ISSN 0869-5938, Stratigraphy and Geological Correlation, 2013, Vol. 21, No. 1, pp. 48–78. © Pleiades Publishing, Ltd., 2013.
Original Russian Text © N.K. Lebedeva, G.N. Aleksandrova, B.N. Shurygin, M.N. Ovechkina, Z.N. Gnibidenko, 2013, published in Stratigrafiya. Geologicheskaya Korrelyatsiya, 2013, Vol. 21, No. 1, pp. 43–73.

Paleontological and Magnetostratigraphic Data on Upper Cretaceous Deposits from Borehole no. 8 (Russkaya Polyana District, Southwestern Siberia)

N. K. Lebedeva[a], G. N. Aleksandrova[b], B. N. Shurygin[a], M. N. Ovechkina[c, d], and Z. N. Gnibidenko[a]

[a] *Trofimuk Institute of Petroleum Geology and Geophysics, Siberian Branch of Russian Academy of Sciences, pr. Akad. Koptyuga 3, Novosibirsk, 630090 Russia*

[b] *Geological Institute, Russian Academy of Sciences, Pyzhevskii per. 7, Moscow, 119017 Russia*

[c] *School of Agricultural, Earth & Environmental Sciences, University of KwaZulu-Natal, Durban, Republic of South Africa KwaZulu-Natal Museum, Pietermaritzburg, Republic of South Africa*

[d] *Paleontological Institute, Russian Academy of Sciences, Profsoyuznaya ul. 123, Moscow, 117997 Russia*

e-mail: LebedevaNK@ipgg.sbras.ru

Received February 7, 2012; in final form, April 4, 2012

Abstract—This work presents results of complex research (palynological, macro- and microfaunistic, and paleomagnetic) of Upper Cretaceous deposits, opened by borehole no. 8 in the Russkaya Polyana District (the southern margin of the Omsk Depression, Southwestern Siberia). The paleontological data obtained allowed us to establish the age of deposits. Based on dinocysts, nannoplankton and spore-pollen complexes, the section of borehole no. 8 has been divided into Pokur, Kuznetsovo, Ipatovo, Slavgorod, and Gan'kino Formations. This work gives data on the composition of zonal palynomorphs, nannoplankton, and microfaunistic complexes. Based on the complex data obtained, the magnetostratigraphic section of Upper Cretaceous deposits has been developed. The section consists of three magnetozones: normal and two reversed polarity magnetozones. The Pokur, Kuznetsovo and Ipatovo Formation (Cenomanian–Santonian) belong to the long normal polarity magnetozone; the Slavgorod and Gan'kino Formations (Campanian–Maastrichtian), separated by a stratigraphic break, belong to reversed polarity magnetozones. The magnetostratigraphic section has been correlated with the general magnetostratigraphic and magnetochronological time scales.

Keywords: biostratigraphy, Upper Cretaceous, southwestern Siberia, palynology, dinocyst, ammonites, bivalves, nannoplankton, magnetostratigraphy, magnetozones, polarity

DOI: 10.1134/S086959381301005X

INTRODUCTION

As was noted at the Interdepartmental Stratigraphic Meeting (Novosibirsk, 2003), where improved regional stratigraphic schemes of Mesozoic deposits of Western Siberia were under discussion, there is a lack of the new paleontological material for regional correlation of the Upper Cretaceous geochronological scheme of Southwestern Siberia. This is due to a sharp reduction in drilling, in general, and a lack of actual data on the Upper Cretaceous deposits, in particular. In recent years, as a result of drilling works with total core sampling carried out by the Omsk geological survey expedition it has become possible to perform detailed palynological, magnetostratigraphic, and micropaleontological research in the Russkaya Polyana District. Much of the published works on results of studying the borehole sections describe only Cenozoic deposits (Volkova et al., 2002, 2005; Akhmetiev et al., 2004a, 2004b, 2010; Iakovleva et al., 2010, 2011; Akhmetiev, 2011; Iakovleva, Heilmann-Clausen, 2010; etc.). Upper Cretaceous deposits were described only in some intervals of the Gan'kino Formation (Benyamovskii et al., 2002; Kuzmina et al., 2003; Aleksandrova et al., 2004).

In the period 2007-2009, researchers from IPGG RAS and GIN RAS (Z.N. Gnibidenko, O.B. Kuzmina, N.K. Lebedeva, G.N. Aleksandrova, and V.N. Benyamovskii) have collected rock samples for palynological, micropaleontological and paleomagnetic studies, and also macrofauna from Upper Cretaceous and Cenozoic deposits in boreholes, drilled in the Russkaya Polyana District, the south of the Omsk Region (Fig. 1).

The borehole no. 8 was drilled within the southern flank of the Omsk Depression. According to the scheme of zonal distribution of Upper Cretaceous deposits in Western Siberia, this borehole is located within the Omsk-Lar'yak facies zone (*Reshenie* ...,

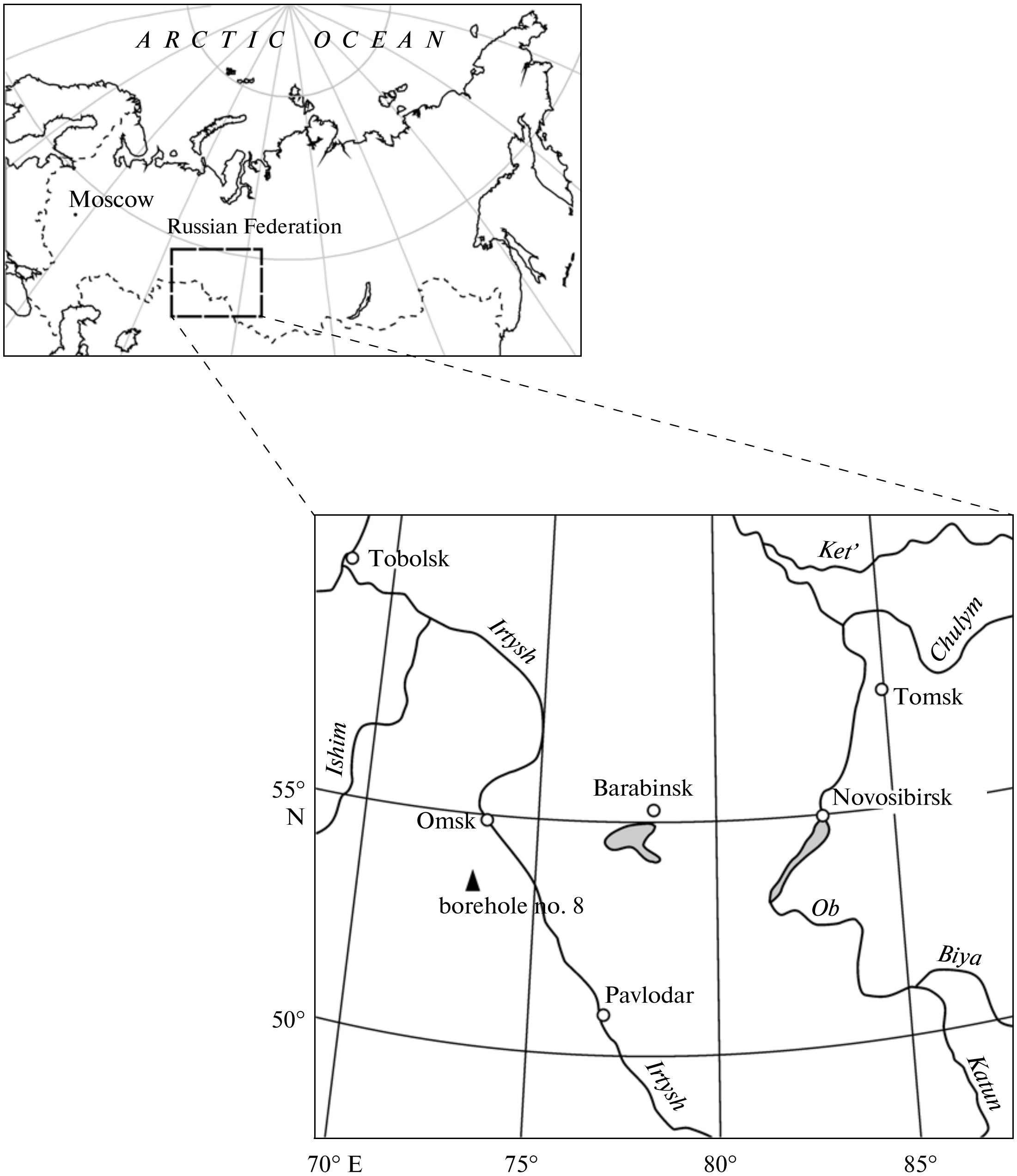


Fig. 1. Location of the borehole no. 8 in the Russkaya Polyana District.

1991). It opened a nearly 600-meter thick section of Mesozoic-Cenozoic deposits, including those of the Pokur, Kuznetsovo, Ipatovo, Slavgorod and Gan'kino Formations.

The first paleontological and paleomagnetic data were published (Podobina and Kseneva, 2007; Gnibidenko et al., 2008; Aleksandrova et al., 2011). This paper aims to clarify the age of Upper Cretaceous deposits and their division on the basis of paleontological, palynological, paleoalgologic and paleomagnetic data.

MATERIAL AND RESEARCH METHODS

Palynological Researches

For palynological and paleoalgologic researches 105 samples have been collected in the section of the borehole no. 8. To extract microphytofossils from rock samples, Sodium Pyrophosphate, as water treatment agent to remove clayparticles, and cadmium liquid with a specific gravity of 2.25, to separate mineral and organic fractions from the residue, were used. Glycerol Jelly reagent has been used for making permanent preparations.

In fact, in all the samples diverse phytofossil remains with satisfactory and good preservation have been described. They are represented by mosses and fern spores, pollen of gymnosperms and angiosperms, and cysts of dinoflagellates (Division Dinoflagellata), prasinophytes (Division Chlorophyta, Class Prasinophyceae), acritarchs (a group of uncertain systematics), and freshwater microscopic algae (Division Chlorophyta, similar to the modern Zygnemataceae).

To calculate the palynological spectra the volume of all microphytofossils (spores, pollen and microphytoplankton) was normalized to 100%. At this, not less 200–300 grains of different components were taken into consideration.

The palynomorph complexes were selected on the basis of their first appearance, the disappearance of taxa and their number.

The collection of studied samples from the borehole no. 8 is stored in the laboratory of Mesozoic and Cenozoic paleontology and stratigraphy of the Institute of Petroleum Geology and Geophysics of SB RAS (Novosibirsk, Russia).

Researches of Calcareous Nannoplankton

In order to study calcareous nannoplankton, the standard methodology (Bown and Young, 1998; Ovechkina, 2007) was used. Permanent preparations were studied using a light microscope (Zeiss Axiolab) in the Department of Natural Sciences KwaZulu-Natal Museum (Pietermaritzburg, Republic of South Africa) with magnification of ×1200.

For biostratigraphic subdivision two zonal scales: the Sissingh's standard scale (Sissingh, 1977), modified by K. Perch-Nielsen (CC) (Perch-Nielsen, 1985) and the Barnett's boreal scale (UC) (Burnett, 1998) were used. Photographs were taken with a light microscope using crossed nicols and a scanning electron microscope at the Center for Electron Microscopy of the University of KwaZulu-Natal (Pietermaritzburg, Republic of South Africa).

In order to describe the frequency of occurrence of species and a preservation degree of nannofossils the following characteristics have been taken into consideration:

The amount of grains in the field of view: a lot—6–10 grains; many—1–5 grains, usual—1 grain for 2–5 fields of view, and small—1 grain for 6–10 fields of view, rare grains—1 grain for more than 10 fields of view, single grains—1 grain for a preparation.

Preservation: G (good)—most nannofossils are not broken, there is no evidence of secondary recrystallization and dissolution, A (average)—there are insignificant signs of secondary recrystallization; nannofossils may be slightly broken (identification is possible), P (poor)—grains are badly broken; evidence of significant recrystallization (identification is problematic).

Paleomagnetic Researches and Apparatus

In general, collection of oriented samples for paleomagnetic research and data processing were carried using the standard procedures (Khramov and Sholpo, 1967; Paleomagnitologiya, 1982; Molostovskii and Khramov, 1997, etc.). It should be noted that collection of oriented massive samples was carried out during drilling works.

The samples were oriented in the "top-down" direction. In total, 500 oriented samples, representing 159 temporary stratigraphic levels were collected.

Measurement of the natural remanent magnetization has been carried out using a JR-4 and JR-6 spinner magnetometers; measurement of magnetic susceptibility was performed with KT-5 and KLY-2 kappameters. Magnetic cleaning was performed using TD48 and LDA-3A demagnetizers (Czech Republic). In order to plot the normal magnetization curves of rock samples, a static 5-R electromagnet with an electromagnet with a maximum magnetizing field of 1088 kA/m was used.

LITHOLOGY

The **Pokur Formation** (depth interval of 593–408 m, thickness of 185 m) is represented by complex alternation of clays, aleurolites, sands and sandstones of pale- to dark-gray and greenish-gray color. In the lower part of the section sandstones and argillites predominate with interbeds clays and argillites. Upper in the succession, the clay content in deposits increases. Variability in lithology of deposits is clearly seen on the well log as differentiable apparent resistivity (AR) and spontaneous polarization (SP) curves (Fig. 2).

Kuznetsovo Formation (depth interval of 408–380 m, thickness of 28 m) is represented by gray, dark- and greenish-gray, massive, thin-platy, silty to sandy clays; in the upper part of the section—gray, fine-grained, micaceous sands. Clays are characterized by low (1–2.5 Ohm) AR values and undifferentiated SP curve.

Ipatovo Formation (depth interval of 380–343 m, thickness of 37 m) is represented by inhomogeneous interbedding of sands and subordinate interbeds of sandstones, aleurites and clays. Rocks vary in color from gray to dark-gray and greenish-gray. In addition, inclusions of pyrite and glauconite, as well as plant detritus occur. Sands and sandstones are fine- to coarse-grained, quartz-glauconite and feldspar-quartz, with low mica content, with rounded quartz and flint pebbles, and rare interbeds of gravellites. Aleurites are massive, clayey and sandy, calcareous. Clays are silty and sandy, montmorillonite, opoka-

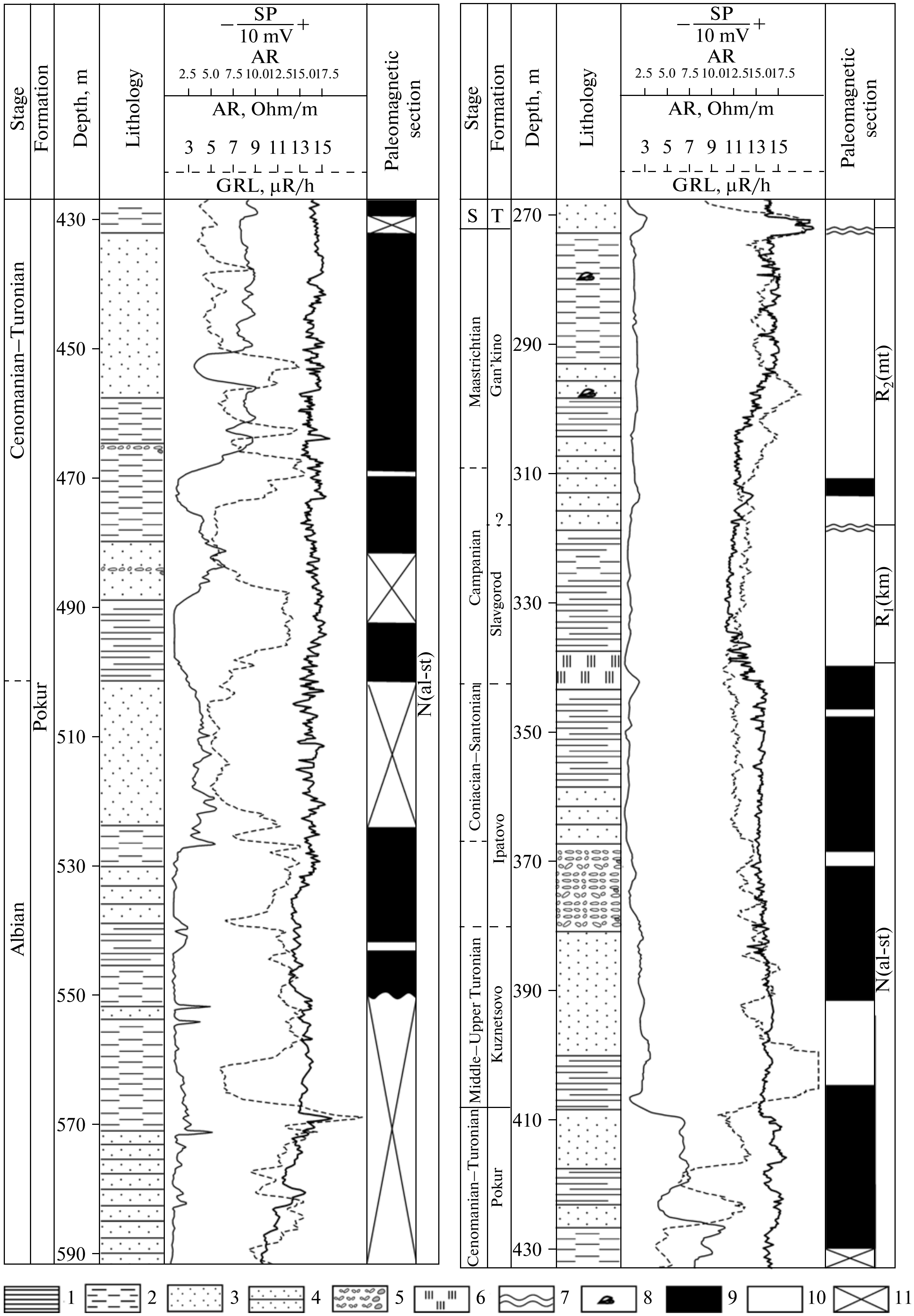


Fig. 2. Section of the borehole no. 8, drilled in the Russkaya Polyana District and its geophysical description. 1—clays; 2—aleurites; 3—sands; 4—sandstones; 5—gravellites; 6—opoka; 7—gap; 8—sites of faunistic findings; 9, 10—polarity; 9—direct, 10—reverse; 11—absence of data. Abbreviations: S—Selandian; T—Talitsa.

like, with rare quartz pebbles. At the base of Formation, a 13 m thick bench of conglomerates lies.

Slavgorod Formation (depth interval of 343–319 m, thickness of 24 m) is composed of clays with subordinate interbeds of aleurites, aleurolites, sands and sandstones. Clays are gray to dark-gray and greenish-gray, dark green, silty, sandy, sometimes opoka-like, homogeneous, with polished surfaces. Aleurites and aleurolites are clayey, sandy, glauconitic and quartz-glauconitic, micaceous. In addition, plant remnants, fragments of shells, and inclusions of pyrite occur.

Gan'kino Formation (depth interval of 319–273 m; thickness of 46 m) is represented by greenish-gray and dark gray, massive, calcareous and silty clays. Gray to dark gray, dark green, quartz-glauconitic sands and sandstones are in less volume. Throughout the section of this Formation isolations of pyrite and rare plant detritus occur. In the lower part of the Formation are beds with abundant fauna.

PALYNOLOGICAL CHARACTERISTICS

Beds with Palynological Complexes

Based on changes in the composition of spores and pollen of land plants, five biostratons of the same rank as beds with spores and pollen have been established. The description of palynocomplexes (PC), characteristic for these biostratons are given below. Characteristic species are listed in Plate I.

Beds with PC I (Depth interval of 590.5–500.5 m). Pokur Formation. In some samples collected in the lower and upper parts of this interval (Fig. 3) extremely poor palynological spectra have been established. Among spores of mosses and ferns the next types have been found: *Leiotriletes* spp., *Gleicheniidites* spp., *Cyathidites* sp., *Trilobosporites* sp., *Stereisporites* spp., *Cicatricosisporites* spp., *Appendicisporites* sp. etc. Pollen of gymnosperms is represented by *Alisporites* spp., *Cedripites* sp., *Taxodiaceaepollenites hiatus* (Pot.) Kremp, *Ginkgocycadophytus* sp. In addition, pollen of angiosperms (*Tricolpites* sp.) occurs. In some sandstone samples microphytofossils are absent.

The rest of samples are characterized by significantly more diverse spore-pollen complexes. The quantitative content of single groups of palynomorphs varies. The content of spores of 17–87%, pollen of gymnosperms—12–79%, pollen of angiosperms—0–4%, microphytoplankton—0–3%.

In the spore composition, the next types are in predominance: *Leiotriletes* spp., *Gleicheniidites* spp. (*G. senonicus* Ross, *G. circinidites* (Cook.) Dett., *G. carinatus* (Bolkh.) Bolkh., *G. umbonatus* (Bolkh.) Bolkh., *Plicifera delicata* (Bolkh.) Bolkh., and *Cyathidites* sp. (*C. minor* Coup., *C. australis* Coup.). Representatives of Family Schizaeaceae (*Cicatricosisporites* spp., *Appendicisporites* spp., *Trilobosporites* sp.) are numerous and diverse. In addition, there are *Aequitriradites verrucosus* Cook. et Dett., *Stereisporites* spp., *Ornamentifera echinata* Bolkh., *Laevigatosporites ovatus* Wils. et Web., *Appendicisporites* sp., *A. bilateralis* Singh, *A. matesovae* (Bolkh.) Nor., *A. macrorhyzus* (Mai.) Bond., *A. markovae* Vor., *Cicatricosisporites annulatus* Arch. et Gam., *C. dorogensis* Pot. et Gell., *C. ludbrookiae* Dett., *Matonisporites* sp., *Biretisporites* sp., *Kuylisporites lunaris* Cook. et Dett., *Ruffordia aralica* Bolkh., *Rouseisporites reticulatus* Poc., *R. laevigatus* Poc., *Lobatia involucrata* (Chlon.) Chlon., *Impardecispora apiverrucata* (Coup.) Venk., Kar et Raza, *Lycopodiumsporites* sp., *Densoisporites microrugulatus* Brenn., *Balmeisporites glenelgensis* Cook. et Dett., etc.

Pollen of gymnosperms are represented by numerous poorly preserved bisaccate conifer pollen (Coniferales gen. indet., as well as *Pinuspollenites* spp., *Alisporites* spp., *Phyllocladidites* sp., *Cedripites* sp., *Taxodiaceaepollenites hiatus*, and *Ginkgocycadophytus* sp.). Pollen of angiosperms (*Tricolpites* spp. and *Retitricolpites* spp.) always occur. Other palynomorphs are characterized by occurrence of prasinophytes (*Leiosphaeridia* sp.), acritarchs (*Michrystridium* sp.), freshwater green algae species of the Family Zygnemataceae (*Ovoidites*, *Schizosporis*).

According to the regional stratigraphic schemes for Mesozoic deposits of the West Siberian Plain (*Reshenie* ..., 1991), a similar complex is typical of the Albian Stage. The Albian palynocomplexes are well studied throughout the territory of Western Siberia. The fundamental works were published where the characteristics of spore-pollen complexes from different regions of Western Siberia are given (Markova, 1971; Chlonova, 1974; Rovnina et al., 1978). However, as was noted in (Markova, 1971), Albian spore-pollen complexes are sufficiently homogeneous and do not differ from each other throughout the studied territory. In works (Strepetilova, 1980, 1984), on the basis of the data of study of Albian palynological complexes (PC) from samples from a large number of boreholes, drilled within the Nadym-Taz interfluve area the main features of these complexes have been revealed. According to these features, the Albian palynological complexes differ from older and younger complexes. In the section of the borehole no. 41-R (depth interval of 1583–1610 m), drilled in the Nakhodka area, the characteristic Albian palynological complex has been found with the Lower and Middle Albian foraminifera complex. According to (Strepetilova, 1980, 1984), the main part of the spore part of the spectrum is represented by *Leiotriletes*, Gleicheniaceae (typical species with exine sculpture, such as *Ornamentifera echinata*), species of Family Schizeaceae are not diverse, and their content does not exceed 9%.

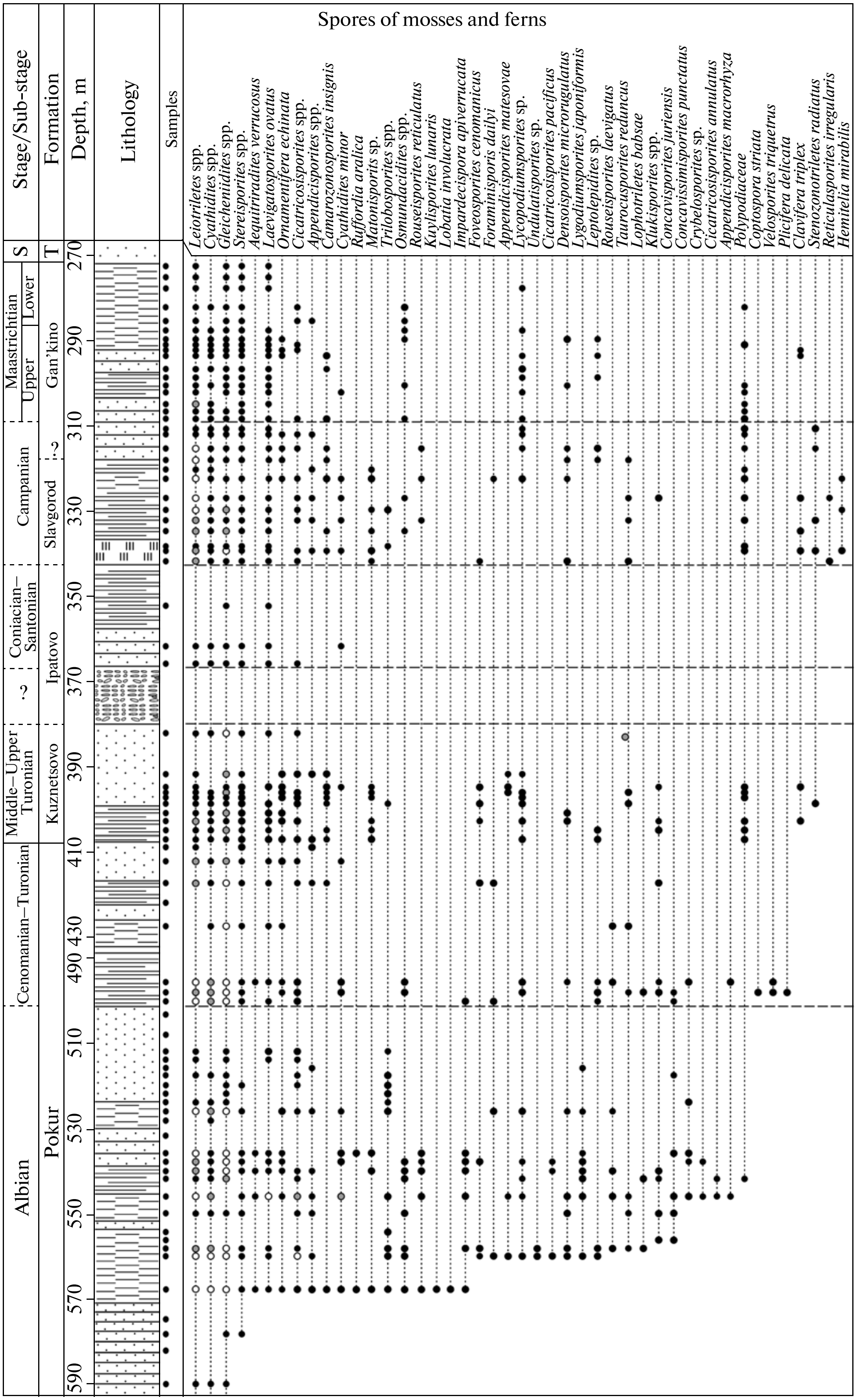


Fig. 3. Distribution of characteristic spores and pollen taxa of land plants in the section of the borehole no. 8 in the Russkaya Polyana District. Symbols are the same as in Fig. 2. Abbreviations: S—Selandian, T—Talitsa.

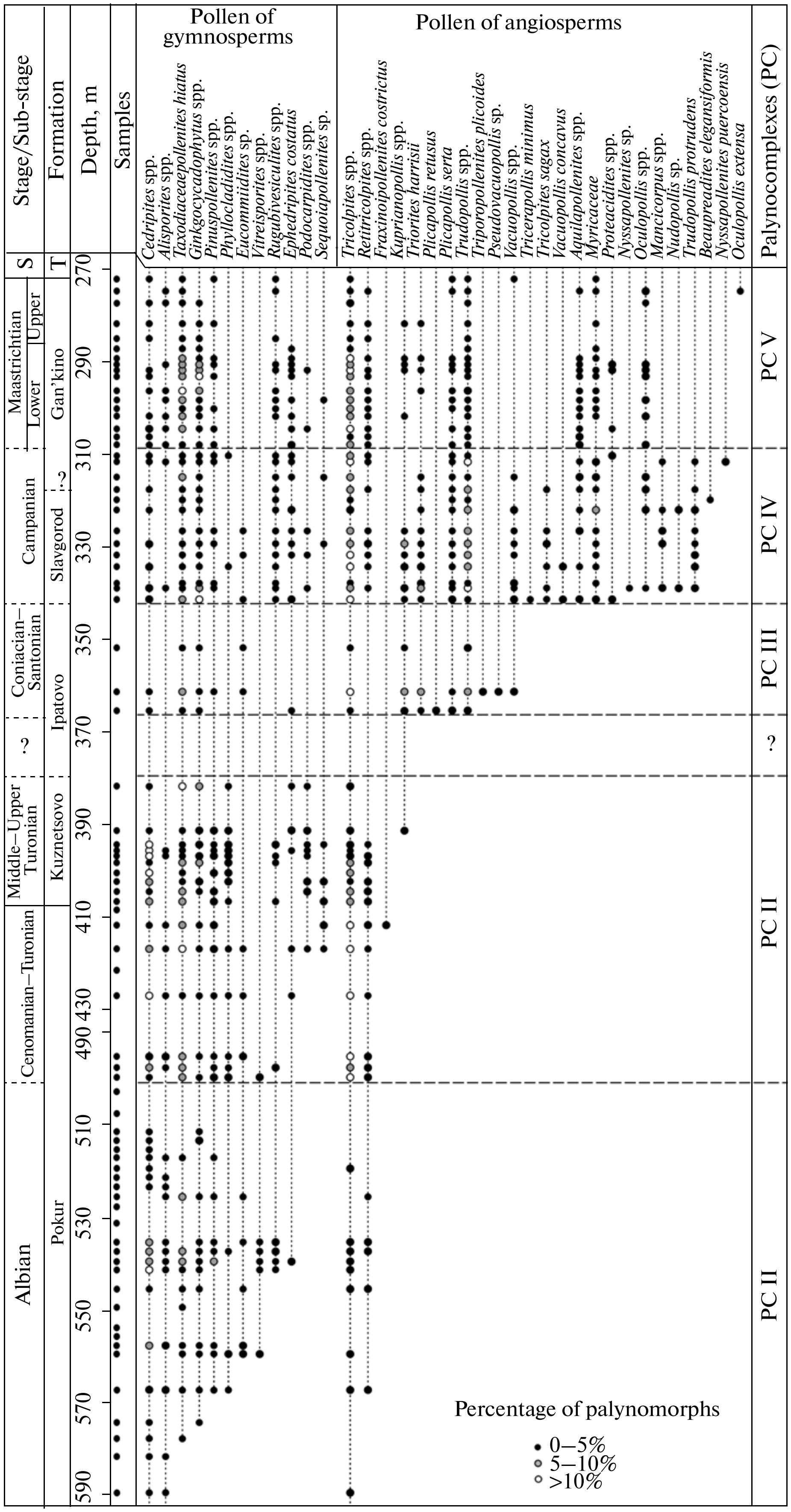

Stage/Sub-stage
Formation
Depth, m
Samples
Pollen of gymnosperms
Cedripites spp.
Alisporites spp.
Taxodiaceaepollenites hiatus
Ginkgocycadophytus spp.
Pinuspollenites spp.
Phyllocladidites spp.
Eucommiidites sp.
Vitreisporites spp.
Rugubivesiculites spp.
Ephedripites costatus
Podocarpidites spp.
Sequoiapollenites sp.
Pollen of angiosperms
Tricolpites spp.
Retitricolpites spp.
Fraxinoipollenites costrictus
Kuprianopollis spp.
Triorites harrisii
Plicapollis retusus
Plicapollis serta
Trudopollis spp.
Triporopollenites plicoides
Pseudovacuopollis sp.
Vacuopollis spp.
Triceropollis minimus
Tricolpites sagax
Vacuopollis concavus
Aquilapollenites spp.
Myricaceae
Proteacidites spp.
Nyssapollenites sp.
Oculopollis spp.
Mancicorpus spp.
Nudopollis sp.
Trudopollis protrudens
Beaupreadites elegansiformis
Nyssapollenites puercoensis
Oculopollis extensa
Palynocomplexes (PC)
S
T
Maastrichtian
Lower
Upper
Gan'kino
Campanian
Slavgorod
Coniacian–Santonian
Ipatovo
?
Middle–Upper Turonian
Kuznetsovo
Cenomanian–Turonian
Albian
Pokur
270
290
310
330
350
370
390
410
430
490
510
530
550
570
590
PC V
PC IV
PC III
?
PC II
PC II
Percentage of palynomorphs
0–5%
5–10%
>10%

Fig. 3. (Contd.)

Osmundaceae and Polypodiaceae dominate. *Lycopodium*, *Rouseisporites*, *Camarozonosporites insignis* are less common. In the pollen composition of gymnosperms, saccate conifers (Pinaceae), Ginkgoaceae, and Podocarpaceae dominate; ancient pollen of Taxodiaceae (sometimes up to 20%) also occurs. Pollen of angiosperms occurs in small amounts. Palynologists from the city of Tyumen (Russia) have studied the Albian palynological complexes from different localities in Siberia (Shirokova, 1972; Purtova et al., 1980; Strepetilova, 1989, 1994), which are characterized by an increase (compared to the Aptian palynological complexes) in the diversity of the Family Gleicheniaceae and the common occurrence of *Ornamentifera echinata*, different species of *Rouseisporites* and Polypodiaceae, typical ribbed spores of Schizaeaceae, less numerous *Kuylisporites lunaris*, *Cooksonites variabilis*, *Klukisporites* sp. and some other species.

In the Tanopcha Formation of Northern Siberia the Albian palynological complex (Strepetilova and Popovicheva, 1980), similar to the PC I has been established.

Similar spore-pollen complex has been established in deposits of the Khanty-Mansi Formation, spread along the western margin of Western Siberia. Deposits of this Formation have been opened by the Sogomskaya 1 borehole. This PC has been dated on the basis of finding of Early Albian ammonite (Savchenkova, 2004).

Thus, a comparative analysis of Albian palynocomplexes (often dated on the basis of findings of ammonites and foraminifera) confirms the Albian age of the Pokur Formation in the depth interval of 590.5–500.5 m (borehole no. 8).

Beds with PC II (depth interval of 500.5–382.0 m). The upper part of the Pokur Formation, Kuznetsovo Formation. The content of spores is 11–40%, gymnosperm pollen—14–57%, angiosperm pollen—2–54%, and microphytoplankton—12–43%.

In the spore part of the complex, *Gleicheniidites* spp., *Leiotriletes* spp., and *Cyathidites* sp. dominate. In addition, there are *Todisporites minor* Coup., *Laevigatosporites ovatus*, *Stereisporites* spp., *Rouseisporites laevigatus*, *Taurocusporites reduncus* (Bolkh.) Stov., *Camarozonosporites insignis* Nor., *Ornamentifera echinata*, *Cicatricosisporites* spp., *Appendicisporites* sp., *Foveosporites cenomanicus* (Chlon.) Schvet., *Aequitriradites verrucosus*, *Baculatisporites comaumensis* (Cook.) Pot., *Velosporites triquetrus* (Lantz) Dett., *Foraminisporis asymmetricus* (Cook. et Dett.) Dett., *Lophotrilets babsae* (Bren.) Singh., *Matonisporites* sp., *Polypodiaceae* (fabaceous, ornamented), *Plicifera delicata* (Bolkh.) Bolkh., etc. (Fig. 3). Single *Stenozonotriletes radiatus* Chlon., *Cicatricosisporites hallei* Delc. et Spr., and *Camarozonosporites bullatus* Kr. have been noted. Compared to PC I, a number and variety of Schizaeaceae decreases.

In the pollen composition of gymnosperms Coniferales gen. indet, *Cedripites* sp., and *Taxodiaceaepollenites hiatus* dominate. In addition, there are *Pinuspollenites* spp., *Alisporites* spp., *Phyllocladidites* sp., *Ginkgocycadophytus* sp., *Ephedripites costatus* Bolch., and *Eucommiidites* sp.

Compared to PC I, an amount of angiosperm pollen (*Tricolpnes* sp., *Retitrcolpites* sp., *Fraxinoipollenites constrictus* (Chlon.) Chlon., *Menispermum turonicum* N. Mtch., *Vacuopollis* sp.) essentially increases (4–9%, on average).

Among microphytofossils, the next species have been established: *Chomotriletes fragilis* Pos., *Scatula baccata* Chlon., *Sangarella lenaensis* (Frad.) Frad. et Pesch.

According to the spore-pollen composition, the complex described corresponds the Cenomanian (PC VII (5)) and Turonian (PC VIII (3)) complexes (*Reshenie* ..., 1991). The works, describing the spore-pollen complexes of Southwestern Siberia (Chlonova, 1976) and the Southern Trans-Urals (*Verhnemelovye* ..., 1990) contains information about the PC of undifferentiated Cenomanian–Turonian interval without clear evidence to allow us to distinguish it from underlying and overlying complexes, except for quantitative variations in the contents of some components, mainly pollen of angiosperms.

Among spores, *Taurocusporites reduncus* and *Stenozonotriletes radiatus* play the leading role; *Gleicheniidites* sp., *Aequitriradites verrucosus*, *A. spinulosus*, *Rouseisporites reticulatus*, *Cicatricosisporites*, *Appendicisporites* sp., etc. are common.

Quantity and diversity of angiosperm pollen increases. In the Cenomanian–Turonian palynological complex of the Southeast of Western Siberia (Chulym-type complex), this group of pollen is morphologically uniform and represented mainly by small tricolpate and tricolpate-porous grains (Chlonova, 1976). The same feature is noted for the PC II, described in the section of the borehole no. 8. *Fraxinoipollenites* is a common component in both complexes being compared. Due to the occurrence of *Menispermum turonicum* and *Vacuopollis* sp., the PC II is similar to the Cenomanian–Turonian complexes of Upper Tobol (*Verhnemelovye* ..., 1990), although the latter are characterized by a much more diverse taxonomic composition. The appearance of the genus *Vacuopollis* is noted in the Turonian deposits of the studied region. The upper part of the interval of the PC II distribution in the borehole no. 8 is characterized by occurrence of Turonian dinocyst complex.

Thus, the age of the deposits, containing the PC II, opened by the borehole no. 8 can be considered as Cenomanian–Turonian. Poor spore-pollen composition prevents separation of the Cenomanian and Turonian palynocomplexes, although in more northern areas they differ quite clearly.

Beds with PC III (depth interval is 372.1–343.0 m). Ipatovo Formation.

The content of spores of mosses and ferns is 11–21%, the pollen of gymnosperms—18–34%, the pollen of angiosperms—2–56%, and microphytoplankton—14–43%. Taxonomic composition is very poor. The quantity and diversity of spores decreases. *Gleicheniidites* spp., *Leiotriletes* spp., *Cyathidites* sp., *Stereisporites* spp., and *Laevigatosporites ovatus* are common components. *Taurocusporites reduncus*, *Cicatricosisporites* spp., *Foveosporites cenomanicus*, and *Densoisporites* sp. are less common. There are no essential changes in the pollen composition of angiosperms.

The diversity of angiosperm pollen essentially increases. The following species have been established: *Tricolpites* sp., *Triorites harrisii* Coup., *Kuprianipollenites* sp., *Plicapollis retusus* Tsch., *P. serta* Pf., *Causarinidites cainozoicus* Cook. et Pike, *Trudopollis* sp., *Triporopollenites plicoides* Zakl., *Pseudovacuopollis* sp., *Vacuopollis* sp., *Tricerapollis minimus* Chlon. (Fig. 3).

A similar composition of the pollen of angiosperms has been noted in the palynocomplex from the Coniacian-Santonian deposits of the Southern Trans-Urals (*Verhnemelovye* ..., 1990), although it is much more diverse than the PC III. In the modern regional stratigraphic schemes of Western Siberia (*Reshenie* ..., 1991), undifferentiated Coniacian–Santonian palynological complex (PC IX (3)), similar to III PC in the taxa composition and the ratio between some components is indicated for the Omsk–Chulym Region.

However, in the PC III the pollen of angiosperm (Stemm Normapolles) is more abundant and diverse. According to the above data, the age of the Ipatovo Formation, the section of which in the borehole no. 8 is well-studied, is Coniacian–Santonian.

Beds with PC IV (depth interval is 343.10–311.2 m). Slavgorod Formation–Lower Part Gan'kino Formation.

The content of spores is 19–33%, gymnosperm pollen—16–34%, angiosperm pollen—15–48%, and microphytoplankton—7–35%. The composition of spores and pollen of gymnosperms again becomes more diverse, although there no significant changes compared with the palynological complex PC III. Quantitatively, an amount of angiosperm pollen increases. In addition, an amount of *Trudopollis* sp. (6–8%, on average) increases.

The pollen of betuloid-myricoid-type always occurs. This is characteristic of the Campanian palynological complexes. Species such as *Triorites harrisii*, *Kuprianipollenites* sp., *Plicapollis serta*, *Aquilapollenites* sp. are common. *Proteacidites* sp., *Nyssapollenites* sp., *Oculopollis* sp., *Mancicorpus* sp., *Nudopollis* sp. and some others appear.

In general, the palynological complex PC IV corresponds the Campanian palynocomplex (PC X (3)) (*Reshenie* ..., 1991). Characteristic features of the PC IV are an occurrence of the Normapolles Group in the composition of subdominants, the absence of such important taxa as *Chlonovaia sibirica* (Chlon.) Elsik, *Orbiculapollis globosus* Chlon., abundance of microphytoplankton compared to an occurrence of single species in the PC X (3). It is probably due to the fact that in the regional stratigraphic schemes of Western Siberia, only data for the Chulym Region are given, as there were no data for the Omsk Region in time of compilation of these schemes.

The Campanian palynoflora of Upper Tobol, as well as the PC IV are characterized by an increase in an amount and diversity of pollen of genera *Trudopollis*, an appearance of *Nudopollis*, as well as the pollen of *Aquilapollenites* and *Mancicorpus*, characteristic of the Siberian-Canadian paleofloristic region (*Verhnemelovye* .., 1990). Thus, the age of the PC IV can be considered as Campanian.

Beds with PC V (depth interval of 309.9–274.2 m). Gan'kino Formation.

The content of spores is 2–16%, gymnosperm pollen—12–25%, angiosperm pollen—4–22%, and microphytoplankton—46–74%.

The amount and variety of spores and pollen of land plants decreases significantly compared to the palynological complex PC IV, due to increasing an amount of marine microphytoplankton.

Among spores, the following species, *Gleicheniidites* spp., *Leiotriletes* spp., *Cyathidites* sp., *Laevigatosporites ovatus*, *Stereisporites* spp. are common; *Ornamentifera echinata*, *Osmundacidites* sp., *Cicatricosisporites* spp., *Camarozonosporites insignis*, *Polypodiaceae* (bean-shaped, ornamented), *Lycopodiumsporites* sp., *Leptolepidites* sp., and *Lophotriletes* sp. occur as single grains.

The pollen of gymnosperms is represented by Coniferales gen. indet., *Cedripites* sp., *Taxodiaceaepollenites hiatus*, *Pinuspollenites* spp., *Alisporites* spp., *Rugubivesiculites* sp., *Podocarpidites* sp., *Phyllocladidites* sp., *Ginkgocycadophytus* sp., and *Ephedripites costatus*.

In the pollen of angiosperms, species such as *Tricolpites* sp., *Retitricolpites* sp., *Kuprianipollis* sp., *Triorites harrisii*, *Plicapollis serta*, *Trudopollis* sp., *Aquilapollenites* sp., Myricaceae, *Oculopollis* sp., *Proteacidites* sp. have been identified.

The palynocomplex PC V is poor in the composition of spores and pollen due to their low quantities. However, the PC V corresponds in general to the Maastrichtian palynocomplex (PC XI (3)) (*Reshenie* ..., 1991).

Beds with Dinocysts

At a depth of 412 m, marine microphytoplankton appears, sometimes reaching 74% of the total palynomorphs. Cysts of dinoflagellates (dinocysts) in this microphytoplankton play the most important stratigraphic role. Changes in their composition allow us to distinguish five biostratons at the rank of beds with characteristic complexes of dinocysts (DC) (Fig. 4).

Throughout the borehole section the following taxa occur: *Spiniferites ramosus* (Ehr.) Mant., *Kallosphaeridium* ? *ringnesiorum* (Man. et Cook.) Helby, *Palaeotetradinium silicorum* Defl., *Rhiptocorys veligera* (Defl.) Lej.-Carp. et Sarj., *Trithyrodinium suspectum* (Man. et Cook.) Dav., *Glyphanodinium facetum* Drugg, *Trigonopyxidia ginella* (Cook. et Eis.) Dow. et Sarj., *Chlonoviella agapica* Leb., *Eisenackia* sp., *Oligosphaeridium complex* (White) Dav. et Will., *Leberidocysta chlamydata* (Cook. et Eis.) Stov. et Evitt, Group *Circulodinium/Cyclonephelium*, *Microdinium ornatum* Cook. et Eis.

Typical and index taxa are given in Plates II–IV.

Marine microphytoplankton appears in the upper part of the Pokur Formation. In addition, prasinophytes (*Leiosphaeridia* sp., 9%) occur. The species *Geiselodinium cenomanicum* Leb., an index species species of the biostraton, identified earlier in the Ust'-Yenisei Region in Upper Cenomanian deposits (Lebedeva, 2006) has been established. This allows us to suggest that there are Upper Cenomanian deposits in borehole no. 8, but there are no reliable data to support this assumption.

Beds with Heterosphaeridium difficile–Chatangiella spectabilis (depth interval of 407.0–380.0 m). Kuznetsovo Formation.

In these beds, species such as *Surculosphaeridium longifurcatum* (Firt.) Dav. et al., *Heterosphaeridium difficile* (Man. et Cook.) loan., *Dorocysta* sp. A, *Alterbidinium* sp., *Microdinium* sp., *Palaeohystrichophora infusorioides* Defl., *Odontochitina operculata* (Wetz.) Defl. et Cook., *Chatangiella* sp. are common. In the sandy part of the section (from a depth of 399.7 m), *Chatangiella spectabilis* (Alb.) Lent. et Will., *C. bondarenkoi* (Vozzh.) Lent. et Will., *C. tripartita* (Cook. et Eis.) Lent. et Will. appear.

Eurydinium sp., *E. saxoniense* Mar. et Bat., *Isabelidinium magnum* (Dav.) Stov. et Evitt, *Odontochitina costata* Alb., *Laciniadinium* sp., *Leberidocysta* sp., *Chatangiella serratula* (Cook. et Eis.) Lent. et Will. and some others occur rarely.

A dinocyst complex similar to the above-described one has been established in boreholes of 1002 and 2031 drilled within the Var'egan Megabar (Aleksandrova et al., 2010), together with Early Turonian foraminifera species. This complex is characterized by the absence of the genus *Chatangiella* and more diverse composition of chorate dinocysts. The presence of these taxa as *Heterosphaeridium difficile*, *Chatangiella* sp., *C. spectabilis*, *Surculosphaeridium longifurcatum*, *Dorocysta* sp. is characteristic of beds with Chatangiella spectabilis–Heterosphaeridium difficile, established in the Upper–Middle Turonian stratigraphic interval of the Western Siberia, dated based on the inoceramid fauna (Zakharov et al., 2002; Lebedeva, 2006).

Beds with DC II (depth interval of 372.1–343.0 m). Ipatovo Formation.

The palynological complex is extremely poor. In contrast to the above-described complex, the number of members of the genus *Chatangiella* increases. In addition, *Alterbidinium* sp., *Palaeotetradinium silicorum*, *Microdinium* sp., *Glyphanodinium facetum*, *Odontochitina costata*, and *O. operculata* occur. Taxa such as *Eurydinium* sp., *E. saxoniense*, *Heterosphaeridium difficile*, *Surculosphaeridium longifurcatum*, *Dorocysta* sp. A. disappear. Composition of dinocysts does not allow us to determine the age of the country rocks. According to the position of representative complexes in the section in overlying and underlying sediments one can only suggest a wide age range (Coniacian–Santonian).

Beds with Chatangiella manumii–Chatangiella vnigrii (depth interval of 339.9–311.2 m). Slavgorod Formation-Lower part of Gan'kino Formation, the composition of dinocysts increases. *Chlonoviella agapica*, *Chatangiella* sp., *C. serratula*, *C. spectabilis*, *C. bondarenkoi*, *Alterbidinium* sp., *Microdinium* sp., *Eisenackia* sp., *Laciniadinium* sp., *L. arcticum* (Man. et Cook.) Lent. et Will., *Fromea chytra* (Drugg) Stov. et Evitt, *F.* ? *laevigata* (Drugg) Stov. et Evitt. and some others (Fig. 4).

In addition, *Chatangiella manumii* (Vozzh.) Lent. et Will., *C. vnigrii* (Vozzh.) Lent. et Will., *C. ditissima* (McInt.) Lent. et Will., *Amphigymnium mitratum* (Vozzh.) Lent. et Will., *Laciniadinium rhombiforme* (Vozzh.) Lent. et Will., *Phoberocysta* sp., *Dinogymnium* sp., *D. sibiricum* (Vozzh.) Lent. et Will., *D. digitus* (Defl.) Evitt et al., *Microdinium kustanaicum* Vozzh. and some others appear.

The dinocyst complex established is similar in the taxonomic composition to the Campanian complexes of the Polar Fore-Ural Region and the Ust'-Yenisei Region (Lebedeva, 2005, 2006, 2007), but differs in the absence of large ribbed forms of *Chatangiella* (*Chatangiella niiga* Vozzh., *Chatangiella spinata* Leb.), fewer members of *Laciniadinium*, *Alterbidinium*, and more abundant and diverse members of *Dinogymnium*, that seems to be associated with the provincialism of dinoflagellates.

In the Kushmurun section (Northern Kazakhstan) beds with *Chatangiella manumii* have been established (Vasilieva, 2005; Vasilieva and Levina, 2007). A common feature of comparable complexes is the presence of such taxa as *Chatangiella manumii*, *Ch. vnigrii*, *Ch. ditissima*,

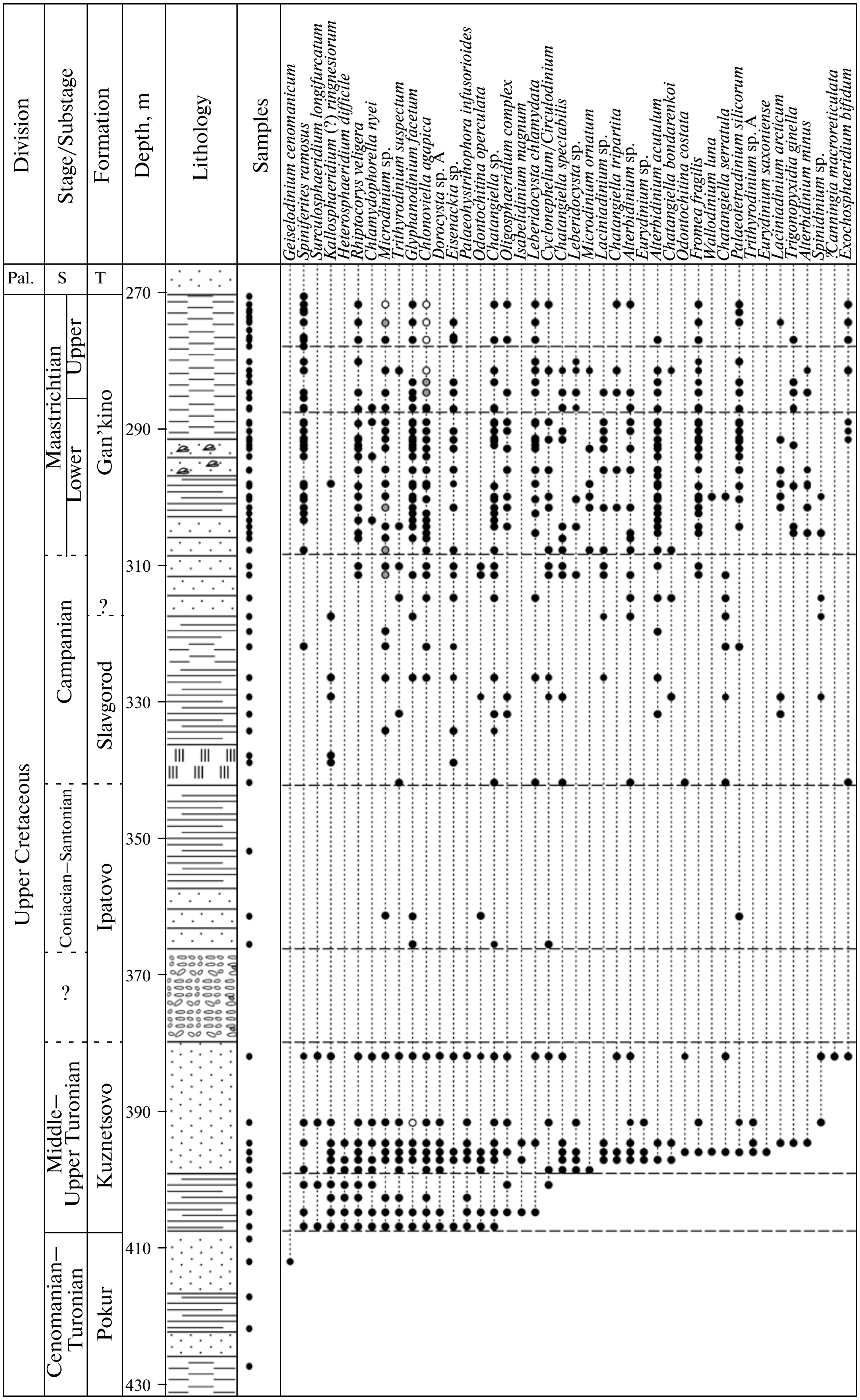


Fig. 4. Distribution of dinocysts in the section of the borehole no. 8 in the Russkaya Polyana District. Symbols are the same as in Fig. 2. Abbreviations: Pal—Paleogene, S—Selandian, T—Talitsa.

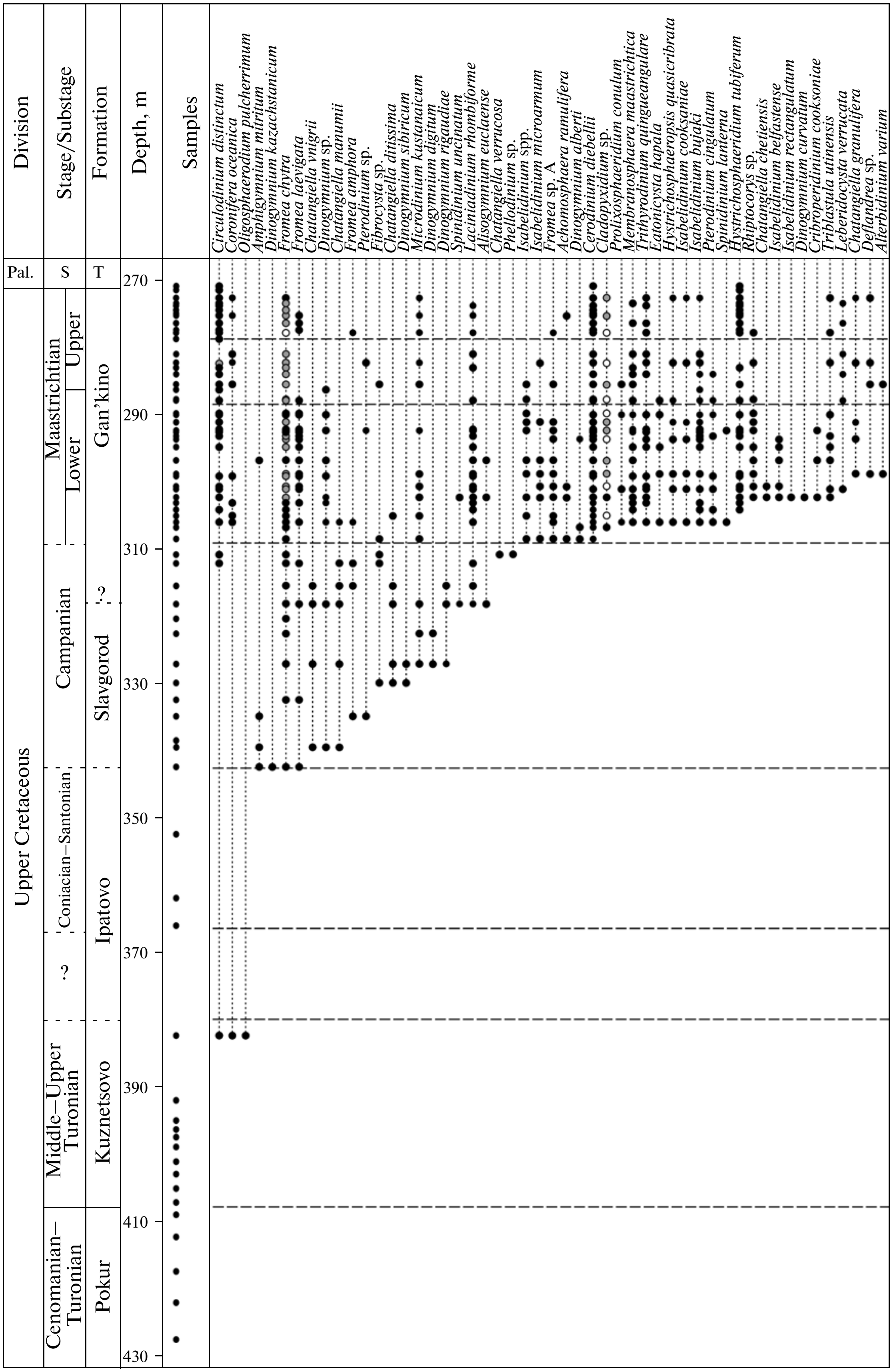

Division
Stage/Substage
Formation
Depth, m
Samples
Pal.
S
T
Upper Cretaceous
Maastrichtian
Lower
Upper
Campanian
Coniacian–Santonian
Middle–Upper Turonian
Cenomanian–Turonian
Gan'kino
Slavgorod
Ipatovo
Kuznetsovo
Pokur
270
290
310
330
350
370
390
410
430

Fig. 4. (Contd.)

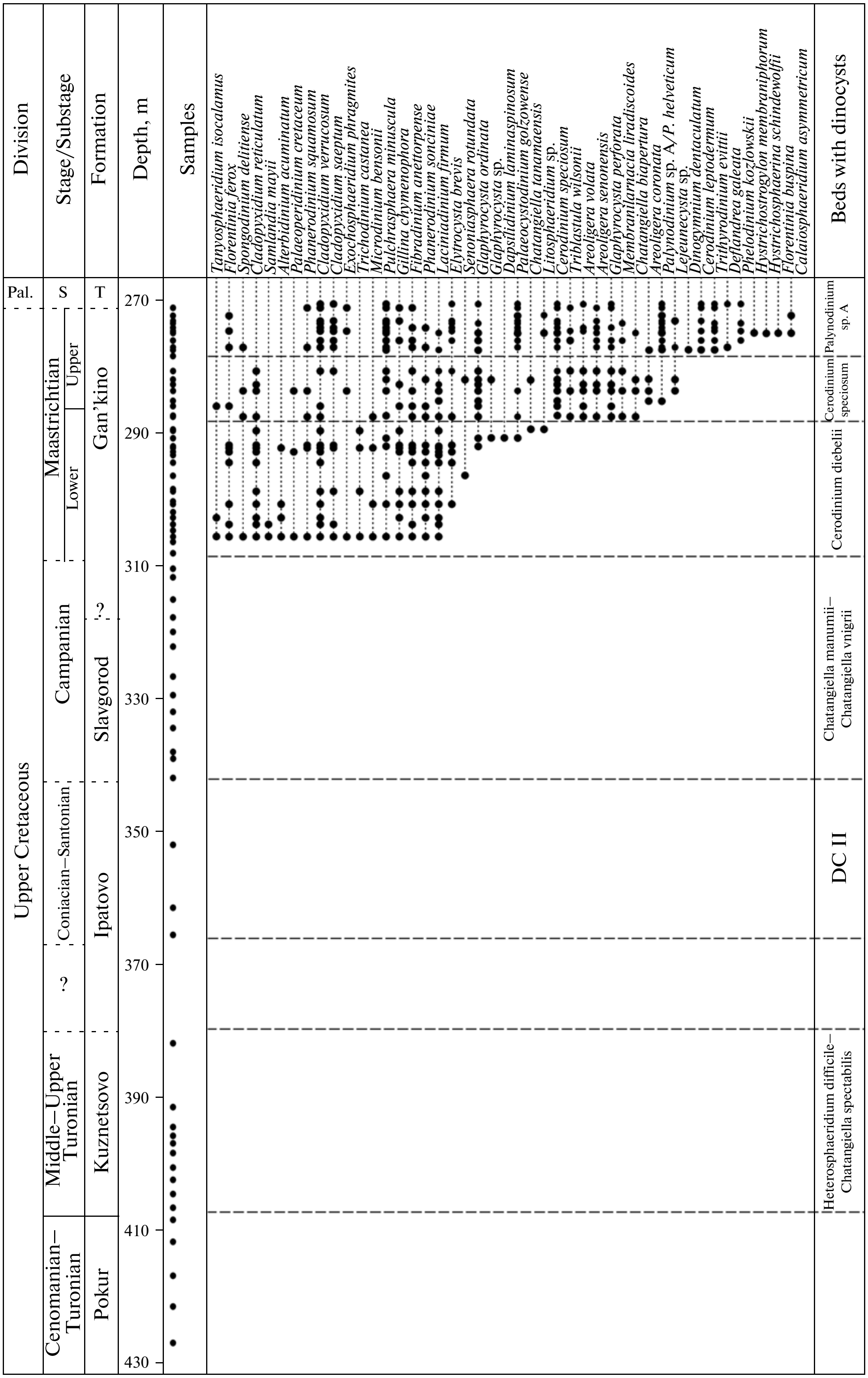

Division
Stage/Substage
Formation
Depth, m
Samples
Beds with dinocysts
Pal.
S
T
Upper Cretaceous
Maastrichtian
Lower
Upper
Campanian
Coniacian–Santonian
?
Middle–Upper Turonian
Cenomanian–Turonian
Gan'kino
?
Slavgorod
Ipatovo
Kuznetsovo
Pokur
270
290
310
330
350
370
390
410
430
Tanyosphaeridium isocalamus
Florentinia ferox
Spongodinium delitiense
Cladopyxidium reticulatum
Samlandia mayii
Alterbidinium acuminatum
Palaeoperidinium cretaceum
Phanerodinium squamosum
Cladopyxidium verrucosum
Cladopyxidium saeptum
Exochosphaeridium phragmites
Trichodinium castanea
Microdinium bensonii
Pulchrasphaera minuscula
Gillina chymenophora
Fibradinium anettorpense
Phanerodinium sonciniae
Laciniadinium firmum
Elytrocysta brevis
Senoniasphaera rotundata
Glaphyrocysta ordinata
Glaphyrocysta sp.
Dapsilidinium laminaspinosum
Palaeocystodinium golzowense
Chatangiella tanamaensis
Litosphaeridium sp.
Cerodinium speciosum
Triblastula wilsonii
Areoligera volata
Areoligera senonensis
Glaphyrocysta perforata
Membranilarnacia liradiscoides
Chatangiella biapertura
Areoligera coronata
Palynodinium sp. A/P. helveticum
Lejeunecysta sp.
Dinogymnium dentaculatum
Cerodinium leptodermum
Trithyrodinium evittii
Deflandrea galeata
Phelodinium kozlowskii
Hystrichostrogylon membraniphorum
Hystrichosphaerina schindewolfii
Florentinia buspina
Calaiosphaeridium asymmetricum
Palynodinium sp. A
Cerodinium speciosum
Cerodinium diebelii
Chatangiella manumii–Chatangiella vnigrii
DC II
Heterosphaeridium difficile–Chatangiella spectabilis

Fig. 4. (Contd.)

Spinidinium uncinatum, *Alterbidinium acutulum*, *Amphigymnium mitratum*, *Laciniadinium rhombiforme*, *L. arcticum*, *Microdinium kustanaicum*, *Dinogymnium* spp. and some others. Based on the presence of the ammonite *Placenticeras meeki* (Boehm.), the age of the beds has been defined as Late Campanian. Since the composition of dinocysts in the section of borehole no. 8 is not as rich as in the Kushmurun section. Moreover, among dinocysts there are no taxa typical of Upper Campanian deposits. Thus, we can assume a wide age range (Campanian) for beds characterized by dinocyst complexes with Chatangiella manumii–Chatangiella vnigrii.

In general, the combination of taxa such as *Chatangiella manumii*, *S. vnigrii*, *S. ditissima*, *Spinidinium uncinatum*, *Laciniadinium arcticum*, *Microdinium* sp., *Eisenackia* sp., *Dinogymnium* spp. is typical of Campanian dinocysts complexes in North America and northwestern Europe. Detailed analysis of this combination is given in the following works (Lebedeva, 2005; Vasilieva and Levina, 2007).

Beds with Cerodinium diebelii (depth interval of 309.9–288.4 m) Gan'kino Formation. The complex dinocysts becomes significantly richer. An amount of chorate forms, such as *Spiniferites ramosus*, *Oligosphaeridium complex*, *Kiokansium* sp., *Pterodinium* sp., *Achomosphaera ramulifera* (Defl.) Evitt, *Coronifera oceanica* Cook. et Eis., *Hystrichosphaeridium tubiferum* (Her.) Defl., *Reciculacysta* sp., *Prolixosphaeridium* sp. increases. *Cladopyxidium* spp. and *Fromea chytra* are numerous. Such taxa as *Chatangiella* sp., *C. spectabilis*, *Alterbidinium* sp., *A. minus* (Alb.) Lent. et Will., *Microdinium* sp., *Eisenackia* sp., *Rhiptocorys veligera*, *Laciniadinium* sp., *L. arcticum*, *L. rhombiforme*, *Dinogymnium* sp., *Membranosphaera maastrichtica* Samoil., *Trithyrodinium quingueangulare* Marheinecke, *Microdinium kustanaicum* are common in the complex. *Palaeocystodinium golzowense* Alb., *Chatangiella ditissima*, *Isabelidinium rectangulatum* Leb., *Alterbidinium varium* Kirsch and some others occur sporadically. Many new taxa such as *Cerodinium diebelii* (Alb.) Lent. et Will., *Isabelidinium* sp., *I. microarmum* (McInt.) Lent. et Will., *I. belfastense* (Cook. et Eis.) Lent. et Will, *I. cooksoniae* (Alb.) Lent. et Will., *I. bujaki* Marh., *Dinogymnium albertii* Clarke et Verd., *D. longicorne* (Vozzh.) Harl., *Microdinium reticulatum* Vozzh., *Triblastula utinensis* Wetz., *Hystrichosphaeropsis quasicribrata* (O. Wetzel) Gocht and some others appear. *Chatangiella manumii*, *S. vnigrii*, and *Odontochitina operculata* (Wetz.) Defl. et Cook. disappear.

The work (Ioannides, 1986) describes the Maastrichtian complex from the Eureka Sound Formation on the Bellot and Devon islands (Arctic Archipelago), where the index species are *Cerodinium diebelii*, *Palaeocystodinium golzowense*, *Spinidinium uncinatum*, and *Membranosphaera maastrichtica*. In beds with Cerodinium diebelii all these species occur. It is difficult to compare the identified DC complex with that from the Tunhout section of Maastrichtian deposits in Belgium, dated on the basis of findings of belemnites due to much greater diversity of dinocysts in the latter and a small number of common taxa (Slimani, 2001). However, the joint occurrence of *Cerodinium diebelii*, *Palaeocystodinium golzowense*, *Cladopyxidium* spp., *Alterbidinium varium*, *Trithyrodinium quingueangulare* in the Alterbidinium varium subzone of the Tunhout section and in beds with *Cerodinium diebelii* indicates that these beds are of Early Maastrichtian age. The palynological complex from beds with Cerodinium diebelii is also similar in composition of dinocysts to the Early Maastrichtian Bavarian complex of the Alterbidinium varium subzone of the Cerodinium diebelii zone (Kirsch, 1991). This gives grounds to refer the depth interval of 309.9–288.4 m in the borehole no. 8 to the Lower Maastrichtian, which is consistent with the faunistic data.

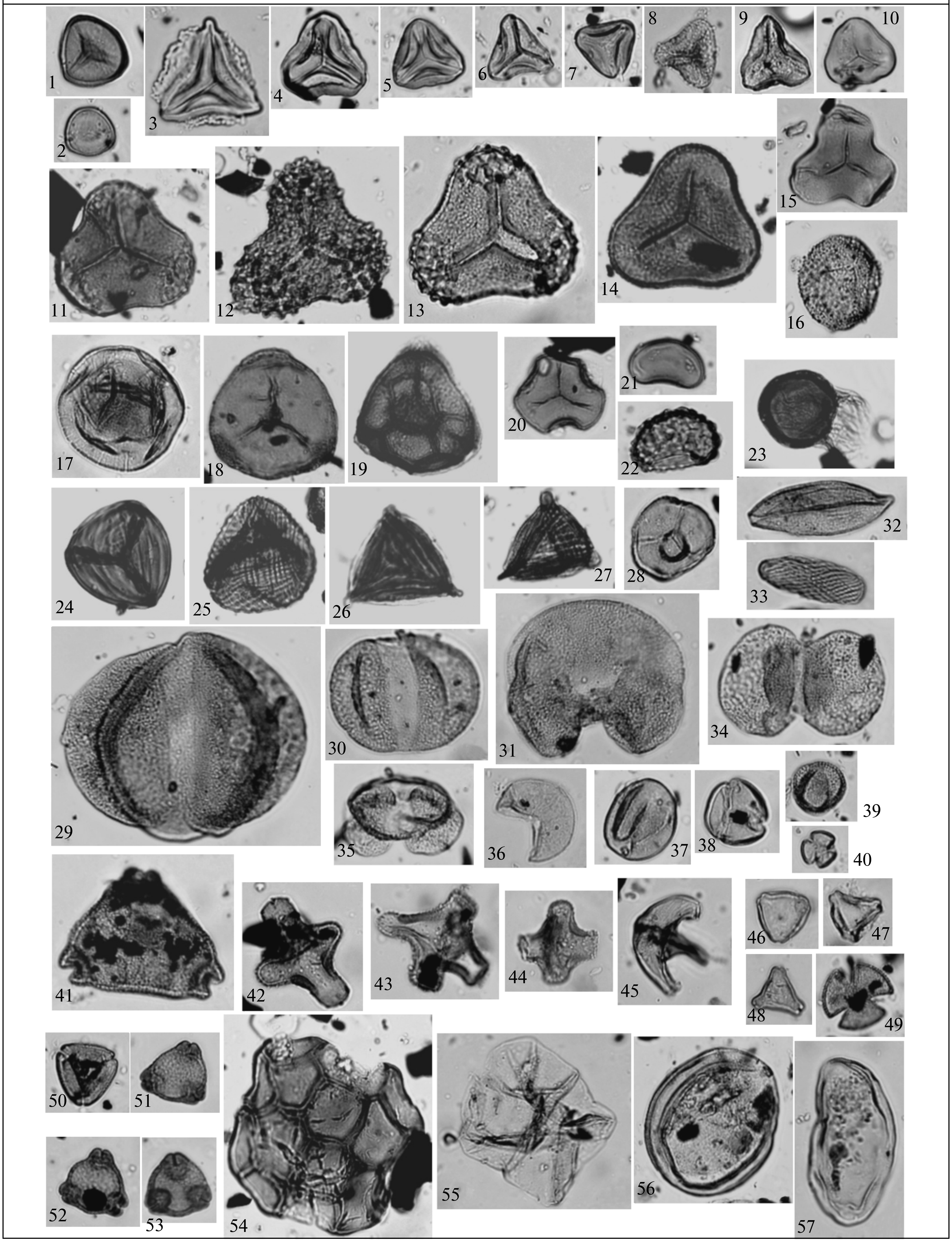
Beds with Cerodinium speciosum (depth interval of 288.4–278 m). Gan'kino Formation.

The palynological complex of these beds include numerous *Cladopyxidium* spp., *Fromea chytra*, and *Chlonoviella agapica*. In addition, there are *Chatangiella* sp., *Leberidocysta chlamydata*, *Triblastula utinensis*, *Exochospharidium bifidum* (Clarke et Verd.) Clarke et al., *Cerodinium diebelii*, *Hystrichosphaeridium tubiferum*, *Coronifera oceanica*, *Microdinium kustanaicum*, *Areoligera* spp., *Glaphyrocysta* spp., *Spiniferites* spp., etc.

A number of chatangielles decreases; members of the genera *Isabelidinium* and *Dinogymnium* practically disappear; a number of new taxa appear: *Chatangiella biapertura* (McInt.) Lent. et Will., *Triblastula wilsonii* Slim., *Areoligera coronata* (Wetz.) Lej.-Carp., *A . volata* Drugg, *Pulchrasphaera minuscula* Sch. et al., *Cerodinium speciosum* (Alb.) Lent. et Will., *Spongodinium delitiense* (Ehr.) Defl., and *Palynodinium helveticum* Kirsch. There are single *Florentinia buspina* (Dav. et Verd.) Dux., *F. ferox* (Defl.) Dux., *Lejeunecysta* sp. and some others.

The Late Maastrichtian complex of dinocysts, established by O.N. Vasilieva (Vasilieva and Levina, 2007) in the upper part of Zhuravlevskaya Formation, the Kushmurun section (Northern Kazakhstan) differs significantly from that described complex from beds with Cerodinium speciosum opened in the borehole no. 8. Similar features of these complexes are abundance of members of genera *Fromea* and *Microdinium*, the presence of *Cerodinium diebelii* and *Triblastula utinensis*. However, if in the section of the borehole no. 8 the index taxon is *Cerodinium speciosum*, then in the Kushmurun section–*Deflandrea galeata* (Lej.-Carp.) Lent. et Will. Perhaps, in the Kushmurun section younger deposits have Maastrichtian age.

Plate I


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57

Drilled within the Omsk Depression, the borehole no. 9 opened deposits of the Gan'kino Formation in a depth interval of 527.0–521.0 m. In these deposits, the complex with dinocysts of *Cerodinium diebelii* of Middle Late Maastrichtian has been established (Benyamovskii et al., 2002, Akhmetiev et al., 2004a, 2004b; Aleksandrova et al., 2004). The data on nannoplankton and foraminifera from this depth interval also indicate Late Maastrichtian age. The complex of dinocysts, established in the borehole no. 9 is most similar to the complex from beds with Cerodinium speciosum from the borehole no. 8. Common species of both complexes being compared are *Cerodinium diebelii*, *C. speciosum*, *Rhiptocorys veligera*, *Microdinium kustanaicum*, *Laciniadinium firmum*, *Membranosphaera maastrichtica*, *Chatangiella granulifera*, *Isabelidinium* sp., *Exochospharidium bifidum*, *Areoligera* sp., *Chlonoviella* sp., *Hystrichosphaeridium tubiferum*, and *Glaphyrocysta ordinata*.

The appearance of *Cerodinium speciosum*, as assumed in a number of publications, marks the boundary between the Lower and Middle Maastrichtian (Kirsch, 1991; Slimani, 2001). This complex of dinocysts is similar to that described from the Middle Maastrichtian deposits of Upper Bavaria (Kirsch, 1991). At a depth of 288 m, *Eatonicysta hapala* has been noted for the last time. In the sections of the North Sea, *Eatonicysta hapala* disappears at the top of the belemnites zone *Belemnella lanceolata* (Schiøler and Wilson, 1993).

In the upper part of beds with Cerodinium speciosum, the last appearance of *Alterbidinium acutulum* is noted. This is closer to the Lower–Upper Maastrichtian boundary (somewhat below the top of the zone Belemnella occidentalis). Given the above, as well as the data on other groups of fauna, the age of the beds is considered as transitive from Early to Late Maastrichtian.

Beds with Falynodinium sp. A (depth interval of 278–270.5 m). Gan'kino Formation.

In the upper part of the Gan'kino Formation, beds with Palynodinium sp. A have been established on the basis of the first appearance of the species.

In the complex of dinocysts a number of *Areoligera* spp. and *Glaphyrocysta* spp. significantly decreases, *Cladopyxidium reticulatum* (Defl.) Marh., *C. verrucosum* Marh., *C. saeptum* (Morgen.) Stov. et Evitt, *Membranosphaera maastrichtica*, *Fromea chytra*, *Phanerodinium* spp. often occur, and most of species from underlying beds occur as well.

Plate I. Palynomorphs from Upper Cretaceous deposits opened by the borehole no. 8 in the Russkaya Polyana District. Magnification of all samples is ×550.

(1) *Stereisporites pocockii* Burger, depth int.: 283.2–283.3 m, prep. (preparation) 2446.2; (2) *S. antiquasporites* (Wilson et Webster) Dettman, depth int.: 540.0–540.1 m, prep. 2508.3; (3) *Clavifera* sp., depth int.: 316.1–316.2 m, prep. 2463.2; (4) *Gleicheniidites carinatus* (Bolkhovitina) Bolkhovitina, depth int.: 538.0–538.1 m, prep. 2507.2; (5) *G. umbonatus* (Bolkhovitina) Bolkhovitina, depth int.: 540.0–540.1 m, prep. 2508.3; (6) *G. senonicus* Ross, the same depth int., prep. 2508.1; (7) *Plicifera delicata* (Bolkhovitina) Bolkhovitina, depth int.: 546.0–546.1 m, prep. 2511.2; (8) *Ornamentifera echinata* (Bolkhovitina) Bolkhovitina, depth int.: 538.0–538.1 m, prep. 2507.3; (9) *O. granulata* (Bolkhovitina) Bolkhovitina, depth int.: 568.0–568.1 m, prep. 2522.1; (10) *Cyathidites minor* Couper, depth int.: 546.0–546.1 m, prep. 2511.1; (11) *Trilobosporites purverulentus* (Vervitskaya) Bondarenko, the same depth int., prep. 2511.2; (12) *Impardecispora apiverrucata* (Couper) Venkatachala, Kar et Raza, the same depth int., prep. 2511.1; (13) *Trilobosporites trioreticulosus* Cookson et Dettmann, depth int.: 538.0–538.1 m, prep. 2507.1; (14) *Concavissimisporites punctatus* (Delcourt et Sprumont) Brenner, depth int.: 546.0–546.1 m, prep. 2511.1; (15) *Cyathidites australis* Couper, the same depth int., prep. 2511.2; (16) *Baculatisporites comaumensis* (Cookson) Potonie, depth int.: 568.0–568.1 m, prep. 2522.3; (17) *Velosporites* sp., depth int.: 427.0–427.1 m, prep. 2485.1; (18) *Densoisporites microrugulatus* Brenner, depth int.: 546.0–546.1 m, prep. 2511.1; (19) *Rouseisporites reticulates* Pocock, the same depth int., prep. 2511.4; (20) *R. triangularis* Pocock, the same depth int., prep.2511.3; (21) *Laevigatosporites ovatus* Wilson et Webster, the same depth int., prep. 2511.2; (22) Polypodiaceae (fabaceous, ornamented), depth int.: 292.9–293.0 m, prep. 2451.1; (23) *Crybelosporites punctatus* Dettmann, depth int.: 546.0–546.1 m, prep. 2511.4; (24) *Cicatricosisporites striatus* Rouse, the same depth int., prep. 2511.1; (25) *C. mtchedlishviliae* Griazeva, depth int.: 540.0–540.1 m, prep. 2508.1; (26) *Appendicisporites macrorhyzus* (Maljavkina) Bondarenko, depth int.: 568.0–568.1 m, prep. 2522.2; (27) *A. markovae* Voronova, depth int.: 546.0–546.1 m, prep. 2511.2; (28) Spores gen. indet., depth int.: 526.0–526.1 m, prep. 2501.2; (29) *Alisporites grandis* (Cookson) Dettmann, depth int.: 540.0–540.1 m, prep. 2508.4; (30) *A. similis* (Balme) Dettmann, the same depth int., (31) *Cedripites parvisaccatus* (Sauer) Chlonova, the same depth int., (32) *Ginkgocycadophytus* sp., depth int.: 308.9–309.0 m, prep. 2460.1; (33) *Gnetaceapollenites* sp., depth int.: 290.3–290.4 m, prep. 2449.1; (34) *Podocarpidites multesimus* (Bochovitina) Pocock, depth int.: 500.0–500.1 m, prep. 2488.1; (35) *Pinuspollenites minimus* (Couper) Kemp, depth int.: 526.0–526.1, prep. 2501.2; (36) *Taxodiaceaepollenites hiatus* (Potonie) Kremp, depth int.: 316.1–316.2 m, prep. 2463.2; (37) *Fraxiniopollenites* sp., depth int.: 538.0–538.1 m, prep. 2507.2; (38) *Nyssapollenites* sp., depth int.: 343.0–343.1 m, prep. 2473.1; (39) *Menispermum turonicum* N. Mtchedlishvili, depth int.: 546.0–546.1 m, prep. 2511.1; (40) *Tricolporopollenites* sp., depth int.: 318.4–318.5 m, prep. 2464.3; (41) *Proteacidites tumidiporis* Samoilovich, the same depth int., prep. 2464.1; (42) *Triprojectus dispositus* N. Mtchedlishvili, depth int.: 323.5–323.5 m, prep. 2466.1; (43) *Aquilapollenites unicus* Chlonova, depth int.: 299.3–299.4 m, prep. 2455.3; (44) *A. quadrilobus* Rouse, depth int.: 302.8–302.9 m, prep. 2457.2; (45) *Mancicorpus anchoriforme* N. Mtchedlishvili, the same depth int., prep. 2457.1; (46) *Triorites harrisii* Couper, depth int.: 290.3–290.4 m, prep. 2449.1; (47) *Kuprianipollis* sp., depth int., 326.9–327.0 m, prep. 2467.2; (48) *Pseudovacuopollis* sp., depth int.: 301.0–301.1 m, prep. 2456.1; (49) *Tricolpites* sp., depth int.: 304.6–304.7 m, prep. 2458.1; (50) *Cupaniedites* sp., the same depth int., prep. 2458.3; (51) *Trudopollis protrudens* Pflug, depth int.: 291.3–291.4 m, prep. 2450.1; (52) *Trudopollis* sp., depth int.: 316.1–316.2 m, prep. 2463.1; (53) *Ocullopollis* sp., depth int.: 318.4–318.5 m, prep. 2464.2; (54) Form 1 indet., depth int.: 498.0–498.1 m, prep. 2487.1; (55) Form 2 indet., depth int.: 538.0–538.1 m, prep. 2507.1; (56) *Schizosporis* sp., depth int.: 540.0–540.1 m, prep. 2508.1; (57) *Ovoidites* sp., depth int.: 546.0–546.1 m, prep. 2511.4.

In addition to the index-species, the next ones appear in the complex: *Cerodinium leptodermum* (Vozz.) Lent. et Will., *Phelodinium kozlowskii* (Córka) Lind., *Trithyrodinium evittii* Drugg, and *Deflandrea galeata* (Lej.-Carp.) Lent. et Will.

Palynodinium sp. A (Plate IV) is probably the vicariate of *Palynodinium grallator* Gocht, which is the index-species of the same-name Upper Maastrichtian zone of the stratotype area (Schiøler et al., 1997; etc.). This allows us to correlate this zone with beds with Palynodinium sp. A. In the established complex the index species of the upper subzone of the zone of Palynodinium grallator–Thalassiphora pelagica (Eis.) Eis. et Gocht is absent.

The presence of this subzone in the stratotype area (Hansen, 1979; Schiøler and Wilson, 1993; Brinkhuis and Schiøler, 1996; Schiøler et al., 1997; Herngreen et al., 1998) is correlated with the upper part of the Belemnitella kazimirovensis belemnite zone and the CC26 nannoplankton zone. The above data, as well as those on nannoplankton allow us to consider beds with Palynodinium sp. A as Early Late Maastrichtian.

Deposits of the Talitsa Formation (Selandian) (Iakovleva et al., 2011) erosively overlie those of the Gan'kino Formation.

CALCAREOUS NANNOPLANKTON

Calcareous nannoplankton has been found in large quantities. It is characterized by a rich diversity of species (64, in total) (Fig. 5). Preservation in the lower part of the studied interval is average,—mainly good.

In general, the complex of nannofossils is typical of Maastrichtian deposits and is characterized by a large number of *Arkhangelskiella cymbiformis*, *A. specillata*, *Cribrosphaerella ehrenbergii*, and the presence of *Eiffellithus parallelus*, *Lithraphidites praequadratus* and *Zeugrhabdotus bicrescenticus* (Plate V). In the complex there are large *Kamptnerius magnificus* (Plate VI), *Microrhabdulus undosus* and *M. helicoides*. In addition, from a depth of 294.7 m *Rhagodiscus angustus*, *R. reniformis* and *Rhombolithion rhombicum* are common.

The lower part of the Gan'kino Formation (depth interval of 304–286.4 m) refers to Lower Maastrichtian zones CC24 (Perch-Nielsen, 1985) or UC18 (Burnett, 1998) due to the presence of *Reinhardtites levis*. The disappearance of this species marks the upper boundary of zones. The upper part of the Gan'kino Formation (a depth interval of 284–274 m) refers to the subzone CC25a (Perch-Nielsen, 1985) or the zone UC19 (Burnett, 1998) of Upper Maastrichtian. The lower boundaries of these zones have been established by the disappearance of *R. levis* (a depth of 284 m). In the terminal part of the Gan'kino Formation (a depth interval of 273.5–270 m) nannoplankton has been noted.

FINDINGS OF FAUNA

Macrofauna has been found only in deposits of the Gan'kino Formation. In a depth interval of 285.8–286.3 m, a complex of bivalves characteristic of the Maastrichtian has been established. Among them are *Chlamys (Aequipecten) pseudopulchellus* Glasunova and *Nuculoma* cf. *variabilis* (Sowerby).

In a depth interval of 288.0–288.5 m the next fauna species have been recognised: **ammonites** *Hoploscaphites* cf. *constrictus* (Sowerby), and *Baculites* cf. *knorrianus* Desmarest (4 units); **bivalves** *Spyridoceramus ravni* sp. juv. Dobrov, *Entolium anlaevis* Glasunova, *Oxytoma* cf. *uralica* Glasunova, *Chlamys (Aequipecten)* cf. *pseudopulchellus* Glasunova; and **gastropods** *Turritella* sp. ind.

The ammonite species found are characteristic of Lower Maastrichtian. The finding of *Hoploscaphites* cf. *constrictus* (Sowerby) indicates Upper Lower Maastrichtian age of deposits, and the level of the Acanthoscaphites tridens zone and the Belemnella

Plate II. Dinocysts from Upper Cretaceous deposits opened by the borehole no. 8 in the Russkaya Polyana District. Magnification in figs. 17–18 is ×900. In other figures ×550.

(1) *Heterosphaeridium difficile* (Manum et Cookson) Ioannides, depth int.: 402.0–402.1 m, prep. 2480.2; (2) *Chatangiella tripartita* (Cookson et Eisenack) Lentin et Williams, depth int.: 283.2–283.3 m, prep. 2446.2; (3) *Chatangiella granulifera* (Manum) Lentin et Williams, the same depth int., prep. 2446.1; (4) *Surculosphaeridium longifurcatum* (Firtion) Davey et al., depth int.: 402.0–402.1 m, prep. 2480.2; (5) *Chatangiella bondarenkoi* (Vozzhennikova) Lentin et Williams, depth int.: 316.1–316.2 m, prep. 2463.2; (6) *Chatangiella spectabilis* (Alberti) Lentin et Williams, depth int.: 294.3–294.4 m, prep. 2452.2; (7) *Isabelidinium cooksoniae* (Alberti) Lentin and Williams, depth int.: 288.4–288.5 m, prep. 2448.1; (8) *Isabelidinium rectangulatum* Lebedeva, depth int.: 302.8–302.9 m, prep. 2457.2; (9) *Chatangiella ditissima* (McIntyre) Lentin et Williams, depth int.: 326.9–327.0 m, prep. 2467.2; (10) *Chatangiella manumii* (Vozzhennikova) Lentin et Williams, depth int.: 316.1–316.2 m, prep. 2463.3; (11) *Palaeoperidinium pyrophorum* (Ehrenberg) Sarjeant, depth int.: 302.8–302,9 m, prep. 2457.3; (12, 13) *Trithyrodinium quingueangulare* Marheinecke: 12—depth int.: 288.4-288.5 m, prep. 2448.1, 13—depth int.: 278.0–278.1 m, prep. 2444.3; (14) *Leberidocysta chlamydata* (Cookson et Eisenack) Stover et Evitt, depth int.: 283.2–283.3 m, prep. 2446.4; (15) *Fromea fragilis* (Cookson et Eisenack) Stover et Davey, depth int.: 297.4–297.5 m, prep. 2454.1; (16) *Fromea ? laevigata* (Drugg) Stover et Evitt, depth int.: 308.9–309.0 m, prep. 2460.2; (17, 18) *Fromea chytra* (Drugg) Stover et Evitt, depth int.: 304.6–304.7 m, prep. 2458.2; (19) *Hystrichosphaeridium tubiferum* (Ehrenberg) Deflandre, depth int.: 288.4–288.5 m, prep. 2448.1; (20) *Dingymnium digitus* (Deflandre) Evitt et al., depth int.: 318.4–318.5 m, prep. 2464.1; (21) *Alterbidinium acutulum* (Wilson) Lentin et Williams, depth int.: 304.6–304.7 m, prep. 2458.2; (22) *Xenikoon* sp., depth int.: 297.4–297.5 m, prep. 2454.1; (23) *Glaphyrocysta* sp., depth int.: 283.2–283.3 m, prep. 2446.3; (24) *Paralecaniella indentata* (Deflandre et Cookson) Cookson et Eisenack, depth int.: 316.1–316.2 m, prep. 2463.1; (25) *Pterospermella australiensis* Deflandre et Cookson, depth int.: 291.3–291.4 m, prep. 2450.1.

Plate II

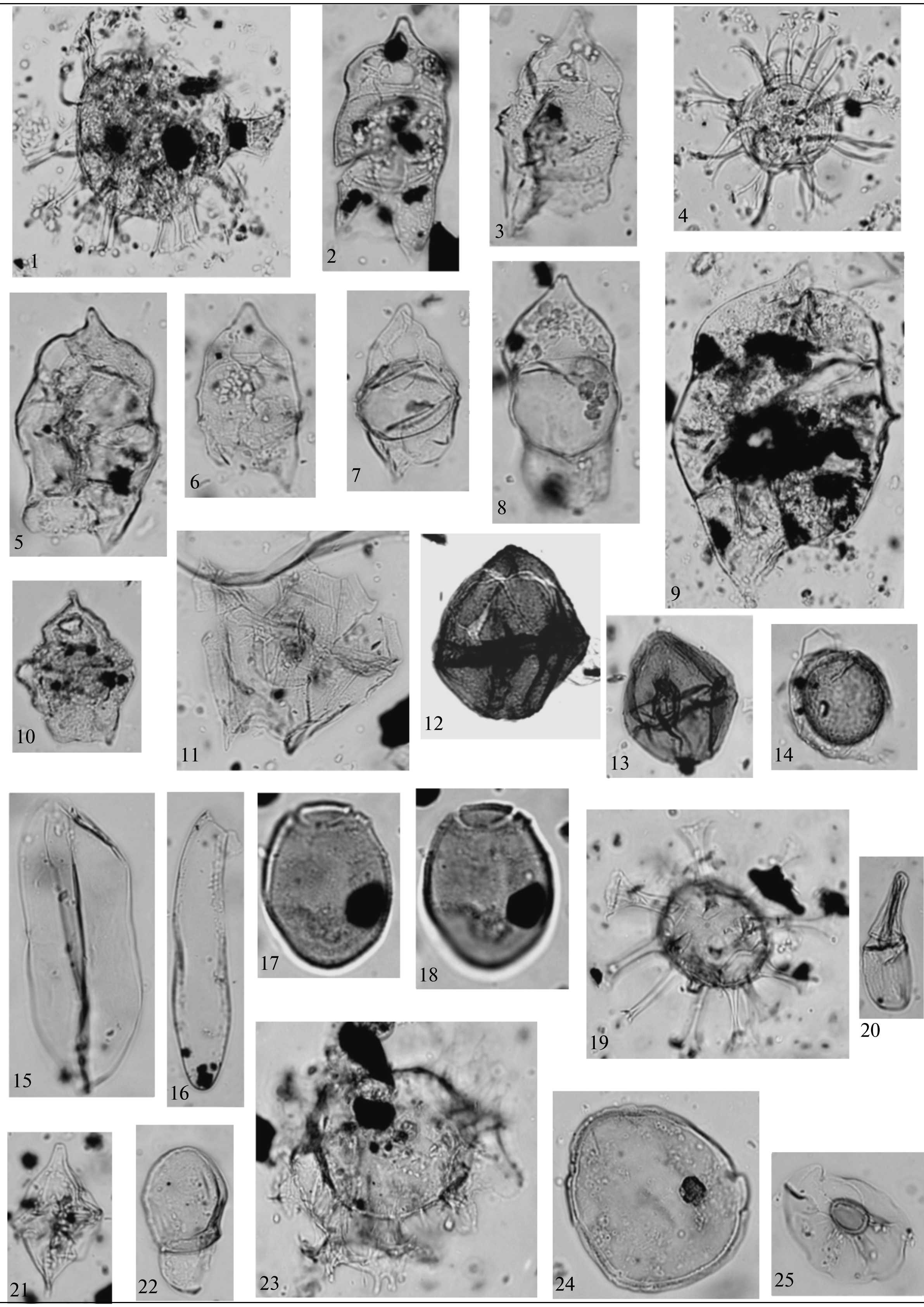
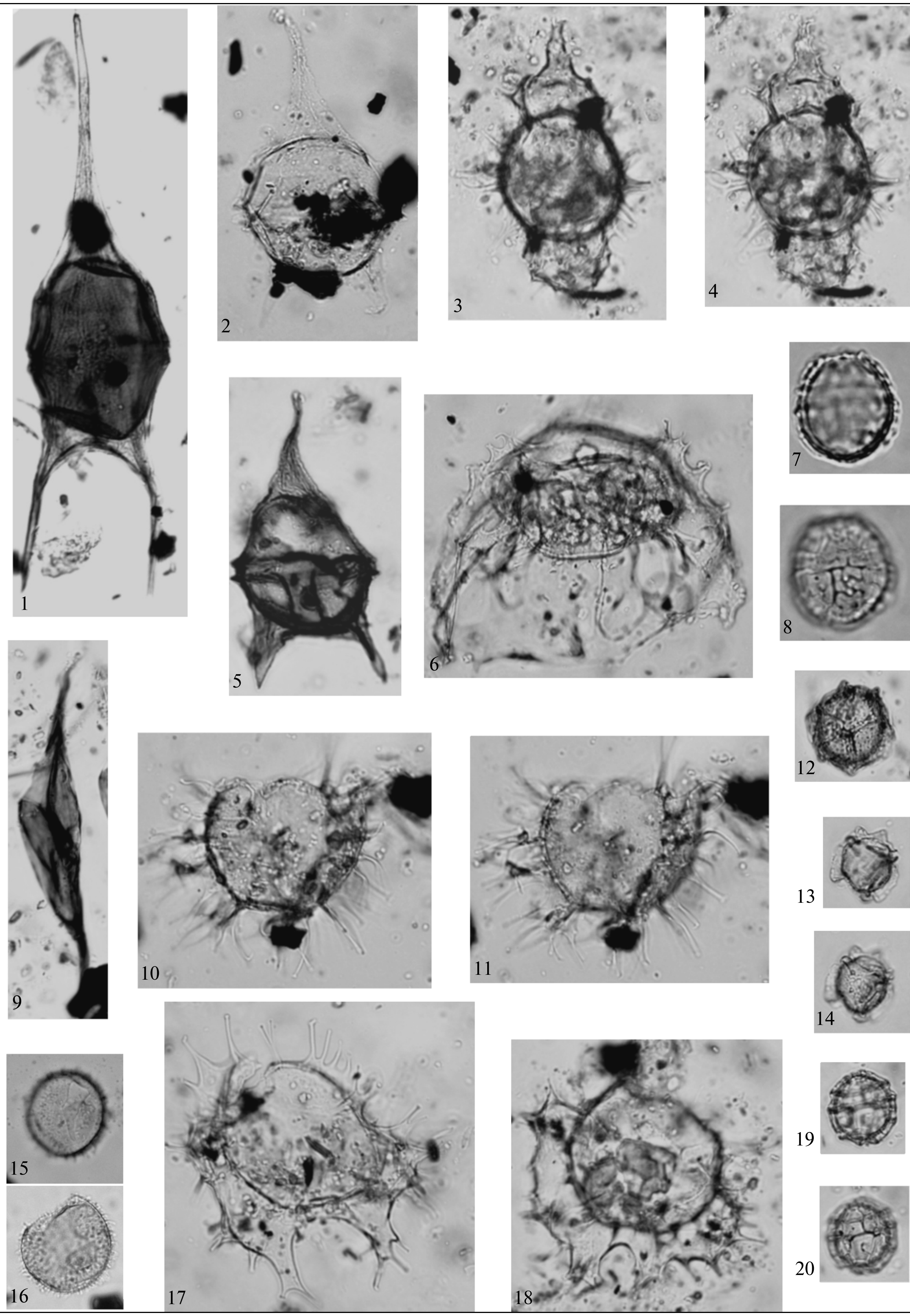


Plate III



sumensis subzone (Olfer'ev and Alekseev, 2003). The complex of bivalves contains species, typical of Maastrichtian (Glazunova, 1960). Findings of gastropods do not contradict this conclusion.

MAGNETOSTRATIGRAPHIC SECTION

A detailed description and analysis of paleomagnetic data obtained for Upper Cretaceous deposits in the borehole no. 8 are given in (Gnibidenko et al., 2012). This paper presents a generalized magnetostratigraphic section for these deposits.

Let us briefly recall that, in general, Cretaceous deposits in the section of the borehole no. 8 are referred to the class of weakly magnetic rocks and heterogeneous in their magnetic properties. The magnetic susceptibility (χ) varies in the range of 4.7–135.7 $\times$ 10^{-5} SI units (11.7–22.4 $\times$ 10^{-5} SI units for Formation, on average). The value of the natural remanent magnetization (J_n) varies from unit fractions to 33.5 mA/m (0.48–5.37 mA/m for Formation, on average). The Koenigsberger ratio (Q) varies from 0.01 to 4.12. Deposits of the Pokur Formation are characterized by higher values of χ, J_n, and Q in a depth interval of 495–482 m. Major magnetic minerals are magnetite, hematite and iron hydroxides.

The magnetostratigraphic section was plotted on the basis of the primary component or characteristic remanent magnetization (ChRM), measured according to the results of step thermodemagnetization and demagnetization with an alternating magnetic field.

According to the data of thermodemagnetization (step of 25–50–100°C), most Carbonaceous deposits are characterized by low- and high-temperature magnetization components. As a rule, the first component is recorded to the temperature values of 100–180–280°C, the second one preserves to 550–600°C and above.

Results of stepwise demagnetization with an alternating magnetic field (step of 5–10 mT) have demonstrated the presence of one or two magnetization components: unstable, detected in small alternating fields up to 12–20 mT, and very stable, detected in fields from 20 to 80 mT.

Some rock samples are very stable to alternating magnetic field, when, in the fields of 100–110 mT only 10% of the natural remanent magnetization was removed, and the magnetization direction remains unchanged.

The selection of the characteristic component has been performed using the Zijderveld's diagrams (Zijderveld, 1967), Kirschvink's algorithms (Kirschvink, 1980) and Enkin's programs (Enkin, 1994). All the samples studied, represented by clays, aleurites, aleurolites, sandstones and sands have oriented magnetization, which indicates the primacy of the natural remanent magnetization.

The nature of oriented magnetization of these rocks is also confirmed by low values of the Koenigsberger ratio (hundredths and tenths of unit. In a depth interval of 495–482 m aleurolites of the Pokur Formation have orientated chemical magnetization, as evidenced by the Q ratio, varying from 1.5 to 4.12.

In addition, the compiled magnetostratigraphic section corresponds the criterion of external convergence, which is the most important factor indicating the primacy of the natural remanent magnetization. Thus, the paleomagnetic zoning identified is well consistent with magnetostratigraphic data obtained for the coeval deposits of other regions, such as Tuarkyr, Caucasus, Kopet-Dag, the Volga Region (Guzhikov et al., 2007).

The paleomagnetic section has been compiled on the basis of the characteristic magnetization component, detected as a result of magnetic cleaning. This section is controlled by the paleontological data and divided into three distinct magnetic zones (from bottom to top): normal polarity and two reverse polarity (Fig. 2). The Pokur Formation (thickness of 185 m, palynological complexes of PC I and PC II (Albian-Turonian)) has normal polarity in general. On the background of this polarity are two thin horizons with reverse magnetization in the lower (545–543 m) and middle (468–466 m), parts of the section of the Pokur Formation. According to the age dating of deposits, using the available palynological data, the first of these R-horizons corresponds to the Albian Stage, the second-to the Cenomanian.

Plate III. Dinocysts from Upper Cretaceous deposits opened by the borehole no. 8 in the Russkaya Polyana District. Magnification in figs. 7, 8 is ×900. In other figures ×550.

(1) *Cerodinium diebelii* (Alberti) Lentin et Williams, depth int.: 297.4–297.5 m, prep. 2454.2; (2) *Cerodinium speciosum* (Alberti) Lentin et Williams, depth int.: 283.2–283.3 m, prep. 2446.1; (3, 4) *Triblastula utinensis* Wetzel, depth int.: 274.2–274.3 m, prep. 2442.1; (5) *Cerodinium albertii* (Corradini) Lentin et Williams, depth int.: 283.2–283.3 m, prep. 2446.3; (6) *Reciculacysta* sp., the same depth int., prep. 2446.1; (7, 8) *Cladopyxidium reticulatum* (Deflandre) Marheinecke, depth int.: 304.6–304.7 m, prep. 2458.1; (9) *Palaeocystodinium golzowense* Alberti, depth int.: 274.2–274.3 m, prep. 2442.1; (10, 11) *Areoligera coronata* (Wetzel) Lejeune-Carpentier, depth int.: 283.2–283.3 m, prep. 2446.1; (12) *Rhiptocorys veligera* (Deflandre) Lejeune-Carpentier et Sarjeant, depth int.: 302.8–302.9 m, prep. 2457.1; (13, 14) *Microdinium carpentieriae* Slimani, depth int.: 290.3–290.4 m, prep. 2449.1; (15, 16) *Pulchrasphaera minuscula* Schiøler et al., depth int.: 273.5 m, prep. 8/273.5; (17) *Palynodinium* sp. A, depth int.: 276.8–276.9 m, prep. 2443.1; (18) *Palynodinium helveticum* Kirsch, depth int.: 274.2–274.3 m, prep. 2442.1; (19, 20) *Microdinium kustanaicum* Vozzhennikova, depth int.: 276.8–276.9 m, prep. 2443.1.

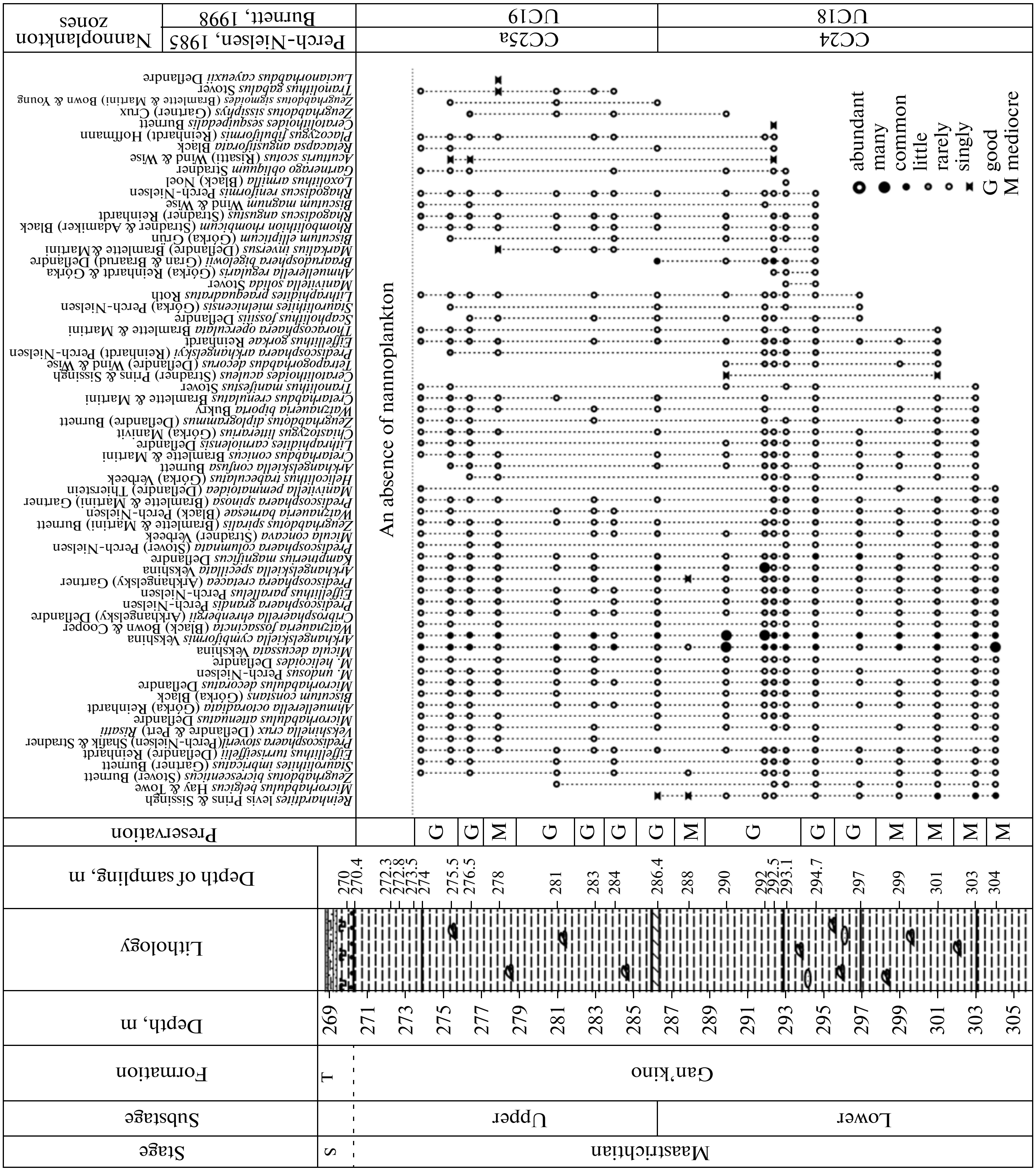


Fig. 5. Distribution of calcacerous nannoplankton in the section of the borehole no. 8 in the Russkaya Polyana District. Symbols are the same as in Fig. 2. Abbreviations: S—Selandian, T—Talitsa.

The Kuznetsovo and Ipatovo Formations, as well as the base of the Slavgorod Formation (palynological complexes PC II and PC III and the complex of dinocysts in beds with Heterosphaeridium difficile–Chatangiella spectabilis, as well as Turonian and Coniacian-Santonian complex of dinocysts), also have normal polarity.

On the background of this polarity are three horizons with reverse magnetization in the lower, middle

Plate IV

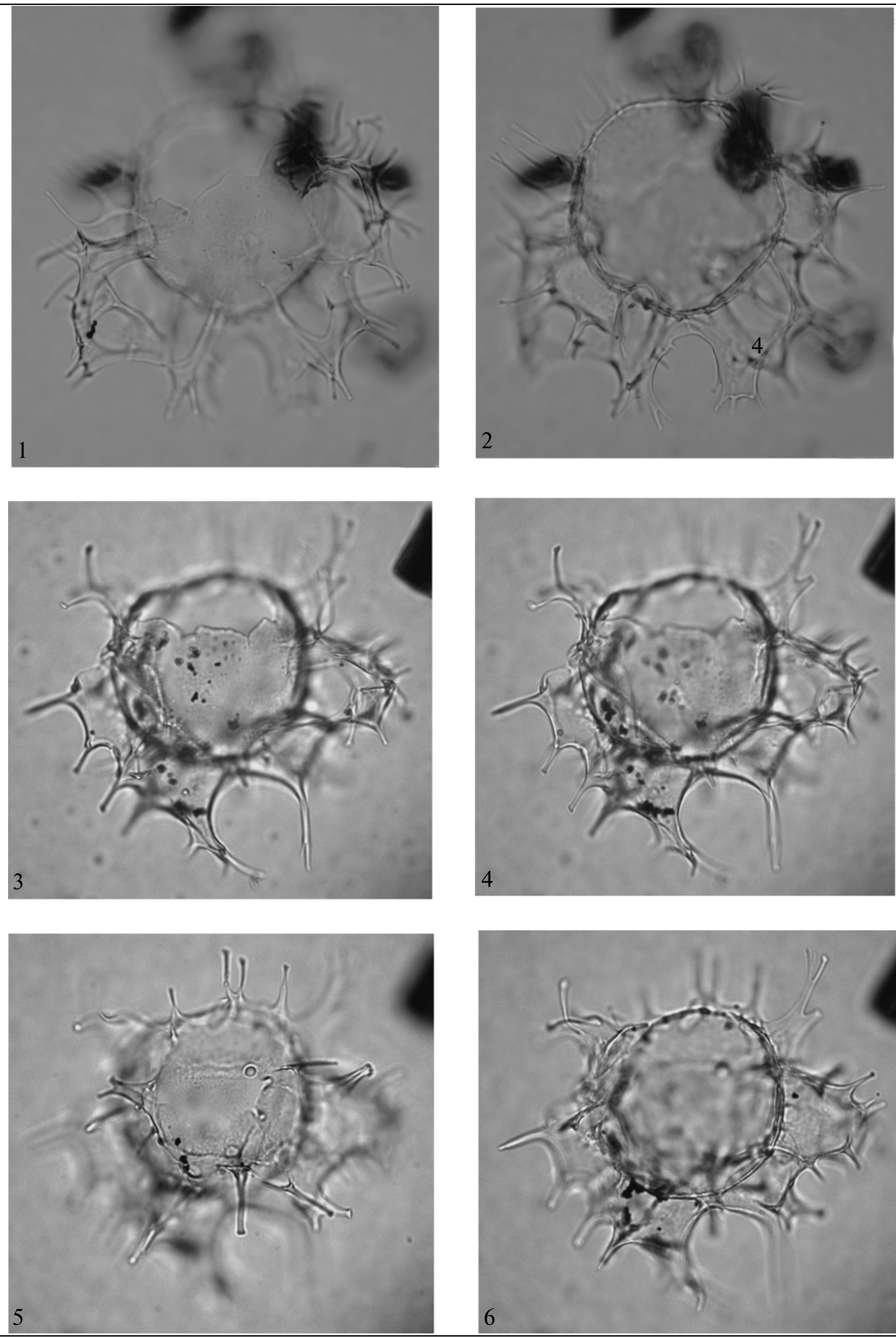
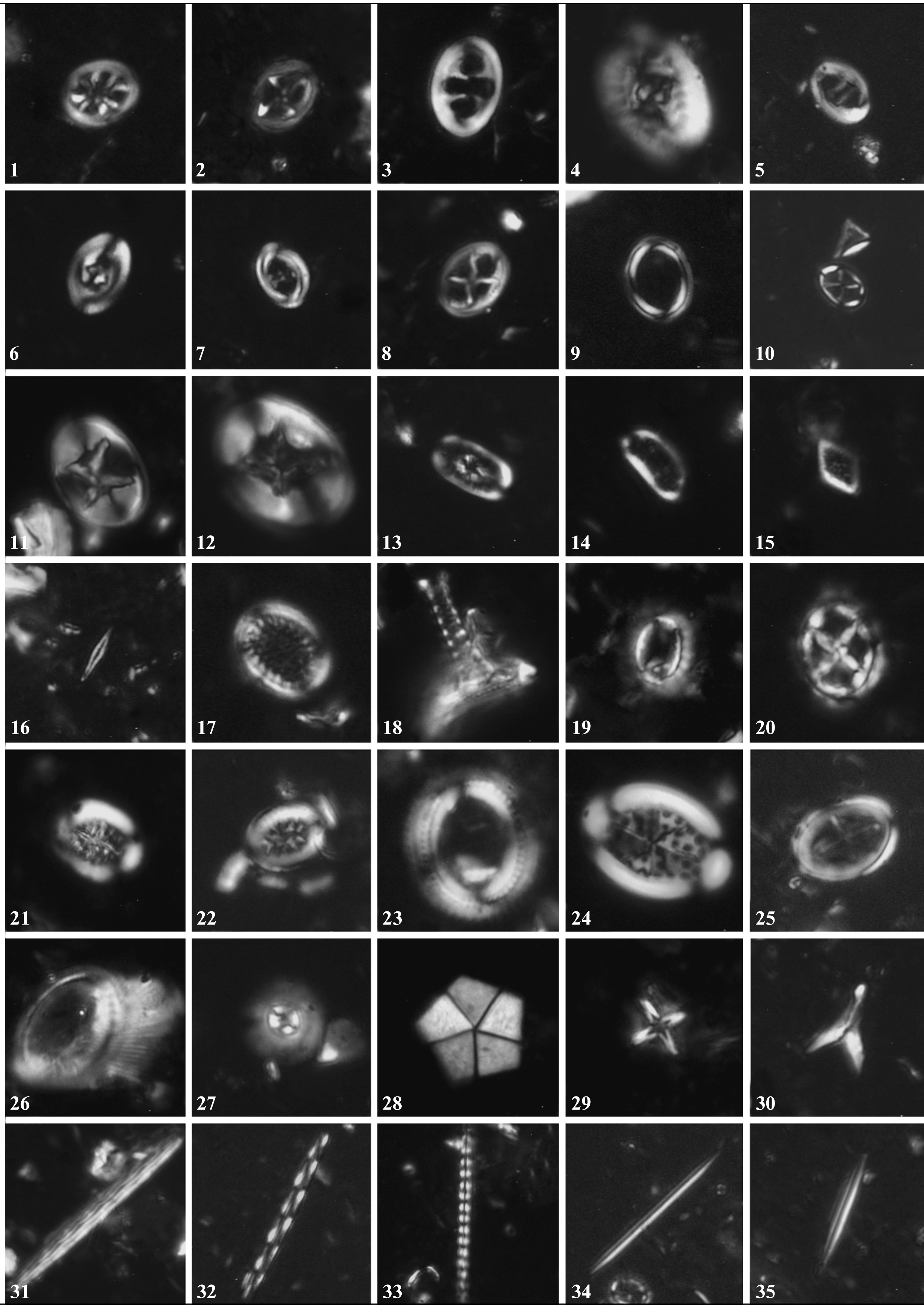


Plate IV. Dinocysts from Upper Cretaceous deposits opened by the borehole no. 8 in the Russkaya Polyana District. Magnification of all samples is ×500.

(1–6) *Palynodinium* sp. A: (1, 2) depth int.: 273.5 m, prep. 8/273.5; (3–6) depth int.: 272.3 m, prep. 8/272.3.

Plate V


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35

and upper parts of this zone. The lower horizon (thickness of 14 m, a depth interval of 406–392 m) with reverse magnetization is confined to the middle part of the Kuznetsovo Formation. Two other horizons with reverse magnetization are located in the lower (a depth interval of 372–368 m) and upper (a depth interval of 347–345 m) parts of the Ipatovo Formation.

According to the age dating of deposits on the basis of complexes of dinocysts and the palynological data, R-horizon in the section of the Kuznetsovo Formation corresponds to the Middle–Upper Turonian; two overlying R-horizons—to Coniacian–Santonian.

In the Gan'kino and Slavgorod Formations (palynological complexes PC IV and PC V; Campanian–Maastrichtian complexes of dinocysts) two magnetozones with reverse polarity are noted up to Paleogene, except for a 3-m horizon with reverse magnetization at the base of the Slavgorod Formation, which is referred to the upper part of the underlying magnetozone with normal polarity. On the background of reverse polarity, at the base of the Gan'kino Formation (312–310.5 m) the N-horizon with normal magnetization is noted.

Summarizing the data obtained, it should be noted that section of deposits of the Pokur, Kuznetsovo, and Ipatovo Formations (a total thickness of 210 m) is a thick zone of normal polarity (N(al-st)) with five subhorizons of reverse magnetization. In turn, the Slavgorod and Gan'kino Formations (thickens of about 70 m) form two zones with reverse polarity of R_1(km) and R_2(mt). As for the structure of the paleomagnetic record as a whole, it should be noted that the presence of gaps (up to 10 m) in the paleomagnetic section does not preclude the presence of R-intervals here.

However, it is unlikely that the paleomagnetic section can be essentially modified due to identification of these horizons and this will affect correlation of this section with the global paleomagnetic scale. Thus, paleomagnetic column, compiled on the basis of paleontological, lithological and stratigraphic data is controlled by the regional stratigraphic scale.

Based on reference levels (magnetozones), which are well characterized by paleontological data, the compiled magnetostratigraphic section can be correlated with the international scales (Fig. 6). Recently, there are several magnetostratigraphic (*Dopolneniya* ..., 2000; Molostovskii, 2002; Guzhikov et al., 2007) and magnetochronological (Harlend et al., 1985; Cande and Kent, 1992; Gradstein et al., 1995, 2004, 2008; etc.) scales. The long magnetozone with normal polarity N(al-st), established in the paleomagnetic section of the borehole cover the Albian, Cenomanian, Turonian, Coniacian, and Santonian deposits. According to the general magnetostratigraphic scale (*Dopolneniya*..., 2000; Molostovskii, 2002; etc.), this magnetozone corresponds to the Jalal hyperzone and can be associated with chron C34 of the international magnetochronological global scale in the age intervals of 112.5–83.6 Ma (Gradstein et al., 2004, 2008).

Plate V. Nannoplankton from the Gan'kino Formation in the Russkaya Polyana District. All photos are in crossed nicols. Magnification in figs. 1–30, 32, 34, 35 is ×3800; figs. 31, 33 ×2800.

(1) *Ahmuellerella octoradiata* (Górka) Reinhardt, Lower Maastrichtian, borehole no. 8, depth, 303 m; (2) *Staurolithites mielnicensis* (Górka) Perch-Nielsen, Lower Maastrichtian, borehole no. 8, depth, 293.1 m; (3) *Tranolithus manifestos* Stover, Lower Maastrichtian, borehole no. 8, depth, 293.1 m; (4) *Reinhardtites levis* Prins et Sissingh, Lower Maastrichtian, borehole no. 8, depth, 303 m; (5) *Zeugrhabdotus bicrescenticus* (Stover) Burnett, Lower Maastrichtian, borehole no. 8, depth, 293.1 m; (6) *Placozygus fibuliformis* (Reinhardt) Hoffmann, Lower Maastrichtian, borehole no. 8, depth, 292.5 m; (7) *Zeugrhabdotus spiralis* (Bramlette et Martini) Burnett, Upper Maastrichtian, borehole no. 10, depth, 262 m; (8) *Chiastozygus litterarius* (Gorka) Manivit, Upper Maastrichtian, borehole no. 10, depth, 262 m; (9) *Loxolithus armilla* (Black) Noel, Lower Maastrichtian, borehole no. 8, depth, 293.1 m; (10) *Helicolithus trabeculatus* (Gorka) Verbeek, Lower Maastrichtian, borehole no. 8, depth, 293.1 m; (11) *Eiffellithus turriseiffelii* (Deflandre) Reinhardt, Lower Maastrichtian, borehole no. 8, depth, 292.5 m; (12) *Eiffellithus parallelus* Perch-Nielsen, Lower Maastrichtian, borehole no. 8, depth, 286.4 m; (13) *Rhagodiscus angustus* (Stradner) Reinhardt, Lower Maastrichtian, borehole no. 8, depth, 290 m; (14) *Rhagodiscus reniformis* Perch-Nielsen, Lower Maastrichtian, borehole no. 8, depth, 292.5 m; (15) *Rhombolithion rhombicum* (Stradner et Adamiker) Black, Lower Maastrichtian, borehole no. 8, depth, 290 m; (16) *Scapholithus fossilis* Deflandre, Lower Maastrichtian, borehole no. 8, depth, 290 m; (17) *Cribrosphaerella ehrenbergii* (Arkhangelsky) Deflandre, Lower Maastrichtian, borehole no. 8, depth, 292.5 m; (18) *Tetrapodorhabdus decorus* (Deflandre) Wind et Wise, Lower Maastrichtian, borehole no. 8, depth, 293.1 m; (19) *Biscutum magnum* Wind et Wise, Lower Maastrichtian, borehole no. 8, depth, 293.1 m; (20) *Prediscosphaera grandis* Perch-Nielsen, Upper Maastrichtian, borehole no. 10, depth, 262 m; (21) *Cretarhabdus conicus* Bramlette et Martini, Lower Maastrichtian, borehole no. 8, depth, 292.5 m; (22) *Cretarhabdus crenulatus* Bramlette et Martini, Upper Maastrichtian, borehole no. 10, depth, 262 m; (23) *Manivitella pemmatoidea* (Deflandre) Thierstein, Lower Maastrichtian, borehole no. 8, depth, 293.1 m; (24) *Arkhangelskiella cymbiformis* Vekshina, Lower Maastrichtian, borehole no. 8, depth, 290 m; (25) *Gartnerago obliquum* Stradner, Lower Maastrichtian, borehole no. 8, depth, 290 m; (26) *Kamptnerius magnificus* Deflandre, Lower Maastrichtian, borehole no. 8, depth, 286.4 m; (27) *Markalius inversus* (Deflandre) Bramlette et Martini, Lower Maastrichtian, borehole no. 8, depth, 292.5 m; (28) *Braarudosphaera bigelowii* (Gran et Braarud) Deflandre, Lower Maastrichtian, borehole no. 8, depth, 292.5 m; (29) *Micula decussata* Vekshina, Lower Maastrichtian, borehole no. 8, depth, 303 m; (30) *Ceratolithoides sesquipedalis* Burnett, Lower Maastrichtian, borehole no. 8, depth, 292.5 m; (31) *Microrhabdulus helicoides* Deflandre, Lower Maastrichtian, borehole no. 8, depth, 286.4 m; (32) *Microrhabdulus decoratus* Deflandre, Lower Maastrichtian, borehole no. 8, depth, 292.5 m; (33) *Microrhabdulus undosus* Perch-Nielsen, Lower Maastrichtian, borehole no. 8, depth, 292.5 m; (34) *Lithraphidites carniolensis* Deflandre, Lower Maastrichtian, borehole no. 8, depth, 293.1 m; (35) *Lithraphidites praequadratus* Roth, Lower Maastrichtian, borehole no. 8, depth, 293.1 m.

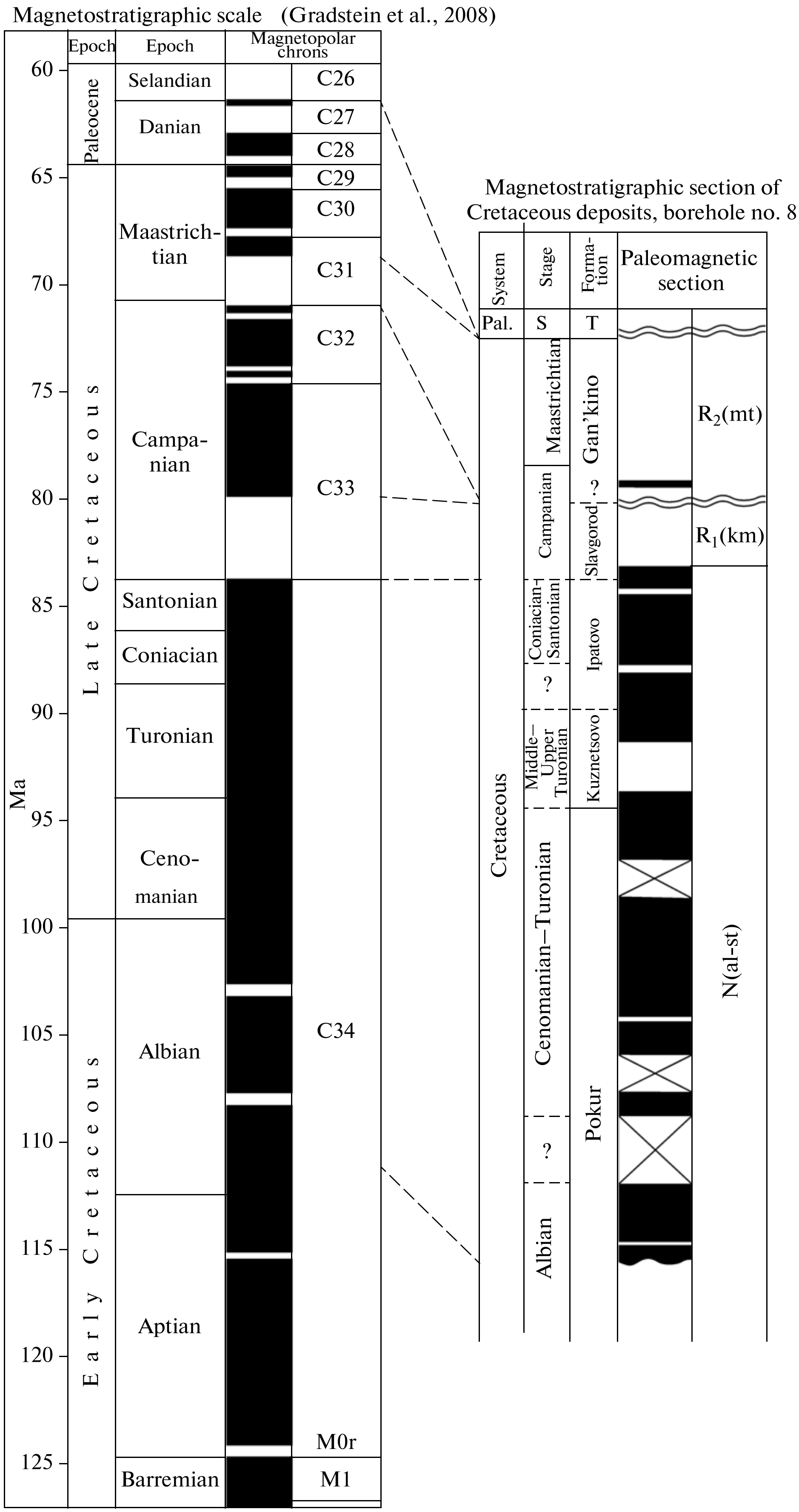


Fig. 6. Comparison of the magnetostratigraphic section of Upper Cretaceous deposits in the borehole no.8 with the magnetochronological scale (Gradstein et al., 2008).

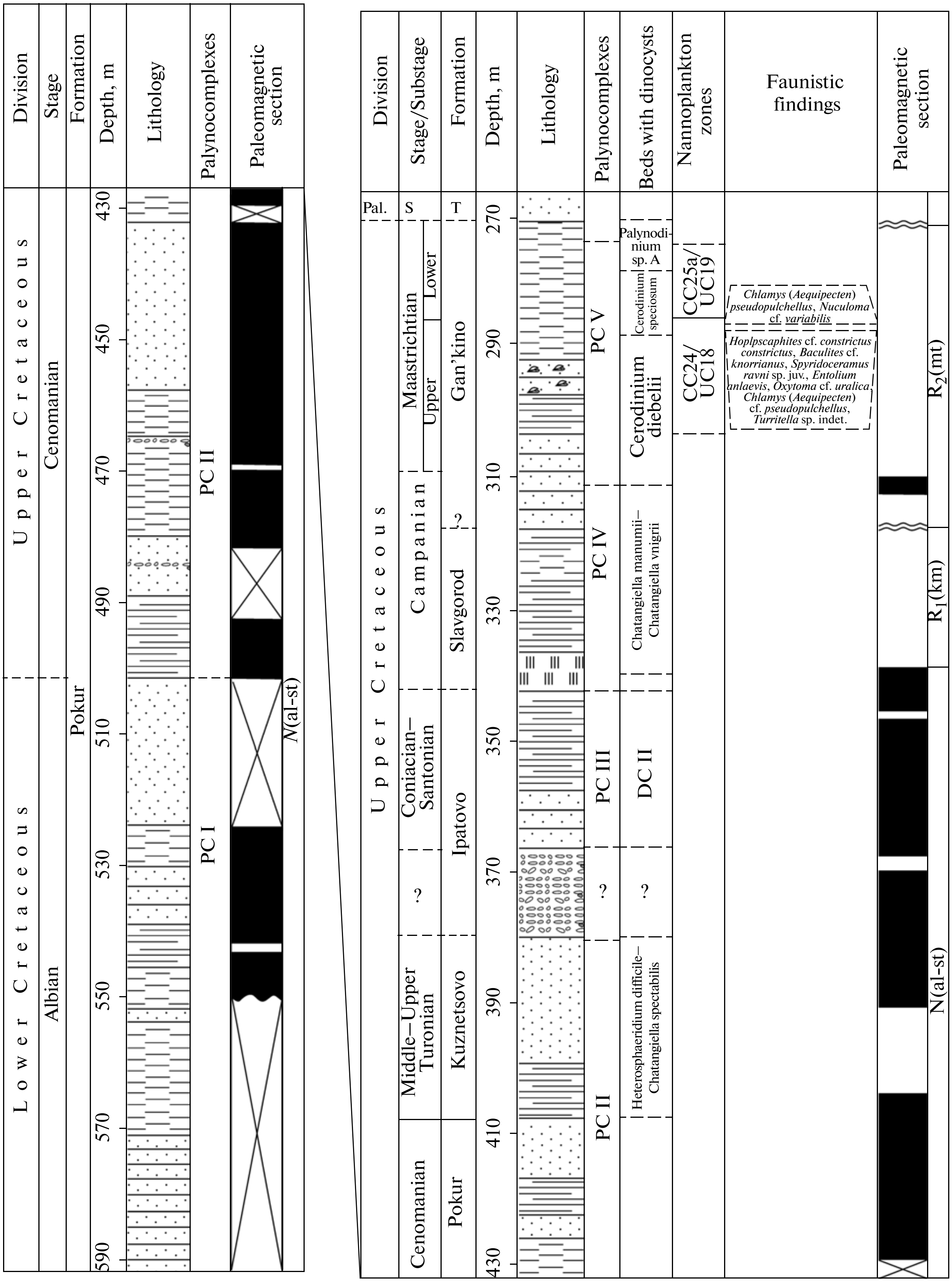
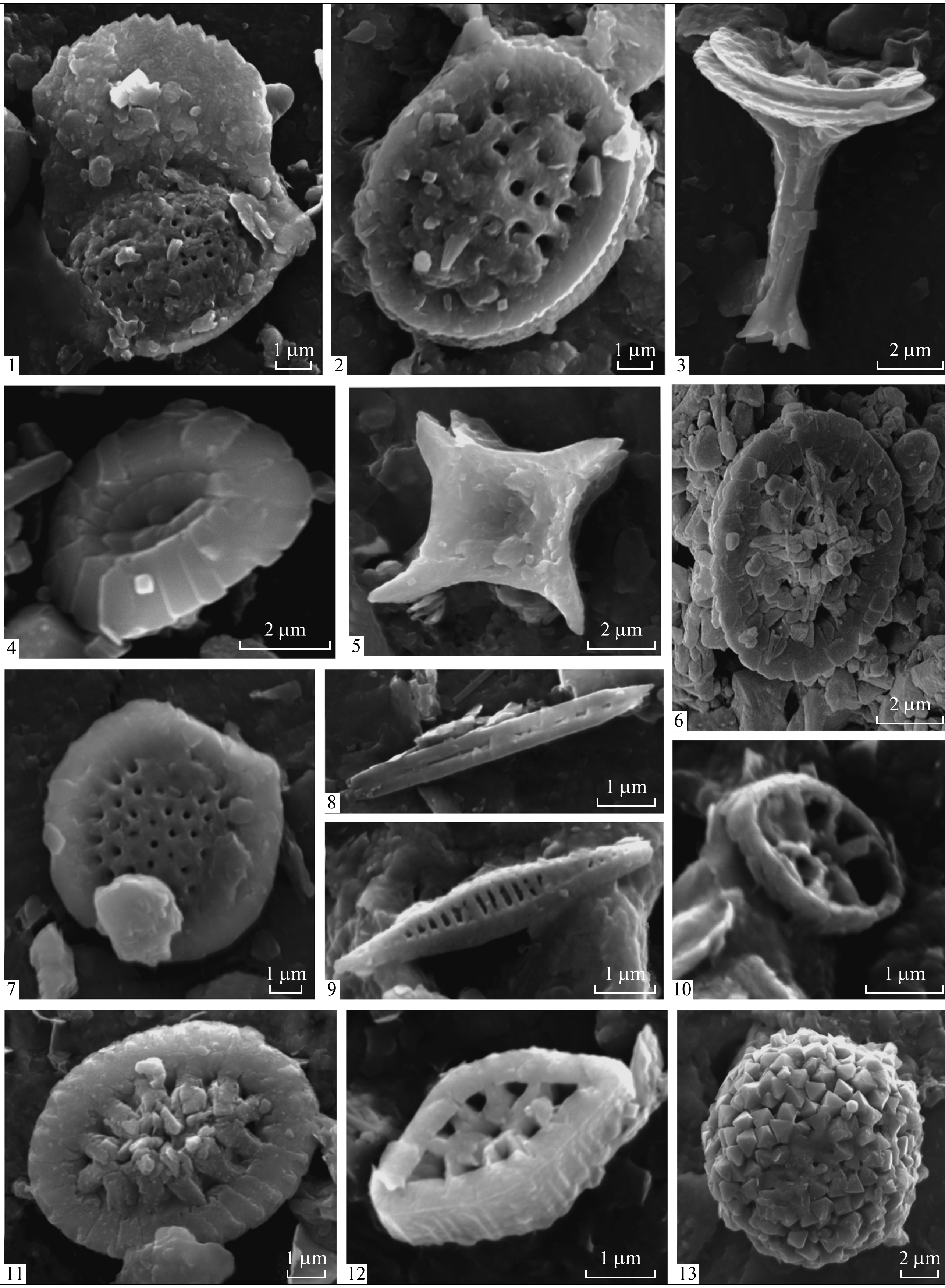


Fig. 7. Magnetobiostratigraphic section of Upper Cretaceous deposits of the borehole no. 8 in the Russkaya Polyana District. Symbols are the same as in Fig. 2. Abbreviations: Pal—Paleocene, S—Selandian, T—Talitsa.

Plate VI



1
1 μm
2
1 μm
3
2 μm
4
2 μm
5
2 μm
6
2 μm
7
1 μm
8
1 μm
9
1 μm
10
1 μm
11
1 μm
12
1 μm
13
2 μm

Plate VI. Nannoplankton from the Gan'kino Formation, the Russkaya Polyana District.

(1) *Kamptnerius magnificus* Deflandre, distal side, Lower Maastrichtian, borehole no. 8, depth, 292 m; (2) *Arkhangelskiella cymbiformis* Vekshina, distal side, Lower Maastrichtian, borehole no. 8, depth, 292 m; (3) *Prediscosphaera cretacea* (Arkhangelsky) Gartner, general view of rhabdolith, Lower Maastrichtian, borehole no. 8, depth, 292.5 m; (4) *Biscutum ellipticum* (Górka) Grün, distal side, Lower Maastrichtian, borehole no. 8, depth, 292.5 m; (5) *Micula concava* (Stradner) Verbeek, general view, Lower Maastrichtian, borehole no. 8, depth, 292.5 m; (6) *Cretarhabdus conicus* Bramlette et Martini, distal side, Upper Maastrichtian, borehole no. 10, depth, 262 m; (7) *Cribrosphaerella ehrenbergii* (Arkhangelsky) Deflandre, distal side, Lower Maastrichtian, borehole no. 8, depth, 292 m; (8) *Lithraphidites carniolensis* Deflandre, general view, Lower Maastrichtian, borehole no. 8, depth, 292 m; (9) *Scapholithus fossilis* Deflandre, general view, Lower Maastrichtian, borehole no. 8, depth, 286.4 m; (10) *Stradnerlithus geometricus* (Górka) Bown et Cooper, general view, Upper Maastrichtian, borehole no. 10, depth, 262 m; (11) *Cretarhabdus crenulatus* Bramlette et Martini, distal side, Upper Maastrichtian, borehole no. 10, depth, 262 m; (12) *Rhombolithion speetonensi* Rood et Barnard, general view, Upper Maastrichtian, borehole no. 10, depth, 262 m; (13) *Thoracosphaera operculata* Bramlette et Martini, general view, Lower Maastrichtian, borehole no. 8, depth, 286.4 m.

Two magnetozones with reverse polarity, separated by a stratigraphic break (R_1(km) and R_2(mt)) cover the lower part of the Campanian (Slavgorod Formation) and Maastrichtian (Gan'kino Formation). These magnetozones are correlated with chrones of C33(r) and C31(r) and 83.6–80 and 71–68.5 Ma, respectively (Fig. 6).

Comparing the magnetostratigraphic section of Cretaceous deposits opened in the borehole no. 8 with the international magnetochronological scale (Gradstein et al., 2008), we can estimate a break interval between the Slavgorod (R_1(km)) and the Gan'kino (R_2(mt)) Formations as approximately 9 Ma (a part of Upper Campanian). Thus, chrons with normal polarity of C33(n) and C32 (Upper Campanian) in the age interval of 80–71 Ma are absent in the section.

In turn, a break interval between the Gan'kino (R_2(mt)) and the Talitsa Formations will be determined by the duration of chrones of C31(n), C30, C29, C28 and C27 (~68.5–61.5 Ma).

CONCLUSIONS

As a result of our work, the complex stratigraphic (paleomagnetic and paleontological) researches of Upper Cretaceous deposits of the southern margin of the Omsk depression (on the example of the section of the borehole no. 8, drilled in the Russkaya Polyan District) for the first time.

Stratigraphically, the studied section includes deposits of Albian–Cenomanian (Pokur Formation), Middle–Upper Turonian (Kuznetsovo Formation), undifferentiated Coniacian–Santonian (Ipatovo Formation), Campanian (Slavgorod Formation), and Maastrichtian (Gan'kino Formation) (Fig. 7).

Palynological studies in the southern part of the Omsk depression make it possible to add the taxonomic characteristics of Late Cretaceous palynomorphs, identify the taxonomic composition of dinocysts and other groups microphytoplankton for the first time, justify the age of deposits, determine intervals of stratigraphic breaks and divide the section of the borehole no. 8. All of this will allow us in the future to modify the regional stratigraphic schemes of Western Siberia and correct paleogeographic reconstructions.

In addition, it has been established that nannoplankton occurs in deposits of the Gan'kino Formation. Based on this, we have been able to establish the age of deposits on the one hand, and to compare palynological biostratons with the common scale on the other. An absence of nannoplankton in the terminal parts of the Gan'kino Formation has been revealed. This can be connected with secondary changes, as deposits of this Formation is overlain with a great stratigraphic break by Paleocene deposits, or with variations in hydrological conditions in a sedimentation basin in the Late Maastrichtian.

In addition, the complex of ammonites, bivalves and gastropods has been identified. This is a unique case for weakly consolidated Upper Cretaceous deposits, opened in boreholes.

Using the data obtained as a result of detailed paleomagnetic studies, as well as paleontological data, a magnetostratigraphic section of the Upper Cretaceous deposits opened in the borehole no. 8 has been compiled.It has been established that in Albian, Cenomanian, Turonian, Coniacian, Santonian (Pokur, Kuznetsovo, and Ipatovo Formations) there existed a long period of predominantly normal polarity N(al-st). This period corresponds to the chron C34 with five thin (14–2 m) horizons with reverse magnetization. In the upper part of these deposits, two separated zones with reverse polarity (R_1(km) and R_2(mt)), covering the most part of the Slavgorod (Campanian) and Gan'kino Formations (Maastrichtian) have been established.

These zones correspond to chrons C33(r) and C31(r).

The conclusion that there was a stratigraphic break in a part of Upper Campanian, does not contradict the above paleontological evidence.

The correctness of the paleomagnetic data, that was the basis for construction of the paleomagnetic section of Cretaceous deposits (borehole no. 8) is controlled by component composition of the natural remanent magnetization of rocks and possibility to determine its primary component, as well as the structural similarity of the paleomagnetic section of Cretaceous deposits with magnetostratigraphic and magnetochronological scales and magnetostratigraphic sections of coeval deposits in other regions.

Thus, complex paleontological and paleomagnetic studies allowed us to get new data on the structure and age of Upper Cretaceous deposits of Southwestern Siberia, identify key milestones in rearrangements of planktonic organisms and to correlate the data obtained with adjacent and stratotype regions.

ACKNOWLEDGMENTS

We are grateful to Zh.A. Dolya (Omsk geological prospecting expedition) for providing geological materials, O.B. Kuzmina for providing the collection of palynological samples, A.Yu. Guzhikov (Saratov State University), and E.A. Scherbinina (GIN RAS) for valuable comments and remarks that helped us to improve the manuscript.

This work was supported by the Grants of the Presidium of the Russian Academy of Sciences (Fundamental problems of oceanology, physics, geology, biology, ecology and The Origin of the biosphere and the evolution of geo-biological systems), the Russian Foundation for Basic Researches (projects nos. 10-05-00021 and 12-05-00196a), and the National Research Foundation, South Africa via Incentive Funding for Rated Researchers.

Reviewers A.Yu. Guzhikov, E.A. Scherbinina, and V.A. Zakharov

REFERENCES

Akhmetiev, M.A., Aleksandrova, G.N., Ben'yamovskii, V.N., et al., New Data on the Marine Paleogene of the Southwestern Siberian Plate, Paper 1, *Stratigr. Geol. Correlation*, 2004a, vol. 12, no. 1, pp. 67–93.

Akhmetiev, M.A., Aleksandrova, G.N., Ben'yamovskii, V.N., et al., New Data on the Marine Paleogene of the Southwestern Siberian Plate, Paper 2, *Stratigr. Geol. Correlation*, 2004b, vol. 12, no. 5, pp. 65–86.

Akhmetiev, M.A., Zaporozhets, N.I., Iakovleva, A.I., et al., Comparative analysis of Marine Paleogene Sections and Biota from West Siberia and the Arctic Region, *Stratigr. Geol. Correlation*, 2010, vol. 18, no. 6, pp. 635–659.

Akhmetiev, M.A., Problems of Paleogene Stratigraphy and Paleogeography in Mid-Latitudes of Central Eurasia, *Geol. Geofiz.*, 2011, no. 10, pp. 1367–1387.

Aleksandrova, G.N., Alekseev, A.S., Ben'yamovskii, V.N., and Ovechkina, M.N., New data on Terminal Cretaceous Dinocysts, Nannoplankton and Foraminifers from the South of the West Siberian Lowland in *Melovaya sistema Rossii: problemy stratigrafii i paleogeografii. Shkola "Printsipy i metody stratigraficheskikh issledovanii". Tez. dokladov* (Cretaceous System of Russia: Problems of Stratigraphy and Paleogeography. School: Principles and Methods of Stratigraphic Researches. Book of Abstracts), Arkad'ev V.V., Ed., St. Petersburg, 2004.

Aleksandrova, G.N., Kosmynin, V.A., and Postnikov, A.V., Stratigraphy and Sedimentary Environments for Cretaceous Deposits in the Southern Part of the Var'egansk Megabar (Western Siberia), *Stratigr. Geol. Correlation*, 2010, vol. 18, no. 4, pp. 411–435.

Aleksandrova, G.N., Ovechkina, M.N., and Ben'yamovskii, V.N., Data on Dinocysts, Nannoplankton, and Foraminifers from Upper Cretaceous and Paleocene Deposits of the South of the Russian and West Siberian Plates, in *Paleontologiya, stratigrafiya i paleogeografiya mezozoya i kainozoya boreal'nykh raionov. Materialy nauchn. sessii. T. I* (Paleontology, Stratigraphy and Paleogeography of the Mesozoic and Cenozoic of Boreal Regions. Proc. of Sci. Session. Vol. 1) Shurygin, B.N., Lebedeva, N.K., and Goryacheva, A.A., Eds., Novosibirsk: INGG SO RAN, 2011.

Ben'yamovskii, V.N., Akhmetiev, M.A., Alekseev, A.S., et al., Marine Terminal Cretaceous and Paleogene in the South of Western Siberia, *Byull. Mosk. O-va Isp. Prir. Otd. Geol*, 2002, vol. 77, no. 5, pp. 28–48.

Bown, P.R. and Young, J.R., Technique, in *Calcareous Nannofossil Biostratigraphy. British Micropaleontol. Soc. Series*, Bown P.R., Ed., London: Chapman & Hall, 1998, pp. 16–28.

Brinkhuis, H. and Schiøler, P., Palynology of the Geulhemmerberg Cretaceous/Tertiary Boundary Section (Limburg, SE Netherlands in *The Geulhemmerberg Cretaceous/Tertiary boundary section (Maastrichtian type area, SE Netherlands)*, Brinkhuis, H. and Smit, J. Eds., Geologie en Mijnbouw, 1996, vol. 75, nos. 2–3, pp. 193–213.

Burnett, J.A., Upper Cretaceous in *Calcareous Nannofossil Biostratigraphy*, Ed. Bown P.R., Dordrecht, the Netherlands: Kluwer Acad. Publ., 1998, pp. 132–199.

Cande, S.C. and Kent, D.V., A New Geomagnetic Polarity Time Scale for the Late Cretaceous and Cenozoic, *J. Geophys. Res.*, 1992, vol. 97, no. B10, pp. 13917–13951.

Dopolneniya k stratigraficheskomu kodeksu Rossii (Supplements to the Stratigraphic Code of Russia), St. Petersburg: Izd. VSEGEI, 2000 [in Russian].

Enkin, R.J., A Computer Program Package for Analysis and Presentation of Paleomagnetic Data, *Pacific Geosci. Centre. Geol. Surv. Canada. Sidney*, 1994.

Glazunova, A.E., New Cretaceous Pectinidae in Western Siberia in *Novye vidy drevnikh rastenii i bespozvonochnykh SSSR. Chast' II* (New Species of Ancient Plants and Invertebrates of the USSR. Part II) Markovskii, B.P., Ed., Moscow: Gos. Nauch.-tekh. Izd. Lit. po Geologii i Okhrane Nedr, 1960, pp. 47–60.

Gnibidenko, Z.N., Lebedeva, N.K., and Dolya, Zh.A., Magnetostratigraphic and Palynological Analysis of Cretaceous (Borehole no. 8, the Russkaya Polyana District, the Southeastern Part of Western Siberia) in *Melovaya sistema Rossii i blizhnego zarubezh'ya: problemy stratigrafii i paleogeografii. Materialy IV Vseross. soveshch.* (Cretaceous System of Russia and CIS Countries: Problems of Stratigraphy and Palaeogeography. Proc. IV All-Russ. Meet.) Dzyuba, O.S., Zakharov, V.A., and Shurygin, B.N., Eds., Novosibirsk: Izd. SO RAN, 2008.

Gnibidenko, Z.N., Lebedeva, N.K., and Shurygin, B.N., Magnetostratigraphic Section of Cretaceous Deposits of the South of Western Siberia, *Geol. Geofiz.*, 2012 (in press).

Gradstein, F.M., Agterberg, F.P., Hardenbol, J., et al., Triassic, Jurassic and Cretaceous Time Scale, *Geochronology Time Scales and Global Stratigraphic Correlation. SEPM Spec. Publ.*, 1995, no. 54, pp. 95–126.

Gradstein, F.M., Ogg, J.G., Smith, A.G., et al., *A Geological Time Scale*, Cambridge: Cambridge Univ. Press, 2004, vol. 43, no. 1, pp. 5–13.

Gradstein, F.M., Ogg, J.G., and van Kranendonk, M., On the Geological Time Scale 2008, *Newsletters on Stratigraphy*, 2008, vol. 43, no. 1, pp. 5–13.

Guzhikov, A.Yu., Baraboshkin, E.Yu., and Fomin, V.A., Magnetostratigraphic Scale of the Cretaceous System: Modern State, Problems of Reconstruction, and Trends, in *Melovaya sistema Rossii i blizhnego zarubezh'ya: problemy stratigrafii i paleogeografii* (Cretaceous System of Russia and CIS Countries: Problems of Stratigraphy and Paleogeography), Saratov: Izd. SGU, 2007, pp. 69–86.

Hansen, J.M., A New Dinoflagellate Zone at the Maastrichtian/Danian Boundary in Denmark, *Danmarks Geol. Unders., Arbog.*, 1979, pp. 131–140.

Herngreen, G.F.W., Schuurman, H.A.H.M., Verbeek, J.W., et al., Biostratigraphy of Cretaceous/Tertiary Boundary Strata in the Curfs Quarry, the Netherlands, *Mededelingen Nederlands Instituut voor Toegepaste Geowetenschappen TNO*, 1998, no. 61, pp. 3–58.

Iakovleva, A.I. and Heilmann-Clausen, C., Eocene Dinoflagellate Cyst Biostratigraphy of Research Borehole 011-BP, Omsk Region, Southwestern Siberia, *Palynology*, 2010, vol. 34, no. 2, pp. 195–232.

Ioannides, N.S., Dinoflagellate Cysts from Upper Cretaceous–Lower Tertiary Sections Bylon and Devon Islands Arctic Archipelago, *Geol. Surv. Canada*, 1986, Bull. 371, pp. 3–99.

Kharlend, U.V., Koks, A.V., Llevelin, P.G., et al., *Shkala geologicheskogo vremeni* (Scale of Geological TIme), Moscow: Mir, 1985 [in Russian].

Chlonova, A.F., *Palinologiya melovykh otlozhenii Sibiri i Dal'nego Vostoka* (Palynology of Cretaceous Deposits of Siberia and the Far East), Novosibirsk: Nauka, 1974 [in Russian].

Chlonova, A.F., *Palinologicheskaya kharakteristika melovykh otlozhenii na r. Kie (Zapadnaya Sibir')* (Palynology of Cretaceous Deposits on the Kiya River (Western Siberia), Moscow: Nauka, 1976 [in Russian].

Khramov, A.N. and Sholpo, L.E., *Paleomagnetizm* (Paleomagnetism), Leningrad: Nedra, 1967 [in Russian].

Kirsch, K.-H., Dinoflagellatenzysten aus der Obekreide des Helvetikums und Nordultrahelvetikums von Oberbayern, *Abh. Munchner Geowiss*, 1991, A. 92, pp. 1–306.

Kirschvink, J.L., The Least Square Line and Plane and the Analysis of Paleomagnetic Data, *Geophys. J. R. Astron. Soc.*, 1980, vol. 62, pp. 699–718.

Kuz'mina, O.B., Volkova, V.S., Gnibidenko, Z.N., and Lebedeva, N.K., Microphytofossils and Magnetostratigraphy of Upper Cretaceous and Cenozoic Deposits of the Southeastern Part of the West Siberian Plane, *Geol. Geofiz.*, 2003, vol. 44, no. 4, pp. 348–363.

Lebedeva, N.K., Dinocyst Biostratigraphy of Upper Cretaceous Deposits in the Usa River Basin (Polar Cis-Urals), *Stratigr. Geol. Correlation*, 2005, vol. 13, no. 3, pp. 310–326.

Lebedeva, N.K., Dinocyst Biostratigraphy of the Upper Cretaceous of Northern Siberia, *Paleontol. J.*, 2006, vol. 40, Suppl. 5, pp. S604–S621.

Lebedeva, N.K., Dinocyst Biostratigraphy of Upper Cretaceous Deposits of Northern Siberiain *Melovaya sistema Rossii i blizhnego zarubezh'ya: problemy stratigrafii i paleogeografii. Sb. nauch. tr.* (Cretaceous System of Russia and Adjacent Countries: Problems of Stratigraphy and Paleogeography. Book of Abstracts), Pervushov, E.M., Ed., Saratov: Izd. Saratov Univ., 2007.

Markova, L.G., *Istoriya razvitiya rannemelovoi flory Zapadno-Sibirskoi nizmennosti (po dannym palinologii)* (History of Development of Early Cretaceous Flora in West Siberian Lowland), Moscow: Nedra, 1971 [in Russian].

Molostovskii, E.A. and Khramov, A.N., *Magnitostratigrafiya i ee znachenie v geologii* (Magnetostratigraphy and Its Geological Significance), Saratov: Izd. SGU, 1997 [in Russian].

Molostovskii, E.A., Magnetostratigraphic Timescale of the Phanerozoic. Its Modern Structure and Significance for Stratigraphy and Geodynamics, in *Geologiya, geokhimiya i geofizika na rubezhe XX i XXI vekov. T. 3. Geofizika* (Proc. All-Russian Conf. Geology, Geochemistry, and Geophysics at the Boundary of XX–XXI Centuries. Vol. 3. Geophysics), Moscow: Regional. Obsh. Organiz. Uchenykh po Probl. Prikladn. Geofiz., 2002, pp. 63–64.

Olfer'ev, A.G. and Alekseev, A.S., Zonal Stratigraphic Scale of the Upper Cretaceous of the East-European Platform, *Stratigr. Geol. Correlation*, 2003, vol. 11, no. 2, pp. 75–101.

Ovechkina, M.N., *Izvestkovyi nannoplankton verkhnego mela (kampan i maastrikht) yuga i vostoka Russkoi plity* (Calcareous Nannoplankton of the Upper Cretaceous (Campanian and Maastrichtian) of the South and East of the Russian Plate), Moscow: Nauka, 2007 [in Russian].

Paleomagnitologiya (Paleomagnetology) Khramov, A.N., Ed., Leningrad: Nedra, 1982 [in Russian].

Perch-Nielsen, K., Cenozoic Nannofossils in *Plankton Stratigraphy*, Bolli, H.M., Saunders, J.B., and Perch-Nielsen, K., Eds., Cambridge: Cambridge Univ. Press, 1985, pp. 329–426.

Podobina, V.M. and Kseneva, T.G., Stratigraphy and Microfauna of the Upper Cretaceous of the South of Western Siberia (Borehole no. 8, Russkaya Polyana District), *Izv. Biiskogo Otd. Russk. Geogr. Obsh.*, 2007, no. 28, pp. 26–30.

Purtova, S.I., Strepetilova, V.G., Shirokova, Yu.F., and Bezrukova, T.S., Major Types of Spore-Pollen Complexes from Upper Cretaceous Deposits of the West Siberian Plane in *Palinologicheskie issledovaniya mezozoya i kainozoya Zapadnoi Sibiri. Tr. ZapSibNIGNI* (Palynologicval Studies of the Mesozoic and Cenozoic in Western Siberia. Tr. ZapSibNIGNI), 1980, no. 149, pp. 37–43.

Reshenie 5-go Mezhvedomstvennogo regional'nogo stratigraficheskogo soveshchaniya po mezozoiskim otlozheniyam Zapadno-Sibirskoi ravniny (Resolution of the 5th Interdepartmental Regional Stratigraphic Conference on the Mesozoic Deposits of the West Siberian Plane) Tyumen': ZapSibNIGNI, 1991.

Rovnina, L.V., Rodionova, M.K., Sadovnikova, T.K., et al., *Kompleksnye issledovaniya stratigrafii yury i nizhnego mela Zapadnoi Sibiri* (Complex Studies of Jurassic and Lower

Cretaceous in Western Siberia), Moscow: Nauka, 1978 [in Russian].

Savchenkova, O.O., First Finding of Dinocysts in Albian Deposits of Western Siberia, in *Novosti paleontologii i stratigrafii. Prilozhenie k zhurnalu "Geologiya i geofizika"* (News of Paleontology and Stratigraphy. Supplement to the Journal Geologiya i Geofizika), 2004, vol. 45, nos. 6–7, pp. 183–190.

Schiøler, P. and Wilson, G.J., Maastrichtian Dinoflagellate Zonation in the Dan Field, Danish North Sea, *Rev. Palaeobot. Palynol.*, 1993, vol. 78, pp. 321–351.

Schiøler, P., Brinkhuis, H., Roncaglia, L., and Wilson, G.J., Dinoflagellate Biostratigraphy and Sequence Stratigraphy of the Type Maastrichtian (Upper Cretaceous), ENCI Quarry, the Netherlands, *Marine Micropaleontol.*, 1997, vol. 31, pp. 321–351.

Shirokova, Yu.F., Aptian, Albian, and Senomanian Stages in *Stratigrafo-paleontologicheskaya osnova detal'noi korrelyatsii neftegazonosnykh otlozhenii Zapadno-Sibirskoi nizmennosti, Tr. ZapSibNIGNI* (Stratigraphic-Paleontological Basis for Detail Correlation of Oil-and-Gas Deposits of West Siberian Lowland. Tr. ZapSibNIGNI), 1972, no. 48, pp. 202–205.

Sissingh, W., Biostratigraphy of Cretaceous Calcareous Nannoplankton, *Geol. Mijnbouw.*, 1977, vol. 56(1), pp. 37–65.

Slimani, H., Les Kystes de Dinoflagelles du Campanien au Danien dans la Region de Maastricht (Belgique, Pays-Bas) et de Turnhout (Belgique): Biozonation et Correlation Avec d'Autres Regions en Europe Occidentale, *Geol. Paleontol.*, 2001, vol. 35, pp. 161–201.

Strepetilova, V.G. and Popovicheva, L.V., Justification of the Age of the Tanopcha Formation Based on Palynological Data in *Palinologicheskie issledovaniya mezozoya i kainozoya Zapadnoi Sibiri. Tr. ZapSibNIGNI* (Palynological Studies of Mesozoic and Cenozoic in Western Siberia. Tr. ZapSibNIGNI), 1980, no. 149, pp. 89–96.

Strepetilova, V.G., Biostratigraphy of Aptian–Turonian Deposits in the Nadym-Taz Interfluve, in *Palinologicheskie issledovaniya mezozoya i kainozoya Zapadnoi Sibiri. Tr. ZapSibNIGNI* (Palynological Studies of Mesozoic and Cenozoic in Western Siberia. Tr. ZapSibNIGNI), 1980, no. 149, pp. 103–109.

Strepetilova, V.G., Palynological Correlation of Lower Cretaceous Deposits in the Nadym-Taz Interfluve, in *Sporovopyl'tsevoi metod pri rekonstruktsii paleorastitel'nosti i opredelenii biofatsii. Tr. ZapSibNIGNI* (The Use of Spore-Pollen Method for Reconstruction of Paleovegetation and Determination of Paleofacies), 1984, no. 187, pp. 80–87.

Strepetilova, V.G., Features of Spore-Pollen Complexes at the Early–Late Cretaceous Boundary in *Biostratigrafiya osadochnogo chekhla Zapadno-Sibirskoi ravniny* (Biostratigraphy of the Sedimentary Cover of the West Siberian Plane), Tyumen: ZapSibNIGNI, 1989, pp. 107–115.

Strepetilova, V.G., Palinostratigraphy of Aptian–Albian Deposits of the Eastern Part of the West Siberian Plane, in *Palinologiya v stratigrafii* (Palynology in Stratigraphy), Moscow: Nauka, 1994, pp. 90–92.

Vasilieva, O.N., Upper Cretaceous Dinocysts in the Kushmurun Section (Northern Kazakhstan), in *Palinologiya: teoriya i praktika. Materialy IX Vserossiiskoi palinologicheskoi konferentsii* (Palynology: Theory and Practice. Proc. IX All-Russian Palynol. Conf.), Moscow: PIN RAN, 2005, pp. 40–41.

Vasilieva, O.N. and Levina, A.P., Organic-Walled Phytoplankton in Upper Cretaceous and Paleogene Deposits in the Kushmurun Section, Turgai Depression (Kazakhstan), *Byull. Mosk. O-va Ispyt. Prir. Otd. Geol.*, 2007, vol. 82, no. 2, pp. 40–55.

Verkhnemelovye otlozheniya Yuzhnogo Zaural'ya (raion verkhnego Pritobol'ya) (Upper Cretaceous Deposits of the Southern Trans-Urals (Region of the Upper Tobol River)), Papulov, G.N., Zhelezko, V.I., and Levin, A.P., Eds., Sverdlovsk: Izd. UrO AN SSSR, 1990 [in Russian].

Volkova, V.S., Kul'kova, I.A., and Kuz'mina, O.B., Palynostratigraphy of Paleogene and Neogene Deposits of the Baraba-Kulunda Facies Zone of West Siberia, *Geol. Geofiz.,* 2002, vol. 43, no. 11, pp. 1017–1037.

Volkova, V.S., Kuz'mina, O.B., and Kul'kova, I.A., Marine and Continental Paleogene and Miocene of Southern Part of the Baraba Facies Zone of West Siberia, *Geol. Geofiz.,* 2005, vol. 46, no. 1, pp. 60–71.

Iakovleva, A.I., Aleksandrova, G.N., and Zaporozhets, N.I., The Results of Studying Dinocysts from Upper Cretaceous–Lower Paleogene (Boreholes nos. 8, 10; Russkaya Polyana Area, Southwestern Siberia) in *Evolyutsiya zhizni na Zemle. Materialy IV Mezhdunarodnogo simpoziuma, 10–12 noyabrya 2010 g.* (Evolution of Life in the Earth. Proc. IV Intern. Symp. November, 10–12, 2010), Podobina V.M., Ed., Tomsk: TML-Press, 2010, pp. 432–435.

Iakovleva, A.I., Aleksandrova, G.N., and Gnibidenko, Z.N., Age Refinement of Lyulinvor Formation in the South of Western Siberia in *Paleontologiya, stratigrafiya i paleogeografiya mezozoya i kainozoya boreal'nykh raionov. Materialy nauch. sessii. T. II* (Paleontology, Stratigraphy and Paleogeography of the Mesozoic and Cenozoic of Boreal Regions. Proc. of Sci. Session. Vol. 2) Shurygin, B.N., Lebedev, N.K., and Goryachev, A.A., Eds., Novosibirsk: INGG SO RAN, 2011.

Zakharov, V.A., Lebedeva, N.K., and Khomentovsky, O.V., Upper Cretaceous Inoceramid and Dinoflagellate Cysts Biostratigraphy of the Northern Siberia, in *Tethyan/Boreal Cretaceous Correlation. Mediterranean and Boreal Cretaceous Paleobiogeographic Areas in Central and Eastern Europe,* Michalik J., Ed., Bratislava: VEDA, Publ. House Slovak Ac. Sci., 2002, pp. 137–172.

Zijderveld, J.D.A., A.C. Demagnetization of Rocks: Analysis of Results, in *Methods in Paleomagnetism*, Amsterdam: Elsevier, 1967, pp. 254–286.