BULETINUL Universităţii Petrol – Gaze din Ploieşti	Vol. LXVIII No. 2/2016	1 - 12	Seria Tehnică

Sedimentological Setting of Debris Flows from Paleogene-Miocene Formations of Tarcău Unit in the Siriu Dam Area (Buzău Valley)

Dumitru Frunzescu, Gheorghe Branoiu

Universitatea Petrol-Gaze din Ploieşti, Bd. Bucureşti nr.39, 100680, Ploieşti
e-mail: dfrunzescu@yahoo.com

Abstract

In the structural development as imbricated folds structures of the Paleogene-Miocene Formations belonging to Tarcău Unit from Eastern Carpathian Curvature, one of the geological landmark can be considered the breccia deposit that repeats with increasing thickness from the inside to outside, revealing clear characters of debris-flow deposit. In the paper were determined several adjacent descriptive facies, which then used as interpretative facies allows genetic sedimentological remarks on the whole ensemble of Tarcău Unit.

Key words: *Eastern Carpathians, internal Moldavides, debris flow deposits, Podu Secu Formation, Pucioasa-Fusaru Formation, sedimentological remarks*

Introduction

The outcrops occurred in the slopes of the national road DN 10 Siriu-Brasov, in the adjacent area of Siriu dam, reveals different sedimentological aspects in deposits of Paleogene flysch (internal facies) in the Tarcau Unit belonging to the Moldavides of the Eastern Carpathians.

The paper gives attention to aspects of some debris flows associated to different turbiditic facies encountered in Paleocene-Miocene formations (Podu Secu and Pucioasa-Fusaru) of Tarcau Unit.

Stratigraphic setting

In the area of internal curvature of Eastern Carpathians, the Tarcau Unit appear as a plurifacial tectonic unit bordered between Audia fault to the West and Tarcau fault to the East, in which were highlighted several lithofacies (fig. 1), from west to east, called Tarcau facies, Ciunget facies, Tazlau-Colti facies, and Lesunt-Doamna facies. [1]

In a classical stratigraphic framework (fig. 1, 2, 3), within Tarcau lithofacies, Paleocene-Eocene suite includes: Tarcau Sandstone Formation (divided in basal horizon of Tarcau Sandstone; Lower Tarcau Sandstone; Giurgiu-Ghelinta Beds; Upper Tarcau Sandstone) and Podu Secu Beds, having in the top formation of red marls with Globigerina. Paleocene-Eocene formations underlying on Horgazu Beds of Senonian age and is covered by Oligocene-Miocene in Pucioasa-Fusaru facies.

Paleocene-Lutetian belongs to Tarcau Sandstone facies and to intermediary facies. Tarcau Sandstone facies appear divided in: basal horizon with variegated shales and green sandstones, Lower Tarcau Sandstone, Giurgiu-Ghelinta Beds and Upper Tarcau Sandstone [2]. The latter is covered by Podu Secu Beds or Plopu Beds.

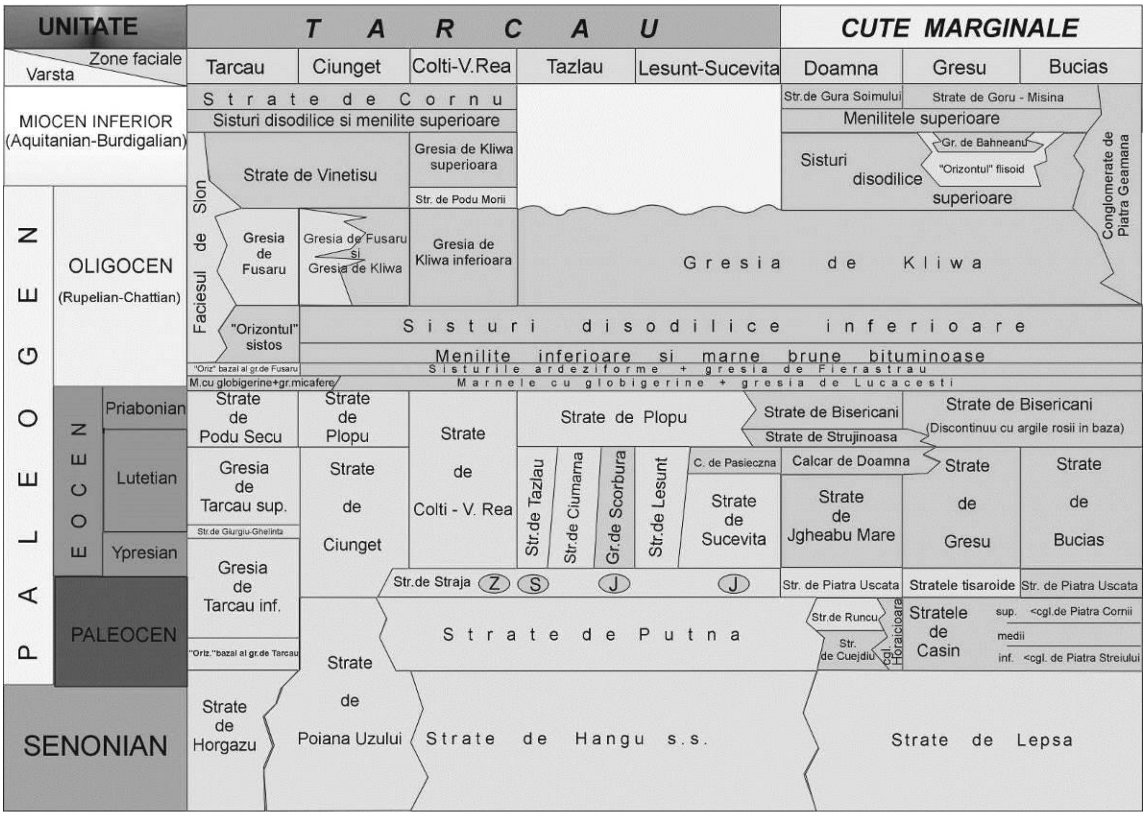

Fig. 1. *Parallel alignment of the geological formations in the Moldavides Units of the Eastern Carpathians*. [3].

Intermediary facies is developed between Tarcau Sandstone facies and Colti facies. Priabonian is developed either in internal facies of Tarcau Unit as Podu Secu Beds or in external facies as Plopu Beds. Podu Secu Beds are composed of repeated alternation of calcareous sandstones frequent diaclased, marls and grey and green clays, sometimes with fucoides. Frequent is intercalated grey marly-limestones. The intercalations of red shales are missing. Plopu Beds are represented by a shaly-sandy flysch of hieroglyphs Beds type in which, especially in lower part, are intercalated frequent red shales. Both in Podu Secu Beds and in Plopu Beds outcrops in their final part a marly-limestone layer, called marls with Globigerina. This layer of marls with Globigerina contains intercalations or sometimes is totally replaced by sandstones in thick beds. In Podu Secu Beds these sandstones are developed in Fusaru Sandstone facies and are called basal Fusaru Sandstone; in Plopu Beds these sandstones are quartzose, greenish or whitish, of Kliwa sandstones types being known as Lucacesti Sandstone.

Oligocene-Lower Miocene is represented in Tarcau Unit by bituminous and flysch formations [4] reportable to an ***internal lithofacies*** (Fusaru-Pucioasa) following the Eocene in Tarcau Sandstone facies with Carpathian source area in Monteoru–Smeuret–Homoraciu structure and (with particular characters) in Slon structure; and an ***external lithofacies*** (bituminous lithofacies with Kliwa Sandstone) following the Eocene in Colti facies in Lera-Valeni-Bustenari structure, with source area in foreland, between these two are located transition lithofacies with interference of source area.

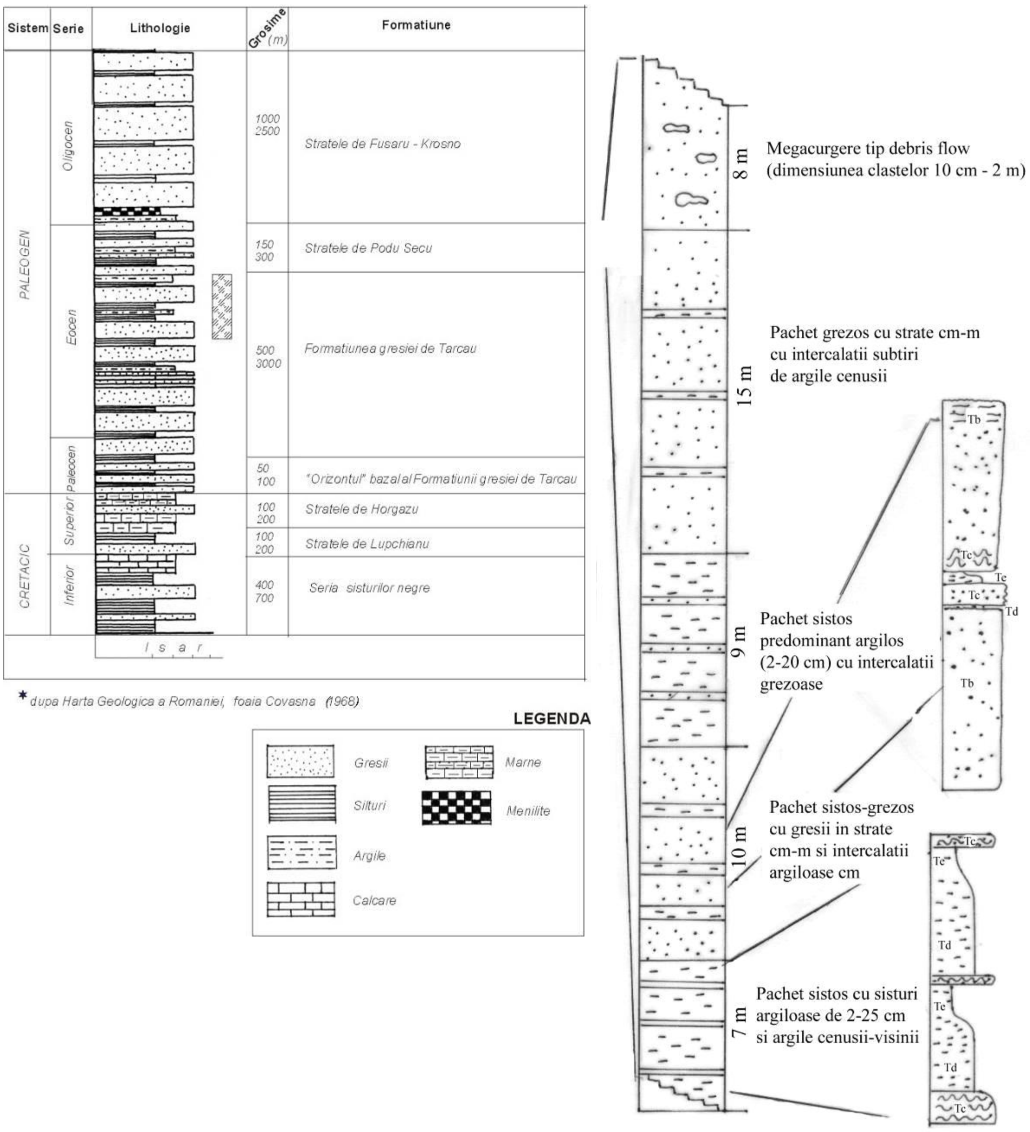

Fig. 2. *Stratigraphic setting of the case study (after [5] modified).*

Pucioasa-Fusaru Lithofacies has as lower boundary “Marls with Globigerina” belonging to terminal Priabonian of Plopu Formation. It includes a lower sequence predominantly lutitic of marls and clays dark colored with thin sand intercalations; sometimes, are intercalated dysodilic shales and sometimes even menilites in thin sequence, as well as the arenites of Fusaru Sandstones with Carpathic source area, opposite to foreland source area specific to the arenites of bituminous lithofacies with Kliwa Sandstones.

The flexoturbidites character of Fusaru Sandstones is outlined by coarse grained intercalations developed at different levels. The green schists from foreland are missing, the metaclasts being particularly mesometamorphites. Above Fusaru Sandstone is developed an important sequence of flysch type, with thickness of 1,000-2,000 meters and even more, called Vinetisu Formation. The youngest lithostratigraphic unit of Fusaru-Pucioasa lithofacies is represented by Starchiojd Formation [6] = *Upper Dysodiles and Menilites Formation*, an equivalent of *Upper Menilites Formation* of external facies [4].

Sedimentological setting

Paleocen-Eocene suite is dominated by lithic sandstones (with polymictic conglomerates subordinate) and clays. Ruditic petrofacies is represented by paraconglomerates and orthoconglomerates with lithoclasts (quartzites, micaschists, and gneisses) in arenitic matrix. Arenitic petrofacies includes sandstones and litho-feldspathic, feldspatho-lithic and lithic sandstones and greywacke. The liant is represented by a calcareous cement and a silt-lutitic siliciclastic matrix. Lutitic petrofacies includes green and red clays, marls or grey shaly clays. At different order sequence are encountered stratonomic sequences upward decreasing – thinner-upward or granulometric sequence upward decreasing – fining-upward.

Previous sedimentological investigations [7, 5] has identified eight types of facies diagnosed from compositional, textural and structural point of view, those succession from coarser to fine granulometric is: *F*1 – non-bedded paraconglomerates (*bouldery*); *F*2 – thick-bedded orthoconglomerates (*pebbly*), amalgamated; *F*3 – week bedded paraconglomerates and coarser sandstone; *F*4 – coarser-grained bedded sandstone; *F*5 – medium-grained bedded sandstones; *F*6 – thin bedded sandstones; *F*7 – thin bedded sandstone and mudstone; *F*8 – laminated mudstones and limestones, thin bedded.

It can be noticed F1 facies of non-bedded paraconglomerates having significance of flows of *debris flow* or *debris flow-mud flow* type. As stratigraphic position the F1 facies is developed both in Podu Secu Beds having thickness of over ten meters (fig. 3, 4, 5, 6, 7, 8, 9), and in Pucioasa-Fusaru Formation (in the area between Giurca viaduct and Pascului quarry) having submetric to metric thickness (fig. 10, 11).

The F1 facies outcrops in Podu Secu Beds in four locations, having similar stratigraphic position, that belongs to folded structures/imbricated folds from Tarcau Unit from interior to exterior encompassing in: the flanks of Secuiu syncline (adjacent to the confluence of Buzau river and Sasului River), in the eastern flank of Baile Siriu anticline (in the Groapa Vantului area from the confluence of Buzau River and Teherau River) (fig. 7), both with *debris-flow* la *mud-flow* character, and in the area downstream from the Siriu dam (in the slopes of the road DN 10, adjacent to the visiting tunnel of Siriu dam, near to Bontu fault and spring with sulphurous water) (fig. 5, 6, 8, 9) having *debris-flow* character.

The flow type *debris flow* is developed as a grey matrix, non-bedded, sometimes red-brownish by alteration, bordered by clear contacts – on top with load-casts structures (exaggerated) related to the rapid accumulation of suprajacent facies F2. The matrix is mainly composed of arenites-silts material, weak lutites, micaceous, with low percentage of fine clastorudites – metaclasts (sericiteous/chloriteous schists, white and black quartzites, micaschists, gneisses) and sediclasts (sandstones, limestones, marly-limestones), subparallel to fluidal oriented compared to general stratification, arranged mainly to the interval base.

The matrix includes decimetric and metric blocks, arranged from subparallel/fluidal with general stratification to chaotic, accumulated in the lower part of this sequence, having constitution similar to the matrix (ruditic metaclasts, marly-limestones, diagenized Mesozoic limestones, Tarcau-type sandstone, altered lithic sandstone, micaceous or conglomeratic, clayey-silty shales, greyish-blackish orthoquartzitic sandstones).

F1 facies is interpreted as the product of a cohesive debris-flow, located proximal to the source, respectively as channel-mouth lobe (*mother-flow*) [12]. It is the product of a siliciclastic accumulation with evolution in *slump* and then *debris flow* during movement on the slope. The fluidal texture of elongated clasts suggests laminar flow conditions.

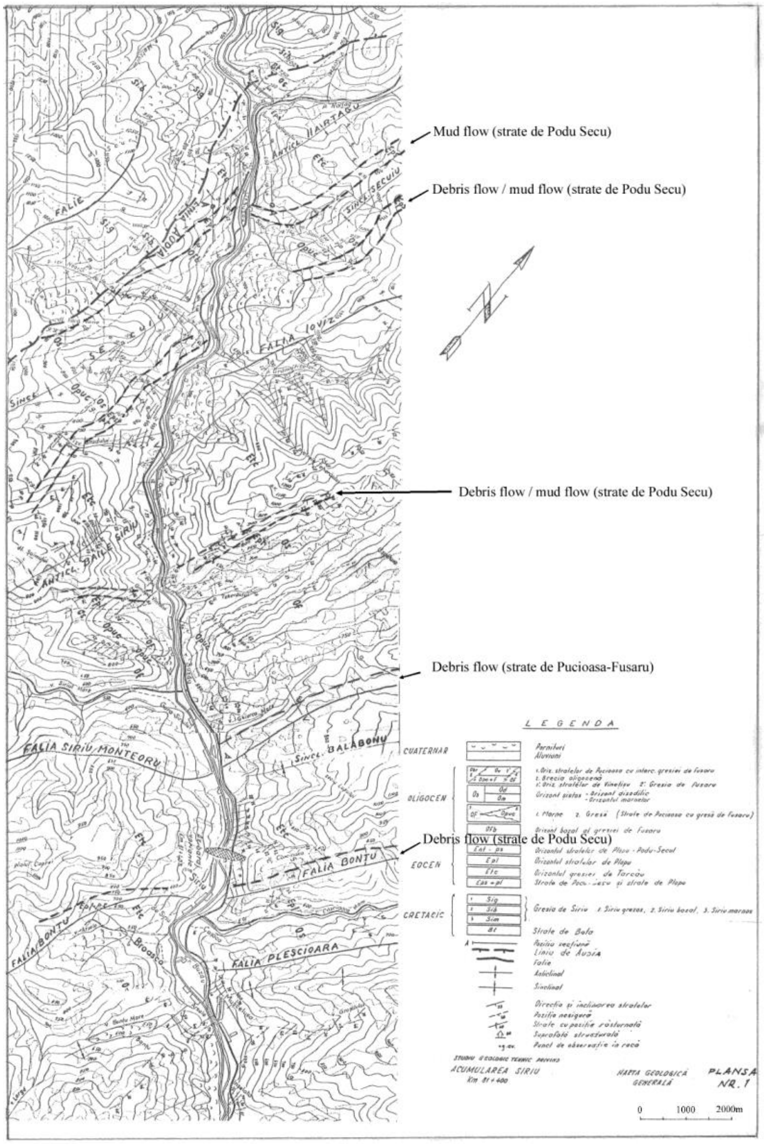

Fig. 3. *Geological sketch of upper valley of the Buzau River in the Siriu dam area* [10, 11]

F2 facies (fig. 5, 6) consist of microconglomerates with elements composed mainly of fragments of sedimentary rocks and metamorphic rocks, coarse-grained and amalgamated bedded; sometimes are well sorted, standing out a normal grading in FUS (finning-upward sequence) trend; the texture is massive, and sometimes, subparallel; do not show bioturbation structures; the lower contact is marked by *load casts* structures and erosional structures; the upper contact is graded. This sequence is interpreted as product of gravelly high-density turbidity currents [12, 13] derived from transformation of previous debris flow (F1) into amalgamated flow and then hyperconcentrated flow [12].

F3 facies (fig. 4, 5, 6) is composed of submetric coarser arenites (sometimes microparaconglomerates) alternating with siltolutites of 1-2 cm thickness, with massive texture, sometimes with deformation of horizontal stratification, with current erosional structures, with clear contacts in the base and irregular contacts in the top; the interpretation is deposition from high-density turbidity currents [12, 13].

Fig. 4. *Panoramic view of the top of Eocene at the contact between Tarcau Sandstone and Podu Secu Formations – left slope of the Buzau Valley, downstream of the Siriu dam, in the road curve adjacent to the base of dam overflow.*

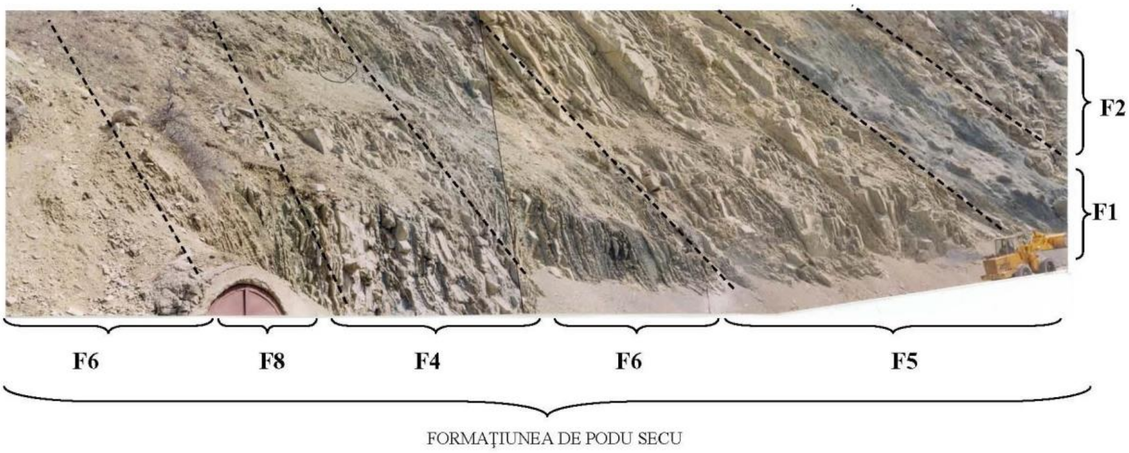

Fig. 5. *Panoramic view of the top of Eocene at the contact between Tarcau Sandstone and Podu Secu Formations – left slope of the Buzau Valley, downstream of the Siriu dam, in the road curve adjacent to the base of dam overflow.*

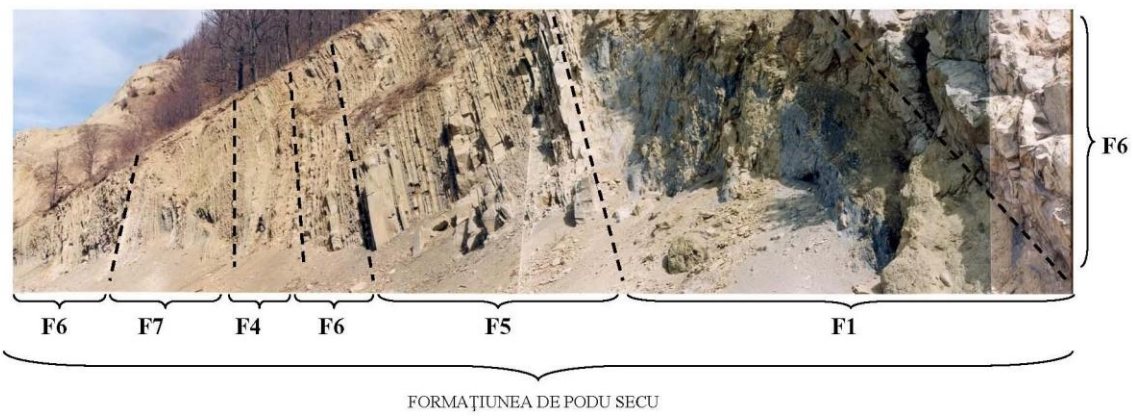

Fig. 6. *Panoramic view of the Eocene top in the arenite-silt-lutites piles of Podu Secu Formation with visualisation of megaflow type debris flow and the base of suprajacent sequence of 10 m thickness of massive coarse sandstones with load casts structures.*

Fig. 7. *Megaflow type debris flow – mud flow in Podu Secu Formation in left slope of Buzau Valley, approx. 150 m upstream of the Teherău viaduct.*

Fig. 8. *Panoramic view on megaflow type debris flow in Podu Secu Formation (left side Buzau Valley, downstream of the Siriu dam, near dam water overflow)*

Fig. 9. *Detail image in megaflow type debris flow in Podu Secu Formation (left slope of Buzau Valley, downstream of Siriu dam, in first curve of the road near to dam water overflow)*

Fig. 10. *Panoramic view on the rhythmites of Pucioasa-Fusaru Formation in left slope of Buzău Valley, in the road segment between Pascului quarry and Giurca viaduct, upstream of km 83.*

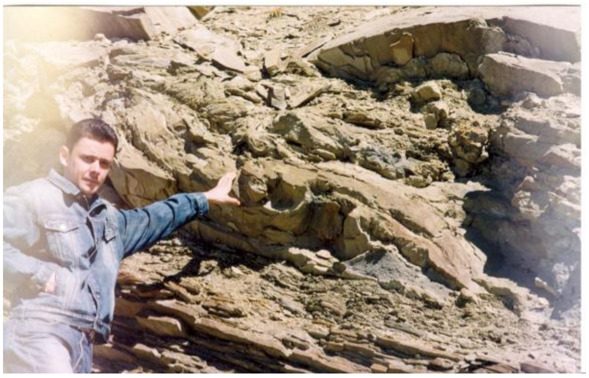

Fig. 11. *Sequences of debris flow and slump structures in a shaly pile of sandstones and decimetric silto-lutites of Pucioasa-Fusaru Formation in left slope of Buzău Valley, in the road segment between Pascului quarry and Giurca viaduct, upstream of km 83.*

F4 facies (fig. 5, 6) includes decimetric arenites alternating with siltolutites of 1-2 cm thickness, horizontally stratificated or with oblique stratification of current, on top with bioturbation structures, interpreted as product of high-density turbidity currents.

F5 facies (fig. 5, 6) consist of fine-grained and well sorted arenites, submetric thickness, with massive texture, in alternation with siltolutites of 1-2 cm thickness with biotic structures of *borings* type and deltoidal deformation structures of subaquatic flow, interpreted as result of high-density turbidity currents.

F6 facies (fig. 4, 5, 6) includes fine sandstones, bedded, of centimetric thickness, in alternation with siltolutites of 1-2 cm thickness; the sandstones are graded, with parallel stratification, ripple marks; in top bioturbation structures; interpreted as deposits of low-density turbidity currents.

F7 facies (fig. 4, 5, 6) is represented by fine arenites, thinner (parallel or weak bedded, or with ripple marks) with submetric siltolutites (massive or laminitic texture, with bioturbation structures) in FUS arrangement; interpreted as product of low-density turbidity currents.

F8 facies (fig. 4, 5) includes grey or grey-greenish clays, sometimes siltic, with biotic structures of borings type, with thin marly intercalations, interpreted as hemipelagic deposits and typical pelagic deposits respectively.

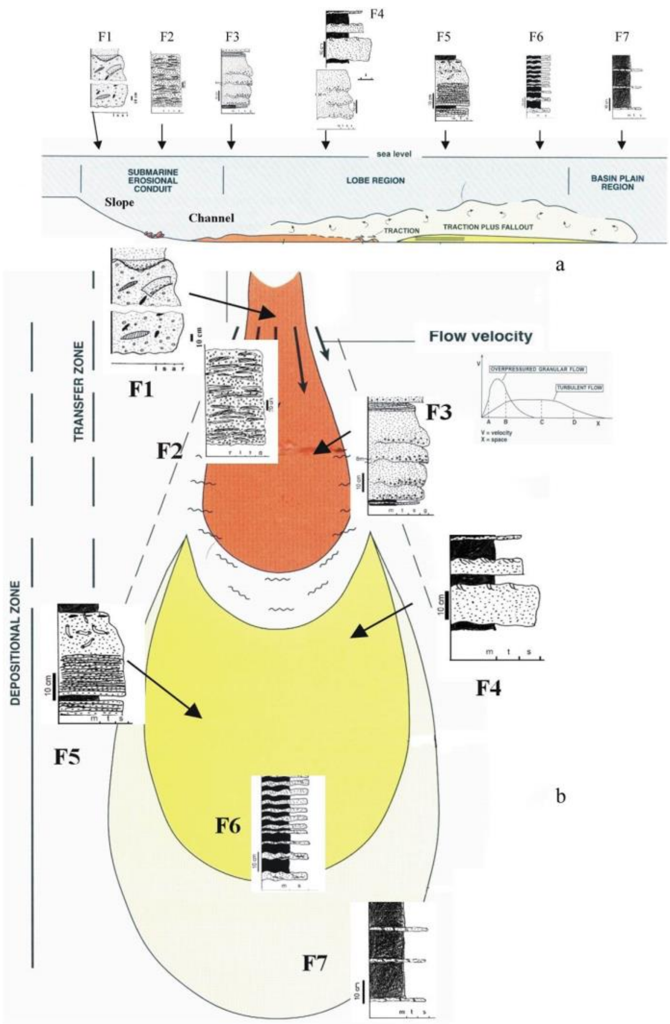

Fig. 12. *Distribution of sedimentary facies: a – between slope and basinal plain; b – within depositional transfer zones of turbiditic system according to* [12] *in* [7].

Case study in a sequence from Podu Secu Beds Formation

The profile analyzed in detail (fig. 2, 3, 4, 5, 6, 8) lies on the road connecting Siriu and Brasov localities, near to the visiting tunnel downstream of Siriu dam in the Buzau river, in the road curve adjacent to dam overflow in the left slope of Buzau Valley, in Podu Secu Formation of Tarcau Unit.

Podu Secu Formation of Eocene age (Priabonian) is composed of sandstone piles with 7-15 m thickness alternating with shaly-clayey piles with 5-7 m thickness (fig. 2, 3, 4, 5, 6, 13, 14). From the measurements performed has resulted that sandstone piles shows lithons of sandstone with 0.05 to 1 m thickness, with thin millimeters-centimeters intercalations of clays and shaly-clayey piles includes silto-lutites layers with thickness up to 0.030 m, cherry-reddish and greyish colored. From analyzed profile were detailed from sedimentological point of view two sequences: one shaly-clayey and other sandstone, for which were build specific columns.

Shaly-clayey sequence

Stratonomy: within this pile (fig. 13) we have clayey layers with thickness of 0.50-0.35 cm with sandstone intercalations with 2-10 cm thickness.

Microsequences: from measurements was observed a granulometric trend descending to top, which overall forming a *fining-up* sequence.

Mesosequences: both in sandstone layers and in silto-lutitic ones, from the base to top of the piles is observed a decrease of the thickness of lithons, this representing trends of *thinner-up* type.

Megasequences: overall mezosequences of *thinner-up* type and microsequences of *fining-up* type forming a macrosequence type *fining-upward* (FUS).

Contacts: similar to sandstone pile, between clayey layers and sandstone intercalations there are clear contacts, and within clayey layers there is a transitional zone from silts to lutite.

Granofacies: there is a normal grading with clasticity index (P1) in the range 0.001-0.032 mm for clayey layers and median percentile (P50) of 0.01-0.02 mm, and sorting is very good having values in the range 0.1-0.3.

Structofacies: it was found both mechanical structures and biotic structures. Among mechanical structures we recall: parallel stratifications and laminations, oblique lamination of current, convolute structures, slumps and constructional structures (normal grading).

Paleobatimetric evolution: within this shaly-clayey pile resulting an oscillation of bathymetry from higher level for clayey layers to medium level for sandstone layers

In the case of energy of basin we have a higher energy in the time of deposition of sandstones and a lower energy when the clays are sedimented.

Sandstone pile

Stratonomie: the sandstone pile (fig. 14) is composed of sandstone layers with thickness in the range 4-95 cm with silto-lutites intercalations with 2-4 cm thickness.

Microsequences: from measurements was observed a granulometric trend descending to top, which overall forming a *fining-up* sequence.

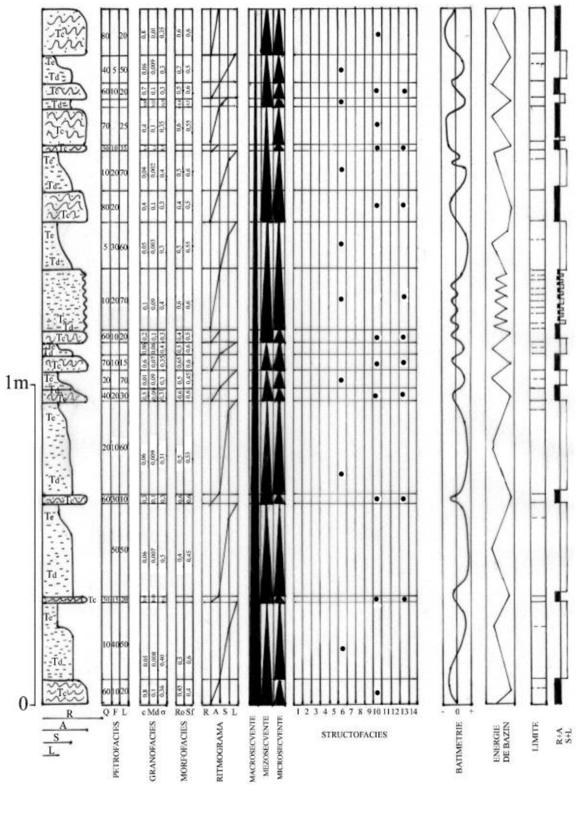

Fig. 13. *Sedimentological column of the shaly-clayey pile analyzed (with sandstone intercalations), at approx. 4 m from the entrance into visiting tunnel in the dam base, in the road curve adjacent to the dam overflow.*

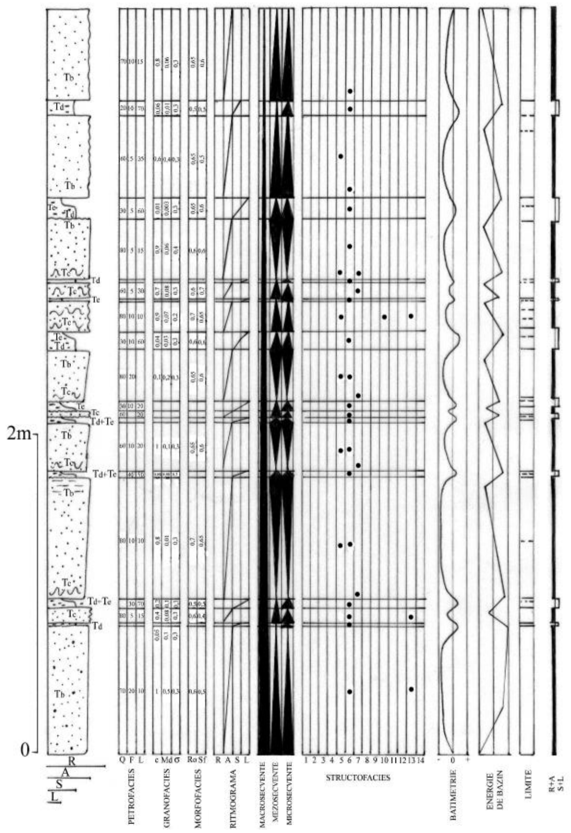

Fig. 14. *Sedimentological column of sandstone pile analyzed, at approx. 10 m from the entrance into visiting tunnel in the dam base, in the road curve adjacent to the dam overflow.*

Mesosequences: both in sandstone layers and in silto-lutitic ones, from the base to top of the piles is observed a decrease of the thickness of lithons, this representing trends of *thinner-up* type.

Megasequences: overall mezosequences of *thinner-up* type and microsequences of *fining-up* type forming a macrosequence type *fining-upward* (FUS).

Contacts: sandstone layers are separated from the clayey ones by clear contacts, and within clayey layers there is a transitional zone from silts to lutite.

Granofacies: overall within sandstone layers there were clasticity index (P1) in the range 0.1-1 mm; median percentile (P50) is in the range 0.30-0.60 mm, and sorting has values in the range 0.50-0.35.

Structofacies: it was found both mechanical structures and biotic structures. Among mechanical structures we recall: parallel stratifications and laminations, oblique lamination of current, convolute structures, slumps and constructional structures (normal grading).

Paleobatimetric evolution: within this sandstone pile is outlined an oscillation of bathymetry from lower level for sandstone layers to medium level for clayey intercalations.

Regarding basin energy we have a higher energy in the time of deposition of the sandstones and a lower energy in the time of deposition of the clays.

Conclusions

In the stratigraphic interval of sandstone pile analyzed representing a megasequence were observed 14 mesosequences and 20 microsequences and in clayey pile were observed 9 mesosequences and 18 microsequences that also led to a megasequence.

In terms of granofacies we are dealing with a trend type FUS both in sandstone piles and in clayey piles, due to rising of bathymetric level and lower energy basin.

At boundaries between sandstone lithons and clayey lithons can be observed clear contacts, which suggests a period of non-deposition and abrupt passing from lower bathymetries to higher bathymetries respectively from higher basin energies to lower basin energies. In the lithons of fine granulometry are outlined transitional contacts from silts to lutites, this suggesting a minor increase of the bathymetry amid of decreasing of basin energy.

In the deposition period of shaly-clayey pile, bathymetric level remained higher in a long period (when the clay were sedimented) and recorded falls in short periods of time, when were sedimented sandstone layers. This is deduced by differences in thickness between clayey layers and sandstone layers.

The suite of mesosequences resulted by interpreting of curves of bathymetry and of basin energy reflects the cyclic evolution of short-term of sedimentary environment conditions. Overall these sequences are included in a long-term cycle edifying for basin evolution.

The recorded facies belongs to deep-sea environments and rhythmites resulted by their by repeated them are recorded effects of some turbiditic bouts.

In the profile analyzed from Podu Secu Formations are outlined two facieses: F5 – fine-grained bedded sandstones; and F6 – thin bedded fine-grained sandstones and clays.

The analyzed piles belongs to F5 facies that included fine-grained sandstones, normal graded, with thin silto-lutite intercalations, separated by clear contacts and that shows on the layer surface frequent biotic structures (this unit was sedimented in a low-density turbidity current) and in F6 facies = fine arenite and shaly-clayey facies (like F5 this unit was sedimented in a low-density turbidity current).

In support of the above, in these facieses were encountered ichnofossils as *Sabularia*, *Thalassinoides* and *Helminthopsis*, specific to these marine environments.

Thalassinoides ichnogenus [15]: burrows of a lithophaga animal = *fodichnia*, post-depositional, indicator of opportunistic species adapted to variations of the salinity conditions, temperature, quantity of oxygen, suggesting shallow-marine environment with high energy basin. [14] According to [14] Crustaceans producing *Thalassinoides* may survive in turbidity currents and produce burrow under anoxic conditions.

Sabularia ichnogenus [15]: millimetric burrows, straight or sinuous, sandy embankments, partly coated with clayey particles, on lower bedding plane of the sandstones, and sometimes inside, interpreted as feeding traces = *pascichnia*, post-depositional, generated by opportunistic species.

Helminthopsis ichnogenus [15], *Helminthopsis tenuis* ichnospecies: irregular shape (meandering or sinuous irregular braids) of 1.5-2 mm diameter, as protuberance on lower bedding plane of the sandstones, interpreted as crawling traces of a lithophaga animals = *pascichnia*, predepositional, indicators of deep marine environments.

References

1. S ă n d u l e s c u , M . – *Geotectonica României*, Editura Tehnică, Bucureşti, 1984.
2. S ă n d u l e s c u , M . , S ă n d u l e s c u , J . , K u s k o , M . – Structura geologică a părţii de nord-est a munţilor Buzăului şi sud-vestul munţilor Vrancei, *Dări de Seamă ale Şedinţelor, Comitetul Geologic*, XLVIII (1960–1961), Bucureşti, 1962
3. B a d e s c u , D . – *Modelul structural al zonei externe a flişului din Carpaţii Orientali (partea centrală şi nordică) şi paleogeografia palinspastică la nivelul Senonianului şi Paleogenului*. Teza doctorat. Arhiva Facultatii de Geologie si Geofizica, Universitatea Bucuresti, 1999.
4. S ă n d u l e s c u , M . , M ă r u n ţ e a n u , M . , P o p e s c u , G h . – Lower-Middle Miocene Formations in the folded Area of the East Carpathians, Guide to Excursion B1 (post-congress), X-th Congress RCMNS, *Romanian Journal of Stratigraphy*, 76, suppl. 5, Bucureşti, 1995
5. R o b a n , R . – *Analiza şi distribuţia structurilor de bioturbaţie în cadrul depozitelor turbiditice din flişul Est Carpatic de vârstă Paleocen-Eocen, Siriu – Valea Buzăului*, Disertatie Universitatea Bucureşti, 2000.
6. P o p e s c u , G h . – Marine Middle-Miocene stratigraphy of the Central Paratethys (Romanian Area), *Anuarul Institutului Geologic al Romaniei*, Bucureşti, 2002.
7. V a r b a n , B . , D e r e r , C . , A n a s t a s i u , N . , R o b a n , R . , P o p a , M . – Architecture of turbidite systems as revealed by the East Carpathians Eocene Sequences (Tarcău Formation – Siriu, Romania*), Revue Roumaine de Géologie, Géophysique et Géographie, Serie de Géologie*, Academia Română, Bucureşti, 2000.
8. F r u n z e s c u , D .– *Studiul stratigrafic şi sedimentologic al evaporitelor miocene dintre valea Buzăului şi valea Teleajenului*, Teza de doctorat, Universitatea Bucureşti, 1998.
9. F r u n z e s c u , D . – *Noţiuni de sedimentologie*, Editura Premier, Ploieşti, 2000.
10. F r u n z e s c u , D . , B r a n o i u , G . – *Monografia geologică a bazinului râului Buzău*, Editura Universităţii Petrol-Gaze din Ploieşti, 2004.
11. C r a c i u n F . e t a l . – ISPIF reports, 1973.
12. M u t t i , E . – *Turbidite sandstone*s, San Donato Milanese, Agip-Istituto di Geologia, Universita di Parma, 275 pp., 1992.
13. L o w e , D . R . – Sediment gravity flows: II. Depositional models with special reference to the deposits of high-density turbidity, *Journal of Sedimentary Petrology*, 52, p. 279-297, 1982.
14. S e i l a c h e r , A . – Sedimentological classification and nomenclature of trace fossils. *Sedimentology*, 3, p. 253-256, 1964.
15. K s i a z k i e w i c h , M . – Trace fossils in the flysch of the Polish Carpathians, *Palaeontologica Poloniae*, 36, p. 208, Warszawa, 1977.

Contextul sedimentologic al unor curgeri debritice din formațiuni paleogen-miocene ale Unității de Tarcău, în zona lacului de baraj Siriu (Valea Buzăului)

Rezumat

Pe fondul structural al dezvoltării in cute solzi a formațiunilor paleogene ale Unității de Tarcău de la curbura Carpaților Orientali, unul din repere poate fi considerat depozitul brecios ce se repeta cu grosimi crescătoare de la interior către exterior, relevând caractere nete de depozit de tip debris-flow. In lucrare s-au determinat mai multe faciesuri descriptive adiacente, care utilizate apoi ca faciesuri interpretative permit considerații sedimentologice genetice asupra întregului ansamblu al Unității de Tarcău.