

Characteristics of the Middle Cenomanian Rhythmic Sequence from Mount Selbukhra in Southwest Crimea

E. Yu. Baraboshkin and I. A. Zibrov

Faculty of Geology, Moscow State University, Moscow, 119991 Russia

e-mail: barabosh@geol.msu.ru

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Abstract—New lithological, ichnological, and isotope data are given for the rhythm from the section of the Middle Cenomanian rhythmic sequence at Mount Selbukhra. The intense rock bioturbation has distinct multistage structure that is typical of writing chalk sections and corresponds to the Cruziana ichnofacies that are characteristic of the soft grounds of the open shelf. The values of the $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ ratios in ichnofossils contradicts the model of the farming structures for the *Chondrites* and *Zoophycos* and indicate the passive infilling of *Thalassinoides* burrows by sediments. It was established that organic-rich marlstones accumulated under higher bioproductivity and the bottom anoxia were augmented by dissolution cycles. Based on our data, it is not possible to relate the rhythmicity to the precession cycles with confidence.

Keywords: rhythm, Upper Cretaceous, Middle Cenomanian, trace fossils, stable isotopes, cycles of dilution, Crimea

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INTRODUCTION

Many studies have been dedicated to the structure and formation conditions of the Middle Cenomanian rhythmic carbonate section in Mount Selbukhra (southwest Crimea) (Alekseev, 1989; Naidin and Kiyashko, 1994a, b; Gabdullin, Guzhikov, and Dundin, 1999; Gabdullin, 2002; Naidin, 2004, 2005, 2008). In 2010, E. Yu. Baraboshkin and I. A. Zibrov studied the section of this sequence, characterized the structure and ichnology of one rhythm in detail, and obtained new data on the $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ ratios in rocks and ichnofossils, which was briefly reported previously (Baraboshkin, Zibrov, and Pokrovskii, 2011).

The reviewed section is situated at a small distance from the training base of Moscow State University in the settlement of Prokhladnoe (southwest Crimea), in the washout at the southern slope of Mount Selbukhra, 180 m to the east–southeast from its top (44°44.248'N, 33°59.879'E) (Fig. 1). The section corresponds to member V of the “rhythmic alternation of marlstones, light-gray calcareous marlstones, and muddy limestones” which conform to the *Rotalipora cushmani* foraminifera zone, and is a compound of the Belogorskaya Formation (Cenomanian–Lower Turoanian) (Alekseev, 1989). The interval that was studied in detail corresponds to the top of rhythms 2 and 3 and the basement of rhythm 4 (dark-gray marlstones after Naidin, 2004). The rocks gently dip to the northwest at an azimuth of 300 and at an angle of 10.

The ichnofossil collection no. 114 is stored in the Museum of Earth Science Museum of Moscow State University.

LITHOLOGICAL COMPOSITION

The studied rhythm contains two clear elements (petrotype 3, after Gabdullin (2004)), which are represented by two lithotypes.

The more calcareous upper element is lithotype 1 (limestones, Fig. 2A), which microscopically consists of light-gray bioturbated foraminifera–calcispheric wackestones (10–25% of foraminifera and up to 88.8% CaCO_3) with single silty quartz grains, fragments of an inoceramus prismatic layer, and pyrite crystals up to 0.05 mm (Gabdullin, 2002). The amount of clay is 4.5–5%; illite is the dominant clay mineral and the content of organic matter is 0.08% (Gabdullin, Guzhikov, and Dundin, 1999; Gabdullin, 2002). The top of the layers, which is composed of lithotype 1, is a break surface of the soft (Baraboshkin et al., 2002) not the hardground, as it was considered previously (Naidin, 2008).

The less carbonate and more muddy lower element is formed by lithotype 2 (marlstones, Fig. 2B) gradually alternating with lithotype 1. It is a dark-brown muddy bioturbated foraminifera–calcispheric wackestones (10–20% foraminifera and up to 69.7% CaCO_3 , after Gabdullin, 2002) with single 0.05–0.15 mm silty quartz and glauconite grains. The darker rock color is explained by the large amount of clay (12.5%) and organic (0.44%) matter (Gabdullin, Guzhikov, and Dundin, 1999; Gabdullin, 2002). The composition of clays is more diverse (illite, montmorillonite, and chlorite) but illite dominates (Gabdullin, 2002). The base of this rhythmic element is always sharp.

Both lithotypes are characterized by dominant plankton foraminifera (80–90% of the total amount) where L.F. Kopaevich has identified the *Heterohelix* spp., *Whiteinella* spp., *Whiteinella archaeocretacea* Pessagno, *Rotalipora* sp., and the *Thalmanninella* sp. The benthic foraminifera include calcareous and agglutinate forms such as *Lenticulina* sp. and *Textularia*(?) sp. Locally, autigenic quartz fills foraminifera shells.

The absence of coarse-grained terrigenous material, illitic clay fraction, and the sharp predominance of plankton foraminifera over the benthic ones indicate sedimentation in a marine basin far from the coast, in a deep (several hundred meters) shelf (Alekseev, 1989).

ICHNOCOMPLEXES AND ICHNOFOSSILS

The previous works reported on *Chondrites* isp., *Phycosiphon* isp., *Teichichnus* isp., *Thalassinoides* isp., and *Zoophycos* isp. in the studied section (Gabdullin, 2002). We have identified *Arenicolites* isp., *Asterosoma*? isp., *Chondrites intricatus* Sternberg, *Ch.* isp., *Cylindrichnus* isp., *Helminthopsis* isp., *Planolites* isp., *Thalassinoides paradoxicus* (Woodward), *Th.* isp., *Taenidium* isp., *Zoophycos* cf. *brianteus* Massalongo, and *Zoophycos* isp.

The bioturbation and ichnofossils are unevenly distributed through the rhythm elements. The estimation of bioturbation intensity is based on the semiquantitative bioturbation (ichnofabric) indices (BI) suggested by M.D. Droser and D.J. Bottier (1986). The rocks of both rhythm elements are completely bioturbated (BI = 6), which was shown by the absolute absence of primary structures when varying numbers of separate burrows can be distinguished on a background of a completely bioturbated mass. According to our observations (Fig. 3), the upper part of the more carbonate rhythm element (light limestones, BI = 4/6) is the most bioturbated and the least carbonate rhythm element is less bioturbated (dark marlstones, BI = 2/6). The basement of the light limestone layer occupies an intermediate position (BI = 3/6).

The taxonomic composition of the ichnofossils changes downward in the rhythm. *Thalassinoides* and *Planolites* filled with gray muddy wackestone are dominant in the upper part of the light element; *Zoophycos* and *Chondrites* prevail in the base of the light element; and only *Chondrites* are present in the dark limestones. Thus, the location of ichnofossils is clearly stratified, which is typical of writing chalk sections (Bromely, 1996) and characterizes the decrease in sediment aeration and increase in anoxia (Fig. 4). Only *Chondrites* are revealed in the lower rhythm element; this contains the greatest amount of clay and organic matter, which is consequently more oxygen-free, as is explained by anoxia-stable *Chondrites* (Bromely, 1996; Stanley, 1996). In addition, numerous *Chondrites* were noted inside *Thalassinoides* holes (Fig. 4) passively

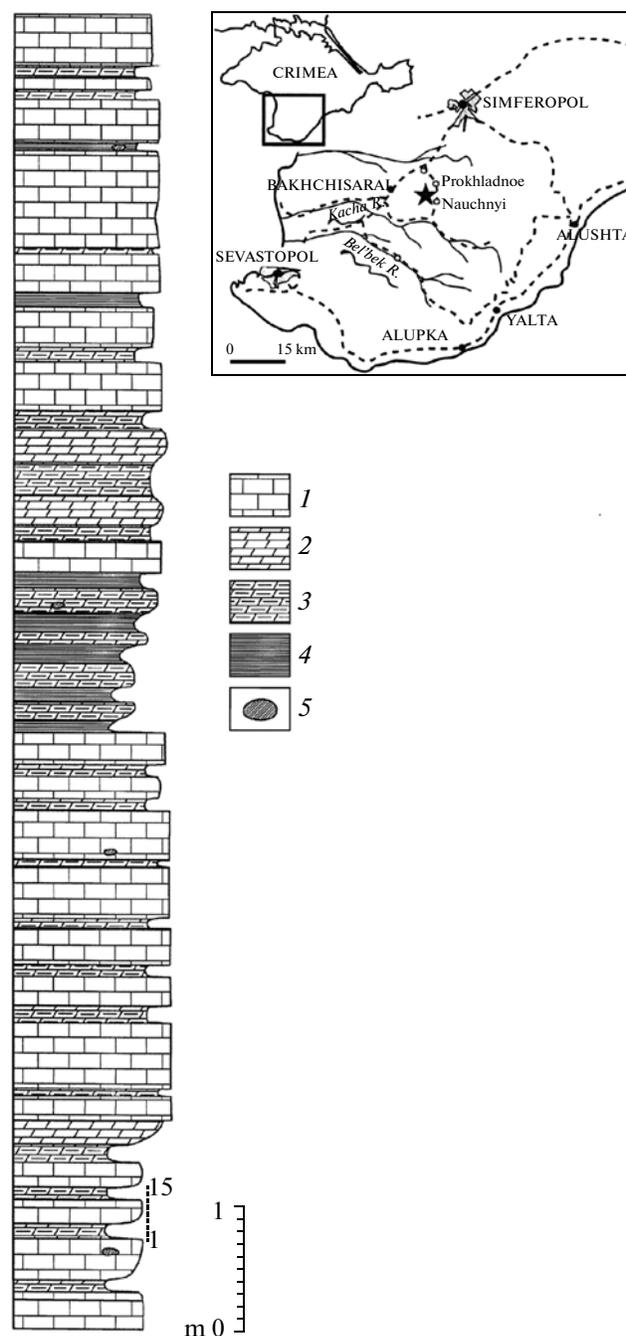


Fig. 1. The location and structure of the studied section: (1) wackestones; (2) muddy wackestones; (3) strongly muddy wackestones; (4) calcareous mud; (5) large pyrite nodules.

filled with dark-colored rocks of the lower anoxic rhythm element. In comparison to *Thalassinoides*, the infill of the *Planolites* is lighter and probably is not related to the sediments of the lower rhythm element.

The following ichnofossils are the most widespread in the section.

***Chondrites* (Brongniart, 1828)** consist of systems of small cylindrical dichotomically branched (but never

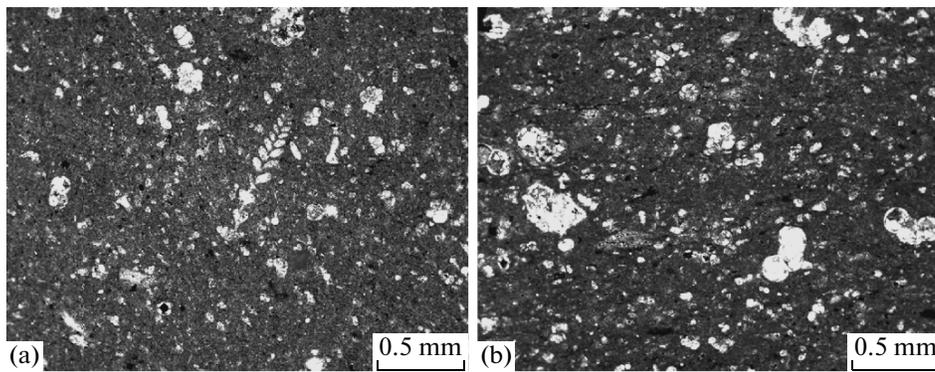


Fig. 2. Basic lithotypes of the studied rhythm: (a) lithotype 1, wackestones with *Textularia* (?) sp., thin section KR-10-3/7; (b) lithotype 2, muddy wackestone with *Whiteinella* sp. and *Thalmanninella* sp., thin section KR-10-3/3. Scale bar is 0.5 mm, crossed nicols.

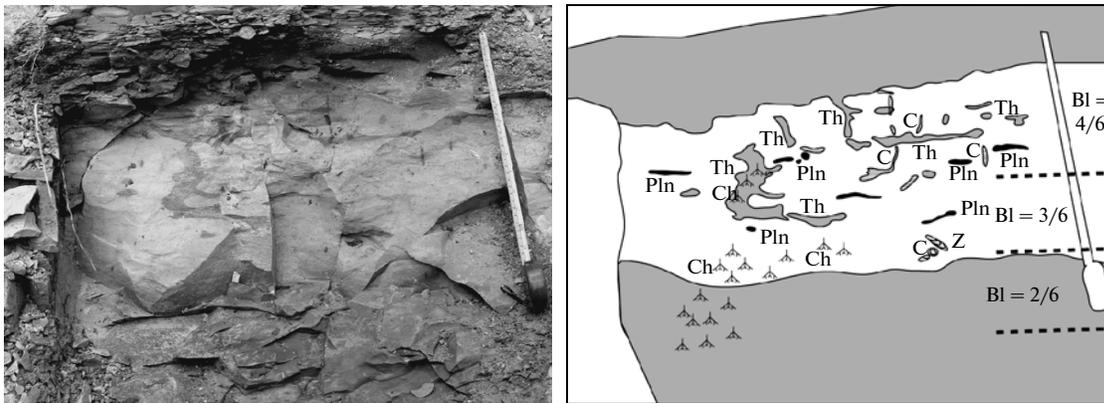


Fig. 3. Stratified location of the ichnofossils in the studied rhythm. Photograph (left) and its interpretation (right): (BI) bioturbation indices after (Droser and Bottjer, 1986); (C) *Cylindrichnus* isp., (Ch) *Chondrites* isp., (Pln) *Planolites* isp., (Th) *Thalassinoides* isp., (Z) *Zoophycos* isp.

crossing) burrows—tunnels (plate, 5). The typical size of an entire system is several centimeters across and along. *Chondrites* burrows are often reported in the sediment filling the digging traces of larger organisms, for example, in *Thalassinoides* holes (plate, 3). *Chondrites* occur in the various marine ichnofacies and are stable to anoxia. The *Chondrites* burrows are interpreted as farming fabrics (Bromely and Ekdale, 1984) and worms (siphunculids and polychaetes) are their probable creators.

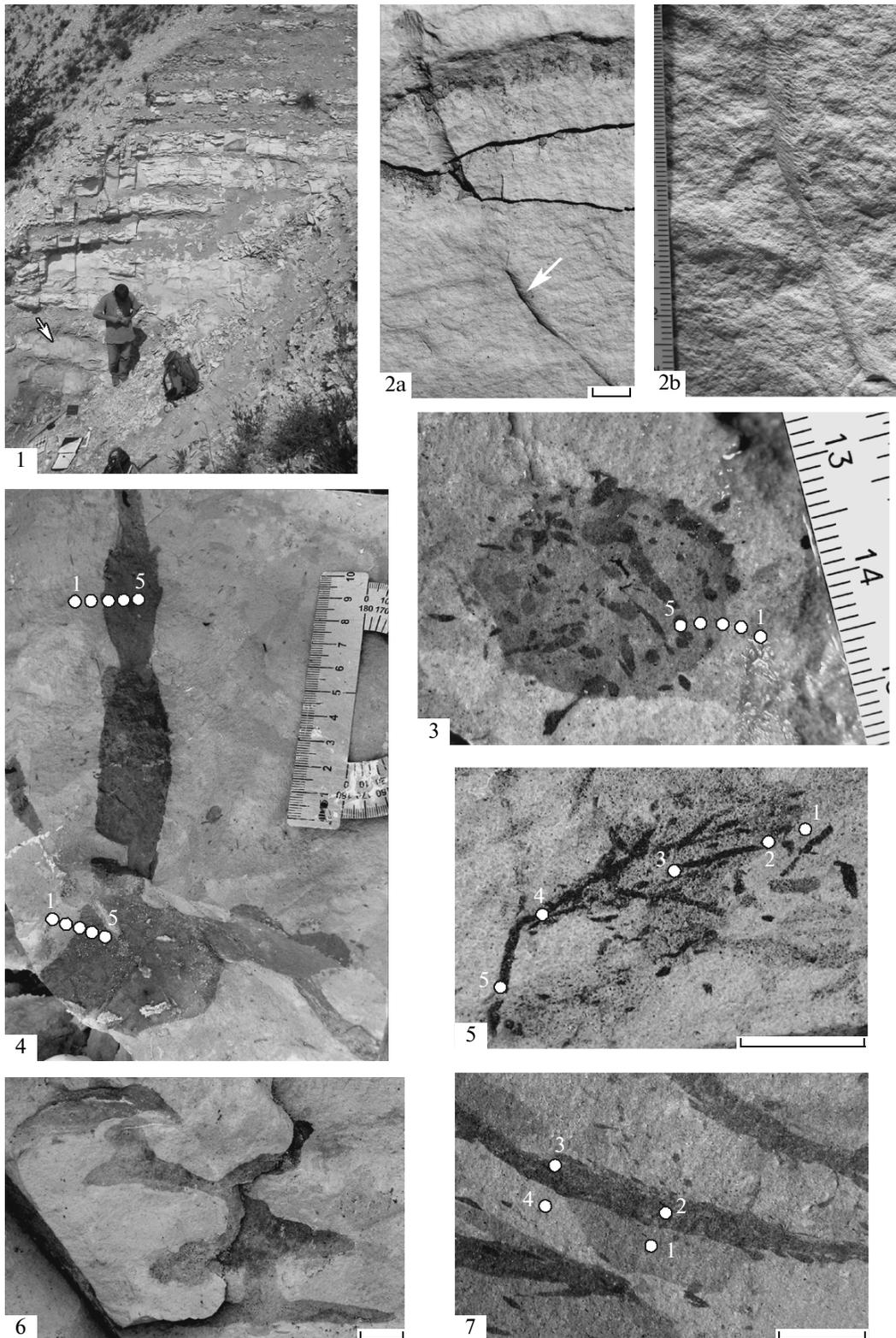
***Thalassinoides* (Ehrenberg, 1944)** are 3-D hole systems composed of cylindrical tunnels and shafts with even walls (plate, 3 and 4). The tunnels are branched more or less evenly forming Y- and T-shaped conjugations, occasionally, with swells. The diameters of the burrows vary from 5 to 45 mm. The depth of the location of burrows in the sediment ranges from several centimeters up to 1.5 m. *Thalassinoides* occur in all facies (from coastal to abyssal) but are most typical of the shoal. The most probable builders of *Thalassinoides* are Decapods.

***Zoophycos* (Massalongo, 1855)** are compound systems of burrows inside the sediment with a common spiral stair shape (plate, 6 and 7). The spiral surface is made up of blades formed by the arcs of individual burrows enclosed each in other and filled with sediments. The morphology of the body varies from flat to cone-shaped. The cone axis is oriented almost transverse to the bedding, whereas its slopes are directed outside. The diameter of the consequent turns increases upward.

Zoophycos are dominant in the ichnofacies of the same name on the continental slope but may occur in the shoal.

The probable interpretations of the *Zoophycos* are food storage (Löwemark and Schäfer, 2003) or nutrition of skeleton-free deposit feeders. Worms (echurids, siphunculids, and polychaetes) are their possible creators.

***Arenicolites* (Salter, 1857)** are simple U-shaped holes several millimeters across (plate, 2). They are confined to the coastal and shoal marine settings of the Cruziana ichnofacies, although they are known in the



The general view of section (1), the arrows indicate the location of the studied rhythm. Ichnofossils are: (2) *Arenicolites*(?) isp. (sample 114/4; (2a) general view, the arrows indicate the location of the fragment shown on (2b); (3) *Chondrites* isp. inside the *Thalassinoides* isp. hole (sample 114/2); (4) *Thalassinoides paradoxicus* (Woodward) (sample 114/3); (5) *Chondrites intricatus* Sternberg (sample 114/4); (6) *Zoophycos* cf. *brianteus* Massalongo; (7) *Zoophycos* isp. (sample 114/5). The points with numerals indicate the locations of the samples that were drilled for isotope analysis; the scale bar is 1 cm.

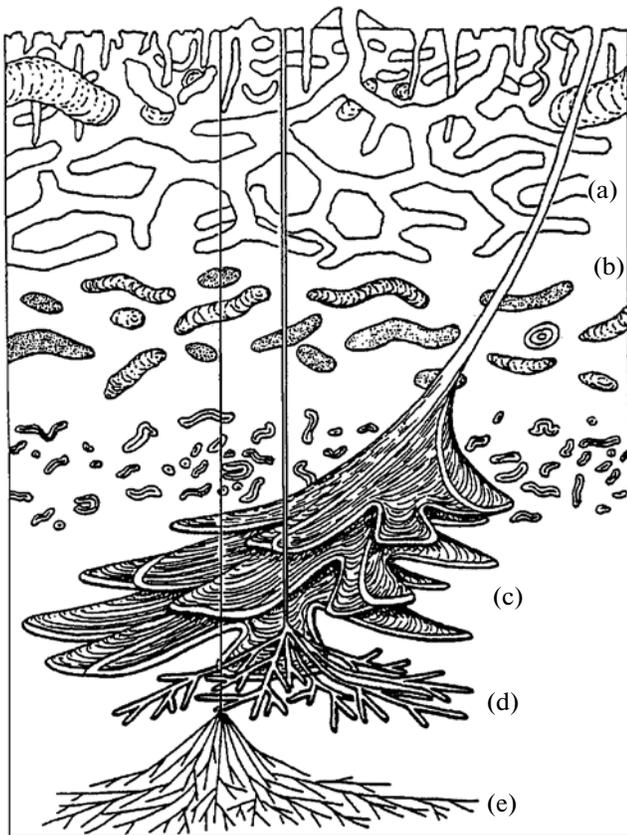


Fig. 4. Vertical stratification of the location of holes of the major bioturbators: (a) *Thalassonoides*; (b) *Planolites*; (c) *Zoophycos*; (d) large *Chondrites*; (e) small *Chondrites* (after Stanley, 1996).

abyssal sediments. *Arenicolites* are interpreted as the habitat and feeding holes of digging invertebrates such as worms (annelids) or small Crustacea (Bromely, 1996).

***Planolites* (Nicholson, 1873)** includes straight, inclined, or slightly curved burrows with flat or weakly ornamented walls (Fig. 3). The vertical section of the tunnels is round or oval after sediment consolidation. The tunnels are chaotically filled, which can be considered as active infill by sediment with participation by the organism.

Planolites occur in the continental and marine ichnofacies. They are interpreted as the traces of worm-like organisms feeding with silt of different genus or class (Bromely, 1996).

Summarizing the above-stated, we can confirm that the studied complex of ichnofossils characterizes the Cruziana ichnofacies and was formed at depth in the open marine basin, which is consistent with (Aleksiev, 1989).

It is evident that the stratification of ichnofossils is related to the sedimentation rhythmicity: the formation of the more muddy organic-rich element was accompanied by anoxia; this is also typical of the

accumulation of the upper element, which is obvious from the location of the *Chondrites* burrows. The sediment was normally aerated during the formation of the more carbonate element. Due to the break in sedimentation ("soft ground") between adjacent rhythms, the sediment was colonized by Crustacea, whose holes are more filled with anoxia sediment. The cementation and consolidation of the bottom surface did not occur because of the large amount of the muddy component in the wackestones. The next stage of sedimentation again resulted in the formation of the local anoxia and the death of most bioturbators, except for the *Chondrites*.

ISOTOPIC ANALYSIS DATA

The isotope composition was determined on a Delta V Advantage mass-spectrometer and Gas-Bench-II device in the Laboratory of Isotopic Geochemistry and Geochronology at the Geological Institute of the Russian Academy of Sciences (GIN RAS) by analyst B.G. Pokrovskii. Thirty-nine analyses of $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ ratios were carried out, viz., 15 analyses of bulk rock composition (Table 1, Fig. 1) and 24 analyses of the composition of the *Thalassinoides paradoxicus* (Woodward), *Chondrites intricatus* Sternberg, and the *Zoophycos* isp. ichnofossils (Table 2, plate, 3–7).

Powders that weighed 500–1000 mg were produced for each analysis from the samples whose location is shown on Fig. 1 and in the plate. The decomposition of the samples and the KH-2 and NBS-19 standards was carried out using H_3PO_4 at 50°C . $\delta^{13}\text{C}$ values are given for relative V-PDB and $\delta^{18}\text{O}$, relative V-SMOW and V-PDB standards. The reproducibility of $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ analyses is $\pm 0.2\text{‰}$.

RESULTS

The marlstones and limestones were sampled from the two rhythms for the bulk isotope analysis (Fig. 1, Table 1). The carbon isotope compositions in the different rhythm elements are similar (Fig. 5A); the average $\delta^{13}\text{C}$ value (PDB) is 2.7‰ for both lithotypes. The oxygen isotope compositions are also similar: the average $\delta^{18}\text{O}$ values of both elements is 27.6‰ (SMOW).

The temperature was calculated using the following formula: $T = 16.5 - 4.3(\delta^{18}\text{O}_{\text{sample}}(\text{PDB}) - \delta^{18}\text{O}_{\text{water}}(\text{PDB})) + 0.14(\delta^{18}\text{O}_{\text{sample}}(\text{PDB}) - \delta^{18}\text{O}_{\text{water}}(\text{PDB}))^2$. The isotope composition of Cenomanian ocean water is accepted as -1.5‰ (PDB). The calculated temperature for both rhythm elements is $\sim 24^\circ\text{C}$, which is consistent with the data of Gabdullin (2002), according to which both elements were formed at temperatures of $23.5\text{--}25^\circ\text{C}$.

The isotope composition of ichnofossils was studied to verify the hypotheses on their probable formation conditions, in particular, chemosymbiosis for the *Chondrites* and *Zoophycos* (Löwemark and Schäfer,

Table 1. $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ values in bulk rock samples

Number of sample	$\delta^{13}\text{C}$, ‰ (PDB)	$\delta^{18}\text{O}$, ‰ (SMOW)	$\delta^{18}\text{O}$, ‰ (PDB)	Paleotemperature, °C
KR-10-01	2.6	28	-2.82	22.4
KR-10-02*	2.7	27.7	-3.11	23.8
KR-10-03	2.8	27.7	-3.11	23.8
KR-10-04	2.8	27.6	-3.21	24.3
KR-10-05	2.8	27.6	-3.21	24.3
KR-10-06	3	27.6	-3.21	24.3
KR-10-07	2.8	27.6	-3.21	24.3
KR-10-08	2.8	27.4	-3.40	25.2
KR-10-09	2.8	27.7	-3.11	23.8
KR-10-10	2.6	27.5	-3.31	24.7
KR-10-11	2.6	27.6	-3.21	24.3
KR-10-12	2.6	27.9	-2.92	22.9
KR-10-13	2.6	28	-2.82	22.4
KR-10-14	2.8	27.2	-3.60	26.1
KR-10-15	2.6	27.3	-3.50	25.7

Note: The samples from the less carbonate rhythm element (marlstone) are marked in bold.

Table 2. The $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ values in the studied ichnofossils

Ichnofossils	Sample	Weight, μg	$\delta^{18}\text{O}$, ‰ (PDB)	$\delta^{13}\text{C}$, ‰ (PDB)	$\delta^{18}\text{O}$, ‰ (SMOW)
<i>Chondrites intricatus</i> Sternberg	1	760	-4.08	2.5	26.7
	2	900	-3.6	2.8	27.2
	3	980	-3.89	2.8	26.9
	4	970	-3.6	2.6	27.2
	5	910	-3.6	2.6	27.2
<i>Thalassinoides</i> isp.	1	600	-2.82	2.2	28
	2	800	-2.82	2.4	28
	3	680	-3.02	2.4	27.8
	4	960	-3.02	2.4	27.8
	5	890	-3.11	2.5	27.7
<i>Thalassinoides paradoxicus</i> (Woodward)	1	590	-4.18	1.6	26.6
	2	720	-4.28	2.6	26.5
	3	960	-4.76	2.5	26
	4	980	-4.08	2.5	26.7
	5	930	-4.18	2.5	26.6
	6	860	-3.79	2.6	27
	7	910	-3.99	2.6	26.8
	8	750	-4.18	2.7	26.6
	9	1000	-5.64	2.8	25.1
	10	970	-4.47	2.6	26.3
<i>Zoophycos</i> isp.	1	900	-3.02	2.4	27.8
	2	900	-2.82	2.3	28
	3	750	-2.73	2.3	28.1
	4	740	-2.82	1.8	28

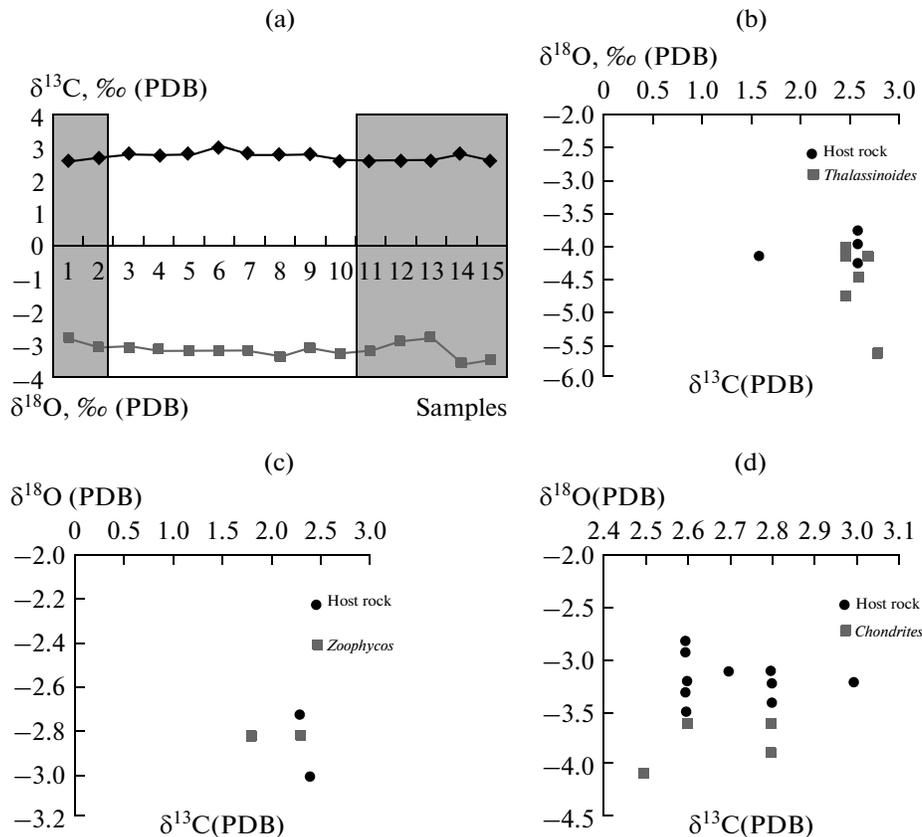


Fig. 5. Isotopic composition ($\delta^{13}\text{C}$ vs. $\delta^{18}\text{O}$) of: (a) the bulk rock composition; gray, analyses in the less carbonate element (lithotype 2); others, analyses in more carbonate element (lithotype 1), the location of the samples is shown on Fig. 1; (b) the infill of the *Thalassinoides paradoxicus* hole and host rock (sample 114/3; plate, 3 and 4); (c) *Zoophycos* isp. hole and host rock (sample 114/5, plate, 7); (d) *Chondrites intricatus* and host rock (sample 114/4, plate, 5).

2003). For this purpose spot samples (plate, 3–7), whose isotope composition was comparable to that from the host and filling rock, were drilled from several ichnofossils. The results are shown in Fig. 5B–D and in Table 1.

In the *Thalassinoides paradoxicus* holes, whose creators were probably detritophages (Griffis and Suchanek, 1991), the difference between the $\delta^{13}\text{C}$ values is insignificant inside the hole in the feeding chamber (-2.5 to -2.8 ‰) and in the rock (-2.5 to 2.6 ‰); no difference is determined for $\delta^{18}\text{O}$ values (Fig. 5B). The similarity of the isotope composition of the rock that fills the hole and the host rock confirms the passive infill of the hole with sediment.

The $\delta^{13}\text{C}$ values in the *Zoophycos* burrows are close to those from the host rock (Fig. 5B), which is quite consistent with data in (Löwermark et al., 2004); this allows us to corroborate the idea that farming did not occur by the creators of the *Zoophycos*. In regard to detritophages, the *Zoophycos* formation model should lead to a difference in the carbon isotope composition in the hole and the rock. However, the data also contradict this model. The model of food storage in *Zoo-*

phycos holes (the cache model) (Löwermark and Schäfer, 2003) agrees with the data that show an equivalent carbon isotope composition in the sediment and holes.

In the case of the *Chondrites* that are involved in complex bioturbation (inside *Thalassinoides* burrows), the $\delta^{18}\text{O}$ values (PDB) in the holes (from -3.6 to -4.1 ‰) are lower than those in the host rock (from -2.8 to -3.6 ‰) (Fig. 5D). Because oxygen isotopes are more mobile, the obtained difference in values is probably explained by overprinted diagenesis. Thus, the model of farming fabrics has no direct confirmation when the rock should be enriched in ^{13}C due to the biological fractionation of carbon isotopes (Löwermark et al., 2004).

DISCUSSION

The results of these studies are generally consistent with previous results for this section (Alekseev, 1989; Naidin and Kiyashko, 1994b; Frolov and Jaikrishnan, 1996; Gabdullin, 2002; Korchagin et al., 2010). According to these data, the Middle Cenomanian rhythmic sequence was formed in the deep shelf (up to

300 m) with a surface water temperature of about 24–25°C (Gabdullin, 2002) and temperatures from 14–16°C in marlstones and up to 24°C in limestones (Frolov and Jaikrishnan, 1996); the sediment was undersaturated in oxygen, which is evident from pyrite nodules, their higher C_{org} content, and the development of *Chondrites*.

It was established for similar rhythmic carbonate sections that less carbonate rhythm elements are formed at lower temperatures (by 1–2°C) than more carbonate sections (Gabdullin, 2002; Naidin, 2005) or by 4–5°C (Korchagin et al., 2010), which should affect the oxygen isotope composition. The similar $\delta^{18}O$ values through the section we identified are probably related to the intense bioturbation of sediment or to averaging of near-bottom and surface temperatures determined in the bulk samples.

We would like to note the bulk isotope composition of carbonates inside the marlstone layer obtained for the same section by O.A. Korchagin et al. (2010) who distinguished smaller rhythms expressed in variations of $\delta^{18}O$ values. Based on our data, which were obtained following the same method and using the same device, the oxygen isotope composition varies little and it is impossible to separate even the rhythm elements. In addition, only secondary bioturbation structures are present in the section and thin sections, so, from our point of view, the data of Korchagin et al. (2010) require more precise definition.

FORMATION CONDITION OF THE STUDIED RHYTHMS

The rhythmicity of the section, as was shown previously (Naidin et al., 1994; Gabdullin, Guzhikov, and Dundin, 1999; Gabdullin, 2002; Naidin, 2004, 2005, 2008), corresponds to cycles of the precession of the Earth's axis that were 20–25 ka long. Each layer corresponds to a semicycle, i.e., it formed for 10–12 ka. The concrete mechanisms of the formation of rhythmicity are related to variations in productivity, dilution, and dissolution cycles (Gabdullin, 2002; Naidin, 2004, 2005, 2008).

During dilution cycles, accumulation of marlstones occurred as a result of the gain of terrigenous material in humid epochs and the deposition of limestones in arid epochs, which was accompanied by insignificant drift.

During productivity cycles, the formation of limestones occurred in epochs of high productivity of carbonate plankton, in contrast to marlstones.

During dissolution cycles (this model works together with the previous one): the periodic dissolution of accumulated carbonates occurred along with the formation of less carbonate rhythm elements from the condensation of clay matter during the dissolution of carbonate sediments.

Considering the similar amounts of plankton foraminifera in the limestones from two lithotypes, which are distinct only in the amount of the clay constituent, we suggest the following model of dissolution cycles to explain the origin of the rhythmicity in the section of Mount Selbrukha: (i) the amount of the foraminifera bioclasts in different rhythm elements is similar but some foraminifera in marlstones are characterized by dissolution traces and (ii) only *Chondrites* ichnofossils were found in marlstones, which indicates anoxia conditions, which, in turn, are explained by the presence of a large amount of organic matter.

Thus it was probably marlstones and not limestones, as previously believed, that were formed in epochs of higher bioproductivity. Unfortunately, it is impossible to relate this fact to the variations in temperatures based on our data.

In addition, no relationship between rhythmicity and the semicycles of precession was identified because of the absence (at least, in the bottom carbonates) of variations in the oxygen isotope composition. The variations are most likely fixed in the carbonate of shells of plankton foraminifera.

Finally, the Middle Cenomanian rhythmic sequence was formed in the deep shelf; the average water temperature was 24°C and more muddy elements accumulated under anoxia conditions. The rhythmicity of the section may be explained by the model of dissolution cycles, which is in agreement with the conclusions of R.R. Gabdullin (2002).

CONCLUSIONS

1. The Middle Cenomanian rhythmic sequence of Mount Selbukhra was formed in the deep shelf; the average water temperature was 24°C and did not fluctuate during the formation of different rhythm elements; the marlstones accumulated under higher bioproductivity and bottom anoxia. The rhythmicity of the section is explained by the model of the dissolution cycles, which is in agreement with the conclusions of R.R. Gabdullin (2002). Based on our data, it is impossible to relate the rhythmicity with precession cycles with certainty.

2. The intense rock bioturbation (BI from 2/6 up to 4/6) is clearly stratified, which is typical of the writing chalk sections, and the ichnofossil assemblage corresponds to the *Cruziana* ichnofacies that are characteristic of the soft grounds of the open shelf below the wave influence basis.

3. The $\delta^{18}O$ values (PDB) in the *Chondrites* holes are lower than those from the host rocks, which is probably related to diagenetic rock alterations.

4. The $\delta^{13}C$ and $\delta^{18}O$ ratios did not support the model of farming fabrics for the *Chondrites* and *Zoophycos* and testify to the passive infill of the *Thalassinoides* holes by sediment.

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