Radiolarian biostratigraphy of Paleogene deposits of the Russian Platform (Voronesh Anticline)

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ABSTRACT
The aim of the present biostratigraphic investigation is to construct a discrete radiolarian biochronological scale for the Paleogene of the Voronesh Anticline, processing data with the BIOGRAPH program (Savary & Guex 1991). The subdivisions of this scale are characterized by unique and mutually exclusive assemblages of taxa which are similar to "Concurrent Range Zones" or "Oppel Zones". This new approach allows to resolve the contradictions in correlation that have existed in numerous previous publications and resulted in the creation of three different radiolarian biostratigraphic schemes for the same region of the Russian Platform. The base material for our study are radiolarian assemblages collected from four Paleogene sections located in

Russia and Ukraine. Eighteen Unitary Associations and seven Unitary Associations Zones are established for the (?)late Paleocene and Eocene deposits of this area. These Unitary Associations Zones are tied to the standard stages by means diatoms, nannoplankton, foraminifera, silicoflagellates and dinoflagellates co-occurring with radiolarians in the same sections. We give a brief descriptions of 119 determined and zoned radiolarian taxa.

KEY WORDS
Radiolaria,
Paleogene,
Unitary Associations,
Russian Platform,
biostratigraphy.

RÉSUMÉ
Biostratigraphie des radiolaires des dépôts paléogènes de la plateforme russe (anticlinal de Voronesh).
Le but du présent travail de recherches biostratigraphiques est de construire une échelle biochronologique discrète basée sur les radiolaires paléogènes de la plateforme russe. Pour cela nous avons traité nos données avec l'aide du programme BIOGRAPH de Savary & Guex (1991). Les subdivisions de cette échelle sont caractérisées par des assemblages taxonomiques uniques et mutuellement exclusifs qui sont semblables aux « Concurrent Range Zones » et aux « Oppel Zones ». Cette approche permet de résoudre les corrélations contradictoires qui caractérisent de nombreuses publications parues ces dernières années et qui ont engendré la création de trois schémas biostratigraphiques distincts basés sur les radiolaires de cette même région de la plateforme russe. Le matériel de base de notre étude provient de récoltes de faunes à radiolaires dans quatre sections des dépôts paléogènes situés dans des territoires russes et ukrainiens. Dix-huit Associations Unitaires et sept Zones d'Associations Unitaires ont été établies pour le Paléocène Supérieur et l'Éocène de cette région. Ces asssociations ont été calibrées aux étages standards avec l'aide des diatomées, du nannoplancton, des foraminifères ainsi que des silico- et dinoflagellés coexistant avec les radiolaires des mêmes sections. Une brève description et des illustrations de 119 espèces de radiolaires utilisés pour l'échelle biochronologique sont données.

MOTS CLÉS
Radiolaires,
Paléogène,
Associations Unitaires,
plateforme russe,
biostratigraphie.

INTRODUCTION

The present paper is giving a paleontological and new biostratigraphical information about the Voronesh Anticline region – Russian Platform (southern part) – which has an importance for everyone interested in correlation of Paleogene sediments deposited on territories under mixed subtropical and boreal influence.

A main problem in radiolarian biostratigraphy nowadays remains the correlation of paleontological data between high latitude and low latitude areas. This gap has several reasons: 1) different paleogeographic realms; 2) most of the high latitude data were acquired in Russia where technical facilities were and are different from the western ones; and 3) the existence of different methodological approaches in radiolarian biostratigraphy.

It has long been recognized that radiolarian biogeography depends on the control of ocean currents and it differs not only between low and high latitudes, but also between adjacent epicontinental basins occurring within the same latitudinal range with different types of connection to the open ocean. As a consequence, one can observe a certain endemism of microfauna in epicontinental seas. The Cenozoic radiolarian stratigraphy reflects this distinctive biogeographic pattern. For example, there are separate zonal schemes created for the tropics (Sanfilippo *et al.* 1985; Johnson & Nigrini 1985a, b), Antarctic (Caulet 1991; Lazarus 1992), Norwegian-

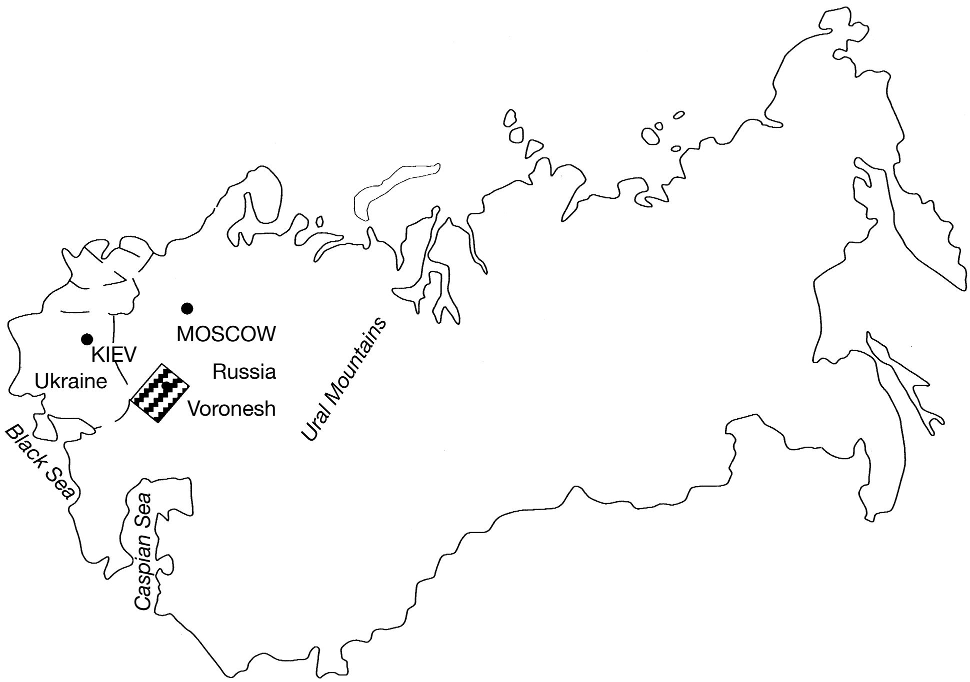


FIG. 1. — Locality of studied territory (within the boundary of the ex-USSR).

Greenland Sea (Bjørklund 1976; Goll & Bjørklund 1989) and Russian Platform (Lipman 1976, 1993; Kozlova 1993, 1999). During the Late Cretaceous-Paleogene the Voronesh Anticline was under the influence of the Tethyan and the Boreal faunal provinces, depending on the relative height of sea level that allowed connections either to the Arctic or the Tethys-ParaTethys Oceans. Hence, this area is well suited for establishing a zonation that links the two realms. If such a zonation includes enough cosmopolitan species, it may allow for a correlation of the regional zonations proposed so far, and overcome the inherent problems of diachroneity and endemism.

GEOLOGICAL OVERVIEW

Geographically the Voronesh Anticline territory belonging to the territories of two republics – Ukraine and Russia (Fig. 1). Voronesh Anticline (Fig. 2) is known from the literature under another term: Kursk-Voronesh crystallin core-area. It is a buried elevation composed of complicate dislocated metamorphic and magmatic rocks, Archeozoic and Paleozoic in age. Its southern and south-western part is joint with Dnepr-Donets Rivers depression, the north-western part with Orsha-Smolensk flexure, the northern with Moscow syncline and the north-eastern with Razan-Saratov flexure. Morphology of this zone's relief looks like a chain of small hills of 20-50 m height, outlining a ledge with a north-western trend. The dip of beds ranges from 0.5° to 3°.

Paleogene deposits of the Russian Platform are cropping out as relicts on a tops of watersheds and hills. They are represented by terrigenous, biogenic and authigenic types of rocks. Sand, sandstone, siltstone and clay are characteristic for the first rock type. Diatomite, radiolarite, radiolarite-spongolite, carbonates and coals represents the second type and glauconites, phosphorites, zeolites and Fe-Mn concretions form the third

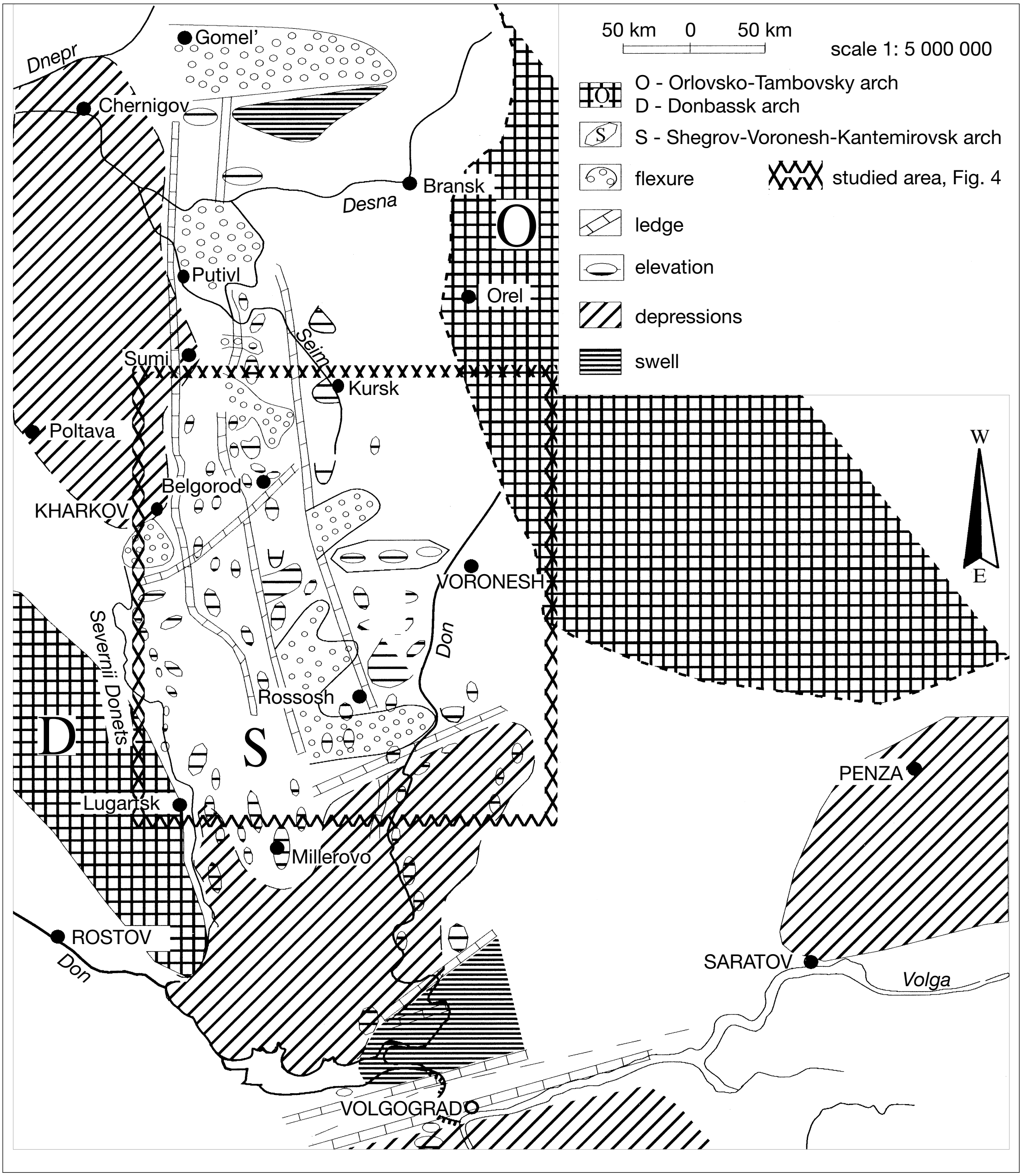


FIG. 2. — Structural scheme of the Voronesh Anticline (after Semenov 1965).

type of rocks. According to its lithological features the Paleogene deposits can be subdivided into four lithofacies-quarts, quartz-glauconite, silty-clay and carbonate or clay-marl units. The quartz-glauconite formation is dominant. The thickness of Paleogene deposits in the Voronesh Anticline region is about 150-200 m and it is decreasing towards the North. The stratigraphic

AGE				Regional stratigraphic subdivisions of Northern Ukraine		Regional and local stratrigraphic subdivisions — Tectono – facial zones of Voronesh Anticline territory: I. South-Eastern and Southern Zone (bassins of Don, Khoper, Aidar Rivers)	II. Western and South-Western Zone (right-bank of Don, upper reachers of Seim, Desna and Oscol Rivers)
NEOGENE	MIOCENE	lower	Burdigalian	Poltavsky	Novopetrovsky	Novopetrovsky Group N_1np; N_1np^3 third member; N_1np^2 second member; N_1np^1 first member	Novopetrovsky Group N_1np; N_1np^3 third member; N_1np^2 second member; N_1np^1 first member
NEOGENE / PALEOGENE	MIOCENE / OLIGOCENE	lower / upper	Aquitanian / Chatian	Poltavsky	Bereksky	Bereksky Group $(P_3\text{-}N)$ br; N_1sv Sivashsky Formation; P_3zm Zmievsky Formation	Bereksky Group $(P_3\text{-}N_1)$ br; N_1*sh* *Shuravkinsky* Formation
PALEOGENE	OLIGOCENE	upper / lower	Chatian / Rupelian	Kharkovsky	Meshigorsky	P_3knt Kantemirovsky Formation	P_3knt Kantemirovsky Formation
PALEOGENE	OLIGOCENE	lower	Rupelian	Kharkovsky	Meshigorsky	Pasekovsky Formation P_3ps; P_3ps_2 subformation 2; P_3ps_1 subormation 1 / *Kasianovskaya* F. top	P_3ps Pasekovsky Formation
PALEOGENE	EOCENE	upper	Priabonian	Kharkovsky	Obykhovsky	P_2ob Obykhovsky Group; P_2ks *Kasianovskaya* F., bottom; P_2tsh *Tishkinskaya* Formation, top	P_2ob Obykhovsky Group; P_2ks *Kasianovskaya* Formation; P_2tsh *Tishkinskaya* Formation
PALEOGENE	EOCENE	middle	Bartonian / Lutetian		Kievsky	Kievsky Group P_2kv; P_2fd_2 Upper member of Fedorovskaya Formation / *Tishkinskaya* F., bot.; P_2fd_1 Lower member of Fedorovskaya F. / *Sergeevskaya* F.	Kievsky Group P_2kv; P_2fd_2 Upper member of Fedorovskaya Formation; P_2fd_1 Lower member of Fedorovskaya Formation
PALEOGENE	EOCENE	middle	Lutetian		Buchaksky	Buchaksky Group $P_2bç$; P_2vs_2 Upper member of Vislovskaya F. / *Osinovsky* F.; P_2vs_1 Lower member of Vislovskaya / *Khripunskaya* F.	$P_2bç$ Buchaksky horizon
PALEOGENE	EOCENE	lower	Ypresian		Kanevsky	Kanevsky Group P_2kn; P_2kr Kartamishevskaya / *Sheptykhovskaya* Formation; P_2obn Oboyanskaya / *Syrovikinskaya* Formation	Kanevsky Group P_2kn; P_2kr Kartamishevskaya Formation; P_2obn Oboyanskaya Formation
PALEOGENE	PALEOCENE	upper	Selandian	Symsky	Merlinsky	Merlinsky Group P_1mr; P_1vs Veshenskaya Formation; P_1bz Buzinovskaya Formation	P_1mr Merlinsky Group
PALEOGENE	PALEOCENE	lower	Danian		Pselsky		

FIG. 3. — Regional and local stratigraphic subdivisions, in italics: the names of Formations, after Semenov (1965).

schemes of this region were revised several times (Leonov 1961; Semenov 1965. Nowadays the Paleocene deposits of the Voronesh Anticline territory are subdivided into the Symsky Group with the Pselsky and Merlinsky formations, the Eocene deposits into the Kanevsky, Buchaksky, Kievsky and Obykhovsky formations, and the Oligocene into the Meshigorsky and the Bereksky formations (Fig. 3).

PREVIOUS RADIOLARIAN STUDIES

The Radiolaria of this territory have been studied by many specialists: Zagorodnyuk (1969, 1981), Lipman (1972), Tochilina (1969, 1971, 1975), Kozlova (1984, 1990, 1993, 1999) and Khokhlova (Ben'yamovsky *et al.* 1993; Khokhlova 1996; Khokhlova *et al.* 1999). Radiolaria-bearing deposits have been observed in the Merlinsky, Kanevsky, Buchaksky, Kievsky and the Obykhovsky groups. The most abundant and well preserved assemblages were extracted from the deposits of the Kanevsky and Kievskaya groups. In many sections the radiolarian assemblages occur together with diatoms, planktic and benthic foraminifera, nannoplankton, silicoflagellates and dinoflagellates. The development of biota in general (reflected in species composition) was under a strong control of sea level fluctuations. Tochilina (1969, 1971, 1975) identified three periods in the Paleocene-Eocene time-interval closely connected with transgressions and regressions in the basin: 1) late Paleocene-early Eocene; 2) middle Eocene; 3) late late Eocene.

The Don River basin territory (no precise localities published) was studied by Zagorodnyuk (1969, 1975, 1981). She investigated radiolarians from the Asovo-Kubansk trough, the Salo-Manyhsk interflow (both territories are in Ukraine, to the east from the Aral Sea) and the basin of the Northern Emba (Pre-Caspian lowland). Three different radiolarian assemblages from the Don River lower flow area and four assemblages from the North Caspian lowland territory were introduced. The Eocene deposits of all studied by Zagorodnyuk areas have served as a basis for an integrated investigation on foraminiferas and radiolarian distribution (Nikitina & Zagorodnyuk 1981).

Paleocene to middle Eocene radiolarian assemblages have been discovered by Khokhlova (1996) in cores of two wells drilled near the Yaruga Village (Belgorod area) and in two outcrops one near the Sergeevka Village and another near the Kantemirovka Village (Khokhlova *et al.* 1999). In both articles radiolarian data are represented only by a list of taxa.

The Paleogene radiolarians from the Don River basin (Fedorovka, Vorobjevka, Russkie Tishki villages region) were described by Kozlova (1999). *Heliodiscus inca* Zone was proposed in this publication for the upper part of the Sheptykhovskaya Formation. The upper part of the Sergeevskaya, Tishkinskaya and the lower part of the Kasianovskaya Formation (stratigraphical scheme after Semenov 1965) were attributed to *Heliodiscus quadratus*, *Cyrtophormis alta*, *Ethmosphaera polysiphonia* and *Theocyrtis andriashevi* Zones respectively.

The radiolarian zonation schemes proposed by Lipman (1993) and Kozlova (1993, 1999) for the former Soviet Union territory are different and can be correlated only with a difficulty, as they have different biostratigraphical conceptions of their establishment. Thus, after Lipman, the zonal bottom-top limits were created following the key species first (FAD) and last (LAD) appearance datum. The zones created by Kozlova are based on an evolutionary lineage and a co-occurrence of a characteristic species. The majority of zonal stratotypes of both authors were chosen on the territories of the North Caspian Sea lowland, North to Aral Sea and Western Turkmenistan. Its correlation with the Don River basin deposits was not evident for us, especially this concerns the lateral traceability of the zonal limits. The problem was also to find the index-species. Thus middle Eocene index-species of *Ethmosphaera polysiphonia* Zone of Kozlova (1990, 1993, 1999) has been never observed neither by Khokhlova (Khokhlova *et al.* 1999), nor by our investigations. We did not

discover typical *Cyrtophormis alta* and *Heliodiscus inca* (see systematic part). The occurrence of *Heliodiscus quadratus* is very sporadic – it had not been found by Khokhlova and only once observed during our studies.
Besides the problems mentioned above – the lists of taxa published contain a lots of synonyms and the range charts of species reported usually differ from our data.
These factors give no chance to establish a correct correlation. For that the main objectives of this article are: 1) to re-examine the Paleocene-Eocene radiolarian taxonomy from the Voronesh Anticline deposits provided with images and brief descriptions of the characteristic species; 2) to apply a quantitative deterministic approach (the Unitary Associations method) for the establishment of late Paleocene-Eocene radiolarian biochronology of the region; and 3) to carry out the independent regional calibration of a new radiolarian biozonation, involving data on the other fossil groups: diatoms, foraminifera, nannoplankton.

METHOD

It is known that an on-land collections of data are frequently isolated, scattered stratigraphically and geographically and sometimes it is too difficult to establish a correlation. For the large number of datasets, it is possible to apply the Graph theory (Roberts 1976). The algorithms of the method described as Unitary Association (U.A.) by Savary & Guex (1990, 1991) are largely based on this theory. The Unitary Associations are constructed by stacking the co-occurrence information of the whole data set and searching for maximal sets of really or mutually coexisting taxa establishing biostratigraphic subdivisions which are similar to “Concurrent Range Zones” or “Oppel Zones”.
We chose this method for our investigation because it allows us to detect possible diachronism between different basins.
In recent years the Unitary Association method has been used to integrate large quantities of radiolarian biostratigraphic data into a biochronological framework. This method analyses the first and last occurrences of species in all available sections and defines maximal sets of mutually coexisting species (Unitary Associations). It also produces maximum ranges of the taxa relative to each other by stacking co-occurrence data from all sections to compensate for local dissolution and poor preservation.
The procedures are described in Guex (1991) and are not repeated here. Savary & Guex (1990, 1991) developed a computer program BIOGRAPH to deal more efficiently with a large volume of data. This program was used by many researchers: Carter (1993), Jud (1994), Gorican (1994), O’Dogherty (1994) and Baumgartner *et al.* (1995) in zoning Triassic, Jurassic and Cretaceous radiolarians from different areas of the Tethys and of the Pacific Realm. For the radiolarian biostratigraphy of the Russian Platform the Unitary Associations method was used to create a new zonal scheme which will help to overcome the problems and contradictions of earlier proposed biostratigraphic schemes.

BIOZONES

In the two wells and two outcrops (Figs 4; 5) examined in this study a system of seven biozones is established (Fig. 6).

Unitary Association Zone PE-1

Well 730C, near the Petropavlovka Village, Don River basin.

Category. — Concurrent Range Zone or Oppel Zone.

Designation. — PE-1.

Lithostratigraphic formation. — Kanevsky Group, Sheptukhovskaya Formation. Silty-clay-rich, diatomit-like, light grey unit. The radiolaria-bearing beds were found at the bottom of this unit.

Depth range. — Interval 44.3-43.7 m.

Age. — Late Paleocene-early Eocene.

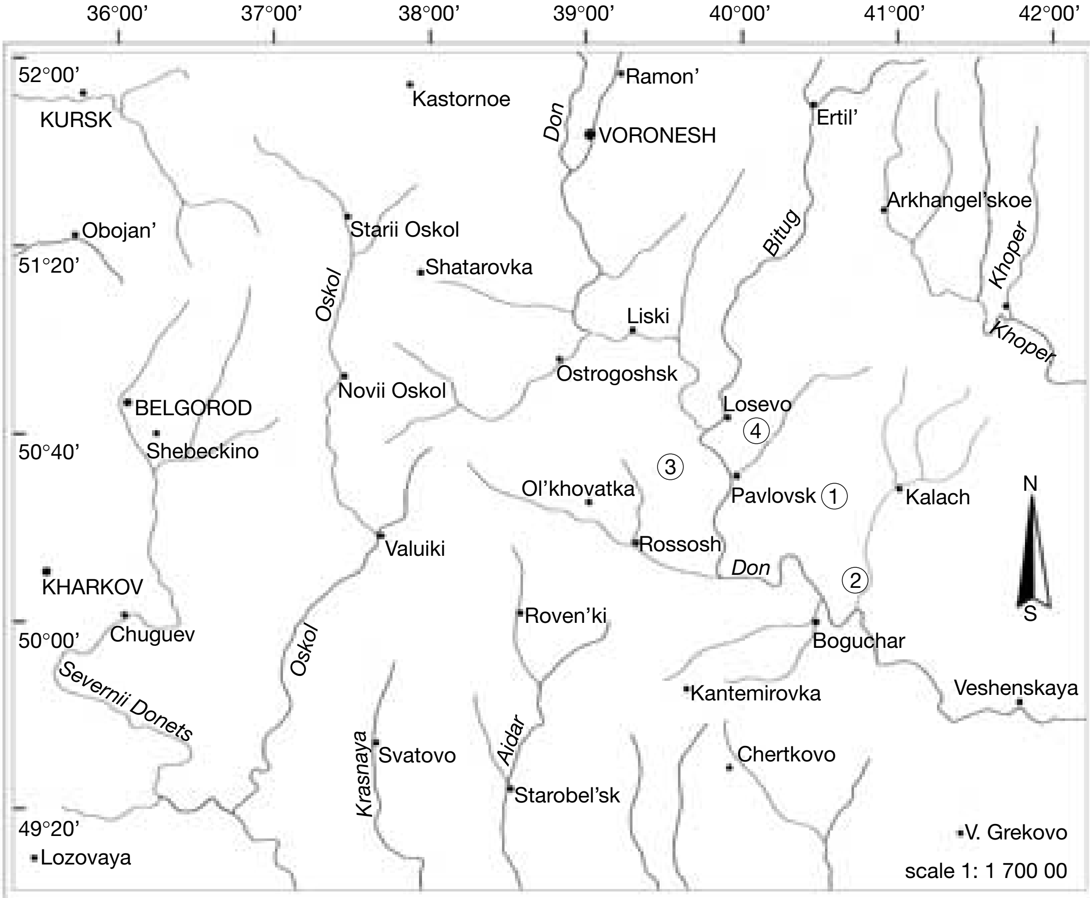


FIG. 4. — Location of the wells and outcrops within the Voronesh Anticline territory. **1**, Pirogovo Village, well 510C; **2**, Petropavlovka Village, well 730C; **3**, Sergeevka Village, outcrop S1; **4**, Baltinovsky Village, outcrops 294 and 2484.

BOUNDARY CRITERIA. — The bottom is not defined, the top is marked by LAD of *P. ampla longispina*, *P.* sp. aff. *inca*, *H. faceta*, *R. satelles*, *L. bellum longipes* and FAD of *H. formosa trispina*, *L.* sp. aff. *bandyca*, *Prunobrachium* sp.

ASSEMBLAGE. — The radiolarian tests are moderately preserved and taxonomic diversity is restricted to 10-12 determinable species. Some specimens are bearing the traces of dissolution as black spots and caverns. Because of these facts we cannot exclude the possible redeposition of Paleocene microfauna in early Eocene deposits and the late Paleocene age of this unit is given with the "?". The species characteristic for this assemblage are *Lychnocanomma bellum*, *Mita* cf. *regina*, *Podocyrtis* cf. *papalis*, *Heterosestrum formosa trispina*, *Spongoprunum* sp. aff. *probus*, *Spongodiscus cruciferus*, *Pterocodon ampla longispina*, *Dictyoprora urceolus*, etc. (Fig. 6; Appendix).

Unitary Association Zone E-1

Well 730C, near the Petropavlovka Village, Don River basin.

CATEGORY. — Concurrent Range Zone or Oppel Zone.

DESIGNATION. — E-1.

LITHOSTRATIGRAPHIC FORMATION. — Kanevsky Group, Sheptukhovskaya Formation. Light grey unit, the radiolaria-bearing beds are interlaid with clays and fine-grained sands.

DEPTH RANGE. — Interval 43.7-38.8 m.

AGE. — Early Eocene.

BOUNDARY CRITERIA. — The bottom is defined by LAD of *D. urceolus*, *P. argiscus*, *Mita* cf. *regina*, *O. biconstrictus*, *C. barbadensis*, the top is marked by FAD of *P. septenaria*.

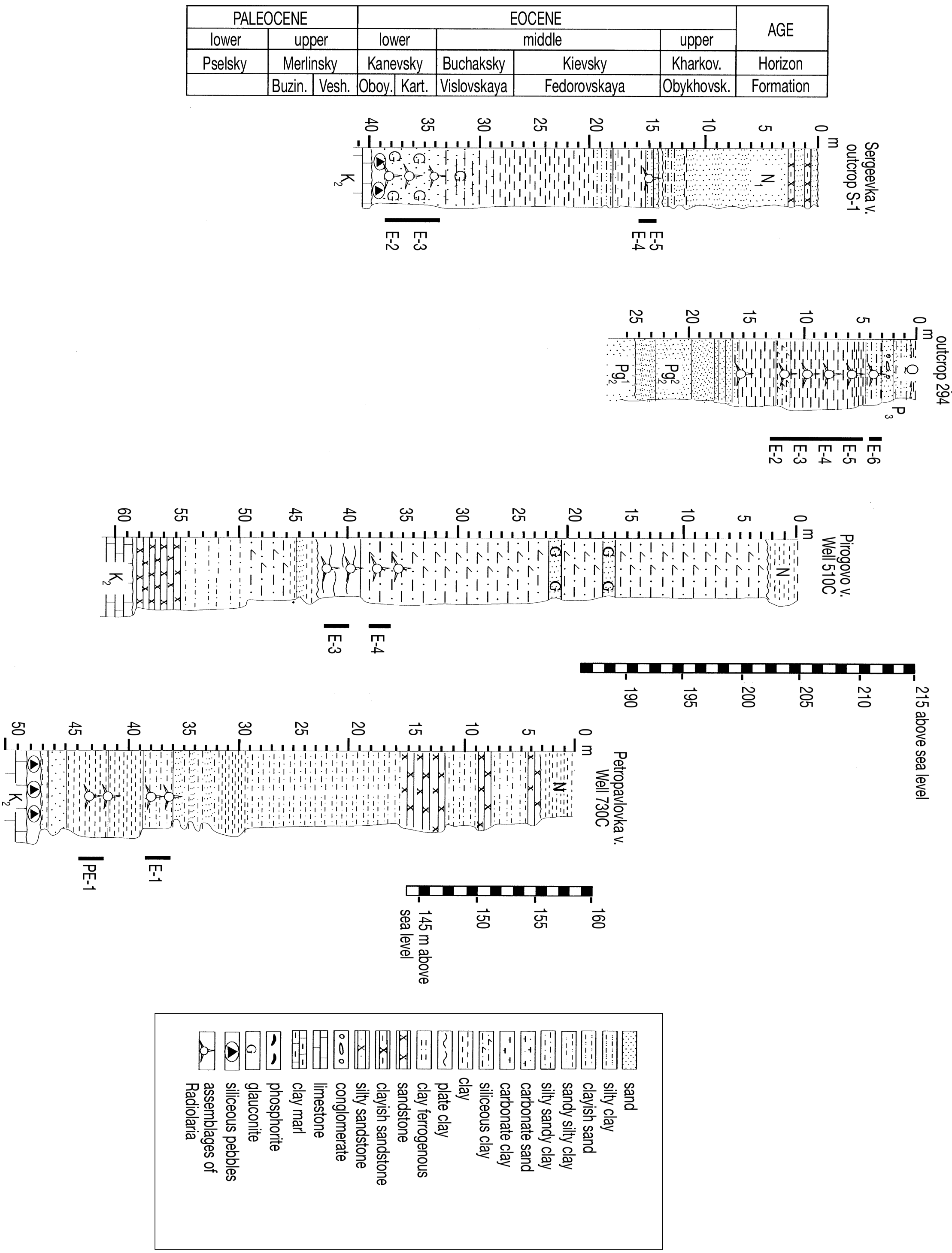
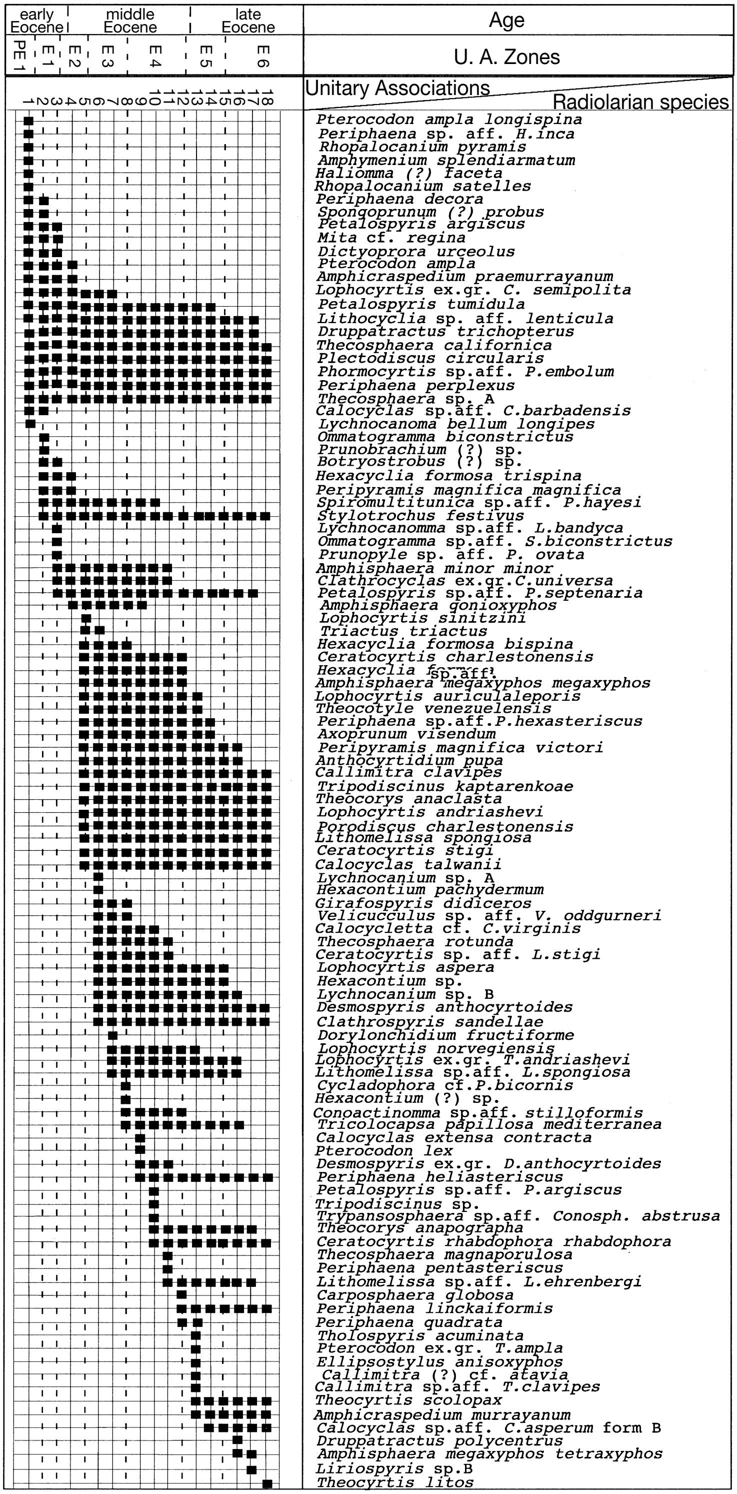


FIG. 5. — The log and Unitary Association Zones correlation of the outcrops and wells examined.


early Eocene
middle Eocene
late Eocene
Age
PE 1
E 1
E 2
E 3
E 4
E 5
E 6
U. A. Zones
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Unitary Associations
Radiolarian species
Pterocodon ampla longispina
Periphaena sp. aff. H.inca
Rhopalocanium pyramis
Amphymenium splendiarmatum
Haliomma (?) faceta
Rhopalocanium satelles
Periphaena decora
Spongoprunum (?) probus
Petalospyris argiscus
Mita cf. regina
Dictyoprora urceolus
Pterocodon ampla
Amphicraspedium praemurrayanum
Lophocyrtis ex.gr. C. semipolita
Petalospyris tumidula
Lithocyclia sp. aff. lenticula
Druppatractus trichopterus
Thecosphaera californica
Plectodiscus circularis
Phormocyrtis sp.aff. P.embolum
Periphaena perplexus
Thecosphaera sp. A
Calocyclas sp.aff. C.barbadensis
Lychnocanoma bellum longipes
Ommatogramma biconstrictus
Prunobrachium (?) sp.
Botryostrobus (?) sp.
Hexacyclia formosa trispina
Peripyramis magnifica magnifica
Spiromultitunica sp.aff. P.hayesi
Stylotrochus festivus
Lychnocanomma sp.aff. L.bandyca
Ommatogramma sp.aff. S.biconstrictus
Prunopyle sp. aff. P. ovata
Amphisphaera minor minor
Clathrocyclas ex.gr.C.universa
Petalospyris sp.aff. P.septenaria
Amphisphaera gonioxyphos
Lophocyrtis sinitzini
Triactus triactus
Hexacyclia formosa bispina
Ceratocyrtis charlestonensis
Hexacyclia f[illegible] sp.aff.
Amphisphaera megaxyphos megaxyphos
Lophocyrtis auriculaleporis
Theocotyle venezuelensis
Periphaena sp.aff.P.hexasteriscus
Axoprunum visendum
Peripyramis magnifica victori
Anthocyrtidium pupa
Callimitra clavipes
Tripodiscinus kaptarenkoae
Theocorys anaclasta
Lophocyrtis andriashevi
Porodiscus charlestonensis
Lithomelissa spongiosa
Ceratocyrtis stigi
Calocyclas talwanii
Lychnocanium sp. A
Hexacontium pachydermum
Girafospyris didiceros
Velicucculus sp. aff. V. oddgurneri
Calocycletta cf. C.virginis
Thecosphaera rotunda
Ceratocyrtis sp. aff. L.stigi
Lophocyrtis aspera
Hexacontium sp.
Lychnocanium sp. B
Desmospyris anthocyrtoides
Clathrospyris sandellae
Dorylonchidium fructiforme
Lophocyrtis norvegiensis
Lophocyrtis ex.gr. T.andriashevi
Lithomelissa sp.aff. L.spongiosa
Cycladophora cf.P.bicornis
Hexacontium (?) sp.
Conoactinomma sp.aff. stilloformis
Tricolocapsa papillosa mediterranea
Calocyclas extensa contracta
Pterocodon lex
Desmospyris ex.gr. D.anthocyrtoides
Periphaena heliasteriscus
Petalospyris sp.aff. P.argiscus
Tripodiscinus sp.
Trypansosphaera sp.aff. Conosph. abstrusa
Theocorys anapographa
Ceratocyrtis rhabdophora rhabdophora
Thecosphaera magnaporulosa
Periphaena pentasteriscus
Lithomelissa sp.aff. L.ehrenbergi
Carposphaera globosa
Periphaena linckaiformis
Periphaena quadrata
Tholospyris acuminata
Pterocodon ex.gr. T.ampla
Ellipsostylus anisoxyphos
Callimitra (?) cf. atavia
Callimitra sp.aff. T.clavipes
Theocyrtis scolopax
Amphicraspedium murrayanum
Calocyclas sp.aff. C.asperum form B
Druppatractus polycentrus
Amphisphaera megaxyphos tetraxyphos
Liriospyris sp.B
Theocyrtis litos

ASSEMBLAGE. — *A. praemurrayanum*, *P. ampla*, *M.* cf. *regina*, *P. argiscus*, *P. tumidula*, *D. urceolus*, *C.* ex. gr. *universa*, *R. satelles*, *O.* sp. aff. *biconstrictus*, *P. perplexus*, etc. (Fig. 6).

REMARKS
The boundaries of all zones are informal, as they coincide with the hiatuses in pelagic sediments deposition.

Unitary Association Zone E-2

Well 510C, near the Pirogovo Village, Pavlovsk City region.

CATEGORY. — Concurrent Range Zone or Oppel Zone.

DESIGNATION. — E-2.

LITHOSTRATIGRAPHIC FORMATION. — Kievsky Group, Lower member of Fedorovskaya Formation (Sergeevskaya Formation). Light gray unit of radiolaria-bearing silty claystones with glauconit, interlaid with fine/medium grained sands and clays.

DEPTH RANGE. — Interval 44.00-42.00 m.

AGE. — Early middle Eocene.

BOUNDARY CRITERIA. — The bottom is defined by LAD of *P. magnifica magnifica*, *P. ampla*, *A. praemurrayanum*, *H. formosa trispina*, the top is marked by 20 FAD among them are *L. sinitzini*, *T. triactis*, *H. formosa bispina*, etc.

ASSEMBLAGE. — *P. ampla*, *A. praemurrauanum*, *L.* ex. gr. *C. semipolita*, *P. tumidula*, *L.* sp. aff. *lenticula*, *D. trichopterus*, *T. californica*, *P. circularis*, *P.* sp. aff. *embolum*, *P. perplexus*, *Thecosphaera* sp. A, *H. formosa trispina*, *P. magnifica magnifica*, *Spiromultitunica* sp. aff. *P. hayesi*, *S. festivus*, *A. minor minor*, *C.* ex. gr. *universa*, *P.* sp. aff. *septenaria*, *A. gonioxyphos*.

REMARKS
The similar assemblage was observed in the silty-clay unit of the well 730C, interval 37.00 m and in diatomit of the outcrop S1, Sergeevka Village, depths 35.5 m.
In the sample from interval 44.00 m the radiolarians are co-occurred with diatoms *Arachnodiscus ehrenbergii* Bail., *Sheshukovia polycystinora* (Pant.) Glezer, *Hemialus* sp. aff. *polycystinorum* Her., *Trinacria* sp., *Pyxidicula* sp., *Sheshukovia* sp. and some other species (determination of Z. Glezer, here and down below).

Unitary Association Zone E-3

Well 510C, near the Pirogovo Village, Pavlovsk City region.

CATEGORY. — Concurrent Range Zone or Oppel Zone.

DESIGNATION. — E-3.

LITHOSTRATIGRAPHIC FORMATION. — Kievsky Group, Lower member of Fedorovskaya Formation (upper part of Sergeevskaya Formation). Greenish-grey unit of radiolaria-bearing silty claystones with glauconit.

DEPTH RANGE. — Interval 40.00-36.00 m.

AGE. — Middle Eocene.

BOUNDARY CRITERIA. — The bottom is defined by 20 FAD and the top is marked by LAD of *L.* ex. gr. *C. semipolita*, *T. triactis*, *G. didiceros* and *V.* sp. aff. *oddgurneri*.

ASSEMBLAGE. — It contains long ranging species *P. tumidula*, *L.* sp. aff. *lenticula*, *D. trichopteris*, etc., and recently appeared *Lophocyrtis auriculaleporis*, *L. norvegiensis*, *Heterosestrum formosa*, *Lithomelissa stigi*, *L. charlestonensis*, *Theocorys anaclasta*, *Calocyclas talwanii*, *Lophocyrtis aspera*, *L.* ex. gr. *T. andriashevi*, *Tripodiscinus kaptarenkoae*, *Anthocyrtidium pupa*, *Calocycletta* cf. *virginis*, *Velicucullus* sp. aff. *oddgurneri*, etc. (Fig. 6).

REMARKS
In the sample of well 510C, core 40 radiolarians were observed together with diatoms **Hemianlus tschestnovii* Pantoaek, **Cristodiscus succinctus* (Sheshuk et Glezer) Glezer et Olshtinskaya, **Pyxidicula charkoviana* (Jouse) Strelnikova et Nikolaev, **Corona retinervis* Sheshukova et Glezer, *Arachnoidiscus ehrenbergii* Bail., **Biddulphia tuomeyi* var. *tridentata* Jouse, **Actinoptychus intermedius* A.S., **Aulacodiscus excavatus* A.S., *Pseudopodosira mixta* (Possn) Olshtinskaya, **Bipalla (Paralia) oamaruensis*, etc. All species marked by * (here and down below) are characteristic for *Bipalla oammaruensis* Zone (Glezer 1979a).

FIG. 6. — Unitary Associations of Paleogene Radiolaria from the southern part of the Russian Platform, with the virtual range-charts of species.

Unitary Association Zone E-4

Outcrop 294.

CATEGORY. — Concurrent Range Zone or Oppel Zone.

DESIGNATION. — E-4.

LITHOSTRATIGRAPHIC FORMATION. — Kievsky Group, Upper member of Fedorovskaya Formation (Tishkinskaya Formation, bottom). Light gray unit of radiolaria-bearing clayey siltstones with rare glauconit.

DEPTH RANGE. — Interval 12.80-6.30 m.

AGE. — Late middle Eocene.

BOUNDARY CRITERIA. — The bottom is defined by LAD of *H. formosa bispina*, *G. didiceros*, *V.* sp. aff. *oddgurneri* and FAD of *C. extensa contracta*, *P. lex*, *C.* sp. aff. *stilloformis*, *T. papillosa mediterranea*. The top is marked by LAD of *C.* sp. aff. *stigi*, *A. megaxyphos megaxyphos* and FAD of *P. pentasteriscus*, *L.* sp. aff. *ehrenbergi*, *C. globosa*, *P. linckaiformis*, *P. quadrata*.

ASSEMBLAGE. — It contains a majority of species from the previous U.A. Zone E-3. We indicate the presence of some new taxa as *T. anapographa*, *C.* sp. aff *stilloformis*, *P. lex*, *D.* sp. aff *anthocyrtoides*, *Tripodiscinus* sp., *Trypansosphaera* sp. aff. *C. abstrusa*. (Fig. 6).
The deposits of the outcrop 294/7, interval 9.30 m, are radiolaria and diatom bearing. The diatom assemblage contains *Paralia complexa* Andrws., **Sheshukovia mammilianum* (Pant.), *Arachnodiscus ehrenbergii* Bail., *Trinacria* (?) sp., *Sheshukovia* sp., **Pyxidicula charkoviana* (Jouse) Streln. et Nikol., **Aulacodiscus excavatus* A.S, *Hemialus* sp. aff. *polycistinorum* Her.

Unitary Association Zone E-5

Outcrop 294.

CATEGORY. — Concurrent Range Zone or Oppel Zone.

DESIGNATION. — E-5.

LITHOSTRATIGRAPHIC FORMATION. — Obykhovsky Group, Tishkinskaya Formation, top. Light yellowish gray unit of clayey silt.

DEPTH RANGE. — Interval 5.30-4.20 m.

AGE. — Late Eocene.

BOUNDARY CRITERIA. — The bottom is defined by LAD of *A. auriculaleporis*, *L. norvegiensis*, *T. venesuelensis*, *C. globosa* and FAD of *T. acuminata*, *P.* ex. gr. *T. ampla*, *C.* cf. *atavia*, *C.* sp. aff. *T. clavipes*, *T. scolopax*. The top is marked by LAD of *P. tumidula*, *P.* sp. aff. *hexasteriscus*, *A. visendum*.

ASSEMBLAGE. — It contains a majority of species from the previous U. A. Zone E-4. We indicate the presence of some new taxa as *T. acuminata*, *P.* ex. gr. *ampla*, *E. anisoxyphos*, *C.* (?) cf. *atavia*, *C.* sp. aff. *T. clavipes*, *T. scolopax*, etc. (Fig. 6).

Unitary Association Zone E-6

Outcrop 294.

CATEGORY. — Concurrent Range Zone or Oppel Zone.

DESIGNATION. — E-6.

LITHOSTRATIGRAPHIC FORMATION. — Kharkovsky Group, Obykhovsky Subgroup, Derezovskaya (ex Kasianovskaya) Formation, bottom. Light gray unit of diatomite.

DEPTH RANGE. — Interval 3.20 m.

AGE. — Late Eocene.

BOUNDARY CRITERIA. — The bottom is defined by LAD of *P. magnifica victory*, *A. pupa*, *Lychnocanium* sp. B, *C.* sp. aff. *stilloformis* and FAD of *D. polycentrus*, *Liriospyris* sp. B, *A. megaxyphos tetraxyphos*. The top is not determined.

ASSEMBLAGE. — It contains characteristic species *P.* sp. aff. *embolum*, *C. clavipes*, *T. kaptarenkoae*, *T. anaclasta*, *L. andriashevi*, *L. spongiosa*, *C. stigi*, *C. sandellae*, etc. We indicate the presence of some new taxa as *A. megaxyphos tetraxyphos*, *Liriospyris* sp. B and *T. litos* (Fig. 6).

REMARKS

This radiolarian assemblage is co-occur with the diatoms in the same sample.
The latter are represented by *Coscinodiscus obscurus* A.S. var. *cancavus* Glezer, **Trinacria ventricosa* Grove et Stuart, *T. excavata* Heib., *Arachnoidiscus ehrenbergii* Bail., **Aulacodiscus excavatus* A.S., *Paralia complexa* Andrews., **Sheshukovia squamatum* Pant. (?), **S. mammilianum* Pant. (?) and some other species, not yet described.

CORRELATION OF RADIOLARIAN DATA

The co-occurrence of a key-species from tropical zonal scale (Sanfilippo *et al.* 1985) – *Pterocodon ampla*, *Calocycletta* sp. aff. *virginis*, *Tricolocapsa papillosa mediterranea*, *Theocorys anaclasta*, *T. scolopax*, *Giraffospyris didiceros*, *Phormocyrtis* *embolum*, *Periphaena decora*, *Theocotyle venezuelensis*, etc. – and those from boreal one (Bjørklund 1976; Goll 1989) – *Calocyclas talwanii*, *Lophocyrtis auriculaleporis*, *L. norvegiensis*, *Lithomelissa spongiosa*, *Ceratocyrtis stigi*, *C. charlestonensis*, *Lophocyrtis andriashevi*, *Clathrospyris sandellae*, *Calimitra clavipes*, etc. – provided our Unitary Associations not only with a positive local correlation but also a distant one (lateral traceability).

Thus the co-occurrence of *P. lex-T. anaclasta* and *L. norvegiensis-C. talwanii* in the same samples allows a long distant correlation between middle Eocene zonal assemblages of *Phormocyrtis striata striata* to *Thyrsocyrtis triacantha* zonal assemblages of tropics and *L. norvegiensis* and *C. talwanii* zonal assemblages of the Norwegian-Greenland basin.

The most ancient radiolarian assemblage from cores 44.3 to 43.7 m (well 730C, Petropavlovka Village) with *Pterocodon ampla*, *Dictyoprora urceolus*, *Amphicraspedium praemurrayanum*, etc., can be correlated with early Eocene radiolarian assemblages of *Becoma bidartensis* to *Phormocyrtis striata striata* Zones of the Atlantic Ocean and with those of *H. inca* Zone introduced by Kozlova (1999) for Voronesh Anticline.

CALIBRATION OF UNITARY ASSOCIATIONS ZONES (U.A. ZONES)

In the process of Unitary Associations Zones calibration we involved data on planktic and benthic foraminifera, nannoplankton, diatoms and dinoflagellates (Fig. 6) (data of Glezer 1979a, b and this study; Kozlova 1993; Benyamovsky *et al.* 1993; Radionova *et al.* 1994; Khokhlova *et al.* 1999; Kozlova 1999).

PE-1 U.A. Zone

Diatoms assemblages of Merlinsky Group (Veshenskaya Formation) deposits are characteristic for *Trinacria ventriculosa* and *Hemiaulus proteus* Zones, benthic foraminifera are correlated with *Cibicidoides lectus* (Vasilenko) assemblage, radiolaria of *Petalospyris foveolata* Zone, of late Paleocene.

E-1 U.A. Zone

From Kanevsky Group (Sheptykhovskaya Formation) there were described a dinoflagellates of *Deflandrea phosphoritica* and *Kisselovia reticulata* Zones, planktic foraminifera of *Globorotalia marginodentata* and *Globorotalia aragonensis* Zones, nannoplankton of the Zones N11-13, diatoms of *Trinacria ventriculosa* and *Hemiaulus proteus* Zones, early Eocene, Ypresian.

E-2 to E-4 U.A. Zones

The sediments of Kievsky Group, Fedorovskaya Formation (lower member-Sergeevskaya and upper member-Tishkinskaya formations) are characterized by the presence of benthic foraminifera of *Pseudoclavulina subbotinae-Uvigerina spinocostata-Bolivina cookei* regional zones (Radionova *et al.* 1994) and planctic foraminifera belonging to *Acarinina rotundimarginata-H. alabamensis* Zones. Nannoplankton is represented by assemblage of *Nannotetrina fulgens* (or *Discoaster bifax*, lower subZone) Zone (local geological service, unpubl. data) or *Nannotetrina quadrata* and *Reticulofenestra umbilica* Zones (Khokhlova *et al.* 1999), diatoms from *B. oamaruensis* Zone and upper part of *Pyxilla oligocaenica* Zone (Glezer 1979a; Glezer *et al.* 1997). Our radiolarian data were correlated with ODP/DSDP data (Bjørklund 1976; Goll 1989; Hull 1996) and it appeared that the middle Eocene, Lutetian-Bartonian assemblages of *Calocyclas talwanii* and *Lophocorys norvegiensis* Zones of Norwegian-Greenland basin are estimated more that 50% of common species with those from U.A. Zones E-2 to E-4. A high similarity was observed between our assemblages and the zonal ones of *Heliodiscus quadratus* and *Cyrtophormis alta* Zones of Kozlova (1999). Khokhlova *et al.* (1999) reported this radiolarian assemblages co-occurring with diatoms of the *Brightwellia imperfecta* Zone, middle Eocene (Fenner 1984).

E-5 TO E-6 U.A. ZONES

The deposits of Kharkovsky Group (the top of Tishkinskaya and the bottom of Kasianovskaya formations) contain dinoflagellates of *Kisselovia clathrata* subsp. *angulosa* Zone and radiolarians from *Theocyrtis andriashevi* Zone (Kozlova 1999). The latter was calibrated to upper part of *Paralia oamaruensis* Zone (diatoms), *Corbisema apiculata* Zone (silicoflagellates) and *Chiasmolithus oamaruensis* Zone (nannofossils), late Eocene (Priabonian) (Khokhlova *et al.* 1999).

CONCLUSIONS

We studied the radiolarian fauna from five sections (four sections have been used for BIOGRAPH program) of Paleogene deposits located in the territories of Russia and Ukraine. 119 taxa were determined. Each description is accompanied by images made in transmitted light microscope and SEM. The systematic section of this article contains an important information about the synonymy of radiolarian species observed in Paleogene deposits of the Voronesh Anticline, Western Siberia, North Caspian Sea lowland, Turkmenistan, etc.

The absence in studied deposits of some of the index-species proposed for the biozonation of the North Caspian Sea lowland, Western Turkmenia and Northern Aral Sea territories stratotypes and some other major problems in correlation (described in text) did not allow to apply subdivisions introduced by Lipman (1973, 1993), and Kozlova (1993, 1999). As a solution we proposed to use a quantitative deterministic approach (the Unitary Associations method) for the establishment of late Paleocene(?)-Eocene radiolarian biochronology of the region. Eighteen Unitary Associations (U.A.) are determined from (?)late Paleocene to latest Eocene deposits of the Voronesh Anticline territory. The U.A. were grouped into seven U.A. Zones.

The most ancient radiolarian assemblages (U.A. Zones PE-1 and E-1) with *Pterocodon ampla*, *Dictyoprora urceolus*, *Amphicraspedium praemurrayanum*, etc., can be correlated with latest Paleocene-early Eocene radiolarian assemblages of *Becoma bidartensis-Phormocyrtis striata striata* Zones of tropics (Sanfilippo *et al.* 1985). It has many common species with zonal assemblages of *P. aphorma-H. inca* Zones of Kozlova (1999), proposed for North Caspian Sea lowland biostratigraphy and than traced in the Don River basin.

Middle Eocene radiolarian assemblages of the U.A. Zones E-2, E-3 and E-4 are correlated to *L. norvegiensis-C. talwanii* zonal ones. The co-occurrence of the boreal and tropical index/key-species as *L. norvegiensis-C. talwanii* and *P. lex-T. anaclasta* in assemblages of aforementioned U.A. Zones allow a direct correlation of the zonal scales from a different geographic domain. Thus it becomes possible to calibrate the radiolarian assemblages of *L. norvegiensis* and *C. talwanii* Zones from the Norwegian-Greenland basins to those of *T. cryptocephala-T. triacantha* Zones from tropics.

The U.A. zonal assemblages (E-2 to E-4) have many species in common with zonal ones of *H. quadratus-E. polysiphonia* Zones established by Kozlova (1999) for the North Caspian Sea lowland territory and those traced in the Don River basin. The time-interval spanning by latter zones was attributed to Lutetian-Bartonian (Khokhlova *et al.* 1999).

The late Eocene (U.A. Zones E-5 and E-6) assemblages were correlated with those characteristic for *T. andriashevi* Zone of Kozlova (1999). These Zones were tied to the standard stages (Priabonian) by means of diatoms, foraminifera, nannoplankton, silicoflagellates and dinoflagellates, co-occurring with radiolarians in the same sections (Khokhlova *et al.* 1999).

SYSTEMATICS

The species names are given in the alphabetical order to facilitate a search. The collection is stored in the Department of Earth Sciences of the University of Lausanne.

Genus *Actinommura* Haeckel, 1887

Actinommura sp. B (Fig. 15F, G)

Actinommura sp. B – Petrushevskaya & Kozlova 1972: 519, pl. 9, fig. 14.

GEOGRAPHIC DISTRIBUTION. — Atlantic Ocean, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Eocene (Petrushevskaya & Kozlova 1972); middle to late Eocene (this study).

Genus *Amphymenium* Haeckel, 1881

Amphymenium splendiarmatum Clark & Campbell, 1942 (Fig. 7M)

Amphymenium splendiarmatum Clark & Campbell, 1942: 46, pl. 1, figs 12, 14. — Sanfilippo & Riedel 1973: 524, pl. 11, figs 6-8; pl. 28, figs 6, 8. — Westberg-Smith & Riedel 1984: 14, pl. 6, fig. 17. — Nishimura 1987: 719, pl. 1, fig. 20.

Spongurus crispus Borisenko, 1960: 227, pl. II, fig. 3a, b.

GEOGRAPHIC DISTRIBUTION. — California, North Atlantic, Western Ukraine, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Paleocene to latest middle Eocene (Clark & Campbell 1942; Blueford & White 1984; Blueford 1988; Westberg-Smith & Riedel 1984; Nishimura 1987; this study).

Genus *Amphicraspedium* Haeckel, 1881

Amphicraspedium praemurrayanum Kozlova, 1999 (Fig. 10L, M)

Amphicraspedium praemurrayanum Kozlova, 1999: 99, pl. 22, figs 8, 14; pl. 42, fig. 9.

Amphicraspedium murrayanum – Sanfilippo & Riedel 1973: 524, pl. 10, figs 3-6, pl. 28, fig. 1. — Kozlova 1984: pl. X, fig. 10. — Nishimura 1987: 719, pl. 1, figs 14, 18. — Blueford & Amon 1993: 74, pl. 1, figs 7, 9; pl. 2, figs 2, 3, 5, 7; pl. 3, figs 1, 5, 6; pl. 6, figs 4, 9.

Amphicarydiscus ovoides Lipman, 1972: 51, fig. 15, pl. 10, figs 1, 2.

Amphicarydiscus fusoideus Lipman, 1972: 53, pl. 10, figs 3, 4.

Amphicarydiscus tshelkarensis Lipman, 1972: 54, pl. 10, figs 5, 6.

Amphibrachium mugodsharicum Gorbunov, 1979: 132, pl. 8, fig. 1a-b.

GEOGRAPHIC DISTRIBUTION. — Atlantic Ocean, a territory to the north of Aral Sea, Russian Platform, southern part.

STRATIGRAPHIC RANGE. — Paleocene-early Eocene (Riedel & Sanfilippo 1973; Nishimura 1987; Kozlova 1999). Middle Eocene (Lipman 1972); (?)Late Paleocene-Early Eocene (this study).

REMARKS

The images of the species mentioned below are very much similar, to our point of view they are synonyms.

Amphicraspedium murrayanum (Haeckel, 1879)

Amphymenium murrayanum Haeckel, 1879: MS et atlas, pl. XLIV, fig. 10.

Amphicraspedium murrayanum – Haeckel 1887: 523, pl. 44, fig. 10.

GEOGRAPHIC DISTRIBUTION. — Atlantic Ocean, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Late Eocene-Quaternary. Middle-Late Eocene (this study).

Genus *Amphisphaera* Haeckel, 1881

Amphisphaera gonioxyphos (Clark & Campbell, 1942) (Fig. 16A, F)

Stylosphaera gonioxyphos Clark & Campbell, 1942: 30, pl. 5, fig. 28.

Amphistylus ensiger Kozlova & Gorbovets, 1966: 55, pl. VIII, fig. 3.

GEOGRAPHIC DISTRIBUTION. — California, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Middle to latest middle Eocene (Clark & Campbell 1942; Blueford & White 1984; Blueford 1988); middle Eocene (this study).

Amphisphaera megaxyphos megaxyphos (Clark & Campbell, 1942) (Fig. 14O)

Stylosphaera megaxyphos megaxyphos Clark & Campbell, 1942: 25, pl. 6, fig. 6.

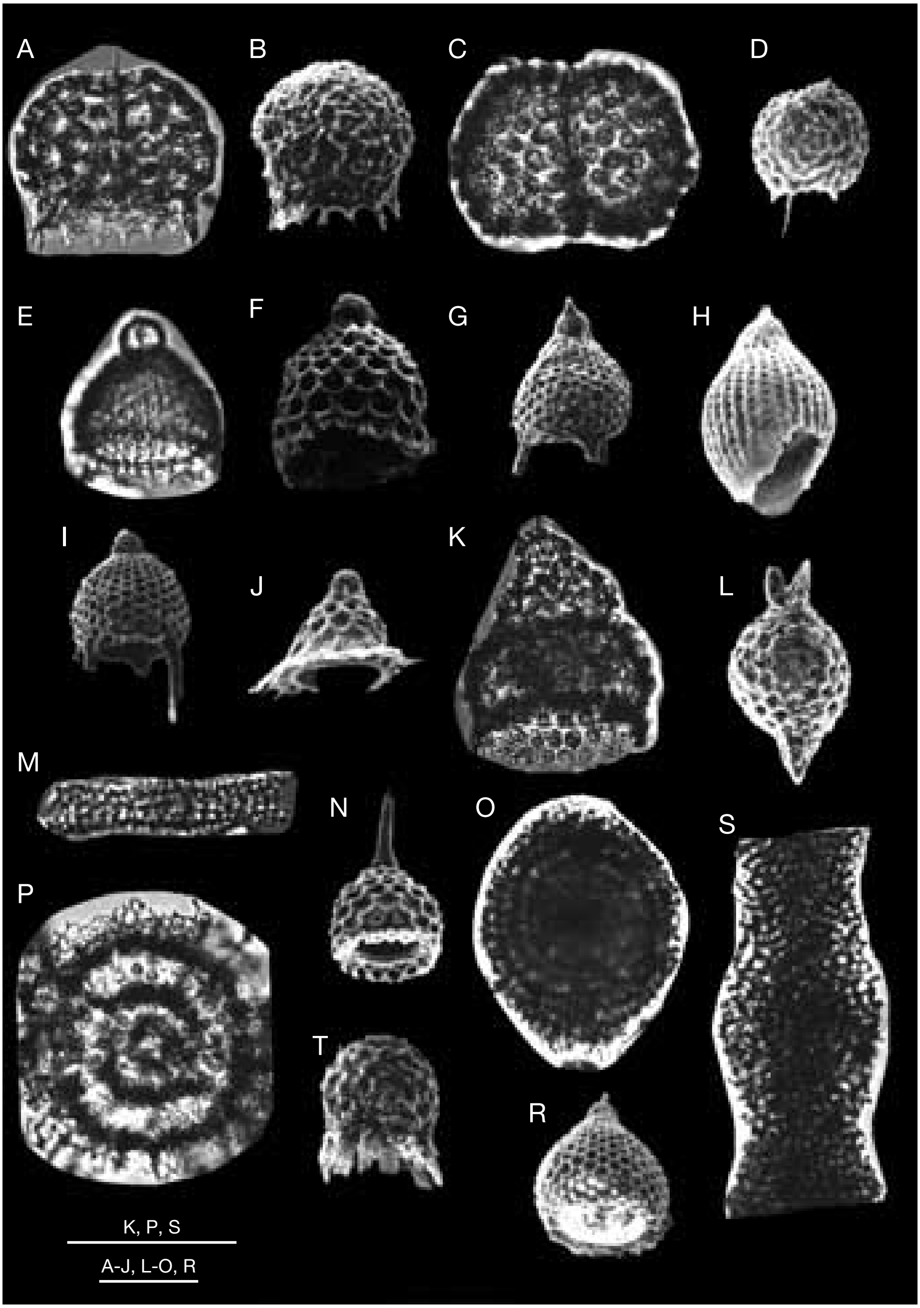


FIG. 7. — Early Eocene Radiolarian association, Petropavlovka Village, well 730, interval 44,3 m; **A**, **B**, *Petalospyris* sp. aff. *argiscus* Ehrenberg, 1875; **C**, **D**, *Petalospyris* (?) sp.; **E**, **F**, *Pterocodon ampla* (Brandt, 1936); **G**, *Lychnocanoma bellum longipes* (Kozlova, 1966); **H**, *Podocyrtis* cf. *papalis* Ehrenberg, 1875; **I**, *Lychnocanoma* sp. aff. *bandyca* Mato & Theyer, 1980; **J**, *Cycladophora* cf. *Pterocorys bicornis* Popofsky, 1908; **K**, *Lithostrobus picus* (Ehrenberg, 1875); **L**, *Amphisphaera megaxyphos trixyphos* (Clark & Campbell, 1942); **M**, *Amphymenium splendiarmatum* Clark & Campbell, 1942; **N**, *Clathrocyclas* ex. gr. *universa* Clark & Campbell, 1942; **O**, *Prunopyle* sp. aff. *ovata* Kozlova, 1966; **P**, *Plectodiscus circularis* (Clark & Campbell, 1942); **Q**, *Petalospyris argiscus* Ehrenberg, 1875; **R**, *Anthocyrtidium* sp. aff. *pupa* Clark & Campbell, 1942; **S**, *Ommatogramma biconstrictus* (Lipman, 1953). Scale bars: 100 µm.

GEOGRAPHIC DISTRIBUTION. — California, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Middle to latest middle Eocene (Clark & Campbell 1942; Blueford & White 1984; Blueford 1988); middle-early late Eocene (this study).

Amphisphaera megaxyphos trixyphos (Clark & Campbell, 1942) (Fig. 7L)

Stylosphaera megaxyphos trixyphos Clark & Campbell, 1942: 25, pl. 5, fig. 9.

GEOGRAPHIC DISTRIBUTION. — California, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Middle to latest middle Eocene (Clark & Campbell 1942; Blueford & White 1984; Blueford 1988); (?)late Paleocene-early Eocene (this study).

Amphisphaera megaxyphos tetraxyphos (Clark & Campbell, 1942) (Fig. 16D)

Stylosphaera megaxyphos tetraxyphos Clark & Campbell, 1942: 26, pl. 6, figs 1, 8.

Anomalocantha (?) sp. – Kozlova, 1999: pl. 29, fig. 6.

GEOGRAPHIC DISTRIBUTION. — California, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Latest middle Eocene (Clark & Campbell 1942; Blueford & White 1984; Blueford 1988); middle Eocene (Kozlova 1990; 1999; this study).

Amphisphaera minor minor (Clark & Campbell, 1942)

Stylosphaera minor minor Clark & Campbell, 1942: 27, pl. 5, figs 1, 2, 2a. — Clark & Campbell 1945: 11, pl. 1, figs 13, 14. — Blueford 1988: 247, pl. 4, figs 4-6. — Kozlova 1999: 175, pl. 38, fig. 3.

Actinommura (?) sp. aff. *S. minor* – Petrushevskaya & Kozlova 1972: 519, pl. 9, fig. 15.

Amphisphaera minor Sanfilippo & Riedel, 1973: 486, pl. 1, figs 1-5; pl. 22, fig. 4. — Chen 1975: 452, pl. 3, fig. 1. — Nishimura 1987: 719, pl. 1, fig. 5.

GEOGRAPHIC DISTRIBUTION. — Atlantic Ocean, California, Volga River middle reaches, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Early Eocene to late Miocene (Clark & Campbell 1942; Clark & Campbell 1945; Blueford & White 1984; Nishimura 1987; Blueford 1988); late Paleocene (Kozlova 1999); early-middle Eocene (this study).

Genus *Anthocyrtidium* Haeckel, 1881

Anthocyrtidium pupa Clark & Campbell, 1942 (Figs 11A, B; 13C, D)

Anthocyrtidium pupa Clark & Campbell, 1942: 74, pl. 7, figs 30-32.

Albatrossidium laguncularis – Kozlova 1999: 145, pl. 30, figs 10-12.

GEOGRAPHIC DISTRIBUTION. — California, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Middle to latest middle Eocene (Clark & Campbell 1942; Blueford & White 1984; Blueford 1988); middle Eocene (Kozlova 1999); middle to late Eocene (this study).

Genus *Axoprunum* Haeckel, 1887

Axoprunum visendum (Kozlova, 1966) (Fig. 11H)

Xiphatractus visendum Kozlova *in* Kozlova & Gorbovets, 1966: tabl. X, figs 1, 2.

Axoprunum visendum – Kozlova 1984: pl. X, fig. 4; 1990: pl. XI, figs 6, 8.

GEOGRAPHIC DISTRIBUTION. — Western Siberia, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Early-middle Eocene (Kozlova 1984, 1990); middle to late Eocene (this study).

Genus *Botryostrobus* Haeckel, 1887

Botryostrobus (?) sp. (Fig. 16U)

Botryostrobus (?) sp. – Petrushevskaya 1981: 127, fig. 360.

GEOGRAPHIC DISTRIBUTION. — Voronesh Anticline.

STRATIGRAPHIC RANGE. — Early middle Eocene (this study).

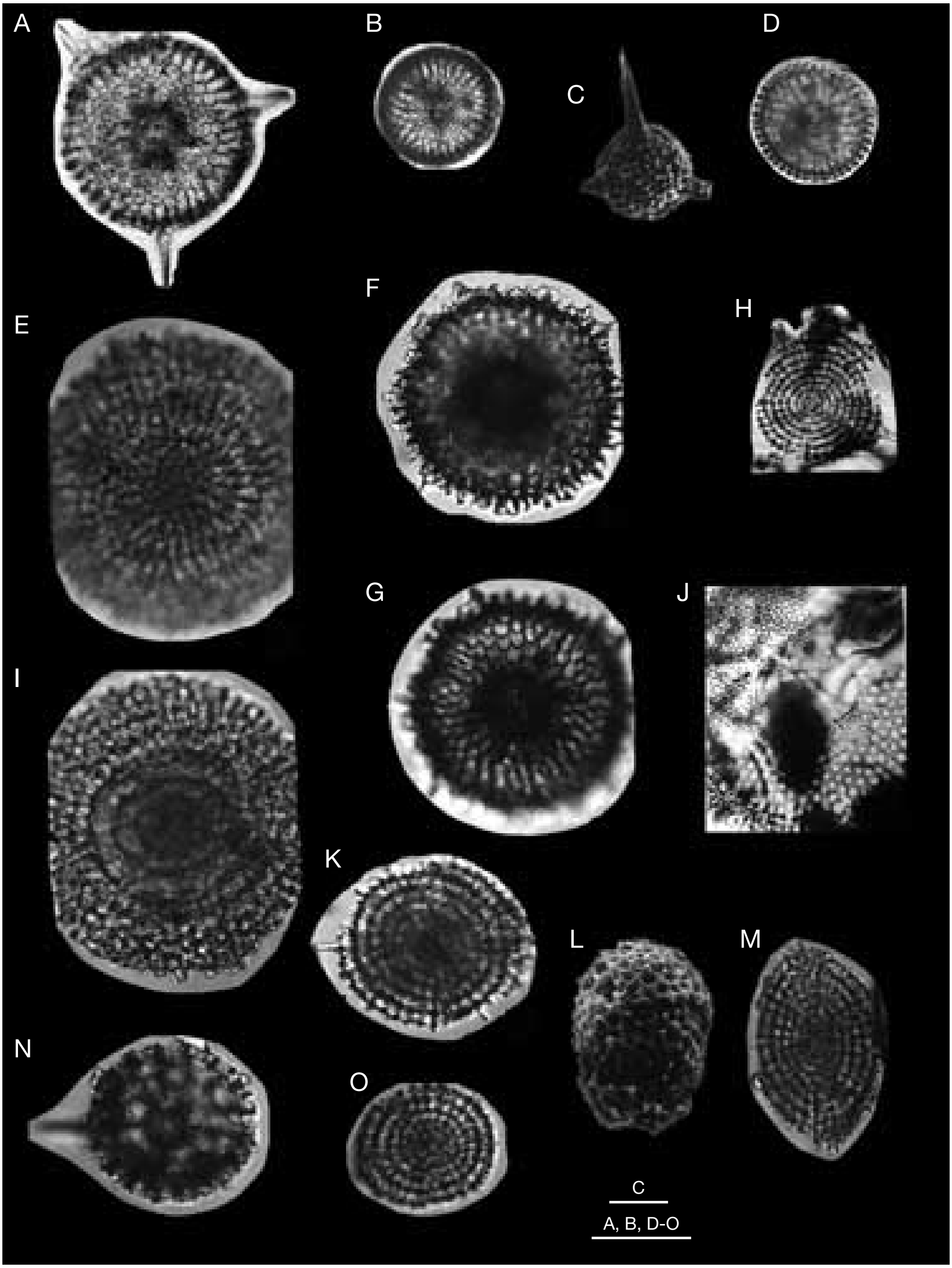


FIG. 8. — Early Eocene (**3**, **5**-**7**, **9**, **11**-**15**) and middle-late Eocene (**1**, **2**, **4**, **8**) Radiolarian association, Petropavlovka Village, Well 730, interval 44.3 m; **A**, *Triactis triactis* (Ehrenberg, 1873); **B**, **D**, *Thecosphaera rotunda* Borisenko, 1960; **C**, *Heterosestrum formosum trispinum* (Tochilina, 1972) emend.; **E**, **I**, *Lithocyclia* sp.; **F**, **G**, *Periphaena heliasteriscus* (Clark & Campbell, 1942); **H**, *Stylodictya targaeformis* (Clark & Campbell, 1942); **J**, *Velicucullus* sp. aff. *oddgurneri* Bjørklund, 1976; **K**, **O**(?), *Spiromultitunica* sp. aff. *Prunopyle hayesi* Chen, 1975; **L**, **M**, *Spongoprunum* (?) *probus* (Rüst, 1888); **N**, *Hexacontium* (?) sp. Scale bars: 100 μm.

Genus *Callimitra* Haeckel, 1887

Callimitra clavipes (Clark & Campbell, 1945) (Fig. 11E)

Tripilidium clavipes Clark & Campbell, 1945: 34, pl. 7, fig. 30. — Blueford & White 1984: pl. 2, fig. 10. — Blueford 1988: 244, pl. 1, figs 7-9.

Tripodiscinus clavipes – Petrushevskaya & Kozlova 1979: 117, fig. 302.

GEOGRAPHIC DISTRIBUTION. — California, Atlantic Ocean, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Middle Eocene (Clark & Campbell 1945; Blueford & White 1984; Blueford 1988); middle to late Eocene (this study).

Callimitra sp. aff. ***Tripilidium clavipes*** Clark & Campbell, 1945 (Fig. 16R)

Tripodiscinus sp. aff. *Tripilidium clavipes* – Kozlova 1999: pl. 44, fig. 8.

GEOGRAPHIC DISTRIBUTION. — Western Siberia, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Eocene (Kozlova 1999); middle to late Eocene (this study).

Callimitra cf. ***atavia*** Goll, 1979 (Fig. 16V)

Callimitra atavia Goll, 1979: 388, pl. 5, figs 1, 5-9, 11.

GEOGRAPHIC DISTRIBUTION. — Equatorial Pacific (Site 77), Voronesh Anticline.

STRATIGRAPHIC RANGE. — Early Miocene (Goll 1979); middle to late Eocene (this study).

Genus *Calocyclas* Ehrenberg, 1847

Calocyclas sp. aff. ***barbadensis*** Ehrenberg, 1875 (Fig. 16J)

Calocyclas barbadensis Ehrenberg, 1875: pl. XVIII, fig. 8.

GEOGRAPHIC DISTRIBUTION. — Voronesh Anticline.

STRATIGRAPHIC RANGE. — (?)Late Paleocene-early Eocene (this study).

Calocyclas extensa contracta Clark & Campbell, 1942 (Fig. 14K)

Calocyclas extensa contracta Clark & Campbell, 1942: 85, pl. 8, figs 15, 16.

GEOGRAPHIC DISTRIBUTION. — California, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Middle to latest middle Eocene (Clark & Campbell 1942; Blueford & White 1984; Blueford 1988); early to middle Eocene (this study).

Calocyclas talwanii Bjørklund & Kellogg, 1972 (Fig. 13B, O)

Calocyclas talwanii Bjørklund & Kellogg, 1972: 387, pl. 1, figs 1, 6. — Bjørklund 1976: 1124, pl. 21, figs 1-3. — Hull 1996: 137, pl. 4, figs 11, 16.

Clathrocyclas talwanii – Petrushevskaya & Kozlova *in* Dzionoridze *et al.* 1978: pl. 27, figs 1, 2; pl. 34, figs 8-10. — Petrushevskaya & Kozlova 1979: 133, figs 502, 503. — Kozlova 1990: pl. XII, fig. 5. — Kozlova 1999: pl. 44, figs 1, 2.

GEOGRAPHIC DISTRIBUTION. — Norwegian-Greenland-Barents seas, North Caspian Sea lowland, Russian Platform (Voronesh Anticline, Obshii Syrt).

STRATIGRAPHIC RANGE. — Middle Eocene-(?)early Miocene (Bjørklund 1976; Hull 1996; Eidvin *et al.* 1998; Kozlova 1999); middle to late Eocene (this study).

Calocyclas undella (Clark & Campbell, 1942) (Fig. 16Q)

Clathrocyclas universa undella Clark & Campbell, 1942: 87, pl. 7, figs 8-10, 21, 25.

GEOGRAPHIC DISTRIBUTION. — California, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Middle to latest middle Eocene (Clark & Campbell 1942; Blueford & White 1984; Blueford 1988); middle to late Eocene (this study).

Genus *Calocycletta* Haeckel, 1887

Calocycletta sp. aff. ***virginis*** Haeckel, 1887 (Fig. 13E, I, L)

Calocyclas virginis Haeckel, 1887: 1381, pl. 74, fig. 4.

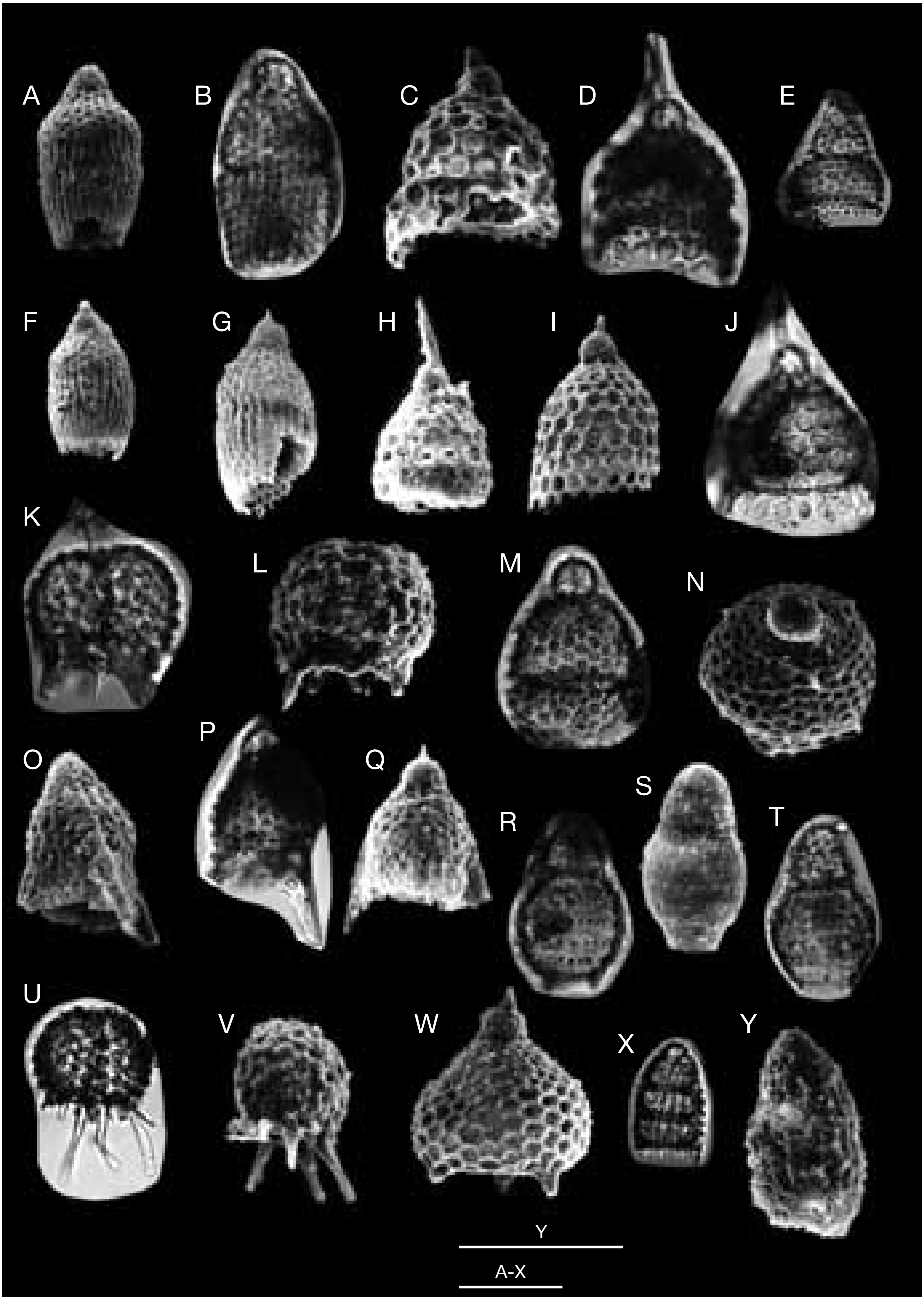


FIG. 9. — Early Eocene Radiolarian association, Petropavlovka Village, Well 730-C, interval 44.3 m; **A**, **B**, **F**, **G**, *Phormocyrtis* sp. aff. *proxima* Clark & Campbell, 1942; **C**, **D**, *Pterocodon ampla longispina* (Clark & Campbell, 1942) n. comb.; **E**, *Lithostrobus picus* (Ehrenberg, 1875); **H**, *Pterocodon* ex. gr. *ampla* (Brandt, 1936); **I**, **J**, *Pterocodon ampla* (Brandt, 1936); **K**, **L**(?), *Petalospyris tumidula* Kozlova, 1966; **M**, **N**, *Phormocyrtis* sp.; **O**, **P**, *Rhopalocanium pyramis* (Haeckel, 1887); **Q**, *Rhopalocanium satelles* (Kozlova, 1966); **R**-**T**, *Dictyoprora urceolus* Haeckel, 1887; **U**, **V**, *Petalospyris* sp. aff. *septenaria* Kozlova, 1966; **W**, *Lychnocanoma* cf. *bellum* Clark & Campbell; **X**, **Y**, *Mita* cf. *regina* (Campbell & Clark, 1944). Scale bars: 100 µm.

Albatrossidium laguncularis – Kozlova 1999: 145, pl. 30, figs 10-12; pl. 46, fig. 6.

GEOGRAPHIC DISTRIBUTION. — Turkmenia, Kazakhstan, north Caspian Sea lowland, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Upper Eocene (Kozlova 1999); middle Eocene (this study).

REMARKS

The second segment is longer and the size of the shell is bigger than that of *C. virginis* typ., the same differences have been observed between the *C.* sp. aff. *virginis* and two species described by Moksyakova (1961): *S. laguncularis* (p. 240, pl. 1, fig. 12) and *T. trimembris* (p. 244, pl. 1, fig. 18).

Genus *Carposphaera* Haeckel, 1887

Carposphaera globosa Clark & Campbell, 1945
(Fig. 16E)

Carposphaera globosa Clark & Campbell, 1945: 9, pl. 1, figs 6-8.

GEOGRAPHIC DISTRIBUTION. — California, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Middle to latest middle Eocene (Clark & Campbell 1945; Blueford & White 1984; Blueford 1988); middle Eocene (this study).

Genus *Ceratocyrtis* Bütschli, 1882

Ceratocyrtis sp. aff. ***Helotholus amplus***
Popofsky, 1908
(Fig. 15J, K)

(?) *Helotholus amplus* Popofsky, 1908: 283, pl. 34, fig. 3. — Petrushevskaya 1975: 590, pl. 11, figs 3-6, 13; pl. 19, fig. 2; pl. 44, fig. 4; 1986: pl. 1, figs 2, 4.

GEOGRAPHIC DISTRIBUTION. — Of *H. amplus*: Circum-Antarctic regions; of *Ceratocyrtis* sp. aff. *H. amplus*: Voronesh Anticline.

STRATIGRAPHIC RANGE. — Of *H. amplus*: middle to late Eocene (Petrushevskaya 1975); of *Ceratocyrtis* sp. aff. *H. amplus*: middle to late Eocene (this study).

Ceratocyrtis charlestonensis
(Clark & Campbell, 1945)
(Figs 12A; 14T)

Lithomelissa charlestonensis Clark & Campbell, 1945: 37, pl. 7, figs 45, 46.

Pseudodictyophimus sp. C – Hull 1996: 140, pl. 7, figs 7, 10.

Pseudodictyophimus charlestonensis – Kozlova 1999: 117, pl. 28, fig. 10; pl. 30, fig. 4; pl. 44, figs 10, 13.

GEOGRAPHIC DISTRIBUTION. — California, Norwegian-Greenland Sea, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Middle Eocene (Clark & Campbell 1945; Blueford & White 1984; Blueford 1988); late early Oligocene (Hull 1996); middle Eocene (Kozlova 1999); early to middle Eocene (this study).

Ceratocyrtis stigi (Bjørklund, 1976)
(Fig. 14N, Q)

Lithomelissa stigi Bjørklund, 1976: 1125, pl. 15, figs 12-17.

Lithomelissa sp. C – Chen 1975: 458, pl. 11, figs 3(?), 4.

Ceratocyrtis stigi – Nigrini & Lombari 1984: 13, pl. 15, fig. 7. — Abelman 1990: 694, pl. 4, fig. 12. — Hull 1996: 138, pl. 5, figs 1, 2.

GEOGRAPHIC DISTRIBUTION. — Norwegian-Greenland Sea, Antarctic, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Eocene-Oligocene (Bjørklund 1976; Petrushevskaya & Kozlova 1979; Hull 1996); early to late Eocene (this study).

Ceratocyrtis sp. aff. ***stigi*** (Bjørklund, 1976)
(Fig. 12B, E, F)

Pseudodictyophimus charlestonensis – Kozlova 1999: 117, pl. 30, fig. 4.

GEOGRAPHIC DISTRIBUTION. — Voronesh Anticline.

STRATIGRAPHIC RANGE. — Middle Eocene (Kozlova 1999); middle to late Eocene (this study).

Ceratocyrtis rhabdophora rhabdophora
(Clark & Campbell, 1945)
(Fig. 16T)

Bathrocalpis rhabdophora rhabdophora Clark & Campbell, 1945: 34, 35, pl. 7, figs 38-41.

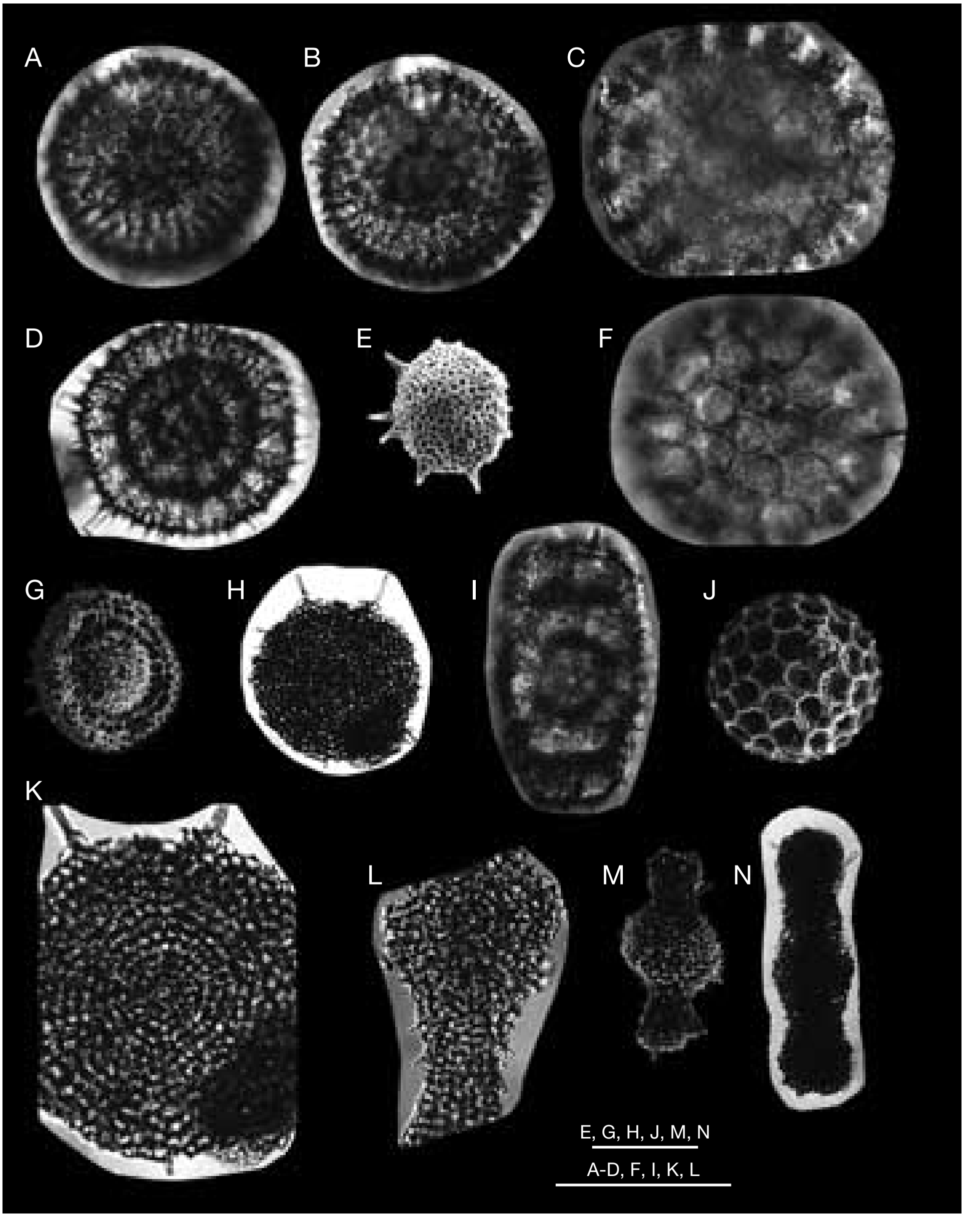


FIG. 10. — Early Eocene Radiolarian association, Petropavlovka Village, Well 730, interval 44.3 m; **A**, **B**, *Periphaena perplexus* (Clark & Campbell, 1942); **C**, **F**, **J**, *Haliomma* (?) *faceta* (Krasheninnikov, 1960); **D**, **G**, *Heterosestrum formosum* (Tochilina, 1970); **E**, *Periphaena* sp. aff. *Heliodiscus inca* (Clark & Campbell, 1942); **H**, **K**, *Stylotrochus festivus* Clark & Campbell, 1942; **I**, *Heterosestrum* (?) sp.; **L**, **M**, *Amphicraspedium praemurrayanum* Kozlova, 1999; **N**, *Ommatogramma biconstrictus* (Lipman, 1953). Scale bars: 100 µm.

GEOGRAPHIC DISTRIBUTION. — California, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Middle to latest middle Eocene (Clark & Campbell 1945; Blueford & White 1984; Blueford 1988); early-middle Eocene (Kozlova 1999); middle to late Eocene (this study).

Genus *Clathrocyclas* Haeckel, 1881

Clathrocyclas ex. gr. ***universa*** Clark & Campbell, 1942 (Fig. 7N)

Clathrocyclas universa Clark & Campbell, 1942: 86, pl. 7, figs 11, 14, 20 (not 19). — Chen 1975: 459, pl. 1, figs 2, 3. — Blueford 1988: 244, 246, pl. 2, figs 1-3. — Takemura 1992: 745, pl. 7, fig. 11.

Anthocyrtella sp. – Kozlova 1999: pl. 18, fig. 3.

GEOGRAPHIC DISTRIBUTION. — California, Antarctic, southern Indian Ocean, Western Siberia, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Late middle Eocene (Clark & Campbell 1942; Blueford & White 1984; Blueford 1988); Eocene (upper Eocene?) (Chen 1975); Eocene (Takemura 1992); early Eocene (Kozlova 1999); (?)late Paleocene-early Eocene (this study).

Genus *Clathrospyris* Goll, 1980

Clathrospyris sandellae Goll, 1980 (Fig. 11D)

Clathrospyris sandellae Goll *in* Goll & Bjørklund 1980: 360, 361, pl. 2, figs 11-18, pl. 3, figs 1-11.

Liriospyris fenestra – Kozlova 1999: 165, pl. 31, figs 23, 24.

GEOGRAPHIC DISTRIBUTION. — Norwegian-Greenland Sea, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Middle Miocene (Goll & Bjørklund 1980); late middle Eocene (Kozlova 1999); middle to late Eocene (this study).

REMARKS

It is not clear if *C. sandellae* is a synonym of *L. fenestra*, as in Ehrenberg monograph one can see only the saggital view of a specimen.

Genus *Conoactinomma* Gorbunov, 1979

Conoactinomma sp. aff. ***Conosphaera stilloformis*** Lipman, 1960 (Fig. 16H, I)

Conosphaera stilloformis Lipman *in* Lipman *et al.*, 1960: 76, pl. X, fig. 9; pl. XIII, fig. 7.

GEOGRAPHIC DISTRIBUTION. — Voronesh Anticline.

STRATIGRAPHIC RANGE. — Middle to late Eocene (this study).

REMARKS

This species is different from *C. stilloformis* in bearing 1.3 time more pores than the holotype.

Genus *Cycladophora* Ehrenberg, 1847

Cycladophora cf. ***Pterocorys bicornis*** Popofsky, 1908 (Fig. 17J)

Pterocorys bicornis Popofsky, 1908: 228, 229, pl. XXXIV, figs 7, 8.

Theocalyptra bicornis – Riedel 1958: 240, pl. 4, fig. 4. — Chen 1975: 462, pl. 13, figs 1, 2.

Theocalyptra (?) *bicornis* – Petrushevskaya 1967: 124-127, fig. 71, II-IX; fig. 72, I-IV.

Clathrocyclas bicornis – Petrushevskaya & Kozlova 1972: 540, figs 11, 12.

Cycladophora bicornis bicornis Lombari & Lazarus, 1988: 106, pl. 5, figs 9-12.

Cycladophora bicornis Takemura, 1992: 745, pl. 2, fig. 15.

GEOGRAPHIC DISTRIBUTION. — Cosmopolite species.

STRATIGRAPHIC RANGE. — Paleogene-Quaternary (Lombari & Lazarus 1988); middle Eocene (this study).

Genus *Desmospyris* Haeckel, 1881

Desmospyris anthocyrtoides (Bütschli, 1882) (Fig. 14A)

(?) *Petalospyris anthocyrtoides* Bütschli, 1882b: taf. XXXII, fig. 19.

Dendrospyris anthocyrtoides – Goll 1968: 1469, pl. 17, figs 9, 11-14.

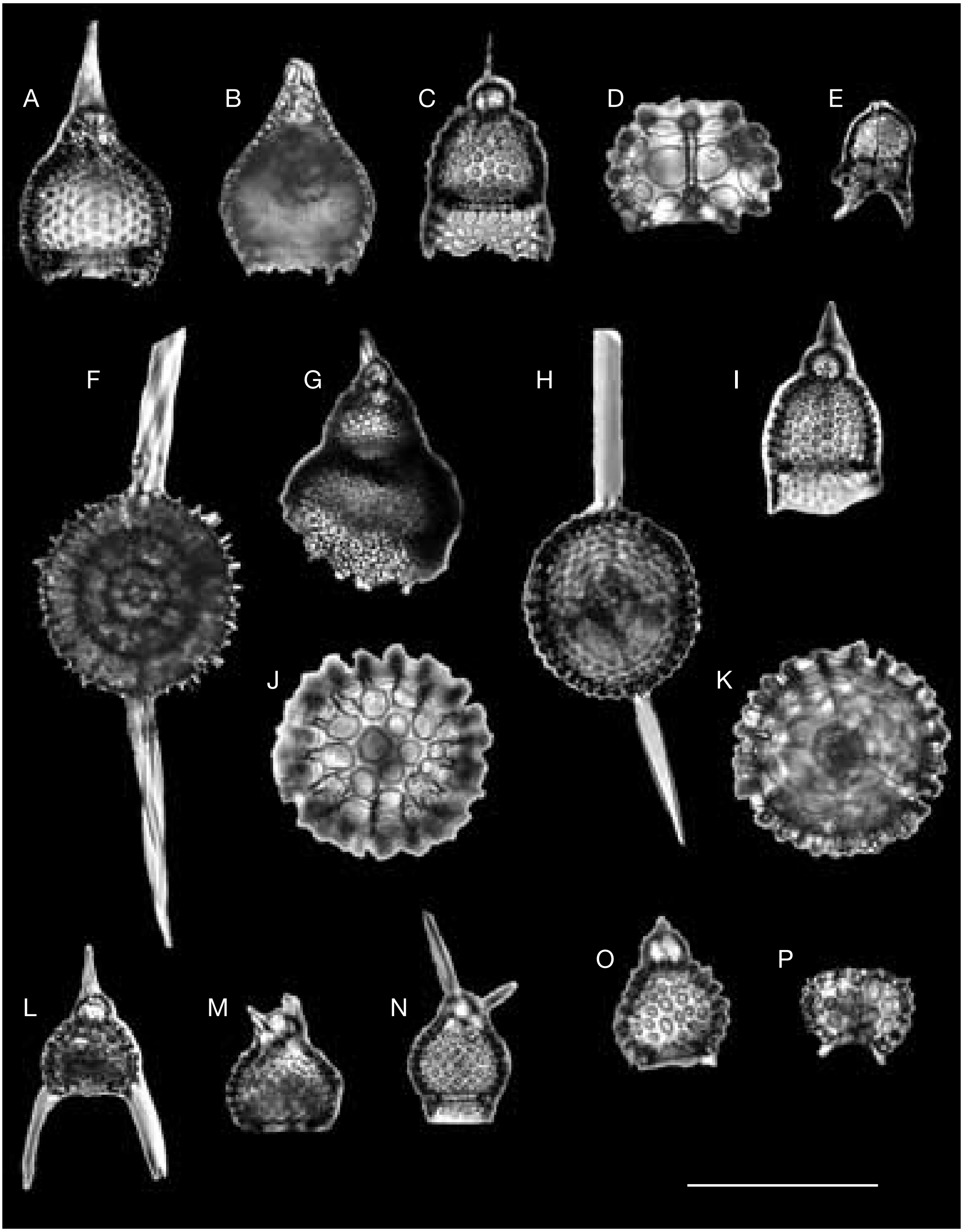


FIG. 11. — Middle-early late Eocene Radiolarian association, Pirogovo Village, Well 510C, 44.0 m; **A**, **B**, *Anthocyrtidium pupa* Clark & Campbell, 1942; **C**, *Lophocyrtis aspera* (Ehrenberg, 1873); **D**, *Clathrospyris sandellae* Goll, 1980; **E**, *Callimitra clavipes* (Clark & Campbell, 1945); **F**, *Heterosestrum formosum bispinum* (Tochilina, 1972) emend.; **G**, *Theocorys anaclasta* Riedel & Sanfilippo, 1970; **H**, *Axoprunum visendum* (Kozlova, 1966); **I**, *Lophocyrtis* ex. gr. *Calocyclas semipolita* Clark & Campbell, 1942; **J**, **K**, *Hexacontium* sp.; **L**, *Lychnocanium* sp. B; **M** *Lophocyrtis norvegiensis* (Bjørklund & Kellogg, 1972); **N**, *Lophocyrtis auriculaleporis* (Clark & Campbell, 1942); **O**, *Lychnocanium* sp. A; **P**, *Desmospyris* ex. gr. *anthocyrtoides* Bütschli, 1882. Scale bar: 100 µm.

Desmospyris anthocyrtoides – Petrushevskaya & Kozlova 1972: 532, fig. 4.

GEOGRAPHIC DISTRIBUTION. — Atlantic Ocean, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Oligocene, Atlantic Ocean (Petrushevskaya & Kozlova 1972); middle to late Eocene (this study).

Desmospyris ex. gr. ***anthocyrtoides*** Bütschli, 1882 (Figs 11P; 14B)

GEOGRAPHIC DISTRIBUTION. — Voronesh Anticline.

STRATIGRAPHIC RANGE. — Middle to late Eocene (this study).

Genus *Dictyoprora* Haeckel, 1881 *sensu* Nigrini 1977

Dictyoprora urceolus Haeckel, 1887 (Fig. 9R-T)

Dictyoprora urceolus Haeckel, 1887: 1305. — Nigrini 1977: 251, pl. 4, figs 9, 10. — Nishimura 1987: 725, pl. 2, figs 1, 2. — Kozlova 1999: 137, pl. 44, figs 22, 23.

Theocampe urceolus – Foreman 1973: 432, pl. 8, figs 14-17, pl. 9, figs 6, 7. — Chen 1975: 456, pl. 3, fig. 7.

GEOGRAPHIC DISTRIBUTION. — Western-North Atlantic, Antarctic, Russian Platform, Siberia.

STRATIGRAPHIC RANGE. — (Upper?) Eocene (Chen 1975); early Eocene (Nishimura 1987; Kozlova 1999); (?)late Paleocene-early Eocene (this study).

Genus *Dorylonchidium* Haeckel, 1887

Dorylonchidium fructiforme Clark & Campbell, 1942 (Fig. 16G)

Dorylonchidium fructiforme Clark & Campbell, 1942: 23, pl. 5, fig. 26.

GEOGRAPHIC DISTRIBUTION. — California, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Middle to late Eocene (Clark & Campbell 1942; Blueford & White 1984; this study).

Genus *Druppatractus* Haeckel, 1887

Druppatractus trichopterus Clark & Campbell, 1942 (Fig. 14L)

Druppatractus trichopterus Clark & Campbell, 1942: 34, pl. 5, fig. 4.

GEOGRAPHIC DISTRIBUTION. — California, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Early to late Eocene (Clark & Campbell 1942; Blueford & White 1984; this study).

Druppatractus polycentrus Clark & Campbell, 1942 (Fig. 17A)

Druppatractus polycentrus Clark & Campbell, 1942: 35, pl. 5, fig. 19.

GEOGRAPHIC DISTRIBUTION. — California, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Middle to late Eocene (Clark & Campbell 1942; Blueford & White 1984; Blueford 1988; this study).

Genus *Ellipsostylus* Haeckel, 1887

Elipsostylus anisoxyphos Clark & Campbell, 1942 (Fig. 17B)

Elipsostylus anisoxyphos Clark & Campbell, 1942: 32, pl. 5, figs 7, 11.

GEOGRAPHIC DISTRIBUTION. — California, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Middle to latest middle Eocene (Clark & Campbell 1942; Blueford & White 1984; Blueford 1988; this study).

Genus *Euscenarium* Haeckel, 1887 emend. Petrushevskaya 1981

(?) *Euscenarium* sp. (Fig. 17F)

GEOGRAPHIC DISTRIBUTION. — Voronesh Anticline.

STRATIGRAPHIC RANGE. — (?)Late Paleocene-early Eocene (this study).

FIG. 12. — Middle Eocene Radiolarian association, Pirogovo Village, Well 510C, interval 44.0 m (except 8: 730C, 44.3 m); **A**, *Ceratocyrtis charlestonensis* (Clark & Campbell, 1945); **B**, **E**, **F**, *Ceratocyrtis* sp. aff. *stigi* (Bjørklünd, 1976); **C**, *Lithomelissa spongiosa* Bütschli, 1882; **D**, **N**, *Giraffospyris didiceros* (Ehrenberg, 1875); **G**, *Patagospyris morkleyensis* (Clark & Campbell, 1942); **H**, **K**, *Giraffospyris* sp. aff. *didiceros* (Ehrenberg, 1875); **I**, **J**, *Petalospyris tumidula* Kozlova, 1966; **L**, **M**, *Peripyramis magnifica* (Clark & Campbell, 1942) *sensu* Kozlova 1999; **O**, *Heterosestrum formosum* (Tochilina, 1970), saggittal view. Scale bars: 50 µm.

Genus *Giraffospyris* Haeckel, 1881 emend. Goll 1969

Giraffospyris didiceros (Ehrenberg, 1875) (Fig. 12D, N)

Ceratospyris didiceros Ehrenberg, 1875: taf. XXI, fig. 6.

Aegospyris transitionalis – Kozlova & Gorbovets 1966: 94, tabl. XV, fig. 5a, b.

Giraffospyris didiceros ex. gr. – Riedel & Sanfilippo 1970: 550, pl. 5, figs 3-5.

Dorcadospyris confluens Nishimura, 1987: 725, pl. 3, figs 18, 19.

Triospyrium sp. ex. gr. *didiceros* – Kozlova 1999: 175, pl. 31, figs 21, 25.

GEOGRAPHIC DISTRIBUTION. — Western-North Atlantic, California, Western Siberia, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Middle to late Eocene (Ehrenberg 1875; Clark & Campbell 1945; Kozlova & Gorbovets 1966; Riedel & Sanfilippo 1970; Blueford & White 1984; Kozlova 1999; this study).

(?) *Giraffospyris* sp.

GEOGRAPHIC DISTRIBUTION. — Voronesh Anticline.

STRATIGRAPHIC RANGE. — Middle to late Eocene (this study).

REMARKS

The generic name is given with a "?" because of the abnormal position for *Giraffospyris* of its legs on the saggittal ring (Fig. 11).

Genus *Haliomma*

Haliomma (?) ***faceta*** (Krasheninnikov, 1960) (Fig. 10C, F, J)

Cenosphaera faceta Krasheninnikov, 1960: 274, pl. 1, fig. 4.

Haliomma (?) *faceta* – Kozlova 1999: 73, pl. 21, fig. 1, pl. 25, fig. 4, pl. 37, fig. 10.

GEOGRAPHIC DISTRIBUTION. — Russian Platform, Western Caucasus, Kazakhstan, Ousbekistan, North Caspian Sea lowland.

STRATIGRAPHIC RANGE. — Late early Eocene-early middle Eocene (Kozlova 1999); early Eocene (this study).

Genus *Heterosestrum* Campbell & Clark, 1945

Heterosestrum formosum (Tochilina, 1970) (Fig 10D, G; 12O)

Hexacyclia formosa Tochilina, 1970: 175, figs 2, 3; 1972, pl. 5, figs 1, 2, 5.

Heterosestrum formosum – Petrushevskaya & Kozlova 1979: 103, figs 441-445.

Amphicyclia pentaspina Tochilina, 1972: 136, pl. 4.

Stylodictya variabilis Bjørklund & Kellogg, 1972: 391, pl. 1, figs 5, 9a, b.

Staurocromyum densum – Gorbunov 1979: 94, pl. 1, fig. 4.

Stylodictya tschuenkoi – Gorbunov 1979: pl. 13, fig. 1a-g.

Heterosestrum sp. cf. *schabalkini* – Kozlova 1999: pl. 34, figs 3, 6.

Heterosestrum sp. cf. *tschujenkoi* – Kozlova 1999: 92, pl. 29, fig. 8.

GEOGRAPHIC DISTRIBUTION. — California, Norwegian Sea, Western Siberia, Russian Platform.

STRATIGRAPHIC RANGE. — Early-middle Eocene of Norwegian Sea, Plato Vøring (Bjørklund & Kellogg 1972; Petrushevskaya & Kozlova 1979); early-middle Eocene (this study).

REMARKS

The images and descriptions of all the species mentioned below are very much similar and to our point of view they represent a group of different local morphotypes of *Stylodictya sexispinata*. For that reason it is better not to join them together under the same specific name, but to use their original names, to indicate their different geographical domains:

Stylodictya sexispinata Clark & Campbell, 1942: 45, pl. 3, fig. 7.

Stylodictya schabalkini Lipman, 1949: 116, pl. 13, fig. 8.

Stylodictya magnifica Lipman, 1950: 60, pl. 1, fig. 13.

Distriacti (?) *hexagona* Lipman, 1953: 142, pl. VII, fig. 8.

Porodiscus turgaicus Lipman, 1953: 144, pl. VII, fig. 10.

Stylodictya tschujenkoi Lipman, 1953: 145, pl. VII, fig. 11.

Stylodictya zonata Lipman, 1953: 146, pl. 7, figs 8, 10-12. — Gorbunov 1979: pl. 6, fig. 1a-d.

Staurocromyum densum Kozlova *in* Kozlova & Gorbovets, 1966: 57, pl. VIII, figs 6, 7.

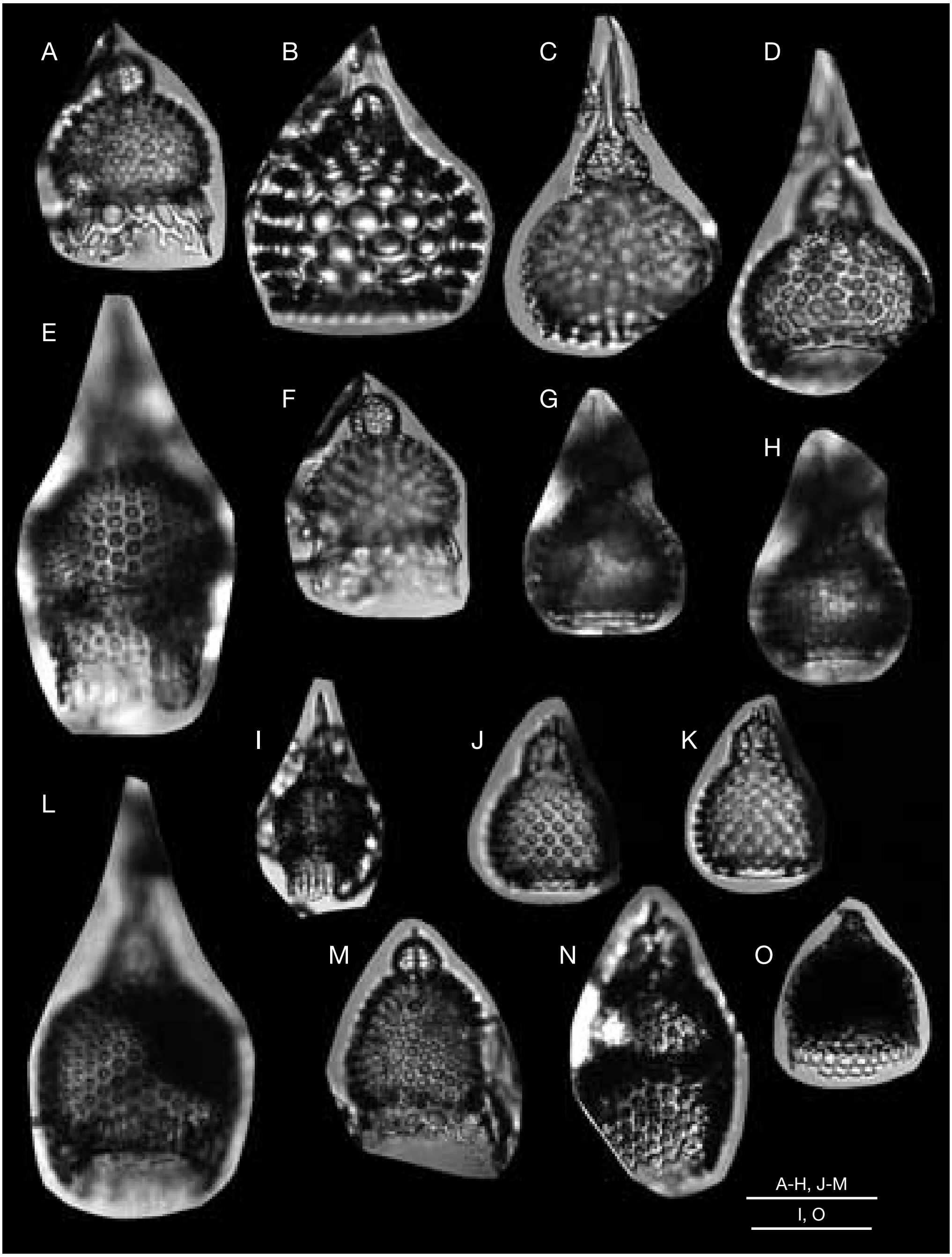


FIG. 13. — Middle Eocene Radiolarian association, Pirogovo Village, Well 510C, interval 44.0 m; **A**, **F**, *Lophocyrtis aspera* (Ehrenberg, 1873); **B**, **O**, *Calocyclas talwanii* Bjørklund & Kellogg, 1972; **C**, **D**, *Anthocyrtidium pupa* Clark & Campbell, 1942; **E**, **I**, **L**, *Calocycletta* sp. aff. *virginis* Haeckel, 1887; **G**, **H**, *Lophocyrtis norvegiensis* (Bjørklund & Kellogg, 1972); **J**, **K**, *Lophocyrtis auriculaleporis* (Clark & Campbell, 1942); **M**, *Lophocyrtis sinitzini* (Lipman, 1949) *sensu* Kozlova 1999; **N**, *Phormocyrtis* sp. aff. *proxima* Clark & Campbell, 1942. Scale bars: A-H, J-N, 100 mm; I, O, 50 µm.

Heterosestrum formosum bispinum
(Tochilina, 1972) emend.
(Fig. 11F)

Amphicyclia bispina Tochilina, 1972: 134, pl. 1.

Heterosestrum formosum – Kozlova 1999: pl. 34, fig. 1.

Heterosestrum sp. cf. *formosum* – Kozlova 1999: pl. 28, fig. 9.

Heterosestrum sp. aff. *tschujenkoi* – Kozlova 1999: pl. 41, fig. 2.

GEOGRAPHIC DISTRIBUTION. — Voronesh Anticline.

STRATIGRAPHIC RANGE. — Middle Eocene, Kievsky Group, Fedorovskaya Formation, Voronesh Anticline, Pirogovo Village, well 510C, 44.0 m depth.

REMARKS

The quantity of outershell spines and peripheral concentric inner shells (the double medullar shell's central part has a stable construction) are very changeable characteristics for *Heterosestrum formosum*. However, in the same sample it was observed abundant amount of specimens bearing only two (or only three to six) polar spines and three to five concentric inner shells. This phenomena can be explained by local environmental conditions of the siliceous microfauna existence. Because of that the latter gave the rise for a different morphotype better adjusted for special life conditions. In order to reflect this local (but very important for age determination) phenomena and to preserve the stratigraphical resolution of this group, we decided not to generalize its systematics, joining under the name *Heterosestrum formosum* all its possible morphotypes, but to introduce a group of subspecies, where the name of each morphotype was earlier (Tochilina 1972) described as a different species, because of a difference in quantity of the inner shells and outershell spines. The attribution of *Amphicyclia trispina*, *A. quadrispina* and *A. pentaspina* to *H. shabalkini* (Lipman, 1949) by Kozlova (1999) is not correct, as the most characteristic feature of latter – the amplification of the thickness of the shell in its peripheral part (lateral view) – was not observed (Fig. 10D, G), or illusive, when the central part of an outershell is broken (Fig. 12O).

Heterosestrum formosum trispinum
(Tochilina, 1972) emend.
(Figs 8C; 17D)

Amphicyclia trispina Tochilina, 1972: 135, pl. 2.

GEOGRAPHIC DISTRIBUTION. — Voronesh Anticline.

STRATIGRAPHIC RANGE. — Early Eocene (this study).

Heterosestrum sp.

GEOGRAPHIC DISTRIBUTION. — Voronesh Anticline.

STRATIGRAPHIC RANGE. — (?)Late Paleocene-early Eocene (this study).

Heterosestrum (?) sp.
(Fig. 10I)

GEOGRAPHIC DISTRIBUTION. — Voronesh Anticline.

STRATIGRAPHIC RANGE. — (?)Late Paleocene-early Eocene (this study).

Genus *Hexacontium* Haeckel, 1881

Hexacontium pachydermum Jørgensen, 1900
(Fig. 17C)

Hexacontium pachydermum Jørgensen, 1900: 53. — Bjørklund 1976: 1124, pl. 1, figs 4-9.

Hexalonche hexacantha – Vanhøffen 1897: l. 113, t. 6, fig. 22.

GEOGRAPHIC DISTRIBUTION. — Norwegian-Greenland Sea, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Middle to late Eocene, Plato Vøring (Bjørklund 1976); middle to late Eocene (this study).

Hexacontium sp.
(Fig. 11J, K)

GEOGRAPHIC DISTRIBUTION. — Voronesh Anticline.

STRATIGRAPHIC RANGE. — Middle to late Eocene (this study).

Hexacontium (?) sp.
(Fig. 8N)

GEOGRAPHIC DISTRIBUTION. — Voronesh Anticline.

STRATIGRAPHIC RANGE. — Early Eocene (this study).

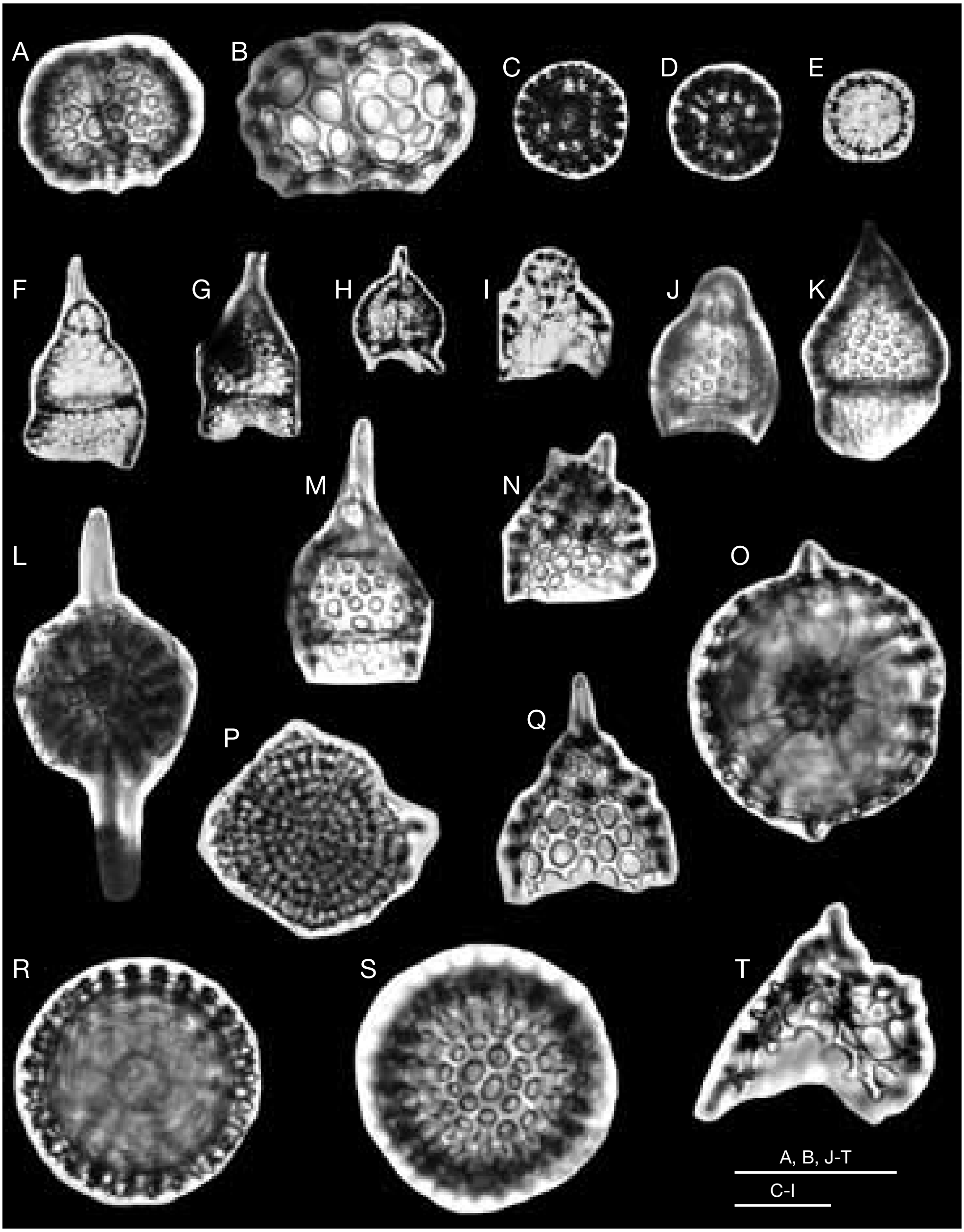


FIG. 14. — **A**-**I**, Early and middle Eocene Radiolaria; **A**, *Desmospyris anthocyrtoides* (Bütschli, 1882), o/p 1, interval 35.5-39.3 m; **B**, *Desmospyris* sp. aff. *anthocyrtoides* Bütschli, 1882, o/p 1, interval 35.5-39.3 m; **C**, **D**, *Thecosphaera magnaporulosa* (Clark & Campbell, 1942), Well 510C, interval 40.0 m; **E**, *Trypansosphaera* sp. aff. *Conosphaera abstrusa* Moksyakova, 1970, o/p 294/7, interval 9.3 m; **F**, *Theocyrtis litos* (Clark & Campbell, 1945), o/p 294/2, interval 4.2 m; **G**, *Theocyrtis scolopax* (Ehrenberg, 1875), o/p 294/1, interval 3.2 m; **H**, *Tholospyris acuminata* Hertwig, 1879, o/p 294/6, interval 8.3 m; **I**, *Tripodiscium* sp., o/p 294/7, interval 9.3 m; **J**-**T**, middle-early late Eocene Radiolarian association from Sergeevka Village, o/p 1, interval 35.5-39.3m; **J**, *Phormocyrtis* sp. aff. *embolum* (Ehrenberg, 1873); **K**, *Calocyclas extensa contracta* Clark & Campbell, 1942; **L**, *Druppatractus trichopterus* Clark & Campbell, 1942; **M**, *Pterocodon lex* Sanfilippo & Riedel, 1979; **N**, **Q**, *Ceratocyrtis stigi* (Bjørklund, 1976); **O**, *Amphisphaera megaxyphos megaxyphos* (Clark & Campbell, 1942); **P**, *Porodiscus* sp.; **R**, **S**, *Thecosphaera californica* Clark & Campbell, 1942; **T**, *Ceratocyrtis charlestonensis* (Clark & Campbell, 1945). Scale bars: A, B, J-T, 100 mm; C-I, 50 µm.

Genus *Hexaspyris* Haeckel, 1881

Hexaspyris morkleyensis Clark & Campbell, 1942

Hexaspyris morkleyensis Clark & Campbell, 1942: 56, pl. 9, fig. 9.

Liriospyris sp. B – Petrushevskaya & Kozlova 1972: 531, pl. 39, figs 17-20.

Patagospyris morkleyensis – Kozlova 1999: 174, pl. 36, figs 21, 26.

GEOGRAPHIC DISTRIBUTION. — California, Atlantic Ocean, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Middle to latest middle Eocene (Clark & Campbell 1942; Blueford & White 1984; Blueford 1988); middle Eocene (this study).

Genus *Lithocyclia* Ehrenberg, 1847

Lithocyclia sp. aff. ***lenticula*** Haeckel, 1887

Lithocyclia lenticula Haeckel, 1887: 459, taf. 36, figs 3, 4.

GEOGRAPHIC DISTRIBUTION. — Of *Lithocyclia lenticula*: Pacific Ocean; of *Lithocyclia* sp. aff. *lenticula*: Voronesh Anticline.

STRATIGRAPHIC RANGE. — Early to late Eocene (this study).

REMARKS

It is different from *L. lenticula* holotype in having a higher number of peripheral rings.

Genus *Lithomelissa* Ehrenberg, 1847

Lithomelissa spongiosa Bütschli, 1882 (Figs 12C; 15I)

Lithomelissa spongiosa Bütschli, 1882b: 517, taf. 33, fig. 25.

Lithomelissa mitra Chen, 1975: 458, pl. 8, figs 4, 5.

GEOGRAPHIC DISTRIBUTION. — Barbados, Antarctic, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Eocene, Barbados (Bütschli 1882a, b); Oligocene, Antarctic (Chen 1975); middle to latest Eocene (this study).

Lithomelissa sp. aff. ***spongiosa*** Bütschli, 1882 (Fig. 17N)

GEOGRAPHIC DISTRIBUTION. — Voronesh Anticline.

STRATIGRAPHIC RANGE. — Middle to late Eocene (this study)

REMARKS

The difference between the holotype and the specimens we have observed lies in the lengths of spines *D*, *L* and *Ax*. The holotype has shorter spines than the specimens from Voronesh.

Lithomelissa sp. aff. ***ehrenbergi*** Bütschli, 1882 (Fig. 17E)

Lithomelissa ehrenbergi Bütschli, 1882: 517, taf. 33, fig. 21.

Lithomelissa sp. aff. *ehrenbergi* – Chen 1975: 458, pl. 11, figs 1, 2.

Sethoconus parvus – Gorbunov 1979: pl. 15, fig. 3.

GEOGRAPHIC DISTRIBUTION. — Of *Lithomelissa ehrenbergi*: Barbados, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Of *L. ehrenbergi*: Eocene (Bütschli 1882); of *Lithomelissa* sp. aff. *ehrenbergi*: lower to upper Miocene (Chen 1975); late Eocene (Gorbunov 1979); middle Eocene (this study).

REMARKS

The first segment of the holotype is larger than that of the specimen we observed in the collection.

Genus *Lithostrobus* Bütschli, 1882 *sensu* Petrushevskaya & Kozlova 1972

Lithostrobus picus (Ehrenberg, 1875) (Figs 7K; 9E)

Eucyrtidium picus Ehrenberg, 1875: pl. 11, fig. 1.

Lithostrobus picus – Kozlova 1999: pl. 15, fig. 18.

GEOGRAPHIC DISTRIBUTION. — Barbados, Voronesh Anticline.

STRATIGRAPHIC RANGE. — (?)Late Paleocene-early Eocene (this study).

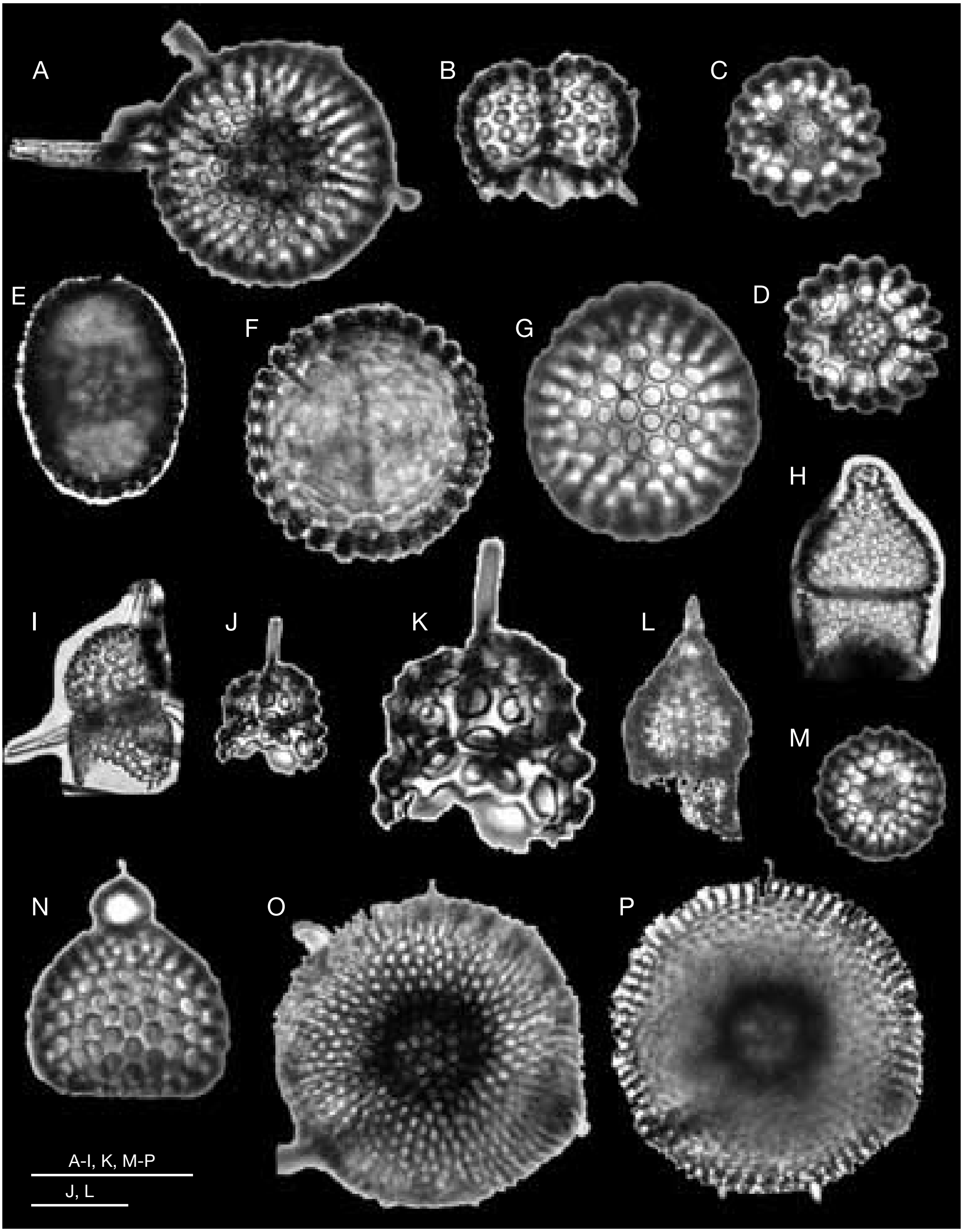


FIG. 15. — Middle-early late Eocene Radiolarian association, Sergeevka Village, outcrop 1, interval 14.3-15.5 m; **A**, *Periphaena* sp. aff. *Heliodiscus hexasteriscus* Clark & Campbell, 1942; **B**, *Petalospyris* sp.; **C**, **D**, *Thecosphaera* sp. A; **E**, *Phacodiscinus* (?) sp.; **F**, **G**, *Actinommura* sp. B; **H**, *Lophocyrtis* ex. gr. *Theocyrtis andriashevi* (Petrushevskaya, 1979); **I**, *Lithomelissa spongiosa* Bütschli, 1882; **J**, **K**, *Ceratocyrtis* sp. aff. *Helotholus amplus* Popofsky, 1908 or *Tripodiscinus* (?) sp.; **L**, *Phormocyrtis* sp. aff. *ligulata* Clark & Campbell; **M**, *Thecosphaera* sp. B; **N**, *Lophocyrtis aspera* (Ehrenberg, 1873); **O**, **P**, *Periphaena heliasteriscus* (Clark & Campbell, 1942). Scale bars: 100 µm.

Genus *Lophocyrtis* Haeckel, 1887 emend. Sanfilippo & Caulet 1998

Lophocyrtis auriculaleporis (Clark & Campbell, 1942) (Figs 11N; 13J, K)

Lophophaena auriculaleporis Clark & Campbell, 1942: 76, pl. 8, fig. 29 (only). — Blueford 1988: 246, pl. 3, fig. 1 (only).

Lophoconus titanothericeraos Clark & Campbell, 1942: 89, pl. 8, fig. 25 (only).

Lophocyrtis auriculaleporis – Kozlova 1999: 133, pl. 27, fig. 14; pl. 31, figs 1, 2 (only).

GEOGRAPHIC DISTRIBUTION. — California, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Middle to latest middle Eocene (Clark & Campbell 1942; Blueford & White 1984; Blueford 1988); middle to late Eocene (this study).

Lophocyrtis norvegiensis (Bjørklund & Kellogg, 1972) (Figs 11M; 13G, H)

Lophocorys norvegiensis Bjørklund & Kellogg, 1972: 388, pl. 1, figs 2, 6, 7. — Dzionoridze *et al.* 1978: pl. 28, figs 17, 18; pl. 34, figs 2, 3. — Hull 1996: 139, pl. 6, figs 11, 12.

Artobotrys norvegiensis Petrushevskaya, 1979: figs 394, 395.

Lophocyrtis norvegiensis – Westberg-Smith & Riedel 1984: 493, pl. 6, fig. 7.

Lophocyrtis auriculaleporis – Kozlova 1999: pl. 31, fig. 3; pl. 35, fig. 15.

GEOGRAPHIC DISTRIBUTION. — Norwegian-Greenland Sea, North Caspian Sea lowland, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Middle Eocene (Bjørklund 1976; Hull 1996); late middle Eocene (Khokhlova 1996); middle-early late Eocene (this study).

Lophocyrtis andriashevi (Petrushevskaya, 1979)

Theocyrtis andriashevi Petrushevskaya *in* Petrushevskaya & Kozlova 1979: 145, figs 392, 525. — Kozlova 1999: 152, pl. 36, fig. 19 (only).

Lophocyrtis andriashevi – Hull 1996: 139, pl. 5, figs 11, 12, 16.

Lophocyrtis semipolita group. Hull, 1996: 139, pl. 6, figs 8, 9.

GEOGRAPHIC DISTRIBUTION. — Norwegian-Greenland Sea, North Caspian Sea area, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Eocene (Petrushevskaya & Kozlova 1979); upper Eocene (Kozlova 1993, 1999); middle(?)-late Eocene (Hull 1996; this study).

Lophocyrtis ex. gr. ***Theocyrtis andriashevi*** (Petrushevskaya, 1979) (Fig. 15H)

Theocyrtis litos – Petrushevskaya & Kozlova 1979: fig. 522.

Theocyrtis andriashevi – Kozlova 1999: pl. 36, figs 18, 20.

GEOGRAPHIC DISTRIBUTION. — Voronesh Anticline.

STRATIGRAPHIC RANGE. — Late(?) Eocene (Kozlova 1999); middle to late Eocene (this study).

REMARKS

The specimens of this group are 1.5 time smaller than *T. andriashevi* typ.

Lophocyrtis aspera (Ehrenberg, 1873) emend. Sanfilippo & Caulet 1998 (Figs 11C; 13A, F; 15N)

Calocyclas asperum Ehrenberg, 1873: 266; 1875: taf. 8, fig. 15. — Petrushevskaya & Kozlova 1972: 548, pl. 28, figs 16-18. — Petrushevskaya & Kozlova 1979: 144, figs 389, 505-508. — Kozlova 1999: 153, pl. 35, fig. 6.

Lophocyrtis aspera emend. Sanfilippo & Caulet 1998: 14, pl. 3B, figs 1, 2, 5-9.

GEOGRAPHIC DISTRIBUTION. — Cosmopolite species.

STRATIGRAPHIC RANGE. — Middle Eocene to late Oligocene (Sanfilippo & Caulet 1998); middle to late Eocene (this study).

Lophocyrtis sinitzini (Lipman, 1949) *sensu* Kozlova 1999 (Fig. 13M)

Sethocyrtis sinitzini Lipman, 1949: 118, pl. 13, fig. 14.

Lophocyrtis jacchia Riedel & Sanfilippo, 1970: 530. — Sanfilippo & Riedel 1979: 504, tabls 2, 3.

Lophocyrtis sinitzini – Kozlova 1999: 160, pl. 32, fig. 18, pl. 35, figs 1, 2, pl. 46, fig. 5.

GEOGRAPHIC DISTRIBUTION. — Barbados, Antarctic, Russian Platform, Kazakhstan, North Caspian Sea lowland, Ouzbekistan.

STRATIGRAPHIC RANGE. — Middle to late Eocene (Riedel & Sanfilippo 1979; Kozlova 1999; this study).

Lophocyrtis **ex. gr.** ***Calocyclas semipolita***
Clark & Campbell, 1942
(Fig. 11I)

Calocyclas semipolita Clark & Campbell, 1942: 83, pl. 8, figs 12, 14, 17-19.

Albatrossidium litos – Kozlova 1999: 146, pl. 30, figs 13, 14; pl. 35, fig. 3 (only).

GEOGRAPHIC DISTRIBUTION. — Of *Calocyclas semipolita*: California; of *Lophocyrtis* ex. gr. *C. semipolita*: Voronesh Anticline.

STRATIGRAPHIC RANGE. — Of *Calocyclas semipolita*: middle to latest middle Eocene (Clark & Campbell 1942; Blueford & White 1984; Blueford 1988); of *A. litos*: middle Eocene (Kozlova 1999); of *Lophocyrtis* ex. gr. *C. semipolita*: early-middle Eocene (this study).

REMARKS
The third segment of this specimen is longer than that of *Calocyclas semipolita* typ. and the width of the second and third segments are equal, which also makes difference between this specimen and *C. semipolita* typ. Kozlova (1999) did attribute the specimens (pl. 30, figs 13, 14; pl. 35, fig. 3 [only]) to *Albatrossidium litos*. To our point of view this definition is not correct, because the *C. litos* typ. has a very irregular distribution of pores on its surface comparing to *C. semipolita* (Clark & Campbell 1945).

Genus *Lychnocanium* Ehrenberg, 1847

Lychnocanium sp. A
(Fig. 11O)

GEOGRAPHIC DISTRIBUTION. — Voronesh Anticline.

STRATIGRAPHIC RANGE. — Middle Eocene (this study).

Lychnocanium sp. B
(Fig. 11L)

Rhopalocanium sp. cf. *ornatum* – Kozlova 1999: 132, pl. 31, figs 8, 11; pl. 45, fig. 9.

GEOGRAPHIC DISTRIBUTION. — Russian Platform.

STRATIGRAPHIC RANGE. — Middle Eocene (Kozlova 1999); middle Eocene (this study).

Genus *Lychnocanoma* Haeckel, 1887
sensu Riedel & Sanfilippo 1970

Lychnocanoma **sp. aff.** ***bandyca***
Mato & Theyer, 1980
(Fig. 7I)

Lychnocanoma bandyca Mato & Theyer, 1980: 225, pl. 1, figs 1-6. — Sanfilippo *et al.* 1985: 676, pl. 19, fig. 3a, b.

GEOGRAPHIC DISTRIBUTION. — Atlantic Ocean, tropical zone; Voronesh Anticline.

STRATIGRAPHIC RANGE. — Late Eocene (Sanfilippo *et al.* 1985); (?)late Paleocene-early Eocene (this study).

REMARKS
The difference between the holotype and our specimens lies in the shape of feats that are curved.

Lychnocanoma bellum longipes (Kozlova, 1966)
(Fig. 7G)

Lychnocanium bellum longipes Kozlova *in* Kozlova & Gorbovets, 1966: 101, tabl. XVI, fig. 4. — Kozlova 1990: pl. 12, fig. 1; pl. 18, figs 12, 13; pl. 45, figs 1, 6, 7.

Lychnocanium bellum – Khokhlova *et al.* 1994: pl. 13.6, fig. 12.

Lychnocanium longipes – Kozlova 1999: 129, pl. 20, fig. 10.

GEOGRAPHIC DISTRIBUTION. — Western Siberia; North Caspian Sea lowland, eastern slope of the Ural Mountains, Kazakhstan, Russian Platform, southern part.

STRATIGRAPHIC RANGE. — Paleocene-early middle Eocene (Kozlova 1990); middle Eocene (Khokhlova 1996); (?)late Paleocene-early Eocene (this study).

Genus *Mita* Pessagno, 1977

Mita **cf.** ***regina*** (Campbell & Clark, 1944)
(Fig. 9X, Y)

(?) *Lithomitra regina* Campbell & Clark, 1944: 41, pl. 8, figs 30, 38, 40(?).

Dictyomitra regina – Foreman 1968: 68, pl. 8, fig. 5a-c. — Johnson 1974: pl. 1, fig. 5.

Dictyomitra cf. *regina* – Dumitrica 1973: 789, pl. 8, fig. 9. — Riedel & Sanfilippo 1974: 778, pl. 15, figs 1-3.

Archaeodictyomitra (?) *regina* – Pessagno 1975: 1016, pl. 4, figs 11, 12; 1976: 49, pl. 14, figs 1-3. — Ling & Lazarus 1990: 355, pl. 2, figs 1, 2.

Dictyomitra (?) sp. aff. *regina* – Petrushevskaya & Kozlova 1972: 550, pl. 8, fig. 11.

Mita regina – Taketani 1982: 60, pl. 5, fig. 3a, b; pl. 12, fig. 2. — Iwata & Tajika 1986: pl. 2, fig. 9. — Hollis 1991: 119, pl. 16, figs 1-5; 1993: 324; 1997: 70, pl. 17, figs 1-4, 10.

Siphocampe minuta – Kozlova 1999: 141, pl. 18, fig. 9.

GEOGRAPHIC DISTRIBUTION. — California, Antarctic, Japan, New Zealand, Russian Platform, Siberia.

STRATIGRAPHIC RANGE. — Of *M. regina*: Campanian-Maastrichtian (Campbell & Clark 1944; Foreman 1968; Ling & Lazarus 1990); Campanian-early Paleocene, Hokkaido (Iwata & Tajika 1986); Maastrichtian to late Paleocene (Hollis 1997); early Eocene (Kozlova 1999); (?)late Paleocene-early Eocene (this study).

Genus *Ommatogramma* Ehrenberg, 1860

Ommatogramma biconstrictus (Lipman, 1953) (Figs 7S; 10N)

? *Spongurus biconstrictus* Lipman, 1953: tabl. 7, fig. 5. — Gorbunov 1979: 113, pl. 10, fig. 3. — Blueford & Amon 1993: 80, pl. 6, figs 3, 5-8.

Ommatogramma biconstrictus – Petrushevskaya & Kozlova 1979: 109, figs 510-514.

Amphicarydiscus biconstrictus – Kozlova 1999: 97, pl. 42, figs 7, 8.

GEOGRAPHIC DISTRIBUTION. — Turkmenistan, Norwegian Sea, Russian Platform, western Siberia.

STRATIGRAPHIC RANGE. — Eocene, Kizil-Kum (Lipman 1953); Plato Vøring (Petrushevskaya & Kozlova 1979); Western Siberia (Blueford & Amon 1993); (?)late Paleocene-early Eocene (this study).

Ommatogramma sp. aff. ***biconstrictus*** (Lipman, 1953) (Fig. 17O)

GEOGRAPHIC DISTRIBUTION. — Voronesh Anticline.

STRATIGRAPHIC RANGE. — Early Eocene, Kanevsky Group, Kartamishevskaya Formation, Voronesh Anticline, Petropavlovka Village, well 730C, 38.8 m depth.

Genus *Periphaena* Ehrenberg, 1873

Periphaena decora Ehrenberg, 1873 (Fig. 17H)

Periphaena decora Ehrenberg, 1873: 246; 1875: pl. 28, fig. 6. — Riedel 1957: 258, pl. 62, fig. 1. — Sanfilippo & Riedel 1973: 523, pl. 8, figs 8-10, pl. 27, figs 2-5. — Petrushevskaya & Kozlova 1972: 523, pl. 14, figs 1, 2.

GEOGRAPHIC DISTRIBUTION. — Atlantic Ocean, Gulf of Mexico, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Eocene-Oligocene (Petrushevskaya & Kozlova 1972); early-middle Eocene (Sanfilippo & Riedel 1973); (?)late Paleocene-early Eocene (this study).

REMARKS

The image of *Periphaena paleogenica sensu* Kozlova (1999: 87, pl. 13, fig. 4) from early Eocene of Western Siberia is similar to our species.

Periphaena sp. aff. ***Heliodiscus inca*** (Clark & Campbell, 1942) (Fig. 10E)

Heliodiscus inca – Kozlova 1999: 84, pl. 17, fig. 14; pl. 21, fig. 8; pl. 24, figs 2, 4; pl. 40, fig. 9.

GEOGRAPHIC DISTRIBUTION. — California, Western Siberia, Ouzbekistan, eastern slope of the Ural mountains, Russian Platform.

STRATIGRAPHIC RANGE. — Middle to latest middle Eocene (Clark & Campbell 1942, 1945); early-middle Eocene (Kozlova 1999); (?)late Paleocene-early Eocene (this study).

REMARKS

The specimen is different from the holotype in the larger number of spines and in their round shape.

Periphaena heliasteriscus (Clark & Campbell, 1942) (Figs 8F, G; 15O, P)

Heliodiscus heliasteriscus Clark & Campbell, 1942: 39, pl. 3, figs 10, 11. — Muzylev *et al.* 1996: 143, fig. 1.

Heliodiscus cf. *heliasteriscus* – Clark & Campbell 1945: 22, pl. 5, fig. 5.

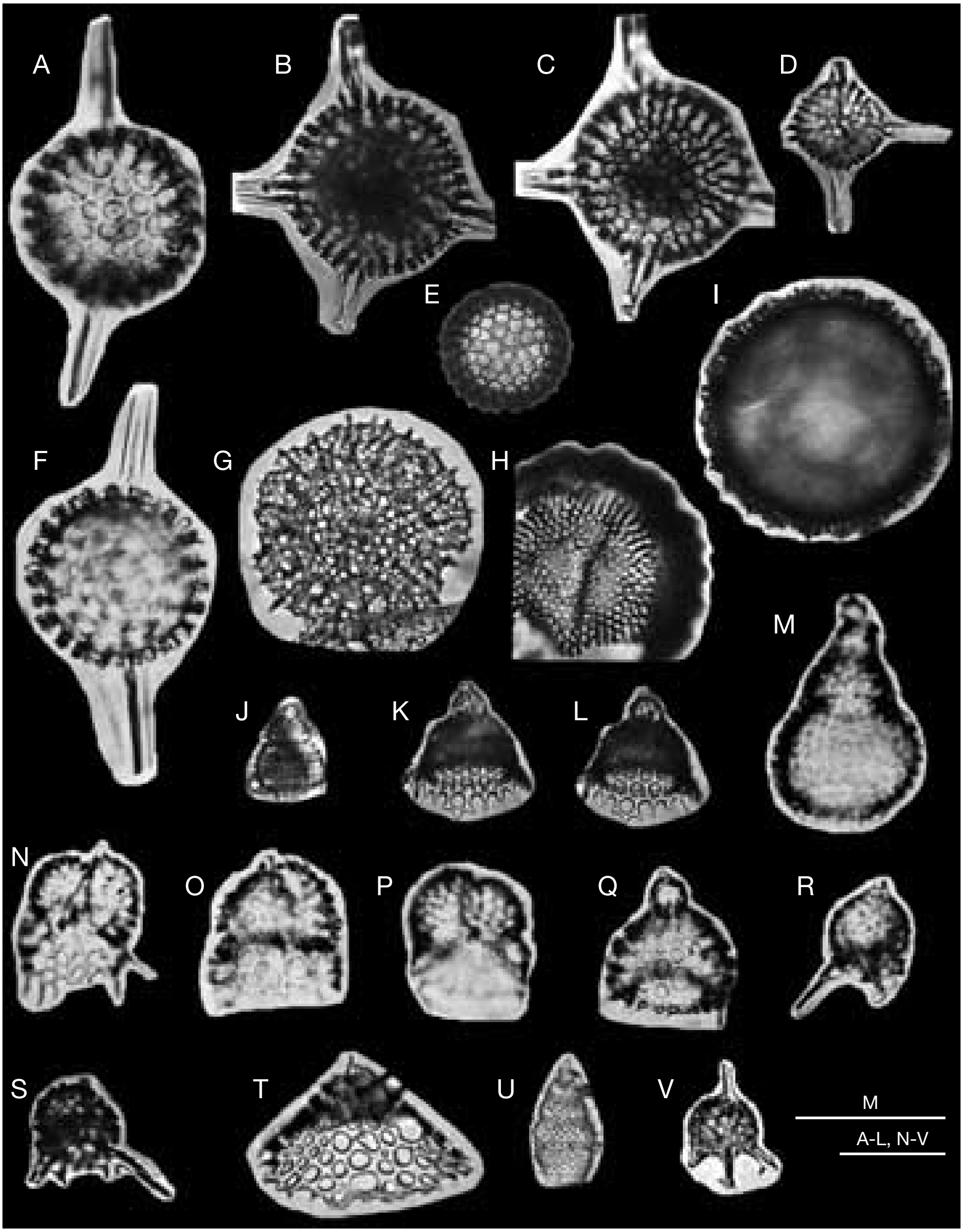


FIG. 16. — Early and middle-late Eocene Radiolarians from different localities; **A**, **F**, *Amphisphaera gonioxyphos* (Clark & Campbell, 1942), o/p 294/11, interval 12.8 m; **B**, **C**, *Periphaena quadrata* (Clark & Campbell, 1942), well 510C, interval 36.0 m; **D**, *Amphisphaera megaxyphos tetraxyphos* (Clark & Campbell, 1942), o/p 294/4, interval 6.3 m; **E**, *Carposphaera globosa* Clark & Campbell, 1945, well 510C, interval 36.0 m; **G**, *Dorylonchidium fructiforme* Clark & Campbell, 1942, o/p 294/10, interval 12.2 m; **H**, **I**, *Conoactinomma* sp. aff. *Conosphaera stilloformis* Lipman, 1960, well 510C, interval 36.0 m; **J**, *Calocyclas* sp. aff. *barbadensis* Ehrenberg, 1875, well 730C, interval 43.7 m; **K**, **L**, *Anthocyrtium* sp., well 730C, interval 38.8 m; **M**, *Theocotyle venezuelensis* Riedel & Sanfilippo, 1970, o/p 294/11, interval 12.8 m; **N**-**P**, *Tripodiscinus kaptarenkoae* (Gorbunov, 1979), o/p 294/10, interval 12.2 m; **Q**, *Calocyclas undella* (Clark & Campbell, 1942), o/p 294/2, interval 4.3 m; **R**, *Callimitra* sp. aff. *Tripilidium clavipes* Clark & Campbell, 1945, o/p 294/6, interval 8.3 m; **S**, *Tripodiscinus* sp., well 730C, interval 38,8 m; **T**, *Ceratocyrtis rhabdophora rhabdophora* (Clark & Campbell, 1945), o/p 294/5, interval 7.3 m; **U**, *Botryostrobus* sp., well 730C, interval 38.8 m; **V**, *Callimitra* cf. *atavia* Goll, 1979, o/p 294/6, interval 8.3 m. Scale bars: 100 μm.

Heliodiscus pentasteriscus Clark & Campbell, 1942: 39, pl. 3, fig. 8. — Kozlova 1984: 284, pl. 10, fig. 11.

Periphaena heliasteriscus – Sanfilippo & Riedel 1973: 523, pl. 9, figs 1-6, pl. 27, figs 8-10. — Takemura 1992: 743, pl. 4, fig. 13. — Khokhlova *et al.* 1994: 228, pl. 13.7, fig. 8. — Kozlova 1999: 87, pl. 34, figs 2, 11, 12; pl. 40, fig. 4.

GEOGRAPHIC DISTRIBUTION. — Southern Indian Ocean, California, Mexico basin, Western Siberia, eastern slope of the Ural Mountains, Turkmenistan, Russian Platform, southern part.

STRATIGRAPHIC RANGE. — Eocene (Kozlova & Gorbovets 1966; Sanfilippo & Riedel 1973); middle Eocene (Clark & Campbell 1942, 1945; Blueford & White 1984); middle Eocene-late Oligocene, Southern Indian Ocean (Takemura 1992), middle-upper Eocene, Mediterranean (Khokhlova *et al.* 1994); middle-upper Eocene, Fergansk depression (Muzylev *et al.* 1996); Paleocene-Eocene (Kozlova 1999); (?)late Paleocene-late Eocene (this study).

Periphaena sp. aff. *Heliodiscus hexasteriscus* Clark & Campbell, 1942 (Fig. 15A)

Heliodiscus hexasteriscus Clark & Campbell, 1942: 40, pl. 3, figs 14, 15. — Kozlova 1990: pl. XI, fig. 3.

GEOGRAPHIC DISTRIBUTION. — California, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Middle Eocene (Clark & Campbell 1942; Blueford & White 1984; Kozlova 1994); middle to late Eocene (this study).

REMARKS

The spines are without facets.

Periphaena pentasteriscus (Clark & Campbell, 1942) (Fig. 17I, J)

Heliodiscus pentasteriscus Clark & Campbell, 1942: 39, pl. 3, fig. 8. — Petrushevskaya & Kozlova 1972: 523, pl. 13, figs 6, 7.

GEOGRAPHIC DISTRIBUTION. — Atlantic Ocean, California, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Middle to latest middle Eocene (Clark & Campbell 1942; Blueford & White 1984); Eocene (Petrushevskaya & Kozlova 1972); middle to late Eocene (this study).

Periphaena perplexus (Clark & Campbell, 1942) (Fig. 10A, B)

Heliodiscus perplexus Clark & Campbell, 1942: 40, pl. 3, fig. 12.

Trochodiscus hoplites Lipman, 1953: 141, pl. XII, fig. 7.

Heliodiscus lentis Lipman, 1960: 83, pl. XI, figs 5, 6; pl. XIV, figs 1, 2. — Kozlova 1984: 205, pl. 10, fig. 10; 1990: pl. XI, fig. 12.

Astrophacus testatus Kozlova *in* Kozlova & Gorbovets 1966: 73, pl. XI, fig. 7.

Heliodiscus inca – Kozlova 1999: 222, pl. 17, fig. 14; pl. 21, fig. 8; pl. 24, fig. 2 (only).

GEOGRAPHIC DISTRIBUTION. — California, Northern and Western Siberia, eastern slope of the Ural Mountains, Russian Platform, southern part.

STRATIGRAPHIC RANGE. — Middle to latest middle Eocene (Clark & Campbell 1942; Blueford & White 1984); early Eocene (Lipman 1953, 1960; Kozlova & Gorbovets 1966; Kozlova 1990); (?)late Paleocene-early Eocene to late Eocene (this study).

REMARKS

It is very difficult to see the difference between *Heliodiscus perplexus* and *Heliodiscus lentis* Lipman, 1960 (p. 83, pl. XI, figs 5, 6; pl. XIV, figs 1, 2), as the thickness of spines might be a result of a dissolution and because of that it can not be considered as the feature for a new species definition. To our point of view all above mentioned species are synonyms.

H. inca sensu Kozlova (1999) is a group of species, in a major quantity of images, different to *H. inca* holotype by: 1) the number and shape of main spines – for example, pl. 17, fig. 14 and pl. 21, fig. 8, the specimen has 10 or more round main spines, instead of nine angular, described by Clark & Campbell; and 2) by the surface porosity – for example, pl. 40, fig. 9, specimen has an irregular size and distribution of pores, and a round main spines.

Periphaena quadrata (Clark & Campbell, 1942) (Fig. 16B, C)

Heliodiscus quadratus Clark & Campbell, 1942: 38, pl. 3, fig. 16. — Kozlova 1990: pl. XI, fig. 2.

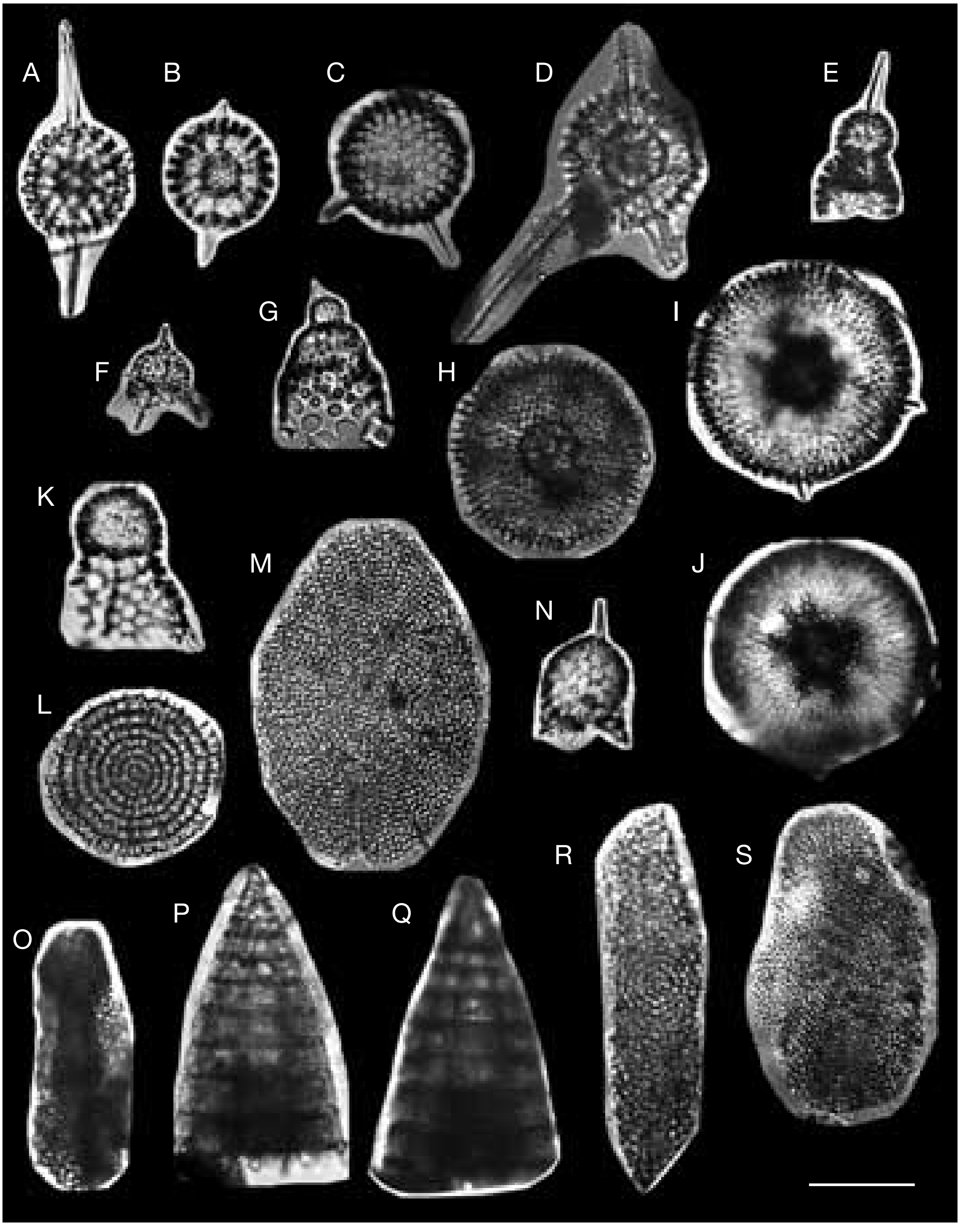


FIG. 17. — Early and middle-late Eocene Radiolarians from different localities; **A**, *Druppatractus polycentrus* Clark & Campbell, 1942, o/p 294/4, interval 6.3 m; **B**, *Ellipsostylus anisoxyphos* Clark & Campbell, 1942, o/p 294/6, interval 8.3 m; **C**, *Hexacontium pachydermum* Jørgensen, 1900, well 510C, interval 44.0 m; **D**, *Heterosestrum formosum trispinum* (Tochilina, 1972) emend., well 730C, interval 43.7 m; **E**, *Lithomelissa* sp. aff. *ehrenbergi* Bütschli, 1882, well 510C, interval 40.0 m; **F**, *Euscenarium* (?) sp., well 730C, interval 44.3 m; **G**, *Theocorys anapographa* Riedel & Sanfilippo, 1970, o/p 294/3, interval 5.3 m; **H**, *Periphaena decora* Ehrenberg, 1873, well 730C, interval 43.7 m; **I**, **J**, *Periphaena pentasteriscus* (Clark & Campbell, 1942), well 510C, interval 40.0 m; **K**, *Tripocyrtis* (?) sp., o/p 294/11, interval 12.8 m; **L**, *Porodiscus charlestonensis* Clark & Campbell, 1945, well 510C, interval 44.0 m; **M**, **S**, *Spongodiscus* ex. gr. *cruciferus* (Clark & Campbell, 1942), well 730C, interval 43.7 m; **N**, *Lithomelissa* sp. aff. *spongiosa* Bütschli, 1882, o/p 294/4, interval 6.3 m; **O**, *Ommatogramma* sp. aff. *biconstrictus* (Lipman, 1953), well 730C, interval 38.8 m; **P**, **Q**, *Peripyramis magnifica magnifica* (Clark & Campbell, 1942), well 730C, interval 43.7 m; **R**, *Prunobrachium* (?) sp., well 730C, interval 43.7 m. Scale bar: 100 µm.

Astrophacus tetradialis – Tochilina 1966: 285, pl. 2, fig. 2a, b.

Heliodiscus hexasteriscus – Kozlova 1990: pl. XI, fig. 3.

GEOGRAPHIC DISTRIBUTION. — California, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Middle Eocene (Clark & Campbell 1942; Kozlova 1990); middle to late Eocene (this study).

Genus *Peripyramis* Haeckel, 1881

Peripyramis magnifica magnifica (Clark & Campbell, 1942) *sensu* Kozlova 1999 (Fig. 17P, Q)

Peripyramis magnifica magnifica – Kozlova 1999: 126, pl. 47, figs 19, 20, 22.

GEOGRAPHIC DISTRIBUTION. — Western Siberia, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Middle to late Eocene (Lipman *et al.* 1960); (?)late Paleocene-early Eocene (this study).

Peripyramis magnifica victori (Lipman, 1960) *sensu* Kozlova 1999

Sethopyramis magnifica Clark & Campbell, 1942: 72, figs 1, 5, 9.

Sethopyramis victori – Lipman *et al.* 1960: 91, tabl. XIV, figs 4-7.

Peripyramis magnifica – Petrushevskaya & Kozlova 1972: 551, pl. 31, fig. 3. — Bjørklund 1976: pl. 22, fig. 14 (only). — Hull 1996: 140, pl. 6, fig. 4.

Peripyramis magnifica victori – Kozlova 1999: 126, pl. 14, figs 3, 4; pl. 47, figs 23, 26, 27.

GEOGRAPHIC DISTRIBUTION. — California, Western Siberia, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Middle Eocene (Clark & Campbell 1942; Blueford & White 1984; Blueford 1988); middle to late Eocene, Norwegian-Greenland Sea (Hull 1996); middle to late Eocene (this study).

Genus *Petalospyris* Ehrenberg, 1847

Petalospyris argiscus Ehrenberg, 1875 (Fig. 7Q)

Petalospyris argiscus Ehrenberg, 1875: pl. XXII, figs 1, 2. — Bütschli 1882: taf. XXIX, fig. 6a, b.

Gorgospyris hemisphaerica sibirica – Kozlova & Gorbovets 1966: 97, pl. XV, fig. 8.

Dorcadospyris argisca – Chen 1975: 456, pl. 3, fig. 9.

GEOGRAPHIC DISTRIBUTION. — Barbados, Western Siberia, eastern slope of the Ural Mountains, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Eocene (Kozlova & Gorbovets 1966); Antarctic, Upper (?)Eocene (Chen 1975); (?)late Paleocene-early Eocene (this study).

REMARKS

All specimens observed contain a short “apical” horn located on saggittal ring.

Petalospyris sp. aff. ***argiscus*** Ehrenberg, 1875 (Fig. 7A, B)

GEOGRAPHIC DISTRIBUTION. — Voronesh Anticline.

STRATIGRAPHIC RANGE. — (?)Late Paleocene-early Eocene (this study).

Petalospyris sp. aff. ***septenaria*** Kozlova, 1966 (Fig. 9U, V)

Petalospyris septenaria Kozlova *in* Kozlova & Gorbovets, 1966: 96, pl. XV, fig. 7.

GEOGRAPHIC DISTRIBUTION. — Voronesh Anticline.

STRATIGRAPHIC RANGE. — (?)Late Paleocene-early to late Eocene (this study).

REMARKS

We observe eight to ten more basal feet than in the holotype.

Petalospyris tumidula Kozlova, 1966 (Figs 9K, L; 12I, J)

Petalospyris tumidula Kozlova *in* Kozlova & Gorbovets, 1966: 97, tabl. XV, figs 10, 11. — Kozlova 1984: 204, tabl. XII, fig. 11.

Petalospyris (?) sp. – Gorbunov 1979: 141, tabl. 3, fig. 5.

GEOGRAPHIC DISTRIBUTION. — Volga River middle reaches basin, North Caspian Sea lowland, Western Siberia, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Early Eocene (Kozlova & Gorbovets 1966; Kozlova 1984); middle Eocene (Khokhlova 1996); (?)late Paleocene-early Eocene (this study).

Genus *Phormocyrtis* Haeckel, 1887

Phormocyrtis **sp. aff.** ***embolum*** (Ehrenberg, 1873)
(Fig. 14 J)

Eucyrtidium embolum Ehrenberg, 1873: 228; 1875, pl. 10, fig. 5.

Phormocyrtis embolum – Kozlova 1999: pl. 31, fig. 14.

GEOGRAPHIC DISTRIBUTION. — Of *Phormocyrtis embolum*: Barbados; of *Phormocyrtis* sp. aff. *embolum*: Voronesh Anticline.

STRATIGRAPHIC RANGE. — Of *Phormocyrtis embolum*: Eocene (Ehrenberg 1873), Eocene-Oligocene (Kozlova 1999); of *Phormocyrtis* sp. aff. *embolum*: middle to late Eocene (this study).

REMARKS
The third segment of the specimens observed is longer than in the holotype.

Phormocyrtis sp. aff. ***proxima***
Clark & Campbell, 1942
(Figs 9A, B, F, G; 13N)

Phormocyrtis proxima Clark & Campbell, 1942: 82, pl. 7, figs 24, 26. — Kozlova 1999: pl. 18, fig. 22 (21 is a misprint).

Podocyrtis turgida – Kozlova 1999, pl. 15, fig. 7.

Cryptocarpium phyzella – Kozlova 1999: pl. 26, fig. 12.

GEOGRAPHIC DISTRIBUTION. — Of *Phormocyrtis* sp. aff. *proxima*: Western Siberia, North Caspian Sea lowland, Tyrgai, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Early to middle Eocene (Kozlova 1999); (?)late Paleocene-early Eocene (this study).

REMARKS
The shape of the shells observed is different from *P. proxima* holotype.

Genus *Plectodiscus* Kozlova, 1972

Plectodiscus circularis (Clark & Campbell, 1942)
(Fig. 7P)

Porodiscus circularis Clark & Campbell, 1942: 42, pl. 11, figs 2, 6, 10.

Porodiscus uralicus – Lipman 1960: 86, pl. XI, figs 9-11.

Xiphospira circularis – Sanfilippo & Riedel 1973: 526, pl. 14, figs 5-12, pl. 31, figs 4-7.

Plectodiscus circularis – Petrushevskaya & Kozlova 1972: 526, pl. 19, figs 9-12. — Blueford 1988: 250, pl. 5, figs 7, 8.

Circodiscus circularis – Kozlova 1999: pl. 9, fig. 2.

GEOGRAPHIC DISTRIBUTION. — California, Western Siberia, Gulf of Mexico, Atlantic Ocean, Russian Platform, southern part.

STRATIGRAPHIC RANGE. — Late Paleocene to middle Eocene (Clark & Campbell 1942; Blueford & White 1984; Blueford 1988; Sanfilippo & Riedel 1973; Kozlova 1999); (?)late Paleocene-early Eocene (this study).

Genus *Podocyrtis* Ehrenberg, 1847

Podocyrtis cf. ***papalis*** Ehrenberg, 1875
(Fig. 7H)

Podocyrtis papalis Ehrenberg, 1875: 62, pl. XV, fig. 6. — Sanfilippo *et al.* 1989: 696, fig. 30 (1). — Kozlova 1999: 151, pl. 24, figs 16, 17.

GEOGRAPHIC DISTRIBUTION. — Of *Podocyrtis* cf. *papalis*: Caribbean Sea, Atlantic Ocean, Russian Platform, southern part.

STRATIGRAPHIC RANGE. — Paleocene-middle Eocene (Sanfilippo *et al.* 1989; Nishimura 1992); early-middle Eocene (Kozlova 1999); early Eocene (this study).

Genus *Porodiscus* Haeckel, 1881
emend. Kozlova 1972

Porodiscus charlestonensis Clark & Campbell, 1945
(Fig. 17L)

Porodiscus charlestonensis Clark & Campbell, 1945: 23, pl. 3, figs 11-15.

Stylotrochus charlestonensis – Nishimura 1987: pl. 1, fig. 13.

GEOGRAPHIC DISTRIBUTION. — North American basin, California, Western North Atlantic, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Middle Eocene to latest middle Eocene (Clark & Campbell 1945; Blueford & White 1984; Blueford 1988); Paleocene (Nishimura 1987); early to late Eocene (this study).

Genus *Prunobrachium* Kozlova, 1966

Prunobrachium (?) sp.
(Fig. 17R)

Geographic distribution. — Voronesh Anticline.

Stratigraphic range. — (?)Late Paleocene-early Eocene (this study).

Genus *Prunopyle* Dreyer, 1889

Prunopyle sp. aff. ***ovata*** Kozlova, 1966
(Fig. 7O)

Prunopyle ovata Kozlova *in* Kozlova & Gorbovets, 1966: 67, pl. X, figs 5-8.

Geographic distribution. — Western Siberia, Voronesh Anticline.

Stratigraphic range. — Late Eocene (Kozlova & Gorbovets 1966); (?)late Paleocene-early Eocene (this study).

Remarks

The difference between species from Voronesh Anticline and *P. ovata* typ. is in the structure of pylom.

Genus *Pterocodon* Ehrenberg, 1847

Pterocodon ampla (Brandt, 1936)
(Figs 7E, F; 9I, J)

Theocyrtis ampla Brandt, 1936: 56, pl. 9, figs 13-15.

Pterocodon ampla – Foreman 1973: 438. — Sanfilippo & Riedel 1979: 505, pl. 1, figs 7, 8. — Sanfilippo *et al.* 1985: 680, pl. 1, figs 7, 8. — Khokhlova *et al.* 1994: 229, pl. 13.6, fig. 8.

Clathrocyclas ampla – Kozlova 1999: 118 (not pl. 18, fig. 1); pl. 21, fig. 16; pl. 44, fig. 14.

Clathrocyclas elegans – Kozlova 1999: pl. 15, fig. 9; pl. 18, fig. 2.

Geographic distribution. — Cosmopolite species.

Stratigraphic range. — Ranges across Paleocene-Eocene boundary (Sanfilippo *et al.* 1985); early Eocene (Kozlova 1990, 1999); middle Eocene (Khokhlova *et al.* 1996); (?)late Paleocene-early Eocene (this study).

Remarks

This species is very similar to *Clathrocyclas angusta* (see Kozlova 1990: pl. XII, fig. 9; 1999, pl. 14, fig. 1) the only difference we observed is irregular size of pores (second row) perforated the upper part of the third segment.

Pterocodon ampla longispina
(Clark & Campbell, 1942) n. comb.
(Fig. 9C, D)

Clathrocyclas universa longispina Clark & Campbell, 1942: 88, pl. 7, fig. 15.

Clathrocyclas extensa – Kozlova 1999: pl. 14, fig. 6.

Geographic distribution. — California, western Siberia, Russian Platform, southern part.

Stratigraphic range. — Early Eocene to latest middle Eocene, (Clark & Campbell 1942; Blueford & White 1984; Blueford 1988; Kozlova 1999); (?)late Paleocene-early Eocene (this study).

Remarks

The first and second segments of *Clathrocyclas universa longispina* are similar to *Pterocodon ampla*, but the third segment is different, its diameter is 1.1 to 1.2 time bigger than that of the second segment and it is what we observed for *C. universa longispina*. Thus the new combination of a species and subspecies names will be more correct according to the taxonomic priority.

Pterocodon ex. gr. ***ampla*** (Brandt, 1936)
(Fig. 9H)

Geographic distribution. — Voronesh Anticline.

Stratigraphic range. — (?)Late Paleocene-early Eocene (this study).

Remarks

The *Clathrocyclas ampla* (Kozlova 1990: pl. XII, fig. 19), from Western Siberia, Irbitsk Formation, *Heliodiscus lentis* Zone, is very similar to this specimen, but its size is less.

Pterocodon lex Sanfilippo & Riedel, 1979
(Fig. 14M)

Pterocodon lex Sanfilippo & Riedel, 1979: 505, pl. 1, figs 9, 10.

GEOGRAPHIC DISTRIBUTION. — North Atlantic, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Early Eocene (Sanfilippo & Riedel 1979); early to middle Eocene (this study).

Genus *Rhopalocanium* Ehrenberg, 1847

Rhopalocanium pyramis (Haeckel, 1887) (Fig. 9O, P)

Dictyophimus pyramis Haeckel, 1887: 1330, pl. 68, fig. 7.

Rhopalocanium pyramis – Kozlova 1999: pl. 7, fig. 16.

GEOGRAPHIC DISTRIBUTION. — Pacific Ocean, Russian Platform.

STRATIGRAPHIC RANGE. — Late Paleocene-Recent (Haeckel 1887; Kozlova 1999); (?)late Paleocene-early Eocene (this study).

Rhopalocanium satelles (Kozlova, 1966) (Fig. 9Q)

Theopodium satelles Kozlova *in* Kozlova & Gorbovets, 1966: 105, pl. XVI, fig. 8.

Rhopalocanium satelles – Kozlova 1999: 132, pl. 24, fig. 10; pl. 45, fig. 17.

GEOGRAPHIC DISTRIBUTION. — Pacific Ocean, Western Siberia, Russian Platform, southern part.

STRATIGRAPHIC RANGE. — Early to late Eocene (Kozlova & Gorbovets 1966; Kozlova 1999); (?)late Paleocene-early Eocene (this study).

Genus *Spiromultitunica* (Tochilina, 1985)

Spiromultitunica sp. aff. ***Prunopyle hayesi*** Chen, 1975 (Fig. 8K, O)

Prunopyle hayesi Chen, 1975: 454, pl. 9, figs 3-5.

GEOGRAPHIC DISTRIBUTION. — Antarctic, North Pacific region, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Early Oligocene to Miocene (Chen 1975; Tochilina 1985); (?)late Paleocene-middle Eocene (this study).

Genus *Spongodiscus* Ehrenberg, 1854

Spongodiscus ex. gr. ***cruciferus*** (Clark & Campbell, 1942) (Fig. 17M, S)

Spongasteriscus cruciferus Clark & Campbell, 1942: 50, pl. 1, figs 1-6, 8, 10, 11, 16-18. — Kozlova 1984: pl. X, fig. 16. — Blueford & White 1984: pl. 3, fig. 12. — Blueford 1988: 252, pl. 6, figs 7, 8. — Blueford & Amon 1993: 78, pl. 1, fig. 8, pl. 3, fig. 2.

Spongodiscus cruciferus – Sanfilippo & Riedel 1973: 50, pl. 11, figs 14-17, pl. 28, figs 10, 11.

Amphicarydiscus fusoideus – Lipman 1984: pl. XIV, fig. 10.

Amphibrachium paleogenicum – Gorbunov 1979: 130, pl. 7, fig. 2, pl. 9, figs 1a-3.

GEOGRAPHIC DISTRIBUTION. — Of *S. cruciferus*: California, Gulf of Mexico, Russian Platform, southern part.

STRATIGRAPHIC RANGE. — Middle to latest Eocene (Clark & Campbell 1942; Sanfilippo & Riedel 1973; Blueford & White 1984; Blueford 1988; Gorbunov 1979); (?)late Paleocene-early Eocene (this study).

Genus *Spongoprunum* Haeckel, 1862

Spongoprunum (?) ***probus*** (Rüst, 1888) (Fig. 8C, M)

Cyphinus probus Rüst, 1888: 196, pl. 24, fig. 4.

Spongoprunum sp. aff. *Cyphantus probus* – Petrushevskaya & Kozlova 1972: 529, pl. 4, figs 6, 7.

GEOGRAPHIC DISTRIBUTION. — Europe, Atlantic Ocean, Voronesh Anticline.

STRATIGRAPHIC RANGE. — (?)Late Paleocene-early Eocene (this study).

Genus *Stylotrochus* Haeckel, 1862

Stylotrochus festivus Clark & Campbell, 1942 (Fig. 10H, K)

Stylotrochus festivus Clark & Campbell, 1942: 48, pl. 2, figs 5, 8.

Spongotrochus echinodiscus – Clark & Campbell 1942: 48, pl. 2, fig. 3.

Porodiscus compactus Lipman, 1950: 60, pl. 2, fig. 4.

Spongotrochus (?) sp. – Petrushevskaya & Kozlova 1972: 528, pl. 3, fig. 4, pl. 5, fig. 11.

Spongodiscus alveatus Kozlova, 1984: pl. XI, fig. 6.

Spongotrochus radiatus Kozlova, 1999: 96, pl. 9, fig. 5; pl. 11, fig. 11; pl. 13, fig. 8; pl. 41, fig. 4.

GEOGRAPHIC DISTRIBUTION. — California, Turkmenistan, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Middle to latest middle Eocene (Clark & Campbell 1942; Blueford & White 1984; Blueford 1988); Eocene (Lipman 1950); (?)late Paleocene-late Eocene (this study).

Genus *Stylodictya* Ehrenberg, 1847

Stylodictya targaeformis (Clark & Campbell, 1942) (Fig. 8H)

Staurodictya targaeformis Clark & Campbell, 1942: 43, pl. 3, fig. 6.

Stylodictya targaeformis – Petrushevskaya & Kozlova 1972: 526, pl. 18, fig. 9. — Petrushevskaya 1975: 576, pl. 6, figs 7, 8. — Hull 1996: 136, pl. 3, fig. 13.

Stylodictya targaeformis rosella – Dzionoridze *et al.* 1978: pl. 25, fig. 3.

GEOGRAPHIC DISTRIBUTION. — California, Norwegian-Greenland Sea, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Middle to late Eocene (Clark & Campbell 1942; Blueford & White 1984; Blueford 1988; Khokhlova 1996; Hull 1996); (?)late Paleocene-late Eocene (this study).

Genus *Thecosphaera* Haeckel, 1881

Thecosphaera californica Clark & Campbell, 1942 (Fig. 14R, S)

Thecosphaera californica Clark & Campbell, 1942: 22, pl. 4, fig. 7; 1945: 10, pl. 1, fig. 10. — Blueford & White 1984: pl. 3, fig. 5. — Blueford 1988: 247, pl. 3, figs 10-12.

Thecosphaera californica sumensis Gorbunov, 1979: 91, pl. 12, fig. 1a-b.

GEOGRAPHIC DISTRIBUTION. — California, Russian Platform, southern part.

STRATIGRAPHIC RANGE. — Middle to latest middle Eocene (Clark & Campbell 1942, 1945; Blueford & White 1984; Blueford 1988); middle Eocene (Khokhlova 1996); late Eocene, Kievsky Group (Gorbunov 1979); early-middle Eocene (this study).

Thecosphaera rotunda Borisenko, 1960 (Fig. 8B, D)

Thecosphaera rotunda Borisenko, 1960: 222, pl. 1, fig. 3, pl. 3, figs 2, 3. — Lipman 1984: pl. 14, fig. 4.

Thecosphaera melitomma Kozlova & Gorbovets, 1966: 52, pl. 7, figs 7, 8.

Thecosphaerella rotunda Kozlova, 1999: 80, pl. 7, figs 1, 2; pl. 11, figs 1, 2; pl. 27, figs 1, 4.

Thecosphaera sp. aff. *larnacium* – Kozlova 1999: pl. 33, fig. 2.

GEOGRAPHIC DISTRIBUTION. — Russian Platform, Western Siberia, Kazakhstan, Atlantic Ocean.

STRATIGRAPHIC RANGE. — Late Paleocene-middle Eocene (Kozlova 1999); (?)late Paleocene-late Eocene (this study).

Thecosphaera magnaporulosa (Clark & Campbell, 1942) (Fig. 14C, D)

Carposphaera magnaporulosa Clark & Campbell, 1942: 21, pl. 5, figs 15, 17, 21, 23.

GEOGRAPHIC DISTRIBUTION. — California, North Caspian Sea lowland, Russian Platform, southern part.

STRATIGRAPHIC RANGE. — Middle Eocene (Clark & Campbell 1942, 1944; Blueford & White 1984; Blueford 1988; Khokhlova 1996); middle to late Eocene (this study).

Thecosphaera sp. A (Fig. 15C, D)

Thecosphaera sp. A – Petrushevskaya & Kozlova 1972: 519, pl. 9, fig. 17.

GEOGRAPHIC DISTRIBUTION. — Atlantic Ocean, Russian Platform.

STRATIGRAPHIC RANGE. — Maastrichtian(?) African coast of Atlantic Ocean (Petrushevskaya & Kozlova 1972); (?)late Paleocene-early Eocene (this study).

Genus *Theocorys* Haeckel, 1881

Theocorys anaclasta Riedel & Sanfilippo, 1970 (Fig. 11G)

Theocorys anaclasta Riedel & Sanfilippo, 1970: 530, pl. 10, figs 2, 3.

Lamptonium (?) sp. aff. *Phormocyrtis cubensis* – Kozlova 1999: pl. 35, fig. 14.

GEOGRAPHIC DISTRIBUTION. — Atlantic Ocean, tropical zone, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Late early to middle Eocene (Sanfilippo & Riedel 1970; Kozlova 1999); middle to late Eocene (this study).

Theocorys anapographa **Riedel & Sanfilippo, 1970**
(Fig. 17G)

Theocorys anapographa Riedel & Sanfilippo, 1970: 530, pl. 10, fig. 4. — Sanfilippo *et al.* 1985: 683, fig. 24.2.

GEOGRAPHIC DISTRIBUTION. — Atlantic Ocean, tropical zone, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Late early to late middle Eocene (Sanfilippo & Riedel 1970); middle to late Eocene (this study).

Genus *Theocotyle* Riedel & Sanfilippo, 1970

Theocotyle venezuelensis **Riedel & Sanfilippo, 1970**
(Fig. 16M)

Theocotyle venezuelensis Riedel & Sanfilippo, 1970: 525, pl. 6, figs 9, 10; pl. 7, figs 1, 2; 1971: 740, pl. 1, fig. 11. — Sanfilippo *et al.* 1985: 685, figs 25.4a-c.

Cyrtophormis alta – Kozlova 1999: 155, pl. 30, fig. 7 (not 9); pl. 46, fig. 4.

GEOGRAPHIC DISTRIBUTION. — Atlantic Ocean, tropical zone, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Late early to early middle Eocene (Sanfilippo & Riedel 1970; Sanfilippo *et al.* 1985; Kozlova 1999); middle to late Eocene (this study).

REMARKS
Cyrtophormis (?) *alta* (Moksyakova, 1961) holotype has no vertical rows of pores on its third segment, as it was observed for *Theocotyle venezuelensis* during our investigation.

Genus *Theocyrtis* Haeckel, 1887

Theocyrtis litos **(Clark & Campbell, 1945)**
(Fig. 14F)

Calocyclas litos Clark & Campbell, 1945: 44, pl. 6, fig. 13.

GEOGRAPHIC DISTRIBUTION. — California, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Middle to late Eocene (Clark & Campbell 1945; Blueford & White 1984; Blueford 1988); late Eocene (this study).

REMARKS
The specimen named *Albatrossidium litos* (see Kozlova 1999: pl. 35, fig. 3) can not be attributed to species named *Theocyrtis litos*, because of the difference in: 1) shape of the third segment – the holotype has no trend to reduce conicaly the diameter of its operture; and 2) in porosity – the diameter of pores of the third segment is much larger than in the holotype.

Theocyrtis scolopax **(Ehrenberg, 1875)**
(Fig. 14G)

Eucyrtidium scolopax Ehrenberg, 1875: pl. XI, fig. 5.

GEOGRAPHIC DISTRIBUTION. — Barbados, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Eocene (Ehrenberg 1875); latest Eocene (this study).

Genus *Tholospyris* Haeckel, 1881

Tholospyris acuminata **Hertwig, 1879**
(Fig. 14H)

Tholospyris acuminata Hertwig, 1879 *sensu* Schaaf 1981: 243, pl. 1, fig. 5.

GEOGRAPHIC DISTRIBUTION. — Voronesh Anticline.

STRATIGRAPHIC RANGE. — Tertiary (Hertwig 1879); middle to late Eocene (this study).

Genus *Triactis* Haeckel, 1881

Triactis triactis **(Ehrenberg, 1873)**
(Fig. 8A)

Haliomma triactis Ehrenberg, 1873: 236; 1875: pl. 28, fig. 4. — Petrushevskaya & Kozlova 1972: 523, pl. 13, fig. 2.

Staurolonche pachyxyphos – Clark & Campbell 1945: 15, pl. 1, fig. 22.

Heliodiscus triactis – Kozlova 1990: pl. XI, fig. 5.

Triactis triactis – Kozlova 1999: pl. 28, fig. 8; pl. 29, fig. 5.

GEOGRAPHIC DISTRIBUTION. — Barbados, California, Atlantic Ocean, tropical zone, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Middle Eocene (Petrushevskaya & Kozlova 1972; Clark & Campbell 1945; Blueford 1988; Kozlova 1999; this study).

Genus *Tricolocapsa* Haeckel, 1881

Tricolocapsa papillosa mediterranea (Haeckel, 1887) *sensu* Petrushevskaya 1971

Tricolocapsa papillosa mediterranea (Haeckel, 1887) *sensu* Petrushevskaya 1971: pl. 91, figs 7, 8.

Tricolocapsa papillosa – Bjørklund 1976: pl. 16, figs 22, 23.

GEOGRAPHIC DISTRIBUTION. — Mediterranean Sea, Norwegian Sea, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Eocene-Recent (Petrushevskaya 1971); middle to late Eocene (this study).

Genus *Tripodiscinus* Haeckel, 1887 emend. Petrushevskaya & Kozlova 1979

Tripodiscinus kaptarenkoae (Gorbunov, 1979) (Fig. 16N-P)

Botryopyle kaptarenkoae Gorbunov, 1979: pl. 15, fig. 2.

Tripodiscinus kaptarenkoae – Kozlova 1999: 109, pl. 31, fig. 4; pl. 35, fig. 4.

GEOGRAPHIC DISTRIBUTION. — Circum-Antarctic regions, Russian Platform, southern part.

STRATIGRAPHIC RANGE. — Middle Eocene (Gorbunov 1979; Khokhlova 1996; Kozlova 1999); middle to late Eocene (this study).

Tripodiscinus sp. (Fig. 16S)

GEOGRAPHIC DISTRIBUTION. — Voronesh Anticline.

STRATIGRAPHIC RANGE. — Middle-early late Eocene (this study).

Tripodiscinus (?) sp. (Fig. 15J, K)

GEOGRAPHIC DISTRIBUTION. — Voronesh Anticline.

STRATIGRAPHIC RANGE. — Early Eocene (this study).

Genus *Trypansosphaera* Haeckel, 1887

Trypansosphaera sp. aff. ***Conosphaera abstrusa*** Moksyakova, 1970 (Fig. 14E)

Conosphaera abstrusa Moksyakova, 1970: 139, pl. II, fig. 3.

GEOGRAPHIC DISTRIBUTION. — Turkmenistan, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Of *Conosphaera abstrusa*: late Eocene, Kumsky Formation (Moksyakova 1970); middle to late Eocene (this study).

REMARKS

The resolution of the holotype's image is not sufficient to say whether it is the same species as ours, the description is similar.

Genus *Velicucullus* Riedel & Campbell, 1952

Velicucullus sp. aff. ***oddgurneri*** Bjørklund, 1976 (Fig. 8J)

Velicucullus oddgurneri Bjørklund, 1976: 1126, pl. 19, figs 6-9.

GEOGRAPHIC DISTRIBUTION. — Norwegian-Greenland Sea, Voronesh Anticline.

STRATIGRAPHIC RANGE. — Of *Velicucullus oddgurneri*: Oligocene-Pliocene, Norwegian-Greenland Sea (Bjørklund 1976; Petrushevskaya & Kozlova 1979); middle Eocene (this study).

REMARKS

The difference between the holotype and our species is in the structure and size of the first segment.

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APPENDIX

The data on taxa of Radiolaria in each sample.

WELL 730, VILLAGE PETROPAVLOVKA: BOTTOM 1 TOP 4

< 4 {37.00}, LOWER-EARLY MIDDLE EOCENE, KANEVSKY HORIZON
Pterocodon ampla; *Amphicraspedium* sp. aff. *murrayanum*; *Petalospyris tumidula*; *Prunopyle* sp. aff. *ovata*; *Heterosestrum formosum trispinum* emend.; *Amphisphaera gonioxyphos*; *Periphaena perplexus*; *Druppatractus trichopterus*; *Lophocyrtis* ex. gr. *Calocyclas semipolita*; *Spiromultitunica* sp. aff. *Prunopyle hayesi*; *Stylotrochus festivus*.

< 3 {38.80}, LOWER-EARLY MIDDLE EOCENE, KANEVSKY HORIZON
Amphicraspedium murrayanum; *Clathrocyclas* ex. gr. *universa*; *Dictyoprora urceolus*; *Tripodiscinus* sp.; *Petalospyris argiscus*; *Lychnocanoma* sp. aff. *bandyca*; *Botryostrobus* sp.; *Rhopalocanium satelles*; *Amphisphaera minor minor*; *Pterocodon ampla*; *Periphaena perplexus*; *Petalospyris* sp. aff. *septenaria*; *Mita* cf. *regina*; *Lophocyrtis* ex. gr. *C. semipolita*; *Ommatogramma* sp. aff. *S. biconstrictus*.

< 2 {43.70}, LOWER EOCENE, KANEVSKY HORIZON
Stylotrochus festivus; *Periphaena perplexus*; *Dictyoprora urceolus*; *Heterosestrum formosum trispinum* emend.; *Peripyramis magnifica magnifica*; *Petalospyris tumidula*; *Periphaena decora*; *Phormocyrtis* sp.; *Plectodiscus circularis*; *Pterocodon ampla*; *Spiromultitunica* sp. aff. *Prunopyle hayesi*; *Botryostrobus* sp.; *Prunobrachium* (?) sp.; *Spongodiscus* ex. gr. *cruciferus*; *Calocyclas* sp. aff. *barbadensis*; *Spongoprunum* (?) *probus*.

< 1 {44.30}, LOWER EOCENE, KANEVSKY HORIZON
Pterocodon ampla longispina n. comb.; *Thecosphaera californica*; *Thecosphaera* sp. A; *Plectodiscus circularis*; *Spongoprunum* (?) *probus*; *Mita* cf. *regina*; *Amphicraspedium praemurrayanum*; *Pterocodon ampla*; *Phormocyrtis* sp. aff. *embolum*; *Petalospyris argiscus*; *Periphaena perplexus*; *Amphymenium splendiarmatum*; *Periphaena decora*; *Petalospyris tumidula*; *Spongodiscus* ex. gr. *S. cruciferus*; *Euscenarium* (?) sp.; *Stylodictya targaeformis*; *Rhopalocanium pyramis*; *Lophocyrtis* ex. gr. *C. semipolita*; *Lithocyclia lenticulata*; *Dictyoprora urceolus*; *Spongoprunum* (?) *probus*; *Druppatractus trichopterus*; *Ommatogramma biconstrictus*; *Periphaena* sp. aff. *Heliodiscus inca*; *Cycladophora* cf. *Pterocorys bicornis*; *Lithostrobus picus*; *Amphisphaera megaxyphos trixyphos*; *Haliomma* (?) *faceta*; *Lychnocanoma bellum longipes*; *Podocyrtis* cf. *papalis*; *Rhopalocanium satelles*; *Thecosphaera rotunda*.

WELL 510C, VILLAGE PIROGOVO: BOTTOM 1 TOP 5

< 5 {36.00}, MIDDLE EOCENE, KIEVSKY HORIZON, FEDOROVSKAYA FORMATION
Amphisphaera megaxyphos megaxyphos; *Heterosestrum formosum*; *Conoactinomma* sp. aff. *Conosphaera stilloformis*; *Porodiscus charlestonensis*; *Ceratocyrtis charlestonensis*; *Tripodiscinus kaptarenkoae*; *Carposphaera globosa*; *Ceratocyrtis stigi*; *Calocyclas asperum*; *Peripyramis magnifica victori*; *Anthocyrtidium pupa*; *Periphaena quadrata*.

< 4 {38.00}, MIDDLE EOCENE, KIEVSKY HORIZON, FEDOROVSKAYA FORMATION
Lophocyrtis auriculaleporis; *Amphisphaera megaxyphos megaxyphos*; *Heterosestrum formosum*; *Axoprunum visendum*; *Anthocyrtidium pupa*; *Calocyclas asperum*; *Ceratocyrtis charlestonensis*; *Lithomelissa spongiosa*; *Hexacontium* sp.; *Ceratocyrtis stigi*; *Periphaena linckaiformis*; *Tripodiscinus kaptarenkoae*.

< 3 {40.00}, MIDDLE EOCENE, KIEVSKY HORIZON, FEDOROVSKAYA FORMATION
Periphaena heliasteriscus; *Desmospyris* ex. gr. *anthocyrtoides*; *Ceratocyrtis charlestonensis*; *Lithomelissa spongiosa*; *Thecosphaera* sp. aff. *californica*; *Porodiscus charlestonensis*; *Periphaena perplexus*; *Stylotrochus festivus*; *Thecosphaera* sp. A; *Anthocyrtidium pupa*; *Ceratocyrtis stigi*; *Calocyclas asperum*; *Hexacontium* sp.; *Heterosestrum formosum*; *Periphaena pentasteriscus*; *Thecosphaera magnaporulosa*; *Ceratocyrtis* sp. aff. *stigi*; *Desmospyris anthocyrtoides*; *Lithomelissa* sp. aff. *ehrenbergi*; *Tripodiscinus kaptarenkoae*; *Thecosphaera rotunda*.

< 2 {42.00}, MIDDLE EOCENE, KIEVSKY HORIZON, FEDOROVSKAYA FORMATION
Conoactinomma sp. aff. *Conosphaera stilloformis*; *Peripyramis magnifica magnifica*; *Anthocyrtidium pupa*; *Calocyclas asperum*; *Ceratocyrtis charlestonensis*; *Lychnocanium* sp. B; *Hexacontium* (?) sp.; *Cycladophora* cf. *P. bicornis*; *Giraffospyris didiceros*; *Lophocyrtis auriculaleporis*; *Velicucullus* sp. aff. *oddgurneri*; *Hexacontium* sp.; *Porodiscus charlestonensis*; *Calocycletta* cf. *virginis*; *Periphaena perplexus*; *Tricolocapsa papillosa mediterranea*; *Tripodiscinus kaptarenkoae*; *Stylotrochus festivus*; *Axoprunum visendum*; *Lithomelissa spongiosa*; *Heterosestrum formosum bispina*; *Amphisphaera gonioxyphos*.

< 1 {44.00}, MIDDLE EOCENE, KIEVSKY HORIZON, FEDOROVSKAYA FORMATION
Amphisphaera gonioxyphos; *Ceratocyrtis charlestonensis*; *Periphaena perplexus*; *Giraffospyris didiceros*; *Axoprunum visendum*; *Ceratocyrtis* sp. aff. *stigi*; *Clathrospyris sandellae*; *Tripodiscinus kaptarenkoae*; *Lychnocanium* sp. B; *Calocyclas asperum*; *Callimitra clavipes*; *Calocyclas talwanii*; *Peripyramis magnifica magnifica*; *Spongodiscus* ex. gr. *cruciferus*; *Theocorys anaclasta*; *Lychnocanium* sp. A; *Desmospyris anthocyrtoides*; *Heterosestrum formosum bispinum* emend.; *Lophocyrtis auriculaleporis*; *Calocycletta* cf. *virginis*; *Hexacontium pachydermum*; *Thecosphaera* sp. aff. *californica*; *Triactis triactis*; *Porodiscus charlestonensis*; *Velicucullus* sp. aff. *oddgurneri*; *Hexacontium* sp.; *Stylotrochus festivus*; *Lithomelissa spongiosa*; *Anthocyrtidium pupa*.

OUTCROP 294, VILLAGE BALTINOVSKY: BOTTOM 1 TOP 10

< 10 {B2 3.20}, late Eocene, Obykhovsky Horizon, Derezovskaya Formation
Periphaena perplexus; *Clathrospyris sandellae*; *Desmospyris anthocyrtoides*; *Ceratocyrtis stigi*; *Theocorys anaclasta*; *Calocyclas talwanii*; *Theocyrtis scolopax*; *Lithomelissa spongiosa*; *Lophocyrtis andriashevi*; *Ceratocyrtis rhabdophora rhabdophora*; *Thecosphaera californica*; *Stylotrochus festivus*; *Porodiscus charlestonensis*; *Plectodiscus circularis*; *Anthocyrtidium pupa*; *Thecosphaera rotunda*.

< 9 {B2 4.30}, late Middle Eocene, Kievsky Horizon, Fedorovskaya Formation
Calocyclas talwanii; *Phormocyrtis* sp. aff. *embolum*; *Lithomelissa spongiosa*; *Porodiscus charlestonensis*; *Theocyrtis litos*; *Desmospyris anthocyrtoides*; *Calocyclas* sp. aff. *asperum* Ehrenberg form B; *Clathrospyris sandellae*; *Ceratocyrtis stigi*; *Thecosphaera* sp. A; *Periphaena heliasteriscus*; *Tripodiscinus kaptarenkoae*; *Calocyclas undella*; *Anthocyrtidium pupa*.

<8 {B2 5.30}, late middle Eocene, Kievsky Horizon, Fedorovskaya Formation
Tripodiscinus kaptarenkoae; *Lithomelissa* sp. aff. *ehrenbergi*; *Amphisphaera megaxyphos tetraxyphos*; *Ceratocyrtis stigi*; *Callimitra clavipes*; *Theocyrtis scolopax*; *Theocorys anapographa*; *Petalospyris* sp. aff. *septenaria*; *Druppatractus trichopterus*; *Periphaena linckaiformis*; *Hexaspyris morkleyensis*; *Lithocyclia lenticulata*; *Porodiscus charlestonensis*; *Phormocyrtis* sp. aff. *embolum*.

< 7 {B2 6.30}, late middle Eocene, Kievsky Horizon, Fedorovskaya Formation
Lithocyclia lenticulata; *Lophocyrtis* ex. gr. *T. andriashevi*; *Tripodiscinus kaptarenkoae*; *Amphisphaera megaxyphos tetraxyphos*; *Druppatractus polycentrus*; *Lychnocanium* sp. B; *Theocorys anapographa*; *Lithomelissa* sp. aff. *spongiosa*; *Porodiscus charlestonensis*; *Anthocyrtidium pupa*; *Ceratocyrtis stigi*; *Callimitra clavipes*; *Periphaena heliasteriscus*; *Tricolocapsa papillosa mediterranea*; *Periphaena perplexus*; *Phormocyrtis* sp. aff. *embolum*; *Peripyramis magnifica victori*.

< 6 {B2 7.30}, middle Eocene, Kievsky Horizon, Fedorovskaya Formation
Spongodiscus ex. gr. *cruciferus*; *Lophocyrtis norvegiensis*; *Ceratocyrtis rhabdophora rhabdophora*; *Calocyclas asperum*; *Anthocyrtidium pupa*; *Ceratocyrtis stigi*; *Phormocyrtis* sp. aff. *embolum*; *Theocorys anapographa*; *Calocyclas talwanii*; *Ellipsostylus anisoxyphos*; *Peripyramis magnifica victori*; *Thecosphaera* sp. A; *Lophocyrtis auriculaleporis*; *Desmospyris anthocyrtoides*; *Porodiscus charlestonensis*; *Lithomelissa spongiosa*.

< 5 {B2 8.30}, middle Eocene, Kievsky Horizon, Fedorovskaya Formation
Theocotyle venezuelensis; *Peripyramis magnifica magnifica*; *Clathrospyris sandellae*; *Anthocyrtidium pupa*; *Porodiscus charlestonensis*; *Phormocyrtis* sp. aff. *embolum*; *Ellipsostylus anisoxyphos*; *Amphicraspedium murrayanum*; *Axoprunum visendum*; *Lithomelissa spongiosa*; *Callimitra* sp. aff. *T. clavipes*; *Lithomelissa* sp. aff. *spongiosa*; *Pterocodon* ex. gr. *T. ampla*; *Theocyrtis scolopax*; *Calocyclas talwanii*; *Desmospyris anthocyrtoides*; *Tholospyris acuminata*; *Ceratocyrtis rhabdophora rhabdophora*; *Theocorys anaclasta*; *Periphaena perplexus*; *Callimitra* cf. *atavia*.

< 4 {B2 9.30}, middle Eocene, Kievsky Horizon, Fedorovskaya Formation
Amphisphaera minor minor; *Ceratocyrtis charlestonensis*; *Trypansosphaera* sp. aff. *Conosphaera abstrusa*; *Amphisphaera megaxyphos megaxyphos*; *Porodiscus charlestonensis*; *Thecosphaera* sp. A; *Ceratocyrtis stigi*; *Lophocyrtis* ex. gr. *T. andriashevi*; *Lophocyrtis auriculaleporis*; *Tripodiscium* sp.; *Ceratocyrtis rhabdophora rhabdophora*; *Clathrocyclas* ex. gr. *universa*; *Anthocyrtidium pupa*; *Amphicraspedium murrayanum*; *Phormocyrtis* sp. aff. *embolum*; *Clathrospyris sandellae*; *Theocorys anapographa*; *Calocycletta* cf. *virginis*; *Desmospyris* ex. gr. *anthocyrtoides*; *Petalospyris* sp. aff. *argiscus*; *Trypansosphaera* sp. aff. *Conosphaera abstrusa*.

< 3 {B2 12.20}, middle Eocene, Kievsky Horizon, Fedorovskaya Formation
Periphaena sp. aff. *Heliodiscus hexasteriscus*; *Hexacontium* sp.; *Lophocyrtis* ex. gr. *T. andriashevi*; *Theocorys anaclasta*; *Periphaena perplexus*; *Anthocyrtidium pupa*; *Tripodiscinus kaptarenkoae*; *Heterosestrum formosum*; *Ceratocyrtis stigi*; *Dorylonchidium fructiforme*; *Lophocyrtis norvegiensis*; *Ceratocyrtis charlestonensis*; *Calocyclas talwanii*; *Porodiscus charlestonensis*; *Lithomelissa* sp. aff. *spongiosa*; *Lophocyrtis* ex. gr. *C. semipolita*; *Callimitra clavipes*; *Heterosestrum formosum bispina*; *Clathrospyris sandellae*.

< 2 {B2 12.80}, middle Eocene, Kievsky Horizon, Fedorovskaya Formation
Amphisphaera megaxyphos megaxyphos; *Porodiscus charlestonensis*; *Lophocyrtis* ex. gr. *T. andriashevi*; *Stylotrochus festivus*; *Peripyramis magnifica magnifica*; *Lophocyrtis auriculaleporis*; *Anthocyrtidium pupa*; *Lophocyrtis sinitzini*; *Heterosestrum formosum*; *Callimitra clavipes*; *Calocyclas talwanii*; *Tripodiscinus kaptarenkoae*; *Ceratocyrtis charlestonensis*; *Theocorys anaclasta*; *Amphisphaera minor minor*; *Theocotyle venezuelensis*; *Ceratocyrtis stigi*; *Periphaena* sp. aff. *H. hexasteriscus*.

< 1 {B2 16.20}, Middle Eocene, Kievsky Horizon, Fedorovskaya Formation
Triactis triactis; *Lithomelissa spongiosa*; *Porodiscus charlestonensis*; *Calocyclas talwanii*; *Lophocyrtis auriculaleporis*; *Heterosestrum formosum bispina*; *Axoprunum visendum*; *Amphisphaera megaxyphos megaxyphos*; *Ceratocyrtis stigi*; *Petalospyris tumidula*.

OUTCROP S1, VILLAGE SERGEEVKA: BOTTOM 1 TOP 5

< 5 {S3 14.20}, late middle Eocene, Obykhovsky Horizon, Derezovskaya Formation

Lithomelissa spongiosa; *Hexacontium* sp.; *Lophocyrtis* ex. gr. *T. andriashevi*; *Tripodiscinus kaptarenkoae*; *Calocyclas asperum*; *Periphaena heliasteriscus*; *Ceratocyrtis* sp. aff. *H. amplus*; *Anthocyrtidium pupa*.

< 4 {S3 15.80}, late middle Eocene, Obykhovsky Horizon, Derezovskaya Formation
Calocyclas sp. aff. *asperum* form B; *Petalospyris tumidula*; *Axoprunum visendum*; *Actinommura* sp. B; *Thecosphaera* sp. A; *Periphaena* sp. aff. *H. hexasteriscus*; *Ceratocyrtis* sp. aff. *H. amplus*.

< 3 {S3 30.80}, lower middle Eocene, Buchaksky Horizon
Spongodiscus ex. gr. *cruciferus*; *Spiromultitunica* sp. aff. *P. hayesi*.

< 2 {S3 35.50}, lower middle Eocene, Buchaksky Horizon
Hexacontium sp.; *Lophocyrtis norvegiensis*; *Ceratocyrtis charlestonensis*; *Periphaena perplexus*; *Desmospyris anthocyrtoides*; *Desmospyris* ex. gr. *anthocyrtoides*; *Heterosestrum formosum*; *Axoprunum visendum*; *Phormocyrtis* sp. aff. *embolum*; *Pterocodon lex*; *Calocyclas extensa contracta*; *Stylotrochus festivus*; *Calocyclas asperum*; *Periphaena heliasteriscus*; *Ceratocyrtis stigi*; *Thecosphaera* sp. aff. *californica*; *Amphisphaera gonioxyphos*.

< 1 {S3 39.30}, lower middle Eocene, Buchaksky Horizon
Druppatractus trichopterus; *Porodiscus charlestonensis*.