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Cyclostratigraphic Correlation of Cenomanian and Turonian Deposits of the Eastern European Platform

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Abstract—Depositional conditions at the Cenomanian–Turonian time have been specified and a cyclostratigraphic scheme of the correlation of the Turonian sections has been proposed based upon generalizations of our own results concerning sections of Voronezh anteclise, Ulyanovsk–Saratov trough, Crimea, and the Caucasus.

Keywords: Cenomanian, Turonian, cyclicity, correlation, sequences, Eastern European Platform

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INTRODUCTION

This paper summarizes the results of long-term works that were performed by the authors' team from the investigation of structure and formation conditions of the Upper Cretaceous deposits in the Eastern European Platform, in particular, in the Voronezh anteclise and the Ulyanovsk–Saratov trough.

RESEARCH METHODS

Field observations and subsequent laboratory studies have been carried out in the following natural and artificial outcrops within the Russian Federation (Fig. 1): Bryansk Province (Chernetovo Settlement, section no. 1; Betovo Settlement, section no. 2; Fokino Settlement, section no. 3); Voronezh Province (Strelitsa, Latnoe quarry, section no. 4); Belgorod Province (Stary Oskol, section no. 5); Saratov Province (Khvalynsk, section no. 6; Volsk, section no. 7; Lower Bannovka Settlement, section no. 8). Sections nos. 1–5 are located within the Voronezh anteclise (VA), while sections nos. 6–8 are localized in the Ulyanovsk–Saratov trough (UST).

Having analyzed the palinospastic maps by A.G. Smith and J. C. Briden (1977) in the Cenomanian we determined that the studied sections of the Voronezh anteclise were at the same paleolatitude in the Late Cenomanian–Early Turonian, while the studied sections of the Ulyanovsk–Saratov trough were approximately at the same paleomeridian, but at different paleolatitudes (Fig. 1).

Field description involved analysis of the *elementary sheet cyclicity* to determine its genesis and to estimate its relationship to the sequences and astronomic climatic cycles of Milutin Milankovitch. The Latnoe quarry (Fig. 2) was studied by N.V. Badulina (Department of Geology, Moscow State University) during the field trip of the All-Russian Scientific Conference on Actual Problems of Dynamic Geology in the Study of Platform Areas (May 24–26, 2016).

Earlier, sections of the Voronezh anteclise and the Ulyanovsk–Saratov trough were studied by R.R. Gabdullin and other researchers (A.V. Ivanov (Yuri Gagarin State Technical University of Saratov), E.N. Samarin (Moscow State University)) using *a set of methods,* including petrographic methods (macroscopic study of the rocks in the outcrop and the microscopic study of rocks in thin sections), chemical methods (determination of the CO_2 content by the volumetric method using the Knopp–Fresenius apparatus and of the organic carbon content (C_{org}) by automatic coulometric titration based on pH using an AN-7529 express analyzer), physical methods (X-ray phase analysis with the DRON-4 X-ray diffractometer, the analysis results were automatically processed with the help of the X-Ray software), petromagnetic methods (determination of magnetic susceptibility (k), natural residual magnetization (Jn), residual saturation magnetization (Jrs), collapsing field of residual saturation magnetization ($H'cs$), and the increment of magnetic susceptibility after heating to 500°C in the air medium (dk), as well as their relationships, for example, Jrs and $H'cs$ correlation), the paleoecological method, and the paleoecological–paleontological method.

The correlation of Jrs and $H'cs$ shows the mixing cycles of background sediments deposited in the basin

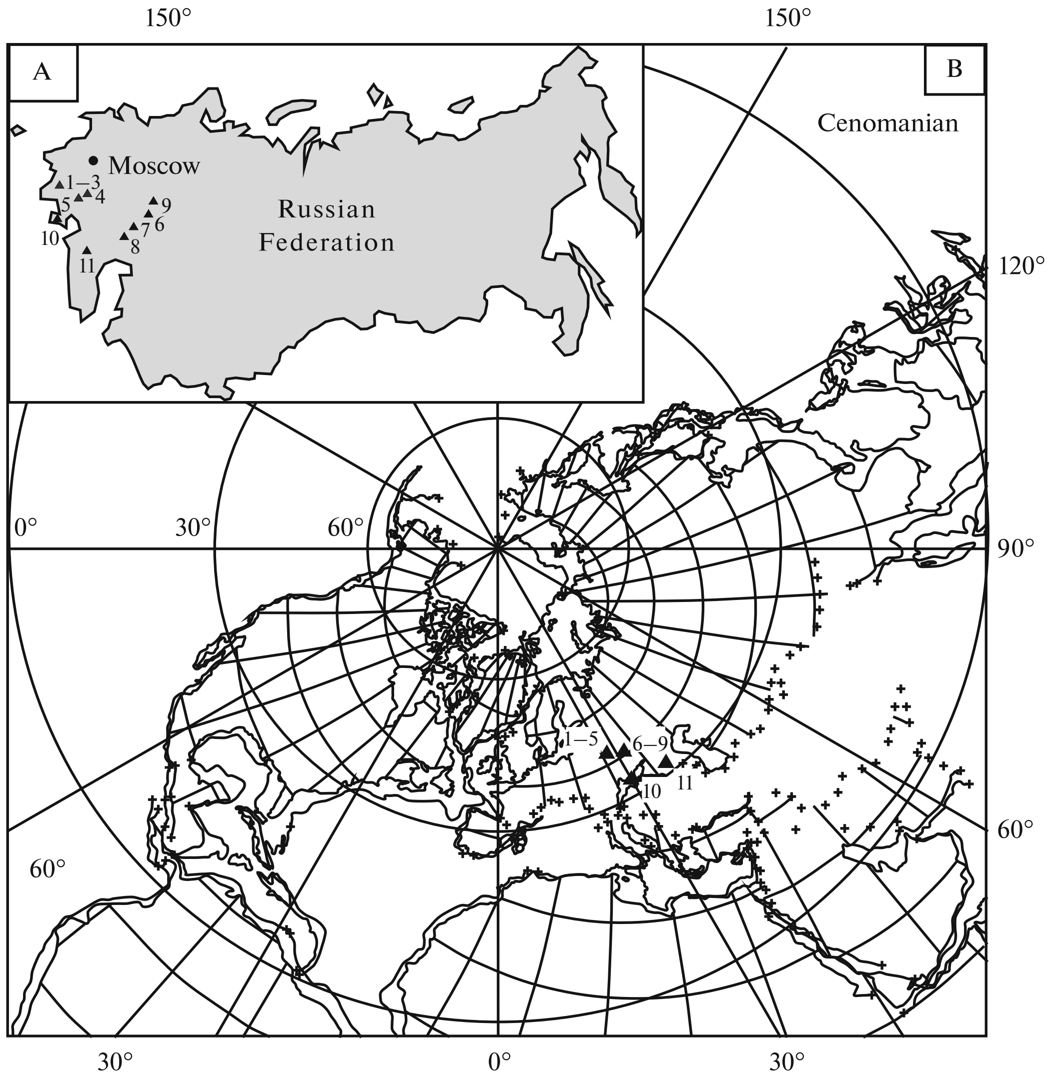

Fig. 1. The location of the studied sections: (A) map of the Russian Federation with localization of sections (shown with triangles): (*1*) Chernetovo Settlement, (*2*) Betovo Settlement, (3) Fokino Settlement, (*4*) Strelitsa Settlement (Latnoe quarry), (*5*) Stary Oskol, (*6*) Khvalynsk, (*7*) Volsk, (*8*) Lower Bannovka, (9) Sengilei, (*10*) Mount Besh-Kosh, (*11*) Daria River; (B) location of the sections on the palinospastic scheme for the Cenomanian age, after A.G. Smith and J.C. Briden (1977).

and terrigenous material containing magnetic minerals, which is washed away from the land. In particular, at negative correlations, the volume of magnetic minerals washed away from the land is minimal, while at positive values it is maximal. The results of these studies have been given in a number of works (Gabdullin, 2002, 2004a–2004c; Gabdullin and Ivanov, 2001, 2003a, 2003b, 2004; Gabdullin et al., 1999, etc.). The obtained cyclic variations of the investigated parameters have been analyzed from the standpoint of the Milankovitch astronomical climatic cycles.

The formation models and mechanisms of the sheet cyclicity were proposed earlier for most considered sections (except for the Latnoe quarry), and relationship to the Milankovitch cycles was determined. The eccentricity cycles of the Earth's orbit were found to be of key importance in the formation of the elementary sheet cycling (Gabdullin, 2004a–2004c; Gabdullin and Ivanov, 2001, 2003a, 2003b; Gabdullin et al., 1999, 2014). The relationship of most studied sections to the Milankovitch cycles was determined by "manual" calculation (dividing the stratum formation duration by the number of parameter oscillations) and spectral analysis (Gabdullin, 2002; Gabdullin and Ivanov, 2004). D.P. Naidin (1995) identified six sequences in the generalized section of the Russian Plate corresponding to eleven units identified by Gabdullin (2002, 2007).

Description of the Upper Cretaceous Sections. Gabdullin (2002) previously proposed a subdivision of the Upper Cretaceous deposits by units in the sections of the Eastern European Platform (EEP). Comparison of the investigated Cenomanian–Turonian EEP sections is shown in Fig. 2A. Some geochronous units (Gabdullin and Ivanov, 2003) are described in Fig. 2B. The identified units are sequences subdivided into system tracts (Gabdullin, 2007). According to the cyclostratigraphic scale proposed by (Gabdullin, 2004a–2004c), the sequences (units) correlate with eustatic cycles, and the latter, in their turn, with Milankovitch cycles (eccentricity cycles (Olfer'ev et al., 2005)).

The Cenomanian stage is presented by sequence I_1 according to Naidin (1995) and unit I according to Gabdullin (2002, 2007): greenish–grayish, brown, medium-grained, glauconite sand (Fig. 2) and brown iron-bearing compact sandstone. The unit contains two or three horizons of phosphorite concretions. Macrophossils are observed as bivalve mollusks (including oyster banks), abundant remains of sharks, chimeras, and teleost fish; belemnites rostra and rare ammonites. Petrified tree trunks and coprolites of large marine reptiles occur (Ilyin, 1997). The unit is 0–50 m in thickness. Cenomanian deposits are absent in some areas of the Ulyanovsk–Saratov trough (Khvalynsk and Volsk), where Turonian rocks cover Albian sediments. The deposits of unit I have been studied in a number of sections.

The section of the cement plant quarry near Fokino (Bryansk Province). This section is located in the southeastern side of the cement plant quarry in Fokino (Bryansk Province). The generalized section of Cenomanian–Coniacian deposits of the Bryansk Province (based on Fokino, Betovo, and Vygonichi sections) is given in (Ilyin and Naidin, 1995). The Cenomanian–Coniacian deposits of the anteclise, including the previously mentioned sections, were described in (Olfer'ev at al., 2005).

The sands are greenish–grayish medium-grained glauconite. The visible thickness is 2.5 m. The maximum thickness of the Cenomanian deposits in the Bryansk Province is approximately 9.6 m (Ilyin and Naidin, 1995). The unit is characterized by a great diversity of macrofauna. The unit roof contains ichnofossils of *Thalassinoides* and *Teichnichnus*. No cyclicity is observed in the section.

The section on the outskirts the Chernetovo Settlement (Bryansk Province). This section is located on the southern outskits of the Chernetovo Settlement on the right bank of the Desna River above Bryansk.

In terms of lithology, the section is almost identical to that of the Fokino quarry. It consists of two phosphorite horizons and is more than 8 m in visible thickness. The Lower Cenomanian top is characterized by findings of belemnite rostra *Praeactinocamax primus primus*. The belemnite rostra *Praeactinocamax* cf. *plenus longus* (plenus zone) can be indicative of the unit confinement to the Upper Cenomanian deposits.

The section on the outskirts of the Betovo Settlement (Bryansk Province). This section is located in the coastal cliff at the pond near the northwestern end of the Betovo Settlement, between Betovo and Chernetovo, on the right bank of the Desna River above Bryansk.

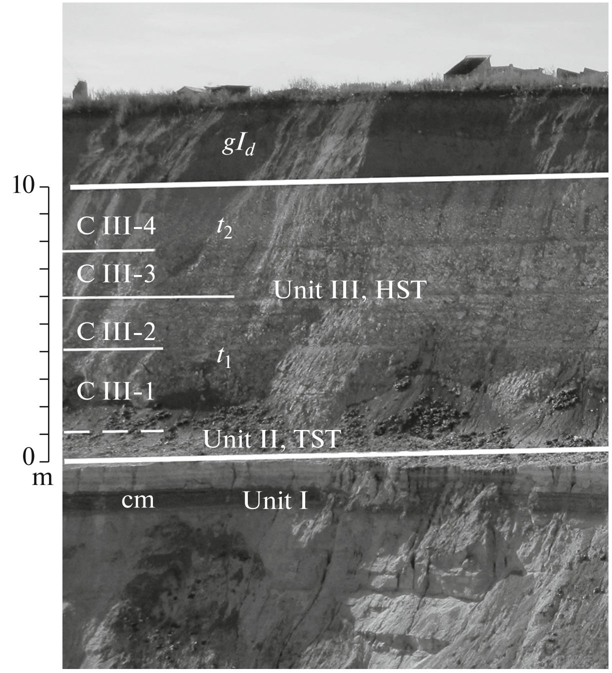

Fig. 2. A fragment of the Latnoe quarry section (Voronezh Province). The Cenomanian sand sequence (cm) is overlapped by Turonian writing chalk stone (*t*) overlain by Quaternary glacial deposits (gI_d). Abbreviations: (TST) transgressive system tract, (HST) highstand tract.

Individual Cenomanian sand outcrops of unit I are observed in the slightly exposed coastal cliff covered by landslide bodies. The level, which presumably corresponds to the phosphorite horizon, is identified in the weathering profile. The visible thickness of the deposits is 4 m. The section contains belemnite rostra *Praeactinocamax primus primus* (Ilyin and Naidin, 1995). Cyclicity has not been detected.

The section near the Lower Bannovka Settlement (Saratov Province). The Upper Cretaceous section is located on the slope of Mount Syrt south of the Lower Bannovka Settlement in the Saratov Province on the right bank of the Volga River. This section has been studied in detail and described in a number of works (Arkhangelskii, 1912; Milanovskii, 1940; *Volgo–Ural'skaya*..., 1959; Gerasimov et al., 1962; Kamysheva-Elpatievskaya, 1967; Glazunova, 1972).

Sand and sandstone with two lenticular phosphorite horizons and "hard bottom" ground. The (visible) thickness of the unit is more than 16.4 m. The total thickness of the Cenomanian is estimated in this section at 50 m (Milanovskii, 1940). The macrofauna includes oyster banks of *Amphidonte obliquatum*; shells *Schloenbachia varians*; and shark teeth. Nanoplankton of the CC10 zone (Microrabdulus decoratus) and Whiteinella archaeocretacea plankton have been found here (according to the unpublished data of A.G. Olfer'ev).

Cyclicity is observed as alternation of two lenticular phosphorite interlayers (0–0.35 m) and three sandstone and sand intervals (6–7 m).

The section of the Stoilenskii Mining and Processing Plant (Belgorod Province) is located in the northwestern side of the quarry in the Stary Oskol town area.

The lower part of the section is a unit of rhythmically layered grey, grey–green sandstone with brown iron-bearing compact sandstone (7–8 m). The macrofauna includes teeth of chimeras *Ischyodus "bifurcates"* Case and sharks *Protosquales* sp.; shells of *Neithea* sp.; rostra of *Praeactinocamax primus* (determined by A.S. Alekseeva, Moscow State University); microfauna: Cenomanian–Maastrichtian forms of calcareous nannoplankton *Manivitella redimiculata*, *Prediscosphaera cretacea* (Arkh.), Cenomanian–Turonian *Broisonia matalosa*, etc. (determined by M.N. Ovechkina, Moscow State University).

The sandstone unit is underlain by lenticular interlayers of clay and clayey sand with phosphorites (0–2.5 m). The lenticular interlayer is underlain by the Upper Albian sand and sandstone unit containing *Mortoniceras inflatum* found by Gabdullin (determined by E.Yu. Baraboshkin, Moscow State University). Hence, the Upper Albian–Lower Cenomanian boundary is traced at the level of phosphorite-bearing lenticular sands.

This unit is characterized by cyclicity (four rhythms: compact sandstone (0.2–0.3 m)–sand, sandstone (0.5–0.7 m)).

The section of the Latnoe quarry (Voronezh Province) is located in the Strelitsa Settlement (Voronezh Province), 15 km west of Voronezh. Aptian refractory clay is mined there in the face of the quarry. This raw material and the geological structure of this site were first investigated by R. Murchison in 1847–1853.

The Cenomanian quartz–glauconite sand sequence is approximately 10 m in thickness. It contains two horizons of phosphorite concretions. The lower horizon is underlain by a clay layer.

The reference level of two phosphorite horizons in the Lower Cenomanian sections near Chernetovo and Lower Bannovka settlements, as well as in the section at the Betovo Settlement, makes it possible to correctly correlate the sections of the Ulyanovsk–Saratov trough and Voronezh Anteclise. The absence of phosphorite horizons in the Fokino section can be explained by an outcrop of the top of unit I (Ilyin and Naidin, 1995). Only one system tract, transgressive, can be identified reliably in the studied sections in unit I. The highstand system tract is either eroded or hardly distinguishable in terrigenous facies from the transgressive system tract. It is assumed that the highstand system tract can be identified in the section of the Latnoe quarry, in the clay unit foot of up to 1 m in thickness in the lower (or middle) part of the Cenomanian sequence (2–4 m above the Cenomanian rock bottom).

The *Turonian stage* in the EEP sections consists of sequence I_2 according to Naidin (1995) and two geochronous units II and III according to Gabdullin (2002, 2007) (Fig. 2). Unit II corresponds to the transgressive system tract, while unit III corresponds to the highstand tract. The Lower Turonian deposits occur sporadically in the sections of the Voronezh Anteclise (Latnoe quarry, quarry of the Stoilenskii Mining and Processing Plant, Fokino quarry, outcrops near Betovo and Chernetovo settlements). They are composed of writing chalk stone and their bottom consists of sandy and phosphorite nodules (commonly corresponding to unit II). The widespread Middle and Upper Turonian deposits are attributed usually to unit III. Middle and Upper Turonian deposits are represented by writing chalk stone in the Voronezh Anteclise sections (Latnoe quarry, Stoilenskii MPP quarry, Stary Oskol, Belgorod Province) and the Ulyanovsk–Saratov trough (outcrop on the northern outskirts of Khvalynsk, Bolshevik Cement Plant quarry on the outskirts of Volsk, and Lower Bannovka section, Saratov Province).

In the *Voronezh anteclise*, a "phosphorite plate" lies at the base of the Turonian carbonate unit. The latter is overlain by a sandy variety of chalk with phosphorite nodules. This interval of the section corresponds to unit II. The thickness of the "phosphorite plate" is 0.2 m and that of the unit is 0.5–2 m. In the studied sections, Lower Turonian deposits overlap with erosion Cenomanian sands. In most cases, Turonian carbonate rocks transgressively cover Cenomanian (Albian–Cenomanian) terrigenous sediments, which explains the presence of the Turonian sandy facies of writing chalk stone in the basal part. In the cases where the Albian clayey sediments or other more ancient non-terrigenous rocks form the underlying layer the Turonian bottom is composed of clay marls rather than sand chalk (Savko and Ivanova, 2009).

The Turonian age of the sandy variety of chalk in the Stary Oskol section is confirmed by findings of calcisphaeras *Broisonia matalosa*, *Br. parca*, *Zygodiscus chelmiensis*, and *Prediscosphaera spinosa* that coexisted in the Turonian (determined by M.N. Ovechkina). The findings of belemnite rostra *Pr. plenus triangulus* in the Chernetovo and Fokino sections prove the Early Turonian age of unit II. According to L.F. Kopaevich (Moscow State University), the Fokino unit contains the Lower–Upper Turonian foraminiferal assemblage *Ataxophragmium nautiloides* and *Gavelinella praeinfrasantonica*, which is expected to expand considerably its stratigraphic range.

Unit II is followed by unit III composed of writing chalk stone with bentonite clay interlayers. The *Fokino quarry section* contains a large amount of brachiopod shells (rhinchonellide *Cretirhynchia robusta* and terebratulide), Inoceramus, oyster (*Ostrea* sp.), sporadic shark teeth (*Cretoxyrhina* sp.), fish scales, and coprolites completely composed of fish scales. The findings of the belemnite rostra *Pr. plenus* subsp. (determined by D.P. Naidin, Moscow State University) confirm the Early Turonian age of this unit (*plenus triangulus* zone). The erosion surface is observed at the upper boundary of the unit. Traces of the vital activities of *Thalassinoides*, *Teichichnus*, and *Planolites* have been identified in the unit. Writing chalk stone contains brachiopod shells (rhinchonellide *Cretirhynchia robusta* and terebratulide) in the *Chernetovo section* and shark teeth (*Cretoxyrhina* sp.) in the *Betovo section*.

The cyclically deposited Lower Turonian deposits are mainly composed of writing chalk stone with two bentonite clay interlayers. The presence of the latter in the middle and upper parts of the Lower Turonian interval makes it possible to accurately correlate the Voronezh Anteclise sections (Fig. 1). Correlation of the intervals of the Turonian deposits has been specified based on the observation data obtained in the Latnoe quarry: subunit III-1 corresponds to the Lower Turonian, while subunit III-2 corresponds to the Middle and Upper Turonian. Unit III is almost 20 m in thickness in the Stary Oskol section (quarry of the Stoilenskii Mining and Processing Plant) at a common thickness of approximately 10 m or less.

Cyclostratigraphic analysis of Turonian deposits in the anteclise has been applied to assign numbers to the bedding cyclites C_{III-1}, C_{III-2}, C_{III-3}, and C_{III-4} generated by eccentricity cycles. Cyclites C_{III-1} and C_{III-2} correspond to the Lower Turonian and subunit III-1, while cyclites C_{III-3} and C_{III-4} correspond to the Middle–Upper Turonian.

The comprehensive study of the most complete section of the Turonian anteclise in Stary Oskol revealed slight variations in a number of geochemical and petromagnetic parameters in bedding cyclites, which allowed interpreting them (Gabdullin, 2002) as bioproductivity cycles (Einzele and Zeilacher, 1985).

Turonian deposits of the *Ulyanovsk–Saratov trough* differ in structure from their analogs in the Voronezh anteclise. Cyclicity is not identifiable or is hardly identifiable. Reliable tracing of cyclites found in the Voronezh anteclise is not possible. The local Lower Turonian deposits of the labiatus zone in the Ulyanovsk–Saratov trough (*Stratigrafiya*..., 1986) have not been considered under our investigation. The Middle–Upper Turonian deposits of the Ulyanovsk–Saratov trough have been studied in three sections of the Saratov Province, which are well-correlated (Khvalynsk, Volsk, and Lower Bannovka). The rock sequence was given the name “inoceramus chalk” by A.P. Pavlov in 1887. Turonian deposits are represented by a writing chalk unit underlain by a “phosphorite plate.” This unit is overlain by a sandy variety of chalk. The latter is overlapped by pure writing clay stone. A thickness of the Turonian deposits in the Volsk–Khvalynsk basin reaches 8–10 m (Kamysheva-Elpatievskaya, 1967). The overlying Coniacian deposits, which are visually indistinguishable from the Turonian are lithologically identical to the Turonian deposits. A phosphorite conglomerate at the base of the Turonian deposits, that is, the “phosphorite plate,” serves as a good marking horizon (reference level) in correlation of the Turonian sections in the Saratov Volga Region (Kamysheva-Elpatievskaya, 1951). The thickness of the Turonian deposits increases from the north to the south of the Volsk–Khvalynsk depression from 1 to 7 m (*Volgo–Ural'skaya*..., 1957). We give a selective description of these deposits in a few sections.

The section is located in the northwestern side of the *Bolshevik Cement Plant quarry* (Volsk, Saratov Province). The sections in the vicinity of Volsk and the cement plant quarries have been studied in detail and described in a number of works (Arkhangelskii, 1912; Matesova, 1930; Milanovskii, 1940; *Volgo–Ural'skaya*..., 1959; Gerasimov et al., 1962; Kamysheva-Elpatievskaya, 1967; Glazunova, 1972). The section was studied by Gabdullin (Moscow State University) and later by E.V. Yakovishin and L.F. Kopaevich (Moscow State University), as well as by other researchers (Olfer'ev et al., 2009; Seltser and Ivanov, 2010; etc.).

Turonian deposits are composed of carbonate rocks of the Middle–Upper substage with shells of *Inoceramus lamarcki* and sea urchins, erosively overlapping Albian sandy dark grey clay. Unit II consists of marl with phosphorite nodules and fragments of a prismatic layer with a thickness of 2 m. The thickness of inoceramus horizons decreases from below upwards along the section from 0.1–0.25 to 0.04–0.05 m. Iron-bearing fragments of chalk are sporadic. An analog of the “phosphorite plate” (0.3 m) is located at the base of this unit. Marl contains abundant variably shaped phosphorite concretions, mostly half-rounded. Their maximum concentration is characteristic for the middle part of the “plate” analog.

The same stratigraphic interval (unit II) in the *Lower Bannovka section* is composed of sandy chalk (0.8 m) with evenly scattered phosphorite nodules. Oyster shells are sporadic in the layer. The phosphorite plate (0.3–0.4 m) is at the base of the unit. Phosphorite nodules are well-rounded and are black and brown in color.

The section on the northern outskirts of Khvalynsk (Saratov Province) is located on the slope of Mount Bogdanikha on the right bank of the Volga River in the vicinity of Khvalynsk. This section has been thoroughly studied and described in a number of works (Arkhangelskii, 1912; Milanovskii, 1940; Gerasimov et al., 1962). Unit II is represented by a “phosphorite plate” and a sandy variety of chalk.

The following unit III in the *Volsk section* is composed of yellowish grey chalk, occasionally silicified, with a thickness of up to 2.5 m. In terms of microscopy, the rocks are biocrystalloclastic limestone. The deposits contain: *Inoceramus lamarcki*, *In. apicalis*, *Lewesiceras peramplum* (Mant.), *Micraster corbovis*,

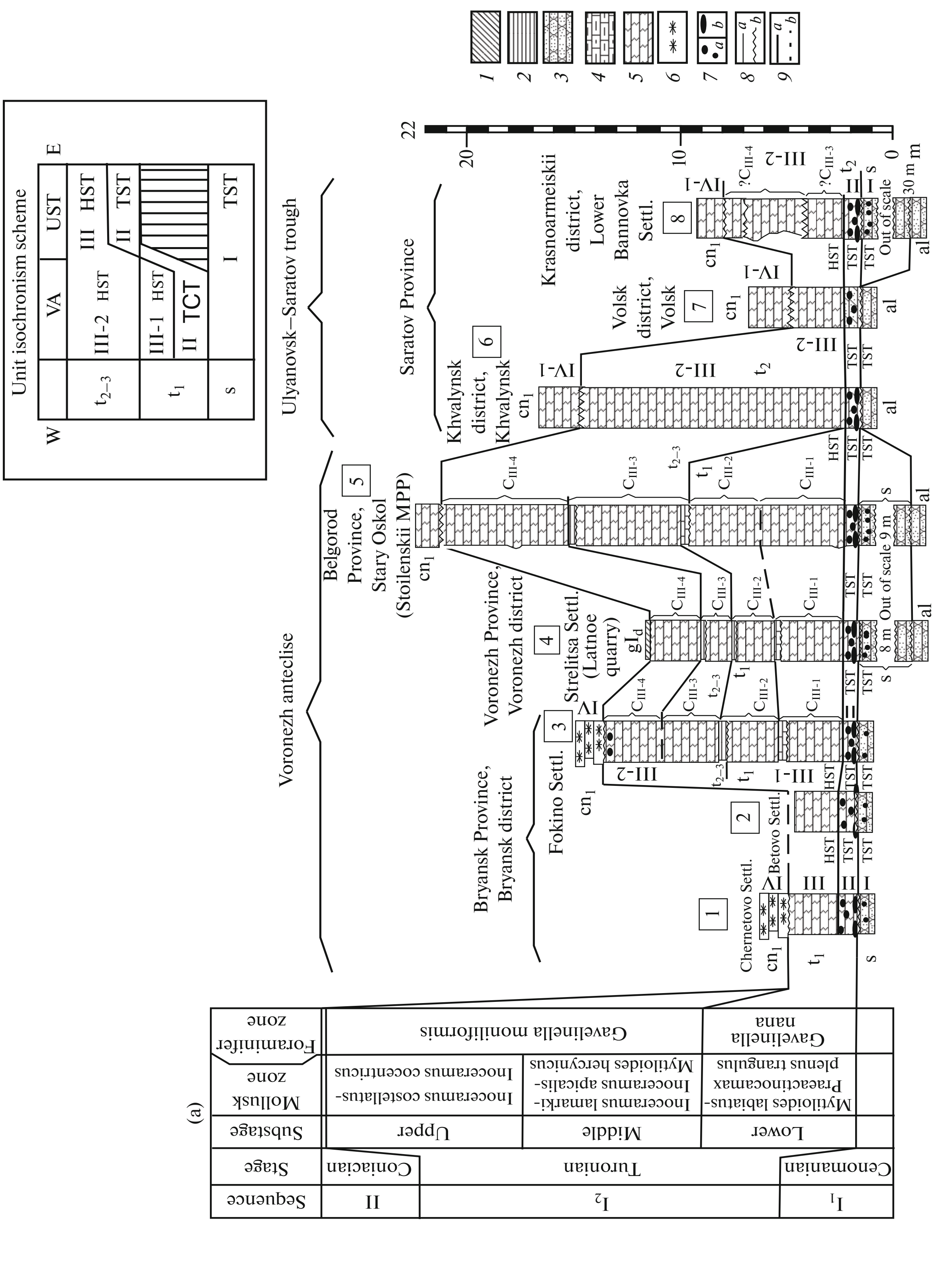

Fig. 3. Some sections of Upper Cretaceous deposits of the Eastern European Platform: (a) comparison of Cenomanian–Turonian sections of the Voronezh anteclise and the Ulyanovsk–Saratov trough; (b) isochronism scheme of the units. Abbreviations: (VA) Voronezh anteclise, (UST) Ulyanovsk–Saratov trough, (TST) transgressive system tract, (HST) highstand tract, (C_{III-1}) bedding cyclite number. Legend: (*1*) clay loam, (*2*) clay, (*3*) sandstone, (*4*) clay limestone, (*5*) writing chalk stone, (*6*) diatomites, opoka, (*7*) phosphorites: (*a*) nodules and small concretions, (*b*) concretion layers ("phosphorite plate"), (*8*) stratigraphic boundaries: (*a*) conformable, (*b*) nonconformable; (*9*) correlation lines: (*a*) reliable, (*b*) assumed.

Holaster planus, *Conulus subrotundus*, and *C. subconicus*. The Middle Turonian age of these deposits is determined by the presence of zonal species *Inoceramus lamarcki* and *In. apicalis*, while the Late Turonian age is confirmed by findings of echinoderms *Holaster planus*. According to (Matesova, 1930), numerous findings of oysters, brachiopods, teeth and calcified vertebrae of shark fish were noted in the Turonian deposits. The Turonian fauna complex in this section is very similar to the coeval assemblage in the Stary Oskol section. The Turonian deposits contain traces of the vital activities of *Chondrites*, *Teichichnus*, and *Planolites*.

In the section in the northern end of Khvalynsk, unit III is composed of slightly bioturbated (10% of the rock volume) white writing chalk stone with belemnite rostra of *Actinocamax intermedius*, fragments of sea urchin shells, and a prismatic layer of inoceramus. In terms of microscopy, the rock is biocrystalloclastic limestone. The visible thickness is 2 m. The section groundmass is hidden under landslide bodies, and the total thickness of the Turonian is estimated at approximately 15 m (Arkhangelskii, 1912). The cyclicity has not been established.

The same deposits in the *Lower Bannovka section* are composed of writing chalk stone, marly chalk, and marls. Cyclicity has been identified. This is the Lamarcki zone, Middle–Upper Turonian (unit III). Findings of *Actinocamax intermedius* have also been made here. The deposits of the unit are approximately 5.5–6 m in thickness. The rock sequence gradually passes into a "spongy" layer.

Finally, units II and III should be described. Unit II is a sandy variety of chalk with regularly distributed phosphorite nodules and horizons with fragments of the inoceramus prismatic layer. The unit base consists of a "phosphorite plate" (absent in the Volsk section) as a highly condensed layer of variably shaped cemented phosphorite nodules, rounded, black and brown, with glauconite. This unit contains oyster shells, sponge goblets, rounded teeth, and vertebrae of sharks. The cyclicity has not been established in the unit.

Unit III is writing chalk of white (or tiled), light gray, and yellowish–grayish color. This unit contains numerous macrofossils: belemnites, inoceramus, brachiopods, sea urchins, shark teeth, fish scale, coprolites, and ichnofossils. The cyclicity has been established in this unit. The unit is 2.5–20 m in thickness. The cyclicity is observed as interstratification of marl or bentonite clay (0.5–2 m) and chalk (1–2.2 m).

DISCUSSION

Eustatic cycles in the section are expressed as changes in the lithological composition and paleontological characteristics of the stratigraphic units. The system tracts have been identified for the studied sections (transgressive tract (TST) and highstand tract (HSS)) and referenced to the units. Eustatic fluctuations are controlled by the Milankovitch astronomical climatic cycles, in particular, by eccentricity cycles of the Earth's orbit. They are easily identifiable in the Turonian section. The cyclostratigraphic correlation with indication of sequential numbers of sheet cyclites has been proposed for the first time for Turonian deposits in the Voronezh anteclise. The Latnoe quarry section studied by this method in May 2016 made it possible to compare the sections more reliably.

CONCLUSIONS

The cyclic structure of the studied deposits and a relationship of variations in the studied parameters to eustatic and climatic cycles based on the Milankovitch astronomical climatic cycles (in particular, eccentricity cycles) have been noted.

The cyclostratigraphic correlation of Turonian deposits of the Voronezh anteclise has been carried out for the first time. The studied sections of the Voronezh anteclise were at the same paleolatitude in the Late Cenomanian–Early Turonian, while the Campanian–Maastrichtian sections of the Ulyanovsk–Saratov trough were almost at the same paleomeridian (Smith and Briden, 1977).

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