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# CYCLICITY AND HIGH-RESOLUTION (HIRES) STRATIGRAPHY OF THE CHUGOVITZA FORMATION FROM THE AREA OF CHELOPECH VILLAGE, SOFIA DISTRICT

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**ABSTRACT.** On the base of specialized lithological and lithofacial investigations of three drills that cross the rocks of Chugovitza Formation (Campanian-Maastrichtian) just NW of Chelopech Village, Sofia district, is developed high-resolution (HIRES) stratigraphic subdivision of the unit in the studied area. The unit is presented by cyclic alternation of mainly thin-bedded poorly sorted polymictic sandstones, limy siltstones and claystones, marls and hyporocks. Thin beds of sandy limestone, tuffaceous sandstones are also established. The rocks have abundant structural features. Generally the structure of the cycles is characterized by lower, mainly psammitic, middle – alternation of sandstone and mixed rocks (hyporocks, hyposiltstone and sandy marls), and upper part, where dominate fine grained materials that, from their hand, could be covered again by sandstone. The proportion between these three parts varies significantly. There are cycles in which the middle and upper part completely absent, as well as those in which they dominate. Often the last ones are with more significant thickness. More of the cycles are asymmetric, often cut off, but are established symmetrical as well. Together with the cyclicity analysis in the unit it was possible to be identified and traced various marked and correlative levels as: levels with development of relatively thick cycles; levels with development of packages of amalgamated cycles; levels with more intensive development of erosion processes, intrabasinal re-deposition, subaeral exponation etc.; levels with features of rapid sedimentation; levels with features of active hydrodynamic setting development; levels enriched by bio- and plant detritus; and levels that contain or are enriched by fresh volcanic products.

**ЦИКЛИЧНОСТ И ВИСОКОРАЗДЕЛИТЕЛНА (HIRES) СТРАТИГРАФИЯ НА ЧУГОВИШКАТА СВИТА В РАЙОНА НА С. ЧЕЛОПЕЧ, СОФИЙСКО**

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**РЕЗЮМЕ.** На основата на специализирани литоложки и литофациални изследвания на три сондажа, пресичащи скалите на Чуговишката свита (кампан-мастрихт) непосредствено СЗ от с. Челопеч, Софийско, е разработена високоразделителна (HIRES) стратиграфска подялба на единицата в изучения район. Единицата е представена от циклична алтернация на предимно тънкопластови разнозърнести полимиктови пясъчници, варовити алевролити, варовити аргилити, мелгели и хипоскали. Установяват се още тънки прослойки от песъчливи варовици, туфозни пясъчници и др. Скалите са богати на текстурни белези. Най-общо строежът на циклите се характеризира с долна предимно псамитова, средна – алтернация на пясъчници и смесени скали (хипопясъчници, хипоалевролити и песъкливи мергели), и горна част, в която преобладават финозърнести материали, които от своя страна могат да се покриват отново от пясъчници. Съотношението между тези три части варира значимо. Установяват се както цикли в които средното и горното ниво напълно отсъстват, така и такива в които те доминират. Често последните са с по-значима дебелина. По-голямата част от циклите са асиметрични, често отсечени, но се установяват и симетрични такива. Наред с анализът на цикличността в единицата бе възможно идентифицирането и проследяването на редица маркиращи или корелационни нива като: нива на развитие на относително дебели цикли; пакети от амалгамиране на цикли; нива с по-мащабно проявление на ерозионни процеси, вътрешнобасейново преотлагане, субаерална експонация и т.н.; нива с белези на по-бърза седиментация; нива на активна хидродинамика; нива обогатени на био- и растителен детрит; и нива съдържащи и обогатени на свежи вулкански материали.

## Introduction

The Chugovitza Formation is introduced as formal lithostratigraphical unit by Moev and Antonov (1976). The name comes from the Chugovitza countryside, NW of Chelopech village, Sofia district that also is recommended as holostratotype area but the section is not described. In previous studies the unit is described as "third horizon of the Senonian (Nikolaev, 1947) and "fourth horizon of Maastrihtian" (Vrablyansky et al., 1961).

On the base of published and new obtained data, mainly abundant fossil foraminifera and limy nanno-plankton associations Zhelev et al. (1999f) accepted that main part of the unit is with the Maastrichtian age. The lowermost levels of the Formation that outcrops to the west of the studied area belong to the Campanian stage. The same authors accept that the Campanian/Maastrichtian boundary is inside the first (lowermost) sandstone stratigraphical marking level in the unit.

During the period of 2006-2007 year Balkan Mineral and Mining (BMM) EAD, with which permission is published this study, realized large scale prospecting drilling program in the area of Chelopech syncline, NW of Chelopech village, that include the type area of the unit. This gave good opportunity to

be collected and analyzed new data about the lithology and the structure of the Chugovitza Formation in its holostratotype area.

The aim of this study is to present the lithological data obtained from the specialized lithofacial study of the Chugovitza Formation in three drillings in the eastern part of Chelopech syncline, NW of Chelopech village, Sofia district, and to be demonstrated the possibility to be applied high-resolution (HIRES) approach for subdivision of such sedimentary sequence.

## Material and methods

The paper is based on the results of the specialized lithofacial studies of core material from three drillings, situated in the northern limb of the Chelopech syncline (Fig. 1). The core material is storied in the core-depository of BMM EAD in Chavdar village, Sofia district. The calculation of the true thickness of the units is based on the structural data given by BMM EAD as well as on National Geofund materials (Zhelev et al., 1999). During the macroscope study of the core materials were recognized, studied and described lithological and lithofacial types under application of standard abbreviation code that correspond to the content, texture and structure of the protolith. The vertical scale of the lithological column in the text description corresponds to the drilling data (depth from the surface) but no to the real thickness of the units.

The description of the mixed clastic-carbonate rocks is based on the classification scheme proposed by Sultanov (1980). The field grain-size characteristic of the clastic and the carbonate rocks is based the developed by Friedman and Sanders (after Miall, 1990, Table 2.1) standard scale.

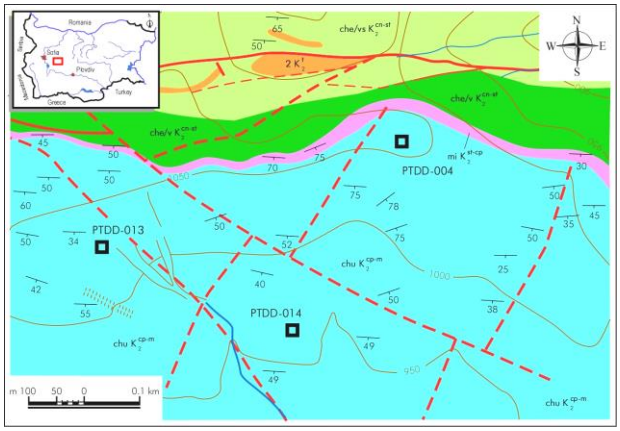


**Fig. 1. Schematic geological map of the studied area position of the studied and sampled during this investigation drillings (on the base of data given by BMM EAD and after Zhelev et al., 1999). *Abbreviations*: 2 $K_2^t$ – sandstone suite; Chelopech Formation: che/v $K_2^{cn-st}$ – volcanogenic package; che/vs $K_2^{cn-st}$ – volcano-sedimentary package; mi $K_2^{st-cp}$ – Mirkovo Formation; chu $K_2^{cp-m}$ – Chugovitza Formation**

## Lithological characteristic

The rocks of the Chugovitza Formation are established in three of the studied drillings – PTDD-004, 013 and 014. The thickness of the unit varies from about 25 m (drilling PTDD-04) to over 128 m (interval 0-155 m) in drilling PTDD-14.

According to Moev and Antonov (1976) the Formation is presented by flysch-like (cyclic) alternation of thin bedded poor sorted polymictic sandstone, limy siltstone and limy claystones. Some thin beds of sandy limestone, tuffs and tuffaceous sandstone are established also. The average thickness of the cycles is from 45 to 70 cm.

In the studied sections of the unit the lowermost levels are dominated by sandstones. In the rest part of the Formation is observed cyclic flysch-like alternation of sandstone, clayey and silty sandstone, marls and mixed rocks as hyposiltstone, hyposandstone and hypolimestone. The sandstones are polymictic. The texture is medium to fine- and very fine grained. Coarse- and very coarse grained varieties are observed relatively rare, mainly in the lower part of the unit. They are built up by mineral fragments and lithoclasts with very varied size – from fine grained psammitic to gravel. Most often they are built up by clastic and pyroclastic component. The clastic component dominates and is presented by quartz, plagioclase, K-feldspar, muscovite, epidote and lithites. Their summary amount most often is over 55-60%. The quartz and plagioclases dominate. The mica (mainly muscovite) and the K-feldspar are in subordinate amount. The lithoclasts are presented mainly by quartzites, phyllites and gneisses. Rarer are observed some rock fragment by siltstone, granite etc.

The pyroclastic component is presented by plagioclases, biotite and lithoclasts. The biotite is fresh, reddish-brown, feature that indicate for its volcanic origin (Fig. 2a). The pyroclastic plagioclases, in contrast to the clastic ones, are fresher and with more rectangle-like form. The lithoclasts are angular to semi-rounded and built up by medium as chemistry porphyric and aphyric volcanites (Fig. 2b), and of the ground mass microlithic and hyalopelitic texture. Average generalized amount of the pyroclasts is in the range 10-15%. The cement of the sandstones is clayey-limy or completely calcitic, most often basal or contact-pore type.

The sandstones demonstrate significant variety of structural features. Generally dominate the massive, parallel laminated and flaser structure. The lamination is fine to crude, often heterolithic (most often manifested by the mica and the intraclasts). In the base of the flysch-like cycles, mainly in the lower part of the unit, is established normal grading according to the grain size (the texture), which lower part is built up by very coarse to coarse grained sandstone, in some cases enriched with gravel and/or psephitic fragments, and the upper part is presented by medium- to fine grained sandstones. Very often the sandstones are weakly to medium affected by horizontal and vertical bioturbations. The cross-bedding is established only in several beds, and is presented by small scale (current ripples) and mesoscale (low-angel) one. Other typical feature of the sandstones is the wide development of the convolute lamination, which is established as in the lower part of the cycles as well as in their middle and upper parts. Some features of syn-sedimentary slumps are observed as well.

The other lithological varieties are presented by clayey siltstones, hyposiltstones, silty and limy claystones, silty marls as well as very thin solitary beds and lenses of hypolimestones. The structures are massive, fine nodular, fine parallel laminated to lenticular one. In them the bioturbations are more often horizontal and more abundant and could be seen in several levels in one bed indicating that the bed is formed in several stages.

The lower boundary of the Formation represents gradual lithological transition (interval with thickness between 4.5 and 7.7 m) towards mainly reddish limestone of the Mirkovo Formation. In its upper part this transition is presented by alternation of mainly reddish in different degree limy sandstones and mixed rocks, while in its lower part is observed irregular alternation of reddish sandstones and clayey limestones, mixed rocks and limited amount of sandstones. Lithologically these rocks are significantly different from those of the proposed by Moev and Antonov (1976) Voden Member of Chugovitza Formation that is built up by fine laminated, grey claystones and marls with different amount of psammite-silty component. That is why this interval has to be accepted as the transition between the Chugovitza and Mirkovo Formation.

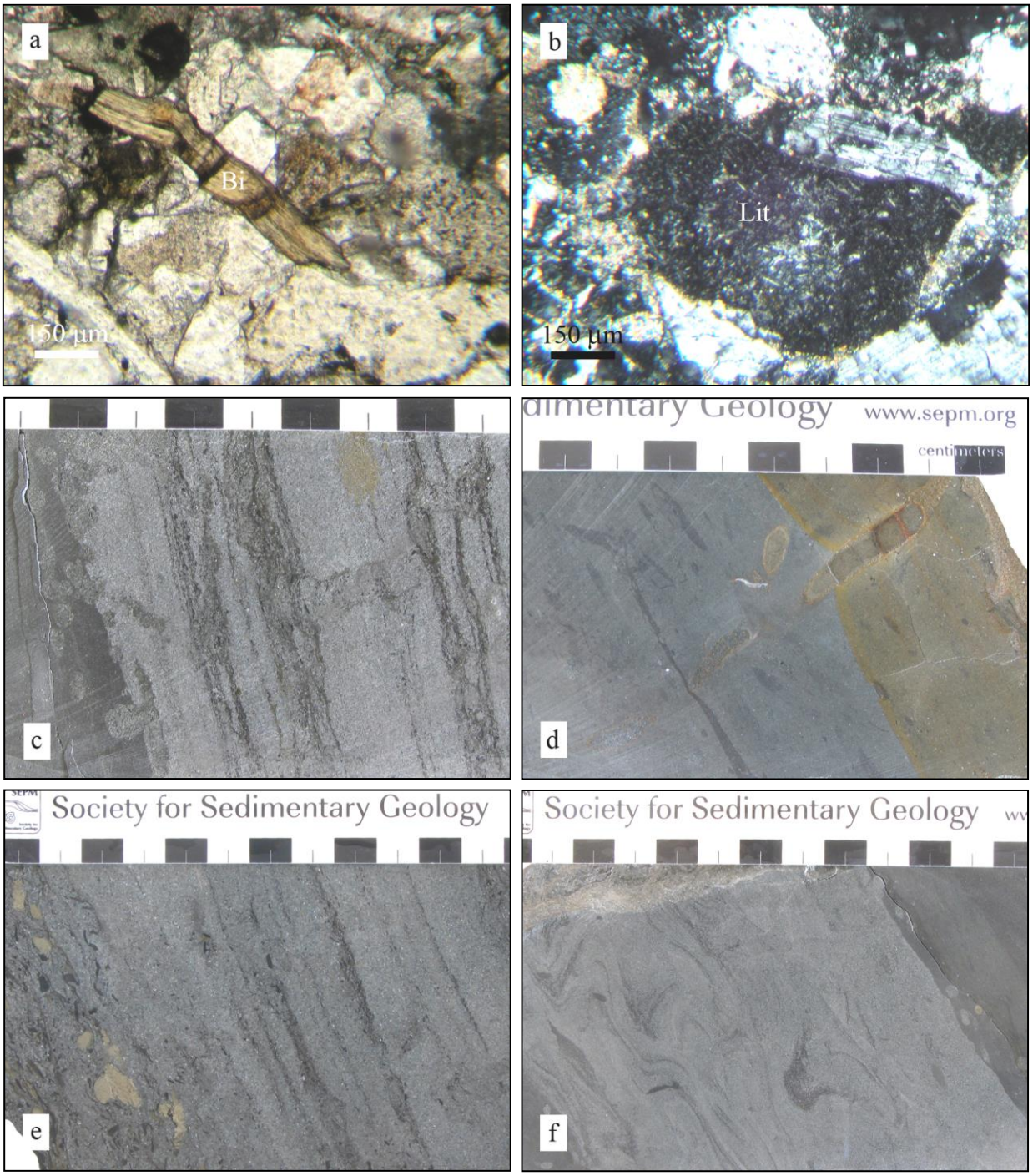


**Fig. 2. Micro- and macrophotographs of characteristic lithologies and structures for the Chugovitza Formation: a – deformed fresh biotite (II N, PTDD-013, 88.40 m); b – lithit from volcanic rock in sandstone with pyroclastics (+ N, PTDD-013, 88.40 m); c – heterolithic, crude parallel lamination from the base of the cycle, affected by vertical bioturbations. In it lower part (left end of the photo) are developed small scale bioturbations and load casts, (PTDD-013, 91 m, base – left end of the photo); d – vertical bioturbation, that start from the lower part of sandstone bed from the base of cycle and is developed downwards in the hyporocks from the uppermost part of the previous cycle, (PTDD-013, 13 m, base – left end of the photo); e – very crude heterolithic (according to carbonized plant detritus and biotite) parallel lamination in 115 cm thick, dominated by sandstone cycle. In their lower (left part of the photo) part – framboidal pyrite inside level enriched by organic (PTDD-014, 116 m, base – left end of the photo); f – convolute lamination in sandstone from the middle part of cycle (PTDD-014, 53 m, base – right end of the photo). Abbreviations: Bt – biotite; Lit – lithit**

## Cyclicity

Generally the structure of the cycles is characterized by lower, mainly psammitic, middle – alternation of sandstone and mixed rocks (hyporocks, hyposiltstone and sandy marls), and upper part, where dominate fine grained materials that could be covered again by sandstone (Fig. 3). The proportion between these three parts varies significantly. There are cycles in which the middle and upper part completely absent, as well as those in which they dominate. Often the last ones are with more significant thickness. More of cycles are asymmetric, often cut off, but are established symmetrical as well.

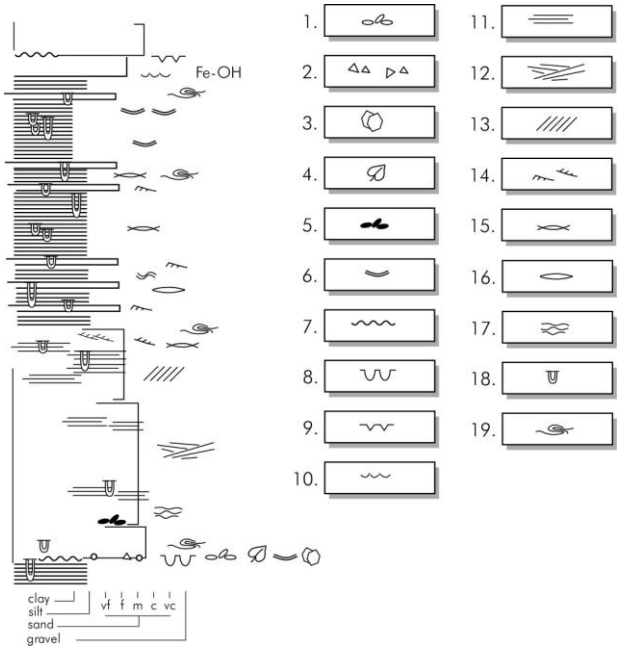


**Fig. 3. Schematic model of the structure of idealized cycle typical for the studied sections of Chugovitsa Formation: *extraformational rock fragments* (1-2): 1 – terrigenous; 2 – volcanic; 3 – enrichment with muscovite (terrigenous); 4 – carbonized plant detritus; *intraformational rock fragments* (5-6): 5 – terrigenous; 6 – bioclasts; 7 – erosional surface; 8 – load casts; 9 – cracks; 10 – tepee structure; 11 – parallel lamination; *cross-bedding* (12-14): 12 – mesoscale trough and low-angel; 13 – mesoscale planar; 14 – small scale (current and climbing ripples); 15 – flaser structure; 16 – lenticular structure; 17 – nodular structure; 18 – bioturbations; 19 – syn-sedimentary deformations**

Most often the base of the cycle represent flat surface. Rarer it is low amplitude erosional one. It is quite possible, because of the limitation that comes from the size of the studied core material when the bounding cycle surfaces were studied, the quota of the erosional bases of the cycles to be significantly larger. Often the base is connected with development of load cast (Fig. 2c). In some cases the base of the cycles is enriched by intra- and extraformational fragments. Other typical feature of this part of the cycles is the development of vertical bioturbations that start most often from the sandstone beds in their lower part and cross down the base surface continuing in the fine materials from the cycle bellow. In some cases they are filled with partially oxidized materials (Fig. 2d). The frequency (density) of this type bioturbation varies. It is important to be mentioned that in most cases they start from some part inside the sandy interval. Some bioturbation with significant amplitude (over 25 cm) are found in different levels inside this part of the cycles.

The sandstones from the lower part of the cycles are massive to parallel laminated and is observed some alternation of these two structure as well. Often the lamination is crude, heterolithic (Fig. 2e). Cross bedding is observed rarer. It is presented mainly by low angle and small scale (ripple marks), the last one typical for the uppermost parts of this interval. Different in scale syn-sedimentary deformations are established also. The thickness of the sandstone part of the cycles vary from 7-12 to over 100 cm, average 30-35 cm. The sandstone/mixed rocks alternation in the middle part of the cycles most often leads to development of various forms of flaser structure. As a rule the sandstone in this level are medium to fine grained, rare very fine grained. Various as form and density vertical and horizontal bioturbation are observed as well. In some cycles in this interval is observed clear developed convolute lamination (Fig. 2f). The transition between this part of the cycle into the lower one is gradual.

The upper part of the cycles is characterized by the domination of the fine grained (siltstone and claystone) and mixed rocks. Here the sandstones are rare. Most often they are developed as solitary lenses or participate in lenticular bedding. This part of the cycles is most intensively bioturbated with the domination of the horizontal ones. The total thickness of the middle and upper part of the cycles vary from 5-10 to over 135 cm, average 25-40 cm.

## High-resolution stratigraphy

The great variety of structure and texture features in the rocks of the Chugovitza Formation, as well as the presence of some specific lithologies in it gives good opportunity for development of more detail (including the high-resolution ones – HIRES) stratigraphical scheme. Despite that the unit was established only in three of the studied drillings, it was possible to be identified and traced many stratigraphically correlative levels as follows: levels with development of relatively thick cycles; levels with packages of amalgamate cycles; levels that contain fresh volcanic products; levels with features of rapid sedimentation; levels with more intensive development of erosional processes, intrabasinal re-deposition, subaeral exposition etc.

Macroscopically most contrast presented are the levels with development and preservation of thicker cycles, as well as those with cycle amalgamation. As whole the cycle thickness in the Chugovitza Formation vary in wide range – from 15-25 cm to over 1.7-1.8 m (drilling PTDD-013 – 42th and 78th meter, as well as drilling PTDD-014 –13-th and 66-th meter) at average value 45-70 cm. The study of the lithofacial peculiarities of the cyclicity in the drillings PTDD-013 and PTDD-014 reveal similarity (according to the content, structure and position in the unit profile) of eleven, situated one over another relatively thick cycles (with thickness over 1.20 m). In most of the cases these are solitary cycles. In the lower part of the Formation are established some series of such cycles also. For example fifth level contain two cycles, the first and fourth levels – three cycles, and the third level is built up by four cycles.

The use of above described levels for stratigraphical correlation has to take very careful in account the specificity of the sediment accumulation in the concrete outcrop or drilling. For example there are indications that some local factors, as the volume of the accommodation space and/or the terrigenous supply, influencing the structure and the summary thickness of the cycles. This imposes the stratigraphic value of these levels to be estimated through their tracing in the other

drills and/or in the outcrops. This problem could be solved easy through tracing of the levels with thick cycles accompanied with those of other stratigraphic correlative (marker) levels as those with enrichment with fresh volcanic materials, enrichment with plant debris, those with features of rapid sedimentation, erosional levels etc.

The amalgamation of cycles and, as a result of this, the forming of packages dominated by deposits, typical for the lower part of the cycles (as sandstones) is the other, macroscopically clear pronounced form of correlative (marker) levels. Such levels were established at the base of the Formation. In drillings PTDD-013 and PTDD-014 they form interval with thickness 22.5-23.4 m, in which are observed three or more traceable packages that are built up mainly by sandstones. The thickness of these packages varies from 6.9 to over 11.8 m. The intervals between these packages have more pronounced cyclic structure in which take parts fine grained materials as well. In drilling PTDD-004 this interval is more uniform and is built up almost completely by sandstones, among which are established solitary thin beds of allochemical, sandy, red-colored nodular limestone. The core diameter not allows correct estimation of the origin of these intercalation and it is completely possible these to be some intraformational fragments (?). Since the level with limestone is only 8 m above the upper boundary of the transitional interval with the Mirkovo Formation, it is possible also this limestone to be in situ and to presents, actually, the beginning of this transition between the two units. Limestone (but as fine grained, fine parallel laminated and massive calcarenite) built up significant part (over 2.5 m) of the third uppermost sandstone package in drilling PTDD-013. They are intercalated by sandy limestone and limy sandstone, enriched with pyroclastic material. As according to the position in the profile, as well as according to their content and structure, these rocks are not analog to the limestone of the Mirkovo Formation.

Because of multiple fine-grained hyporock, marl and siltstone intercalation, upwards the sandstone packages in drillings PTDD-013 and PTDD-014 stay more and more inhomogeneous. The correlation of these packages between the drillings gives the impression of development of accretional body that growth towards south-southwest, with source area to the north. In fact in drilling PTDD-004, the northernmost of the three ones, are established most as number and clear developed erosional surfaces, the rocks are coarser, including the appearance of breccia-conglomerate. Contrariwise, in the most southern drilling this interval contain most as number and thickness finegrained intercalations. Again here are established carbonized plant debris and framboidal pyrite. The amalgamated sandstone level from the base of the Chugovitza Formation probably correspond to the lowermost (the first from the three in the unit) sandstone marker level established by Zhelev et al. (1999f). The same authors accept that these marker levels are well traceable mostly in the northern part of the Chelopech syncline.

Till the moment accepted model for the genesis of these packages is connected with the amalgamation of multiple cycles (indication for which is the great number of erosional surfaces developed in them), as a result of which it was preserved only their lower sandstone part. In the lowermost parts among the sandstones there are large, relatively well rounded volcanic rock fragments as well. The discussed above peculiarities, however, give the reason to be take in mind the possibility this sandstone level to be formed in shallow marine or coastal settings, most probably as prograding structure.

As support of similar interpretation could be mentioned the fact that the upper boundary of this interval most probably is not isochronous one. Indication of similar idea are its cross relationship with the lowerer from the two situated one over another about 5.5 m levels with re-deposited (oxidized) volcanic rock fragments from the lower part of the Formation, established respectively on 105 m in drilling PTDD-013 and 117 m in drilling PTDD-014. Also in this interval are established desiccation cracks that, no doubt, are evidence for subaeral exposure.

In drilling PTDD-014 are established two levels with thickness from 1.7 to 4.1 m that are dominated by mixed and fine-grained rocks, which built up respectively 80-83 and 92-97 m of the core of the drilling. Similar level was established also in drilling PTDD-013, but it is situated obviously straigraphicaly “higher” than the described above four. Other appropriate correlation (marker) levels are those in which enrichment of volcanic material has been found. Five such levels have been established: *first* (PTDD-013 – 105 m, and PTDD-014– 117 m), *second* (PTDD-013 – 99 m, and PTDD-014 – 112 m), *third* (PTDD-013 – 88 m, and PTDD-014 – 99 m); *fourth* (PTDD-013 – 43 m, and PTDD-014 – 55 m) and *fifth* – respectively PTDD-013 – 14.5 m, and PTDD-014 – 27 m. In the first two levels are presented mainly oxidized volcanic rock fragments, and in the upper two – pyroclastic, including fresh dark-brown biotite. Fresh pyroclastic biotite was established also in the second level. Because of the very limited number of the drillings in which they were established, the origin (volcanogenic or epiclastic one) of these levels was not clarified enough. Despite this we accept them as enough reliable chronostratigraphical marker level.

Four levels with features for relatively rapid sedimentation have been suggested. Among the most easy recognizable typomorphic features of these levels is the wide development of load cast structure. They are situated as follows: *first* (PTDD-013 – 92 m, and PTDD-014 – 105 m), *second* (PTDD-013 – 79 m, and PTDD-014 – 92 m), *third* (PTDD-013 – 66 m, and PTDD-014 – 79 m) and *fourth* – respectively PTDD-013 – 56 m, and PTDD-014 – 68.5 m.

Despite that the erosion is among the typical features of the described above cyclicity it was recognized nine different levels with more intensive development of erosional processes and intrabasinal re-deposition outside the volume (over) the package of the amalgamed sandstones from the base of the Formation. They are situated as follows: *first* (PTDD-013 – 102-104 m, and PTDD-014– 115 m), *second* (PTDD-013 – 88,5 m, and PTDD-014 – 100 m), *third* (PTDD-013 – 75 m, and PTDD-014 – 86 m), *fourth* (PTDD-013 – 45,5 m, and PTDD-014 – 58 m), *fifth* (PTDD-013 – 39 m, and PTDD-014 – 52 m), *sixth* (PTDD-013 – 34 m, and PTDD-014 – 47 m), *seventh* (PTDD-013 – 9,5 m, and PTDD-014 – 23 m), *eight* (PTDD-013 – 7 m, and PTDD-014 – 18,5 m) and *ninth* – respectively PTDD-013 – 4,5 m, and PTDD-014 – 16,5 m. The manner of manifestation of these levels is not completely equal. Except the presence of erosional surfaces in drillings, they are connected also with simultaneously with them development of: (*i*) intraformational lag deposits and mesoscale cross bedding (for example in the second level); (*ii*) primary oxidation of the sediments, con-

firmed also with the character of the infill of the bioturbations – for example in third level, there is the jointly development of the both features; (*iii*) tepee structures and intraformational lag deposits (for example in seventh level).

Among the easy recognizable correlative markers are also the three levels with features of active hydrodynamic setting of sedimentation, revealed as development of meso- and small scale cross-bedding: *first* (PTDD-013 – 63 m, and PTDD-014– 75 m), *second* (PTDD-013 – 38 m, and PTDD-014 – 50 m) and *third* - respectively PTDD-013 – 3 m, and PTDD-014 – 15 m. Because of the discussional character of the genesis of the cyclicity in the Formation, the stratigraphical importance (value) of this marker levels is relatively low.

It was established also two intervals with significant appearance of bioclasts, mainly as lag deposits: *first* (PTDD-013 – 89-93 m, and PTDD-014 – 96-112 m), *second* (PTDD-013 – 64-76 m, and PTDD-014 – 74-87 m). These levels might be interpreted also as those of *increased bioproductivity*. In this group should be included also two other groups of levels in which are established increased amount of carbonized plant debris: *first* (PTDD-013 – 96 m, and PTDD-014 – 106 m), in which were established some features connected with primary oxidation of the sediments (connected, probably, with subaeral exposition), and *second* (PTDD-013 – 92 m, and PTDD-014 – 105 m) which, contrariwise of the first, has the features of reductional sedimentary setting (development of framboidal pyrite). The second level coincides with the first level with features of relatively rapid sedimentation.

## Discussion and conclusions

No doubt the diversity as origin and as features and the significant number of the established and traced correlative (marker) levels in the section of the Chugovitza Formation allows it more detail and precise subdivision and intraformational correlation. Some of these levels are combined in specific manner that forms easy and well recognizable succession of levels that make their stratigraphical application very convenient. From the other hand, the presented study is still in its initial stage and the proposed approach need to be applied in wider area that will test more correctly the stratigraphic value of the proposed above types of marker levels. The obtained data allows to be given also a new meaning of the probable flysch (turbidite) genesis of the cyclicity in the rocks of Chugovitza Formation.

First of all it is connected with the establishment of features of multy-act formation of the lower part of the cycles. These are: 1 – the great number of multistory, imposed one over another levels of bioturbation in one and the same solitary cycle; 2 – the development of several and not connected each other stages of syn-sedimentary deformations (convolutions) in the profile of one and the same cycle as well. Other specific feature is connected with the lower boundary of the cycles that very often is cross-cut by vertical bioturbations, which start from inside of and contain (are filled with) materials from the lower part of the cycles, which usually is massive or uneven laminated sandstones, structure accepted as features of "ephemeral" sedimentation. Often, exactly inside these "ephemeral" deposits, also are observed several, clearly separated one from another levels (therefore stages also) of bioturbation that, factually, reject the possibility these to be flysch type sediments. Quite often the bioturbation that starts from the lower parts of some cycle and continue in the upper part of the below situated one to be filled with oxidized materials (Fig. 2d).

The possible non-flysch character of the genesis of the materials of the Chugovitza Formation is indicated also by the existence of well preserved fragments and lag deposits of carbonized plant debris, with which associate the development of framboidal pyrite. In some cases on the base of the cycles together with the plant debris was found intraformational clasts that shows features of syn-sedimentary oxidation of the materials that could be interpreted as result of subaeral exposure of these materials during their precipitation.

Other specific feature of the cycles is the forms of erosion and re-deposition inside of the small cycles. Very often in the upper half of the cycles, where it could be found as sharp erosional surface, as well as lag deposits of intraformational clasts which lithology are analogical with those of this part of the cycle. The forming of this type of intraformational clasts needs some lithification of the sediments before their short transport and re-deposition.

In regional view the rocks of the Mirkovo Formation, that lie below those of Chugovitza Formation, indisputable, mark stage during which it was formed wide shallow marine sedimentary environment that could be traced continuously in wide area. The transition between these two units is gradual, and in the rocks of the Chugovitza Formation it was not found features of re-sedimentation of materials from the Mirkovo Formation. These facts rather not support the idea that the genesis of the rocks of the Chugovitza Formation is connected with the flysch generation that needs trough forming, which no doubt had to led to some re-deposition of the materials of the Mirkovo formation in the profile of the Chugovitza Formation.

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