საქართველოს მეცნიერებათა ეროვნული აკადემიის მოამბე, ტ. 10, №2, 2016
BULLETIN OF THE GEORGIAN NATIONAL ACADEMY OF SCIENCES, vol. 10, no. 2, 2016

Geology

Some Data on the Rate of Sedimentation

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ABSTRACT. The paper presents new data on the sedimentation rates obtained from the study of the Upper Eocene sediments of the western part of Abkhazia, where deposition of subplatform sediments in the form of marls, on the one hand, and of terrigene formations of piedmont trough, on the other, took place in heterogeneous facies and paleogeographic conditions. In the second half of the Late Eocene, as a result of the Pyrenean folding, paleogeo-graphic and facial changes took place that naturally had affected the rate of sedimentation. First for the southern slope of the Greater Caucasus, on the example of the Upper Eocene formations with due regard to their diagenetic and subsequent transformations tentative primary thicknesses of sediments and their sedimentation rates were established. Determination of the latter was carried out with the method, which involves the division of the total thickness of the rocks on the number of years during which they were formed. Exactly set lithologic and stratigraphic boundaries of the studied formations, make more or less accurate the figures on the rate of sedimentation. Besides, the data obtained both for subplatform sediments and rocks of the piedmont trough, fully correspond to the data that are available for different sedimentary basins of the adjacent regions. At the same time, the time of accumulation of separate suites that compose Upper Eocene sections is established.

Key words: rate of sedimentation, mixed facies, subplatform facies, Late Eocene, primary thickness

In the paper the results of the study of Upper Eocene deposits of the western part of Upper Abkhazia are presented and their rates of sedimentation are determined. The choice of this territory, which covers the Psou, Bzyb and Kodori river basins to solve the assigned task, is conditioned by several factors. In particular, two tectonic units are situated here: folded system of the Greater Caucasus (in the North) and the Transcaucasian intermountain area (in the South). In the study area during the Early Cretaceous-Oligocene an integrated sedimentary basin existed, where a continuous deposition of calcareous-terrigene rocks took place.

As for timing, it is conditioned by the paleogeographic and facies changes that took place in the Caucasus, as well as throughout the Alpine - Himalayan fold belt as a result of the Pyrenean folding in the second half of the Late Eocene [1], which naturally affected the rate of sedimentation .

Before proceeding to the actual material, it must be emphasized that one of the important factors for the reconstruction of sedimentation conditions is to establish both real and primary thicknesses of rocks. As is well known, as a result of diagenetic and subsequent changes (loss of water and other active components, deformation due to compaction and so on) re-

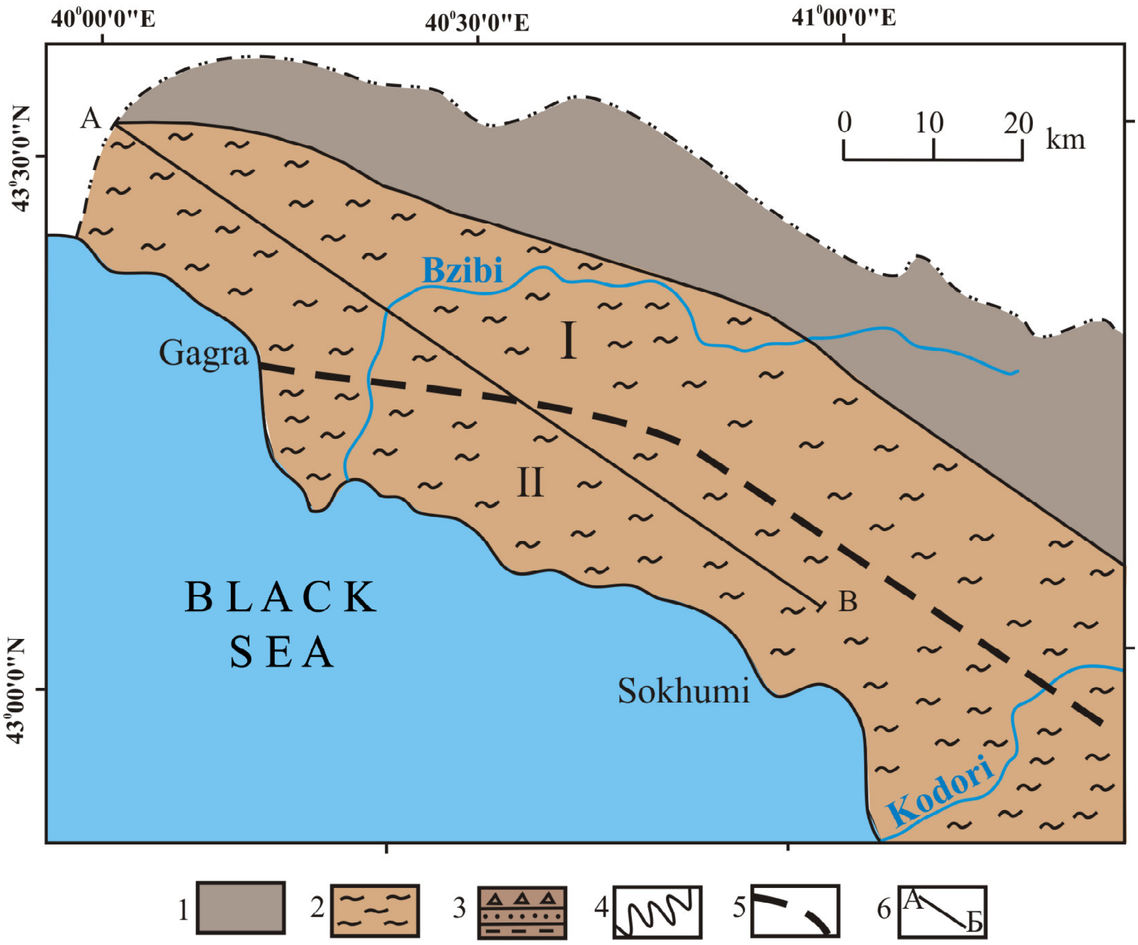

Fig. 1. Paleogeographic of the Western Abkhazia at the beginning of the Late Eocene
1-dry land; 2-mixed facies zone (clays, sandstones, olistostromes); 3-zone of subplatform facies(marls); Boundaries: 4- of facies zones; 5- of tectonic units; 6-profile line; I- Southern slope of the Greater Caucasus; II-Transcaucasian intermountain area

duction of sediment thickness took place. According to U. Fayfa et al. [2] the total effect of these processes leads to the reduction of thickness by 25-50 %. Considering that the Upper Eocene sediments underwent weak tectonic processing (in which developed mainly germanotype folding) and are of relatively young age (that determines their low density), reduction of their primary thickness should not exceed 35 %. An exception may be only olistostromes of the Matsesta suite, as they are built up of ancient rock debris and a slight amount of matrix, which probably led to an insignificant reduction of their primary thickness.

During the Late Eocene in the study area there were two different depositional facies zones: mixed (in the western part) and subplatform (in the eastern and southern parts) (Fig. 1, 2). In the first one, both subplatform (first half of the Late Eocene) and regressive molasse deposits of the piedmont trough (second half of the Late Eocene) were deposited, while in the eastern zone throughout the Late Eocene exclusively subplatform deposits in the form of marls were deposited. The mixed facies zone was situated only within the limits of the southern slope of the Greater Caucasus (present-day Adler depression), while the subplatform facies zone covers both tectonic units (Fig. 2).

Mixed facies deposits are mostly widespread within the limits of Achmarda and Troytskaya synclines and the subplatform deposits are spread in the Musera - Apsta interfluves and in the vicinity of

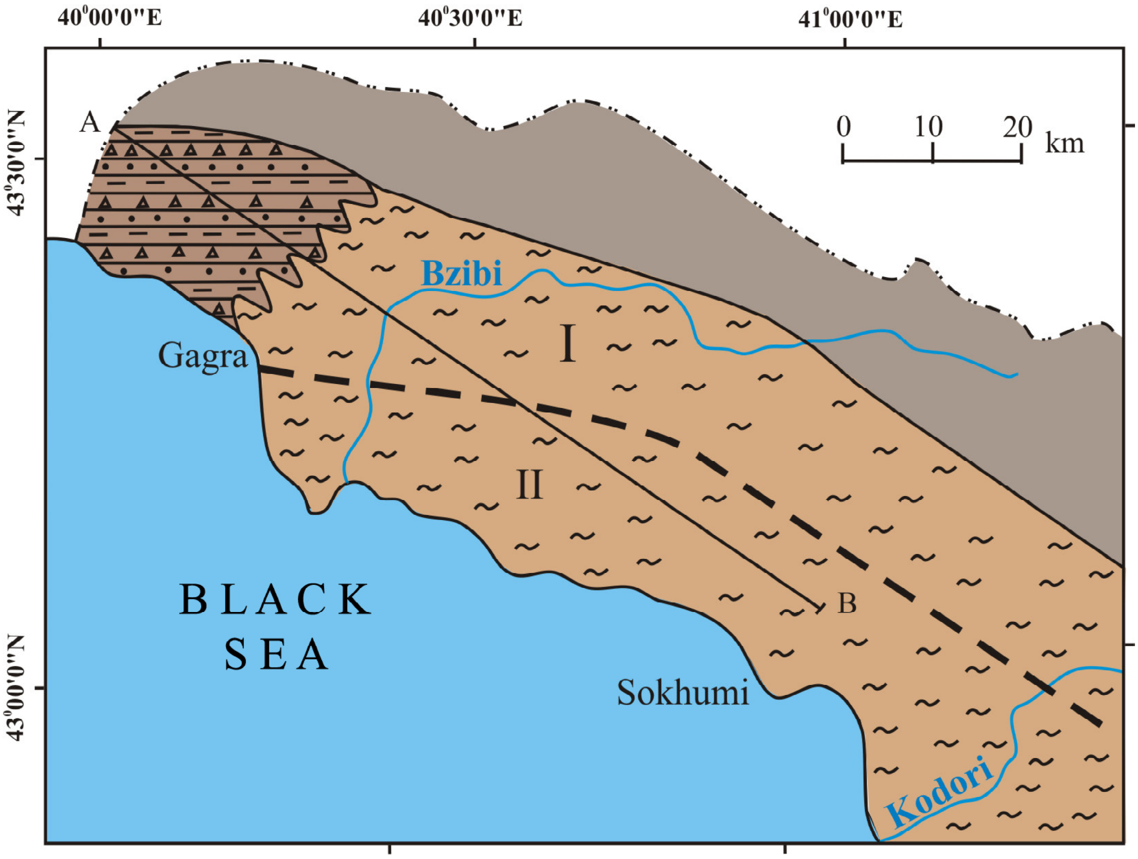

Fig. 2. Paleogeographic of the Western Abkhazia at the end of the Late Eocene
Conventional signs see in Fig. 1.

Novy Afon situated respectively on the Southern slope of the Greater Caucasus and in the Transcaucasian intermountain areas (Fig. 2).

Generalized sections of Upper Eocene formations by tectonic unites for separate facies zones are presented below (Fig. 3). For each suite both real and tentative maximum primary (in brackets) thickness is shown.

The Southern Slope of the Greater Caucasus

Mixed Facies Zone

Upper Eocene sediments in the considered facies zone with a gradual tran-sition follow the rocks of the Bagnari suite represented by greenish-gray and gray marls. Middle Eocene age of these deposits is confirmed by nannoplankton [3] and small foraminifera [4].

The lowermost Upper Eocene is represented by the Egrisi suite (Fig. 2) built up of brownish-gray, brown platy, bituminous marls with numerous remnants of fish scal-es, including Lirolepis caucasica Rom. These deposits are known in the literature as “lirolepis marls” which are analogue of Kuma suite of the North Caucasus. The stratig-raphic position of the latter and thus the age of lirolepis marls still remain disputable.

Some authors attributed these deposits to the uppermost Middle Eocene [5, 6 et al.], the others - to the lowermost Upper Eocene [7, 8 et al.]. Some researchers attribute lirolepis marls to the upper parts of the Middle Eocene and lower parts of the Upper Eocene [9, 10].

For the specification of the Egrisi suite age there occur interesting data on the area under consideration. In particular, in the eastern part of the district [between the vil-lages Kaldakhvara and Blaburkhva] in the upper part of the Egrisi suite were identified Nummulites incrassatus, N. Chavannesi, pointing to

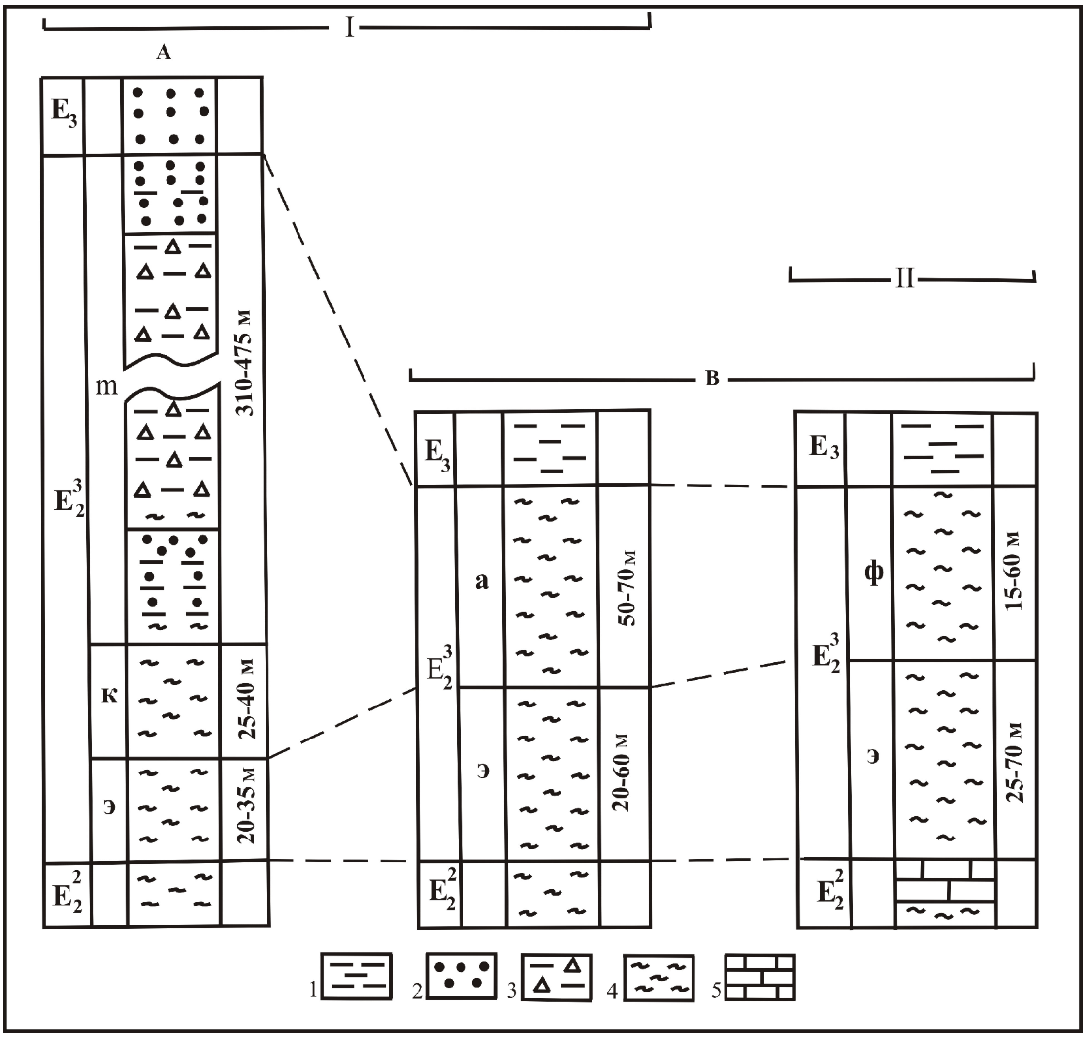

Fig. 3. Litho-stratigraphic columns of generalized sections.
I- Southern slope of the Greater Caucasus; II-Transcaucasian intermountain area; A – mixed facies zone; B – zone of subplatform facies; 1-clays; 2-sandstones; 3-olistostromes; 4-marls; 5-limestones; a-the Argveti suite; k-the Kldiani suite; m-the Matsesta suite; f- upper foraminiferal marls; e-the Egrisi suite.

the Upper Eocene age of the enclosing rocks [8]. Lirolepis marls contain redeposited Middle Eocene fossils as well. They also contain foraminiferas of the zone Globigerina turcmenica.

Based on the above and taking into account the specifics of sedimentation conditions (hydrogen sulfide pollution of the marine environment) can be assumed that Egrisi (Kuma) suite has no well-defined stratigraphic boundaries and its lower and upper limits are moving from the top to the bottom of the upper parts of the Middle Eocene to the lower parts of the Upper Eocene inclusive. Thickness of the suite is 35 (52-54) m.

The Kldiani suite without the trace of discontinuity overlies the marls of the Egrisi suite (Fig.2). Lithologically it is represented by greenish-gray marls. Pyrite incl-us--ions and limonitizated concretions occur in them. According to fine foraminifers present in these marls G.S.Goderdzishvili [11] allocated the Globigerapsis index zone indicating the Upper Eocene age of the enclosing rocks. The thickness of the suite amounts 40 (60-62) m.

The Matsesta suite that follows upper plays an important role in geological built up of the considered facies zone and of all Adler depression as well. It spreads in the Matsesta-Khashupse interfluves and lithologically is represented by regressive formations, where three horizons are distinguished: the lower – sandy-argillaceous, middle – "horizon with inclusions" (olistostromes) and the upper one – argillo-arenaceous [12]. On the basis of fauna data the Upper Eocene age of the considered suite has been established by numerous researchers [13-18].

Sandy-argillaceous horizon of the lower part is represented by marls, rarely calcareous clays. Up the section amount and thickness of sandstones gradually incre-ases. Thickness of the horizon is 80 (121-123) m.

For more details we would like to rest on the "horizon with inclusions" (olisto-s-tromes) that is widespread in the Achmarda syncline. To the south, outcrops of these formations are not observed – here, the upper horizon of the Matsesta suite (sandy-argillaceous) rests directly on the lower one (argillo-arenaceous).

The transition of olistostromes into the underlying sandy-argillaceous and the following argillo-arenaceous horizons is conformable. Due to lithological difference, the boundary between them is rather distinct. Composition of olistostromes is diverse (marls, limestones, sandstones, cherts, etc.), and their size in diameter varies from sev-e-ral cm-s to several m-s and more. Cementing matrix in olistostromes is represented by sandy marls and carbonate clays. Olistostromes are characterized by confused bedding and they are formations of tectonic-gravitational origin.

Among olistostromes platy Upper Eocene lirolepis marls are distinguished. They prevail over other debris both in number and size. Some of their blocks exceed several tens of meters in diameter.

Their bedding often coincides with elements of horizon position that can create a false impression of the primary occurrence of some of these inclusions. It was established that all the detrital material composing the horizon with inclusions, is a product of redeposition of sediments directly involved in the structure of the eastern termination of the Adler depression.

Olistostromes of the Matsesta suite are the synchronous formations of Upper Eocene olistostromes spread in the eastern segment of the Southern slope of the Greater Caucasus [19], being "event deposits". They are a kind of the marker formations, allowing to establish the time and duration of manifestation of the Pyrenean phase of folding, and thus giving the opportunity to correlate tectonic movements, including the catastrophic events in the Alpine folded system and beyond its limits [20]. As the olistostromes are poorly exposed the researchers interpret their thickness in different ways. According to our observations their thickness is versatile and it does not exceed 245 (250-255) m.

The upper part of the Matsesta suite – *argillo-arenaceous horizon*, in the lower part is built up of dark grey clays and less amount of sandy marls. They comprise thin partings of quartz-arkose fine-grained carbonaceous sandstones; their amount visibly increases upwards in the section. These sandstones together with calcareous clays and sandy marls compose upper horizon of the 150 (230-232) meter thick Matsesta suite.

In ascending section above the Matsesta suite conformably rests the Khosta suite of Oligocene built up mainly of more dense sandstones.

Subplatform Facies Zone

In the present facies zone Upper Eocene formations are completely represented by the marlaceous facies (Fig. 3). They gradually replace the *"lower foraminifera marls"* that are synchronous formations of the above mentioned *Baghnari suite* of the Middle Eocene.

The lower part of the Upper Eocene is built up of lirolepis marls of *the Egrisi suite* represented by platy dark marls, where abundant fish scales and teeth are observed. Thickness – 60 (89-91) m.

In ascending section the lirolepis marls are substituted by lithologically uniform grayish-grey marls of *the Argveti suite* comprising rare partings of dense limest-ones. According to nummulitic fauna [8] and nannoplankton [3] the Argveti suite is dated as the Upper Eocene. It is a synchronous formation of the Kldiani and Matsesta suites (Fig. 3). Thickness of the suite amounts 70 (108-110) m.

In ascending section marls of *the Argveti suite* are replaced with Oligocene deposits of *the Maikop series* – its lower part is represented by carbonaceous clays mostly.

The Transcaucasian Intermountain Area *Subplatform Facies Zone*

Upper Eocene formations in the study area occur in limited amounts, cropping out between the rivers Bzyb and Achandara and in thei environs of resort Novy Afon. They follow conformably after the Middle Eocene formations that in the western part are represented by greenish-grey marls and in the eastern part (environs of the resort Novy Afon) by dence organogenic-detrital limestones.

Upper Eocene formations in the lower part are represented by brownish-black platy marls of *the Egrisi suite* – 70 (108-110) m, and in the upper – by the *"upper foraminifera marls"* – 60 (89-91) m conformably overlapped by the *Maikop series* rocks.

In the papers on the sedimentation rate, the results of researches of both modern and ancient sediments are presented. These figures reflect the general laws on the subject for different sedimentary basins and of course are approximate.

In our case, when lithological boundaries of the suites (allowing to determine their true thicknesses) are well established and their age is faunistically (including nummulites and their stratigraphic position in the section) confirmed and besides, when all the Upper Eocene is represented exclusively by marls (subplatform formations), the figures we obtained on the rate of sedimentation can be considered more or less reliable.

It must be taken into account that among the various factors that influence the process of sedimentation, including its speed, an important role is played by the ratio of the intensity of sediment supply in the basin, distance of transport of terrigenous material, the morphology of the basin floor and the rate of subsidence etc.

To determine the rate of sedimentation we have chosen geological method, which involves the division of the total thickness of the rocks on the number of years during which they were formed [21]. While determining the rate we used the initial maximum thicknesses of the suites. According to one of international chrono-stra-tigraphic diagrams [22] the duration of the Late Eocene is 4.1ma.

When applying this method it turned out that for the zone of subplatform facies of the southern slope of the Greater Caucasus, where during the Late Eocene litho-logically homogeneous sediments were deposited in the form of marls (*the Egrisi and Argveti suites*) and for the zone of subplatform rocks of the Transcaucasian intermountain area (*the Egrisi suite*, "*upper foraminifera marls*"), an initial maximum thickness of which apparently was 175 m, the sedimentation rate amounted 4.26 cm/1000 years. Proceeding from this figure, we can calculate the time of accumulation for separate suites. In particular, in the area of mixed facies accumulation of *the Egrisi suite* took 1.1ma and the Kldiani suite - 1.3ma. After summing up these two indicators we can determine the duration of accumulation of the Matsesta suite, which equals 1.7ma, Its average sedimentation rate amounts 33.8 cm / 1,000 years. It should be taken into account that the heterogeneous lithological composition of the Matsesta suite, because of which most of the time is spent on the deposition of normal-sedimentary rocks (lower and upper horizons of the suite). As for olistostromes, their formation generally takes place as a result of catastrophic events that cover a very short period of time. In particular, it is evidenced by the fact that often foraminifera occurring in sediments that directly underlie and overlie olistostromes actually belong to the same microfauna assemblage [23]. In our case, according to the assemblage of fine foraminifera, first two horizons of the Matsesta suite (sandy-clayey and olistostromes) belong to the zone

Globigerapsis index (Finlav), and the upper (argillo-arenaceous) – to the zone Bolivina [17, 18].

For subplatform deposits of the eastern part of the southern slope of the Greater Caucasus accumulation time *for the Egrisi suites* is 1.9ma and for *the Argveti suite* - 2.2ma. For subplatform deposits of the Transcaucasian intermountain area, these figures are similar: 2.2ma for *the Egrisi suite* and 1.9ma for "upper-foraminifera marls".

Before passing to the final part of this paper, it is interesting to review in brief those geological processes that took place in the study area during the Late Eocene.

The existing sedimentary basin to the north was limited by a low Akhtsu-Katsirkha land, which is the main supplier of terrigenous material to the basin. At the beginning of the Late Eocene marine environment has been contaminated with hydrogen sulfide, which led to the accumulation of specific rocks in the form of lirolepis marls (the Egrisi suite). In the rest of the first half of the Late Eocene, when in the basin still remained subplatform conditions deposition of marls (*the Kldiani suite* and the lower part of *the Argveti suite*) continued. Since the second half of the Late Eocene, as a result of activation of tectonic movements induced by the Pyrenean phase of folding, Gagra submarine uplift was formed, separating the basin into two parts: the Western (mixed facies zone), and the Eastern (subplatform facies zone) (Fig. 4). The latter encompassed both the southern slope of the Greater Caucasus and the Transcaucasian intermountain area.

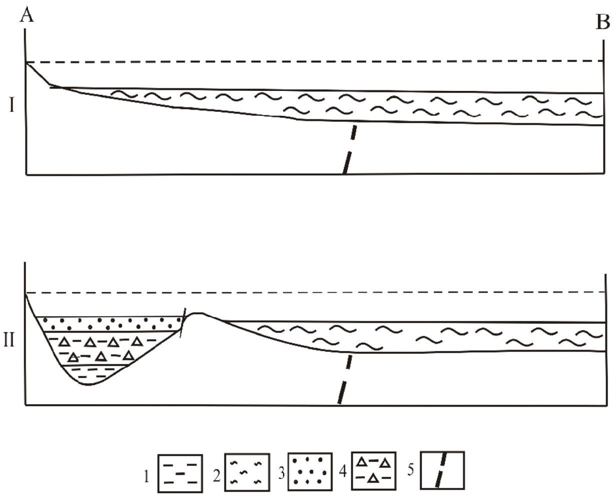

Fig. 4. Paleogeographic profiles of sedimentary basin along the A-B line (see Fig.1, 2)
I – the beginning of the Late Eocene, II – the end of the Late Eocene.
1-clays; 2-marls; 3-sandstones; 4-olistostromes; 5-fault.

In the western basin, from the second half of the Late Eocene, was distinctly outlined subsidence of the basin floor, formation of the piedmont trough (present Adler depression) (Fig. 4) and the regression of the sea. As is evident from the litho-facial characteristics of Upper Eocene sediments of the eastern termination of the Adler depression, at that time there took place delivery of considerable amount of terrigenous material causing accumulation of the Matsesta suites with thickness about 475 (600-610) m. As for the eastern part of the basin, there in the second half of the Late Eocene sub-platform conditions were preserved and deposition of marls continued (Fig. 2).

To compare our figures with similar data for modern inland and marginal seas (the territory of the Southern slope of the Greater Caucasus also belonged to the latter in the past), let's familarize with some figures existing for the neighboring regions. For example, in the Black Sea, the most intense sedimentation was recorded in the southern and eastern parts of the basin, where the sedimentation rate is 20 cm/1000 years, and in the west and in the central part - 0-10 cm / 1000 years [24]. According to A.P.Lisytsin [25] sedimentation rate for the entire Black Sea varies within 1-40 cm /1000 years, and according to W. *Schwarzacher* [26] the average rate amounts 20 cm / 1000 years.

For the Mediterranean, these data as well as for the Black Sea, vary within certain limits. As a result of deepwater drilling empirical sedimentation rate curves were compiled; they present the average values from the Pliocene to the present day, respectively showing 2.6 cm / 1000 years and 3.2 cm / 1000 years [27].

From the above mentioned we can infer that the rate of sedimentation in different tectonic structures (platform troughs, marginal seas, piedmont troughs, rift valleys etc.) confirms the slowest rate of sedimentation in the platform basins, and the fastest - in the piedmont troughs (2 -6 and 4-1100 cm / 1000 years respectively) [28].

In our case, for the piedmont trough of Adler depression relatively low sedimentation rate (33.8 cm / 1,000 years) is recorded that probably can be explained by the fact that in the Late Eocene relief of Akhtsu-Katsirkha land was dissected insufficiently and supplied the basin with a limited amount of terrigenous material. Moreover, as for the compensated depressions rate of sedimentation is a definite criterion for the characterization of tectonic subsidence, we can resume that in the second half of the Late Eocene in the mixed facies zone slow subsidence of the basin floor took place. Considerable dissection of the Akhtsu-Katsirkha dry land and a significant subsidence of the piedmont trough were established already in the Oligocene. At that time thick (up to 1500 m) terrigene deposits of the Khosta and Sochi suites accumulated.

Thus, we can ascertain that the figures we have obtained, 4.26 cm / 1000 years for subplatform basin and 33.8 cm / 1000 years for piedmont trough, fully comply with the data that exist for the various sedimentary basins of the adjacent regions.

გეოლოგია

ზოგიერთი მონაცემი ნალექდაგროვების სიჩქარის შესახებ

ფ. მაისაძე

აკადემიის წევრი, ა.ჯანელიძის გეოლოგიის ინსტიტუტი, თბილისი

დასავლეთ აფხაზეთის ზედაეოცენური ნალექების შესწავლის საფუძველზე მიღებულია ახალი მონაცემები ნალექდაგროვების სიჩქარეების შესახებ. არაერთგვაროვან ფაციესურ და პალეოგეოგრაფიულ პირობებში გვიანეოცენურ დროში ადგილი ჰქონდა, ერთი მხრივ, სუბპლატფორმული ნალექების დაგროვებას მერგელების სახით, ხოლო მეორე მხრივ, მთისწინა როფის რეგრესიული ტერიგენული წარმონაქმნების დალექვას (მაცესტის წყება).

გვიან ეოცენის მეორე ნახევარში, პირენეული დანაოჭების შედეგად საკვლევ ტერიტორიაზე ადგილი ჰქონდა პალეოგეოგრაფიულ და ფაციესურ ცვლილებებს, რამაც თავის მხრივ გავლენა მოახდინა როგორც ნალექების ხასიათზე, ასევე მათი დალექვის სიჩქარეებზე. დიაგენეზის და შემდგომი გეოლოგიური პროცესების გათვალისწინებით, კავკასიონის სამხრეთი ფერდობის ფარგლებში, დასავლეთ აფხაზეთის ზედაეოცენური წარმონაქმნების მაგალითზე პირველად იქნა დადგენილი ნალექების პირველადი სავარაუდო სიმძლავრეები და მათი დალექვის სიჩქარეები. ამასთან, განისაზღვრა თითოეული წყების დაგროვების ხანგრძლივობაც.

დალექვის სიჩქარეების გამოთვლა ხდებოდა გეოლოგიური მეთოდით, რაც გულისხმობს ნალექების საერთო სიმძლავრის შეფარდებას წლების იმ რაოდენობაზე, რაც მათ დალექვას დასჭირდა. შესწავლილი წყებების დეტალურმა ლითოლოგიურმა შესწავლამ და მათი სტრატიგრაფიული საზღვრების ზუსტმა დადგენამ, მნიშვნელოვნად განაპირობა მიღებული შედეგების სიზუსტე და სანდოობა.

გაირკვა, რომ ჩვენ მიერ მიღებული შედეგები ნალექდაგროვების სიჩქარეების შესახებ სუბპლატფორმული და მთისწინა როფის წარმონაქმნებისთვის სრულად შეესაბამება იმ მონაცემებს, რომლებიც არსებობს მოსაზღვრე რეგიონების გეოლოგიური წარსულის სედიმენტაციური აუზებისთვის.

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Received April, 2016