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Abstract—Despite the fact that crinoids were an important component of the benthic communities in the Early Carboniferous seas of central European Russia, their remains have been only poorly studied so far. The present work partly fills this gap in knowledge. In addition to the description of these fossils, attention is paid to blastoids and other organisms from the same faunas, as well as to localities where crinoids and blastoids are abundant. This study may be of interest to paleontologists and geologists.

INTRODUCTION

Crinoids are widespread in the Upper Carboniferous deposits of the central European Russia, being an important element of the benthic communities; nevertheless, they are extremely poorly understood. Better studied are the Middle–Late Carboniferous crinoids of this region. Nevertheless, their sampled remains are only partially described; the number of species and genera to be described is approximately the same as the number of previously described taxa; and the discovery of many new forms is not inconceivable. Such poor knowledge of these fossils is attributable to the very limited number of specialists, insufficient state of collections, and poor study of sampled remains.

In the former USSR, the last four decades were marked by an enhanced interest to columns of extinct crinoids because they are most widespread amid crinoid remains. Nevertheless, they are almost completely ignored in the last years. Moreover, the researchers who studied columns of Ordovician, Silurian, Devonian, and, partly, Early Carboniferous crinoids did not pay attention to the Carboniferous deposits of the Russian Platform.

Several decades earlier (1956–1958), I studied the Lower Carboniferous sections in the southern and, partly, northwestern flanks of the Moscow Syneclise and sampled various fossils from these localities. These works contributed to the paleoecological studies that were carried out by R.F. Hecker, A.I. Osipova, and T.N. Belskaya in the Paleontological Institute of the Academy of Sciences of the USSR (subsequently, the Paleontological Institute of the Russian Academy of Sciences, Moscow) (Osipova *et al.*, 1965, 1967, 1971, 1975). Simultaneously, I sampled echinoderms and examined most of them (according to the recommendation by Hecker); the study of certain forms was accomplished later (Arendt, 1959a, 1959b, 1960, 1962, 1981). The present work is dedicated to the description of crinoid columns (which were mainly performed late in the 1950s), calyces of crinoids and microcrinoid forms found in old collections. In addition, other pelmatozoan echinoderms, i.e., the blastoid *Orbitremites musatovi* first discovered in 1956 (Arendt, 1960, 1967), are described.

Simultaneously, I present here a description and the correlation of certain sections previously exposed along the Oka River near the town of Tarusa, the village of Mitino, and others, but now mostly buried under landslides. The main attention is paid to the Steshev Horizon of the Lower Serpukhovian Substage, where echinoderms are particularly abundant and diverse. The material sampled in different horizons was previously substantially more representative, but unfortunately most of the collection was lost during the many movements. I hope that the description presented here will be of some use for researchers.

Most of species described in the work were collected by Yu.A. Arendt. Some specimens were collected by A.I. Osipova, T.N. Belskaya, and S.V. Rozhnov. Invertebrates sampled by the Paleoecological party from the PIN were determined by T.A. Dobrolyubova and N.V. Kabakovich (corals), T.G. Sarycheva (brachiopods), and by other specialists. A.I. Osipova, who was always interested in my work, revised some of these determinations, and I am deeply grateful to her.

Almost all determinations of crinoid columns were performed with the assistance of the late G.A. Stukalina. Almost all of these determinations, which made possible this work, remained unchanged. We were going to prepare this monograph together, but, unfortunately, this idea was not realized. I will always remember G.A. Stukalina with the special gratitude.

I am also very obliged to L.A. Nevesskaya, A.A. Shevyrev, A.S. Alekseev, S.V. Rozhnov, R.V. Goryunova, M.R. Hecker, A.O. Kuz'min, E.A. Zhegallo, I.O. Renga, I.A. Rodionova, and D.D. Shterenberg for their valuable comments and help in preparing the manuscript.

The studied collection is stored at the Paleontological Institute of the Russian Academy of Sciences (PIN), nos. 1557 and 4106.

CHAPTER 1. DESCRIPTION OF CRINOIDS AND BLASTOIDS

CLASS CRINOIDEA MILLER, 1821

SUBCLASS CAMERATA WACHSMUTH ET SPRINGER, 1885

Order Diplobathrida Moore et Laudon, 1843

Suborder Eudiplobathrina Ubaghs, 1953

Superfamily Rhodocrinitacea Roemer, 1855

Family Rhodocrinitidae Roemer, 1855

Genus *Rhodocrinites* Miller, 1821

***Rhodocrinites osipovae* Arendt, sp. nov.**

Plate 1, fig. 1

Etymology. In honor of A.I. Osipova.

Holotype. PIN, no. 1557/547, theca; town of Tarusa, Ignatova Gora quarry; Exposure 9d, Bed 38, Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part).[1]

Description. The theca of the holotype is significantly secondarily compressed. Some plates are displaced, and others are lost. It is obvious, however, that the calyx primarily had a wide and deep column-adjoining concavity. The theca is round and doughnut-shaped in the lower half and hemispheric–pyramidal in the upper half; primarily, it was most likely slightly compressed. A wide and deep column-adjoining concavity comprised the base, radials, and interprimibrachials. The near-column breakthrough that resulted from compression of the calyx yielded a complete infrabasal pentagonal circlet consisting of five plates that belonged almost undoubtedly to this specimen. The circlet is narrow, steeply concave, thin-plated, with a narrow rounded-angular axial canal. The column was probably significantly wider than this circlet.

The next basal circlet is represented by the largest three radials adjoining each other and a smaller basal. The radials are hexagonal and equal in size, their lower and upper sides are parallel to each other; they are in almost natural position. The basal is displaced and located away from the neighboring basal at a distance approximately equal to its width.

The bend between concave column-adjoining concavity and convex lateral surface of the calyx corresponds to another circlet of plates, large, though smaller than in the previous circlet, and located at the same level of regularly alternating larger first radials, deeply submerged into the calyx base, and slightly smaller interradials. The latter are located at the continuation of every plate of the underlying basal circlet, whereas the radials are between the first interradials.

The vertical continuation of the first radials bears two other smaller plates that are fixed first-order brachials, each distal of which is axillary. Every axillary has an attached second-order brachial bearing the free arm facet.

Such facets occupy about one-third of the external surface of every joined host second-order brachial, are steeply externally inclined and concave, and bear a deep notch for the ambulacrum. This notch is more or less vertically elongated, closed in the upper part, oval, and bounded by additional four plates from the sides and above; two plates located one above the other (the lower is the first second-order interbrachial, and the second is an overlying plate) are common for neighboring notches. The pairs of free arms are widely spaced rather than deviate from the calyx over the entire perimeter.

The radials were, thus, separated from each other by the first interradials, axillary plates located at the base of the first interbrachial zones. Each zone, extending to the free arms, probably comprised 9–12 plates, successively decreasing in size and arranged as follows: one at the base; then, two; three; four; and then, most likely, again three plates; the latter plates become the tegmen in the upper part.

The anal interray comprised a greater number of plates and was somewhat wider than the other interrays. The anal tube is absent, and the anus pierces the tegmen. The anus is rounded-angular, located in a small depression, and bounded by six plates. All plates of the calyx, except for the plates of the base and proximal parts of the radials and interprimibrachials, are strongly convex externally and have deep depressions in the articular zones at the corners. The plates composing the tegmen are undifferentiated and located irregularly; the oral plates are absent.

Dimensions, mm[2]

Specimen PIN, no.	H	W	D_{cc}	W_{cc}	Wa	H/W
Holotype 1557/547, theca	20.0(?)	32.0	12.0	14.0	1.8	0.63(?)

Comparison. The new species is similar to *R. baccatus* (Wright, 1942) from the Z-coral zone (after D. Hill) of the Viséan Stage of the Lower Limestone Group from Scotland. It differs from the latter in (1) slightly larger, relatively lower, and pentagonal in section theca, with a higher ambitus; (2) strongly concave wide column-adjoining cavity, which is formed by a dicyclic base and lower halves of the radials and the first interradials; (3) the larger fixed first second-order brachials with arm articular facets; (4) less regular lower second-order interbrachials; and (5) both regular and irregular interprimibrachials, at least in the holotype.

Remarks. The large column-adjoining depression of the calyx; the small and, probably, short (as is evident from their facets) free arms; and the absence of anal tube suggest adaptation to intense water flows.

Material. Holotype.

[1] Makhlina *et al.* (1993) believe that echinoderms assigned here to the lower part of the Steshev Horizon originate from the Glazechnino Subformation (C_1st_1), the lower unit of the Steshev Formation.

[2] Hereinafter the following designations are used: (A, B, C, D, and E) rays; (AB, BC, CD, DE, and EA) interrays; [IB(IBB)] infrabasals; [B(BB)] basals; [R(RR)] radials; [O(OO)] orals; (D^1) deltoid plate; (Hp) hypodeltoid; (Su) superdeltoid; (Cr) cryptodeltoid; (Hs) hydrospire; (Ht) hydrospire tube; (L) lancet plate; (S) spiracle; (AS) anal spiracle; (O^1) oral area; (A^1) ambulacral plates; (a) anus; (an) anal area; (ie) internal elevation; (re) elevation on the radial facet; (id) depression on the inner side of the plate; (ml) marginal limb; (cr) crenelles; (pa) plate articulation; (cd) central depression of the articular facet; (Brr) brachials; (H) maximum height of the skeleton or the height of segments and elements; (W) maximum width of the skeleton or the width of the segments and elements; (h) minimal height; (w) minimal width; (H_1, H_2, etc.) height of columnals of the first (nodal), second, and higher orders; (Dm) diameter of the columnal and column facet of the cup; (Dm_1) their maximum diameter; (Dm_2) their minimal diameter; (dm) diameter of the axial canal; (dm_1) maximum diameter of the axial canal; (dm_2) minimal diameter of the axial canal; (Dm_c) diameter of the cirrus; (H_c) height of the cirral; (ds) distance from the center of the axial canal to the middle of the anterior margin of the columnal; (Lh) length of the arm facet; (T) thickness of the arm facet; (Wcc) width of the column-adjoining cavity; (Dcc) depth of the column-adjoining cavity; and (N) number of crenelles (to the bifurcation).

Order Monobathrida Moore et Laudon, 1943

Suborder Glyptocrinina Moore, 1952

Superfamily Platycrinitacea T. Austin et T. Austin, 1842

Family Platycrinitidae T. Austin et T. Austin, 1842

Genus *Platycrinites* Miller, 1821

***Platycrinites tenuiplatensis* Arendt, sp. nov.**

Plate 1, figs. 2–8; Plate 2, figs. 1–6

Etymology. From the Latin *tenuiplatensis* (thin-plated).

Holotype. PIN, no. 1557/548, radial (incomplete) with proximal brachials; town of Tarusa, Ignatova Gora quarry; Exposure 9b, Bed 38, Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part).

Description (Figs. 1a–1c). The calyx is thin-plated and medium-sized. The basal circlet is regularly convex, usually tripartite, with two wide equidimensional plates and one, probably, EA interradial, half as wide as the others; one specimen is quinquepartite with one very narrow plate adjoining two three-fold wider plates and, in addition, two plates twice as wide as the first plate (most likely, this is an abnormal specimen; Pl. 1, fig. 6). The external areas along the sutures between the basals are sometimes marked by weak depressions, the distal ends of the sutures have small depressions.

The column facet occupies one-fifth to one-sixth of the maximum base diameter and is oval (the long axis of the oval does not coincide with the plane of the base symmetry but probably coincided with the plane of the calyx symmetry, A–C). The facet is shallow. The axial canal is very narrow, rounded, and irregular in shape or relatively large and pentagonal. The central area of the facet is smooth; in one specimen, it is strongly concaved (Pl. 1, fig. 2). An elevated or even narrow zone comprising 70–75 thin and low crenelles extends toward the periphery of the central area grading into a moderately wide smooth peripheral zone, which gently slopes outward.

The radials are moderately or rather strongly convex, with the height slightly larger than the width, with slightly downward-converging sides, curved lower side, and large abruptly diverging upper lateral parts. The thin arm facet is steeply inclined outward and one-third as wide as the distal margin of the plate. The facet surface is rough. In specimen PIN, no. 1557/549, the facet bears axillary of the same width, very low along the sides, and relatively high in the middle. The holotype has a high lower brachial, which occupies one-fifth of the facet width. The first second-order brachials of the holotype are twice as large as the others and occupy the arm facet surface free from the primaxils; these lateral areas are more elongated than the areas adjoining the primaxil. The brachial located above the left secundibrachial is also axillary and relatively large. The surfaces of the articular facets of these brachials are covered in places by weak, very thin, and closely spaced crenelles.

The columnals are of two orders: the first-order columnals are turning, and the second-order columnals are simple. The ratio between the turning and simple columnals is 1 : 10. The turning columnals are relatively high, with similar lower and upper articular facets located at an angle of 60–90° to each other. They are rounded-quadrangular, the lateral surfaces are convexo–concave, and the articular facets are similar to those of the simple columnals.

The simple columnals are small, oval in section, and elongated to a greater or lesser extent. The axial canal is hardly distinguishable and oval. The articular facet is slightly concave or flattened, varying in different specimens. The area along its long axis is usually occupied by a well-developed, gently sloping, and wide elevation, the articular ridge. The latter is either uniformly wide or, more frequently, slightly narrowing or, occasionally, widening toward the ends of the long axis of the oval. Some specimens bear significantly more distinct elevations, and in this case, the external margins of the articular facet are steeply raised. The opposite ends of the long axis of the articular ridge bear two to four well-developed radial denticles separated by grooves. The columnals are moderately high, and their lateral surfaces are even and almost always bear widely spaced tubercles (3 to 18) along the midline. The tubercles are relatively high and located at different distances from each other. Occasionally, there are significantly larger elevations amid them; they are flattened at the end and, occasionally, have a narrow canal in the center; however, these elevations hardly represent attachment areas for the cirri (sockets).

One specimen is a very small fragment of the column cirrus consisting of two elongated cirrals of different sizes (Pl. 2, fig. 3). Their articular facets are moderately and regularly concaved and have a relatively narrow rounded axial canal but lack articular ridge; the marginal rim bears 12–14 sharp denticles. The lateral surface of the smaller segment is strongly and gently concave, whereas that of the larger cirral is convex. One side of the latter has a large longitudinal oval articular facet with the longitudinal articular ridge and denticles along the entire margin. The facet was on the distal part of the column at the area of cirrus attachment. The column cirri are oval in section and lack articular ridges on the articular facet. This is likely an initial state of the column in platycrinitaceans, whereas the oval columnals with articular ridges are the secondary state.

Variability. In some specimens, the articular facets are more or less flattened or bear well-developed elevations along the long axis and the margin. Denticles are usually located along the margin of the articular facet; in some cases, they are relatively long and extend for approximately one-fourth of the axis length on each side. One specimen has a narrow elevation covered by poorly developed denticles along the entire margin of

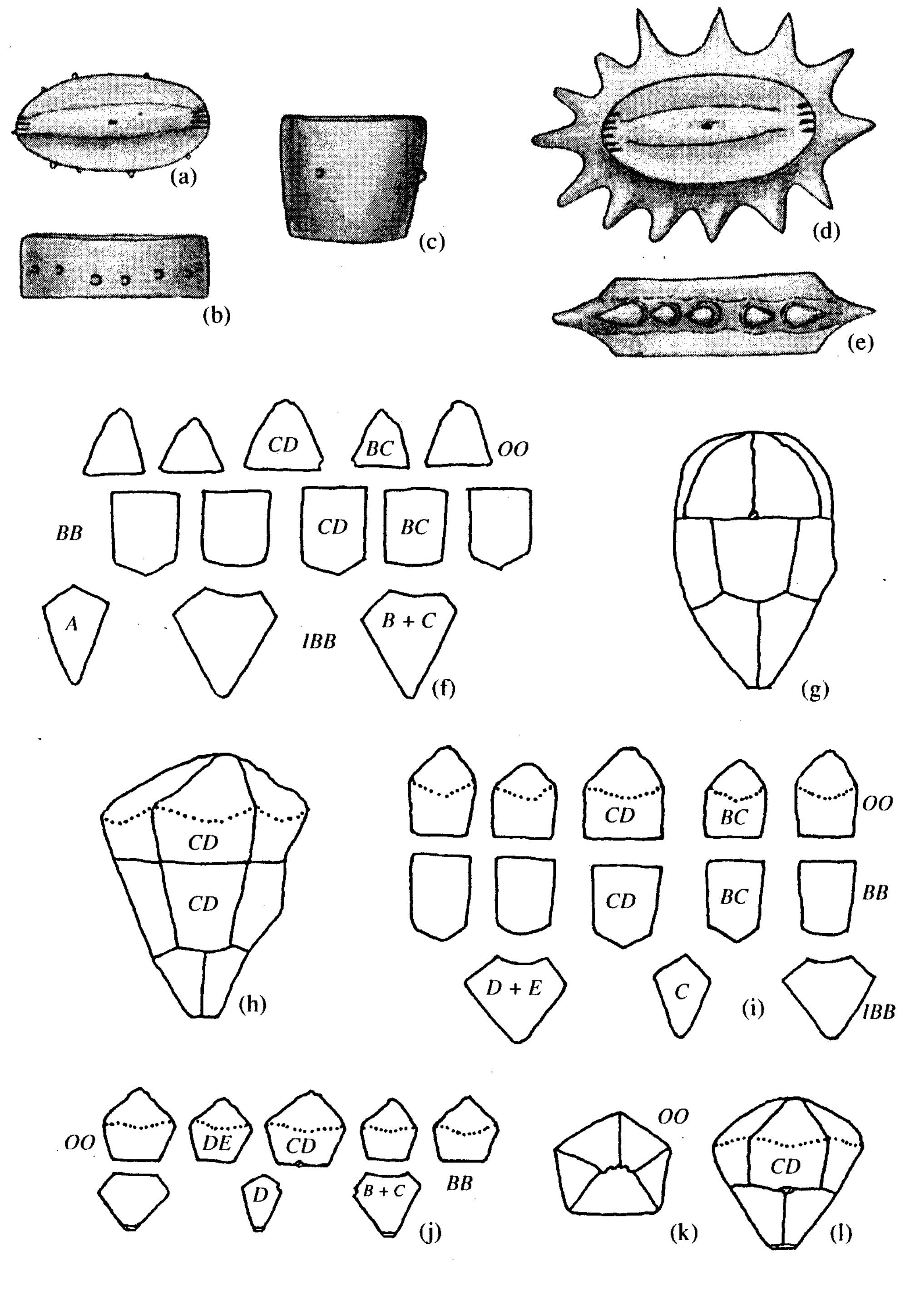


Fig. 1. Monobathrida (a–e) and Cyathocrinina (f–l). (a–c) *Platycrinites tenuiplatensis* Arendt, sp. nov.: (a, b) no. 1557/76, simple columnal: (a) articular facet view, (b) side view, (c) no, 1557/75, side view of the turning columnal, ×8; quarry near the village of Mitino, Exposure 11, Bed 38; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part); (d, e) *Platycrinites spinifer* Arendt, sp. nov.: no 1557/75a, simple columnal: (d) articular facet view, (e) side view, ×8; town of Tarusa, Ignatova Gora quarry, Exposure 9d, Bed 40; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part). (f, g) *Streptostomacrinus heckerae* Arendt, sp. nov., holotype, no. 1557/541: (f) elements of calyx, (g) side view of calyx, interray CD, ×40; town of Tarusa, Ignatova Gora quarry, Exposure 9d, Bed 40; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part); (h, j) *Okacrinus nodosus* Arendt, gen. et sp. nov., holotype, no. 1557/535: (h) side view of calyx, interray CD, ×40, (j) elements of calyx; the same locality; (i–l) *Amphipsalidocrinus astrus* Arendt, sp. nov., holotype, no. 1557/534: (j) elements of calyx, (k) top view, (l) side view, interray CD, ×40; town of Tarusa, Ignatova Gora quarry, Exposure 9d, Bed 39; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part). For letter designations see Footnote 2.

the articular facet. In the specimen demonstrated in Pl. 2, fig. 4, the columnal has a tendency to transition from a biradiate symmetry to the bilateral symmetry.

Dimensions, mm

Specimen PIN, no.	Dm	W_{BB}	H_R	W_R	Lh	
Cup fragments:						
Holotype 1557/548	–	–	16.5	18.0	7.0	
1557/549	–	–	13.9	15.0	7.0	
1557/553	5.6	30.0	–	–	–	
1557/554	5.6	22.8	–	–	–	
Columnals:	Dm_1	Dm_2	dm	H	Dm_1/Dm_2	H/Dm_2
1557/81, turning	4.0	3.0	0.1	2.0	1.33	0.67
1557/87	6.0	3.5	0.1	2.5	1.70	0.70
1557/83	6.8	5.0	0.1	2.5	1.36	0.50
1557/75	5.0	3.0	0.1	2.5	1.67	0.83
1557/76	4.5	2.8	0.1	1.7	1.61	0.61

Comparison. The new species differs from the close form *P. gigas* (Phillips) from the Lower Carboniferous of Scotland in the lower base and proportions of radials (they are wider in the lower rather than upper part), wider arm facets where the primibrachials are narrower than the latter. It differs from *P. (?)tuberculatus* Yakovlev from the Upper Carboniferous of the Fergana Depression in smaller dimensions of the columnals, and the presence of denticles at the margins of the articular ridge. In the new species, the medial region of the lateral surface of the columnals has a larger number of tubercles. *P. tenuiplatensis* also shows a great similarity to *P. permiensis* Yakovlev from the Lower Permian of the Fore-Urals, differing from the latter by the absence of rounded (in cross section) columnals and crenelles on the margin of the articular facets. From *P. schmidti* Stuckenberg from the Lower Permian of the Indiga River it differs in noticeably smaller dimensions of columnals, less concave articular facet, occasional presence of crenelles at its periphery, and in a more dense arrangement of tubercles at the midline of the lateral surface.

Remarks. The Middle Carboniferous species *Platyplateium notatum* (Eichwald) from the Moscow Region probably has similar localization of first- and second-order columnals. The new species differs from the latter in substantially smaller columnals, usually wider and oval second-order columnals, less concave or frequently almost flat articular facets, and in flat or less concave lateral surfaces, almost always having tubercles at the midline, including widely spaced large ones with flattened distal parts. The first-order columnals of *P. tenuiplatensis* are relatively higher and slightly differ in shape.

Occurrence. Serpukhovian Stage, Lower Serpukhovian Substage, Tarusa and Steshev horizons; southern Moscow basin.

Material. Ten columnals from the town of Tarusa, Ignatova Gora quarry; Tarusa Horizon (top), Exposure 9d, Bed 34, limestones; 20 columnals, three bases, and five radials, mostly incomplete, from the town of Tarusa, Ignatova Gora quarry; Steshev Horizon (lower part), Exposure 9b–9d, Beds 38–40, marls, limestones; and 35 columnals from a quarry near the village of Mitino; Steshev Horizon (lower part), Exposure 11, Bed 38, marls.[3]

Platycrinites spinifer Arendt, sp. nov.

Plate 2, figs. 7 and 8

Etymology. From the Latin *spinifer* (bearing spines).

Holotype. PIN, no. 1557/512, well-preserved columnal; town of Tarusa, Ignatova Gora quarry; Exposure 9b, Bed 38, Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part).

Description (Figs. 1d and 1e). Small columnals with a very narrow and almost round axial canal. The articular facet is wide and oval, with a wide, poorly expressed, gently sloping, and fusiform or flat elevation along the longitudinal axis, i.e., the articular ridge. The opposite ends of the ridge located on the margins of ring elevation bounding the facet bear 3–8 distinct short radial denticles. The areole almost lacks elevations and varies from slightly to strongly concave. The perilumen is weakly developed and, in some cases, lowered relative to the lateral parts of the articular ridge.

The lateral surface of the columnals is moderately high and protrudes as a wide keel, the base of which extends for almost entire width of the surface. The keel terminates in 5–14 long thorns, wide at the base, and slightly compressed in the lower and upper parts (in the holotype). The thorns vary in length and thickness and are frequently located at different distances from each other. Some of them are broken, whereas others are primarily truncated at the ends and have a narrow axial canal. This concerns a tiny columnal of a juvenile, the thorns of which are widely spaced, always truncated, and cylindrical in shape. The areole of this specimen is significantly deeper, and the number of denticles is smaller than in adult, i.e., the holotype.

Dimensions, mm

Specimen PIN, no.	Dm_1	Dm_2	dm	H	Dm_1/Dm_2	H/Dm_2
Holotype 1557/512a	3.3	2.5	0.03	1.5	1.32	0.60
1557/500	1.2	1.0	0.03	0.8	1.20	0.75

Comparison. By the dimensions of columnals and the pattern of the articular facet, this new species is very similar to *P. tenuiplatensis*, differing from the latter by a larger number of radial denticles on the articu-

[3] Recently, Beds 33–37 are usually referred to as the Tarusa Horizon, which is supported, for instance, by the data on corals (Hecker, 1997; etc.).

lar facet of adults and by the presence of a large keel with long thorns on the lateral surface of the columnal.

Remarks. The presence of only two columnals of a juvenile and a three times larger adult, together with impossibility to establish the position of these elements in the column do not allow for the reliable reconstruction of ontogenetic changes. However, they most likely included the following: (1) the axial canal becomes relatively narrower; (2) the articular ridge (initially divided into two parts in the middle) joined to become fusiform rather than straight in section; (3) the number of radial denticles increases at both ends of the long axis of the articular ridge; (4) the lateral keel is slightly widened; (5) the number of keel thorns considerably increases because of the formation of new thorns between the widely spaced juvenile ones; (6) the cylindrical and truncated thorns become conical and tapering; and (7) the internal open canals that stimulated the thorn growth become closed.

Material. Two well-preserved columnals from the type locality.

SUBCLASS INADUNATA WACHSMUTH ET SPRINGER, 1885

Order Disparida Moore et Laudon, 1943

Superfamily Allagecrinacea Carpenter et Etheridge, 1881

Family Allagecrinidae Carpenter et Etheridge, 1881

Genus *Kallimorphocrinus* Weller, 1830

***Kallimorphocrinus scoticus* (Wright, 1932)**

Plate 3, figs. 1–4

Kallimorphocrinus scoticus: Wright, 1932, p. 35, pl. 23–25, figs. 1–35; 1952, p. 143, pl. 40, figs. 1 and 4–6; text-fig. 75; Bassler and Moodey, 1943, p. 528; Webster, 1973, p. 160.

Description. The theca is pyriform–pyramidal with a moderately extended base, rounded–pentagonal in the distal part, and with a flattened domed tegmen. The column facet is wide, rounded, lacking crenelles, and with the surface slightly declining toward the axial canal. The axial canal is occasionally fringed by a small triangular depression; the canal is very narrow, capillary or only little wider, and stellate in cross section. The base is low and tripartite, with a small A plate and distinct or indistinguishable boundary between two large but differing in size CD plates.

The radials are rather high with wide longitudinal keel-shaped elevations expanding upward. Each terminates in a large and deep arm facet at the base of boundaries between adjacent oral plates, which is characteristic of allagecrinaceans. The radials are moderately elongated outward at the facet bases. The orals bear gently sloping and weak elevations along the boundaries and wide small depressions along the midline. The madreporite on the CD oral is indistinguishable, and the madreporite tubercle is absent. Each oral wedges to the upper part of the boundary between two adjacent radials. The arm facet is slightly wider than one-third of the distal margin of the radial. The facets are tear-drop- or onion-shaped in section.

The facets of the smallest specimen (PIN, no. 1557/537) and the second smallest specimen (PIN, no. 1557/536) are not developed, but in places, slitlike expansions are seen on two orals at the boundary with the radial. The basals and orals in these specimens are much higher than in the largest specimens. The column facets are very narrow, and the basals occasionally curve somewhat sideways. Specimen PIN, no. 1557/536 has a distinct *Trophocrinus*-like projection located slightly below the middle of two adjacent orals. However, a similar protrusion of *Trophocrinus* only extends to the orals, being located on the adjacent radials. Two considered specimens are at relatively early ontogenetic stages, prior to the arm formation.

Dimensions, mm

Specimen PIN, no.	H	W	H_{BB}	H_{RR}	H_{OO}	Dm	H/W
1557/532	1.2	1.1	0.1	0.8	0.3	0.3	1.09
1557/533	1.1	0.7	0.1	0.8	0.2	0.3	1.59
1557/536	0.5	0.3	0.2	0.2	0.2	0.03	1.67
1557/537	0.3	0.3	0.1	0.1	0.1	0.04	1.00

Remarks. This species was previously recorded only in the Lower Carboniferous of Scotland: Bed 1 "Invertiel," the Lower Limestone Group, Z coral zone after D. Hill. Wright (1952) mentioned the material of 2000 calyces from the same bed.

Occurrence. The Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (bottom); southern Moscow basin; and Lower Limestone Group of the Lower Carboniferous of Scotland.

Material. Four well-preserved thecae from the town of Tarusa, Ignatova Gora quarry; Exposure 9d, Bed 38; and a quarry near the village of Mitino; Exposure 11, Bed 38; Steshev Horizon (lower part).

Order Cladida Moore et Laudon, 1943

Suborder Cyathocrinina Bather, 1899

Superfamily Hypocrinacea Wanner, 1916

/nom. transl. Arendt, 1970 (ex Hypocrinidae Wanner, 1916)/

/=Cordiacrinacea Bather, 1890 (pars) (nom. transl. Lane, 1967, ex. subfam. *Codiacrinites* Bather, 1890 (pars)/

Family Sycocrinitidae Lane, 1967

Genus *Streptostomocrinus* Yakovlev, 1927

***Streptostomocrinus heckerae* Arendt, sp. nov.**

Plate 4, figs. 1–6

Etymology. In honor of M.R. Hecker.

Holotype. PIN, no. 1557/541, well-preserved theca; town of Tarusa, Ignatova Gora quarry; Exposure 9d, Bed 38, Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part).

Description (Figs. 1f and 1g). The calyx is differently, sometimes, strongly elongated, without constrictions, usually rounded–pentagonal or, sometimes, pentagonal in section at the level of ambitus between the basals and orals. The column facet is narrow, smooth, rounded in section, and flat, with a narrow round axial canal. The cup is high and conical, and its boundary with the gently convex and, sometimes, lopsided tegmen is obscure. There are three infrabasals, i.e., a small A and the boundaries of two larger plates within the CD. The basals are high, often with a weak longitudinal ridge. The hydropore is usually present, whereas periproct is absent.

Dimensions, mm

Specimen PIN, no.	H	W	H_{IBB}	H_{BB}	H_{OO}	Dm	H/W
Holotype 1557/541	0.6	0.4	0.2	0.2	0.2	0.1	1.50
1557/538, damaged	–	0.3	–	0.2	0.2	–	–
1557/539	0.6	0.3	0.2	0.2	0.2	0.02	2.00
1557/540	0.6	0.4	0.2	0.2	0.2	0.1	1.50
1557/542	0.6	0.3	0.1	0.2	0.2	0.1	1.67
1557/543	0.6	0.4	0.2	0.2	0.2	0.1	1.50

Comparison. From the most similar form, *S. tsherepanovae* Arendt, the considered species differs by smaller dimensions of the theca, a higher position of the ambitus, greater variability of the theca shape, and by the proportions of the circlets.

Occurrence. Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part); southern Moscow basin.

Material. Seven well-preserved thecae: four from the town of Tarusa, Ignatova Gora quarry; Exposure 9d, Bed 38; and three from a quarry near the village of Mitino; Exposure 11, Bed 38; Steshev Horizon (lower part).

Family Lageniocrinidae Arendt, 1970

Genus *Okacrinus* Arendt, gen. nov.

Etymology. After the Oka River.

Type species. *O. nodosus* Arendt, sp. nov.; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon; southern Moscow basin.

Diagnosis. Theca small, subpyriform, rounded–pentagonal in section, consisting of three almost equally high circlets, i.e., infrabasal, basal, and oral circlets. Three infrabasals present: small A and two larger with CD boundary. In center of each basal, there large elevation, which rounded or slightly longitudinally elongated. Orals abruptly curved just below midheight, pentagonal, slightly stellate, and bilaterally symmetrical in position. Above ambitus, tegmen slightly elevated and with longitudinal elevations along orals. Five vertical protrusions of orals continued by protrusions of basals. Boundaries between orals continued by boundaries between basals without displacement relative to each other. Periproct, anus, and madreporite absent.

Species composition. Type species.

Comparison. The new genus sharply differs from the closest genus, *Neolageniocrinus*, by having the subpyriform (rather than subspherical) theca, slightly pentagonal and stellated in section; the ambitus located in the middle of the orals rather than at the boundary of the latter with the basals; and by the absence of madreporite. From the *Lageniocrinus*, it differs in smaller dimensions and shape of theca and the absence of external periproct and madreporite.

Remarks. It is probable that the considered specimens are juveniles of certain unknown hypocrinoids. However, no adults, which could be associated with the described forms, were found in the residues. Previously, I referred *Lageniocrinus cassidus* Weller, 1930 from the Lower Pennsylvanian of North America, also represented by small thecae, to the genus *Neolageniocrinus* Arendt, 1970. However, the similarity in the shape of the calyx, the absence of perforations in the latter, and similar dimensions suggest that it should probably be assigned to *Okacrinus*.

Okacrinus nodosus **Arendt, sp. nov.**

Plate 3, fig. 5

Etymology. From the Latin *nodosus* (tuberculate).

Holotype. PIN, no. 1557/535; town of Tarusa, Ignatova Gora quarry; Exposure 9d, Bed 38, Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part).

Description (Figs. 1h and 1i). The theca is small, pyriform, pentagonal, slightly stellate in section, with several rounded rays along the ambitus forming the extended parts of the orals. The slightly pyramidal appearance of the theca is determined by gently sloping longitudinal ridges that become more expressed from the middle of the bases of basals toward the rays of the star. There are flat depressions between elevations; they extend onto the gently convex distal margin of the calyx, which also bear grooves. The ribs in the middle parts of the basals bear several large and tapering tubercles (one in each plate). The circlet of the infrabasals consists of a small plate A and two large equidimensional plates with the CD boundary. This circlet is relatively high, conical, with moderately cut, narrow, and smooth column facet containing a narrow rounded axial canal. The boundaries between the orals and basals continue each other without displacement. The calyx ambitus is slightly below the midheight of the orals. The posterior oral lacking madreporite is larger than others. The external periproct is indistinguishable.

Dimensions, mm

Specimen PIN, no.	H	W	H_{IBB}	H_{BB}	H_{OO}	Dm	H/W
Holotype 1557/535	0.9	0.9	0.8	0.6	0.5	0.03	1.00

Material. Holotype.

Superfamily Amphipsalidocrinacea Arendt, 1970

Family Amphipsalidocrinidae Arendt, 1970

Genus *Amphipsalidocrinus* Weller, 1930

***Amphipsalidocrinus astrus* Arendt, sp. nov.**

Plate 5, fig. 3

Etymology. From the Latin *astrus* (stellate).

Holotype. PIN, no. 1557/534; theca; town of Tarusa, Ignatova Gora quarry; Exposure 9e, Bed 39, Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (bottom).

Description (Figs. 1j–1l). The calyx is low, abruptly and regularly widening upward, quinqueradiate, stellate with short rays in section near the ambitus, slightly compressed sagittally and widened frontally, with the laterally curved ray A, wide longitudinal elevations stretching to the rays, and wide longitudinal depressions between them. The theca consists of 11 plates, the arrangement of which is typical of the genus. The column facet is relatively wide. The axial canal is narrow and rounded. The infrabasal circlet consists of three plates, a small D and two larger plates with the boundary in the AB interray. The basal circlet is low, also consisting of three plates with vertical boundaries slightly shifted clockwise toward the boundaries of the infrabasals. The ambitus is located in the middle of the orals. Above the ambitus, the tegmen raises gently; the CD oral is rather large. The ends of the star rays are rounded. The well-expressed elevations alternating with depressions stretch from the rays toward the center of the tegmen. The CD oral bears a weakly developed madreporite. The radials and periproct are indistinguishable.

Dimensions, mm

Specimen PIN, no.	H	W	H_{IBB}	H_{BB}	H_{OO}	Dm	H/W
Holotype 1557/534, theca	0.5	0.5	0.1	0.2	0.2	0.02	1.00

Comparison. From *A. inconsuetus* (Peck) recorded in the Rockford Limestone, Lower Osagian, USA. The new species differs in the theca that widens toward the ambitus significantly more abruptly, its asymmetrical structure, narrower axial canal, differently located convex areas of the lateral surface, the lateral curvature of the ambitus projection of A, and in a wider CD oral. It differs from *A. alamogordoensis* (Strimple et Koening) (Lake Valley, Osagian, USA) in a higher located ambitus, lower distal parts of the orals, shorter ambulacral protrusions of the orals, laterally curved ambulacral protrusion of A, and narrower column facet. As compared with *A. scissurus* (Weller) from the Lower Pennsylvanian of the United States, the new species has a wider conical calyx with a higher located ambitus, its more extended protrusions, and different proportions of the lateral and upper parts of the tegmen.

Remarks. Lane and Webster (1985) noted that none of numerous examined specimens of the genus had infrabasals and that its position within the Silurian–Permian interval is uncertain. They emphasized that this genus does not belong to the subclass Inadunata, which includes most of Paleozoic microcrinoid genera. In their opinion, the genus should be referred to the subclass Camerata related to monocyclic platycrinitaceans; most likely, they represent unusually small adult forms. Nevertheless, similarly to the previously described Permian material, my new specimen has clearly distinguishable infrabasals. It is probable that this form belongs to other taxon rather than to the superfamily Codiacrinacea (=Hypocrinacea), the more so as the genus *Amphipsalidocrinus* is known since the Silurian; i.e., it is older than any other codiacrinaceans. However, most probably, these specimens should be referred to the Inadunata rather than to the Camerata; they possibly belong to codiacrinaceans. On the assumption that they lack infrabasals but have three basals, one of which is half as large as each of the two other equidimensional plates, and the tegmen consisting of five orals, they are similar to the Monobathrida (subclass Camerata). Nevertheless, the tegmen is highly oligomerous, and the anus occupies a lateral rather than upper position. The neotenic appearance of these forms is obvious. Infrabasals either present or absent in the members of this genus. Three basals were probably formed by paired fusion of four plates of five. The infrabasals, anus, and radials are usually somewhat shifted, which is frequently observed in codiacrinaceans.

Material. Holotype.

Suborder Poteriocrinina Jaekel, 1918

Superfamily Poteriocrinitacea T. Austin et T. Austin, 1842

Family (?)Poteriocrinitidae T. Austin et T. Austin, 1842

Genus *Stukalinocrinus* Arendt, gen. nov.

Etymology. In memory of G.A. Stukalina.

Type species. *S. gigas* Arendt, sp. nov.; Viséan Stage, Mikhailov Horizon; southern Moscow basin.

Diagnosis. Massive thick columns round in cross section, containing round axial canal, changing from narrow at distal end to wide in proximal part. Column composed of very low columnals of two or, usually, three orders. Articular facet entirely covered by numerous branching crenelles; distally, it even; proximally, it becoming narrow and consisting of concave internal (or two internal) and flat external parts. Columnals of first to third orders intruding in axial canal to progressively lesser extent. Distally, numerous cirri located on column; they rounded-bilateral in section (similarly to axial canals) and composed of low segments. Facets for cirri extending for up to 12 columnals. Cirri directed obliquely downward and regularly distributed round the column. Proximal cirri abruptly decreasing in thickness and number down to almost complete disappearance.

Species composition. *P. gigas* Arendt, sp. nov. from the Mikhailov Horizon and *P. magnus* Arendt, sp. nov. from the Aleksin Horizon, southern Moscow basin.

Comparison. The new genus differs from the most similar genus *Poteriocrinites* by the more massive, always rounded column, and wider axial canal varying in width, different rank columnals, and very massive distal cirri rounded-bilateral in cross section, similarly to their axial canals.

Remarks. Regular distribution of the massive cirri in the distal part of the column suggests that it did not creep over the bottom but was directed more or less upward. G.A. Stukalina noted that these columns should conditionally be referred to *Poteriocrinites*, whereas R.S. Moore, who examined this material, emphasized that the identification of such columns is rather difficult (Arendt and Stukalina, 1968).

Stukalinocrinus gigas **Arendt, sp. nov.**

Plate 8, fig. 1; Plate 9, fig. 1

Etymology. From the Latin *gigas* (gigantic).

Holotype. PIN, nos. 4106/39a–39d, well-preserved column; southern Moscow basin, quarry at the Myshiga River near the village of Gremnitsy in the vicinity of the town of Aleksin; Viséan Stage, Mikhailov Horizon (lower part).

Description (Figs. 2a–2d). The column is very large and massive. The rounded axial canal changes from very narrow in the distal part to wide in the proximal part. The articular facet is flat in the distal and external parts, with one or two concentric slightly concave inner zones; it is covered by numerous thin crenelles, which dichotomize one to three times. The columnals are very low in the distal part and slightly higher in the proximal part; they are of two orders, but they only slightly vary in height. The lateral surfaces of the columnals are slightly convex and covered by small, irregularly shaped, and densely spaced low tubercles. In the center of the lateral surface, the tubercles become slightly higher and, occasionally, longitudinally elongated. The distal part is often marked by the cirrus sockets irregularly distributed over the column; the sockets are large, extending over five to ten columnals, round cup-shaped, and located on small elevations of the column. Budlike underdeveloped cirri are present. Distally, the number and size of the cirri gradually decrease.

The material includes a very large distal part of the column 3 cm wide and 28 cm long, round in cross section, and containing a very narrow axial canal. Its width varies from 0.06 to 0.19 of the column diameter in the distal and proximal parts, respectively.

The articular facet is flat and entirely covered by abundant thin low crenelles, most of which dichotomize one to three times, although some do not dichotomize. The marginal part is occasionally marked by small intercalatory ridges lacking contacts with neighboring ridges. There are about 150 crenelles near the axial canal and approximately 350 crenelles along the margin of the articular facet. In the distal part of the column, the axial canal is fringed by a very narrow (1 mm wide) central area.

In this part of the column, the columnals are extremely low (2–2.5 mm high), they are also of two orders. The lateral surfaces of the columnals are slightly convex and covered by low densely spaced tubercles, which are slightly higher and longitudinally elongated in the center of the lateral surface.

This part of the column bears abundant cirrus sockets located throughout the entire lateral surface at a distance of 1–3 cm from each other and usually at different levels; toward the proximal part of the column, they slightly decrease in size and density. The sockets are rounded or almost round, large, 0.8–1.8 cm across (in one case, 0.3 cm). The areas where the cirri are attached to the column are marked by flattened conical elevations, gently sloping in the upper part and relatively steep in the lower part, raising above its surface for 2–4 mm, and having a sharp curvature just at the edge of the proximal segment of the cirrus. The elevations encircle cup-shaped or flattened conical facets, which are 1–2 mm deep relative to the surface. The articular facets of cirri are of the same structure as the articular facets of the columnals, differing only in a smaller number of crenelles; the lower part of each proximal segment of a cirrus is concave.

Occasionally, the cirrus sockets bear one or two narrow concentric furrows fringing the areas with slightly different inclination. In the areas occupied by the cirrus sockets, the edges of the columnals deflect upward and downward. The axial canal in a socket is at most 1 mm wide.

Some specimens consist of one to ten cirrus segments. Their lateral surfaces are inclined at an angle of 50°–70° relative to the longitudinal axis, and their diameters abruptly decrease distally.

In one case, four cirrus segments form a very low (4 mm) and wide (5 mm) budlike protrusion with a cap-shaped uppermost segment. It is probable that some other cirrus facets had such budlike expansions.

Proximally, the column and cirrus sockets slightly decrease in diameter, whereas the axial canal becomes significantly wider. The distal holdfast-adjoining part of the column of this crinoid, which is very large, was probably creeping over the sea bottom and partly anchoring by the cirri in the sediment.

The same rock sample contained three additional column fragments of the same individual or other individuals similar in size and belonging to the same species. The first fragment 7 cm long is similar to the upper part of the largest region of the column. The second region 6.3 cm long most likely belonged to a more proximal part of the same individual. Its axial canal is 6.5 mm across, i.e., 1.3 times wider than the canal in the

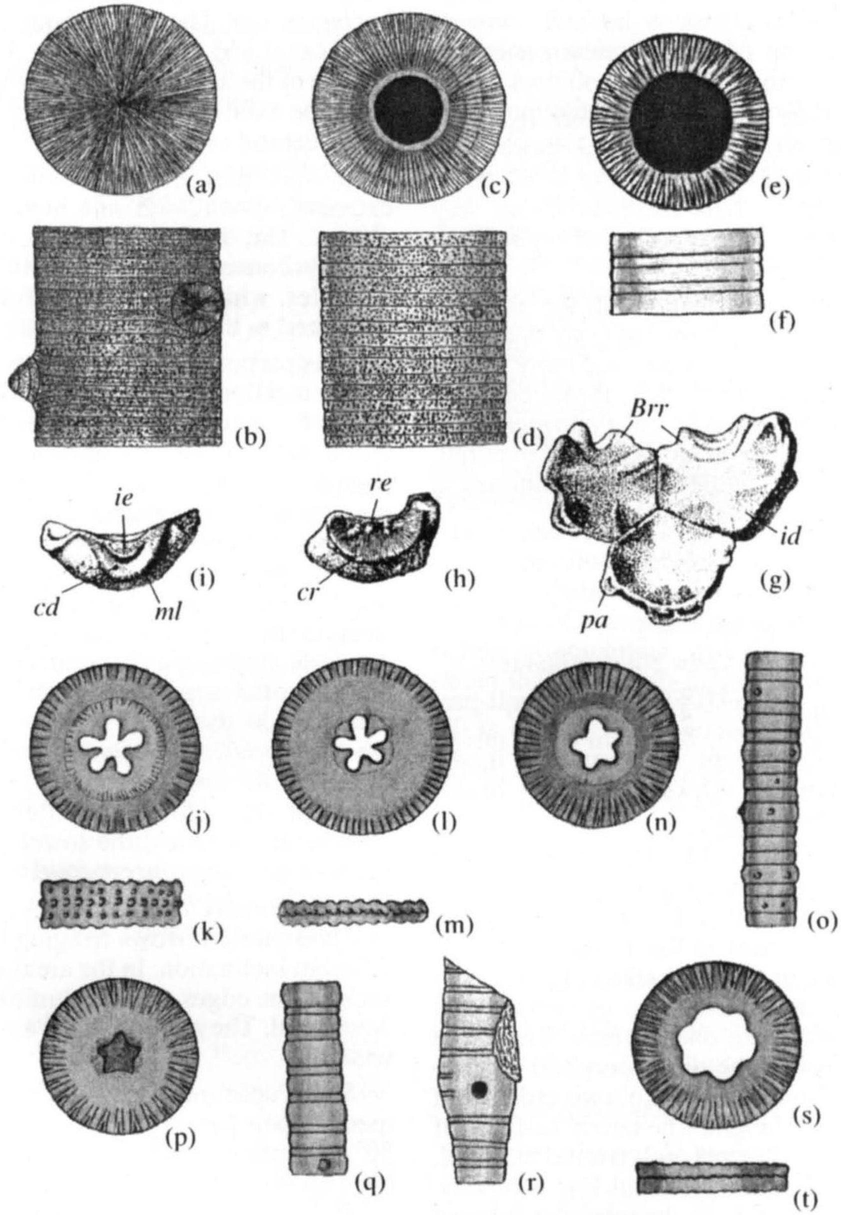


Fig. 2. (?)Poteriocrinitidae (a–f), Rhabdocrinidae (g–i), and Floricyclidae (j–t). (a–d) *Stukalinocrinus gigas* Arendt gen. et sp. nov., holotype PIN, no. 4106/39, fragments of the column belonging, probably, to a single specimen, ×1.2: (a, b) distal thick-cirrus part of the column with a flat articular facet and narrow axial canal: (a) articular facet, (b) side view with cirrus socket and cirrus "bud", (c, d) more proximal thin-cirrus part of the column with the concave internal part of the articular facet and wide axial canal: (c) articular facet, (d) side view; quarry at the Myshiga River near the village of Gremnitsy in the vicinity of the town of Aleksin; Viséan Stage, Mikhailov Horizon. (e, f) *Stukalinocrinus magnus* Arendt, gen. et sp. nov., holotype, no. 1557/167, thin-cirrus part of the column with a narrow flat articular facet and very wide axial canal, ×1.2: (e) articular facet, (f) side view of column fragment; quarry near the village of Bekhovo; Viséan Stage, Aleksin Horizon; (g–i) *Rhabdocrinus vatagini* Arendt, 1962, holotype no. 1557/40, fragment of the cup, morphological peculiarities of plates: (g) basal AB and inner side of radials A and B, (h) radial C with the arm facet, (i) articulation of the radial A, ×1.7; town of Tarusa, Ignatova Gora quarry, Exposure 9d, Bed 40; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part); (j–m) *Floricyclus paratus* (Sisova, 1983), articular facets of columnals (j, l) and side view of columnals (l, k), ×5: (j, k) no. 1557/45, (l, m) no. 1557/514; quarry near the village of Mitino, Exposure 11, Bed 38; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part); (n–t) *Plummeranteris candidus* (Sisova, 1983), column fragments: (n, o) no. 1557/87: (n) articular facet, ×3.5, (o) side view, ×1.5; quarry near the village of Mitino, Exposure 11, Bed 38; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part); (p, q) no. 1557/68: (p) articular facet, ×2.5, (q) side view, ×1.2; town of Tarusa, Ignatova Gora quarry, Exposure 9d, Bed 34; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part); (r) no. 1557/67, with parasite *Phosphannulus* and overgrowing large pillow-shaped hydroid, ×2; town of Tarusa, Ignatova Gora quarry, Exposure 9d, Bed 40; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part); (s, t) no. 1557/66, column segment of two columnals with a hexagonal axial canal: (s) articular facet, (t) side view, ×2.5; quarry near the village of Mitino, Exposure 11, Bed 38; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part). For letter designations see Footnote 2.

upper part of the largest region of the column; the columnals are 1.2–1.3 times higher. In this region, the column is slightly (by 1 mm) narrower than at the proximal end of the largest column. There are one cirrus socket of lesser diameter than that of the main column (0.4 versus 0.8–1.8 cm) and one budlike protrusion, which is wide, very low, and consists of two segments. The lower segment is 0.2–0.3 mm high, visible on only one side of the bud, and wedges in on the other side. The upper segment is cap-shaped and 1.5–1.7 mm high.

By size, number of crenelles, height, and orderedness of columnals, the considered column fragments are similar to the isolated fragment from the same sample. Simultaneously, there are certain differences: the axial canal is significantly (1.7–2.3 times) narrower, the articular facet is flat rather than consists of several inclined zones, and there is a smaller number of irregularly dichotomizing crenelles. The columnals are 1.5–2.0 times lower, slightly convex, noncylindrical, and bear tubercles on the lateral surface. The tubercles are more developed in the central part of the surface, whereas in the mentioned column fragment, they are evenly distributed. Two smaller fragments are positioned almost in parallel to each other, whereas the largest fragment is inclined relative to them in the plane of host rock at an angle of 30°.

The fragment buried at a large distance from the others is similarly large and has a wide axial canal. The articular facet is divided into external, middle, and internal zones. The external zone is flat and relatively wide. The other two are narrower and concave. The middle zone is located lower than the external zone, and the internal zone is located lower than the middle zone. The articular facet is covered by abundant high and narrow crenelles. The crenelles usually twice dichotomize in certain areas within the middle and external zones. The internal zone lacks crenelles; the columnals of two orders are present, they are low and slightly varying in height. Their lateral surfaces are covered by weak, densely spaced, and isometric tubercles.

This column fragment is as large as the above-mentioned specimen (2.8 cm wide and 11.5 cm long) from the same rock plate, but it noticeably differs in morphology. The column is round in cross section and the axial canal is round and relatively wide. The articular facet consists of three concentric zones. The most depressed internal zone is 1.8 mm wide, slightly inclined toward the axial canal, and completely lacks crenelles. The middle zone is located external to a wide fold, and its margin raises by 1 mm above the internal zone; its surface is inclined toward the longitudinal axis of the column at an angle of 30°; the zone is covered by high sharp crenelles dichotomizing close to its internal part; the zone is 1.8 mm wide.

The external zone is widest; it is separated from the middle zone by a fold. The inner part of this zone (occupying one-third of the width) is slightly inclined and separated from the external area by a weak depression. Almost all crenelles passing from the middle zone dichotomize once again at the level of this depression. In the marginal part of the zone, the crenelles are abundant, very thin, and high. The internal, middle, and external (at the margin) zones bear approximately 180, 270, and 400 crenelles, respectively.

The columnals are very low and cylindrical; however, they are 1.5–2.5 times higher than those in the distal part of the column. The columnals of two orders are present, but they only slightly differ from each other in height.

The ornamentation is represented by gentle and densely spaced tubercles. The boundary between adjacent columnals is marked by a well-pronounced narrow and shallow (0.2 mm deep) furrow.

By size, appearance of crenelles, height, and orderedness of columnals, this part of the column is similar to a more distal region. Simultaneously, it shows the following differences: (1) the axial canal is significantly larger in diameter (1.7–2.3 times); (2) the articular facet consists of three zones and bears relatively more abundant twice dichotomizing crenelles, whereas in the distal part of the column, it is smooth, and crenelles dichotomize less regularly; and (3) the columnals are 1.5–2.0 times higher, cylindrical, and bear regular ornamentation, whereas in the distal part, they are slightly convex and characterized by different ornamentation in the central part of the lateral surfaces.

D i m e n s i o n s, mm

Specimen PIN, no.	Dm_1	Dm_2	dm_1	dm_2	N	H_1	H_2
Holotype 4106/39a	30.0	27.0	5.0	1.5	150	2.0	1.8
4106/39b	27.0	–	5.2	–	150	2.2	2.0
4106/39c	26.2	–	7.0	–	150	2.6	2.3
4106/39d	28.0	26.5	–	11.5	80	3.2	3.0

Specimen PIN, no.	Dm_1/dm_2	Dm_2/dm_1	dm_1/dm_2	N/dm_2	H_1/dm_2	H_2/Dm_2
Holotype 4106/39a	6.0	5.5	0.3	1.50	0.40	0.36
4106/39b	–	5.0	–	–	0.42	0.39
4106/39c	–	3.7	–	–	0.37	0.33
4106/39d	2.4	–		1.57	0.28	0.26

M a t e r i a l. Holotype and the column fragments from the same limestone plate that belong most likely to the same individual (or, probably, to another individual or individuals of the same species).

***Stukalinocrinus magnus* Arendt, sp. nov.**

Plate 9, fig. 2

E t y m o l o g y. From the Latin *magnus* (very large).

H o l o t y p e. PIN, no. 4106/167; well-preserved pluricolumnal; southern Moscow basin, right bank of the Oka River, quarry near the village of Bekhovo

0.5 km downstream; Viséan Stage, Aleksin Horizon (uppermost layers).

Description (Figs. 2e–2f). The columnals are very large and round in cross section. The axial canal is wide and round. The articular facet is almost flat; slightly inclined toward the center; and entirely covered by abundant sharp, low, and flattened crenelles. They dichotomize only occasionally one or two times near the external margin. The intercalatory ridges are present. The columnals of three orders are present and differ from each other in height. They are low, slightly convex, almost cylindrical, and smooth. Every two high first-order columnals alternate with three lower columnals, the middle of which is of the second order and the other two are of the third order. The axial canal is variable in width: it is wider in third-order columnals, narrower in the second-order columnals, and, probably, even narrower in the columnals of the first order.

Dimensions, mm

Specimen PIN, no.	Dm	dm_1	dm_2	H_1	H_2	H_3	N	Dm/dm_2
Holotype 1557/396	20.0	12.0	10.7	2.0	1.5	1.3	160–170	1.87

Comparison. By the articular facet pattern and general shape, the new species resembles *S. gigas* sp. nov., differing from the latter in smaller size; relatively wider axial canal; the presence of columnals of three, instead of two, orders; and the absence of ornamentation on these columnals.

Material. Several isolated columnals and a well-preserved column fragment consisting of 26 columnals from the type locality.

Family Rhabdocrinidae Ramsbottom, 1960

Genus *Rhabdocrinus* Wright, 1944

Rhabdocrinus vatagini Arendt, 1962

Plate 6, fig. 1

Rhabdocrinus vatagini: Arendt, 1962, p. 118, text-figs. 1 and 2; Arendt, 1963, p. 1675, text-figs. 1 and 2; Webster, 1973, p. 230.

Holotype. PIN, no. 1557/40; town of Tarusa, Ignatova Gora quarry; Exposure 9d, Bed 40, Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lowermost layers).

Description (Figs. 2g–2i). The cup is relatively large, wide conical, and consisting of massive pentagonal plates. The plates are particularly massive in the central parts and middle part of margins. At the corners having external depressions, the plates are relatively thin. The infrabasals, anals, and some basals and radials are not preserved. In every circlet, the plates vary in size and shape. The basals are scalene and slightly higher than the radials. Amid basals, AB is larger than BC. B is the largest radial, and C is the smallest and scalene plate. The radial facets are wide but narrower than the radials (Pl. 6, figs. 1c and 1h). They are moderately concave and covered by abundant, well-developed, and locally dichotomizing crenelles. The internal margin of the facet is marked by elevations of irregular shape covered by tubercles. This tuberculate surface bears narrow and weak concentric elevations consisting of small tubercles.

The attachment areas of the plate almost always have arched articular structures, which usually vary in size even within the same plate (Pl. 6, figs. 1d–1f and Fig. 2i). The narrow external margin of such structure strongly protrudes and is separated by a wide central depression from a wide and usually slightly flattened internal elevation. The depression gradually becomes deeper from the external margin to the internal elevation, which has a clear boundary. The external margins bear well-developed denticles; some median elevations are ornamented by curved ridges and tubercles. Two equal or different-size articular structures can occur on the same side of a plate, for instance on the AB basal (Pl. 6, figs. 1e and 1f). However, occasionally, a plate side lacks such structures, as observed on the right side of the AB basal (Pl. 6, fig. 1b). The articulation on the left side of the C radial lacks central elevation, whereas the articular facet for the B radial is marked by a depression for a well-developed elevation location on the B radial (Pl. 6, fig. 1b, on the right).

At the boundary between the AB and BC basals, there is a gap between the lower parts of the plates. The internal surfaces of the plates are uneven; therefore, a more or less developed wedge-shaped depression narrowed to the center of the plate and occupying one-third to one-fifth of its length is located under almost every articulation (Pl. 6, figs. 1b and Fig. 2g). In the lower part, the brachials are fused with the radials and with each other; the lowermost segment extrudes externally, and others become slightly narrower (Pl. 6, figs. 1a and 1b). Their articular facets are covered by well-developed dichotomous crenelles (preserved in places), strongly deflect outward, bear wide and relatively deep ambulacral notches, and are oval or round externally. Two or three concentric grooves corresponding to boundaries between the brachials are well distinguishable on the inner side (Pl. 6, figs. 1a, 1b, and Fig. 2g).

The interradials are not preserved, but judging from the depressions on the radials, their lowermost parts are wedged in between B and A, A and E radials, whereas between B and C radials, they were absent. The bases of the lowermost interradials were wide and truncated (Pl. 6, figs. 1g and 1i). The contacts between the interradials and radials are marked by denticles.

Ornamentation is represented by high curved fusing in places ridges occupying the centers of the plates. The ridges are most developed on the AB basal, whereas on the BC basal, they are weak. In addition, some areas along the peripheral parts of the ridges are covered by low tubercles (Pl. 6, fig. 1a).

Dimensions, mm

Specimen PIN, no.	H	W	Lh	T
Holotype 1557/40				
B_{BC}	12.0	13.1	–	–
B_{AB}	15.0	15.1	–	–
R_C	9.0	15.1	11.0	6.1
R_B	10.0	17.1	12.0	8.1
R_A	12.1	14.0	9.1	5.0

Remarks. Depressions in jointing areas between plates and on their internal sides probably hosted ligaments, so that plates of living crinoids could passively move relative to each other. Such mobility could help crinoids to resist intense water flows, which is evident from the occurrence of abundant solitary corals strongly abraded by shelly detritus in marly–limy rocks.

Material. Holotype.

Superfamily Cromyocrinacea Bather, 1890

Family Ulocrinidae Moore et Strimple, 1973

Genus *Ureocrinus* Wright et Strimple, 1945

***Ureocrinus rozhnovi* Arendt, 1981**

Plate 7, figs. 1a–1e

Ureocrinus rozhnovi: Arendt, 1981, p. 25, pl. 3, fig. 1.

Holotype. PIN, no. 1557A/1, well-preserved calyx; Zaborie quarry near the town of Serpukhov; Serpukhovian Stage, Upper Serpukhovian Substage, Protvino Horizon (lower part), gray clays with bright yellow dolomites.

Description. The slightly concave column facet is distinctly pentagonal with slightly convex margins, occupied by an extremely low similarly pentagonal first columnal, which is concaved toward the distal articular facet. Two edges of this columnal extending from the CD interray terminate short of the margin of the facet, whereas in other parts, the columnal fills it completely. The axial canal is narrow, slightly irregular, and stellate in cross section; external outlines of the canal repeat those of the columnal and its edges correspond to the boundaries between the infrabasals. The canal is adjoined by a smooth lowered concave areole whose diameter is equal to two-thirds of the columnal radius and peripheral part is covered by 22 simple irregular and variably developed crenelles, which steeply slope both inward and outward.

The cup is rather large, subspherical, but so compressed that it is much wider in the frontal than sagittal plane. Such a form probably results partly from secondary compression, because, locally, the plates slightly diverge along the boundaries marked by secondary calcite filling. Because of this compression, the cup is not oval in side view. The maximum width of the cup is slightly above the midheight, approximately at the base of the upper third of the height of the basal circlet. The lateral outlines are gentle, and only the column-adjoining part slightly projects downward.

The low infrabasal circlet of five plates widens gradually toward the distal part. Its A plate is the narrowest one, the E plate is larger, and the other three are even larger and almost equidimensional. The basal circlet is the highest one, and its plates are variable in size and shape; the DE and CD plates are larger than others; CD is heptagonal, whereas others are hexagonal.

The cup with radials inclined toward its axis is compressed at the top. The pentagonal radials also vary in size: their width is slightly larger than the height, except for the quadrangular C radial, which is characterized by opposite proportions. This smallest plate is the only one that does not alternate with the basals and is located on the distal continuation of the BC basal. The arm facets are as wide as the distal margins of the radials. Externally, every facet is fringed by a horizontal wide arcuate area, behind which there is a deep wedge-shaped ligament fossa incised internally by a distinct long and deep ligament groove. The transverse ridge is wedge-shaped in cross section and well developed. In the area between the external margin of the distal surface and its crest, the facets are horizontal and rather narrow. The internal wide part of every facet is slightly inclined inward and bears wide regularly and deeply concave muscle fossae, and each fossa has a narrow, small, and poorly expressed muscle pit. The intermuscular groove dividing the fossae into two is short and narrow.

The anal area is occupied, almost up to the distal margin of the cup, by a large (slightly larger than the C radial) hexagonal radianal inclined downward and to the right. The distal margin of this plate bears tiny X and RX anals (the latter is slightly smaller than the former) located at its two upper wings, which are equal in size. The anals wedge in the cup only slightly by their basal parts somewhat below the level of its distal margin. These plates are overlain by a displaced wide plate covering the upper margins of both anals. This is probably the fourth anal located significantly above the distal margin of the cup. The aperture of the cup is narrow.

The material includes four most proximal brachials of four arms. The C brachial is lost, whereas the D brachial is preserved in almost a natural position. The E brachial is slightly displaced similarly to the A brachial, which is displaced even closer to the calyx axis. Both retained the vertical position, while the fourth one (B) extends horizontally. These brachials are high, and their lateral margins narrow down steeply in the lower half and are almost parallel in the upper part. Their basal parts are dissymmetric: the left edge in the D brachial is more acute than the right one, whereas in the B brachial, the situation is opposite. In the E brachial, these edges are almost identical. The distal surfaces of the D and B brachials are contrarily inclined to the anal area; the E brachial is inclined similarly to D, while the A brachial is inclined downward from the left to the right. In the right lower side of the latter, there is a relatively large irregular groove of unclear origin. The ambulacral grooves are rather deep and wide in the upper parts. The distal surfaces of these plates are uneven. They show a distinct transverse ridge and a hardly distinguishable gently sloping and wide ligament fossa and wide flattened muscle fossae of irregular shape. Ligament groove and muscle pits are absent. The lateral edges of the brachials are flattened.

Owing to this, the basal parts of arms could tightly join each other. The arms inclined inward at the level of the lower brachials and above them, they probably also joined tightly. The high mobility was characteristic of only the boundary between the arms and the cup; in the upper parts, it was weak. Joint C and D arms abutted the anal cone.

D i m e n s i o n s, mm

Specimen PIN, no.	H	h	W	w	H_{IBB}	H_{BB}	H_{RR}	H_{an}	W_{an}	H/W
Holotype 1557A/1, calyx	11.9	11.0	12.7	11.7	2.6	7.03	5–4	6.6	4.3	0.9

C o m p a r i s o n. The considered species differs from *U. bockschii* (Gein.) recorded in the Viséan Stage (Lower Limestone Group, Calciferous Sandstone Series) of Scotland and Germany in (1) the pentagonal column facet and proximal part of the column, (2) cup compressed more or less along the frontal plane and its closer approach to bilateral symmetry, (3) more rounded shape of the cup, (4) peculiar features of the anal area, (5) greater size-variability of infrabasals, (6) somewhat wider distal margin of the cup and slightly steeper inward inclination of the internal parts of the facets, (7) higher proximal brachial of each arm with more expressed curvature of its sides at the mid-height, and (8) flattened sides of the brachials. From *U. doliolus* (Wright) from the Viséan Stage (Lower Limestone Group, Calciferous Sandstone Series) of Scotland, it differs in (1) lower proximal columnal, (2) pentagonal cross section of the proximal columnal and narrower column facet, (3) significantly less elongated globoid cup, (4) substantially lower infrabasal circlet with well-pronounced bilateral symmetry, (5) lower basal circlet, (6) position of the C radial strictly on the continuation of the BC basal, (7) slightly higher raising radial, (8) slightly smaller X and RX anals and probable presence of an additional anal, (9) higher and slightly varying in shape brachials of every arm.

M a t e r i a l. Holotype.

S u p e r f a m i l y Zeacrinitacea Bassler et Moodey, 1943

Family Zeacrinitidae Bassler et Moodey, 1943

Genus *Zeacrinites* Troost in Hall, 1858

***Zeacrinites heckeri* Arendt, sp. nov.**

Plate 5, figs. 1 and 2

E t y m o l o g y. In memory of R.F. Hecker.

H o l o t y p e. PIN, no. 1557/546; well-preserved calyx, quarry near the village of Zaborie in the vicinity of the town of Serpukhov; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon.

D e s c r i p t i o n. The narrow steep-sided column facet of the calyx is filled, almost to the entire height of infrabasals, with the upper part of the column, which is rounded in section. The axial canal is narrow, and its diameter is one-seventh of the cup diameter. The canal is pentagonal in cross section, with a noticeable lobe. Inside the canal, there are five longitudinal isolated radial ribs that pass along the middle part of the sides. The columnals are low, and the column facet contains at least three or four columnals. The canal is fringed by a weakly developed stellate elevation, the perilumen. The internal zone of the articular facet (areola) is relatively wide, flattened, and tuberculate. The peripheral zone (crenularium) is as wide as one-third to one-ninth of the column diameter and bears 35 high and small denticles; at the external margin, they are fused in places. The surface of the distal part of the cup is gently curved, and the strongest curvature is observed at the level of the distal parts of the basals. From this point, the inclination of walls of the column facet toward the cup axis increases, and they are steeply inclined in the lower part of the basals. At the distal margins of the radials, the inclination of the cup walls only slightly increases. The plates composing the cup are thick. In the dorsal part of the calyx, the infrabasal circlet (in the holotype) is almost completely covered by the column, whereas in the ventral part, it forms a large regular expansion almost reaching distally the apices of the radials. There, the axial canal is almost twice as wide as in the column and almost round in cross section; within the infrabasals, it abruptly narrows toward the column. The basals are large, with strongly elongated apices, varying in size, and hexagonal (except for the BC plate, which is heptagonal). BC is the largest basal, smallest is the opposite DE basal, and the elongated CD is the narrowest basal; AB and EA are equal in size. The radials are much more uniform in size.

The anal area comprises three plates: irregularly hexagonal RA anal and the X and RX anals leaned upon the latter and strongly raised above the cup (X anal is badly broken, RX anal is represented by imprint). The cup cavity is moderately wide and very shallow, with central infrabasal elevation. At the cavity bottom, there are triangular basals. The arm facets are very thick and wide, typical of the genus, with well-developed elements. The moderately thick transverse ridge extends over the entire width of the facet; the narrow, deep, and slitlike ligament fossa exceeds slightly one half of the facet length. It is separated from a long, narrow external depression by a narrow low well-developed ridge covered by densely spaced denticles, similarly to the transverse ridge.

Every facet has a relatively large, slightly flattened, and well-pronounced central elevation with the intermuscular groove extending and widening toward the cup axis. In the holotype with preserved biserial covering ambulacral plates, the muscular fossae are convexo-concave. Every side of the facet bears a very large, well-developed, and high elevation slightly irregular in shape and located closer to its internal margin, although not joining it. The interarticular ligament fossae near the internal margin are poorly expressed; closer to the external margin, they become deep and fusiform.

D i m e n s i o n s, mm

Specimen PIN, no.	H	W	H_{IBB}	H_{BB}	H_{RR}	Dm	H/W
Holotype 557/535, calyx	7.0	19.0	3.9	3.8	6.8	3.4	0.37

C o m p a r i s o n. From close *Z. konincki* (Bather) from the Lower Limestone Group of the Viséan Stage of Scotland (Z coral zone, according to D. Hill), the new species differs in (1) IBB plates less sharply protruding inward; (2) significantly more size-variable and narrow BB plates, (3) proportions of the anals; (4) external margins of the RR plate, which are straight or slightly concave rather than slightly convex in section; (5) doughnut cup cavity; (6) more distinct central and lateral elevations of the arm facets and better developed small denticles at the ridges on its margins; and (7) in the axial canal of the column, which is wider and distinctly quinqueradiate rather than almost punctuate and rounded.

R e m a r k s. There is also a small column fragment, which I refer to the same species; it is highly probable that it belongs to the same individual. The columnal diameter is slightly larger than in the column-adjoining cup cavity. If this fragment belongs to the same crinoid organism, one to three columnals presumably located between the fragment and the columnals preserved in the cup cavity of the holotype seem to be lost.

The axial canal is slightly wider than those of the columnals preserved in the column cavity, distinctly pentagonal, and fringed by better expressed narrow perilumen. The internal areola is noticeably concave. The peripheral denticles are slightly less developed and fuse in the external part into a continuous and very narrow ring zone. The column is strongly curved and, probably, adjoined to the cup. The columnals are of two orders. The first-order columnals are regularly convex, protruding laterally, moderately high, and everywhere uniformly thick. The second-order columnals are at least three or four times lower and slightly convex; the thickest columnals are in the most convex part of the column, and almost completely or completely wedge out toward the most concave part.

M a t e r i a l. Holotype and PIN, no. 1557/545, column fragment, from the same locality and bed.

Incertae subclass et order

Family Floricyclidae Moore et Jeffords, 1968

Genus *Floricyclus* Moore et Jeffords, 1968

Floricyclus paratus (Sisova, 1983)

Plate 10, figs. 1–6

Plummerantericrinus paratus: Sisova, 1983, p. 271, pl. 1, figs. 13 and 14.

Floricyclus paratus: Chernova and Stukalina, 1989, p. 124, pl. 3, figs. 1–10.

H o l o t y p e. TsNIGR Museum, no. 14/11955; well-preserved columnal; southern Kazakhstan, Betpak-Dalta, Kyzyltuz Syncline; Serpukhovian Stage, Beleuta Horizon.

D e s c r i p t i o n (Figs. 2j–2m). Small columns, round in cross section. The articular facet is flat. The axial canal is medium in diameter, quinquelobate with lobes widening and becoming rounded externally. The central area occupies one to two-thirds of the articular facet radius and consists of two zones. The perilumen is slightly raised, flattened, and frequently bears size-variable small tubercles or vermicules; sometimes, its external surface is covered by poorly expressed radial ribs. The perilumen is equal to or narrower than the external zone, the lowered and flattened areola. The crenularium includes 25–40 very well expressed and short crenelles that significantly raise above the adjacent part of the central area and are characterized by rounded or, less commonly, flattened surfaces.

The columnals are low and, most likely, of three orders; each second-order columnal is bounded from two sides by third-order columnals, which, in turn, adjoin the first-order columnals. However, this arrangement is arbitrary, because available column fragments consist of at most three columnals and the order of adjoining remains uncertain (Pl. 10, fig. 5). The lateral surfaces of the columnals are cylindrical or slightly convex; along the midline, there is an elevation developed to a greater or lesser extent (usually weakly developed); occasionally, it is sharp as a keel and bears abundant commonly low, truncated or more or less tapering tubercles arranged in a line. Sometimes, one or two of them are significantly larger than others, with truncated rounded ends bearing small depressions in the center and probably providing the attachment for narrow cirri. The elevations are especially large in the first-order columnals. In one of the columnals, each side of such elevation bears one row of small tubercles; each tubercle corresponds, by its location, to a crenelle of the articular facet. The other columnal has two rows of similar tubercles; the tubercles from the external row are larger than those of the internal row. When the median ridge is well developed, these zones with tubercles are absent. The area stretching from the distal margins of the crenelles to the lateral surface of the columnals is occupied by gradually flattening elevations.

The axial canal is probably characterized by variable proportions relative to that of the column. The perilumen is usually as wide as a half of the central area. In one of the columnals, it is extremely small, being preserved only between the lobes of the axial canal, and bears no radial ribs. The crenelles of the crenularium vary from relatively long to very short and almost square. The lateral surface can be slightly convex and cylindrical, with either poorly or well-pronounced ornamentation.

Dimensions, mm

Specimen PIN, no.	Dm	dm	H_1	H_2	H_3	N	Dm/dm	H_2/dm
1557/514	3.3	1.1	2.4	2.0	1.6	28	3.00	1.82
1557/45	6.3	1.9	–	–	1.5	39	3.00	–
1557/513	7.9	2.7	–	3.0	–	37	2.91	1.1

Comparison. The considered species differs from the type species *F. hebes* Moore et Jeffords, 1968 from the Middle Pennsylvanian (Desmoinesian) of the USA in a somewhat narrower axial canal and wide perilumen, only slightly concave granulated areola, and more convex and more tuberculate lateral surface of the two-order columnals. From *F. virgalensis* (Sisova et Stukalina, 1973) from the Lower–Middle Carboniferous of the Transbaikal Region and northern Mongolia, it differs by the higher two-order columnals with a strongly ornamented lateral surface. It is distinguished from *F. pulverlus* (Dubatolova et Shao, 1959) from the uppermost Lower–basal Middle Carboniferous of southern China by the two-order columnals, better expressed ornamentation of their lateral surface, and the absence of cirri.

Remarks. The species is very similar to *Plummeranteris candidus* in the column shape, relative width of the axial canal, and relative dimensions of the columnals. However, the latter has a stellate axial canal, longer crenelles frequently varying in length, and ornamentation on the lateral surface is less developed.

Occurrence. Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part) of the southern Moscow basin; Viséan and Serpukhovian stages, Dalnii and Beleuta horizons of southern Kazakhstan (Sisova, 1983; Chernova and Stukalina, 1989).[4]

Material. Nine columnals and column fragments consisting of two or three columnals found in the quarry near the village of Mitino, Exposure 11, Bed 38, marl; and one long column fragment, town of Tarusa, Ignatova Gora quarry, Exposure 9d, Bed 40, marl; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part).

Genus *Plummeranteris* Moore et Jeffords, 1968

Plummeranteris candidus (Sisova, 1983)

Plate 11, figs. 2–5; Plate 13, fig. 1

Floricyclus candidus: Sisova, 1983, p. 268, pl. 1, figs. 10 and 11.

Floricyclus isolitus: Sisova, 1983, p. 269, pl. 1, fig. 12.

Floricyclus virgalensis: Eltysheva and Polyarnaya, 1975, p. 207.

Plummeranteris candidus: Chernova and Stukalina, 1989, p. 119, pl. 2, figs. 1–7.

[4] The uppermost, fifth, member of the Beleuta Horizon in central and southern Kazakhstan is aged as the Lower Bashkirian (Litvinovich *et al.*, 1985). It is probable that *F. candidus* was found in the lower layers of the horizon belonging to the Serpukhovian Stage (Chernova and Stukalina, 1989; Stukalina, the letter of March 12, 1998).

Holotype. TsNIGR Museum, no. 10/11955, central Kazakhstan, Dzhezkazgan Depression, Ittas Mountains area; Serpukhovian Stage, Beleuta Horizon.

Description (Figs. 2n–2t). Small columns, round in cross section, with medium-sized quinquelobate axial canal. The apices of lobes are usually rounded, but the canal can be stellate in section. Most commonly, the canal cross section resembles a pentagonal star with slightly different-size rays rounded at the ends. The articular facet is generally flattened.

The central area is approximately half as wide as the radius of the articular facet. Approximately half of this area that adjoins the axial canal (perilumen) is a low and flattened elevation of irregular rounded–pentagonal shape covered by weakly developed tubercles and depressions and sometimes bearing obscure radial denticles.

The peripheral part of the central area (areola) is smooth and slightly concave. The margin of the columnal bears virtually nondichotomizing crenelles, which are narrow, frequently flattened, prominent, and varying in length. Occasionally, the crenelles are wide and slightly dichotomous in the area most distant from the axial canal.

Three-order columnals are present; they are moderately high, sometimes low, and often slightly convex laterally. The area between two highest and convex (first-order) columnals is occupied by three columnals, external two of which are equidimensional and lowest (third-order), whereas the middle one is slightly higher (second-order). Occasionally, fourth-order columnals are also present.

A low ridge occasionally extends along the midline of the first-order columnal. The ridge bears several tubercles that are arranged in a row extending in parallel to the margins of the articular facet. Almost always, one to three tubercles are distinguished by their larger size. The ends of the tubercles are flattened and bear tiny depressions, most likely marking places for the attachment of narrow cirri. Similar elevations, but significantly less expressed, are frequently observed on the second-order columnals.

Sometimes, large cirrus sockets are also present on the columnals of the first and second orders. They are located on small elevations and usually occupy more than half of the columnal height (Pl. 2, fig. 5b). Every articular facet bears crenularium consisting of 20–25 nondichotomous ridges, slightly narrower areola, and a narrow axial canal, which is round rather than quinqueradiate, as in the column proper.

Variability. Most variable is the columnal height. In some specimens, it is 2–2.5 times larger than in others. Noticeably variable is also a number of crenelles. Certain variations are characteristic of the axial canal shape, relative width of the elements on the articular facets, convexity of the lateral surface, and development of ornamentation on the latter.

One of the medium-sized specimens has a relatively large hexactinal axial canal with rounded ends of rays of almost regular shape (Pl. 11, fig. 3). Its central area occupying a half of the articular facet is divided into different-sized external and internal zones. The internal zone is slightly elevated and characterized by irregular outlines and tuberculate surface; in places, it also bears weak radial denticles. The external zone is also slightly differentiated and lowered. The crenelles are abundant and nondichotomous. Only two low columnals are preserved, and their lateral surfaces are even; one is twice as thick as the other. These columnals are probably of the second and third orders.

One column is damaged (Pl. 11, fig. 4); i.e., a relatively wide (3.5 mm across) rounded perforation is located in a small depression on the lateral surface of four columnals partly fused in this area. The column is slightly inflated at the point of injury. The area near the perforation is occupied by a spacious pillow-like hydroid excrescence. The depression is filled with a semitransparent dark brown phosphate material 0.5 mm thick overlying limestone. Adjacent is another similar very small structure of irregular shape. These structures recorded recently in abundance belong to parasites of the genus *Phosphannulus*.

D i m e n s i o n s, mm

Specimen PIN, no.	Dm	dm	H_1	H_2	H_3	N	Dm/dm
1557/1	7.2	3.0	1.9	1.5	1.2	52	2.40
1557/2	5.7	2.0	4.0	3.0	2.7	27	2.85
1557/3	4.0	1.2	2.6	2.3	2.0	25	3.33
1557/147	7.0	1.8	2.1	1.3	0.7	47	3.89
1557/66	10.2	3.6	–	1.2	0.6	62	2.83
1557/87	6.3	3.1	2.4	2.0	1.5	56	2.06

C o m p a r i s o n. The species differs from the type species *P. sansaba* Moore et Jeffords, 1968 recorded in the Middle Pennsylvanian (Atokan) of North America by significantly less developed crenularium with occasionally dichotomous crenelles, shallow lobes of the axial canal, wider perilumen, and two- rather than one-order column with sparse cirri. *P. pulcher* (Moore et Jeffords, 1968) and *P. hebes* (Moore et Jeffords, 1968) from the Middle Pennsylvanian (Desmoinesian) of North America differ from the considered species in a significantly wider quinquelobate axial canal and two-order cirri.

R e m a r k s. The species shows a significant similarity to some species of the genus *Floricyclus*, in particular, to the above-mentioned *F. paratus* (Sisova). This is seen in the column shape, relative width of the axial canal, orderedness of columnals, and their proportions. The distinctive features of *F. paratus* are the presence of expansions at the margins of lobes of the axial canal, the shorter and uniform in size denticles on the articular facet, and the presence of an elevation with tubercles along the midline of the lateral surface of each columnal. There is a noticeable similarity to the columns of some poteriocrinins, for instance, to Middle–Late Carboniferous *Moscovicrinus* (Blothrocrinidae, Scytalocrinacea): the columnals of three orders are similar in shape and dimensions, convexity, the structure of articular facets, and in quinqueradiate stellate axial canals.

O c c u r r e n c e. Serpukhovian Stage, Lower Serpukhovian Substage, Tarusa and Steshev (lower part) horizons of the southern Moscow basin; and Viséan and Serpukhovian stages of central and southern Kazakhstan.

M a t e r i a l. Nineteen well-preserved specimens: five column fragments from the Ignatova Gora quarry near the town of Tarusa; Exposure 9b, Bed 32, limestone, Tarusa Horizon; nine columnals from Exposures 9d and 9e, Bed 34, limestone, Steshev Horizon; five columnals and column fragments from the quarry near the village of Mitino; Exposure 11, Bed 38, marl, Steshev Horizon (lower part).

***Plummeranteris(?) ignatovensis* Arendt, sp. nov.**

Plate 11, fig. 1

E t y m o l o g y. After the Ignatova Gora locality.

H o l o t y p e. PIN, no. 1557/600, well-preserved pluricolumnal; town of Tarusa, Ignatova Gora quarry, Exposure 9b, Bed 33; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon.

D e s c r i p t i o n. The column is homeomorphous, consisting of high and small cylindrical columnals. The axial canal is narrow, quadrilobate, and cruciform, with rounded ends of lobes. The articular facet includes a significantly concave and wide areola (with poorly developed perilumen or lacking the latter) and narrow crenularium consisting of 14–18 well-pronounced crenelles, which are wide, short, and flat at the contact with each other. On the external surface, the crenelles and depressions between them form a distinct regular crenulate suture. Approximately half of columnals bear small tubercles and large isolated protrusions on their external surfaces. One of them is discoid and has canal-bearing tubercles along its equator and also a pair of larger canal-free tubercles on the lateral side. The crinoid was attached by a wide bifurcate column base to the auricle of concave valve of a very large and transversely elongated productid, *Latiproductus saritshevae* Le Green, 1972. The crinoid and productid existed in the conditions of strong currents directed from the cardinal area of the brachiopod during its life time. The supporting roots and the column are directed posterior relative to the hinge of the brachiopod.

Above the column base, there are six columnals, five of which were separated from the base and the lower columnal and buried close to them; therefore, the sixth columnal proved to be the distal one. The axial canal of the latter has one lobe twice as wide as the others. The articular facet of this columnal bears 18 denticles, whereas those of the second and first columnals have 14 denticles each. In the second columnal, the axial canal is perfectly quadriradiate, and in the first, it is dissymmetrical.

Dimensions, mm

Specimen PIN, no.	Dm	dm	H	N	dm/Dm
Holotype 1557/600	3.3	1.0	2.0	14–18	0.30

Comparison. The new species differs substantially from *P. candidus* (Sisova, 1983) in a smaller size, nonheteromorphous column, sharp crenular sutures on the lateral surface, and in concave articular facets with a smaller number of crenelles.

Remarks. The differences are great, and it is not inconceivable that the described species should be ranked as a separate genus. It is not clear whether or not the quadriradiate pattern of the axial canal is characteristic of this species. It is quite probable that forms with the quinqueradiate axial canal prevailed, whereas quadriradiate forms are a rare variant of individual variation.

Material. Holotype.

Plummeranteris(?) profundus **Arendt, sp. nov.**

Etymology. From the Latin *profundus* (deep).

Holotype. PIN, no. 1557/147, well-preserved column fragment consisting of several columnals; left bank of the Myshiga River near the village of Gremnitsy; Exposure 1, Bed 4, limestone, Viséan Stage, Aleksin Horizon.

Description (Figs. 3a and 3b). The column is small, rounded in cross section, and has a narrow pentagonal axial canal with slightly concave sides. The articular facet consists of the perilumen and areola separated from each other by a distinct almost vertical fold. The rounded and flattened perilumen is slightly inclined toward the axial canal, and its weakly tuberculate surface ornamentation is difficult to distinguish and is absent in places. The areola and crenularium occupy one-third and two-thirds of the column radius (except for the axial canal), respectively. The crenularium bears abundant moderately developed crenelles, which are simple and nondichotomous. The columnals are low, regularly cylindrical, of two orders, but similar in height.

Dimensions, mm

Specimen PIN, no.	Dm	dm	h_1	h_2	N	Dm/dm
Holotype 1557/147	3.8	1.0	1.4	1.1	60	3.8

Comparison. The species differs from *P. candidus* in pentagonal rather than quinquelobate axial canal, round and inclined perilumen, and in the presence of cylindrical columnals of two orders. From *P(?) ignatovensis*, it differs in the quinqueradiate rather than cruciform axial canal and in the presence of two orders of columnals rather than one order.

Material. Five well-preserved column fragments from the same locality and bed.

Family Arcariocrinidae Yeltyscheva et Sisova, 1969

Genus *Unilineatocrinus* Dubatolova et Yeltyscheva, 1969

Unilineatocrinus inconstantistellatus **Arendt, sp. nov.**

Plate 13, figs. 3–5

Etymology. From the Latin *inconstante* + *stellatus* (irregularly + stellate). The name is given because of characteristic outlines of the axial canal of the column.

Holotype. PIN, no. 1557/88; column fragment consisting of five well-preserved columnals; quarry near the village of Mitino at the Oka River; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part).

Description (Figs. 3c and 3d). The column is narrow or relatively wide, round in cross section, with the quinqueradiate axial canal. The articular facet is flat in the external half (crenularium), concave funnel-shaped in the areola, and flattened–convex in the area adjacent to the axial canal (perilumen). The axial canal is wide, having outlines of irregular quinqueradiate star with dissymmetrical, generally short and wide rays varying in size and having rounded ends. The concave part of the articular facet is divided into two parts characterized by different incline, i.e., external (areola) and internal (perilumen). The internal zone is very narrow, almost completely located between the rays of the axial canal, and has a smooth surface only slightly inclined to the crenularium. The areola is inclined to the latter much steeper, at an angle of 45°. Its surface is covered by relatively gentle crenelles converging and weakening toward the inner part of the zone and becoming more distinct toward the external zone. The crenularium in the internal half bears abundant crenelles, very distinct, relatively wide and flattened, directly becoming the ridges of the concave part. Externally, these ridges commonly dichotomize or become narrower and have intercalatory short ridges on the sides; occasionally, the latter also dichotomize at the ends. Locally, the ridges dichotomize twice; there are also abundant, usually long intercalatory ridges. The columnals are low and cylindrical or, more frequently, slightly inflated along the midline; they are of two orders or somewhat higher and lower columnals alternate. A row of high and densely spaced tubercles extends along the midline of every columnal. Frequently, two or three tubercles fuse and form a slightly zigzag line (mainly on the first-order columnals). There are isolated small cirrus sockets at the middle of the lateral surface of some first-order columnals, which become higher and wider in these areas. Sometimes, the sockets occupy the entire columnal height. They are deep fossae fringed by a nar-

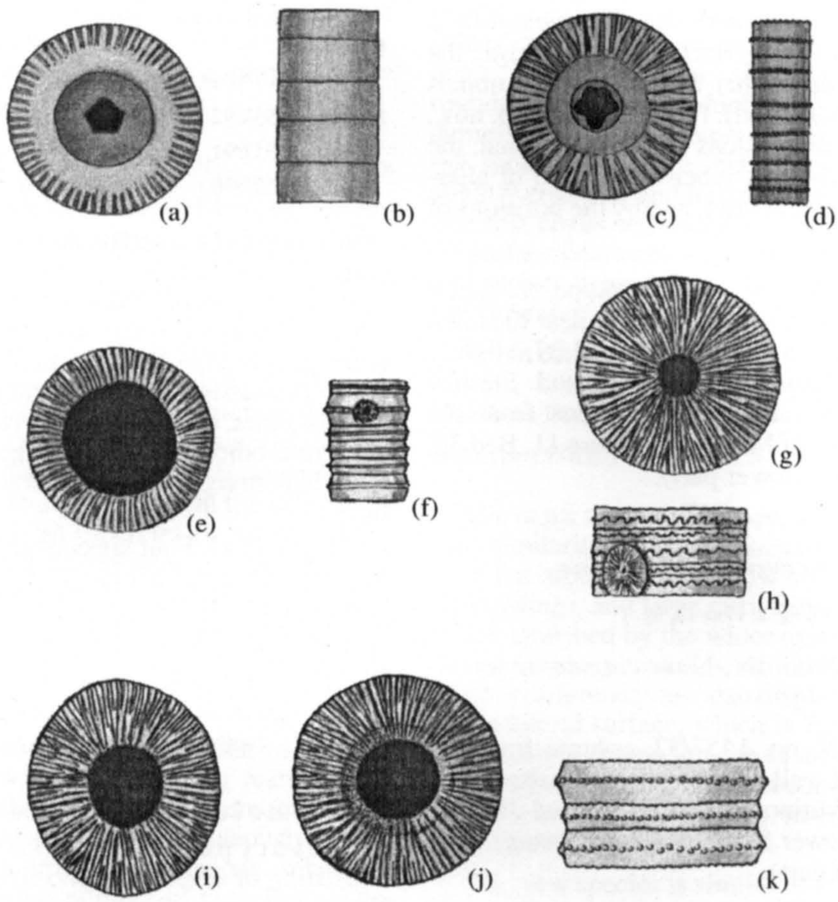


Fig. 3. Floricyclidae (a, b) and Arcariocrinidae (c–k). (a, b) *Plummeranteris(?) profundus* Arendt, sp. nov., holotype, no. 1557/147, column fragment consisting of several well-preserved columnals: (a) articular facet, ×3, (b) side view, ×2; left bank of the Myshiga River near the village of Gremnitsy, Exposure 1, Bed 4, limestone; Viséan Stage, Aleksin Horizon; (c, d) *Unilineatocrinus inconstantistellatus* Arendt, sp. nov., holotype, no. 1557/88, column fragment consisting of six well-preserved columnals: (c) articular facet, ×4, (d) side view, ×1.2; quarry near the village of Mitino, Exposure 11, Bed 38; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part); (e, f) *Unilineatocrinus cingulatus* Arendt, sp. nov., holotype, no. 1557/92, column fragment consisting of six well-preserved columnals: (e) articular facet, ×3, (f) side view, ×1.5; quarry near the village of Mitino, Exposure 11, Bed 38; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part); (g, h) *Unilineatocrinus tarusaensis* Arendt, sp. nov., holotype, no. 1557/89, column fragment consisting of seven well-preserved columnals: (g) articular facet, ×3, (h) side view, ×2.5; town of Tarusa, Ignatova Gora quarry, Exposure 9d, Bed 41; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part); (i) *Unilineatocrinus rectus* Arendt, sp. nov., holotype, no. 1557/101, articular facet, ×3, quarry near the village of Mitino, Exposure 11, Bed 38; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part); (j, k) *Unilineatocrinus serpukhovensis* Arendt, sp. nov., holotype, no. 1557/110, column fragment consisting of three well-preserved columnals, ×3: (j) articular facet, (k) side view; the same locality.

row belt bearing not numerous poorly pronounced crenelles.

D i m e n s i o n s, mm

Specimen PIN, no.	Dm	dm	H_1	H_2	N	Dm/dm
Holotype 1557/88	5.9	2.0	1.5	1.3	42	2.95
1557/1	11.5	5.5	1.7	1.4	80	2.00
1557/113	8.8	3.5	1.5	1.3	55	2.51
1557/3	5.8	2.0	1.4	1.2	3.5	2.90

V a r i a b i l i t y. The axial canal significantly varies in size and shape from the rounded to pentagonal and irregularly stellate. The width of the internal concave part of the articular facet noticeably varies as well. Some articular facets bear one or two poorly pronounced and irregularly rounded furrows. The ornamentation on the lateral surface of the columnals is usually formed by a single line of tubercles, although it can include two or, in one case, three rows of tubercles.

C o m p a r i s o n. The new species differs from *U. serpukhovensis* sp. nov. by the much narrower axial canal and flat crenularium, noticeably concave areole, and by crenelles occupying almost entirely the articular facet. It also differs from *U. tarusaensis* sp. nov. by a relatively wider axial canal; the midline area of the lateral surface of *U. inconstantistellatus* is marked by a row of tubercles but usually lacks a zigzag ridge, the cirri are located on one rather than several columnals (one cirrus on each columnal). From *U. rectus* sp. nov., it differs by smaller dimensions of the axial canal, the lateral surface with lines of tubercles instead of alternating even ridges and tubercles, and by the positions of cirri, one per columnal.

M a t e r i a l. In addition to the holotype, 52 specimens: 50 from the Ignatova Gora quarry, near the town of Tarusa; Exposures 9a–9c, beds 34 and 37, slightly clayey limestone; Tarusa (uppermost) and Steshev (lowermost) horizons; and two specimens from the quarry near the village of Mitino, Exposure 11, Bed 38, marl; Steshev Horizon (lower part).

Unilineatocrinus cingulatus Arendt, sp. nov.

Plate 13, fig. 2; Plate 14, fig. 1

E t y m o l o g y. From the Latin *cingulatus* (encircled).

H o l o t y p e. PIN, no. 1557/32; column fragment consisting of several well-preserved columnals; quarry near the village of Mitino, Exposure 11, Bed 38; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part).

D e s c r i p t i o n (Figs. 3e and 3f). Relatively thick columns rounded in cross section; the axial canal is wide and large.

The articular facet is only slightly concave and densely covered by abundant crenelles, which are usually simple, but sometimes dichotomize one or two times. The columnals are of three orders. Every two first-order columnals alternate with three columnals, the middle of which is of the second order and the other two are of the third order. They differ in height and width of the articular facet, which is maximum in the third-order columnals. An even and wide ridge extending for one-third to half of the columnal height stretches along the midline of the lateral surface of every columnal. It is especially large on the columnals of the first order and minimal on the columnals of the third order where it is occasionally partially represented by tubercles. Sometimes, the columnals bear small cirrus sockets looking like concave areas located on small elevations and bounded by a narrow and flattened belt with radial denticles.

V a r i a b i l i t y. There is an insignificant variation in the relative width of the axial canal, the height of columnals, and the dimensions of the lateral ridge. In the third-order columnals, the latter can be very low or consist of isolated tubercles. The crenelles on the articular facet can dichotomize to various extent.

D i m e n s i o n s, mm

Specimen PIN, no.	Dm	dm	H_1	H_2	H_3	N	Dm/dm
Holotype 1557/92	8.8	5.0	2.5	1.6	1.2	82	1.76
1557/91	5.2	3.6	–	1.8	–	72	2.00
1557/90	7.3	–	1.6	1.3	1.0	80	2.43

C o m p a r i s o n. The new species differs from the close *U. tarusaensis* sp. nov. in a much wider axial canal and narrower articular facet with simple or weakly dichotomizing crenelles, the presence of columnals of three rather than only two orders, straight and very massive median lateral ridges at least those of the first order, and isolated and very narrow cirrus sockets. From other species of the genus, it differs by very large and straight median lateral ridges and other features.

M a t e r i a l. Four specimens: three from the quarry near the village of Mitino, Exposure 11, Bed 38, marl; and one from the Ignatova Gora quarry near the town of Tarusa; Exposure 9c, Bed 40, marl; Steshev Horizon (lower part).

Unilineatocrinus tarusaensis Arendt, sp. nov.

Plate 13, fig. 6

E t y m o l o g y. After the town of Tarusa.

H o l o t y p e. PIN, no. 1557/89; column fragment consisting of seven well-preserved columnals, town of Tarusa, Ignatova Gora quarry; Exposure 9b, Bed 41; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part).

D e s c r i p t i o n (Figs. 3g and 3h). The column is medium-sized, with a narrow axial canal. The articular facet is flat and entirely covered by crenelles. The latter are abundant; variably wide; and dichotomizing one, two, or, rarely, three times at different distances from the axial canal.

The columnals of two orders are present. They are low and cylindrical or slightly convex. Along the midline of the lateral surface of every columnal, there is a narrow, relatively high, and zigzag ridge; it is almost continuous or, frequently, discontinuous. The first-order columnals are distinguished by a greater height and more pronounced ridges.

There are very wide cirrus sockets extending for five or six columnals. They are widely oval, slightly concave, and densely spaced; their axial canal is relatively narrower than in the column. The intersections of the columnal articulation lines and the sockets are marked by sharp folds and expansion of the column.

V a r i a b i l i t y. The axial canal ranges from very narrow to relatively wide. Near the canal, the articular facet is occasionally slightly concave. In some columnals, the crenelles dichotomize once, usually in the center of the articular facet. The ridges on the lateral surface are more or less curved in the zigzag manner and vary in the extent to which they are divided into tubercles; on the second-order columnals, they can be almost straight. In some cases, the cirrus sockets are relatively small and extend for only two or three columnals.

D i m e n s i o n s, mm

Specimen PIN, no.	Dm	dm	H_1	H_2	N	Dm/dm
Holotype 1557/89	8.5	2.2	1.3	1.1	47	3.86
1557/89a	5.8	2.0	1.0	1.4	42	2.90

C o m p a r i s o n. The new species shows a significant similarity to *U. rectus* sp. nov. but differs from the latter in the narrower axial canal and the crenelles that usually dichotomize two times. Especially different is ornamentation of the lateral surface, which in the new species is formed by zigzag ridges observed on the columnals of both orders, whereas in *U. rectus*, it is formed by higher and straight ridges (in the columnals of the first order) and high tubercles (in second-order columnals). *U. tarusaensis* sp. nov. is distinguished from *U. inconstantistellus* sp. nov. by a relatively larger axial canal, the presence of zigzag ridges rather than a row of tubercles on the midline of the lateral surface of each columnal, and by the attachment of cirri to five or six columnals rather than to a single columnal.

R e m a r k s. The new species is similar to *Stukalinocrinus gigas* sp. nov. in the following features: the shape of columnals, the number of columnal orders, and the articular facet patterns. Simultaneously, it differs from the latter in smaller dimensions, relatively wider axial canal, smaller number of crenelles on the articular facets, higher columnals, and different ornamentation. The cirrus sockets are similarly large, but in *Stukalinocrinus gigas*, they occupy a greater number of columnals.

M a t e r i a l. A dozen of well-preserved column fragments consisting of several columnals: one from the Ignatova Gora quarry near the town of Tarusa; Exposure 9b, Bed 41, marl; and 11 specimens from a quarry near the village of Mitino; Exposure 11, beds 38 and 51, marl; Steshev Horizon.

***Unilineatocrinus rectus* Arendt, sp. nov.**

Plate 12, fig. 9

E t y m o l o g y. From the Latin *rectus* (straight).

H o l o t y p e. PIN, no. 1557/101; column fragment consisting of seven well-preserved columnals, quarry near the village of Mitino; Exposure 11, Bed 38, marl, Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part).

D e s c r i p t i o n (Figs. 3i and 3j). The columnals are medium-sized with a round and large axial canal. The articular facet is covered by abundant crenelles, which are narrow, flattened, and simple or dichotomizing once; the intercalatory ridges are present.

The columnals are low and slightly convex, of two orders. The first-order columnals are slightly higher. The midline area of the lateral surfaces bears a high, straight, and narrow keel, which is prominent and in places divided into elongated fragments. The second-order columnals bear similarly located high and rounded tubercles, which are sharply manifested, densely spaced, and sometimes fused in pairs. The cirrus sockets are large, extending for five columnals, slightly concave, and having a very narrow axial canal. The first cirrus segment is convexo-concave, its articular surface bears abundant intercalatory ridges; the lateral surface bears tubercles, as on the columnals of the second order.

D i m e n s i o n s, mm

Specimen PIN, no.	Dm	dm	H_1	H_2	N	Dm/dm
Holotype 1557/101	5.7	2.3	1.1	0.9	68	2.48

C o m p a r i s o n. The new species shows a significant similarity to *U. tarusaensis* sp. nov. Both forms have flat articular facets, low columnals of two orders (alternating), and large cirri. Simultaneously, *U. rectus* is distinguished by the wider axial canal and relatively more numerous crenelles, which dichotomize one time. Certain differences are also displayed in ornamentation of the lateral surface, which is formed in *U. rectus* by high straight ridges (on the first-order columnals) and high tubercles (on the second-order columnals), whereas in *U. tarusaensis* sp. nov., by zigzag ridges on the columnals of both orders.

The new species is similar to *U. inconstantistellatus* sp. nov. in the same features, differing from the latter in the larger axial canal; ornamentation of the lateral surface, particularly that of the first-order columnals (*U. inconstantistellatus* has several tubercles, whereas *U. rectus* has continuous ridge); and in the attachment of cirri to five or six columnals instead of one.

M a t e r i a l. Holotype.

***Unilineatocrinus serpukhovensis* Arendt, sp. nov.**

Plate 14, figs. 3, 4, and 7

E t y m o l o g y. After the Serpukhovian Stage.

H o l o t y p e. PIN, no. 1557/110; column fragment consisting of two well-preserved columnals, quarry near the village of Mitino; Exposure 11, Bed 38, Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part).

D e s c r i p t i o n (Figs. 3k, 3l, 4a, and 4b). The columns are large, rounded in cross section, and having a very wide rounded axial canal. The articular facet consists of three or two (depending on the columnal order) zones of different sizes. The zones are separated from each other by sharp folds. The external zone (crenularium) is flat, and the next one (areola) is inclined to the latter zone at an angle of approximately 45°, and the third, i.e., internal zone (perilumen), is almost flat. The internal zone lacks crenelles, which completely cover the other zones. The crenelles are abundant, wide, and

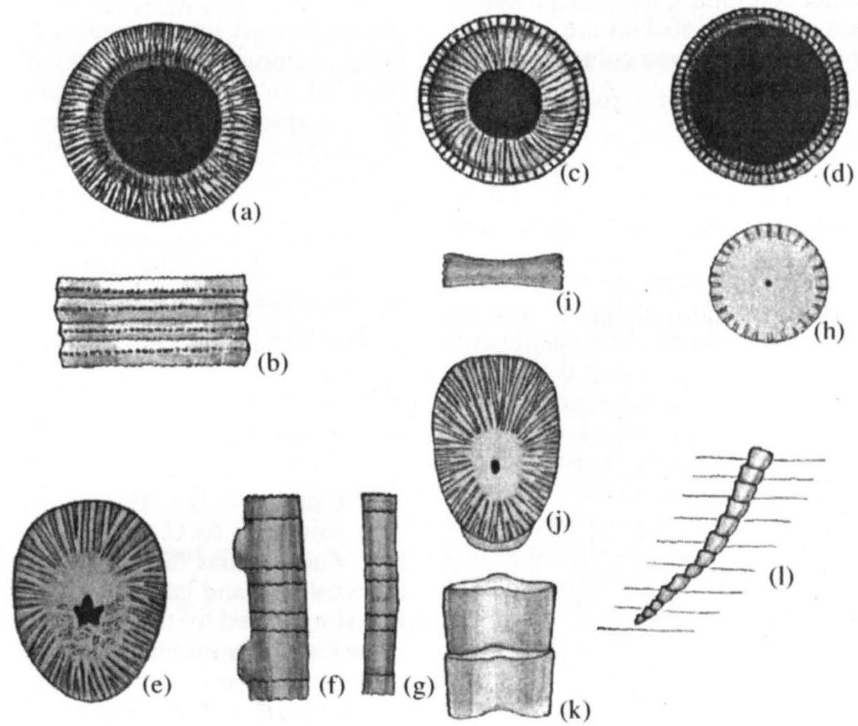


Fig. 4. Arcariocrinidae (a–d) and Incertae familiae (e–l). (a, b) *Unilineatocrinus serpukhovensis* Arendt, sp. nov., holotype, no. 1557/110, column fragment consisting of four well-preserved columnals, ×3: (a) articular facet, (b) side view; quarry near the village of Mitino, Exposure 11, Bed 38; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part); (c, d) *Unilineatocrinus(?) tenuicarinatus* Arendt, sp. nov., holotype, no. 1557/100, well-preserved column fragment, articular facet at its opposite ends, ×2; the same locality. (e–i) *Konicrinus(?) excentricus* Arendt, sp. nov., holotype, no. 1557/516, well-preserved column segment ("column fragment" with protruding large cirrus sockets): (e) articular facet, ×6, (f) side view, with cirrus sockets, ×3, (g) back view, ×3, (h, i) no. 1557/108, cirral: (h) articular facet, ×6, (i) side view, ×2; the same locality; (j–l) *Carinatocrinus carinatus* Arendt, gen. et sp. nov.: (j) holotype, 1557/523, well-preserved cirrus fragment, ×3: (j) articular facet, (k) back view, (l) distal part of a cirrus penetrated into the sediment, ×1; town of Tarusa, Ignatova Gora quarry, Exposure 9b, Bed 37; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part).

flattened; they dichotomize in the center of the external zone; the intercalatory denticles are frequently present.

The columnals are medium in height and cylindrical; the midline of the lateral surface bears tubercles usually arranged in a line. The columnals are of two orders, slightly different in height. The first-order columnals have an almost flat internal zone in the articular facet, whereas the second-order columnals terminate internally with a zone inclined at an angle of about 45°.

V a r i a b i l i t y. The relative width of the axial canal and the width of the articular facet vary. The crenelles are sometimes simple, particularly, in relatively small columnals.

D i m e n s i o n s, mm

Specimen PIN, no.	Dm	dm_1	dm_2	H_1	H_2	N	Dm/dm_2
Holotype 1557/110	6.7	4.2	2.6	2.3	1.8	72	1.59
1557/111	10.3	6.6	6.0	2.3	2.0	103	1.56
1557/112	3.5	2.2	–	–	1.4	40	1.59

C o m p a r i s o n. By size, height, and the number of columnal orders, as well by the arrangement of ornamentation on the lateral surface, the new species is similar to *U. inconstantistellatus* sp. nov., differing from the latter by the significantly wider axial canal, which differs in width of the columnals of the first and second orders. In addition, it differs in the zones of the articular facets, i.e., there are three zones of equal width, two of which are flat and one is concave; two inner zones of the first-order columnals lack crenelles. On the contrary, *U. inconstantistellatus* has flat articular facets.

M a t e r i a l. In addition to the holotype, 24 column fragments usually composed of well-preserved columnals; quarry near the village of Mitino, Exposure 11, beds 38–40, marl and limestone; Steshev Horizon (lower part).

Unilineatocrinus tenuicarinatus Arendt, sp. nov.

Plate 14, figs. 5 and 6

E t y m o l o g y. From the Latin *tenuis* and *carinatus* (thin and keeled).

H o l o t y p e. PIN, no. 1557/98; broken column fragment consisting of three columnals; quarry near the village of Mitino; Exposure 11, Bed 38, marl, Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part).

D e s c r i p t i o n (Figs. 4c and 4d). The columns are large and rounded in cross section, and the axial canal is wide and round or irregularly pentagonal. The articular facet is divided into two zones, a very wide concave internal (areola) and narrow flat external (crenularium) zones separated from each other by a sharp fold. The internal zone is cup-shaped and forms a thin keel tapering toward the axial canal on every columnal. The articular facet is covered by densely spaced and low crenelles, which occasionally dichotomize at the center of the facet. At a distance equal to two-thirds of the width of this zone, there is a weak concentric depression. A narrow and almost straight margin of the articular facet is covered by prominent denticles located on the continuation of crenelles of the concave surface.

The columnals are of two orders; they are cylindrical, moderately high, and strongly differing from each other. The first-order columnals are twice as wide as those of the second-order. The middle of their lateral surfaces bears a thick belt composed of high ridges, varying in length and in zigzag pattern, and not numerous tubercles of various shapes. The articular facets of the columnals are relatively wide.

The lateral surface of the second-order columnals is covered by small distinct tubercles forming a line. The articular facets of these columnals are very narrow (2.5 times narrower than those of the first-order columnals), and they project inward at relatively large angles, so that there are large spaces between the columnals. At the margins, the lateral surfaces of the columnals are slightly elevated.

V a r i a b i l i t y. The smallest individual is characterized by a relatively wider external zone of the articular facet (crenularium) and a narrower internal zone (areola) as compared with those of large individuals. Ornamentation on the lateral surfaces of the first- and second-order columnals of this individual is uniform and looks like a belt of weakly differentiated tubercles arranged in a line.

D i m e n s i o n s, mm

Specimen PIN, no.	Dm	dm_1	dm_2	H_1	H_2	N	Dm/dm_2
Holotype 1557/98	12.5	8.5	5.0	3.2	1.8	120	2.50
1557/99	11.0	–	4.3	3.2	–	110	2.58
1557/100	5.0	3.5	2.0	1.6	0.9	60	2.50

C o m p a r i s o n. The new species is most similar to *U. cingulatus* sp. nov., differing from the latter by the slightly wider crenularium, significantly wider and concave areola of the columnals of the first order, substantially wider axial canal at the level of the columnals of the second order, and by the absence of large belts on the lateral surfaces of columnals.

M a t e r i a l. Five specimens from a quarry near the village of Mitino; Exposure 11, beds 38 and 51, marl, Steshev Horizon.

Incertae familiae

Genus *Konicrinus* Sisova, 1988

***Konicrinus(?) excentricus* Arendt, sp. nov.**

Plate 15, figs. 1–3, 6, and 9

E t y m o l o g y. From the Latin *excentricus* (eccentric).

H o l o t y p e. PIN, no. 1557/516; well-preserved pluricolumnal; quarry near the village of Mitino; Exposure 11, Bed 38; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part).

D e s c r i p t i o n (Figs. 4h–4l). The columnals are small, usually elongated and tapering at one side, and laterally are so compressed that their cross section is a trapezoid with strongly rounded sides. The axial canal is very narrow, pentagonal, and located in the eccentric manner, i.e., it is usually displaced toward the narrower (anterior) part of the column. In section, it is a quinqueradiate star with two slightly shortened rays located in the anterior part of the column.

The articular facet is flat. Its elements are located in the eccentric manner, becoming shorter toward the anterior and longer toward the posterior parts.

The central area occupies about one-third of the articular facet. It is slightly lowered and covered in the anterior part by irregular variably curved ridges alternating with depressions; in the posterior part, it is smooth.

The crenelles are low and slightly flattened from above but have clear boundaries. In the anterior part, the crenelles are three or four times shorter than in the posterior part. Toward the periphery, they become wider and sometimes dichotomize; occasionally, short intercalatory ridges are present.

The lateral surfaces of the columnals are even, less frequently, slightly concave or slightly convex. The columnals are medium in height, of two orders. They slightly differ in height and in the presence of relatively wide (occupying more than a half of the columnal height) elevations with cirrus sockets on the columnals of the first order. The sockets are regularly rounded, fringed by short and wide denticles (14–20), and slightly concave in the center. The axial canal of the sockets is narrow and rounded. In some specimens, the cirrus segments are preserved; they are relatively high, with flat articulations, and arched laterally. These specimens allowed a group of isolated cirrus segments to be determined as the cirri belonging to the considered species. These segments are narrow, high, and round in cross section, with concave lateral surfaces (Pl. 15, figs. 6–8). The axial canal in the latter is very narrow and round in cross section. The articular surfaces of the segments are flat, fringed by not numerous short crenelles, distinctly elevated above the central area. The cirri vary in the proportions of their segments.

Variability. The outlines of the column elements widely vary. Some specimens are regular in shape, i.e., widely oval or almost circular. In such specimens, the axial canal is also regular in shape; the central area is significantly wider than in other specimens and partly (at the periphery) or entirely covered by regularly spaced elevations and depressions; the crenelles look like denticles equal in size and are located along the margin of the articular facet.

In some specimens, the axial canal is slightly compressed anteroposteriorly. In this case, two anterior rays of the star are shortened, whereas the posterior ray is strongly elongated, and the lateral rays are curved toward the latter. Weak variations are observed in the relative height of columnals and relative width of the axial canal.

Occurrence peculiarities. Usually, the column fragments consist of four or five columnals. Many specimens are overgrown by colonies of the fenestrate bryozoan *Fistulipora steshevensis* Schulga-Nesterenko, 1955. The latter regularly overgrow the lateral surfaces of the columnals and are absent on the articular facets. In such cases, longer column fragments are preserved. This fouling occurred during the crinoid lifetime.

Dimensions, mm

Specimen PIN, no.	Dm_1	Dm_2	dm	ds	N	H_1	H_2	Dm_1/dm	Dm_1/H_1
Small trapezoid columnals:									
Holotype 1557/516	4.4	3.5	0.8	2.4	32	2.6	1.9	5.50	1.69
1557/517	4.1	3.9	0.6	2.5	32	2.0	1.7	6.83	2.05
1557/522	5.0	4.5	0.8	3.0	34	2.1	1.9	6.25	2.39
Small rounded cirrals:									
1557/94	2.6	–	0.1	0.6	17	4.0	–	26.0	0.45
1557/95	2.3	–	0.2	0.6	20	6.1	–	11.5	0.38
1557/96	2.0	–	0.05	0.6	18	5.0	–	40.0	0.40
1557/97	2.5	–	0.05	0.5	22	6.6	–	12.5	0.38

Remarks. No similar forms with the quinqueradiate axial canal are in the collection. The new species has much in common with *Inclarocrinus inclarus* sp. nov., i.e., similar dimensions, shape of column elements, columnal height, and the structure of the articular facets. The main difference is that the axial canal of the latter form is rounded, oval, or eight-shaped in cross section rather than quinqueradiate. In addition, the new species possesses cirri.

The new species also shows a noticeable similarity to *Carinatocrinus carinatus* sp. nov. in dimensions, shape, and columnal height. The features differing *K. excentricus* from the latter are the quinqueradiate rather than regularly round axial canal, which is usually displaced to the posterior margin; the absence of carinate protrusion on the surface of every columnal; weakly developed ornamentation; and the absence of cirrus sockets.

The heteromorphism of the column elements, including high nodals with large cirri and internodals; rough ridged articular facets; quinquelobate cross section of the axial canal; and other peculiarities indicate that the new species most likely belongs to the genus *Konicrinus*, which is the Late Famennian in age as was indicated in the original description (Sisova, 1988). The main difference is that the form described here is characterized by a well-pronounced bilateral symmetry, whereas in the Late Famennian forms, this feature is weakly developed (in particular, this was not indicated in description). The considered Serpukhovian species acquired the features of bilateral symmetry because of dwelling in the conditions of intense water currents.

Material. In addition to the holotype, 29 well-preserved specimens; quarry near the village of Mitino; Exposure 11, Bed 38, marl, Steshev Horizon (lower part).

Genus *Carinatocrinus* Arendt, gen. nov.

Etymology. After the type species.

Type species. *Carinatocrinus carinatus* Arendt, sp. nov.; Serpukhovian Stage, Lower Serpukhovian Substage, Tarusa (upper part) and Steshev (lower part) horizons; southern side of the Moscow Basin.

Description. The cirri are small with tear-shaped cross section, elongated and tapered to a point on one side, with a narrow axial canal, which roughly follows the external outlines of the column and is tapered toward the narrower part of the column. The articular facet is flat; the central area is half as wide as the facet, crenelles are relatively abundant, flattened, sometimes dichotomous.

The width of the cirrals gradually decreases from the wide proximal end to the quite narrow distal end. The anterior margin of the proximal end of every cirral always bears a large carinate protrusion, one side of which is slightly convex and steeply inclined toward the lateral surface in the proximal part, and the other side gently slopes toward the distal part.

Species composition. Type species.

Comparison. Differs from the genus *Inclarocrinus* in having an axial canal that never possesses an eight-shaped cross section and in the presence of keeled protrusions on the anterior margin of each cirral.

Carinatocrinus carinatus Arendt, sp. nov.

Plate 16, figs. 1–3

Etymology. Latin *carinatus* (keeled).

Holotype. PIN, no. 1557/523; fragment of a well preserved cirrus; town of Tarusa, Ignatova Gora quarry, Exposure 9b, Bed 35; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part).

D e s c r i p t i o n (Figs. 4m–4o). The cirrus is small, with cirrals tear-shaped or, sometimes, rounded triangular in cross section. Bilaterally, symmetrical cirrals have anterior (narrowest), posterior, and lateral parts. The very narrow axial canal with a shape imitating that of the cirral is located slightly anteriorly or at the center of the columnal. The central area is about half as wide as the cirral articulum and roughly follows the outlines of the cirrals. The entire surface of the articulum is flat, and its peripheral part bears abundant, sometimes dichotomous, low crenelles.

The relatively high cirrals are of two orders, which differ little and only in height. The cirrals almost always widen toward the proximal end of the cirrus and narrow distally. The anterior margin of the articula in every proximal cirral is usually slightly elevated. The keeled protrusion can occupy the anterior margin either entirely or partially. The ornamentation is poorly developed and represented by small, widely spaced tubercles.

V a r i a b i l i t y. The cross sections of the cirri can vary from irregularly rounded and widely oval to rounded cuneiform. The axial canal can be located either centrally or anteriorly. The central area varies in width. The keeled protrusions also can be variable in width.

D i m e n s i o n s, mm

Specimen PIN, no.	Dm_1	Dm_2	dm	ds	N	H_1	H_2	Dm_1/dm
Holotype 1557/523	4.3	3.3	0.5	1.7	58	2.5	2.3	8.6

O c c u r r e n c e p e c u l i a r i t i e s. Bed 34 of Exposure 9 (town of Tarusa) encloses abundant and usually long structures composed of 15–30 cirrals. Some of them are preserved in their life-time position. The enclosing rock is loose, thinly bedded marl. Cirrals are always relatively wide (3–6 mm) at one end of the structure and significantly narrower (1–2 mm) or, sometimes, almost wedging out at the other end.

The cirri are almost always slightly curved. Most of them are slightly inclined to the bedding surfaces of rock (at an angle of 10°–15°), with their carinate protrusions and convex parts oriented upward and downward, respectively.

Some of these structures are inclined to the bedding surfaces of rock at an angle of 45°–60°. In this case, the cirrals are relatively large, frequently arranged in pairs, and almost touching each other. It is obvious that, in both cases, the cirrals penetrated into the as-yet soft sediment to provide secure attachment. The above-mentioned keeled protrusions served for better anchorage in the sediment. Small cirri are characterized by the following peculiar feature: the lower end of each cirral is significantly narrower than its upper end, thus forming steps for better anchorage in the sediment. The inclined position in the sediment also helped to resist water currents. Most likely, these structures represent cirri of some missing columns that used them for anchoring in the substrate.

R e m a r k s. The described species shows a great similarity to *Konicrinus(?) excentricus* sp. nov. in measurements, shape, cirral height, and articula, but differs from the latter in having a pentagonal cross section of the axial canal, no keeled protrusions, and a better-developed ornamentation.

O c c u r r e n c e. Lower Carboniferous, Viséan Stage (Mikhailov and Venev horizons), Serpukhovian Stage (Tarusa and Steshev horizons); Moscow Basin.

M a t e r i a l. Thirty-five well-preserved specimens: five specimens, left bank of the Oka River near the village of Gremnitsy, Exposure 1, Bed 4, limestone; Mikhailov Horizon; five specimens, left bank of the Oka River, immediately downstream of the town of Aleksin, Exposure 3, Bed 33, limestone and Bed 47, clay; Mikhailov Horizon; ten specimens, left bank of the Oka River near the village of Parsukovo, Exposure 2, Bed 35, limestone and talus immediately above Bed 47, limestone; Mikhailov and Venev horizons; five specimens, the town of Tarusa, Ignatova Gora quarry, Exposure 9, Bed 4, limestone (1 specimen) and Exposure 9b, Beds 32 (two specimens) and 35 (two specimens), slightly claylike limestone; Mikhailov, Tarusa (upper part), and Steshev (lower part) horizons; ten specimens, quarry near the village of Mitino, Exposure 11, Beds 38 and 51, marl and clay; Steshev Horizon.[5]

Genus *Inclarocrinus* Arendt, gen. nov.

E t y m o l o g y. After the type species.

T y p e s p e c i e s. *Inclarocrinus inclarus*, sp. nov.; Serpukhovian Stage, Lower Serpukhovian Substage, Tarusa Horizon (upper); southern side of the Moscow Basin.

D e s c r i p t i o n. The cirri are small with tear-shaped cross section, elongated and narrowed on one side. The axial canal is very narrow, irregularly rounded, widely oval or, sometimes, eight-shaped, usually eccentrically located, more commonly displaced toward the wider part of the cirrus. The articular facet is flat and covered by low crenelles, which are simple or, sometimes, dichotomize only once. The lateral surface bears well-defined tubercles or ridges, which are less developed on the narrower part of the column and arranged in a single or, less commonly, two or three rows.

S p e c i e s c o m p o s i t i o n. Type species.

C o m p a r i s o n. Was given above when characterizing the genus *Carinatocrinus*.

Inclarocrinus inclarus Arendt, sp. nov.

Plate 15, fig. 4

E t y m o l o g y. Latin *inclarus* (unclear).

[5] In the field descriptions by the Paleontological Team (Paleoecological Institute, Russian Academy of Sciences), the beds in Exposures 1, 2, and 3 are numbered differently than the same beds in Exposures 9 and 11.

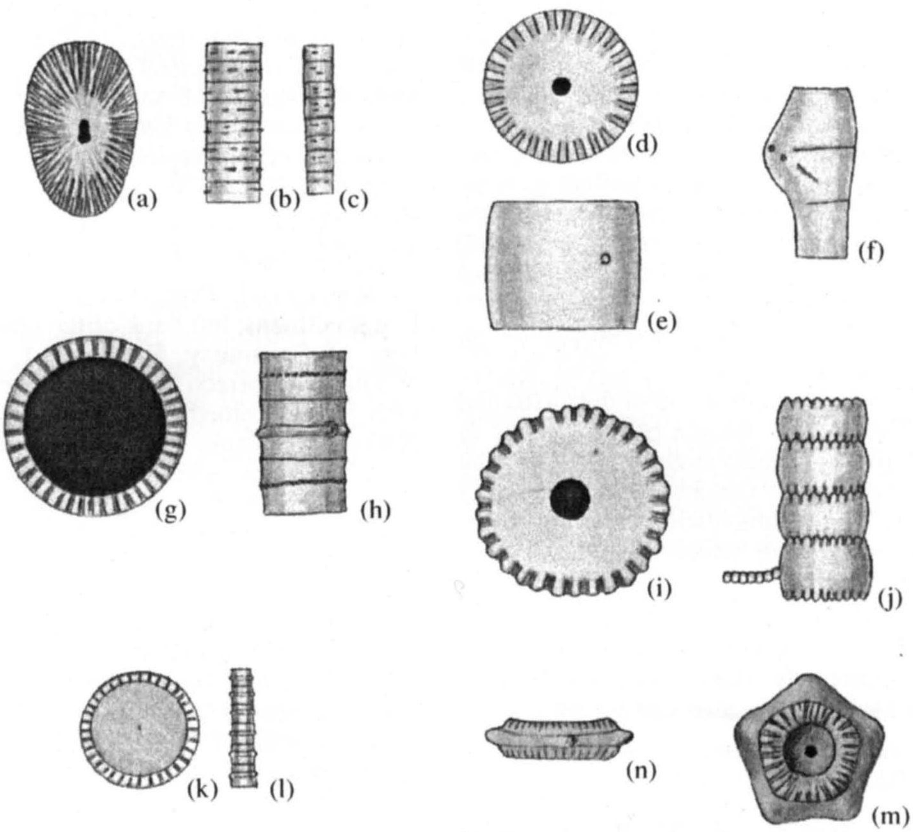


Fig. 5. Incertae familiae. (a–c) *Inclaricrinus inclarus* Arendt, gen. et sp. nov., holotype, 1557/525, pluricirral with well-preserved cirrals: (a) cirral articulum, ×6, (b) back view, ×2, (c) front view, ×2; town of Tarusa, Ignatova Gora quarry, Exposure 9d, Bed 32; Serpukhovian Stage, Lower Serpukhovian Substage, Tarusa Horizon (upper part); (d–f) *Breimerocrinus laevis* Arendt, gen. et sp. nov., well-preserved fragments of columns: (d, e) holotype, no. 1557/107: (d) articular facet, ×8, (e) side view of the columnal, ×8; (f) no. 1557/511b, fragment of the column with swelling probably formed by myzostomids, side view, ×5; quarry near the village of Mitino, Exposure 11, Bed 38; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part); (g, h) *Govorovocrinus okaensis* Arendt, gen. et sp. nov., holotype, no. 1557/105, column fragment consisting of three columnals: (g) articular facet, ×4, (h) side view, ×7; the same locality; (i, j) *Polenovocrinus mitinensis* Arendt, gen. et sp. nov., holotype, no. 1557/108, well-preserved column fragment: (i) articular facet, ×6, (j) side view, ×1.5; quarry near the village of Mitino, Exposure 11, Bed 38; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part); (k, l) *Tzvetaevocrinus cadiformis* Arendt, gen. et sp. nov., holotype, no. 1557/152, well-preserved column fragment: (k) articular facet, ×7, (l) side view, ×4; town of Tarusa, Ignatova Gora quarry, Exposure 9e, Bed 34; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part); (m, n) *Dipentagonocrinus magnocarinatus* Arendt, gen. et sp. nov., holotype, no. 1557/87, well-preserved columnal, ×6: (m) articular facet, (n) side view; town of Tarusa, Ignatova Gora quarry, Exposure 9d, Bed 40; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon.

H o l o t y p e. PIN, no. 1557/525; plurricirral of six well-preserved cirrals; town of Tarusa, Ignatova Gora quarry, Exposure 9d, Bed 32; Serpukhovian Stage, Lower Serpukhovian Substage, Tarusa Horizon (upper part).

D e s c r i p t i o n (Figs. 5a–5c). All cirrals are tear-shaped in cross section, elongated, and narrowed on one side. Bilaterally symmetrical columnals have anterior (narrowest), posterior, and lateral parts. The axial canal is narrow; irregularly rounded; widely oval, or, sometimes, eight-shaped; and located either centrally, or anteriorly, or posteriorly. The cirral articula are flat. The central area is one-third to half as wide as the articulum and follows the outlines of the cirrus; the positions of the axial canal relative to the central area and the entire cirrus are similar. Abundant crenelles are low; of medium width; slightly widened toward the posterior part; and, sometimes, dichotomizing and intercalatory.

Cirrals are, probably, of two orders but almost equal in height. Ornamentation is poorly developed: usually two rows of low, rounded, or elongated tubercles in the anterior part; a median discrete ridge on the lateral surfaces; and two or three long ridges in the posterior part.

V a r i a b i l i t y. The relative dimensions, shape, and position of the axial canal are highly variable. The cross sections of the cirri vary from a widely oval to rounded trapezoid with strongly flattened sides. The central area can occupy from one- to two-thirds of the width of articulum. The ornamentation of the lateral surfaces can be dominated either by rounded tubercles or by more or less elongated ridges. They are arranged into a single, two, and, less commonly, three rows.

Measurements, mm

Specimen PIN, no.	Dm_1	Dm_2	dm	ds	N	H_1	H_2	Dm_1/dm
Holotype 1557/525	4.0	3.0	0.5	2.4	54	1.8	1.5	8.00
1557/524	4.0	3.5	0.7	2.5	52	1.8	1.6	5.71

Remarks. This species differs from the closest form *Carinatocrinus carinatus* in having slightly larger dimensions, an axial canal that may be displaced posteriorly and frequently eight-shaped in cross section, no peculiar carina formed by a protruded anterior margin of the lateral surface in every cirral, and in better developed ornamentation. It has also many features in common with *Konicrinus(?) excentricus* (similar dimensions, shape of cirri, cirral height, structure of articula), but the latter differs in having a pentagonal axial canal.

Occurrence. Lower Carboniferous, Viséan Stage (Mikhailov and Venev horizons), Serpukhovian Stage (Tarusa and Steshev horizons); Moscow Basin.

Material. Twenty well-preserved specimens: six specimens, left bank of the Oka River near the village of Parsukovo, Exposure 2, Beds 39 (one specimen) and 47 (five specimens), limestone; Mikhailov and Venev horizons; seven specimens, the town of Tarusa, Ignatova Gora quarry, Exposure 9, Bed 4, limestone (one specimen) and Exposure 9, Bed 22, limestone; Venev Horizon; seven specimens, quarry near the village of Mitino, Exposure 11, Beds 38 and 51, marl; Steshev Horizon.

Genus *Breimerocrinus* Arendt, gen. nov.

Etymology. In honor of A. Breimer, the paleontologist who visited the Balstoidea and Crinoidea locality in the Mitino quarry in 1968.

Type species. *Breimerocrinus laevis* Arendt, sp. nov.: Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon; southern side of the Moscow Basin.

Description. The columns are very small with narrow axial canals. The articular facet is flat, and the central area is wider than a half of the facet. The crenelles are few, relatively wide, and simple; the areola is rough. The columnals are of two orders, which differ little and only in height; sometimes, rare cirri occur on the first-order columnals. The lateral surface is smooth.

Species composition. Type species.

Comparison. Differs from all known crinoid genera that are defined based on isolated fragments of crinoid columns in having an extremely narrow axial canal and, in contrast, very wide articular facet with a crenularium composed of short simple crenelles and flat rough areola lacking perilumen.

Breimerocrinus laevis Arendt, sp. nov.

Plate 12, figs. 7 and 8

Etymology. Latin *laevis* (smooth).

Holotype. PIN, no. 1557/107; well-preserved column fragment; quarry near the village of Mitino, Exposure 11, Bed 38; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part).

Description (Figs. 5d–5f). The column is very small and cylindrical, with a narrow axial canal. The articular facet is flat. The central area (areola without perilumen) is half or almost half as wide as the facet, sometimes being covered by irregularly shaped tubercles and pits; it resembles a chagreen. The crenelles are not numerous, simple, and relatively wide, particularly on the periphery. The columnals are of two orders and high.

The lateral surfaces are smooth. The depressions left by the cirri are rare; they occupy about a half of the lateral surface of the first-order columnals and rise above the columnal surface, each forming a crater fringed by a high narrow ridge with radial denticles.

Variability. There are small variations in relative dimensions of the axial canal, columnal height, and width of the central area.

Measurements, mm

Specimen PIN, no.	Dm	dm	H_1	H_2	N	Dm/dm
Holotype 1557/107	2.4	0.5	2.2	2.0	29	4.8
1557/510	2.2–2.8	0.4	2.0	1.6	33	6.0
1557/511a	2.8–3.2	0.6	2.0	1.8	29	5.0
1557/511b	1.0–1.6	0.3	1.2	1.0	18	4.3
1557/511c	1.7	0.4	1.3	1.2	20	4.3

Remarks. Columns frequently bear swellings, which are apparently caused by the myzostomid activity. There is one column that has two adjacent columnals that are inflated, particularly on one side, where a relatively large irregularly rounded orifice is present. Slightly lower and to the right of this perforation, there is another orifice, which is smaller and irregular in outline, with a deep and wide furrow diverging outward. These orifices open into the cavity located within the column. The smaller orifice represents, probably, an accidental breakthrough of the thin cavity wall. The larger orifice is adjacent to two fused columnals.

The columns usually bear a single orifice, which is always located on the continuation of a conjunction line between two neighboring columnals, which are fused at this point. It seems that the myzostomids fed on the content of the axial canal, which was easier to reach through the areas where the columnals met. The presence of a parasite resulted in the swelling of the column and the fusion of its columnals.

The area near the axial canal usually lacks perilumen, but it bears a narrow funnel-shaped depression. The collection includes a large specimen with a small swelling and relatively large depression that adjoins the boundary between the columnals and resembles a bite mark (Pl. 12, fig. 7b). Another tiny barrel-shaped specimen consisting of three columnals has small high cylindrical elevations with regular orifices at the centers that mark columnal boundaries. The lateral surface of the specimen is covered by crenelles. The column of one more specimen is winded around by the distal segment of other column belonging, most probably, to a representative of the Catillocrinacea or Allagecrinacea (Pl. 12, fig. 8). This column fragment consisting of moderately high columnals is rounded-trapezoidal in cross section with a very narrow axial canal and dentate crenularium at the distal end and has a polygonal, partly bilateral attachment base. One of the specimens with a very narrow crenularium and rough areola has a pentagonal axial canal.

M a t e r i a l. Twenty well-preserved column fragments: quarry near the village of Mitino, Exposure 11, Bed 38; marl, Steshev Horizon (lower part).

Genus *Govorovocrinus* Arendt, gen. nov.

E t y m o l o g y. In honor of T.V. Govorova, an artist who helped to draw crinoids.

T y p e s p e c i e s. *Govorovocrinus okensis* Arendt, sp. nov.: Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon; southern side of the Moscow Basin.

D e s c r i p t i o n. The column is small, with a very wide axial canal. The articular facet is very narrow, flattened, covered by about 50 low radial denticles. The column skeleton is thin and tubular. The columnals are of two orders, which are almost equal in height. The middle of the lateral surface on every columnal is crossed by a low belt, which, in second-order columnals, consists of separate tubercles. The axial canal in second-order columnals is slightly narrower than that in first-order columnals (with contractions). The marginal parts of the lateral surfaces of columnals bear slight elevations, and the first-order columnals bear isolated narrow cirrus sockets.

S p e c i e s c o m p o s i t i o n. Type species.

C o m p a r i s o n. Differs from all known crinoid genera that are defined based on column fragments in having an extremely wide axial canal and thin tubular column skeleton with slight contractions and very narrow articular facets of columnals that are entirely covered by well-defined short crenelles.

Govorovocrinus okensis Arendt, sp. nov.

Plate 12, figs. 7 and 8

E t y m o l o g y. After the Oka River.

H o l o t y p e. PIN, no. 1557/105; well-preserved column fragment consisting of four columnals; quarry near the village of Mitino, Exposure 11, Bed 38; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part).

D e s c r i p t i o n (Figs. 5g and 5h). The column is small and cylindrical, with a very wide, cylindrical axial canal. The articular facet is very narrow, flattened, covered by about 50 short low denticles.

Two-order columnals are moderately high. The middle of the lateral surface in every columnal is marked by a small, flat elevation that gives way to low tubercles in second-order columnals. There are gentle elevations along articulation lines. Second-order columnals are characterized by slightly wider axial canals, whereas first-order columnals have wider articular facets.

M e a s u r e m e n t s, mm

Specimen PIN, no.	Dm	dm_1	dm_2	H_1	H_2	N	Dm/dm_1
Holotype 1557/105	3.2	2.2	2.4	1.6	1.4	50	1.52

M a t e r i a l. Holotype.

Genus *Tzvetaevocrinus* Arendt, gen. nov.

E t y m o l o g y. In honor of A.I. Tsvetaeva, who lived in the town of Tarusa.

T y p e s p e c i e s. *Tz. cadiformis* Arendt, sp. nov.: Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part); southern side of the Moscow Basin.

D e s c r i p t i o n. The columns are small with slightly concave articular surfaces; the width of the central area is slightly more than two-thirds of the facet width. The crenelles are moderately high, not numerous, short, and simple. The middle part of the lateral surface in every barrel-shaped columnal is crossed by longitudinal poorly-developed gentle accessory elevations, whereas its sides bear short, indistinct transverse ridges, which continue the crenelles. The columnals are of three orders: first-order columnals are separated by three columnals, of which two outer columnals are of the third order. The first-order columnals bear small cirri consisting of barrel-shaped cirrals.

S p e c i e s c o m p o s i t i o n. Type species.

C o m p a r i s o n. Differs from the relatively close genus *Polenovocrinus* in having crenelles partly seen in the side view, poorly-developed belts on the lateral surface, and barrel-shaped columnals of three rather than two orders and in the form and measurements of cirri and their articula.

Tzvetaevocrinus cadiformis Arendt, sp. nov.

E t y m o l o g y. Latin *cadiformis* (barrel-shaped).

H o l o t y p e. PIN, no. 1557/152; well-preserved column segment; town of Tarusa, Ignatova Gora quarry, Exposure 9e, Bed 34; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part).

D e s c r i p t i o n (Figs. 5i, 5j). Small cylindrical columns with a moderately wide cylindrical axial canal. The articular facet is slightly concave. The central area width slightly exceeds one-third of that of the articular facet. The crenelles are not numerous, wide, moderately raised, and often seen in the side view. The columnals are of medium height and of three orders:

first-order columnals are separated by three columnals, of which two outer columnals are of the third order, and the central columnal is of the second order. In height, they differ from each other, at maximum, by a factor of two. The columnals are barrel-shaped. The middle part of their lateral surfaces is crossed by longitudinal poorly-developed accessory elevations; its sides bear short, indistinct transverse ridges, each of which continues a crenelle to the lateral surface.

The first-order columnals bear rare crater-shaped cirrus sockets with narrow cylindrical axial canals at their centers and poorly-defined short and wide crenelles on the margins. Such craters occupy half of the columnal height and are located in the middle of its lateral surface. Cirri are generally similar to columnals but significantly more concave and higher. No longitudinal and transverse ridges are observed on the lateral surfaces. It seems that cirrals become lower and wider away from the column.

Measurements, mm

Specimen PIN, no.	Dm	dm	H_1	H_2	H_3	N	Dm_c	H_c	Dm/dm
Holotype 1557/152	2.3	0.8	1.2	1.4	2.0	24	1.4	0.7	2.88

Material. Four well-preserved specimens: town of Tarusa, Ignatova Gora quarry, Exposure 9, Bed 34; Steshev Horizon (lower part).

Genus *Polenovocrinus* Arendt, gen. nov.

Etymology. In honor of V.D. Polenov, an artist.

Type species. *Polenovocrinus mitinensis* Arendt, sp. nov.: Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon; southern side of the Moscow Basin.

Description. The column is very small, with a thin axial canal. The central area is wide and slightly concave. The margin of the articular facet bears a few sharp denticles. The lateral surface of each columnal is slightly concave, with a high encircling ridge—a keeled elevation. The columnals are of two orders, which differ in the columnal height and dimensions of the ridge.

Species composition. Type species.

Comparison. Differs from the genus *Breimerocrinus* in the rank of columnals, their lesser concavity, and presence of well-defined keeled elevation in the middle of the lateral surface in every columnal, whereas the latter genus virtually lacks it.

Polenovocrinus mitinensis Arendt, sp. nov.

Plate 12, figs. 1–6

Etymology. After the village of Mitino.

Holotype. PIN, no. 1557/108; well-preserved column; quarry near the village of Mitino, Exposure 11, Bed 38; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part).

Description (Figs. 5k and 5l). The column is very small and cylindrical, with a narrow cylindrical axial canal. The central area is slightly concave and wider than a half of the articular facet. The peripheral zone is flat and covered by a few high radial denticles. The columnals are relatively high, slightly convex, of two orders, and alternating. The middle part of the lateral surface is marked by a narrow, low, even, and sharply outlined ridge, which is slightly smaller in the second-order columnals (which are smaller). The holotype is represented by a column fragment consisting of six columnals and bears a cirrus socket that lies on a low truncated elevation, is slightly concave, and bears a narrow dentate crenularium, wide concave areola, and narrow axial canal. Two-order rank of columnals is indistinct. In some specimens, columnals are distinctly of two orders, and one of five columnals bears a cirrus socket, which is wide but does not cross the longitudinal ridge (Pl. 12, fig. 4). One specimen consisting of seven columnals has no cirrus sockets, and two-order columnals are almost equal in height but differ distinctly in the width of longitudinal ridges in columnals (Pl. 12, fig. 3). Two specimens from the collection show a high level of individual variability. They are characterized by particularly concave areolae; although areolae are more or less concave in other specimens as well (Pl. 12, figs. 5, 6). In the smallest specimen, the crenelle is smooth and rounded-pentagonal, and its axial canal is moderately wide (Fig. 6). One larger specimen bears a particularly wide longitudinal ridge that is rounded and covered by abundant ridges continuing those of crenularia, whereas the axial canal is extremely narrow (Fig. 5). These specimens belong, most likely, to the species under consideration and represent its young forms with particularly concave areolae, thus indicating that the individual variability was significant during early developmental stages as well.

Measurements, mm

Specimen PIN, no.	Dm_1	Dm_2	Dm	H_1	H_2	N	Dm_1/dm
Holotype 1557/108	1.9	2.3	0.6	1.7	1.5	21	3.17
1557/507	2.0	2.2	0.6	1.5	1.0	23	3.33
1557/506	2.0	3.0	0.6	1.6	0.9	27	3.33
1557/505	1.8	2.0	0.6	1.2	0.9	29	3.00
1557/508	1.2	2.2	1.0	0.6	–	30	7.00
1557/509	1.8	1.6	0.2	0.8	–	26	7.00

Material. Seven well-preserved column fragments: quarry near the village of Mitino, Exposure 11, Bed 38; Steshev Horizon (lower part).

Genus *Dipentagonocrinus* Arendt, gen. nov.

Etymology. Greek *di* and *pentagon* (two and pentagon). The name is given because of the pentagonal outline of both columnals and axial canal.

Type species. *Dipentagonocrinus magnocarinatus* Arendt, sp. nov.: Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon; southern side of the Moscow Basin.

Description. The column is small, with a thin pentagonal axial canal, low areola, and highly raised crenularium with short denticles. The area outside the crenularium is occupied by a wide thickened keeled zone, rounded-pentagonal in section, characterized by slightly concave sides, and is particularly thickened at ends. The edges of the axial canal correspond to the middle parts of the sides.

Species composition. Type species.

Comparison. Differs from all known crinoid genera in that the edges of the pentagonal axial canal do not correspond to those of the column proper, but, instead, they regularly alternate. It also differs in having sharply lowered and thickened columnal parts in the areola areas.

Dipentagonocrinus magnocarinatus Arendt, sp. nov.

Plate 12, fig. 10

Etymology. Latin *magnus* and *carinatus* (large and carinate). The name is given because of a large keel located at the lateral surface of a columnal.

Holotype. PIN, no. 1557/87; well-preserved columnal; town of Tarusa, Ignatova Gora quarry, Exposure 9d, Bed 40; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part).

Description (Figs. 5m and 5n). The column is very small and pentagonal, with a narrow pentagonal axial canal. The articular facet is composed of two equally wide parts (internal and external), both of which are more or less flat but separated form each other by a sharp, almost vertical bend. The internal part is characterized by a slightly tuberculate surface and located in a deep depression where the columnal is very thin.

The external part bears a few denticles along its periphery. The denticles are narrow, low, substantially sharp, and partly occupying the lateral surface.

The columnal is rounded-pentagonal in cross section in the area of the articular facet. The lateral surface of the columnal bears a thick wide keel in its middle part that is even more thickened at edges of the pentagon. Thus, the columnal acquires a pentagonal outline with slightly concave sides between rounded angles. Sometimes, the middle part of the lateral surface bears poorly defined tubercles. The edges of the rounded pentagonal axial canal correspond to the middle parts of the external sides of the columnal.

Measurements, mm

Specimen PIN, no.	Dm	dm	H	N	Dm/dm
Holotype 1557/87	3.5	0.2	1.8	32	18.0

Material. Three specimens: town of Tarusa, Ignatova Gora quarry, Exposure 9d, Beds 34 and 40, marl (two specimens); quarry near the village of Mitino, Exposure 11, Bed 38, marl; Steshev Horizon (lower part).

CLASS BLASTOIDEA SAY, 1825

Order Spiraculata Jaekel, 1918

Family Orbitremitidae Bather, 1899

Genus *Orbitremites* T. Austin et T. Austin, 1842

Orbitremites musatovi (Arendt, 1960)

Plate 17, figs. 1–12

Orbitremites derbiensis musatovi: Arendt, 1960, p. 149; 1962, p. 117; 1967, p. 67, text-fig. 1, pl. pp. 72, 73, figs. 1–12; *Osnovy Paleontologii*, 1964, pp. 51, 210, 211, pl. 6, figs. 11a–11d.[6]

Lectotype. PIN, no. 1557/1, well-preserved calyx; right bank of the Oka River, quarry near the village of Mitino; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part).

Description (Figs. 6a–6f). The calyx is close to spheroid in shape, frequently with rounded-decagonal cross section, and slightly compressed base. It is usually widest at the level of the boundary between the radial and deltoid plates, and its maximum diameter substantially exceeds, as a rule, the maximum height. The column-adjoining cavity occupies about one-third of the surface of basals. The axial canal is narrow. The small basals lie entirely within the basal cavity; the smallest of them, which is located in the AB interray, is tetragonal, whereas the other two are pentagonal. The radials occupy less than one-third of the cup and have narrow bases varying in width: their width is less by half in the area where they contact with a single rather than two basals (within rays C and E). The boundary between the radial and deltoid plates usually forms an almost right angle with the ray margin (Fig. 6f). The deltoid plates occupy at least two-thirds of the cup height. The distal part of many deltoid plates forms a distinct gently sloping depression. In the actinal part, the plate is terminated by an elevation with a spiracle, which usually tapers toward the oral end; its surface is more or less strongly inclined to the mouth. The anal spiracle is several times larger than the other spiracles and usually rounded-triangular in shape. The rays are relatively narrow; in the smallest specimens, they are slightly petaloid; they penetrate into the cup base only slightly and into the radials more than a half of their height. They are bounded by marginal ridge-shaped gentle elevations, which frequently are wider in the middle of the height of deltoid plates and terminating by large trapezoid elevations in the abactinal part. The lancet-shaped plate occupying about a half of the ray is

[6] All data on *Orbitremites* mentioned in *Osnovy Paleontologii* are mine.

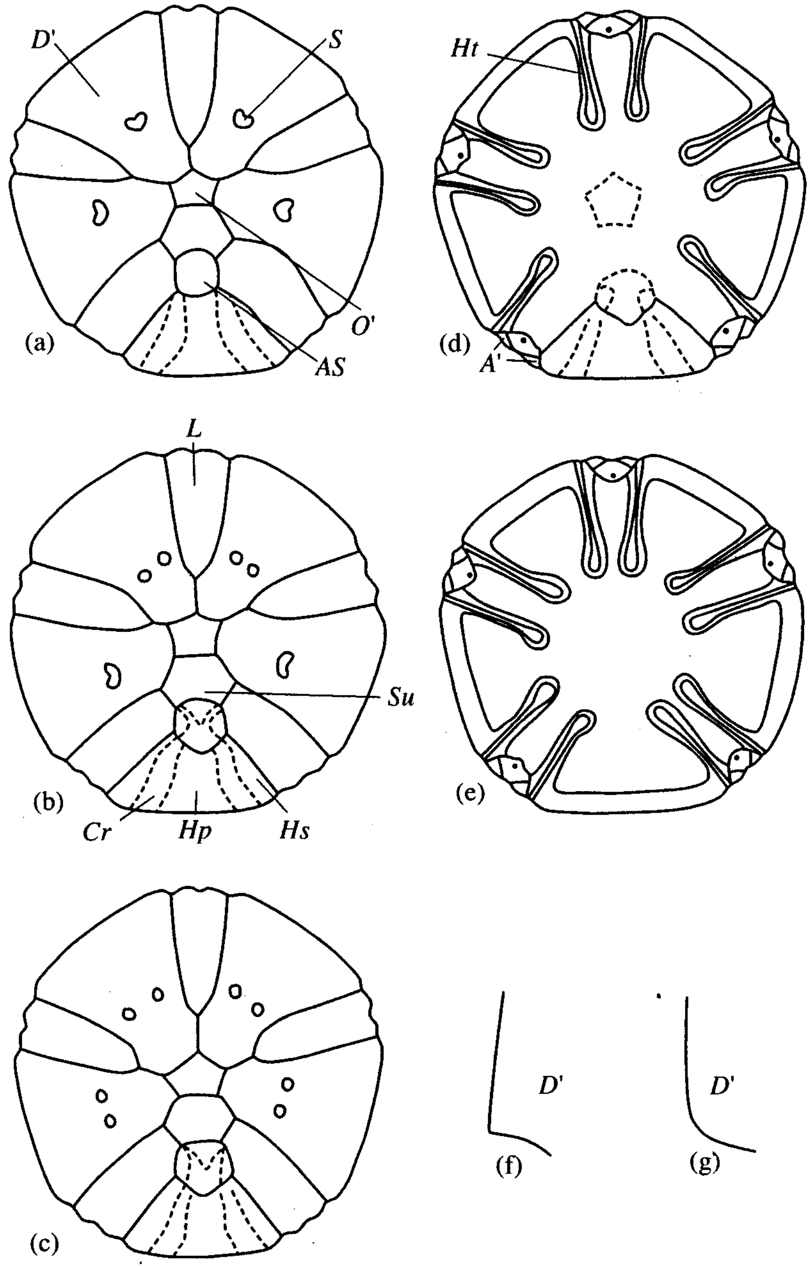


Fig. 6. Orbitremitidae: (a–f) *Orbitremites musatovi* (Arendt, 1960): (a–e) successive polished sections of theca, PIN, no. 1557/30, ×5: (a) 0.1 of a height, (b) 0,0.15, (c) 0.2, (d) 0.3, (e) 0.5, (f) side outline of the deltoid plate, PIN, 1557/25; quarry near the village of Mitino, Exposure 11, Bed 38; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part); (g) *Orbitremites derbiensis* (Sowerby, 1926), side outline of the deltoid plate; Gressington, Yorkshire, England, Middle Limestone, Subzone D_2, upper Viséan; collection by K.A. Joysey. For letter designations see Footnote 2.

open over one-third of its width. The lateral plates are short, irregularly trapezoidal, narrower at the level of radials than at the level deltoid plates, each with a large elevation slightly displaced from the center of the plate toward the ray. The external lateral plates are small, relatively low, triangular, inserted between lateral plates. Laterally, they and lateral plates are adjacent to irregularly rounded hydrospire pores. The attachment scars of brachioles are poorly distinguishable. Every lateral plate corresponds to about five grooves left by covering plates and oriented toward the ray. The number of lateral and external plates ranges from 7 to 23 on each side of the ray; the number of pores is 1.5 times larger, mainly because of their concentration at the level of deltoid plates. The pores are frequently separated by elevations stretching from the radial and deltoid plates toward the middle of the external lateral plates. The hydrospire folds are straight in cross section and, as is seen in the specimen prepared from the inside (Pl. 17, fig. 6), extend toward the base of rays, gradually becoming shorter and noticeably tapering. The series of sections shows that the peripheral parts of hydrospire tubes split partly beginning already from the oral area so that their cross sections acquire cordiform outlines (Fig. 6). At a distance of about 1/6–1/5 of the calyx height from the oral plate, the tubes completely bifurcate first within the two interrays adjacent to ray A and subsequently within the two neighboring interrays. The anal spiracle split into three parts; well-prepared specimens demonstrate protrusions separating the anus from the spiracles. The CD interray bears a small superdeltoid, large hypodeltoid, two narrow slightly curved cryptodeltoid (their boundaries are poorly distinguishable), and (farther to the periphery) elongated hydrospire plates. The irregularly pentagonal oral disc is usually slightly narrower than the anal spiracle.

The ornamentation is developed only on the radial and deltoid plates and is missing from the basals. The proximal parts of radials usually bear four to five well-expressed growth ridges that are arranged in parallel to their margins and locally passing into tubercles, the number of which increases distally. Beginning from about the half of their height, the radials are covered by sufficiently large, irregularly rounded tubercles, which loss their distinct confinement to the growth ridges near the upper margin. The deltoid plates are entirely covered by tubercles, which are usually slightly larger and are located mainly in the lower part in parallel to the proximal margins of the plates. In all calyx plates, the rows of tubercles are located at similar levels. Almost all specimens bear a poorly defined elevation composed of the rows of tubercles aligned along the symmetry planes of the deltoid plates.

V a r i a b i l i t y. Many calyces are slightly to, sometimes, strongly asymmetrical (Pl. 17, figs. 3, 4). Some of them bear fairly wide depressed zones located between the neighboring growth lines; in this case, the ornamentation of the deltoid plates is poorly developed, which can probably be explained by the lack of carbonate material during the growth. Many specimens almost lack ornamentation on the distal margins of the radials, and some specimens almost lack growth ridges but have, instead, tubercles. Sometimes, poorly developed ridges are located in parallel with the upper margins of plates. Surfaces adjacent to spiracles may be almost horizontal (usually in small specimens). The anal spiracle can be round or oval; the elevations surrounding spiracles may be sometimes fairly high. Variations in proportions of calyces and of their separate elements are evident from the table given below.

M e a s u r e m e n t s, mm

Specimen PIN, no.	H	W	$H_{D'}$	H_R	$N_{A'}$	$N_{A'D'}$	$N_{A'R}$
1557/1	3.7	4.2	3.0	1.2	14	10	4
1557/8	3.9	4.8	3.1	1.3	16	11	5
1557/10	4.0	4.4	3.4	1.1	13	9	4
1557/28	4.5	5.5	3.4	1.4	18	12	6
1557/32	6.3	6.2	4.8	1.7	22	17	5
1557/35	6.0	6.2	4.8	1.6	23	17	6
1557/39	3.9	4.9	3.2	1.3	14	10	4
1557/40	2.3	2.8	1.9	1.0	7	5	2
1557/41	2.9	3.6	2.2	1.0	11	8	3
Variation limits	2.3–6.3	2.8–6.6	1.9–4.8	1.0–1.9	7–23	5–17	2–7
Average values[7]	4.225	4.919	3.311	1.344	11.694	11.194	4.417

C o m p a r i s o n. The species under consideration is close to *Orbitremites derbiensis* (Sowerby), the type species of the genus *Orbitremites* from the D_2 Subzone of the Upper Viséan of England. The most complete description of this blastoid form is given in (Etheridge and Carpenter, 1886). Its thorough study was performed by Joysey (1959). Some new data on this form were presented by Fay (1960, 1961). Direct comparison of Blastoidea forms from the Moscow Basin and England became possible owing to K.A. Joysey, who sent 15 specimens of *O. derbiensis* (Sowerby) from the Lower Carboniferous deposits of England to the Paleontological Institute.

During the study of blastoid specimens from the Moscow Basin, the following parameters were measured: (1) height and diameter of all complete calyces, (2) height of the deltoid and radial plates, and (3) total number of the lateral ambulacral plates and their number on the radial and deltoid plates. The results of some measurements are discussed below. Some pairs of these features were used to compile dispersion diagrams. The latter were compared with the diagrams compiled for *O. derbiensis* by Joysey (1959). This comparison revealed that statistically significant differences are established only for the ratio of height to diameter (the confidence level is 0.01). The height of most of blastoid specimens from the Moscow Basin is less than the diameter (only 2.5% have reversed ratios), whereas in 80% of blastoids from England, the height prevails over the diameter. Nevertheless, the taxonomic significance of this feature, taken alone, should not be overestimated, because this parameter in the available youngest specimens from the England collection is frequently similar to that in the blastoid representatives from the Moscow Basin. There are important differences in features that were not statistically characterized by Joysey.

[7] Average values in (Joysey, 1959) presented for *O. derbiensis* are as follows: 8.579, 8.127, 6.439, 3.072, 29.527, 20.309, and 9.218, respectively.

These are the following: (1) in blastoids from the Moscow Basin, the boundary between the radial and deltoid plates usually forms almost a right angle with the ray margin, whereas in those from England, the latter is significantly inclined toward the actinal side of the calyx; (2) relative diameter of the column depression is significantly larger in the specimens from the Moscow Basin than in the specimens from England; moreover, the depression in the latter is characterized by steeper slopes; (3) on average, the blastoid specimens from the Moscow Basin are almost half as large as those from England. The last of these differences can hardly be explained by the fact that blastoids from the Moscow Basin are represented by younger specimens. Amid other differences characteristic of the forms from the Moscow Basin, noteworthy are the following: the rays are slightly wider, the swellings of the ridges fringing the deltoid plates are more developed, the number of pores is less, the anal spiracle is usually larger, and the linear patterns of ornamentation are more distinct. It should be noted, however, that these differences are relative and can be variably expressed in specimens from different localities. All these dissimilar and similar morphological features, as well as the stratigraphic position and geographic distribution of the compared blastoid species, imply that they represent two separate species of the *Orbitremites* genus rather than two subspecies of the species *O. derbiensis* (Sowerby), as I thought previously.

Remarks. Previously, blastoid specimens were found in Carboniferous (Tournaisian) deposits within two localities of the Moscow Basin. Kh.I. Pander discovered several specimens of *Pentremites puzos* Münst. (=*Orophocrinus puzos*) near the village of Filimonovo in the Tula Region (Lahusen, 1895). The second find (*Pentremites* sp.) is reported from the clayey *Citerina* sequence of the Upino Horizon without indication of the exact locality. The material sampled in both localities is lost and revision of the determinations is impossible. Prior to my publications, blastoids from the Viséan and Serpukhovian deposits of the Moscow Basin were completely unknown.

Despite the mass occurrence of crinoids, whose remains frequently form crinoid limestones and marls in the Steshev Horizon, Blastoidea are very rare. In 1956 and 1958, I sampled in the Steshev Horizon uncovered in the quarries near the village of Mitino and town of Tarusa on the Oka River and subsequently described 40 small excellently preserved calyces of the Blastoidea species *Orbitremites musatovi* (Arendt, 1960) (Arendt, 1960, 1967). Almost all of them were found in the Mitino quarry. The quarry near the town of Tarusa yielded the only specimen found at the same stratigraphic level. Despite the fact that the bed with these blastoids remains was later studied in many localities, no additional finds have been made.

In the Mitino quarry, blastoids are rare, averaging one specimen per 8 m^2 of the bed surface and being distributed more or less regularly. Sufficiently numerous specimens were sampled only owing to the fact that the enclosing bed turned to be uncovered by a bulldozer over a significant area. At present, this bed, as well as the section as a whole, is inaccessible for study in the Mitino quarry, because the latter is abandoned and covered by landslides. The samples of marls enclosing blastoid remnants were extensively washed. Examination of large volumes of the sediments revealed that blastoid thecas with diameter less than 2.8 mm are absent, whereas similarly sized skeletons of various other organisms occur in abundance.

Beds in the lower part of the Steshev Horizon are highly variable in lithology (Fig. 9). In the Ignatova Gora quarry, sharp changes in the bed thickness, replacements of limestones by marls and clays, and significant faunal differences between different parts of the same layer can be observed at a distance of a hundred of meters. The sediments show undoubted signs of high-energy depositional environment (Arendt, 1960, 1962, 1967).

The Steshev deposits in the Ignatova Gora quarry provided, in addition to a single blastoid theca, a cup of crinoid species *Rhabdocrinus vatagini* Arendt close to *Rh. scotocarbonarius* (Wright) from the Viséan of Scotland. The blastoid species from the Moscow Basin also show a significant similarity with the upper Viséan blastoids from Great Britain. On the other hand, representatives of some species, such as *Claviphyllum eruca* (McCoy), *C. carruthersi* (Hill), and *Konickophyllum interruptus* Thomson et Nicholson occurring together with blastoid forms similar to those from the Moscow Basin, are distributed in the basal Namurian layers of Scotland. Thus, it is not inconceivable that the blastoid species *O. derbiensis* (Sowerby) from England can be slightly older than those from the Moscow Basin and is, probably, ancestral to them.

It should be noted that microcrinoid species *Kallimorphocrinus scoticus* (Wright) described here is characterized by the stratigraphic distribution similar to those of *Rhabdocrinus scotocarbonicus* (Wright) and *Orbitremites derbiensis* (Sowerby) in the Britain Isles. The species *Floricyclus paratus* (Sisova) and *Plummeranteris candidus* (Sisova) described from the lower part of the Steshev Horizon in the Tarusa and Mitino quarries are also characteristic of the upper Viséan and lower Serpukhovian stages (Dalnii and Beleuta horizons) of central and southern Kazakhstan. The majority of forms described here are new, and some of them were described by myself previously and are so far known only from the southern side of the Moscow Basin (Arendt, 1962, 1963, 1981).

Material. Forty-one excellently preserved thecas: quarry near the village of Mitino; Exposure 11, Bed 38, marl; Serpukhovian Stage, Lower Serpukhovian Substage, lower part of the Steshev Horizon (40 thecas); Ignatova Gora quarry in the town of Tarusa; Exposure 9d, Bed 38, marl; Serpukhovian Stage, Lower Serpukhovian Substage, lower part of the Steshev Horizon (one well-preserved theca).

Plate 1

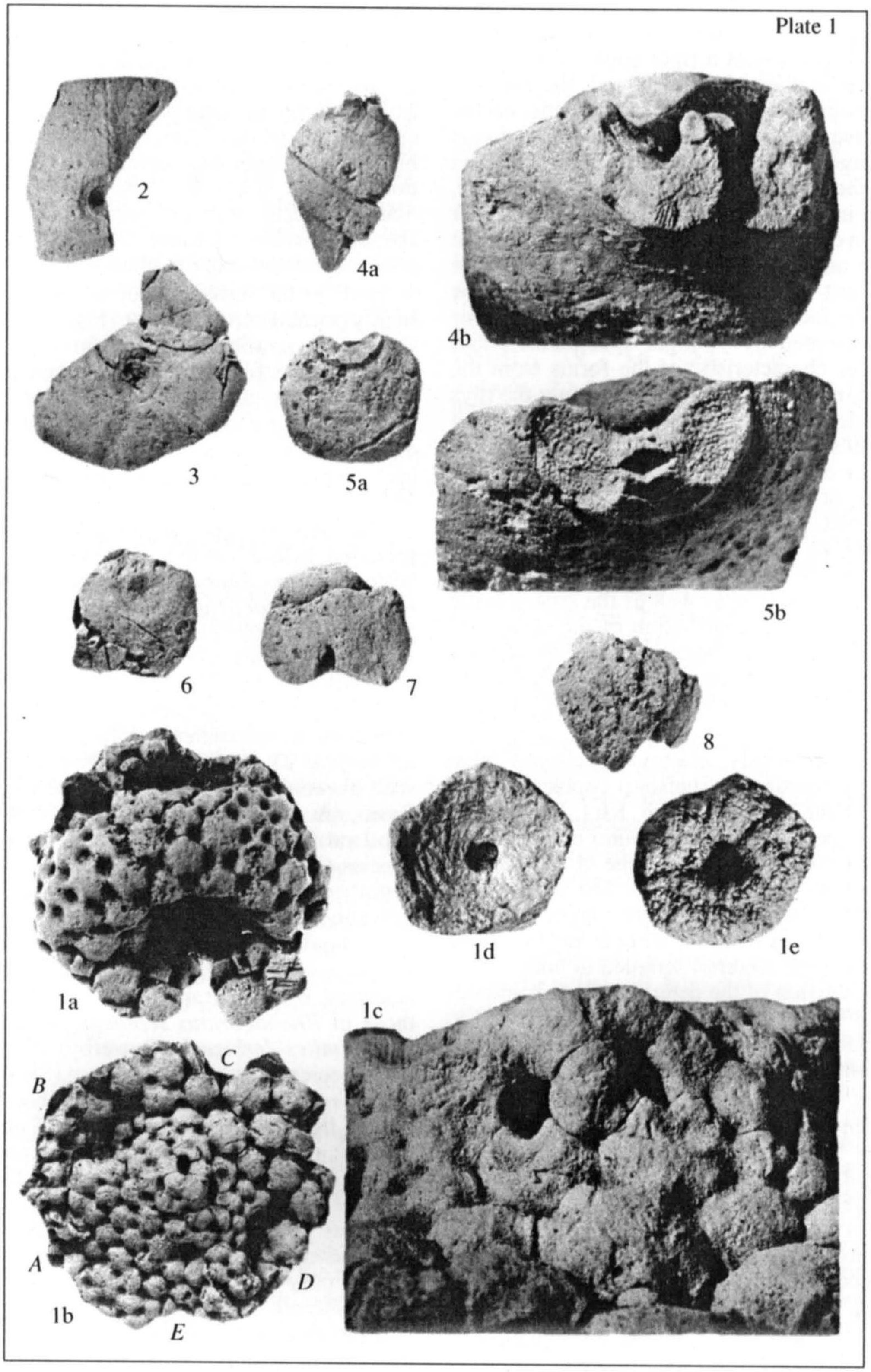
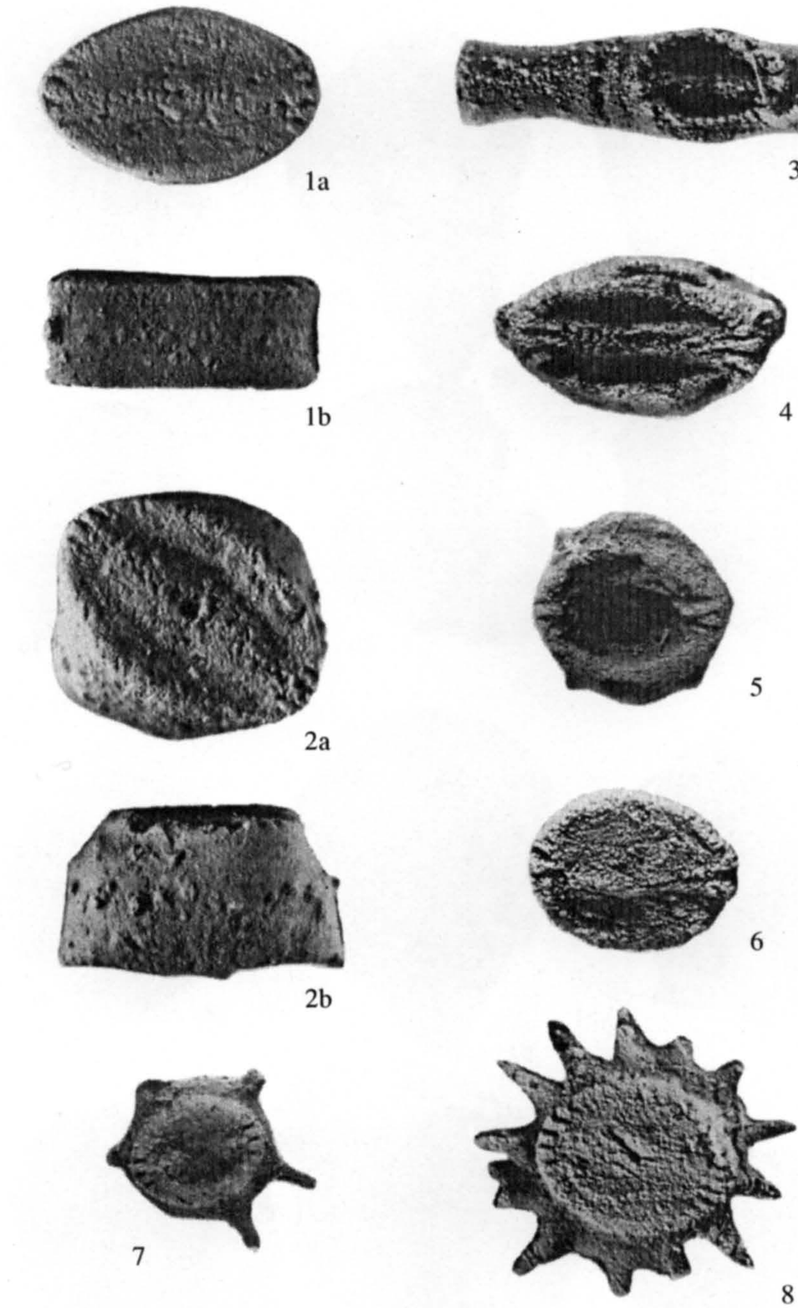


Plate 2



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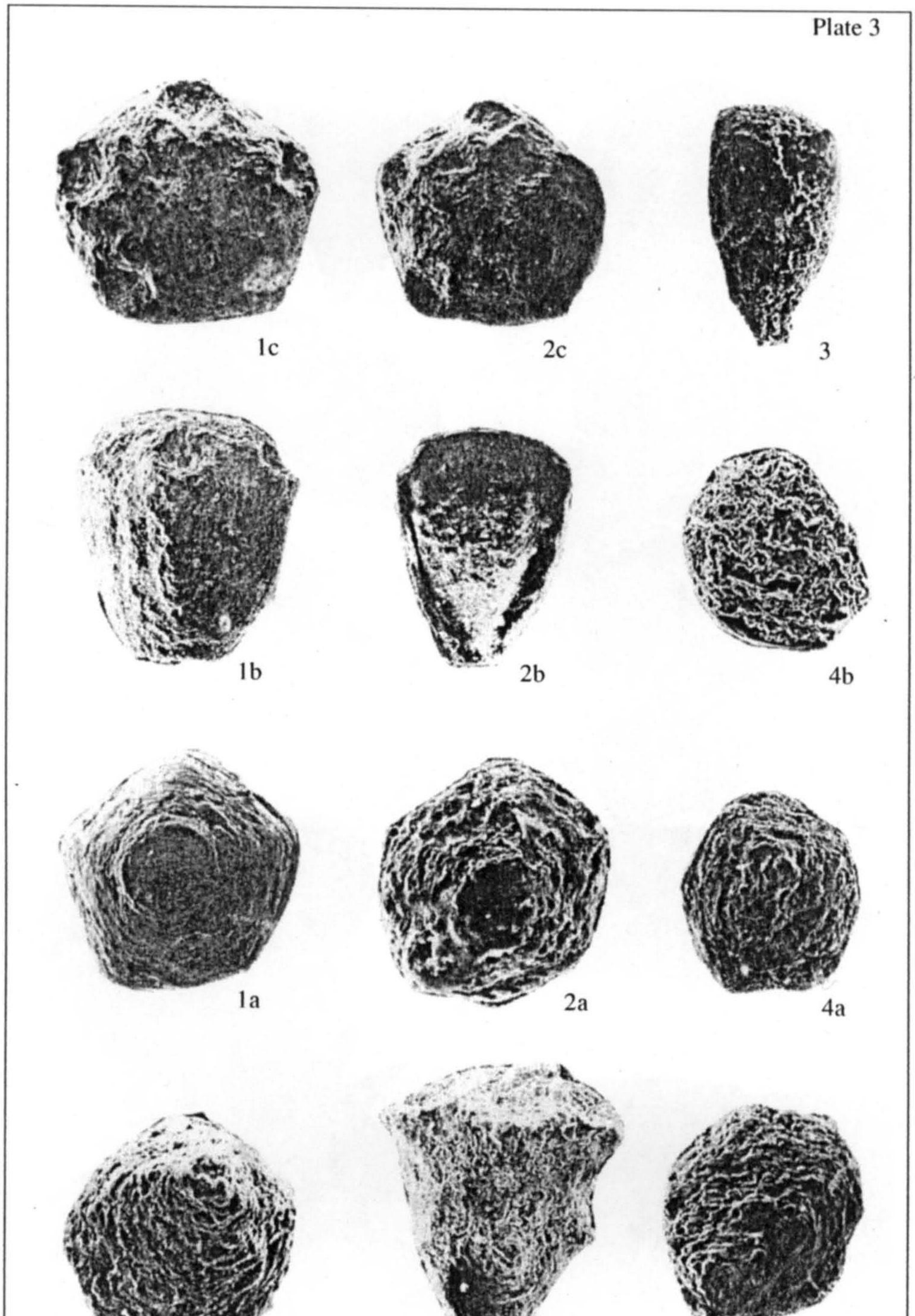

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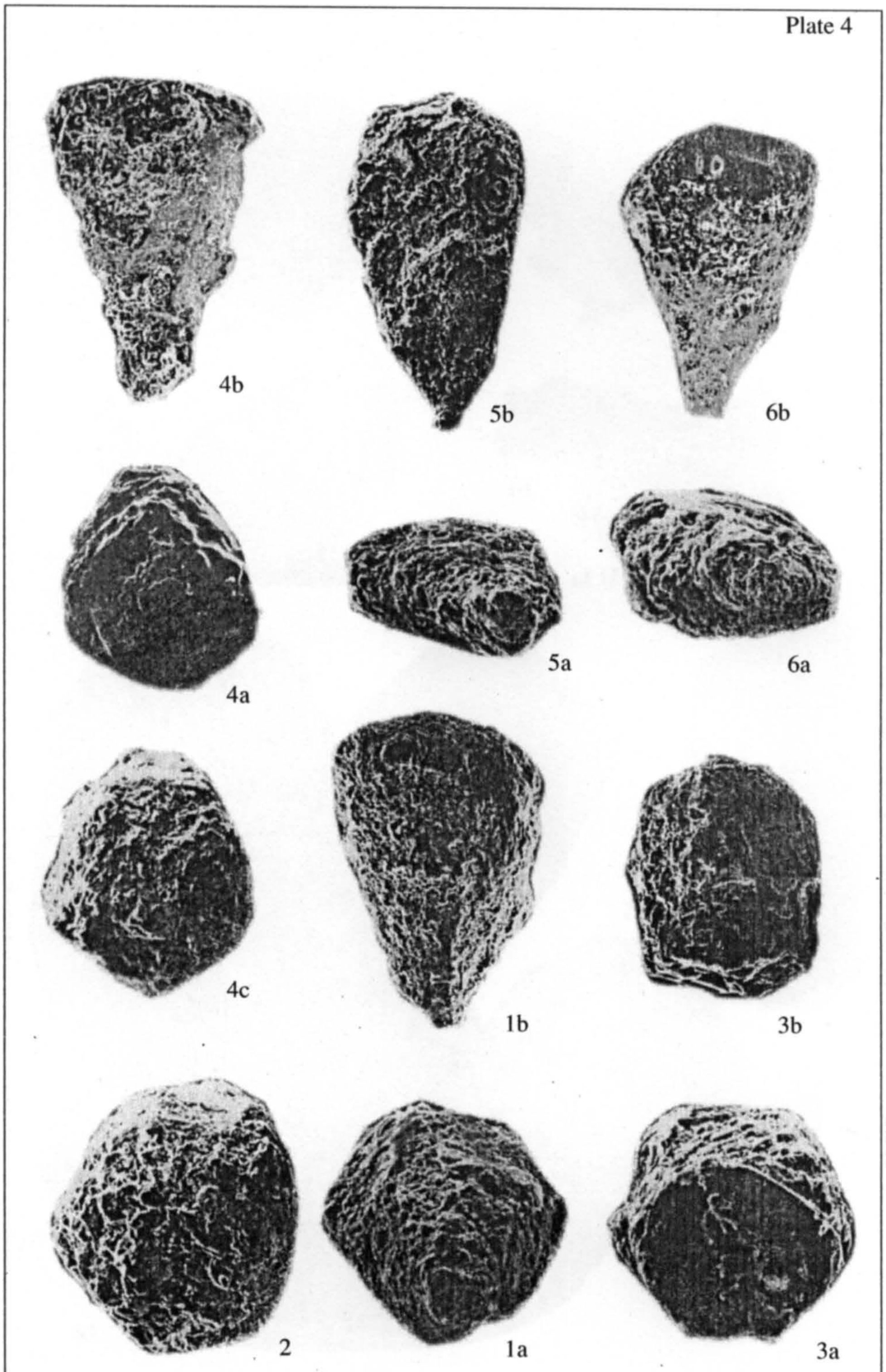

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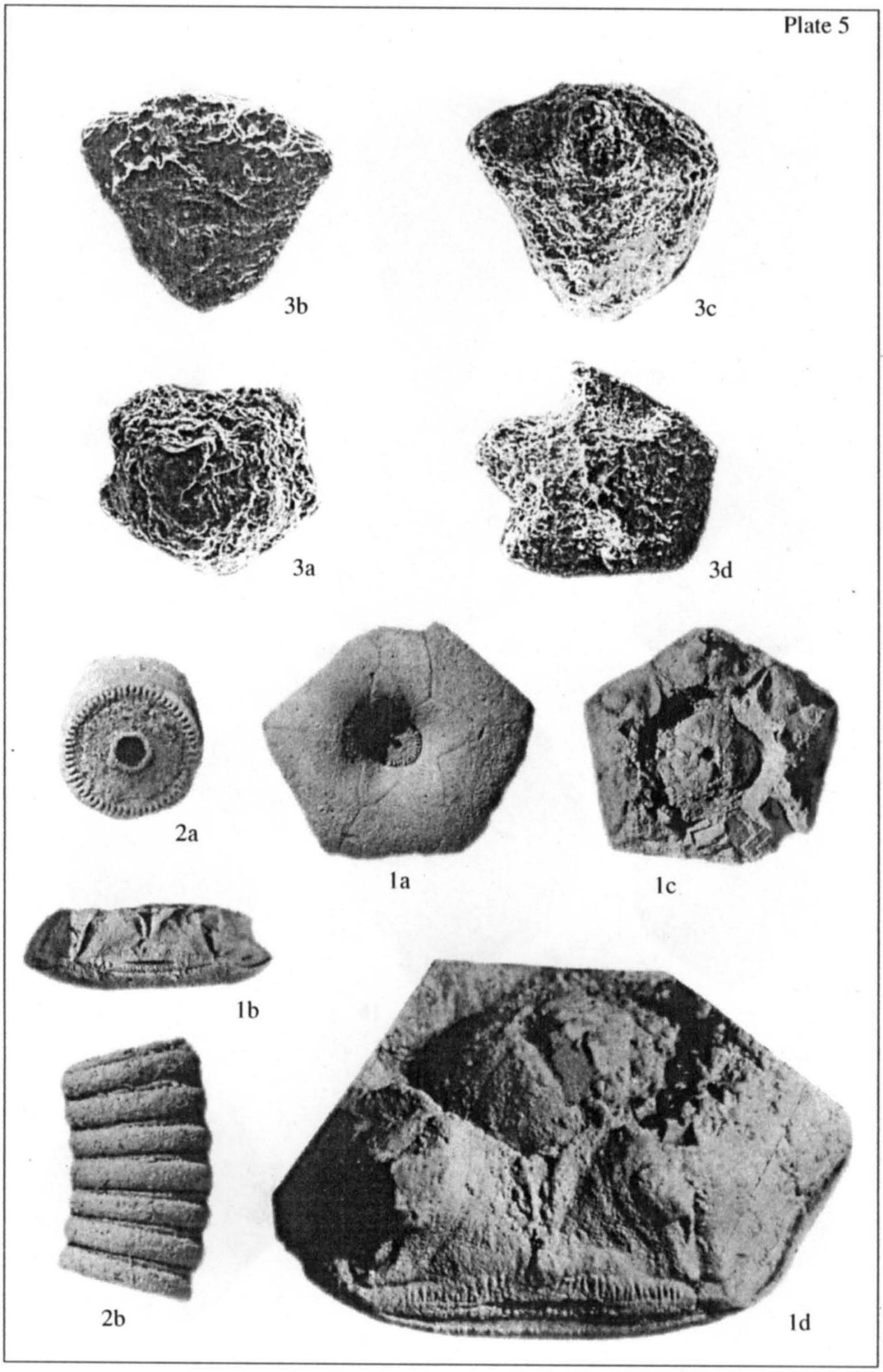

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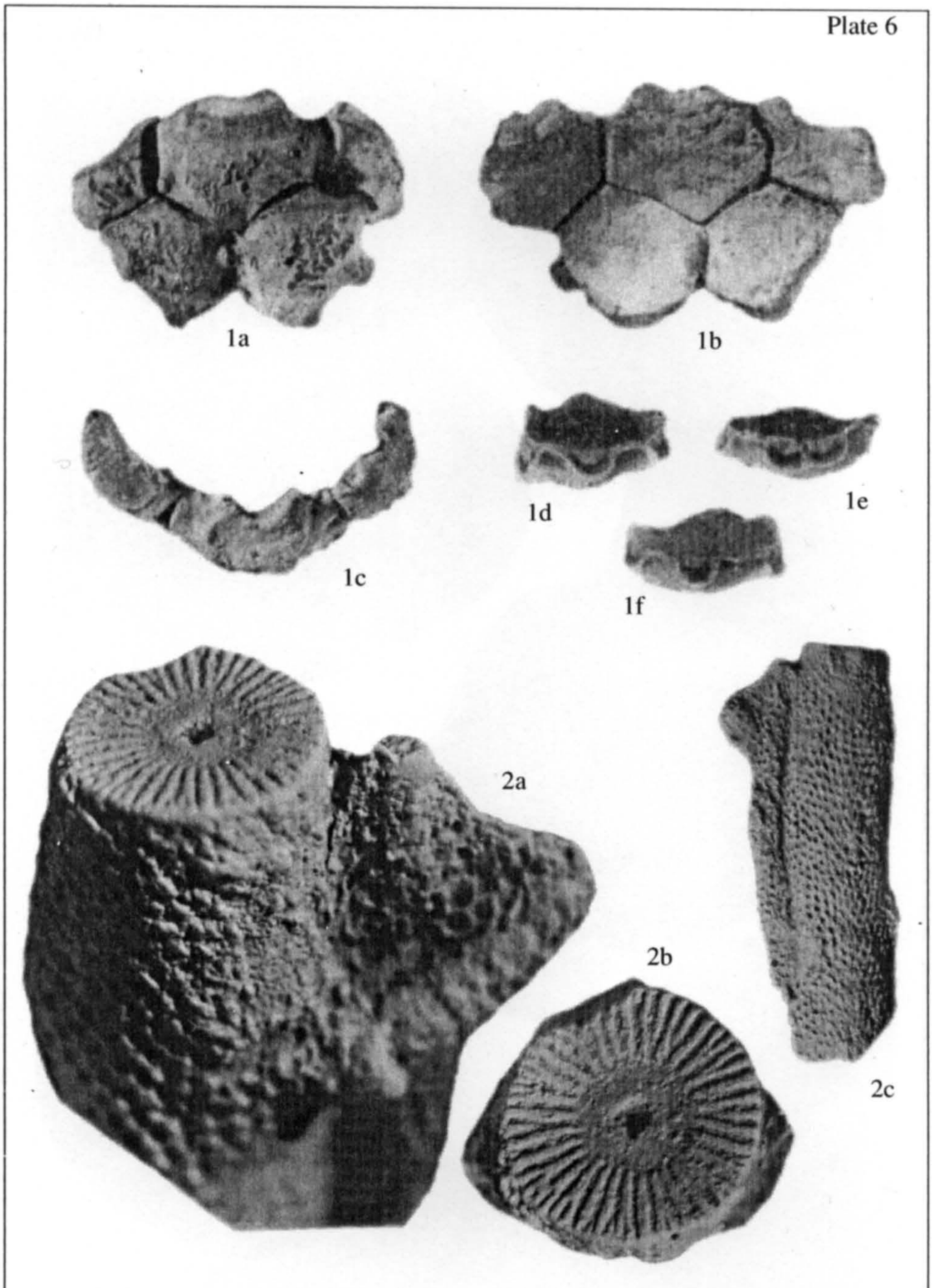


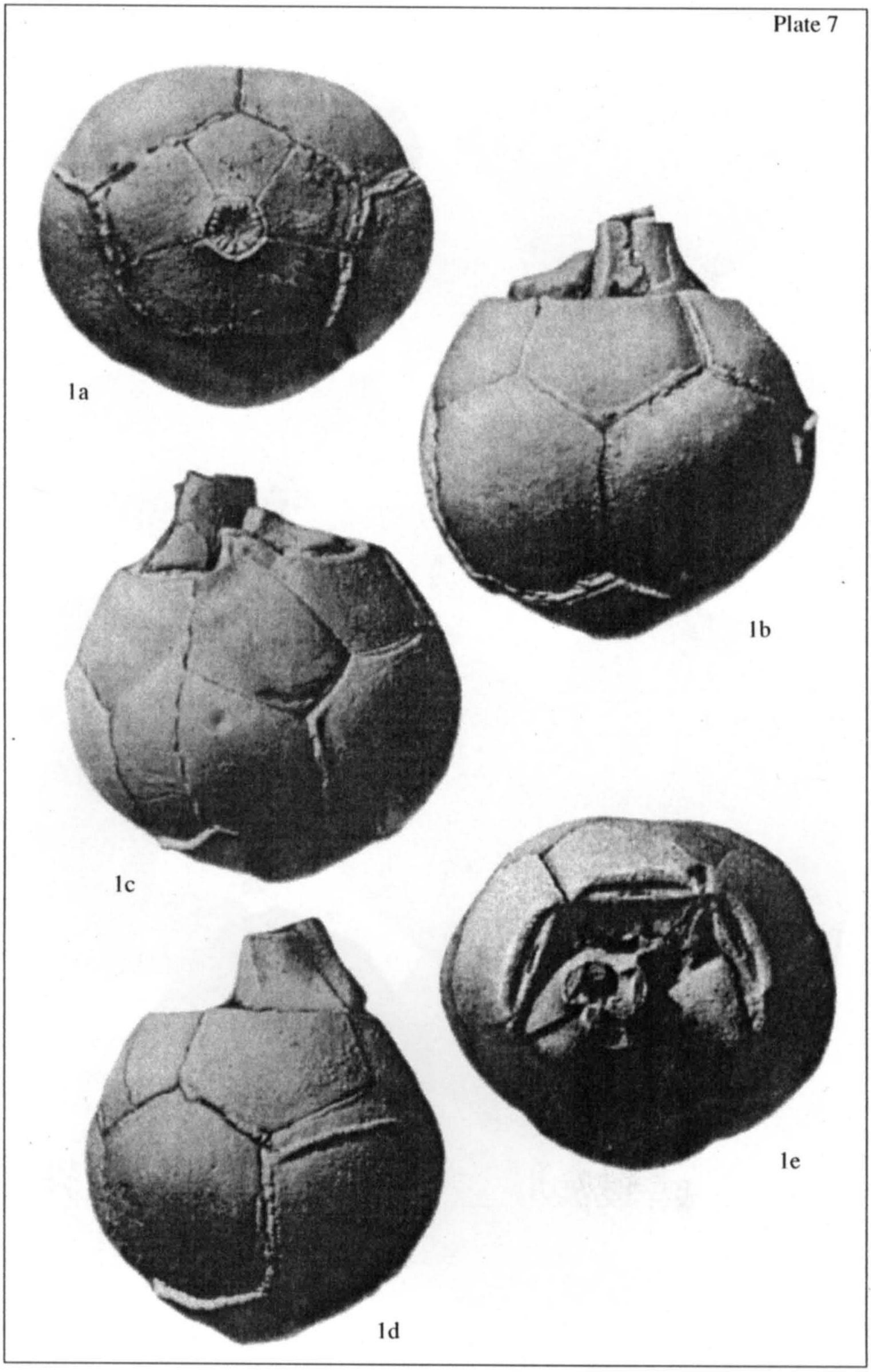
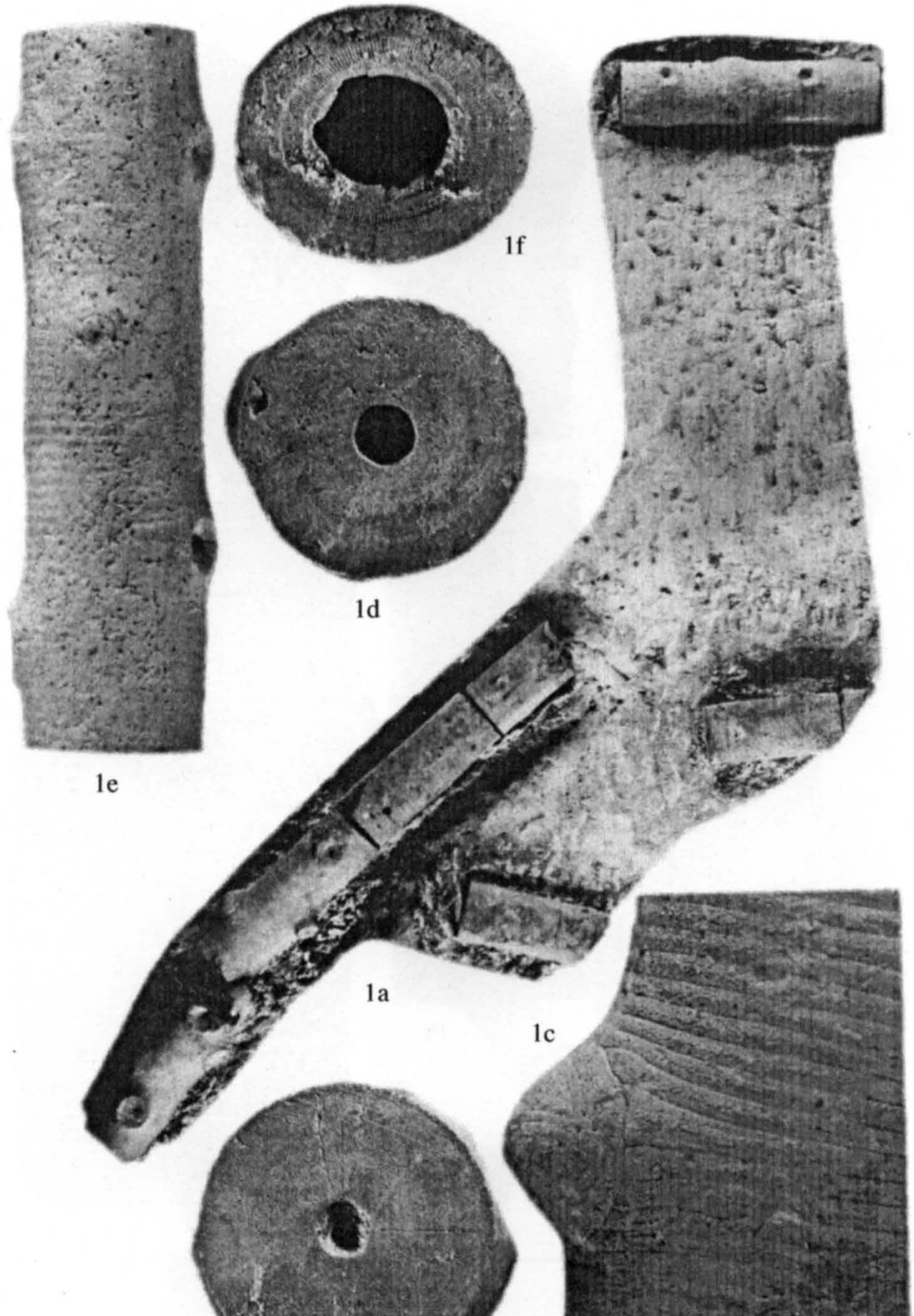


Plate 7
1a
1b
1c
1d
1e

Plate 8



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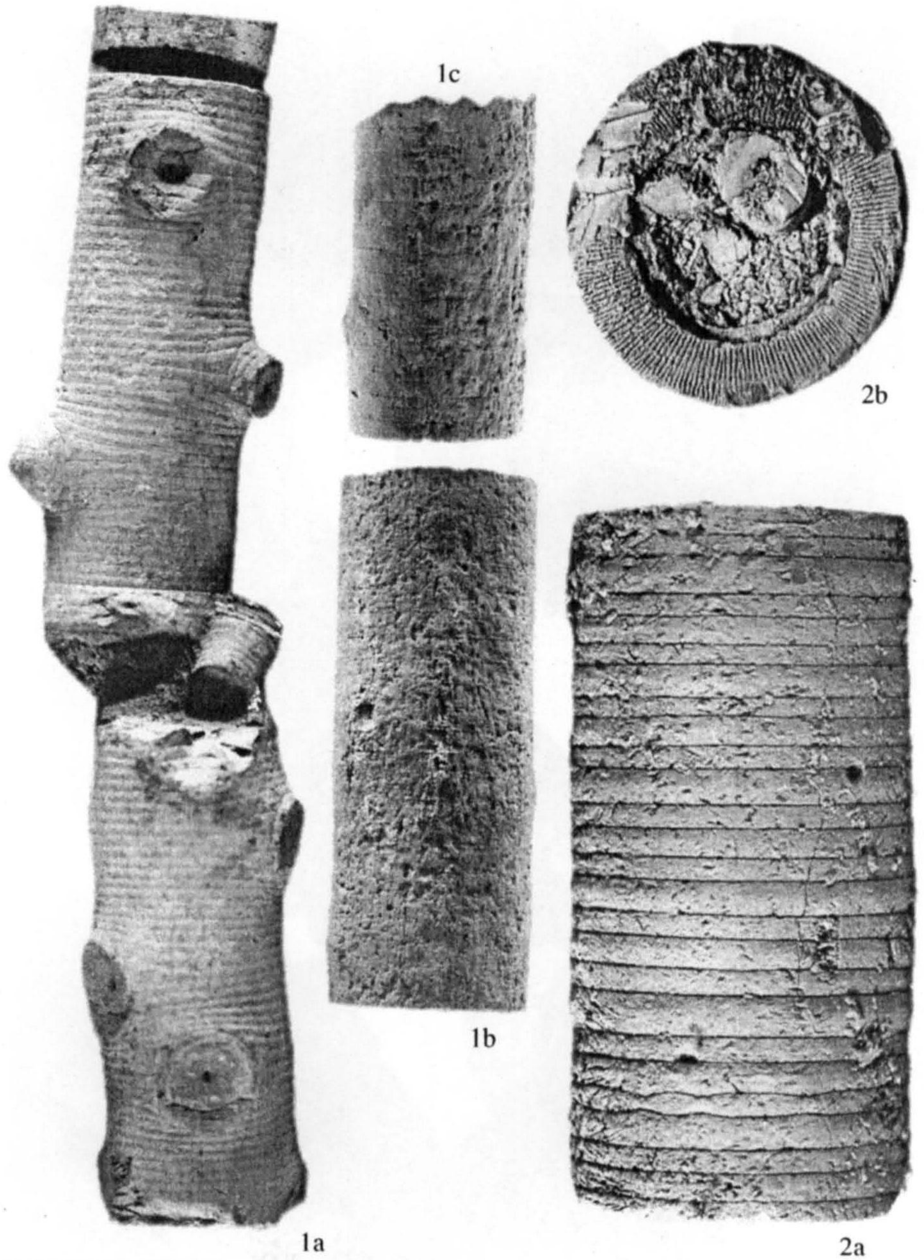

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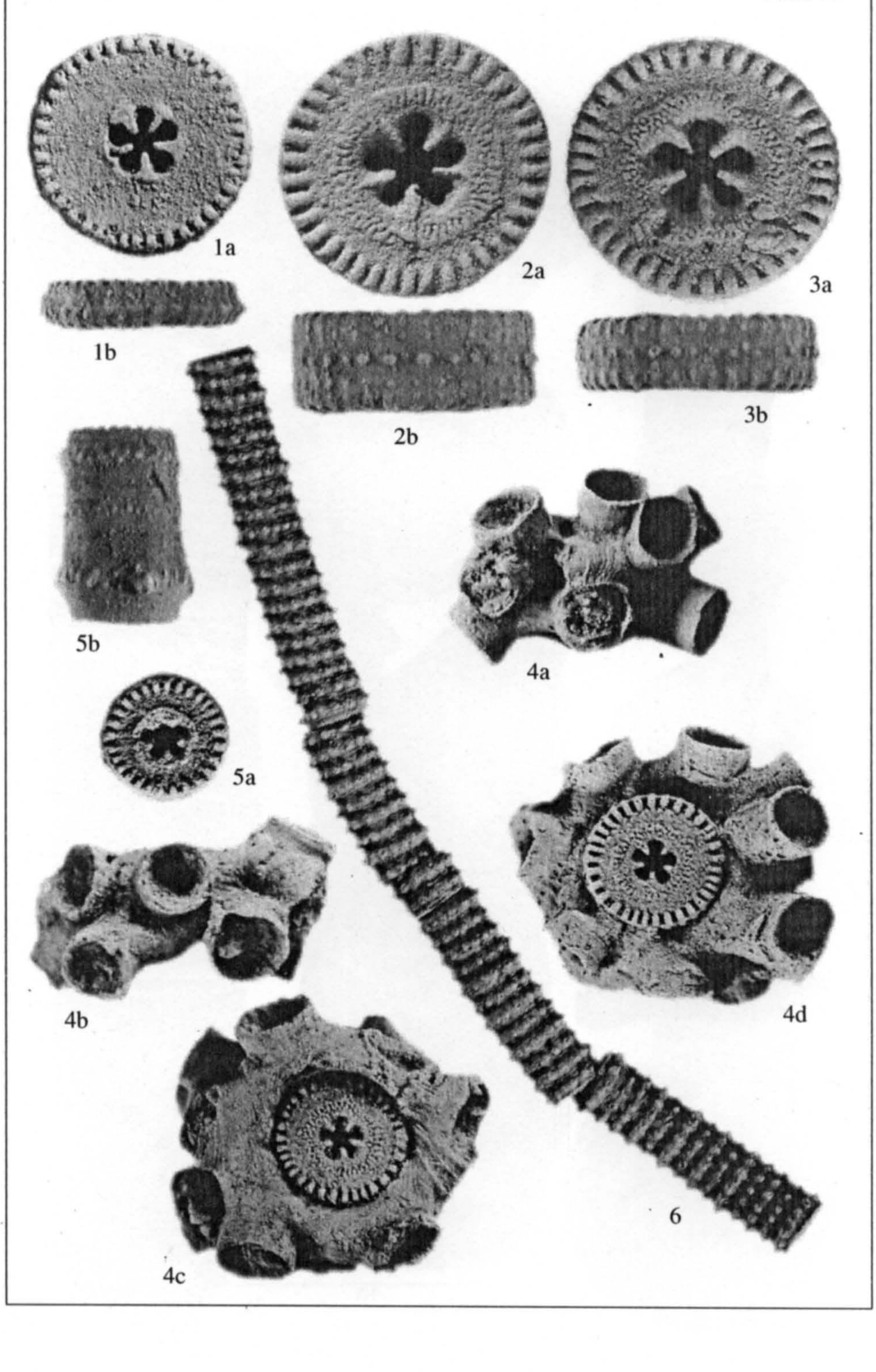


Plate 11

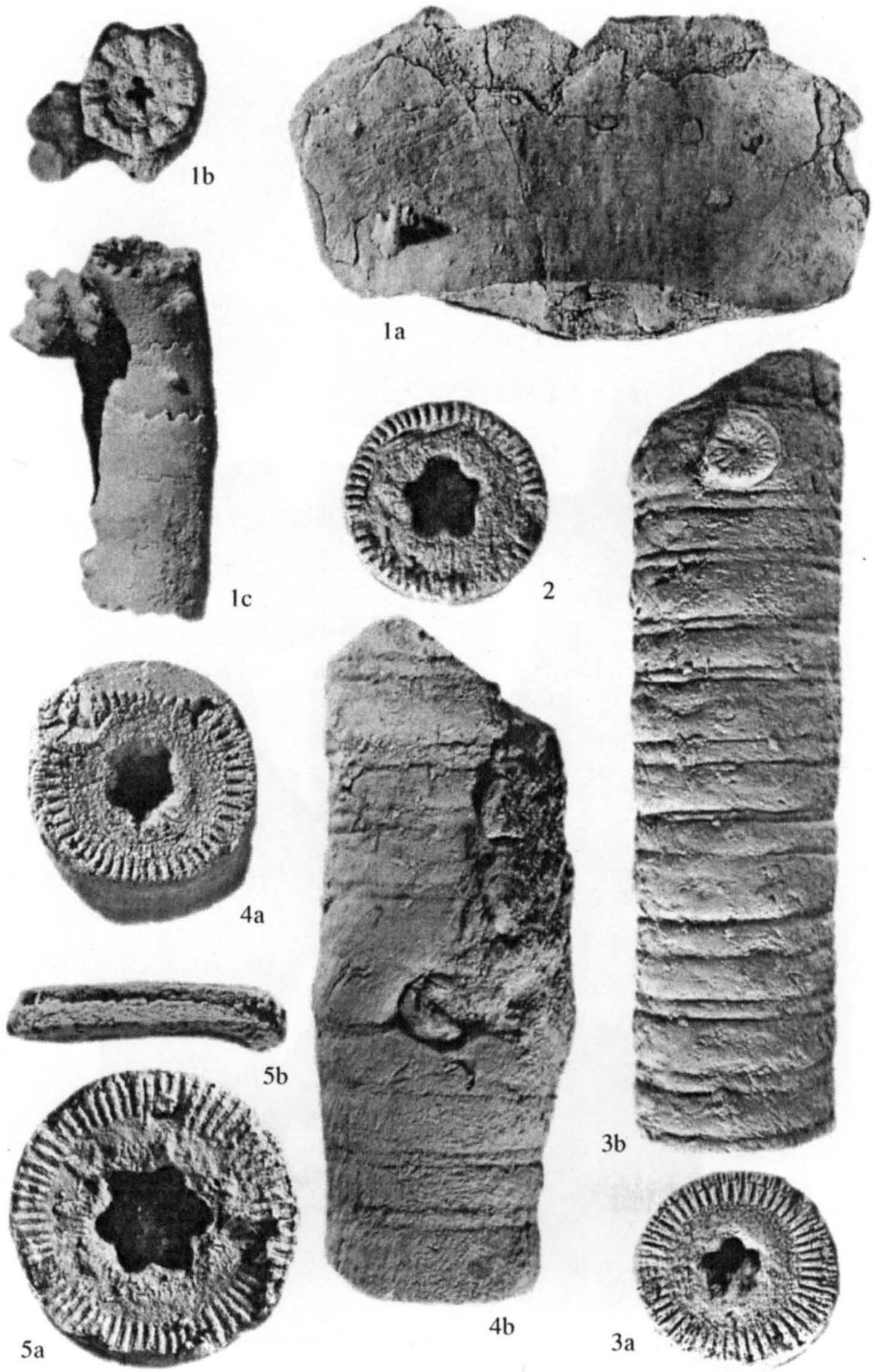


Plate 12

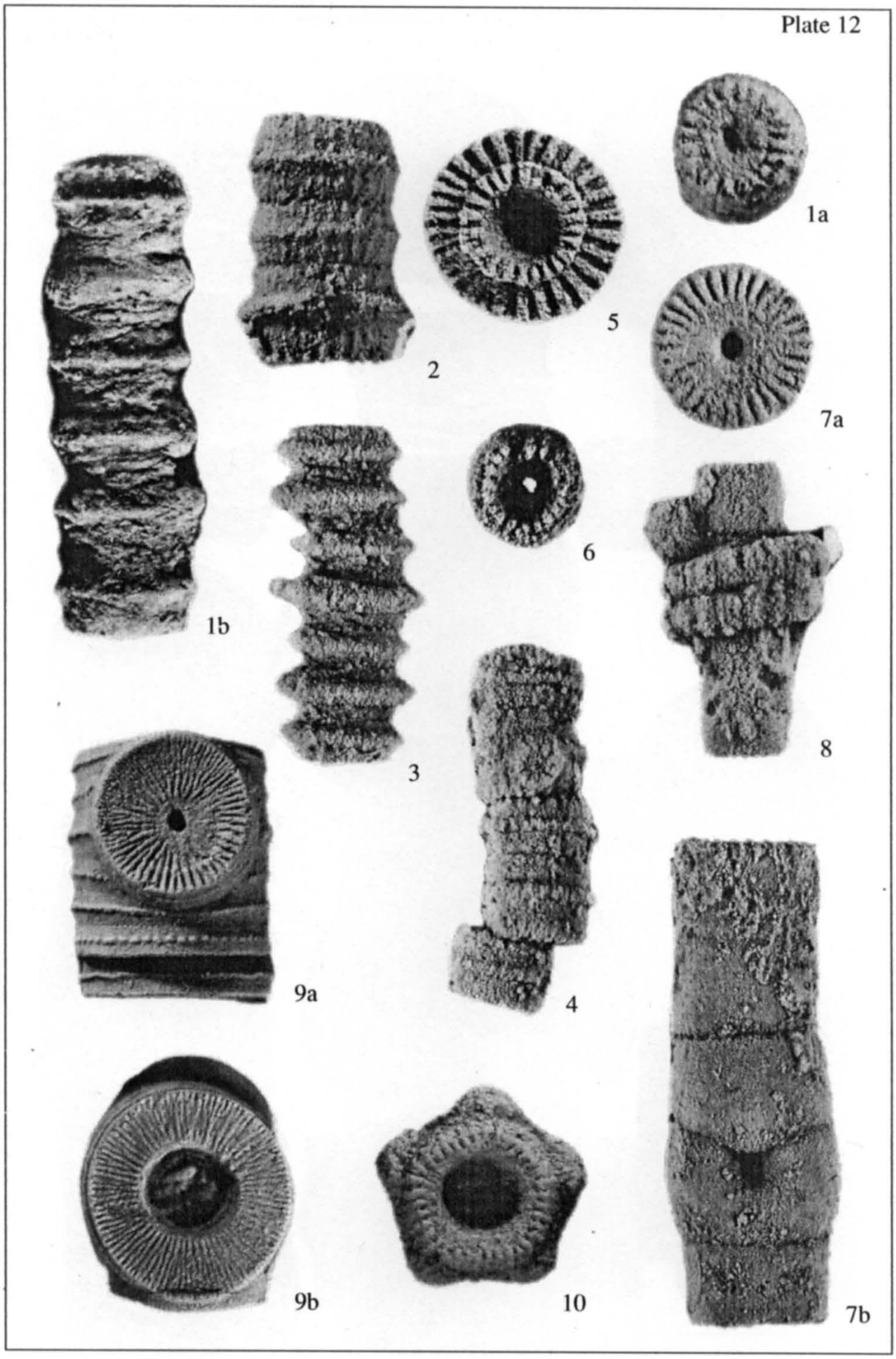


Plate 13

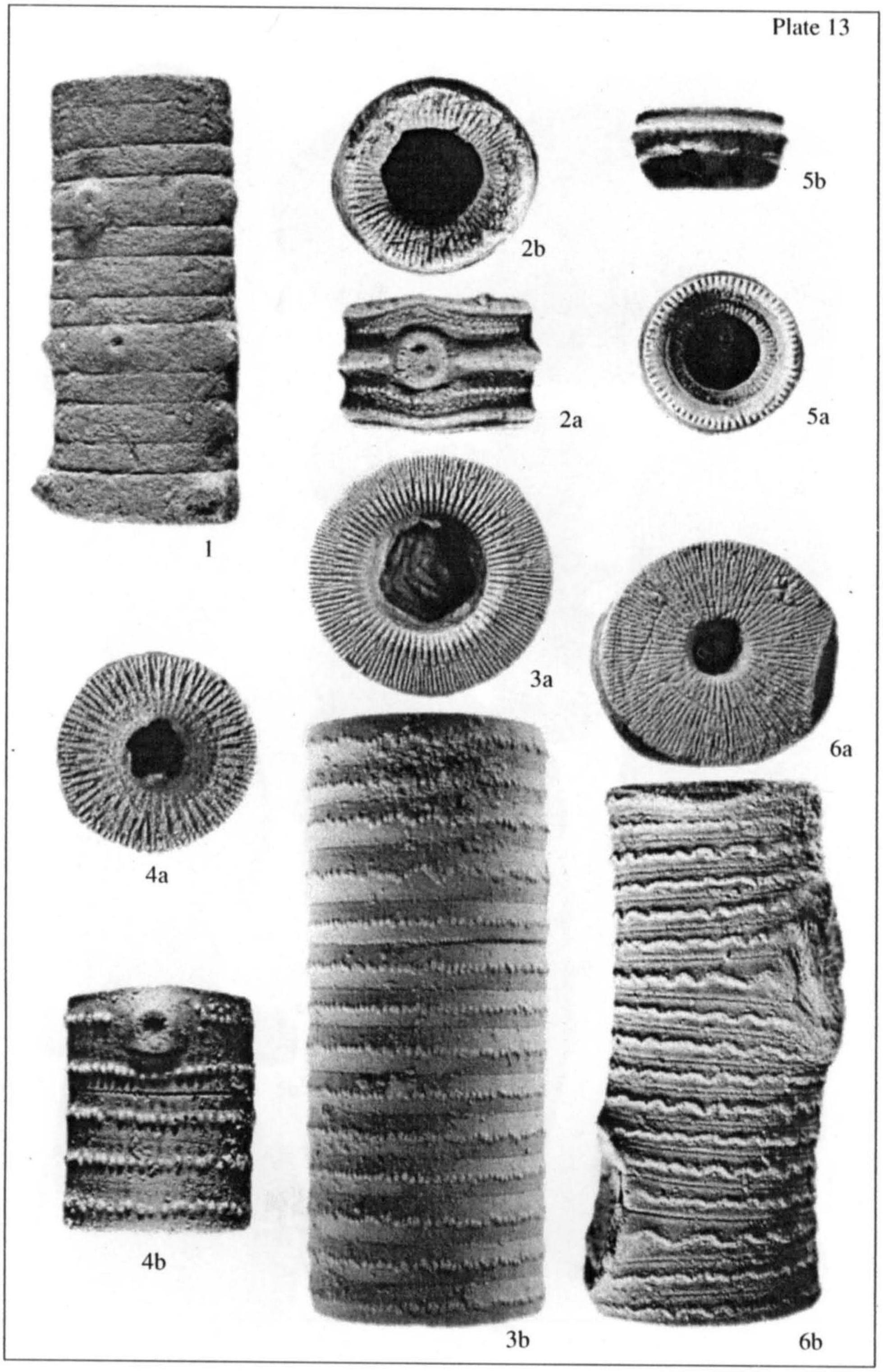
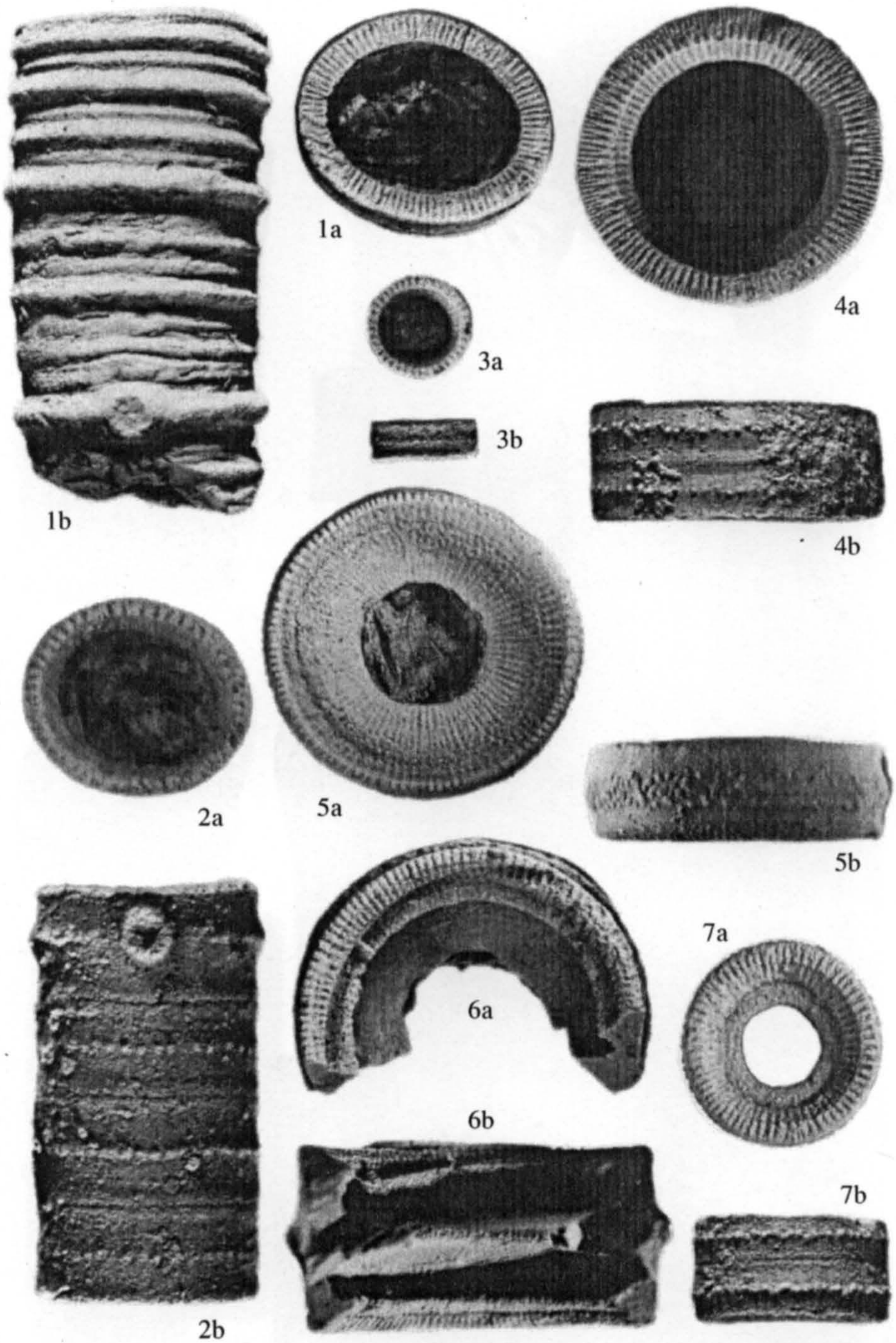


Plate 14



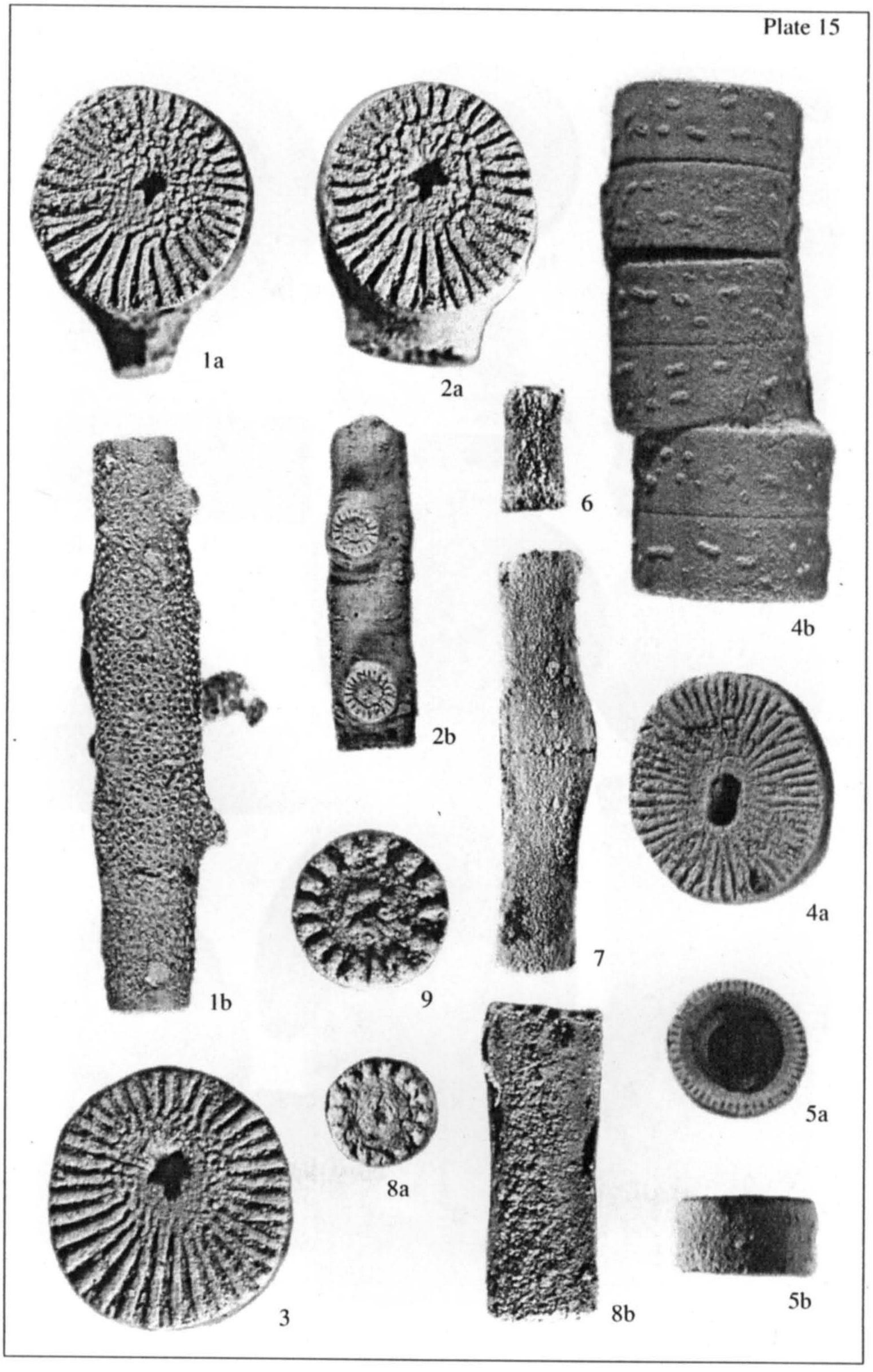
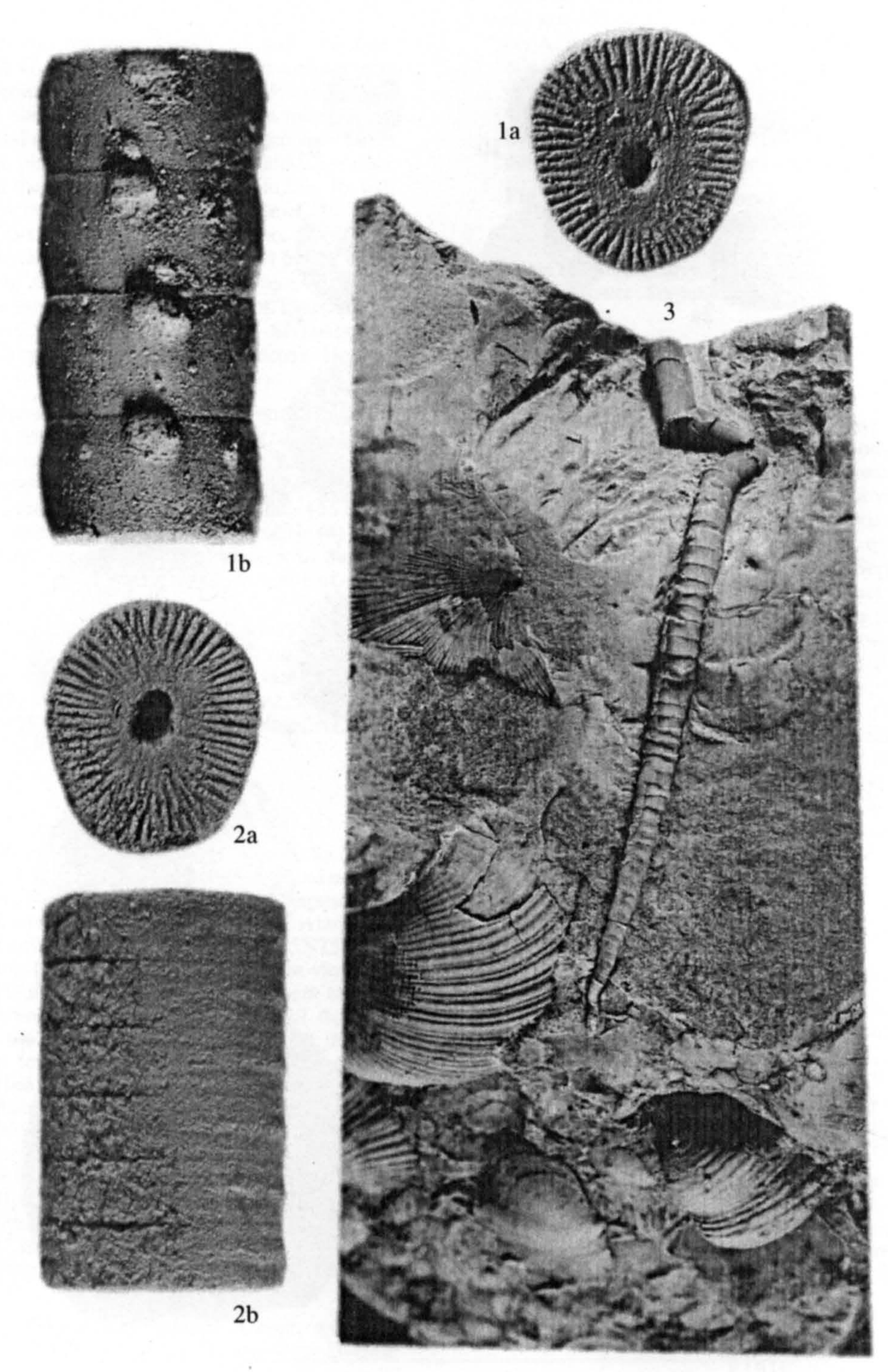


Plate 15
1a
2a
6
1b
2b
7
4b
4a
9
3
8a
8b
5a
5b

Plate 16



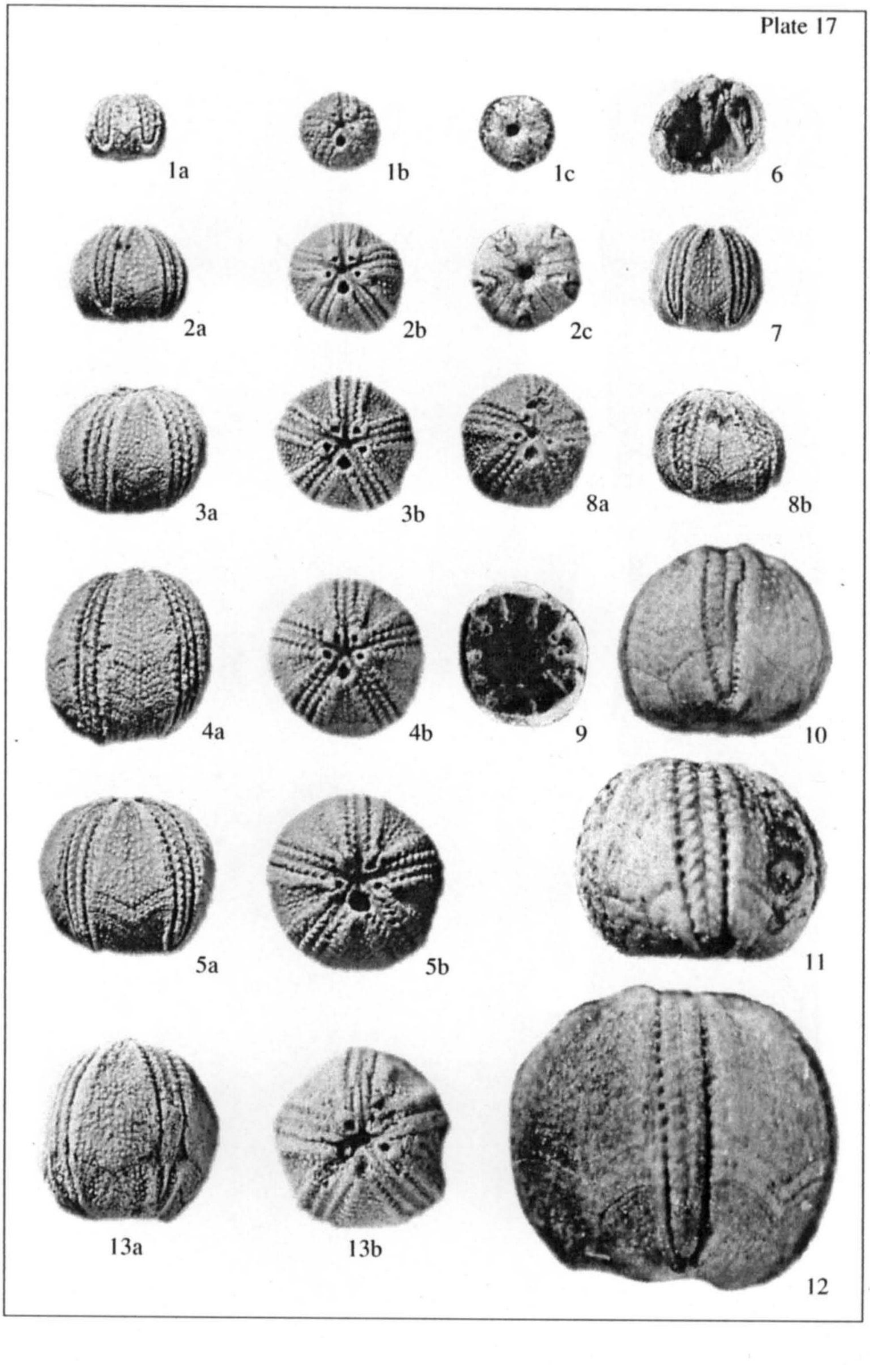


Plate 17
1a
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1c
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2c
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4a
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5a
5b
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13a
13b
12

Explanations of Plates

Plate 1

Fig. 1. *Rhodocrinites osipovae* Arendt, sp. nov.; (1) holotype, no. 1557/547, compressed calyx: (1a) upward side view from the column-adjoining cavity, ×1.5; (1b) downward side view, showing the pair of free arm facets at the center, ambulacral notches under them, and the anus in the lower part of the picture, ×1.5; A, B, C, D, and E are rays; (1c) fragment of the calyx with the same, as in Fig. 1b, pair of facets of free arms (turned round at an angle of 180°) and ambulacral notches over them, ×5; (1d, 1e) no. 1557/547a, circlet of five infrabasals (at the base and top) buried in the column-adjoining cavity of the holotype and, probably, belonging to the same specimen, ×5; town of Tarusa, Ignatova Gora quarry, Exposure 9d, Bed 38; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part).

Figs. 2–8. *Platycrinites tenuiplatensis* Arendt, sp. nov.; (2) no. 1557/553, fragment of the basal circlet, upward view, ×1.5; town of Tarusa, Ignatova Gora quarry, Exposure 9d, Bed 40; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part); (3) no. 1557/554, partly broken basal circlet, ×1.5; the same locality; (4) holotype, no. 1557/548, incomplete radial plate with the arm base: (4a) ×1.5, (4b) arm base with the adjacent part of the plate, ×4; the same locality; (5) no. 1557/549, radial with the arm base: (5a) ×1.5, (5b) the arm base with the adjacent part of the plate, ×4; the same locality; (6) no. 1557/551, fragment of the basal circlet, ×1.5; the same locality; (7) no. 1557/552, fragments of cup plates, ×1.5; the same locality; (8) no. 1557/550, fragments of cup plates, ×1.5; the same locality.

Plate 2

Figs. 1–6. *Platycrinites tenuiplatensis* Arendt, sp. nov.; (1) paratype, no. 1557/76, columnal, ×8: (1a) articular facet, (1b) side view; quarry near the village of Mitino, Exposure 11, Bed 38; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part); (2) no. 1557/75, turning columnal, ×8: (2a) articular facet, (2b) side view; the same locality; (3) no. 1557/504, column fragment consisting of two columnals and the articular facet of the third columnal from the column-adjoining part of the juvenile specimen, ×10; town of Tarusa, Ignatova Gora quarry, Exposure 9d, Bed 38; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part); (4) no. 1557/503, columnal with the bilateral symmetry dominanting over the biradial symmetry, as viewed from the articular facet, ×11; town of Tarusa, Ignatova Gora quarry, Exposure 9c, Bed 34; Serpukhovian Stage, Lower Serpukhovian Substage, Tarusa Horizon (uppermost part); (5) no. 1557/502, turning columnal, articular facet view, ×8; the same locality; (6) no. 1557/501, columnal, ×10; the same locality.

Figs. 7 and 8. *Platycrinites spinifer* Arendt, sp. nov.; (7) paratype, no. 1557/500, turning columnal of the juvenile specimen, as viewed from the articular facet, ×8; town of Tarusa, Ignatova Gora quarry, Exposure 9d, Bed 40; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part); (8) holotype, no. 1557/512, columnal, as viewed from the articular facet, ×8; the same locality.

Plate 3

Figs. 1–4. *Kallimorphocrinus scoticus* (Wright); (1) no. 1557/532, theca: (1a) bottom view, (1b) side view, ray A, (1c) top view, ×40; town of Tarusa, Ignatova Gora quarry, Exposure 9d, Bed 38; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part); (2) no. 1557/533, theca: (2a) bottom view, (2b) side view, ray A, ×40; the same locality; (3) no. 1557/537, theca: juvenile specimen, side view, ray B, ×40; the same locality; (4) no. 1557/536, theca, juvenile specimen: (4a) bottom view, (4b) side view, ×40; quarry near the village of Mitino, Exposure 11, Bed 38; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part).

Fig. 5. *Okacrinus nodosus* Arendt, gen. et sp. nov.; (5a–5c) holotype, no. 1557/535, theca: (5a) bottom view, (5b) side view, ray A, (5c) top view, ×40; town of Tarusa, Ignatova Gora quarry, Exposure 9d, Bed 40; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part).

Plate 4

Figs. 1–6. *Streptostomocrinus heckerae* Arendt, sp. nov.; (1) holotype, no. 1557/541, theca: (1a) bottom view, (1b) side view, interray CD, ×40; town of Tarusa, Ignatova Gora quarry, Exposure 9d, Bed 38; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part); (2) no. 1557/539, theca, top view, ×40; quarry near the village of Mitino, Exposure 11, Bed 38; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part); (3) no. 1557/538, theca, broken in the lower part: (3a) bottom view, (3b) side view; ×40; town of Tarusa, Ignatova Gora quarry, Exposure 9d, Bed 38; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part); (4) no. 1557/543, theca: (4a) bottom view, (4b) side view, interray CD, (4c) top view, ×40; the same locality; (5) no. 1557/542, compressed theca: (5a) bottom view, (5b) side view, 40; the same locality; (6) no. 1557/540, compressed theca: (6a) bottom view, (6b) side view, interray CD, ×40; quarry near the village of Mitino, Exposure 9d, Bed 38; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part).

Plate 5

Figs. 1 and 2. *Zeacrinites heckeri* Arendt, sp. nov.; (1) holotype, no. 1557/546, calyx: (1a) bottom view, (1b) side view, ray A, (1c) top view, ×2, (1d) facet of the arm A and adjacent distal part of the calyx, ×5; (2) no. 1557/545, fragment of the column, probably, belonging to the holotype, ×6: (2a) articular facet, (2c) side view; quarry near the village of Zaborie in the vicinity of Serpukhov; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon.

Fig. 3. *Amphipsalidocrinus astrus* sp. nov.; holotype, no. 1557/534, theca: (3a) bottom view, (3b) back view, interray CD, (3c) side view, ray A, (3d) top view, ×40; town of Tarusa, Ignatova Gora quarry, Exposure 9e, Bed 39; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part).

Plate 6

Fig. 1. *Rhabdocrinus vatagini* Arendt, 1962; holotype, no. 1557/40, incomplete calyx, ×1.5: (1a) external view, basals AB and BC and radials A and B (with fused lower brachials) and C; (1b) inside view; (1c) radials and brachials, top view; (1d–1f) different articulation types of basals AB; town of Tarusa, Ignatova Gora quarry, Exposure 9d, Bed 40; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part).

Fig. 2. *Konicrinus(?) excentricus* Arendt, sp. nov. with lifetime overgrowth of the column by a bryozoan colony of *Fis-*

tulipora steshevensis Schulga-Nesterenko; no. 1557/522a: (2a) column fragment, oblique side view, ×10; (2b) top view, ×10; (2c) side view, ×3; quarry near the village of Mitino; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part).

Plate 7

Fig. 1. *Ureocrinus rozhnovi* Arendt, 1981; holotype, no. 1557A/1, cup with proximal brachials and columnal, ×5: (1a) bottom view, (1b–1d) side view: (1b) ray A, (1c) ray C, (1d) interray CD, (1e) top view; quarry near the village of Zaborie in the vicinity of Serpukhov; Serpukhovian Stage, Upper Serpukhovian Substage, Protvino Horizon (lower part).

Plate 8

Fig. 1. *Stukalinocrinus gigas* Arendt, gen. et sp. nov.; holotype, no. 4106/39 (Museum of the Paleontalogical Institute, Russian Academy of Sciences), joint and isolated column parts, probably, belonging to a single specimen: (1a) fragment of the limestone slab with above-mentioned remains, ×0.5; (1b) articular facet in the distal part of the column with a thick cirrus and narrow axial canal and lacking concavity (holotype s.s.), ×2; (1c) "bud" of underdeveloped cirrus in the column part with the thinner cirrus, ×3; (2d) articular facet in the thinner-cirrus part of the column with a wider, than in (1b), axial canal and noticeable concavity of the inner part of the facet; (1e) more proximal, relatively thin-cirrus part of the column, side view, ×1; (1f) articular facet of the thin-cirrus part of the column with the sharply concave inner part and wide axial canal, ×2; quarry at the Myshiga River near the village of Gremnitsy in the vicinity of town of Aleksin; Viséan Stage, Mikhailov Horizon (lower part).

Plate 9

Fig. 1. *Stukalinocrinus gigas* Arendt, gen. et sp. nov.; holotype, no. 4106/39 (Museum of the Paleontalogical Institute, Russian Academy of Sciences), joint and isolated column fragments, probably, belonging to a single specimen:, side view, ×1: (1a) distal thick-cirrus part of the column with cirri fragments and "bud" (holotype s.s.); (1b, 1c) more proximal, relatively thiner-cirrus and cirrus-free parts of the column; quarry at the Myshiga River near the village of Gremnitsy in the vicinity of Aleksin; Visean Stage, Mikhailov Horizon (lower part).

Fig. 2. *Stukalinocrinus magnus* Arendt, gen. et sp. nov.; holotype, no. 1557/167, thin-cirrus part of the column, ×2: (2a) side view, (2b) articular facet view; quarry near the village of Bekhovo, 0.5 km downstream; Viséan Stage, Aleksin Horizon (uppermost part).

Plate 10

Figs. 1–6. *Floricyclus paratus* (Sisova, 1983); (1–3) columnals, articular facet views (a) and side views (b), ×5: (1a, 1b) no. 1557/514, (2a, 2b) no. 1557/45, (3a, 3b) no. 1557/513; quarry near the village of Mitino, Exposure 11, Bed 38; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part); (4) no. 1557/518, small fragment of the column with lifetime ringlike overgrowth by a colony of *Cladochonus* sp. (Tabulata), ×4: (4a) side view, (4b) opposite side view, (4c) bottom view, (4d) top view; the same locality; (5) no. 1557/527, column fragment consisting of three columnals: (5a) articular facet view, (5b) side view, ×5; the same locality; (6) no. 1557/515, column fragment of 57 columnals, side view, ×1.5; town of Tarusa, Ignatova Gora quarry, Exposure 9d, Bed 40; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part).

Plate 11

Fig. 1. *Plummeranteris(?) ignatovensis* Arendt, sp. nov.; holotype, no. 1557/600, part of the column of six columnals and column base, attached near the ala in the concave part of the intact large brachil valve of *Latiproductus saritshevae* Le Grenn, 1972 (Productida, Brachiopoda): (1) general top view (in the left, crinoid column fragment and in the right, small swelling in the brachiopod brachial valve), ×0.5; (1b, 1c) column fragment of five columnals: (1b) view of the articular facet of the upper columnal, (1c) side view, ×4.5; town of Tarusa, Ignatova Gora quarry, Exposure 9b, Bed 33; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part).

Figs. 2–5. *Plummeranteris candidus* (Sisova, 1983); (2) no. 1557/87, articular facet view, ×4; quarry near the village of Mitino, Exposure 11, Bed 38; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part); (3) no. 1557/68, column fragment: (3a) articular facet view, (3b) side view, with the articulum of the first cirral at one of the first-order columnal, ×4; town of Tarusa, Ignatova Gora quarry, Exposure 9d, Bed 34; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part); (4) no. 1557/67, column fragment with penetrated parasite *Phosphannulus* sp. and large pillow-shaped hydroid overgrowth: (4a) articular facet view, (4b) side view, area of parasite penetration, ×4; town of Tarusa, Ignatova Gora quarry, Exposure 9e, Bed 34; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part); (5) no. 1557/66, two-columnal fragment of the column with a hexagonal axial canal: (5a) articular facet view, (5b) side view, ×4; quarry near the village of Mitino, Exposure 11, Bed 38; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part).

Plate 12

Figs. 1–6. *Polenovocrinus mitinensis* Arendt, gen. et sp. nov.: (1) holotype, no. 1557/108, column fragment of six columnals: (1a) side view, (1b) articular facet view, ×8; quarry near the village of Mitino, Exposure 11, Bed 38, marl; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part); (2) no. 1557/505, column fragment of three columnals, ×10; the same locality; (3) no. 1557/506, column fragment of seven columnals, ×10; the same locality; (4) no. 1557/507, column fragment with the cirrus socket, ×7; the same locality; (5) no. 1557/8, articular facet view of the columnal, ×10, the same locality; (6) no. 1557/509, articular facet view of the columnal, ×10, the same locality.

Figs. 7 and 8. *Breimerocrinus laevis* Arendt, gen. et sp. nov.; (7) no. 1557/511a, part of the column of five columnals, with penetrated myzostomids between two of them and, probably, relevant swelling, ×7: (7a) top view, (7b) side view; the same locality; (8) no. 1557/511c, column fragment with twisted around distal segment of another column belonging, most probably, to the catillocrinid or allagecrinid representative, ×7; the same locality.

Fig. 9. *Unilineatocrinus rectus* Arendt, sp. nov.; holotype, no. 1557/101, column fragment of seven columnals: (9a) side view, the cirrus socket, (9b) articular facet view, ×4; the same locality.

Fig. 10. *Dipentagonocrinus magnocarinatus* Arendt, gen. et sp. nov.; holotype, no. 1557/87, columnal, articular facet view, ×7.5; town of Tarusa, Ignatova Gora quarry, Expo-

sure 9d, Bed 40, marl; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part).

Plate 13

Fig. 1. *Plummeranteris candidus* (Sisova, 1983); no. 1557/87, column fragment, side view, ×3.5; quarry near the village of Mitino, Exposure 11, Bed 38, marl; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part).

Fig. 2. *Unilineatocrinus cingulatus* Arendt, sp. nov.; no. 1557/90, column fragment; ×4: (2a) articular facet, (2b) side view, with the cirrus socket; the same locality.

Figs. 3–5. *Unilineatocrinus inconstantistellatus* Arendt, sp. nov.; no. 1557/113, column fragment: (3a) articular facet view, (3b) side view; ×4; the same locality; (4) holotype, no. 1557/88, column fragment: (4a) articular facet view, (4b) side view, with cirrus facet; ×5; the same locality; (5) no. 1557/147, column fragment: (5a) articular facet view, (5b) side view; ×5; the same locality.

Fig. 6. *Unilineatocrinus tarusaensis* Arendt, sp. nov.; holotype, no. 1557/89, column fragment: (6a) articular facet view, (6b) side view, with the cirrus socket; ×4; the same locality; town of Tarusa, Ignatova Gora quarry, Exposure 9b, Bed 41; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part).

Plate 14

Fig. 1. *Unilineatocrinus cingulatus* Arendt, sp. nov.; holotype no. 1557/92, column fragment; (1a) articular facet view, (1b) side view; ×4; quarry near the village of Mitino, Exposure 11, Bed 38, marl; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part).

Fig. 2. *Govorovocrinus okensis* Arendt, gen. et sp. nov.; holotype, no. 1557/105, column fragment, with the cirrus socket: (2a) articular facet view, (2b) side view; ×10; quarry near the village of Mitino, Exposure 11, Bed 51, clay; the same stratigraphic interval.

Figs. 3, 4, and 7. *Unilineatocrinus serpukhovensis* Arendt, sp. nov.; (3) no. 1557/112, columnal: (3a) articular facet view, (3b) side view; ×4; (4) no. 1557/111, column fragment consisting of three columnals: (4a) articular facet view, (4b) side view; ×4; the same locality; (7) holotype, no. 1557/110, column fragment of two columnals: (7a) articular facet view, (7b) side view; ×4; the same locality.

Figs. 5 and 6. *Unilineatocrinus tenuicarinatus* Arendt, sp. nov.; (5) no. 1557/99, columnal: (5a) articular facet view, (5b) side view; ×4; the same locality; (6) holotype, no. 1557/98, column fragment consisting of three columnals and broken transversally in two halves: (6a) articular facet view, (6b) internal side view; ×4; the same locality.

Plate 15

Figs. 1–3 and 6–9. *Konicrinus(?) excentricus* Arendt, sp. nov.; (1) no. 1557/517, "pluricolumnal" with lifetime overgrowth by bryozoan species *Fistulipora steshevensis* Schulga-Nesterenko, 1955: (1a) articular facet view; ×6.5; (1b) lateral surface; ×3; quarry near the village of Mitino, Exposure 11, Bed 38, marl; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part); (2) holotype, no. 1557/516, "pluricolumnal" with protruding large cirrus sockets: (2a) articular facet view; ×7; (2b) side view; ×3.5; the same locality; (3) no. 1557/522, articular facet; ×7.5; the same locality; (6–9) small cirri: (6) no. 1557/520, side view; ×8; the same locality; (7) no. 1557/521, fragment of two cirrals, side view; ×7; the same locality; (8) no. 1557/519, cirral (8a) articular facet view; (8b) side view; ×7; the same locality; (9) no. 1557/93, articular facet; ×7; the same locality.

Fig. 4. *Inclarocrinus inclarus* Arendt, gen. et sp. nov.; holotype, no. 1557/525, column fragment of six columnals: (4a) articular facet view; (4b) side view, in the narrowest part (seen opposite is an ornamentation in the form of belts); ×7; quarry near the town of Tarusa, Exposure 9, Bed 22; Serpukhovian Stage, Lower Serpukhovian Substage, Tarusa Horizon.

Fig. 5. *Unilineatocrinus tenuicarinatus* Arendt, sp. nov.; no. 1557/100, columnal: (5a) articular facet view, (5b) side view; ×4; quarry near the village of Mitino, Exposure 11, Bed 38, marl; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part).

Plate 16

Figs. 1–3. *Carinatocrinus carinatus* Arendt, gen. et sp. nov.; (1) holotype, no. 1557/523, part of the column of four "columnals": (1a) articular facet view, (1b) side view, the narrowest part; ×6; quarry near the town of Tarusa, Exposure 9b, Bed 37, marl; Serpukhovian Stage, Lower Serpukhovian Substage, Tarusa Horizon; (2) no. 1557/524, "column fragment" of six columnals: (2a) articular facet view, (2b) side view (ornamentation in the right); ×7; the same locality; (3) no. 1557/526, part of the column (cirrus) obliquely crossing a layer of whitish semilithified marl with brachiopods; ×1; Oka River, abandoned quarry near the village of Luzhki; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (collection by A.I. Osipova, 1956).

Plate 17

Figs. 1–12. *Orbitremites musatovi* (Arendt, 1960). All figures, except for Fig. 8, originate from the quarry located near the village of Mitino, Exposure 11, Bed 38, marl; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part). (1) no. 1557/40a, the smallest specimen in collection; ×4: (1a) side view, (1b) top view, (1c) bottom view; (2 and 10) no. 1557/1, lectotype (original shown in *Osnovy paleontologii*, 1964, pp. 210, 211, Plate 6, figs. 11a–11c), ×4: (2a) side view on the interray CD, (2b) top view, (2c) bottom view; (10) view on the ray E; lateral and external lateral plates are partly removed, seen are lancet-shaped plate and hydrospire pores; ×7; (3) no. 1557/28, ×4: (3a) side view on interray CD, (3b) top view; (4) no. 1557/32, ×4: (4a) side view on interray CD, (4b) top view; (5) no. 1557/35, ×4: (5a) side view on interray CD, (5b) top view; (6) no. 1557/5, ×4; specimen prepared inside, view on interray CD, seen are hydrospire tubes; (7) no. 1557/105, ×4; side view on interray CD; (8) no. 1557/39, ×4: (8a) top view, (8b) side view interray CD; town of Tarusa, Ignatova Gora quarry, Exposure 9d, Bed 38; Serpukhovian Stage, Lower Serpukhovian Substage, Steshev Horizon (lower part); (9) no. 1557/19, ×4, partly broken specimen polished approximately at its mid-height (original shown in *Osnovy paleontologii*, 1964, pp. 210, 211, pl. 6, fig. 11d), seen are transverse sections of hydrospire tubes; (11) no. 1557/8, ×7, view on ray C; (12) no. 1557/35, ×7, view on ray C.

Fig. 13. *Orbitremites derbiensis* (Soverby, 1826), ×4, Middle Limestone, Subzone D_2, Upper Viséan; Grassington, Yorkshire, England; (13a) side view, interray AE, (13b) top view; ×4 (specimen from collection by K.A. Joysey).

CHAPTER 2. OCCURRENCE AND DISTRIBUTION OF CRINOIDS AND BLASTOIDS

The remains of the Early Carboniferous Crinoidea under consideration were sampled from the deposits of the Viséan (Aleksin, Mikhailov, and Venev horizons) and Serpukhovian (Tarusa, Steshev, and Protvino horizons) stages in the southern Moscow Basin. Their finds in the Viséan deposits are substantially scarcer than in those of the Serpukhovian Stage, particularly, in the Steshev Horizon. Crinoidea skeletons are usually highly fragmented, difficult to extract from the rock, and rather uniform in composition both in the Viséan and Serpukhovian limestones. They are slightly more diverse in the limestones of the Tarusa and lowermost Steshev horizons. Particularly abundant are crinoids in the sequences where thick members of limestones are interstratified by marls and clays, for example, in the alternating facies of the Steshev Horizon. Therefore, more attention is paid to the Steshev Horizon and its sections exposed along the Oka River from the town of Tarusa to the village of Mitino. However, before going to their detailed description, I briefly characterize other horizons in the southern Moscow Basin bearing only few crinoid species and sections described by myself in the Ignatova Gora quarry near the town of Tarusa and partly in the Mitino quarry (Figs. 7–9).

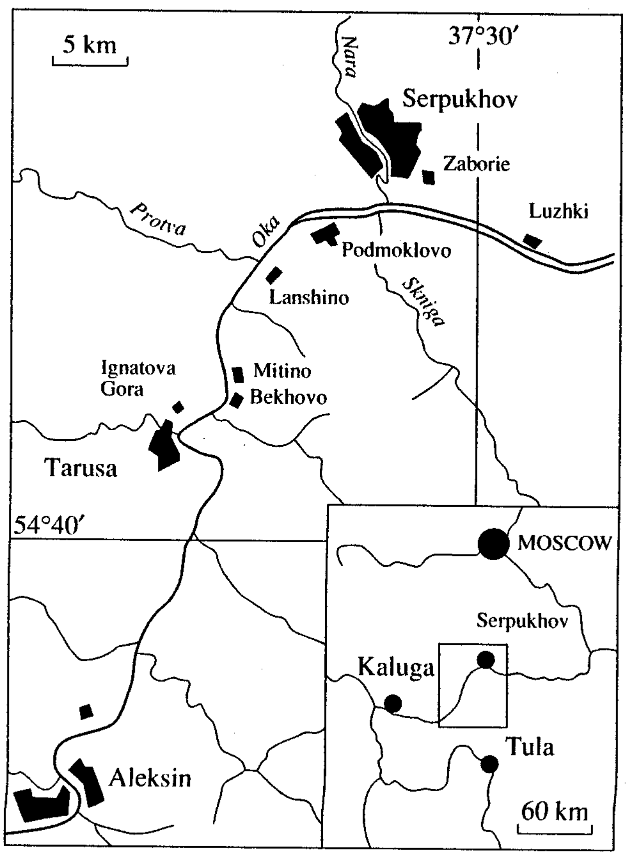


Fig. 7. Sketch map of the middle course basin of the Oka River between Aleksin and Serpukhov.

In the southern Moscow syncline, the Okaian Substage of the Viséan Stage is represented by a 30- to 35-m-thick member of mostly continuous limestones with rare thin interbeds of marl, sand, and soot. These deposits correspond to a single sedimentation cycle. They are subdivided into the Aleksin, Mikhailov, and Venev horizons composed mainly of pure limestones, which are hard and thick-bedded, softer microlaminated, aphanitic with stigmaria rhizoids, and mottled. The fossils are distributed irregularly, commonly abundant, and include both the species characteristic of a single horizon and of all above-mentioned horizons.

The base of the Aleksin Horizon is usually marked by a layer up to 2 m thick and composed of yellow quartzose mica-bearing sand. Higher, there is a uniform alternation of hard massive and soft obscurely microlaminated limestones. The basal strata of the horizon enclose *Semiplanatus semiplanus* (Schw.) and, commonly, straight and convolute nautiloids. Characteristic are the following fossils: foraminifers *Haplophragmella irregularis* Rays. and *Endothyra crassa compressa* Raus. et Reitl.; sponges *Siderospongia sirenis* Trd.; corals *Lithostrotion junceum* Flem., bryozoans *Fenestella aleksinensis* Sch.-Nest. and *F. pseudoangulata* Sch.-Nest.; brachiopods *Striatifera spinifera* (Paeck.), *Gigantoproductus janishevskii* (Sar.), *G. sinuatus* (Sar.), *G. submaximus* (Bolkh.), *Schellwinella repinski* Sok., *Daviesella comoides* (Sow.), and *Megachonetes sibly* Paeck; and crinoids *Stukalinocrinus magnus* sp. nov. and *Plummeranteris(?) profundus* sp. nov. The boundary with the Mikhailov Horizon coincides with the occurrence level of well-defined stigmaria beds and abundant fossils. The thickness is 11–14 m.

The Mikhailov Horizon is also almost completely composed of limestones. Most characteristic of them are aphanitic varieties with stigmaria rhizoids and, frequently, desiccation fissures indicating their shallow-water sedimentation settings. Most abundant are the following fossil remains: Siphonifera algae *Calciofolium okense* Schw. et Bir.; foraminifers *Endothyra crassa* Brady, and *Eostafella okensis* Viss.; sponges *Siderospongia sirenis* Trd.; corals *Lithostrotion caespitosum* Mart. and *Dibunophyllum turbinatum* McCoy; bryozoans *Fenestella mikhailovensis* Sch.-Nest.; brachiopods *Gigantoproductus moderatus* (Schw.), *G. giganteus* (Mart.), *Striatifera striata* (Fisch.), *Punctospirifer pectinoides* (Phill.), *Athyris variabilis* Moll., *Pugilus rossicus* Sar., and *Davidsonia septosa* Phill.; and crinoids *Stukalinocrinus magnus* sp. nov. and *Inclarocrinus inclarus* sp. nov. Typical are large forms. The thickness is 6–11 m.

The Venev Horizon is represented by thick-bedded limestones, either compact or relatively soft, sometimes mottled or with large caverns; in the upper part (0.6 m), they are aphanitic and contain stigmaria rhizoids. The lower part of the horizon (3 m) is composed of compact thick-bedded yellowish gray limestone. Fossils are relatively rare and usually represented by large forms including Siphonifera algae *Calciofolium okense* Schw. et Bir., sponges *Siderospongia sirenis* Trd., solitary corals, brachiopods *Striatifera striata* (Fisch.) and *Gigantoproductus giganteus* (Mart.), and crinoids *Inclarocrinus inclaris* sp. nov. The thickness is about 10 m.

The Tarusa Horizon is composed of thin-platy limestones characterized by large-scale lentil jointing and clayey admixture in the middle part and with abundant *Taonurus*-type and thin (0.5 cm) vertical cylindrical fucoids; the upper part of the horizon also shows a noticeable admixture of clayey material. Organic remains of the horizon are usually represented by substantially smaller forms than those from the other mentioned units. The Tarusa, Mitino, Bekhovo, and neighboring sections contain corals *Dibunophyllum bipartitum* McCoy, abundant brachiopods *Schizoporia resupinata* (Mart.), *Fluctuaria undata* (Defr.), *Schellwinella rotundata* Thomas, *Gigantoproductus giganteiformis* (Liss.), *Eomarginifera longispina* (Sow.), *Fusella pseudotrigonalis* (Semich.), *Avonia youngiana* (Dav.), *Camarophoria crumena* Mart., *Pugilus tarussensis* Sar., bryozoans, crinoids *Inclarocrinus inclarus* sp. nov. and *Carinatocrinus carinatus* sp. nov., rare gastropod molds, and shark teeth. One of the limestone layers (0.6 m) from the Mitino quarry almost completely consists of *Martinia glabra* and *Composita ambigua* (Sow.) shells and shows a gradual transition to the overlaying rocks. The thickness is about 9 m.

In contrast to the Tarusa Horizon, the Steshev Horizon is characterized by a significantly higher clay content. Its lower part (usually 1–2 m) is, however, represented by limestones resembling those from the Tarusa Horizon but characterized by a slightly higher abundance of fossils. Immediately higher, there are alternating clayey and limy layers of a variable thickness. The sediments composing this part of the section are particularly variable with respect to their lithologic and paleontologic properties. They also show substantial variations in thickness even within a small distance. All these variations are observable within a single exposure (Figs. 9a–9e).[8]

Farther upward, these layers are replaced by a thick clayey member, the uppermost part of which encloses dolomite and dolomitized limestone beds.

The lower part of the horizon includes mainly the following rock varieties (Figs. 8a–8h): (1) limestones commonly with minor amounts of clay, usually completely reworked by *Taunurus* fucoids, and grading into similar rocks in the Tarusa Horizon; limestones usually occur at the base of the horizon and can locally be up to 2 m thick and more; (2) similar limestones with abundant crinoid fragments or completely crinoid; the thickness usually does not exceed 1.0–1.5 m; (3) black or reddish black soft plastic clays with abundant shells of small productid *Eomarganifera lobata* Sow. Because of their abundance, the rocks are termed as *Lobata* Clays. They can be as thick as 1.0–1.5 m. Less common is hard black microgranular limestone with abundant small pyritic inclusions. The rocks enclose abundant corals, bryozoans, and other organic remains.

The upper, less variable part of the horizon is composed of gray to black clays, sometimes with a lilac tint, enclosing rare thin beds of gray or yellow dolomite. In the lower layers, the clays host abundant *Eomarginifera* shells and are very similar to the underlying *Lobata* Clays. Higher, fossils are scarce (mostly ostracods).

In the lower part of the horizon, the fauna is extremely diverse and abundant. Its representatives are commonly large and often almost completely compose the sediment. Simultaneously, it is marked by a sharply decreased abundance of foraminifers, corals, and bryozoans as compared with the Tarusa Horizon. The upper layers of the Steshev Horizon enclose only poorly preserved fish remains, small brachiopods with spines, and gastropods; all other fossils are virtually missing. M.S. Shvetsov believed that the Steshev deposits accumulated in shallower settings as compared with those of the Tarusa sediments. The intervals marked by a high species diversity imply very favorable conditions for the development of the marine fauna.

Characteristic are the following forms: foraminifers *Endothyra crassa sphaerica* Raus. et Reitl.; corals *Caninia okensis* Stuck., *C. inostranzewi* Stuck., *Camphophyllum vermiculare* Stuck., *Lithostrotion rossicum diphyloides* Dobr., *Lonsdalea floriformis* (Mart.), *Dibunophyllum bipartitum* McCoy, *Aulophyllum jungites* Edw. et Hall, *Palaeacis okense* (Arendt); bryozoans *Fenestella exigua* Ulr., *F. paradoxa* Sch.-Nest., *F. praeforaminosa* Sch.-Nest., *Polypora cesteriensis* Ulr.; brachiopods *Schizophoria resupinata* (Mart.), *Pseudoleptaena distora* (Sow.), *Chonetes (Chonetes) dalmanianus* Kon., *Buxtonia mosquensis* Ivan., *Productus productus* Mart., *P. concinnus* Sow., *Antiquatonia insculpta* (M.-W.), *Eomarginifera longispina* (Sow.), *E. lobata* (Sow.), *E. praecursor* (Sow.), *Spirifer pseudotrigonalis* Semich., *S. parabisulcatus* Semich., *S. gröbberi* Schw., *S. botscharovensis* Semich., *S. gamma* Semich., *Phricodothyris lineata* (Mart.), *Athyris ambigua* (Sow.); bivalves; gastropods; crinoids; shark and bradyodont teeth; and problematics.

Crinoids are most diverse and abundant in the member of alternating limestone, marls, and clays (about 1.5 m thick), beds 38–50 in the Tarusa and Mitino quarries, which overly bedded limestones of the basal part of the horizon (0.7–1.2 m, beds 33–37). Their highest diversity is characteristic of the base of Bed 38 in both of these quarries. However, blastoids (*Orbitremites*) and sponges(?) (*Palaecis*) are scarce in the Tarusa quarry and abundant, particularly sponges, in the Mitino quarry.

[8] Fig. 8a shows the section exposed in the upper part of the Ignatova Gora quarry shown in Fig. 9a.

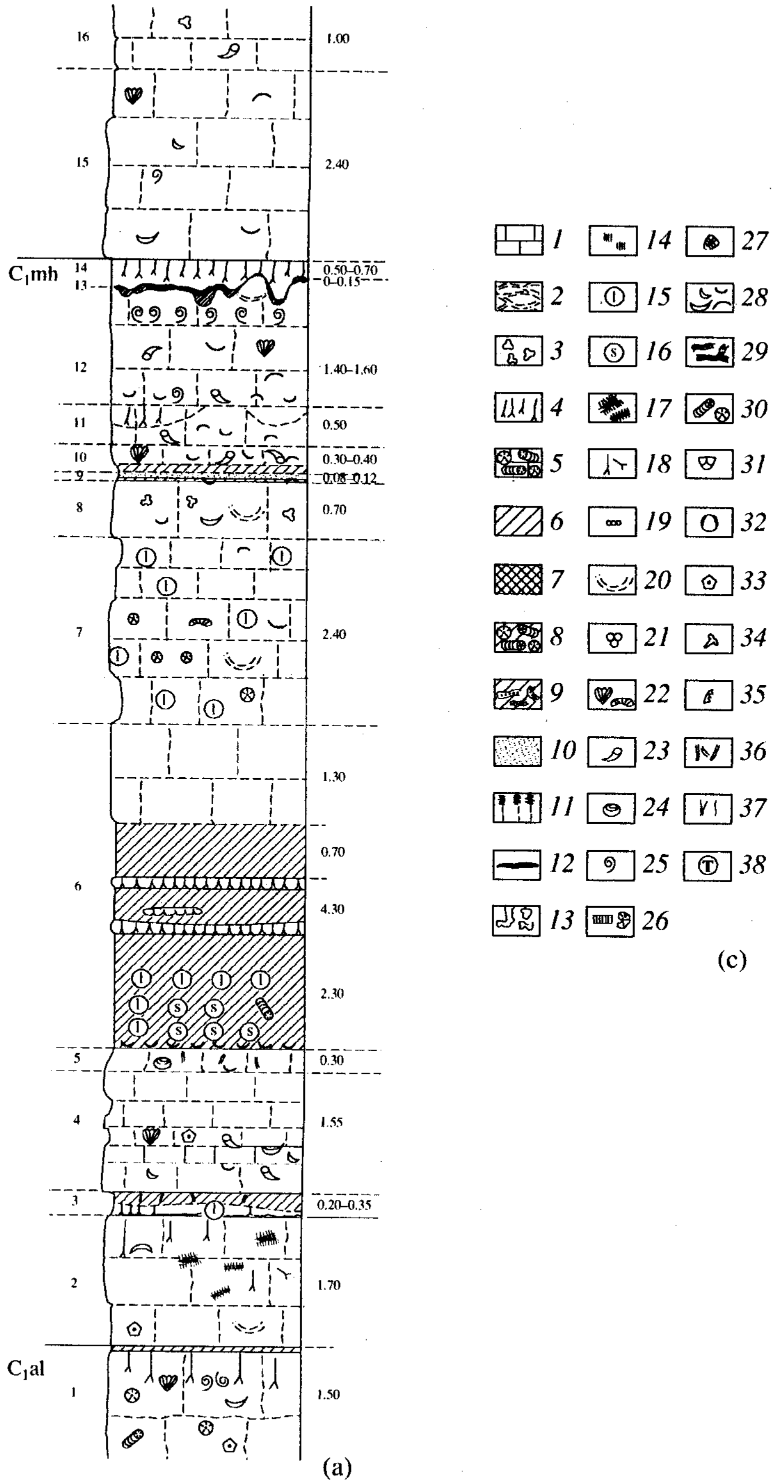
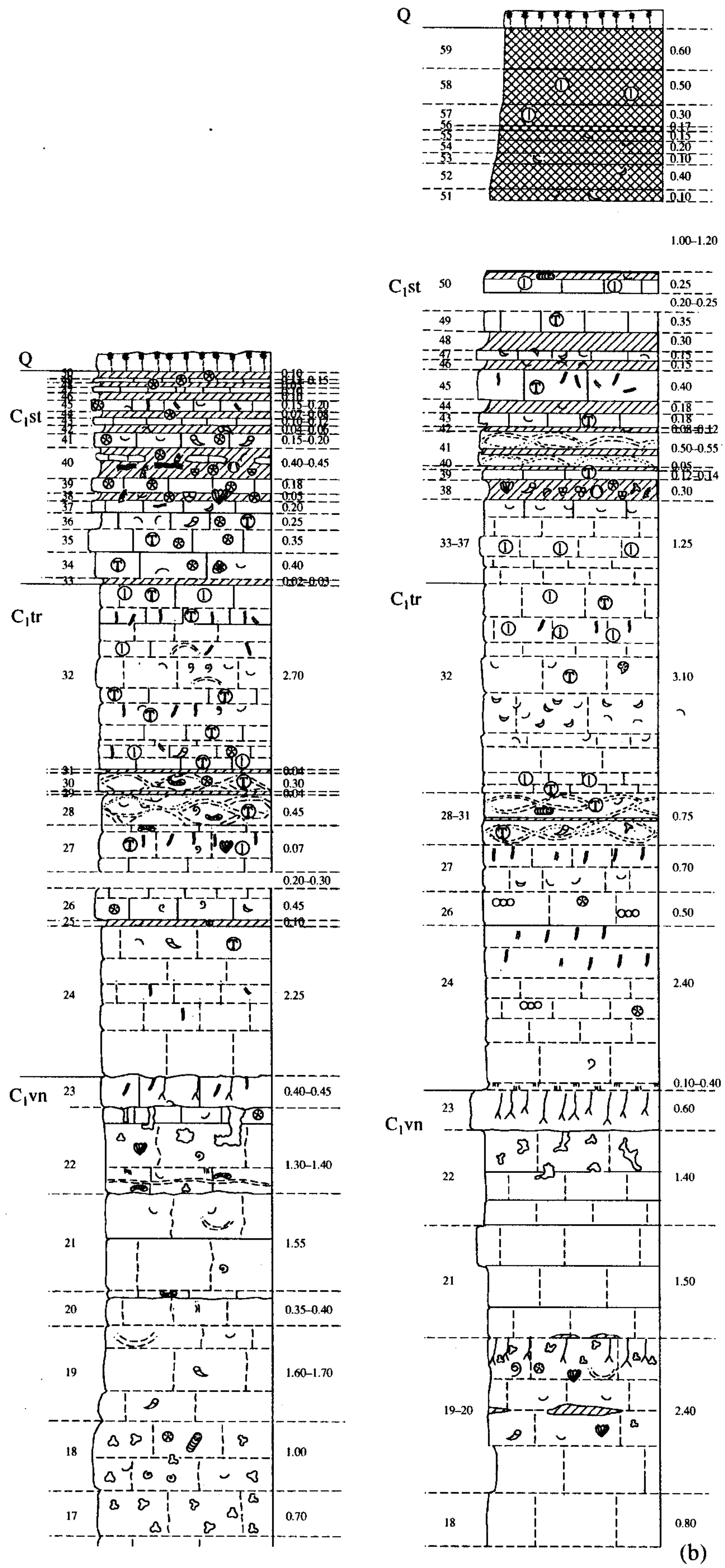


Fig. 8. Sections of the upper Viséan–Serpukhovian deposits: (a) Ignatova Gora quarry near the town of Tarusa (Exposure 9), (b) quarry near the village of Mitino (Exposure 11), and (c) legend: (*1*) fine-grained limestone; (*2*) limestone with lenticular jointing; (*3*) mottled limestone; (*4*) aphanic limestone, with stigmaria rhizoids; (*5*) crinoid limestone; (*6*) marls and clays (gray, greenish); (*7*) clays (cherry–red, black, dark gray); (*8*) crinoid marl; (*9*) marl, bryozoan; (*10*) subsurface fluvial sand; (*11*) soil and fluvial loam; (*12*) soot; (*13*) caverns; (*14*) stylolites; (*15*) limonite concretions; (*16*) siderite concretions; (*17*) stigmaria; (*18*) stigmaria rhizoids; (*19*) foraminifers; (*20*) sponges; (*21*) *Paleacis*; (*22*) colonial, spheroid, and platy corals; (*23*) solitary corals; (*24*) bivalves; (*25*) gastropods; (*26*) straight and convolute nautiloids; (*27*) trilobites; (*28*) small and large brachiopods; (*29*) branching bryozoans; (*30*) crinoidcolumnals and column fragments; (*31*) macro- and microcrinoid cups and thecas; (*32*) blastoid thecas; (*33*) echinoids; (*34*) shark and bradyodont teeth; (*35*) conodonts; (*36*) middle- and large-sized fucoids; (*37*) smaller-size fucoids; (*38*) *Taonurus* fucoids; Viséan Stage (upper part): (C_1al) Aleksin Horizon, (C_1mh) Mikhailov Horizon, (C_1vn) Venev Horizon; Serpukhovian Stage: (C_1tr) Tarusa Horizon, (C_1st) Steshev Horizon.


Q
C_1st
C_1tr
C_1vn
Q
C_1st
C_1tr
C_1vn
(b)

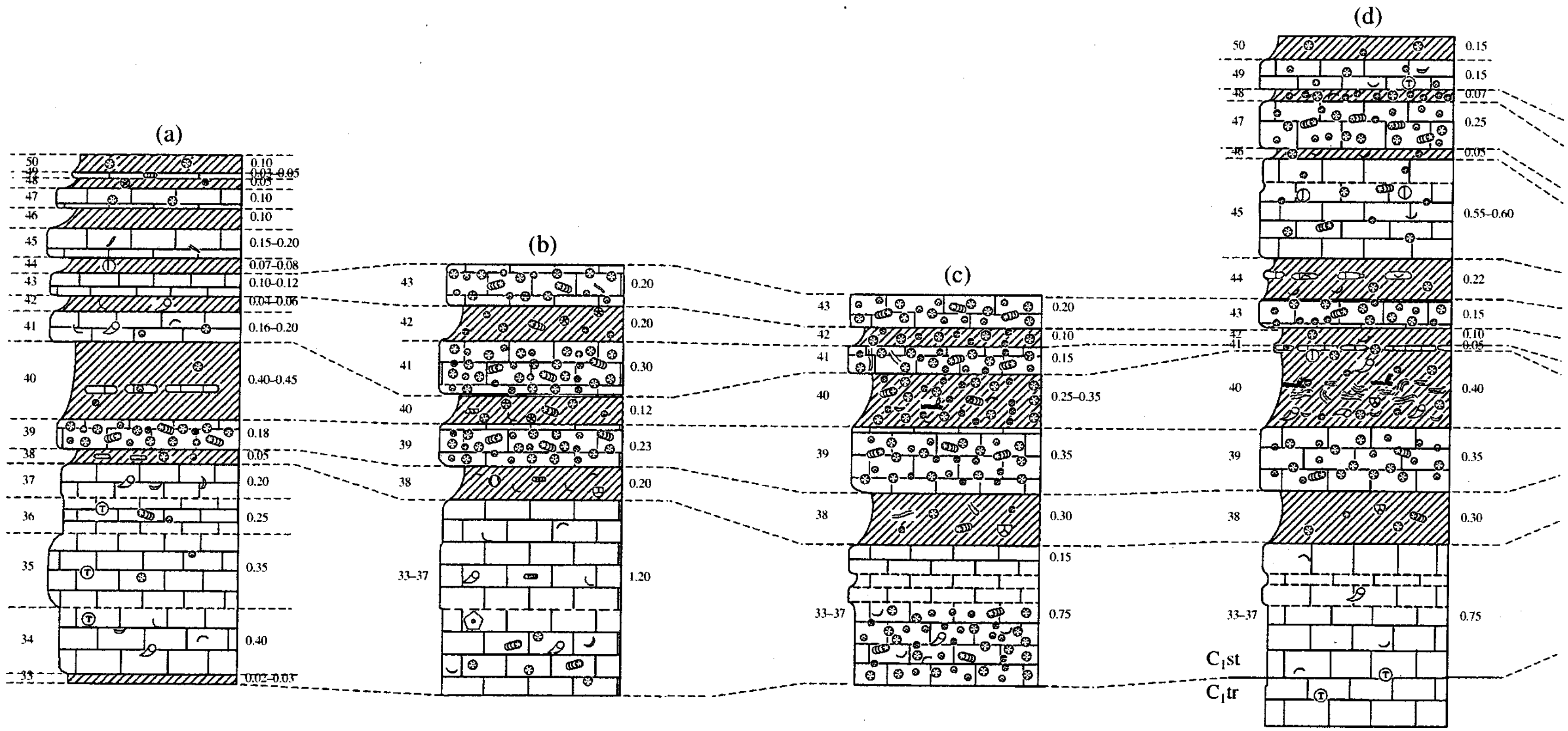


Fig. 9. Changes in the structure of the lower part of the Steshev Horizon in the southern Moscow syneclise (in the area from the Ignatova Gora quarry near the town of Tarusa to the quarry near the village of Mitino, 8 km in the SW–NE direction). (a–e) Tarusa quarry, (f) Bekhovo quarry, (g) nameless quarry, (h) Mitino quarry. Distances: a–b, b–c, c–d, d–e, e–f, f–g, and g–h are 50, 15, 25, 15–20, 6000, 1000, and 1000 m, respectively. For legend see Fig. 8.

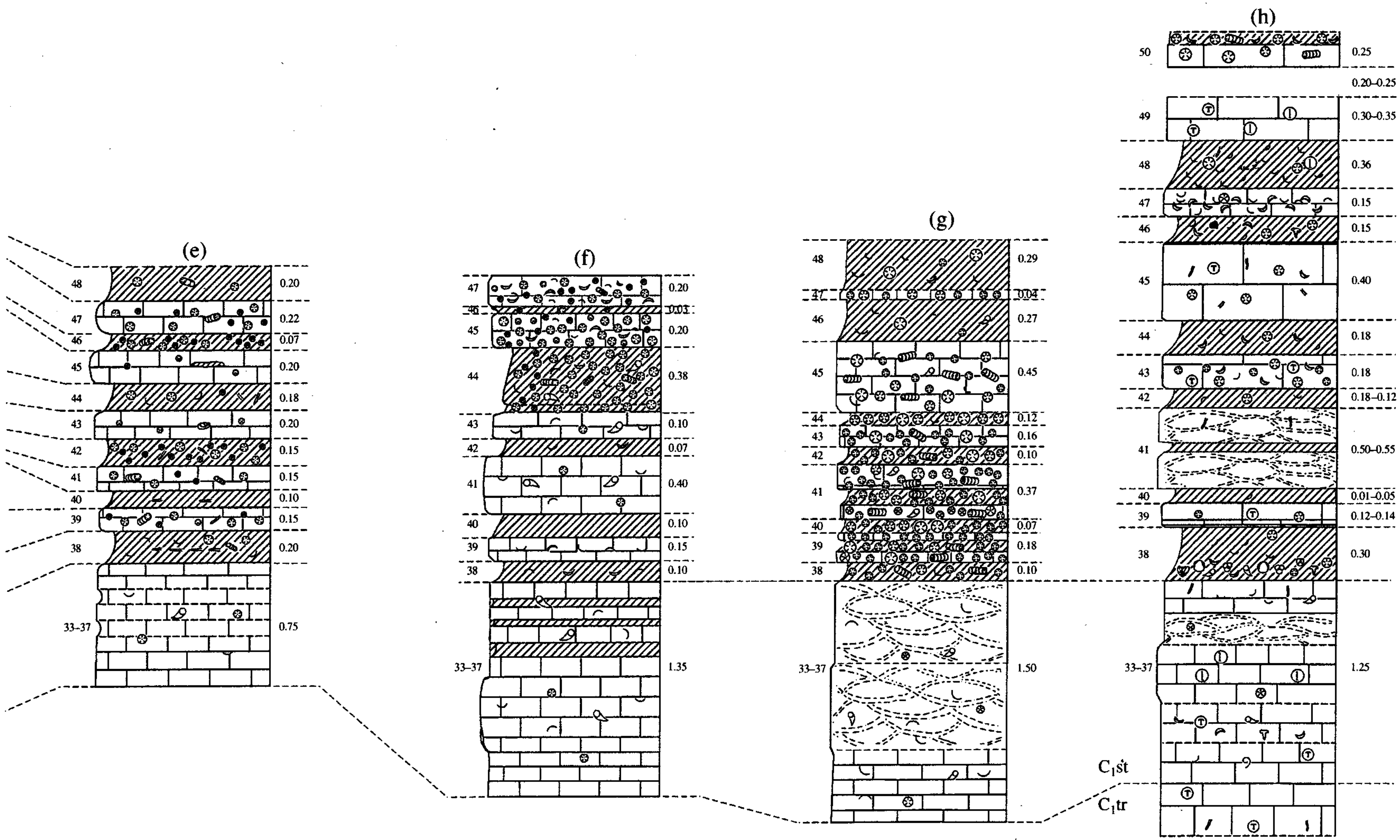


Fig. 9. (Contd.)

The following species were determined amid echinoderms from this member (almost all of them are described above): *Orbitremites musatovi* (Arendt), *Rhodocrinites ossipovae* sp. nov., *Platycrinites tenuiplatensis* sp. nov., *P. spinifer* sp. nov., *Kallimorphocrinus scoticus* (Wright), *Streptostomocrinus heckerae* sp. nov., *Okacrinus nodosus* sp. nov., *Amphipsalidocrinus astrus* sp. nov., *Rhabdocrinus vatagini* Arendt, *Zeacrinites heckeri* sp. nov., *Floricyclus paratus* (Sisova), *Plummeranteris candidus* (Sisova), *P(?) ignatovensis* sp. nov., *Unilineatocrinus inconstantistellatus* sp. nov., *U. cingulatus* sp. nov., *U. tarusaensis* sp. nov., *U. rectus* sp. nov., *U. serpukhovensis* sp. nov., *U. tenuicarinatus* sp. nov., *Konicrinus(?) excentricus* sp. nov., *Carinatocrinus carinatus* sp. nov., *Inclarocrinus inclarus* sp. nov., *Breimerocrinus laevis* sp. nov., *Govorovocrinus okensis* sp. nov., *Tzvetaevocrinus candiformis* sp. nov., *Polenovocrinus mitinensis* sp. nov., and *Dipentagonocrinus magnocarinatus* sp. nov.

In both quarries, Bed 38 yields diverse and abundant conodonts discovered by the author, i.e., *Gnathodus bilineatus bilineatus* (Roundy), *G. girtyi girtyi* Hass, *G. girtyi intermedius* Hass, *Lochriea cumutata* (Rhodes), *L. nodosa* (Rhodes), *L. mononodosa* (Rhodes), and many others.[9]

The boundary with the Protvino Horizon is arbitrarily placed at the level marked by the prevalence of dolomitized limestones over other rock varieties. Locally, the boundary shows signs of desiccation (Osipova and Belskaya, 1967). Because of high lithological variability in the lower part and the development of plastic clays in its upper part, it is difficult to measure the thickness of the horizon. It is probably ranges from 3 to 8 m for the lower part and from 8 to 12 m for the upper part. The total thickness is 11–20 m.

Below, I describe the sections uncovered in the Ignatova Gora quarry near the town of Tarusa (immediately downstream of the Oka River at its left side) and partly in the quarry near the village of Mitino (Fig. 8). A special attention is paid to lithological changes in the lower part of the Steshev Horizon (Fig. 9). The Aleksin, Mikhailov, Venev, Tarusa, and Steshev horizons correspond to Beds 1, 2–14, 5–23, 24–32, and 33–59, respectively.

The section exposed in the Ignatova Gora quarry includes the following beds (from the base upward):

Bed 1.[10] Limestone is fine-grained, with small rare caverns. The uppermost part of the layer encloses laminae (up to 5 cm) of soft limestone, frequently clayey, grading into calcareous clay, locally with a sooty powder at the surface. The upper 0.3 cm of the bed are crossed by abundant mainly vertical stigmaria rhizoids. Common are foraminifers and small crinoid fragments. The uppermost layer 0.3 cm thick yielded a coral colony and gastropod molds (up to 3.5 cm across), whereas the lower 0.3 cm provided a *Gigantoproductus* valve (6 cm across) with a convex surface oriented downward. A single echinoid plate was found near the base of the layer. The thickness is 1.5 m.

Bed 2. Limestone similar to that of Bed 1, but with the higher content of shelly detritus, foraminifers, and tiny gastropods. It comprises two platy laminae 0.5 and 1.2 m thick. The rock contains echinoid spines and abundant small crinoid columnals. The upper part of the bed yielded a brachiopod valve with convex surface oriented upward. Upper 0.7 m contains abundant horizontal or slightly inclined stigmaria with vertical rhizoids. Approximately 0.4 m below the bed roof, there are two horizontal cavities up to 6 and 8 cm across that formed after stigmaria and bear impressions of attachment scars and rhizoids diverging up and down. Sediments at the level of 0.65 m below the roof provided a piece of inclined stigmaria also with the attachment scars, but lacking rhizoids. Also present are the sponge species *Siderospongia sirenis* Trd. Stigmaria and rhizoids are yellow-colored owing to iron oxides. Observable is a sooty powder at the surface as well. The thickness is 1.7 m.

Bed 3. The bed comprises laminae (from the base upward): (a) black or brown soot 0.02–0.06 m thick, locally with mottles of iron oxides; (b) fine-grained limestone 0.01–0.15 m thick with accumulations of the shelly detritus and stigmaria rhizoids; one vertical stigmaria (3 cm in cross section) bears attachment scars. The rock contains rounded and elongated (up to 3 cm across) inclusions of loose limonite; present are also large chonetids and molds of large gastropods. The upper boundary is uneven, locally with sooty powder and (c) soft marl with brachiopod detritus, locally obscurely bedded, thin-platy at the top, with large (up to 2 cm across) inclined, sometimes curved fucoids, and fragments of thin-walled brachiopods (up to 0.7 cm across). The thickness of laminae is 0.1–0.2 cm. The total thickness of the bed is 0.2–0.35 m.

[9] Barskov and Alekseev (1979) noted that the "first five conodont species from the Carboniferous deposits of the Moscow region and Tula Governorship were described by Pander (1856) who was a discoverer of this fossil group of organisms. After their discovery, conodonts from the Carboniferous deposits of the Moscow Region were ignored by researchers during more than a century. Only in 1967, Yu.A. Arendt noted, when describing blastoids, the presence of abundant conodonts in the Steshev layers of the Mitino quarry on the Oka River." I have found conodonts in the basal part of the Mitino Horizon in the lower 0.02–0.06 m of the layer of loose yellowish gray marl (Bed 38 in the present work) with diverse fauna, some representatives of which were not mentioned previously in the Carboniferous deposits of the Moscow Region. Mass accumulations of conodonts were recorded in 1956–1958 when I washed out large volumes of rocks to obtain remains of Blastoidea and other echinoderms from the lower part of the Steshev Horizon in the Mitino and Ignatova Gora quarries (Beds 38 and 40); this discovery was repeatedly reported.

[10] Hereinafter, the bed numbers correspond to those in my field books stored at the Paleontological Institute (Russian Academy of Sciences). They contain more detailed descriptions of the sections.

Bed 4. Fine-grained detrital limestone forming a succession of hard and soft varieties (from the base upward) 0.35–0.4, 0.2–0.25, 0.2, 0.3, and 0,4 m thick. Fossils are abundant and diverse in lower three layers. Common among them are solitary corals *Bothrophyllum* up to 3 cm across and 11 cm long, usually almost cylindrical and buried in horizontal position. Colonies of *Syringopora* (10 cm wide and 4 cm high) buried in the lifetime position occur less commonly. Both these forms are most abundant in the second (from the base) layer. Present are two closely spaced platy colonies of *Chaetetes* (15 cm wide and 4 cm high) as well as rare gastropods and orthoceratids (1 cm across) and abundant, particularly in the two lower layers, complete *Gigantoproductus* shells (7–15 cm across) with the ventral valve oriented downward. Less common are differently oriented shells of productids and spiriferids (3–4 cm across) and echinoid plates. The thickness is 1.5–1.55 m.

Bed 5. The limestone is composed of laminae thinning upward and grading, first, into soft limestone and, then, into marl. Boundaries between laminae are marked by large (up to 2 cm in diameter) fucoids filled with clayey limestone. The middle part of the bed with marly laminae and gypsum lenses enclose abundant small branching fucoids filled with clay. At different levels, small coalified plant remains and fish scales are present. The layer located 0.3 m below the bed roof is composed of calcareous spotty clay with fine-grained detritus of brachiopod spines and shells. There are rare impressions of bivalve shells (up to 4 cm across) and their fragments with preserved pearl layer (in the lower part of the bed). The thickness is 0.3 m.

Bed 6. The basal part of the bed is represented by black clay with laminae of detrital–clayey limestone of variable thickness. About 0.05 m above the base, present are abundant, mainly isolated white linoproductid valves (2–4 cm across), closely spaced and with well preserved spines. The thickness of this lamina is 0.2 m. Higher, the clay (0.15 m thick) is greenish gray with light and dark thin bands and grading upward into gray-colored clay. The lower part of the bed contains abundant limonite and siderite concretions (up to 0.6 cm wide and 4 cm high), frequently joined by a crosspiece. Abundant are also coalified plant remains. The upper 0.9 m of the bed contain jarosite admixture. Concretions are oval in shape in the basal part of the bed, more elongated and, sometimes, platy in higher layers, and of an irregular form, compact, and heavy in its upper part. There, they host brachiopod valves (2 cm across). The layer located 1 m above the bed base contains abundant bivalve shells (up to 2.5 cm across), including bellerophonids (up to 1.5 cm across), and orthoceratid fragments (up to 2 cm in diameter). There are two laminae (each 0.1 m thick) and lenticular limestone inclusion with stigmaria rhizoids. The upper lamina is located 2.3 m below the bed roof. Uppermost 2 m of the bed mainly closed by a talus include dark gray clay (0.7 m thick) overlain by light gray fine-grained limestone (1.3 m thick). The total thickness of the bed is 4.3 m.

Bed 7. Fine-grained limestone with dark inclusions of organogenic detritus. The bed consists of four platy laminae (0.4, 1.0, 0.5, and 0.4 m thick) different in compactness and detritus content. Common are rounded or, occasionally, eight-shaped limonite concretions (2–5 cm in diameter). The latter are minimal in size in the second plate and maximal in the third one. Spaces between plates are sometimes filled with Quaternary subsurface fluvial clay and sand. The lower 0.2 m of the second plate yielded the cup-shaped sponge *Siderospongia sirensis* Trd. (18 cm high) with the convex part oriented downward, *Gigantoproductus* valve, echinoid spine, and abundant small crinoid columnals. The thickness is 2.4 m.

Bed 8. Limestone with dark brown mottles (1–2 cm across), mainly brown in the lower half of the bed and almost white, in the upper. Small-sized shelly detritus is abundant. The lower half of the bed provided a sponge of the *Siderospongia* genus, large *Gigantoproductus* in the life-time position, and abundant small crinoid columnals. The thickness is 0.7 m.

Bed 9. Clay and soot composing four laminae: (a) waxlike rich clay up to cm thick; (b) black highly ferruginous soot 5.0–5.5 cm thick and with ocherous inclusions (up to 1 cm across); (c) clay with microlaminae of light and dark varieties, locally ferruginous and carbonaceous, 1–2 cm thick; and (d) thickness-variable clay with the sooty upper surface, 0–1.5 cm thick. About 10 m downstream of the Oka River, these four laminae are replaced by thin-laminated clay 0.01–0.15 m thick with abundant poorly preserved brachiopod remains. The total thickness of the bed is 0.08–0.12 m.

Bed 10. The basal part of the bed (0.4 m) is composed of calcareous clay with shelly detritus. Higher, it grades into soft fine-grained limestone with yellow mottles (0.3–1 cm across). Abundant and regularly distributed fossils are represented by solitary corals (up to 7 cm long), *Gigantoproductus* (up to 12 cm across) lying on the ventral valve, and others. Platy chaetetids (up to 6 cm wide) and *Siringopora* forms (up to 8 cm across) are less common. The thickness is 0.35–0.4 m.

Bed 11. Fine-grained limestone, almost white and aphanitic in the upper third of the bed, occasionally black, frequently with vertical caverns, probably, developed after stigmaria. The upper surface is slightly tuberculate in case of aphanitic limestone and flat in case of its fine-grained variety. Present are solitary corals (up to 5 cm long) occurring in horizontal position and productid valves (2–4 cm across). Aphanitic limestone lacks any fossils. The thickness is 0.5 m.

Bed 12. Hard fine-grained limestone with abundant shelly detritus. Fossils are abundant in the interval of

0.15–0.25 cm above the base. Preponderant are solitary cylindrical corals (up to 6 cm long), *Striatifera* (up to 7 cm across) and other brachiopods (1–4 cm across) irregularly, usually closely spaced. Less common are *Syringopora*, small (up to 1 cm across) gastropods, *Gigantoproductus* with the ventral valve always oriented downward, and spiriferids. At the level of 1.2–1.4 m from the base, fossils are also abundant, but more freely spaced. They are mainly represented by small (5–7 cm across) gastropods. Also present is one bellerophonid specimen with an aperture 9.5 cm across. In other layers, fossils are scarce and include a solitary coral (6 cm in diameter) 0.6 m above the base, *Gigantoproductus* (9 cm across) with a ventral valve oriented upward slightly higher, and the sponge *Siderospongia sirenis* Trd. (6 cm across) near the roof. The boundary with Bed 13 is uneven with topography amplitude of 0.25 m and less. The thickness is 1.4–1.6 m.

Bed 13. Waxlike clay, sometimes black with anthracite glance, containing inclusions of aphanic limestone and, locally, accumulations of shelly detritus and small crinoid columnals. The thickness is 0–0.15 m.

Bed 14. Dark aphanic limestone with abundant cavities developed after rhizoids that are hollow or filled with limy powder. One of the rhizoids crosses Beds 14 and 13 and terminates in Bed 12. The thickness is 0.5–0.7 m.

Bed 15. Gray very compact limestone with abundant shelly detritus and caverns. The bed includes several platy, locally joint layers with Quaternary sand and clay between them. Determinable fossils are rare: *Siringopora* (5 cm), solitary corals (2–3 cm), gastropod molds, differently oriented *Gigantoproductus* (7–8 cm) shells, and small brachiopods. The thickness is 2.4 m.

Bed 16. The lower part (0.4 m) is composed of variably lithified limestone, locally with mottles (0.5 cm across) and caverns. Abundant are brachiopod detritus and small crinoid columnals. In the upper part (0.6 m), limestone is very compact, with rare horizontal and vertical fucoids (up to 0.6 cm in diameter) and foraminifers. The thickness is 1 m.

Bed 17. Limestone with cavities, resembling conglomerate owing to irregular distribution of dark compact mottles within a loose rock. The upper 3–5 cm lack such mottles and limestone becomes clayey. Fossils are virtually missing. The thickness is 0.7 m.

Bed 18. Fine-grained mottled, compact or loose, limestone with shelly detritus. Reddish brown or bright yellow mottles (up to 10 cm across and larger) are usually of capricious outlines and form a peculiar rock lace. Common are foraminifers, small crinoid columnals, gastropods, and *Gigantoproductus* shells buried in life-time position. No mottles are observed in the upper 4 cm. The thickness is 1 m.

Bed 19. Limestone, with yellow mottles and caverns in the upper part and soft at the top. Abundant are shelly detritus and foraminifers; present are also solitary corals (up to 8 cm long) and bellerophonids (3–5 cm). The thickness is 1.6–1.7 m.

Bed 20. White and yellow to black, aphanic, compact, fossil-free limestone with caverns, including vertical ones, which are filled, sometimes, with powdery ocherous material. The thickness is 0.35–0.4 m.

Bed 21. Fine-grained, fairly compact limestone with abundant detritus and foraminiferal tests and thin thickness-variable loose laminae at 0.1 and 0.8 m above the bed base. The layer at 0.2 m below the top shows the presence of sooty material. The rock yielded the following fossils: an oval colony of *Lithostrotion* (5 cm wide) with corallites oriented upward at the bed base, a gastropod shell (8 cm across) 0.1 m above the base, a fragment of sponge *Siderosongia sirenis* Trd. 0.6 m above the latter, a complete shell of *Gigantoproducrtus* (9 cm across), and a small productid valve with the convex side oriented downward. The thickness is 1.55 m.

Bed 22. Fine-grained limestone with abundant shelly detritus. The bed consists of four plates with slightly tuberculate boundaries marked by loose or thinly laminated limestone varieties. The lower plate bears dark mottles, whereas the bottom surface of the second plate shows stylolite striation. The third and fourth plates, which are locally merged together, are composed of limestone with differently shaped and, frequently, branching cavities, from small-sized to 0.25 m and, sometimes, 0.6 m across; large cavities open at the top of the bed. Cavities enclose shelly detritus and small columnals. Other fossils are rare: one flat lamellae 20-cm-wide colony of *Chaetetes* was found in the first plate and another 12-cm-wide colony, in which the upper surface was concave and the lower surface was convex, was found in the second plate. The thickness is 1.3–1.4 m.

Bed 23. Compact aphanic limestone with vertical rhizoid canals, which are filled with a soft, sometimes brecciated, variety of limestone. Locally, there are large caverns in the lower part of the bed that are similar to the mentioned above. The thickness is 0.4–0.45 m.

Bed 24. Fine-grained limestone, soft near the contacts of plates. The bed consists of five hard plates 0.6, 0.4, 0.3, 0.4, and 0.55 m thick (from the base upward, respectively). The boundaries of the plates are marked by erosion surfaces with subsurface-alluvial deposits (up to 0.25 m thick). In the upper 5 cm of the bed, the limestone is clayey and grading into similar rocks of Bed 23. The second and third plates enclose inclined elongated hollow fucoids. In the fourth and fifth plates, the oblique fucoids are filled with clayey calcareous material. The sediments contain abundant foraminiferal tests, shelly detritus, and crinoid remains. Macrofaunal remains are represented by a solitary coral (1 cm across) and productids (4–5 cm across). The thickness is 2.25 m.

Bed 25. Varicolored clay, massive in the middle part and locally laminated in the lower and upper parts of the bed. Lenticular accumulations of limonite occur near the base. Present is rare shelly detritus, including a fragment of a thin-walled brachiopod valve. The thickness is 0.09 m.

Bed 26. Light gray limestone with manganese mottles. The lower, hardest plate (0.3 m) contains single foraminifers as well as shelly and crinoid detritus, whereas the upper plate encloses inclined hollow fucoids (0.4 cm in cross section). At the level 0.25 m above the base, there is a group of four platyceratid gastropods (0.5–1 cm across) located between thin-walled brachiopod valves. The rocks lying 0.2–0.3 m above this level are unexposed. The thickness is 0.45 m.

Bed 27. Fine-grained limestone with abundant shelly and crinoid detritus composes the lower (0.2 m) and upper (0.5 m) plates. Abundant are vertical fucoids (0.3–0.6 cm across), which either are filled with soft limestone from Bed 28 or remain hollow. The upper 10 cm of the bed enclose abundant horizontal and slightly inclined *Taonurus* fucoids. The base of the bed yielded a *Spirifer* (2 cm across) and several small productids, and the upper plate, a single platyceratid gastropod shell. The thickness is 0.7 m.

Bed 28. Limestone with *Taonurus* fucoids is rather soft, with uneven bedding surfaces, and encloses brachiopod detritus and valve fragments (up to 1.2 cm across). The abundant fucoids are horizontal or slightly inclined to the bedding surface, up to 15 cm long and up to 0.7 cm across. Limestone that fills fucoids is almost white and grades into yellow at the periphery. The middle part of the bed yielded an orthoceratid (1.5 cm across), a gastropod (0.8 cm across), and a large (8 cm) thin-walled costate brachiopod shell with a ventral valve oriented downward. The thickness is 0.45 m.

Bed 29. Marl with abundant detritus and rare fragments of shells (about 0.5 cm across). Present are small crinoid columnals and column fragments consisting of 3–4 columnals. The thickness is 0.04 m.

Bed 30. Limestone with abundant *Taonurus* fucoids almost identical to that of Bed 28, but differing from the latter in having a violet coloration. Present are column fragments of 8–10 columnals. The thickness is 0.3 m.

Bed 31. Varicolored marl composed of thin variably alternating light and dark laminae and containing abundant white shelly detritus. The thickness is 0.04 m.

Bed 32. Limestone with abundant *Taonurus* fucoids and brachiopod detritus and fragments. In addition, present are vertical fucoids similar to those in Bed 27. Common are limonite and yellow ocherous inclusions, particularly common near the base and roof of the bed. The bed consists of 10 hard plates 0.15, 0.15, 0.1, 0.2, 0.4, 0.18, 0.48, 0.27, 0.45, and 0.33 m thick (from the base upward, respectively). The boundaries of the plates are emphasized by soft limestone varieties and, sometimes, erosion marks. In the middle of the second plate, there are rare inclined and vertical fucoids of two types. The plate yielded a single solitary coral and fragment of crinoid column (0.5 cm across). The fifth plate encloses abundant vertical thin fucoids similar to those in Bed 27. *Taonurus* fucoids are steeply inclined to the bedding surface; present are bellerophonid molds. The sixth plate is completely reworked by vertical and slightly oblique fucoids. In the seventh plate, such fucoids are rare, whereas *Taonurus* fucoids are abundant. This plate yielded several bellerophonid shells as well as chaotically oriented valves of spirifirids and productids. The ninth plate also encloses thin vertical fucoids. In the tenth plate, particularly abundant are limonite concretions (2–4 cm across) locally contacting each other and arranged in horizontal chains. The bed is poor in faunal remains. The thickness is 2.7 m.

Bed 33.[11] Marl with thin variably alternating light and dark laminae and enclosing scarce shelly detritus and abundant *Taonurus* fucoids. The thickness is 0.02–0.03 m.

Bed 34. Light gray fine-grained soft limestone with a minor admixture of clay and bedding similar to that in Bed 33. Present are shelly detritus and abundant *Taonurus* fucoids (up to 0.5 cm across). The thickness is 0.4 m.

Bed 35. Light gray with a yellowish tint fine-grained compact limestone, with abundant irregularly distributed shelly detritus (1–3 mm in size). Common are *Taonurus* fucoids. Present are also crinoid columnals up to 3 mm in cross section. Transition to the overlying bed is gradual. The thickness is 0.35 m.

Bed 36. Limestone with a minor admixture of clay, similar to that from Bed 34. There are lenticular, more calcareous areas (4–8 cm long and 2–3 cm high), some of which are, as well as the entire bed, thinly and irregularly laminated. Abundant are *Taonurus* fucoids. The bed yielded a single spiriferid shell (1 cm across) with the ventral valve oriented downward and a single solitary coral (2 cm across and 3.5 cm high) with the cup oriented upward. Common are crinoid columnals. Transition to the overlying bed is gradual. The thickness is 0.25 m.

Bed 37. Limestone similar to that in Bed 35, but more compact, forming two plates that are separated by a more clayey variety. Present are cylindrical fucoids 0.8 cm across, horizontal, filled with limestone. The bed yielded a single *Spirifer* shell buried in the lifetime position. The upper surface of the bed is wavy. The thickness is 0.2 m.

Bed 38. Irregularly colored marl: dark gray to black in the middle part of the bed and lighter greenish and

[11]Beds 33–50 are described from that part of the quarry the section of which is presented in Fig. 9a. Beds 38 and 40 contain blastoids, macro- and microcrinoid calyces, paleacids first described by myself from the Moscow Basin, and conodonts (for reference see Footnote 8).

brownish gray in its peripheral parts. Present are thin (up to 0.6 cm) and long (3–4 cm) limestone lentils arranged parallel to the bedding. The middle part of the bed encloses rusty-brown ferruginous inclusions (up to 1 cm across). Abundant are fragments of thin-shelled brachiopods and their detritus (1–3 mm in size) oriented parallel to thin (1–2 mm) variable lamination. The bed yielded rare small (4 mm across) poorly preserved bivalves and scarce small crinoid columnals. The thickness is 0.05 m.

Bed 39. Gray fine-grained compact limestone almost entirely composed of isolated whole and broken virtually equidimensional crinoid columnals (sometimes present are column fragments of 6–7 columnals) and shell detritus (0.5–3 mm across). The bed consists of three hard plates; the lower and middle plates contain small (1–3 mm) and larger (0.5–2.5 cm) rounded rusty brown inclusions. They are more abundant in the lower plate, which is locally yellow-colored because of ferric oxides. The thickness is 0.18 m.

Bed 40. Marl with more abundant, as compared with Bed 38, detritus and similarly obscure bedding. In the basal part (6–8 cm), marl is relatively light, greenish gray, locally rusty brown. At the level of 8–11 cm above the base, there is a poorly sustained lamina (frequently lenticular) of light gray to yellowish gray fine-grained limestone with rare shell fragments and isolated crinoid columnals (1–3 mm in cross section). The lentils are 3.0–3.3 cm thick and 5–25 cm long. In the overlying layers, marl is brownish gray near the contact with limestone lenses and lighter at the contact with the overlying bed. Present are single crinoid fragments. The upper surface of the bed is uneven. The thickness is 0.40–0.45 m.

Bed 41. Light to white fine-grained limestone divided into poorly sustained irregular laminae (0.5–0.6 cm thick) in the lower 7–8 cm. There are rare shelly detritus and fragments. The lower part of the bed encloses solitary corals (1–2 cm across) with cups oriented upward, and the upper part contains horizontally lying corals. Common are also productids, from small (1–1.5 cm) to large (up to 8 cm) in size, and spiriferids (2–5 cm), as well as isolated crinoid columnals; larger productid shells occur with the ventral valve, faced downward whereas the shells of smaller productids are chaotically oriented. The boundary with the overlying bed is uneven. The thickness is 0.16–0.20 m.

Bed 42. Light to greenish gray marl consisting of thin (5–6 mm thick) laminae that are, in turn, composed of obscurely alternating dark and light subordinate (1 mm thick) laminae. Abundant is shelly detritus (0.5–2.0 mm in size). The rock yielded a small solitary corral (0.7 cm across) and large (6 cm) thin-walled productid shell with the convex side oriented downward. The boundary with the overlying bed is uneven. The thickness is 0.04–0.06 m.

Bed 43. Limestone similar to that in Bed 41 forms a single plate with an uneven surface consisting of hummocks and depressions. The rock locks faunal remains. The thickness is 0.10–0.12 m.

Bed 44. Marl similar to that in Bed 42. The upper 5 cm enclose irregularly shaped limonite inclusions (about 1 cm across). The boundary with the overlying bed is uneven. The thickness is 0.07–0.08 m.

Bed 45. Limestone similar to that in beds 41 and 43 but differing in the occurrence of either roughly isometric (1–2 cm across) or horizontally elongated (0.5 cm across and up to 10 cm long) gray mottles. There are rare horizontal and oblique fucoids. The horizontal fucoids (0.5–0.8 cm in diameter and 3–4 cm long) occur throughout the bed, are partly filled with calcite crystals, and are rusty brown in coloration because of ferric oxides. The oblique fucoids (0.2–0.3 cm across and 5–8 cm long) are filled with material, which is lighter and softer than the surrounding rock. The rocks show no faunal remains. The thickness is 0.15–0.20 m.

Bed 46. Fossil-free greenish gray marl similar to that in Bed 44. The thickness is 0.1 m.

Bed 47. Limestone similar to that composing beds 42, 43, and 45. It contains no faunal remains except for separate crinoid fragments. The thickness is 0.1 m.

Bed 48. Greenish gray soft marl locally thickly colored by Fe oxides. It contains rare shelly detritus and isolated crinoid columnals (1–1.5 mm across). No other faunal remains are observable. The boundary with the overlying bed is uneven. The thickness is 0.05 m.

Bed 49. Light greenish gray fine-grained semilitified limestone with rare small-sized shelly detritus and, locally, abundant crinoid columnals (2–3 mm across). The thickness is 0.03–0.05 m.

Bed 50. Clay yellowish green in the lower part of the bed and dark gray in the upper part, locally waxlike. The lower part encloses rounded (about 1 cm in diameter) limonite aggregates. There are also dispersed shelly detritus (1.0–1.5 mm) and rare crinoid columnals. The apparent thickness is 0.1 mm.

Fifty meters downstream the Oka River (Fig. 9b), beds 33–37 are composed of limestones, which are almost identical in lithology, thickness, and faunal characteristic to those described above (Fig. 9a).

Bed 38. Marl similar to that described above. The middle part of the bed contains abundant thin-walled brachiopod shells (0.5–2.0 cm across) arranged parallel to the bedding. There are also rare columnals and column fragments of crinoids (0.2–0.6 cm in diameter), as well as rare columns. The thickness is 0.2 m.

Bed 39. Crinoid platty limestone, which is replaced 1.5 m away along the strike by a variety almost lacking crinoids and 1 m farther again grades into crinoid limestone. The thickness is 0.23 m.

Bed 40. Irregularly colored marl,which contains a spiriferid (2 cm across) buried in the lifetime position and abundant crinoid columnals (1–3 mm in cross section), which are particularly numerous in the upper half of the bed. The thickness is 0.12 m.

Bed 41. Crinoid limestone similar to that in Bed 39. It forms two equally thick plates, which lack fauna except for crinoid remains. The thickness is 0.3 m.

Bed 42. Irregularly colored marl similar to that composing Bed 40. Fossils are represented only by rare crinoid columnals. The thickness is 0.2 m.

Bed 43. Crinoid limestone consisting of two plates, with the thickness of 0.07 (lower) and 0.13 m (upper), respectively. The total thickness is 0.2 m.

In Exposure 9b located 15 m downstream the Oka River, the integral thickness of Beds 33–37 is reduced to 0.75 m (Fig. 9c). The upper part of Bed 34 (0.45 m thick) yielded abundant columns of *Unilineatocrinus inconstantistellatus* sp. nov., size-variable, often long (up to 0.25 m), and with abundant cirri. Crinoids were frequently buried in their natural habitat.

Bed 38. Marl similar to that composing the same layer described above (Fig. 9a). There are rare crinoids, including microcrinoid remains. The thickness is 0.3 m.

Bed 39. Crinoid limestone similar to that from the same bed described above. The thickness is 0.35 m.

Bed 40. Marl enclosing abundant crinoid columnals and column fragments (1–5 mm in diameter). There are colonies of branching and cylindrical bryozoans, as well as spiriferids and other brachiopods (1–1.5 cm across), occurring usually as isolated valves. The thickness is 0.25–0.35 m.

Bed 41. Crinoid limestone with short inclined fucoids (0.7 cm across and 2–3 cm long). The thickness is 0.15 m.

Bed 42. Marl with a thin poorly defined lamination and enclosing shelly detritus and abundant size-variable crinoid columnals. The thickness is 0.1 m.

Bed 43. Crinoid limestone. The thickness is 0.2 m.

Twenty five meters farther downstream the Oka River, Beds 33–39 are similar to their equivalents in Exposure 9c (Fig. 9d). Beds 40–42 are poorly distinguishable here. They are composed of dirty gray and greenish marl locally with almost black horizontally elongated lenses (2–3 cm thick) containing abundant invertebrate remains. The most common amid them are branching, horizontally spread bryozoans, forming a kind of bioherms; crinoid columnals and large column fragments accompanied by plates and cups of macrocrinoids and microcrinoid calyces and thecas; and brachiopods. The basal part of the bed hosts abundant well-preserved large (5–6 cm across) *Shizophoria resupinata* Mart. (all with the ventral valves oriented downward) accompanied by less common *Athyris ambigua* (Sow.), spiriferids, and other brachiopod forms, often with the downward oriented umbos. Common are diverse, frequently very large, solitary corals (up to 5–6 cm in diameter), most of which are buried with their apertures oriented upward and are elongated along a single direction.

At the level of 0.4 m above the base, there is a lenticular lamina (0.05 m thick) of somewhat clayey limestone with rare crinoid columnals, which probably corresponds to Bed 41. The lamina and its lower boundary contain abundant rounded ferruginous concretions of 1–2 cm in diameter. Marl overlying this lamina is substantially impoverished in fossils. The total thickness of Beds 40–42 is 0.55 m.

Bed 43. Crinoid limestone. The thickness is 0.15 m.

Bed 44. Brownish to almost black marl grading in the middle part of the bed into a lamina composed of limestone lentils. The lamina is again overlain by similar marl locally replaced by black and yellow waxlike clay. The marl hosts rare differently oriented small (0.3–1.1 cm) brachiopods and small crinoid columnals. The thickness is 0.22 m.

Bed 45. Crinoid limestone composed of small isolated crinoid columnals. It forms two plates 0.4–0.45 and 0.15 m thick. The upper part of the bed contains abundant small limonite concretions. The thickness is 0.55–0.60 m.

Bed 46. Brownish gray marl with abundant small-sized shelly detritus and crinoid columnals (1–3 mm across). The thickness is 0.05 m.

Bed 47. Crinoid limestone. The thickness is 0.25 m.

Bed 48. Marl with crinoid columnals. The thickness is 0.07 m.

Bed 49. Crinoid limestone. The thickness is 0.15 m.

Bed 50. Marl with rare crinoid columnals. The apparent thickness is 0.15 m.

Exposure 9e, located 15–20 m away from the previous exposure, shows the following beds:

Beds 33–37. Similar to their equivalents in Exposure 9c. The total thickness is 0.75 m.

Bed 38. Greenish gray clay with small shelly detritus, the abundance of which is higher in the upper part of the bed. There are very small (2–4 mm across) *Athyris ambigua* (Sow.) and *Eomarginifera lobata* (Sow.), crinoid columnals and column fragments. Some *Athyris* shells are significantly larger (up to 8 mm across). At the level of 0.08 m above the base, there is a lamina of fine detrital limestone (1.5 cm) with limonite concretions (1–3 cm across); it is overlain by clay composed of alternating dark- and light-colored thin (2–3 mm) laminae. The upper part of the bed is represented by greenish gray massive marl. The thickness is 0.2 m.

Bed 39. Crinoid limestone, locally laminated (2–3 mm). Crinoid columnals are very small (0.5 mm across). Abundant is small regularly distributed detritus. The thickness is 0.15 m.

Bed 40. Gray marl obscurely bedded in the lower half of the bed and distinctly laminated (1.0–1.5 mm) in the upper one. The thickness is 0.1 m.

Bed 41. Clayey limestone with obscure lamination due to the alternation of laminae rich in carbonate with those rich in clay. There are detritus and small crinoid columnals. The lower part of the bed encloses small (up to 3 mm in diameter) limonite concretions. The thickness is 0.15 m.

Bed 42. Yellowish gray marl with fine detritus of unclear composition. There are crinoid columnals (0.5 mm across). The rock encloses lenticular limestone concretions (2–4 cm thick) and horizontal cylindrical fucoids (up to 0.8 cm in diameter). The thickness is 0.18 m.

Bed 43. Similar in lithology to Beds 41 and 39. There are regularly dispersed crinoid columnals (3–4 mm in diameter). The thickness is 0.2 m.

Bed 44. The bed is mainly composed of varicolored clayey laminae (from the base upward): yellowish gray silty clay (0.04 m); detrital limestone (0.01 m); dark gray to greenish gray thinly laminated clay with limonite concretions (0.02–0.03 m); gray clay almost free of detritus (0.02 m); dark gray locally yellow waxlike clay (0.02 m); dark gray clay with abundant brachiopods and rare crinoid columnals (0.02 m); greenish gray light-colored calcareous clay, rich in fine detritus and similar to that occurring at the base of the bed (0.05 m). Detritus and crinoid columnals are abundant, limonite concretions are less common. The thickness is 0.18 m.

Bed 45. Limestone with an insignificant admixture of clay and rare small crinoid columnals. At the level of 0.15 m above the base, limestone shows an elevated clay content. The thickness is 0.2 m.

Bed 46. Gray marl with abundant crinoid columnals. The thickness is 0.07 m.

Bed 47. Crinoid limestone with small limonite inclusions and isolated brachiopod valves (2–4 cm across). The thickness is 0.22 m.

Bed 48. Dark gray soft marl with rare crinoid remains. The thickness is 0.2 m.

In the Bekhovo quarry, located 6 km downstream the Oka River, Beds 33–37 are close in lithology to their equivalents described above for other exposures, although they differ from the latter in having a greater thickness and marly varieties in the upper part of the section (Fig. 9f). The overlying beds are as follows:

Bed 38. Black consolidated book clay with shells of *Athyris ambigua* (Sow.), *Eomarginifera lobata* (Sow.), and other brachiopods. The thickness is 0.1 m.

Bed 39. Light gray, fine-grained hard limestone with small pyrite aggregates and abundant shells of *Productus undatus*, spiriferids, and other brachiopods. The thickness is 0.15 m.

Bed 40. Clay similar to that in Bed 38. The thickness is 0.1 m.

Bed 41. Limestone similar to that in Bed 39, with brachiopods and rare solitary corals and crinoid columnals. The thickness is 0.4 m.

Bed 42. Dark gray, occasionally almost black, foliate marl with brachiopod remains. The thickness is 0.07 m.

Bed 43. Light gray fine-grained limestone with invertebrate remains. The thickness is 0.1 m.

Bed 44. Violet to black thinly laminated clay containing brachiopod remains similar to those in Bed 38 and grading up the section into dirty gray marl with abundant crinoid fragments. There are also brachiopods *Productus, Martinia, Shizophoria resupinata* (Mart.), *Spinifer grobberi* Schw., and *S. parabisulcatus* Semich. The thickness is 0.38 m.

Bed 45. Light gray limestone almost completely composed of crinoid columnals and small brachiopods. The basal and uppermost parts enclose marly laminae. Fossils are similar to those in Bed 44. The thickness is 0.2 m.

Bed 46. Dark gray marl with shelly and crinoid detritus and rare columnals and column fragments. The thickness is 0.03 m.

Bed 47. Crinoid limestone similar to that in Bed 45. The apparent thickness is 0.2 m.

In the small quarry located between the Bekhovo and Mitino quarries (Exposure 9g), Beds 33–37, which are composed mainly of limestones with lenticular jointing, are overlain by Beds 38–45, which are composed of crinoid limestones with crinoid clayey–marly laminae and contain abundant brachiopod and corals. Crinoids are represented by fragments of size-variable columns, which were probably often buried in their lifetime positions. The thickness is 1.43 m. Beds 46–48 are dark gray clays with abundant invertebrate remains and thin interbed of crinoid limestone. The apparent thickness is 0.6 m.

In the Mitino quarry, the section of the Steshev Horizon includes the following beds (Fig. 9h):

Beds 33–37. Limestone varying in density and clay content with rare limonite concretions up to 1.5–2.0 cm across. The upper part of this section includes lentils of hard fine-grained or even aphanic limestone and encloses abundant small (0.2–0.5 cm across) rounded limonite nodules and rare stylolites (2–3 cm high and 1–2 cm in diameter). The upper 0.2 m are crossed by rare oblique fucoids (0.5 cm in diameter and 2–3 cm long) frequently filled with crystalline calcite. Faunal remains are uncommon, particularly in the lower part of the section. They are represented by gastropod molds (2 cm), productids (1 cm), two *Spirifer* shells belonging to two different species (0.8 and 2.5 cm across, one in the lifetime position), solitary corals (0.8 and 1.8 cm in diameter, the cup of the latter is oriented upward), and shark teeth (1 cm). The thickness is 1.25 m.

Bed 38. Heterogeneous marl with a variable content of carbonate material, as well as fossils and organogenic detritus. The rock is yellowish gray, locally gray or rusty brown, and massive in the lower part (0.02–0.06 m), shows obscure bedding in the upper part of the section, and encloses rare limonite nodules (5–7 mm in diameter), abundant shelly detritus (from fractions of a millimeter to 2 mm in size), and larger (up to 5 mm) fragments of thin-walled shells, the abundance of which increases from the base upward. The diverse and distinctive faunal remains include (1) solitary conical corals (0.5–2.0 cm long and 0.3–0.8 cm across and larger), sometimes with abundant spines on the lateral surface; (2) peculiar small colonial corals (0.7–3.0 cm long and 0.4–1.5 cm high) nodular in shape and often overgrowing brachiopod shells and other hard substrate; (3) rare bryozoans; (4) abundant *Spirifer parabisulcatus* Semich. (1–3 cm across), less common *Eomarginifera lobata* (Sow.) and *Athyris ambigua* (Sow.) (0.5–1.5 cm), and seven other, usually smaller, brachiopod species; (5) rare small (0.35–0.60 cm) blastoid species *Orbotremites musatovi* (Arendt) occurring with an approximate density of one specimen per every 8 m^2; (6) abundant crinoid columnals and column fragments; and (7) several shark and bradyodont teeth (0.3–0.5 cm long). Up the section, this rock grades into yellowish gray thinly laminated (from fractions of a millimeter to 5 mm) marl (0.1 m thick) with laminae separated by shelly detritus; some of them are almost black. There are rare limonite concretions, as well as abundant *Eomarginifera lobata* (up to 1 cm) with the ventral valve often oriented downward and other small brachiopods (3 or 4 species). Transition to overlying marly laminae (0.14–0.18 m) is gradual. The marl is yellowish gray to gray, locally black, laminated. There are alternating varieties with distinct (at 0.20–0.23 m from the base of the section and within the upper 0.2–0.4 m) and obscure (at 0.15–0.20 m and 0.23–0.28 m from the base) lamination. The rare faunal remains of the upper part of the bed include small (up to 0.1 cm) thin-walled, differently oriented shells of *Chonetes* and other brachiopods and small (2–3 mm across) crinoid columnals. The upper surface of the bed is gently wavy. The thickness is 0.3 m.

Bed 39. Light gray to white fine-grained limestone with rare fine (up to 1 mm) detritus and crinoid columnals (0.2–0.4 cm across). The fucoids are abundant and may be horizontal of the *Taonurus* type and vertical, cylindrical, slightly twisting (0.4 cm across), hollow or filled with gray marl. Transition to the overlying bed is gradual. The thickness is 0.12–0.14 m.

Bed 40. Dirty yellow marl with black mottles and obscure thin (0.5–2.0 mm) variable lamination; there is abundant shelly detritus (0.5–1.5 mm across) with a single valve of *Spirifer* (2 cm across) with the downward oriented concave side. The thickness is 0.01–0.05 m.

Bed 41. Limestone with a fine (up to 1 mm) shelly detritus and lenticular bedding (lentils are 2–3 cm thick and 10–20 cm across). In the every lentil, the rock is light gray in the central part and yellowish gray in the peripheral part. There are horizontal and vertical cylindrical fucoids (0.5–0.7 cm across, up to 8 cm long) filled by material different from the host rock. The middle part of the bed encloses a thin marly layer. The lower and upper surfaces of the bed bear hummocks and depressions, which correspond to the lenticular jointings. This is particularly true of the lower surface, which bears stylolites. The thickness is 0.50–0.55 m.

Bed 42. Greenish gray marl with rare irregular black mottles and thin (1–2 mm) horizontal variable lamination formed by alternating light- and dark-colored laminae and sometimes emphasized by the uneven distribution of shelly detritus (0.5–2.0 mm across). The bed contains rare, small (0.5–0.7 cm in size) chonetids, a *Lingula* (0.3 cm across), rare small (2 mm in cross section) crinoid columnals, and column fragments consisting of two columnals. The thickness is 0.08–0.12 m.

Bed 43. Compact limestone with irregularly distributed gray and dark gray coloration. There are numerous *Taonurus* fucoids (0.5–0.6 mm across); sometimes, the fresh surface bears dark gray small (1 mm) circles probably representing cross sections of fucoids. The rocks are riched in detritus (0.5–1.0 mm in size) and contain abundant crinoid columnals (1–3 mm across), common productids (1.2–1.5 cm across) with a downward oriented convex sides, and fairly frequent representatives of *Martinia* (0.5–2.0 cm), which usually lie with the ventral valves faced downward and are particularly abundant at the contact with the underlying bed. The thickness is 0.18 m.

Bed 44. Light gray to almost black marl characterized by a thin (2 mm) horizontal variable lamination. Marl varieties form the following succession (from the base upward): (1) light marl 0.01–0.02 m thick and rich in shelly detritus (1–3 mm across) and whole shells of *Eomarginifera lobata* with the convex side oriented downward; (2) black and brownish clayey marl 0.1 m thick and with limonite concretions (1 cm high and 2–3 cm long) occurring in the upper part and shells of *Lingula* (0.5 cm across); (3) marl 0.01 m thick, lightest in color, rich in detritus and extremely thin poorly preserved productids (0.3–0.8 cm across) and containing *Lingula*; (4) yellowish clayey marl 0.01 m thick, with poorly defined lamination, and enclosing abundant detritus, crinoid columnals (1–2 mm across), and chaotically oriented productid and *Athyris* shells (1 cm across); (5) greenish gray marl (up to 0.5 cm thick) with variable thin lamination and containing the same but less numerous faunal remains. The thickness is 0.18 m.

Bed 45. Gray fine-grained limestone with rare crinoid columnals. The fresh surface shows the presence of small dark rounded spots (1 mm across) probably representing cross sections of fucoids. There are also rare cylindrical oblique fucoids (0.6 cm across). On the weathered surfaces, there are vertical straight or slightly curved fucoids (0.2–0.4 cm across) as well as horizontal fucoids of the *Taonurus* type (0.3–0.5 cm in diameter), which are most abundant in the upper third of the bed. The thickness is 0.4 m.

Bed 46. Brownish gray marl with thin (1 mm thick) variable obscure lamination. The lower half of the bed hosts limonite nodules (1 cm across) and abundant detritus of brachiopod shells (from fractions of a millimeter to 3 mm across). Its upper half yielded abundant *Eomarginifera lobata* (1 cm in size) and other tiny whole brachiopod shells (0.4–0.5 cm in size), as well as a single *Lingula* shell (0.4 cm in size). Faunal remains are randomly oriented, frequently with the convex side oriented upward. One locality yielded, abundant plant remains (0.5–1.5 cm across). The rocks yielded also isolated chaotically buried crinoid columnals (1–3 mm across) and a single trilobite pygidium (1cm across) with a long tail spine. The transition to the overlying bed is gradual. The thickness is 0.15 m.

Bed 47. Dark gray fine-grained limestone with abundant shells and isolated valves of small brachiopods, crinoid fragments, crinoid detritus, and rare *Taonurus* fucoids. The thickness is 0.15 m.

Bed 48. Clayey–marly sediments forming the following succession: (1) brownish gray irregularly and thinly laminated marl 0.03 cm thick and rich in detritus, faunal remains, and whole small (4–5 mm across) isolated a brachiopod valves and includes also *Eomarginifera lobata* (1 cm), rare fragments of branching bryozoans, crinoid columnals (1–2 mm in diameter), and fish scales; (2) bright yellow waxlike clay 0.01 m thick with rare limonite concretions (0.5–0.7 cm high and up to 2–3 cm across); (3) limy laminated clay of uncertain coloration and 0.06 cm thick, with abundant detritus and small brachiopod shells similar to those from the lower part; (4) marl 0.04 m thick, similar to that in the basal part of the bed, with rare bryozoan and crinoid remains; (5) laminated waxlike clay 0.04 cm thick, grading into dark gray and brownish gray marl with detritus and horizontal twisting fucoids (0.5–0.7 cm across) filled with surrounding sediments in the upper part. The thickness is 0.36 m.

Bed 49. Gray compact limestone with rare fine (fractions of a millimeter) organogenic detritus and abundant *Taonurus* fucoids; the surface is dotted with abundant small (3–4 mm) rounded openings, which are sometimes filled with rusty brown limonite. The apparent thickness is 0.30–0.35 m. The upper 0.20–0.25 m are unexposed.

Bed 50. Dark gray fine-grained compact limestone 0.19 m thick, with rare limonite inclusions, shelly detritus (1–2 mm across), and few *Taonurus* fucoids, grades into black marl, which forms small thin uneven plates (0.1–3 cm across) under the effect of weathering and contains abundant irregularly dispersed detritus (1–3 mm in size), valves of *Eomarginifera lobata* (1–1.2 cm, with the convex sides usually oriented upward), crinoid columnals, and small column fragments. There are also rare irregularly shaped pyrite inclusions (1–2 cm). The apparent thickness is 0.25 cm. The following 1–1.2 m of the exposure are unexposed and overlain by the beds referred to the upper, mainly clayey part of the Steshev Horizon (Fig. 8b).

Bed 51. Dark gray to almost black slightly calcareous clay with rare shell fragments. The apparent thickness is 0.1 m.

Bed 52. Black slightly calcareous clay with irregular jointings (1–5 mm) and fragments of small productid shells and their spines. The thickness is 0.4 m.

Bed 53. Clay similar to that in Bed 51, with very rare detritus and shell fragments and rounded ocherous (1 cm across) and irregularly shaped limonite inclusions. The thickness is 0.1 m.

Bed 54. Clay similar to that in Bed 52, soft, with abundant remains of *Eomarginifera lobata*; in the upper part, clay becomes violet-colored. The thickness is 0.2 m.

Bed 55. Greenish gray slightly calcareous soft clay with small irregularly shaped ocherous inclusions and abundant fragments and whole shells of *Eomarginifera lobata* (0.5–2.0 cm across) with their convex valves usually oriented downward and *Athyria ambigua* (2 cm across) with their ventral or dorsal valves oriented downward. The thickness is 0.2 m.

Bed 56. Violet–gray clay with abundant small-sized shell detritus (from fractions of a millimeter to 1.5 mm across) and rare small randomly oriented brachiopods. The thickness is 0.1 m.

Bed 57. Clay, violet-gray in the lower part and yellowish gray in the upper part, with abundant irregularly distributed rounded bright yellow ocherous inclusions (1–2 cm across). The thickness is 0.3 m.

Bed 58. Dark gray (locally violet) clay with rare rounded carbonate and limonite inclusions. The thickness is 0.5 m.

Bed 59. Greenish gray slightly calcareous clay with rounded or oval limy inclusions, which are rare in the lower part of the bed and become abundant in its upper part. There are also abundant fragments of brachiopod shells (0.1–1 cm across). The apparent thickness is 0.6 m.

Stratigraphic distribution of crinoids and blastoids in the Lower Carboniferous deposits of the southern Moscow Basin

Genus, species	Viséan Stage			Serpukhovian Stage		
	C_1al	C_1mh	C_1vn	C_1tr	C_1st	C_1pr
Rhodocrinites osipovae sp. nov.					+	
Platycrinites tenuiplatensis sp. nov.				+	+	
P. spinifer sp. nov.					+	
Kallimorphocrinus scoticus (Wright)					+	
Streptostomocrinus heckerae sp. nov.					+	
Okacrinus nodosus gen. et sp. nov.					+	
Amphipsalidocrinus astrus sp. nov.					+	
Stukalinocrinus gigas gen. et sp. nov.		+				
S. magnus gen. et sp. nov.	+					
Rhabdocrinus vatagini Arendt					+	
Ureocrinus rozhnovi Arendt						+
Zeacrinites heckeri sp. nov.					+	
Floricyclus paratus (Sisova)					+	
Plummeranteris candidus (Sisova)				+	+	
P. (?) ignatovensis sp. nov.					+	
P. (?) profundus sp. nov.	+					
Unilineatocrinus inconstantistellatus sp. nov.				+	+	
U. cingulatus sp. nov.					+	
U. tarusaensis sp. nov.					+	
U. rectus sp. nov.					+	
U. serpukhovensis sp. nov.					+	
U.(?) tenuicarinatus sp. nov.					+	
Konicrinus(?) excentricus sp. nov.					+	
Carinatocrinus carinatus gen. et sp. nov.		+	+	+	+	
Inclarocrinus inclatus gen. et sp. nov.		+	+	+	+	
Breimerocrinus laevis gen. et sp. nov.					+	
Govorovocrinus okensis gen. et sp. nov.					+	
Tzvetaevocrinus cadiformis gen. et sp. nov.					+	
Polenovocrinus mitinensis gen. et sp. nov.					+	
Dipentagonocrinus magnocarinatus gen. et sp. nov.					+	
Orbitremites musatovi (Arendt)					+	

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