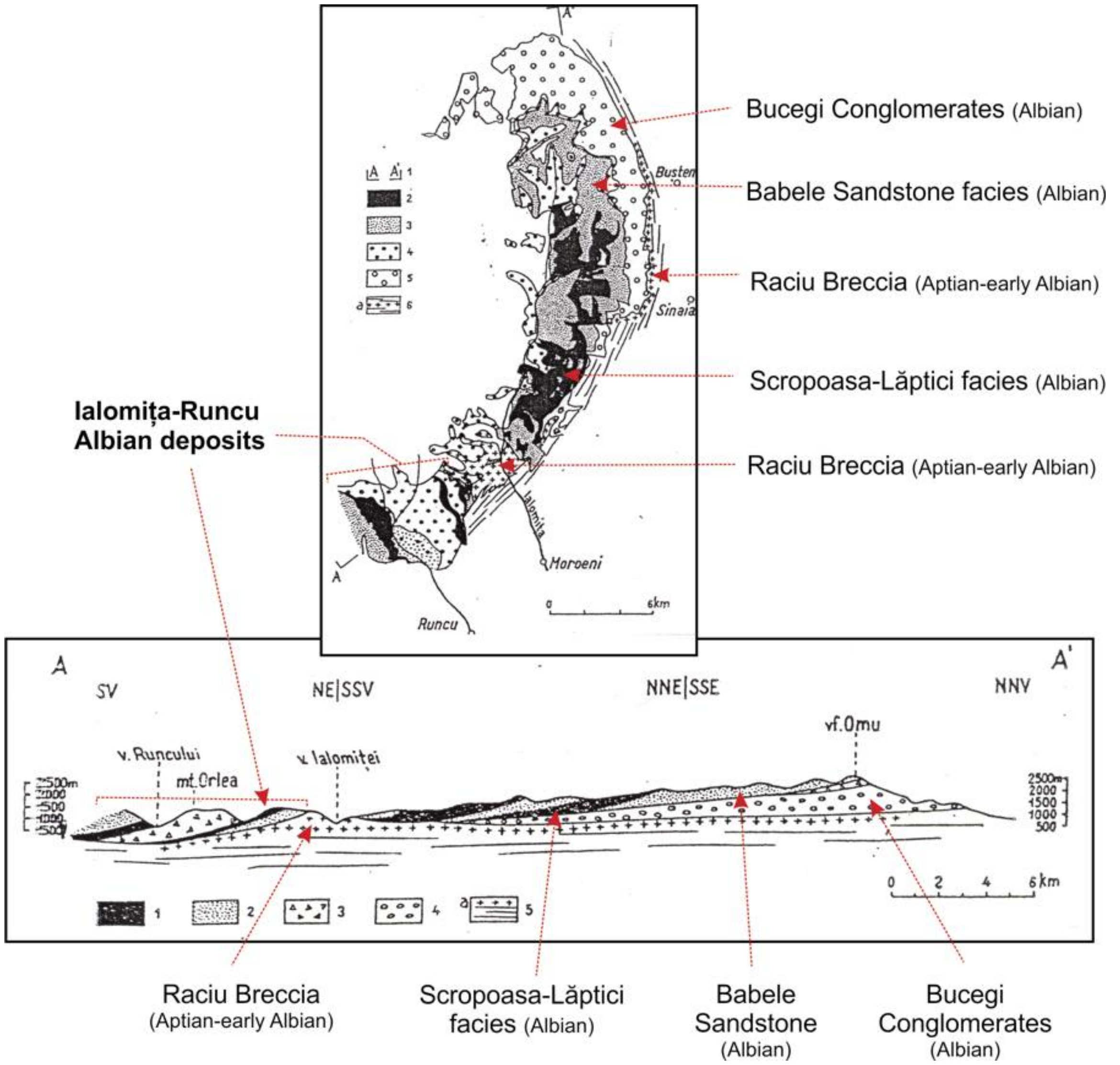


Fig. 37. Large-scale progradation of the Bucegi Mountain Albian deposits. Annotated, original figures from Jipa (1982). *Legend*: **1**. Siltstones and fine-grained sandstones (Albian). **2**. Medium- and coarse-grained sandstones (Albian). **3**. Sandstone-conglomerates (Ialomița-Dâmbovița area) (Albian). **4**. Bucegi Conglomerates. **5**. Raciu Breccia in the Moroeni Formation (Aptian to Early Albian). The idea of the progradation relies on the overlap of the successive Albian lithostratigraphic horizons of the Bucegi Albian deposits, each of which have direct contact with the underlying Raciu Breccia.

A more reasonable thickness of the Albian deposits of approximately 1,000 m (between 700 m and 1,500 m) is supported by the large-scale progradation concept (Fig. 38a).

4.4. Sedimentation environment

In the large-scale progradation concept, the thickness of the Ialomița-Dâmbovița Albian sedimentary body is estimated at about 1,000 m (Fig. 39a). This indicates the minimum water depth required for the accumulation of the Albian sediments. Therefore, the accumulation of the Albian sediments in the Ialomița-Dâmbovița area took place in a narrow deep-water basin.

The northern edge of the Ialomița-Dâmbovița sedimentary basin is well defined by the extension of the metamorphic rock area of the Leaota Series (Gheuca and Dinică, 1986). In contrast, there are no indications regarding the southern edge of the basin. South of the Albian Ialomița-Dâmbovița area, there are no known Albian sandstone-conglomerate deposits. The southern limit of the Ialomița-Dâmbovița sedimentary basin could have been marked by the, here presumed, westward prolongation of the Zamura Rise (Fig. 39a). According to Murgeanu *et al*. (1963), this rise is a high submarine relief (an haut-fond type) formed during Aptian time by the uplifting of the Neocomian (Sinaia Beds) large anticline, from west of the Sinaia area.

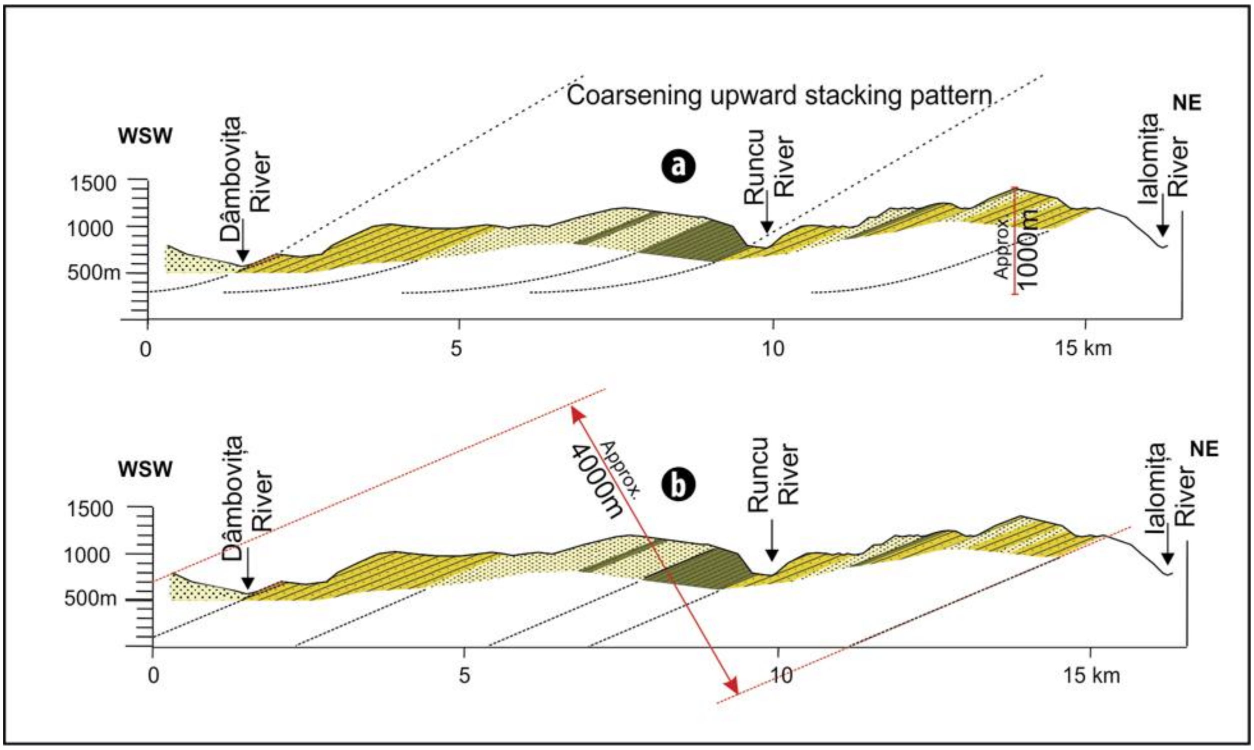


Fig. 38. General genetic interpretation of the Ialomița-Dâmbovița Albian sedimentary succession. (**a**) The structure of the Albian deposits in the concept of sedimentary evolution by large-scale progradation. The thickness of the deposits is about 1,000 m (thickness of the prograding sedimentary body). (**b**) The structure of the Albian deposits in the concept of sedimentary aggradation. The thickness of the Albian deposits would be at least 3,500 – 4,000 m. See Fig. 6 for legend.

Sediment transport by gravity mass flow, high density turbidity currents and low-density turbidity currents are the main paleotransport mechanisms and sedimentation features of the Albian deposits of the Ialomița-Dâmbovița area. These features are suggestive of sediment flow transport on inclined surfaces dipping basinward, that is, a clinoform system.

The Ialomița-Dâmbovița Albian clinoform system is shared by the synchronous sedimentary units from the Bucegi Mountains area. Three main lithofacies units that overlie the Middle Bucegi conglomerates, correspond to three major environments (Fig. 39b):

1. The Babele Sandstone facies unit is located in the northern Bucegi Mountains area. According to Olariu *et al.* (2014), the Babele Sandstone unit is made up of shelf sediments.
2. The Scropoasa-Lăptici Sandstone facies extends in the southern Bucegi Mountains area. It consists of silty and fine-grained sandstones (turbidites) with thick coarse-grained intercalations. According to its fine-grained texture and turbidite attributes, the sediments of this facies accumulated in deep water, presumably on the continental slope.
3. The Ialomița-Dâmbovița facies, with dominant coarse-grained sediments and around 1000 m estimated water depth, is assumed to represent sedimentary accumulation on the deep bottom of the basin, probably at the base of the continental slope.

The three Albian lithofacies units mentioned above have been involved in a very active, large-scale progradation process (see section 4.3). The abundance of coarse-grained sediments (conglomerates and sandstones) in the Albian Ialomița-Dâmbovița area suggests that the progradation development was stimulated by a large sediment supply. The intercalated turbidite-like, siltstone and sandstone units reveal periods of reduced sediment supply.

The clinoform system that developed during the Albian progradation extends for about 35 km, if one takes into consideration only Scropoasa-Lăptici and the Ialomița-Dâmbovița units (Fig. 39 B). This is a south-westward-sloping continental margin clinoform system (Patrunoa and Helland-Hansen, 2018) that extends from the Babele shelf edge to the Scropoasa-Lăptici continental slope and the Ialomița-Dâmbovița continental rise (Fig. 39b).

A second clinoform system is implied by the turbidity currents flowing north-eastward. The two clinoform systems intermingle in the Ialomița-Dâmbovița area, which is suggestive of the flat relief of the deep sea bottom of the Babele-Dâmbovița Basin in the Ialomița-Dâmbovița area.

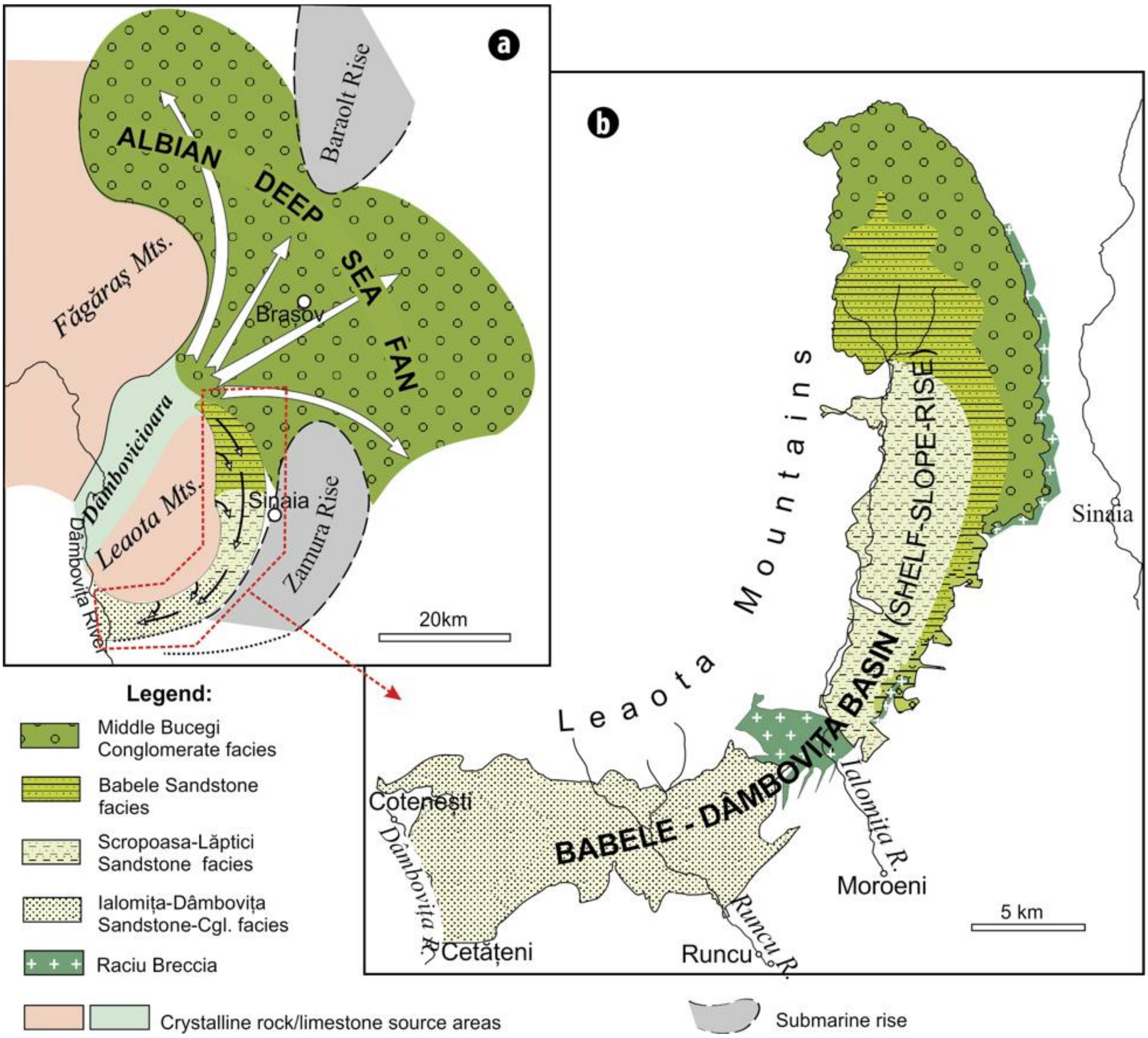


Fig. 39. Albian sedimentary systems from the Carpathian Bend zone. (**a**) Regional depositional environments and associated sedimentary units: source area, sedimentary accumulation areas (deep sea fan and continental shelf-slope-rise basin). (**b**) Conceptual sketch of the main Albian facies from the Bucegi Mountains (based on Patrulius, 1969) and from the southern area of the Leaota Mountains. Raciu Breccia is shown as an index stratigraphic level. Paleocurrent system of the gravelly Albian deep sea fan after Panin *et al.* (1963), Mihăilescu *et al.* (1967) and Patrulius *et al.* (1967).

4.5. Genetic and stratigraphic relationship with the Bucegi Conglomerates

In the Bucegi Mountains area, the Albian deposits belong to two large sedimentary units. The lower and middle Bucegi conglomerates (Fig. 5a) are part of the Albian gravelly deep-water fan from the Carpathian Bend zone (Murgeanu *et al.*, 1963; Panin *et al.*, 1963; Mihailescu *et al.*, 1967; Patrulius *et al.*, 1967; Olariu *et al.*, 2014; Jipa and Olariu, 2018) (Fig. 39a).

Overlying the Bucegi Conglomerates are the Babele Sandstone and Scropoasa-Lăptici Sandstone units and their westward continuation – the Ialomița-Dâmbovița sedimentary succession (Fig. 39a and b). These three major units are part of an elongated sedimentary basin that includes presumed shelf, continental slope and continental rise sediments (see section 4.4). This basin is referred to as the "Babele-Dâmbovița Basin" in this paper. The data we possess suggests that genetically, the Upper Bucegi Conglomerates (Fig. 5a) are also part of this basin.

The geometry, the facies and the area setting of the sedimentation basins show that in the Bucegi Mountains area, the sediments accumulated first in the Albian gravelly deep-sea fan (including the lower and middle Bucegi Conglomerates) (Fig. 39a). Subsequently, sedimentation shifted to the Babele-Dâmbovița Basin (Fig. 39a and b). The existence of two distinct Albian basin units and source-to-sink systems in the Carpathian Bend zone was highlighted by Jipa and Olariu (2018).

This discussion points out that, as sediments accumulated in the Babele-Dâmbovița Basin, the Ialomița-Dâmbovița Albian sediments were not being deposited at the same time and therefore do not correlate to the Bucegi (lower and middle) Conglomerates. Stratigraphically, the Ialomița-Dâmbovița Albian deposits are younger than the Bucegi Conglomerates. Genetically, from the basin physiography, sediment lithology and source-to-sink system, the Babele-Dâmbovița Basin is different from the Albian gravelly deep-sea fan (Fig. 39a).

The correlation discussed above also applies to all the Albian deep-sea fan conglomerates other than the Bucegi Conglomerates: the Albian conglomerates from the Ciucaș, Postăvaru-Piatra Mare, Perșani, Baraolt mountains and from the Codlea area (east of the Făgăraș Mountains). These conglomerate deposits correlate with the Bucegi (lower and middle) Conglomerates, not with the Babele Sandstone or the other major units of the Babele-Dâmbovița Basin.

5. CONCLUSIONS

The purpose of this work was to conduct a sedimentological investigation on the Albian deposits from the Ialomița River-Dâmbovița River area (the eastern part of the Southern Carpathians).

Lithostratigraphic mapping revealed three major Albian lithofacies: the silty and fine-grained sandstone facies, the medium- and coarse-grained sandstone facies, and the sandstone and conglomerate facies. In addition, the investigated Albian deposits also showed other facies with minor lateral distribution: the sandstone with very coarse-grained conglomerates facies and the metamorphic rock breccias facies.

For the evaluation of the clastic material provenance, the data provided by paleocurrent analyses and by rudite clast petrography and roundness suggest that the origin of the clastic material was from source areas located to the north, east and west of the outcrop area of the Ialomița-Dâmbovița Albian deposits.

Disorganized textural aspects, poor grain-size sorting, matrix with a variable degree of abundance and the presence of megaclasts are the main features of the Albian conglomerates. These features suggest transport of the clastic material by gravity mass flow. Some conglomerates are normal graded, which advocates for the action of high-density turbidity currents.

The medium- and coarse-grained sandstones share most of the characteristics of the conglomerates, regarding homogeneity, low degree of sorting and the embedded megaclasts. Gravity mass flow is also considered to be the transport agent of the coarse-grained sandstones. Occasionally, the sandstones show medium- to high-angle cross bedding, which is not associated with small-scale cross-lamination.

The Albian silty and fine-grained sandstone deposits are normal graded and planar and cross-laminated. The transport of their detrital material is attributed to low-density turbidity currents.

Successive lithostratigraphic horizons of the Bucegi Albian deposits come in direct contact with the same, older, underlying horizon, the Raciu Breccia. These units describe a large-scale progradation structure. In this paper, the progradation depositional concept is also extended to the Albian deposits cropping out in the Ialomița-Dâmbovița area. The monocline geological structure of the Ialomița-Dâmbovița Albian deposits and the coarsening-upward stacking pattern of the lithofacies units provide additional arguments for applying the concept of large-scale progradation to the entire Albian Ialomița-Dâmbovița succession. The abundance of prograded Albian coarse-grained sediments (conglomerates and sandstones) suggests the progradation development was fueled by a large sediment supply, from an extensive fluvial network. The intercalated turbidite-like, silty-sandy units reveal periods of decreased sediment supply.

In the area from the Bucegi Mountains to Dâmbovița River, there are three Albian, major lithofacies units sharing similar genetic origin: Babele Sandstone, Scropoasa-Lăptici and Ialomița-Dâmbovița. These units have been involved in an active, large-scale progradation process. The progradation involved a continental margin clinoform system, which extended from the Babele shelf edge to the Scropoasa-Lăptici continental slope and the Ialomița-Dâmbovița continental rise.

The Albian deposits in the Ialomița-Dâmbovița area are genetically and stratigraphically correlated with the deposits of the Babele Sandstone and the Scropoasa-Lăptici Sandstone units in the Bucegi Mountains. The Babele-Dâmbovița sedimentary basin is distinct and different from the sedimentation area of the deep-water Albian Conglomerate Fan from the Carpathian Bend zone, to the north of the Babele-Dâmbovița sedimentary basin.

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